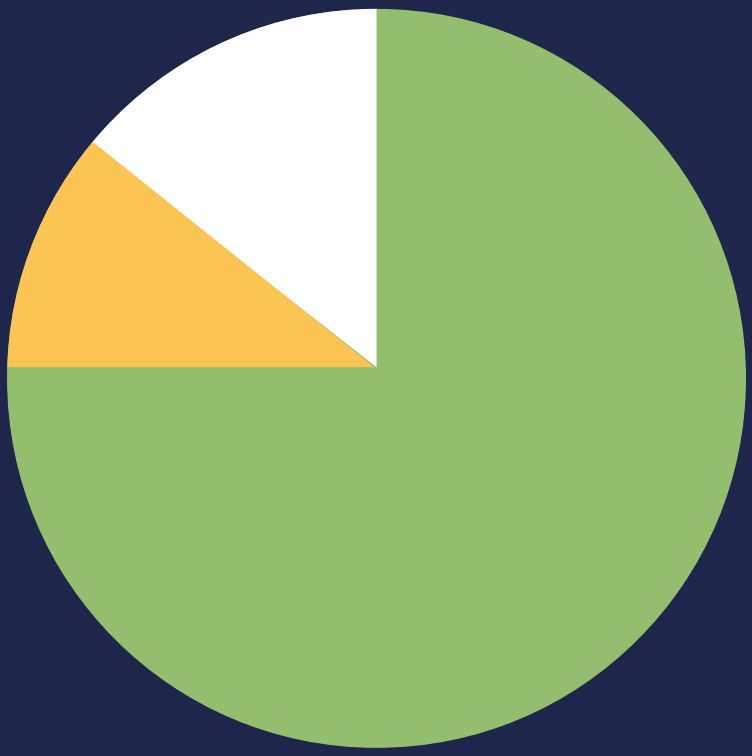
Global Electricity Review

March 2020

EMBER
COAL TO CLEAN ENERGY POLICY

Up-to-date data and insights on the transition to fossil-free electricity

2020



Introduction

Ember is an independent climate think-tank accelerating the global electricity transition.

We have rebranded from "Sandbag", where every January for the last 6 years, we have released a report called "European Power Sector Review", analysing Europe's rapid electricity transition. This is our first annual review of the global power sector.

This report has two aims.

First, to be the earliest authoritative report to give unbiased insights into last year's global electricity generation changes. It incorporates 2019 electricity generation data covering 85% of world's electricity generation, and informed estimates of the remaining 15%. For the key four regions, we have taken 2019 as follows:

- China - China Electricity Council (CEC) from 21st January
- United States - Energy Information Administration (EIA) 26th February
- India - Central Electricity Authority (CEA) from 31st January
- European Union - via Ember's 'European Power Sector Review' from 5th February

Second, to make the entire dataset free and easy to download for others to perform their own analysis.

DOWNLOAD THE DATASET

The spreadsheet contains a complete dataset of 224 countries, with generation by fuel type by year from 2000 to 2019.

Whilst BP and the IEA do a similar task, BP publish 4 months later and through the analytical lens of an oil and gas major, and the IEA data is delayed for 1-2 years, is under copyright and not easily accessible.

In a world racing to reduce power sector greenhouse gas emissions we want to give people access to critical information as quickly as possible.

We hope you enjoy reading this report,

Harry Benham, Chairman of Ember

Bryony Worthington, Founder of Sandbag and Non-Executive Director of Ember

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Disclaimer

The dataset used for this report is provided on an 'as is' basis, and was assembled using the best available data at the time of writing. In order to remain as transparent as possible, we have prioritised clarity over complexity where appropriate. A full explanation of the methodology used to assemble the dataset is provided in the 'Data Method' section. Unless their organization is mentioned, peer reviewers are commenting in an independent capacity. We take no responsibility for errors. Please do contact us if you spot any errors or have suggestions at euan@ember-climate.org.

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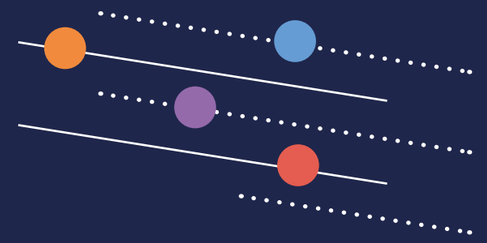


Key Findings

Key Findings Summary

The following pages give evidence on each of these key findings and discuss their implications.

#1

Global coal-fired electricity generation fell by 3% in 2019, leading to a 2% fall in CO_2 power sector emissions. Both of these are the biggest falls since at least 1990. Coal collapsed in the EU and the US; but Chinese coal generation rose and for the first time was responsible for half of global coal generation. The carbon-intensity of global electricity is now 15% lower than in 2010.

#2

But falling coal generation is not yet the "new normal", which means limiting climate change to 1.5 degrees is looking extremely difficult. The coal fall in 2019, as well as relying on the structural shift towards wind and solar, relied on many other one-off factors. Progress is being made on reducing coal generation, but with nothing like the urgency needed to meet global climate goals, especially in Asia.

#3

Wind and solar generation rose by 15% in 2019, generating 8% of the world's electricity. Compound growth rate of 15% of wind and solar generation is needed every year to meet the Paris climate agreement. This was achieved in 2019 and lower prices provide hope it can be sustained. However, maintaining this high growth rate as volumes scale up will require a concerted effort from all regions.

#4

The US coal collapse is undermined by a switch to gas, whereas the EU is leap-frogging from coal to wind and solar. Coal generation collapsed by 24% in the EU and 16% in the US in 2019, and is now half the level of 2007 in both the EU and US. Since 2007, US CO_2 power sector emissions fell by 19-32%, whereas they fell by 43% in the EU.

#1

Global coal-fired electricity generation fell by 3% in 2019, leading to a 2% fall in CO_2 power sector emissions. Both of these are the biggest falls since at least 1990. Coal collapsed in the EU and the US; but Chinese coal generation rose and for the first time was responsible for half of global coal generation. The carbon-intensity of global electricity is now 15% lower than in 2010.

Coal generation fell 3% (-259 TWh)
This is because:

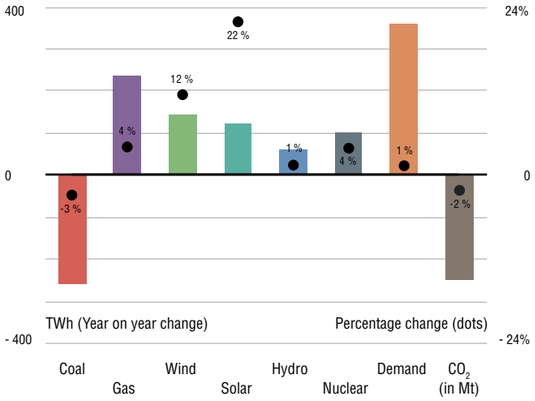
1. Electricity demand increased by the least in a decade due to low economic growth and mild winter months. It rose by +357 TWh in 2019, almost half the 2010-2019 average of +643 TWh.
2. Wind and solar generation rose by 15% (+270 TWh).
3. Coal-to-gas switching in the US (113 TWh) and the EU (73 TWh).
4. Nuclear generation rose by the highest this century (+101 TWh), following one-off re-starts in South Korea and Japan, and new plants in China.

Global power sector CO_2 emissions fell 2%. This takes into account the 4% rise in gas generation; although doesn't include the climate impact of the methane leaks. It includes a fall in oil generation and the small improvement in China's coal fleet efficiency.

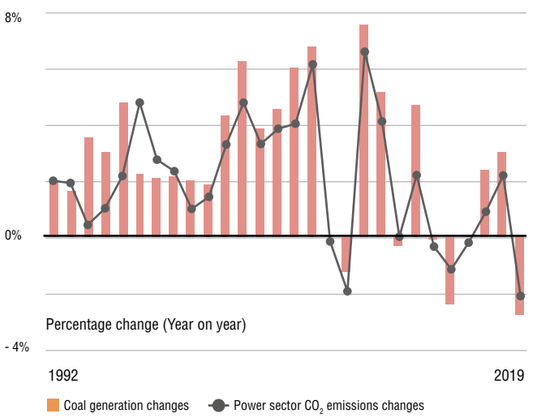
The falls are the biggest since at least 1990, when the IEA started reporting.

This is true for both the 3% fall in coal generation and the 2% fall in power sector CO_2 emissions.

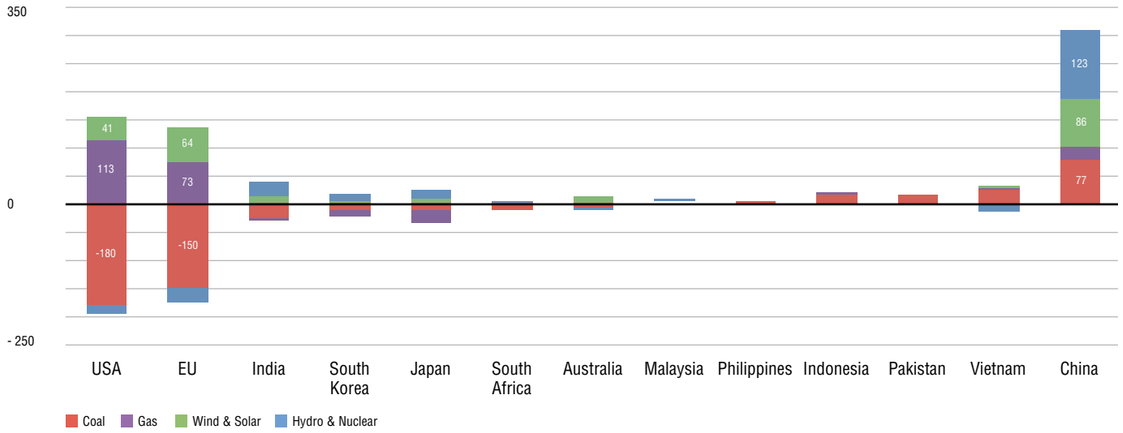
2019 global electricity generation changes



Global coal generation & power sector emissions changes



2019 global electricity generation changes in key coal consuming countries



Coal collapsed in the EU and the US; but China coal rose and is now responsible for half of global coal generation

Coal generation collapsed by 24% in the EU and 16% in the US due to a combination of new wind and solar installations, more gas generation and a small drop in electricity demand.

China saw the biggest increase in coal generation, 77 TWh (2%), pushing it to 50.2% of global coal generation. In China, wind, solar, nuclear and hydro all saw increases, but this was not enough to meet another year of rapid electricity demand growth. It grew at 4.7%, over three times the global average, despite its weakest economic growth in 30 years. To meet this demand, both coal and gas generation increased. Chinese coal fleet efficiency increased by 0.3%, the lowest fall since 2006 when reporting began.

Some Asian countries also saw an increase in coal: Indonesia (+11%) Malaysia (+5%) and Philippines (+12%) saw higher electricity demand which was met almost exclusively with coal, with near-zero wind and solar being built. Pakistan commissioned a new coal plant, which replaced oil generation. Vietnam coal increased (+34%) caused by a record drought, despite a huge surge in solar capacity built.

But some Asian countries saw less coal: incredibly even India (-3%) fell as electricity demand growth paused, new solar was added and hydro had bumper conditions. Coal fell in South Korea (-5%) and Japan (-4%) due to nuclear restarts, and a fall in electricity demand.

#2 But falling coal is not yet the "new normal", which means limiting climate change to 1.5 degrees is looking extremely difficult.

The coal fall in 2019, as well as relying on the structural shift towards wind and solar, relied on many other one-off factors. Progress is being made on reducing coal generation, but with nothing like the urgency needed to meet global climate goals, especially in Asia.

The 3% (-259 TWh) fall in global coal generation is not yet the "new normal" - it happened largely due to one-off factors.

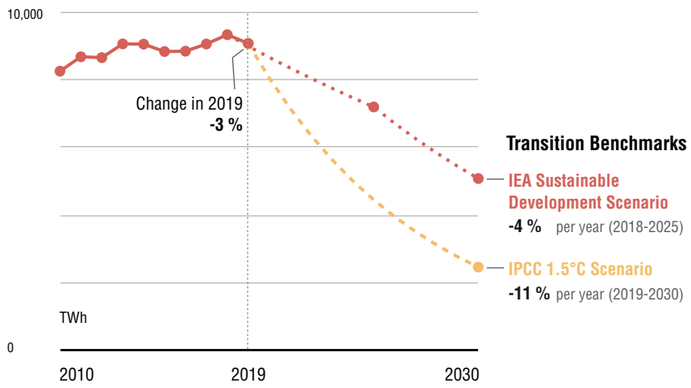
Electricity demand increased by the least in a decade, by 357 TWh in 2019, which was almost half the 2010-2019 average of 643 TWh. The 73 TWh of coal-to-gas switching in the EU cannot be repeated, as the economics in 2019 swung firmly against coal, and few new gas plants are being built.

Nuclear generation rose by 101 TWh, of which 39 TWh was restarts in South Korea and Japan. However, the 270 TWh increase in wind and solar was bigger than the 259 TWh fall in coal. Sustaining the decrease in emissions seen this year will require increasing investments in zero emissions capacity and increasing energy efficiency.

Coal generation needs to collapse by 11% per year to keep to 1.5 degrees.

Even if the record 3% fall in coal were to happen every year, it still wouldn't be enough. The IPCC's 1.5 degrees median scenario shows coal generation must collapse at 11% per year to 2030. The IEA's Sustainable Development Scenario requires year-on-year falls of 4% every year from 2018 to 2025.

Coal generation with future scenarios



The lack of urgency on coal - especially in the top 10 coal-generating countries - means limiting climate change to 1.5 degrees is looking extremely difficult.

Ten countries account for 87% of the world's coal generation. Whilst progress is being made in most countries on coal, none of the top 10 coal countries have yet made commitments to reduce coal that are consistent with the IEA's Sustainable Development Scenario, let alone the tougher IPCC 1.5 degrees scenario. The only one of these countries to set a coal phase-out date is Germany, of 2038, which is not consistent with what is required to meet 1.5 degrees.

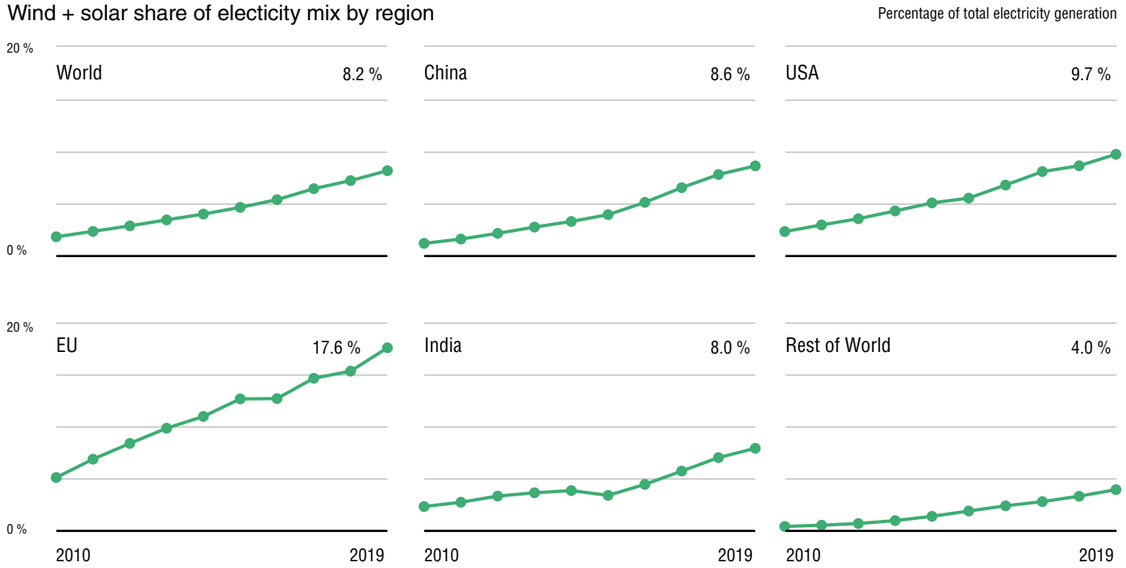
Country	Percentage of global coal generation in 2019	Generation TWh (% change in 2019)	GW opened in 2019*	GW closed in 2019*	Coal phase-out date
1. China	50.2%	4560 (+2%)	43.8	7.0	-
2. India	11.0%	999 (-3%)	8.1	0.8	-
3. United States	10.6%	966 (-16%)	0	16.5	-
4. Japan	3.1%	285 (-4%)	1.3	0.1	-
5. South Korea	2.5%	223 (-5%)	0.2	0	-
6. South Africa	2.2%	198 (-4%)	1.6	0.5	-
7. Germany	1.9%	172 (-25%)	0	1.2	2038
8. Russia	1.8%	166 (0%)	0.9	1.4	-
9. Indonesia	1.8%	163 (+11%)	2.4	0	-
10. Australia	1.6%	144 (-4%)	0	0	-

* Source: Global Energy Monitor, "Global Coal Plant Tracker," January 2020

#3

Wind and solar generation rose by 15% in 2019, generating 8% of the world's electricity.

Compound growth rate of 15% of wind and solar generation is needed every year to meet the Paris climate agreement. This was achieved in 2019 and lower prices provide hope it can be sustained. However, but maintaining this high growth rate as volumes scale up, will require a concerted effort from all regions.



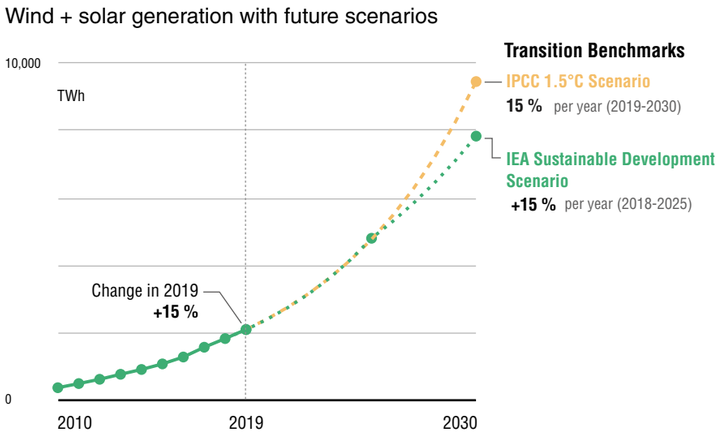
Wind and solar generation grew by 15% (+270 TWh) in 2019.

The wind and solar growth rate of 15% must be maintained to meet the emissions reductions needed for the Paris climate agreement.

The wind and solar generation rise of 270 TWh was the second biggest on record, but the growth rate is slowing - the 15% growth rate was the lowest this century.

Of the four key regions, China showed the fastest growth of 16% (+86 TWh) and the US the slowest with 11% (+41 TWh); India and EU both recorded 13% growth rates (+13 TWh and +64 TWh respectively). Five further countries added 40 TWh between them: Japan, Brazil, Mexico, Australia and Vietnam.

Compound growth of 15% is needed for many years, to meet both the IEA's Sustainable Development Scenario, and also the IPCC's 1.5 degree median case.



Wind and solar generated 8% of the world's electricity in 2019, up from only 3% in 2013.

Record low wind and solar prices in 2019 should give hope that compound growth rates can be maintained.

In the biggest countries, wind and solar made up a sizeable amount of national electricity production in 2019: 8% in India, 9% in China and 11% in the US. The EU stands out, with 18% - more than double the global average - coming from wind and solar.

The Rest of the World generated only 4% of its electricity from wind and solar in 2019. Some of the lowest rates are: South Korea with 2.9%, Philippines 2.2%, Ukraine 1.3%, Taiwan 1.0%, Kazakhstan 1.0%. Malaysia 0.7%, Iran 0.4% Saudi Arabia 0.2%, Russia 0.1%, and Indonesia 0.1%, and Iraq 0.1%.

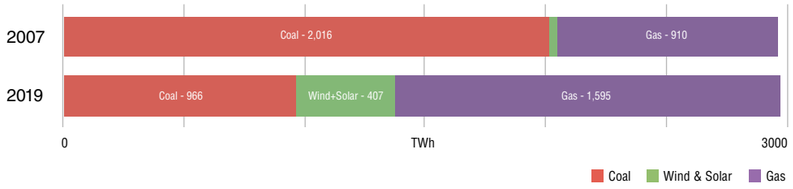
Record solar prices were established in Portugal where French developer Akuo won a project with a price of US$16/MWh. Record wind prices were established in Brazil with a price of US$21/MWh.

#4

The US coal collapse is undermined by a switch to gas, whereas the EU is leap-frogging from coal to wind and solar. Coal generation collapsed by 24% in the EU and 16% in the US in 2019, and is now half the level of 2007 in both the EU and US. Since 2007, US CO_2 power sector emissions fell by 19-32%, whereas they fell by 43% in the EU.

United States

United States electricity generation

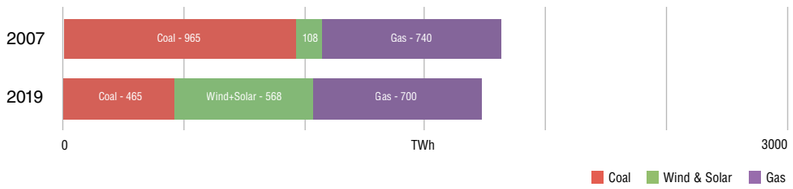


US since 2007:

- Coal halved
- Replaced 35% with wind and solar
- Replaced 65% with gas generation

European Union

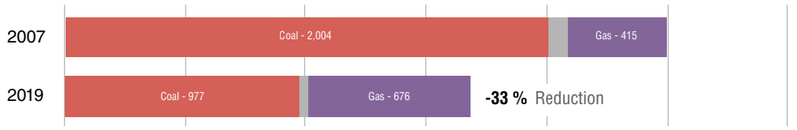
European Union electricity generation



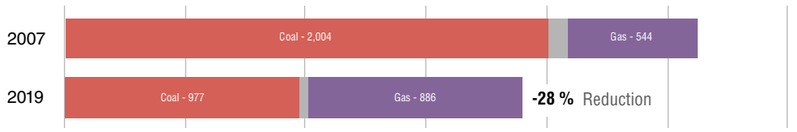
EU since 2007:

- Coal halved
- Replaced entirely with wind and solar
- Gas generation unchanged
- In 2019, wind and solar generation exceeded coal generation for the first time in the EU

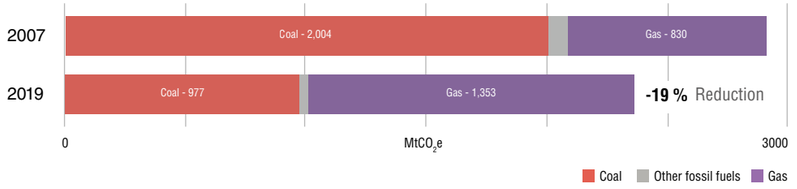
United States power sector CO_2 emissions



Factoring in methane leakage - based on 100-year warming period



Factoring in methane leakage - based on 20-year warming period

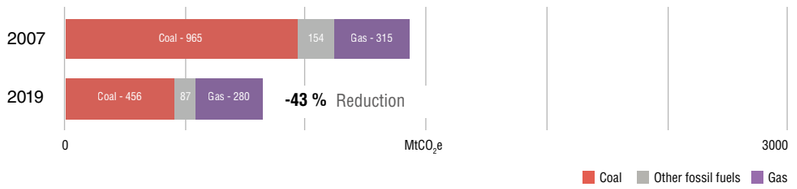


The calculation uses a methane leakage rate of 2.3% for U.S gas production, as documented in **EDF's 2015 research.** *Note, we didn't include EU gas methane as the generation was broadly unchanged.*

US since 2007:

- CO_2 fell 33%
- CO_2e fell 23%, when including methane leaks on 100-year warming period.
- CO_2e fell 19%, when including methane leaks on 20-year warming period.

