statistics

CO_2 emissions from fuel combustion

Overview

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The following analysis is an overview from the publication *CO_2 Emissions from Fuel Combustion 2019*.

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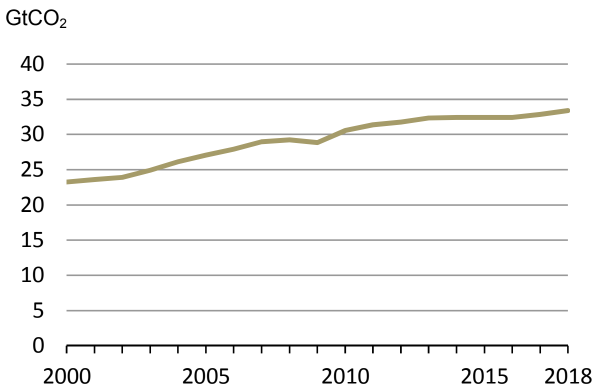
CO_2 EMISSIONS: AN OVERVIEW

CO_2 emissions from fuel combustion reach new heights

After three years of stability, global carbon dioxide (CO_2) emissions from fuel combustion started rising again in 2017, reaching 32.8 billion tons. Provisional data show they grew even faster in 2018 (Figure 1), with robust economic growth and the slowdown in renewables penetration more than offsetting some improvement in energy productivity.

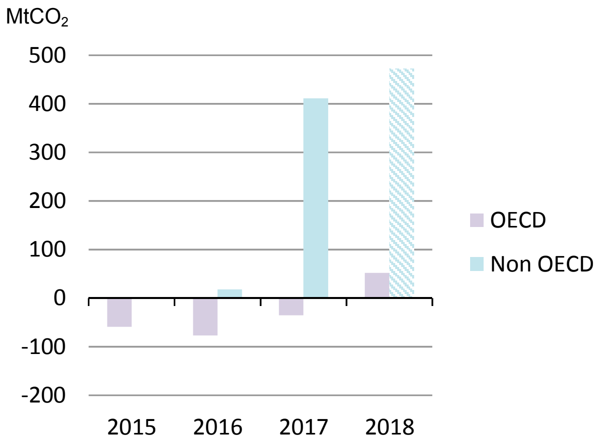
Figure 1. CO_2 emissions from fuel combustion: global trend



Source: values up to 2017 for World and 2018 for OECD are based on IEA (2019) *CO_2 emissions from fuel combustion*. The 2018 value for World is based on IEA (March 2019) *Global Energy & CO_2 Status Report* (https://www.iea.org/geco/).

As has been the case for the last several years, growth in 2017 and 2018 was largely due to non-OECD countries, mainly South-East Asia and Middle East. The non-OECD region as a whole showed growth rates higher than 2% for both years (Figure 2) and exceeded 20 billion tons in 2018. With changes ten times greater than in the OECD, non–OECD emissions are rapidly approaching twice the emissions levels of the OECD.

Figure 2. Annual change in CO_2 emissions for OECD and non-OECD Countries



Source: values up to 2017 for World and 2018 for OECD are based on IEA (2019) *CO_2 emissions from fuel combustion*. The 2018 value for World is based on IEA (March 2019) *Global Energy & CO_2 Status Report* (https://www.iea.org/geco/).

For the first time since 2013, in 2018 OECD's emissions increased, due in large part to the stark increase in total primary energy supply which reached 5.4 billion tons of oil equivalent (toe), the highest value since 2010. Natural gas grew the most, with additional 70 Mtoe in 2018; despite the increase in renewable energy and the fall in coal, low-carbon energy sources did not keep pace with gas growth, resulting in a 0.5% increase in CO_2 emissions. After a 1% average annual drop in the 2010-2017 period, driven by improvements in energy efficiency and increased penetration of renewables, economic output has been the most important driver of the increase in the OECD region for 2018. In contrast with earlier years, improvements in energy efficiency have not been able to offset the growth in energy demand and consequently emissions (Figure 3). While trends in Europe and Japan were in line with those of recent years, the United States in 2018, for the first time ever, registered an increase in energy intensity. The extreme weather conditions that affected North America during winter may have played a role on this.

