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TRENDS IN GLOBAL CO_2 AND TOTAL GREENHOUSE GAS EMISSIONS

2021 Summary Report

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Summary

Revised growth of 0.6% in global greenhouse gas emissions in 2019

In 2019, the growth in total global greenhouse gas (GHG) emissions (excluding those from land-use change) slowed down to 0.6% (±1%), reaching 51.7 gigatonnes of CO_2 equivalent ($GtCO_2$ eq) (with a 95% uncertainty range of ±8%). This revised growth rate is half of last year's estimate of 1.1% and less than half of the average annual growth rate of 1.5% since 2005. However, in 2020, the year in which the world economy and society was fully affected by the COVID-19 pandemic, global total GHG emissions are estimated to have declined by about 4% (±1%) to 49.8 $GtCO_2$ eq.

The 2019 global GHG emissions amounted to 58.8 $GtCO_2$ eq when also including those from land-use change (estimated at a very uncertain 7.1 $GtCO_2$ eq (±50%)), which is an increase of 19% compared to 2018 (Figure S.1). The CO_2 emissions related to land-use change were based on the Global Carbon Budget 2020 (Friedlingstein et al., 2020). The 2019 global GHG emissions excluding those from land-use change were about 57% higher than in 1990 and 23% higher than in 2005.

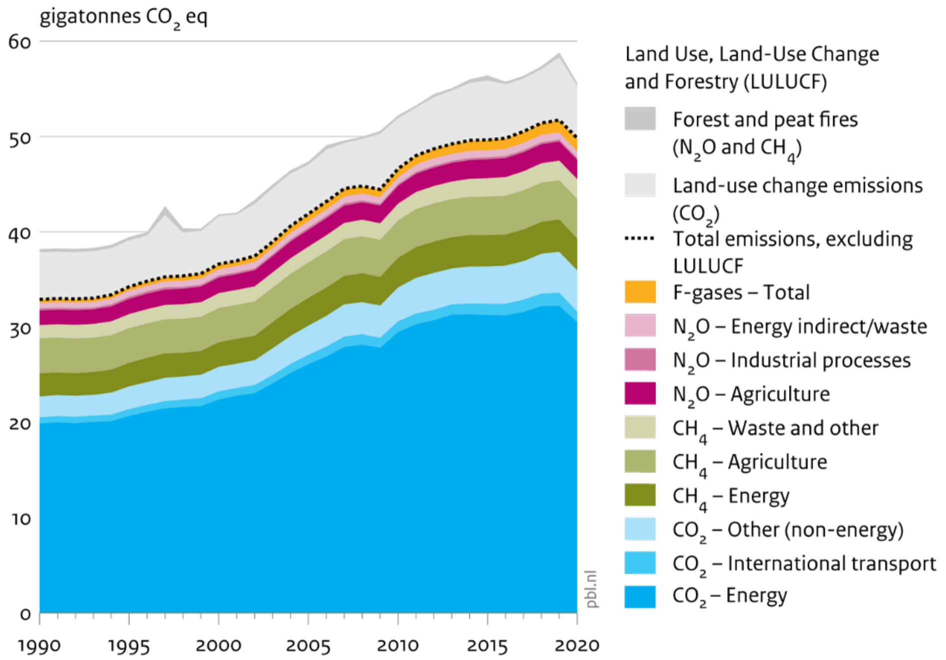
The 0.6% increase in global GHG emissions in 2019 was mainly due to a 0.5% increase in global CO_2 emissions from fossil-fuel combustion and industrial non-combustion processes, including cement production, which contributed by about three quarters to the total GHG emissions in 2019. Although global GHG emissions mostly consisted of CO_2 (about 73% in 2019, excluding land-use change), other significant shares are from methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (F-gases) with 18%, 6% and 2.5%, respectively. Collectively, these other greenhouse gas emissions increased by 0.9% in 2019; emissions of CH_4, N_2O and F-gases changed in 2019 by a respective 1.0%, -0.7% and 3.9%.

These figures are based on the new EDGAR v6.0 data set on all greenhouse gases over the 1970–2018 period and the Fast-Track FT2020 for CO_2 in 2019 and 2020$_2$ *excluding* land-use change (as described in the JRC 2021 booklet). For this report, the CH_4, N_2O and F-gas emissions in 2019 and 2020 were also calculated using the Fast-Track methodology.

However, we acknowledge that estimating global GHG emissions for 2020 using trend extrapolations for non-CO_2 greenhouse gases when preliminary activity statistics are not available — such as for methane from waste and waste water — is likely to overestimate the actual trend in 2020. A somewhat better preliminary estimate of global *GHG* emissions in 2020 is the total *decline* in *global total* GHG emissions by about -4.0% (with a 2σ uncertainty range of -1.5% to +1.0%).

The FT2020 *estimate* of 2020 global total GHG emissions amounts to 55.5 $GtCO_2$ eq when also including those from land-use change (estimated at a very uncertain 5.7 $GtCO_2$ eq (±50%)), a decrease of 19% compared to 2019, effectively nullifying the strong increase in land-use change estimated for 2019). The peaks in land-use-change emissions in Figure S.1 all coincide with major El Niños since 1990, in 1997, 2009, 2014–2015 and 2019, illustrating the impact of an El Niño on global forest fires.

Figure S.1
Global greenhouse gas emissions, per type of gas and source, including LULUCF



Source: CO_2, CH_4, N_2O, F-gases excl. land-use change: EDGAR v6.0 FT2020; incl. CH_4 and N_2O from savannah fires: FAO 2021; GHG from land-use change: CO_2 from Global Carbon Budget (GCB 2020); CH_4 and N_2O from forest and peat fires: GFED4.1s 2021
Note: CO_2 eq with GWPs from IPCC AR4

Decrease of more than 3.7% in global emissions in 2020 due to COVID-19 pandemic recession

In 2020, the year in which the world economy and society was fully affected by the COVID-19 pandemic, the global total of Gross Domestic Product (GDP) showed a 2.8% *decline*. Similarly, the *standard Fast-Track estimate* of *global total* GHG emissions in 2020 (*'FT2020') declined* by -3.7% (±1.5%) to 49.8 GtCO_2 eq (and likely a somewhat larger real decline, see below). In 2020, global GHG emissions mostly consisted of CO_2 (about 72%, excluding land-use change), other significant shares are from methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (F-gases) with 19%, 6% and 2.7%, respectively.

The Fast-Track estimates of total GHG emissions in 2020 for the top-5 countries and the European Union showed that all declined, except for those in China, which saw an increase of 1.5%. The five others saw declining GHG emissions in 2020: United States -8.5%, European Union (EU-27) -8.4%, India -3.9%, Russian Federation-4.9%, and Japan -6.3%.

The more than 3.7% decrease in global GHG emissions in 2020 was mainly due to a 5.1% decrease in global CO_2 emissions from fossil-fuel combustion and industrial non-combustion processes (excluding those from land-use change), which in turn was mainly due to a 5.9% decline in CO_2 emissions from fossil fuel combustion. The latter estimate is very close to the IEA estimate of 5.8% decline published in April 2021 and the estimate of 5.6% decline estimated by the Global Carbon Budget in December 2021 for the emissions from fossil-fuel combustion.

However, the actual changes in global non-CO_2 emissions of CH_4, N_2O and F-gases in 2020 were likely smaller or more negative than the Fast-Track estimates of +0.1%, -0.4% and +4.6% (collectively resulting in a small *increase* of 0.4%), due to recession effects not included in the FT extrapolation method. A better estimate for 2020 than the FT2020 of the global non-CO_2 emissions, including sectoral recession impacts, is that these other greenhouse gas emissions collectively *decreased* by 0.9%; individually, emissions of CH_4, N_2O and F-gases changed in 2020 by a respective -0.7%, -1.4% and -1.2%. Including this would lead to additionally *decreasing* global total GHG emissions by about 0.18 $GtCO_2$ eq or about 0.3% percentage points, which would lead to a 'better' estimate for the total *decline* in global GHG emissions in 2020, including COVID-19 recession impacts, of about -4.0% (or 49.7 $GgCO_2$ eq rounded) (not shown in Figure S.1).

1 Introduction

This summary report presents recent trends, up to and including 2020, in total greenhouse gas (GHG) emissions, for both carbon dioxide (CO_2) and non-CO_2 GHG emissions. We calculated these emissions based on the new EDGAR version 6.0 data set[1] for CO_2, methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (F-gases, i.e. HFCs, PFCs, SF_6 and NF_3), which covers the 1970–2018 period and includes comprehensive activity statistics and emission factor data up to 2018 (Crippa et al., 2021a,b; Minx et al., 2021).

For 2019 and 2020, a fast-track (FT) method was used for CO_2 emissions, for a description we refer to the JRC booklet by Crippa et al. (2021a). That report presents and discusses the global CO_2 trends for the 1970–2020 period and CO_2 trends per country for 1990 to 2020. In addition, for total GHG emissions, it presents the trends up to 2018, using data from EDGAR 6.0. For sectoral and country details on the 2019 and 2020 trend for CO_2 and on the total GHG trends up to 2018, we refer to the JRC booklet.

This PBL report focuses on the trends in total greenhouse gas emissions from 1990 to 2020 and, in particular, on the trends in 2019 and 2020. For the CH_4, N_2O and F-gas emissions in 2019 and 2020, we used a fast-track (FT) method using statistics for activity data on 2019 for about 80% to 90% of their global emissions and for about half of the global total emissions in 2020 (about 60% for CH_4, 45% for N_2O and 30% for F-gases). For sources and countries for which early activity statistics were missing on 2019 or 2020, the FT trend estimates were made using the average annual emission trend of the three most recent years in the EDGAR v6.0 dataset[2], viz. 2015–2018, and compared the trend extrapolation for 2019 and 2020 against emission trends observed in other historical recessions.

The FT analysis is based primarily on GHG emission data (CO2 from fossil-fuel use and industrial processes, and all anthropogenic emissions of CH4, N2O and fluorinated gases), but excluding CO2 from land-use change, using data from EDGAR v6.0 GHG FT2020. This new version v6.0 includes new statistics and emission factors and several revisions to previous years. In general, for non-CO_2 sources, we used updated international statistics from IEA, BP, USGS, FAO, USDA, IFA, UNFCCC (CRF data) and other sources to estimate the trends for 2019 and 2020 emissions of CH_4, N_2O and F-gases.

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[1] EDGARv6.0 uses mainly the energy balance statistics of IEA (2019) on 1970–2017 to estimate CO_2 from fossil fuel combustion, per country. CO_2 emissions were then extended with a Fast Track approach up to 2020, using the publicly available IEA CO_2 emissions by main fuel type (coal, oil and natural gas) for the year 2018 (IEA, 2020) and BP statistics for the years 2019 and 2020 (BP, 2021), assuming the same sectoral breakdown as in the last year of the IEA national energy balance statistics. For more details see Annex I in Crippa et al. (2021a).

[2] For more details on the methodologies and data sources used for EDGAR v6.0, please see Annex I in Crippa et al. (2021a) and Minx et al. (2021), which also provides detailed comparisons with other data sets. Olivier et al. (2017) and Maenhout et al. (2019) provide descriptions of methods and data sources used in v4.3.2 that were also largely used in v6.0.

1.1 Recalculations in EDGAR v6.0 data set

In the EDGAR v6.0 data set, the time series of CO_2, CH_4 and N_2O emissions were extended from 2015 in v5.0 to 2018, and for F-gases from 1990–2008 in v4.2 FT2010 to 1990–2018. This firstly means that recent emissions up to 2018 have now been calculated using the same methodology and data sources as for the emissions over the years before 2015 and, secondly, also the emissions for the 1970–2015 period which were updated when activity data or emission factors were revised as well (1970–2008 for F-gases). Table 1.1 in Box 1.1 provides a summary of the main changes.

For F-gases in this report, we used the new EDGAR v6.0 data set that covers the 1970–2018 period, for which mostly other data sources were used for the main sources of HFC and PFC emissions than in the previous version: for the 1990–2018 period, the new data set contains extensive data on emissions on the most important F-gases and sources reported annually by the so-called Annex-I countries (industrialised countries under the UN Climate Convention) (UNFCCC, 2021a), supplemented with F-gas emissions reported by, or for, 6 of the largest non-Annex-I countries (UNFCCC, 2021b) and 15 other non-Annex I countries that reported at least a substantial time series for all F-gases or for total HFC gases (UNFCCC, 2021b). These total emissions were compared, per HFC, with other bottom-up estimates of global emissions per specific HFC. The remainder was allocated to 79 other developing countries, in proportion to their share in total HCFC emissions for 2009 and 2010, reported to the UNEP Ozone Secretariat (2021), and indicative of the amount of HFC that will be used as substitute for HCFC which will be phased out by developing countries from 2013 to 2030). For a summary of the main changes, see Table 1.2 in Box 1.1. The methodology and data sources used are described in more detail in Appendix A.

F-gas emissions in 2019 and 2020 were estimated, using the fast-track (FT) method. For so-called Annex-I countries, we used reported emission trends for the most important F-gases and sources in 2019 and the average of the annual trend in 2016, 2017 and 2018 as estimator for the trend in 2020. For all other countries, for F-gases, we generally used the same trend estimation method (average of the annual trend in 2016, 2017 and 2018) for 2019 and 2020, as recent national and international statistics are generally not available for most of these countries.

For 2020, the extrapolation method was also applied to many CH_4 and N_2O emissions from agricultural sources (whereas, for 2019, we used FAO data for agricultural statistics). Exceptions, however, are CH_4 emissions in 2020 from fossil-fuel production for which IEA and/or BP statistics are available and from cattle and harvested areas in rice cultivation, for which international statistics for 2020 were available from the US Department of Agriculture (USDA, 2021).

Box 1.1 Revisions of GHG emissions from EDGAR v5.0 to v6.0

In EDGAR v6.0, the time series for CO_2, CH_4 and N_2O emissions were extended from 2015 in v5.0 to 2018 and for F-gases from 2010 in v4.2FT2010 to 2018, and the emissions for the 1970–2015 period were updated when sources, activity data or emission factors were revised, as well (see Table 1.1 for the impact on global total emissions per greenhouse gas, which also includes the FT2019 emissions for the years 2016 to 2019 that were reported on, last year).

Table 1.1
Revisions of global total GHG emissions in the 1970–2019 period

Gas	Average 1970–1989	Average 1990–2019
CO_2	0.5%	0.4%
CH_4	-11.2%	-1.2%
N_2O	3.0%	7.4%
F-gases (CO_2 eq)	9.6%	-15.2%
Total CO_2 eq	-2.4%	0.1%

These changes are mainly caused by changes in the following GHG sources (in percentages, the impact on global total emissions per gas, compared to v5.0 and to v4.2 for F-gases).
For CO_2, the largest revisions are in these sources (IPCC 1996 source codes between brackets):

- *Other industries* (1A2f) for 2005–2015 (+0.5%) and 1970–1977 (+0.3%);
- *Urea application* (4D4a) for all years (-0.1%), and the addition of a new source:
- *Fugitive emissions from coal mines* (1B1a1) (new source) (+0.1%) (IPCC, 2019) (Crippa et al., 2021a).

For CH_4, the largest changes due to revisions of data sources are found for three sources (Crippa et al., 2021a; Janssens-Maenhout et al., 2019; Minx et al., 2021):

- *Venting from oil and natural gas production* (1B2c) in the 1970s (-10% to -15%) then gradually down to 1997 (-0.5%) and varying from 2000 (+2.2%) to 2018 (+0.1%);
- *Landfill* (6A1) for all years: for 1970–2010 around -2%, then decreasing to -1.0% in 2018;
- *Industrial waste water* (6B1): for 1970–1990 about +0.1%, and increasing to +1.0% in 2018.

For N_2O, the largest changes are found for 2000–2015 (+0.3% to +2.2%):

- *Atmospheric deposition* (4D3a,4D13-14,4D2): for 1970–1997 (+1.2% to 1.7%) and 2012–2018 (2.1% to +3.1%);
- *Leaching and run-off* (4D3b + 4D11): for 1970–1997 (-1.1% to -0.8%) and 1988–2015 (-1.0% to -0.1%);
- *Industrial processes* (2B): from 2000–2015 (+0.3%);
- *Indirect N_2O emissions from NO_x in 1A* (7A1): for 1970–2015 (+5.1% to +6.4%);
- *Indirect N_2O emissions from NH_3 in 1A* (7A1): for 1970–2015 (+0.7% to +0.9%).

For F-gases, major revisions were made for the HFC emissions and for PFC emissions, with the largest changes found for 2010–2018 (-26%), as is shown in Table 1.2.

Table 1.2
Revisions of global F-gas emissions in the 1990–2018 period (in CO_2 eq)

F-gas	1990	2000	2010	2018
HFCs	+45%	-7%	-27%	-28%
PFCs	-24%	-23%	-54%	-54%
SF_6	-5%	-8%	-7%	-9%
NF_3	new	new	new	new
Total F-gases	+3%	-10%	-26%	-27%

Box 1.1 Revisions of GHG emissions from EDGAR v5.0 to v6.0 (continued)

For HFCs, most of the changes were from switching for main sources to the use of data reported by Annex I countries and other countries reporting time series of HFC emissions, which resulted in revisions in global F-gas emissions notably for these substances:
in 1990: HFC-23 (+46%);
in 2000: HFC-143a (-48%);
in 2010: HFC-23 (-40%), HFC-143a (-48%), HFC-125 (-21%);
in 2018: HFC-23 (-58%), HFC-143a (-50%), HFC-125 (-31%), HFC-227ea (3%), HFC-134a (+49%).

For PFCs, there is now a substantial difference, from the early 2000s onwards, in CF_4 and C_2F_6 from aluminium production, due to the use of emission factors reported for this industry in v6.0, the calculated emissions of which deviate substantially from v4.2 and top-down inferred PFC emissions, probably due to the occurrence of CF_4 emissions outside of high voltage anode effects (HVAEs) that are not taken into account in this data set (Thonstad and Rolseth, 2017; Marks and Nunez, 2018; Wong et al. 2018). Including these so-called low voltage anode effects (LVAEs) would probably about double the global PFC emissions for ~2005 and later years.

For SF_6, the main changes are in SF_6 emissions from Gas Insulated Switchgear (GIS) used in the electricity sector, the emissions from which are now taken from data reported to the UNFCCC Secretariat by Annex I countries and some other countries reporting time series.

1.2 COVID-19 impact on 2020 emissions: additional uncertainty in FT emissions

In the year 2020, the COVID-19 pandemic started, causing a major global disruption of national economies and human activities. Therefore, in cases where no (preliminary) activity statistics for

Box 1.2 Global temperatures in 2020

The global mean temperature for 2020 was 1.2 ± 0.1 °C above the 1850–1900 baseline, which marks 2020 as one of the three warmest years on record, globally. The past six years, 2015–2020, were the six warmest on record. The Arctic minimum extent of sea ice in September 2020 was the second smallest on record (WMO, 2021).

Continental temperatures, as observed by NCEI (2021):

- *Europe* had its warmest year on record at 2.16 °C above the 1910–2000 average, surpassing the previous record set in 2018 by 0.28 °C;
- *Asia* also had its warmest year on record at 2.07 °C above average, which was 0.35 °C above the now second warmest year set in 2015;
- *South America* had its second warmest year on record with a temperature at 1.40 °C above average;
- *North America*'s annual temperature has increased at an average rate of 0.29 °C per decade since 1981, more than twice of the increase of 0.13 °C per decade since 1910;
- *Africa*'s annual temperature has increased at an average rate of 0.30 °C per decade since 1981, also more than doubled compared with an average rate of 0.13 °C per decade since 1910.

2020 are available, the regular fast-track method for 2020 of using the emissions or activity trend of recent years to estimate the trend of a source in 2020 will likely result in an overestimation of the trend from 2019 to 2020. This is the case for several sources of CH_4, N_2O and F-gases (roughly half of total non-CO_2 GHG emissions in 2020).

Therefore, in addition to the regular fast-track trend in 2020 emissions for countries and sources (FT2020), we also report the 2020 trend with a larger percentage of uncertainty in the lower range, instead of applying a symmetrical uncertainty in the trend (i.e. x% ± y percentage points). This '*lower estimate*' for sources for which no preliminary statistics for 2020 were available was based on the historical impact of *average* annual change in global sectoral emissions in *recession* years, compared to average annual change in non-recession years. This '*lower estimate*', however, is only meant to be *indicative* of the uncertainty in the lower range of the FT estimate, as that is an impact estimate applicable to so-called '*normal*' economic recession years, which 2020 clearly was not. Since the standard deviation around them was large (several percentage points), this lower range uncertainty number is also quite uncertain.

Because about half of the non-CO_2 sources cannot yet be estimated with large accuracy for 2020, this summary report focuses on the revised estimates for 2019 as well, because that year will be the *reference* year to compare with when the greenhouse gas emissions will become available for the first 'normal' year, i.e. when economic activities have fully or partly recovered from the COVID-19 recession, which could possibly be 2021 or 2022.

1.3 First report on global total greenhouse gas emissions for COVID-19 year 2020

Recent global emissions of CO_2 can be reasonably estimated, because in the middle of the calendar year, first international statistics on fossil-fuel consumption per country up to the previous year are compiled and published by BP, which cover the lion's share of the CO_2 emissions (BP, 2021). Similarly, in the middle of year *t*, global emissions of non-CO_2 greenhouse gases can be reasonably estimated for two years back in time ('*t*-2' *and* '*t*-1'), because first international statistics are available on activity levels for most of the main emissions sources: fossil-fuel production reported by BP (and some by the International Energy Agency (IEA)), animal numbers and rice production reported by the UN Food and Agriculture Organization (FAO) (on *t*-2) as well as synthetic and natural fertiliser use reported by FAO (on *t*-2).

For other non-CO_2 GHG sources, the UN Climate Change secretariat (UNFCCC) compiles and publishes statistics up to year '*t*-2', which are reported by most industrialised countries (so-called Annex I countries) by 15 April of year *t*. This refers to CH_4 emissions from landfill and waste water, N_2O emissions from industrial processes such as nitric acid production, and F-gas emissions from the use of HFCs and other fluorinated gases and as a by-product.

For some other statistics, activity data (i.e. country statistics) on the previous year ('*t*-1') are also available, consisting not only of energy data by BP and IEA but also of agricultural data by the US Department of Agriculture (USDA) on rice and selected animal numbers (cattle) and industrial production data by the US and British Geological Survey (USGS, BGS) and sector-specific organisations such as the International Aluminium Institute (IAI), International Fertilizer

Association (IFA) and the World Semiconductor Council (WSC). For landfill and waste water, these statistics are not yet available on 2020, also not for Annex I countries.

During normal years, for other sources and countries for which no recent statistics are available, those '*t-1*' emissions can be reasonably estimated using trend extrapolation of recent years for which emissions are available (part of the fast-track method). However, for '*t-1*' (i.e. 2020), this approach is obviously not appropriate, since we already know that past trends are not continued in the first year of a recession. This applies, for instance, to methane emissions from landfill and waste water. Therefore, for 2020, in addition to the FT data, for all greenhouse gases except for CO_2, we also estimate how much smaller the actual emissions *may be* due to the coronavirus-related recession, which can be regarded as lowering the lower end of the uncertainty range surrounding the percentage trend estimate.

Please note that the EDGAR v6.0 emissions data set does not cover CH_4 and N_2O emissions from savannah burning. Therefore, for this report the EDGAR v6.0 emission data were completed to cover all sources of anthropogenic GHG emissions recommended by the IPCC (2006, 2019) (except for those from land-use change) with the data set on CH_4 and N_2O emissions from savannah burning up to 2019, as reported by the *Food and Agriculture Organization* (FAO)[3], generally causing only very small differences with national emissions reported in Crippa et al. (2021a).

With a share of well over 25% non-CO_2 emissions constitute a significant fraction of global GHG emissions. For climate policies, this refers to CH_4, N_2O and the so-called F-gases. To our knowledge, this report is the first to provide estimates of total global GHG emissions including 2020, whereas the 2019-2020 figures we estimated using a Fast-Track approach based on detailed activity data on most of the sources for these years.

For *global net* GHG emissions from land-use change (LUC), we used net CO_2 data generated in the *Global Carbon Project* (GCP) through 2019 (Friedlingstein et al., 2020)[4], supplemented with CH_4 and N_2O emissions from forest and peat fires from the *Global Fire Emissions Database* version GFED4.1s through 2020 (Van der Werf et al., 2017)[5]. Those data are inherently very uncertain and therefore

[3] The UN Food and Agriculture Organization (FAO) has compiled data on savannah burning emissions, for 1990–2019, 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), and aggregated at country level. The GFED data cover the 1996–2020 period, with data for 2017-2020 based on relations between active fires and emissions. For the years before 1996, FAO used the average of the 1996 to 2014 values. For details, see (a) Data set Information at FAOSTAT_savannah_fires, (b) Metadata at FAOSTAT_metadata.

[4] The GCB 2020 net CO_2 emissions from Land Use Change are the average of three bookkeeping models H&N, BLUE and OSCAR: Houghton and Nassikas (2017), Hansis et al. (2015) and Gasser et al. (2020). We used GCB data for 1970-2019 from GBC2020v1 (2020) (Friedlingstein et al., 2020) and our own estimate for 2020 based on the average of 2000-2019 numbers). In previous reports, we used the data set of H&N (Houghton and Nassikas, 2017).

[5] Total LULUCF emissions presented here include 0.2 $GtCO_2$ eq for fire emissions from CH_4 and N_2O taken from the GFED 4.1s data set (preliminary numbers based on fire counts). Please note that in the recently published GBC 2021 the time series has been revised substantially (Friedlingstein et al., 2021): since 2000 net global CO_2 emissions from LUC are about 20% lower and the annual changes are completely changed (percentages and signs can be quite different). For example, in the 2020 data set the emissions in 2019 are the highest and at a similar very high level as in 1997, whereas in the 2021

typically not included in emission totals of countries (e.g. as reported by countries under the UN Climate Convention). For the comprehensive overview of all GHG emissions and removals, we included them in the main figure (Figure 2.1) to illustrate their share in overall, total global anthropogenic GHG emissions. However, discussions on emission data focus on those derived from the EDGAR database, which excludes LUC emissions per country. For more information on this subject, we refer to the *Global Carbon Project* (2021) and its new 2021 release (Friedlingstein et al., 2021), and to the new regional EDGAR estimates of CO_2 emissions and removals from Land Use, Land-Use Change and Forestry (LULUCF) in the EDGAR booklet[6].

In addition to the global trends, this summary report also briefly discusses the top 5 emitting countries and the European Union as a whole. Uncertainty about non-CO_2 emission data is typically much larger than about CO_2 emissions (excluding forest and other land-use change-related emissions, (LUC)). The reason for this is because these sources are much more diverse and non-CO_2 emissions are determined by technological or other source-specific factors, whereas for CO_2, the emission factors are mainly determined by the characteristics of the fossil-fuel type and carbon content of fuels and carbonates. For more information on the uncertainty in the EDGAR v6.0 data set for GHG, we refer to Minx et al. (2021), and for a review of emission trends and drivers since 1990, we refer to Lamb et al. (2021).

Chapter 2 discusses global emission trends, focusing on trends in emissions and drivers since 2005 and since 1990. First, it discusses the most important variables driving the volume of the GHG sources and which of those are covered by the international statistics used for our fast-track emission estimates, for the years 2019 and 2020. Section 2.2 discusses the global total GHG emissions and subsequent sections describe the global trend in each of the main greenhouse gases, with a focus on the group of non-CO_2 greenhouse gases and the recent global trends in key drivers of these emissions (i.e. fossil-fuel production, cattle stock, rice cultivation (drivers for CH_4), and the use of synthetic fertilisers and manure used as fertiliser (drivers for N_2O)). Then Section 2.5 presents a brief discussion on the 2019 and 2020 trends for the 30 largest emitting countries and the European Union (EU-27), and the chapter finishes with a further characterisation of the emission inventory year 2019 and the pandemic year 2020, in Section 2.6.

Chapter 3 provides information on the five largest emitting countries and the European Union, focusing on the last two years.

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data set the net emissions in 2016-2019 are the lowest and in the 2020 data set these years are among the highest).

[6] The EDGAR booklet provides estimates for CO_2 emissions and removals from LULUCF for 5-year averages around 2000, 2005, 2010 and 2015 and for the seven macro regions and the world (see Chapter 3 and Annex 3 in Crippa et al., 2021a).

2 Trends in global emissions

2.1 Introduction

Our analysis of recent global GHG emissions 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. In 2019, these gases contributed a respective 73%, 19% and 5% to global total GHG emissions excluding land use, with F-gases accounting for the remaining 3% (when including 7 percentage points on average from land-use change, then CO_2 contributes 74% and CH_4 then contributes about 17%). Table 2.1 summarises the main drivers of emissions and their share in global emissions. For details on the methodology and data sources used, see Appendix D in this report and in Olivier et al. (2017) (also Appendix D).

Table 2.1
Key drivers of GHG emissions (excluding land use) (in 2019)

Type of gas	Main source drivers/ Other source drivers	Share in gas total	Last year of statistics
CO_2	**Coal combustion**	**39%**	**2020**
CO_2	**Oil combustion**	**31%**	**2020**
CO_2	**Natural gas combustion**	**18%**	**2020**
CO_2	Cement clinker production	4%	2019
CO_2	**Subtotal main drivers of CO_2**	**88%**	
CH_4	**Cattle** (rumination and droppings)	**21%**	**2020** [b]
CH_4	**Rice cultivation** (area harvested)	**10%**	**2020** [b]
CH_4	**Natural gas production** (including distribution)	**11%**	**2020**
CH_4	**Oil production** (including associated gas venting)	**9%**	**2020**
CH_4	**Coal mining**	**11%**	**2020**
CH_4	Landfill: municipal solid waste	9%	2019 [c]
CH_4	Waste water	12%	2019 [c]
CH_4	**Subtotal main drivers of CH_4**	**62%**	
N_2O	**Cattle** (droppings on pasture, range and paddock)*	**22%**	**2020** [b]
N_2O	**Synthetic fertilisers** (N content)*	**16%**	2019 [a]
N_2O	**Animal manure applied to soils***	**4%**	**2020**
N_2O	Crops (share of N-fixing crops, crop residues and histosols)*	11%	2019 [a]
N_2O	**Fossil-fuel combustion**	**11%**	**2020**
N_2O	Manure management (confined)*	4%	2019 [a]
N_2O	Indirect: atmospheric deposition & leaching and run-off (NH_3)*	9%	2019/**20**
N_2O	**Indirect:** atmospheric deposition (NO_x from fuel combustion)	**7%**	2019/**20**
N_2O	**Subtotal main drivers of N_2O, incl. related drivers (*)**	**60%**	
F-gases	**HFC use** (emissions in CO_2 eq)	**70%**	2019 [c]
F-gases	**HFC-23 from HCFC-22 production** (emissions in CO_2 eq)	**10%**	2019 [c]
F-gases	**SF_6 use in electrical equipment** (emissions in CO_2 eq)	**10%**	2019 [c]
F-gases	PFC use and by-product from aluminium production (emissions in CO_2 eq)	3%	2019 [c]
F-gases	**Subtotal main drivers of F-gases**	**90%**	

[a] Activity data compiled by FAO cf. IPCC source category definitions.
[b] Data for 2020 by USDA (2021).
[c] Statistics for Annex I countries only, reporting annually to UNFCCC (CRF files): up to year 2019 (others: variable).
Sources: EDGAR v6.0 for CO_2, CH_4, N_2O and F-gases (1970–2018); FT 2020 for all gases (IEA, BP, FAO/IFA, USDA, CRF).

For the smaller remaining sources, proxies were also often used for the years '*t*-2' and/or '*t*-1' (e.g. FAO statistics on other livestock and crops in 2019 and Annex I statistics on landfill and waste water in 2019 (= '*t*-2')). For the remaining years, sources and countries, trend extrapolation was applied (i.e. average of the trend in three recent years 2015–2018 for '*t*-1', but also for '*t*-2', in case no recent statistics were available with global coverage (such as for non-Annex I countries).

As we only use the fast-track methodology based on indicators of volume trends for estimating the emissions in the last four years (at maximum), whenever available in international statistics, we assume that non-volume effects that would impact emissions, such as changes in feed and food or in the relative intensity of gas venting, are relatively small on a year-by-year basis. 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 (so-called Annex I countries) (UNFCCC, 2021).

The direct drivers of CO_2 are the combustion of coal, oil and natural gas, representing 88% of global CO_2 emissions, with respective shares of 39%, 31% and 18%. Calcination in cement clinker production accounts for another 4% (Table 2.1).

For CH_4, there are three large groups of sources: agriculture, fossil-fuel production and solid 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 emissions, those from cattle alone are responsible for 21% of current global CH_4 emissions. Rice cultivation on flooded rice fields is another agricultural source, accounting for 10% of CH_4 emissions.

Other large methane sources are coal production, natural gas production and transmission, and oil production (including vented associated gases that consist mostly of CH_4, if it is not utilised as fuel or as chemical feedstock). Together, fossil-fuel production and transmission account for another third of global methane emissions, with more or less equal shares of each fuel. The third largest source is human solid waste and waste water, both estimated at shares of about 10% (Table 2.1).

For N_2O, agricultural activities are the main emission source, with a share of about 60%. Cattle droppings on pastures, rangeland and paddocks are by far the largest global source of nitrous oxide, with an estimated share of 22%, and the use of synthetic nitrogen fertiliser is the second-largest source, accounting for 16%, at present. Indirect N_2O emissions from agricultural activities contribute another 11%. Together, agricultural sources account for two-thirds of global emissions (Table 2.1).