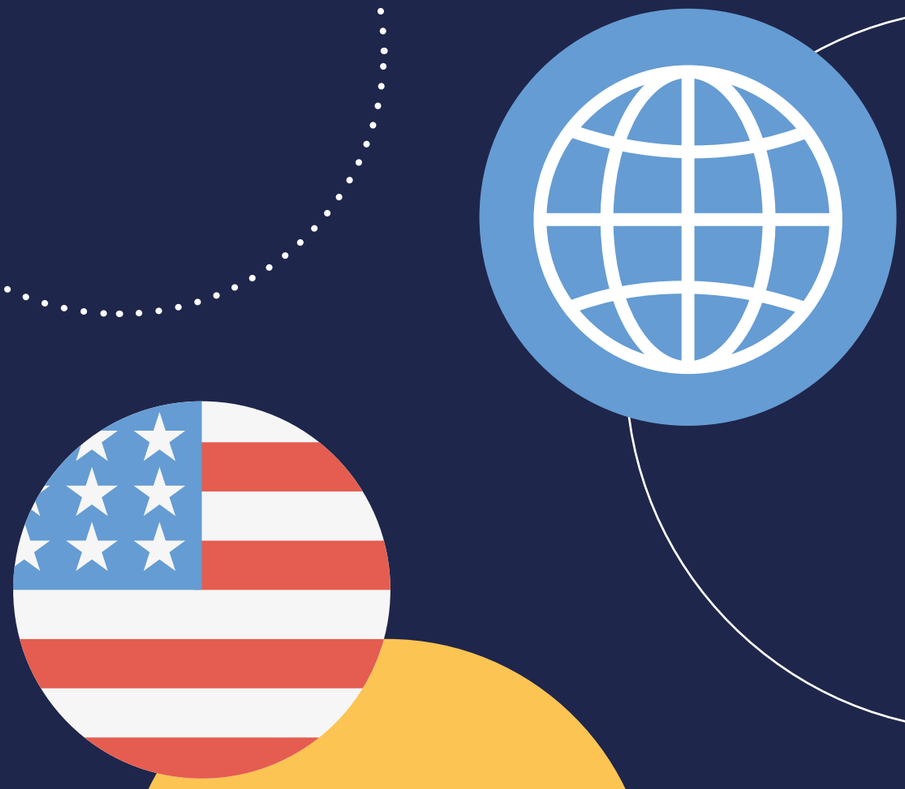
European Union power sector CO_2 emissions



EU since 2007:

- CO_2 emissions fell by 43%

Detailed Regional Analysis



World

Key Messages

- *Coal generation fell a record 3%, but falling coal is not yet the "new-normal"*. Coal fell because wind and solar generation rose, electricity demand growth slowed, gas replaced coal in the US and the EU, and nuclear plants restarted in South Korea and Japan. These were more one-off factors than structural.

- *Global CO_2 power sector emissions fell by a record 2%*. coal was partly offset by a 4% rise in gas generation, which tempered the fall in CO_2 emissions. The carbon intensity of electricity fell by 3% over the year. The carbon intensity of global electricity is now 15% lower than ten years ago.

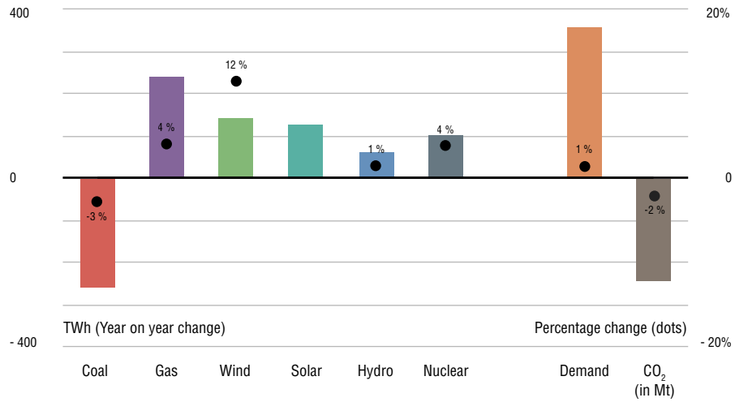
- *2019 saw lowest electricity demand growth since 2009*. This was because of weak GDP growth and a mild winter.

- *Wind and solar growth rose* by 270 TWh, the second biggest rise on record. But the growth rate is slowing - the 15% growth rate was the lowest this century.

What happened in 2019?

Electricity demand rose by 1.4%, the least in a decade. Coal generation fell by a record 3%. All other forms of generation rose. Wind and solar rose but set no records. Gas increased in US and EU. Nuclear grew at a record 4% due to restarts in Japan and South Korea. CO_2 emissions fell 2%.

2019 Changes



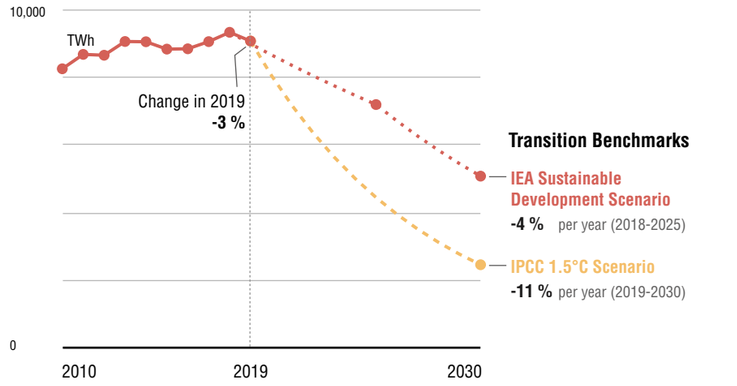
Is the transition happening fast enough?

No. It's not clear yet that falling coal generation is the "new normal".

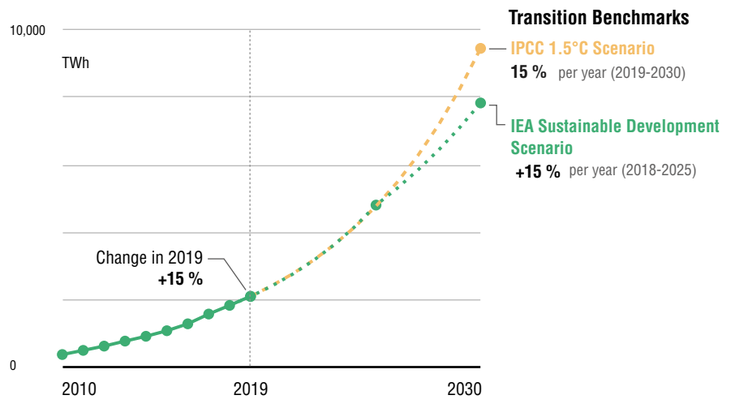
Coal generation will need to fall at 11% per year every year until 2030, to meet the IPCC's median scenario for 1.5 degrees. Even the less ambitious IEA Sustainable Development scenario needs drops of 4% per year.

Compound growth rate of 15% of wind and solar generation is needed every year to meet the Paris climate agreement. This was achieved in 2019 and lower prices provide hope it can be sustained. However, maintaining this growth rate, as the absolute volume increases, will require a concerted effort from all regions.

Coal generation with future scenarios



Wind + solar generation with future scenarios



World

Electricity demand growth slowed

Electricity demand rose by 1.4%, the slowest increase since the 2009 recession. This was due to low GDP growth of 3%, and also because of the weather - especially milder winter months in the US and EU.

Fossil-free generation growth set no records

Nuclear generation rose at the fastest rate this century, because of restarts in Japan and South Korea, and also new capacity installed in China. Hydro generation rose, but mostly due to wet conditions in China and India. In China, where most new hydro is being built, hydro capacity was up only 4 GW, compared to 16 GW average this decade.

Wind and solar generation growth slowed to 15 % (+270 TWh)

The wind and solar generation rise of 265 TWh was the second biggest on record, but the growth rate slowed - the 14% growth rate was the lowest this century. Of the four key regions, China showed the fastest growth of 16% (+86 TWh) and the US the slowest with 11% (+41 TWh); India and EU both recorded 13% growth rates (+13 TWh and +64 TWh respectively). Five further countries added 40 TWh between them, mostly solar: Japan, Brazil, Mexico, Australia and Vietnam.

Coal generation fell a record 3 %

Coal fell 3% (-259 TWh), as coal collapsed in the EU and the US, but rose in China. This is because wind and solar generation rose, electricity demand increased by the least in a decade, gas replaced coal in the US and the EU, and nuclear plants restarted in South Korea and Japan.

New coal-fired generation capacity continues to rise, driven primarily by new additions in China. The overall utilisation of coal-fired plants continues on a downward trend, falling from 54% in 2018 to 51% in 2019. This will reduce coal profitability.

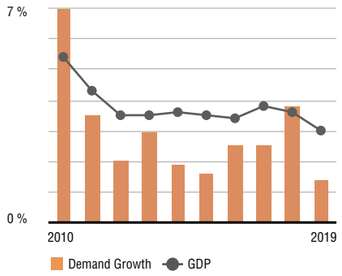
Gas generation rose 4 %

This happened mostly as a result of gas generation replacing coal in the EU and US.

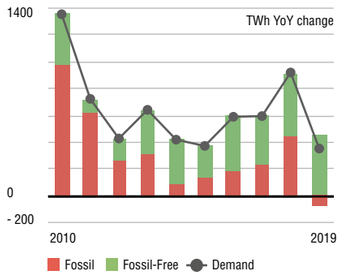
CO_2 emissions fell 2 %

This doesn't take into account the climate impact of methane leaks from the additional gas generation.The carbon intensity of electricity fell by 3% over the year. At 442 gCO_2/kWh, it is now 15% lower than the start of this decade, as fossil-free generation has grown faster than fossil.

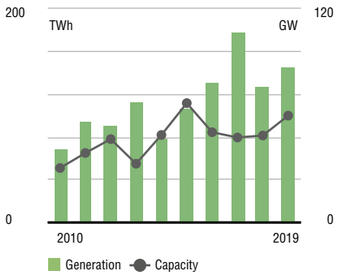
Electricity Demand Change



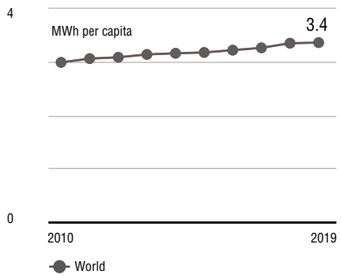
Fossil & Fossil-Free Generation Change



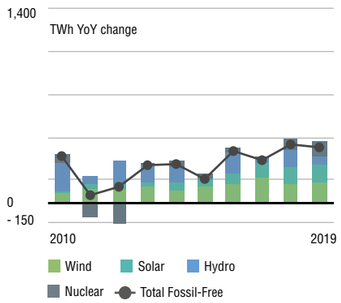
Wind Generation & Capacity Change



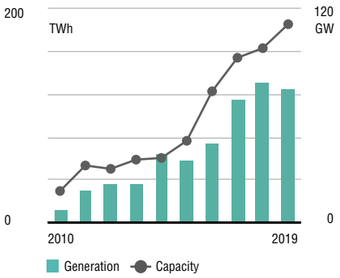
Electricity Demand per Capita



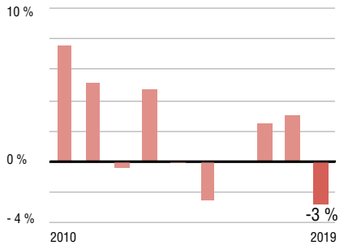
Fossil-Free Generation Change



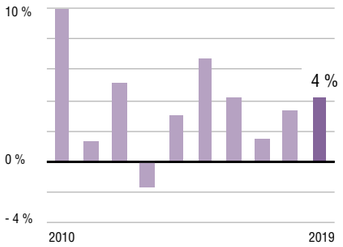
Solar Generation & Capacity Change



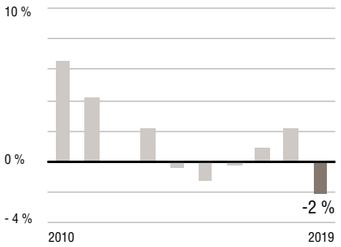
Coal Generation Change



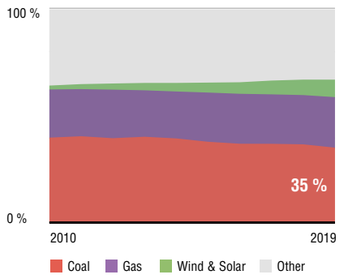
Gas Generation Change



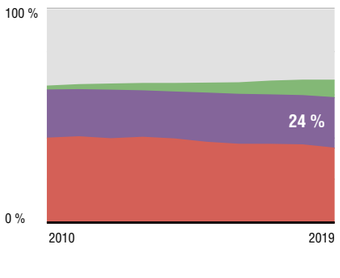
CO_2 Emissions Change



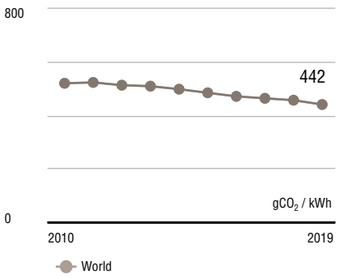
Coal in the Electricity Mix



Gas in the Electricity Mix



CO_2 Intensity Of Electricity



China

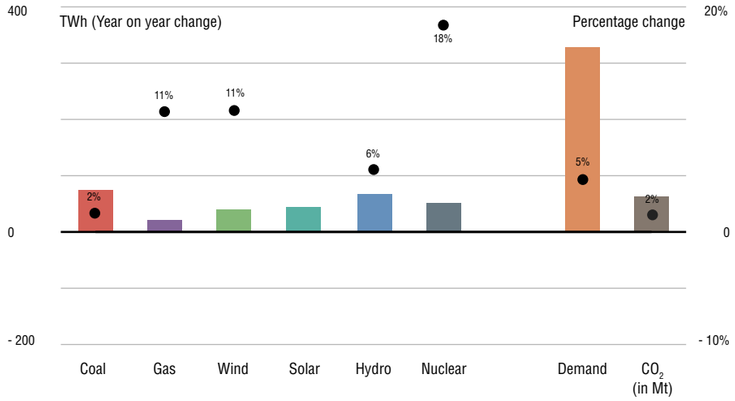
Key Messages

- *China in 2019, for the first time, was responsible for more than half of the world's coal generation.* Since 2015, when the Paris Climate Agreement was signed, China's coal generation has risen by 17%, whereas coal generation in the rest of the world has fallen by 9%.
- *Coal generation rose by 2% in 2019.* This is because the rise in wind, solar, nuclear and hydro was not enough to meet electricity demand growth.
- *China's electricity demand increased by 4.7%, over three times the global average of 1.3%.* Chinese electricity demand per capita is now higher than in the UK, but less than half that in the US.
- *Wind and solar generation grew by 86 TWh. The year on year growth rate of 16% was the lowest for China this century.* The year on year growth rate of 16% was the lowest for China this century. A pick-up in new wind was offset by another big fall in solar installations. New wind installations were 26 GW, below the 34 GW installed in 2015; new solar installations were 30 GW, below the 53 GW installed in 2017.
- *Nuclear growth continuing, but new hydro is slowing.* New nuclear added 54 TWh, on 4 GW of new capacity. The 69 TWh increase in hydro generation was driven by more rain, as new hydro installations slowed.

What happened in 2019?

Wind, solar, hydro and nuclear all increased, but not by as much as electricity demand. This necessitated an increase of 2% in coal generation. Gas generation rose 11%, but from a small base. These led to a 2% rise in CO_2 emissions.

2019 Changes



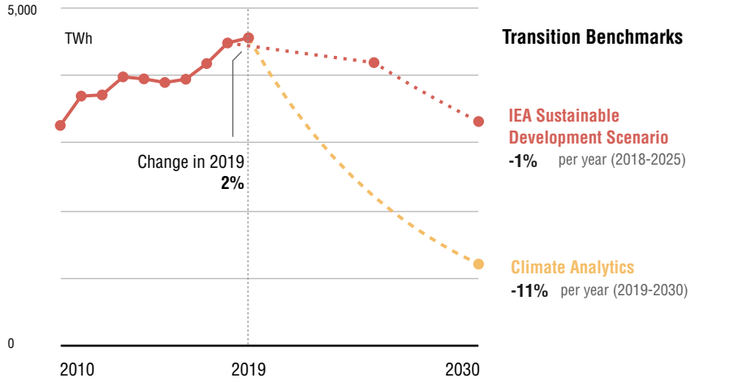
Is the transition happening fast enough?

No. Coal generation rose in China in 2019, but it needs to be falling. Building new coal power plants shows investment is not aligned with reducing climate change.

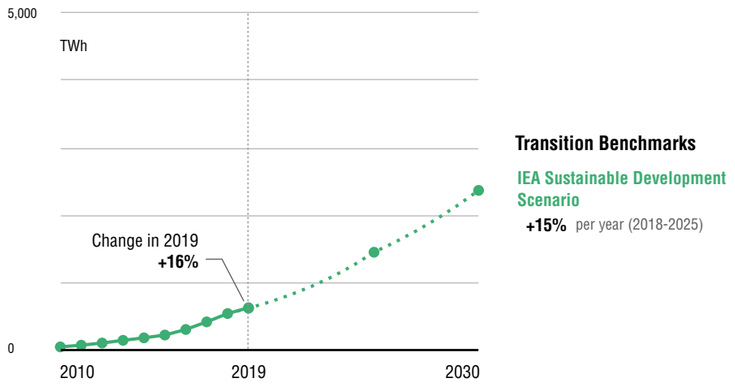
Chinese electricity demand growth rose at twice the rate modelled in the IEA Sustainable Development Scenarios, making the challenge of limiting coal generation very tricky.

Solar and wind need compound growth of 15% per year to triple generation by 2030. Although generation rose by 16% in 2019, the new capacity of wind and solar built in 2019 was not enough to maintain this growth rate for next year.

Coal generation with future scenarios



Wind + solar generation with future scenarios



China

Electricity demand continued to soar

Electricity demand rose by 4.7% in 2019, more than three times the global average of 1.4%. The large rise was despite China's slowest GDP growth in 30 years, and follows on the back of a huge 8% rise in 2018. Electricity demand per capita is now 53% above the global average. At 5.2 MWh, per capita demand now exceeds the level in the UK, but remains less than half the level in the US.

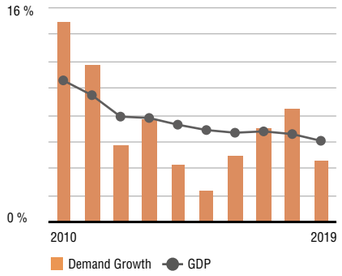
Fossil-free generation added less than electricity demand

Fossil-free generation grew by 10% (+227 TWh), which was less than the 329 TWh growth in electricity demand, necessitating a rise in fossil (coal) generation of 102 TWh to meet extra demand. Hydro generation was driven more by heavy rains rather than new capacity - hydro capacity was up only 4 GW, compared to 16 GW average this decade. Nuclear generation increased as 4 GW more capacity came online.

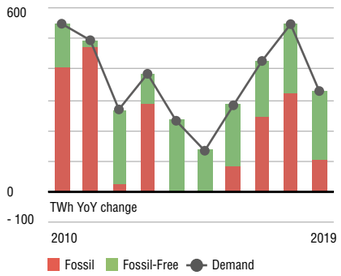
Wind and solar generation growth slowed to 16 % (+86 TWh)

Growth of 86 TWh (40 TWh of wind and 46 TWh of solar) was the lowest growth since 2016. But the growth rate of 16% was the lowest this century. New wind installations were 26 GW, below the 34 GW installed in 2015. New solar installations were 30 GW, below the 53 GW installed in 2017.

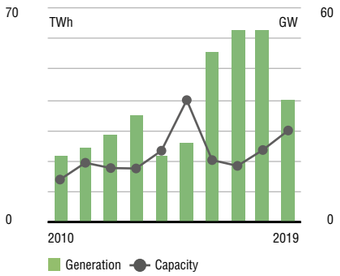
Electricity Demand Change



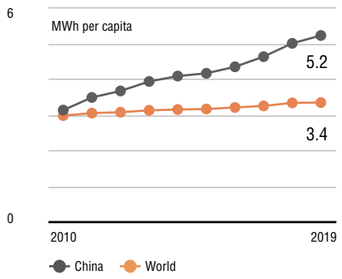
Fossil & Fossil-Free Generation Change



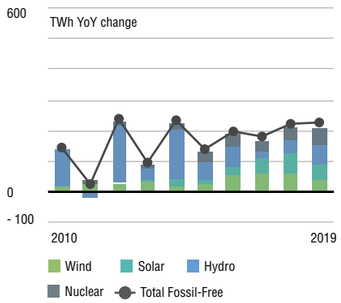
Wind Generation & Capacity Change



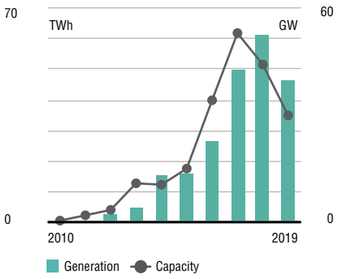
Electricity Demand per Capita



Fossil-Free Generation Change



Solar Generation & Capacity Change



Coal rose to half of the world's coal generation

Coal-fired generation rose 2% in 2019. Since 2015, China's coal generation has risen by 17%, compared to a fall of 9% in the rest of the world. For the first time, China is now responsible for over 50% of global coal generation. At 62%, coal's relative share of the electricity mix is falling, but only because total electricity demand has increased even more dramatically. This hides the absolute rise in coal generation which has doubled in 12 years. China continued to build coal power plants, adding 44 GW in 2019. Coal utilisation fell in 2019 as a result.

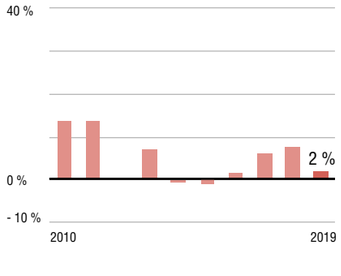
Gas rose from a low base

Gas-fired generation rose by 11% in 2019, increasing to 3% of the electricity mix. 6 GW of new gas capacity was built in 2019.

