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TRENDS IN GLOBAL CO_2 AND TOTAL GREENHOUSE GAS EMISSIONS

2018 Report

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Trends in global CO_2 and total greenhouse gas emissions: 2018 Report

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Contents

* These appendices are only available as separate spreadsheets.

Summary

Growth in global greenhouse gas emissions resumed in 2017

The year 2017 was a remarkable year. The growth in total global greenhouse gas (GHG) emissions resumed in 2017 at an annual rate of 1.3%, reaching 50.9 gigatonnes of CO_2 equivalent[1] (Gt CO_2 eq) after two years of virtually no growth (0.2% in 2015 and 0.6% in 2016) (Figure S.1). This happened while the 2.6% global economic growth of 2017 continued at about the average annual rate of 2.4% since 2002 (excluding the credit crunch years). Present greenhouse gas emissions are about 55% higher than in 1990 and 40% higher than in 2000. The 2017 global greenhouse gas emissions are 55.1 Gt when including the very uncertain land-use-change emissions, which are estimated at 4.2 Gt CO_2 eq.

In 2017, the 1.3%, or 0.6 Gt CO_2 eq, increase in global greenhouse gas emissions was mainly due to a 1.2% increase in both global carbon dioxide (CO_2) emissions and methane (CH_4) emissions, which showed almost no growth in 2015 and 2016. The emissions of nitrous oxide (N_2O) and fluorinated gases (so-called F-gases) continued to grow at rates similar to those in 2015 and 2016. CO_2 emissions are the largest source of global greenhouse gas emissions, with a share of about 73%, followed by CH_4 (18%), N_2O (6%) and F-gases (3%).

The greenhouse gas growth rate of 1.3% is similar to those seen from 2012 to 2014, when the average greenhouse gas emissions growth slowed down to 1.3% per year, which coincidentally also was the average annual growth rate in the decades before 2003. The 2017 increases in CO_2 and CH_4 emissions are also similar to those in 2012 to 2014.

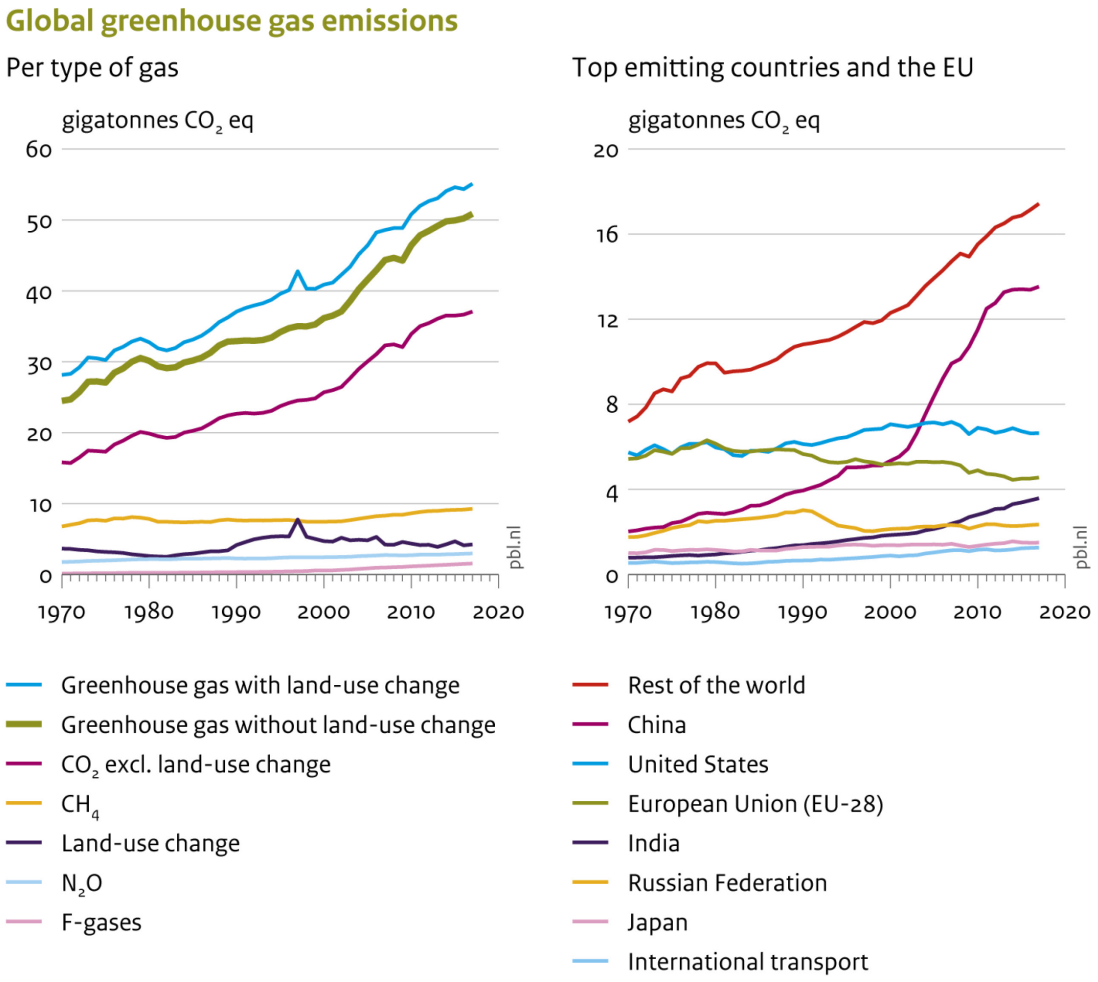
Second, 2017 was remarkable, because it was globally the third warmest year since records began in 1880, behind the record year 2016 and second warmest year on record 2015, the last two influenced by a strong El Niño. However, 2017 ranks as the warmest year on record for all the years without the occurrence of an El Niño. The average global temperature (above both land and ocean surfaces) was 0.84 °C above the 20th century average of 13.9 °C (above land, this was 1.41 °C).

Increase in greenhouse gas emissions in 2017 in largest emitting countries and EU

Five countries and the European Union emit the largest amounts of greenhouse gas emissions, together accounting for 63%, globally. China accounts for 27%, the United States for 13%, the European Union for 9%, India for 7%, the Russian Federation for 5% and Japan for 3%. These countries also have the highest CO_2 emission levels (Figure S.1). In 2017, most of the five largest emitting countries and the European Union showed a real increase in greenhouse gas emissions, with India (+2.9%), China (+1.1%), European Union (+1.1%), Russian Federation (+1.0%) and Japan (+0.3%) (except for the United States, where emissions remained constant, at 0.1%).

[1] For CH_4, N_2O and the F-gases, we use the Global Warming Potential (GWP) metric for 100 years from the Fourth Assessment Report (AR4) of the IPCC. The historical greenhouse gas emission trends from the EDGAR database are also presented in UNEP's Emissions Gap Report 2018, but using the GWPs of the IPCC Second Assessment Report (SAR) (UNEP, 2018). In the UNEP report, the 2017 total annual greenhouse gas emissions are reported at 53.5 Gt CO_2 eq, using SAR GWPs and including 4.2 Gt CO_2 eq from land-use change.

Figure S.1



Source: Greenhouse gas excl. land-use change EDGAR v5.0/v4.3.2 FT2017 land-use change: H&N 2017 (left); EDGAR v5.0/v4.3.2 FT2017 (without land-use change) (right)

Global CO_2 emissions increasing after a standstill of two years

The flat global CO_2 emissions in 2015 and 2016 (0.0% and +0.4%) were mainly due to declining global coal consumption, caused by three years of decreasing coal consumption in China and declines in the United States and the European Union, mainly from increased renewable power generation, in particular, wind and solar power, and fuel switching to natural gas in power plants.

In 2017, the increase in global CO_2 emissions of 1.2% to 37.1 Gt CO_2, which is about 65% higher than in 1990, was mainly due to a new 0.7% rise in global coal consumption, mainly caused by a strong 4.5% increase in India (twice the rate of 2016) and increases in Turkey (+16%), South Korea (+5.4%), Indonesia (+7.1%) and China (+0.2%). In contrast, coal consumption continued to decrease in the United States and the European Union (notably in Germany and the United Kingdom) by more than 2%, and in the Ukraine by 17%.

Global consumption of oil products and natural gas continued to increase, by 1.4% and 2.6% in 2017. The increase in global oil consumption was led by China, the European Union and the United States, whereas for global natural gas consumption this concerned China (+14.8%), the European Union (+4.0%) and Iran (+6.5%).

In 2017, total energy demand increased by 2.3%, half of the increased demand was met by fossil fuels and the other half by renewables plus nuclear power. Since 2010, renewable and nuclear power increased their share in total power generation by 2.5 percentage points, to almost 35%. These figures illustrate that it may still take several years before rapidly increasing renewable energy sources, together with nuclear energy, will become the energy sources of choice for meeting all the increases in global energy demand and replace existing technology.

Global CH_4 emissions increasing after two years of very slow growth

In 2017, similar to CO_2, global CH_4 emissions increased by 1.2% to a total of 370.5 Mt CH_4 (9.3 Gt CO_2 eq), which is 21% higher than in 1990. The increase in 2017 is markedly higher than in 2015 and 2016, which saw growth rates of only 0.5% and 0.4%, but again similar to growth rates in the three years before that. Increases in CH_4 emissions from coal production (+4.2%), livestock and particularly non-dairy cattle (+1.0%), waste water (1.8%) and natural gas transmission (+3.3%) contributed the most to global methane emission changes in 2017. With a 2.1% increase in CH_4 emissions, China accounts for one third of the total net increase, followed by Iran (+7.1%), India (+1.2%), the United States (+1.0%) and the Russian Federation (+1.1%).

Global N_2O emissions and F-gas emissions continue to grow

For 2017, the growth rate of global N_2O emissions is estimated at 1.4%, reaching a total of 10 Mt N_2O (3.0 Gt CO_2 eq), which means that emissions have remained at almost the same level as in 2015 and 2016—years that saw growth rates of 1.1% and 1.7%. Current emissions are 30% higher than in 1990, when they were 2.3 Gt CO_2 eq. Increases in emissions from the largest sources, notably manure dropped in pastures, rangeland and paddocks (+1.5%) and the use of synthetic nitrogen fertilisers (+1.7%), contributed most to global emission changes in 2017. With a 2.6% increase, India accounts for the largest contribution to the global N_2O increase, followed by the United States (+1.6%), China (+0.8%) and the European Union (+1.1%).

F-gases, as a group, show annual global growth rates of 5.6%, on average, in the 2004–2014 period, slowing down to 4.5% in 2016 and 4.1% in 2017. Global total F-gas emissions are estimated for 2017 at 1.6 Gt CO_2 eq worldwide, which is more than four times the emissions in 1990. HFC emissions from their use as a substitute for CFCs—as CFCs are phased out to protect the ozone layer—make up two thirds of present total F-gas emissions.

Outlook for 2018

The first monthly statistics for fossil fuel consumption in 2018 available for China (9 months) and the United States and European Union (both 7 months) suggest that, in 2018, CO_2 emissions are likely to increase in China, continue to decrease, slowly, in the United States, and to decline in the European Union.

Most comprehensive data set

This is the most comprehensive report on global greenhouse gas emissions up to 2017, with detailed data on emissions of all greenhouse gases. Other reports focus on CO_2 emissions only, which make up around three quarters of total greenhouse gas emissions, and/or present shorter historical time series.

1 Introduction

This report presents recent trends, up to 2017, in greenhouse gas (GHG) emissions, for both carbon dioxide (CO_2) and non-CO_2 greenhouse gas emissions. We calculated these emissions based on the new EDGAR database version 5.0 for CO_2 from fossil fuel use (Muntean et al., 2018), mainly based on the IEA energy statistics (IEA, 2017a), and version 4.3.2 for non-CO_2 greenhouse gas emissions (Janssens-Maenhout et al., 2017). The EDGAR v4.3.2 database was finalised in 2017 and includes comprehensive activity and emission factor data up to 2012. For 2016 and 2017, a fast-track (FT) method was used for CO_2 emissions (as described in Olivier et al., 2017 and Muntean et al., 2018). For the methane (CH_4) and nitrous oxide (N_2O) emissions from 2013 to 2017, we mainly used a fast-track method for about 80% to 90% of global emissions. For the remainder, we used extrapolation when international statistics were not available[2].

The JRC booklet by Muntean et al. (2018) shows the time series of global CO_2 emissions, for all countries around the world and for the European Union as a whole, using data from EDGAR v5.0 on 1990–2017. The CO_2 emissions presented in that booklet show the trend for individual countries from 1990 up to 2017, as compiled according to the FT method for 2017, in both Olivier et al. and Muntean et al. reports. The CO_2 emissions from fossil fuel combustion were calculated using the same fuel statistics as in IEA (2017a). For the most recent detailed CO_2 emissions from fossil fuel combustion up to and including 2016, including revisions in previous years, we refer to IEA (2018b), which was released earlier this month.

Please note that the EDGAR v4.3.2 data set does not include emissions from savannah burning (IPCC/UNFCCC subcategory 3E of the agricultural sector), because international statistics were lacking. However, the FAO has compiled emission estimates for CH_4 and N_2O per country, from this source, for 1990–2016, based on the data on area burned, on a spatial grid of pixels in the GFED4.1s data set[3] (Van der Werf et al., 2017) and default emission factors from IPCC (2006). The EDGAR v4.3.2 emission data were completed to cover all sources of anthropogenic greenhouse gas emissions (except for those from land-use change) with data on CH_4 and N_2O emissions from savannah burning, as reported by the FAO. The 2017 emissions from savannah burning were estimated using preliminary regional emission totals, reported by GFED4.1s. The share of these emissions in global total emissions is 1.5% for CH_4 (5.6 Mt CH_4 or 140 Mt CO_2 eq) and 5% for N_2O (0.5 Mt N_2O or 149 Mt CO_2 eq).

[2] This analysis is based primarily on greenhouse gas emission data (CO_2 from fossil fuel use and industrial processes, CH_4, N_2O and fluorinated gases), but excluding CO_2 from land use change using data from EDGAR v5.0 (CO_2)/v4.3.2 (non-CO_2) FT2017. The largest changes compared to v4.3.2 GHG FT2016 (Olivier et al., 2017) are in the CO_2 emissions, since the IEA energy consumption data have been updated for the whole time series to 2015 instead of 2012 (from v4.3.2 to v5.0). Furthermore, updates were included for gas flaring and cement, which also changed the data before 2012. In general, for non-CO_2 sources, updated international statistics from IEA, BP, USGS, FAO, IRRI, UNFCCC (CRF) and other sources were used to estimate the 2012–2017 emissions of CH_4 and N_2O, which means data are now through 2016 or 2017, with new statistics and several revisions to previous years (but without change in the so-called emission factors).

[3] The UN Food and Agriculture Organization (FAO) has compiled data on savannah burning emissions, for 1990–2016, using data on monthly burned area, per 0.25°x0.25° grid cell, for five land-cover types from the GFED4.1s data set (Van der Werf et al., 2017), multiplied by biomass consumption per hectare and tier 1 emission factors from IPCC (2006), aggregated at country level. The GFED data cover the 1996–2017 period. For the years before 1996, FAO used the average of the 1996 to 2014 values. For details, see (a) Data set Information at http://fenixservices.fao.org/faostat/static/documents/GH/GH_e.pdf, (b) Metadata at http://www.fao.org/faostat/en/#data/GH/metadata.

Non-CO_2 emissions constitute a significant fraction of global greenhouse gas emissions. For climate policies, this refers to methane (CH_4), nitrous oxide (N_2O) and the so-called F-gases (HFCs, PFCs, SF_6 and NF_3). To our knowledge, this report is the first to provide estimates of total global greenhouse gas emissions including 2017, based on detailed activity data on most of the sources for these years[4].

For global net CO_2 emissions from land use, land-use change and forestry (LULUCF), we used data recently generated in the Global Carbon Project (GCP) (Houghton et al., 2012) through 2015 (Houghton and Nassikas, 2017), which include data on CO_2 emissions from forest and peat fires, from the Global Fire Emissions Database version GFED4.1s through 2017 (Van der Werf et al., 2017). Those data are inherently very uncertain and therefore typically not included in emission totals of countries (e.g. as reported by countries under the UN Climate Convention) (UNFCCC, 2011). For the comprehensive overview of all greenhouse gas emissions and removals, we included them in the main figure (Figure 2.1) to illustrate their share in overall, total global anthropogenic greenhouse gas emissions. However, discussions on emission data focus on those derived from the EDGAR database, which excludes LULUCF emissions. For more information on this subject, we refer to Global Carbon Project (2018).

In addition to the global trends, the focus of this report is also on the top 5 emitting countries and the European Union as a whole, and on the global total and the countries that were largely responsible for the global emissions changes in 2017. Uncertainty about non-CO_2 emission data is typically much larger than about CO_2 emissions (excluding forest and other land-use-related emissions, 'LULUCF'). This is because these sources are much more diverse and emissions are determined by technological or other source-specific factors, whereas for CO_2, the emission factors are mainly determined by the fossil fuel type and carbon content of fuels and carbonates.

Chapter 2 discusses the global emission trends. Firstly, we discuss the most important variables driving the volume of the greenhouse gas sources and which of those is covered by the international statistics used for our fast-track emission estimates, for the years 2013 to 2017. Section 2.1 discusses the total greenhouse gas emissions, with a focus on CO_2 and on the group of non-CO_2 greenhouse gases. Section 2.2 presents the main trends in CO_2 emissions, showing key trends in the use of main fossil fuels and cement production in the largest countries. Section 2.3 discusses the main trends in non-CO_2 greenhouse gas emissions and illustrates with the recent trends in key drivers of these emissions in the largest countries. Chapter 3 provides more detailed information on the five largest emitting countries and the European Union, as a whole.

This report focuses on trend analysis and identification of the key drivers of CO_2, CH_4 and N_2O emissions, rather than analysing more aggregate drivers, such as Gross Domestic Product (GDP), energy use per unit of GDP, and CO_2 emissions per unit of energy. Last year's report provides more details on the methodology used for estimating non-CO_2 emissions (Olivier et al., 2017), in particular in Box 1.1 and Appendix D of that report. The previous report also discusses the quality and completeness of CH_4 and N_2O emission data by comparing emissions in the EDGAR data set with total CH_4 and N_2O emissions from the officially reported national emissions.

[4] Other work on historical time series of anthropogenic greenhouse gas emissions, up to 2005 or 2014, includes US Environmental Protection Agency (EPA) on global non-CO_2 greenhouse gas emissions for 1990–2005 (US EPA, 2012); the CAIT database for greenhouse gas emissions for 1990-2014, compiled by the WRI (2016); and the PRIMAP-hist data set for 1850–2014, developed at the Potsdam Institute for Climate Impact Research (PIK) (Gütschow et al., 2016).

2 Trends in global emissions

2.1 Introduction

Our analysis focuses on the identification of key trends and the main direct drivers that determine the changes in the quantity of CO_2, CH_4 and N_2O emissions, both globally and for the five largest emitting countries and the European Union, as a whole. These gases, currently, contribute a respective 73%, 18% and 6% to global total greenhouse gas emissions, with F-gases accounting for the remaining 3%. Table 2.1 summarises the main drivers of emissions and their share in global emissions.

Table 2.1 Key drivers of greenhouse gas emissions and global shares of main sources

Type of gas	Share in GHG in 2017	Source driver	Share in gas total in 2017	Most recent year of global statistics
CO_2	**73%**	**Coal combustion**	**40%**	**2017**
		Oil combustion	**31%**	**2017**
		Natural gas combustion	**18%**	**2017**
		Cement clinker production	4%	2017
		Subtotal drivers of CO_2	**92%**	
CH_4	**18%**	**Cattle stock**	**21%**	**2016**
		Rice production	**10%**	**2017**
		Natural gas production (including distribution)	**13%**	**2017**
		Oil production (including associated gas venting)	**11%**	**2017**
		Coal mining	**11%**	**2017**
		Landfill: municipal solid waste ~ food consumption	8%	2013
		Waste water	8%	
		Subtotal drivers of CH_4	**83%**	
N_2O	**6%**	**Cattle stock** (droppings on pasture, range and paddock)*	**21%**	**2016**
		Synthetic fertilisers (N content) *	**18%**	**2016**
		Animal manure applied to soils *	**4%**	**2016**
		Crops (share of N-fixing crops, crop residues and histosols)	11%	2016
		Fossil fuel combustion	10%	2016
		Manure management (confined)	4%	2016
		Indirect: atmospheric deposition & leaching and run-off (NH_3)*	12%	2016
		Indirect: atmospheric deposition (NO_x from fuel combustion)	7%	2016
		Subtotal drivers of N_2O, incl. other, related drivers (*)	**87%**	
F-gases	**3%**	HFC use (emissions in CO_2 eq)	65%	NA
		HFC-23 from HCFC-22 production	19%	NA
		SF6 use	14%	NA
		PFC use and by-product (emissions in CO_2 eq)	2%	NA
		Subtotal drivers of F-gases	**100%**	

Sources: EDGAR v5.0 for CO_2 (1970–2015); EDGARv4.3.2 for CH_4 and N_2O (1970–2012); FT2017 all.

The direct drivers of CO_2 are the combustion of coal, oil and natural gas, representing 89% of global CO_2 emissions, with respective shares of 40%, 31% and 18%. Calcination in cement clinker production accounts for another 4% (Table 2.1). Fossil-fuel-related CO_2 emissions can only be significantly reduced by switching to other energy sources, notably renewable sources such as hydropower, wind, solar and nuclear power and sustainably produced biofuels. Additional reductions may be achieved through energy-efficiency improvements. Furthermore, CO_2 capture from flue gases and storage underground (CCS) may contribute to reducing the seemingly ever-increasing CO_2 concentrations in the atmosphere (Global CCS Institute, 2018).

For CH_4, there are three large groups of sources: agriculture, fossil fuel production and waste/waste water. In agriculture, ruminant livestock, particularly cattle, and rice production are the largest global sources. With a share of three quarters of all ruminant-related CH_4 emissions (36%), those from cattle alone are responsible for 21% of current global CH_4 emissions. Rice cultivation on flooded rice fields is another agricultural source, where anaerobic decomposition of organic material produces methane, accounting for 10% of CH_4 emissions. Other large CH_4 sources are coal production, natural gas production and transmission as well as oil production (including vented associated gas that consists mostly of CH_4, if it cannot be utilised). Together, fossil fuel production and transmission account for another third of global methane emissions, with each fuel having roughly equal share.

The third largest source is human waste and waste water. These are other sources where anaerobic decomposition of organic material produces methane. When biomass waste in landfill and organic substances in domestic and industrial waste water are decomposed by bacteria in anaerobic conditions, substantial amounts of methane are generated. Landfill and waste water are both estimated at shares of about 8%. For these emissions, food supply as a driver would be a good indicator; however, FAO statistics on food balances are lagging several years behind (Table 2.1).

For N_2O, agricultural activities are the main emission source, with a share of almost 75%. The animal droppings on pastures, rangeland and paddocks are by far the largest global source of nitrous oxide, with an estimated share of 21%, and the use of synthetic nitrogen fertiliser is the second-largest source, accounting for 18%, at present. Indirect N_2O emissions from agricultural activities contribute 12%. Together, these sources account for 55% of global emissions, including 4% from animal manure applied to agricultural soils as fertiliser (Table 2.1).

F-gas greenhouse gas emissions consist of emissions of HFCs, PFCs, SF6 and NF3. Emissions from the *use* of these gases are by far the largest source. Other sources are inadvertent *by-product* emissions of HFC-23 during the production of HCFC-22 and PFCs emissions from primary aluminium production. At present emissions of HFCs and SF6 are the largest global sources of fluorinated gases with shares of 84% and 13% (PFCs only 2%. Total F-gas emissions from the *use* of these gases, in particular HFCs, have substantially increased since 2005 with more than 4% per year, as industrialised countries show in their greenhouse gas emission trend reports through 2016 (UNFCCC, 2018). This is an important source of data for F-gases, as there are no global statistics for their use and emissions.

Other than by reducing the volumes of livestock and fertilisers used, CH_4 and N_2O emissions may also be partly reduced by changes in animal feed, optimising nitrogen fertiliser use on arable land, and changes in human food preferences for meat, fish and vegetables, and reduction in losses over the entire food chain, from primary production by farmers to final consumption. Moreover, methane generated in fossil fuel production and in landfill and waste

water may be reduced by recovering CH_4 and either use it as biogas for energy purposes or by flaring it.

As we only use the fast-track methodology based on indicators of volume trends for estimating the emissions in the last five years (at maximum), we assume that these non-volume effects impacting emissions, such as changes in feed and food, are relatively small. Most of these changes are not further discussed in this report. For more information on this we refer to the detailed National Inventory Reports that are submitted annually by most industrialised countries to the UN Climate Secretariat (UNFCCC, 2018).

2.2 Global trends in total greenhouse gas emissions

The year 2017 was a remarkable year. First, the growth in total global greenhouse gas (GHG) emissions has resumed at the rate of 1.3% (±1%) per year, reaching a new greenhouse gas emission record of about 50.9 gigatonnes of CO_2 equivalent[5] [6] (Gt CO_2 eq) (excluding those from land-use change), after two years of virtually no growth: 0.2% in 2015 and 0.6% in 2016 (which was a leap year and therefore 0.3% longer). This ends speculation about peaking of global emissions in 2015 and 2016.

This happened while the global economic growth of 2.6% in 2017 continued at about the average annual growth rate of 2.4% since 2002 (excluding the credit crunch years). Current greenhouse gas emissions are about 55% higher than in 1990 and 40% higher than in 2000. The 2017 greenhouse gas emissions are 55.1 Gt when including the very uncertain land-use change emissions estimated at 4.2 Gt CO_2 eq.

Second, 2017 was remarkable because it was globally the third warmest year since records began in 1880, behind the record year 2016 and second warmest year on record 2015, both influenced by a strong El Niño. However, 2017 was also the warmest year on record without an El Niño present (NOAA, 2018). The average global temperature across land and ocean surface areas was 0.84°C above the 20th century average of 13.9°C (over land: 1.41°C).

Of the 10 warmest years on record, eight occurred within the last decade, and one in 2005, so also in this century, and the other in 1998. That the warmest years globally are concentrated in recent years rather than more evenly distributed over time is also confirmed by the so-called annual number is *Heating Degree Days* in the United States and the European Union, which is used as estimator of the demand for space heating (see sections 3.2 and 3.3).

Second, in 2017, the growth in global greenhouse gas emissions has resumed at the rate of 1.3% (±1%), reaching a new greenhouse gas emissions record of about 50.9 Gt CO_2 eq[7] (excluding those from land-use change), after two years of virtually no growth: 0.2% in

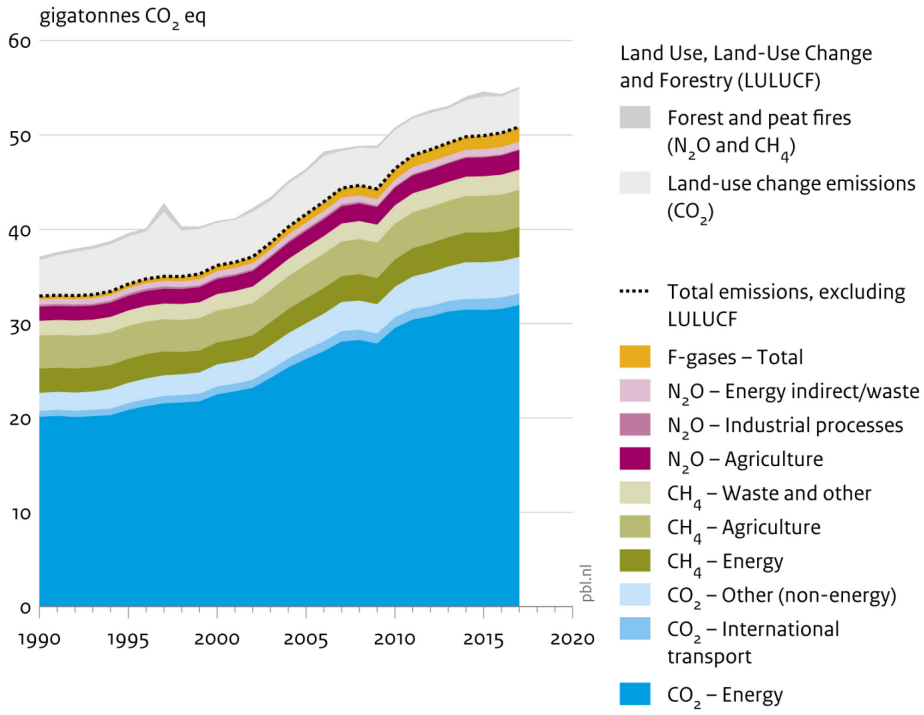
[5] Unless stated otherwise, we use in this report for CH4, N2O and the F-gases the Global Warming Potential (GWP) metric from the Fourth Assessment Report (AR4) of the IPCC (2007), which is also used by industrialised countries in their annual national emissions inventory reports submitted to the UNFCCC (so-called Annex I countries). The time horizon of the GWPs used is 100 years. Please note that developing countries officially report their emissions using GWPs from the Second Assessment Report (SAR) of the IPCC. The largest difference is in the GWP of CH4: the GWP value is 25 in the AR4 and 21 in the SAR, so almost one fifth larger.
[6] The historical EDGAR GHG emission trends in this report are also presented in UNEP's Emissions Gap Report 2018, but using the GWPs of the SAR (UNEP, 2018). The global total in 2017 is estimated at 49.3 Gt CO2 eq when using GWPs from the SAR (excluding emissions from land use change), up from 48.7 Gt CO2 eq in 2016. The global total including 4.2 Gt CO2 eq land use change is 53.5 Gt CO2 eq when using GWPs from the SAR.
[7] The global total in 2017 is estimated at 49.3 Gt CO_2 eq when using GWPs from the SAR (excluding emissions from land-use change), up from 48.7 Gt CO_2 eq in 2016. The SAR 2017 global total, including 4.2 Gt CO_2 eq land-use change, is 53.5 Gt CO_2 eq.