F-gas emissions consist of HFCs, PFCs, SF_6 and NF_3. With a share of almost three quarters, emissions from the *use* of these gases are by far the largest source. Other sources are mainly inadvertent *by-product* emissions of HFC-23 during the production of HCFC-22 and PFC emissions of CF_4 and C_2F_6 that arise from primary aluminium production. At present, emissions of HFCs and SF_6 are the largest global sources of fluorinated gases, with shares of 80% and 16%, whereas PFCs only have a 4% share and NF_3 just 0.2%.

Total F-gas emissions from the *use* of these gases, in particular HFCs, have substantially increased since 2005, with about 6% per year. The annual reports of industrialised countries to the UNFCCC show detailed F-gas emissions from 1990 through 2019 (UNFCCC, 2021), supplemented by other, non-Annex I, countries also reporting F-gas emissions, albeit generally far less detailed. These are important sources of data for individual F-gases, as there are no global statistics on their production, use and emissions per country. We recall that uncertainties in F-gas emissions *at country level* are generally quite large, also when using the countries' self-reported emission data (Solazzo et al., 2021; Minx et al., 2021).

2.2 Global trends in total greenhouse gas emissions

2.2.1 Growth of 0.6% in global greenhouse gas emissions in 2019

In 2019, the growth in total global greenhouse gas (GHG) emissions (excluding those from land-use change) slowed down to 0.6% (±1%), reaching 51.7 gigatonnes of CO_2 equivalent[7] [8] [9] ($GtCO_2$ eq) (with a 95% uncertainty range of ±8% [10]). This revised growth rate is half of last year's estimate of 1.1% (Olivier and Peters, 2021) and less than half of the average annual growth rate of 1.5% since 2005 (Table 2.2). This 0.6% emissions increase in 2019 occurred while global economic growth was 2.7%, which is one per cent point lower than the growth in global Gross Domestic Product (GDP) in preceding years (Table 2.2).

The 0.6% increase in total GHG emissions was mainly due to the 0.5% increase in CO_2 emissions. The emissions of methane and F-gases also contributed to the total emission increase, with increases in 2019 of 1.0% and 3.9%, respectively. However, the 0.7% decrease in N_2O emissions had a small downward impact on the overall increase.

Amongst the countries that contributed most to the 0.6% global GHG emissions increase (about 310 $MtCO_2$ eq), China stands out with an increase of about 290 $MtCO_2$ eq (+2.1%), followed by about

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[7] For this report, for CH_4, N_2O and the F-gases, we used the *Global Warming Potential* (GWP) metric from the IPCC's Fourth Assessment Report (AR4) (2007), which is also used by industrialised countries (i.e. (Annex I countries) in their annual national emissions inventory reports submitted to the UNFCCC. The time horizon of the GWPs is 100 years. Please note that, often, developing countries officially report their emissions using GWPs from IPCC's Second Assessment Report (SAR). The largest difference with the AR4 is in the GWP of CH_4: in the AR4 this is 25 whereas in the SAR it is 21 — almost one fifth larger.

[8] Please note that the synthesis report by the UNFCCC (2021) shows all GHG emissions using GWPs from the latest, Sixth, Assessment Report (AR6) of Working Group I of the IPCC (2021). The differences in GWPs between AR4 and AR6 are: for CH_4 the GWP value is 25 in AR4 and 27.9 in AR6, for N_2O this is 298 in AR4 and 273 in AR6. This changes the CO_2 eq figures by about +11.6% for CH_4, -8.4% for N_2O and between about +3.4% and +9.4% in total global emissions of all F-gases between 1990 to 2020. Using AR6 GWPs increases the AR4's global totals by 1.0 $GtCO_2$ eq for 2019 and 2020 and by 0.7 $GtCO_2$ eq for 1990 emissions.

[9] Historical EDGAR GHG emission trends in this report are also presented in UNEP's Emissions Gap Report 2021 (UNEP, 2021).

[10] We included uncertainties with two standard deviations for global emissions of ±6% for CO_2 (excluding LUC), ±25% for CH_4, ±30% for N_2O and ±20% for fluorinated gases (UNEP, 2012), resulting in 7% uncertainty. Furthermore, we added an additional ±1% to account for the uncertainty in the 2018–2019 GHG emissions trend. The presented uncertainty ranges are consistent with those presented in Appendix 1 of UNEP's Emissions Gap Report 2012 (UNEP, 2012) and IPCC AR5 (Blanco et al., 2014).

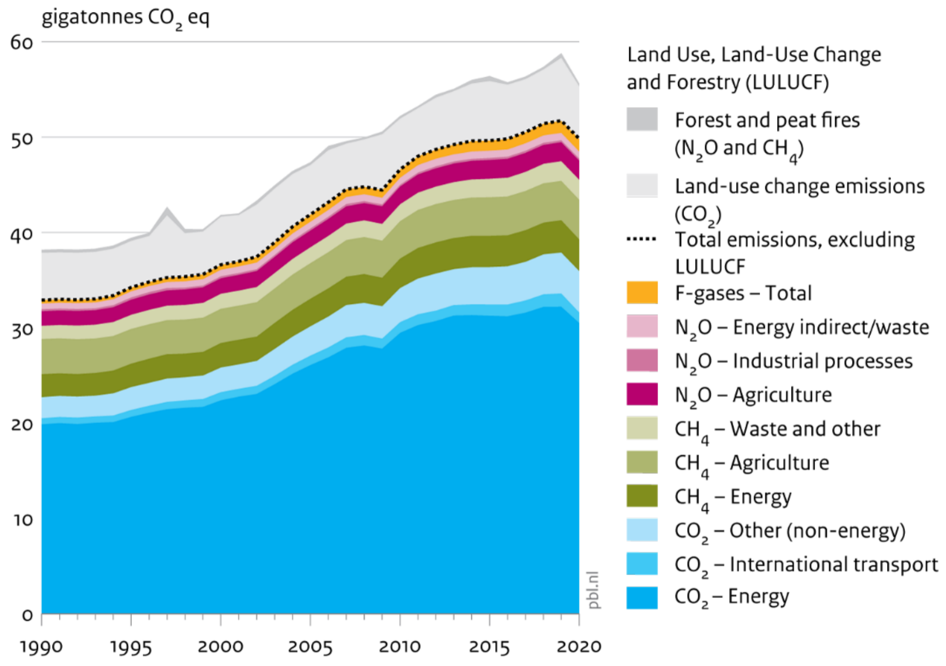
Vietnam with 50 $MtCO_2$ eq (+12.9%), and equal amounts in Indonesia (+4.5%) and India (+1.1%). These increases were partly counterbalanced by countries with decreasing GHG emissions, in particular in the European Union (-3.8%), the United States (-2.1%) and Japan (-2.8%).

The 2019 global GHG emissions amounted to 58.7 $GtCO_2$ eq (±10%) when also including those from land-use change (which are estimated at a very uncertain 7.1 $GtCO_2$ eq (±50%), representing an increase of 19% compared to 2018 due to the impact of a strong El Niño in 2019) (Figure 2.1). The 2019 GHG emissions excluding those from land-use change are about 57% higher than in 1990 and 23% higher than in 2005.

2.2.2 Decline of more than 3.7% in global emissions in 2020 due to COVID-19-related recession

In 2020, the year in which the world economy and society was fully affected by the COVID-19 pandemic, the global total of Gross Domestic Product (GDP) showed a 2.8% *decline*. Similarly, the *standard Fast-Track estimate* of *global total* GHG emissions in 2020 (‘*FT2020*’) shows a *decline* by -3.7% (±1.5%) to 49.8 $GtCO_2$ eq (and likely a somewhat larger decline, as is discussed below). For the Fast-Track estimate for 2020, we applied either international statistics with recent activity trends through 2020 or a trend extrapolation using the average emission trend of the past three years (2016, 2017 and 2018).

Figure 2.1
Global greenhouse gas emissions, per type of gas and source, including LULUCF



Source: CO_2, CH_4, N_2O, F-gases excl. land-use change: EDGAR v6.0 FT2020; incl. CH_4 and N_2O from savannah frires: FAO 2021; GHG from land-use change: CO_2 from Global Carbon Budget (GCB 2020); CH_4 and N_2O from forest and peat fires: GFED4.1s 2021
Note: CO_2 eq with GWPs from IPCC AR4

The estimate for 2020 would be about -4.0% (instead of -3.7%), if we assume that the average sectoral impact of the global recession applies to sources for which no preliminary statistics on 2020 are available, instead of extrapolating the trend observed in recent years, as we do in the Fast-Track method. Moreover, the global decline estimate would be another 0.2 percentage points lower if, for methane emissions from the oil and natural gas sector in 2020, we assume a stronger decline of 8% as is estimated by the IEA (2021a,b) instead of the 1.9% decline we estimated only from the trend in activity data: energy production and export statistics reported by BP (2021).

We conclude that a better preliminary estimate for *total global* GHG emissions in 2020 is composed of FT2020 emissions for sectors with preliminary 2020 activity trends, plus the average global sectoral impact of historical recessions for other non-CO_2 sectors. This would provide a total *decline* in *global total* GHG emissions of about -4.0% (with a 2σ uncertainty range (95%) of between -1.5% and +1.0%) (to 49.7 $GtCO_2$ eq). The larger uncertainty estimate also reflects the impact of possible other effective emission factor changes in 2020. These changes are not taken into account for most sources, such as the IEA (2021a) estimate of a larger decrease in global CH_4 emissions from oil and natural gas systems in 2020, corresponding to a decrease of 0.2 percentage points in global total GHG emissions. Thus, in 2020, global greenhouse gas emissions have declined by more than 3.7%, and if an uncertainty range of between -1.5% and +1% is applied, this is more likely to be about 4%.

Moreover, this somewhat better estimate for 2020 is only available at the *global* level, since, for individual countries, a pandemic recession impact assessment has not been made. We will have to wait for another year to see what a more robust estimate of the change in 2020 will be, when at least for Annex I countries their non-CO_2 greenhouse gas emissions for 2020 will be available through their updated emissions inventory submission to the UNFCCC.

2.2.3 Trends in global greenhouse gas emissions since 1990

The global emission growth rate of 0.6% in 2019 is about half of the average annual growth since 2012. In 2003, global greenhouse gas emission growth accelerated to 4.0% and remained high through 2007 (the average increase was 3.5%, over these years), which was related to the fast industrialisation of China since it became a member of the World Trade Organization (WTO) (Figure 2.1).

Please note that the last global economic crisis was in 2008 and 2009 with global GHG emissions changes of +0.6% and -0.8%, and a rebound in 2010 and 2011 with increases of +4.9% and +3.0%. This brings the average annual growth in global greenhouse gas emissions over the whole 2003–2011 period at 2.8%. Our analysis of recent trends in emissions and drivers focuses on the 2005–2019 period, but includes the last decade of the 20th century, for a broader perspective.

After the rebound in 2010 and 2011, there was a slowdown of the growth in global greenhouse gas emissions. However, the slowdown has discontinued in recent years, after the very low growth of 0.1% and 0.3% in 2015 and 2016, with growth rates in 2017 and 2018 that are presently estimated at 1.4% and 1.8% (Figure 2.1) (this was 1.3% and 3.0%, respectively, in our previous report).

Since 1990, the average annual increase in global GHG emissions of 1.6% was mainly driven by the 1.8% average annual increase in CO_2 emissions. Thus, global GHG emissions have been increasing steadily, over the decades since 1990, from 32.9 $GtCO_2$ eq in 1990 to 37.5 $GtCO_2$ eq in 2002. Subsequently, in the decade thereafter, the annual increase in global emissions accelerated by 2.8%, on average, leading to 48.0 $GtCO_2$ eq in 2011, after which emissions increased at the much slower rate of 0.9%, on average, to the highest level of 51.7 $GtCO_2$ eq in 2019.

In 2020, the first COVID-19 recession year, global GHG emissions *decreased* strongly, by more than 3.7%. This was mainly due to a 5.1% decrease in global CO_2 emissions from fossil-fuel combustion and industrial non-combustion processes (excluding those from land-use change), which in turn was mainly due to a 5.9% decline in CO_2 emissions from fossil-fuel combustion. The last estimate is very close to the IEA (2021c) estimate of 5.8% decline, published in April 2021, and the estimated decrease of 5.6% by the Global Carbon Budget, published in December 2021 (Friedlingstein et al., 2021), for CO_2 emissions from fossil-fuel combustion. In addition, the 5.7% decrease in global CO_2 emissions from fossil fuel combustion and cement production, as reported by the Carbon monitor (2022), is very close to the decrease of 5.6% from these sources, as estimated by EDGAR FT2020 (Crippa et al., 2021a) . However, more recently, IEA has revised its global CO_2 emissions estimate for 2020 to a 5.2% decline and a 6% increase in 2021 (IEA, 2022b).

However, in addition, the actual changes in CH_4, N_2O and F-gas emissions in 2020 are likely smaller or more negative than the Fast-track estimates of +0.1%, -0.4% and +4.6%, respectively, due to recession effects not included in the FT extrapolation method. Including these effects would lead to an additional decrease in global GHG emissions of about 0.18 $GtCO_2$ eq, or about 0.3% percentage points. This would lead to a more 'correct' estimate of the total *decline* in global GHG emissions in 2020 of about -4.0% (or 49.7 $GgCO_2$ eq rounded), including COVID-19 recession impacts.

In 2020, global total Fast-Track GHG emissions *decreased* by an estimated 1.9 $GtCO_2$ or 3.7% to 49.8 $GtCO_2$ eq (rounded). Indeed, most countries (173 of the 212, or 82%) saw a *decrease* in their total GHG emissions, which amounted to a decrease of 2.2 $GtCO_2$ eq. The top-10 decreasing countries capture 60% of the total decreases, to which the United States contributed 520 $MtCO_2$ eq, with an 8.5% decrease, and the EU-27 contributed 320 $MtCO_2$ eq, with an 8.4% decrease, accounting for two thirds of the total top-10 decrease. Apart from international aviation, which decreased by 45.3% (280 $MtCO_2$ eq), for other top-10 decreasing countries, this was -3.9% (140 $MtCO_2$ eq) for India and -4.9% (110 $MtCO_2$ eq) for the Russian Federation, -7.7% (90 $MtCO_2$ eq) for Indonesia, -10.0% for Mexico and -6.3% for Japan, each about 80 $MtCO_2$ eq, -7.2% for Canada, -7.5% for Australia and -10.3% for the United Kingdom, each about 50 $MtCO_2$ eq and -5.7% (30 $MtCO_2$ eq) for South Africa. Within the EU-27, decreases were notably seen (in decreasing order of absolute changes) in Germany (-8.3%, 70 $MtCO_2$ eq), France (-9.1%), Spain (-12.6%) and Italy (-8.8%), each about 40 $MtCO_2$ eq and Poland (-5.3%, 20 $MtCO_2$ eq).

Only 39 countries *increased* their total GHG emissions in 2020, totalling to an increase of about 0.3 $GtCO_2$ eq, most of which concerned China, which accounts for 230 Mt CO_2 eq or 85% of total increases in countries, plus (in decreasing order) Pakistan, Iran, North Korea, Chad, Central African Republic and Myanmar (between 9 and 2 $MtCO_2$ eq) and another 32 countries saw smaller increases.

We 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 GHG trends estimated in this report are in keeping with the total national GHG emission trends as expected from analyses of pledges of countries under the Paris Agreement (see UNEP, 2021; Nascimento et al., 2021; Dafnomilis et al., 2020; PBL, 2021).

2.2.4 Annual change in global GDP and total GHG emissions

Table 2.2 shows annual changes, over the 1990–2020 period, in global *Gross Domestic Product* (GDP) and total global emissions of greenhouse gases and, for each individual gas (with the fluorinated gases (F-gases) aggregated in one group and with a break-out of total HFCs). It shows that, while the average annual growth in the world economy has been fairly constant since 1990, annual growth in total greenhouse gas emissions saw distinct decreases to 0.3% in 2016 and 0.6% in 2019. In 2019, the relatively small increase in global greenhouse gas emissions was accompanied by the relatively low global GDP growth of 2.7%, compared to the 3.3% average annual GDP growth since 2005. The average annual growth in CO_2 emissions since 2005 of 1.6% was very similar to the annual increase of 1.5% in total greenhouse gas emissions. For most years since 2015, the annual increases in CH_4 emissions were higher than in CO_2, and methane had a two-thirds share in total global non-CO_2 gases (Table 2.2). The red and green bars in Table 2.2 indicate increasing and decreasing numbers; the column with blue bars indicates the size of share in total GHG emissions.

Table 2.2
Trend indicators for annual changes in global GHG emissions since 1990 (GDP indicated in blue)

Indicator	1990-2005	2005-2019	Shares 2019	2016	2017	2018	2019	2020	2020 L [1)]
GDP [2)]	3.1%	3.3%		3.1%	3.7%	3.5%	2.7%	-2.8%	n/a [3)]
GHG	1.6%	1.5%	100%	0.3%	1.4%	1.8%	0.6%	-3.7%	-4.0%
CO_2	1.9%	1.6%	73.3%	0.2%	1.3%	2.1%	0.5%	-5.1%	n/a [3)]
CH_4	0.7%	1.3%	18.5%	0.3%	1.5%	0.7%	1.0%	0.1%	-0.7%
N_2O	0.9%	0.7%	5.7%	0.5%	1.1%	-0.4%	-0.7%	-0.4%	-1.4%
F-gases	5.2%	3.8%	2.5%	4.7%	5.8%	5.2%	3.9%	4.6%	-1.2%
o.w. HFCs [4)]	18.1%	6.7%	2.0%	5.2%	6.6%	5.4%	4.0%	4.9%	4.9%

Notes:
[1)] Annual change in total emission projections for 2020 using lower estimates for sources without preliminary statistics for 2020 based on historical impact of average annual global sectoral changes in recession years, compared to non-recession years (instead of past trend extrapolation). This does not apply to CO_2 and GDP.
[2)] GDP is the global total of countries' Gross Domestic Product (at PPP in 2017, in USD).
[3)] n/a is '*not applicable*' to GDP and CO_2 emissions in 2020 (since the actual impact of the COVID-19 pandemic is known from economics and fossil-fuel consumption statistics on 2020).
[4)] o.w. is 'of which'.

When looking at greenhouse gases separately, we can see which of them were mainly responsible for the total GHG trend since 2005 (see Figures 2.1 and 2.2). Although most global GHG emissions consisted of CO_2 (about 73%), methane, nitrous oxide and fluorinated gases also made up significant shares (19%, 6% and 3%, respectively). It shows that the 23% increase in global GHG emissions in 2019 (compared to 2005) was mainly due to a 26% increase in CO_2, aided by an almost 70% increase in F-gas emissions. The 0.6% increase in GHG emissions in 2019 was mainly due to a 0.5% increase in global CO_2 emissions, which contributed almost two thirds to the total GHG increase in 2019. However, also non-CO_2 emissions retained their relatively large annual increase of 0.9% in 2019, aided by the 1.0% increase in CH_4 and 3.9% in F-gases, whereas N_2O emissions showed a 0.7% decrease.

The percentages for the share of individual greenhouse gases in total GHG 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 also reflect the periodically occurring strong El Niňo years, such as the major El Niňos since 1990 in 1997, 2009, 2014-2015 and 2019. This also clearly shows in the grey area above the dashed line in Figure 2.1, illustrating the impact of an El Niño event on global forest fires.

2.3 Global trends in CO_2 emissions

In 2019, global CO_2 emissions *increased* by an estimated 200 $MtCO_2$ or 0.5% to a level of 37.9 $GtCO_2$, to which notably China contributed most, with an increase of 2.1% (about 240 $MtCO_2$). Other large absolute increases were seen in Vietnam (+19.4%; 50 $MtCO_2$), Indonesia (+6.3%; 40 Mt CO_2) and India (+1.5%; 35 $MtCO_2$). These increases were partly counterbalanced by decreases in other countries in 2019, the largest of which were the EU-27 (-4.5%; 140 $MtCO_2$), the United States (-2.4%; 120 $MtCO_2$) and Japan (-2.1%; 35 $MtCO_2$). The decreases amongst the EU-27 Member States in 2019 were notably (in decreasing order of absolute changes) in Germany (-7.3%), Spain (-7.3%), Poland (-5.4%), Italy (-2.7%) and France (-2.4%).

In 2020, global CO_2 emissions *decreased* by an estimated 1.9 $GtCO_2$ or 5.1% to a level of 36.0 $GtCO_2$, of which all countries with decreasing emissions totalled a 2.1 $GtCO_2$ decrease. The top-10 decreasing countries capture 60% of total decreases, of which the United States contributed 500 $MtCO_2$ (-9.9%) and the EU-27 310 $MtCO_2$ (-10.6%) account for two-thirds of the top-10. Within the EU-27, decreases were notably seen (in decreasing order of absolute changes) in Germany (-9.3%), Spain (-16.0%), France (-12.4%) and Italy (-10.7%). Other top-10 decreasing countries - apart from international aviation (-45.3%; 290 $MtCO_2$) - are: India (-5.9%); 150 $MtCO_2$), the Russian Federation (-5.8%; 100 $MtCO_2$), Japan (-6.8%; 80 $MtCO_2$) and Mexico, Indonesia, Canada and South Africa.

These decreases were partly counterbalanced by eight countries that saw *increases* in 2020, totalling 0.2 Gt CO_2 the largest of which were China (+1.4%; 170 $MtCO_2$) and Indonesia (+6.3%; 40 $MtCO_2$). The other countries are: Dominican Republic (+3.4%), Bahrein (+1.1%) and Armenia, Kazakhstan, Kyrgyzstan and Moldova.

Fossil-fuel combustion contributes the lion's share of almost 89%, of which electricity generation is the largest sector with almost 36% followed by industries and road transport, each with about 16% to 17%. Of the remaining 11% emitted from other sources than fuel combustion, there are two that emit more than 4%, namely non-energy use of fuels (e.g. as chemical feedstock for the production of ammonia and other chemicals such as ethylene) and cement clinker production.

Looking at the global shares of coal, oil and natural gas in total CO_2 emissions from fossil-fuel combustion, in 2019, coal had a share of 44%, oil 35% and natural gas 22%, whereas their shares in total fossil-fuel consumption were 32%, 39% and 29%, respectively. Differences between the share in energy use and in CO_2 emissions from fossil-fuel combustion are due to the fact that coal emits about twice as much CO_2 per Joule than natural gas does, and oil is somewhere in between the two.

Please recall that the revised global total CO_2 emissions are slightly higher than in last year's report, from +0.0 Gt in 1990 (+0.2%) to +0.1 Gt from 2000 to 2012 (+0.4%), slightly smaller in 2013 to 2015 (-0.2%) and -0.4% in 2016, no revision for 2017 and +0.1 Gt in 2018 (+0.4%). For a discussion of the long-term CO_2 emission trend from 1970 onwards we refer to Crippa et al. (2021a) and to our previous report (Olivier and Peters, 2020).

In 2020, global **coal consumption** continued to *decline* by 2.9%, following a *decrease* of 1.0% in 2019, which was mainly due to large decreases in the United States (19%) and the European Union (19%), notably in Germany (-17%), Poland (-10%) and the Czech Republic (-19%). Smaller *decreases* were seen in India (10%), Japan (11%), Indonesia (26%), Mexico (24%), Russian Federation (8%), Canada

(11%), Indonesia (5%) and South Africa (4%). Only few countries *increased* coal consumption in 2020, notably China (+0.4%), Malaysia (+19%) and Pakistan (+11%) (BP, 2021).[11]

In 2020, global **consumption of oil products** *declined* by 9.5%, after an *increase* of 0.3% in 2019, which was mainly due to large decreases in the United States (12.4%) and the European Union (13.6%), notably in Spain (-18%), France (-15%), Germany (-10%), Italy (-16%) and Belgium (-30%). Smaller decreases were seen in India (10%), Japan (11%), Indonesia (26%), Mexico (24%), Canada (11%), Russian Federation (5%), South Korea (5%), Thailand (9%) and Malaysia (14%). China is on of very few countries where oil consumption *increased* by 1.1%.

Global **natural gas consumption** *declined* by 2.1% in 2020, after an *increase* of 1.7% in 2019, which was mainly due to decreases in the Russian Federation (7.4%) the United States (2.0%) and the European Union (2.9%), in particular in Spain (-10%), France (-7%), Italy (-4%) and Germany (-2%). Other countries that saw *decreases* in natural gas consumption are Venezuela (27%), Malaysia (15%), Canada (4%), United Kingdom (6%), Thailand (8%), Brazil 10%) and Japan (3%). Countries with relatively large absolute *increases* were China (+7%), Iran (+4%), Turkey (7%) and Taiwan (7%).

Together, total global CO_2 emissions from **fossil-fuel combustion** *declined* by 5.9% in 2020. Global total emissions from cement clinker production and from non-energy use of fuels were estimated to increase by 2.7% and 1.3% in 2020. Together with other non-combustion sources, this explains the 5.1% decrease in global total CO_2 emissions in 2020.

In 2020, the global use of **nuclear power** *declined* by 3.8%, which was the first global decrease since 2011, with the largest *decreases* in France (-10%), United States (-3%), Japan (-35%) and Sweden (-19%), Germany (-15%) and Belgium (-22%). The total decrease in the EU-27 was 11% (BP, 2021). The decline in the European Union was due to lower electricity demand, shutdowns for maintenance and permanent shutdowns. In Japan, some reactors were temporarily shut for work required for meeting new safety standards (IEA, 2021c). The largest *increases* were seen in China (+4%), South Korea (+9%) and the Russian Federation (+3%).

Globally, the use of **hydropower** continued its *increase* by 1.3% in 2020. **Other renewable energy** comprises mainly wind and solar power (about two thirds), but also includes power generated from solid biomass waste and geothermal energy and modern biofuels in transport (BP, 2021). The use of these other renewable energy sources continued their growth and increased by 10.0% in 2020, with the largest contributors being China (+15%), the European Union (+7%) and the United States (+8%), and with smaller absolute increases seen in Japan (+12%), United Kingdom (+10%), India (+5%), Australia (+20%), South Korea (+19%), Vietnam (+130%), Brazil, Indonesia, Mexico and India. Within the EU-27, the largest contributors to the growth in 2020 were Germany (+5%), the Netherlands (+40%), France (+8%), Sweden (+14%) and Belgium (+22%) (BP**,** 2021).

CO_2 emissions from cement production was the largest non-fossil CO_2 source that saw a rather strong 2.7% increase in global emissions in 2020, due to similar increases in global cement clinker production, with China as the largest contributor due to its very large share of 52% in global cement production (NBSC, 2021b).

[11] This ranking according to the largest absolute changes, indicating change in percentages, is used throughout the report, in lists of countries or source categories.

2.4 Global emissions of other greenhouse gases

As discussed in the introduction, the non-CO_2 GHG 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 levels and 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 recent trend in global CO_2 emissions, the FT global trend estimates in 2019 and 2020 of the non-CO_2 GHG emissions vary a lot per gas: for methane small *increases*, for nitrous oxide small *decreases* and for the F-gases rather large *increases* (Table 2.2). However, when looking at the best estimates for 2020 taking into account the global recession felt in most countries, including global recession trends for sources without preliminary full global activity statistics, leads for all three to decreases in 2020 of their global total emissions: -0.7% for CH_4, -1.1% for N_2O and -2.0% for total F-gases.

2.4.1 Methane emissions

The trend in global methane (CH_4) emissions since 1990 is summarised in Table 2.2. The FT estimate for 2020 of CH_4 emissions per country resulted in a change in *global* total methane emissions of 0.1% to a total of 384 Mt CH_4 or 9.6 $GtCO_2$ eq, which is markedly lower than the 1.0% growth in 2019, however note that the uncertainty range in the annual change in 2020 is larger than usual. This 0.1% is also markedly lower than the average annual growth rate since 2005 of 1.3%. At present, emissions are 28% higher than in 1990, when they were 300 Mt CH_4 or 7.5 $GtCO_2$ eq. We recall that our best estimate for the change in *global* total methane emissions in 2020 including the impact of the COVID-19 recession is -0.7% (Table 2.2),and when also including the IEA estimate of the change of global emissions from oil and gas systems of -8% in 2020 (IEA, 2021a), this would result in a total global decline of 1.9%.

Since about one year ago, methane emissions have received more attention from science, media and policy makers than before. This is also related to more extensive use of satellite observations of methane by the TROPOMI instrument on the Sentinel 5-P satellite of ESA, e.g. processed by Kayrros, an earth observation firm, converting the raw data into global and local spatially distributed methane emissions data sets that can be used for e.g. detecting large-scale methane leaks world-wide (Kayrros, 2020, 2021, 2022). In addition to the activities described in last year's report, in 2021 also much more use of the satellite observations of methane were made by scientists e.g. Barré et al. (2021), Lavaux et al. (2022), Palmer et al. (2021), Sadavarte et al. (2021), Lu et al. (2011), Qu et al. (2021) and Tu et al. (2022) and media e.g. on landfills in Madrid by ESA (2021) and by Parra and Hutton (2021) and on pipeline leaks in Florida by Malik and Maglione (2022). Many more examples of scientific papers can be found in Google Scholar with keywords 'methane' and 'satellite').

In 2021, for policy makers the *Global Methane Assessment* by UNEP/CCAC (2021) was published that evaluated the benefits and costs of mitigating methane emissions. In addition there was the *Global Methane Pledge* (CCAC,2021) announced last year at the climate change conference COP26 in Glasgow, UK, which commits signatories to take voluntary actions to contribute to a collective effort to reduce global methane emissions at least 30% from 2020 levels by 2030 and to move towards using best available inventory methodologies to quantify methane emissions, with a particular focus on high emission sources. It mentions that reduction of global CH_4 emissions by 30% in 2030 could eliminate over 0.2˚C warming by 2050. This is a global, not a national reduction target (CCAC, 2021).

Likewise the IEA has published the updated *IEA Methane Tracker* in 2021 (IEA, 2021a), which includes detailed estimates for 2020 that incorporate new data for oil and gas supply as well as the latest evidence from the scientific literature and measurement campaigns and data on large-scale methane leaks detected by satellite processed by Kayyros (IEA, 2021a). It also released a report on the reduction potential by 2030 of this sector (IEA, 2021d). Very recently, it has released the latest and expanded *Global Methane Tracker* 2022 (IEA, 2022b), that also includes CH_4 from coal production and now also includes CH_4 emission estimates from other sectors (mainly Agriculture and Waste) taken from four public sources (UNFCCC, EDGAR, CEDS and CAIT).

Sources that contributed the most to the 1.0% increase in 2019 of global CH_4 emissions were (in decreasing order of absolute changes): *increases* in coal production (+3.6%), natural gas production and transmission (+2.6%), livestock farming (+0.9%), waste water (+1.8%), landfills (+1.6%) and fuel combustion (+1.7%) and *decreases* in savannah burning (-11%), rice cultivation (-1.0%), associated gas venting (-1.0%) and oil production and processing (-1.3%).

Sources that contributed the most to the 0.1% increase in 2020 of global CH_4 emissions were (in decreasing order of absolute changes): *increases* in livestock farming (+1.0%), waste water (+1.8%), landfills (+1.6%), rice cultivation (+1.4%) and *decreases* in coal production (-2.3%), natural gas production and transmission (-1.6%), oil production and processing (-5.8%), savannah burning (-8.7%) and associated gas venting (-0.9%).

Countries that contributed most to the 0.1% growth in 2020 were notably (in decreasing order of absolute changes): China, Brazil, Pakistan, North Korea, India, Chad, Iran, Kenya, Sudan and Ethiopia, in total accounting for two thirds of the *increases*. Countries with largest *decreases* (in decreasing order of absolute changes): the United States, Australia, Indonesia, the Russian Federation, Libya, Uzbekistan, Mongolia, Argentina, Egypt and Turkey, accounting for two thirds of all *decreases*.

2.4.2 Nitrous oxide emissions

The trend in global nitrous oxide (N_2O) emissions since 1990 is summarised in Table 2.2. The FT estimate for 2020 of N_2O emissions per country resulted in a *decline* in *global* total N_2O emissions of -0.4% to a total of 9.92 Mt N_2O or 3.0 $GtCO_2$ eq, which is similar to the decreases of -0.4% and -0.7% in 2018 and 2019. However note that the uncertainty range in the annual change in 2020 is larger than usual. This -0.4% decline in 2020 is markedly lower than the average annual growth rate since 2005 of 0.7%. At present, emissions are 27% higher than in 1990, when they were 7.82 Mt N_2O or 2.3 $GtCO_2$ eq. We recall that our best estimate for the change in *global* total N_2O emissions in 2020 including the impact of the COVID-19 recession is -1.1%.

Sources that contributed the most to the 0.7% net decrease in 2019 were (in decreasing order of absolute changes): savannah fires (-11%) and industrial processes, in particular nitric acid production (-2.9%), accounting for about three-quarters of the total decreasing sources, whereas total increasing sources account for about one quarter of the total net decrease, the largest being fuel combustion (+0.6%), wastewater (+1.0%) and animal manure applied to soils (+0.4%).

The sources that contributed to the 0.4% net decrease in 2020 were (in decreasing order of absolute changes): fuel combustion (-6.4%), savannah fires (-9%) and indirect N_2O from non-agricultural sources, accounting for all decreasing sources. All other main sources increased in 2020 and their total account for about two thirds of the total decreases, the largest sources being manure in pasture, range and paddock (+1.0%), indirect N_2O from agricultural sources (+1.3%) and the use of synthetic nitrogen fertilizers)+0.7%), fuel combustion (+0.6%), wastewater (+1.0%) and animal manure applied to soils (+0.4%).