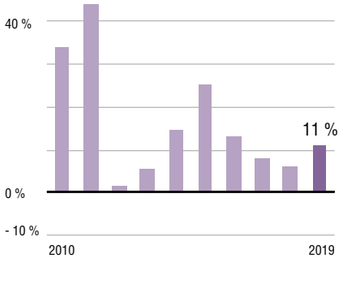
CO_2 emissions rose 1.6 % with coal and gas generation

Despite huge investment in new coal plants, the reported carbon intensity of the Chinese coal fleet improved just 0.3% in 2019, the lowest improvement since reporting began in 2006. China's carbon intensity of electricity has fallen by 24% since 2019. However at 576 gCO_2/kWh it is still 30% above the global average. The high efficiency of its coal fleet only goes so far in limiting the impact of the high coal generation in China.

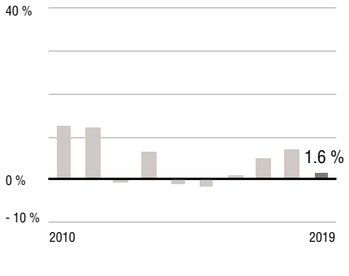
Coal Generation Change



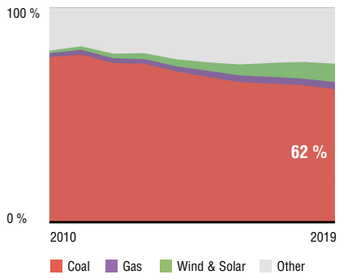
Gas Generation Change



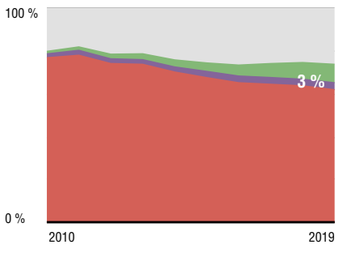
CO_2 Emissions Change



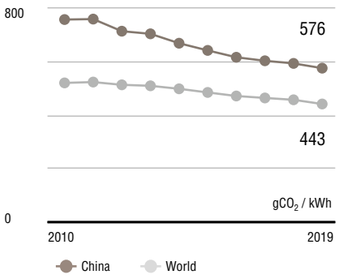
Coal in the Electricity Mix



Gas in the Electricity Mix



CO_2 Intensity Of Electricity



United States

Key Messages

- *Coal generation fell by a record 16% (-180 TWh) in 2019, to the lowest level since 1975*. This was due to a 113 TWh increase in gas generation, a 58 TWh fall in electricity demand, and a 36 TWh rise in wind and solar.

- *The fall in CO_2 emissions was undermined by the "gas bridge"*. Power sector CO_2 emissions fell by 8% in 2019, as coal's 16% fall was tempered by the rise in gas emissions. When including the methane leaks, the additional gas generation means that the drop in US emissions is even smaller. New gas generation capacity continues to be built apace, with 7 GW more in 2019, cumulatively adding over 100 GW last decade. This enabled the switch from coal to gas.

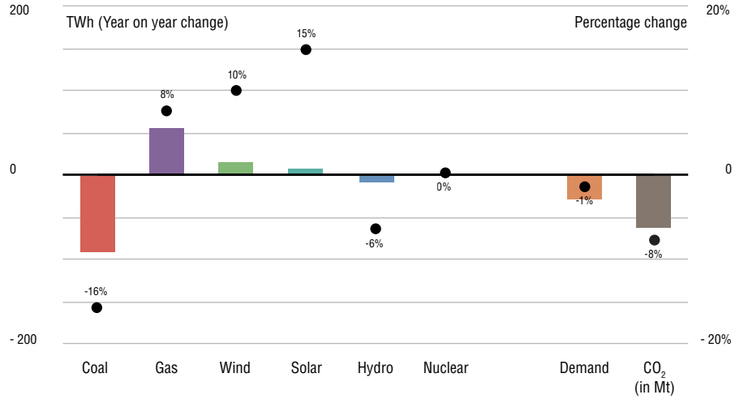
- *Wind and solar growth was lower than in any other region*. Wind and solar generation grew at 11% (+41 TWh). This is the lowest of any major region: China grew at 16% (+86 TWh) India 13% (+13 TWh) and EU 13% (+64 TWh).

- *The small fall in US electricity demand in 2019 is mostly weather-related*. Demand continues to be very high, with US citizens still using four times the global average.

What happened in 2019?

Coal generation collapsed 16%, as the switch into gas accelerated. It was also helped by a rare fall in electricity demand, and by some new wind and solar.

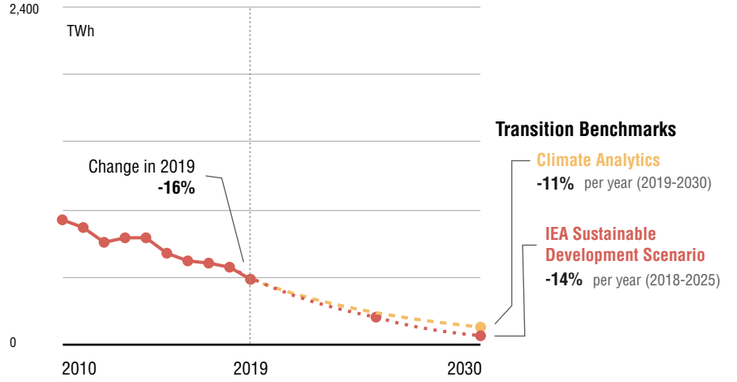
2019 Changes



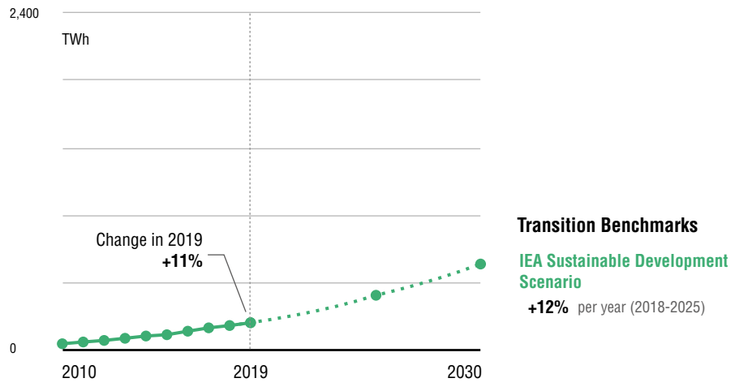
Is the transition happening fast enough?

No. The "unprecedented" fall in US coal needs to happen every year. Coal generation must be mostly phased-out by 2030, and without increasing gas generation. Wind and solar need compound growth at 12% every year to meet the IEA SDS. The 2019 growth rate had already slowed to 11%.

Coal generation with future scenarios



Wind + solar generation with future scenarios



United States

→ Electricity demand fell due to a mild winter

Electricity demand fell 1.4%, correcting for a large rise in 2018. Weather was the biggest driver: 2019 winter months were warm, correcting for a colder 2018. Industrial demand declined at 5% as economic growth slowed. US electricity demand per capita is one of the highest in the world. The average US citizen uses almost four times more electricity than the global average, and more than twice the European or Chinese per capita levels.

→ Fossil-free generation barely grew because of weak wind and solar growth

Nuclear generation was unchanged, and hydro generation fell, after a wet year in 2018.

→ Wind and solar generation grew at only 11% (+41 TWh)

This is the lowest of any major region: China grew at 16% (+86 TWh) India 13% (+13 TWh) and EU 13% (+64 TWh). Wind and solar generation increased by 41 TWh (+27 TWh of wind, 14 TWh of solar). Neither solar nor wind set new records for new installations: 9 GW of solar was installed, below the 11 GW record in 2016, and 9 GW of wind was installed, below the 13 GW record in 2012.

→ Coal generation collapsed - and was replaced largely with gas generation

Coal generation fell by 16% (-180 TWh), to 24% of total generation. This was due to a 113 TWh increase in gas generation, a 58 TWh fall in electricity demand, and a 41 TWh rise in wind and solar. This fall is the largest on record, and the fifth year of consecutive falls. It brings US coal generation to half its 2007 level, and the lowest since 1975.

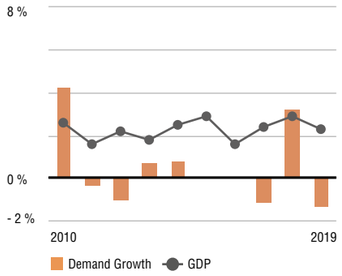
→ Gas generation continued to soar

It rose by 8%, and now stands at 38% of the electricity mix. New gas capacity continues to be built apace, with 7 GW more in 2019, cumulatively adding over 100 GW last decade.

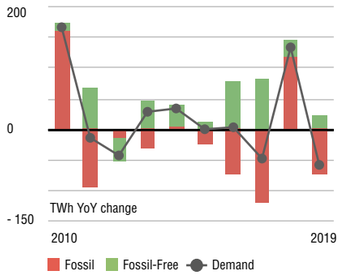
→ CO_2 emissions fell by 8%, coal's fall was tempered by the rise in gas emissions

When you include methane leaks from gas generation the fall in US greenhouse gas emissions is reduced. The carbon intensity of US electricity continued to fall, and is slightly below the global average. However, because the average US citizen uses so much electricity, the absolute CO_2 emissions per person is over three times higher than the global average in the power sector.

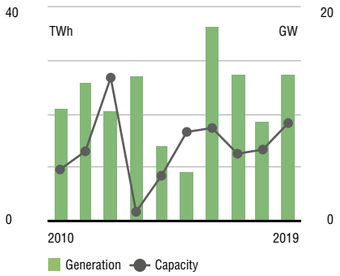
Electricity Demand Change



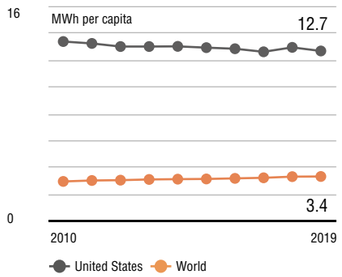
Fossil & Fossil-Free Generation Change



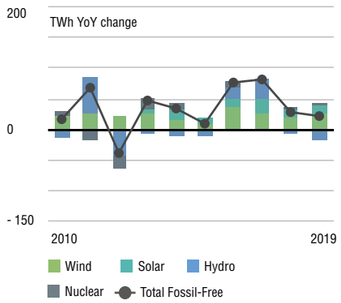
Wind Generation & Capacity Change



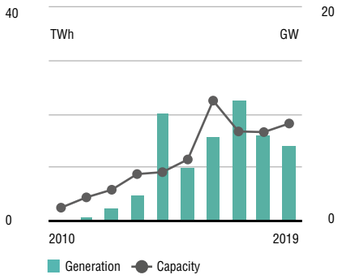
Electricity Demand per Capita



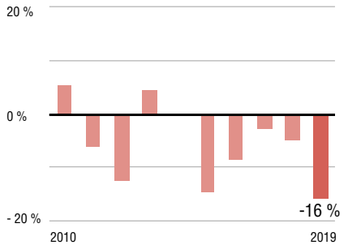
Fossil-Free Generation Change



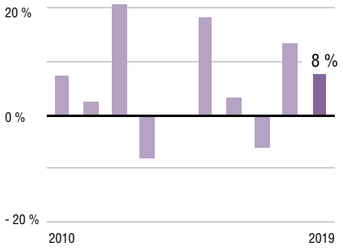
Solar Generation & Capacity Change



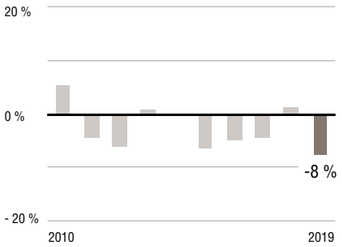
Coal Generation Change



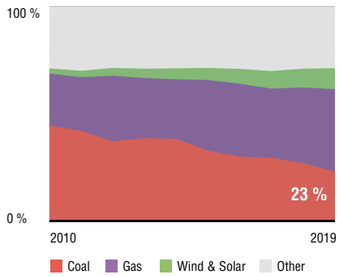
Gas Generation Change



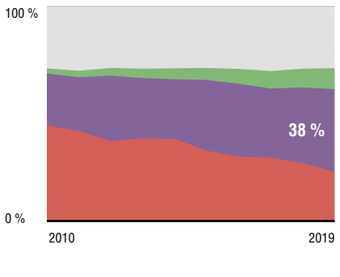
CO_2 Emissions Change



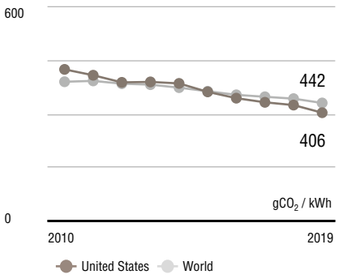
Coal in the Electricity Mix



Gas in the Electricity Mix



CO_2 Intensity Of Electricity



European Union

- *Coal generation collapsed by 24%, leading to a 13% fall in power sector emissions*. Coal fell due to a rise in wind and solar generation, switching from coal to gas driven by increases in the EU carbon price, and a small fall in electricity demand.

- *Since 2007, coal generation has halved, replaced entirely with wind and solar, leaving gas generation unchanged*. The carbon intensity of EU electricity is now 42% below the global average.

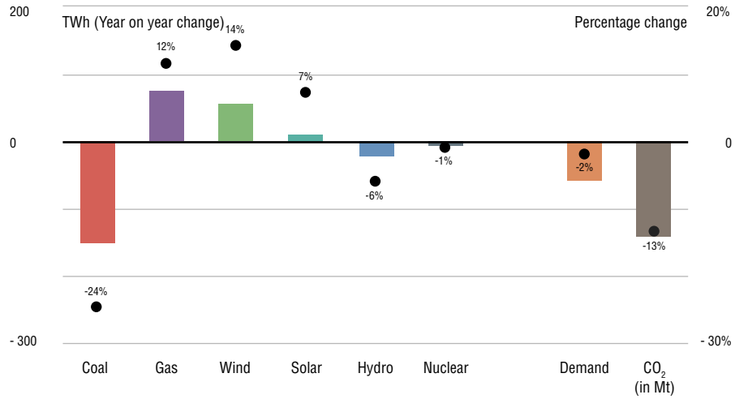
- *Wind and solar growth is healthy*. Although it set no records, falling costs and a positive policy landscape for wind and solar in Europe means that growth will accelerate.

- *Germany, Greece and Hungary made new commitments to phasing-out coal*. This means a total of 15 EU countries have committed to phase-out coal, and will ensure coal generation falls rapidly through the 2020's.

What happened in 2019?

Coal collapsed by 24%. This was caused partly by wind and solar generation, and partly by carbon pricing driving a switch from coal to gas. New wind and solar generation increased by 14% and 7% respectively in 2019, bringing their share of electricity generation up to a new high of 18%.

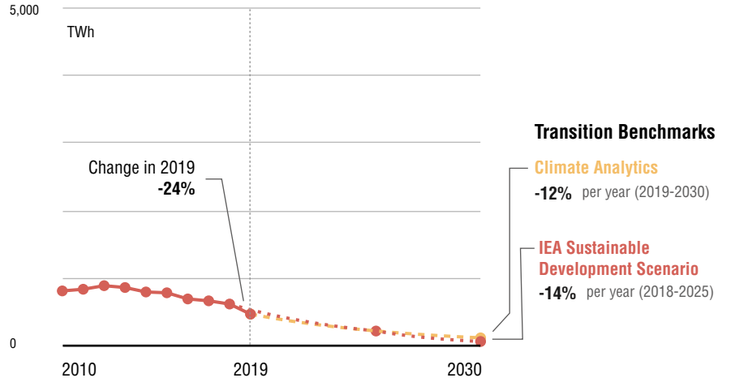
2019 Changes



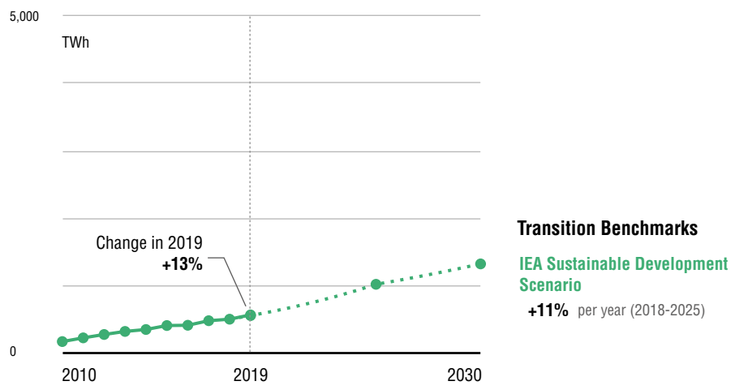
Is the transition happening fast enough?

Yes, if current progress holds. The EU is putting climate at the heart of policy, promising net-zero emissions by 2050, and to increase its 2030 CO_2 target. Coal generation fell by 24% in 2019. With 15 coal countries committing to total phase-out by 2030, coal will continue to collapse. Germany and Poland are the main obstacles to phasing out coal by 2030. Wind and solar generation grew at 13% in 2019, and solar and offshore wind capacity are both growing sufficiently to maintain the growth rates.

Coal generation with future scenarios



Wind + solar generation with future scenarios



European Union

Electricity demand fell due to a mild winter

Electricity demand fell 1.7% in 2019, falling in most countries, because of warm winter months. Electricity demand per person is still almost double the world average but the gap is narrowing as world consumption rises. Anticipated rises in electricity demand from electric cars and electrification of heat and industry are not yet showing.

Fossil-free generation increase driven by wind

Hydro and nuclear generation fell slightly, with drier conditions affecting hydro, and outages at French and UK nuclear plants.

Wind and solar generation increased in 2019 by 13% (+64 TWh)

Wind generation saw a large increase, helped by new offshore installations. However German onshore wind slowed on new planning laws. Solar generation showed a strong rise, with capacity additions doubling over 2018. Spain leapt to become the largest solar installer in the EU. The growth of wind and solar continues to be concentrated in western Europe, with eastern European countries lagging.

Coal generation collapsed

The EU saw a record 24% fall in coal-fired generation in 2019. Coal now stands at half its 2007 peak, and makes up only 14% of the electricity mix. In 2019, coal's fall is attributable to the rise in wind and solar, switching from coal to gas driven by increases in the EU carbon price, and a small fall in electricity demand.

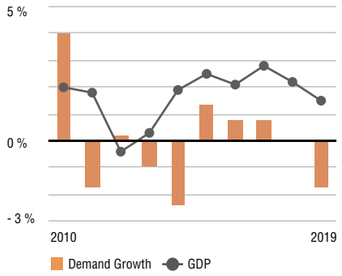
Gas generation increased by 12%

The one-off switch in economics resulted in a 73 TWh rise in gas generation, which was a big contribution to coal's fall.

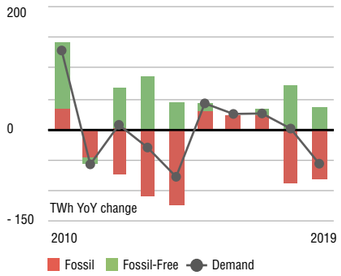
CO_2 emissions collapsed because of the fall in coal

EU power sector emissions fell by 13% in 2019, the largest fall this century. The carbon intensity of EU electricity is collapsing rapidly, and is now 42% below the global average.

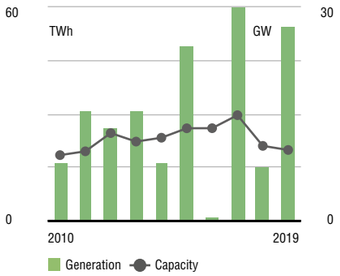
Electricity Demand Change



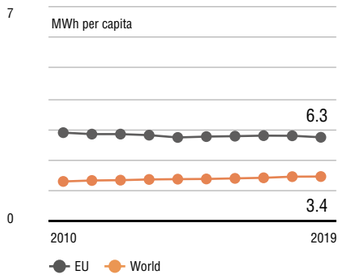
Fossil & Fossil-Free Generation Change



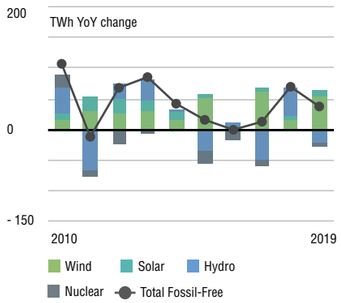
Wind Generation & Capacity Change



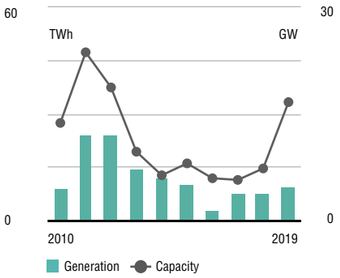
Electricity Demand per Capita



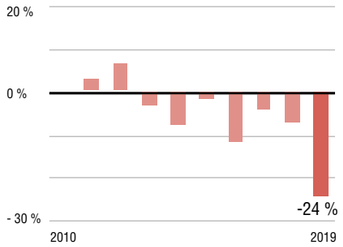
Fossil-Free Generation Change



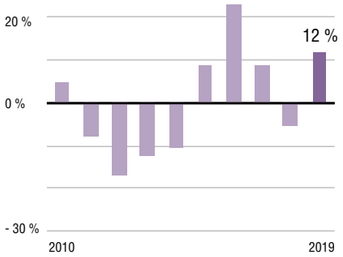
Solar Generation & Capacity Change



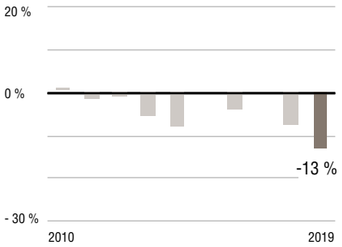
Coal Generation Change



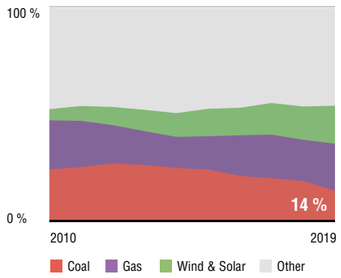
Gas Generation Change



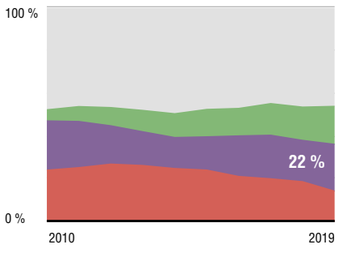
CO_2 Emissions Change



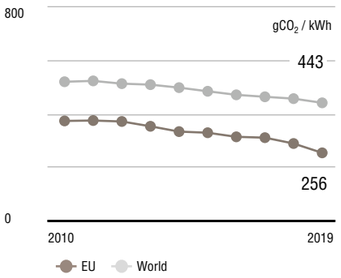
Coal in the Electricity Mix



Gas in the Electricity Mix



CO_2 Intensity Of Electricity



India

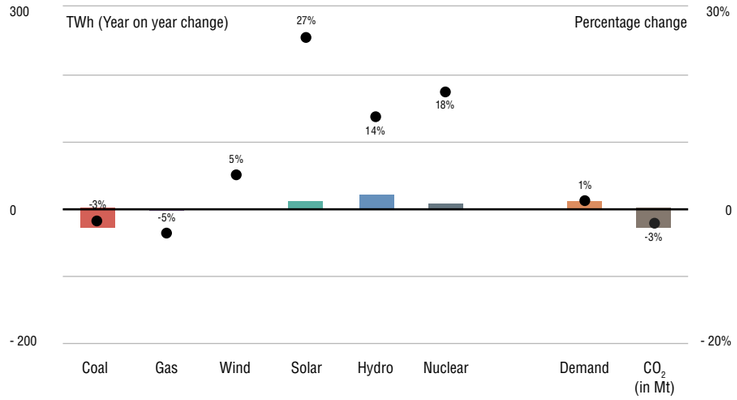
Key Messages

- *Coal generation fell for the first time on record, posting a decline of 3%.* As a result, power sector CO_2 emissions also fell by 3%.
- *Low GDP growth, a bumper hydro year and a nuclear pick-up enabled the fall in coal.* Therefore, the fall in coal is likely to be a one-off for now. Wind and solar did also play a role in coal's falls, and this will become much more important in time.
- *Solar generation saw strong growth, although not-so for wind generation.* New solar capacity installed did set a record, with 12 GW installed in 2019.