2015 and 0.6% in 2016 (which was a leap year and therefore 0.3% longer). This ends speculation about peaking of global emissions in 2015 and 2016.

The growth rate of 1.3% is similar to those seen from 2012 to 2014, when the average greenhouse gas emission growth slowed down to 1.3% per year, and that was also the growth rate in the decades before 2003 (Figure 2.1). Since that year, the global greenhouse gas growth rate had accelerated to 2.9% per year on average, which was related to the fast industrialisation of China since it had become a member of the World Trade organization (WTO) (Figure 2.1). To capture this period of global accelerated growth in our comparison of growth rates, in subsequent analysis of greenhouse gas emissions we will compare growth in recent years (2015 to 2017) to that of the decade 2004–2014.

Figure 2.1

Global greenhouse gas emissions, per type of gas and source, including LULUCF



Source: EDGAR v5.0/v4.3.2 FT 2017 (EC-JRC/PBL, 2018); Houghton and Nassikas (2017)

The slowdown of the emissions growth since 2012 had led to speculation whether global greenhouse gas emissions are now 'plateauing' or 'peaking' at around 50 Gt CO_2 eq and whether we may expect global greenhouse gas emissions to decrease soon, but now we see in 2017 the same growth rate again as we saw for decades in the years before 2003. In those three decades, the average global greenhouse gas emission increase of 1.3% per year was mainly driven by the 1.7% average annual growth in CO_2 emissions. Thus, apart from short interruptions in years of global recessions, global greenhouse gas emissions have been increasing steadily in the decades since, e.g. from 24.5 gigatonnes in CO_2 equivalent (Gt CO_2 eq) in 1970, via 32.9 Gt CO_2 eq in 1990 to 37.1 Gt CO_2 eq in 2002. Subsequently, in the next decade global emissions accelerated growth led to 47.8 Gt CO_2 eq in 2011, after which emissions increased at a much slower rate to 50.2 Gt CO_2 eq in 2016.

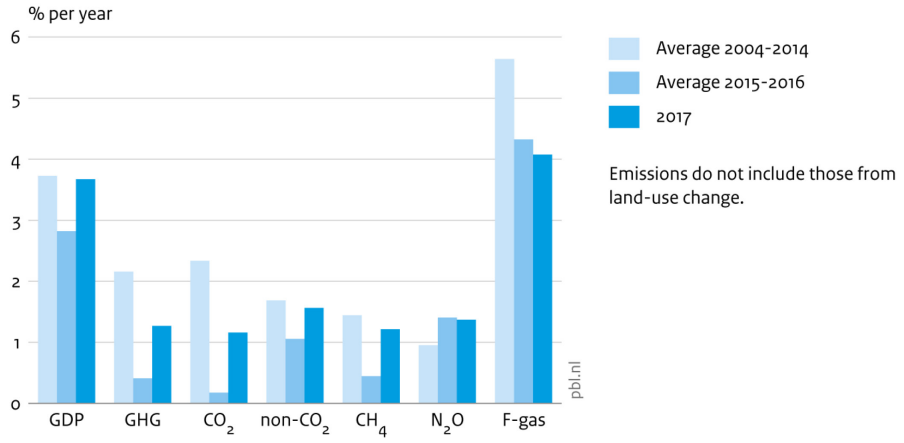
Note that for climate policy purposes the emissions in 1990 are relevant as it is the default base year for the UN Climate Convention, 2005 is the base year for some national targets (such as for the European Union), further 2010 (more precisely the average of 2008-2012)

was the target year for the first commitment period of the Kyoto Protocol. Further analysis may show the extent to which recent global and national greenhouse gas trends estimated in this report are in keeping with the total national greenhouse gas emission trends as expected from analyses of pledges of countries under the Paris Agreement (UNEP, 2018; Kuramochi et al., 2018; PBL, 2016).

Figure 2.2 shows for the years 2004–2014, 2015–2016 and 2017 the average of annual global growth rates of Gross Domestic Product (GDP) and annual emissions of total greenhouse gases and for each individual gas (but aggregating the fluorinated gases in one group called F-gases). It shows that, while the average growth in the world economy was fairly constant since 2002, annual growth in total greenhouse gas emissions have seen a distinct drop in 2015 and 2016 to 0.4%, on average. Moreover, although in 2017, the growth in global greenhouse gas emissions of 1.1% was larger than in the two preceding years, it was still only half of the average annual growth rate in the decade before.

Figure 2.2

Annual increases in global GDP and global greenhouse gas emissions, 2004–2017



Source: World Bank, IMF; EDGAR v5.0/v4.3.2 FT 2017 (EC-JRC/PBL, 2018).

When looking at the separate greenhouse gases, we can see which gases were mainly responsible for the total greenhouse gas trend in these three periods (Figure 2.2). It shows that the greenhouse gas increase in 2017 was mainly due to a 1.2% increase in global CO_2 emissions, which account for about three quarters of the total greenhouse gas increase in 2017, but also non-CO_2 emissions retained their average annual increase of 1.6% in 2017. In contrast, the low greenhouse gas emission growth from 2014 to 2016 of about 0.4% per year is mainly due to the very low average CO_2 growth rate of 0.2% per year in these years, which is mainly caused by a declining global coal consumption, notably in China, the United States and the European Union.

The emissions of the other greenhouse gases CH_4, N_2O and F-gases increased in 2017 by 1.2%, 1.4% and 4.1%, respectively. Although most of global greenhouse gas emissions consist of CO_2 (about 73%), methane, nitrous oxide and fluorinated gases (so-called F-gases) also make up significant shares (18%, 6% and 3%, respectively) (Table 2.1). From these shares and increases in 2017 we can infer that it was CH_4 that caused lower annual growth on non-CO_2 greenhouse gases in 2015 and 2016.

These percentages for the share in total greenhouse gas emissions do not include net emissions from land use, land-use change and forestry (LULUCF), which are usually accounted for separately, because they are inherently very uncertain and show large

interannual variations that reflect the periodically occurring strong El Niño years, such as in 1997–1998 and 2015–2016, as shown by the grey area above the dashed line in Figure 2.1. When including LULUCF emissions—for 2017 estimated at about 4.2 Gt CO_2 eq—estimated global total greenhouse gas emissions come to 55.1 Gt CO_2 eq.

2.3 Global trends in CO_2 emissions

In the 1970–2003 period, global CO_2 emissions (excluding those from LULUCF) increased by 1.7% per year on average. From 2003 to 2011 the emissions growth accelerated to 3.2% per year on average driven by China's fast industrialisation since 2002. However, during the years 2012 to 2014 global growth slowed down to 1.4% per year. Thereafter, the global CO_2 emissions have remained flat in 2015 and 2016 (±0.5%), as shown by the middle area in Figure 2.3.

However, in 2017, after these two years of almost no global CO_2 emissions growth, global CO_2 emissions increased again, this time by 1.2%. This rebound is mainly due to a new rise in global coal consumption by 0.7%, after three years of global declining coal consumption (Figure 2.3). This decline was caused by three years of decreasing coal consumption in China and declines in the United States and the European Union, mainly from fuel switching to natural gas in power plants and increased renewable power generation, in particular, wind and solar power (IEA, 2017a; BP, 2018).

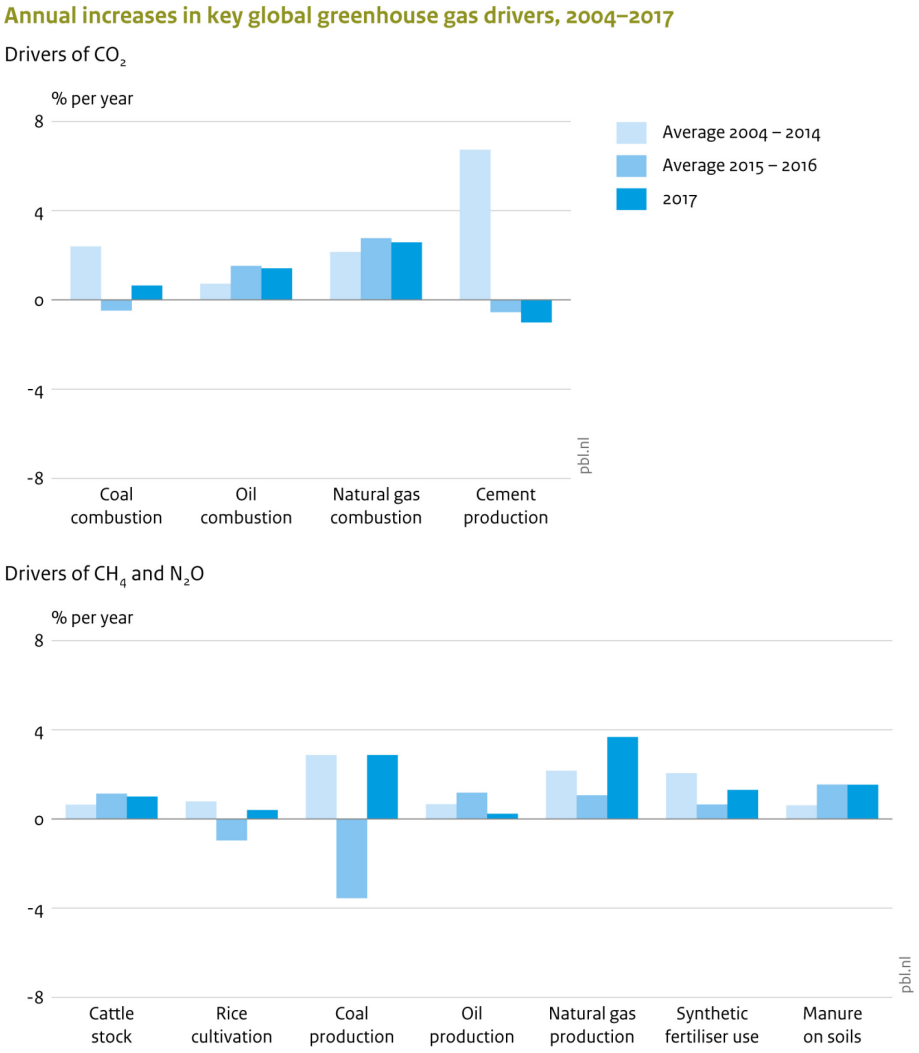
The increase in global coal consumption in 2017 is mostly due to increases in China by 0.2% and India by 4.5% (twice the rate in 2016). In contrast, coal consumption in the United States and the European Union continued to decrease by more than 2% (in particular in Germany and the United Kingdom). Also, in the Ukraine, coal use continued to decline—in 2017, very substantially, by 17%. Coal-fired power plants are by far the largest user of coal. For more details on new coal plants, plants under construction, planned or retired we refer to Shearer et al. (2018a). They conclude that if current trends continue, by 2022 yearly retirements will exceed new capacity added.

Global consumption of oil products and natural gas continued to increase, by 1.4% and 2.7% in 2017. The increase in global oil consumption was led by China, the European Union and the United States, accounting for half of the net increase. The increase in global natural gas consumption in 2017 was led by China (+14.8%), the European Union (+4.0%) and Iran (+6.5%), accounting for two thirds of the net global increase. For more details on these countries and the European Union we refer to Chapter 3.

The increase in global CO_2 emissions in 2017 is closely related to the trends in primary energy demand and energy mix. In 2017, total energy demand increased by 14 EJ, half of the increased demand was met by fossil fuels and the other half by renewable and nuclear power. Taking a somewhat longer view, total primary energy supply (TPES[8]) increased from 2010 to 2017 from almost 563 EJ to 629 EJ and the shares of fossil fuels decreased from 78.3% to 75.8% (down 2.6 EJ: coal -1.9, oil -1.0, natural gas +0.3 EJ)), renewables increased from 17.0% to 20.2% (up 3.2 percentage points: hydropower +0.3, biomass +0.1%, wind and solar power +2.9% percentage points), and nuclear energy decreased from 4.6% to 4.0%). However, with increasing demand, for peaking and curbing CO_2

[8] TPES, or Total Primary Energy Supply, is the total amount of energy consumption of a country (or the world). It is calculated as in BP (2018): using a substitution method for nuclear, hydropower and other non-biomass renewable energy and assuming 38% conversion efficiency in all cases. This is different from the definition that the IEA uses in her publications in that they use different percentages for non-combustion power sources.

Figure 2.3



Source: IEA, BP, USGS, FAO, IRRI, IFA.

emissions, it is not enough to have higher growth rates of renewable and nuclear energy if they have small shares in total energy supply. Of the increase in electricity demand 36 EJ was met by fossils fuels, of which about one sixth by coal, almost half by natural gas and almost the other half by oil. Renewables contributed almost 32 EJ to the increase, two thirds of which from wind and solar power. However, nuclear power saw a net decrease of more than 1 EJ.

We recall that the time series data for global CO_2 emissions have been revised and updated since the 2017 report (Olivier et al., 2017). The updated estimate for total global total CO_2 emissions in 2015 is now 36.5 Gt CO_2, which is 2.5% higher than the estimate of 35.6 Gt CO_2 presented last year. The changes are mainly due to regular annual statistical revisions of fuel consumption in the statistics of the International Energy Agency (IEA) and BP (for example the decrease in global coal consumption in 2015 was revised from -1.8% according to IEA statistics to -2.7% cf. BP (2018) statistics[9] and the growth in natural gas consumption

[9] The very latest IEA revision, according to just published IEA statistics online, is -2.1% (TPES coal and coal products).

in 2016 was 1.1 percentage point higher in the latest BP statistics compared to previous year) as well as revisions and some full updates. For other sources, some emission factors were also updated, such as chemical production processes, such as for ammonia and ethylene, and cement production[10]. The revised global CO_2 emissions in are higher than in last year's report, from about 0.2 Gt in 1990 (+1.0%), decreasing to 0.1 Gt in 2000 (+0.4%) and increasing to 0.9 Gt in 2015 (+2.5%).

2.4 Global emissions of other greenhouse gases

As discussed in the introduction, the non-CO_2 greenhouse gas emissions originate from many different sources and are much more uncertain than CO_2 emissions. Their uncertainty on a country and global level is of the order of 30% or more, whereas for CO_2 this is about ±5% for OECD countries and ±10% for most other countries (Olivier et al., 2016). Note that due to the large diversity of the emission factors within these sources, and the lack of global statistics for F-gas production and their uses, the annual trends in the emission of CH_4, N_2O and F-gases are much more uncertain than those in CO_2.

Compared to the trend in global CO_2 emissions, the increase in other greenhouse gas emissions did not go down as much during the years 2015 and 2016, namely from 1.7% annual growth over the 2004–2014 period to a growth of 1.0% and 1.1% in the years 2015 and 2016. And growth resumed in 2017 by 1.6%.

Although varying per country, non-CO_2 emissions constitute a significant share in total greenhouse gas emissions. The global share of non-CO_2 greenhouse gases is estimated to have declined from 35% in 1970 to 26.6% in 2013, after which it started to increase, very slowly, to about 27% in 2017, because of the slow-down of the annual growth in global CO_2 emissions since 2012.

The trend in global **methane** (CH_4) emissions since 1990 is presented in Figure 2.4. It shows that the largest sources are the production and transmission of coal, oil and natural gas, and livestock: when animals ruminate their feed, they emit considerable amounts of methane. Globally, cattle account for two thirds of the CH_4 emitted by livestock, followed by buffalo, sheep and goats that haves shares of about 10%, 7% and 5%, respectively. The third largest source is human waste and waste water: when biomass waste in landfill and organic materials in domestic and industrial waste water decompose by bacteria in anaerobic conditions, substantial amounts of methane are generated. Likewise, rice cultivation in flooded rice fields is another source where anaerobic decomposition of organic material produces methane.

Since the start of the 21st century global CH_4 emissions started to rise again. From 2004 to 2014 they increased by 15%, which is 1.5% per year on average. Sources that contributed most to this increase were coal mining (+3.4%), livestock (+1.0%) and natural gas production and distribution (+2.8%). Countries with the largest absolute increase over these 10 years are China, India, Brazil and Indonesia, whereas the largest decreases occurred in the European Union, Russian Federation, Nigeria and Ukraine.

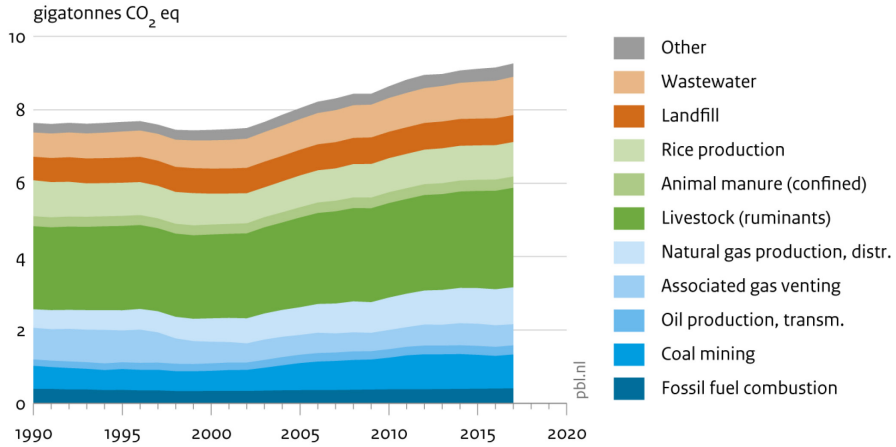
In 2017, the growth rate is estimated at 1.2% to a total of 9.3 Gt CO_2 eq, which is markedly higher than in 2015 and 2016 that saw growth rates of 0.5% and 0.4% but is similar to

[10] The +2.5% revision of total CO2 emissions in 2015 were due to the largest absolute increases occurring in China (+3.2%), the United States (+2.6%), Saudi Arabia (+21%), the European Union (+2.5%), and South Africa (+22%) and Japan (+6.5%), whereas the largest decreases in 2015 were seen in India (-5.4%) and Canada (-14%).

growth rates in the three years before (2012–2014) (Figure 2.4). Present emissions are 21% higher than in 1990, when they were 7.6 Gt CO_2 eq. Increases in emissions from livestock and waste water contributed most to the global emission changes since 2014, partly compensated by decreases seen in emissions from coal production and gas venting, such as in the United States and the European Union.

Figure 2.4

Global methane emissions, per main source

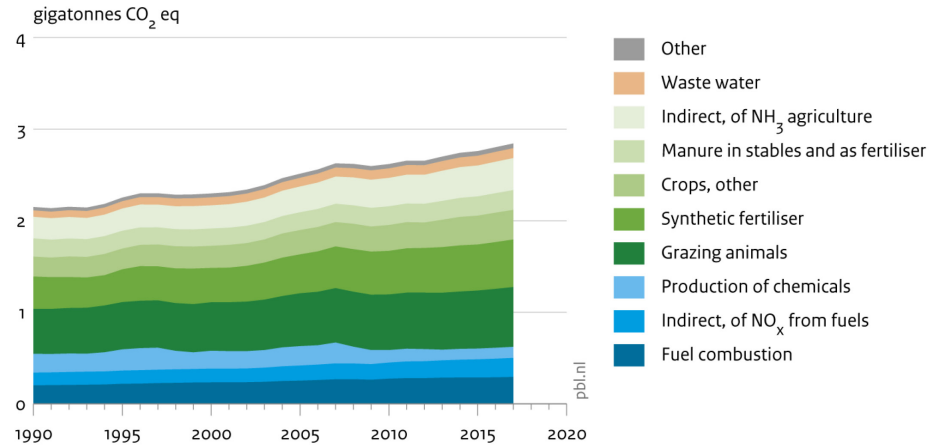


Source: EDGAR v4.3.2 FT2017 based on IEA, FAO, IRRI, UNFCCC, UNEP DTU Partnership (EC-JRC/PBL, 2018).

The trend in global **nitrous oxide** (N_2O) emissions since 1990 is presented in Figure 2.5. It clearly shows that agricultural activities are the largest sources of N_2O accounting for about 75%. The main global sources of N_2O emissions are from manure dropped in pastures, rangeland and paddocks (22%) and the use of synthetic nitrogen fertilisers (18%). More than half of global N fertiliser use is urea. Somewhat smaller sources are other crop-related emissions (from N-fixing crops, crop residues left on the fields and histosols) (11%) and the indirect N_2O emissions related to NH_3 emissions from agriculture (12%). The largest non-agricultural source is fuel combustion (17%, including indirect emissions of N_2O from NO_x emissions), followed by waste water (7%) and the production of chemicals (4%).

Figure 2.5

Global nitrous oxide emissions, per main source



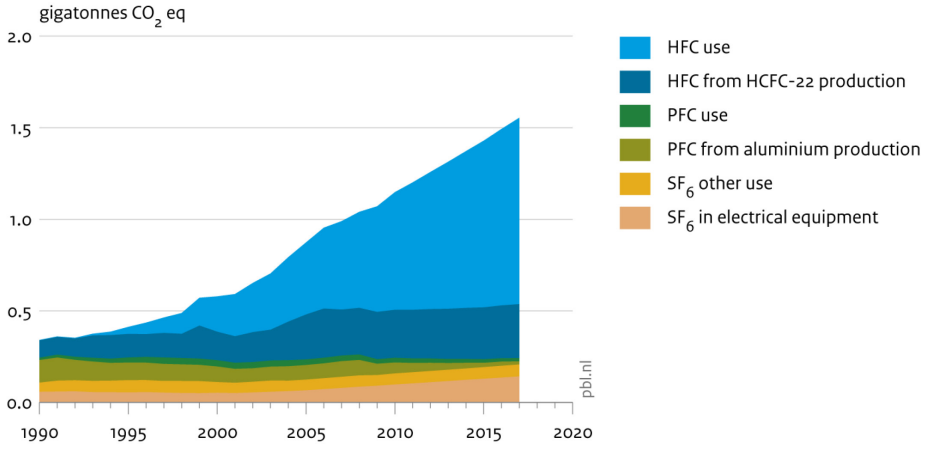
Source: EDGAR v4.3.2 FT2017 based on IEA, FAO, SRIC, UNFCCC, UNEP DTU Partnership (EC-JRC/PBL, 2018).

In 2017, the growth rate of global N_2O emissions is estimated at 1.4% to a total of 3.0 Gt CO_2 eq, so emissions have remained at almost the same level as in 2015 and 2016, which saw growth rates of 1.1% and 1.7% (Figure 2.3). Present emissions are 30% higher than in 1990, when they were 2.3 Gt CO_2 eq. Increases in emissions from the largest sources, notably manure dropped in pastures, rangeland and paddocks and the use of synthetic nitrogen fertilisers, contributed most to the global emission changes since 2014.

Global N_2O emissions of most sources generally developed rather smoothly from 1990 to 2017. An exception is N_2O from the production of chemicals, such as adipic acid and nitric acid, where from 2007 onwards N_2O abatement technology has been applied in many chemical plants, resulting in a reduction in their global N_2O emissions of 40% since 1990. From 2004 to 2014, global N_2O emissions increased by 10%, which is 1.2% per year, on average. Sources that contributed most to this increase were synthetic fertilisers (+1.9%), livestock droppings (+1.1%), other crop-related emissions (+1.7%) and indirect N_2O emissions (+2.0%). Countries with the largest increase over these 10 years are China, India, Brazil and Mexico, whereas the largest decrease occurred in the European Union.

Figure 2.6

Global F-gas emissions, per main source



Source: EDGAR v4.2 FT2017 based on AFEAS, UNFCCC, UNEP, RAND, WSC (EC-JRC/PBL, 2018).

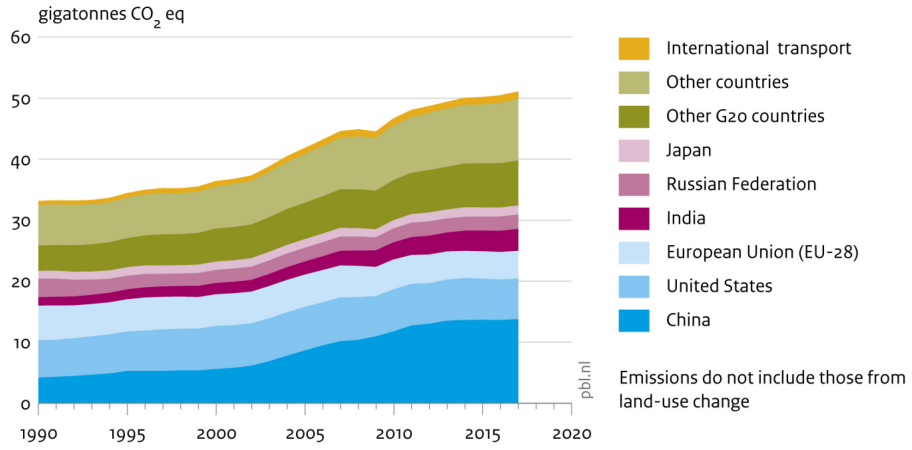
The trend in **F-gas** emissions is presented in Figure 2.6. Although they make up the smallest category of the non-CO_2 greenhouse gases, the group shows the strongest emission growth with estimated annual global growth rates of 5.6% on average, in the 2004–20014 period, and slowing down somewhat to 4.5% in 2016 and 4.1% in 2017, which was estimated by extrapolating the average annual 2007–2010 trend. Using this estimation method, global total F-gas emissions amounted in 2017 to 1.6 Gt CO_2 eq, worldwide, more than four times the emissions in 1990 estimated at 0.3 Gt CO_2 eq.

The main reason for this very high growth is the introduction of HFCs in the early 1990s to replace the use of CFCs as these were first phased out by industrialised countries to comply with the Montreal Protocol to protect the stratospheric ozone layer, and developing countries would follow later. This accounts for about 1.0 Gt CO_2 eq of the global increase, and these HFC emissions account now for two thirds of all F-gas emissions (Figure 2.6), and emissions of HFC-134a , HFC-143a and HFC-125 make up most of them (over 90%). In addition, HFC-23 as by-product adds one fifth to total F-gas emissions. We note that these are very heterogeneous source categories, with large differences in growth rates for the different constituents, and often with very large uncertainties in emissions, at country level and per gas of the order of 100% or more.

Figure 2.7 illustrates the 1990–2017 trends in total greenhouse gas emissions of the five largest emitting countries and the European Union, who collectively have a 63% share in global emissions, complemented with those in the other countries and from international transport (i.e. international marine and aviation emissions). Most of these five countries and the EU showed a real increase in greenhouse gas emissions in 2017, except in the United States, where emissions remained constant (+0.1%): China (+1.1%), India (+2.9%), European Union (+1.1%), Russian Federation (+1.0%) and Japan (+0.3%). Within the European Union, the United Kingdom, Germany and the Netherlands showed decreasing emissions whereas the largest increases in 2017 were seen in Spain and France. Together these five largest emitting countries and the European Union account for 51% of the world population, 65% of global gross domestic product (GDP) and 63% of the global total primary energy supply (TPES), accounted for 68% of total global CO_2 emissions and about 63% of total global greenhouse gas emissions.

Figure 2.7

Global greenhouse gas emissions, per country and region



Source: EDGAR v5.0 (CO_2: IEA and others), v4.3.2 (CH_4, N_2O) FT2017 (EC-JRC/PBL, 2018).

The total group of 20 largest economies (G20[11]), accounting for 78% of 2017 greenhouse gas emissions, showed a 1.1% increase. The collective emissions from the rest of the world showed an 1.9% increase in 2017 (2.5% for the eight largest countries and 1.6% for remaining 186 countries). Appendix B provides more detailed tables, with the 1990–2017 greenhouse gas emission time series for the top 30 countries/regions, as well as per capita and per USD of GDP.

Following UNFCCC reporting and accounting guidelines (UNFCCC, 2011), greenhouse gas emissions from international transport (aviation and shipping) are excluded from the national total in countries' greenhouse gas emission reports, but nevertheless constitute about 2.5% of total global greenhouse gas emissions in 2017, for which 1.2% increase was estimated.

Appendix A provides tables with the 1990–2017 time series of CO_2 emissions for the top 30 countries/regions, as well as per capita and per USD of GDP, whereas Appendix B provides tables with the 1990–2017 time series of total greenhouse gas emissions for these countries/regions. as well as for their CH_4, N_2O and F-gas emissions, and greenhouse gas emissions per capita and per USD of GDP.

[11] Group of Twenty: 19 countries and the European Union. The 19 countries are: Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, the Russian Federation, Saudi Arabia, South Africa, Turkey, United Kingdom, and the United States.