The ten countries with the largest decreases in 2019 were notably (in decreasing order of absolute changes): the United States (-6%), Australia(-15%) and Sudan (-12%), accounting for three quarters of total decreases, and further India, Turkey, Colombia, Canada, France, Central African Republic and Botswana. The ten countries with increasing N_2O emissions in 2019 were notably (in decreasing order of changes): Argentina (+12%) and Belarus (+25%), Angola (+12%) and China (+0.4%), and further Uruguay, Iraq, Bolivia, Afghanistan, Kenya and Syria, accounting for 60% of total increases.

2.4.3 Fluorinated gas emissions

The trend in global F-gas emissions since 1990 is summarised in Table 2.2. The FT estimate for 2020 of F-gas emissions per country resulted in a *increase* in *global* total F-gas emissions of 4.6% to a total of 1.33 $GtCO_2$ eq, which is somewhat higher than the increase in 2019 but is lower than the increases in 2017 and 2018 (Table 2.2). However note that the uncertainty range in the annual change in 2020 is much larger than that of other years. The 4.6% increase in 2020 is somewhat higher than the average annual growth rate since 2005 of 3.8%. At present, F-gas emissions are more than three times higher than in 1995 (the reference year for F-gases for most countries in the Kyoto Protocol), when they were 0.40 $GtCO_2$ eq. We recall that our best estimate for the change in *global total* F-gas emissions in 2020, including the impact of the COVID-19 recession, is *decrease* of 0.6%. So, the FT increase estimated per country for 2020 and totalling a net global *increase* of 4.6% is strikingly different from this “best” estimate for the global total, with a difference of more than 6 per cent points.

Sources that contributed the most to the 3.9% increase in 2019 of global F-gas emissions were (in decreasing order of absolute changes): *increases* in HFC emissions mainly from HFC use (+5.6%), and much smaller increases in SF_6 from electrical equipment (+6.3%) and in PFC emissions from PFC use (+6.3%), and relatively small *decreases* mainly in HFC-23 emitted as by-product from HCFC-22 production (-5.6%).

Sources that contributed the most to the 4.6% increase in 2020 of global F-gas emissions were (in decreasing order of absolute changes): *increases* in HFC emissions mainly from HFC use (+5.7%), and much smaller increases in SF_6 from electrical equipment (+5.9%) and in PFC emissions from PFC use (+6.8%), and relatively very small *decreases* mainly in PFC emitted as by-product from primary aluminium production (-1.3%) and in SF_6 from other uses (-0.2%).

The ten countries with the largest estimated *increases* in 2019 were notably (in decreasing order of absolute changes): China (+5%), Saudi Arabia (+10%), India (+7%), the United States (+2%) and Thailand (+10%), together accounting for more than two thirds of total increases, followed by the United Arab Emirates (+9%), Mexico (+7%), Iran (+8%), Kuwait (+10%) and Egypt (+9%). The ten countries with the largest *decreases* were notably the Russian Federation (-11%), Italy (-17%), France (-9%), Germany (-4%) and the United Kingdom (-3%), together accounting for more than 90% of total decreases, followed by Spain (-4%), Belgium (-6%), Poland (-4%), Denmark (-13%) and Tajikistan (-25%). The total trend for the EU-27 was a decrease of 3.4% in 2019, and the global total net decrease would rank second, after the Russian Federation).

2.5 Greenhouse gas emissions in top-30 countries and the European Union

The five largest emitting countries and the European Union (EU-27), together account for about 60% of total global GHG emissions: China (27%), the United States (12%), the European Union (about 7%), India (7%), the Russian Federation (4.5%) and Japan (2.4%). These countries also have the highest CO_2 emission levels.

Four of these six economies showed a *decrease* in GHG emissions in 2019: the European Union (by 150 $MtCO_2$ eq or -3.8%), the United States (by 130 $MtCO_2$ eq or -2.1%), Japan (by 40 $MtCO_2$ eq or -2.8%) and the Russian Federation (by 10 MtCO2 eq or -0.6%). However, in the other two countries GHG emissions *increased*: in China (by about 290 $MtCO_2$ eq or +2.1% and in India by about 40 $MtCO_2$ eq or +1.1% (ranked according to the largest absolute changes).

Within the European Union most countries, such as Germany, France, Poland, Spain, Italy and the Netherlands, showed decreasing emissions in 2019 and 2020. Moreover, the total increase in the rest of the world in 2019 was almost as large as that of China: 230 $MtCO_2$ eq or +1.2%.

The total group of 20 largest economies (G20[12]) (see table B.1 in Appendix B), accounting for 72% of 2019 global GHG emissions, showed essentially no change in total GHG emissions in 2019 and whereas for 2020 a 3.2% decrease was estimated for the G20 total.

The collective emissions from the rest of the world (i.e. non-G20) (see table B.1 in Appendix B[13]), showed a 1.2% increase in 2019 for the eleven other largest countries[14] (0.8% increase in 2020) and a 2.2% increase for the remaining 186 countries (4.5% decrease in 2020).

In the pandemic year 2020, total GHG emissions of all 30 major economies *decreased* (e.g. in the United States by 8.5%, in the EU-27 by 8.4%, in Japan by 6.3%, in Russia by 4.9% and in India by 3.9%), except for China, Iran and Pakistan, in which they continued to *grow*, by 1.5%, 0.9% and 1.9%. Although this was mainly due to the change in CO_2 emissions, the Fast Track estimate of global total non-CO_2 emissions shows that the total 2020 emissions have not changed much, with the largest *increases* in non-CO_2 emissions among the top-30 largest emitters estimated for China,

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[12] 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.

[13] Appendix B provides tables with the 1990–2020 time series of total GHG emissions for the top 30 countries and the EU-27, as well as for their CO_2, CH_4, N_2O and F-gas emissions. It also contains four tables with the GHG and CO_2 emissions per capita and emissions per USD of GDP.

[14] Other large emitting countries: compared with last year in the list of 30 largest economies Pakistan has been added and Zambia has been removed from the 11 'Other large emitting countries'.

Brazil, Pakistan, India, Iran and Thailand and the largest *decreases* in non-CO_2 emissions were found for the United States, Australia, the Russian Federation, Indonesia, the European Union and Canada.

Following UNFCCC reporting and accounting guidelines (UNFCCC, 2011), GHG emissions from international transport (aviation and shipping) are excluded from the national total in countries' GHG emission reports, but nevertheless constitute about 2.8% of total global GHG emissions in 2019, for which a 5.7% increase was estimated. For CO_2 emissions only, the total share of international transport was 3.7% in 2019: 1.6% for international aviation and 2.0% for international marine transport with estimated increases in 2019 of 5.8% and 1.1%, respectively. In 2020 these figures changed drastically for international aviation due to the impact of COVID-19, with a 45% decline and a share reduced to 0.9%. However, we note that these change percentages are more uncertain, compared to CO_2 emissions trends for country totals (Olivier et al., 2017).

Appendix A is new and provides a description of the new bottom-up methodology and data sources that were used for the EDGAR v6.0 emissions of fluorinated gases (F-gases).
Appendix B provides tables with the 1990–2020 time series of total GHG emissions for the top 30 countries and the EU-27, as well as for their CO_2, CH_4, N_2O and F-gas emissions. It also contains four tables with the GHG and CO_2 emissions per capita and emissions per USD of GDP.
Appendix C provides tables per greenhouse gas with the annual change in global sectoral emissions in recession years and in other years (unchanged from the previous report).
Appendix D is also new and provides a table per non-CO_2 greenhouse gas indicating per detailed EDGAR source category which activity data (i.e. preliminary statistics) was used as proxy was used (if any) and data sources used for them.

2.6 Year 2020: COVID-19 affected global trends and future implications

The year 2019 is the year just *before* the COVID-19 pandemic hit the world, which had a significant impact on anthropogenic greenhouse gas emissions in 2020. At present (end of 2021), the impact of the pandemic on total global greenhouse gas emissions is reasonably clear for CO_2 and CH_4, but still under development and evaluation for N_2O and F-gases. For a discussion of the impact on CO_2 emissions in 2020, we refer the UNEP Emissions Gap Reports 2020 and 2021 (UNEP, 2020, 2021) that provide an overview of studies published to date on the impact of COVID-19 measures on CO_2 emissions in 2020 and estimates for emissions in 2021. The EDGAR FT2020 estimate of a 5.9% decline in 2020 of CO_2 emissions from fossil fuel combustion is very close to the IEA estimate of 5.8% decline published in April 2021 (IEA, 2021c) and the estimate of 5.6% decline estimated by the Global Carbon Budget in December 2021 for fossil fuel combustion emissions (Friedlingstein, 2021), Also the decrease of 5,7% reported in February 2022 by the Carbon Monitor (2022) for CO_2 emissions from fossil fuel combustion and cement production (Liu et al., 2020) is very close to the EDGAR FT2020 estimate of a 5.6% decline from these sources. Interestingly, Weir et al. (2021) show that the impact of short-term regional changes in fossil fuel emissions on CO_2 concentrations was observable from space, when comparing regional atmospheric concentrations over the weeks in 2020 with those of pre-pandemic levels in preceding years. Few studies, however, have so far been conducted on the COVID-19 impact on non-CO_2 greenhouse gas emissions in 2020 (Forster et al., 2020).

For a broader historical perspective and to illustrate the past impact of global recessions on the global emissions of all greenhouse gases, we analysed this impact by comparing annual changes in historical GDP and in GHG emissions in global recession years with non-recession years, using the EDGAR GHG FT2019 emissions data set for 1970–2018. For most sources the difference with the present time series in version 6.0 for all gases is very small. We used the IMF definition of global recession years, which reads: ‘periods with a global annual real GDP growth rate of 3.0% or less’. This definition provides 6 global recessions, including 15 recession years and 32 non-recession years. The period contained 6 global recessions that meet the definition, since 1970: 1974–1975 (first oil crisis), 1980–1983 (second oil crisis), 1990–1993 (Gulf war), 1998 (Asian financial crisis), 2001–2002 (‘9/11’), and 2008–2009 (credit crunch). For each greenhouse gas, we looked at total global emissions and at the impact on emissions from main source categories and from more detailed sectors, either global emission estimates or global total activity data (statistics).

During the analysis, we observed several marked differences: a) in global emission changes in recession years versus other years; b) in the first year after a recession, emission growth was larger than in average non-recession years; c) distinct differences could be observed between main GHG source categories, with some more sensitive to recessions than others; d) the spread in the percentages as indicated by the standard deviation in the percentages per category can be quite large, in some cases. Table 2.3 summarises the results for global emissions per greenhouse gas.

This table shows that, for the three main greenhouse gases CO_2, CH_4 and N_2O, the average annual growth during global recession years was 0.0%, -0.7% and 0.1%, whereas in other years, average annual growth was 2.7%, 1.4% and 1.3%, respectively. In an average ‘normal’ year, this translates into a total GHG emission growth of 2.4% versus 0% change in an ‘average’ recession year. Thus, the respective impact of recessions was -2.7%, -2.1% and -1.2% in percentage points of annual change, on average, whereas the average impact on annual global GDP growth was -2.2%. For F-gases, the figures are mostly much larger because these are fast growing sources, in particular HFCs and SF_6. Therefore we use as recession impact on total F-gases only the impact of the latest 2008-2009 recession, which we estimate at -1.2% for total F-gases and -2.0% for total HFC emissions.

In absolute percentages, the only global recession year since 1970 with a *negative* global GDP change was 2009 (-0.7%). In that year, global emissions also saw negative changes of -1.2%, -0.4% and -0.5% for CO_2, CH_4 and N_2O, respectively. However, global GHG emissions saw negative annual changes also in several other years, with the largest decreases in 1981 for CO_2 (-1.9%) and CH_4 (-5.0%), in 1980 for N_2O (-1.9%) and in 1982 for F-gases (-4.4%).

In absolute percentages, the only global recession year since 1970 with a *negative* global GDP change was 2009 (-0.7%). In that year, global emissions also saw negative changes of -1.2%, -0.4% and -0.5% for CO_2, CH_4 and N_2O, respectively. However, global GHG emissions saw negative annual changes also in several other years, with the largest decreases in 1981 for CO_2 (-1.9%) and CH_4 (-5.0%), in 1980 for N_2O (-1.9%) and in 1982 for F-gases (-4.4%).

Table 2.3
Average annual change of global emissions 1970–2018 in global recession years, in other years and in the year before and after a global recession (recession years shown red; non-recession years shown green)

Gas	Yr before	Recession	StDev	Yr after	Non-recession	StDev	Impact (Rec-Non)	Reces - Yr before	All years
GDP	**4.4%**	**1.9%**	**±1.0%**	**4.1%**	**4.1%**	**±1.0%**	**-2.2%**	**-2.5%**	**3.4%**
CO_2	3.0%	0.0%	±1.0%	3.6%	2.7%	±1.7%	-2.7%	-2.9%	1.8%
CH_4	1.1%	-0.7%	±1.5%	1.5%	1.4%	±1.6%	-2.1%	-1.8%	0.8%
N_2O	1.1%	0.1%	±1.0%	1.4%	1.3%	±1.1%	-1.2%	-1.1%	0.9%
F-gas	5.6%	2.8%	±4.4%	9.3%	6.6%	±3.4%	-3.8%	-2.8%	5.4%
HFCs	9.1%	6.2%	±8.6%	15.3%	9.5%	±6.8%	-3.3%	-2.9%	8.4%
PFCs	1.9%	-3.6%	±6.4%	3.0%	2.5%	±4.0%	-6.1%	-5.5%	0.5%
SF_6	6.1%	4.5%	±5.9%	7.8%	6.2%	±6.1%	-1.7%	-1.6%	5.6%

Notes: StDev = Standard Deviation of annual change in recession years and in non-recession years.
According to an IMF definition, there were 6 recessions since 1970: 15 recession years and 32 other years. The six global recessions were: 1974–1975 (first oil crisis), 1980–1983 (second oil crisis), 1990–1993 (Gulf war), 1998 (Asian financial crisis), 2001–2002 ('9/11'), and 2008–2009 (credit crunch).

Table 2.3 also shows that, although in past *global* recessions global GDP growth using Purchasing Power Parity (PPP) was about half that of other years (from 4.1% ±1.0% SD to 1.9% ±1.0% SD), in those years, the change in global GHG emissions (excluding F-gases) was nil (CO_2 and N_2O) or negative (CH_4). However, it is important to note that average global changes do not imply that the same is true on country, regional or sectoral levels.

Although the figures above refer to global average recession years, they may indicate by how much GDP and greenhouse gas emissions could decline during a global recession due to lockdowns and other changes in society aimed at mitigating the COVID-19 virus. The largest decreases in any recession year in the past 50 years were found in 2009, the year of the 'credit crunch', which is the only year in this period with a 0.7% decrease in global GDP at PPP. In that year, all G20 countries saw large declines, except for China, India, Australia, South Korea and Indonesia. For example, GDP at PPP decreased in the United States (-2.5%), the European Union (-4.3%), the Russian Federation (-7.8%), Japan (-5.4%) and Mexico (-5.3%).

The results from the analysis of sectoral emissions are summarised in Appendix C. For CO_2, we considered the six main source categories and more detailed fossil-fuel combustion sub-sectors and more detailed other non-combustion sectors; for CH_4, five main source categories were used for fossil fuels, three for agriculture and three for waste; for N_2O, we considered two main source categories for fuels and industry, seven for agriculture and three for waste; and for F-gases, we used six categories (per gas, split into use and by-product), but we note that percentages for F-gases are heavily impacted by the strong growth rate over time of emissions from F-has usage.

Please note that the emissions for 2019 presented in this report may be considered the most updated description for a 'normal' year, to be benchmarked with extraordinary emission levels in 2020 and, possibly, subsequent years. It must also be noted that the results for 2019 greenhouse gas emissions have been revised, firstly because as new and refined statistics have become available on 2019 activities, and secondly, because of revisions in the EDGAR emissions up to 2018, in particular for non-CO2 greenhouse gases.

3 Trends in largest emitting countries and the EU-27

3.1 Introduction

This chapter discusses the total GHG emission trends for the 30 largest GHG emitting countries/economies and more in particular the six main emitters, consisting of five large countries: China (with share of 27%), the United States (12%), India (7%), the Russian Federation (4%) and Japan (3%), and one region: the European Union (EU-27) (7%). Globally, the combined shares of the non-CO_2 GHG emissions are about 27% of total GHG emissions (about 19% for CH_4, 6% for N_2O, and 3% for F-gases), but they vary for the six largest emitters, from 8% for Japan to 30% for India.

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

In 2019 of the top-30 economies, among the economies that saw the largest absolute changes of GHG emissions were only China and India that have continued to *grow*, by 2.1% and 1.1%, as did those of Vietnam, Indonesia and Iran, by 12.9%, 4.5% and 1.9%, but those of the European Union (EU-27), United States, Japan and the Russian Federation saw *decreases* of 3.8%, 2.1%, 2.8% and 0.6%, respectively. Of other top-30 countries 11 saw GHG emissions decrease in 2019 and 10 showed increasing emissions.

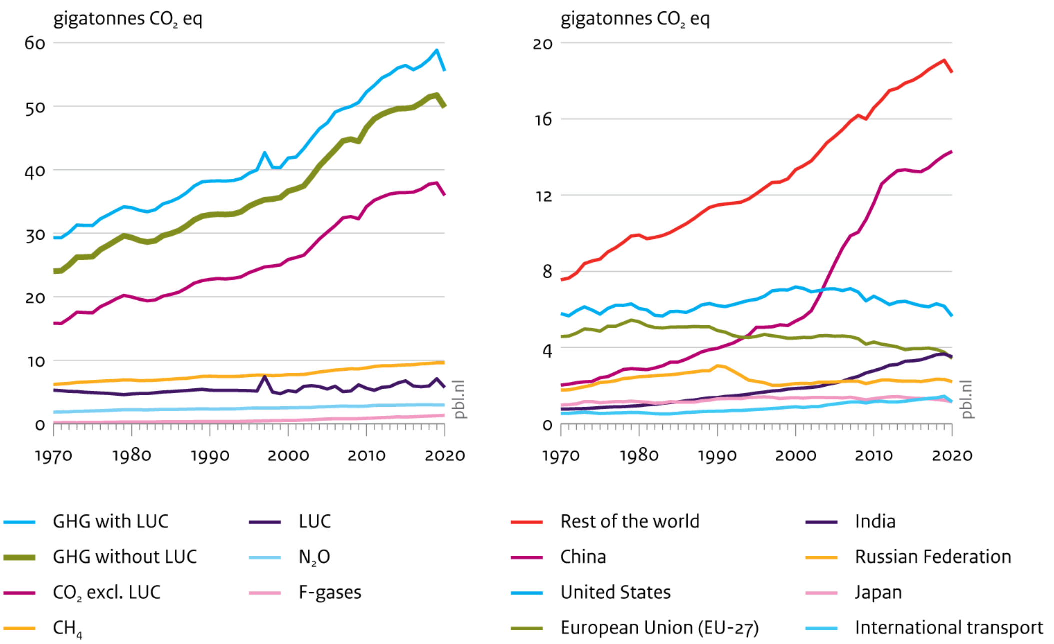
In absolute values, the largest emitters of CO_2 and total GHG emissions are China, the United States, the European Union and India, followed by the Russian Federation and Japan. For non-CO_2 emissions only, India and the European Union switch ranking, and Brazil has higher non-CO_2 emissions than Japan in 2019 and 2020. The uncertainty estimate for annual total GHG emissions for these countries and the EU-27 originates mainly from the uncertainty in annual CO_2 emissions, which are estimated at ±5% or ±10% (95% uncertainty range) (see Figure 3.1). However, the uncertainty in the emission trend is believed to be much smaller at around one percentage point in the most recent year, with a larger uncertainty for the exceptional case of the pandemic year 2020. Also shown in Figure 3.1 is international transport (aviation and shipping), which is since 2017 actually the 7th largest emitter, when included and ranked in the list of countries, that showed the largest decline of 20% in 2020. This is mainly due to international aviation, that had a 45% share in 2019 emissions saw its CO_2 emissions decline by 45% in 2020 (IATA, 2021), whereas international shipping with a 55% emissions share in 2019 did only decrease its CO_2 emissions by 1% in 2020 (Marine Benchmark,2021a,b). The latter was mainly due to a 2.4% decrease in CO_2 emissions from container ships and steep emission declines from the smaller passenger carrying sectors, such as cruise ships and ferries, that were larger than the 1.2% emissions increase from bulk carriers and tankers (Ovcina, 2021).

However, the ranking is different when comparing GHG 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 (3 tCO_2 eq/cap), all five main emitters have per capita emission levels that are significantly higher than those for the rest of the world and the world average (about 2 tCO_2 eq/cap). Now China (with 10 tCO_2 eq/cap in 2020) ranks third (rather than first, which it has for absolute emissions). Although CO_2 eq emissions per capita in the United States have been steadily decreasing since 2000, from 25 tCO_2 eq/cap to about 19 tCO_2 eq/cap by 2019, this is still ten times as high as the global average of 1.8 tCO_2 eq/cap, and it has the highest position of the top 5 emitting countries and the EU, although it is surpassed by three other G20 countries: Australia (25 tCO_2 eq/cap), Saudi Arabia (22 tCO_2 eq/cap) and Canada (20 tCO_2 eq/cap). The United States (19 tCO_2 eq/cap), the Russian Federation (16 tCO_2 eq/cap), and Japan (10 tCO_2 eq/cap) make up the top 3 GHG emitting countries per capita in 2019, of the five main emitting countries and the European Union (9 tCO_2 eq/cap).

Figure 3.1
Global greenhouse gas emissions

Per type of gas | Top emitting countries and the EU



LUC = Land-use change, GHG = greenhouse gas

Source: GHG excl. LUC EDGAR v6.0 FT2020
LUC: GCB (2020)

Note: CO_2 eq with GWPs from IPCC AR4

Source: EDGAR v6.0 FT2020 (without land-use change), but incl. savannah fires (FAO, GFED4.1s)

Uncertainty margins: ±5% for the United States, EU-27, Japan and India; ±10% for Russian Federation and China, based mainly on the uncertainty estimate of annual CO_2 emissions (PBL, 2012, 2017).
Note: CO_2 eq with GWPs from IPCC AR4.

The emissions per USD of GDP (in 2017 prices and corrected for Purchasing Power Parity (PPP)) show another picture. In contrast to the per capita emissions, the top-5 emitting countries and the European Union are not all above the world average when it comes to emissions per USD of GDP. In India, current emissions per USD of GDP are slightly above the 2020 world average, while those in the European Union are the lowest, at about half the world average, closely followed by Japan. Emissions in the United States are somewhere in the middle, at about three quarters of the world average. Emissions per USD of GDP in China are the highest, closely followed by the Russian Federation, and are about 50% higher than the world average. The trend for all countries is downward, including the world average, except for the Russian Federation, where emission levels per USD have remained flat since 2012.

Table 3.1
Greenhouse gas emissions per capita, per G20 country, for selected years (unit: tonnes of CO_2 eq per person).

Size/type	G20 country	1990	2005	2015	2016	2017	2018	2019	2020
Largest	China	3.3	6.3	9.4	9.3	9.4	9.6	9.8	9.9
Largest	United States	24.6	24.0	19.7	19.2	18.9	19.3	18.7	17.1
Largest	European Union (27)	11.9	10.8	9.1	9.1	9.1	8.9	8.6	7.9
- Largest	*- France*	*9.5*	*8.8*	*7.1*	*7.1*	*7.1*	*6.9*	*6.7*	*6.1*
- Largest	*- Germany*	*15.6*	*12.0*	*11.1*	*11.1*	*10.9*	*10.5*	*9.8*	*8.9*
- Largest	*- Italy*	*9.0*	*10.0*	*7.1*	*7.0*	*7.0*	*6.9*	*6.7*	*6.1*
Largest	India	1.6	1.9	2.5	2.5	2.6	2.7	2.7	2.5
Largest	Russian Federation	20.6	15.2	15.4	15.3	15.6	16.0	15.9	15.1
Largest	Japan	10.5	10.7	10.5	10.4	10.3	10.0	9.7	9.1
Other OECD	Australia	29.8	29.4	26.2	24.8	26.3	25.7	24.8	22.7
Other OECD	Canada	21.3	22.8	21.2	20.7	20.5	20.6	20.4	18.8
Other OECD	Mexico	5.4	6.6	6.4	6.4	6.4	6.4	6.2	5.5
Other OECD	South Korea	7.5	11.9	14.1	14.3	14.6	14.8	14.4	13.6
Other OECD	Turkey	4.1	4.9	6.5	6.8	7.2	7.0	6.7	6.6
Other OECD	United Kingdom	13.7	11.2	7.7	7.3	7.1	6.9	6.6	5.9
Other	Argentina	8.2	9.3	9.4	9.4	9.2	9.0	8.8	8.4
Other	Brazil	4.6	5.7	6.4	6.2	6.2	6.0	6.0	5.9
Other	Indonesia	2.3	2.9	3.6	3.6	3.9	4.0	4.2	3.8
Other	Saudi Arabia	14.2	19.1	23.8	23.4	23.2	22.3	22.1	21.7

We note that, since 2018, China's emissions per USD of GDP are below those in the Russian Federation. And, in 2017, China's GDP, calculated with Purchasing Power Parity (PPP), surpassed that of the United States — in 2019, it was 11.6% higher than the GDP of the United States, and in 2020, the difference increased to 18.1% (World Bank, 2021).

We also note that, in this year's data set, total GHG emissions in Brazil in 2019 and 2020 surpassed those in Japan (both excluding LULUCF). This change in ranking is mainly due to a large downward revision of Japan's F-gas emissions, which are now both largely based on emissions reported to the UNFCCC (in BUR4 and CRF, respectively).

Appendix B provides more details for the top 30 countries/regions, totals per country, with 1990–2020 time series on GHG emissions, GHG totals, CO_2, CH_4, N_2O, F-gas and similar tables for GHG emissions per capita as well as for GHG per USD of GDP.

This chapter furthermore briefly describes the emission levels and trends in 2019 and 2020 for the top-5 emitting countries and the European Union, as Chapter 2 does for global total GHG emissions. As mentioned in Chapter 2, the Fast Track estimates of non-CO_2 greenhouse gases in 2020 are far more uncertain in this pandemic and global recession year than in normal years. In 'normal' years, the trends observed in the preceding years can be used to estimate 't-1' emissions, when recent statistics for the activity levels of sources are not available, which is the case for roughly half of both CH_4 and N_2O emissions and most of the F-gas sources.

However, to *illustrate* the possible size of the impact on non-CO_2 GHG, we also show the 'average' impact on emissions of CH_4, N_2O and F-gases and on total GHG emissions for a 'normal recession' year – which 2020 was not. Because, for CO_2, the pandemic impact is known, as is the trend in the main fossil fuel consumption statistics for 2020, the total GHG emission trend does not differ much from the total FT2020 estimates for 2020, as it is largely determined by the trend in CO_2 emissions.

3.2 Greenhouse gas emissions of top-5 countries and the European Union

3.2.1 China

In 2019 and 2020, China's greenhouse gas emissions increased by 2.1% and 1.5% to 14.1 and 14.3 $GtCO_2$ eq, which is well below the annual average of 3.7% since 2005, but in line with the lower growth rates since 2012. As shown in Table 3.2, this growth is mainly due to increases in CO_2 emissions, which comprise 82% of China's total GHG emissions. Although non-CO_2 emission levels are relatively low, compared to CO_2 emissions, increases in CH_4 and F-gas emissions contributed by one fifth to the total increase in 2020. Table 3.2 also shows that, over the past 15 years, the average annual trend in CO_2, N_2O and F-gas emissions has been significantly smaller than in the preceding 15 years (since 1990). For CO_2, this is also evident from the lower annual trends in the years 2016–2020. Clearly, increasing use of renewable and nuclear energy sources is mitigating the fossil-fuel-related CO_2 emission growth, but the figures show that plateauing and curbing CO_2 emissions has not yet been achieved.

In 2020, China contributed about 29% to global greenhouse gas emissions, about 30.5% to global CO_2 emissions and 34% to global F-gas emissions. In 2019, total GHG emissions consisted of 82% CO_2, 11.9% CH_4, 3.0% N_2O and 3.0% F-gas emissions. China's share of CO_2 is about 9 percentage points higher than the global average and its shares of CH_4 and N_2O are much lower than the global average.

Table 3.2
Trend indicators for annual changes in GHG emissions in China (GDP indicated in blue)

Indicator	1990-2005	2005-2019	Shares 2019	2016	2017	2018	2019	2020	2020 L [1]
GDP [2]	9.8%	8.6%		6.7%	6.9%	6.7%	5.8%	2.1%	n/a [3]
GHG	5.2%	3.7%	100%	-0.2%	1.6%	2.6%	2.1%	1.5%	1.1%
CO_2	6.6%	4.3%	82.0%	0.1%	1.8%	3.1%	2.1%	1.4%	n/a [3]
CH_4	1.2%	1.3%	11.9%	-2.3%	0.6%	-0.2%	1.5%	1.7%	-0.6%
N_2O	2.3%	-0.4%	3.0%	-3.7%	-2.8%	-0.5%	0.4%	0.2%	-0.8%
F-gases	27.2%	5.9%	3.0%	4.8%	6.1%	5.4%	5.1%	4.8%	1.4%
o.w. HFCs [4]	0.0%	6.8%	2.1%	4.7%	5.2%	5.0%	4.5%	4.3%	4.3%

Notes:
[1] Annual change in total estimate for 2020 based on historical impact of average annual global change in recession years, compared to non-recession years (instead of past trend extrapolation).
[2] GDP is Gross Domestic Product (at PPP in 2017 USD).
[3] n/a is '*not applicable*' to GDP and CO_2 emissions in 2020 (since the actual impact of the COVID-19 pandemic is known from economics and fossil-fuel consumption statistics on 2020).
[4] o.w. is 'of which'.

The 1.5% increase in CH_4 emissions in 2019 (or 24 $MtCO_2$ eq), was mainly due to a 4% increase in emissions from coal production and 10% increase from the production of natural gas, although partly compensated by a 27% decline in emissions from swine manure. After three years of decreasing emissions, total N_2O emissions increased by 0.4% in 2019 (or 1.7 $MtCO_2$ eq), which was mainly due a 4% increase in emissions from the use of synthetic fertilisers, the largest source of N_2O with a share of about 26% (see Table 3.2). The Fast-Track trend estimates for 2020 are similar to those for 2019, but with a different mix of changes in the sources.

China's F-gas emissions mainly consist of about 70% HFC (see Table 3.2), 25% SF_6, 5% PFC and 0.1% NF_3. In 2019, F-gas emissions increased by 7% or 15 $MtCO_2$ eq. The increase was primarily due to a 7% increase in HFC emissions from HFC use. A quarter of China's total HFC emissions stems from HFC-23 emitted as by-product in the production of HCFC-22. However, please note that the PFC emissions do not include CF_4 emissions from so-called *Low Voltage Anode Effects* occurring during primary aluminium production that were not included in v6.0 in the by-product PFC emissions estimated for this source, which in China will increase CF_4 emissions from 2000 onwards and by 2010 will increase CF_4 emissions by around 10 kt per year, This is in addition to the about 1 kt presently estimated for CF_4 from aluminium production (see Appendix A for more details).

3.2.2 United States

In 2019, the United States contributed 12% to global greenhouse gas emissions, about 13% to global CO_2 emissions and 15% to global F-gas emissions. Total greenhouse gas emissions consisted of 82% CO_2 and 18% non-CO_2, specifically: 10.5% CH_4, 4.7% N_2O and 3.1% F-gas. The US share of CO_2 was about 9 percentage points higher than the global average and the shares of CH_4 and N_2O were much lower than the global average. Table 3.3 shows that, over the past 15 years, the average annual trend in CO_2, N_2O and F-gas emissions has been significantly lower than in the preceding 15 years (since 1990). Decreasing coal use and increasing use of new renewable energy sources have caused CO_2 to decline steadily, since 2005.

In 2019 and 2020, total GHG emissions decreased by 2.1% and 8.5% to 6.2 and 5.6 $GtCO_2$ eq, which was well below the average annual decrease of 1.0% since 2005. As shown in Table 3.3, these declines are mainly due to decreases in CO_2 emissions, which comprise 82% of total GHG emissions in the United States. Although non-CO_2 emission levels are relatively low, compared to CO_2 emissions, the 6% decrease in N_2O emissions also contributed to the total decrease in 2019.

Table 3.3
Trend indicators for annual changes in GHG emissions in the United States (GDP indicated in blue)

Indicator	1990-2005	2005-2019	Shares 2019	2016	2017	2018	2019	2020	2020 L [1]
GDP [2]	3.1%	1.8%		1.7%	2.3%	3.0%	2.2%	-3.5%	n/a [3]
GHG	0.9%	-1.0%	100%	-1.8%	-0.9%	2.6%	-2.1%	-8.5%	-8.6%
CO_2	1.1%	-1.2%	81.7%	-2.0%	-1.4%	3.1%	-2.4%	-9.9%	n/a [3]
CH_4	-0.7%	-0.1%	10.5%	-2.1%	2.0%	1.2%	1.2%	-1.8%	-0.9%
N_2O	0.5%	-0.3%	4.7%	2.2%	0.0%	-0.1%	-6.0%	-4.1%	-7.2%
F-gases	2.6%	1.1%	3.1%	-0.6%	0.6%	-0.5%	1.9%	0.4%	-1.8%
o.w. HFCs [4]	10.6%	2.1%	2.5%	-0.7%	0.8%	-0.6%	2.4%	0.4%	0.4%

Notes: see Table 3.2.