What happened in 2019?

India saw a surprising 3% fall in coal generation because electricity demand unexpectedly shrank in the second half of 2019 due to weak economic growth. A record monsoon season led to a 14% growth in hydro generation, which helped reduce coal. A relatively small 8 GW of new coal plants were built in 2019, although there is a further 29 GW in the pipeline that could be built. Solar capacity installations accelerated considerably. This increased solar generation by 27%, but wind generation increased only 5%.

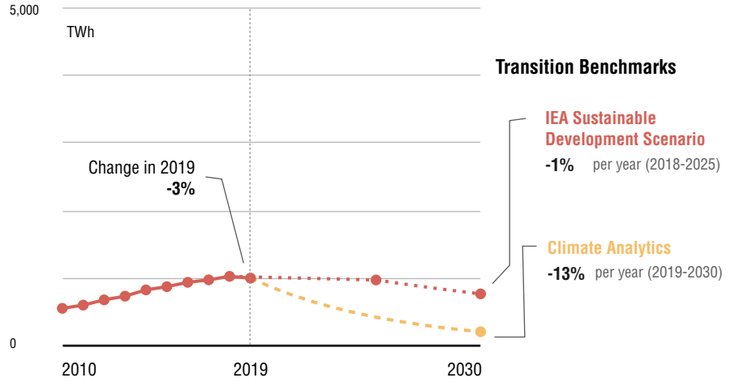
2019 Changes



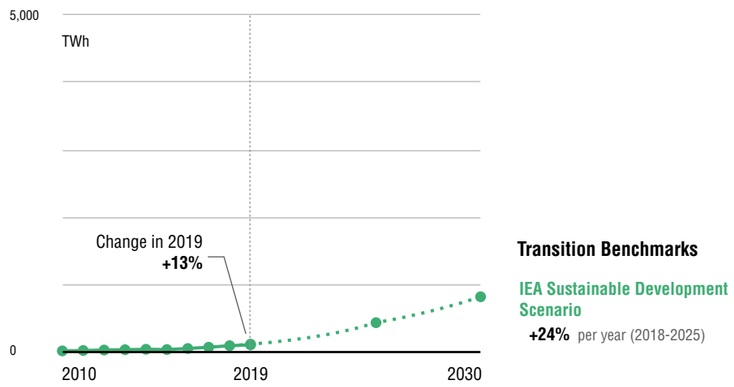
Is the transition happening fast enough?

India has good intentions. India has ambitious plans to deploy new wind and solar. However, it's also building new coal plants. The 3% fall in coal generation in 2019 was a good sign, but it's likely a one-off for now. Coal generation needs to be falling every year. Wind and solar generation grew at 13% in 2019, but from India's low base that's not fast enough - wind and solar generation must quadruple by 2025 to reach the IEA SDS. This requires compound growth rate of 24%.

Coal generation with future scenarios



Wind + solar generation with future scenarios



India

Electricity demand growth paused

Indian electricity demand grew by only 0.8% in 2019 compared to an average annual increase of 7% per year from 2010 to 2018. This was due to low GDP growth of 4.8%, the lowest since 2008. However, with electricity demand per person at less than one-third of the global average, subdued demand growth is likely to be a temporary phenomenon.

Fossil-free generation boosted by record solar additions and monsoon

Hydro generation was boosted by the strongest monsoons in 25 years. Nuclear generation also showed an increase.

Solar capacity additions increased to a record 12 GW

New solar capacity hit a new record at 12 GW, solar provided 3.4% of all electricity in 2019. India opened the world's largest solar farm in 2019. The growth in wind was less impressive. Wind generation grew at the lowest rate since 2015, and new wind installations fell for the second year running.

Coal shows a surprise fall

Coal generation fell for the first time since at least 1990 when the IEA's reporting began. The fall was likely a one-off for now, caused by the combination of a large reduction in demand growth, and weather-driven increase in hydro generation. Wind and solar also played a role. Coal-fired generation fell 3%. However, coal still contributes 72% to the Indian electricity mix, and India is still building new coal plants. In 2019, GEM data shows there was 8 GW of new coal capacity brought online, with almost no old coal plants closed.

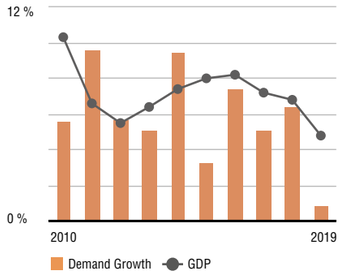
Gas generation also fell in 2019

It fell 5%. However, the change is relatively unimportant as gas only provides a small (3%) part of India's generation.

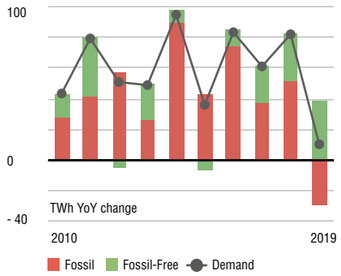
CO_2 emissions fell in line with coal generation

The carbon intensity of India's electricity generation fell by 4% in 2019, but remains much more carbon-intensive than the global average.

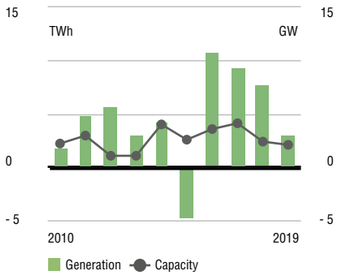
Electricity Demand Change



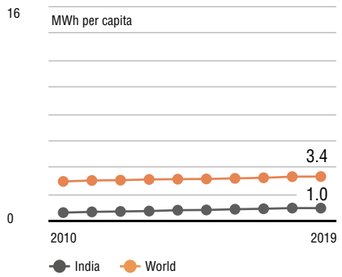
Fossil & Fossil-Free Generation Change



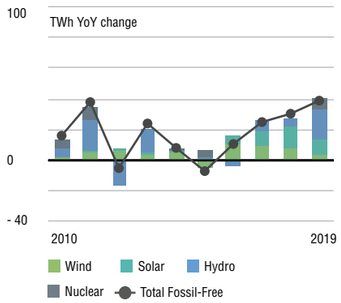
Wind Generation & Capacity Change



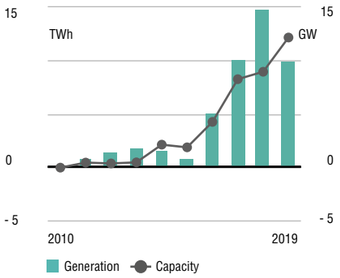
Electricity Demand per Capita



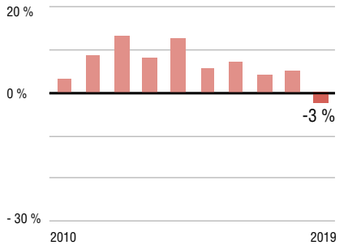
Fossil-Free Generation Change



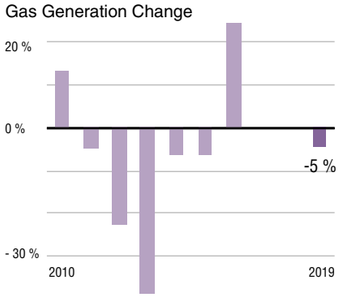
Solar Generation & Capacity Change



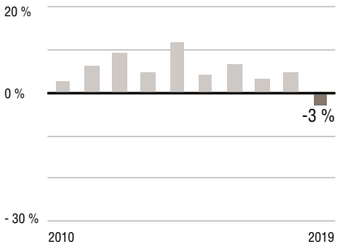
Coal Generation Change



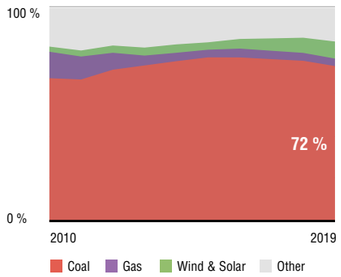
Gas Generation Change



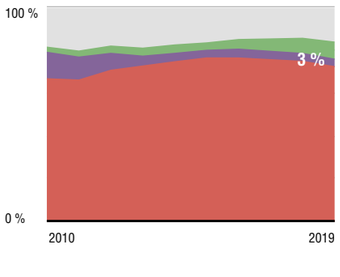
CO_2 Emissions Change



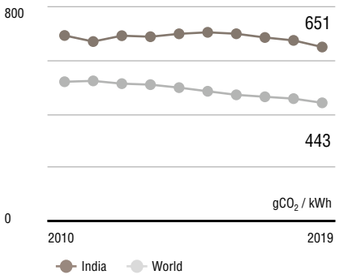
Coal in the Electricity Mix



Gas in the Electricity Mix



CO_2 Intensity Of Electricity



Rest of the World

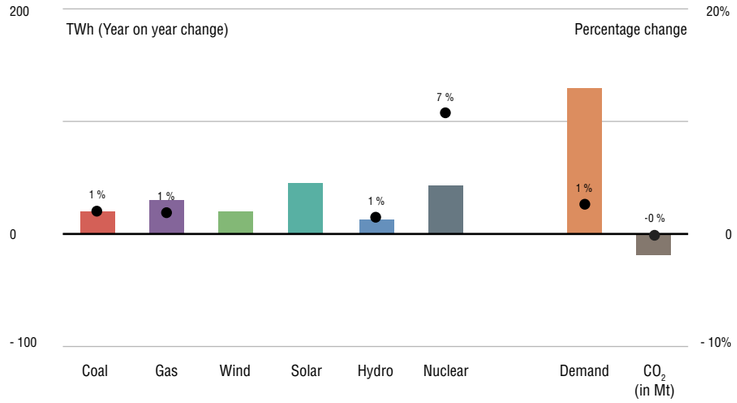
Key Messages

- *Solar growth accelerated, especially Japan, South Korea, Australia and Vietnam*. But wind is setting no growth records.
- *Electricity demand growth slowed*. Falls in OECD demand mask continued increases in developing nations, notably in Vietnam and Indonesia.
- *Coal generation increased slightly, by 1%*. Nuclear restarts led to a fall in coal generation in Japan and South Korea, but that was undermined by a rise in coal in Indonesia, Vietnam and Pakistan.
- *Gas generation also increased slightly, by 1%*. There was strong growth in Saudi Arabia, Mexico and Iran. It was tempered by a big fall in Turkish gas generation on higher hydro generation.

What happened in 2019?

Electricity demand rose by 1.4%, its lowest rate in a decade. Fossil-free sources met most of this increase, although both coal and gas also needed to rise slightly to meet increased electricity demand. Solar generation increased by 33% (+46 TWh), with strong contributions from Japan, South Korea, Vietnam and Australia. Wind generation grew by 11% (+21 TWh) with good additions from Brazil, Argentina and Mexico.

2019 Changes

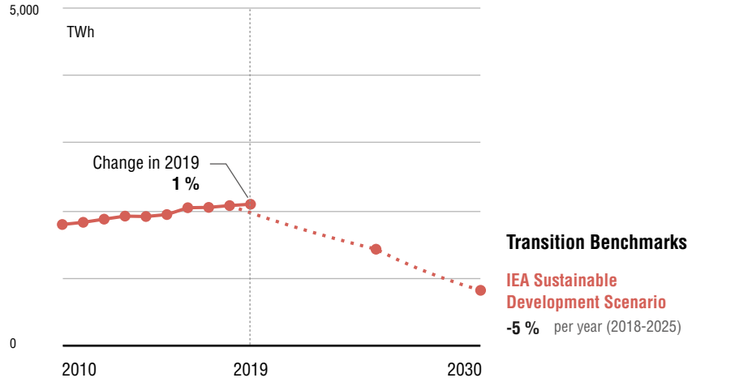


Is the transition happening fast enough?

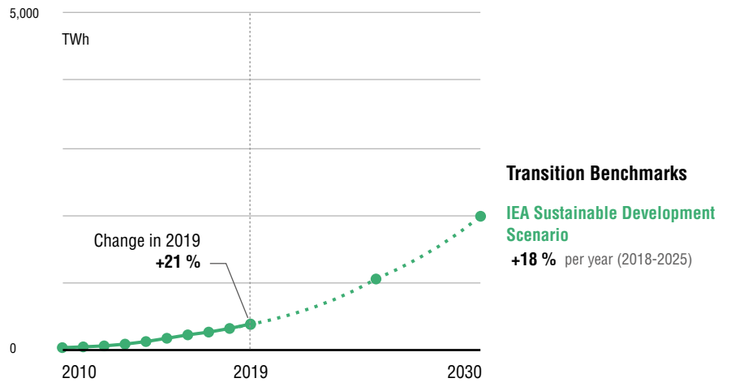
No. Coal generation is still rising, and it needs to be falling. Many countries are doing well, but few are doing well enough.

The biggest coal generators need to take the most urgent action. OECD countries, notably Japan, South Korea and Australia need to have mostly phased-out coal by 2030. Non-OECD countries, notably Russia, South Africa and Indonesia need to have mostly phased out coal by 2040. None of these countries are taking sufficient action to make sure that happens.

Coal generation with future scenarios



Wind + solar generation with future scenarios



Rest of World

Electricity demand rises slowly

Demand rose at 1.4%, its lowest level since 2009. Falls in OECD demand mask continued increases in developing nations, notably in Vietnam and Indonesia. At 2.4 MWh, the average demand per capita is made up of a very wide range of consumption levels. These range from more than 15 MWh in Canada and some Middle Eastern nations to less than 0.2 MWh in many African countries.

Fossil-free generation rises on solar growth and nuclear restarts

Nuclear generation increased as reactors returned in Japan and South Korea.

Solar generation growth accelerated markedly in 2019, but wind generation lags behind

Solar generation increased by 33% (+46 TWh) as a record level of new solar capacity was installed. There were strong additions from Japan, South Korea, Vietnam and Australia. Vietnam solar capacity increased from 0.1 GW to 5.5 GW in 2019 alone. Wind generation grew 11% (+21 TWh) with good additions from Brazil, Argentina and Mexico. However, wind generation grew at only half that of solar generation.

Coal grew slightly by 1%

Coal generation fell in Japan (-4%, -11 TWh), South Korea (-5%, -12 TWh) and South Africa (-4%, -9 TWh), and were offset by rises in Indonesia (+11%, 16 TWh), Vietnam (+34%, 25 TWh) and Pakistan (+95%, +16 TWh).

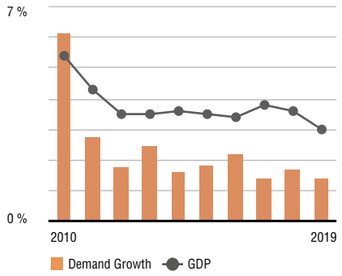
Gas generation rose by 1%

Gas generation rose by 1%. There were significant increases in Saudi Arabia (+11%, 24 TWh), Mexico (+9%, 17 TWh), and Iran (+8%, +20 TWh). These rises were tempered by a large fall in gas generation in Turkey (-39%, 34 TWh), where there was a large increase in hydro generation.

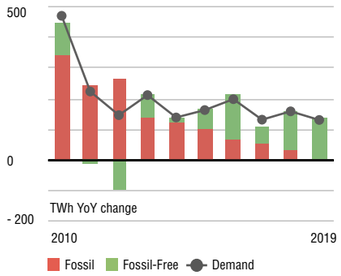
CO_2 emissions fell slightly, by 0.5%

Although coal and gas generation rose very slightly, oil generation falling especially in Iran and Pakistan actually led to a very slight fall in rest of the world CO_2 emissions overall.

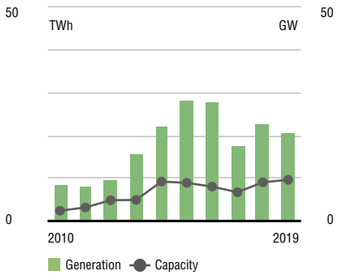
Electricity Demand Change



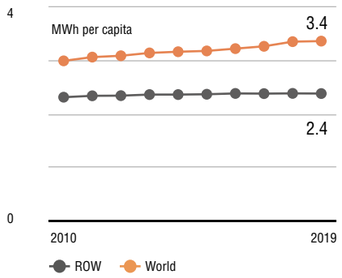
Fossil & Fossil-Free Generation Change



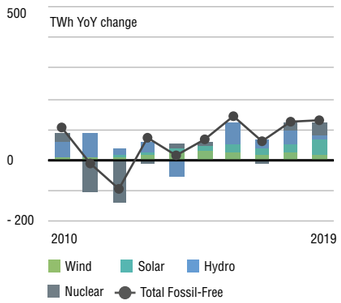
Wind Generation & Capacity Change



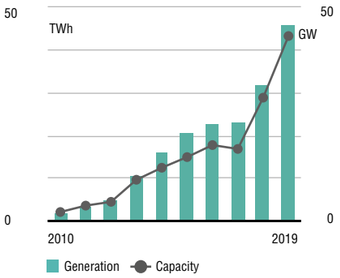
Electricity Demand per Capita



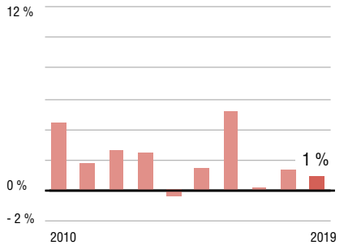
Fossil-Free Generation Change



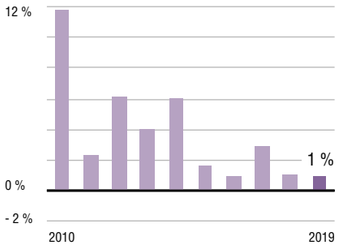
Solar Generation & Capacity Change



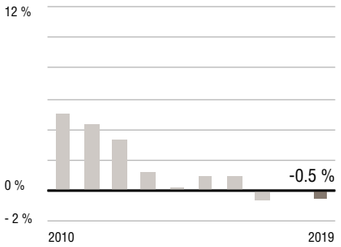
Coal Generation Change



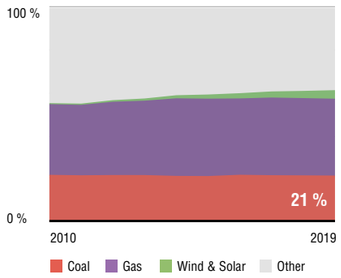
Gas Generation Change



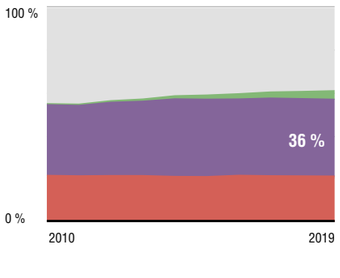
CO_2 Emissions Change



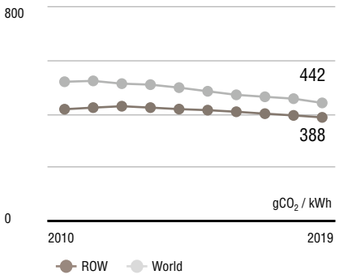
Coal in the Electricity Mix



Gas in the Electricity Mix



CO_2 Intensity Of Electricity



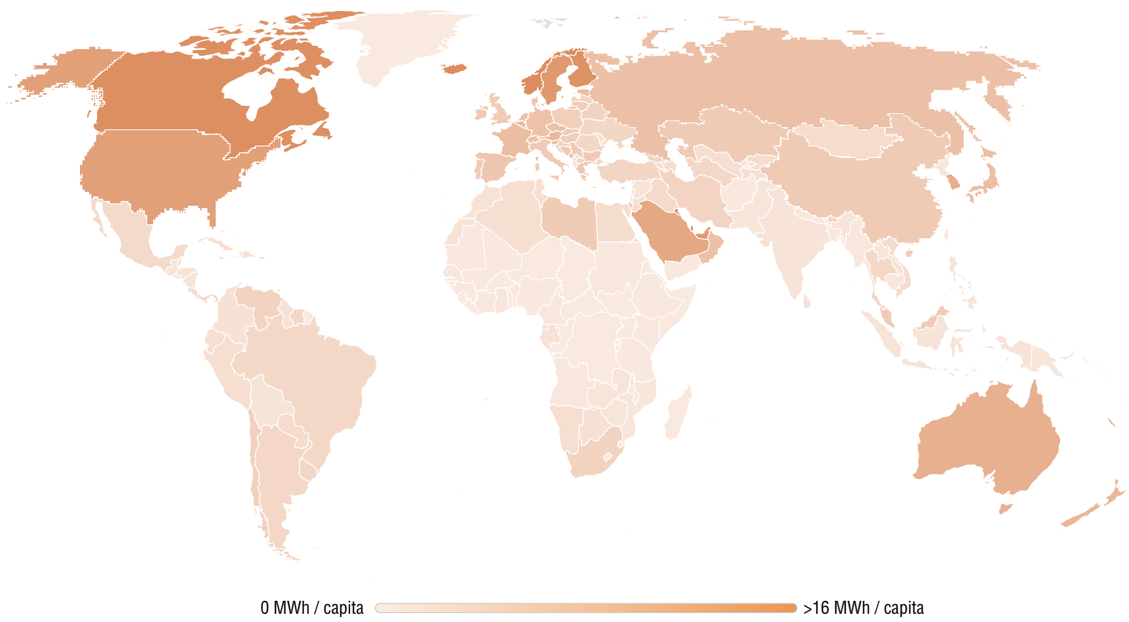
Generation and Demand

Electricity Demand

Key Messages

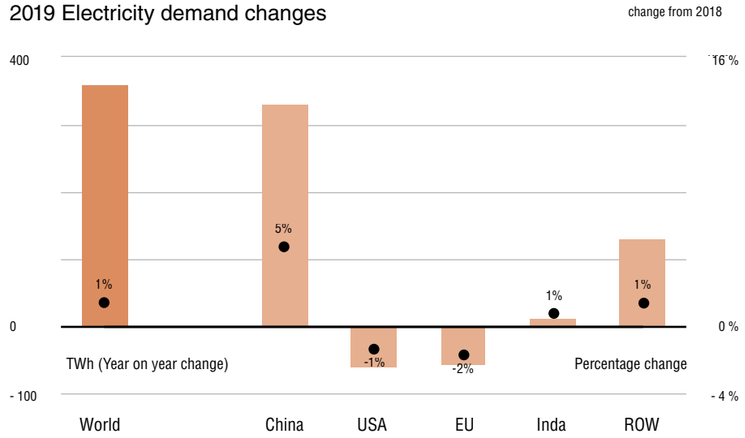
- *Electricity demand growth slowed to 1.4%, the slowest increase since the 2009 recession.* This was due to low GDP growth of 3%, and also because of the weather - especially milder winter months in the US and EU.
- *Chinese electricity demand rose at over three times the global average.* Its demand per capita is now higher than in the UK.
- *Slower electricity demand growth is critical to reducing coal generation.* This will require robust energy efficiency measures to moderate demand pressures from the decarbonisation of transport, industry and heat.