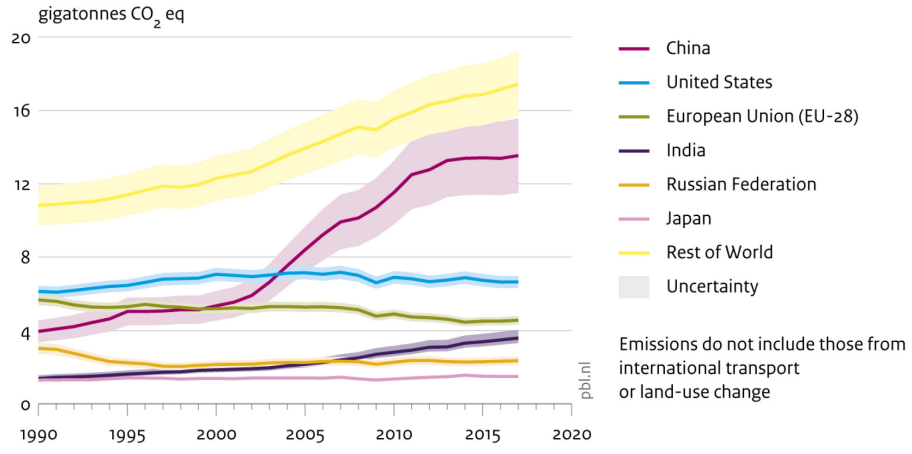
3 Trends in largest emitting countries and the EU-28

In this chapter we discuss the emission trends in the six main emitters, consisting of five large countries, being the United States, China, India, the Russian Federation and Japan, and of the European Union (EU-28) as a region. Between them there are large differences, in the share of the various greenhouse gases, and in the emission intensity of their energy use. Globally, the combined share of CH_4, N_2O and F-gas emissions is about 28% in total greenhouse gas emissions (19%, 6%, and 3%, respectively), but it varies for the largest countries, from 12% for Japan to 32% for India. China's current share is estimated at 19%, that of the United States at 23% and the European Union at 22% and the Russian Federation at 25%.

These shares reflect the relative importance of non-CO_2 greenhouse gas emission sources, such as coal, oil and natural gas production (releasing CH_4), agricultural activities, such as livestock farming (CH_4 emissions from ruminants and manure), rice cultivation (wet fields release CH_4 through fermentation processes in the soil), animal manure and fertiliser use on arable land (N_2O), and landfill and wastewater practices (CH_4).

Figure 3.1

Greenhouse gas emissions, per country and region



Source: EDGAR v5.0 (CO_2: IEA and others), v4.3.2 (CH_4, N_2O) FT2017 (EC-JRC/PBL 2018).

As discussed in Chapter 2, the greenhouse gas emission trends of the largest countries and regions have continued or resumed to grow in 2017, although in the United States and Japan only by 0.1% and 0.3%. In absolute values, the largest emitters for CO_2 and total greenhouse gas emissions are China, the United States, and the European Union, followed by

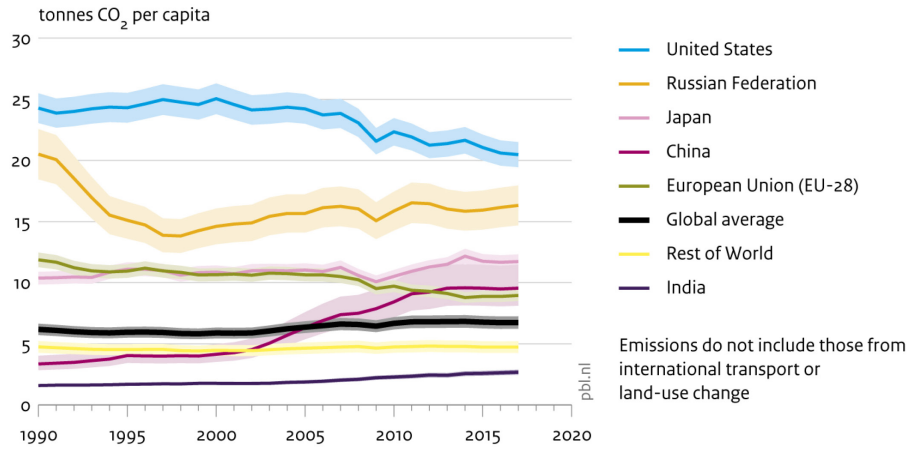
India, the Russian Federation, and Japan. For non-CO_2 emissions only, India and the European Union switch rank.

In 2005, after its very rapid rise in CO_2 emissions caused by the fast industrialisation that started in 2002, China surpassed the United States as the world's largest emitting country. Since 2013, China's CO_2 emissions have been more than twice those of the United States. Using our estimates, the same occurred in 2016 for total greenhouse gas emissions. However, for a proper perspective in comparisons between countries also the size of a country's activities should be accounted for. Therefore, the per capita emissions, and the emissions per USD of GDP, and their trends, are presented below, which allows for better comparison of level and trends between countries because it eliminates either population size or size of the economy of a country from the equation. Apart from that, it also provides reference values to assess in what direction emissions will progress if structural changes occur in population or economy of a country (or in the rest-of-world countries as a group).

Figure 3.2 shows greenhouse gas emissions per capita for the five main emitting countries, the European Union, the rest of the world, and for the world average. Except for India, all main emitters have per capita emission levels that are significantly higher than those for the rest of the world and the world average. China, in this measure, has rank 4, rather than rank 1, which it has for absolute emissions. Although CO_2 emissions in the United States have been steadily decreasing since 2000, from 25.0 tCO_2 eq/cap to about 20.5 tCO_2 eq/cap by 2017, it is the highest amount among the top 5 emitting countries, but it is surpassed by three other G20 countries: Canada, Australia and Saudi Arabia. The United States, the Russian Federation, and Japan make up the top 3 greenhouse gas emitting countries, per capita, among the G20 countries.

Figure 3.2

Greenhouse gas emissions, per capita, per country and region

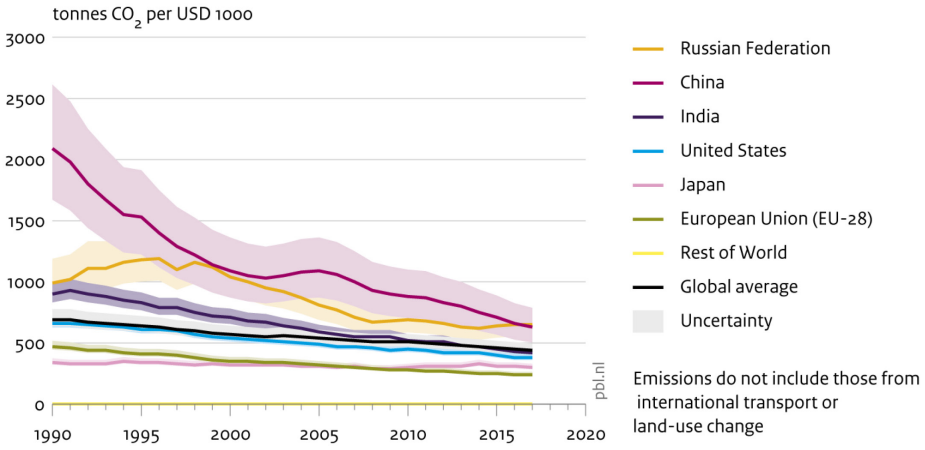


Source: UNDP, EDGAR v5.0 (CO_2), v4.3.2 (other gases) FT2017 (EC-JRC/PBL, 2018).

The emissions per USD of GDP (in 2011 prices and corrected for Purchasing Power Parity (PPP)) presented in Figure 3.3, show yet another image. Contrary to the per capita emissions, the top 5 countries and the European Union are not all above the world average when it comes to emissions per USD of GDP. In the United States, emissions per USD of GDP are virtually equal to the world average, while those in the European Union are the lowest per USD of GDP worldwide, closely follow by Japan. Emissions per USD in China and the Russian Federation are the highest, and significantly higher than the world average. The trend for all countries is downward, including that for the world average, except for the Russian Federation, which emissions per USD remain flat in recent years.

Figure 3.3

Greenhouse gas emissions, per USD of GDP, per country and region



Source: World Bank, IMF, EDGAR v5.0 (CO_2), v4.3.2 (other gases) FT2017 (EC-JRC/PBL, 2018)

Appendix A provides for the top 30 countries/regions more details with 1990–2017 time series of CO_2 emissions, totals per country, per capita CO_2 emissions and also a similar table with CO_2 emissions per USD of GDP. For the top 30 countries/regions, Appendix B provides more details with 1990–2017 time series of greenhouse gas emissions, on greenhouse gas totals, CH_4, N_2O, F-gas and per capita greenhouse gas emissions, as well as per USD of GDP, for the top 30 countries/regions.

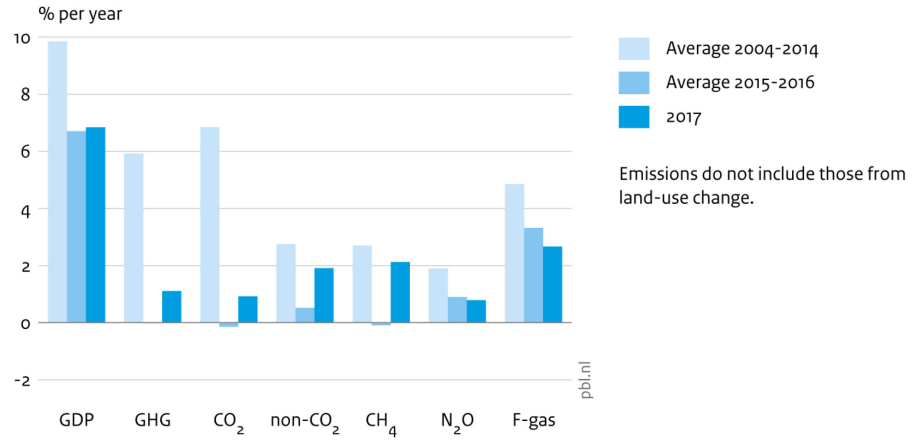
In the remainder of this chapter we analyse the level and trends in emissions for the top-5 emitting countries and the European Union as in Chapter 2 for global total emissions.

3.1 China

Figure 3.4 shows that since 2015 China's annual growth in GDP was about 3% points less than in the decade before. However, in contrast to the 6% annual increase in total greenhouse gas emissions before 2014, emissions were almost flat since 2014: +0.2%, -0.2% and +1.1% in 2015 to 2017, respectively, reaching a level of 13.5 Gt CO_2 eq. This was due to both CO_2 and non-CO_2 emissions showing a similar pattern (Figure 3.4). As illustrated in Figure 3.5, although coal consumption was flat (+0.2%) and cement production declined in 2017 by 2.9% (NBSC, 2018a), the small increase of 0.9% in CO_2 emissions is due to increased oil and natural gas consumption in China of 3.7% and 14.8%, respectively. Electric power production, China's largest source of CO_2 emissions, increased by 5.9% in 2017 to 6.5 GWh. Fossil fuel power plants (95% coal) provided 70% of this total, hydropower 18% and 11% by renewable power and nuclear power (BP, 2018).

Figure 3.4

Annual increases in GDP and greenhouse gas emissions in China, 2004–2017



Source: World Bank, IMF; EDGAR v5.0/v4.3.2 FT 2017 (EC-JRC/PBL, 2018).

In 2017 China's energy use was still very heavily leaning on coal: 58% of total primary energy supply (TPES) was provided by coal, 23% by oil and natural gas, 18% by renewable energy—of which nearly 8% is hydropower and 3% is biomass—and 2% by nuclear power. However, compared with 2010 (seven years ago) the share of coal has been decreased by 10 percentage points and that has been achieved by increasing shares of oil and natural gas and of wind and solar power (both by 4 percentage points). Also, the shares of hydropower and nuclear power increased by 2 and 1 percentage points, respectively (IEA, 2017a; BP, 2018).

This comparison of percentage changes in shares in TPES conceals that the absolute changes look much different: renewable and nuclear power production increased by 134 TWh in 2017 but coal power production increased by 210 TWh (BP, 2018). Similarly, of the increase in power production from 2010 to 2017 of 2300 TWh, 55% was met by fossil-fuel-fired power and 45% by renewable and nuclear power. For the increased electricity production in 2017 it was even 61% vs. 39%. A recent analysis by Coalswarm concluded that 259 Gigawatts (GW) of new coal-fired capacity is presently under development (roughly the same as the total present coal fleet of the United States), which will lead to an increase in the current coal fleet of 25% and an exceedance of the 1100 GW coal cap in China's present Five-Year Plan (Shearer et al., 2018b).

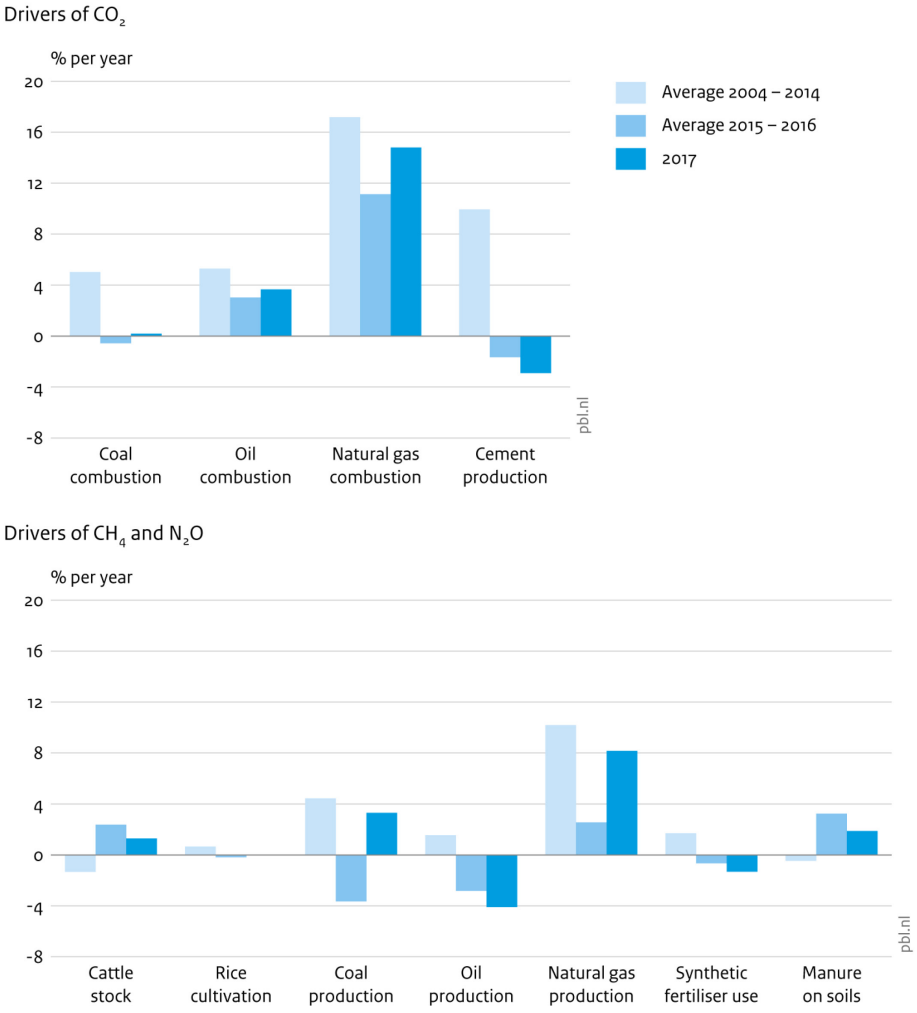
The increase in CH_4 emissions in 2017 of 2.1% was mainly due to higher domestic production of coal (+3.3%) and natural gas (+8.2%) (BP, 2018), while other indicators such

as rice production remained almost constant (IRRI, 2018). With fertilisers use declining but cattle stock increasing in 2017, which are major sources of N_2O, also total N_2O emissions did not change much in 2017.

Recent monthly statistics suggest that China's CO_2 emissions are likely to increase more in 2018 than in 2017: in the first three quarters of 2018 coal production increased by 5%, cement by 1% and crude steel by 6%, compared to the first three quarters of 2017. Power production increased by 7.4% in this period. Two thirds of this increase ware produced by thermal power (mainly coal) and the other third mostly by renewable power and nuclear power (NBSC, 2018b).

Figure 3.5

Annual increases in key greenhouse gas drivers in China, 2004 – 2017



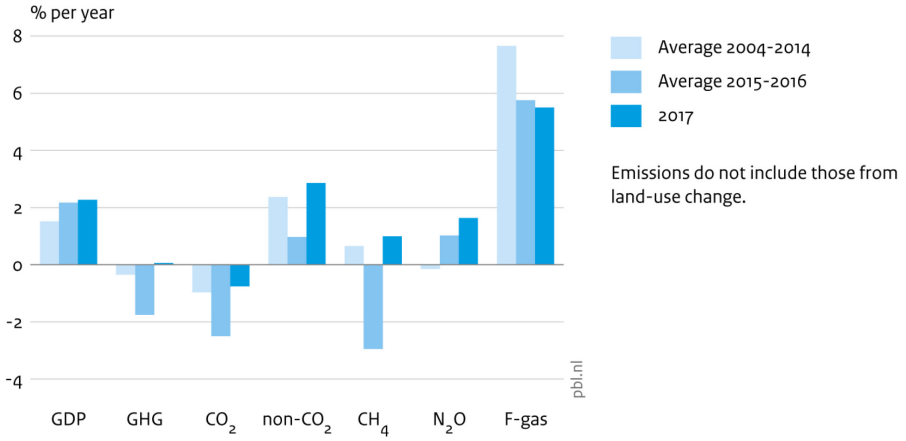
Source: IEA, BP, USGS, FAO, IRRI, IFA.

3.2 United States

In 2017, the US economy grew at the same rate as in the two preceding years. However, its total greenhouse gas emissions remained almost flat in 2017 at 6.6 Gt CO_2 eq (+0.1%), which is different from the decreases in the two years before, but more like that in the preceding decade (almost nil) (Figure 3.6). This is due to the declining trend in CO_2 emissions, which have steadily declined since 2005, from 6.0 Gt to 5.1 Gt CO_2 in 2017, being cancelled in 2017 by the large increase in non-CO_2 emissions, which have been increasing over time, in particular CH_4 (except for 2015 and 2016) and N_2O emissions.

Figure 3.6

Annual increases in GDP and greenhouse gas emissions in the United States, 2004–2017



Source: World Bank, IMF; EDGAR v5.0/v4.3.2 FT 2017 (EC-JRC/PBL, 2018).

CH_4 emissions have been steadily increasing too since 2005 but have decreased in 2015 and 2016 due to increasingly downward trends in fossil fuel production, in particular coal production has plummeted by 15% in 2015–2016 and in 2017 further by 21%. Similarly, the growth in oil and natural gas production was interrupted in 2016 and dropped by respectively 3.9% and 1.5%, however production increased again in 2017 by 5.1% and 0.7% (Figure 3.7). Although CH_4 from rice production increased, this is a small source compared to livestock and fuel production emissions. N_2O increases in recent years are related mainly to agricultural activities such as the use of synthetic and natural nitrogen fertilisers (Figure 3.7).

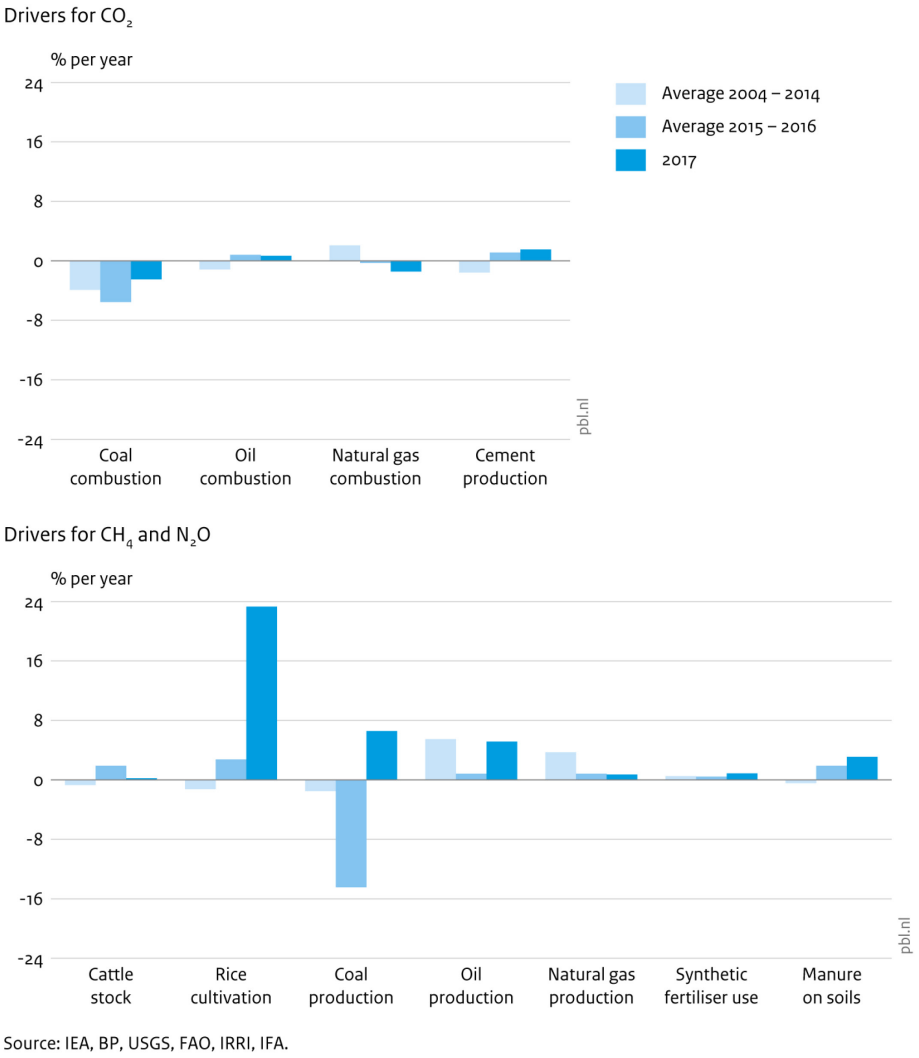
The 0.8% decline in CO_2 emissions in 2017 was mainly due to decreases of 2.5% in coal consumption and 1.4% in natural gas consumption in 2017, whereas oil consumption increased by 0.7% (BP, 2018) (Figure 3.7). These percentages are very close to those reported by the U.S. Energy Information Administration, when considering that their numbers include fuel used for international transport (bunkers) (EIA, 2018e).

With a share in total CO_2 emissions from fossil fuels of almost a quarter, fossil fuel power production is the United States' second largest source of CO_2 emissions with almost three quarters from coal plants. In 2017 electricity production declined by 1.5% to 4.3 GWh. Since 2005, the power generation mix has shifted away from coal and towards natural gas and in recent years also to renewable power. However, although in 2017 coal generation fell by 2.5% from 2016, the almost continuous increase in natural gas used for power generation stopped, and natural gas consumption declined by 7.7% (EIA, 2018a).

This will also relate to the 8.6% less *Cooling Degree-Days* (CDD) than in 2016, indicating less demand for electricity by air conditioning in the summer months than in 2016, which had a record high 1588 CDD since 2010 when the 1400 CDD mark was surpassed, which was then the highest CDD number since 1949 (EIA, 2018d). For the first year in at least a decade, no new coal-fired generators were added in 2017 (EIA, 2018a). In fact, utilities are expecting to accelerate shutdown dates, leading to a record retirement of coal-fired capacity in 2018 (Feaster, 2018; Shearer et al., 2018a).

Figure 3.7

Annual increases in key greenhouse gas drivers, in the United States, 2004–2017



Source: IEA, BP, USGS, FAO, IRRI, IFA.

In 2017 the United States' energy use was still leaning on oil and natural gas: 36% of total primary energy supply (TPES) was provided by oil, 28% by natural gas, 15% by coal, 12% by renewable energy—of which 3% is hydropower and 4% is biomass—and 8% by nuclear power. However, compared with seven years ago the share of coal has been decreased by 7 percentage points and that has been done by increasing shares of natural gas (by 4 percentage points) and of wind plus solar (by 3 percentage points). The shares of hydropower and nuclear power saw no significant changes (IEA, 2017a; BP, 2018).

Apart from the change in CO_2 emissions from the power sector, also CO_2 emissions in the transport sector have declined steadily from 2005 to 2013. However, since 2013 consumption of petrol, diesel and jet fuel, and thus sectoral CO_2 emissions, started to slowly rise again.

In the residential sector the 3831 HDDs in 2017 is the lowest number of so-called *Heating Degree-Days* (HDD) since 1949, which indicates that the winter months of 2017 were even a bit milder than in 2016 that had 3879 HDDs (EIA, 2018c). This also implies that in 2017 the demand for space heating was about one quarter less than in the 1950s to 1970s. Finally, gas flaring emissions of CO_2, estimated by NOAA from satellite data of intensities of gas flares during the night, have increased from 5 Mt CO_2 in 2005 before the fracking boom to 23 Mt in 2015, after which they decreased to 18 Mt CO_2 in 2017 (World Bank, 2018b; Elvidge et al., 2018).

The CDD time series shows that the 10 hottest summers since 1949 all are all-in the last two decades (i.e. after 1997) (EIA, 2018d). Conversely, of the 10 mildest summers since 1949, all but two are in the first two decades (i.e. before 1969), with one in 1974 and the other in 1976. The HDD time series from 1949 onward shows that, of the 10 *coldest* winters since 1949, all are before 1980. And, conversely, of the 10 *mildest* winters since 1949 all but one are in the last two decades (i.e. after 1997), except the one in 1990. These trends in highest and lowest HDDs and CDDs corroborate the observation by NOAA that the 10 globally warmest years on record are all in this century (NOAA, 2018).

In last years report, we wrote that, due to large uncertainties in estimating fugitive CH_4 emissions from the oil and natural gas sector, the United States made several recalculations of these sources as part of their emission inventory improvement programme (Appendix D in Olivier et al., 2017). According to Lyon (2018), the US EPA has not made any significant revisions in its latest report submitted to the UN Climate Secretariat (US EPA, 2018).

In recent years, various measurement studies were made of methane emissions from oil and natural gas operations that indicate that the US national inventory misses substantial amounts of CH_4 emissions from abnormal process conditions, or super emitters. Measurements suggest that the emissions from this sector could be 60% higher because the US EPA's bottom-up method does not account for facility-level high-emitting malfunctioning equipment and 2% of total facilities emit half of the total emissions (Alvarez et al., 2018; Guglielmi, 2018; Zavaka-Araiza et al., 2015; Byron, 2018). These findings may also be applicable to other countries that use similar methods as the US EPA does. Recently, the US *National Academy of Sciences, Engineering, and Medicine* released a comprehensive report on anthropogenic methane emissions in the United States, with specific recommendations for EPA collaboration to improve the accuracy of emission estimates for oil and natural gas and other methane sources, such as expanded efforts to measure emissions with top-down approaches and comparison with EPA's bottom-up methods (NAS, 2018).

Recent monthly fuel statistics for 2018 available for the first 7 months show that coal consumption was down 4.5%, oil products up 0.7% and natural gas up 1.2%, compared with the same months in 2017 (EIA, 2018f). However, the last part of the year can significantly modify this, depending on the weather in the last four months from September to December (influencing the fuel demand for space heating, thereby also affecting the demand for coal and natural gas power). When fossil fuel consumption would change likewise in the total year then the US CO_2 emissions would continue to decrease slowly in 2018.

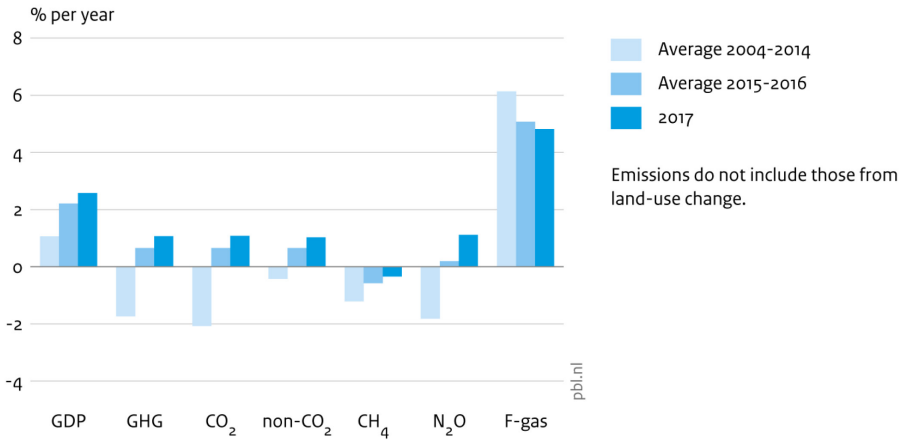
3.3 European Union

The average annual growth rate of the EU economy was 1.1% in the decade starting in 2004. Due to the Eurozone debt crisis in the years from 2008 to 2013 the average annual GDP growth rate of the European Union was nil (0.0%). Since 2014, however, the EU's GDP growth recovered and increased from 2.2% in 2015–2016 to 2.6% in 2017 (World Bank, 2018). In contrast to increasing GDP in the decade starting in the 'peak year' 2004, when greenhouse gas emissions were at their most recent highest level, the EU's total greenhouse gas emissions declined by 1.7%, on average, from 5.3 Gt CO_2 eq in 2004 to 4.5 Gt CO_2 eq in 2014. Thereafter, total greenhouse gas emissions started to increase again, by 1.1% and 0.1% in 2015 and 2016 and by 1.1% in 2017 reaching 4.6 Gt CO_2 eq (Figure 3.8).

The increase of 1.1% is larger than the previously estimated 0.6% reported by the European Environment Agency (EEA), which is based on greenhouse gas emissions in 2016 reported by the Member States and on proxy estimates submitted by the Member States (EEA, 2018). The percentage difference in the 2017 trend will be due to differences in the data sources and emission factors used to compile the 2016 inventory. As a result, totals and shares of emissions of the individual greenhouse gases in the total greenhouse gas emissions in 2016 will be different in the two inventories, in particular for non-CO_2 gases. Also, for the 2017 estimate, countries used national statistics, whereas the EDGAR fast-track estimates rely on international statistics, which will certainly be different due to the somewhat preliminary status of these early statistics. As a result, estimated trends will be different. Since the EEA report does not provide EU totals per greenhouse gas, a more detailed comparison cannot easily be made.