Figure 3: Drivers of the annual changes in CO_2 emissions, selected OECD regions

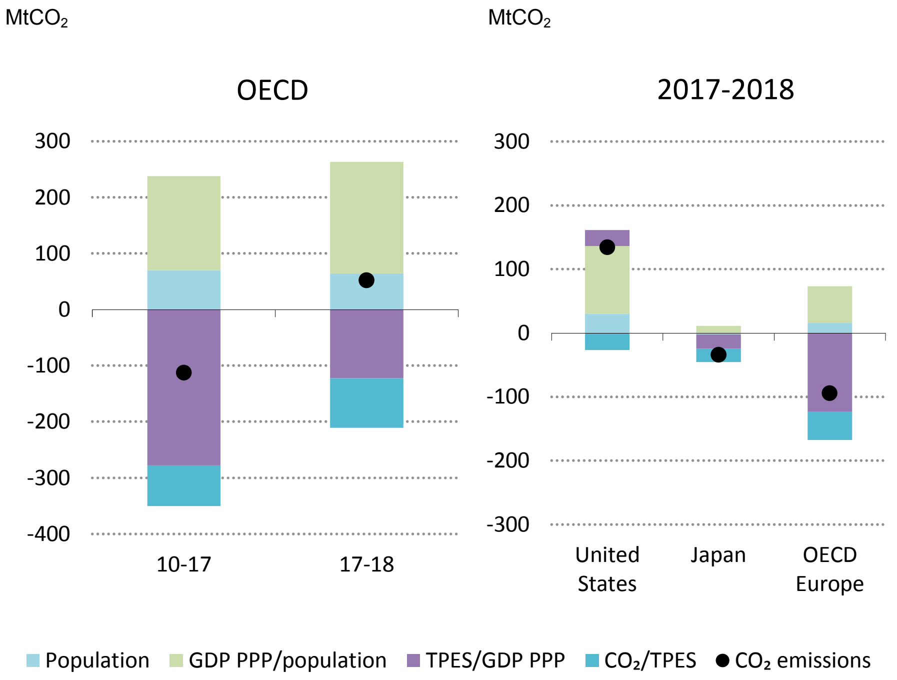
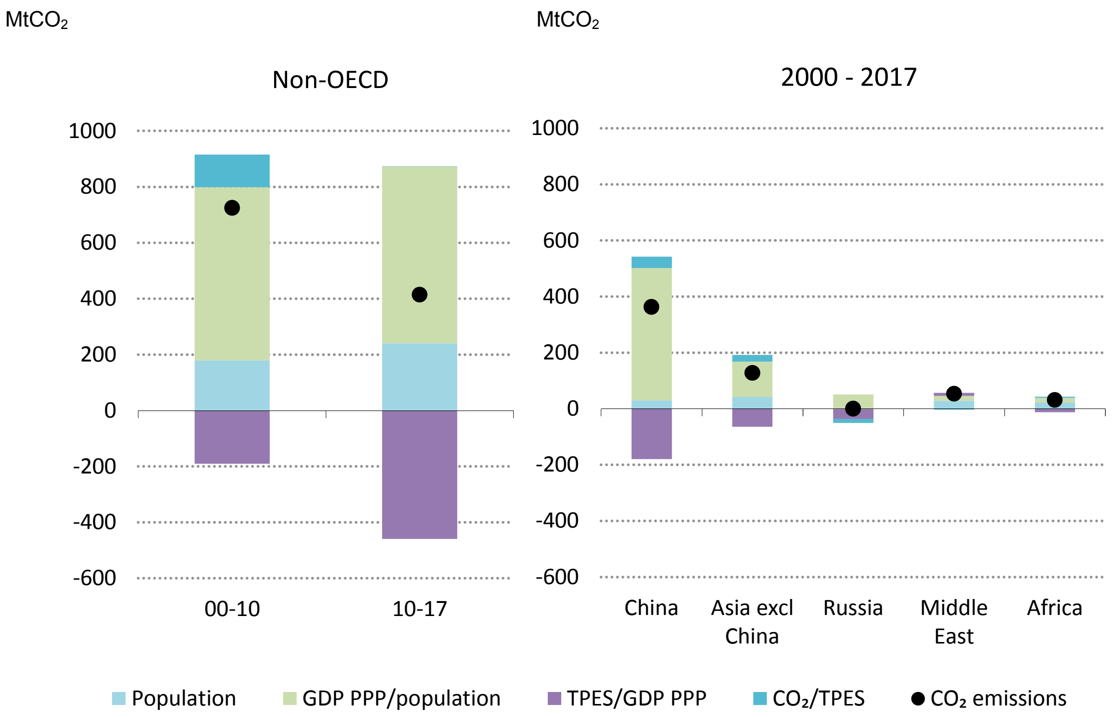


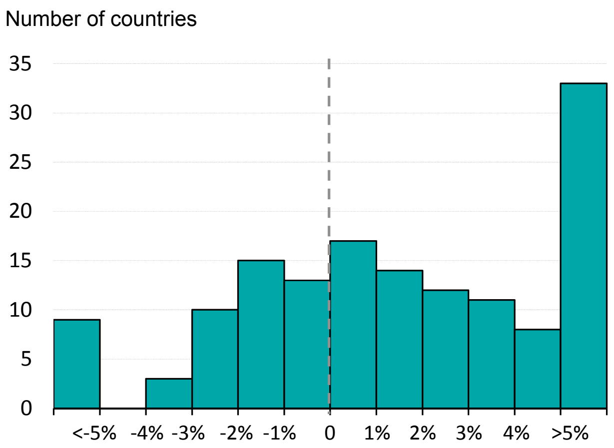
Figure 4. Drivers of the annual changes in CO_2 emissions, non-OECD and selected regions