Electricity demand per capita in 2019



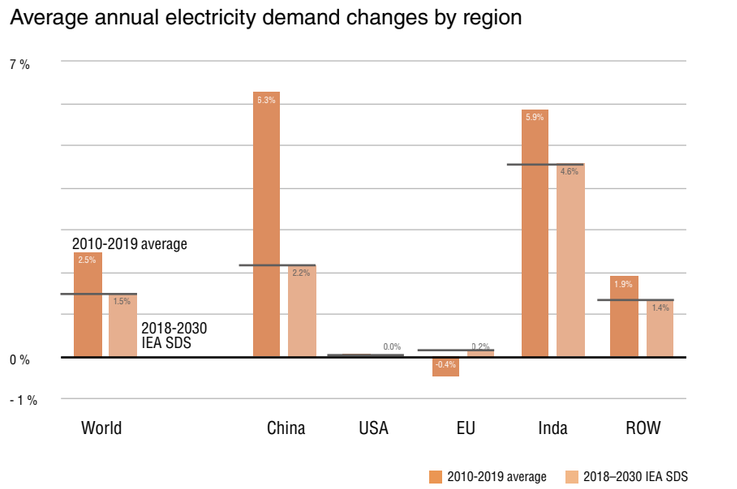
What happened in 2019?

Electricity demand growth slowed to 1.4%, the slowest increase since the 2009 recession. This was due to low GDP growth of 3%, and also because of the weather - especially milder winter months in the US and EU. Almost all the growth came from China. Chinese electricity demand rose at over three times the global average, and demand per capita is now higher than in the UK. Electricity demand was weak elsewhere. Demand even fell in the US, EU, India, Japan, Canada and South Korea.



Is the transition happening fast enough?

It's not yet clear. Electricity demand growth in the coming decade will need to slow to about half the rate of the previous decade. Global electricity demand rose on average 2.5% per year from 2010 to 2019, and the IEA SDS shows just a 1.5% per year increase is needed until 2030. The biggest difference is China. Chinese electricity demand growth will need to slow to 2% this decade, compared to the 6% growth seen in the previous decade. China has already begun its journey to electrify transport. Robust energy efficiency measures will be critical to prevent electricity demand spiralling upward as extra electricity will be needed for the electrification of transport, industry and heat.

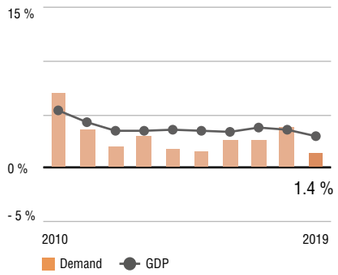


Electricity Demand

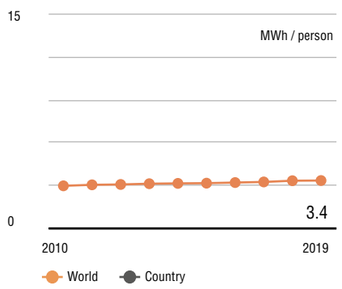
World
Electricity demand growth slowed

Electricity demand rose by 1.4%, the slowest increase since the 2009 recession. This was due to low GDP growth of 3%, and also because of the weather - especially milder winter months in the US and EU.

Electricity Demand Change



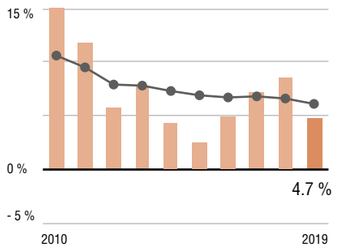
Electricity Demand Change per Capita



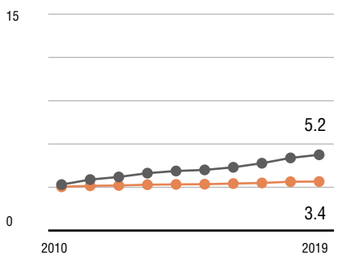
China
Electricity demand continued to soar

Electricity demand rose by 4.7% in 2019, more than three times the global average of 1.4%. The large rise was despite China's slowest GDP growth in 30 years, and follows on the back of a huge 8% rise in 2018. Electricity demand per capita is now 53% above the global average. At 5.2 MWh, per capita demand now exceeds the level in the UK, but remains less than half the level in the US.

Electricity Demand Change



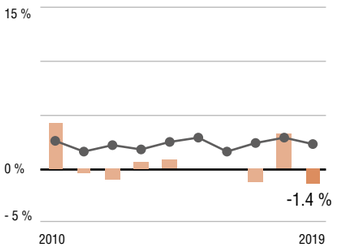
Electricity Demand Change per Capita



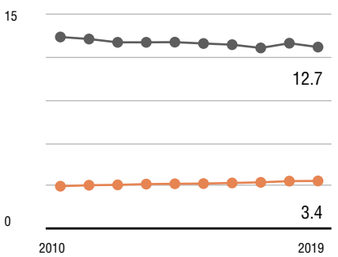
United States
Electricity demand fell due to a mild winter

Electricity demand fell 1.4%, correcting for a large rise in 2018. Weather was the biggest driver: 2019 winter months were warm, correcting for a colder 2018. Industrial demand declined at 5% as economic growth slowed. US electricity demand per capita is one of the highest in the world. The average US citizen uses almost four times more electricity than the global average, and more than twice the European or Chinese per capita levels.

Electricity Demand Change



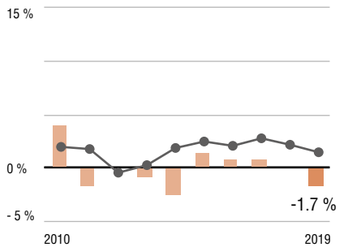
Electricity Demand Change per Capita



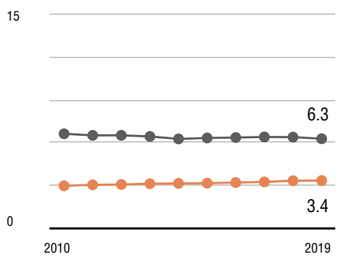
European Union
Electricity demand fell due to a mild winter

Electricity demand fell 1.7% in 2019, falling in most countries, because of warm winter months. Electricity demand per person is still almost double the world average but the gap is narrowing as world consumption rises. Anticipated rises in electricity demand from electric cars and electrification of heat and industry are not yet showing.

Electricity Demand Change



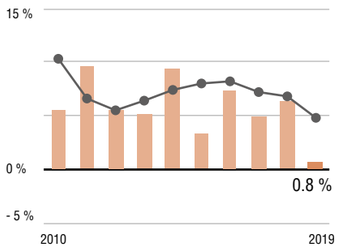
Electricity Demand Change per Capita



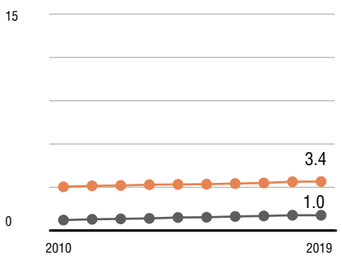
India
Electricity demand growth paused

Indian electricity demand grew by only 0.8% in 2019 compared to an average annual increase of 7% per year from 2010 to 2018. This was due to low GDP growth of 4.8%, the lowest since 2008. However, with electricity demand per person at less than one-third of the global average, subdued demand growth is likely to be a temporary phenomenon.

Electricity Demand Change



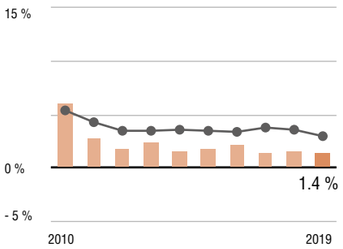
Electricity Demand Change per Capita



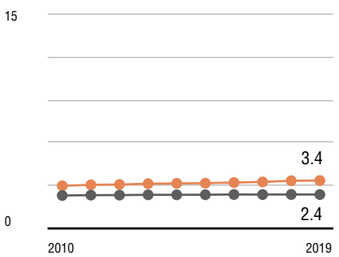
Rest of World
Electricity demand rises slowly

Demand rose at 1.4%, its lowest level since 2009. Falls in OECD demand mask continued increases in developing nations, notably in Vietnam and Indonesia. At 2.4 MWh, the average demand per capita is made up of a very wide range of consumption levels. These range from more than 15 MWh in Canada and some Middle Eastern nations to less than 0.2 MWh in many African countries.

Electricity Demand Change



Electricity Demand Change per Capita

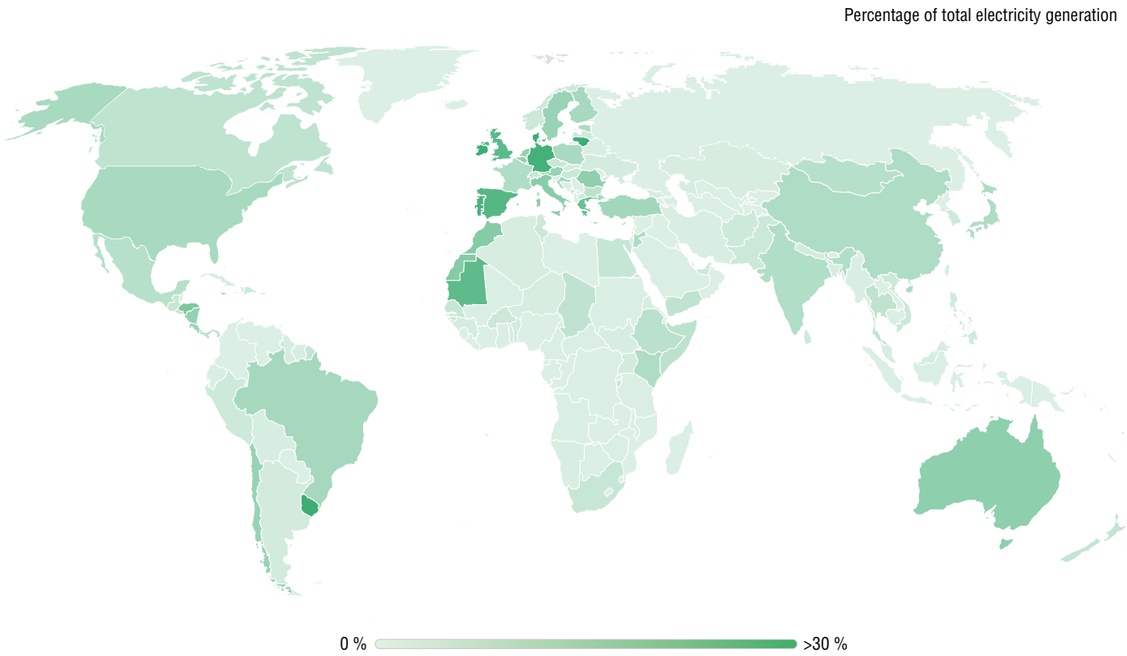


Fossil-Free Generation

Key Messages

- *Wind and solar generation grew by 15% (+270 TWh) in 2019.* The wind and solar generation rise of 270 TWh was the second biggest on record, but the growth rate is slowing - the 15% growth rate was the lowest this century. Of the four key regions, China showed the fastest growth of 16% (+86 TWh) and the US the slowest with 11% (+41 TWh); India and EU both recorded 13% growth rates (+13 TWh and +64 TWh respectively).
- *Hydro and nuclear generation rose, but unlike wind and solar, there is no big pick-up in deployment.* Nuclear plants restarted in Japan and South Korea. Whilst new nuclear plants in China rose, it built less new hydro capacity than the last few years.
- *The compound growth needed for wind and solar over the next years will be very challenging to achieve.* Record low wind and solar prices in 2019 give hope that compound growth rates could be maintained if governments step up.

Wind and solar generation, as a percentage of national electricity production



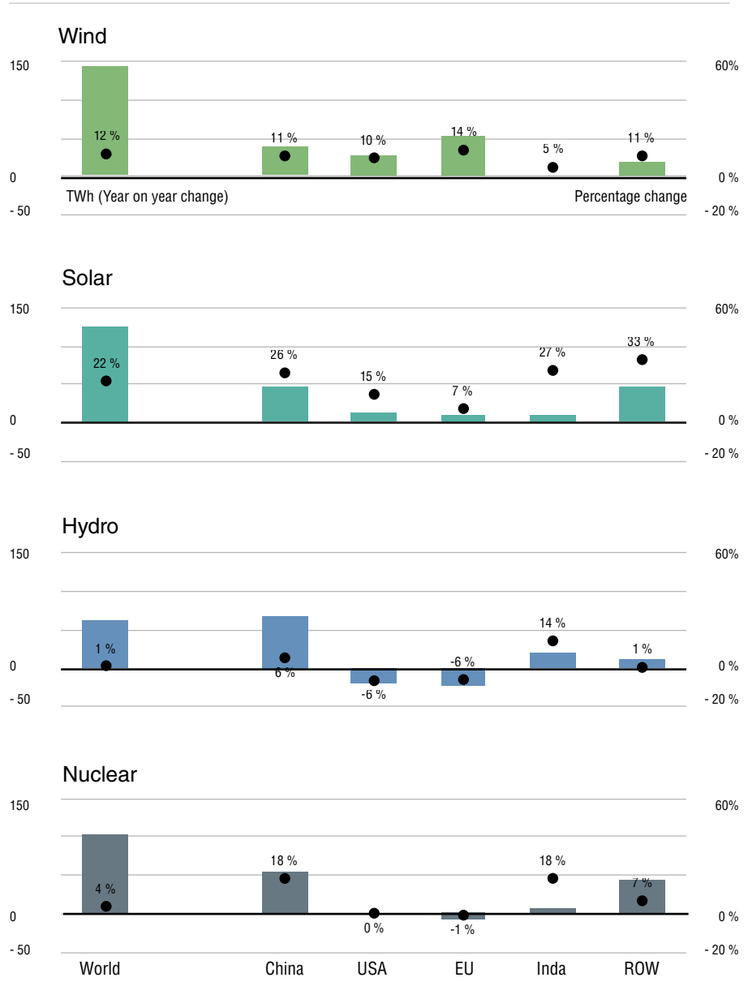
What happened in 2019?

Wind generation increased by 12%. Three-quarters of the rise was from just 7 countries: China, US, Germany, UK, France, Sweden and Brazil.

Solar generation increased by 22%. China saw the biggest generation increase but a capacity slowdown means it will be lower next year.

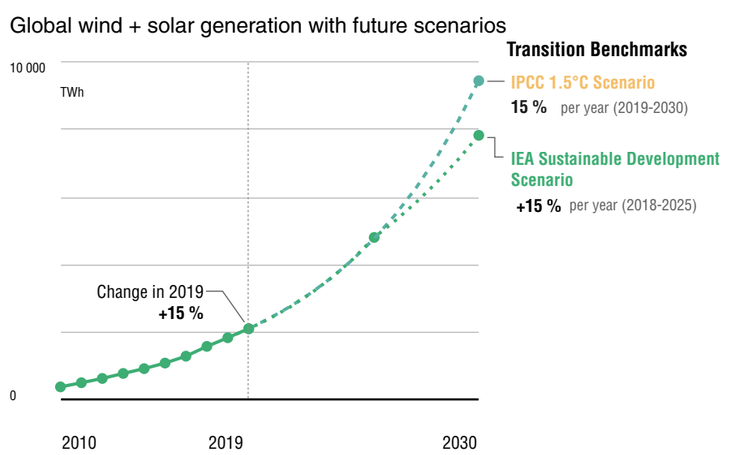
Hydro generation only increased by 1%. China, the main country building new hydro, built much less. Wet conditions in China and India offset a drier EU and US.

Nuclear generation rose 4%, the most this century. This was due to new plants in China and restarts in South Korea and Japan.



Is the transition happening fast enough?

It's not yet clear. Wind and solar generation increased by 15% in 2019. Huge compound growth is needed to more than double wind and solar generation by just 2025. It's not yet clear governments are ready to facilitate this. However, record low prices for wind and solar give hope that deployment rates can be sustained in countries with record deployment, and increased elsewhere.



Fossil-Free Generation

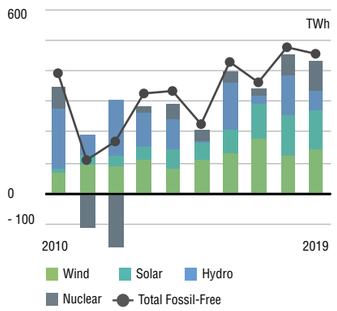
→ World

Fossil-free generation growth keeps pace with weak electricity demand

Nuclear generation rose at the fastest rate this century, because of restarts in Japan and South Korea, and also new capacity installed in China. Hydro generation rose, but mostly due to wet conditions in China and India. In China, where most new hydro is being built, hydro capacity was up only 4 GW, compared to 16 GW average this decade.

Fossil + Fossil-Free Change

Fossil-Free Change



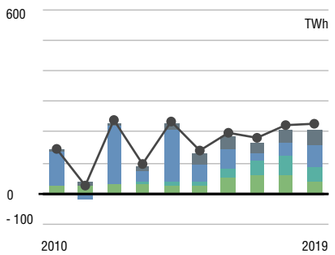
→ China

Fossil-free generation added less than the growth in electricity demand

Fossil-free generation grew by 10% (+227 TWh), which was less than the 329 TWh growth in electricity demand, necessitating a rise in fossil generation of 102 TWh to meet extra demand. Hydro generation increased 69 TWh, driven more by heavy rains rather than new capacity - hydro capacity was up only 4 GW, compared to 16 GW average this decade. Nuclear generation increased 54 TWh as 4 GW more capacity came online.

Fossil + Fossil-Free Change

Fossil-Free Change



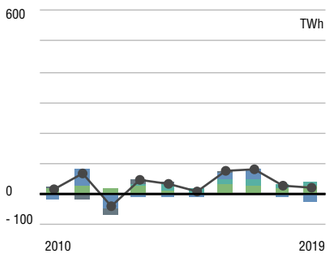
→ United States

Fossil-free generation barely grew because of weak wind and solar growth

Nuclear generation was unchanged, and hydro generation fell, after a wet year in 2018.

Fossil + Fossil-Free Change

Fossil-Free Change



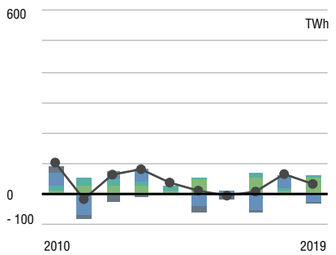
→ European Union

Fossil-free generation increase driven by wind

Hydro and nuclear generation fell slightly, with drier conditions affecting hydro, and outages at French and UK nuclear plants.

Fossil + Fossil-Free Change

Fossil-Free Change



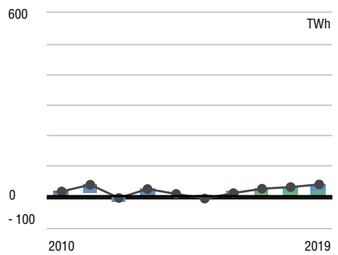
→ India

Fossil-free generation boosted by record solar additions and monsoon

Hydro generation was boosted by the strongest monsoons in 25 years.

Fossil + Fossil-Free Change

Fossil-Free Change



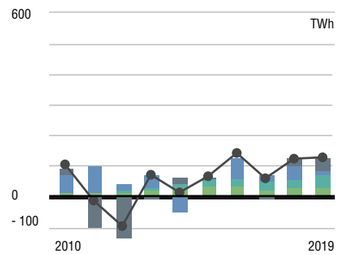
→ Rest of World

Fossil-free generation rises on solar growth and nuclear restarts

Nuclear generation increased as reactors returned in Japan and South Korea.

Fossil + Fossil-Free Change

Fossil-Free Change



Wind & Solar Generation

→ World

Wind and solar generation growth slowed to 15% (+270 TWh)

The wind and solar generation rise of 270 TWh was the second biggest on record, but the growth rate slowed - the 15% growth rate was the lowest this century. Of the four key regions, China showed the fastest growth of 16% (+86 TWh) and the US the slowest with 11% (+41 TWh); India and EU both recorded 13% growth rates (+13 TWh and +64 TWh respectively). Five further countries added 40 TWh between them, mostly solar: Japan, Brazil, Mexico, Australia and Vietnam.

→ China

Wind and solar generation growth slowed to 16% (+86 TWh)

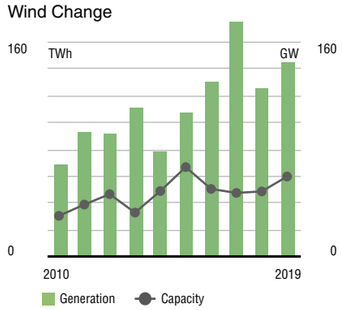
Growth of 86 TWh (40 TWh of wind and 46 TWh of solar) was the lowest growth since 2016. But the growth rate of 16% was the lowest this century. New wind installations were 26 GW, below the 34 GW installed in 2015. New solar installations were 30 GW, below the 53 GW installed in 2017.

→ United States

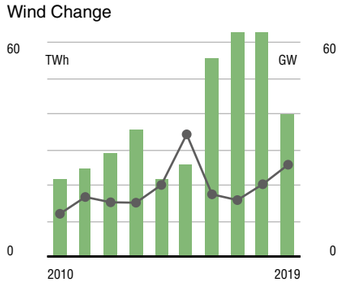
Wind and solar generation grew at only 11% (+41 TWh)

This is the lowest of any major region: China grew at 16% (+86 TWh) India 13% (+13 TWh) and EU 13% (+64 TWh). Wind and solar generation increased by 41 TWh (+27 TWh of wind, 14 TWh of solar). Neither solar nor wind set new records for new installations: 9 GW of solar was installed, below the 11 GW record in 2016, and 9 GW of wind was installed, below the 13 GW record in 2012.