Figure 3.8

Annual increases in GDP and greenhouse gas emissions in the European Union (EU-28), 2004–2017



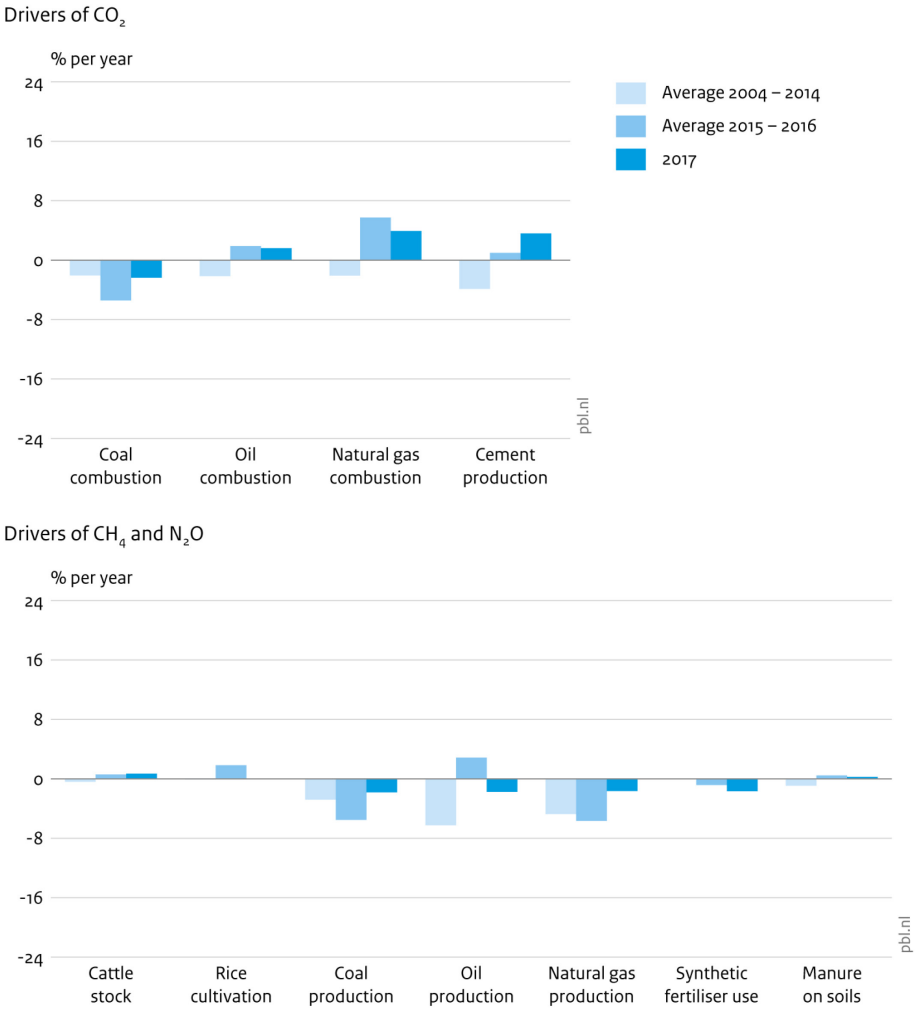
Source: World Bank, IMF; EDGAR v5.0/v4.3.2 FT 2017 (EC-JRC/PBL, 2018).

The trend in total greenhouse gas emissions is mainly set by the trend in CO_2 emissions, which have similarly declined by 1.7% per year since 2004 from 4.3 Gt to 3.5 Gt CO_2 in 2014; they have increased in the following years by the same percentages as total greenhouse gas emissions. In contrast, non-CO_2 emissions saw in the decade starting in 2004 only very small declines of 0.4% on average, while the growth observed in the last three years is almost equal to that of CO_2 and total greenhouse gas. The decreasing CH_4 emissions in the last three years are more than offset by increasing N_2O and F-gas emissions (Figure 3.8). The decreasing methane emissions are mainly due to declining fossil fuel production over more than a decade, in particular coal and natural gas as shown in Figure 3.9.

The 1.1% increase in CO_2 emissions of the European Union in 2017 was mainly due to increases of 4.0% in natural gas consumption and also 1.6% in oil consumption in 2017, partly offset by coal consumption in the EU that declined by 2.2% (BP, 2018) (Figure 3.7). This increase is smaller than the early estimate of 1.8% increase reported by Eurostat based on monthly statistics of fossil fuel consumption per Member State of solids, peat, natural gas and liquids (Eurostat, 2018a). EU countries that have the largest contribution to the total greenhouse natural gas increase in the EU are Germany, Italy, Spain, the Netherlands and Romania. The countries with the largest contribution to the total EU coal use in 2017 are Germany, the United Kingdom, Italy, the Netherlands and Poland (BP, 2018). From this it appears that in Germany, Italy and the Netherlands there is a shift from coal to natural gas.

Figure 3.9

Annual increases in key greenhouse gas drivers in the European Union (EU-28), 2004–2017



Source: IEA, BP, USGS, FAO, IRRI, IFA.

The demand for space heating in 2017 was almost equal to that in 2016, as indicated by the number of so-called *Heating Degree-Days* (3032 and 3025 HDD). These numbers indicate that the winter months of 2016 and 2017 are among the 10 mildest since 1974 (Eurostat, 2018b). Of these 10 mildest winters, 7 occurred in the last decade, 1 in 2000, another in 1994 and the last in 1989. It also implies that, in 2017, the demand for space heating was

about 6% less than on average in the 1970s to 1990s. Similarly, the number of *Cooling Degree Days* in 2017 was more than twice the number than on average in the 1970s to 1990s. These trends in highest and lowest CDDs and HDDs also corroborate the observation by NOAA that the 10 globally warmest years on record are all in this century (NOAA, 2018).

In 2017, the European Union's energy use was still leaning on oil and natural gas: 31% of total primary energy supply (TPES) was provided by oil, 23% by natural gas, 13% by coal, almost 22% by renewable energy—of which 4% is hydropower and 9% is biomass—and 11% by nuclear power. However, compared with seven years ago the shares of coal and natural gas have been decreased each by 2 percentage points and oil by 1 percentage point and that has been achieved by increasing shares of wind and solar power (by 5 percentage points) and of biomass fuels (by 2 percentage points). The shares of hydropower and nuclear power saw no significant changes over these years (IEA, 2017a; BP, 2018).

Electricity production in the European Union was 3.3 GWh in 2017, an increase of 1.0% over 2016 and accounting for 35% of the EU's total CO_2 emissions from fuel combustion. The energy mix of electric power production was in 2017: fossil fuel power plants provided 43% of the total (half coal and half natural gas), hydropower 9%, 20% other renewable power (wind 11%, solar 3% and biomass 6%) and 25% nuclear power (BP, 2018).

Ten EU Member States have ended coal-fired power generation or pledged to phase out by 2030 (Austria, Belgium, Denmark, Finland, France, Italy, Netherlands, Portugal, Sweden, and the United Kingdom). However, at present six EU countries have new coal capacity under development or construction (Germany, Czech Republic, Greece, Hungary, Poland and Romania) (Shearer et al. 2018a). In the United Kingdom the share of coal power decreased from 42% in 2012 to 7% in 2017 as natural gas and renewable power grows and it plans to phase out the remainder by 2025 if the plants do not have *Carbon Capture and Storage* (CCS) (Shearer et al., 2018a). The coal decline was accelerated by the introduction in 2013 of a UK Carbon Price Floor (CPF) cap from 2015 to 2020 that effectively increased the EU ETS CO_2 price from about GBP 5 per tonne of CO_2 in 2012 to GBP 18 per tonne of CO_2 in 2015 by applying a CPF cap from 2015 to 2020 (EIA, 2018b).

For 2018, available fuel statistics for the first 8 months (coal only 7 months) shows that coal consumption in the EU was down by 4.3%, oil products down by 2.6% and natural gas down by 2.4%, compared with the same months in 2017 (Eurostat, 2018c). However, the last third part can significantly modify this, depending on the weather in the last four months from September to December (influencing the demand for space heating and the wind and solar power produced, thereby affecting the demand for natural gas power). When fossil fuel consumption would change likewise in total 2018 then the European Union's CO_2 emissions would decline in 2018.

3.4 India

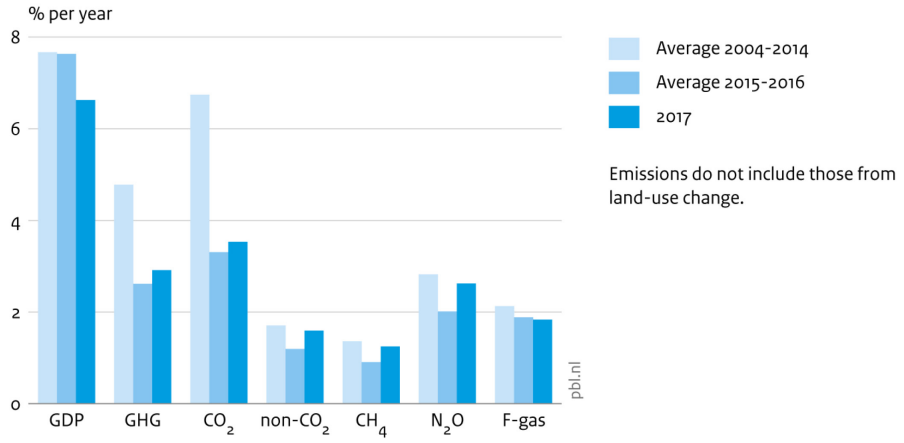
Figure 3.10 shows that, in 2017, India's annual growth in GDP was only about 1 percentage point less than on average in the years before. However, in contrast to the 4.8% annual increase in total greenhouse gas emissions before 2015, the emissions growth was almost half: 2.3% in 2015 and 2.9% in 2016 and 2017, reaching a level of 3.6 Gt CO_2 eq. This was due to CO_2 emissions showing a pattern similar to that of greenhouse gas emissions, whereas non-CO_2 greenhouse gas emissions show a more constant annual trend for all years, also for the three individual gases, CH_4, N_2O and F-gases.

As illustrated in Figure 3.11, it is in particular the lower growth rate of coal consumption since 2015 that is the main cause of lower growth in CO_2 emissions since 2015, as well as of total greenhouse gas emissions. Compared to a growth rate of 7.6% per year on average in the decade before 2015 the annual increases in coal consumption in 2015–2016 of 3.6% and 4.5% in 2017 are substantially lower.

The growth rate of CH_4 emissions is rather moderate, as livestock numbers, which account for half of total CH_4 emissions, are decreasing only very slowly. This does not apply to rice production, but it is a much smaller source. Together with other large CH_4 sources, such as increasing coal mining and increases in landfill and waste water, they add up to net increases in CH_4 emissions by about 1% per year. N_2O emissions similarly add up to net increases of about 2% per year (Figure 3.11).

Figure 3.10

Annual increases in GDP and greenhouse gas emissions in India, 2004–2017



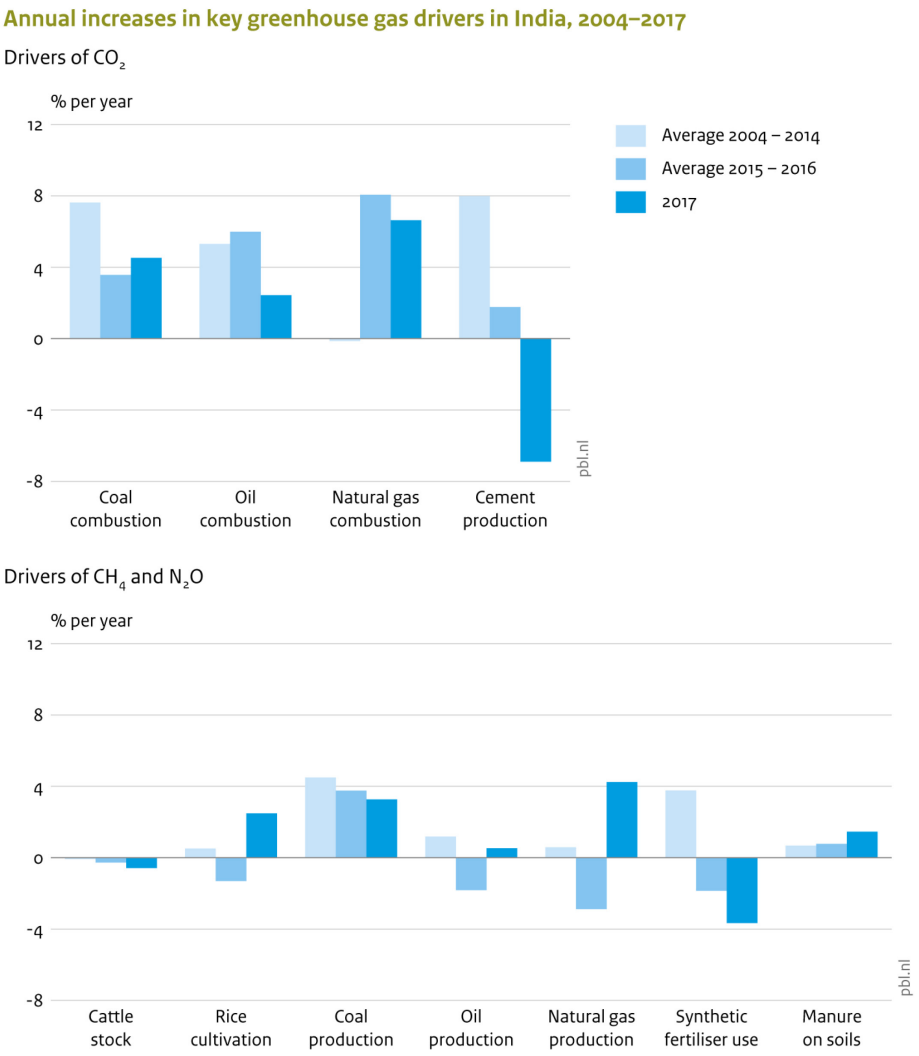
Source: World Bank, IMF; EDGAR v5.0/v4.3.2 FT 2017 (EC-JRC/PBL, 2018).

Coal combustion accounts for more than 70% of India's total fossil fuel combustion CO_2 emissions. Electric power production, with a share of about 50% India's largest source of CO_2 emissions, increased by 5.3% in 2017 to 1.5 GWh. Fossil fuel power plants (93% coal) provided more than 80% of this total, hydropower 9% and 7.5% by other renewable power (wind, solar and biomass each 2.5%) and 2.5% by nuclear power (BP, 2018; IEA, 2017a).

India installed 152 GW of coal power capacity from 2006 to 2017, second only to China. However, in the 2016–2017 financial year, India for the first time added more renewable energy capacity than thermal power capacity. An estimated 65% of the country's present coal power capacity is more costly than new bids for solar and wind power. Therefore, the country's draft 2016 National Electricity Plan calls for rising demand to be met with 275 GW total renewable energy capacity by 2027, without a need for more coal plants besides those under construction (Shearer et al., 2018a).

The second largest source is the manufacturing industry with a share of about a quarter in total CO_2 emissions, of which four fifth stems from coal combustion and half of it stems from iron and steel production, mostly coal use. India is the third largest steel producer after China and Japan and the largest producer of direct reduced iron (DRI). It has in common with the United States that a very large part of crude steel, more than 50%, is produced using electric methods instead of basic oxygen steel furnace that most other large producers use mostly (EIA, 2017).

Figure 3.11



Source: IEA, BP, USGS, FAO, IRRI, IFA.

Unique for India's electric steelmaking is that it uses electric *induction* furnaces for electric-based steelmaking instead of the more common electric arc furnaces. Moreover, it relies on coal, rather than natural gas, to produce direct reduced iron (EIA, 2017). These furnaces tend to operate at much smaller scales than other types, typically a factor of 10 smaller. Since most of the DRI produced in India is powered by coal, it much more carbon intensive than DRI produced in other countries.

In 2017, India's energy use was still heavily leaning on coal: 43% of total primary energy supply (TPES) was provided by coal, 24% by oil, 5% by natural gas, 27% by renewable energy (of which 21 percentage points biomass and 3 percentage points hydropower) and nearly 1% by nuclear power. In 2010 the coal share in TPES was 39%, so it is now 4 percentage points higher than in 2010. Also, the shares of oil and wind plus solar power saw increases of over 1 and 2 percentage points. Natural gas and biomass fuels saw their shares decease by 2 and 4 percentage points.

In the first three quarters of 2018, India's power generation was higher compared with the same period in 2017 (CEIC, 2018). This could suggest increasing CO_2 emissions in 2018, but

only if some of the increase is partly met by coal power, which has sufficient capacity available to meet much higher demands.

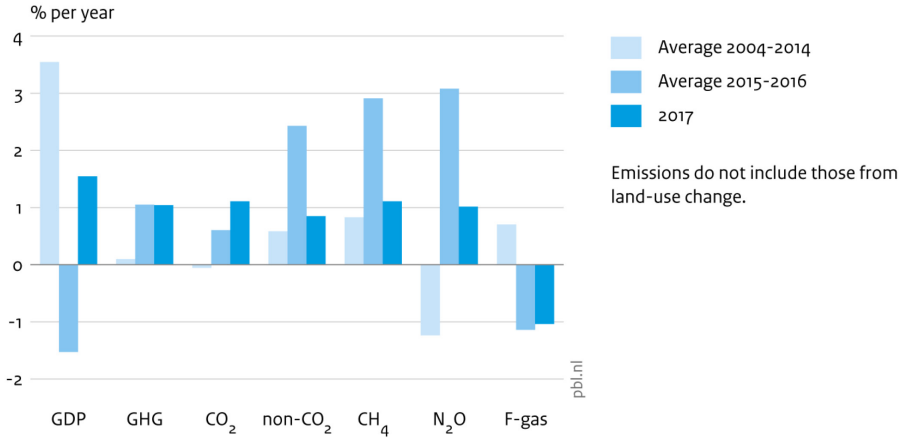
3.5 Russian Federation

Figure 3.12 shows that, in 2017, the annual growth in GDP in Russia of 1.5% was less than half the average growth, in the decade since 2004, after two years of declining GDP. However, in contrast to the trend in GDP, after virtually no growth in the decade since 2004 the increase in total greenhouse gas emissions since 2015 was 1.0% in 2015 and 2016 and 1.0% in 2017, reaching a level of 2.3 Gt CO_2 eq. CO_2 emissions show a similar pattern, whereas non-CO_2 greenhouse gas emissions show a much higher growth rate in 2015–2016, mainly caused by CH_4 and N_2O that follow a similar pattern, except for N_2O emissions, which saw decreases in the years before 2015.

In 2017, CO_2 emissions in the Russian Federation continued to increase, for the third year in a row, by about 1.1% to about 1.8 Gt CO_2. This was mainly due to a 3.5% increase in coal consumption and a 1.1% increase in natural gas consumption, aided by increases in the consumption of oil products of 0.3% and cement production of 3.6% (BP, 2018; USGS, 2018). With a share in fossil fuel CO_2 emissions of more than half, public electricity and heat generation is by far the largest sector. It is also by far the main user of coal and natural gas in Russia. The CO_2 emissions from the fossil fuel mix in power generation is one third coal and about 60% natural gas.

Figure 3.12

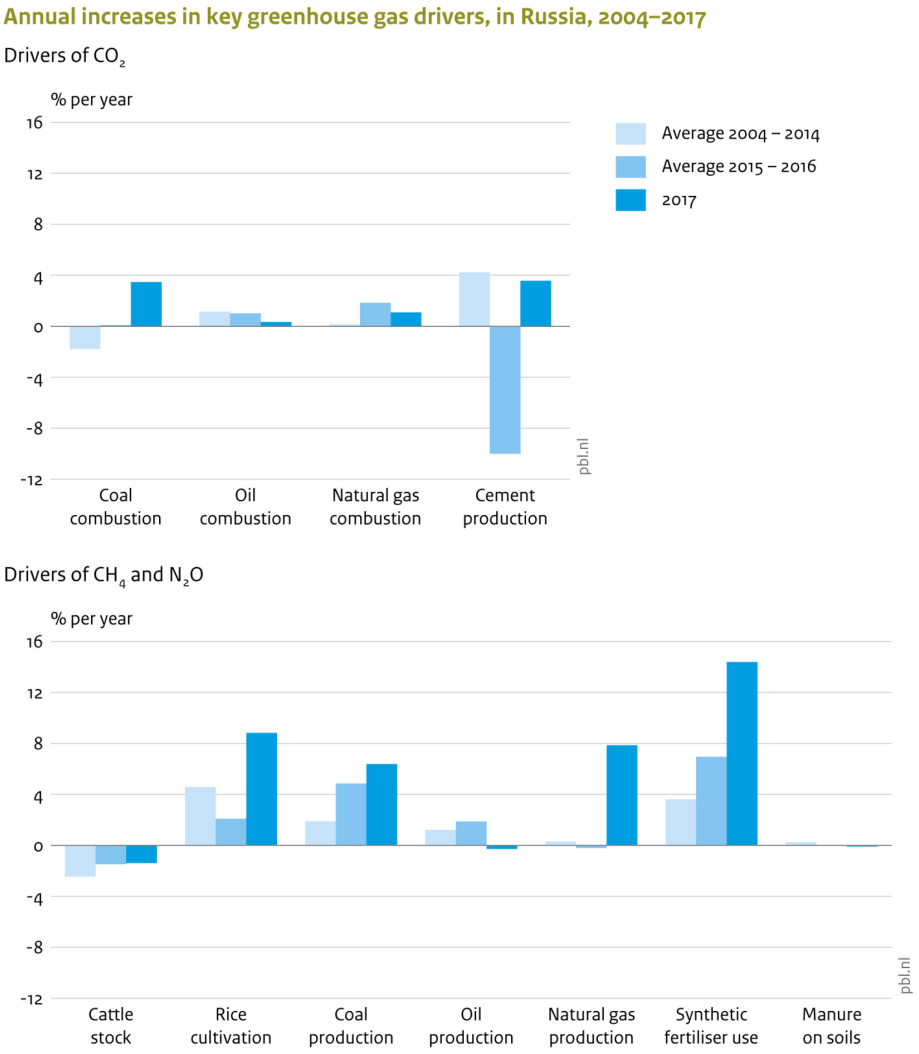
Annual increases in GDP and greenhouse gas emissions in Russia, 2004–2017



Source: World Bank, IMF; EDGAR v5.0/v4.3.2 FT 2017 (EC-JRC/PBL, 2018).

Therefore, it is not surprising that Russia's energy use was leaning on natural gas and oil in 2017. Half of total primary energy supply (TPES) was provided by natural gas and 21% by oil, with shares of coal of 15%, nearly 7% renewable energy (of which 5.5 percentage points hydropower and 1 for biomass power) and 6% nuclear power. In 2010, the natural gas share in TPES was about 54%, which mean that, today, it is 4 percentage points less, whereas the shares of oil and coal have increased accordingly. Apart from hydropower and biomass with a share of 0.1%, the Russian Federation uses hardly any other renewables (wind and solar power).

Figure 3.13



Source: IEA, BP, USGS, FAO, IRRI, IFA.

After two years of 2.9% growth, CH_4 emissions increased by 1.1% in 2017. Fossil fuel production increased in 2017 by 6.4% for coal and 7.9% for natural gas production, whereas oil production saw a small decrease (-0.3%). Gas venting was assumed to follow the same trend as gas flaring, which decreased by 11% in 2017. Together with the decline in livestock numbers, such as 1.4% in cattle, this resulted in a 1.1% increase in total CH_4 emissions in 2017. The 1.0% increase in total N_2O emissions in 2017 was mainly due to increases in fertiliser use, chemical production such as nitric acid, and N-fixing crops (Figure 3.13).

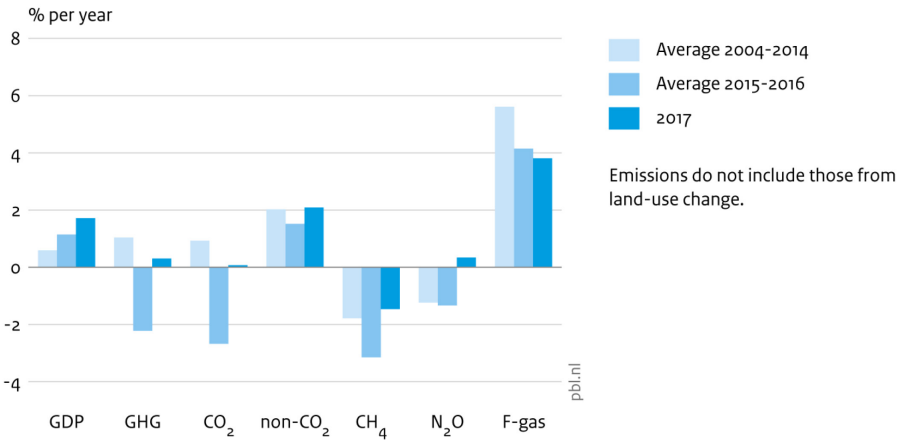
3.6 Japan

In 2017, the annual growth in GDP in Japan was 1.7%, which is significantly higher than in the decade since 2004, when it was 0.6% on average and 1.1% in 2015 and 2016. However, Japan's total greenhouse gas emissions increased, on average, by 1.0% per year, in the decade since 2004 and saw declines of 3.5% and 0.9% in 2015 and 2016. Then, total

greenhouse gas emissions increased slightly by 0.3% in 2017, reaching a level of 1.5 Gt CO_2 eq. This was mainly due to CO_2 emissions showing a similar pattern whereas total non-CO_2 greenhouse gas emissions show a more constant annual trend for all years, also separately for the three gases: CH_4 emissions declining at varying rates since 2004, N_2O emissions decreasing in all years except 2017 and F-gases increasing in all years (Figure 3.14).

Figure 3.14

Annual increases in GDP and greenhouse gas emissions in Japan, 2004–2017



Source: World Bank, IMF; EDGAR v5.0/v4.3.2 FT 2017 (EC-JRC/PBL, 2018).

In 2017, after two years of decreasing emissions, CO_2 emissions in Japan remained at the level of 2016: about 1.3 Gt CO_2. This was mainly due to a 1.4% increase in CO_2 emissions from coal consumption and 0.6% increase in natural gas consumption being offset by the decline of 1.6% in emissions from the consumption of oil products (Figure 3.15) (BP, 2018). With a share in fossil fuel CO_2 emissions of 50%, public electricity and heat generation is by far the largest sector. It is also by far the main user of coal and natural gas in Japan. Currently the CO_2 emissions from the fossil fuel mix in power generation are 55% from coal and about one third from natural gas.

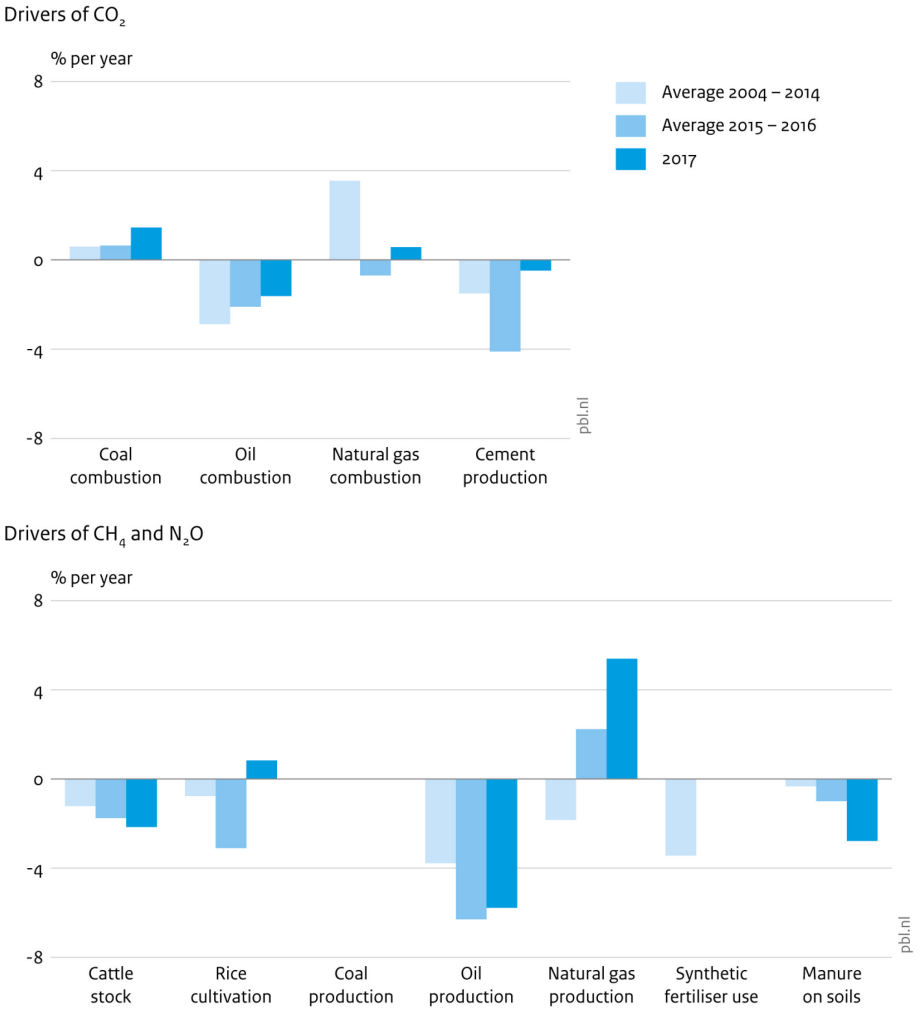
After the Fukushima Daiichi nuclear disaster (caused by the tsunami following the undersea Tōhoku earthquake in 2011), Japan's nuclear plants, which had a share of 30% in power generation in the years before 2011, were almost completely shut down for inspection (EIA, 2013). In 2017, only 4 of the 54 nuclear reactors were in operation (IEA, 2016). To fill the gap, in the following years, natural-gas-fired power production increased by a quarter and coal-fired power production by about 10%. In recent years, renewable power production from wind and solar energy was doubled.