In 2019, CH_4 emissions in the United States *increased* by 1.2% or 8 $MtCO_2$ eq, mainly due to the large increase of 7% in methane emissions from natural gas production and related transport, with livestock, particularly cattle, as its second-largest source. In 2020, however, methane emissions *decreased* by 1.8% or 12 $MtCO_2$ eq, mainly due to a 25% decline in coal production (Table 3.3). N_2O emissions decreased by 6.0% or $MtCO_2$ eq, in 2019, mainly due to large deceases of 20% in N_2O emissions from the N-fixing crops and 50% reduction in N_2O emissions from nitric acid production (Table 3.3). In 2020, total N_2O emissions decreased by less, due to much smaller decreases in these two sources, now with an estimated 10% decrease in emissions from fuel combustion.

The F-gas emissions were mainly composed of about 82% HFC (see Table 3.3), 16% SF_6, 1.7% PFC and 0.3% NF_3. In 2019, F-gas emissions increased by 1.9% or 3.5 $MtCO_2$ eq. The increase was primarily due to a 2.2% increase in HFC emissions from HFC use, by far the largest source of F-gases in the United States (80%).

3.2.3 European Union (EU-27)

In 2019, the European Union (EU-27) [15] contributed 7.3% to global greenhouse gas emissions and about 7.7% to global CO_2 emissions. Total greenhouse gas emissions consisted of 78% CO_2 and 22% non-CO_2, specifically: 12.8% CH_4, 6.7% N_2O and 2.4% F-gas. The EU share of CO_2 is about 5 percentage points higher than the global average and its share of CH_4 is lower than the global average. Table 3.4 shows that, over the past 15 years, the average annual trend in CO_2 and F-gas emissions has been significantly lower than in the preceding 15 years (since 1990). Decreasing fossil fuel use since 2005 (coal -49%, oil -27%, natural gas -9%) and increasing use of new renewable energy sources have caused CO_2 to decline steadily, since 2005.

Table 3.4
Trend indicators for annual changes in GHG emissions in the EU-27 (GDP indicated in blue)

Indicator	1990-2005	2005-2019	Shares 2019	2016	2017	2018	2019	2020	2020 L [1)]
GDP [2)]	2.0%	1.4%		2.1%	3.0%	2.3%	1.7%	-6.1%	n/a [3)]
GHG	-0.4%	-1.4%	100%	0.1%	0.6%	-1.8%	-3.8%	-8.4%	-8.9%
CO_2	-0.2%	-1.6%	78.2%	0.3%	0.8%	-1.7%	-4.5%	-10.6%	n/a [3)]
CH_4	-1.7%	-0.8%	12.8%	-1.4%	0.1%	-0.8%	-0.3%	-0.7%	-2.4%
N_2O	-1.3%	-0.7%	6.7%	0.3%	0.1%	-1.9%	-0.6%	-1.3%	-1.8%
F-gases	3.2%	0.6%	2.4%	0.9%	-1.3%	-6.2%	-5.2%	0.9%	-8.9%
o.w. HFCs [4)]	159.5%	2.4%	2.1%	0.1%	-1.6%	-6.9%	-5.6%	1.3%	1.3%

Notes: see Table 3.2.

In 2019 and 2020, total GHG emissions decreased by 3.8% and 8.4% to 3.6 and 3.4 $GtCO_2$ eq, which is well below the average annual decrease of 1.4%, since 2005. As shown in Table 3.4, these declines are mainly due to decreases in CO_2 emissions, which comprise 78% of the EU total GHG emissions. Although non-CO_2 emission levels are relatively low compared to CO_2 emissions, the 5% decrease in F-gas emissions also contributed to the total decrease in 2019. The country that contributed

[15] This report covers emissions up to and including 2020, the year in which the United Kingdom left the European Union (on 31 January 2020). Therefore, we excluded the United Kingdom from the EU-27 totals discussed here. In our data set on 2019, the UK share in the former EU-28 total greenhouse gas emissions, population and GDP was 11.7%, 13.4% and 13.9%, respectively.

most to the total EU decrease in 2019 was Germany (-6.5%), with smaller decreases in Spain (-5.9%), Poland (-4.3%), Italy (-3.0%) and France (-2.4%).

In 2019, CH_4 emissions in the European Union *decreased* by 0.3% or 1.5 $MtCO_2$ eq, mainly due to decreases of 0.9% in methane emissions from livestock, particularly cattle, and of 6.9% from coal production. In 2020, methane emissions *decreased* by 0.7% or 3.5 $MtCO_2$ eq, also mainly due to a 10.2% decline in emissions from coal production and 1.0% from livestock (Table 3.4). N_2O emissions *decreased* by 0.6% or 1.5 $MtCO_2$ eq, in 2019, mainly due to deceases of 7% in N_2O emissions from industrial processes, notably nitric acid production, and 2% from fuel combustion. In 2020, total N_2O emissions decreased by 1.3% or 3 $MtCO_2$ eq, due to decreases in these two sources and a smaller increase in emissions from crop residues.

EU F-gas emissions mainly consisted of about 89% HFC (see Table 3.4), 7% SF_6, 3.6% PFC and 0.1% NF_3. In 2019, F-gas emissions *decreased* by 5.2% or 5 $MtCO_2$ eq. The increase is primarily due to a 5.7% decrease in HFC emissions from HFC use, by far the largest source of F-gases in the European Union (89%).

3.2.4 India

India's greenhouse gas emissions increased by 1.1% in 2019 and decreased by 3.9% in 2020 to 3.66 and 3.52 $GtCO_2$ eq, respectively. These changes are far less than the average annual increase of 3.9% since 2005. As shown in Table 3.5, these changes are mainly due to the changes in CO_2 emissions, which comprise 70% of India's total GHG emissions. In 2019, increases in CH_4 and F-gas emissions each contributed by one tenth to the total increase. Table 3.5 also shows that, over the past 15 years, the average annual trend in CO_2 and F-gas emissions has been larger than in the preceding 15 years (since 1990). In India, consumption of coal, oil products and natural gas has doubled since 2005, although the annual changes in the use of all three fossil fuel types have shown to be quite variable and large.

In 2019, India contributed about 7.1% to global greenhouse gas emissions, about 6.8% to global CO_2 emissions and 9% to global N_2O emissions. In 2019, total GHG emissions consisted of 70% CO_2 and 30% non-CO_2: 21.1% CH_4, 7.3% N_2O and also 1.6 % F-gas emissions. India's share of CO_2 is about 3 percentage points lower than the global average. The share of CH_4 was larger than the global average and the largest amongst the top-6 countries and the share of F-gases was about half of the global average.

Table 35
Trend indicators for annual changes in GHG emissions in India (GDP indicated in blue)

Indicator	1990-2005	2005-2019	Shares 2019	2016	2017	2018	2019	2020	2020 L [1]
GDP [2]	5.9%	6.7%		8.3%	6.8%	6.5%	4.0%	-8.0%	n/a [3]
GHG	3.0%	3.9%	100%	1.7%	3.7%	4.0%	1.1%	-3.9%	-4.6%
CO_2	4.8%	5.5%	70.0%	1.9%	4.8%	5.2%	1.5%	-5.9%	n/a [3]
CH_4	0.9%	0.7%	21.1%	1.1%	0.7%	0.4%	0.5%	0.5%	-1.6%
N_2O	2.2%	1.8%	7.3%	0.0%	1.5%	2.7%	-1.1%	0.0%	-2.3%
F-gases	1.5%	12.7%	1.6%	8.7%	8.2%	6.9%	6.8%	6.2%	3.1%
o.w. HFCs [4]	14.3%	52.1%	1.4%	9.7%	8.9%	8.1%	7.5%	7.0%	7.0%

Notes: see Table 3.2.

In 2019, the 0.5% increase in CH_4 emissions or 3.5 $MtCO_2$ eq, was mainly due to a 1.6% increase in emissions from waste water and 0.4% from livestock, with similar increases in 2020. Livestock accounts for half of India's methane emissions and wastewater for one fifth. After two years of increasing emissions, total N_2O emissions *decreased* by 1.1% or 3 $MtCO_2$ eq, mainly due to a 3% decrease in emissions from the use of synthetic fertilisers, which is the largest source of N_2O with a share of about 30% (see Table 3.5). For CH_4, the Fast-Track trend estimate for 2020 was also 0.5%, equal to that of 2019, but with a different mix of changes in the sources. For N_2O, the 2020 estimate of 0.0% change was due to emission changes from fertilisers, waste water and other sources, totalling zero.

In 2019, India's F-gas emissions mainly consisted of about 86% HFC (see Table 3.5), 13% SF_6 and 1.3% PFC. F-gas emissions increased by 7% or 4 $MtCO_2$ eq. The increase was primarily due to a 7.5% increase in HFC emissions from HFC use, the main source of F-gases in India.

3.2.5 Russian Federation

In 2019, the Russian Federation contributed 4.5% to global greenhouse gas emissions and about 4.7% to global CO_2 emissions. Total greenhouse gas emissions consisted of 76.5% CO_2 and 23.5% non-CO_2, specifically: 17.9% CH_4, 3.3% N_2O and 2.2% F-gas. Russia's share of CO_2 was about 3 percentage points larger than the global average, and the share of N_2O was much lower than the global average. Table 3.6 shows that, over the past 15 years, the average annual trend in all emission levels was significantly higher than in the preceding 15 years (since 1990), because that period was characterised by the dissolution of the Soviet Union in 1991 and economic reforms that brought a long economic depression in the 1990s. The very slowly increasing use of oil and natural, since 2005, has caused CO_2 to slowly increase by 6% in 2019 compared to 2005.

In 2019 and 2020, total GHG emissions *decreased* by 0.6% and 4.9% to 2.3 and 2.2 $GtCO_2$ eq, respectively, well below the average annual *increase* of 0.4% since 2005. As shown in Table 3.6, these declines were mainly due to decreases in CO_2 emissions, which comprised 76.5% of the Russian Federation's total GHG emissions. Although non-CO_2 emission levels were relatively low compared to CO_2 emissions, the 11% decrease in F-gas emissions also contributed considerably to the total decrease in 2019.

Table 3.6
Trend indicators for annual changes in GHG emissions in the Russian Federation (GDP indicated in blue)

Indicator	1990-2005	2005-2019	Shares 2019	2016	2017	2018	2019	2020	2020 L [1]
GDP [2]	-0.7%	2.4%		0.2%	1.8%	2.8%	2.0%	-3.0%	n/a [3]
GHG	-2.2%	0.4%	100%	-0.8%	2.3%	3.0%	-0.6%	-4.9%	-5.0%
CO_2	-2.1%	0.2%	76.5%	-1.4%	1.7%	3.1%	-0.7%	-5.8%	n/a [3]
CH_4	-2.2%	1.3%	17.9%	1.1%	2.8%	1.4%	1.2%	-2.4%	-0.9%
N_2O	-3.6%	1.3%	3.3%	1.0%	-1.1%	0.8%	0.1%	-1.0%	-1.1%
F-gases	-1.8%	1.9%	2.2%	4.4%	28.9%	16.7%	-11.2%	2.9%	-14.9%
o.w. HFCs [4]	-3.0%	6.0%	1.6%	5.8%	45.6%	24.0%	-15.5%	3.7%	3.7%

Notes: see Table 3.2.

In 2019, CH_4 emissions in the Russian Federation *increased* by 1.2% or about 5 $MtCO_2$ eq, mainly due to increases of 0.9% in methane emissions from natural gas production and its transport, and increases of 2.3% from landfill and of 9.2% from venting of associated gas. In 2020, methane emissions *decreased* by 2.4% or 10 $MtCO_2$ eq, mainly due to a 9% decline in emissions from coal production and 9% emissions decline from natural gas production and its transport (Table 3.6). In 2019, N_2O emissions hardly *increased*, by 0.1% or 0.1 $MtCO_2$ eq, mainly due to the counterbalancing decreases of 1% in N_2O emissions from industrial processes, and 2.7% from synthetic fertilisers, and increases in emissions from crop residues and savannah fires. In 2020, total N_2O emissions *decreased* by 1.0% or 1 $MtCO_2$ eq, mainly due to a 6% decrease in N_2O emissions from fuel combustion, also in indirect emissions, and 10% decrease in emissions from savannah fires.

The Russian Federation's F-gas emissions mainly consisted of about 71% HFC (see Table 3.6), 20% SF_6 and 9.4% PFC. The share of PFC emissions, which are predominantly emitted as by-product of aluminium production, was more than twice the global average. In 2019, F-gas emissions *decreased* by 11.2% or 2 $MtCO_2$ eq. This was primarily due to a 35% decrease in HFC-23 emitted as by-product in HCFC-22 manufacture, partly compensated by a 10% *increase* in HFC emissions from HFC use (in particular HFC-125, HFC-134a and HFC-143a), by far the largest source of F-gases in Russia (41%).

3.2.6 Japan

In 2019, Japan contributed by about 2.4% to global greenhouse gas emissions and about 3.0% to global CO_2 emissions. Total greenhouse gas emissions consisted of 92% CO_2 and 7.7% non-CO_2 emissions (4.2% CH_4, 1.6% N_2O and 1.8% F-gas). Japan's share of CO_2 emissions was about 19 percentage points larger than the global average. Therefore, its shares of CH_4, N_2O and F-gas are all much lower than the global average, and than those of the other top-6 emitting countries and the European Union. Table 3.7 shows that, over the past 15 years, the average annual trend in CO_2 emissions has been lower than in the preceding 15 years (since 1990). Switching the energy mix by decreasing oil use and increasing use of natural gas, both by one third since 2005, while keeping coal use flat, together with an 80% decrease in nuclear energy, have caused total CO_2 emissions to decline since 2005.

In 2019 and 2020, total GHG emissions decreased by 2.8% and 6.3% to a respective 1.2 and 1.2 $GtCO_2$ eq (rounded), well below the average annual decrease of 0.8% since 2005. As shown in Table 3.7, these declines were mainly due to decreases in CO_2 emissions, which comprised 92% of Japan's total GHG emissions. Although non-CO_2 emission levels were relatively low compared to CO_2 emissions, the 0.5% decrease in CH_4 emissions also contributed to the total decrease in 2019.

Table 3.7
Trend indicators for annual changes in GHG emissions in Japan (GDP indicated in blue)

Indicator	1990-2005	2005-2019	Shares 2019	2016	2017	2018	2019	2020	2020 L [1)]
GDP [2)]	1.3%	0.6%		0.5%	2.2%	0.3%	0.3%	-4.8%	n/a [3)]
GHG	0.3%	-0.8%	100%	-0.7%	-1.0%	-3.6%	-2.8%	-6.3%	-6.4%
CO_2	0.6%	-0.8%	92.3%	-0.8%	-1.1%	-3.8%	-3.0%	-6.8%	n/a [3)]
CH_4	-2.3%	-0.4%	4.2%	-1.0%	0.0%	0.1%	-0.5%	-0.4%	-2.6%
N_2O	-1.6%	-1.3%	1.6%	-2.2%	0.3%	-2.8%	0.0%	-4.4%	-1.2%
F-gases	-2.6%	-0.3%	1.8%	5.0%	2.6%	-0.6%	2.8%	2.7%	-0.9%
o.w. HFCs [4)]	-3.2%	7.0%	1.3%	6.0%	4.6%	1.6%	3.7%	3.3%	3.3%

Notes: see Table 3.2.

In 2019, Japan's CH_4 emissions *decreased* by 0.5% or 0.3 $MtCO_2$ eq, mainly due to a large decrease of 5% in methane emissions from landfill and 0.5% from rice cultivation, the second largest source, next to livestock. In 2020, methane emissions *decreased* by 0.5% or 0.2 $MtCO_2$ eq (Table 3.7), again mainly due to similar decreases in emissions from landfill and rice cultivation. The N_2O emissions remained flat in 2019, mainly due to a 3% decrease in N_2O emissions from fuel combustion, thus also in their indirect N_2O emissions, which nullified a 27% increase in N_2O emissions from industrial processes, in particular from the production of nitric acid and caprolactam. In 2020, however, total N_2O emissions decreased by about 4%, mainly due to an estimated 7% decrease in emissions from fuel combustion.

Japan's F-gas emissions mainly consisted of about 72% HFC (see Table 3.7), 18.3% PFC, 8.6% SF_6 and 1.1% NF_3, virtually all from the use of these F-gases. In 2019, F-gas emissions increased by 2.8% or 0.6 $MtCO_2$ eq. The increase was primarily due to a 3.7% increase in HFC emissions from HFC use (mainly HFC-125 and HFC-32), by far the largest source of F-gases in Japan (60%), and a 3.0% increase in emissions from PFC use.

Appendix A

Methodology for the EDGAR v6.0 emissions of fluorinated gases (F-gases)

Introduction

The EDGAR v6.0 data set on 1970–2018 includes, amongst other greenhouse gases, fluorinated greenhouse gases (F-gases), a class of man-made chemicals used in a wide range of industrial applications. F-gases are comprised of three main groups:

1. Hydrofluorocarbons (HFCs), which are mainly *used* as refrigerants (particularly in commercial refrigeration and air conditioning), as blowing agents for foams and as solvents;

2. Perfluorocarbons (PFCs), which are mainly *used* in the electronics sector, notably in photo voltaic cell manufacture and semiconductor manufacture, as solvents and in fire extinguishers;

3. Sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). SF_6 is mainly *used* as insulating gas in high voltage switchgear (GIS) and NF_3 is mainly *used* in the electronics sector.

In addition to the *usage* of these gases, HFC-23 is also emitted as a *by-product* in the production of HCFC-22, and the PFCs CF_4 and C_2F_6 are emitted from the production of primary aluminium.

PFC by-product emissions comprise more than half of global total PFC emissions in CO_2 eq, whereas, at present, HFC-23 by-product emissions contribute globally about 15% to total HFC CO_2 eq emissions. By far the largest share of HFC emissions are those from refrigeration and air conditioning. In particular, HFCs emissions from commercial refrigeration comprise about half of the global total HFC emissions and, for those from air conditioning, this is almost a quarter.

Thus, the use of F-gases plays an important role in some key sectors of the economy, such as refrigeration and air conditioning, electronics manufacturing and high-voltage electricity transport. These fluorinated gases represent a set of powerful greenhouse gases that significantly contribute to climate change, at present around 1300 Mt CO_2 eq, collectively, around 80% of which in HFC emissions.

Data sources used in EDGAR v6.0 for F-gases

HFC emissions

The new v6.0 data set contains completely revised data on the HFC emissions from *HFC use* for the years after 1990. The data on most emissions were obtained from UNFCCC (most detailed for 41 so-called Annex I countries with complete time series per source category for 1990–2018 (NIR/CRF), most of which in 6 sub-categories of refrigeration and air conditioning and the remainder in 5 other categories. These data were supplemented with emissions data on 20 other countries that reported emissions to the UNFCCC (6 larger ones BUR or NIR (UNFCCC, 2021c) plus 14 others that provided a significant time series per F-gas or for total HFC emissions (UNFCCC, 2021b). However, within these six, exceptions are China and India, who do not report long time series. Instead, for China, data were used as reported by Fang et al. (2016), Su et al., (2015) and Liu et al. (2019). For India, we used data reported by Garg et al. (2007), Sharma et al. (2011) and Say (2019). The other four countries are Brazil (BUR), Mexico (BUR), South Korea (NIR) and Taiwan (NIR).

Global total emissions per HFC, between 1990 and 2005, were obtained from the following bottom-up studies: Clodic et al. (2010) for HFC-125, 152a, 143a, 145fa, 227ea, 32 and 365mfc; AFEAS (2005) for HFC-134a (data calculated by McCulloch et al., 2003); Campbell et al. (2008) in the IPCC-TEAP Special Report on Safeguarding the Ozone Layer and the Global Climate System for most of the specific HFC emissions in 2000 and 2002 (all bottom-up estimates), and Lunt et al. (2015) for most of the gases in 2010, reconciling top-down and bottom-up emissions for Annex I and non-Annex I countries. For global emissions per gas, for more recent years, we used top-down inferred emissions in 2012, 2014, 2015 and or 2016, as reported in WMO's Ozone Assessment 2018 (WMO, 2018).

Subsequently, the subtotals of HFC emissions, per gas and year, for Annex I countries and non-Annex I countries were compared with bottom-up estimates of global HFC emissions for the 1990–2005 period, and the years 2010 and 2015. For each gas, the smoothed remainder was allocated to 79 other non-Annex I countries, proportional to their share in average HCFC consumption in 2009 and 2010 as reported to the UNEP Ozone Secretariat (2021). This method was used because HFCs in these countries are mainly introduced as substitutes for HCFCs, which are phased out over time in accordance with the Montreal Protocol (UNEP Ozone Secretariat, 2021).

For years before 1990, the v4.2 data were retained, as these were based on estimated global emissions per gas from their total use as reported by AFEAS (2008). They were allocated to Annex I countries proportional to their historical CFC use, because HFCs were introduced as substitutes for CFCs. which were phased out in accordance with the Montreal Protocol (UNEP Ozone Secretariat, 2021).

Data on *HFC-23 by-product* emissions from HCFC-22 production since 1990 were also completely revised. For the 12 Annex I countries with HCFC-22 production, the data on these emissions were obtained from UNFCCC (NIR/CRF) and for 4 other countries (Brazil, Mexico, South Korea and Taiwan) who, in their national reports (NIR or BUR), also reported full times series of emissions to the UNFCCC (UNFCCC, 2021b). These were supplemented with emissions for 5 more non-Annex I countries, for which Simmonds et al. (2018) report by-product emissions for 1990–2015 (Argentina, China, India, North Korea and Venezuela). For the years 1970–1989, the HFC-23 emissions in 1990 were scaled back in time using the 1970–1990 trend in global HFC-23 emissions as reported by Simmonds et al. (2018). Finally, some HFC emissions from the *production of HFCs* were included for Annex I countries who reported HFC production emissions (Belgium, France, Italy, the Netherlands, Russia and Spain).

PFC emissions
PFC emissions from PFC *use* were also revised, this time by using PFC use emissions as reported by Annex I countries (NIR/CRF) for the 1990–2018 period and from electronics manufacturing reported by non-Annex I countries (NIR or BUR).

PFC emissions as *by-product* from aluminium production were mainly based on the data set compiled by the International Aluminium Institute (IAI, 2021) using the 2006 IPCC methodology for

PFC emissions arising from the occurrence of the Anode Effects, a well-known source of PFCs. However, for CF_4, the resulting global emissions from 2000 onwards deviate from top-down inferred CF_4 emissions by about a factor of 2. This discrepancy has been recognised by emission experts, and limited measurements have been made on the nature of these undetected so-called '*Low Voltage Anode Effects*' (LVAE), as opposed to the well-known so-called *High Voltage Anode Effects* (HVAE). This has led to recommendations about how these unobserved emissions could be included in the emissions inventory (e.g. Wong et al., 2015; Marks and Nunez, 2018) and the incorporation of these in the recently released *2019 Refined IPCC Guidelines for GHG Inventories* (IPCC, 2019). However, users of these data should be aware of this caveat that causes a strongly asymmetrical uncertainty range around the global emissions of CF_4 after 2000.

A calculation of the additional LVAE CF_4 emissions, using the average ratios of LVAE/HAVE per technology as proposed by Marks and Nunez (2018) [column G in Table 1 of the paper], was applied to the global 1990–2019 IAI data set of global production, per technology. This resulted in additional global CF_4 emissions, which increased from about 2 kt around 2000, about 4 kt around 2005 and 7 kt around 2010 to about 13 kt by 2015 (or 15, 29, 51 and 95 Mt CO2 eq, respectively). This suggests that in 2010 to 2020 about 52% to 65% of global total PFC CO2 eq emissions are missing in EDGAR v6.0. China's share of these emissions in this global calculation increased from 20% in 2000 to 70% by 2005 and 90% from 2010 onwards, reflecting the very strong growth in very large-scale Point Feed Pre Bake (PFPB) electrolysis cell technology in primary aluminium production in China since 2000. Noting that the uncertainty range in the most-used PFPB technology in China (since 2005 it is the only one), and in other countries estimated by Marks and Nunez (2018), is very large (from -80% to + 180%), this uncertain addition of LVAE emissions is certainly capable of matching global bottom-up emissions and top-down inferred emissions.

SF_6 and NF_6

For EDGAR v4.2, the global consumption of SF_6 per application (for 1961–2006) was obtained from Knopman and Smythe (2007). For SF_6 containing switchgear (so-called Gas-Insulated Switchgear or GIS), GIS equipment manufacture and stock estimates of GIS in use by utilities were adjusted, using the method in Mais and Brenninkmeijer (1998) with the regional and per country distribution based on various references (*e.g.* Mais and Brenninkmeijer, 1998; Bitsch, 1998, personal communication). For missing countries and years the GIS stock was based on the trend in the increase in electricity consumption as a proxy for GIS stock additions. For primary magnesium production and magnesium diecasting, global consumption was distributed using international production statistics from USGS (2007) and IMA (1999a,b) and others for the number of diecasting companies per country. The amount of SF_6 globally used in soundproof windows and used for their adiabatic properties (in car tyres, sporting shoes and tennis balls) was determined according to CRF reporting in these categories by Annex I countries (and also by Mexico and South Korea). SF_6 used in accelerators was distributed according to the number of high energy physics laboratories per country, and from miscellaneous sources according to the number of Airborne Warning And Control Systems (AWACs) per country. The large remaining amount of unallocated SF_6 consumption that Mais and Brenninkmeijer (1998) attributed to North America, was allocated to the United States and Canada (as unknown/military application). Finally, SF_6 (and NF_3) emissions were allocated to electronics manufacture (semiconductors, flat panel displays and solar photo-voltaic panels) using CRF reporting and, for selected non-Annex I countries, the shares in global IC waver production.

For the EDGAR v6.0 update of SF_6, we only updated the years from 1990 onwards and extended the data set to 2018, using the SF_6 and NF_3 emissions reported by countries to the UNFCCC. These reports are the CRF data reported annually by 43 so-called Annex I countries for detailed IPCC source categories (UNFCCC, 2021a). For all other, mostly developing, countries (the so-called 'non-Annex I countries') we also used SF_6 emissions as reported to the UNFCCC (201b). However, these data are often for fewer years and on fewer and less-detailed emission sources, and sometimes using different methods for different years without recalculation. In addition, for most Non-Annex I countries, these data contain gaps, especially on F-gases. The SF_6 emissions by non-Annex I countries from the main sources: GIS use, magnesium production and diecasting, and, for electronics manufacture, also including NF_3 emissions, were only completely reported in the online database as time-series starting in 1990 for Brazil, Mexico and South Korea. However for Argentina, Malaysia, Singapore and Taiwan we found detailed data on F-gas emissions in the biennial national inventory reports, and for China, in specific recent scientific papers by Xu et al. (2011), Fang et al. (2013) and Zhou et al. (2018). For all other non-Annex I countries, the SF_6 emissions in v4.2 FT2018 for these sources (GIS use by utilities and manufacture of GIS and magnesium) were retained in v6.0. For the years before 1990, in most cases, the v4.2 data for SF_6 were retained, for both groups of countries.

Annex I countries annually report whole time series (the latest in 2021 on 1990–2019), including updates and full recalculations to maintain time-series consistency, when applicable. These data are available online, and can be retrieved per detailed source category. For all other, mostly developing, countries ('non-Annex I'), we also used SF_6 emissions as reported to the UNFCCC. However, often these include fewer years and less-detailed emission sources, and sometimes also without recalculation, and have gaps, especially for F-gases.

Since, in the Paris Agreement in 2015, it was agreed that non-Annex I countries would submit a Biennial Update Report (BUR) containing updated greenhouse gas emissions. Some countries, such as Brazil, Mexico, South Korea and Taiwan, compile annually a National Inventory Report (NIR), with more details and longer time series for F-gases. As discussed above, for China and India we used several scientific papers that provide a long time-series of emissions on several specific HFCs, PFCs and SF_6.

NF_3 is only used in electronics manufacture and, therefore, all NF_3 emissions stem from the manufacture of semiconductors, flat panel displays and PV panels. As we updated and extended the whole time-series with new emission statistics, the NF_3 emissions data set has been revised completely. In the case of China, we made new estimates on the amount of NF_3 (and other F-gases) used in semiconductors and flat panel displays, as the ratio of the production capacity (in million m^2) to that of Taiwan plus South Korea.

Note that, unlike HFC and PFC emissions, for both SF_6 and NF_3, the emissions reported per country and the variables for distributing global total consumption per source category to specific countries are rather accurate. This implies that the uncertainty in estimated SF_6 and NF_3 emissions at country level should be considered as moderate (±25%).

Appendix B

Greenhouse gas emissions: total GHG, CO_2, CH_4, N_2O, F-gases, and total GHG per capita and per USD of GDP

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

We estimated uncertainties with two standard deviations for global emissions of ±7% for CO_2 (excluding LUC), ±25% for CH_4, ±30% for N_2O and ±20% for total fluorinated gases (UNEP, 2012), resulting in 8% uncertainty. In addition, we added an extra ±2% to account for the uncertainty related to the impact of the COVID-19 pandemic on 2020 GHG emissions. These uncertainty ranges are consistent with those presented in UNEP (2012) and in IPCC AR5 WG III (Blanco et al., 2014).

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

For a more detailed uncertainty assessment of the EDGAR v6.0 GHG emissions, we refer to Minx et al. (2021) and for EDGAR v5.0 to Solazzo et al. (2021).

For all tables the following applies:

- Totals and sub-totals may differ due to independent rounding. The number of digits does not indicate the accuracy of the figures,
- CO_2 eq emissions were calculated using the Global Warming Potentials (GWPs) for 100 year from the IPCC's Fourth Assessment Report (AR4).

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

For tables and graphs for *all* individual countries, we refer to the JRC booklet (Crippa et al., 2021a), which is accompanied by a spreadsheet with GHG emissions for all countries: 2021 emissions table.