Since 2000, the trend in non-OECD countries has been of continuous and stable growth, excluding the period 2013-2016. Increases in economic output and population have been the largest drivers of this long-term growth; a high dependence on fossil fuels contributed too (Figure 4). Starting from the 2010s, improvements in energy efficiency and in carbon intensity of the energy mix, in particular in China, contributed to a reduction in emissions growth, which anyway remains considerable.

In total, two thirds of countries increased their emissions levels since 2010 (Figure 5). Thirty-three countries (more than 20% of the total) experienced annual growth rates higher than 5%; they account for five percent of global emissions and are homogeneously spread among the different regions.

Figure 5. 2010-2017 annual change in CO_2 emissions by number of countries

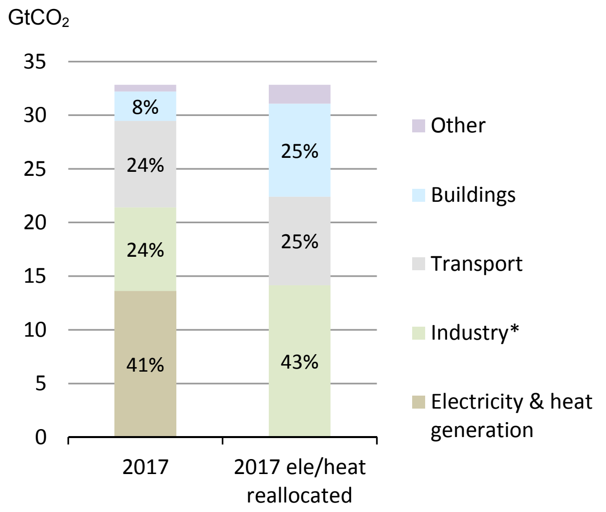


Global emissions grew annually by one percentage point between 2010 and 2017, mostly influenced by the offsetting trends of China (+ 2.4%) and the United States (- 1.7%) - which represent, respectively, 28% and 15% of the world total. India registered annual growth rates above 4%.

Electricity generation is still the largest emissions driver

Electricity/heat generation and transport account for two thirds of total CO_2 emissions (Figure 6) and were equally responsible of almost the entire global growth in emissions since 2010; the remaining third is split between industry and buildings[1]. Shares in final consumption vary across countries: while transport is predominant in many American countries, in Asia one-half of emissions derives from power generation and less than one sixth from transport.

Figure 6. Global CO_2 emissions by sector, 2017



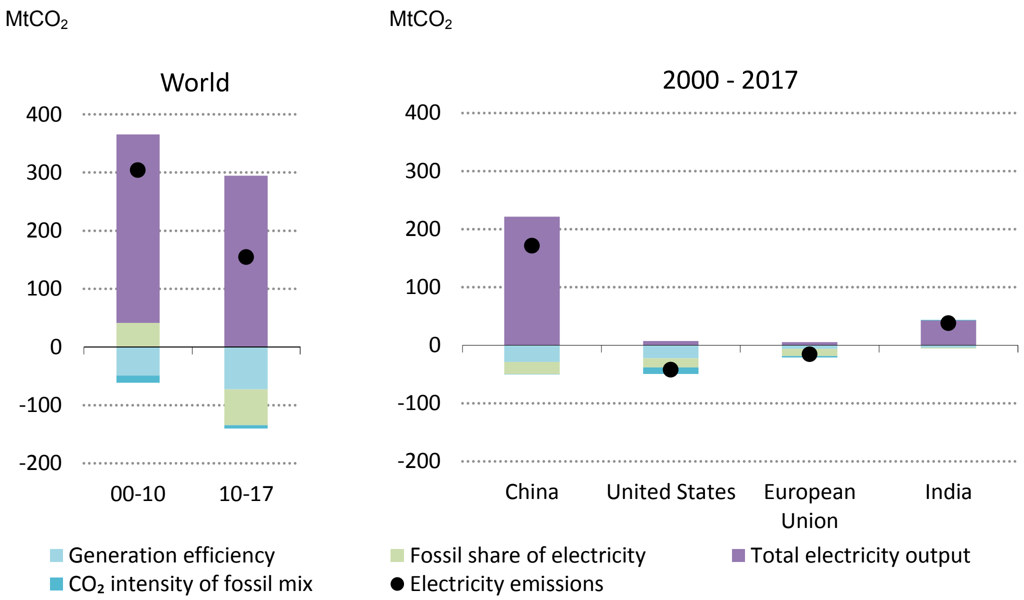
* Industry includes also energy industries own use

The picture changes after reallocating emissions from power generation to the final sectors: industry accounts for slightly less than one half of total emissions, buildings and transport for one quarter each. The buildings sector uses one half of the electricity that is consumed globally (21 000 TWh), industry the other half; transport is not yet visibly electrified. Most of the buildings consumption takes place in the OECD while most of industry in Asia: as these two regions have different carbon intensities of electricity generation, at the global level industry has slightly higher indirect emissions.