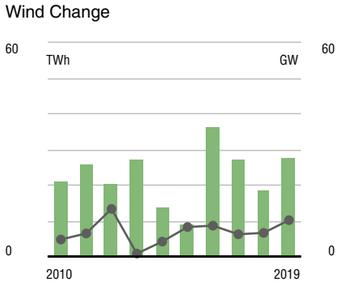
Wind Change



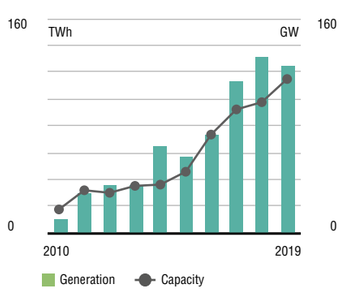
Wind Change



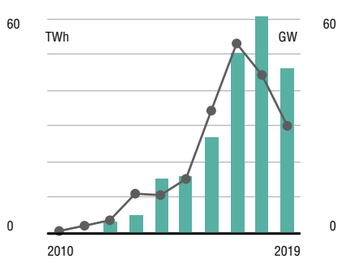
Wind Change



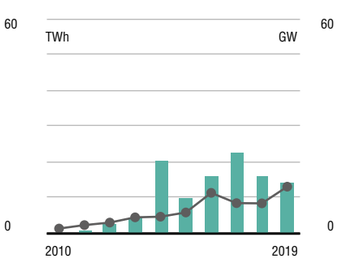
Solar Change



Solar Change



Solar Change



→ European Union

Wind and solar generation increased in 2019 by 13% (64 TWh)

Wind generation saw a large increase, helped by new offshore installations. However, German onshore wind slowed on new planning laws. Solar generation showed a strong rise, with capacity additions doubling over 2018. Spain leapt to become the largest solar installer in the EU. The growth of wind and solar continues to be concentrated in western Europe, with eastern European countries lagging.

→ India

Solar capacity additions increased to a record 12 GW

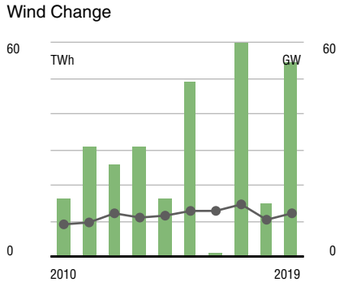
New solar capacity hit a new record at 12 GW, solar provided 3.4% of all electricity in 2019. India opened the world's largest solar farm in 2019. The growth in wind was less impressive. Wind generation grew at the lowest rate since 2015, and new wind installations fell for the second year running.

→ Rest of World

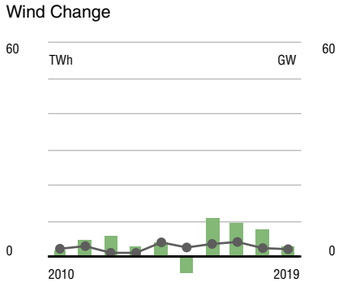
Solar generation growth accelerated markedly in 2019, but wind generation lags behind.

Solar generation increased by 33% (+46 TWh) as a record level of new solar capacity was installed. There were strong additions from Japan, South Korea, Vietnam and Australia. Vietnam solar capacity increased from 0.1 GW to 5.5 GW in 2019 alone.Wind grew 11% (+21 TWh) with good additions from Brazil, Argentina and Mexico. However, wind generation grew at only half that of solar generation.

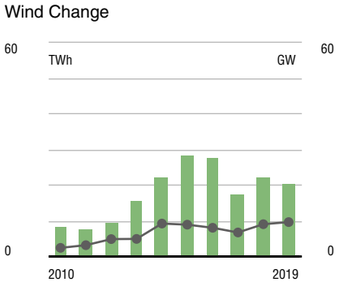
Wind Change



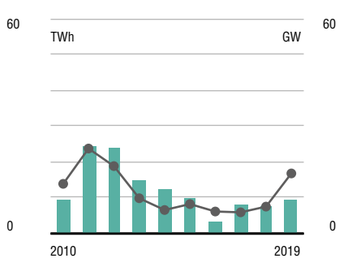
Wind Change



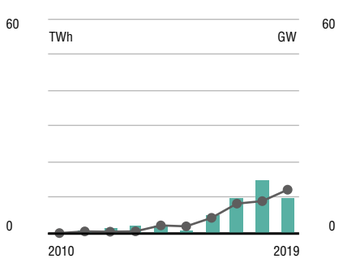
Wind Change



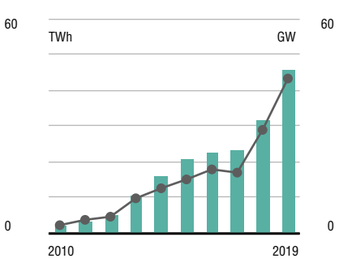
Solar Change



Solar Change



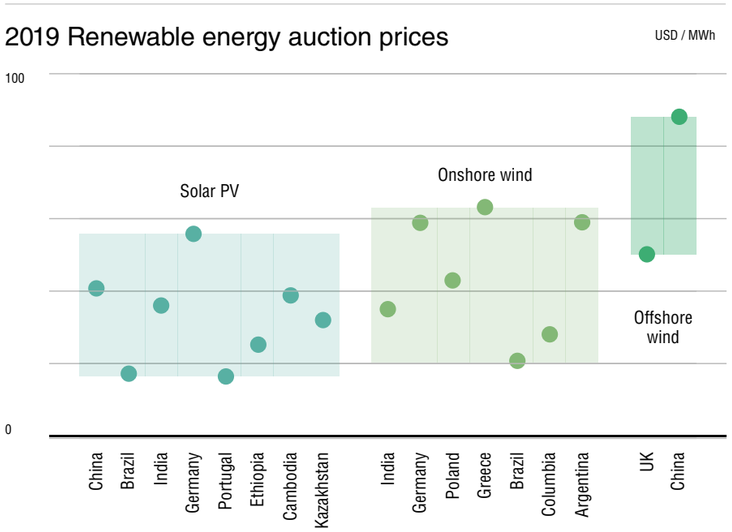
Solar Change



Wind and Solar progress in 2019

Latest Prices

Solar: Solar auctions have delivered record low prices in 2019. The lowest prices were established in Portugal at 16.5 USD/MWh and in Brazil, 17.3 USD/MWh. In January 2020, these records had already been surpassed by an auction in Qatar where the final price was 16 USD/MWh.

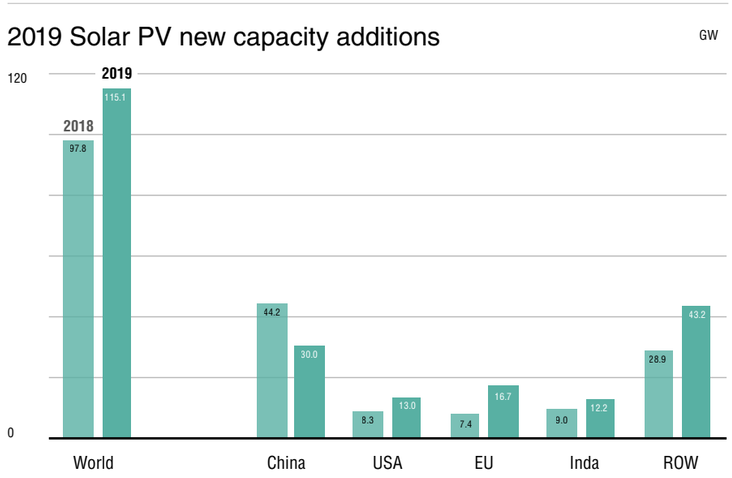


Onshore wind: The lowest price for onshore wind in 2019 was 21 USD/MWh in an auction held in Brazil. The second-lowest price was 28 USD/MWh in Colombia. Projects in Greece were awarded for a price of 63 USD/MWh. India also awarded a record low onshore wind price of 35 USD/MWh.

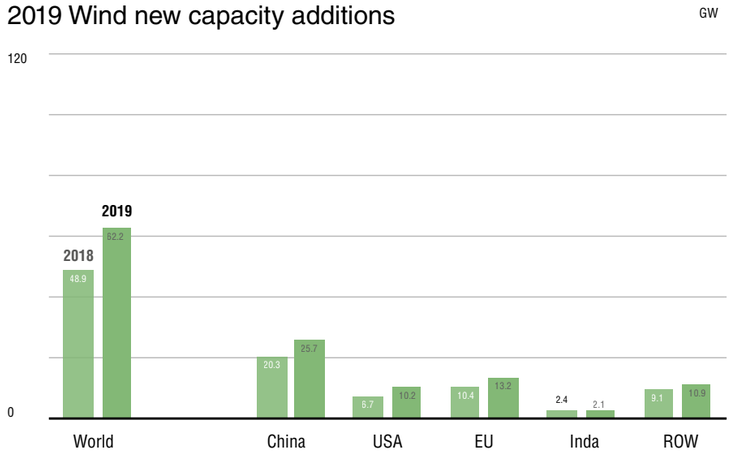
Offshore wind: A zero-subsidy offshore wind project was awarded in 2019 in the Netherlands. In the United Kingdom, auctions have delivered new record low prices for offshore wind at 50 USD/MWh while in China the lowest offshore wind price was 88 USD/MWh. The vast majority of prices of renewable energy project stemming from auctions were below generation costs of fossil fuel alternatives estimated by IRENA to be 49 USD/MWh to 174 USD/MWh. .

New Capacity

Solar: Solar capacity installed in 2019 was around 115 GW, 18% more than the previous year. USA, India and the European Union have seen increases of 56%, 36% and 96% respectively in 2019 compensating for the decline in installations in China. Rest of World countries have increased their installations by 56%.



Wind: Preliminary estimates for wind capacity installed in 2019 are around 62 GW, 27% more than in 2018 but less than the 67 GW added in 2015. As such, growth has started to accelerate from the flat three years before. The European Union, Rest of World, China and USA have seen growth rates of 27%, 19%, 27% and 53% respectively, while India has seen a 12% decline.



Fossil Generation

Key Messages

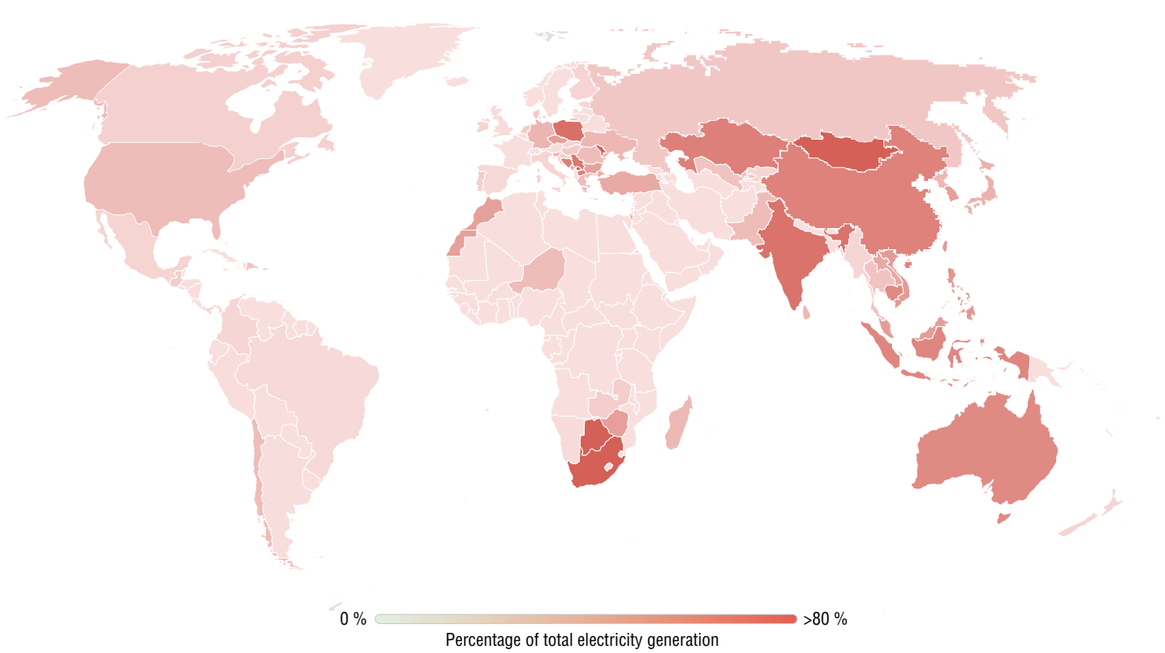
- Coal generation fell a record 3%, but falling coal is not yet the "new normal". Coal fell because electricity demand growth slowed, wind and solar generation rose, gas replaced coal in the US and the EU, hydro increased, new nuclear plants were added and nuclear plants restarted in South Korea and Japan. Some of these factors were one-off factors that are unlikely to be reproduced.

- China in 2019, for the first time, was responsible for more than half of the world's coal generation. Since 2015, when the Paris Climate Agreement was signed, China's coal generation has risen by 17%, whereas coal generation in the rest of the world has fallen by 9%.

- Global power sector CO_2 emissions fell by a record 2%. CO_2 emissions would have fallen faster if fossil-free generation had totally replaced coal, rather than a pick-up in coal-gas switching. The climate impact of methane leaks from the extra gas generation is not included in our calculations.

- Given the one-off nature of some of the reasons for the fall in power sector CO_2 emissions in 2019, there is not sufficient evidence to suggest emissions will fall fast enough to limit climate change to 1.5 degrees.

Coal generation as a percentage of national electricity production



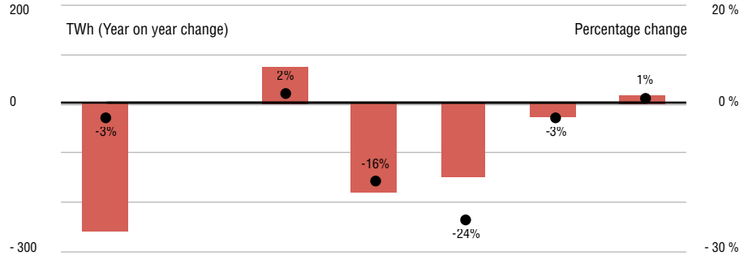
What happened in 2019?

Coal generation fell 3%. Coal collapsed in the EU and the US. Overall fall due to a rise in wind and solar generation, slow electricity demand growth, gas replacing coal in the US and the EU, new nuclear plants (China and India) and restarts (in South Korea and Japan). Coal increased in China.

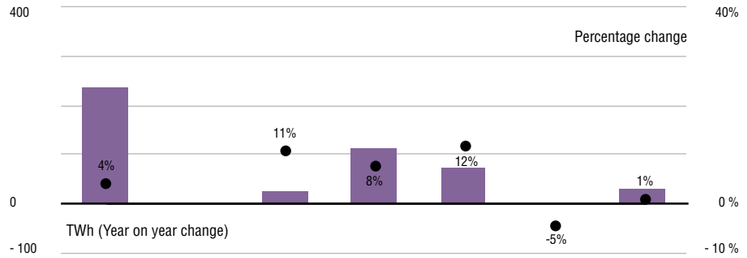
Gas generation rose 4%. Gas use rose in the US and EU, part of the reason for coal collapsing. Gas use rose in China, Saudi Arabia, Mexico and Iran. Only 3 countries saw a big fall in gas: Japan, South Korea and Turkey.

CO_2 emissions fell 2%. The coal collapse in the EU and US meant CO_2 emissions fell faster than the increase in China's CO_2.

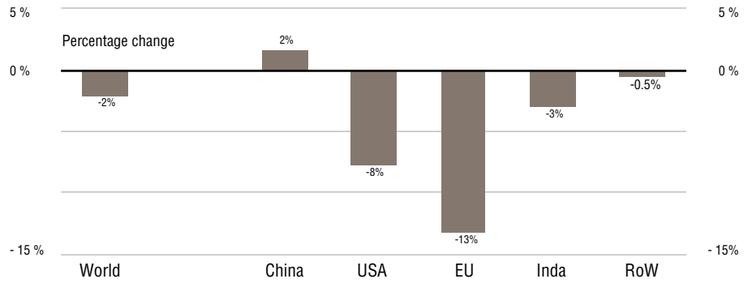
2019 coal generation changes by region



2019 gas generation changes by region



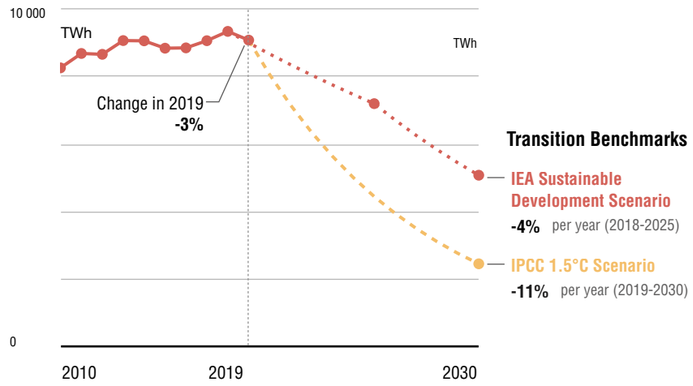
2019 CO_2 emissions changes by region



Is the transition happening fast enough?

No. Despite the 3% fall in coal generation, it's not clear yet that falling coal generation is the "new normal". Coal generation will need to fall at 11% per year every year until 2030, to meet the IPCC's medial level of the 1.5C compatible scenarios. Even the less-ambitious IEA Sustainable Development scenario needs drops of 4% per year.

Global coal generation with future scenarios



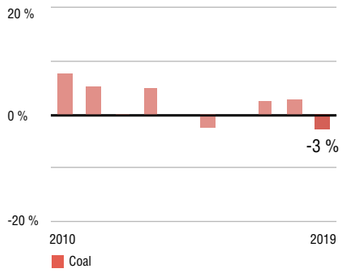
Coal generation

→ World

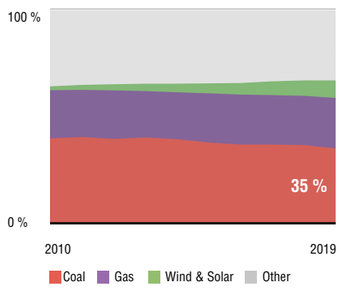
Coal generation fell a record 3%

Coal fell 3% (-259 TWh), as coal collapsed in the EU and the US, but rose in China. This is because wind and solar generation rose, electricity demand increased by the least in a decade, gas replaced coal in the US and the EU, and nuclear plants restarted in South Korea and Japan. New coal-fired generation capacity continues to rise, driven primarily by new additions in China.

Coal generation change



Generation Mix

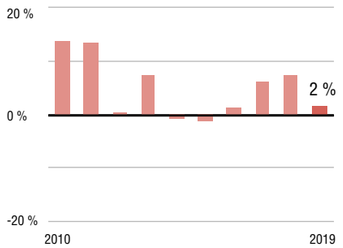


→ China

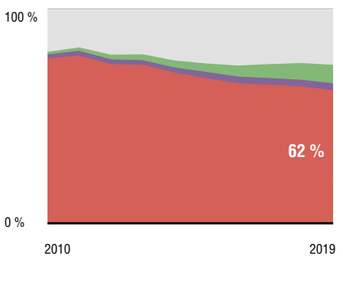
Coal rose to half of the world's coal generation

Coal-fired generation rose 2% in 2019. Since 2015, China's coal generation has risen by 17%, compared to a fall of 9% in the rest of the world. For the first time, China is now responsible for over 50% of global coal generation.At 62%, coal's relative share of the electricity mix is falling, but only because total electricity demand has increased even more dramatically. This hides the absolute rise in coal generation which has doubled in 12 years.

Coal generation change



Generation Mix

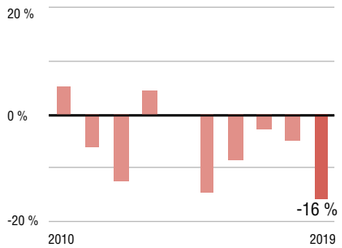


→ United States

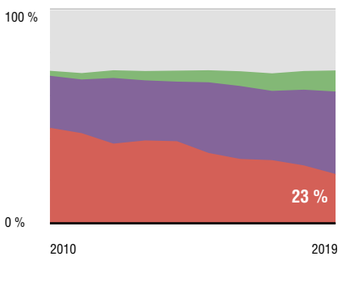
Coal generation collapsed - and was replaced largely with gas generation

Coal generation fell by 16% (180 TWh), to 24% of total generation. This was due to a 113 TWh increase in gas generation, a 58 TWh fall in electricity demand, and a 41 TWh rise in wind and solar. This fall is the largest on record, and the fifth year of consecutive falls. It brings US coal generation to half its 2007 level, and the lowest since 1975.

Coal generation change



Generation Mix

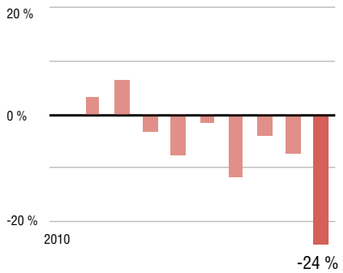


→ European Union

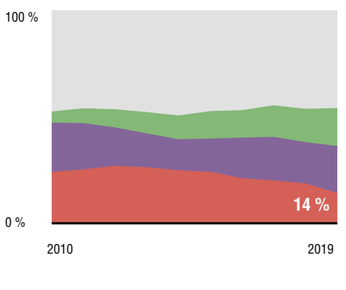
Coal generation collapsed

The EU saw a record 24% fall in coal-fired generation in 2019. Coal now stands at half its 2007 peak, and makes up only 14% of the electricity mix. In 2019, coal's fall is attributable to the rise in wind and solar, switching from coal to gas driven by increases in the EU carbon price, and a small fall in electricity demand.

Coal generation change



Generation Mix

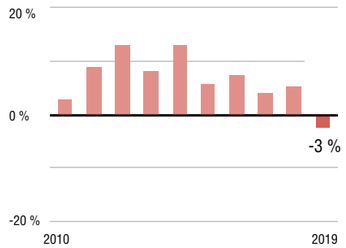


→ India

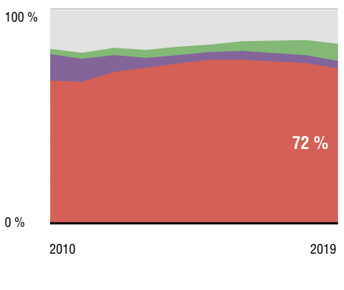
Coal shows a surprise fall

Coal generation fell for the first time since at least 1990 when the IEA's reporting began. The fall was likely a one-off for now, caused by the combination of a large reduction in demand growth, and weather-driven increase in hydro generation. Wind and solar also played a role. Coal-fired generation fell 3%. However, coal still contributes 72% to the Indian electricity mix, and India is still building new coal plants. In 2019, GEM data shows there was 8 GW of new coal capacity brought online, with almost no old coal plants closed.