As a result of these changes after 2011, the energy mix in the total energy supply has changed accordingly and was since leaning more on natural gas and coal. Presently 39% of total primary energy supply (TPES) was provided by oil, 26% by coal and 23% by natural gas. In addition, nearly 11% by renewable energy (of which 4 percentage points hydropower, nearly 5 for wind and solar and 2 for biomass). Nuclear power supplies now 1.5% of TPES, down from 17% in 2010 (2.8% of total power generated). Compared with the years before the accident, the shares of natural gas and coal have increased accordingly by 6 and 4 percentage points, and wind and solar power production increased their share from 2.1% in 2011 to 4.8% in 2017.

Regarding coal power, Japan has commissioned 5 GW of coal-fired capacity since 2006, proposed another 13.5 GW and has 5 GW under construction. About 2.5 GW of proposed coal

Figure 3.15

Annual increases in key greenhouse gas drivers, in Japan, 2004–2017



Source: IEA, BP, USGS, FAO, IRRI, IFA.

capacity was suspended in 2017 (Shearer et al., 2018a). Japan has set 2030 power generation target shares of 26% for coal, 27% for natural gas and 22% for nuclear energy. The power sector's interest in building high-efficiency coal-fired power plants with use of CCS is increasing (Nakayama, 2017).

The decreasing CH_4 emissions were caused mainly by decreasing livestock. As illustrated in Figure 3.15 cattle stock declined from 1.2% per year in the decade since 2004, to 1.8 % in 2015–2016 and 2.2% in 2017, and decreasing rice production by 0.8% per year before 2015 and 3.1% in 2015–2016) except in 2017 when it increased by 0.8% (Figure 3.15). Methane emissions from livestock and rice account for two thirds of Japan's CH_4 emissions (26% and 40% in 2017). Decreasing emissions from landfill and waste water with a share of 17% (not shown) adds to these two thirds. The percentage changes in natural gas and oil production are quite large, but these are very minor sources. N_2O emissions in Japan have been decreasing for many years as the cattle stock decreases over time, also manure in stables decreases. Also, N_2O emissions from chemical production decreased rapidly by applying abatement control technologies. However, some other sources are increasing, such as power generation using biomass fuel (UNFCCC, 2018).

Appendices

A. CO_2 emissions per country, per capita, and per USD of GDP

We note that, for CO_2 emissions, the estimated uncertainty is generally between 2% to 5%, with exceptions of up to 10% or 15%. For CO_2 emissions per USD of GDP, the uncertainty is estimated to be larger, generally at about 10%, but for some countries, such as the Russian Federation and China, this is about 20%, due to the uncertainty estimate in the GDP data.

Table A.1 CO_2 emissions per country and group, 1990–2017[12] (unit: Gt CO_2)

CO_2 emissions per country/group, 1990-2017[x] (unit: Gt CO_2)																													
ISO country/group	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Country/group**
CHN	**2.43**	**2.57**	**2.71**	**2.93**	**3.11**	**3.42**	**3.40**	**3.46**	**3.55**	**3.48**	**3.71**	**3.89**	**4.19**	**4.86**	**5.60**	**6.30**	**7.01**	**7.68**	**7.85**	**8.41**	**9.17**	**10.07**	**10.30**	**10.76**	**10.85**	**10.85**	**10.82**	**10.92**	**China**
USA	**5.09**	**5.05**	**5.13**	**5.25**	**5.33**	**5.38**	**5.53**	**5.70**	**5.72**	**5.74**	**5.94**	**5.88**	**5.80**	**5.88**	**5.96**	**5.97**	**5.87**	**5.95**	**5.75**	**5.34**	**5.58**	**5.45**	**5.27**	**5.34**	**5.41**	**5.25**	**5.15**	**5.11**	**United States**
EU28	**4.41**	**4.36**	**4.20**	**4.12**	**4.10**	**4.15**	**4.27**	**4.17**	**4.16**	**4.10**	**4.12**	**4.19**	**4.16**	**4.27**	**4.27**	**4.25**	**4.27**	**4.22**	**4.12**	**3.79**	**3.92**	**3.77**	**3.73**	**3.63**	**3.47**	**3.51**	**3.51**	**3.55**	**European Union**
FRA	0.39	0.41	0.40	0.38	0.37	0.38	0.40	0.39	0.41	0.40	0.40	0.41	0.40	0.40	0.41	0.41	0.40	0.39	0.38	0.37	0.38	0.35	0.35	0.35	0.32	0.33	0.33	0.34	*France*
DEU	1.02	1.00	0.94	0.93	0.92	0.92	0.95	0.91	0.91	0.87	0.87	0.89	0.87	0.87	0.86	0.84	0.85	0.82	0.83	0.77	0.82	0.79	0.80	0.82	0.78	0.79	0.80	0.80	*Germany*
ITA	0.43	0.43	0.43	0.42	0.41	0.44	0.43	0.44	0.45	0.46	0.46	0.46	0.47	0.49	0.50	0.50	0.49	0.49	0.47	0.42	0.43	0.42	0.40	0.36	0.34	0.35	0.36	0.36	*Italy*
NLD	0.16	0.17	0.17	0.17	0.17	0.18	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.18	0.18	0.18	0.17	0.19	0.17	0.17	0.17	0.16	0.18	0.18	0.17	*Netherlands*
POL	0.37	0.37	0.36	0.36	0.35	0.36	0.37	0.36	0.33	0.32	0.31	0.31	0.30	0.31	0.32	0.32	0.33	0.33	0.32	0.31	0.33	0.33	0.32	0.31	0.30	0.30	0.32	0.32	*Poland*
ESP	0.23	0.24	0.25	0.23	0.24	0.25	0.25	0.26	0.27	0.30	0.31	0.31	0.33	0.34	0.35	0.37	0.36	0.37	0.34	0.30	0.29	0.29	0.28	0.26	0.26	0.27	0.26	0.28	*Spain*
GBR	0.59	0.60	0.58	0.57	0.56	0.55	0.57	0.55	0.55	0.55	0.55	0.57	0.55	0.56	0.56	0.56	0.56	0.55	0.54	0.49	0.50	0.46	0.49	0.47	0.43	0.42	0.39	0.38	*United Kingdom*
IND	**0.61**	**0.65**	**0.67**	**0.70**	**0.74**	**0.79**	**0.83**	**0.87**	**0.88**	**0.95**	**0.99**	**1.00**	**1.04**	**1.07**	**1.16**	**1.21**	**1.29**	**1.40**	**1.49**	**1.66**	**1.75**	**1.85**	**1.99**	**2.03**	**2.22**	**2.29**	**2.37**	**2.45**	**India**
RUS	**2.38**	**2.34**	**2.15**	**1.96**	**1.79**	**1.75**	**1.70**	**1.59**	**1.59**	**1.64**	**1.68**	**1.68**	**1.67**	**1.74**	**1.73**	**1.73**	**1.77**	**1.77**	**1.76**	**1.65**	**1.73**	**1.82**	**1.80**	**1.74**	**1.72**	**1.73**	**1.75**	**1.76**	**Russian Federation**
JPN	**1.15**	**1.15**	**1.16**	**1.15**	**1.21**	**1.22**	**1.23**	**1.23**	**1.19**	**1.23**	**1.24**	**1.23**	**1.27**	**1.27**	**1.27**	**1.28**	**1.26**	**1.30**	**1.21**	**1.15**	**1.20**	**1.25**	**1.29**	**1.31**	**1.39**	**1.34**	**1.32**	**1.32**	**Japan**
Other OECD G20	**1.44**	**1.48**	**1.53**	**1.57**	**1.65**	**1.70**	**1.78**	**1.86**	**1.85**	**1.88**	**2.02**	**2.01**	**2.03**	**2.09**	**2.14**	**2.18**	**2.23**	**2.32**	**2.32**	**2.28**	**2.36**	**2.43**	**2.47**	**2.46**	**2.46**	**2.50**	**2.56**	**2.63**	**Other OECD G20**
AUS	0.28	0.28	0.28	0.29	0.29	0.30	0.31	0.32	0.34	0.35	0.35	0.36	0.37	0.37	0.39	0.39	0.40	0.41	0.41	0.42	0.41	0.41	0.41	0.41	0.40	0.40	0.40	0.40	*Australia*
CAN	0.46	0.45	0.46	0.46	0.48	0.49	0.50	0.52	0.53	0.54	0.56	0.55	0.56	0.58	0.57	0.58	0.57	0.61	0.59	0.55	0.57	0.58	0.58	0.59	0.59	0.59	0.60	0.62	*Canada*
MEX	0.29	0.31	0.31	0.32	0.35	0.33	0.34	0.36	0.38	0.37	0.40	0.40	0.40	0.42	0.43	0.45	0.46	0.47	0.47	0.46	0.48	0.49	0.51	0.50	0.48	0.49	0.52	0.51	*Mexico*
KOR	0.27	0.30	0.31	0.34	0.37	0.40	0.43	0.45	0.39	0.42	0.48	0.50	0.49	0.50	0.52	0.51	0.52	0.53	0.54	0.55	0.60	0.63	0.63	0.63	0.63	0.65	0.65	0.67	*South Korea*
TUR	0.15	0.15	0.16	0.16	0.16	0.18	0.19	0.20	0.21	0.20	0.23	0.21	0.22	0.23	0.24	0.25	0.27	0.30	0.30	0.30	0.31	0.33	0.35	0.33	0.36	0.37	0.39	0.43	*Turkey*
Other G20	**0.98**	**1.00**	**1.03**	**1.07**	**1.12**	**1.18**	**1.25**	**1.32**	**1.36**	**1.38**	**1.42**	**1.45**	**1.48**	**1.56**	**1.64**	**1.68**	**1.74**	**1.82**	**1.91**	**1.88**	**2.00**	**2.04**	**2.14**	**2.22**	**2.33**	**2.33**	**2.30**	**2.32**	**Other G20 countries**
ARG	0.11	0.12	0.12	0.12	0.12	0.13	0.14	0.14	0.15	0.15	0.15	0.14	0.13	0.15	0.16	0.17	0.18	0.18	0.20	0.19	0.19	0.20	0.21	0.20	0.21	0.21	0.21	0.21	*Argentina*
BRA	0.23	0.24	0.24	0.25	0.26	0.28	0.30	0.32	0.33	0.34	0.36	0.36	0.36	0.36	0.38	0.38	0.38	0.40	0.42	0.39	0.45	0.47	0.50	0.53	0.56	0.53	0.49	0.49	*Brazil*
IDN	0.16	0.17	0.18	0.20	0.21	0.24	0.25	0.28	0.28	0.30	0.29	0.32	0.32	0.35	0.36	0.36	0.38	0.40	0.39	0.41	0.42	0.43	0.44	0.45	0.48	0.49	0.49	0.51	*Indonesia*
SAU	0.17	0.17	0.19	0.20	0.22	0.22	0.23	0.23	0.25	0.25	0.26	0.27	0.29	0.30	0.32	0.34	0.36	0.38	0.41	0.44	0.48	0.50	0.53	0.56	0.60	0.62	0.63	0.64	*Saudi Arabia*
SAF	0.31	0.30	0.30	0.30	0.31	0.32	0.33	0.35	0.36	0.34	0.35	0.36	0.37	0.39	0.42	0.43	0.44	0.46	0.49	0.45	0.46	0.45	0.46	0.47	0.48	0.48	0.48	0.47	*South Africa*
Total G20	**18.48**	**18.60**	**18.57**	**18.75**	**19.04**	**19.59**	**19.99**	**20.20**	**20.29**	**20.40**	**21.12**	**21.33**	**21.65**	**22.73**	**23.78**	**24.61**	**25.43**	**26.46**	**26.41**	**26.16**	**27.71**	**28.67**	**28.99**	**29.50**	**29.87**	**29.80**	**29.78**	**30.07**	**Total Group of Twenty (G20)**
Other large emitting cr	**1.68**	**1.70**	**1.67**	**1.58**	**1.51**	**1.53**	**1.52**	**1.52**	**1.49**	**1.55**	**1.60**	**1.65**	**1.70**	**1.81**	**1.88**	**1.96**	**2.03**	**2.12**	**2.16**	**2.05**	**2.16**	**2.21**	**2.23**	**2.28**	**2.26**	**2.20**	**2.26**	**2.31**	**Other large emitting countries**
EGY	0.09	0.09	0.10	0.10	0.09	0.10	0.11	0.11	0.12	0.13	0.13	0.14	0.14	0.15	0.16	0.18	0.19	0.20	0.20	0.21	0.21	0.22	0.23	0.23	0.23	0.24	0.25	0.26	*Egypt*
IRN	0.21	0.23	0.24	0.24	0.27	0.28	0.29	0.30	0.30	0.33	0.35	0.37	0.38	0.40	0.43	0.47	0.50	0.54	0.55	0.57	0.57	0.58	0.59	0.61	0.63	0.62	0.64	0.67	*Iran*
KAZ	0.25	0.26	0.26	0.23	0.21	0.18	0.16	0.14	0.14	0.13	0.13	0.13	0.14	0.16	0.17	0.18	0.20	0.21	0.25	0.23	0.24	0.26	0.26	0.27	0.26	0.25	0.25	0.27	*Kazakhstan*
MYS	0.06	0.07	0.07	0.08	0.08	0.09	0.10	0.11	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.21	0.22	0.20	0.22	0.22	0.22	0.24	0.25	0.25	0.26	0.26	*Malaysia*
NGA	0.07	0.08	0.09	0.08	0.08	0.09	0.10	0.10	0.09	0.09	0.10	0.11	0.10	0.11	0.10	0.10	0.09	0.08	0.09	0.08	0.09	0.10	0.09	0.09	0.09	0.09	0.09	0.09	*Nigeria*
TWN	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.23	0.23	0.24	0.25	0.26	0.27	0.28	0.28	0.27	0.25	0.27	0.27	0.26	0.26	0.27	0.27	0.27	0.28	*Taiwan*
THA	0.09	0.10	0.11	0.13	0.14	0.16	0.18	0.19	0.16	0.17	0.17	0.18	0.19	0.20	0.22	0.23	0.23	0.24	0.24	0.23	0.25	0.24	0.26	0.27	0.27	0.27	0.27	0.28	*Thailand*
UKR	0.78	0.74	0.65	0.57	0.47	0.46	0.39	0.38	0.36	0.36	0.36	0.36	0.36	0.38	0.36	0.35	0.36	0.36	0.35	0.29	0.31	0.33	0.32	0.30	0.26	0.21	0.23	0.21	*Ukraine*
Remaining	**1.88**	**1.84**	**1.79**	**1.81**	**1.84**	**1.90**	**1.95**	**2.05**	**2.05**	**2.06**	**2.13**	**2.20**	**2.24**	**2.29**	**2.39**	**2.49**	**2.56**	**2.63**	**2.77**	**2.80**	**2.93**	**2.98**	**3.14**	**3.19**	**3.26**	**3.32**	**3.41**	**3.47**	**Remaining countries (186)**
Int. transport	**0.63**	**0.64**	**0.68**	**0.67**	**0.69**	**0.72**	**0.74**	**0.77**	**0.79**	**0.83**	**0.85**	**0.82**	**0.86**	**0.87**	**0.95**	**0.99**	**1.05**	**1.10**	**1.10**	**1.05**	**1.12**	**1.14**	**1.09**	**1.10**	**1.13**	**1.19**	**1.21**	**1.22**	**International transport**
Total	**22.67**	**22.78**	**22.70**	**22.80**	**23.08**	**23.74**	**24.20**	**24.54**	**24.63**	**24.83**	**25.70**	**25.99**	**26.45**	**27.70**	**29.00**	**30.05**	**31.07**	**32.31**	**32.45**	**32.07**	**33.92**	**35.01**	**35.45**	**36.06**	**36.52**	**36.51**	**36.65**	**37.07**	**Total**

[12] Available for all countries on http://edgar.jrc.ec.europa.eu/overview.php?v=booklet2018. Totals and sub-totals may differ due to independent rounding. The number of digits does not indicate the accuracy of the figures, See uncertainty information in the Appendix.

Table A.2 CO_2 emissions per capita, per country and group, 1990–2017[13] (unit: tonnes of CO_2 per person)

CO_2 emissions per capita per country/group, 1990-2017[x] (tonnes of CO_2 per person)																													
ISO country/group	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Country/group
CHN	**2.06**	**2.15**	**2.24**	**2.40**	**2.52**	**2.74**	**2.71**	**2.73**	**2.78**	**2.72**	**2.88**	**3.00**	**3.21**	**3.70**	**4.24**	**4.75**	**5.24**	**5.72**	**5.81**	**6.19**	**6.71**	**7.33**	**7.45**	**7.74**	**7.77**	**7.73**	**7.67**	**7.71**	**China**
USA	**20.14**	**19.79**	**19.92**	**20.19**	**20.27**	**20.25**	**20.57**	**20.96**	**20.75**	**20.58**	**21.07**	**20.65**	**20.19**	**20.27**	**20.39**	**20.23**	**19.70**	**19.78**	**18.97**	**17.44**	**18.08**	**17.53**	**16.83**	**16.93**	**17.04**	**16.40**	**15.97**	**15.74**	**United States**
EU28	**9.24**	**9.11**	**8.76**	**8.56**	**8.50**	**8.59**	**8.80**	**8.60**	**8.57**	**8.43**	**8.46**	**8.57**	**8.49**	**8.68**	**8.66**	**8.58**	**8.58**	**8.46**	**8.23**	**7.55**	**7.78**	**7.46**	**7.37**	**7.18**	**6.84**	**6.92**	**6.91**	**6.97**	**European Union**
FRA	6.78	7.16	6.93	6.55	6.43	6.55	6.78	6.61	6.95	6.81	6.74	6.79	6.65	6.69	6.66	6.67	6.46	6.32	6.17	5.88	6.00	5.49	5.49	5.50	4.98	5.08	5.13	5.20	*France*
DEU	12.87	12.52	11.78	11.61	11.42	11.31	11.62	11.21	11.12	10.72	10.69	10.88	10.68	10.69	10.50	10.25	10.47	10.11	10.22	9.50	10.09	9.77	9.92	10.11	9.63	9.67	9.75	9.70	*Germany*
ITA	7.54	7.52	7.47	7.35	7.24	7.67	7.59	7.66	7.85	7.97	8.03	7.99	8.09	8.36	8.50	8.47	8.33	8.18	7.89	7.00	7.16	6.99	6.64	6.10	5.78	5.96	6.00	6.08	*Italy*
NLD	10.79	11.14	10.95	11.15	11.10	11.47	12.07	11.49	11.47	11.10	11.08	11.31	11.28	11.35	11.44	11.09	10.77	10.80	10.83	10.49	11.12	10.38	10.25	10.18	9.70	10.37	10.41	10.26	*Netherlands*
POL	9.78	9.68	9.41	9.38	9.21	9.25	9.61	9.37	8.65	8.41	8.10	8.02	7.85	8.18	8.26	8.24	8.60	8.59	8.45	8.09	8.55	8.49	8.28	8.15	7.84	7.92	8.24	8.36	*Poland*
ESP	5.85	6.03	6.23	5.85	6.09	6.39	6.13	6.59	6.79	7.30	7.62	7.53	7.86	7.91	8.16	8.38	8.04	8.21	7.42	6.49	6.16	6.18	6.08	5.51	5.50	5.84	5.69	6.09	*Spain*
GBR	10.30	10.41	10.15	9.85	9.72	9.55	9.84	9.40	9.40	9.30	9.38	9.57	9.27	9.46	9.41	9.31	9.24	8.98	8.64	7.74	7.94	7.25	7.58	7.30	6.67	6.37	5.95	5.73	*United Kingdom*
IND	**0.70**	**0.73**	**0.74**	**0.75**	**0.78**	**0.82**	**0.85**	**0.87**	**0.87**	**0.92**	**0.94**	**0.94**	**0.96**	**0.96**	**1.03**	**1.06**	**1.11**	**1.19**	**1.24**	**1.37**	**1.42**	**1.48**	**1.57**	**1.59**	**1.72**	**1.75**	**1.79**	**1.83**	**India**
RUS	**16.12**	**15.81**	**14.51**	**13.18**	**12.06**	**11.78**	**11.50**	**10.75**	**10.80**	**11.15**	**11.44**	**11.54**	**11.51**	**12.01**	**12.04**	**12.07**	**12.35**	**12.38**	**12.28**	**11.56**	**12.10**	**12.69**	**12.54**	**12.14**	**12.00**	**12.02**	**12.12**	**12.26**	**Russian Federation**
JPN	**9.23**	**9.23**	**9.26**	**9.15**	**9.57**	**9.66**	**9.74**	**9.67**	**9.34**	**9.64**	**9.73**	**9.62**	**9.92**	**9.93**	**9.91**	**9.95**	**9.81**	**10.12**	**9.44**	**8.92**	**9.31**	**9.73**	**10.04**	**10.24**	**10.87**	**10.44**	**10.33**	**10.36**	**Japan**
Other OECD G20	**5.56**	**5.63**	**5.70**	**5.79**	**5.97**	**6.06**	**6.27**	**6.45**	**6.32**	**6.37**	**6.75**	**6.63**	**6.65**	**6.76**	**6.82**	**6.89**	**6.96**	**7.14**	**7.04**	**6.84**	**7.01**	**7.12**	**7.14**	**7.01**	**6.94**	**6.96**	**7.06**	**7.16**	**Other OECD G20**
AUS	16.16	16.04	16.06	16.12	16.35	16.73	17.14	17.44	18.37	18.44	18.56	18.70	18.92	18.91	19.38	19.35	19.34	19.50	19.29	19.19	18.66	18.26	17.96	17.51	16.88	16.94	16.68	16.45	*Australia*
CAN	16.46	16.01	16.25	16.04	16.40	16.70	16.97	17.38	17.45	17.62	18.17	17.72	17.76	18.20	17.79	18.00	17.60	18.38	17.55	16.31	16.60	16.73	16.52	16.69	16.62	16.33	16.57	16.85	*Canada*
MEX	3.40	3.54	3.51	3.53	3.75	3.47	3.58	3.71	3.88	3.72	3.90	3.83	3.84	3.99	4.03	4.13	4.22	4.22	4.16	4.01	4.08	4.10	4.20	4.05	3.90	3.92	4.09	3.93	*Mexico*
KOR	6.29	6.81	7.16	7.77	8.28	8.91	9.39	9.80	8.30	9.01	10.17	10.39	10.24	10.27	10.62	10.57	10.67	10.85	11.02	11.13	12.04	12.59	12.58	12.62	12.52	12.77	12.81	13.21	*South Korea*
TUR	2.78	2.78	2.83	2.88	2.83	3.02	3.25	3.36	3.35	3.26	3.60	3.22	3.34	3.46	3.51	3.63	3.97	4.31	4.29	4.16	4.27	4.48	4.64	4.39	4.62	4.67	4.87	5.32	*Turkey*
Other G20	**2.35**	**2.36**	**2.37**	**2.43**	**2.50**	**2.60**	**2.71**	**2.82**	**2.85**	**2.85**	**2.89**	**2.91**	**2.93**	**3.04**	**3.17**	**3.19**	**3.27**	**3.37**	**3.50**	**3.40**	**3.57**	**3.60**	**3.73**	**3.82**	**3.97**	**3.92**	**3.83**	**3.82**	**Other G20 countries**
ARG	3.44	3.49	3.55	3.51	3.59	3.66	3.83	3.99	4.06	4.15	4.06	3.76	3.51	3.81	4.19	4.23	4.45	4.60	4.85	4.56	4.64	4.79	4.88	4.75	4.89	4.89	4.84	4.74	*Argentina*
BRA	1.53	1.55	1.55	1.59	1.61	1.71	1.82	1.92	1.94	1.96	2.06	2.04	2.01	1.98	2.05	2.04	2.03	2.10	2.18	2.02	2.26	2.34	2.50	2.64	2.74	2.58	2.37	2.35	*Brazil*
IDN	0.89	0.95	0.97	1.05	1.10	1.21	1.26	1.36	1.36	1.42	1.39	1.47	1.48	1.60	1.60	1.59	1.67	1.70	1.67	1.71	1.72	1.75	1.78	1.77	1.90	1.90	1.87	1.94	*Indonesia*
SAU	10.18	10.24	10.83	11.13	11.86	11.51	11.97	11.88	12.36	12.38	12.72	12.88	13.31	13.51	13.86	14.20	14.63	15.03	15.92	16.37	17.43	17.68	18.25	18.78	19.36	19.67	19.50	19.39	*Saudi Arabia*
SAF	8.32	7.92	7.57	7.43	7.43	7.67	7.79	8.00	8.01	7.51	7.55	7.65	7.83	8.22	8.76	8.87	8.86	9.14	9.64	8.92	9.01	8.53	8.71	8.79	8.88	8.63	8.51	8.25	*South Africa*
Total G20	**4.96**	**4.92**	**4.85**	**4.84**	**4.86**	**4.94**	**4.99**	**4.99**	**4.96**	**4.93**	**5.06**	**5.06**	**5.09**	**5.29**	**5.48**	**5.62**	**5.76**	**5.93**	**5.87**	**5.76**	**6.05**	**6.21**	**6.23**	**6.29**	**6.31**	**6.25**	**6.20**	**6.22**	**Total Group of Twenty (G20)**
Other large emitting cr	**4.51**	**4.50**	**4.34**	**4.05**	**3.82**	**3.82**	**3.74**	**3.70**	**3.57**	**3.64**	**3.72**	**3.78**	**3.85**	**4.02**	**4.12**	**4.24**	**4.34**	**4.45**	**4.48**	**4.19**	**4.33**	**4.38**	**4.34**	**4.36**	**4.25**	**4.09**	**4.12**	**4.16**	**Other large emitting countries**
EGY	1.58	1.58	1.61	1.58	1.48	1.55	1.63	1.71	1.76	1.86	1.80	1.95	1.97	1.97	2.10	2.30	2.40	2.53	2.49	2.55	2.52	2.55	2.65	2.55	2.55	2.56	2.63	2.65	*Egypt*
IRN	3.68	3.96	4.17	4.09	4.58	4.59	4.71	4.83	4.73	5.12	5.32	5.45	5.62	5.87	6.23	6.64	7.05	7.44	7.50	7.70	7.64	7.68	7.68	7.87	8.06	7.83	[7.92]	8.27	*Iran*
KAZ	15.14	15.66	16.01	13.76	12.66	11.34	10.08	8.89	9.24	8.53	8.71	8.55	9.47	10.43	11.14	11.73	12.96	13.53	15.82	13.95	14.82	15.61	15.19	15.86	14.85	14.21	14.13	14.62	*Kazakhstan*
MYS	3.28	3.82	3.89	4.21	4.23	4.45	4.95	5.17	4.99	5.34	5.71	5.81	6.13	6.39	6.77	7.11	7.27	7.80	8.14	7.21	7.73	7.62	7.60	8.02	8.30	8.16	8.21	8.18	*Malaysia*
NGA	0.72	0.78	0.85	0.82	0.76	0.82	0.93	0.89	0.79	0.76	0.82	0.84	0.74	0.80	0.76	0.72	0.63	0.56	0.59	0.50	0.57	0.58	0.54	0.52	0.48	0.49	0.47	0.50	*Nigeria*
TWN	6.12	6.51	6.84	7.25	7.61	7.96	8.35	8.94	9.38	9.71	10.51	10.67	10.97	11.33	11.65	11.91	12.15	12.25	11.70	11.04	11.73	11.68	11.28	11.30	11.32	11.36	11.51	11.84	*Taiwan*
THA	1.64	1.80	1.95	2.19	2.43	2.72	3.03	3.05	2.66	2.75	2.72	2.84	2.98	3.10	3.36	3.45	3.48	3.56	3.59	3.47	3.65	3.62	3.87	3.98	3.90	3.94	3.99	4.05	*Thailand*
UKR	15.22	14.36	12.62	11.03	9.16	9.07	7.81	7.56	7.28	7.33	7.33	7.38	7.46	8.00	7.66	7.56	7.62	7.79	7.51	6.26	6.74	7.15	7.00	6.76	5.89	4.81	5.11	4.65	*Ukraine*
Remaining	**1.53**	**1.46**	**1.38**	**1.37**	**1.36**	**1.37**	**1.38**	**1.42**	**1.39**	**1.37**	**1.38**	**1.40**	**1.40**	**1.40**	**1.44**	**1.46**	**1.48**	**1.49**	**1.54**	**1.52**	**1.56**	**1.56**	**1.61**	**1.60**	**1.61**	**1.60**	**1.61**	**1.61**	**Remaining countries (186)**
Int. transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**International transport**
Total	**4.25**	**4.21**	**4.13**	**4.08**	**4.07**	**4.13**	**4.15**	**4.15**	**4.12**	**4.10**	**4.18**	**4.18**	**4.20**	**4.34**	**4.49**	**4.60**	**4.69**	**4.82**	**4.78**	**4.67**	**4.88**	**4.97**	**4.98**	**5.00**	**5.01**	**4.95**	**4.91**	**4.91**	**Total**

[13] Available for all countries on http://edgar.jrc.ec.europa.eu/overview.php?v=booklet2018. Totals and sub-totals may differ due to independent rounding. The number of digits does not indicate the accuracy of the figures, See uncertainty information in the Appendix.