Table B.1

Total greenhouse gas emissions per country and group, 1990–2020 (unit: $GtCO_2$ eq)

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	2018	2019	2020	Share	Country/group
China	3.96	4.10	4.23	4.44	4.64	5.07	5.06	5.09	5.19	5.15	5.39	5.59	5.93	6.67	7.56	8.42	9.23	9.86	10.1	10.7	11.6	12.6	13.0	13.3	13.3	13.3	13.2	13.4	13.8	14.1	14.3	28.7%	**China**
United States	6.20	6.15	6.25	6.36	6.47	6.53	6.69	6.97	7.03	7.02	7.18	7.10	6.92	6.99	7.07	7.08	6.99	7.09	6.91	6.45	6.69	6.49	6.25	6.39	6.43	6.31	6.20	6.14	6.30	6.17	5.64	11.3%	**Unites States**
European Union, of which:	4.90	4.81	4.63	4.55	4.53	4.58	4.69	4.62	4.56	4.48	4.50	4.53	4.52	4.61	4.63	4.59	4.61	4.57	4.47	4.18	4.29	4.17	4.11	4.03	3.89	3.94	3.94	3.97	3.90	3.75	3.44	6.9%	**EU (27), of which:**
France	0.54	0.56	0.55	0.53	0.52	0.53	0.55	0.54	0.55	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.53	0.52	0.52	0.50	0.51	0.49	0.49	0.49	0.45	0.46	0.46	0.46	0.45	0.44	0.40	0.8%	*France*
Germany	1.23	1.20	1.14	1.13	1.12	1.11	1.14	1.10	1.07	1.03	1.03	1.04	1.03	1.02	1.01	0.98	0.99	0.96	0.96	0.90	0.94	0.91	0.93	0.94	0.90	0.91	0.91	0.90	0.87	0.82	0.75	1.5%	*Germany*
Italy	0.51	0.51	0.51	0.50	0.49	0.52	0.52	0.52	0.53	0.54	0.54	0.54	0.55	0.57	0.58	0.58	0.57	0.56	0.55	0.49	0.50	0.49	0.47	0.44	0.42	0.43	0.43	0.42	0.42	0.41	0.37	0.7%	*Italy*
Netherlands	0.22	0.23	0.23	0.23	0.23	0.24	0.25	0.24	0.24	0.23	0.23	0.23	0.23	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	0.20	0.20	0.19	0.18	0.4%	*Netherlands*
Poland	0.51	0.50	0.49	0.48	0.48	0.48	0.49	0.48	0.45	0.43	0.42	0.41	0.41	0.42	0.42	0.42	0.43	0.43	0.42	0.41	0.43	0.43	0.42	0.42	0.40	0.40	0.41	0.43	0.42	0.41	0.39	0.8%	*Poland*
Spain	0.30	0.31	0.31	0.30	0.31	0.33	0.32	0.34	0.35	0.38	0.40	0.39	0.41	0.42	0.44	0.45	0.45	0.46	0.43	0.39	0.38	0.38	0.37	0.34	0.34	0.35	0.34	0.36	0.35	0.33	0.29	0.6%	*Spain*
India	3.04	2.98	2.77	2.54	2.29	2.22	2.15	2.02	2.01	2.06	2.11	2.12	2.11	2.18	2.18	2.19	2.22	2.23	2.23	2.11	2.20	2.30	2.29	2.25	2.23	2.24	2.22	2.27	2.34	2.32	2.21	4.4%	**India**
Russian Federation	1.31	1.32	1.33	1.32	1.38	1.39	1.41	1.39	1.32	1.35	1.37	1.35	1.38	1.38	1.37	1.38	1.35	1.40	1.32	1.26	1.32	1.37	1.41	1.42	1.38	1.34	1.33	1.32	1.27	1.23	1.16	2.3%	**Russian Federation**
Japan	2.00	2.02	2.02	2.02	2.07	2.11	2.13	2.14	2.09	2.15	2.19	2.19	2.22	2.15	2.18	2.15	2.18	2.23	2.12	2.07	2.12	2.28	2.35	2.29	2.28	2.24	2.20	2.24	2.19	2.13	2.03	4.1%	**Japan**
Other OECD countries G20	0.50	0.51	0.51	0.51	0.52	0.52	0.52	0.53	0.56	0.60	0.63	0.65	0.65	0.57	0.63	0.59	0.64	0.64	0.61	0.63	0.60	0.70	0.70	0.61	0.62	0.63	0.60	0.65	0.64	0.62	0.58	1.2%	**Other OECD countries G20**
Australia	0.59	0.58	0.59	0.60	0.62	0.64	0.66	0.67	0.68	0.69	0.71	0.70	0.71	0.73	0.73	0.73	0.73	0.77	0.74	0.70	0.72	0.73	0.73	0.75	0.76	0.76	0.75	0.75	0.76	0.76	0.71	1.4%	Australia
Canada	0.46	0.47	0.48	0.49	0.53	0.52	0.54	0.57	0.60	0.59	0.62	0.62	0.63	0.66	0.67	0.70	0.72	0.74	0.75	0.75	0.76	0.78	0.79	0.79	0.78	0.78	0.79	0.80	0.80	0.79	0.71	1.4%	Canada
Mexico	0.32	0.35	0.37	0.40	0.43	0.46	0.49	0.52	0.45	0.49	0.55	0.56	0.56	0.56	0.58	0.58	0.59	0.60	0.61	0.62	0.67	0.70	0.70	0.70	0.70	0.72	0.73	0.74	0.76	0.74	0.70	1.4%	Mexico
South Korea	0.22	0.22	0.23	0.24	0.23	0.25	0.27	0.29	0.29	0.29	0.32	0.30	0.30	0.32	0.32	0.33	0.37	0.40	0.39	0.40	0.42	0.44	0.47	0.47	0.50	0.51	0.54	0.58	0.58	0.56	0.55	1.1%	South Korea
Turkey	0.78	0.79	0.77	0.75	0.74	0.74	0.76	0.73	0.72	0.70	0.69	0.70	0.68	0.69	0.69	0.68	0.67	0.66	0.64	0.58	0.60	0.55	0.58	0.56	0.52	0.51	0.49	0.47	0.46	0.45	0.40	0.8%	Turkey
United Kingdom	1.38	1.43	1.46	1.50	1.55	1.62	1.66	1.72	1.75	1.82	1.85	1.88	1.91	1.96	2.06	2.13	2.24	2.38	2.48	2.67	2.78	2.90	3.07	3.11	3.28	3.30	3.36	3.48	3.62	3.66	3.52	7.1%	United Kingdom
Other G20 countries	2.0	2.05	2.10	2.15	2.24	2.33	2.39	2.48	2.53	2.55	2.61	2.67	2.74	2.89	3.02	3.09	3.17	3.27	3.37	3.34	3.49	3.58	3.75	3.81	3.97	3.97	3.96	4.06	4.06	4.13	3.99	8.0%	**Other G20 countries**
Argentina	0.27	0.27	0.27	0.27	0.28	0.29	0.29	0.30	0.31	0.32	0.32	0.31	0.31	0.34	0.36	0.36	0.38	0.38	0.39	0.37	0.37	0.38	0.39	0.39	0.40	0.40	0.41	0.40	0.40	0.39	0.38	0.8%	Argentina
Brazil	0.69	0.71	0.73	0.76	0.79	0.83	0.83	0.86	0.88	0.89	0.92	0.95	0.97	1.01	1.05	1.07	1.07	1.10	1.11	1.09	1.18	1.20	1.24	1.27	1.32	1.30	1.28	1.29	1.26	1.28	1.26	2.5%	Brazil
Indonesia	0.41	0.43	0.45	0.47	0.49	0.51	0.54	0.56	0.56	0.58	0.58	0.60	0.61	0.65	0.66	0.66	0.70	0.72	0.73	0.76	0.76	0.81	0.88	0.88	0.94	0.94	0.95	1.02	1.07	1.12	1.04	2.1%	Indonesia
Saudi Arabia	0.23	0.24	0.26	0.27	0.29	0.28	0.30	0.30	0.32	0.32	0.34	0.36	0.38	0.40	0.43	0.45	0.48	0.50	0.54	0.56	0.61	0.63	0.67	0.68	0.72	0.75	0.76	0.77	0.75	0.76	0.76	1.5%	Saudi Arabia
South Africa	0.40	0.39	0.39	0.39	0.40	0.42	0.43	0.45	0.46	0.44	0.44	0.45	0.47	0.50	0.53	0.54	0.55	0.57	0.60	0.57	0.57	0.55	0.57	0.58	0.60	0.57	0.57	0.58	0.58	0.58	0.55	1.1%	South Africa
Group of Twenty (G20)	24.8	24.9	24.8	24.9	25.2	25.9	26.2	26.4	26.5	26.6	27.2	27.4	27.7	28.8	30.1	31.0	32.0	33.0	33.0	32.8	34.5	35.7	36.2	36.6	36.8	36.6	36.4	36.9	37.5	37.5	36.3	72.8%	**Total G20**
Other Large countries	2.86	2.93	2.92	2.85	2.81	2.86	2.90	2.90	2.84	2.91	3.03	3.11	3.23	3.44	3.59	3.71	3.81	3.95	4.04	3.95	4.09	4.18	4.21	4.31	4.35	4.38	4.49	4.58	4.74	4.80	4.76	9.6%	**Other Large countries**
Egypt	0.14	0.15	0.16	0.16	0.15	0.16	0.17	0.18	0.18	0.20	0.20	0.21	0.22	0.23	0.24	0.27	0.28	0.29	0.30	0.31	0.31	0.32	0.33	0.32	0.33	0.33	0.34	0.36	0.40	0.39	0.38	0.8%	Egypt
Iran	0.32	0.36	0.39	0.39	0.43	0.43	0.45	0.46	0.45	0.48	0.51	0.52	0.54	0.58	0.63	0.67	0.71	0.75	0.75	0.77	0.78	0.79	0.79	0.81	0.83	0.83	0.87	0.90	0.93	0.94	0.95	1.9%	Iran
Kazakhstan	0.35	0.35	0.36	0.31	0.28	0.25	0.22	0.19	0.19	0.17	0.18	0.18	0.20	0.21	0.23	0.25	0.27	0.28	0.33	0.30	0.32	0.34	0.33	0.35	0.34	0.35	0.36	0.38	0.37	0.36	0.36	0.7%	Kazakhstan
Malaysia	0.09	0.10	0.11	0.12	0.12	0.13	0.15	0.16	0.16	0.17	0.18	0.19	0.20	0.21	0.23	0.24	0.25	0.27	0.29	0.26	0.28	0.28	0.28	0.30	0.32	0.32	0.32	0.31	0.32	0.33	0.33	0.7%	Malaysia
Nigeria	0.26	0.28	0.30	0.30	0.32	0.35	0.40	0.39	0.36	0.35	0.38	0.39	0.34	0.38	0.37	0.37	0.34	0.33	0.33	0.31	0.34	0.35	0.35	0.37	0.38	0.37	0.37	0.38	0.39	0.40	0.39	0.8%	Nigeria
Taiwan	0.20	0.20	0.21	0.23	0.23	0.24	0.25	0.26	0.27	0.28	0.28	0.29	0.29	0.31	0.33	0.33	0.36	0.38	0.38	0.39	0.38	0.39	0.39	0.41	0.42	0.43	0.46	0.49	0.50	0.51	0.52	1.0%	Taiwan
Thailand	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.22	0.23	0.24	0.25	0.26	0.32	0.33	0.34	0.34	0.33	0.34	0.32	0.30	0.31	0.31	0.30	0.30	0.31	0.31	0.31	0.32	0.32	0.31	0.31	0.6%	Thailand
Ukraine	0.21	0.22	0.23	0.25	0.26	0.28	0.30	0.31	0.28	0.29	0.29	0.30	0.32	0.33	0.35	0.37	0.37	0.39	0.39	0.39	0.41	0.41	0.43	0.44	0.44	0.43	0.43	0.43	0.43	0.42	0.41	0.8%	Ukraine
United Arab Emirates	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	0.48	0.45	0.44	0.44	0.45	0.44	0.37	0.39	0.42	0.41	0.40	0.35	0.30	0.30	0.27	0.28	0.27	0.26	0.5%	United Arab Emirates
Viet Nam	0.08	0.09	0.09	0.09	0.10	0.11	0.11	0.12	0.12	0.12	0.12	0.14	0.14	0.15	0.15	0.16	0.17	0.18	0.21	0.21	0.22	0.22	0.24	0.25	0.25	0.27	0.27	0.28	0.28	0.28	0.27	0.5%	Viet Nam
Zambia	0.10	0.11	0.11	0.12	0.12	0.13	0.14	0.14	0.15	0.16	0.16	0.17	0.18	0.19	0.21	0.23	0.23	0.25	0.26	0.28	0.29	0.30	0.30	0.30	0.32	0.36	0.38	0.38	0.42	0.47	0.47	0.9%	Zambia
Remaining countries (186)	4.61	4.54	4.53	4.61	4.67	4.79	4.95	5.14	5.22	5.25	5.50	5.57	5.60	5.78	5.95	6.13	6.29	6.42	6.66	6.63	6.88	6.95	7.18	7.19	7.28	7.44	7.61	7.71	7.84	8.01	7.65	15.3%	**Remaining countries (186)**
International transport	0.66	0.67	0.70	0.70	0.72	0.75	0.77	0.80	0.82	0.86	0.89	0.86	0.90	0.91	0.99	1.03	1.09	1.14	1.15	1.09	1.17	1.18	1.14	1.15	1.18	1.24	1.28	1.33	1.36	1.44	1.15	2.3%	**International transport**
Global total	32.9	33.0	33.0	33.0	33.4	34.2	34.8	35.3	35.4	35.6	36.6	37.0	37.5	39.0	40.6	41.9	43.2	44.5	44.8	44.5	46.6	48.0	48.7	49.2	49.6	49.7	49.8	50.5	51.4	51.7	49.8	100%	**Global total**

Table B.2
CO_2 emissions per country and group, 1990–2020 (unit: $GtCO_2$)

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	2018	2019	2020	Share	Country/group
China	**2.46**	**2.60**	**2.74**	**2.96**	**3.14**	**3.45**	**3.42**	**3.50**	**3.59**	**3.52**	**3.75**	**3.92**	**4.23**	**4.90**	**5.64**	**6.38**	**7.08**	**7.72**	**7.9**	**8.5**	**9.3**	**10.2**	**10.5**	**10.8**	**10.8**	**10.8**	**10.8**	**11.0**	**11.3**	**11.6**	**11.7**	**32.6%**	**China**
United States	**5.07**	**5.03**	**5.11**	**5.23**	**5.31**	**5.36**	**5.51**	**5.78**	**5.83**	**5.84**	**6.00**	**5.96**	**5.79**	**5.86**	**5.94**	**5.95**	**5.85**	**5.93**	**5.75**	**5.32**	**5.57**	**5.35**	**5.14**	**5.27**	**5.29**	**5.18**	**5.08**	**5.01**	**5.16**	**5.04**	**4.54**	**12.6%**	**United States**
European Union, of which:	**3.82**	**3.76**	**3.62**	**3.56**	**3.54**	**3.60**	**3.70**	**3.63**	**3.62**	**3.56**	**3.58**	**3.63**	**3.62**	**3.72**	**3.72**	**3.70**	**3.72**	**3.68**	**3.59**	**3.32**	**3.42**	**3.32**	**3.25**	**3.18**	**3.03**	**3.09**	**3.10**	**3.13**	**3.07**	**2.93**	**2.62**	**7.3%**	**European Union, of which:**
France	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	0.40	0.41	0.40	0.39	0.38	0.37	0.38	0.36	0.36	0.36	0.32	0.33	0.33	0.34	0.33	0.32	0.28	0.8%	*France*
Germany	1.02	1.00	0.94	0.94	0.92	0.92	0.95	0.91	0.91	0.87	0.88	0.89	0.88	0.88	0.86	0.84	0.86	0.83	0.83	0.77	0.82	0.79	0.80	0.82	0.78	0.79	0.79	0.78	0.76	0.70	0.64	1.8%	*Germany*
Italy	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	0.35	0.36	0.35	0.35	0.34	0.33	0.30	0.8%	*Italy*
Netherlands	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	0.17	0.17	0.17	0.16	0.16	0.14	0.4%	*Netherlands*
Poland	0.37	0.37	0.36	0.36	0.35	0.36	0.37	0.36	0.33	0.33	0.31	0.31	0.30	0.32	0.32	0.32	0.33	0.33	0.32	0.31	0.33	0.33	0.32	0.32	0.30	0.31	0.32	0.33	0.33	0.31	0.29	0.8%	*Poland*
Spain	0.23	0.24	0.25	0.23	0.24	0.26	0.25	0.27	0.28	0.30	0.31	0.31	0.33	0.34	0.36	0.37	0.36	0.38	0.34	0.30	0.29	0.29	0.29	0.26	0.26	0.27	0.26	0.28	0.28	0.26	0.21	0.6%	*Spain*
India	**0.60**	**0.64**	**0.67**	**0.70**	**0.74**	**0.79**	**0.83**	**0.87**	**0.89**	**0.96**	**0.99**	**1.01**	**1.04**	**1.07**	**1.16**	**1.21**	**1.30**	**1.41**	**1.49**	**1.66**	**1.75**	**1.85**	**2.02**	**2.08**	**2.23**	**2.25**	**2.29**	**2.40**	**2.53**	**2.56**	**2.41**	**6.7%**	**India**
Russian Federation	**2.40**	**2.36**	**2.18**	**1.99**	**1.79**	**1.74**	**1.70**	**1.59**	**1.59**	**1.64**	**1.67**	**1.68**	**1.67**	**1.74**	**1.73**	**1.73**	**1.77**	**1.77**	**1.76**	**1.66**	**1.73**	**1.82**	**1.80**	**1.75**	**1.73**	**1.73**	**1.71**	**1.74**	**1.79**	**1.78**	**1.67**	**4.6%**	**Russian Federation**
Japan	**1.16**	**1.17**	**1.18**	**1.17**	**1.22**	**1.23**	**1.24**	**1.23**	**1.18**	**1.22**	**1.24**	**1.23**	**1.27**	**1.27**	**1.27**	**1.27**	**1.25**	**1.29**	**1.22**	**1.16**	**1.22**	**1.27**	**1.32**	**1.33**	**1.29**	**1.25**	**1.24**	**1.22**	**1.17**	**1.14**	**1.06**	**2.9%**	**Japan**
Other OECD countries G20	1.16	1.17	1.18	1.17	1.22	1.23	1.24	1.23	1.18	1.22	1.24	1.23	1.27	1.27	1.27	1.27	1.25	1.29	1.22	1.16	1.22	1.27	1.32	1.33	1.29	1.25	1.24	1.22	1.17	1.14	1.06	2.9%	**Other OECD countries G20**
Australia	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	0.38	0.39	0.39	0.40	0.41	0.41	0.41	0.41	0.41	0.40	0.39	0.40	0.41	0.41	0.41	0.41	0.39	1.1%	Australia
Canada	0.45	0.45	0.46	0.46	0.48	0.49	0.50	0.52	0.53	0.54	0.56	0.55	0.56	0.57	0.57	0.58	0.57	0.60	0.58	0.55	0.57	0.58	0.58	0.59	0.59	0.60	0.59	0.58	0.59	0.60	0.54	1.5%	Canada
Mexico	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	0.47	0.47	0.47	0.46	0.48	0.49	0.51	0.50	0.48	0.49	0.50	0.50	0.50	0.49	0.41	1.1%	Mexico
South Korea	0.27	0.30	0.32	0.35	0.37	0.41	0.43	0.45	0.39	0.43	0.48	0.50	0.49	0.50	0.52	0.52	0.52	0.53	0.54	0.55	0.60	0.63	0.63	0.63	0.62	0.64	0.66	0.67	0.68	0.66	0.62	1.7%	South Korea
Turkey	0.15	0.15	0.16	0.17	0.16	0.18	0.19	0.20	0.21	0.20	0.23	0.21	0.22	0.23	0.23	0.24	0.27	0.30	0.30	0.30	0.31	0.33	0.34	0.33	0.35	0.37	0.39	0.43	0.42	0.41	0.41	1.1%	Turkey
United Kingdom	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	0.40	0.38	0.38	0.36	0.31	0.9%	United Kingdom
Other G20 countries	**1.0**	**1.01**	**1.03**	**1.07**	**1.12**	**1.19**	**1.26**	**1.33**	**1.36**	**1.38**	**1.42**	**1.46**	**1.49**	**1.57**	**1.65**	**1.69**	**1.75**	**1.83**	**1.92**	**1.89**	**1.99**	**2.06**	**2.18**	**2.22**	**2.34**	**2.32**	**2.28**	**2.34**	**2.34**	**2.37**	**2.22**	**6.2%**	**Other G20 countries**
Argentina	0.11	0.11	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	0.20	0.20	0.19	0.18	0.5%	Argentina
Brazil	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	0.39	0.40	0.42	0.40	0.45	0.47	0.50	0.53	0.56	0.52	0.49	0.50	0.48	0.48	0.45	1.3%	Brazil
Indonesia	0.16	0.18	0.19	0.20	0.22	0.24	0.25	0.28	0.28	0.30	0.30	0.32	0.32	0.35	0.36	0.36	0.38	0.40	0.39	0.41	0.40	0.44	0.47	0.47	0.51	0.51	0.51	0.56	0.61	0.65	0.57	1.6%	Indonesia
Saudi Arabia	0.17	0.18	0.19	0.20	0.22	0.22	0.23	0.23	0.25	0.25	0.27	0.28	0.29	0.31	0.33	0.35	0.37	0.39	0.42	0.44	0.49	0.51	0.54	0.55	0.59	0.61	0.61	0.61	0.59	0.59	0.59	1.6%	Saudi Arabia
South Africa	0.31	0.31	0.30	0.30	0.31	0.32	0.34	0.35	0.36	0.34	0.35	0.36	0.37	0.39	0.42	0.43	0.44	0.46	0.49	0.46	0.46	0.44	0.46	0.47	0.48	0.46	0.46	0.46	0.46	0.47	0.44	1.2%	South Africa
Group of Twenty (G20)	**17.7**	**17.8**	**17.7**	**17.8**	**18.1**	**18.6**	**18.9**	**19.2**	**19.3**	**19.3**	**19.9**	**20.1**	**20.4**	**21.4**	**22.4**	**23.2**	**24.0**	**24.9**	**24.9**	**24.7**	**26.3**	**27.2**	**27.6**	**27.9**	**28.0**	**27.8**	**27.7**	**28.0**	**28.5**	**28.5**	**27.3**	**75.9%**	**Group of Twenty (G20)**
Other Large countries	**1.82**	**1.86**	**1.83**	**1.75**	**1.70**	**1.73**	**1.73**	**1.75**	**1.73**	**1.80**	**1.86**	**1.93**	**2.00**	**2.13**	**2.23**	**2.32**	**2.42**	**2.54**	**2.62**	**2.53**	**2.65**	**2.72**	**2.74**	**2.83**	**2.85**	**2.88**	**2.95**	**2.99**	**3.12**	**3.15**	**3.08**	**8.6%**	**Other Large countries**
Egypt	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	0.30	0.28	0.27	0.8%	Egypt
Iran	0.20	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	0.51	0.54	0.55	0.57	0.58	0.58	0.59	0.61	0.63	0.63	0.64	0.66	0.67	0.69	0.69	1.9%	Iran
Kazakhstan	0.25	0.26	0.27	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	0.27	0.28	0.28	0.28	0.27	0.27	0.8%	Kazakhstan
Malaysia	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	0.25	0.24	0.26	0.26	0.26	0.7%	Malaysia
Nigeria	0.07	0.08	0.09	0.09	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	0.09	0.09	0.11	0.11	0.11	0.11	0.11	0.13	0.13	0.13	0.4%	Nigeria
Taiwan	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.11	0.11	0.12	0.13	0.13	0.14	0.16	0.16	0.16	0.15	0.15	0.15	0.16	0.16	0.17	0.19	0.21	0.22	0.22	0.22	0.6%	Taiwan
Thailand	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.23	0.24	0.25	0.26	0.27	0.27	0.28	0.29	0.28	0.26	0.28	0.28	0.27	0.27	0.28	0.28	0.28	0.29	0.29	0.28	0.28	0.8%	Thailand
Ukraine	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	0.25	0.27	0.28	0.27	0.28	0.28	0.28	0.27	0.27	0.26	0.7%	Ukraine
United Arab Emirates	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	0.39	0.37	0.35	0.35	0.36	0.35	0.29	0.31	0.33	0.32	0.31	0.26	0.22	0.22	0.20	0.21	0.20	0.19	0.5%	United Arab Emirates
Viet Nam	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.11	0.12	0.12	0.13	0.14	0.16	0.17	0.17	0.18	0.19	0.20	0.20	0.21	0.22	0.22	0.21	0.21	0.20	0.6%	Viet Nam
Zambia	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.08	0.09	0.10	0.10	0.11	0.13	0.14	0.16	0.16	0.16	0.16	0.18	0.22	0.24	0.24	0.27	0.33	0.32	0.9%	Zambia
Remaining countries (186)	**2.62**	**2.62**	**2.59**	**2.64**	**2.66**	**2.74**	**2.86**	**3.01**	**3.05**	**3.04**	**3.24**	**3.31**	**3.30**	**3.41**	**3.53**	**3.64**	**3.77**	**3.84**	**4.01**	**3.99**	**4.15**	**4.17**	**4.32**	**4.31**	**4.37**	**4.49**	**4.58**	**4.65**	**4.75**	**4.86**	**4.48**	12.5%	**Remaining countries (186)**
International transport	0.63	0.64	0.67	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	1.04	1.09	1.10	1.05	1.12	1.14	1.10	1.10	1.14	1.19	1.23	1.28	1.31	1.39	1.10	3.1%	**International transport**
Global total	**22.7**	**22.9**	**22.8**	**22.9**	**23.1**	**23.8**	**24.2**	**24.7**	**24.8**	**25.0**	**25.9**	**26.2**	**26.5**	**27.8**	**29.1**	**30.2**	**31.2**	**32.4**	**32.6**	**32.3**	**34.2**	**35.2**	**35.7**	**36.2**	**36.4**	**36.4**	**36.5**	**36.9**	**37.7**	**37.9**	**36.0**	**100%**	**Global total**

Table B.3

CH_4 emissions per country and group, 1990–2020 (unit: $MtCO_2$ eq)

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	2018	2019	2020	Share	Country/group
China	**960**	**1000**	**1010**	**1010**	**1020**	**1040**	**1050**	**1060**	**1060**	**1060**	**1050**	**1040**	**1040**	**1060**	**1080**	**1080**	**1100**	**1110**	**1130**	**1160**	**1170**	**1170**	**1150**	**1140**	**1150**	**1210**	**1210**	**1190**	**1180**	**1180**	**1190**	**15.4%**	**China**
United States	**727**	**735**	**745**	**748**	**747**	**744**	**741**	**732**	**728**	**749**	**759**	**758**	**751**	**726**	**736**	**728**	**720**	**721**	**727**	**731**	**732**	**728**	**730**	**726**	**734**	**724**	**721**	**721**	**710**	**695**	**692**	**8.9%**	**United States**
European Union, of which:	**680**	**686**	**689**	**698**	**709**	**712**	**718**	**723**	**733**	**743**	**738**	**721**	**731**	**725**	**728**	**728**	**723**	**714**	**707**	**698**	**688**	**672**	**648**	**631**	**619**	**611**	**609**	**604**	**584**	**578**	**573**	**7.4%**	**European Union, of which:**
France	93	90	88	88	87	88	88	88	87	87	87	87	86	86	86	84	84	82	79	79	80	80	79	79	78	78	78	77	77	77	79	1.0%	*France*
Germany	150	149	146	145	146	145	145	143	144	147	148	148	146	142	140	142	140	136	133	132	131	125	119	115	111	110	108	104	100	97	94	1.2%	*Germany*
Italy	49	52	53	53	53	52	54	54	54	55	55	54	54	52	55	55	55	55	55	55	55	54	53	52	52	52	54	54	54	54	54	0.7%	*Italy*
Netherlands	28	28	30	32	34	34	35	35	35	36	37	36	36	37	37	38	38	38	37	37	37	38	38	37	37	36	36	34	33	31	30	0.4%	*Netherlands*
Poland	120	122	125	129	133	137	139	140	147	148	142	125	137	134	132	131	130	128	126	119	111	105	101	98	97	96	94	94	85	81	76	1.0%	*Poland*
Spain	28	28	29	29	29	29	29	30	30	30	31	31	34	33	33	33	34	33	35	36	37	37	37	37	37	38	38	40	41	41	42	0.5%	*Spain*
India	**476**	**479**	**480**	**487**	**491**	**502**	**503**	**513**	**519**	**522**	**532**	**544**	**547**	**565**	**573**	**580**	**595**	**599**	**623**	**637**	**617**	**624**	**627**	**629**	**634**	**641**	**647**	**654**	**657**	**661**	**663**	**8.6%**	**India**
Russian Federation	**316**	**324**	**334**	**344**	**355**	**366**	**375**	**382**	**392**	**399**	**406**	**407**	**415**	**421**	**431**	**438**	**448**	**458**	**464**	**468**	**482**	**458**	**437**	**412**	**380**	**360**	**342**	**323**	**316**	**317**	**321**	**4.2%**	**Russian Federation**
Japan	**117**	**109**	**105**	**103**	**103**	**101**	**101**	**101**	**95**	**94**	**91**	**89**	**88**	**88**	**89**	**88**	**87**	**82**	**81**	**80**	**78**	**77**	**77**	**76**	**75**	**73**	**69**	**66**	**62**	**60**	**59**	**0.8%**	**Japan**
Other OECD countries G20	480	480	480	500	500	510	510	500	500	510	520	530	530	530	520	530	550	550	550	560	560	560	560	560	560	570	580	590	600	600	620	8.0%	**Other OECD countries G20**
Australia	134	136	142	141	144	145	145	141	137	135	133	135	135	133	137	137	140	141	139	144	147	148	147	146	145	145	139	140	144	159	169	2.2%	Australia
Canada	66	67	71	75	75	74	72	72	71	74	74	73	72	71	74	74	75	76	79	81	82	83	85	88	91	95	98	100	104	104	105	1.4%	Canada
Mexico	70	71	73	74	78	82	85	88	92	96	103	109	114	115	117	120	120	121	121	125	126	125	124	127	128	132	135	141	143	141	144	1.9%	Mexico
South Korea	32	32	32	33	34	35	35	35	36	36	36	37	37	38	40	41	42	42	41	40	39	39	38	38	37	37	38	39	38	37	39	0.5%	South Korea
Turkey	38	38	38	39	40	40	41	42	43	44	45	47	48	47	47	44	45	46	46	47	46	45	47	47	46	47	51	55	57	59	63	0.8%	Turkey
United Kingdom	136	136	128	133	127	130	128	126	125	127	127	127	126	125	103	116	123	121	120	118	123	126	122	118	114	117	116	115	109	103	98	1.3%	United Kingdom
Other G20 countries	**490**	**500**	**520**	**550**	**560**	**570**	**600**	**620**	**620**	**630**	**660**	**670**	**650**	**660**	**690**	**690**	**710**	**710**	**740**	**760**	**770**	**800**	**820**	**830**	**850**	**870**	**870**	**890**	**880**	**890**	**900**	**11.6%**	**Other G20 countries**
Argentina	101	104	107	111	112	113	116	121	116	116	115	113	111	113	115	114	114	113	117	119	121	120	121	120	121	123	120	121	119	123	125	1.6%	Argentina
Brazil	193	199	208	214	225	232	249	256	256	263	284	289	295	297	312	315	324	334	342	351	348	362	375	384	401	414	404	409	414	417	421	5.4%	Brazil
Indonesia	133	135	135	144	145	144	147	151	157	156	159	162	153	159	169	168	172	170	173	180	185	191	201	202	207	209	218	221	215	213	212	2.7%	Indonesia
Saudi Arabia	24	24	29	37	41	35	43	46	43	49	53	55	41	35	35	31	40	38	43	43	48	56	58	59	59	58	61	63	63	59	65	0.8%	Saudi Arabia
South Africa	38	39	39	41	42	44	45	46	47	50	51	52	55	56	58	59	59	60	62	64	65	66	65	66	66	68	69	72	74	74	74	1.0%	South Africa
Group of Twenty (G20)	**4240**	**4310**	**4360**	**4430**	**4480**	**4540**	**4590**	**4630**	**4650**	**4710**	**4750**	**4760**	**4760**	**4780**	**4840**	**4860**	**4920**	**4950**	**5020**	**5080**	**5100**	**5090**	**5060**	**5010**	**5010**	**5060**	**5050**	**5030**	**4990**	**4980**	**5010**	**64.8%**	**Group of Twenty (G20)**
Other Large countries	**670**	**670**	**700**	**750**	**770**	**740**	**780**	**790**	**780**	**770**	**720**	**680**	**690**	**700**	**710**	**730**	**740**	**740**	**760**	**810**	**840**	**870**	**890**	**900**	**910**	**920**	**960**	**940**	**900**	**900**	**940**	**12.2%**	**Other Large countries**
Egypt	24	24	23	21	22	23	25	26	28	28	30	30	32	33	35	36	36	38	38	39	40	46	44	45	45	47	48	49	46	49	49	0.6%	Egypt
Iran	104	104	115	131	135	123	133	129	121	84	52	49	64	68	65	68	65	71	71	84	91	111	117	119	125	122	128	129	117	116	127	1.6%	Iran
Kazakhstan	77	77	78	77	77	77	77	75	74	73	70	67	66	64	67	63	63	63	62	63	74	69	71	66	56	47	41	38	34	32	34	0.4%	Kazakhstan
Malaysia	13	13	13	13	13	14	14	15	14	17	17	16	17	19	21	21	24	24	25	26	27	28	29	30	31	31	36	39	36	37	40	0.5%	Malaysia
Nigeria	128	129	148	164	177	149	168	171	160	187	174	136	129	127	137	145	144	137	146	166	170	178	191	197	222	242	279	261	242	233	256	3.3%	Nigeria
Taiwan	67	67	68	70	72	74	76	79	82	83	82	85	87	88	90	92	100	102	105	108	111	110	112	116	117	120	125	127	131	133	135	1.7%	Taiwan
Thailand	14	14	14	13	14	14	14	14	14	14	13	13	13	13	13	13	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	0.2%	Thailand
Ukraine	83	84	81	88	85	92	91	95	97	95	97	97	97	99	99	102	98	98	103	104	98	103	103	101	101	99	98	101	96	98	97	1.3%	Ukraine
United Arab Emirates	88	90	93	96	98	101	102	103	105	106	106	105	106	106	107	108	110	111	112	113	122	113	111	105	96	89	81	77	72	71	68	0.9%	United Arab Emirates
Viet Nam	8	8	9	12	13	13	15	16	15	16	15	14	13	12	13	14	15	17	18	21	22	24	24	27	27	28	30	29	28	28	29	0.4%	Viet Nam
Zambia	62	62	63	64	65	61	65	66	69	68	68	69	70	69	69	70	70	69	70	72	73	75	77	79	79	82	83	84	86	89	89	1.2%	Zambia
Remaining countries (186)	**1280**	**1290**	**1290**	**1330**	**1300**	**1340**	**1320**	**1340**	**1370**	**1430**	**1400**	**1330**	**1350**	**1350**	**1380**	**1410**	**1440**	**1460**	**1510**	**1550**	**1550**	**1480**	**1500**	**1530**	**1560**	**1600**	**1640**	**1660**	**1690**	**1730**	**1780**	23.0%	**Remaining countries (186)**
International transport	7.4	7.4	8.0	9.0	8.8	8.2	9.2	9.3	8.9	9.6	8.6	7.6	6.7	6.5	6.6	6.2	6.7	6.8	7.4	7.6	8.7	8.8	9.0	9.3	9.4	9.6	10.0	10.4	10.8	10.6	11.3	0.1%	**International transport**
Global total	**6196**	**6277**	**6362**	**6516**	**6560**	**6629**	**6704**	**6769**	**6809**	**6913**	**6883**	**6777**	**6806**	**6833**	**6938**	**7006**	**7101**	**7152**	**7297**	**7450**	**7495**	**7449**	**7454**	**7442**	**7491**	**7589**	**7656**	**7645**	**7587**	**7620**	**7732**	**100%**	**Global total**

Table B.4

N_2O emissions, per country and group, 1990–2020 (unit: $MtCO_2$ eq)