Coal generation change



Generation Mix

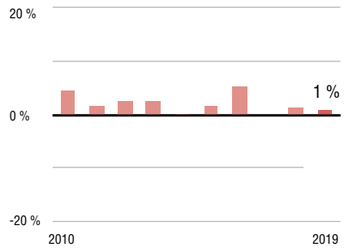


→ Rest of World

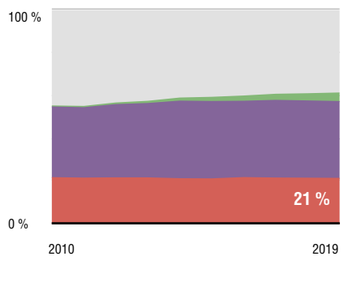
Coal grew slightly by 1%

Coal generation fell in Japan (-4%, -11 TWh), South Korea (-5%, -12 TWh) and South Africa (-4%, -9 TWh), and were offset by rises in Indonesia (+11%, 16 TWh), Vietnam (+34%, 25 TWh) and Pakistan (+95%, +16 TWh).

Coal generation change



Fossil-Free Change



Coal capacity

→ World

68 GW of coal plants were built in 2019, the highest in three years

95% of this new coal capacity was in Asia: China built 44 GW, India 8 GW, Malaysia 2.6 GW, Indonesia 2.4 GW, Pakistan 2.0 GW, Japan 1.3 GW and Philippines 1.2 GW. There were very few closures outside the US and the EU.

→ China

China built almost as much new coal capacity as wind and solar capacity combined

44 GW of new coal was built in 2019, compared to 30 GW of solar and 25 GW of wind. These are not replacing older coal plants. Only 7 GW coal plants were closed in 2019, and the reported carbon intensity of the Chinese coal fleet improved just 0.3%, the lowest improvement since reporting began in 2006.

→ United States

Coal capacity closures continued

16 GW closed in 2019, and 105 GW has been closed since 2010. No new coal plants have come online since 2013. However, 8 GW of gas capacity was built in 2019, with 92 GW now built since 2010. Despite the fall in coal capacity, average coal load factor is also still falling because of the collapse in coal generation, dropping below 50% for the first time.

→ European Union

Coal load factor collapsed in 2019

The fall in coal generation 2019 was much faster than the fall in capacity, which pulled the average load factor down to a record 37%. 7 GW of coal plants closed in 2019, and 66 GW have retired since 2010. In 2019, Germany, Greece and Hungary committed to phasing out coal, bringing the total to 15 EU countries, ensuring closures continue apace.

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→ India

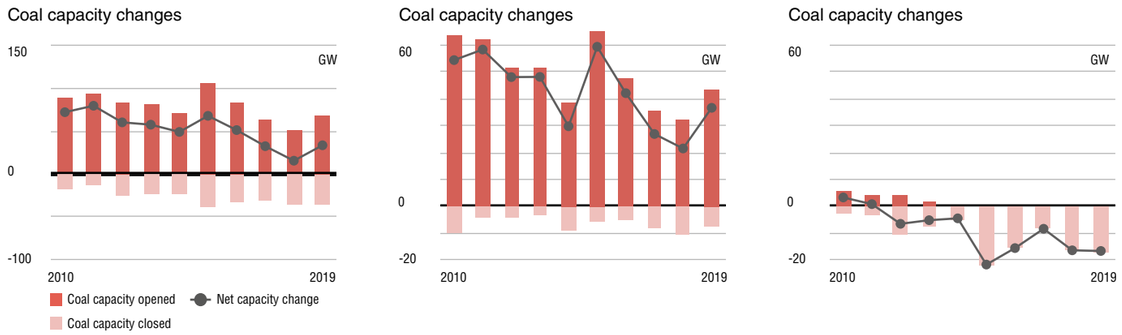
India built 8 GW of new coal plants in 2019

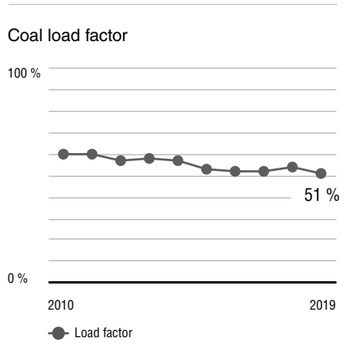
India brought 8 GW of coal plants online in 2019, and closed only 1 GW. Average coal load factor fell in 2019 because both coal generation fell and coal capacity increased. It now stands at a record low of 57%.

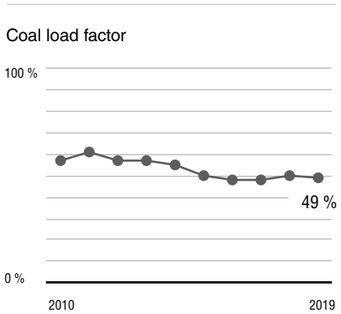
→ Rest of World

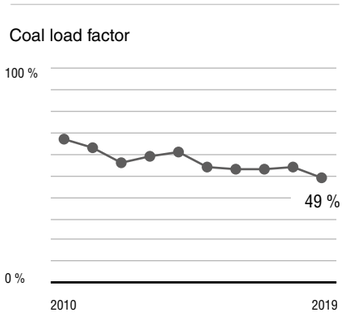
New coal-fired plants continued to be built in 2019 in Asian countries

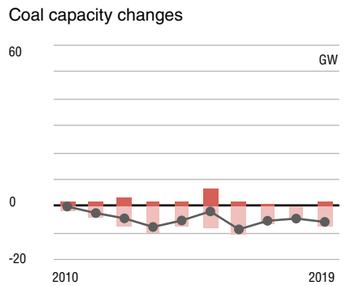
Almost 90% of the 15 GW was in Asian countries. Malaysia built 2.6 GW, Indonesia 2.4 GW, Pakistan 2.0 GW, Japan 1.3 GW and Philippines 1.2 GW. Only 22 GW of coal plants have closed since 2010.

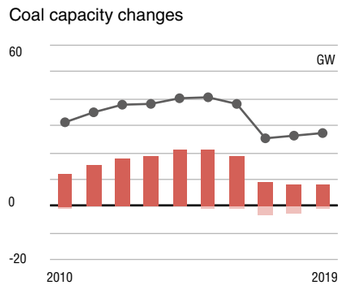


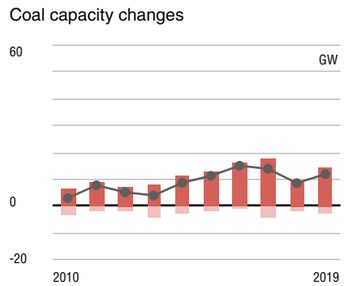


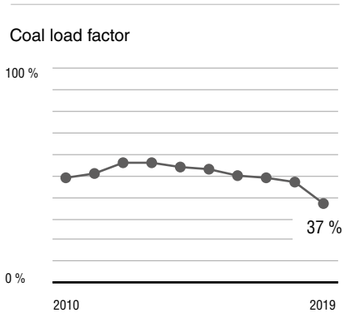


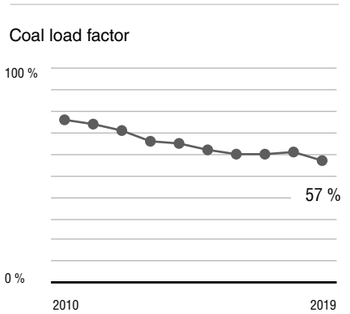


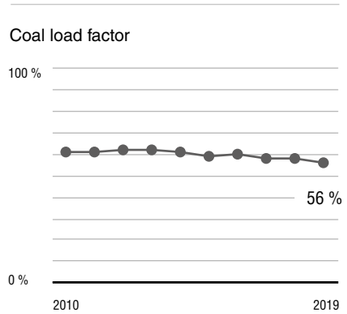












Coal capacity data has been taken from Global Energy Monitor's 'Global Coal Plant Tracker' update of Jan-20. It provides data on net capacity as well as annual additions and retirements. Coal load factors were taken from national sources where available (China, United States, India), and calculated for remaining regions (EU, Rest of World) using the ratio of annual coal-fired generation to annual coal capacity.

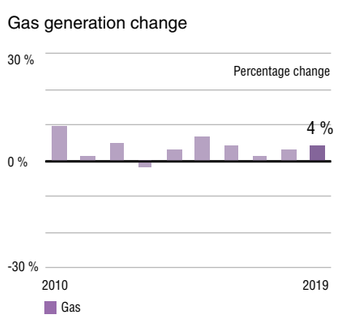
Gas generation

→ World

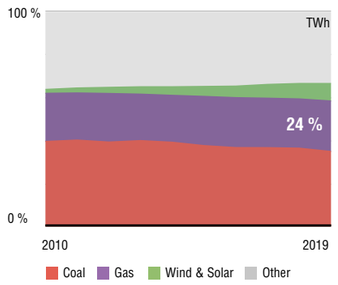
Gas generation rose 4%

This happend mostly as a result of gas generation replacing coal in the EU and US.

Gas generation change



Generation Mix

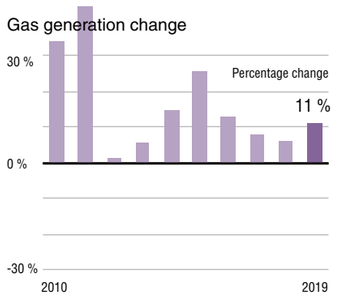


→ China

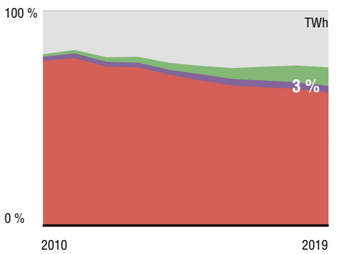
Gas rose from a low base

Gas-fired generation rose by 11% in 2019, increasing to 3% of the electricity mix. 6 GW of new gas capacity was built in 2019.

Gas generation change



Generation Mix

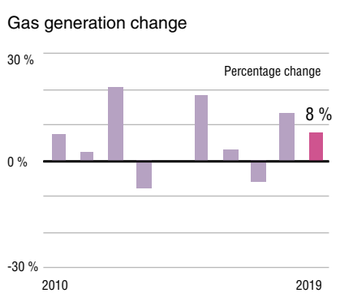


→ United States

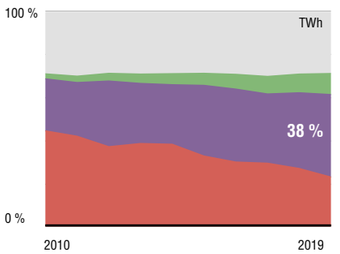
Gas generation continued to soar

It rose by 7%, and now stands at 38% of the electricity mix. New gas capacity continues to be built apace, with 7 GW more in 2019, cumulatively adding over 100 GW last decade.

Gas generation change



Generation Mix

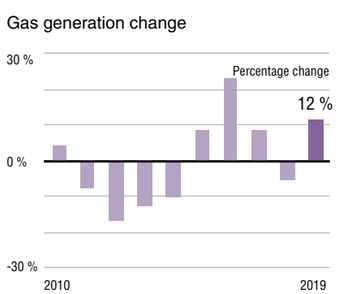


→ European Union

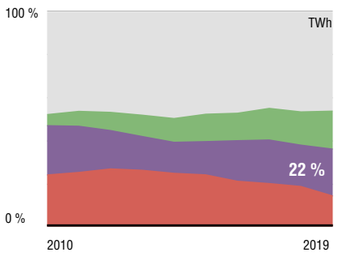
Gas generation increased by 12%

The one-off switch in economics resulted in a 73 TWh rise in gas generation, which was a big contribution to coal's fall.

Gas generation change



Generation Mix

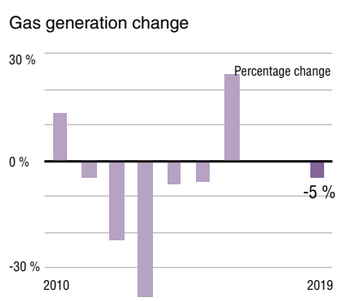


→ India

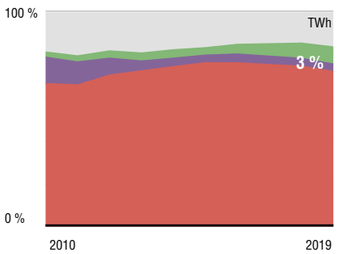
Gas generation fell in 2019 by 5%

However, the change is relatively unimportant as gas only provides a small (3%) part of India's generation.

Gas generation change



Generation Mix

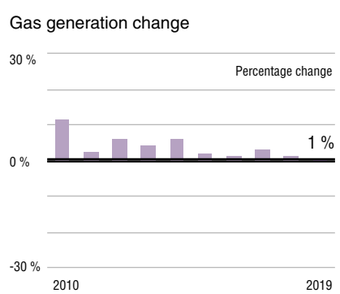


→ Rest of World

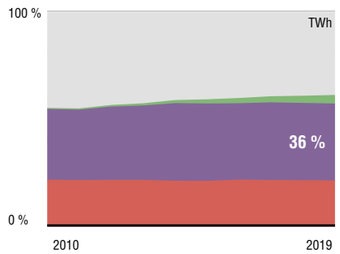
Gas grew slightly by 1%

Gas generation rose by 1%. There were significant increases in Saudi Arabia (+11%, 24 TWh), Mexico (+9%, 17 TWh), and Iran (+8%, +20 TWh). These rises were tempered by a large fall in gas generation in Turkey (-39%, 34 TWh), where there was a large increase in hydro generation.

Gas generation change



Generation Mix



Power sector CO_2 emissions

→ World

CO_2 emissions fell 2%, as the fall in coal generation was partly offset by the rise in gas generation

This doesn't take into account the climate impact of methane leaks from the additional gas generation. The carbon intensity of electricity fell by 3% over the year. At 442 gCO_2/kWh, it is now 15% lower than the start of this decade, as fossil-free generation has grown faster than fossil.

→ China

CO_2 emissions rose 1.6% with coal and gas generation

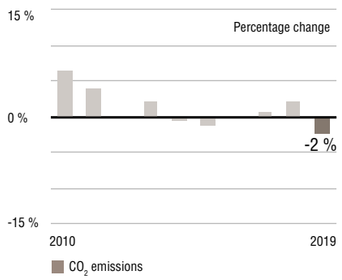
Despite huge investment in new coal plants, the reported carbon intensity of the Chinese coal fleet improved just 0.3% in 2019, the lowest improvement since reporting began in 2006. China's carbon intensity of electricity of 576 gCO_2/kWh is 30% above the global average. The high efficiency of its coal fleet only goes so far in limiting the impact of the high coal generation in China.

→ United States

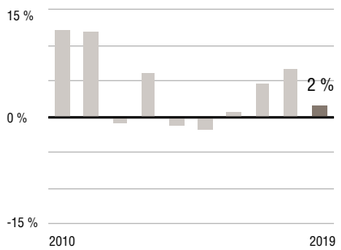
CO_2 emissions fell by 8%, coal's fall was tempered by the rise in gas emissions.

When you include methane leaks from gas generation the fall in US greenhouse gas emissions is reduced. The carbon intensity of US electricity continued to fall, and is slightly below the global average. However, because the average US citizen uses so much electricity, the absolute CO_2 emissions per person is over three times higher than the global average in the power sector.

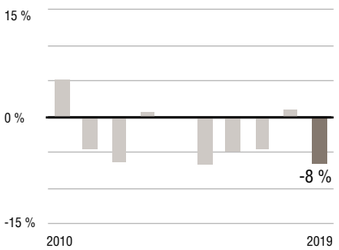
CO_2 emissions change



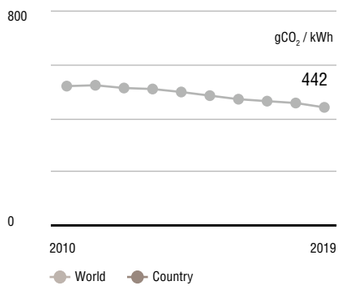
CO_2 emissions change



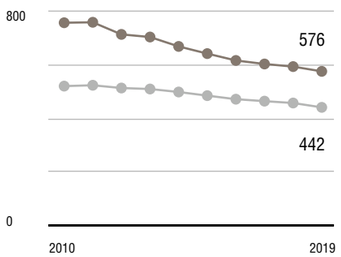
CO_2 emissions change



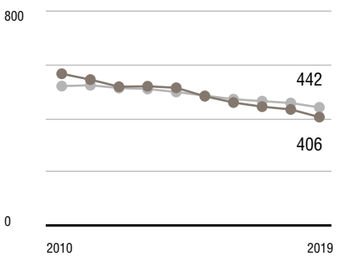
CO_2 intensity of electricity



CO_2 intensity of electricity



CO_2 intensity of electricity



→ European Union

CO_2 emissions collapsed because of the fall in coal

EU power sector emissions fell by 13% in 2019, the largest fall this century. The carbon intensity of EU electricity is collapsing rapidly, and is now 42% below the global average.

→ India

CO_2 emissions fell in line with coal generation

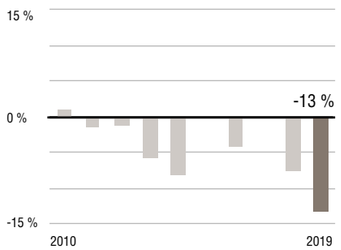
The carbon intensity of India's electricity generation fell by 4% in 2019, but remains much more carbon-intensive than the global average.

→ Rest of World

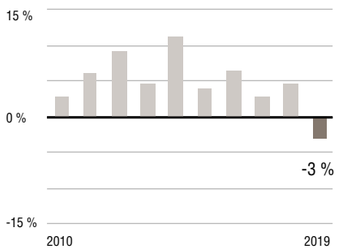
CO_2 emissions fell slightly, by 0.5%

Although coal and gas generation rose very slightly, oil generation falling especially in Iran and Pakistan actually led to a very slight fall in rest of the world CO_2 emissions overall.

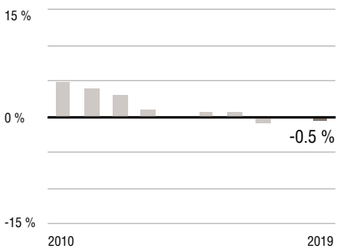
CO_2 emissions change



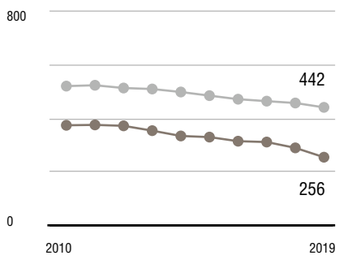
CO_2 emissions change



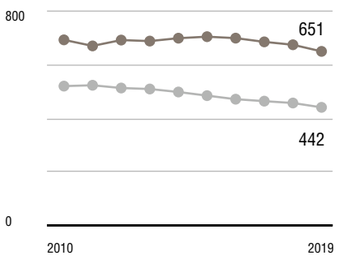
CO_2 emissions change



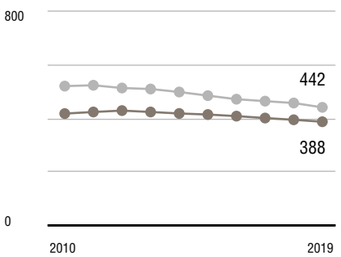
CO_2 intensity of electricity



CO_2 intensity of electricity



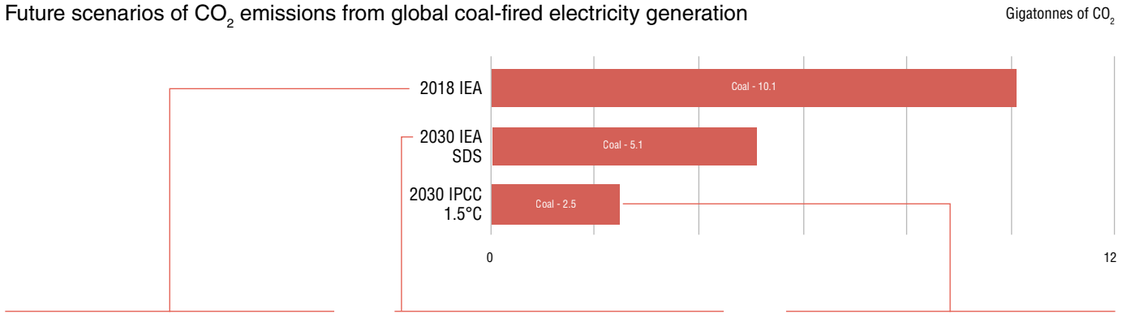
CO_2 intensity of electricity



Future Scenarios

IPCC and IEA modelling both show that immediate and aggressive action to cut coal generation is critical to limiting climate change.

Future scenarios of CO_2 emissions from global coal-fired electricity generation



Coal power plants emitted 10.1GT of CO_2 in 2018. This is equal to 30% of all the CO_2 emissions from all fossil fuels in 2018, according to the IEA.

The IEA's Sustainable Development Scenario (IEA SDS) shows that coal power emissions must halve by 2030.

Emissions must reduce from 10.1 gigatonnes to 5.1 GT to be on target for the Paris Climate Agreement. Falling coal power generation alone delivers 61% of the required global reductions in fossil fuel emissions to 2030

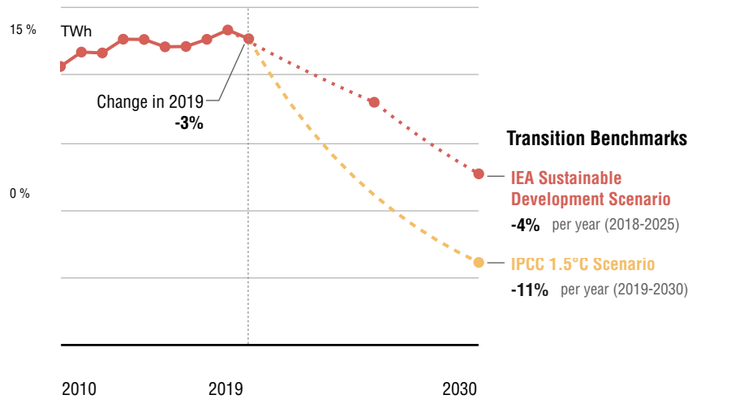
The IPCC's "Special Report on Global Warming of 1.5°C" (IPCC 1.5) implies coal power emissions must fall even faster, by 75% by 2030.

Their modelling implies a fall to 2.5GT, the median value in their below 1.5C and 1.5°C with low-overshoot pathways. We back-calculated the 2.5 GT from their coal electricity generation of 8.83 exajoules, which equals 2453 TWh. We assume there is no significant carbon capture in the IPCC scenario; if there is then the falls in CO_2 would be even higher than this.

The IPCC 1.5 shows much bigger coal generation falls than the IEA SDS.

The IEA SDS is less ambitious than the IPCC, because (a) it assumes 1.65 degrees, not 1.5 degrees, and (b) it relies on net negative emissions after 2050 where the IPCC median scenario does not. Please refer to the IEA's blog "What would it take to limit the global temperature rise to 1.5°C?" for more details.