Table A.3 CO_2 emissions per USD of GDP, per country and group, 1990–2017[14] (unit: kg CO_2 per 1,000 USD of GDP [PPP, 2011 prices])

CO_2 emissions per USD of GDP per country/group, 1990-2017[x] (unit: kg CO_2 per 1000 USD of GDP [PPP, 2011 prices])																														
ISO country/group	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Country/group
CHN	**1290**	**1250**	**1160**	**1110**	**1040**	**1040**	**940**	**880**	**840**	**770**	**760**	**730**	**730**	**770**	**810**	**820**	**800**	**770**	**720**	**710**	**700**	**700**	**670**	**650**	**610**	**570**	**530**	**500**	**China**
USA	**550**	**550**	**540**	**530**	**520**	**510**	**510**	**500**	**480**	**460**	**460**	**450**	**440**	**430**	**420**	**410**	**390**	**390**	**380**	**360**	**370**	**350**	**330**	**330**	**330**	**310**	**300**	**290**	**United States**
EU28	**370**	**360**	**350**	**340**	**330**	**320**	**330**	**310**	**300**	**290**	**280**	**280**	**270**	**270**	**270**	**260**	**250**	**240**	**230**	**220**	**230**	**220**	**210**	**210**	**190**	**190**	**190**	**190**	**European Union**
FRA	220	230	220	210	210	210	210	200	210	200	190	190	180	180	180	180	170	160	160	160	160	140	140	140	130	130	130	130	*France*
DEU	410	380	350	350	340	330	340	320	310	300	290	290	280	290	280	270	260	250	250	240	250	230	230	240	220	220	220	210	*Germany*
ITA	240	240	240	230	230	230	230	230	230	230	220	220	220	230	230	230	220	220	210	200	200	190	190	180	170	170	170	170	*Italy*
NLD	340	340	330	340	330	330	340	310	300	280	270	270	270	270	270	260	240	230	230	230	250	230	230	230	210	220	220	210	*Netherlands*
POL	950	1010	960	930	870	820	800	730	650	600	550	540	520	520	500	480	470	440	420	390	400	370	360	350	320	320	320	310	*Poland*
ESP	250	250	260	250	250	260	240	250	250	260	260	250	250	250	260	260	240	240	220	200	190	190	200	180	180	180	170	180	*Spain*
GBR	380	390	380	360	350	330	340	310	300	290	280	280	270	260	260	250	240	230	230	220	220	200	210	200	180	160	150	140	*United Kingdom*
IND	**400**	**420**	**410**	**410**	**410**	**400**	**390**	**400**	**380**	**380**	**380**	**360**	**360**	**350**	**350**	**330**	**320**	**320**	**330**	**340**	**320**	**320**	**330**	**310**	**320**	**300**	**290**	**290**	**India**
RUS	**780**	**810**	**870**	**860**	**900**	**920**	**930**	**860**	**900**	**870**	**810**	**780**	**740**	**710**	**670**	**630**	**590**	**540**	**510**	**520**	**520**	**520**	**500**	**480**	**470**	**480**	**490**	**490**	**Russian Federation**
JPN	**300**	**300**	**290**	**290**	**300**	**300**	**290**	**290**	**280**	**290**	**290**	**280**	**290**	**290**	**280**	**280**	**270**	**280**	**260**	**260**	**260**	**270**	**280**	**280**	**290**	**280**	**270**	**270**	**Japan**
Other OECD G20	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**380**	**380**	**380**	**380**	**370**	**370**	**360**	**350**	**350**	**350**	**340**	**350**	**340**	**330**	**330**	**320**	**310**	**300**	**300**	**300**	**Other OECD G20**
AUS	560	570	570	560	550	550	550	540	550	530	520	520	510	500	500	490	490	480	470	470	450	440	420	410	390	380	370	370	*Australia*
CAN	520	530	540	520	520	520	520	520	510	490	480	470	460	470	450	440	430	440	420	410	410	400	400	400	390	380	380	380	*Canada*
MEX	260	270	260	260	260	260	260	260	260	250	250	250	250	260	260	260	260	260	260	260	260	260	260	250	230	230	240	230	*Mexico*
KOR	540	540	540	550	540	540	530	530	480	470	490	490	450	440	440	420	400	390	390	390	400	400	390	390	370	370	360	360	*South Korea*
TUR	240	250	240	230	240	250	250	240	240	250	260	250	250	250	230	220	230	240	240	250	240	230	230	200	210	200	200	210	*Turkey*
Other G20	**260**	**250**	**250**	**250**	**250**	**250**	**260**	**260**	**280**	**280**	**280**	**280**	**280**	**290**	**280**	**280**	**270**	**270**	**270**	**270**	**270**	**260**	**260**	**260**	**270**	**260**	**260**	**260**	**Other G20 countries**
ARG	320	290	270	250	250	260	260	260	260	270	270	270	280	290	290	270	270	260	260	270	250	240	250	240	260	260	260	250	*Argentina*
BRA	150	150	150	150	150	150	160	170	170	180	180	180	170	170	170	170	160	160	160	150	160	160	170	170	180	180	170	170	*Brazil*
IDN	190	200	190	200	200	200	200	210	240	250	240	250	240	250	240	230	230	230	210	210	200	200	190	180	190	180	170	170	*Indonesia*
SAU	240	220	230	240	260	260	270	270	280	300	300	310	340	320	310	310	320	330	340	370	380	360	370	380	390	390	390	400	*Saudi Arabia*
SAF	860	840	840	840	830	850	840	860	870	810	790	790	790	820	850	820	790	780	800	760	760	700	710	710	720	700	690	670	*South Africa*
Total G20	**480**	**470**	**460**	**460**	**450**	**450**	**440**	**430**	**420**	**410**	**410**	**400**	**400**	**400**	**400**	**400**	**390**	**390**	**380**	**380**	**380**	**380**	**370**	**360**	**350**	**340**	**330**	**320**	**Total Group of Twenty (G20)**
Other large emitting cr	**570**	**560**	**540**	**510**	**490**	**480**	**460**	**450**	**440**	**440**	**430**	**430**	**420**	**420**	**400**	**400**	**390**	**380**	**380**	**360**	**350**	**350**	**350**	**340**	**330**	**320**	**310**	**310**	**Other large emitting countries**
EGY	270	270	270	260	240	250	250	250	260	260	240	260	260	260	270	290	290	290	270	270	260	260	270	260	260	250	250	250	*Egypt*
IRN	320	320	330	320	370	370	370	380	370	410	400	420	410	400	410	430	430	430	440	450	430	420	460	480	480	470	[430]	430	*Iran*
KAZ	1170	1360	1470	1380	1440	1390	1210	1030	1080	960	890	760	770	790	780	750	760	730	840	740	740	740	700	700	640	610	610	610	*Kazakhstan*
MYS	310	340	330	330	310	300	320	320	340	350	350	360	370	370	380	380	380	390	390	360	370	350	340	350	340	330	320	310	*Malaysia*
NGA	240	260	300	290	270	300	330	320	280	270	290	290	250	250	180	170	140	120	120	100	110	110	100	100	90	90	90	90	*Nigeria*
TWN	370	360	360	360	350	350	340	350	350	350	350	370	360	360	350	340	330	310	300	290	280	270	250	250	240	240	240	240	*Taiwan*
THA	250	250	260	270	280	290	310	320	310	310	300	300	300	290	300	300	290	280	280	280	270	270	270	270	260	260	250	250	*Thailand*
UKR	1440	1490	1440	1470	1580	1770	1680	1670	1620	1620	1520	1390	1320	1280	1090	1040	970	910	860	840	860	860	840	800	750	670	690	610	*Ukraine*
Remaining	**320**	**320**	**300**	**300**	**300**	**300**	**290**	**290**	**280**	**280**	**270**	**270**	**270**	**270**	**260**	**260**	**250**	**240**	**240**	**240**	**240**	**240**	**240**	**230**	**230**	**230**	**230**	**220**	**Remaining countries (186)**
Int. transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**International transport**
Total	**480**	**470**	**460**	**460**	**450**	**450**	**440**	**430**	**420**	**410**	**400**	**400**	**400**	**400**	**400**	**390**	**390**	**380**	**370**	**370**	**370**	**370**	**360**	**350**	**350**	**340**	**330**	**320**	**Total**

[14] Available for all countries on http://edgar.jrc.ec.europa.eu/overview.php?v=booklet2018. Totals and sub-totals may differ due to independent rounding. The number of digits does not indicate the accuracy of the figures, See uncertainty information in the Appendix.

B. Greenhouse gas emissions total greenhouse gas, CH_4, N_2O, F-gases, and total per capita and per USD of GDP

We note that the estimated uncertainty range in non-CO_2 emissions, both in the national CRF data and as calculated using EDGAR data, is much larger than that for CO_2 emission estimates, for which uncertainties are generally between 3% to 5%, with exceptions of up to 10% or 15%.

The uncertainty of total country emissions per non-CO_2 gas in the EDGAR data sets is generally in the same range as that of official national total emissions, such as 30% to 50% for CH_4 and about 50% for N_2O (or 100% including indirect emissions). However, uncertainties for specific F-gas emissions in EDGAR (on the use of these gases) are in the range of 100% or more (Olivier et al., 2017). However, since CO_2 is the dominant greenhouse gas, the uncertainty of total greenhouse gas emissions is small, both globally and at country level, compared to those of the individual other greenhouse gases. For global greenhouse gas emissions, the uncertainty is estimated at 10%, mainly because the uncertainty of global CO_2 emissions is around 10%, when including large-scale biomass fires and post-burn decay and adding uncertainty about erosion and redeposition.

For most countries, the uncertainty in total greenhouse gas emissions is also around 10%, for the same reason as for global greenhouse gas emissions. However, there may be a few exceptions where this is up to 15%, in particular in cases where fossil-fuel-related CO_2 emissions have a much smaller share than three-quarters in total national greenhouse gas emissions (excluding emissions from land-use change).

All tables in the Appendices are also available as spreadsheets on the PBL website.
They can be downloaded from the report page of this report.

Table B.1 Total greenhouse gas emissions per country and group, 1990–2017[15] (unit: Gt CO_2 eq)

Total greenhouse gas emissions per country/group, 1990-2017[x] (unit: Gt CO_2 eq)																													
ISO country/group	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Country/group
CHN	**3.95**	**4.08**	**4.21**	**4.43**	**4.63**	**5.04**	**5.03**	**5.06**	**5.13**	**5.13**	**5.34**	**5.54**	**5.91**	**6.64**	**7.53**	**8.40**	**9.22**	**9.92**	**10.13**	**10.70**	**11.52**	**12.49**	**12.76**	**13.27**	**13.39**	**13.41**	**13.38**	**13.53**	**China**
USA	**6.13**	**6.09**	**6.18**	**6.30**	**6.40**	**6.46**	**6.62**	**6.80**	**6.82**	**6.85**	**7.06**	**7.00**	**6.94**	**7.02**	**7.12**	**7.15**	**7.06**	**7.17**	**7.00**	**6.60**	**6.89**	**6.82**	**6.66**	**6.75**	**6.88**	**6.74**	**6.64**	**6.64**	**United States**
EU28	**5.66**	**5.59**	**5.39**	**5.28**	**5.25**	**5.29**	**5.42**	**5.32**	**5.27**	**5.17**	**5.19**	**5.23**	**5.20**	**5.30**	**5.30**	**5.27**	**5.29**	**5.24**	**5.13**	**4.78**	**4.90**	**4.73**	**4.70**	**4.62**	**4.45**	**4.50**	**4.51**	**4.56**	**European Union**
FRA	0.54	0.56	0.55	0.53	0.52	0.53	0.54	0.54	0.55	0.54	0.53	0.54	0.53	0.54	0.54	0.54	0.53	0.52	0.52	0.50	0.51	0.48	0.48	0.49	0.46	0.47	0.47	0.48	*France*
DEU	1.24	1.21	1.15	1.14	1.13	1.12	1.14	1.11	1.08	1.04	1.03	1.04	1.02	1.02	1.01	0.99	1.00	0.97	0.98	0.92	0.96	0.93	0.94	0.96	0.93	0.93	0.94	0.94	*Germany*
ITA	0.52	0.52	0.51	0.50	0.50	0.52	0.52	0.53	0.54	0.55	0.55	0.55	0.56	0.57	0.58	0.58	0.57	0.57	0.55	0.50	0.51	0.50	0.48	0.44	0.43	0.44	0.44	0.44	*Italy*
NLD	0.22	0.23	0.22	0.23	0.23	0.23	0.24	0.24	0.24	0.23	0.23	0.23	0.22	0.23	0.23	0.22	0.22	0.22	0.22	0.21	0.22	0.21	0.21	0.21	0.20	0.21	0.21	0.21	*Netherlands*
POL	0.50	0.49	0.48	0.48	0.47	0.47	0.48	0.48	0.44	0.43	0.41	0.41	0.40	0.41	0.41	0.41	0.43	0.43	0.42	0.40	0.42	0.42	0.41	0.41	0.39	0.40	0.41	0.41	*Poland*
ESP	0.30	0.30	0.31	0.30	0.31	0.32	0.31	0.34	0.35	0.37	0.39	0.39	0.41	0.41	0.43	0.45	0.44	0.45	0.42	0.38	0.37	0.37	0.36	0.34	0.34	0.35	0.35	0.37	*Spain*
GBR	0.78	0.79	0.76	0.74	0.73	0.73	0.75	0.72	0.72	0.70	0.71	0.71	0.70	0.70	0.70	0.69	0.69	0.68	0.66	0.60	0.61	0.57	0.59	0.58	0.54	0.52	0.49	0.48	*United Kingdom*
IND	**1.38**	**1.44**	**1.46**	**1.50**	**1.55**	**1.62**	**1.67**	**1.72**	**1.75**	**1.82**	**1.86**	**1.88**	**1.92**	**1.96**	**2.07**	**2.15**	**2.25**	**2.39**	**2.50**	**2.70**	**2.81**	**2.93**	**3.08**	**3.10**	**3.31**	**3.38**	**3.48**	**3.59**	**India**
RUS	**3.03**	**2.97**	**2.75**	**2.52**	**2.30**	**2.24**	**2.18**	**2.05**	**2.04**	**2.09**	**2.14**	**2.16**	**2.16**	**2.23**	**2.26**	**2.25**	**2.31**	**2.32**	**2.29**	**2.16**	**2.27**	**2.37**	**2.36**	**2.30**	**2.28**	**2.29**	**2.33**	**2.35**	**Russian Federation**
JPN	**1.29**	**1.30**	**1.31**	**1.31**	**1.37**	**1.40**	**1.41**	**1.40**	**1.35**	**1.38**	**1.39**	**1.37**	**1.40**	**1.41**	**1.41**	**1.42**	**1.40**	**1.45**	**1.36**	**1.30**	**1.35**	**1.41**	**1.45**	**1.48**	**1.56**	**1.50**	**1.49**	**1.49**	**Japan**
Other OECD G20	**2.12**	**2.16**	**2.22**	**2.28**	**2.37**	**2.43**	**2.53**	**2.63**	**2.62**	**2.70**	**2.86**	**2.84**	**2.86**	**2.86**	**2.94**	**2.97**	**3.06**	**3.15**	**3.13**	**3.10**	**3.18**	**3.34**	**3.39**	**3.33**	**3.38**	**3.41**	**3.47**	**3.54**	**Other OECD G20**
AUS	0.50	0.50	0.50	0.51	0.51	0.52	0.52	0.53	0.56	0.60	0.62	0.63	0.63	0.57	0.62	0.60	0.63	0.63	0.61	0.63	0.60	0.69	0.69	0.62	0.63	0.64	0.63	0.63	*Australia*
CAN	0.61	0.61	0.63	0.64	0.66	0.67	0.69	0.70	0.70	0.71	0.74	0.72	0.73	0.75	0.75	0.76	0.76	0.79	0.77	0.73	0.75	0.76	0.77	0.79	0.81	0.80	0.81	0.83	*Canada*
MEX	0.44	0.46	0.46	0.48	0.51	0.51	0.53	0.56	0.59	0.58	0.60	0.60	0.61	0.64	0.65	0.67	0.70	0.71	0.72	0.72	0.74	0.75	0.76	0.75	0.74	0.76	0.79	0.77	*Mexico*
KOR	0.32	0.35	0.37	0.40	0.43	0.46	0.49	0.52	0.45	0.50	0.55	0.56	0.56	0.56	0.58	0.58	0.58	0.59	0.60	0.61	0.66	0.68	0.69	0.69	0.69	0.70	0.71	0.73	*South Korea*
TUR	0.23	0.24	0.25	0.26	0.26	0.28	0.30	0.31	0.31	0.31	0.34	0.31	0.32	0.34	0.34	0.36	0.39	0.42	0.42	0.42	0.44	0.46	0.48	0.48	0.50	0.52	0.54	0.59	*Turkey*
Other G20	**2.02**	**2.06**	**2.11**	**2.17**	**2.25**	**2.31**	**2.38**	**2.45**	**2.48**	**2.50**	**2.54**	**2.60**	**2.67**	**2.80**	**2.92**	**2.98**	**3.05**	**3.15**	**3.26**	**3.22**	**3.39**	**3.44**	**3.56**	**3.65**	**3.79**	**3.80**	**3.79**	**3.82**	**Other G20 countries**
ARG	0.29	0.28	0.29	0.29	0.30	0.29	0.31	0.30	0.30	0.31	0.31	0.31	0.30	0.33	0.34	0.35	0.36	0.37	0.38	0.36	0.36	0.36	0.37	0.37	0.38	0.39	0.39	0.39	*Argentina*
BRA	0.66	0.69	0.71	0.73	0.76	0.80	0.80	0.83	0.85	0.86	0.88	0.90	0.93	0.96	1.00	1.02	1.02	1.04	1.06	1.03	1.12	1.14	1.18	1.21	1.25	1.23	1.19	1.20	*Brazil*
IDN	0.43	0.45	0.48	0.50	0.50	0.52	0.54	0.56	0.56	0.57	0.57	0.59	0.60	0.64	0.65	0.66	0.69	0.71	0.72	0.75	0.77	0.79	0.82	0.83	0.87	0.88	0.88	0.91	*Indonesia*
SAU	0.24	0.25	0.26	0.26	0.29	0.29	0.30	0.31	0.32	0.32	0.34	0.35	0.36	0.39	0.40	0.42	0.45	0.47	0.50	0.52	0.57	0.59	0.63	0.66	0.70	0.73	0.74	0.75	*Saudi Arabia*
SAF	0.40	0.39	0.38	0.39	0.39	0.41	0.43	0.44	0.45	0.43	0.44	0.45	0.47	0.49	0.52	0.54	0.54	0.56	0.59	0.56	0.57	0.55	0.57	0.58	0.59	0.58	0.58	0.57	*South Africa*
Total G20	**25.58**	**25.69**	**25.63**	**25.79**	**26.13**	**26.79**	**27.24**	**27.42**	**27.45**	**27.65**	**28.37**	**28.62**	**29.05**	**30.22**	**31.55**	**32.58**	**33.65**	**34.79**	**34.81**	**34.57**	**36.31**	**37.53**	**37.96**	**38.49**	**39.03**	**39.05**	**39.09**	**39.52**	**Total Group of Twenty (G20)**
Other large emitting cr	**2.59**	**2.62**	**2.60**	**2.49**	**2.41**	**2.41**	**2.40**	**2.37**	**2.27**	**2.30**	**2.35**	**2.40**	**2.45**	**2.60**	**2.70**	**2.79**	**2.88**	**2.97**	**3.02**	**2.90**	**3.03**	**3.10**	**3.15**	**3.19**	**3.17**	**3.10**	**3.16**	**3.24**	**Other large emitting countries**
EGY	0.14	0.15	0.16	0.16	0.15	0.16	0.17	0.18	0.18	0.19	0.19	0.20	0.21	0.22	0.23	0.26	0.27	0.29	0.29	0.30	0.30	0.31	0.32	0.31	0.32	0.32	0.33	0.34	*Egypt*
IRN	0.38	0.40	0.42	0.41	0.45	0.45	0.46	0.47	0.45	0.48	0.50	0.51	0.53	0.57	0.62	0.65	0.70	0.73	0.74	0.76	0.77	0.78	0.78	0.81	0.83	0.83	0.86	0.91	*Iran*
KAZ	0.35	0.36	0.37	0.32	0.29	0.25	0.23	0.20	0.20	0.18	0.18	0.18	0.20	0.22	0.24	0.25	0.27	0.28	0.33	0.30	0.32	0.34	0.36	0.38	0.37	0.36	0.35	0.37	*Kazakhstan*
MYS	0.09	0.11	0.11	0.13	0.13	0.14	0.15	0.16	0.16	0.17	0.18	0.18	0.20	0.21	0.22	0.24	0.25	0.27	0.28	0.26	0.27	0.28	0.28	0.30	0.31	0.32	0.32	0.32	*Malaysia*
NGA	0.33	0.34	0.36	0.37	0.35	0.37	0.41	0.37	0.33	0.31	0.32	0.33	0.29	0.32	0.32	0.32	0.30	0.29	0.29	0.27	0.30	0.31	0.31	0.31	0.30	0.30	0.30	0.31	*Nigeria*
TWN	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.25	0.26	0.27	0.28	0.29	0.29	0.30	0.30	0.29	0.28	0.29	0.29	0.28	0.29	0.29	0.29	0.29	0.30	*Taiwan*
THA	0.21	0.22	0.23	0.24	0.26	0.28	0.30	0.30	0.27	0.28	0.28	0.29	0.31	0.31	0.34	0.35	0.35	0.37	0.37	0.37	0.39	0.39	0.41	0.42	0.40	0.40	0.40	0.40	*Thailand*
UKR	0.95	0.89	0.80	0.70	0.59	0.58	0.50	0.48	0.45	0.45	0.45	0.44	0.45	0.47	0.45	0.44	0.44	0.45	0.43	0.37	0.39	0.41	0.40	0.39	0.35	0.29	0.30	0.28	*Ukraine*
Remaining	**4.09**	**4.03**	**4.03**	**4.08**	**4.15**	**4.24**	**4.32**	**4.42**	**4.44**	**4.46**	**4.55**	**4.63**	**4.68**	**4.85**	**5.00**	**5.19**	**5.31**	**5.45**	**5.68**	**5.71**	**5.93**	**6.02**	**6.21**	**6.33**	**6.44**	**6.56**	**6.72**	**6.83**	**Remaining countries (186)**
Int. transport	**0.66**	**0.67**	**0.70**	**0.70**	**0.72**	**0.75**	**0.77**	**0.80**	**0.83**	**0.86**	**0.89**	**0.86**	**0.90**	**0.91**	**0.99**	**1.04**	**1.09**	**1.14**	**1.15**	**1.10**	**1.17**	**1.19**	**1.13**	**1.15**	**1.18**	**1.23**	**1.25**	**1.27**	**International transport**
Total	**32.91**	**33.01**	**32.97**	**33.06**	**33.42**	**34.19**	**34.74**	**35.01**	**34.99**	**35.26**	**36.16**	**36.51**	**37.08**	**38.57**	**40.24**	**41.60**	**42.93**	**44.35**	**44.66**	**44.27**	**46.43**	**47.83**	**48.45**	**49.16**	**49.81**	**49.94**	**50.22**	**50.86**	**Total**

[15] Totals and sub-totals may differ due to independent rounding. The number of digits does not indicate the accuracy of the figures, See uncertainty information in the Appendix. Calculated using the Global Warming Potentials (GWPs) for 100 year from the IPCC's Fourth Assessment Report (AR4).

Table B.2 CH_4 emissions per country and group, 1990–2017[16] (unit: Mt CO_2 eq)

CH_4 emissions per country/group, 1990-2017[x] (unit: Mt CO_2 eq)																														
ISO country/group	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Country/group
CHN	**1185**	**1176**	**1162**	**1147**	**1153**	**1207**	**1210**	**1184**	**1170**	**1169**	**1170**	**1176**	**1184**	**1223**	**1307**	**1399**	**1458**	**1478**	**1504**	**1529**	**1583**	**1635**	**1660**	**1689**	**1707**	**1717**	**1703**	**1740**	**China**
USA	**668**	**662**	**666**	**663**	**670**	**663**	**656**	**651**	**642**	**632**	**627**	**624**	**622**	**619**	**613**	**610**	**609**	**614**	**626**	**622**	**626**	**645**	**645**	**632**	**654**	**651**	**616**	**622**	**United States**
EU28	**805**	**793**	**769**	**749**	**732**	**727**	**724**	**717**	**697**	**687**	**676**	**662**	**655**	**645**	**635**	**624**	**619**	**612**	**602**	**587**	**584**	**572**	**568**	**567**	**562**	**560**	**556**	**554**	**European Union**
FRA	77	78	77	75	75	75	75	74	73	73	73	73	72	71	70	70	70	69	70	68	68	66	66	67	66	67	67	67	*France*
DEU	143	137	130	125	121	119	115	110	105	102	98	94	91	88	85	82	78	77	76	73	71	70	69	69	68	67	65	64	*Germany*
ITA	55	54	52	51	52	52	54	54	54	53	54	51	52	50	48	47	46	46	45	45	45	43	43	42	41	40	40	39	*Italy*
NLD	37	37	37	36	35	35	35	33	32	31	30	29	27	26	26	25	24	24	24	24	24	23	23	23	22	22	21	21	*Netherlands*
POL	103	98	94	91	90	89	87	86	78	75	70	69	68	68	66	67	68	67	66	64	65	65	66	68	67	68	68	68	*Poland*
ESP	36	37	37	37	37	37	38	39	40	41	41	42	43	43	43	43	43	44	43	44	43	42	42	42	43	43	43	44	*Spain*
GBR	128	129	127	124	119	122	122	122	119	117	113	109	107	102	97	93	90	85	80	75	72	69	66	62	60	58	55	52	*United Kingdom*
IND	**617**	**626**	**632**	**637**	**643**	**650**	**656**	**662**	**666**	**672**	**673**	**680**	**677**	**688**	**700**	**717**	**731**	**746**	**766**	**779**	**794**	**804**	**815**	**794**	**801**	**806**	**816**	**826**	**India**
RUS	**500**	**477**	**450**	**421**	**393**	**375**	**360**	**347**	**332**	**341**	**342**	**351**	**370**	**372**	**394**	**383**	**409**	**415**	**408**	**384**	**415**	**426**	**437**	**433**	**428**	**438**	**454**	**459**	**Russian Federation**
JPN	**78**	**77**	**76**	**75**	**75**	**72**	**69**	**66**	**62**	**60**	**58**	**56**	**55**	**54**	**53**	**52**	**52**	**51**	**50**	**49**	**49**	**47**	**46**	**46**	**44**	**43**	**42**	**41**	**Japan**
Other OECD G20	**462**	**465**	**473**	**483**	**485**	**486**	**494**	**505**	**499**	**514**	**531**	**525**	**519**	**489**	**504**	**497**	**514**	**518**	**507**	**508**	**504**	**544**	**550**	**535**	**559**	**552**	**536**	**538**	**Other OECD G20**
AUS	150	151	149	147	145	145	140	141	144	159	170	172	169	135	152	138	153	147	135	138	128	170	172	144	151	148	143	142	*Australia*
CAN	107	110	118	122	126	118	126	126	119	122	125	119	120	120	121	122	120	120	118	116	117	115	117	125	138	131	120	121	*Canada*
MEX	114	111	110	114	113	118	121	127	127	121	121	121	120	122	122	123	126	130	135	133	134	132	130	132	132	132	131	129	*Mexico*
KOR	39	38	37	37	36	36	37	37	36	36	37	37	35	36	36	36	37	37	36	36	37	36	37	37	36	36	36	36	*South Korea*
TUR	52	55	61	64	64	69	71	74	74	76	78	76	74	75	73	77	79	83	84	84	88	90	94	98	102	105	107	110	*Turkey*
Other G20	**803**	**820**	**839**	**851**	**873**	**867**	**874**	**869**	**857**	**853**	**855**	**873**	**897**	**939**	**962**	**982**	**990**	**996**	**1013**	**1016**	**1040**	**1050**	**1070**	**1073**	**1086**	**1094**	**1109**	**1117**	**Other G20 countries**
ARG	139	132	133	138	143	129	135	125	118	120	121	123	124	132	132	132	134	133	131	125	116	112	115	116	118	117	120	121	*Argentina*
BRA	328	342	352	362	376	388	380	382	387	389	391	404	423	442	462	470	466	464	468	468	486	485	487	484	490	494	498	501	*Brazil*
IDN	207	219	231	235	221	219	225	224	216	212	208	211	214	219	222	227	236	245	253	267	279	289	301	303	308	307	313	314	*Indonesia*
SAU	66	65	59	52	69	66	67	68	65	60	63	64	64	72	71	75	77	77	81	77	80	85	89	90	91	95	99	102	*Saudi Arabia*
SAF	63	64	63	64	65	66	67	70	71	71	71	72	73	74	75	78	77	78	80	79	79	79	80	80	80	80	80	80	*South Africa*
Total G20	**5118**	**5097**	**5066**	**5027**	**5024**	**5046**	**5044**	**5001**	**4926**	**4928**	**4931**	**4946**	**4979**	**5028**	**5168**	**5263**	**5382**	**5430**	**5475**	**5474**	**5594**	**5722**	**5791**	**5768**	**5842**	**5859**	**5831**	**5896**	**Total Group of Twenty (G20)**
Other large emitting cr	**764**	**773**	**781**	**769**	**759**	**739**	**747**	**701**	**636**	**611**	**609**	**607**	**596**	**636**	**647**	**664**	**671**	**670**	**677**	**673**	**692**	**704**	**736**	**735**	**732**	**720**	**728**	**747**	**Other large emitting countries**
EGY	39	41	44	46	46	47	47	46	42	44	42	44	46	49	50	56	58	59	61	60	57	59	60	57	56	55	57	59	*Egypt*
IRN	148	153	153	139	155	145	145	140	124	119	122	119	121	138	141	148	154	154	155	160	164	167	163	164	170	175	[197]	211	*Iran*
KAZ	81	78	80	75	64	54	50	47	42	41	41	40	44	44	49	51	55	54	57	57	60	59	88	87	90	88	80	82	*Kazakhstan*
MYS	27	29	29	37	36	36	38	39	40	38	38	37	38	39	43	45	45	45	46	45	43	45	45	49	50	51	51	51	*Malaysia*
NGA	241	249	254	260	252	260	281	246	214	193	194	196	173	191	189	188	180	176	173	166	175	180	183	180	178	177	176	180	*Nigeria*
TWN	11	11	11	11	11	11	11	11	11	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	*Taiwan*
THA	96	100	101	96	99	96	95	98	93	95	94	95	96	95	99	102	103	108	110	113	121	118	122	122	115	108	103	100	*Thailand*
UKR	120	112	110	104	96	90	81	76	71	70	68	66	68	71	67	66	66	64	66	63	63	66	65	66	62	55	54	53	*Ukraine*
Remaining	**1749**	**1736**	**1787**	**1816**	**1850**	**1874**	**1890**	**1885**	**1881**	**1891**	**1902**	**1908**	**1916**	**1994**	**2037**	**2106**	**2156**	**2197**	**2272**	**2278**	**2342**	**2383**	**2414**	**2461**	**2489**	**2529**	**2584**	**2612**	**Remaining countries (186)**
Int. transport	**9**	**9**	**9**	**9**	**9**	**9**	**10**	**10**	**11**	**10**	**11**	**11**	**11**	**11**	**12**	**13**	**13**	**13**	**13**	**12**	**12**	**13**	**12**	**12**	**13**	**13**	**13**	**13**	**International transport**
Total	**7640**	**7613**	**7644**	**7620**	**7641**	**7669**	**7691**	**7597**	**7454**	**7440**	**7452**	**7471**	**7502**	**7669**	**7864**	**8046**	**8222**	**8310**	**8437**	**8438**	**8641**	**8822**	**8954**	**8977**	**9075**	**9120**	**9155**	**9266**	**Total**

[16] Totals and sub-totals may differ due to independent rounding. The number of digits does not indicate the accuracy of the figures, See uncertainty information in the Appendix. Calculated using the Global Warming Potentials (GWPs) for 100 year from the IPCC's Fourth Assessment Report (AR4).