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	2018	2019	2020	Share	Country/group
China	321	328	333	328	342	390	405	378	390	403	398	396	420	420	443	450	474	469	458	452	435	455	462	469	444	457	440	428	426	428	429	14.5%	**China**
United States	284	284	294	295	305	307	315	316	317	314	313	309	304	306	309	306	311	308	298	295	303	303	296	303	307	305	312	312	311	293	281	9.5%	**United States**
European Union, of which:	337	322	311	307	311	311	320	316	285	278	279	275	276	275	275	276	269	271	253	253	253	247	251	252	254	256	257	257	252	251	248	8.4%	**European Union, of which:**
France	63	63	61	61	62	63	65	65	52	49	48	47	46	45	45	43	42	43	41	40	42	39	40	40	40	41	40	40	39	38	38	1.3%	*France*
Germany	67	66	67	64	67	65	67	64	47	46	45	44	43	43	43	43	42	42	41	40	40	39	40	40	41	40	40	39	37	37	37	1.3%	*Germany*
Italy	28	28	27	27	27	27	28	27	28	28	28	27	27	27	26	26	20	20	19	18	18	18	18	18	17	18	18	17	17	17	17	0.6%	*Italy*
Netherlands	14	14	14	15	15	14	14	14	14	14	14	13	13	14	14	15	17	16	10	9	9	9	12	12	12	12	12	12	12	12	12	0.4%	*Netherlands*
Poland	26	25	24	25	25	26	26	27	26	25	26	26	26	27	27	27	28	28	27	27	28	27	28	27	27	27	28	29	28	28	28	0.9%	*Poland*
Spain	23	23	21	21	22	23	24	25	25	26	26	26	26	26	26	25	24	25	23	23	23	22	22	23	22	23	24	24	24	24	23	0.8%	*Spain*
India	150.8	156.0	160.6	164.8	170.4	175.2	179.7	184.6	188.5	191.6	187.5	190.9	185.7	192.3	199.3	207.5	217.0	226.9	233.3	238.4	246.0	253.7	253.8	253.7	257.1	259.1	259.1	262.9	270.1	267.1	267.0	9.0%	**India**
Russian Federation	111.8	107.4	100.7	93.5	83.9	77.7	73.8	67.6	62.9	60.7	63.3	66.4	67.3	67.6	64.1	64.8	64.8	67.1	70.5	70.6	70.0	74.1	73.3	73.3	74.9	76.9	77.7	76.8	77.4	77.5	76.7	2.6%	**Russian Federation**
Japan	30.2	29.7	29.9	29.9	31.4	31.5	32.5	32.8	24.8	24.5	25.7	24.9	24.7	24.4	24.0	23.7	23.1	23.2	22.2	21.3	21.9	21.6	21.7	21.8	21.1	20.7	20.3	20.3	19.7	19.7	18.9	0.6%	**Japan**
Other OECD countries G20	238.2	236.1	237.2	239.5	248.0	260.1	260.6	265.5	270.1	278.4	287.1	296.2	288.0	252.5	279.4	257.2	279.8	279.6	264.3	275.3	266.6	323.2	339.7	304.6	317.2	313.7	304.1	329.0	323.4	308.5	298.1	10.1%	**Other OECD countries G20**
Australia	74.0	73.0	73.0	73.0	73.0	73.0	68.0	67.0	72.0	89.0	98.0	108.0	101.0	61.0	85.0	63.0	83.0	78.0	62.0	67.0	56.0	109.0	109.0	67.0	79.0	76.0	62.0	84.0	81.0	69.0	60.0	2.0%	Australia
Canada	38.0	37.0	38.0	38.0	41.0	42.0	44.0	42.0	35.0	35.0	36.0	34.0	34.0	35.0	34.0	34.0	35.0	35.0	35.0	34.0	35.0	37.0	38.0	40.0	40.0	40.0	39.0	41.0	40.0	39.0	39.0	1.3%	Canada
Mexico	37.0	36.0	39.0	43.0	50.0	60.0	62.0	69.0	73.0	75.0	78.0	81.0	83.0	87.0	89.0	92.0	94.0	98.0	102.0	108.0	109.0	110.0	110.0	113.0	113.0	112.0	114.0	115.0	114.0	115.0	114.0	3.9%	Mexico
South Korea	9.5	10.2	12.1	12.7	13.3	14.2	14.8	16.6	17.9	16.7	15.3	16.2	12.9	12.4	13.2	13.4	12.9	13.0	12.7	13.0	13.6	13.6	13.8	14.1	13.4	14.0	14.5	14.5	14.5	14.5	14.4	0.5%	South Korea
Turkey	25.0	24.0	26.0	27.0	24.0	26.0	27.0	26.0	28.0	29.0	28.0	26.0	26.0	27.0	28.0	27.0	28.0	28.0	27.0	28.0	28.0	28.0	43.0	45.0	45.0	46.0	48.0	48.0	48.0	45.0	45.0	1.5%	Turkey
United Kingdom	56.0	55.0	49.0	45.0	46.0	44.0	45.0	45.0	44.0	34.0	32.0	31.0	30.0	30.0	29.0	28.0	27.0	27.0	26.0	25.0	26.0	25.0	25.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	0.9%	United Kingdom
Other G20 countries	224.0	227.0	237.0	241.0	250.0	256.0	254.0	256.0	265.0	263.0	271.0	280.0	291.0	304.0	312.0	317.0	315.0	334.0	327.0	321.0	343.0	345.0	348.0	351.0	362.0	369.0	373.0	383.0	375.0	381.0	386.0	13.0%	**Other G20 countries**
Argentina	35.0	35.0	35.0	35.0	36.0	36.0	37.0	37.0	39.0	40.0	42.0	44.0	44.0	49.0	48.0	50.0	52.0	55.0	53.0	47.0	52.0	52.0	50.0	54.0	55.0	56.0	59.0	59.0	55.0	61.0	62.0	2.1%	Argentina
Brazil	105.0	108.0	113.0	117.0	125.0	128.0	121.0	125.0	131.0	130.0	137.0	143.0	148.0	158.0	165.0	167.0	164.0	177.0	171.0	168.0	185.0	186.0	186.0	188.0	194.0	197.0	201.0	207.0	202.0	202.0	206.0	7.0%	Brazil
Indonesia	59.0	59.0	61.0	60.0	62.0	64.0	66.0	63.0	65.0	64.0	64.0	64.0	68.0	67.0	69.0	69.0	69.0	71.0	73.0	77.0	76.0	77.0	80.0	79.0	82.0	85.0	83.0	86.0	88.0	88.0	88.0	3.0%	Indonesia
Saudi Arabia	6.0	6.3	6.6	6.5	6.4	6.0	6.3	6.6	6.5	6.6	6.9	7.0	7.1	7.3	7.6	7.5	7.6	7.9	7.6	7.4	7.7	8.5	8.9	8.9	9.1	9.5	9.5	9.3	9.4	9.6	9.6	0.3%	Saudi Arabia
South Africa	20.0	20.0	21.0	21.0	21.0	22.0	24.0	24.0	24.0	23.0	21.0	22.0	23.0	23.0	23.0	23.0	22.0	23.0	22.0	21.0	22.0	22.0	22.0	22.0	22.0	21.0	20.0	22.0	21.0	20.0	20.0	0.7%	South Africa
Group of Twenty (G20)	1698	1690	1704	1699	1742	1808	1840	1817	1803	1814	1825	1838	1856	1841	1906	1902	1954	1978	1927	1927	1938	2023	2046	2028	2038	2058	2043	2069	2055	2025	2003	67.7%	**Group of Twenty (G20)**
Other Large countries	182	182	188	186	186	184	185	186	187	188	190	192	201	204	223	222	223	236	230	230	236	242	242	245	244	242	255	260	259	261	263	8.9%	**Other Large countries**
Egypt	11.4	11.9	13.3	13.9	13.3	15.1	16.0	15.7	16.6	16.5	17.6	18.3	18.4	19.0	20.6	20.8	20.7	21.0	21.8	21.9	23.0	23.5	23.2	22.7	22.9	23.5	23.9	23.7	23.5	23.6	23.5	0.8%	Egypt
Iran	21.7	22.3	25.1	23.3	24.3	24.6	25.5	26.7	27.4	27.0	27.3	27.7	27.6	28.6	41.1	37.5	38.0	42.7	35.2	31.6	31.6	30.4	30.7	30.0	27.4	26.5	28.5	28.7	29.3	30.0	30.1	1.0%	Iran
Kazakhstan	21.1	20.5	22.1	20.9	19.9	17.6	15.8	14.7	13.4	12.6	12.5	13.1	17.8	14.7	15.6	16.0	16.9	15.9	16.6	15.6	17.1	16.0	15.6	15.0	16.6	17.6	17.6	22.9	20.3	20.0	20.1	0.7%	Kazakhstan
Malaysia	7.7	7.6	8.0	8.1	8.2	8.3	8.2	9.0	9.4	9.2	9.4	9.2	9.6	9.9	11.0	10.7	10.9	11.3	11.3	11.9	11.9	12.0	11.7	12.1	12.1	12.5	11.8	12.6	12.4	13.1	12.8	0.4%	Malaysia
Nigeria	19.2	19.6	20.1	20.8	21.2	21.4	22.3	23.0	24.3	24.5	24.8	25.1	25.1	26.3	26.4	28.0	27.9	28.0	29.6	29.3	31.5	32.2	32.6	34.5	33.9	33.8	35.7	36.9	37.4	37.2	38.2	1.3%	Nigeria
Taiwan	26.5	26.8	28.5	29.1	30.3	32.5	33.0	34.0	34.6	35.9	36.5	37.1	37.9	39.6	41.9	43.3	43.1	45.8	46.5	50.0	48.3	50.0	48.6	51.6	53.4	50.6	58.2	59.2	59.4	59.9	61.5	2.1%	Taiwan
Thailand	4.7	4.9	4.9	5.1	5.2	5.4	5.4	5.2	5.4	5.2	5.3	5.5	5.7	5.6	5.5	5.6	5.6	5.7	5.2	5.3	5.4	5.3	5.3	4.9	4.9	5.0	5.1	5.2	5.2	5.2	5.3	0.2%	Thailand
Ukraine	15.3	15.8	16.7	17.7	17.8	17.2	17.3	17.1	17.1	17.9	16.9	17.2	17.8	18.6	18.7	18.6	18.1	21.5	20.7	22.4	23.3	24.2	24.7	24.8	24.7	23.2	22.9	22.7	22.7	22.7	22.6	0.8%	Ukraine
United Arab Emirates	43.0	40.4	36.5	33.6	30.3	27.3	25.1	24.2	20.9	20.3	20.0	20.2	20.9	20.8	19.9	20.2	20.2	21.7	22.5	19.5	20.9	25.0	25.2	24.6	22.9	21.7	24.3	20.7	21.7	21.5	21.8	0.7%	United Arab Emirates
Viet Nam	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.4	1.5	1.5	1.6	1.8	1.9	1.9	2.0	2.1	2.2	2.3	2.3	2.4	2.4	2.4	2.4	2.3	0.1%	Viet Nam
Zambia	10.5	11.8	11.6	12.2	14.3	14.1	15.5	15.3	17.3	17.8	18.8	17.5	19.0	20.0	20.9	19.7	19.9	20.3	19.4	20.9	21.4	21.6	22.1	23.0	22.6	25.5	24.6	25.0	25.3	25.3	25.2	0.9%	Zambia
Remaining countries (186)	430	429	431	434	438	443	446	452	469	468	479	477	488	502	509	527	523	544	553	551	571	596	601	608	612	620	635	635	637	645	655	22.1%	**Remaining countries (186)**
International transport	19.3	19.8	21.1	20.6	21.3	22.0	22.6	23.3	24.0	25.2	25.9	24.8	25.8	26.2	28.6	29.8	31.6	33.3	33.5	31.9	34.2	34.4	32.5	32.6	33.8	35.2	36.3	37.5	38.2	39.5	35.4	1.2%	**International transport**
Global total	2329	2321	2344	2339	2387	2457	2494	2479	2483	2495	2520	2532	2571	2574	2667	2681	2731	2791	2744	2740	2780	2895	2921	2914	2928	2955	2969	3002	2990	2970	2958	100%	**Global total**

Table B.5

F-gas emissions, per country and group, 1990–2020 (unit: $MtCO_2$ eq)

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	2018	2019	2020	Share	Country/group
China	5.2	6.1	7.2	10.5	13.9	17.6	21.1	24.5	30.7	46.1	57.7	76.0	77.5	107.1	137.8	190.8	221.2	193.6	171.1	212.8	254.7	290.6	328.7	360.0	403.2	347.2	363.8	385.9	406.6	427.2	447.9	33.7%	**China**
United States	113.3	108.8	115.5	115.6	120.9	138.3	148.0	156.7	174.3	170.8	170.7	159.3	165.6	156.5	165.2	165.4	167.8	178.5	179.6	174.2	183.1	188.1	184.6	183.4	188.2	189.4	188.3	189.3	188.4	192.0	192.9	14.5%	**United States**
European Union, of which:	51.2	49.6	48.6	51.4	55.2	59.0	63.9	68.6	71.3	69.2	71.4	64.1	68.7	70.6	79.2	81.7	85.4	93.6	94.8	91.9	96.6	99.3	101.5	103.4	105.9	100.2	101.1	99.7	93.6	88.7	89.5	6.7%	**European Union, of which:**
France	8.4	9.1	8.7	7.5	6.3	4.9	6.4	7.5	7.6	8.8	9.9	10.6	11.9	12.7	14.1	14.7	16.0	16.7	17.5	17.4	18.2	18.9	19.0	18.8	18.8	18.9	18.8	18.0	16.3	14.9	15.0	1.1%	*France*
Germany	14.2	14.0	13.3	15.9	16.2	16.6	15.6	16.2	16.7	15.1	15.6	15.7	16.5	14.9	16.3	15.7	15.2	15.8	15.0	14.7	14.5	14.8	14.9	14.9	15.2	15.5	15.7	15.9	15.0	14.5	14.6	1.1%	*Germany*
Italy	1.7	1.7	1.2	1.2	1.4	1.9	1.7	2.1	2.5	2.8	3.5	4.5	5.3	6.1	7.4	8.4	9.5	10.1	11.1	11.8	12.6	13.6	14.2	14.8	15.5	16.0	16.5	16.9	17.1	14.1	14.1	1.1%	*Italy*
Netherlands	9.8	8.4	9.3	10.0	11.8	11.3	13.1	13.1	13.6	8.2	7.1	2.1	1.9	1.9	2.1	1.9	2.0	2.2	2.1	2.0	2.4	1.9	2.0	2.1	1.7	1.9	1.7	1.5	1.7	1.7	1.7	0.1%	*Netherlands*
Poland	0.3	0.3	0.2	0.3	0.3	0.5	0.6	0.7	0.7	0.8	1.3	1.7	2.3	2.8	3.3	3.9	4.6	5.0	5.5	4.7	6.1	6.6	6.9	7.3	8.0	6.9	5.7	5.8	3.9	3.8	3.7	0.3%	*Poland*
Spain	7.0	6.7	7.5	6.8	8.2	10.1	11.1	12.6	12.7	14.5	15.8	12.0	11.3	12.5	13.6	14.2	16.5	19.1	18.9	17.0	17.4	16.7	16.7	16.2	16.2	9.6	9.5	7.5	5.7	5.5	5.3	0.4%	*Spain*
India	8.7	9.0	8.6	8.4	7.7	7.1	6.9	7.6	9.0	9.6	11.2	11.3	12.1	14.3	14.8	10.9	11.8	13.6	17.1	20.8	24.6	28.3	32.0	35.7	39.5	43.4	47.2	51.1	54.6	58.3	62.0	4.7%	**India**
Russian Federation	52.2	56.2	50.4	41.7	40.1	40.8	40.0	44.6	46.5	46.2	49.5	46.2	41.2	34.7	40.3	39.5	35.7	35.1	35.6	28.0	28.8	26.2	37.5	41.0	39.7	37.1	38.7	49.9	58.2	51.7	53.1	4.0%	**Russian Federation**
Japan	35.4	39.1	41.1	44.6	49.2	59.1	59.6	58.6	53.3	46.9	41.8	35.0	30.5	29.1	24.6	23.7	24.2	22.8	20.9	17.1	18.3	18.5	18.9	19.6	20.4	20.7	21.7	22.3	22.1	22.8	23.4	1.8%	**Japan**
Other OECD countries G20	39.1	41.4	41.3	42.9	44.9	45.9	48.4	53.1	47.0	45.6	44.4	39.9	47.2	45.1	46.6	48.2	53.9	63.9	62.5	63.2	69.6	70.5	71.8	74.4	80.2	77.6	78.2	81.6	84.4	87.1	89.6	6.7%	**Other OECD countries G20**
Australia	5.3	5.3	5.3	5.5	4.5	3.4	2.8	3.0	3.4	3.8	4.0	4.1	4.8	5.4	6.1	6.4	6.3	7.4	6.6	7.4	7.2	7.8	7.3	8.0	8.6	9.7	9.7	9.6	9.7	10.7	11.2	0.8%	Australia
Canada	12.6	14.0	12.7	12.9	12.9	11.6	11.7	12.0	12.7	12.7	13.5	12.5	13.9	13.1	13.7	12.5	15.3	18.9	16.7	15.8	15.8	16.3	16.4	16.9	18.2	17.7	18.7	18.8	19.5	19.5	19.3	1.5%	Canada
Mexico	1.5	1.7	1.1	1.5	1.3	1.2	2.6	2.7	2.4	3.1	2.7	2.4	3.2	3.5	3.7	5.3	7.2	9.0	10.4	10.9	12.0	12.5	12.0	12.9	14.6	13.9	14.9	16.3	17.3	18.5	19.7	1.5%	Mexico
South Korea	2.1	2.1	3.6	3.7	5.9	8.4	8.9	10.8	7.5	13.2	13.0	9.5	13.0	10.4	11.1	11.3	11.7	14.2	14.7	14.5	18.5	16.9	17.9	18.0	19.5	17.1	15.2	16.7	18.3	18.7	19.1	1.4%	South Korea
Turkey	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.4	0.6	0.8	1.1	1.3	1.5	1.8	2.0	2.2	3.1	3.5	4.3	4.5	4.9	4.9	5.3	5.6	5.6	6.1	6.7	0.5%	Turkey
United Kingdom	17.3	18.0	18.4	18.9	19.8	21.1	22.0	24.3	20.7	12.5	10.9	11.1	11.7	11.9	11.0	11.4	11.9	12.6	12.1	12.3	12.9	13.4	13.9	14.3	14.4	14.4	14.4	14.4	14.0	13.5	13.7	1.0%	United Kingdom
Other G20 countries	13.7	13.8	12.1	12.0	12.0	10.5	10.3	11.3	10.7	13.6	17.2	20.9	25.7	31.0	36.5	42.0	45.5	46.2	48.3	49.6	51.1	51.0	52.6	55.2	60.3	66.1	73.8	81.2	89.9	97.8	105.7	8.0%	**Other G20 countries**
Argentina	2.5	2.6	0.3	0.4	0.5	0.3	0.4	0.6	0.9	1.0	1.8	2.4	3.2	4.0	4.9	5.9	6.4	5.4	5.6	5.7	5.7	5.7	5.9	6.4	7.6	8.3	9.3	10.3	11.5	12.6	13.6	1.0%	Argentina
Brazil	5.8	5.9	6.5	6.6	6.5	5.3	4.2	4.5	3.1	4.3	3.0	2.9	3.5	3.9	4.6	4.6	6.0	6.5	7.4	7.4	8.9	8.4	9.2	10.1	10.7	11.5	12.4	13.1	13.7	14.4	15.1	1.1%	Brazil
Indonesia	1.7	1.8	1.8	1.8	1.9	1.8	1.8	1.9	1.6	1.9	2.7	3.1	3.7	4.5	5.1	5.9	6.2	6.5	6.7	6.8	6.8	6.8	7.0	7.2	7.8	8.5	9.5	10.6	11.8	12.9	14.0	1.1%	Indonesia
Saudi Arabia	2.3	2.4	2.2	1.9	1.9	1.9	2.3	2.7	3.2	4.3	7.0	9.3	11.5	14.1	16.6	19.7	20.7	21.2	22.1	22.9	22.8	23.1	23.6	24.3	26.5	29.3	33.0	36.7	41.2	45.2	49.2	3.7%	Saudi Arabia
South Africa	1.3	1.2	1.2	1.2	1.3	1.2	1.5	1.6	1.9	2.1	2.7	3.2	3.8	4.5	5.3	5.9	6.3	6.6	6.6	6.8	6.8	6.9	7.0	7.3	7.8	8.5	9.5	10.5	11.7	12.7	13.7	1.0%	South Africa
Group of Twenty (G20)	318.8	324.1	324.7	327.2	344.0	378.2	398.2	424.8	442.8	447.8	463.9	452.9	468.6	488.3	545.0	602.2	645.4	647.3	630.0	657.7	726.7	772.5	827.5	872.7	937.4	881.7	912.8	960.9	997.8	1026	1064	80.1%	**Group of Twenty (G20)**
Other Large countries	17.6	16.5	17.1	17.8	18.2	17.9	20.6	23.2	25.8	31.4	42.3	53.3	110.4	122.8	138.0	137.3	126.1	132.1	132.6	131.2	121.5	123.1	123.3	126.6	137.2	148.2	164.9	179.7	201.7	220.3	238.7	18.0%	**Other Large countries**
Egypt	1.5	1.9	1.9	1.8	1.8	1.7	1.9	1.9	2.0	2.3	3.1	3.6	4.2	4.8	5.4	6.1	6.4	6.5	6.9	7.0	7.1	7.2	7.3	7.5	8.1	8.8	9.9	10.9	12.1	13.2	14.3	1.1%	Egypt
Iran	2.6	3.1	2.9	2.6	2.4	2.2	2.1	2.2	2.3	2.9	3.3	3.9	4.8	5.6	6.1	7.0	7.3	7.6	8.0	8.2	8.3	8.4	8.6	8.9	9.5	10.3	11.4	12.4	13.7	14.8	16.0	1.2%	Iran
Kazakhstan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0	1.4	1.4	1.6	1.7	1.7	1.6	1.7	1.6	1.8	1.8	1.8	1.9	1.8	0.1%	Kazakhstan
Malaysia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.7	1.0	1.2	1.1	1.3	1.5	1.6	1.8	1.9	2.1	2.2	2.3	2.4	2.5	2.9	3.7	4.4	1.9	1.9	2.1	2.2	0.2%	Malaysia
Nigeria	0.2	0.2	0.1	0.1	0.2	0.2	0.3	0.4	0.6	0.9	1.5	2.1	2.6	3.2	3.8	4.5	4.7	4.8	5.0	5.2	5.2	5.3	5.4	5.5	6.0	6.6	7.5	8.4	9.4	10.4	11.3	0.9%	Nigeria
Taiwan	1.0	0.9	0.8	0.6	0.5	0.4	0.5	0.6	0.6	0.8	1.3	1.8	2.2	2.7	3.2	3.8	4.0	4.1	4.3	4.4	4.4	4.5	4.6	4.7	5.1	5.6	6.3	6.9	7.7	8.4	9.1	0.7%	Taiwan
Thailand	0.1	0.7	1.2	2.4	3.0	3.4	4.4	5.0	6.2	6.3	5.0	6.6	53.1	54.0	57.4	43.1	26.0	29.5	25.8	21.0	10.5	10.7	8.6	8.7	9.3	8.3	7.1	6.9	8.2	8.2	8.2	0.6%	Thailand
Ukraine	1.4	1.4	1.4	1.3	1.3	1.3	1.5	1.6	1.9	2.4	4.1	5.6	7.0	8.6	10.3	12.3	13.0	13.2	13.8	14.2	14.2	14.3	14.7	15.1	16.4	18.1	20.4	22.8	25.6	28.1	30.6	2.3%	Ukraine
United Arab Emirates	0.2	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.3	0.2	0.1	0.2	0.2	0.3	0.4	0.5	0.7	0.8	0.7	0.8	0.8	0.9	0.9	0.9	0.8	0.9	1.0	1.4	1.6	1.7	0.1%	United Arab Emirates
Viet Nam	0.7	0.9	0.9	0.9	1.0	0.8	1.1	1.3	1.6	2.0	3.1	4.0	4.8	5.7	6.7	7.8	8.2	8.6	8.7	9.0	9.1	9.3	9.4	9.7	10.5	11.6	13.0	14.4	16.1	17.7	19.1	1.4%	Viet Nam
Zambia	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.5	0.9	1.2	1.5	1.9	2.2	2.7	2.8	2.9	3.0	3.1	3.1	3.1	3.2	3.2	3.6	4.0	4.7	5.7	6.5	7.3	8.2	0.6%	Zambia
Remaining countries (186)	15.9	16.6	11.7	9.9	9.3	8.6	8.7	9.7	10.4	11.6	12.9	11.7	13.0	11.8	15.1	14.1	14.4	16.8	15.2	12.9	13.3	15.9	16.9	15.7	15.8	17.9	19.4	20.2	22.1	23.5	24.8	1.9%	**Remaining countries (186)**
International transport																																	**International transport**
Global total	352.3	357.1	353.5	354.8	371.5	404.8	427.5	457.7	479.0	490.8	519.1	517.9	592.0	622.9	698.1	753.6	785.9	796.2	777.8	801.7	861.5	911.5	968	1015	1090	1048	1097	1161	1222	1270	1328	100%	**Global total**

Table B.6

Greenhouse gas emissions per capita, per country and group, 1990–2020 (unit: tonnes of CO_2 eq per person)

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	2018	2019	2020	Country/group
China	**3.35**	**3.42**	**3.49**	**3.63**	**3.76**	**4.06**	**4.03**	**4.01**	**4.06**	**4.00**	**4.15**	**4.28**	**4.51**	**5.05**	**5.68**	**6.29**	**6.86**	**7.29**	**7.4**	**7.8**	**8.4**	**9.1**	**9.3**	**9.5**	**9.5**	**9.4**	**9.3**	**9.4**	**9.6**	**9.8**	**9.9**	**China**
United States	**24.6**	**24.2**	**24.3**	**24.5**	**24.7**	**24.6**	**24.9**	**25.7**	**25.5**	**25.2**	**25.5**	**24.9**	**24.1**	**24.1**	**24.2**	**24.0**	**23.5**	**23.6**	**22.8**	**21.1**	**21.7**	**20.8**	**19.9**	**20.2**	**20.2**	**19.7**	**19.2**	**18.9**	**19.3**	**18.7**	**17.1**	**United States**
European Union, of which:	**11.9**	**11.6**	**11.2**	**10.9**	**10.9**	**11.0**	**11.2**	**11.1**	**10.9**	**10.7**	**10.7**	**10.8**	**10.7**	**10.9**	**10.9**	**10.8**	**10.8**	**10.7**	**10.4**	**9.7**	**9.9**	**9.7**	**9.5**	**9.3**	**9.0**	**9.1**	**9.1**	**9.1**	**8.9**	**8.6**	**7.9**	**European Union, of which:**
France	9.5	9.9	9.6	9.2	9.0	9.1	9.4	9.2	9.4	9.2	9.1	9.1	9.0	8.9	8.9	8.9	8.6	8.5	8.3	8.0	8.1	7.8	7.7	7.6	7.0	7.1	7.1	7.1	6.9	6.8	6.1	*France*
Germany	15.6	15.1	14.3	14.0	13.8	13.7	14.0	13.5	13.2	12.7	12.7	12.8	12.6	12.5	12.3	12.0	12.2	11.8	11.9	11.1	11.7	11.3	11.4	11.6	11.1	11.1	11.1	10.9	10.5	9.8	9.0	*Germany*
Italy	9.0	9.0	8.9	8.7	8.6	9.1	9.1	9.2	9.4	9.5	9.6	9.5	9.6	9.9	10.0	10.0	9.7	9.6	9.3	8.4	8.5	8.3	7.9	7.3	7.0	7.1	7.0	7.0	6.9	6.7	6.1	*Italy*
Netherlands	14.9	15.2	15.0	15.2	15.2	15.5	16.2	15.4	15.3	14.5	14.3	14.1	14.0	14.1	14.2	13.7	13.5	13.4	13.1	12.7	13.4	12.5	12.5	12.4	11.8	12.3	12.2	12.0	11.6	11.2	10.4	*Netherlands*
Poland	13.4	13.1	12.7	12.6	12.4	12.4	12.8	12.6	11.6	11.2	10.8	10.7	10.5	10.8	10.9	10.9	11.3	11.3	11.1	10.6	11.2	11.1	11.0	10.9	10.6	10.6	10.9	11.3	11.2	10.7	10.2	*Poland*
Spain	7.6	7.8	8.0	7.6	7.8	8.2	8.0	8.6	8.8	9.4	9.8	9.6	9.8	9.9	10.2	10.3	10.0	10.2	9.3	8.4	8.0	8.0	7.8	7.3	7.2	7.5	7.3	7.6	7.5	7.0	6.2	*Spain*
India	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.7**	**1.7**	**1.7**	**1.7**	**1.8**	**1.8**	**1.8**	**1.7**	**1.8**	**1.8**	**1.9**	**1.9**	**2.0**	**2.1**	**2.2**	**2.3**	**2.3**	**2.4**	**2.4**	**2.5**	**2.5**	**2.5**	**2.6**	**2.7**	**2.7**	**2.6**	**India**
Russian Federation	**20.6**	**20.2**	**18.7**	**17.1**	**15.4**	**15.0**	**14.6**	**13.7**	**13.7**	**14.0**	**14.4**	**14.6**	**14.5**	**15.1**	**15.2**	**15.2**	**15.5**	**15.6**	**15.6**	**14.7**	**15.3**	**16.0**	**15.9**	**15.6**	**15.4**	**15.4**	**15.3**	**15.6**	**16.0**	**15.9**	**15.2**	**Russian Federation**
Japan	**10.5**	**10.6**	**10.6**	**10.5**	**10.9**	**11.0**	**11.1**	**10.9**	**10.4**	**10.6**	**10.7**	**10.5**	**10.8**	**10.8**	**10.7**	**10.7**	**10.6**	**10.9**	**10.3**	**9.8**	**10.3**	**10.7**	**11.0**	**11.1**	**10.8**	**10.5**	**10.4**	**10.3**	**10.0**	**9.7**	**9.1**	**Japan**
Other OECD countries G20	12.8	12.8	12.7	12.7	12.8	12.9	13.2	13.3	13.1	13.1	13.6	13.5	13.3	13.1	13.3	13.2	13.4	13.5	13.1	12.7	12.9	13.2	13.3	12.8	12.6	12.6	12.4	12.6	12.5	12.1	11.1	**Other OECD countries G20**
Australia	29.8	29.5	29.2	29.1	29.0	29.1	28.8	29.0	30.3	32.0	32.9	34.1	33.5	29.1	31.7	29.4	31.1	30.7	28.7	28.9	27.2	31.3	30.7	26.3	26.5	26.3	24.8	26.3	25.7	24.8	22.7	Australia
Canada	21.3	20.8	21.1	20.9	21.5	21.9	22.3	22.6	22.6	22.7	23.3	22.7	22.8	23.2	22.8	22.9	22.5	23.3	22.2	20.8	21.0	21.2	21.0	21.2	21.3	21.2	20.7	20.5	20.6	20.4	18.8	Canada
Mexico	5.4	5.5	5.5	5.6	5.8	5.7	5.8	6.1	6.3	6.1	6.3	6.2	6.2	6.4	6.5	6.6	6.7	6.8	6.8	6.6	6.7	6.7	6.8	6.6	6.4	6.4	6.4	6.4	6.4	6.2	5.5	Mexico
South Korea	7.5	8.0	8.4	9.0	9.6	10.3	10.8	11.3	9.7	10.5	11.6	11.8	11.6	11.5	11.9	11.9	12.0	12.3	12.4	12.5	13.5	14.1	14.1	14.0	13.8	14.1	14.4	14.6	14.8	14.4	13.6	South Korea
Turkey	4.1	4.1	4.2	4.2	4.1	4.3	4.6	4.7	4.8	4.7	5.0	4.6	4.6	4.8	4.8	4.9	5.3	5.7	5.6	5.6	5.8	6.0	6.4	6.2	6.5	6.5	6.8	7.2	7.0	6.8	6.6	Turkey
United Kingdom	13.7	13.9	13.4	13.0	12.8	12.7	13.0	12.6	12.4	11.9	11.8	11.9	11.5	11.6	11.5	11.3	11.1	10.7	10.3	9.3	9.4	8.7	8.9	8.6	8.0	7.7	7.3	7.1	6.9	6.6	5.9	United Kingdom
Other G20 countries	**4.8**	**4.8**	**4.9**	**4.9**	**5.0**	**5.1**	**5.2**	**5.3**	**5.3**	**5.3**	**5.3**	**5.4**	**5.5**	**5.7**	**5.9**	**5.9**	**6.0**	**6.1**	**6.2**	**6.1**	**6.3**	**6.4**	**6.6**	**6.6**	**6.8**	**6.7**	**6.6**	**6.7**	**6.6**	**6.7**	**6.4**	**Other G20 countries**
Argentina	8.2	8.2	8.2	8.0	8.2	8.3	8.3	8.5	8.5	8.7	8.7	8.4	8.2	8.8	9.3	9.3	9.6	9.7	9.8	9.2	9.1	9.2	9.2	9.2	9.3	9.4	9.4	9.2	9.0	8.8	8.4	Argentina
Brazil	4.6	4.7	4.8	4.8	5.0	5.1	5.1	5.2	5.2	5.2	5.3	5.3	5.4	5.5	5.7	5.7	5.7	5.8	5.8	5.6	6.0	6.1	6.2	6.3	6.5	6.4	6.2	6.2	6.0	6.0	6.0	Brazil
Indonesia	2.3	2.3	2.4	2.5	2.5	2.6	2.7	2.8	2.7	2.8	2.7	2.8	2.8	2.9	3.0	2.9	3.1	3.1	3.1	3.2	3.2	3.3	3.5	3.5	3.7	3.6	3.6	3.9	4.0	4.2	3.8	Indonesia
Saudi Arabia	14.2	14.5	14.9	15.1	15.7	15.2	15.7	15.7	16.1	16.0	16.6	16.8	17.3	17.9	18.4	19.1	19.5	19.9	20.8	20.9	22.1	22.4	23.0	22.6	23.3	23.8	23.4	23.2	22.3	22.1	21.7	Saudi Arabia
South Africa	10.9	10.4	10.0	9.8	9.8	10.0	10.2	10.4	10.5	9.9	9.9	10.0	10.2	10.6	11.2	11.3	11.3	11.6	12.0	11.2	11.2	10.6	10.8	10.9	10.9	10.3	10.2	10.1	10.0	10.0	9.3	South Africa
Group of Twenty (G20)	**6.8**	**6.8**	**6.7**	**6.6**	**6.6**	**6.7**	**6.7**	**6.7**	**6.6**	**6.6**	**6.7**	**6.7**	**6.7**	**6.9**	**7.1**	**7.3**	**7.4**	**7.6**	**7.5**	**7.4**	**7.7**	**7.9**	**8.0**	**8.0**	**8.0**	**7.9**	**7.8**	**7.8**	**7.9**	**7.8**	**7.5**	**Group of Twenty (G20)**
Other Large countries	**5.2**	**5.2**	**5.1**	**4.9**	**4.8**	**4.8**	**4.7**	**4.7**	**4.5**	**4.5**	**4.6**	**4.7**	**4.8**	**5.0**	**5.1**	**5.2**	**5.3**	**5.4**	**5.4**	**5.2**	**5.3**	**5.3**	**5.3**	**5.3**	**5.3**	**5.2**	**5.3**	**5.3**	**5.4**	**5.4**	**5.2**	**Other Large countries**
Egypt	2.6	2.7	2.7	2.6	2.5	2.6	2.7	2.8	2.8	2.9	2.9	3.0	3.1	3.1	3.3	3.5	3.6	3.8	3.8	3.8	3.7	3.7	3.8	3.7	3.6	3.6	3.6	3.7	4.1	3.9	3.7	Egypt
Iran	5.7	6.3	6.6	6.5	7.0	7.0	7.2	7.3	7.0	7.4	7.8	7.8	8.0	8.6	9.1	9.6	10.1	10.5	10.4	10.6	10.6	10.6	10.4	10.6	10.8	10.6	11.0	11.2	11.3	11.4	11.3	Iran
Kazakhstan	21.1	21.5	22.1	19.5	17.6	15.5	13.9	12.4	12.5	11.6	12.0	11.9	13.5	14.2	15.2	15.9	17.4	17.9	20.6	18.5	19.7	20.4	19.9	20.5	19.6	20.2	20.3	20.8	20.2	19.6	19.0	Kazakhstan
Malaysia	5.1	5.7	5.7	6.0	6.2	6.4	7.0	7.4	7.1	7.4	7.9	8.0	8.3	8.7	9.1	9.5	9.7	10.1	10.5	9.5	9.9	9.8	9.7	10.3	10.6	10.6	10.3	9.9	10.3	10.4	10.2	Malaysia
Nigeria	2.8	2.9	3.0	3.0	3.1	3.3	3.7	3.4	3.1	2.9	3.1	3.1	2.7	2.9	2.8	2.7	2.4	2.2	2.2	2.0	2.1	2.2	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.0	1.9	Nigeria
Taiwan	1.9	1.8	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.2	2.3	2.2	2.2	2.1	2.1	2.1	2.1	2.2	2.2	2.3	2.4	2.4	2.4	2.4	Taiwan
Thailand	6.9	7.3	7.7	8.2	8.5	8.9	9.4	10.0	10.5	10.8	11.6	12.0	14.3	14.7	15.2	14.8	14.3	14.7	14.0	13.2	13.3	13.3	12.8	13.0	13.1	13.0	13.1	13.6	13.5	13.2	13.0	Thailand
Ukraine	3.7	3.9	4.1	4.3	4.5	4.7	5.0	5.0	4.5	4.7	4.6	4.8	4.9	5.1	5.4	5.6	5.6	5.8	5.9	5.8	6.1	6.1	6.4	6.5	6.4	6.3	6.2	6.3	6.3	6.1	5.9	Ukraine
United Arab Emirates	18.4	17.3	15.5	13.7	11.6	11.4	9.9	9.6	9.1	9.2	9.1	9.2	9.3	10.1	9.6	9.4	9.4	9.7	9.4	8.1	8.6	9.1	9.0	8.8	7.8	6.6	6.7	6.1	6.3	6.1	5.9	United Arab Emirates
Viet Nam	44.1	46.4	43.1	43.7	44.2	44.5	44.5	43.3	41.7	40.6	38.9	41.3	39.8	39.4	37.8	35.7	32.2	29.4	29.5	26.5	25.5	25.1	25.8	26.9	27.2	28.6	29.3	29.6	28.8	28.5	27.2	Viet Nam
Zambia	1.5	1.6	1.6	1.6	1.7	1.7	1.8	1.9	2.0	2.0	2.1	2.1	2.3	2.3	2.6	2.7	2.7	2.9	3.0	3.2	3.3	3.3	3.3	3.4	3.5	3.9	4.0	4.0	4.4	4.9	4.8	Zambia
Remaining countries (186)	**2.3**	**2.2**	**2.2**	**2.2**	**2.2**	**2.2**	**2.2**	**2.3**	**2.3**	**2.3**	**2.3**	**2.2**	**2.2**	**2.2**	**2.3**	**2.3**	**2.3**	**2.3**	**2.4**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.1**	**Remaining countries (186)**
International transport																																**International transport**
Global total	**1.9**	**1.87**	**1.85**	**1.82**	**1.81**	**1.82**	**1.82**	**1.79**	**1.76**	**1.75**	**1.75**	**1.74**	**1.73**	**1.75**	**1.78**	**1.79**	**1.81**	**1.81**	**1.80**	**1.77**	**1.79**	**1.82**	**1.83**	**1.81**	**1.81**	**1.80**	**1.79**	**1.80**	**1.80**	**1.79**	**1.78**	**Global total**