Around one half of the global increase in emissions between 2000 and 2017 came from power generation in Asia: India and China alone pushed emissions from electricity generation up by 200 $MtCO_2$ annually (Figure 7).

1. Buildings include residential and commercial and public services.

Figure 7. Drivers of the annual changes in emissions from electricity generation

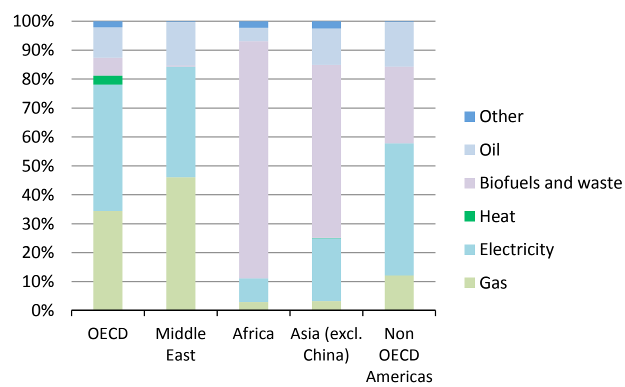


The huge increase in demand, +600 TWh annually since 2000, was the main driver of the increase in global emissions from electricity generation and was not offset by any notable decrease in the carbon intensity of generation. The increasing role of Asia, heavily reliant on coal-fired plants, meant that despite falling carbon intensities across most major producers in the last two decades, the world average remained relatively flat. The improvements in renewables penetration and efficiency of power plants registered in the 2010s contributed to decreasing the emissions per unit of electricity generated and lowered the annual growth rates of emissions between 2010 and 2017 to half the values of the previous decade.

Buildings are one of the two sectors responsible for the increase in electricity demand. However, despite the great reliance on electricity at the global level, differences exist in the energy mix among countries. In the OECD, 80% of the consumption derives from natural gas for heating and electricity for appliances, lighting and air conditioning (Figure 8). Among non-OECD countries, different patterns can be observed: shares of biomass, in particular traditional use of biomass for cooking often consumed non-sustainably, are usually high, in particular in Africa and Asia (excluding China).

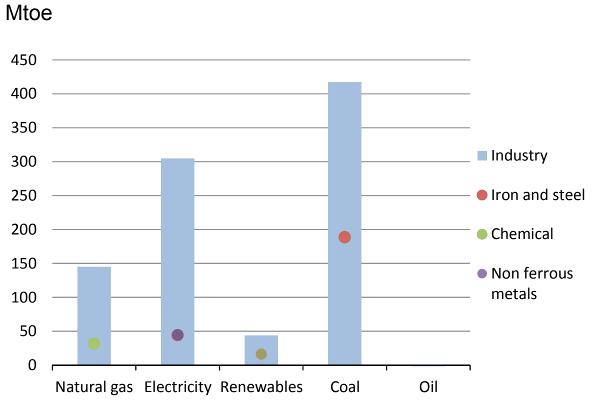
In most of the regions, the mix in the buildings sector remained almost unchanged since 2000, with the exception of China where consumption of biomass dropped by more than forty percentage points while electricity and gas grew.

Figure 8. Energy consumption by source in the buildings sector - 2017



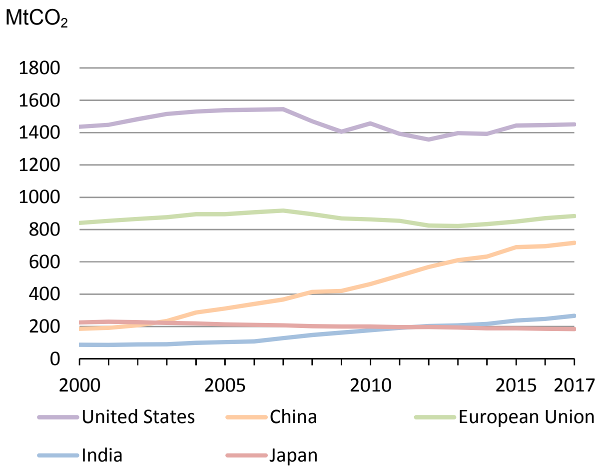
The other sector strongly relying on electricity is industry. Mostly driven by electricity and coal, industry's total energy consumption increased globally by 1 Gtoe in the last two decades (Figure 9) and reached almost 3 Gtoe, 30% of the global final consumption. While many countries experienced decreases, China and India tripled their consumptions touching respectively 1 Gtoe and 0.2 Gtoe; emissions from industry in China (including indirect emissions from electricity) exceeds the total emissions of the United States.