Table B.3 N_2O emissions, per country and group, 1990–2017[17] (unit: Mt CO_2 eq)

N_2O emissions per country/group, 1990-2017[x] (unit: Mt CO_2 eq)																														
ISO country/group	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Country/group
CHN	**317**	**322**	**328**	**324**	**337**	**385**	**394**	**375**	**383**	**397**	**394**	**395**	**419**	**418**	**440**	**467**	**498**	**518**	**526**	**506**	**505**	**518**	**522**	**528**	**531**	**537**	**541**	**545**	**China**
USA	**274**	**275**	**283**	**285**	**295**	**296**	**304**	**304**	**304**	**303**	**302**	**298**	**295**	**296**	**300**	**299**	**297**	**296**	**288**	**283**	**289**	**293**	**282**	**287**	**296**	**294**	**302**	**307**	**United States**
EU28	**388**	**372**	**355**	**347**	**351**	**349**	**358**	**354**	**323**	**305**	**302**	**298**	**296**	**296**	**297**	**297**	**289**	**288**	**273**	**267**	**251**	**244**	**243**	**245**	**247**	**248**	**248**	**251**	**European Union**
FRA	62	62	59	60	60	61	64	63	51	47	45	45	44	43	43	43	41	41	42	41	40	38	39	40	40	40	39	40	*France*
DEU	68	66	67	64	67	66	67	64	48	45	44	44	43	43	43	42	43	42	48	47	40	39	39	40	41	40	40	40	*Germany*
ITA	28	28	28	27	27	28	28	28	28	28	28	28	28	27	26	25	21	20	20	19	18	18	18	18	18	18	18	18	*Italy*
NLD	13	14	14	14	14	14	14	13	13	13	13	12	12	14	14	14	16	15	9	9	9	9	9	9	9	9	9	8	*Netherlands*
POL	26	25	25	25	25	26	26	27	26	26	26	26	25	27	27	27	27	27	26	23	23	23	23	23	22	22	23	23	*Poland*
ESP	22	22	20	21	21	22	23	24	24	25	25	24	24	25	24	24	23	23	22	22	21	20	20	22	22	22	22	23	*Spain*
GBR	54	53	47	43	44	42	43	42	42	32	30	28	28	28	27	26	25	25	25	23	24	23	23	23	24	23	23	23	*United Kingdom*
IND	**146**	**151**	**156**	**160**	**166**	**170**	**175**	**180**	**184**	**187**	**182**	**186**	**180**	**187**	**194**	**201**	**211**	**221**	**227**	**231**	**238**	**246**	**251**	**252**	**256**	**259**	**266**	**273**	**India**
RUS	**118**	**113**	**105**	**94**	**79**	**74**	**72**	**66**	**62**	**60**	**63**	**65**	**65**	**65**	**63**	**63**	**63**	**63**	**54**	**52**	**51**	**54**	**53**	**54**	**55**	**57**	**59**	**59**	**Russian Federation**
JPN	**31**	**31**	**31**	**31**	**33**	**33**	**34**	**34**	**33**	**26**	**27**	**25**	**25**	**25**	**25**	**25**	**24**	**24**	**23**	**23**	**23**	**22**	**22**	**22**	**22**	**21**	**21**	**21**	**Japan**
Other OECD G20	**182**	**181**	**187**	**193**	**201**	**215**	**217**	**222**	**228**	**246**	**258**	**258**	**250**	**223**	**246**	**230**	**248**	**247**	**240**	**249**	**241**	**290**	**294**	**259**	**272**	**273**	**275**	**278**	**Other OECD G20**
AUS	71	70	69	70	70	70	66	65	70	87	96	96	91	59	78	61	76	70	58	62	52	98	99	61	72	71	69	68	*Australia*
CAN	38	37	38	38	41	42	44	42	37	35	35	33	34	34	35	34	35	34	37	34	35	36	37	39	41	40	40	41	*Canada*
MEX	37	36	39	42	50	60	62	70	73	75	79	82	83	87	90	92	94	99	103	109	110	112	112	112	113	115	118	120	*Mexico*
KOR	9	10	12	13	13	14	15	17	16	17	18	18	13	12	13	13	13	12	12	13	13	13	13	12	12	12	12	12	*South Korea*
TUR	28	27	29	30	27	30	30	30	31	32	31	29	29	30	31	30	31	31	31	31	32	32	33	35	35	36	36	36	*Turkey*
Other G20	**217**	**220**	**229**	**233**	**242**	**247**	**247**	**249**	**258**	**257**	**259**	**269**	**281**	**295**	**299**	**306**	**305**	**318**	**315**	**311**	**329**	**327**	**328**	**336**	**349**	**355**	**355**	**356**	**Other G20 countries**
ARG	35	34	35	34	36	36	37	36	38	39	41	46	45	49	47	49	51	53	52	47	51	50	48	52	55	57	57	56	*Argentina*
BRA	99	101	106	111	118	121	116	120	125	125	126	131	140	150	155	158	156	165	162	160	175	174	175	180	186	190	190	191	*Brazil*
IDN	58	58	61	60	61	63	65	63	65	63	64	64	67	67	68	69	69	71	72	75	75	75	76	75	77	77	78	78	*Indonesia*
SAU	6	6	7	7	6	6	6	7	7	7	7	7	7	7	8	8	8	8	7	7	7	8	8	8	9	9	9	9	*Saudi Arabia*
SAF	19	19	21	21	21	21	23	24	24	23	21	21	23	22	22	23	22	22	21	21	22	21	21	21	22	21	21	21	*South Africa*
Total G20	**1674**	**1664**	**1674**	**1666**	**1703**	**1768**	**1799**	**1784**	**1774**	**1780**	**1786**	**1793**	**1811**	**1804**	**1863**	**1887**	**1935**	**1975**	**1946**	**1922**	**1926**	**1994**	**1996**	**1983**	**2028**	**2043**	**2066**	**2089**	**Total Group of Twenty (G20)**
Other large emitting cr	**141**	**140**	**145**	**140**	**136**	**132**	**131**	**131**	**130**	**129**	**130**	**133**	**139**	**140**	**155**	**154**	**155**	**163**	**158**	**152**	**159**	**159**	**159**	**156**	**155**	**153**	**156**	**157**	**Other large emitting countries**
EGY	11	12	13	14	13	15	16	16	17	16	17	18	18	19	21	21	22	22	23	23	25	25	25	21	21	21	21	22	*Egypt*
IRN	21	21	23	22	23	23	24	26	26	26	26	27	26	27	39	36	36	41	34	31	31	30	30	29	28	28	[28]	28	*Iran*
KAZ	19	19	22	20	19	17	16	15	13	13	12	13	17	14	15	15	16	15	16	15	16	15	15	15	16	16	17	17	*Kazakhstan*
MYS	8	8	8	8	8	9	8	9	10	9	10	9	10	10	11	11	11	11	12	12	12	12	12	12	12	12	12	12	*Malaysia*
NGA	19	20	20	21	21	21	22	23	24	24	25	26	25	26	26	28	28	28	28	28	30	30	31	34	33	33	34	34	*Nigeria*
TWN	4	4	4	4	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	*Taiwan*
THA	15	16	16	18	18	17	17	17	17	18	17	17	18	18	18	18	17	20	20	22	22	22	22	22	22	21	21	22	*Thailand*
UKR	44	41	38	32	29	25	22	22	20	19	19	19	21	20	20	20	20	21	20	17	18	19	18	19	19	18	18	19	*Ukraine*
Remaining	**432**	**429**	**431**	**439**	**444**	**451**	**460**	**470**	**486**	**487**	**496**	**505**	**505**	**536**	**544**	**560**	**558**	**578**	**589**	**588**	**607**	**612**	**609**	**628**	**631**	**650**	**673**	**688**	**Remaining countries (186)**
Int. transport	**19**	**20**	**21**	**21**	**21**	**22**	**22**	**23**	**24**	**25**	**26**	**25**	**26**	**26**	**28**	**30**	**32**	**33**	**33**	**32**	**34**	**35**	**32**	**32**	**33**	**33**	**33**	**33**	**International transport**
Total	**2265**	**2252**	**2271**	**2265**	**2305**	**2374**	**2413**	**2408**	**2414**	**2421**	**2437**	**2456**	**2480**	**2505**	**2589**	**2630**	**2680**	**2749**	**2727**	**2694**	**2727**	**2800**	**2796**	**2799**	**2847**	**2878**	**2927**	**2967**	**Total**

[17] Totals and sub-totals may differ due to independent rounding. The number of digits does not indicate the accuracy of the figures, See uncertainty information in the Appendix. Calculated using the Global Warming Potentials (GWPs) for 100 year from the IPCC's Fourth Assessment Report (AR4).

Table B.4 F-gas emissions, per country and group, 1990–2017[18] (unit: Mt CO_2 eq)

F-gas emissions per country/group, 1990-2017[x] (unit: Mt CO_2 eq)																													
ISO country/group	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Country/group
CHN	**14.9**	**13.0**	**14.7**	**22.0**	**32.3**	**24.4**	**28.1**	**39.0**	**30.3**	**82.5**	**67.7**	**84.5**	**115.2**	**139.0**	**184.5**	**225.4**	**256.7**	**237.9**	**251.8**	**255.7**	**263.0**	**271.3**	**279.7**	**288.1**	**296.4**	**304.8**	**316.4**	**324.9**	**China**
USA	**101.5**	**103.1**	**102.3**	**101.9**	**108.4**	**118.2**	**130.9**	**139.5**	**160.5**	**179.5**	**191.7**	**195.2**	**215.5**	**226.0**	**245.9**	**266.8**	**290.2**	**312.2**	**330.5**	**357.3**	**398.8**	**427.7**	**456.5**	**485.4**	**514.2**	**543.9**	**575.1**	**606.7**	**United States**
EU28	**61.6**	**64.3**	**60.2**	**63.4**	**66.4**	**65.5**	**72.8**	**74.8**	**81.9**	**83.6**	**89.0**	**82.6**	**88.3**	**92.9**	**97.7**	**104.0**	**112.8**	**121.5**	**130.8**	**135.7**	**143.8**	**151.6**	**159.6**	**168.5**	**177.2**	**186.5**	**195.6**	**205.1**	**European Union**
FRA	10.8	11.6	13.4	16.7	13.6	9.0	9.9	10.7	12.5	13.3	14.8	15.3	16.2	16.7	17.4	17.2	18.7	20.4	22.1	23.1	25.0	26.5	28.0	29.7	31.4	33.1	34.8	36.5	*France*
DEU	13.7	14.5	12.8	12.7	13.8	15.1	16.7	17.7	18.2	17.8	20.5	18.5	19.4	20.0	21.8	23.8	26.4	27.9	30.2	29.2	30.0	30.8	31.8	33.2	34.5	35.9	37.1	38.6	*Germany*
ITA	4.7	4.5	4.1	4.3	5.0	5.3	7.9	7.8	9.1	10.4	10.0	11.4	11.7	11.4	11.5	11.8	13.2	14.3	15.3	16.5	17.8	18.9	20.1	21.3	22.5	23.6	24.8	26.0	*Italy*
NLD	7.5	7.6	7.5	8.2	8.6	8.1	8.9	8.6	9.5	8.8	9.1	4.8	3.6	4.3	3.9	4.2	4.6	4.9	5.2	5.4	5.7	5.9	6.2	6.5	6.7	7.0	7.3	7.5	*Netherlands*
POL	0.6	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.3	1.4	1.5	1.7	1.9	2.1	2.5	2.9	3.2	3.5	3.7	3.3	2.9	2.7	2.7	2.6	2.8	2.8	2.9	3.0	*Poland*
ESP	7.3	7.4	7.6	7.5	7.5	7.7	8.1	8.0	8.8	7.2	8.8	7.8	8.1	9.0	9.7	10.4	11.4	12.3	13.2	13.5	14.1	14.6	15.2	15.8	16.4	17.3	18.1	19.0	*Spain*
GBR	6.2	6.9	6.8	5.8	8.8	9.2	9.1	8.9	9.9	10.3	9.6	9.8	10.8	11.2	10.8	11.7	12.6	14.0	14.8	15.3	16.4	17.4	18.2	19.2	20.0	21.0	21.8	22.8	*United Kingdom*
IND	**10.0**	**10.6**	**10.2**	**10.0**	**9.4**	**9.4**	**9.0**	**9.7**	**12.6**	**13.1**	**15.8**	**16.0**	**16.2**	**20.0**	**24.3**	**18.1**	**18.2**	**26.1**	**24.0**	**25.9**	**27.8**	**28.3**	**28.9**	**29.5**	**30.1**	**30.6**	**31.2**	**31.8**	**India**
RUS	**29.2**	**38.8**	**40.4**	**43.8**	**42.4**	**45.1**	**45.3**	**48.1**	**50.8**	**53.6**	**57.9**	**58.5**	**56.0**	**56.6**	**64.6**	**68.7**	**70.3**	**75.2**	**75.8**	**66.6**	**72.5**	**71.8**	**70.9**	**70.2**	**69.3**	**68.6**	**67.8**	**67.1**	**Russian Federation**
JPN	**32.9**	**39.4**	**43.0**	**55.2**	**53.7**	**77.0**	**69.5**	**68.6**	**67.3**	**63.5**	**59.4**	**59.4**	**55.1**	**57.7**	**57.5**	**61.7**	**66.5**	**70.6**	**74.4**	**77.7**	**82.5**	**86.4**	**90.8**	**94.8**	**99.2**	**103.2**	**107.6**	**111.7**	**Japan**
Other OECD G20	**32.5**	**33.9**	**32.1**	**33.4**	**32.4**	**33.0**	**40.5**	**42.7**	**43.2**	**52.3**	**50.0**	**45.7**	**53.7**	**53.4**	**54.1**	**60.6**	**64.9**	**66.2**	**69.0**	**69.4**	**73.9**	**76.5**	**80.0**	**83.3**	**86.9**	**90.1**	**93.9**	**98.1**	**Other OECD G20**
AUS	5.6	5.2	4.7	4.2	3.5	3.4	3.3	3.5	3.9	4.3	4.7	5.0	5.5	6.1	6.7	7.3	8.2	8.8	9.5	10.0	10.3	10.8	11.3	11.9	12.4	12.9	13.5	14.1	*Australia*
CAN	14.2	15.2	14.4	15.4	15.2	15.2	16.3	16.7	17.9	19.1	19.9	20.2	21.2	22.6	23.4	24.9	26.6	27.8	28.8	30.2	33.4	35.3	37.1	39.1	41.1	43.1	45.0	47.9	*Canada*
MEX	3.4	3.5	2.5	3.3	2.9	2.8	5.8	6.0	5.2	6.7	5.6	4.6	6.0	5.9	6.0	9.2	12.4	11.2	11.4	12.1	12.9	13.4	14.0	14.5	15.1	15.7	16.2	16.8	*Mexico*
KOR	6.7	7.3	7.7	8.0	8.5	9.3	12.9	14.3	14.1	20.0	17.2	13.0	17.6	14.9	13.3	13.7	11.9	11.9	12.3	10.0	9.4	8.6	8.7	8.4	8.5	8.2	8.4	8.1	*South Korea*
TUR	2.6	2.6	2.7	2.6	2.4	2.3	2.2	2.2	2.1	2.2	2.7	2.9	3.4	3.9	4.7	5.5	5.9	6.5	7.1	7.1	7.9	8.4	8.8	9.3	9.8	10.2	10.7	11.2	*Turkey*
Other G20	**17.9**	**17.8**	**15.9**	**15.0**	**14.1**	**13.2**	**11.9**	**11.9**	**11.7**	**10.3**	**10.1**	**10.0**	**11.3**	**13.4**	**14.8**	**16.1**	**17.2**	**18.6**	**19.2**	**19.4**	**20.3**	**20.8**	**21.4**	**21.9**	**22.5**	**23.0**	**23.6**	**24.1**	**Other G20 countries**
ARG	2.7	2.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.7	0.9	0.7	0.6	1.1	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	*Argentina*
BRA	9.6	9.8	10.1	9.8	9.4	9.0	7.4	7.4	7.5	5.9	5.6	5.3	6.3	7.7	8.5	9.6	10.4	11.1	11.5	11.4	11.8	12.1	12.3	12.6	12.8	13.1	13.3	13.6	*Brazil*
IDN	1.8	1.8	1.9	1.8	1.7	1.5	1.4	1.3	1.0	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.5	1.5	*Indonesia*
SAU	2.3	2.3	2.1	1.8	1.4	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.6	1.8	1.9	2.1	2.2	2.4	2.5	2.7	2.8	2.9	3.1	3.2	3.4	3.5	3.6	3.8	*Saudi Arabia*
SAF	1.5	1.3	1.2	1.2	1.1	1.1	1.5	1.7	1.7	1.8	1.8	1.8	2.0	2.3	2.5	2.6	2.8	2.9	3.0	3.2	3.3	3.4	3.6	3.7	3.8	3.9	4.0	4.2	*South Africa*
Total G20	**300.4**	**320.9**	**318.8**	**344.8**	**359.1**	**385.8**	**407.9**	**434.3**	**458.3**	**538.4**	**541.6**	**552.0**	**611.3**	**659.1**	**743.5**	**821.5**	**896.7**	**928.3**	**975.3**	**1007.7**	**1082.5**	**1134.4**	**1187.8**	**1241.6**	**1295.7**	**1350.8**	**1411.2**	**1469.4**	**Total Group of Twenty (G20)**
Other large emitting cr	**9.1**	**10.0**	**9.7**	**9.0**	**8.5**	**8.1**	**8.9**	**9.5**	**9.6**	**11.4**	**13.2**	**13.3**	**15.2**	**16.5**	**17.2**	**17.0**	**18.8**	**19.7**	**20.7**	**19.1**	**20.1**	**20.3**	**20.5**	**20.7**	**20.9**	**21.1**	**21.2**	**22.1**	**Other large emitting countries**
EGY	2.2	2.3	2.3	2.2	2.2	2.0	2.6	2.2	2.4	2.6	2.7	2.8	2.9	2.9	3.1	3.4	3.6	3.8	3.9	4.0	4.2	4.3	4.4	4.6	4.7	4.8	5.0	5.1	*Egypt*
IRN	2.5	3.0	2.8	2.5	2.2	2.0	1.8	1.7	1.8	2.0	1.8	1.9	2.2	2.3	2.2	2.4	2.5	2.6	2.7	2.9	3.0	3.1	3.2	3.4	3.5	3.6	[3.7]	3.9	*Iran*
KAZ	-	-	-	-	-	-	-	-	-	-	0.1	0.1	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	*Kazakhstan*
MYS	0.6	0.7	0.7	0.7	0.7	0.7	0.6	0.5	0.5	0.5	0.5	0.7	0.8	1.0	1.0	1.1	1.2	1.3	1.4	1.2	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	*Malaysia*
NGA	0.2	0.2	0.1	0.1	0.1	-	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.3	1.4	1.5	1.6	1.7	*Nigeria*
TWN	2.0	2.1	2.1	2.0	1.9	2.1	2.6	3.8	3.7	5.0	6.9	6.4	7.6	8.3	8.4	7.3	8.4	8.7	9.0	7.1	7.6	7.2	6.9	6.6	6.2	5.9	5.6	6.0	*Taiwan*
THA	1.4	1.4	1.3	1.2	1.0	0.9	0.8	0.7	0.5	0.5	0.4	0.5	0.7	0.8	0.9	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	*Thailand*
UKR	0.3	0.4	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.5	*Ukraine*
Remaining	**31.3**	**29.0**	**24.2**	**21.1**	**18.7**	**18.3**	**18.7**	**19.7**	**20.0**	**21.4**	**24.1**	**26.1**	**25.7**	**28.3**	**32.1**	**35.2**	**38.4**	**41.4**	**44.7**	**43.8**	**45.3**	**46.7**	**50.4**	**52.0**	**55.7**	**57.4**	**61.1**	**62.8**	**Remaining countries (186)**
Int. transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**International transport**
Total	**341**	**360**	**353**	**375**	**386**	**412**	**435**	**463**	**488**	**571**	**579**	**591**	**652**	**704**	**793**	**874**	**954**	**990**	**1041**	**1071**	**1148**	**1201**	**1259**	**1314**	**1372**	**1429**	**1494**	**1554**	**Total**

[18] Totals and sub-totals may differ due to independent rounding. The number of digits does not indicate the accuracy of the figures, See uncertainty information in the Appendix. Calculated using the Global Warming Potentials (GWPs) for 100 year from the IPCC's Fourth Assessment Report (AR4).

Table B.5 Greenhouse gas emissions, per capita, per country and group, 1990–2017[19] (unit: tonnes of CO_2 eq per person)