Table B.7

Greenhouse gas emissions per USD of GDP, per country and group, 1990–2020 (unit: kg CO_2 per 1,000 USD of GDP [PPP])

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	2018	2019	2020	Country/group
China	**2223**	**2114**	**1922**	**1783**	**1656**	**1638**	**1494**	**1378**	**1313**	**1215**	**1172**	**1126**	**1098**	**1126**	**1159**	**1161**	**1131**	**1060**	**989**	**967**	**946**	**939**	**898**	**855**	**800**	**744**	**695**	**661**	**636**	**614**	**610**	**China**
United States	**614**	**610**	**599**	**593**	**580**	**570**	**563**	**562**	**542**	**517**	**508**	**497**	**476**	**467**	**456**	**441**	**423**	**421**	**411**	**394**	**398**	**380**	**358**	**360**	**353**	**336**	**324**	**314**	**313**	**300**	**284**	**United States**
European Union, of which:	**414**	**404**	**387**	**382**	**370**	**365**	**366**	**351**	**337**	**322**	**311**	**306**	**302**	**305**	**297**	**289**	**279**	**269**	**260**	**254**	**256**	**244**	**243**	**238**	**226**	**223**	**219**	**214**	**205**	**194**	**190**	**European Union, of which:**
France	273	283	271	262	253	252	257	247	243	231	222	220	215	214	209	206	196	190	187	187	187	175	175	172	158	159	157	155	148	143	141	*France*
Germany	423	393	366	366	354	346	351	333	319	301	293	291	287	288	280	271	264	248	247	244	246	229	231	235	220	218	214	205	197	183	177	*Germany*
Italy	248	244	239	237	230	235	231	228	229	228	222	216	219	227	227	226	218	212	208	199	199	193	191	181	173	176	172	168	164	159	159	*Italy*
Netherlands	409	409	401	403	394	392	398	367	349	317	301	293	291	293	292	278	265	256	245	247	258	239	241	240	227	231	227	216	205	195	188	*Netherlands*
Poland	1182	1247	1182	1133	1061	995	965	892	784	728	669	654	631	626	599	580	565	527	497	464	470	446	435	424	397	383	379	374	353	323	315	*Poland*
Spain	279	279	284	272	277	283	271	280	277	283	282	269	274	273	275	274	259	260	238	224	216	218	220	206	202	201	190	193	185	171	168	*Spain*
India	**869**	**896**	**867**	**848**	**823**	**798**	**763**	**757**	**725**	**693**	**680**	**657**	**643**	**611**	**597**	**573**	**556**	**548**	**556**	**554**	**532**	**528**	**530**	**504**	**495**	**461**	**433**	**421**	**411**	**399**	**417**	**India**
Russian Federation	**957**	**988**	**1073**	**1076**	**1112**	**1125**	**1134**	**1049**	**1104**	**1060**	**986**	**945**	**897**	**865**	**807**	**760**	**715**	**661**	**628**	**643**	**643**	**643**	**618**	**595**	**586**	**600**	**594**	**596**	**597**	**582**	**570**	**Russian Federation**
Japan	**329**	**321**	**321**	**321**	**331**	**326**	**319**	**312**	**300**	**308**	**303**	**297**	**303**	**300**	**291**	**287**	**279**	**283**	**271**	**272**	**274**	**285**	**289**	**286**	**277**	**265**	**262**	**253**	**244**	**236**	**233**	**Japan**
Other OECD countries G20	508	510	504	492	487	487	481	467	455	445	443	441	427	412	405	389	384	377	367	371	364	364	361	340	330	323	315	312	306	296	288	**Other OECD countries G20**
Australia	952	960	959	929	900	880	846	828	836	850	852	874	835	711	755	689	720	698	642	646	608	694	666	564	562	554	517	541	521	498	462	Australia
Canada	652	661	670	656	652	652	661	661	648	632	624	606	595	588	562	542	518	508	486	474	471	466	459	457	451	450	440	427	421	415	407	Canada
Mexico	363	360	352	357	363	383	374	371	370	354	355	357	363	374	366	371	368	367	368	386	376	370	364	356	341	334	329	324	319	313	307	Mexico
South Korea	593	578	578	586	576	569	560	556	511	498	510	496	456	443	437	420	404	391	385	388	393	396	389	376	362	361	359	354	350	335	319	South Korea
Turkey	325	325	323	309	317	316	318	310	309	320	325	321	308	304	281	267	276	284	281	300	288	274	281	257	259	251	256	257	248	239	231	Turkey
United Kingdom	450	461	446	422	402	390	390	360	343	319	308	303	288	283	275	263	255	243	236	225	225	207	212	202	183	174	164	156	151	144	143	United Kingdom
Other G20 countries	**511**	**496**	**496**	**489**	**485**	**486**	**480**	**479**	**498**	**506**	**498**	**505**	**516**	**519**	**511**	**497**	**486**	**475**	**465**	**461**	**453**	**439**	**445**	**437**	**446**	**441**	**439**	**439**	**430**	**429**	**432**	**Other G20 countries**
Argentina	577	536	503	460	453	475	460	437	427	457	465	476	529	529	513	477	461	432	424	425	387	372	383	376	395	391	404	389	395	397	426	Argentina
Brazil	438	447	463	458	452	453	446	447	455	459	456	460	460	470	465	456	438	425	411	401	406	397	403	401	412	422	428	428	411	409	423	Brazil
Indonesia	499	489	480	469	454	444	431	431	495	504	479	481	470	473	459	439	437	426	404	403	381	382	389	370	374	358	345	352	353	351	331	Indonesia
Saudi Arabia	342	314	321	338	358	354	365	368	374	393	396	416	453	435	426	430	441	453	458	485	501	477	478	472	484	486	481	490	468	470	490	Saudi Arabia
South Africa	1055	1046	1054	1049	1034	1050	1043	1060	1074	1009	980	976	975	997	1017	991	945	932	949	914	897	840	850	845	849	803	800	798	789	800	811	South Africa
Group of Twenty (G20)	**590**	**585**	**575**	**567**	**557**	**555**	**542**	**527**	**515**	**499**	**488**	**481**	**475**	**477**	**475**	**469**	**461**	**454**	**442**	**445**	**446**	**444**	**438**	**429**	**417**	**401**	**387**	**378**	**370**	**360**	**361**	**Group of Twenty (G20)**
Other Large countries	**740**	**740**	**730**	**710**	**700**	**690**	**670**	**660**	**640**	**640**	**620**	**620**	**610**	**610**	**600**	**590**	**570**	**560**	**560**	**550**	**530**	**530**	**520**	**510**	**500**	**490**	**490**	**480**	**480**	**480**	**480**	**Other Large countries**
Egypt	422	443	433	425	396	401	405	400	387	391	369	385	389	387	399	420	413	406	384	376	357	363	371	355	350	341	336	338	356	331	307	Egypt
Iran	659	662	687	678	760	746	741	762	726	769	772	778	752	750	771	796	812	786	790	805	770	760	815	838	824	833	772	770	841	919	912	Iran
Kazakhstan	1572	1799	1941	1868	1912	1820	1595	1383	1398	1248	1166	1020	1057	1030	1016	979	976	932	1045	942	946	923	876	865	806	832	839	838	791	746	750	Kazakhstan
Malaysia	495	515	492	481	465	448	460	463	489	493	493	511	512	516	521	525	514	519	522	489	481	459	440	450	445	427	403	370	373	368	384	Malaysia
Nigeria	850	893	921	951	1033	1124	1239	1147	1041	1006	1050	1008	773	795	715	663	586	522	494	432	431	430	412	401	388	372	375	381	391	384	386	Nigeria
Taiwan	648	619	605	628	619	618	611	622	620	628	611	599	597	589	584	563	564	572	567	565	543	543	528	523	520	508	514	514	502	502	509	Taiwan
Thailand	311	311	306	311	314	315	311	314	317	314	322	345	403	407	403	369	354	353	349	344	320	308	293	301	294	294	301	300	298	284	278	Thailand
Ukraine	519	512	497	487	477	469	475	499	495	491	472	476	467	457	458	454	439	434	431	433	425	421	413	412	401	387	368	361	346	331	343	Ukraine
United Arab Emirates	1161	1191	1176	1215	1331	1474	1416	1399	1352	1347	1255	1147	1097	1074	903	852	793	755	714	714	726	731	715	697	656	617	610	537	533	497	502	United Arab Emirates
Viet Nam	396	438	417	442	441	438	435	412	416	415	380	419	415	403	386	393	372	383	428	454	464	448	450	449	436	439	441	441	430	425	436	Viet Nam
Zambia	910	894	844	822	800	772	746	720	725	716	697	675	691	676	700	686	658	650	644	656	656	621	590	576	572	609	596	560	578	610	586	Zambia
Remaining countries (186)	**457**	**446**	**448**	**447**	**452**	**450**	**447**	**442**	**442**	**441**	**433**	**417**	**415**	**415**	**402**	**392**	**377**	**366**	**357**	**348**	**343**	**334**	**322**	**318**	**318**	**323**	**324**	**321**	**315**	**315**	**296**	**Remaining countries (186)**
International transport																																**International transport**
Global total	**628**	**622**	**612**	**605**	**597**	**592**	**581**	**566**	**555**	**539**	**530**	**523**	**516**	**517**	**513**	**505**	**495**	**486**	**476**	**476**	**475**	**471**	**464**	**455**	**444**	**431**	**419**	**410**	**403**	**395**	**391**	**Global total**

Appendix C

Annual change in global sectoral emissions in recession years and other years

For each gas, we looked at the impact of global recession years on total global greenhouse gas emissions, and of global recession years on global emissions from main source categories and from more detailed sectors, using global sectoral emissions per gas. Global recessions since 1990 were due to the Gulf War (1990–1993), the Asian financial crisis (1998), the 9/11 event (2001–2002), and the credit crisis (2008–2009). The results from this analysis for sectoral emissions as well as the totals per greenhouse gas can also be found in Appendix C of the previous trend report (Olivier and Peters, 2020).

Table C.1

Average annual change of global CO_2 emissions 1970-2018 in global recession years (red), in other years (green) and in the year before and after a recession (GDP in blue).

Share in 2019	Source category	Yr before	Recession	StDev	Yr after	Non-recession	StDev	Impact (Rec-Non)	Reces-Yr before	All years	StDev
	GDP (global)	4.4%	1.9%	1.0%	4.1%	4.1%	1.0%	-2.2%	-2.5%	3.4%	1.4%
	Main source category										
88.6%	Fuel combustion	2.9%	0.2%	1.1%	3.4%	2.6%	1.7%	-2.4%	-2.7%	1.8%	1.9%
4.4%	Non-energy fuel use	2.7%	-1.8%	3.2%	3.6%	3.0%	2.2%	-4.8%	-4.4%	1.5%	3.3%
0.8%	Gas venting/ flaring	3.4%	-3.8%	8.0%	4.7%	2.3%	8.1%	-6.0%	-7.1%	0.4%	8.4%
1.1%	Solid fuel transformation	8.5%	-4.9%	9.4%	9.3%	4.7%	8.4%	-9.6%	-13.5%	1.7%	9.7%
4.0%	Cement production	2.5%	1.7%	2.8%	6.6%	4.2%	4.1%	-2.5%	-0.8%	3.5%	3.9%
1.2%	Other carbonate use	1.7%	-0.8%	2.7%	2.7%	2.7%	2.3%	-3.4%	-2.5%	1.6%	2.9%
100%	Total CO_2	3.0%	0.0%	1.0%	3.6%	2.7%	1.7%	-2.7%	-2.9%	1.8%	2.0%
88.6%	Main CO_2 combustion sectors										
35.8%	Electricity and heat generation	4.1%	1.7%	2.4%	4.4%	3.3%	2.3%	-1.6%	-2.4%	2.7%	2.5%
16.7%	Industries	3.0%	-1.7%	2.1%	3.0%	2.4%	3.7%	-4.1%	-4.7%	1.1%	3.7%
15.9%	Road transport	3.0%	1.6%	1.5%	3.2%	3.2%	1.8%	-1.6%	-1.4%	2.6%	1.8%
8.7%	Building sector (Resid, Commerc., Other)	0.6%	-1.2%	2.9%	1.9%	1.0%	1.9%	-2.3%	-1.8%	0.4%	2.4%
7.9%	Other domestic fuel combustion	3.1%	-0.2%	1.8%	2.6%	2.3%	1.7%	-2.5%	-3.3%	1.5%	2.1%
1.7%	International air transport	4.3%	-0.5%	4.2%	3.1%	4.3%	2.3%	-4.8%	-4.8%	2.8%	3.7%
1.9%	International marine transport (bunkers)	2.7%	-1.5%	6.0%	3.8%	3.0%	3.1%	-4.5%	-4.2%	1.6%	4.6%
3.5%	Non-combustion CO_2 category										
0.8%	Lime production	2.6%	-0.2%	3.8%	3.2%	3.3%	3.1%	-3.5%	-2.8%	2.2%	3.6%
0.9%	Ammonia production (gross CO_2)	2.1%	0.9%	3.0%	7.4%	4.2%	4.8%	-3.3%	-1.2%	3.1%	4.6%
0.4%	Crude steel production total	4.8%	-2.6%	3.7%	5.3%	4.0%	4.9%	-6.7%	-7.4%	2.1%	5.4%
0.2%	Blast furnaces	2.3%	-7.8%	21.5%	-10.0%	15.7%	71.3%	-23.5%	-10.1%	8.2%	60.3%
0.4%	Ferroy Alloy production	7.1%	-10.3%	13.9%	16.6%	6.2%	15.2%	-16.5%	-17.5%	1.1%	16.4%
0.3%	Aluminium production (primary)	4.7%	1.0%	6.0%	6.1%	5.4%	3.6%	-4.5%	-3.7%	4.2%	5.0%
0.2%	CO_2 from urea application	5.1%	4.6%	5.7%	4.4%	4.9%	5.7%	-0.3%	-0.5%	4.7%	5.6%
0.2%	CO_2 from agricultural lime application	0.5%	-1.2%	2.8%	4.5%	2.5%	4.8%	-3.7%	-1.7%	1.4%	4.6%

Notes: StDev = Standard Deviation of annual change in recession years, non-recession years and in all years.

According to an IMF definition there were 6 recessions since 1970: 15 recession years; and 32 other years. The six global recessions were: 1974–75 (1st oil crisis), 1980–83 (2nd oil crisis), 1990–93 (Gulf war), 1998 (Asian financial crisis), 2001–02 (“9-11”), and 2008–09 (credit crunch).

Table C.2
Average annual change of global CH_4 emissions 1970-2018 in global recession years (red), in other years (green) and in the year before and after a recession (GDP in blue).

Share in 2019	Source category	Yr before	Recession	StDev	Yr after	Non-recession	StDev	Impact (R-N)	Reces-Yr before	All years	StDev
	GDP (global, PPP)	4.4%	1.9%	1.0%	4.1%	4.1%	1.0%	-2.2%	-2.5%	3.4%	1.4%
4.1%	Fossil fuel combustion	1.1%	0.0%	2.2%	0.5%	0.8%	2.0%	-0.8%	-1.1%	0.5%	2.1%
12.2%	Coal mining	1.8%	-0.7%	2.8%	2.0%	2.9%	5.8%	-3.5%	-2.5%	1.8%	5.2%
2.6%	Oil production, transmission	4.4%	-1.2%	3.0%	2.9%	2.6%	2.7%	-3.7%	-5.5%	1.4%	3.3%
10.9%	Associated Gas venting	4.5%	2.6%	1.5%	4.2%	3.7%	1.6%	-1.1%	-1.9%	3.4%	1.6%
6.5%	Gas production, distribution	-0.3%	-6.4%	7.6%	1.8%	1.3%	7.7%	-7.7%	-6.1%	-1.1%	8.3%
28.0%	Ruminants	0.8%	1.0%	0.7%	0.9%	0.9%	0.7%	0.1%	0.2%	0.9%	0.7%
9.5%	Animal manure (confined)	-1.1%	-1.0%	1.7%	-0.1%	-0.2%	1.7%	-0.8%	0.1%	-0.5%	1.7%
5.2%	Rice production	0.8%	0.4%	1.7%	0.6%	0.9%	3.1%	-0.4%	-0.4%	0.7%	2.7%
9.9%	Landfills	1.1%	0.3%	1.7%	1.1%	1.4%	1.9%	-1.2%	-0.8%	1.1%	1.9%
10.5%	Wastewater	2.1%	1.5%	0.6%	2.3%	2.0%	0.6%	-0.4%	-0.6%	1.8%	0.6%
0.6%	Other	1.1%	0.3%	2.4%	0.6%	0.9%	2.5%	-0.6%	-0.8%	0.7%	2.5%
100%	Total CH_4	1.1%	-0.7%	1.5%	1.5%	1.4%	1.6%	-2.1%	-1.8%	0.8%	1.8%

Table C.3
Average annual change of global N_2O emissions 1970-2018 in global recession years (red), in other years (green) and in the year before and after a recession (GDP in blue).

Share in 2019	Source category	Yr before	Recession	StDev	Yr after	Non-recession	StDev	Impact (R-N)	Reces-Yr before	All years	StDev
	GDP (global, PPP)	4.4%	1.9%	1.0%	4.1%	4.1%	1.0%	-2.2%	-2.5%	3.4%	1.4%
10.7%	Fuel combustion	2.7%	1.0%	1.5%	2.8%	2.5%	1.7%	-1.5%	-1.8%	2.0%	1.8%
8.0%	Industrial processes	1.9%	-5.2%	6.2%	0.2%	1.3%	4.3%	-6.5%	-7.1%	-0.7%	5.7%
3.6%	Manure management (confined)	0.8%	0.8%	1.0%	0.7%	0.8%	1.6%	-0.1%	0.0%	0.8%	1.4%
13.7%	Synthetic Fertilizers	0.1%	1.3%	4.6%	3.3%	2.2%	3.3%	-1.0%	1.1%	1.9%	3.7%
4.6%	Animal Manure Applied to Soils	0.7%	0.3%	1.3%	0.5%	0.8%	1.0%	-0.4%	-0.3%	0.6%	1.1%
9.9%	Other agriculture	0.9%	1.0%	2.6%	1.9%	1.1%	2.5%	-0.1%	0.1%	1.0%	2.5%
22.8%	Pasture, Range & Paddock Manure	1.0%	1.2%	0.6%	1.1%	1.0%	0.6%	0.1%	0.2%	1.1%	0.6%
9.2%	Indirect N_2O from agriculture	0.8%	0.7%	1.1%	1.4%	1.2%	1.0%	-0.5%	0.0%	1.1%	1.0%
7.5%	Indirect N2O non-agriculture	1.9%	0.0%	1.4%	2.1%	2.1%	1.7%	-2.1%	-1.9%	1.5%	1.8%
4.7%	Savannah fires	1.4%	0.0%	6.2%	-1.5%	0.5%	8.7%	-0.5%	-1.3%	0.3%	7.9%
4.3%	Wastewater	1.3%	2.1%	0.9%	2.2%	2.0%	0.9%	0.2%	0.8%	2.0%	0.9%
1.0%	Field burning and other waste	1.7%	1.1%	1.3%	3.3%	2.1%	1.7%	-1.0%	-0.6%	1.8%	1.6%
100%	Total N_2O	1.1%	0.1%	1.0%	1.4%	1.3%	1.1%	-1.2%	-1.1%	0.9%	1.2%

Note: StDev = Standard Deviation of annual change in recession years (red), non-recession years (green) and in all years (blue).

Table C.4
Average annual change of global F-gas emissions 1970-2018 in global recession years (red), in other years (green) and in the year before and after a recession (GDP in blue).

Share in 2019	Source type	Source category	Yr before	Recession	StDev	Yr after	Non-recession	StDev	Impact (R-N)	Reces-Yr before	All years	StDev
		GDP (global, PPP)	4.4%	1.9%	1.0%	4.1%	4.1%	1.0%	-2.2%	-2.5%	3.4%	1.4%
80.8%	Total	HFCs	9.1%	6.2%	8.6%	15.3%	9.5%	6.8%	-3.3%	-2.9%	8.4%	7.4%
6.4%	Total	PFCs	1.9%	-3.6%	6.4%	3.0%	2.5%	4.0%	-6.1%	-5.5%	0.5%	5.6%
12.8%	Total	SF_6	6.1%	4.5%	5.9%	7.8%	6.2%	6.1%	-1.7%	-1.6%	5.6%	6.0%
100%	Total	Total F-gases	5.6%	2.8%	4.4%	9.3%	6.6%	3.4%	-3.8%	-2.8%	5.4%	4.1%
20.7%	By-product	HFC-23 from HCFC-22 production	4.5%	3.3%	9.1%	11.8%	6.6%	9.3%	-3.3%	-1.2%	5.6%	9.2%
5.4%	By-product	PFCs from aluminium production [1]	1.0%	-4.7%	6.6%	2.7%	2.5%	4.7%	-7.2%	-5.6%	0.2%	6.2%
9.0%	Electr, Equipm.	SF_6 use of Electrical equipment (GIS)	6.4%	3.3%	5.8%	8.4%	6.1%	5.6%	-2.9%	-3.1%	5.2%	5.7%
35.0%	By-product+EE	Total by-production + SF_6 Electr. Equipm.	2.9%	0.0%	4.9%	7.1%	4.7%	5.1%	-4.7%	-3.0%	3.2%	5.4%
60.1%	Usage	HFC use	42.9%	40.0%	48.9%	43.7%	30.7%	37.3%	9.3%	-3.0%	33.0%	40.8%
1.0%	Usage	PFC use	32.8%	14.3%	17.4%	15.3%	15.3%	7164%	-1.0%	-18.5%	14.7%	5879%
3.9%	Usage	Other SF_6 use	7.9%	6.5%	9.7%	6.5%	8.2%	15.9%	-1.7%	-1.5%	7.5%	14.0%
65.0%	Usage	Total F-gas use excl SF_6 GIS	16.0%	11.9%	7.2%	14.8%	14.8%	14.5%	-2.9%	-4.1%	13.7%	12.6%

[1] Excluding CF_4 emissions from the occurrence of Low Voltage Anode Effects (LVAE) that occur in modern prebake (see Appendix A for more details).
Note: StDev = Standard Deviation of annual change in recession years (red), non-recession years (green) and in all years (blue).

Appendix D

Fast-track method used for CH_4, N_2O and F-gases:
activity data (preliminary statistics) and other proxy data sources used in the Fast-Track method per detailed EDGAR source category

For significant sources with preliminary activity (production or use statistics) or other proxy data (e.g. reported emissions), we used those data to estimate the very recent emissions in 2019 and 2020. This appendix provides per EDGAR source which proxy data and data sources were used for the Fast-Track estimates of the non-CO_2 greenhouse gases CH_4, N_2O and the F-gases.

For sources without proxy data the average trend in the last three years of the v6.0 dataset was used as estimator for the trend in 2019 and/or 2020.

Table D.1 EDGAR 6.0 Fast Track CH_4 emissions: emission sources, proxies and data sources

2018	IPCC 96	IPCC category	Share	Proxy	Proxy source
381.83	kton (sum in Mt)		100%	90%	
167.0	1A1a1	Public Electricity Generation	0.0%	1A1	1A1-CO2
44.5	1A1a2	Public Combined Heat and Power gen.	0.0%	1A1	1A1-CO2
2.5	1A1a3	Public Heat Plants	0.0%	1A1	1A1-CO2
0.8	1A1a4	Public Electricity Generation (own use)	0.0%	1A1	1A1-CO2
31.6	1A1a5	Electricity Generation (autoproducers)	0.0%	1A1	1A1-CO2
17.0	1A1a6	Combined Heat and Power gen. (autoprod.)	0.0%	1A1	1A1-CO2
8.4	1A1a7	Heat Plants (autoproducers)	0.0%	1A1	1A1-CO2
29.0	1A1a1x	Public Electricity Generation (biomass)	0.0%		
21.8	1A1a2x	Public Combined Heat and Power gen. (biom.)	0.0%		
7.8	1A1a3x	Public Heat Plants (biomass)	0.0%		
0.1	1A1a4x	Public Electricity Gen. (own use) (biom.)	0.0%		
91.7	1A1a5x	Electricity Generation (autoproducers) (biom.)	0.0%		
34.8	1A1a6x	Combined Heat and Power gen. (autopr.) (biom.)	0.0%		
3.0	1A1a7x	Heat Plants (autoproducers) (biomass)	0.0%		
17.4	1A1b	Refineries	0.0%	1A1	1A1-CO2
0.0	1A1bx	Refineries (biomass)	0.0%		
1.2	1A1c1	Fuel combustion coke ovens	0.0%	2C1	WSA
0.3	1A1c2	Blast furnaces (pig iron prod.)	0.0%	2C1	WSA
0.2	1A1c3	Gas works	0.0%	1A1	1A1-CO2
32.7	1A1c5	Other transformation sector (BKB, etc.)	0.0%		
0.0	1A1c3x	Gas works (biom.)	0.0%		
0.0	1A1c4x	Fuel comb. charcoal production (biom.)	0.0%	1B1b3x	IEA 1)
15.5	1A1c5x	Other transf. sector (BKB, etc.) (biom.)	0.0%		
91.6	1A2a	Iron and steel	0.0%	1A2	1A2-CO2
25.2	1A2ax	Iron and steel (biomass)	0.0%		
11.4	1A2b	Non-ferrous metals	0.0%	1A2	1A2-CO2
0.1	1A2bx	Non-ferrous metals (biomass)	0.0%		
56.7	1A2c	Chemicals	0.0%	1A2	1A2-CO2
0.8	1A2cx	Chemicals (biomass)	0.0%		
9.8	1A2d	Pulp and paper	0.0%	1A2	1A2-CO2
84.9	1A2dx	Pulp and paper (biomass)	0.0%		
14.9	1A2e	Food and tobacco	0.0%	1A2	1A2-CO2
53.9	1A2ex	Food and tobacco (biomass)	0.0%		
180.3	1A2f	Other industries (stationary) (fos.)	0.0%	1A2	1A2-CO2
4.8	1A2f1	Off-road machinery: construction (diesel)	0.0%	1A2	1A2-CO2
3.5	1A2f2	Off-road machinery: mining (diesel)	0.0%	1A2	1A2-CO2
117.1	1A2fx	Other industries (stationary) (biom.)	0.0%		
2.7	1A3a	Domestic air transport	0.0%	1A3	1A3-CO2
989.3	1A3b	Road transport (incl. evap.) (foss.)	0.3%	1A3	1A3-CO2
13.0	1A3bx	Road transport (incl. evap.) (biom.)	0.0%		
5.1	1A3c	Non-road transport (rail, etc.) (fos.)	0.0%	1A3	1A3-CO2
0.1	1A3cx	Non-road transport (rail, etc.)(biom.)	0.0%		
16.2	1A3d	Inland shipping (fos.)	0.0%	1A3	1A3-CO2
0.0	1A3dx	Inland shipping (biom.)	0.0%		
3.2	1A3e	Non-road transport (fos.)	0.0%	1A3	1A3-CO2
0.0	1A3ex	Non-road transport (biom.)	0.0%		
96.0	1A4a	Commercial and public services (fos.)	0.0%	1A4	1A4-CO2
326.6	1A4ax	Commercial and public services (biom.)	0.1%		
2608.2	1A4b	Residential (fos.)	0.7%	1A4	1A4-CO2
8522.3	1A4bx	Residential (biom.)	2.2%	1A4x	IEA 2)
218.3	1A4c1	Agriculture and forestry (fos.)	0.1%	1A4	1A4-CO2
122.7	1A4c1x	Agriculture and forestry (biom.)	0.0%	1A4x	IEA 2)
16.4	1A4c2	Off-road machinery: agric./for. (diesel)	0.0%	1A4	1A4-CO2
1.8	1A4c3	Fishing (fos.)	0.0%	1A4	1A4-CO2
0.0	1A4c3x	Fishing (biom.)	0.0%		
355.7	1A4d	Non-specified other (fos.)	0.1%	1A4	1A4-CO2
31.8	1A4dx	Non-specified other (biom.)	0.0%		
1.2	1A5b1	Off-road machinery: mining (diesel)	0.0%	1A4	1A4-CO2
38255.2	1B1a1	Hard coal mining (gross)	10.0%	1B1	IEA+BP
-5566.4	1B1a1r	Methane recovery from coal mining	-1.5%	1B1a1r	CRF+CDM
3035.5	1B1a2	Abandoned mines	0.8%		
992.1	1B1a3	Brown coal mining	0.3%		
806.1	1B1b1	Fuel transformation coke ovens	0.2%	2C1	WSA
4688.7	1B1b3x	Fuel transformation charcoal production	1.2%	1B1b3x	IEA 1)
8889.1	1B2a1	Oil production	2.3%	1B2a1	IEA+BP
39.9	1B2a2	Oil transmission	0.0%	1B2a2	IEA+BP
241.0	1B2a3-l	Tanker loading	0.1%	1B2a3-l	IEA+BP
469.2	1B2a4-l	Tanker oil transport (crude and NGL)	0.1%		
31.4	1B2a4-t	Transport by oil trucks	0.0%		
723.1	1B2a5(e)	Oil refineries (evaporation)	0.2%		
28246.4	1B2b1	Gas production	7.4%	1B2b1	IEA+BP
5818.8	1B2b3	Gas transmission	1.5%	1B2b3	IEA+BP
25590.3	1B2c	Venting and flaring during oil and gas production	6.7%	1B2c	**CRF**

Table D.1 EDGAR 6.0 CH_4 Fast Track 2020 emissions (continued).