Global coal generation with future scenarios



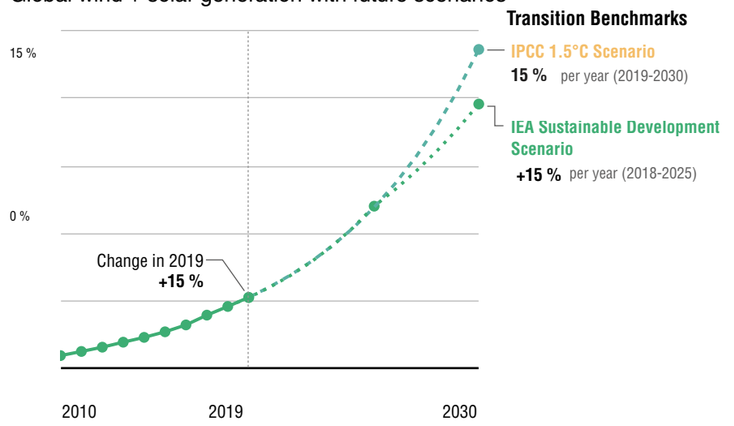
A four-fold increase in wind and solar generation is needed by 2030 to replace the coal generation, according to the IEA SDS.

The median value of their below 1.5C and 1.5°C with low-overshoot scenarios is 34.02 exajoules of wind and solar generation in 2030 is equal to 9450 TWh.

How did we split this by region?

The IEA SDS already outputs generation by region, however the IPCC 1.5 does not. For wind and solar, we do not give a regional breakdown for IPCC. For coal generation, we do give a regional breakdown of IPCC 1.5, sourced from Climate Analytics. In their report "Global and regional coal phase-out requirements of the Paris Agreement: Insights from the IPCC Special Report on 1.5°C", they showed that OECD countries must reduce coal generation by 86%, and non-OECD Asia must reduce by 63%, relative to 2010. We applied the 86% to the US and EU, and the 63% to China and India.

Global wind + solar generation with future scenarios



Data

Data Method

This report provides data that aggregates 2019 generation for 85% of the world's electricity production.

For the following countries, we have taken data from national sources:

- China - China Electricity Council (CEC) 21st January
- United States - Energy Information Administration (EIA) 26th February
- India - Central Electricity Authority (CEA) 31st January
- European Union - via Ember's 'European Power Sector Review' 5th February

For all other countries, we have used the EIA's 'International data browser' to obtain historical data. Accessed on 5th February 2020.

And for 2019, we used national datasets for the following additional countries:

- Brazil - ONS data, 30th January 2020
- Canada - Stats Canada data, 28th January 2020
- Japan - ENECHO data, 28th January 2020
- South Korea - KEPCO data, 22nd January 2020
- Turkey - Teias data, 28th January 2020
- Vietnam - EVN data, 15th November 2019
- Argentina - Cammesa data, 28th January 2020
- Chile - CEN data, 23rd January 2020
- South Africa - ESKOM data, 6th February 2020
- Philippines - NGCP data, 16th January 2020
- Mexico - CRE data, 16th January 2020
- Taiwan - Taipower data (via Electricity-Map), 6th January 2020
- Australia -AEMO data, 10th February 2020
- Pakistan - NEPRA data, 22nd January 2020
- Russia - Minenergo data, 30th January 2020

China
CEC Data

Year	Demand	Net imports	Total Generation	Coal	Gas	Other Fossil	Nuclear	Hydro	Wind	Solar	Biomass and Waste	Other Renewables	CO_2 Emissions
	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	Mt CO_2
2000	1310	-9	1319	1034	20	25	16	220	1	0	2	0	1104
2001	1455	-9	1464	1120	22	27	17	275	1	0	2	0	1186
2002	1626	-8	1634	1265	25	31	25	285	1	0	2	0	1328
2003	1851	-7	1859	1468	29	36	42	281	1	0	2	0	1529
2004	2155	-6	2161	1685	33	41	48	350	1	0	2	0	1741
2005	2415	-6	2421	1890	37	46	50	393	2	0	2	0	1937
2006	2774	-7	2781	2207	44	54	55	415	4	0	2	0	2244
2007	3217	-10	3227	2571	51	63	63	471	6	0	2	0	2594
2008	3419	-13	3431	2651	52	65	69	566	13	0	15	0	2654
2009	3670	-11	3682	2867	57	77	70	572	28	0	12	0	2846
2010	4214	-14	4228	3261	76	64	75	687	49	0	16	0	3200
2011	4718	-13	4731	3696	109	72	87	668	74	1	23	0	3582
2012	4976	-11	4986	3713	110	71	98	856	103	4	32	0	3560
2013	5361	-11	5372	3981	116	86	112	892	138	8	38	0	3782
2014	5593	-11	5605	3951	133	97	133	1060	160	24	46	1	3750
2015	5728	-12	5740	3898	167	112	171	1113	186	40	54	0	3687
2016	6010	-13	6023	3946	188	128	213	1175	241	67	65	0	3714
2017	6437	-12	6449	4178	203	125	248	1193	303	117	81	0	3892
2018	6984	-12	6996	4483	216	133	294	1233	366	178	94	0	4155
2019	7313	-12	7325	4560	239	135	349	1302	406	224	112	0	4220

National data

Central Electricity Council (CEC) data has been used wherever possible, as a timely source of official national generation data for China. Biomass and Waste includes Biomass power and waste incineration CEC data. Other fossils generation is equivalent to CEC total thermal generation minus Coal, Gas and Biomass and Waste generation. This mapping implicitly includes CEC 'Waste heat, pressure, and gas' generation data within Other Fossil - it is possible that other statistical reviews categorize this as coal generation. CEC coal generation data does not include generation for industry self-use - BP and IEA likely estimate this, resulting in larger values.

EIA

Where possible, data from the EIA's 'International Data Browser' has been used to complete historical generation if CEC data was unavailable.

Disaggregation

If a disaggregated source of fossil generation data was unavailable, thermal generation data from the National Bureau of Statistics (NBS) was disaggregated according to Coal, Gas and Other Fossil's share of total thermal generation in 2009 CEC data.

Estimates

Gas generation has been estimated to increase by 2.4 % in 2019. Biomass and Waste generation for 2019 has been estimated using the growth rate published by the National Energy Administration (NEA). Data from 2017 has been carried forward for both Net Imports and Other Renewables.

Ember calculations

Total generation is the sum of generation from all fuel types, and Demand the sum of total generation and net imports. CO_2 emissions are calculated from generation data; the methodology for this is explained on page 72.

United States
EIA Data

Year	Demand	Net imports	Total Generation	Coal	Gas	Other Fossil	Nuclear	Hydro	Wind	Solar	Biomass and Waste	Other Renewables	CO_2 Emissions
	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	Mt CO_2
2000	3836	34	3802	1966	615	116	754	270	6	0	61	14	2399
2001	3759	22	3737	1904	648	137	769	208	7	1	50	14	2365
2002	3879	21	3858	1933	702	108	780	256	10	1	54	14	2372
2003	3890	6	3883	1974	666	133	764	267	11	1	53	14	2411
2004	3982	11	3971	1978	725	135	789	260	14	1	54	15	2442
2005	4080	25	4055	2013	774	135	782	264	18	1	54	15	2501
2006	4083	18	4065	1991	831	77	787	283	27	1	55	15	2434
2007	4188	31	4157	2016	910	78	806	241	34	1	56	15	2497
2008	4152	33	4119	1986	895	58	806	249	55	1	55	15	2438
2009	3984	34	3950	1756	932	51	799	269	74	1	54	15	2219
2010	4151	26	4125	1847	999	50	807	255	95	1	56	15	2340
2011	4137	37	4100	1733	1025	44	790	313	120	2	57	15	2236
2012	4095	47	4048	1514	1238	37	769	271	141	4	58	16	2100
2013	4124	58	4066	1581	1138	41	789	264	168	9	61	16	2117
2014	4158	53	4105	1582	1139	44	797	253	182	29	64	16	2114
2015	4158	67	4092	1352	1347	42	797	244	191	39	64	16	1978
2016	4162	67	4095	1239	1391	38	806	261	227	55	63	16	1884
2017	4115	56	4058	1206	1309	34	805	294	254	77	63	16	1804
2018	4248	44	4204	1146	1482	38	807	287	273	93	62	16	1826
2019	4191	38	4153	966	1595	32	809	268	300	107	58	16	1685

National data

Energy Information Administration (EIA) national data has been used for all years. Solar includes 'Utility scale' and 'Small scale' solar, and Other Fossil includes 'Petroleum Liquids', 'Petroleum Coke', and 'Other' generation.

Ember calculations

Total generation is the sum of generation from all fuel types, and Demand the sum of total generation and net imports. CO_2 emissions are calculated from generation data; the methodology for this is explained on page 72.

India
CEA Data

Year	Demand	Net imports	Total Generation	Coal	Gas	Other Fossil	Nuclear	Hydro	Wind	Solar	Biomass and Waste	Other Renewables	CO_2 Emissions
	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	Mt CO_2
2000	487	1	486	350	43	3	14	74	2	0	1	0	385
2001	510	1	508	366	45	2	18	73	2	0	2	0	399
2002	521	1	520	382	45	2	18	68	3	0	2	0	412
2003	552	2	551	396	50	3	16	80	4	0	2	0	425
2004	588	2	587	415	58	2	15	90	4	0	2	0	444
2005	617	2	615	429	61	2	18	97	7	0	2	0	455
2006	663	3	660	456	61	2	18	112	9	0	2	0	478
2007	699	5	694	469	67	3	18	122	12	0	2	0	491
2008	731	6	725	494	73	5	15	115	14	0	10	0	515
2009	786	5	781	534	90	4	17	106	18	0	12	0	556
2010	830	6	824	550	102	3	23	111	20	0	15	0	571
2011	909	5	904	598	97	2	32	132	25	1	18	0	606
2012	960	5	955	676	75	2	33	116	30	2	21	0	662
2013	1009	4	1005	731	46	2	33	132	33	4	23	0	692
2014	1104	1	1103	824	43	2	35	130	37	6	26	0	772
2015	1140	0	1140	872	41	0	38	132	33	7	17	0	804
2016	1223	-1	1224	936	50	0	38	129	43	12	16	0	857
2017	1284	-2	1286	973	50	0	38	136	53	22	13	0	882
2018	1366	-2	1368	1025	50	0	38	141	60	36	16	0	924
2019	1377	-2	1378	999	48	0	45	162	63	46	15	0	897

National data

Central Electricity Authority (CEA) data has been used wherever possible. CEA data does not include generation from auto-producers, leading to differences with other sources, particularly for fossil generation.

EIA

Where possible, data from the EIA's 'International Data Browser' has been used to complete historical generation if CEA data was unavailable.

Disaggregation

BP Statistical Review data* was used as a source of disaggregated fossil generation data, scaled to fit CEA data by the ratio between CEA and BP data for each fossil fuel type in 2005.

Estimates

Net imports values for 2018 and 2019 were carried forward from 2017 due to a lack of available data.

Ember calculations

Total generation is the sum of generation from all fuel types, and Demand the sum of total generation and net imports. CO_2 emissions are calculated from generation data; the methodology for this is explained on page 72.

*Data from BP statistical review 2018, accessed on 22/10/2019.

European Union
Ember Data

Year	Demand	Net imports	Total Generation	Coal	Gas	Other Fossil	Nuclear	Hydro	Wind	Solar	Biomass and Waste	Other Renewables	CO_2 Emissions
	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	Mt CO_2
2000	3033	23	3010	920	480	215	945	387	22	0	41		1354
2001	3094	7	3087	924	496	208	979	408	27	0	44		1357
2002	3129	16	3113	939	525	220	990	353	36	0	50		1393
2003	3205	0	3205	987	570	208	996	342	44	0	58		1447
2004	3271	-4	3275	967	619	189	1008	363	59	1	70		1427
2005	3312	16	3297	944	669	185	998	348	70	1	81		1418
2006	3348	8	3340	965	684	173	990	351	82	3	92		1432
2007	3368	16	3352	965	740	154	935	348	104	4	101		1434
2008	3381	23	3358	881	791	145	937	364	120	7	112		1361
2009	3215	20	3195	807	733	125	894	367	133	14	122		1239
2010	3344	8	3336	809	765	125	917	408	149	23	140		1252
2011	3287	7	3279	834	705	115	907	341	180	48	150		1235
2012	3294	19	3276	886	585	111	882	368	206	72	166		1222
2013	3265	13	3252	859	511	102	877	404	237	86	175		1155
2014	3188	15	3172	793	458	99	876	407	253	98	186		1064
2015	3230	14	3216	781	498	99	857	372	302	108	198		1065
2016	3255	18	3237	690	612	99	840	381	303	111	202		1023
2017	3281	10	3271	662	664	96	830	331	362	119	207		1023
2018	3283	27	3255	614	627	94	827	375	377	127	213		947
2019	3227	16	3211	465	700	89	821	354	432	137	215		823

National data

Each year Ember publishes data on European power sector generation, which has been used in this report. This dataset is predominantly made using Eurostat data from 2000 to 2017. 2018 and 2019 data has been calculated by obtaining annual changes in generation from ENTSO-E's transparency platform as well as national sources.

Ember calculations

Total generation is the sum of generation from all fuel types, and Demand the sum of total generation and net imports. CO_2 emissions are calculated from generation data; the methodology for this is explained on page 72.

Rest of World
EIA international data

Year	Demand	Net imports	Total Generation	Coal	Gas	Other Fossil	Nuclear	Hydro	Wind	Solar	Biomass and Waste	Other Renewables	CO_2 Emissions
	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	Mt CO_2
2000	6106	-53	6159	1331	1534	742	768	1679	1	0	50	53	2721
2001	6204	-26	6229	1390	1631	707	784	1607	2	1	55	53	2771
2002	6405	-23	6428	1431	1738	711	781	1652	3	1	59	53	2838
2003	6588	-1	6589	1494	1852	710	750	1659	4	1	63	55	2930
2004	6871	-1	6872	1517	1973	712	808	1735	5	1	65	56	2978
2005	7089	-35	7124	1586	2031	731	830	1807	7	2	74	57	3068
2006	7384	-19	7403	1654	2163	725	865	1847	10	2	77	59	3168
2007	7671	-37	7708	1745	2321	767	838	1876	14	2	83	62	3340
2008	7757	-47	7804	1760	2407	766	822	1888	17	3	79	62	3371
2009	7731	-42	7773	1716	2422	729	833	1897	24	4	82	66	3279
2010	8201	-23	8224	1793	2708	710	860	1948	33	6	99	68	3444
2011	8425	-29	8454	1825	2773	853	754	2028	40	9	103	68	3591
2012	8572	-52	8623	1872	2943	899	615	2052	50	14	110	69	3708
2013	8784	-52	8836	1917	3060	875	604	2087	66	25	130	71	3753
2014	8923	-49	8972	1912	3242	820	622	2031	88	41	142	75	3761
2015	9086	-53	9139	1940	3293	838	632	2031	116	61	150	76	3795
2016	9285	-67	9352	2042	3325	774	632	2105	143	84	169	78	3828
2017	9416	-47	9463	2047	3423	721	623	2129	161	107	172	81	3806
2018	9575	-44	9620	2073	3461	687	648	2171	183	139	174	83	3807
2019	9706	-48	9754	2093	3491	641	692	2185	204	185	178	86	3789

EIA

Energy Information Administration (EIA) 'International Data Browser' data has been used where possible. The EIA provides data for 193 countries excluding the US, China, India, and EU member states. These countries make up the 'Rest of World' category, and their generation and CO_2 data is aggregated in the table above. Other renewables includes 'Tide and wave' and 'Geothermal' generation.

Disaggregation

EIA international fossil fuel generation data is not split by fuel type. In order to disaggregate this data, it was necessary to estimate the respective ratios of coal, gas and other fossil generation. These ratios were taken from BP's 'Statistical Review of World Energy'* where available (21 countries), and estimated using the ratio of installed capacities for each fuel type from the WRI global power plant database** for all other countries.

* Data from BP statistical review 2018, accessed on 22/10/2019.
** Data from WRI global power plant database accessed on 9/1/2020.

Rest of World
2018–2019 data

2018–2019 changes in the table below

Country	Demand	Net imports	Total Generation	Coal	Gas	Other Fossil	Nuclear	Hydro	Wind	Solar	Biomass and Waste	Other Renewables
	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh	TWh
Brazil	12	0	12	0	1	0	0	0	2	7	0	
Canada	-3	0	-3	1	1	0	1	-7	0	1	0	-0
Japan	-14	0	-14	-11	-23	-7	26	-9	8	0	0	1
South Korea	-13	0	-13	-12	-8	-7	12	2	4	0	-2	-1
Turkey	2	1	2	-0	-34	2		29	3	2	0	1
Taiwan	-3	0	-3	-4	-2	-4	4	1	1	0	0	
Vietnam	18	0	18	25	3	2		-15	3		0	
Philippines	5	0	5	5	1	1		-2	0	-0	0	-1
Argentina	-9	-0	-9	-0	-7	-1	1	-5	0	2	1	
Pakistan	1	0	1	16	0	-14	-1	0	0	0	0	0
Chile	0	0	0	-1	2	-0		-2	1	1	-1	0
South Africa	-2	0	-2	-9	2	0	3	0	0	0	0	0
Mexico	9	-0	9	-3	17	-3	-4	-5	4	3	0	-0
Australia	-7	0	-7	-7	2	0	0	-3	0	-0	-0	0
Russia	5	-0	5	1	2	0	1	1	0	0	0	0

Ember calculations

Total generation is the sum of generation from all fuel types, and Demand the sum of total generation and net imports. CO_2 emissions are calculated from generation data; the methodology for this is explained on page 72.

Estimates

The EIA publishes complete data to 2017. For 2018, data is incomplete for some countries, notably renewables generation data in smaller countries. The following methods were used to obtain a complete dataset for 2018 and 2019:

2018

- For countries with significant wind and solar capacity added in 2018, wind and solar generation data was estimated by multiplying the 2018 net wind/solar capacity by a fleet capacity factor for each country.
- For all other missing data, it was assumed that any generation change was negligible, and so 2017 data was copied forward.

2019

- National data was used where available to calculate annual % increase by fuel. This % increase was applied to 2018 EIA data to give 2019 forecast values. This method was applied to 15 countries, accounting for 61% of rest of world generation.
- Where national data was unavailable, the 3-year average EIA generation increase was applied to 2018 values. This method was applied to 177 countries, accounting for 15% of global generation.
- For countries with significant wind and solar capacity added in 2019, wind and solar generation data was estimated by multiplying the 2019 net wind/solar capacity by a fleet capacity factor for each country.

CO_2 methodology

China

The CEC state the efficiency of the Chinese coal fleet annually back to 2006. This is converted into a carbon intensity (assuming 1 tonne of coal produces 2.86 tonnes of CO_2), and multiplied by generation data to obtain CO_2 emissions from coal. From 2000 to 2006, a 0.8% increase in efficiency has been assumed, in line with the improvements of the last decade. Other fossil generation is assumed to be largely based around coal generation, as this is how other statistical agencies decide to classify it, so the same carbon intensity was assumed as for coal. There is no data on Chinese gas plant efficiencies, so the average of the US and EU carbon intensity of Gas generation has been assumed.

United States

The EIA publish CO_2 emissions by fuel type for the 'Electric utility' sector. It has been assumed that these carbon intensities can be applied to Coal, Gas, and Other Fossil generation from 'All sectors', in order to obtain CO_2 emissions from 'All sectors'.

India

The CEA does not publish any data on carbon intensity or power sector emissions. The carbon intensity of the China coal fleet has been assumed for India's coal and other fossil generation, and has been used to calculate CO_2 emissions for each fuel type. In order to calculate CO_2 emissions from gas generation, the average of the US and EU carbon intensity for gas generation in each year has been assumed.

European Union

From 2010 to 2018 CO_2 emissions are taken from the EU Emissions Trading Log for Coal, Gas, and Other Fossil generation. Prior to 2010, CO_2 emissions are calculated using the carbon intensity from 2010, assuming a slight improvement each year in line with improvement over the last decade. For 2019, the carbon intensity for 2018 is assumed for each fuel type and multiplied by generation data to obtain an estimate for CO_2 emissions.

Rest of World

The carbon intensity of the Chinese coal fleet has been assumed in order to calculate emissions from coal generation. For gas generation, the average carbon intensity of the US and EU gas fleet has been assumed. Other fossil generation is predominantly from oil, so a typical carbon intensity of 800gCO_2/MWh has been assumed.

Additional data

Wind and solar capacity

IRENA

Wind and Solar capacity data has been taken from IRENA for the years 2010-2018 for all countries.

Ember

For 2019, Ember has built up 2019 Wind and Solar capacity by using a combination of national data and media reports. Capacity estimates were compiled using CEC data for China, CEA data for India, EIA data for United States, WindEurope and Solar Power Europe for European Union and various media reports for Rest of World countries.

Coal capacity

Global Energy Monitor

Coal capacity data has been taken from Global Energy Monitor's 'Global Coal Plant Tracker' update of Jan-20. It provides data on net capacity as well as annual additions and retirements.

Coal load factors

China

CEC utilization hours for thermal power plants were used to estimate the load factor for coal plants in China.

United States

EIA annual coal load factors were taken from the EIA's Electric Power Monthly reports.

India

Coal plant load factors were taken from the CEA's monthly generation reports.

European Union

Coal load factors were calculated using the ratio of annual coal-fired generation to annual coal capacity.

Rest of World

Coal load factors were calculated using the ratio of annual coal-fired generation to annual coal capacity.

Contributors to this report

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Dave has been an electricity analyst since 2000. He worked for 13 years at the utility E.ON on European markets, and for the last 6 years at Ember, specialising in coal power. He has been the lead author for all previous six editions of Ember's "Europe's Power Sector Review".

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This project received substantial input from the other members of Ember: Charles Moore, Phil McDonald and Chris Rosslowe. Also, thanks to Andrew Smith (Zap Carbon) for his contribution, and to Ember Board members Bryony Worthington and Harry Benham for their comments.

Acknowledgements:

We would like to thank China Energy Portal for providing detailed translations of CEC reports. Also thanks to the EIA who, on 4th February launched a new platform containing international energy data, which helped with our data.

Joseph Zacune
Ted Nace, Global Energy Monitor
Christine Shearer, Global Energy Monitor
Matt Phillips, European Climate Foundation
Lauri Myllyvirta, CREA
Gregor Mcdonald
Robbie Andrew, CICERO
Yan Qin, Refinitiv
Tim Buckley, IEEFA
Jarrad Wright, CSIR
Kai Zhang
Meri Pukarinen, Europe Beyond Coal
Mathis Rogner, Agora Energiewende

We would also like to thank **Designers for Climate** for all the design and layout work that went into this report.

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