Figure 9. Industry energy consumption by source and sub-sector: 2000-2017 change



Much of the increase in energy demand for the iron and steel and non-ferrous metals industries is from coal; the chemical sector experienced a big increase in natural gas consumption and also coal (almost exclusively in China), while oil remained flat; electricity increased at comparable rates in all industrial sub-sectors. Globally, coal combustion in the iron and steel industry alone is responsible of 2 billion tons of CO_2.

Figure 10. Road transport CO_2 emissions by country



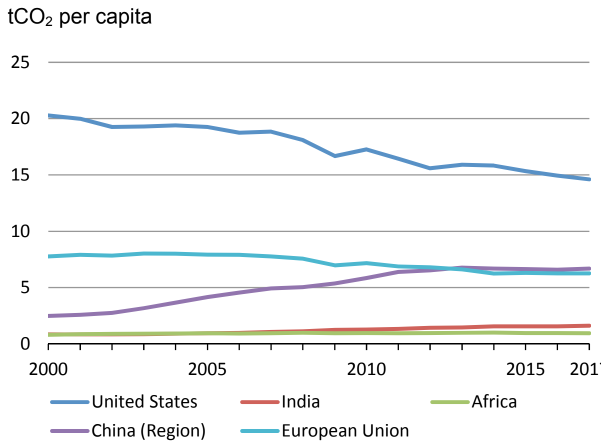
Emissions from transport increased by 2% annually at the global level in the period 2000-2017, reaching 8 $GtCO_2$. Transport did not experience any major decrease across any regions, except for the drop during the years of the crisis. Road transport, mostly for passenger travel, accounts for three quarter of total transport emissions and it is the mode that increased the most in absolute terms (+ 1.7 GtCO2), second only to international aviation for rate of growth (2% annually vs. 3%). Such a big increase was mostly propelled by Asian countries (Figure 10).

China and India increased their emissions from road transport by a factor of four and three respectively since 2000; similar growth rates were experienced by Cambodia, Indonesia, Viet Nam and Thailand. However, despite such increases, levels of road emissions per capita in many Asian countries still remain lower by an order of magnitude than in the United States where transport accounts for more than one third of total emissions.

Great differences on per capita emissions remain

Great differences exist in per capita emissions not only for transport, but overall: global emissions of CO_2 per capita amounted to 4.4t in 2017, but more than one-half of the global population is below 2 tons per capita (Figure 11). Per capita emissions in China almost tripled since 2000, reaching values similar to those of the European Union (EU) in the early 2010s; while population grew by less than 10%, total CO_2 emissions almost tripled. Between 2000 and 2017, India doubled emissions, but its per capita value is still one quarter of that of the European Union. Africa has the lowest per capita emissions among all regions - around one tenth of those of the US - and did not show any increase. Should India and Africa reach similar levels of per capita emissions than those of the EU, an additional 13 $GtCO_2$ (more than one third of current levels) would be released in the atmosphere.

Figure 11. Per capita CO_2 emissions in selected regions

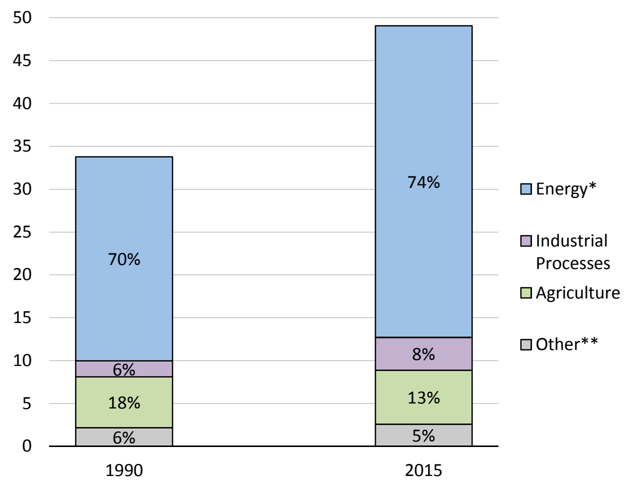


Energy as a key driver for emissions

Driven by CO2 emissions from fuel combustion, energy-related GHG emissions increased by 12.6 GtCO2 equivalent, and also as a percentage of total GHG emissions, between 1990 and 2015; the other GHG sources (industrial processes, agriculture and other) together increased by 2.7 $GtCO_2$ eq. (Figure 12).

Figure12. Global anthropogenic GHG emissions

$GtCO_2$ eq.