2018	IPCC 96	IPCC category	Share	Proxy	Source
4.3	1C1	International air transport	0.0%	1C1	1C-CO2
64.1	1C2	International marine transport (bunkers)	0.0%	1C2	1C-CO2
0.1	1C2x	International marine transport (biom.)	0.0%		
3.1	2B4a	Silicon carbide production	0.0%		
0.6	2B5a	Carbon black production	0.0%		
49.9	2B5b	Ethylene production	0.0%		
0.9	2B5d	Styrene production	0.0%		
217.9	2B5e	Methanol production	0.1%		
47.7	2B5g	Other bulk chemicals production	0.0%		
87.8	2C1d	Sinter production	0.0%		
55.0	2C2	Ferroy Alloy production	0.0%		
18181.8	4A1-d	Dairy cattle	4.8%	4A1-d	FAO 1)+USDA
62130.9	4A1-n	Non-dairy cattle	16.3%	4A1-n	FAO 1)+USDA
11363.1	4A2	Buffalo	3.0%	4A2	FAO 1)
7077.4	4A3	Sheep	1.9%	4A3	FAO 1)
5229.6	4A4	Goats	1.4%	4A4	FAO 1)
1634.2	4A5	Camels and Lamas	0.4%	4A5	FAO 1)
1040.0	4A6	Horses	0.3%	4A6	FAO 1)
589.6	4A7	Mules and asses	0.2%	4A7	FAO 1)
1138.3	4A8	Swine	0.3%	4A8	FAO 1)
2331.7	4B1-d	Manure Man.: Dairy Cattle (confined)	0.6%	4A1-d	FAO 1)+USDA
1996.0	4B1-n	Manure Man.: Non-Dairy Cattle (confined)	0.5%	4A1-n	FAO 1)+USDA
867.9	4B2	Manure Man.: Buffalo (confined)	0.2%	4A2	FAO 1)
210.9	4B3	Manure Man.: Sheep (confined)	0.1%	4A3	FAO 1)
194.9	4B4	Manure Man.: Goats (confined)	0.1%	4A4	FAO 1)
84.0	4B5	Manure Man.: Camels and llamas (confined)	0.0%	4A5	FAO 1)
100.3	4B6	Manure Man.: Horses (confined)	0.0%	4A6	FAO 1)
59.3	4B7	Manure Man.: Mules and asses (confined)	0.0%	4A7	FAO 1)
4066.6	4B8	Manure Man.: Swine (confined)	1.1%	4A8	FAO 1)
2389.7	4B9	Manure Man.: Poultry (confined)	0.6%	4A9	FAO 1)
37903.9	4C	Rice cultivation	9.9%	4C	FAO +USDA 2)
4495.7	4E	Savannah fires	1.2%		FAO (+GFED)1)
1393.8	4F1	Field burning of agric. res.: cereals	0.4%	4F	FAO 2)
198.7	4F2	Field burning of agric. res.: pulses	0.1%	4F	FAO 2)
49.2	4F3	Field burning of agric. res.: tuber and roots	0.0%	4F	FAO 2)
341.7	4F4	Field burning of agric. res.: sugar cane	0.1%	4F	FAO 2)
6.6	4F5	Field burning of agric. res.: other	0.0%	4F	FAO 2)
34632.1	6A1	Managed waste disposal on land	9.1%	6A1	CRF
13061.2	6B1	Industrial wastewater	3.4%		
31372.3	6B2	Domestic and commercial wastewater	8.2%	6B2	CRF
1343.5	6C	Waste incineration - hazardous	0.4%		
3.4	6Cax	Waste incineration - biogenic	0.0%		
160.1	6Cb1	Waste incineration - uncontrolled MSW burning	0.0%		
4.2	6Cb2	Waste incineration - other non-biogenic	0.0%		
273.0	6D	Other waste	0.1%		
150.6	7A1	Coal fires (underground)	0.0%		constant
0.0	7A2	Oil fires (Kuwait)	0.0%		constant

Notes on proxy sources of CH_4 and N_2O:

1A-CO_2 (totals from FT2020)
1A1,2,3,4-CO_2 (totals per subcategory from FT 2020)
WSA (World Steel Institute) (crude steel production)
IEA 1) (charcoal production)
IEA 2) (Primary Solid Biofuel production)
FAO 1) (animal stock)
FAO 1)+USDA (animal stock) (US Department of Agriculture) (cattle stock)
FAO 2) (emissions)
FAO 3) (amount used)
FAO 4) (sum of 4B (= total manure N generated))
FAO 5) (total amount of N)
FAO 6) (trend of N_2O in sum of 4D1)
FAO +USDA 2) (US Department of Agriculture) (harvested area)
FAO (+GFED) 1) (preliminary emissions from Global Fire Emissions Database 4.1s for 2019 and 2020) (based on fire counts)
CRF (Annex I emissions data from UNFCCC Locator tool)

Note on 'x' in EDGAR IPCC 1A subcodes: this refers to combustion of biomass fuels (all other 1A codes refer to fossil fuel combustion).

Note on the Fast Track method applied for all other sources:

For sources without proxy data the average trend in the last three years of the v6.0 dataset was used as estimator for the trend in 2019 and/or 2020. However, 'constant' means that the source was assumed to remain constant, as it was in the last years in v6.0.

Table D.2 EDGAR 6.0 N_2O Fast Track 2020 emissions: emission sources, proxies and data sources.

2018	IPCC 96	IPCC category	Share	Proxy	Proxy source
12,051.1	< kt (sum too)		100%	83%	
170.5	1A1a1	Public Electricity Generation	1.4%	1A1	1A1-CO2
59.9	1A1a2	Public Combined Heat and Power gen.	0.5%	1A1	1A1-CO2
1.2	1A1a3	Public Heat Plants	0.0%	1A1	1A1-CO2
0.4	1A1a4	Public Electricity Generation (own use)	0.0%	1A1	1A1-CO2
15.8	1A1a5	Electricity Generation (autoproducers)	0.1%	1A1	1A1-CO2
5.8	1A1a6	Combined Heat and Power gen. (autoprod.)	0.0%	1A1	1A1-CO2
1.5	1A1a7	Heat Plants (autoproducers)	0.0%	1A1	1A1-CO2
3.9	1A1a1x	Public Electricity Generation (biomass)	0.0%		
2.9	1A1a2x	Public Combined Heat and Power gen. (biom.)	0.0%		
1.0	1A1a3x	Public Heat Plants (biomass)	0.0%		
0.0	1A1a4x	Public Electricity Gen. (own use) (biom.)	0.0%		
12.2	1A1a5x	Electricity Generation (autoproducers) (biom.)	0.1%		
4.6	1A1a6x	Combined Heat and Power gen. (autopr.) (biom.)	0.0%		
0.4	1A1a7x	Heat Plants (autoproducers) (biomass)	0.0%		
2.0	1A1b	Refineries	0.0%	1A1	1A1-CO2
0.0	1A1bx	Refineries (biomass)	0.0%		
0.9	1A1c1	Fuel combustion coke ovens	0.0%	2C1	WSA
0.0	1A1c2	Blast furnaces (pig iron prod.)	0.0%	2C1	WSA
0.1	1A1c3	Gas works	0.0%	1A1	1A1-CO2
3.6	1A1c5	Other transformation sector (BKB, etc.)	0.0%		
0.0	1A1c3x	Gas works (biom.)	0.0%		
0.0	1A1c4x	Fuel comb. charcoal production (biom.)	0.0%	1B1b3x	IEA 1)
2.1	1A1c5x	Other transf. sector (BKB, etc.) (biom.)	0.0%		
13.5	1A2a	Iron and steel	0.1%	1A2	1A2-CO2
0.5	1A2ax	Iron and steel (biomass)	0.0%		
1.7	1A2b	Non-ferrous metals	0.0%	1A2	1A2-CO2
0.0	1A2bx	Non-ferrous metals (biomass)	0.0%		
8.7	1A2c	Chemicals	0.1%	1A2	1A2-CO2
0.1	1A2cx	Chemicals (biomass)	0.0%		
1.4	1A2d	Pulp and paper	0.0%	1A2	1A2-CO2
11.6	1A2dx	Pulp and paper (biomass)	0.1%		
2.2	1A2e	Food and tobacco	0.0%	1A2	1A2-CO2
10.9	1A2ex	Food and tobacco (biomass)	0.1%		
27.7	1A2f	Other industries (stationary) (fos.)	0.2%	1A2	1A2-CO2
0.7	1A2f1	Off-road machinery: construction (diesel)	0.0%	1A2	1A2-CO2
0.5	1A2f2	Off-road machinery: mining (diesel)	0.0%	1A2	1A2-CO2
15.4	1A2fx	Other industries (stationary) (biom.)	0.1%		
10.9	1A3a	Domestic air transport	0.1%	1A3	1A3-CO2
249.3	1A3b	Road transport (incl. evap.) (foss.)	2.1%	1A3	1A3-CO2
2.1	1A3bx	Road transport (incl. evap.) (biom.)	0.0%		
35.0	1A3c	Non-road transport (rail, etc.) (fos.)	0.3%	1A3	1A3-CO2
0.0	1A3cx	Non-road transport (rail, etc.)(biom.)	0.0%		
4.6	1A3d	Inland shipping (fos.)	0.0%	1A3	1A3-CO2
0.0	1A3dx	Inland shipping (biom.)	0.0%		
0.5	1A3e	Non-road transport	0.0%	1A3	1A3-CO2
0.0	1A3ex	Non-road transport (biom.)	0.0%		
5.0	1A4a	Commercial and public services	0.0%	1A4	1A4-CO2
4.2	1A4ax	Commercial and public services (biomass)	0.0%		
9.1	1A4b	Residential	0.1%	1A4	1A4-CO2
127.4	1A4bx	Residential (biomass)	1.1%	1A4x	IEA 2)
1.4	1A4c1	Agriculture and forestry	0.0%	1A4	1A4-CO2
1.6	1A4c1x	Agriculture and forestry (biomass)	0.0%	1A4x	IEA 2)
112.7	1A4c2	Off-road machinery: agric./for. (diesel)	0.9%	1A4	1A4-CO2
0.2	1A4c3	Fishing	0.0%	1A4	1A4-CO2
0.0	1A4c3x	Fishing (biomass)	0.0%		
2.3	1A4d	Non-specified other	0.0%	1A4	1A4-CO2
0.4	1A4dx	Non-specified other (biomass)	0.0%		
8.3	1A5b1	Off-road machinery: mining (diesel)	0.1%	1A4	1A4-CO2
6.4	1B1b3x	Fuel transform. charcoal production (biom.)	0.1%	1B1b3x	IEA 1)
0.4	1B2a1	Oil production	0.0%	1B2a1	IEA+BP
3.9	1B2c	Venting and flaring during oil and gas production	0.0%		
17.0	1C1	International air transport	0.1%	1C1	1C-CO2
18.3	1C2	International marine transport (bunkers)	0.2%	1C2	1C-CO2
0.0	1C2x	International marine transport (biomass)	0.0%		
297.5	2B2	Nitric acid production	2.5%	2B2	CRF
372.2	2B3	Adipic acid production	3.1%	2B3	CRF
61.2	2B5f	Caprolactam production	0.5%	2B5f	CRF
0.0	2B5h1	Glyoxal production	0.0%		

Table D.2 EDGAR 6.0 N_2O Fast Track emissions: sources, proxies and data sources (continued).

2018	IPCC 96	IPCC category	Share	Proxy	Proxy source
35.4	3D1	Use of N2O as anaesthesia	0.4%		
56.9	3D3	Use of N2O in aerosol spray cans	0.6%		
38.4	4B1-d	Manure Man.: Dairy Cattle (confined)	0.4%	4A1-d	FAO 1)+USDA
127.6	4B1-n	Manure Man.: Non-Dairy Cattle (confined)	1.3%	4A1-n	FAO 1)+USDA
30.2	4B2	Manure Man.: Buffalo (confined)	0.3%	4A2	FAO 1)
3.1	4B3	Manure Man.: Sheep (confined)	0.0%	4A3	FAO 1)
0.9	4B4	Manure Man.: Goats (confined)	0.0%	4A4	FAO 1)
0.0	4B5	Manure Man.: Camels and llamas (confined)	0.0%	4A5	FAO 1)
0.8	4B6	Manure Man.: Horses (confined)	0.0%	4A6	FAO 1)
0.0	4B7	Manure Man.: Mules and asses (confined)	0.0%	4A7	FAO 1)
104.4	4B8	Manure Man.: Swine (confined)	1.0%	4A8	FAO 1)
21.7	4B9	Manure Man.: Poultry (confined)	0.2%	4A9	FAO 1)
1587.0	4D11	Synthetic Fertilizers	15.8%	4D11	FAO 3)
432.6	4D12	Animal Manure Applied to Soils	4.3%	4D12	FAO 4)
390.6	4D13	Direct soil emissions	3.9%	4D13	FAO 5)
365.5	4D14	Crop Residue	3.6%	4D14	FAO 5)
329.8	4D15	Cultivation of Histosols	3.3%		constant
2159.1	4D2	Pasture, Range and Paddock Manure	21.5%	4D2	FAO 4)
665.1	4D3a	Indirect N2O: Atm. Depos. - agricult. (4D)	6.6%	4D3	FAO 6)
415.3	4D3b	Indirect N2O: Leaching and Run-Off - agri.	4.1%	4D3	FAO 6)
410.5	4E	Savanna burning	4.1%		FAO (+GFED) 1)
36.1	4F1	Field burning of agric. res.: cereals	0.4%	4F	FAO 2)
5.2	4F2	Field burning of agric. res.: pulses	0.1%	4F	FAO 2)
1.3	4F3	Field burning of agric. res.: tuber and roots	0.0%	4F	FAO 2)
8.9	4F4	Field burning of agric. res.: sugar cane	0.1%	4F	FAO 2)
0.2	4F5	Field burning of agric. res.: other	0.0%	4F	FAO 2)
77.5	6B1	Industrial wastewater	0.8%		
314.8	6B2	Domestic and commercial wastewater	3.1%		
0.7	6Cax	Waste incineration - biogenic	0.0%		
2.9	6Cb1	Waste incineration - uncontrolled MSW burning	0.0%		
2.8	6Cb2	Waste incineration - other non-biogenic	0.0%		
20.5	6D	Other waste	0.2%		
0.8	7A1	Coal fires (underground)	0.0%		constant
0.0	7A2	Oil fires (Kuwait)	0.0%		constant
566.3	7B1	Indirect N2O from NOx emitted in cat. 1A	5.6%	1A	1A-CO2
2.1	7B2	Indirect N2O from NOx emitted in cat. 2-3	0.0%		constant
79.1	7C1	Indirect N2O from NH3 emitted in cat. 1A	0.8%	1A	1A-CO2
3.7	7C2	Indirect N2O from NH3 emitted in cat. 2-3	0.0%		constant

Notes on proxy sources for N_2O:

1A-CO_2 (totals from FT2020)
1A1,2,3,4-CO_2 (totals per subcategory from FT 2020)
WSA (World Steel Institute) (crude steel production)
IEA 1) (charcoal production)
IEA 2) (Primary Solid Biofuel production)
FAO 1) (stock)
FAO 1)+USDA (stock)
FAO 2) (emissions)
FAO 3) (amount used)
FAO 4) (sum of 4B (= total manure N generated))
FAO 5) (total amount of N)
FAO 6) (trend of N2O in sum of 4D1)
FAO +USDA (US Department of Agriculture) 2) (harvested area)
FAO (+GFED) 1) (preliminary emissions from Global Fire Emissions Database 4.1s for 2019 and 2020)(based on fire counts)
CRF (Annex I emissions data from UNFCCC Locator tool)

Note on the Fast Track method applied for all other sources:
For sources without proxy data the average trend in the last three years of the v6.0 dataset was used as estimator for the trend in 2019 and/or 2020. However. 'constant' means that the source was assumed to remain constant, as it was in the last years in v6.0.

Table D.3 EDGAR 6.0 (1970-2018) Fast Track F-gas emissions: sources, proxies and data sources.
Fraction of F-gas emissions covered by proxies in 2019: about 35% (Annex I CRF data mostly).

2018	IPCC 96	IPCC category	Gas	% CO_2eq	2018	Proxy	Proxy.gas	Proxy source
501.5	ton (sum in kt)			100%	1,220.1	Mt CO_2eq	35%	
461.9	2C3a	Aluminium production (primary)	C2F6	0.5%	5.64	2C3a	2C3a.C2F6	IAI
3,511.8	2C3a	Aluminium production (primary)	CF4	2.1%	25.64	2C3a	2C3a.CF4	IAI 1)
361.9	2C4a	Magnesium foundries: SF6 use	SF6	0.7%	8.25	2C4a	2C4a.SF6	CRF
0.6	2C4b	Aluminium foundries: SF6 use	SF6	0.0%	0.01			
0.4	2E	Production of halocarbons and SF6	C2F6	0.0%	0.01			
4.2	2E	Production of halocarbons and SF6	C3F8	0.0%	0.04			
2.8	2E	Production of halocarbons and SF6	C4F10	0.0%	0.03			
0.0	2E	Production of halocarbons and SF6	C5F12	0.0%	0.00			
0.6	2E	Production of halocarbons and SF6	C6F14	0.0%	0.01			
0.4	2E	Production of halocarbons and SF6	c-C4F8	0.0%	0.00			
0.6	2E	Production of halocarbons and SF6	CF4	0.0%	0.00			
38.3	2E	Production of halocarbons and SF6	HFC-125	0.0%	0.13			
6.5	2E	Production of halocarbons and SF6	HFC-134a	0.0%	0.01			
3.5	2E	Production of halocarbons and SF6	HFC-143a	0.0%	0.02			
0.0	2E	Production of halocarbons and SF6	HFC-152a	0.0%	0.00			
3.4	2E	Production of halocarbons and SF6	HFC-227ea	0.0%	0.01			
4.6	2E	Production of halocarbons and SF6	HFC-32	0.0%	0.00			
4.6	2E	Production of halocarbons and SF6	HFC-365mfc	0.0%	0.00			
3.4	2E	Production of halocarbons and SF6	NF3	0.0%	0.06			
203.6	2E	Production of halocarbons and SF6	SF6	0.4%	4.64	2E	2E.SF6	CRF
9,609.7	2E1	Production of F-gases (by-product)	HFC-23	11.7%	142.22	2E1	2E1.HFC-23	CRF
42,647.9	2F1a	Commercial refrigeration	HFC-125	12.2%	149.27	2F1a	2F1a.HFC-125	CRF
131,755.6	2F1a	Commercial refrigeration	HFC-134a	15.4%	188.41	2F1a	2F1a.HFC-134a	CRF
26,151.8	2F1a	Commercial refrigeration	HFC-143a	9.6%	116.90	2F1a	2F1a.HFC-143a	CRF
14,688.1	2F1a	Commercial refrigeration	HFC-152a	0.1%	1.82	2F1a	2F1a.HFC-152a	CRF
3,012.9	2F1a	Commercial refrigeration	HFC-227ea	0.8%	9.70	2F1a	2F1a.HFC-227ea	CRF
16.0	2F1a	Commercial refrigeration	HFC-236fa	0.0%	0.16	2F1a	2F1a.HFC-236fa	CRF
154.0	2F1a	Commercial refrigeration	HFC-245fa	0.0%	0.16	2F1a	2F1a.HFC-245fa	CRF
19,390.5	2F1a	Commercial refrigeration	HFC-32	1.1%	13.09	2F1a	2F1a.HFC-32	CRF
53.2	2F1b	Domestic refrigeration	HFC-125	0.0%	0.19	2F1b	2F1b.HFC-125	CRF
1,856.8	2F1b	Domestic refrigeration	HFC-134a	0.2%	2.66	2F1b	2F1b.HFC-134a	CRF
18.9	2F1b	Domestic refrigeration	HFC-143a	0.0%	0.08	2F1b	2F1b.HFC-143a	CRF
36.3	2F1b	Domestic refrigeration	HFC-32	0.0%	0.02	2F1b	2F1b.HFC-32	CRF
3,485.8	2F1c	Industrial refrigeration	HFC-125	1.0%	12.20	2F1c	2F1c.HFC-125	CRF
3,445.6	2F1c	Industrial refrigeration	HFC-134a	0.4%	4.93	2F1c	2F1c.HFC-134a	CRF
2,794.6	2F1c	Industrial refrigeration	HFC-143a	1.0%	12.49	2F1c	2F1c.HFC-143a	CRF
808.9	2F1c	Industrial refrigeration	HFC-32	0.0%	0.55	2F1c	2F1c.HFC-32	CRF
1,286.2	2F1d	Transport refrigeration	HFC-125	0.4%	4.50	2F1d	2F1d.HFC-125	CRF
1,566.0	2F1d	Transport refrigeration	HFC-134a	0.2%	2.24	2F1d	2F1d.HFC-134a	CRF
1,335.5	2F1d	Transport refrigeration	HFC-143a	0.5%	5.97	2F1d	2F1d.HFC-143a	CRF
91.7	2F1d	Transport refrigeration	HFC-32	0.0%	0.06	2F1d	2F1d.HFC-32	CRF
141.8	2F1e	Mobile Air Conditioning	HFC-125	0.0%	0.50	2F1e	2F1e.HFC-125	CRF
79,107.1	2F1e	Mobile Air Conditioning	HFC-134a	9.3%	113.12	2F1e	2F1e.HFC-134a	CRF
83.1	2F1e	Mobile Air Conditioning	HFC-143a	0.0%	0.37	2F1e	2F1e.HFC-143a	CRF
69.1	2F1e	Mobile Air Conditioning	HFC-32	0.0%	0.05	2F1e	2F1e.HFC-32	CRF
21,876.4	2F1f	Stationary Air Conditioning	HFC-125	6.3%	76.57	2F1f	2F1f.HFC-125	CRF
6,754.6	2F1f	Stationary Air Conditioning	HFC-134a	0.8%	9.66	2F1f	2F1f.HFC-134a	CRF
947.0	2F1f	Stationary Air Conditioning	HFC-143a	0.3%	3.50	2F1f	2F1f.HFC-143a	CRF
59.4	2F1f	Stationary Air Conditioning	HFC-236fa	0.0%	0.58	2F1f	2F1f.HFC-236fa	CRF
23,236.5	2F1f	Stationary Air Conditioning	HFC-32	1.3%	15.68	2F1f	2F1f.HFC-32	CRF
6,872.9	2F2a	Closed cell foam	HFC-134a	0.8%	9.83	2F2a	2F2a.HFC-134a	CRF
115.6	2F2a	Closed cell foam	HFC-227ea	0.0%	0.37	2F2a	2F2a.HFC-227ea	CRF
12,048.3	2F2a	Closed cell foam	HFC-245fa	1.0%	12.41	2F2a	2F2a.HFC-245fa	CRF
4,763.1	2F2a	Closed cell foam	HFC-365mfc	0.3%	3.78	2F2a	2F2a.HFC-365mfc	CRF
557.4	2F2b	Open cell foam	HFC-134a	0.1%	0.80	2F2b	2F2b.HFC-134a	CRF
941.4	2F2b	Open cell foam	HFC-152a	0.0%	0.12	2F2b	2F2b.HFC-152a	CRF
5.3	2F2b	Open cell foam	HFC-227ea	0.0%	0.02	2F2b	2F2b.HFC-227ea	CRF
127.3	2F2b	Open cell foam	HFC-245fa	0.0%	0.13	2F2b	2F2b.HFC-245fa	CRF
113.6	2F2b	Open cell foam	HFC-365mfc	0.0%	0.09	2F2b	2F2b.HFC-365mfc	CRF

Table D.3 EDGAR 6.0 Fast Track F-gas emissions: sources, proxies and data sources (continued).

2018	IPCC 96	IPCC category	F-gas	% CO_2eq	2018	Proxy	Proxy.gas	Proxy source
1.3	2F3	Fire Extinguishers	C4F10	0.0%	0.01	2F3	2F3.C4F10	CRF
13.7	2F3	Fire Extinguishers	c-C4F8	0.0%	0.14	2F3	2F3.c-C4F8	CRF
6.8	2F3	Fire Extinguishers	CF4	0.0%	0.05	2F3	2F3.CF4	CRF
318.4	2F3	Fire Extinguishers	HFC-125	0.1%	1.11	2F3	2F3.HFC-125	CRF
805.2	2F3	Fire Extinguishers	HFC-227ea	0.2%	2.59	2F3	2F3.HFC-227ea	CRF
21.9	2F3	Fire Extinguishers	HFC-23	0.0%	0.32	2F3	2F3.HFC-23	CRF
78.6	2F3	Fire Extinguishers	HFC-236fa	0.1%	0.77	2F3	2F3.HFC-236fa	CRF
12,341.5	2F4	Aerosols	HFC-134a	1.4%	17.65	2F4	2F4.HFC-134a	CRF
35,312.8	2F4	Aerosols	HFC-152a	0.4%	4.38	2F4	2F4.HFC-152a	CRF
2,580.2	2F4	Aerosols	HFC-227ea	0.7%	8.31	2F4	2F4.HFC-227ea	CRF
-	2F5	Solvents	C3F8	0.0%	-	2F5	2F5.C3F8	CRF
-	2F5	Solvents	CF4	0.0%	-	2F5	2F5.CF4	CRF
20.7	2F5	Solvents	HFC-125	0.0%	0.07	2F5	2F5.HFC-125	CRF
59.1	2F5	Solvents	HFC-134a	0.0%	0.08	2F5	2F5.HFC-134a	CRF
13.7	2F5	Solvents	HFC-143a	0.0%	0.06	2F5	2F5.HFC-143a	CRF
149.3	2F5	Solvents	HFC-365mfc	0.0%	0.12	2F5	2F5.HFC-365mfc	CRF
18.0	2F5	Solvents	HFC-43-10-mee	0.0%	0.03	2F5	2F5.HFC-43-10-mee	CRF
-	2F5	Solvents	C6F14	0.0%	-	2F5	2F5 .C6F14	CRF
898.5	2F6	Other ODS	HFC-125	0.3%	3.14	2F6	2F6.HFC-125	CRF
26.0	2F6	Other ODS	HFC-134	0.0%	0.03	2F6	2F6.HFC-134	CRF
8,189.4	2F6	Other ODS	HFC-134a	1.0%	11.71	2F6	2F6.HFC-134a	CRF
2.9	2F6	Other ODS	HFC-143	0.0%	0.00	2F6	2F6.HFC-143	CRF
743.1	2F6	Other ODS	HFC-143a	0.3%	3.32	2F6	2F6.HFC-143a	CRF
1,675.2	2F6	Other ODS	HFC-152a	0.0%	0.21	2F6	2F6.HFC-152a	CRF
35.1	2F6	Other ODS	HFC-227ea	0.0%	0.11	2F6	2F6.HFC-227ea	CRF
103.3	2F6	Other ODS	HFC-23	0.1%	1.53	2F6	2F6.HFC-23	CRF
0.2	2F6	Other ODS	HFC-236fa	0.0%	0.00	2F6	2F6.HFC-236fa	CRF
376.6	2F6	Other ODS	HFC-245fa	0.0%	0.39	2F6	2F6.HFC-245fa	CRF
448.4	2F6	Other ODS	HFC-32	0.0%	0.30	2F6	2F6.HFC-32	CRF
58.1	2F6	Other ODS	HFC-365mfc	0.0%	0.05	2F6	2F6.HFC-365mfc	CRF
30.4	2F6	Other ODS	HFC-41	0.0%	0.00	2F6	2F6.HFC-41	CRF
2.3	2F6	Other ODS	HFC-43-10-mee	0.0%	0.00	2F6	2F6.HFC-43-10-mee	CRF
281.9	2F7a	Semiconductor Manufacture	C2F6	0.3%	3.44	2F7a	2F7a.C2F6	CRF
50.1	2F7a	Semiconductor Manufacture	C3F8	0.0%	0.44	2F7a	2F7a.C3F8	CRF
62.1	2F7a	Semiconductor Manufacture	c-C4F8	0.1%	0.64	2F7a	2F7a.c-C4F8	CRF
672.7	2F7a	Semiconductor Manufacture	CF4	0.4%	4.91	2F7a	2F7a.CF4	CRF
0.0	2F7a	Semiconductor Manufacture	HFC-125	0.0%	0.00	2F7a	2F7a.HFC-125	CRF
61.9	2F7a	Semiconductor Manufacture	HFC-23	0.1%	0.92	2F7a	2F7a.HFC-23	CRF
0.7	2F7a	Semiconductor Manufacture	HFC-32	0.0%	0.00	2F7a	2F7a.HFC-32	CRF
117.3	2F7a	Semiconductor Manufacture	NF3	0.2%	2.02	2F7a	2F7a.NF3	CRF
87.8	2F7a	Semiconductor Manufacture	SF6	0.2%	2.00	2F7a	2F7a.SF6	CRF
17.7	2F7b	Flat Panel Display (FPD) Manufacture	CF4	0.0%	0.13	2F7b	2F7b.CF4	CRF
0.1	2F7b	Flat Panel Display (FPD) Manufacture	HFC-23	0.0%	0.00	2F7b	2F7b.HFC-23	CRF
21.5	2F7b	Flat Panel Display (FPD) Manufacture	NF3	0.0%	0.37	2F7b	2F7b.NF3	CRF
287.0	2F7b	Flat Panel Display (FPD) Manufacture	SF6	0.5%	6.54	2F7b	2F7b.SF6	CRF
46.0	2F7c	Photo Voltaic (PV) Cell Manufacture	C2F6	0.0%	0.56	2F7c	2F7c.C2F6	CRF
0.2	2F7c	Photo Voltaic (PV) Cell Manufacture	c-C4F8	0.0%	0.00	2F7c	2F7c.c-C4F8	CRF
1,165.5	2F7c	Photo Voltaic (PV) Cell Manufacture	CF4	0.7%	8.51	2F7c	2F7c.CF4	CRF
0.0	2F7c	Photo Voltaic (PV) Cell Manufacture	NF3	0.0%	0.00	2F7c	2F7c.NF3	CRF
0.1	2F7c	Photo Voltaic (PV) Cell Manufacture	SF6	0.0%	0.00	2F7c	2F7c.SF6	CRF
525.0	2F8a	Electrical Equipment Manufacture	SF6	1.0%	11.97	2F8a	2F8a.SF6	CRF
5,203.8	2F8b	Electrical Equipment Use (incl. site inst)	SF6	9.7%	118.65	2F8b	2F8b.SF6	CRF
0.1	2F9a	Adiabatic prop.: shoes and others	SF6	0.0%	0.00	2F9a	2F9a.SF6	CRF
168.8	2F9c	Soundproof windows	SF6	0.3%	3.85	2F9c	2F9c.SF6	CRF
1.5	2F9d	Accelerators/HEP	C2F6	0.0%	0.02			
1.9	2F9d	Accelerators/HEP	C3F8	0.0%	0.02			
3.1	2F9d	Accelerators/HEP	C4F10	0.0%	0.03			
61.5	2F9d	Accelerators/HEP	SF6	0.1%	1.40			
43.3	2F9e	Misc. (AWACS, other military and misc.)	SF6	0.1%	0.99			
1,600.0	2F9f	Unknown SF6 use	SF6	3.0%	36.48			

Notes on proxy sources for F-gases:

IAI (International Aluminium Institute) (primary aluminium production)

IAI 1) Excluding CF_4 from Low Voltage Anode Effects (LVAE). For more information see Appendix A.

CRF (Annex I emissions data from UNFCCC Locator tool)

For sources without proxy data the average trend in the last three years of the v6.0 dataset was used as estimator for the trend in 2019 and/or 2020.

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