Total GHG emissions per capita per country/group, 1990-2017[x] (tonnes of CO_2 per person)																														
ISO country/group	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Country/group
CHN	**3.35**	**3.41**	**3.48**	**3.62**	**3.75**	**4.04**	**4.01**	**4.00**	**4.03**	**4.00**	**4.14**	**4.27**	**4.52**	**5.05**	**5.70**	**6.32**	**6.90**	**7.38**	**7.50**	**7.88**	**8.43**	**9.09**	**9.23**	**9.55**	**9.58**	**9.55**	**9.49**	**9.55**	**China**
USA	**24.27**	**23.87**	**24.00**	**24.22**	**24.36**	**24.31**	**24.62**	**24.98**	**24.77**	**24.57**	**25.05**	**24.57**	**24.13**	**24.20**	**24.35**	**24.22**	**23.72**	**23.85**	**23.07**	**21.57**	**22.34**	**21.92**	**21.25**	**21.38**	**21.65**	**21.05**	**20.61**	**20.47**	**United States**
EU28	**11.87**	**11.67**	**11.22**	**10.97**	**10.88**	**10.95**	**11.19**	**10.96**	**10.84**	**10.64**	**10.65**	**10.70**	**10.61**	**10.78**	**10.74**	**10.65**	**10.63**	**10.50**	**10.24**	**9.52**	**9.72**	**9.38**	**9.29**	**9.12**	**8.78**	**8.88**	**8.87**	**8.95**	**European Union**
FRA	9.40	9.80	9.54	9.18	8.99	9.05	9.32	9.13	9.27	9.06	8.97	9.00	8.84	8.84	8.80	8.78	8.56	8.42	8.33	7.99	8.12	7.56	7.58	7.63	7.12	7.26	7.30	7.41	*France*
DEU	15.70	15.26	14.40	14.11	13.91	13.76	14.05	13.57	13.22	12.74	12.69	12.80	12.55	12.54	12.33	12.06	12.28	11.92	12.13	11.34	11.83	11.50	11.65	11.86	11.39	11.41	11.48	11.44	*Germany*
ITA	9.07	9.04	8.94	8.80	8.70	9.16	9.15	9.21	9.43	9.58	9.65	9.56	9.66	9.87	9.97	9.91	9.69	9.53	9.24	8.35	8.51	8.33	8.00	7.45	7.14	7.33	7.38	7.48	*Italy*
NLD	14.63	15.01	14.78	14.98	14.85	15.12	15.72	15.03	14.96	14.43	14.32	14.18	13.95	14.04	14.11	13.70	13.51	13.46	13.15	12.78	13.42	12.63	12.50	12.45	11.93	12.58	12.59	12.42	*Netherlands*
POL	13.19	12.92	12.53	12.43	12.21	12.25	12.57	12.34	11.37	11.04	10.62	10.53	10.32	10.71	10.76	10.78	11.16	11.13	10.94	10.45	10.94	10.86	10.68	10.58	10.24	10.34	10.69	10.82	*Poland*
ESP	7.52	7.70	7.87	7.48	7.73	8.08	7.85	8.36	8.60	9.08	9.46	9.32	9.65	9.70	9.93	10.12	9.77	9.97	9.11	8.18	7.82	7.83	7.74	7.21	7.24	7.63	7.50	7.93	*Spain*
GBR	13.58	13.71	13.29	12.85	12.69	12.54	12.83	12.37	12.33	12.00	11.96	12.05	11.72	11.83	11.66	11.48	11.34	11.01	10.57	9.56	9.70	8.96	9.24	8.92	8.26	7.93	7.47	7.22	*United Kingdom*
IND	**1.59**	**1.62**	**1.62**	**1.63**	**1.65**	**1.69**	**1.70**	**1.73**	**1.72**	**1.76**	**1.76**	**1.76**	**1.76**	**1.77**	**1.84**	**1.88**	**1.94**	**2.03**	**2.09**	**2.22**	**2.28**	**2.35**	**2.44**	**2.43**	**2.56**	**2.59**	**2.63**	**2.68**	**India**
RUS	**20.51**	**20.06**	**18.52**	**16.95**	**15.52**	**15.10**	**14.72**	**13.88**	**13.82**	**14.25**	**14.60**	**14.79**	**14.89**	**15.42**	**15.66**	**15.66**	**16.13**	**16.24**	**16.04**	**15.07**	**15.86**	**16.53**	**16.46**	**16.02**	**15.84**	**15.94**	**16.15**	**16.32**	**Russian Federation**
JPN	**10.37**	**10.41**	**10.46**	**10.43**	**10.85**	**11.10**	**11.10**	**10.99**	**10.62**	**10.82**	**10.86**	**10.73**	**10.97**	**11.00**	**10.96**	**11.03**	**10.92**	**11.25**	**10.59**	**10.08**	**10.51**	**10.93**	**11.28**	**11.50**	**12.16**	**11.75**	**11.67**	**11.73**	**Japan**
Other OECD G20	**8.17**	**8.21**	**8.29**	**8.40**	**8.57**	**8.68**	**8.91**	**9.12**	**8.96**	**9.12**	**9.55**	**9.37**	**9.33**	**9.23**	**9.39**	**9.37**	**9.54**	**9.70**	**9.52**	**9.32**	**9.43**	**9.78**	**9.81**	**9.52**	**9.52**	**9.51**	**9.55**	**9.65**	**Other OECD G20**
AUS	29.42	29.15	28.80	28.61	28.58	28.78	28.59	28.77	30.04	31.74	32.76	32.91	32.53	29.10	31.23	29.54	30.82	30.30	28.77	28.87	27.25	30.66	30.32	26.87	26.88	26.69	26.02	25.63	*Australia*
CAN	22.20	21.81	22.24	22.15	22.68	22.68	23.26	23.55	23.19	23.42	24.02	23.28	23.33	23.79	23.40	23.61	23.15	23.88	23.03	21.64	22.00	22.12	22.00	22.45	22.78	22.29	22.22	22.57	*Canada*
MEX	5.21	5.27	5.21	5.29	5.54	5.39	5.55	5.80	5.96	5.74	5.92	5.84	5.86	6.03	6.06	6.21	6.34	6.37	6.35	6.22	6.27	6.26	6.32	6.16	5.99	6.01	6.17	5.99	*Mexico*
KOR	7.57	8.08	8.45	9.05	9.57	10.21	10.80	11.27	9.73	10.54	11.69	11.81	11.61	11.56	11.90	11.86	11.93	12.10	12.24	12.31	13.23	13.76	13.76	13.75	13.64	13.88	13.92	14.31	*South Korea*
TUR	4.31	4.33	4.49	4.59	4.46	4.75	4.98	5.11	5.10	5.03	5.35	4.90	4.98	5.11	5.13	5.28	5.65	6.04	6.01	5.88	6.03	6.25	6.47	6.28	6.53	6.59	6.79	7.27	*Turkey*
Other G20	**4.84**	**4.85**	**4.88**	**4.92**	**5.02**	**5.08**	**5.16**	**5.22**	**5.22**	**5.17**	**5.18**	**5.23**	**5.29**	**5.48**	**5.63**	**5.68**	**5.73**	**5.84**	**5.96**	**5.83**	**6.05**	**6.07**	**6.21**	**6.28**	**6.45**	**6.40**	**6.30**	**6.29**	**Other G20 countries**
ARG	8.81	8.57	8.56	8.58	8.76	8.38	8.69	8.49	8.38	8.51	8.45	8.27	7.98	8.54	8.84	8.85	9.14	9.27	9.41	8.81	8.73	8.69	8.76	8.72	8.94	8.92	8.89	8.75	*Argentina*
BRA	4.45	4.53	4.58	4.66	4.77	4.90	4.87	4.96	5.00	4.97	5.04	5.07	5.17	5.27	5.43	5.45	5.38	5.45	5.50	5.30	5.68	5.72	5.86	5.98	6.12	5.96	5.74	5.73	*Brazil*
IDN	2.36	2.46	2.54	2.60	2.57	2.65	2.72	2.79	2.72	2.75	2.69	2.76	2.78	2.89	2.90	2.90	3.00	3.06	3.05	3.14	3.19	3.23	3.30	3.28	3.41	3.40	3.37	3.43	*Indonesia*
SAU	14.73	14.57	14.73	14.50	16.06	15.40	15.86	15.74	16.00	15.72	16.16	16.27	16.62	17.12	17.31	17.75	18.17	18.49	19.43	19.62	20.71	21.06	21.69	22.16	22.73	23.09	22.98	22.89	*Saudi Arabia*
SAF	10.56	10.11	9.74	9.58	9.54	9.78	9.93	10.18	10.18	9.64	9.61	9.70	9.90	10.29	10.84	10.99	10.91	11.21	11.71	10.94	11.03	10.51	10.67	10.73	10.82	10.54	10.38	10.09	*South Africa*
Total G20	**6.86**	**6.80**	**6.70**	**6.66**	**6.66**	**6.76**	**6.79**	**6.77**	**6.71**	**6.69**	**6.79**	**6.79**	**6.82**	**7.03**	**7.27**	**7.44**	**7.62**	**7.80**	**7.74**	**7.62**	**7.93**	**8.13**	**8.15**	**8.20**	**8.25**	**8.19**	**8.14**	**8.17**	**Total Group of Twenty (G20)**
Other large emitting cr	**6.97**	**6.94**	**6.78**	**6.40**	**6.11**	**6.02**	**5.92**	**5.74**	**5.43**	**5.41**	**5.47**	**5.50**	**5.54**	**5.78**	**5.92**	**6.04**	**6.14**	**6.24**	**6.26**	**5.91**	**6.08**	**6.12**	**6.12**	**6.11**	**5.96**	**5.74**	**5.77**	**5.83**	**Other large emitting countries**
EGY	2.49	2.52	2.59	2.59	2.47	2.55	2.63	2.66	2.66	2.78	2.70	2.87	2.90	2.93	3.07	3.33	3.46	3.60	3.58	3.60	3.54	3.58	3.67	3.46	3.44	3.42	3.50	3.53	*Egypt*
IRN	6.72	7.06	7.23	6.87	7.61	7.40	7.50	7.50	7.10	7.38	7.59	7.65	7.82	8.30	8.85	9.29	9.76	10.19	10.13	10.32	10.30	10.33	10.25	10.41	10.64	10.42	10.76	11.26	*Iran*
KAZ	21.19	21.53	22.18	19.61	17.80	15.81	14.24	12.81	12.85	12.04	12.25	12.03	13.50	14.22	15.32	16.00	17.52	17.90	20.39	18.42	19.50	20.14	21.33	21.84	20.92	20.15	19.55	20.11	*Kazakhstan*
MYS	5.26	5.85	5.91	6.58	6.47	6.66	7.18	7.41	7.23	7.45	7.77	7.79	8.14	8.41	8.93	9.31	9.46	9.96	10.32	9.32	9.76	9.66	9.60	10.10	10.41	10.26	10.27	10.23	*Malaysia*
NGA	3.46	3.53	3.59	3.56	3.36	3.42	3.67	3.26	2.84	2.58	2.61	2.61	2.29	2.46	2.35	2.28	2.09	1.96	1.93	1.77	1.86	1.88	1.82	1.78	1.69	1.66	1.61	1.63	*Nigeria*
TWN	6.96	7.35	7.67	8.07	8.42	8.79	9.19	9.83	10.25	10.62	11.52	11.64	11.99	12.37	12.69	12.90	13.19	13.30	12.74	12.01	12.72	12.65	12.23	12.24	12.24	12.25	12.39	12.74	*Taiwan*
THA	3.64	3.84	3.99	4.15	4.42	4.64	4.91	4.94	4.45	4.56	4.49	4.61	4.76	4.86	5.17	5.29	5.32	5.52	5.57	5.50	5.79	5.71	6.02	6.11	5.92	5.83	5.80	5.83	*Thailand*
UKR	18.41	17.33	15.50	13.69	11.60	11.33	9.85	9.53	9.11	9.14	9.12	9.15	9.32	9.91	9.50	9.41	9.48	9.64	9.39	8.02	8.52	9.04	8.87	8.67	7.72	6.46	6.78	6.30	*Ukraine*
Remaining	**3.32**	**3.20**	**3.12**	**3.09**	**3.07**	**3.07**	**3.06**	**3.06**	**3.01**	**2.96**	**2.96**	**2.96**	**2.93**	**2.97**	**3.01**	**3.05**	**3.07**	**3.08**	**3.15**	**3.10**	**3.16**	**3.14**	**3.18**	**3.18**	**3.17**	**3.16**	**3.18**	**3.17**	**Remaining countries (186)**
Int. transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**International transport**
Total	**6.18**	**6.09**	**5.99**	**5.92**	**5.90**	**5.95**	**5.96**	**5.93**	**5.85**	**5.82**	**5.89**	**5.87**	**5.89**	**6.05**	**6.23**	**6.36**	**6.48**	**6.62**	**6.58**	**6.44**	**6.68**	**6.80**	**6.80**	**6.82**	**6.83**	**6.77**	**6.73**	**6.74**	**Total**

[19] The number of digits does not indicate the accuracy of the figures, See uncertainty information in the Appendix. Calculated using the Global Warming Potentials (GWPs) for 100 year from the IPCC's Fourth Assessment Report (AR4).

Table B.6 Greenhouse gas emissions, per USD of GDP, per country and group, 1990–2017[20] (unit: kg CO^2 per 1,000 USD of GDP [PPP])

Total GHG emissions per USD of GDP per country/group, 1990-2017[x] (unit: kg CO_2 per 1000 USD of GDP [PPP, 2011 prices])																														
ISO country/group	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Country/group
CHN	**2090**	**1980**	**1800**	**1670**	**1550**	**1530**	**1400**	**1290**	**1220**	**1140**	**1090**	**1050**	**1030**	**1050**	**1080**	**1090**	**1060**	**1000**	**930**	**900**	**880**	**870**	**830**	**800**	**750**	**710**	**660**	**630**	**China**
USA	**660**	**660**	**650**	**640**	**630**	**610**	**610**	**600**	**570**	**550**	**540**	**530**	**520**	**510**	**500**	**490**	**470**	**470**	**460**	**440**	**450**	**440**	**420**	**420**	**420**	**400**	**380**	**380**	**United States**
EU28	**470**	**460**	**440**	**440**	**420**	**410**	**410**	**400**	**380**	**360**	**350**	**350**	**340**	**340**	**330**	**320**	**310**	**300**	**290**	**280**	**280**	**270**	**270**	**260**	**250**	**250**	**240**	**240**	**European Union**
FRA	310	320	310	300	290	290	290	280	280	260	250	250	240	240	240	230	220	220	210	210	210	200	200	200	180	190	190	190	*France*
DEU	500	460	430	430	420	410	410	390	370	350	340	340	330	340	330	320	310	290	290	290	290	270	270	280	260	260	260	250	*Germany*
ITA	290	290	280	280	270	280	270	270	270	270	270	260	260	270	270	270	260	250	250	240	240	230	230	220	210	210	210	210	*Italy*
NLD	460	460	450	450	440	440	440	410	390	360	340	330	330	330	330	320	300	290	280	280	300	270	280	280	260	270	270	250	*Netherlands*
POL	1280	1350	1280	1230	1150	1080	1050	970	850	790	730	710	680	680	650	630	610	570	540	500	510	480	460	450	420	410	410	400	*Poland*
ESP	320	320	330	310	320	320	310	320	310	320	320	310	310	310	310	310	290	290	270	250	240	250	250	240	230	240	220	230	*Spain*
GBR	510	520	500	470	450	440	440	410	390	370	360	350	340	330	320	310	300	290	280	270	270	250	250	240	220	210	190	180	*United Kingdom*
IND	**900**	**930**	**900**	**880**	**850**	**830**	**790**	**790**	**750**	**720**	**710**	**680**	**670**	**640**	**620**	**590**	**570**	**550**	**550**	**550**	**520**	**510**	**510**	**480**	**470**	**450**	**430**	**420**	**India**
RUS	**990**	**1020**	**1110**	**1110**	**1160**	**1180**	**1190**	**1100**	**1160**	**1120**	**1040**	**1000**	**950**	**920**	**870**	**810**	**770**	**710**	**670**	**680**	**690**	**680**	**660**	**630**	**620**	**640**	**650**	**650**	**Russian Federation**
JPN	**340**	**330**	**330**	**330**	**350**	**340**	**340**	**330**	**320**	**330**	**320**	**320**	**320**	**320**	**310**	**310**	**300**	**310**	**290**	**290**	**300**	**310**	**310**	**310**	**330**	**310**	**310**	**300**	**Japan**
Other OECD G20	**590**	**590**	**590**	**580**	**580**	**580**	**570**	**560**	**550**	**540**	**540**	**540**	**520**	**510**	**500**	**480**	**480**	**470**	**460**	**470**	**460**	**460**	**450**	**430**	**420**	**410**	**410**	**400**	**Other OECD G20**
AUS	1030	1030	1030	990	970	950	910	900	900	920	920	920	880	770	810	750	780	750	700	700	660	740	710	620	620	610	580	570	*Australia*
CAN	710	720	730	720	710	700	720	700	670	650	640	620	610	610	590	580	560	580	560	540	540	540	530	530	530	520	510	510	*Canada*
MEX	400	390	380	380	390	410	400	400	400	380	380	380	380	400	390	390	390	390	390	410	400	390	390	380	360	350	360	350	*Mexico*
KOR	650	640	630	640	630	620	610	610	560	550	570	550	510	490	490	470	450	440	430	430	440	440	430	420	410	400	390	390	*South Korea*
TUR	380	380	390	370	380	390	380	370	370	380	390	380	370	360	340	320	330	340	340	350	340	320	320	290	290	280	290	290	*Turkey*
Other G20	**530**	**510**	**510**	**500**	**500**	**490**	**490**	**490**	**500**	**510**	**500**	**500**	**510**	**510**	**500**	**490**	**480**	**470**	**460**	**460**	**450**	**430**	**430**	**430**	**440**	**430**	**430**	**420**	**Other G20 countries**
ARG	810	710	650	620	610	600	600	550	530	560	570	590	640	640	610	570	550	520	510	510	470	440	460	450	480	470	480	460	*Argentina*
BRA	430	440	450	450	440	440	440	440	450	450	440	450	450	460	450	440	430	410	400	390	390	380	390	390	400	410	410	410	*Brazil*
IDN	510	510	500	490	450	440	430	420	480	490	460	460	450	460	440	420	420	410	390	390	380	370	360	340	340	330	310	310	*Indonesia*
SAU	350	310	310	320	360	350	360	360	360	380	380	390	420	400	390	390	400	410	420	440	460	430	440	450	450	460	460	470	*Saudi Arabia*
SAF	1090	1080	1090	1080	1070	1080	1070	1090	1100	1040	1010	1000	1000	1030	1050	1020	970	960	980	940	930	870	870	870	870	850	840	820	*South Africa*
Total G20	**660**	**650**	**640**	**630**	**620**	**620**	**610**	**590**	**570**	**560**	**550**	**540**	**530**	**530**	**530**	**530**	**520**	**510**	**500**	**500**	**500**	**490**	**480**	**470**	**460**	**450**	**430**	**420**	**Total Group of Twenty (G20)**
Other large emitting cr	**880**	**870**	**840**	**800**	**780**	**760**	**720**	**700**	**670**	**650**	**630**	**630**	**610**	**600**	**570**	**570**	**550**	**530**	**530**	**510**	**490**	**490**	**490**	**480**	**460**	**450**	**440**	**430**	**Other large emitting countries**
EGY	420	430	430	430	400	410	410	400	390	390	360	380	380	380	390	420	410	410	380	380	360	360	370	350	350	340	340	330	*Egypt*
IRN	590	560	570	540	620	600	580	590	560	590	580	590	570	560	580	590	600	590	590	600	570	570	620	640	630	630	580	590	*Iran*
KAZ	1640	1880	2030	1970	2020	1930	1710	1490	1500	1350	1240	1080	1100	1070	1070	1030	1020	970	1080	980	980	950	980	960	900	870	840	840	*Kazakhstan*
MYS	500	520	490	510	470	460	460	450	490	490	480	490	490	490	500	500	490	500	500	470	460	440	420	430	430	410	400	380	*Malaysia*
NGA	1140	1200	1250	1240	1190	1240	1300	1150	1000	930	920	900	780	780	570	550	480	430	410	360	360	360	340	320	300	290	300	300	*Nigeria*
TWN	420	410	400	400	390	380	380	380	390	380	390	400	390	390	380	370	360	340	330	310	300	290	270	270	260	260	260	260	*Taiwan*
THA	550	540	520	510	500	490	500	520	520	510	490	490	480	460	460	460	440	440	440	440	430	420	420	410	400	380	370	360	*Thailand*
UKR	1740	1790	1770	1820	2000	2210	2120	2100	2030	2020	1890	1720	1650	1590	1350	1290	1210	1130	1070	1070	1090	1090	1060	1030	980	900	920	830	*Ukraine*
Remaining	**700**	**700**	**690**	**680**	**670**	**660**	**640**	**630**	**610**	**600**	**580**	**580**	**570**	**580**	**550**	**540**	**520**	**500**	**500**	**490**	**490**	**480**	**470**	**460**	**450**	**450**	**450**	**440**	**Remaining countries (186)**
Int. transport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**International transport**
Total	**690**	**690**	**670**	**660**	**650**	**640**	**630**	**610**	**600**	**580**	**570**	**560**	**550**	**560**	**550**	**540**	**530**	**520**	**510**	**510**	**510**	**500**	**490**	**480**	**470**	**460**	**450**	**440**	**Total**

[20] Calculated using the Global Warming Potentials (GWPs) for 100 year from the IPCC's Fourth Assessment Report (AR4). GDP in USD for Purchasing Power Parity (PPP) and in prices of 2011.

C. Recent trends in electricity production

This Appendix is only available as separate spreadsheet. It contains:

- fossil-fuel power generation
- different types of renewable power generation
- nuclear power generation

D. Recent trends in key drivers of greenhouse gas emissions

This Appendix is only available as separate spreadsheet. It contains:

- coal, oil and natural gas consumption (CO_2)
- cement production (CO_2)
- coal, oil and natural gas production (CH_4)
- cattle (CH_4, N_2O)
- rice production (CH_4)
- synthetic fertiliser consumption (N_2O)
- manure on soils (N_2O)

References

Alvarez RA, Zavala-Araiza D, Lyon DR, Allen DT, Barkley ZR, Brandt AR, Davis KJ, Herndon SC, Jacob DJ, Karion A, Kort EA, Lamb BK, Lauvaux T, Maasakkers JD, Marchese AJ, Omara M, Pacala SW, Peischl J, Robinson AL, Shepson PB, Sweeney C, Townsend-Small A, Wofsy SC and Hamburg SP. (2018). Assessment of methane emissions from the US oil and gas supply chain. *Science*,10.1126-science.aar7204, 21 June 2018. https://doi.org/10.1126/science.aar7204

BP (2018). Statistical Review of World Energy 2018. https://on.bp.com/1jtdBhB

Byron D. (2018). EPA's updated annual oil and gas methane inventory doesn't convey entire picture, 3 April 2018. Environmental Defense Fund (EDF). https://shar.es/aauW0b

CEIC Data (2018). What was India's Electricity Production in Sep 2018? Graph for months Jan 2017 to Sep 2018. https://www.ceicdata.com/en/indicator/india/electricity-production

EC-JRC/PBL (2018) Emissions Database for Global Atmospheric Research v4.3.2. Joint Research Centre of the European Commission/PBL Netherlands Environmental Assessment Agency. http://edgar.jrc.ec.europa.eu/overview.php?v=432. This data set does not contain emissions from savannah fires (so no CH_4 nor N_2O emissions)

EEA (2018). Approximated EU GHG inventory: proxy GHG estimates for 2017, 26 Oct 2018. https://www.eea.europa.eu/publications/approximated-eu-ghg-inventory-proxy.

EIA (2013). Japan's fossil-fueled generation remains high because of continuing nuclear plant outages. *Today in Energy*, 15 March 2013. https://www.eia.gov/todayinenergy/detail.php?id=10391

EIA (2016). Five and a half years after Fukushima, 3 of Japan's 54 nuclear reactors are operating. *Today in Energy*, 13 September 2016. https://www.eia.gov/todayinenergy/detail.php?id=27912

EIA (2017). India's steel industry, like America's, is dominated by electric-based processes. *Today in Energy*, 8 December 2017. https://www.eia.gov/todayinenergy/detail.php?id=34052

EIA (2018a). U.S. energy-related CO_2 emissions fell slightly in 2017. *Today in Energy*, 20 March 2018. https://www.eia.gov/todayinenergy/detail.php?id=35412

EIA (2018b). Coal power generation declines in United Kingdom as natural gas, renewables grow. *Today in Energy*, 24 April 2018. https://www.eia.gov/todayinenergy/detail.php?id=35912

EIA (2018c). Table 1.9 Heating Degree-Days by Census Division. May 2018 Monthly energy review. https://www.eia.gov/totalenergy/data/browser/?tbl=T01.09.

EIA (2018d). Table 1 10 Cooling Degree Days By Census Division. May 2018 Monthly energy review. https://www.eia.gov/totalenergy/data/browser/index.php?tbl=T01.10

EIA (2018e) U.S. energy-related CO_2 emissions fell slightly in 2017. *Today in Energy*, 5 September 2018. https://www.eia.gov/todayinenergy/detail.php?id=36953

EIA (2018f). Monthly statistics for the consumption of coal (Jan-Aug), finished oil products (Jan-Aug) and natural gas (Jan-Aug). https://www.eia.gov/coal/data.php#consumption etc.

Elvidge CD, Bazilian MD, Zhizhin M, Ghosh T, Baugh K and Hsu F-S. (2018). The potential role of natural gas flaring in meeting greenhouse gas mitigation targets. *Energy Strat Rev*, 20, 156-162. https://doi.org/10.1016/j.esr.2017.12.012

Eurostat (2018a). In 2016, CO_2 emissions in the EU estimated to have slightly decreased compared with 2015. News release, 4 May 2017. http://ec.europa.eu/eurostat/documents/2995521/8010076/8-04052017-BP-EN.pdf

Eurostat (2018b). Heating Degree Days (HDD): Actual heating degree-days. (EU27 from 1980 until 2004 / EU-28 from 2005 until 2016). http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_chdd_a&lang=en

Eurostat (2018c). Monthly statistics for the gross inland deliveries of hard coal (Jan-Jul), oil products (excluding biofuels) (Jan-Aug) and natural gas (Jan-Aug). Data > Database > Energy (nrg) > Energy statistics – supply, transformation, consumption (nrg10m) http://ec.europa.eu/eurostat/data/database

FAO (2018). FAOSTAT Production of live animals, crops, consumption of nitrogen fertilisers, burning – savannah. http://www.fao.org/faostat/en/#data

Feaster, S. (2018). Record Drop in U.S. Coal-Fired Capacity Likely in 2018. Utilities Are Accelerating Shutdown Dates as Plants Grow Increasingly Uneconomic. IEEFA report, October 2018. http://ieefa.org/wp-content/uploads/2018/10/Record-Drop-in-U.S.-Coal-Fired-Capacity-in-2018_October2018.pdf

Global Carbon Project (2018). http://www.globalcarbonproject.org/carbonbudget/index.htm.

Global CCS Institute (2018). The global status of CCS: 2017. Internet: https://status.globalccsinstitute.com

Guglielmi G. (2018) Methane leaks from US gas fields dwarf official estimates. Latest studies suggest that emissions could be coming from faulty equipment. *Nature*, 558,496-497.

Gütschow J, Jeffery ML, Gieseke R, Gebel R, Stevens D, Krapp M, and Rocha M. (2016). The PRIMAP-hist national historical emissions time series, Earth Syst. Sci. Data, 8, 571–603, https://doi.org/10.5194/essd-8-571-2016.

Houghton RA and Nassikas AA. (2017). Global and regional fluxes of carbon from land use and land cover change 1850-2015. *Global Biogeochem. Cycles*, 31, 457–472. http://onlinelibrary.wiley.com/doi/10.1002/2016GB005546/full

Houghton RA, Van der Werf GR, DeFries RS, Hansen MC, House JI, Le Quéré C, Pongratz J and Ramankutty N. (2012). Chapter G2 Carbon emissions from land use and land-cover change, *Biogeosciences*, 9, 5125-5142, doi: 10.5194/bgd-9-835-2012

IEA (2017a). Energy Statistics of OECD Countries and Non-OECD Countries, 1970-2015. International Energy Agency, Paris.

IEA (2017b). CO_2 Emissions from Fuel Combustion. Ed. 2017 (1971–2015). https://webstore.iea.org/search?q=co2+emissions+from

IEA (2018a). World Energy Balances. Production, consumption, import, export, 1971–2016. http://data.iea.org/payment/products/117-world-energy-balances-2017-edition.aspx

IEA (2018b). CO_2 Emissions from Fuel Combustion. Ed. 2018 (1971–2016). https://webstore.iea.org/search?q=co2+emissions+from

IFA (2018). Urea production and consumption as fertiliser 2011–2017. http://www.fertiliser.org/statistics

IMF (2018). World Economic Outlook Database Update April 2018. International Monetary Fund. http://www.imf.org/external/pubs/ft/weo/2018/01/weodata/index.aspx

IPCC (2006). IPCC Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme (NGGIP). Intergovernmental Panel on Climate Change. Internet: https://www.ipcc-nggip.iges.or.jp/public/2006gl

IPCC (2007). Working Group I Fourth Assessment Report 'The Physical Science Basis'. In particular Chapter 10. https://wg1.ipcc.ch/publications/wg1-ar4/wg1-ar4.html https://www.ipcc.ch/publications_and_data/a4/wg1/en/ch2s2-10-2.html

IRRI (International Rice Research Institute) (2018). World rice statistics online. http://ricestat.irri.org:8080/wrsv3/entrypoint.htm

Janssens-Maenhout G, Crippa M, Guizzardi D, Muntean M, Schaaf E, Dentener F, Bergamaschi P, Pagliari V, Olivier JGJ, Peters JAHW, Van Aardenne JA, Monni S, Doering U and Petrescu AMR. (2017). EDGAR v4.3.2 Global Atlas of the three major Greenhouse Gas Emissions for the period 1970–2012. *Earth Syst. Sci. Data Discuss.*, in review. https://doi.org/10.5194/essd-2017-79 http://edgar.jrc.ec.europa.eu/overview.php?v=432&SECURE=123

Kuramochi T, Fekete H, Hans F. et al. (2018). Greenhouse gas mitigation scenarios for major emitting countries: Analysis of current climate policies and mitigation commitments. 2018

update, NewClimate Institute (Cologne), PBL (The Hague), IIASA (Laxenburg), www.pbl.nl/en

Lyon, DR.(2018) EPA's Updated Annual Oil And Gas Methane Inventory Doesn't Convey Entire Picture. Environmental Defense Fund (EDF), Energy Exchange Blog, 13 April 2018. https://shar.es/aa1T80

Muntean M, Guizzardi D, Schaaf E, Crippa M, Solazzo E, Olivier JGJ, Vignati E. (2018). Fossil CO_2 emissions of all world countries, 2018 Report, EUR 28766 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-73207-2, doi:10.2760/709792, JRC107877. http://edgar.jrc.ec.europa.eu/whats_new.php

Nakayama S. (2017). Coal-Fired Power Generation in Japan and the World. World Coal Association, 3 May 2017. https://www.worldcoal.org/coal-fired-power-generation-japan-and-world

NAS (National Academies of Sciences, Engineering, and Medicine) (2018).. Improving Characterization of Anthropogenic Methane Emissions in the United States. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/24987

NBSC (National Bureau of Statistics of China) (2018a). Statistical Communiqué of the People's Republic of China on the 2017 National Economic and Social Development. 28 February 2018. http://www.stats.gov.cn/english/pressrelease/201702/t20170228_1467503.html

NBSC (National Bureau of Statistics of China) (2018b). Monthly data > Energy > Output of energy products. http://data.stats.gov.cn/english/login.htm

NOAA (2018). Global Climate Report - Annual 2017. US National Oceanic and Atmospheric Administration's National Centers for Environmental Information (NCEI). Formerly the National Climatic Data Center (NCDC). https://www.ncdc.noaa.gov/sotc/global/201713

Olivier JGJ, Van Aardenne JA, Monni S, Döring UM, Peters JAHW and Janssens-Maenhout G. (2010). Application of the IPCC uncertainty methods to EDGAR 4.1 global greenhouse gas inventories. In: '3rd International Workshop on Uncertainty in Greenhouse Gas Inventories, 22–24 September, 2010'. Proceedings. Lviv Polytechnic National University, Lviv, Ukraine. https://bit.ly/2CscDzI

Olivier JGJ, Schure KM and Peters JAHW. (2017). Trends in global CO_2 and total greenhouse gas emissions. 2017 Report. PBL Netherlands Environmental Assessment Agency, The Hague. PBL report no. 2983. https://bit.ly/2y2Nw2F

PBL (2016). PBL Climate Pledge NDC tool. https://themasites.pbl.nl/climate-ndc-policies-tool/.

Shearer C, Mathew-Shah N, Myllyvirta L, Yu A and Nace T. (2018a). Boom and Bust 2018. Tracking the global coal plant pipeline. https://endcoal.org/global-coal-plant-tracker/reports/boom-bust-2018/

Shearer C, Yu A and Nace T. (2018b). Tsunami Warning. Can China's central authorities stop a massive surge in new coal plants caused by provincial overpermitting? https://endcoal.org/2018/09/tsunami-warning/

UNPD (2017). United Nations Population Division. World Population Prospects, 2017 revision. https://esa.un.org/unpd/wpp

UNEP (United Nations Environment Programme) (2018). The Emissions Gap Report 2018. United Nations Environment Program (UNEP), Nairobi. Internet: https://www.unenvironment.org/resources/emissions-gap-report-2018 https://www.pbl.nl/en/publications/unep-emissions-gap-report-2018

UNEP DTU Partnership (2017) CDM/JI Pipeline Analysis and Database. Internet: http://www.cdmpipeline.org

UNFCCC (2011). Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention. Decision 24/CP.19. FCCC/CP/2013/10/Add.3. http://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf

UNFCCC (2018). National Inventory Submissions 2018. https://bit.ly/2y02yWU

US EPA (2012). Global Anthropogenic Non-CO_2 Greenhouse Gas Emissions: 1990–2030 Revised December 2012 Report EPA 430-R-12-006. https://bit.ly/2NtNXba

US EPA (2018) Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2016. EPA report no. EPA-R-430-18-003. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2016

USGS (United States Geological Survey) (2018). 2012–2017 production data on cement, lime, ammonia, crude steel and aluminium, from the USGS Commodity Statistics. https://minerals.usgs.gov/minerals/pubs/commodity/

Van der Werf GR, Randerson JT, Giglio L, Van Leeuwen TT, Chen Y, Rogers BM, Mu M, Van Marle MJE, Mortan DC, Collatz J, Yokelson RJ, Kasibhatla PS (2017). Global fire emissions estimates during 1997–2016. Earth Syst. Sci. Data, 9, 697-720. https://doi.org/10.5194/essd-9-697-2017

World Bank (2018a). World Development Indicators (WDI).Data set of 1 July 2018. http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators https://data.worldbank.org/indicator/NY.GDP.MKTP.PP.KD

World Bank (2018b). Global Gas Flaring Reduction Partnership (GGFR). Gas flaring volumes for 2012-2017. http://www.worldbank.org/en/programs/gasflaringreduction#7

WRI (2016). CAIT Country Greenhouse Gas Emissions: Sources & Methods June 2015. World Resources Institute, http://cait.wri.org/historical

Zavala-Araiza, D, Lyon, DR, et al. (2015) Reconciling divergent estimates of oil and gas methane emissions, *Proc Natl Acad Sci USA (PNAS),* 112, 15597-15602. http://www.pnas.org/content/112/51/15597