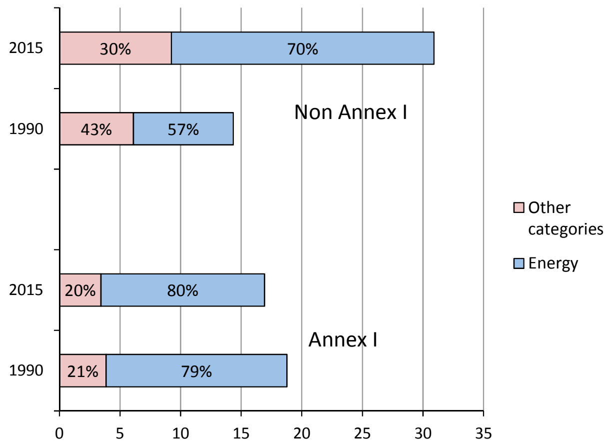
* Energy includes IPCC categories Fuel combustion and Fugitive emissions from fuels.
** Other includes large-scale biomass burning (excluding CO_2), post-burn decay, peat decay, indirect N_2O emissions from non-agricultural emissions of NO_x and NH_3, Waste, and Solvent use.

Source: based on IEA estimates for CO_2 from fuel combustion and EDGAR version 4.3.2FT2016 for CO_2, CH_4 and N_2O emissions and 4.2FT2010 for the F-gases; based on 100-year Global Warming Potential (GWP).

The share of energy-related emissions in the total GHG emissions grew mostly due to non-Annex I countries increasing their energy consumption, with energy-related emissions growing from 57% to 70% of total GHG emissions in 2015, after more than doubling (Figure 13). In the same period, Annex I countries reduced total GHGs by around 10% across both energy and other sources. As around 90% of energy-related emissions derived from the oxidation of carbon, CO_2 was the largest source of GHG emissions for the energy category.

Figure13. GHG emissions – energy and other sources

$GtCO_2$ eq.



Globally CO_2 emissions from the energy sector represented around three quarters of total GHG emissions in 2015, four percentage points more than in 1990. Thus, they remain at the core of the climate change mitigation debate and represent one of the main issues to address in the broader political agenda.

Developing a low-carbon world

With the energy sector accounting for around three quarters of global greenhouse gas (GHG) emissions, action in the energy sector can make or break efforts to achieve global climate goals. In the past, industrialised countries emitted the large majority of anthropogenic GHGs. In 2007 however, shares of emissions from non-Annex I countries surpassed those of Annex I countries, and have kept rising very rapidly (Figure 13). To shift towards a low-carbon world, mitigation efforts must occur across all countries, targeting energy demand as well as emission from energy supply.

The Paris Agreement: International action beyond 2020

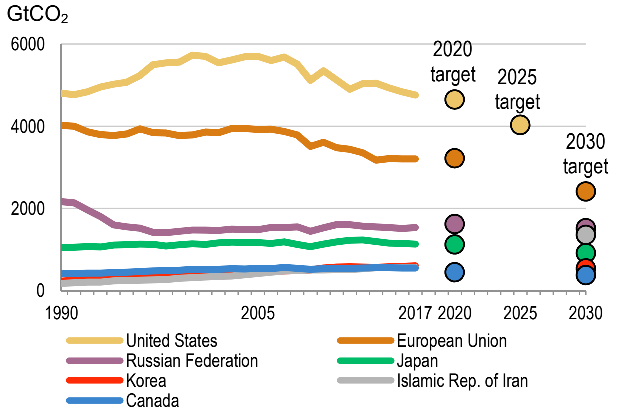
The global community adopted the historic Paris Agreement in December 2015, which includes GHG mitigation actions covering the time period from 2020 onward. It is the first international climate agreement to extend mitigation obligations to all countries, both developed and developing.

The long-term goals of the Paris Agreement are ambitious: to limit temperature rise to "well below 2°C above pre-industrial levels" and pursue efforts to limit the rise to 1.5°C. To achieve these goals, countries "aim to reach global peaking of GHG emissions as soon as possible" and "to undertake rapid reductions thereafter" to "achieve a balance between anthropogenic emissions by sources and removals by sinks of GHGs in the second half of this century," equating essentially to achieving net-zero emissions by this time.

The Agreement was ratified in record pace and came into force on the 4 November 2016. As of 20 September 2019, there are 197 signatories to the Paris Agreement of which 185 have ratified the agreement (UNFCCC, 2019).

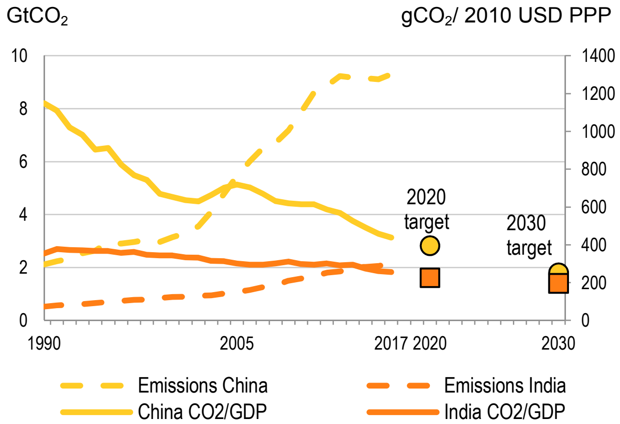
In December 2018, countries concluded agreement on a "rulebook" for implementation of the Paris Agreement at COP24 in Katowice Poland. The rulebook provides guidelines on issues such as emissions accounting and transparency of mitigation action and financial support.

Figure 14 A. Historical CO_2 emissions (1990-2017) and emissions reduction targets (2020, 2025, 2030) for the top ten emitting Parties, excluding China and India



Notes: The United States, the Russian Federation and the Islamic Republic of Iran have set emission reduction targets within a specified range (Table 1). Only the most ambitious ends of the targets are indicated in the graph. Korea has a target for 2030 only. Saudi Arabia has a target to achieve "annual mitigation co-benefits" of "up to 130 million tons of CO_2eq by 2030," not indicated on the graph. Historical emissions are indicated using $MtCO_2$, while numerous emissions targets use CO_2-equivalent (Table 1). China and India are excluded from this graph as these countries have specified emission intensity targets (see Figure 14B).

Figure 14 B. Historical CO_2 emissions (1990-2017) and emission-intensity reduction targets (2020, 2030) for China and India, 1990-2016



Notes: Intensity targets for India and China are specified within a range for both 2020 and 2030 (Table 1). Only the most ambitious target levels are indicated in the graph. India's targets use CO_2-equivalent (CO_2e)/GDP, so the target levels indicated on the graph may not reflect the full range of GHGs covered by the targets.

Countries have now shifted their focus to clear and transparent implementation of their commitments and enhancement of the levels of ambition. The Paris Agreement is founded on Nationally Determined Contributions (NDCs) made by countries, which are intended outline their "highest possible ambition" to address climate change including reducing GHG emissions. Current NDCs cover the period from 2020 to 2030 or 2025, and most include quantitative emissions reductions targets, summarized in Table 1 and Figure 14 (A and B) for the top-ten emitting countries and remaining IEA member countries. Countries that have submitted an (intended) NDC represent 96% of global CO_2 emissions.

NDCs are due to be updated every five years, each new NDC is to represent a progression from the previous one with a raised level of ambition The first round of revisions are due in 2020, inviting countries communicate or update their commitments for the next round of NDC.

Timely and accurate CO_2 and GHG statistics (complemented by other metrics to assess underlying transformation of the energy system) are central to taking stock of the implementation to assess the progress towards achieving climate targets and drive further ambition, both at the international and national levels. The IEA continues to support countries through provision of energy and emissions statistics, and training country officials in policy, modelling, and energy statistics, including in the context of their NDCs. The IEA's Clean Energy Transitions Programme enhances efforts to help countries – with a focus on key emerging countries including IEA Association and Partner countries – better collect, use, and communicate robust energy and emissions data.

Pre-2020 action

The delivery of the Paris Agreement's goals also calls for the enhanced implementation of the pre-2020 actions and commitments which builds on a long history of international cooperation on climate change. The first binding commitments to reduce greenhouse gas emissions were set under the Kyoto Protocol's first commitment period (2008-12), requiring participating industrialised countries (as a group) to curb emissions by about 5% relative to 1990 over this period. Thirty-eight Parties also agreed to take commitments under a second commitment period (2013-2020) set out by the Doha Amendment to the Kyoto Protocol; however, the Amendment has not reached its ratification threshold.

Alongside agreement of a second Kyoto Protocol commitment period, developed and developing countries submitted voluntary emission reduction pledges for 2020 under the Copenhagen Accord and Cancún Agreements, with the participating Parties producing over 80% of global GHG emissions (Table 1; Figure 14A and B). This marked a significant improvement in the coverage of countries taking action to address GHG emissions, compared with the Kyoto Protocol, and laid the groundwork for the Paris Agreement.

COP23 invited Parties to submit information on progress on enhanced action prior to 2020. At the High-level meeting on the Pre-2020 Stocktake of COP24, countries stressed the need to keep up the initiative with various approaches including further engagements with non-Party stakeholders, scale-up of mitigation and adaptation efforts, and provision of support for developing countries. The IEA supports the pre-2020 actions through identifying remaining gaps, supporting immediate climate actions and cooperating with non-Party stakeholders through the Marrakech Partnership for Global Climate Action.

References

IEA (2019), *World energy balances.*

EDGAR version 4.3.2_FT2016 for CO_2, version 4.4 for CH_4 and N_2O emissions and 4.2FT2010 for the F-gases.

United Nations Framework Convention on Climate Change (2019). Paris Agreement – Status of Ratification, https://unfccc.int/process/the-paris-agreement/status-of-ratification

Table 1. Greenhouse gas reduction targets of the ten largest emitters (based on 2016) emissions and IEA member countries

Ten highest emitting Parties *(as per IEA estimates of CO_2 emissions from fuel combustion in 2016)*	1990	2005	2017	2020 GHG target	Base year level	2017 level	% change to 2017	(I)NDC GHG target[1]
	$MtCO_2$							
China (incl. Hong Kong)	2 122	5 448	9 302	emissions/GDP 40-45% below 2005	0.72 $kgCO_2$ / 2010 USD PPP	0.44 $kgCO_2$ / 2010 USD PPP	-39%	Reduce CO_2 per unit of GDP by 60-65% below 2005
United States[2]	4 803	5 703	4 761	17% below 2005	5 703 Mt	4 761 Mt	-15%	26-28% reduction by 2025 below 2005 levels
European Union	4 027	3 922	3 209	20% below 1990[3]	4 027 Mt	3 209 Mt	-20%	40% reduction compared to 1990 levels
India	529	1 073	2 161	emissions/GDP 20-25% below 2005[4]	0.30$kgCO_2$ / 2010 USD PPP	0.26 $kgCO_2$ / 2010 USD PPP	-15%	Emissions/GDP 33-35% below 2005 levels[5]
Russian Federation	2 163	1 482	1 536	15-25% below 1990	2 164 Mt	1 536 Mt	-30%	25-30% below 1990 levels[6]
Japan	1 037	1 166	1 132	3.8% below 2005	1 164 Mt	1 147 Mt	-6%	26% below 2013 levels[7]
Republic of Korea (Korea)	232	458	600	*None*[8]		600 Mt		37% below BAU emissions of 850.6 $MtCO_2e$ in 2030[9]
Islamic Republic of Iran (Iran)	171	418	567	*None*		*x*		4% below BAU of 1540 Mt CO_2 in 2030; 12% with international support[10]
Canada	420	540	548	17% below 2005	540 Mt	548 Mt	+1%	30% below 2005 levels
Saudi Arabia	151	298	532	*None*		*X*		Annual GHG-emission abatement of up to 130 $MtCO_2e$
Other IEA member countries								
	1990	**2005**	**2017**	**2020 GHG target**	**base year level**	**2017 level**	**change % to 2017**	
	$MtCO_2$							
Australia	260	365	385	5% below 2000 levels	335 Mt	385 Mt	+5%	26-28% below 2005 levels
New Zealand	22	34	33	5% below 1990 levels	34 Mt	33 Mt	%	30% below 2005 levels
Norway	27	35	35	40% below 1990[11]	27 Mt	35 Mt	+29%	40% below 1990 levels
Switzerland	41	44	37	20% below 1990[12]	41 Mt	37 Mt	-9%	50% below 1990 levels. 35% anticipated reduction by 2025
Turkey	129	216	378	*None*				21% emission reduction below BAU of 1175 $MtCO_2e$[13]
Mexico	257	412	446	30% below BAU scenario.	906 $MtCO_2e$ (2020 BAU)	446 Mt		22% below BAU[14]

1. Targets are for the year 2030 and include total GHG reduction targets unless otherwise specified.
2. US: The United States announced on 1 June 2017 its intention to withdraw from the Paris Agreement.
3. EU 2020: The EU's 2020 target excludes LULUCF (included in 2030 target)
4. India's 2020 target excludes emissions from agriculture
5. India's 2030 NDC also includes mitigation of 2.5–3 GtCO2e by 2030 through carbon sequestration.
6. Based on Russia's nationally determined contribution (NDC).
7. Japan's 2030 target includes overseas credits.
8. In 2016, Korea replaced its 2020 target of 30% below business-as-usual with a 2030 target as defined in its NDC.
9. It is still to be decided by the Korean government whether LULUCF will be included in the 2030 target.
10. Target based on INDC and 2030 BAU emissions level from Iran's 2015 Third National Communication to UNFCCC.
11. Norway sets a minimum 16% reduction for any given year during 2013-2020 under the Kyoto Protocol second commitment period.
12. Switzerland sets a minimum 15.8% reduction for any given year during 2013-2020 under the Kyoto Protocol second commitment period.
13. Based on Turkey's INDC.
14. Mexico's 2030 target consists of a 22% GHG reduction and 51% reduction in black carbon, which together would result in a 25% emission reduction compared to its BAU scenario. Mexico aims to peak emissions in 2026 while reducing emission intensity by 40% between 2013 and 2030 (based on NDC).