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Trends and drivers of EU greenhouse gas emissions

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Executive summary

This report presents an overview of past greenhouse gas (GHG) emission trends and underpinning drivers in the European Union (EU) [1] between 1990 — the base year for reporting GHG emission inventories under the United Nations Framework Convention on Climate Change (UNFCCC) — and 2018, the latest year reported. It also provides a short summary of the results for 2018 compared with those for 2017. The analysis is mostly based on data reported by the 27 EU Member States (EU-27), Iceland and the United Kingdom as part of the preparation of the European Union's GHG inventory under the UNFCCC and its Kyoto Protocol (KP).

The analysis in this report does not yet take into account the effects of the COVID-19 pandemic on GHG emissions, which will be substantial. Preliminary estimates of total GHG emissions in the EU in 2020, based on official reporting by Member States, will only be available in the autumn of 2021, as part of the approximated GHG inventories for 2020. The national GHG inventories under the UNFCCC covering the time series 1990-2020 will be available on 15 April 2022 [2].

Key messages

- ***Greenhouse gas emissions continue to decrease in absolute terms, per capita and per Euro generated in the economy***

  The EU reduced its GHG emissions again in 2018, to reach the lowest level since 1990. Total GHG emissions decreased by 23.2 % and stood at 4 392 million tonnes of carbon dioxide equivalent ($MtCO_2e$) for the EU-27 plus the United Kingdom in 2018. The figure for the EU without the UK would be 20.7 % over the 28-year period. The EU accounted for less than 8 % of global GHG emissions in 2018, compared with 15 % in 1990. The average EU citizen emitted 8.9 tonnes of CO_2e (tCO_2e), down from 12.2 tCO_2e in 1990, and the total GHG intensity of the EU economy more than halved during the period. The EU emitted 277 grams of CO_2 (gCO_2e) for each Euro generated in the economy in 2018, compared with 582 gCO_2 per Euro in 1990.

- ***Most sectors reduced emissions in the past three decades, with the notable exception of transportation where demand outpaces climate-policy benefits***

  GHG emissions decreased in the majority of sectors between 1990 and 2018, and particularly in energy supply, industry and the residential sector. When allocating emissions from the energy supply sector to final end users, sectoral emission trends confirm that the largest energy-related emission reductions took place in industry and the residential sector. Emissions from agriculture and waste management have also contributed to the positive trend since 1990. Emissions from road transportation increased, both for passsenger and freight transport, in spite of climate policies and the deployment of less carbon intensive and more efficent vehicles on the market.

  Elsewhere, increasing demand has outpaced climate benefits. Hydrofluorocarbon (HFC) emissions from refrigeration and air conditioning also increased overall during the 28-year period but have decreased for the fourth consecutive year since 2014 because of the phase down of F-gases demanded by EU legislation. Of the net EU reduction in total GHG emissions between 2005 and 2018, two thirds was accounted for by the EU

(1) The United Kingdom left the EU on 1 February 2020 but will apply EU law until the end of the transition period. Key provisions of Regulation (EU) No 525/2013 (*Mechanism for Monitoring and Reporting GHG emissions*) apply to the United Kingdom in respect of greenhouse gases emitted during 2019 and 2020.

(2) For an overview of the different GHG emission estimates published regularly by bodies of the EU, see https://www.eea.europa.eu/themes/climate/different-emission-estimates/emission-estimates-produced-by-eu.

(3) https://ec.europa.eu/clima/policies/ets_en

emissions trading system (3). The final third was covered by sectors not covered under the ETS, which fall under the Effort sharing legislation (4), where national targets apply. Electricity and heat production under the ETS and road transportation under the Effort sharing legislation remain the largest sources of GHG emissions in the EU.

- ***Many factors and policies have contributed to lower greenhouse emissions, but much faster emission reductions will be needed to achieve climate neutrality by 2050***

  The reduction in GHG emissions since 1990 can be attributed to a combination of economic factors and the implementation of policies and measures. These include improvements in the carbon intensity of energy production and consumption resulting from the strong uptake of renewables and the switch to less carbon intensive fossil fuels, as well as improvements in the gross energy intensity of the economy, triggered by better energy efficiency, both in transformation and end-use. Despite these positive trends, fossil fuels are still the largest source of energy and emissions in the EU. Decarbonising the EU economy will require substantial additional GHG emission reductions in the next 30 years if the EU is to become a climate neutral economy by 2050. The effort required to achieve net-zero emissions by 2050 could imply a tripling of the mitigation efforts achieved to date, in a sustained manner, over the next 30 years.

- ***Integrated policies and sustainable green investments are key for reaching long-term climate objectives***

  Meeting the climate change challenge does not necessarily mean a trade-off with other environmental and socio-economic policies. The EU has been able to reduce GHG emissions, improve energy efficiency and achieve higher shares of renewable energies while increasing economic growth and employment. The objectives of the European Green Deal and the just transition to a green economy, based on solidarity and fairness (5), represent an opportunity for stronger integrated policies and long-term green investments. These will enable the EU and its Member States to achieve their long-term climate and sustainable development objectives.

(4) https://ec.europa.eu/clima/policies/effort_en
(5) https://ec.europa.eu/info/news/launching-just-transition-mechanism-green-transition-based-solidarity-and-fairness-2020-jan-15_en

1 Results from the EU greenhouse gas inventory for 2018

The latest GHG inventory prepared by the EU (see Box 1) and submitted to the UNFCCC shows that, in 2018, total GHG emissions (excluding land use, land use change and forestry (LULUCF)) [6] decreased by 92.6 million tonnes or 2.1 % compared to 2017, to reach 4 392 $MtCO_2e$ in 2018. This decrease in emissions came with an increase in GDP of 2.0 %. Germany and France accounted for more than half of the net reduction in GHG emissions in absolute terms in the EU in 2018. The decrease without the UK was 83.6 million tonnes, to reach 3 893 $MtCO_2e$ in 2018.

At the EU level, two thirds of the net reduction in GHG emissions in 2018 took place in main activity producers of heat and electricity, including combined heat and power. Emissions from the combustion of solid fuels for power generation decreased by almost 50 million tonnes in 2018 compared with 2017. Natural gas input to power stations also decreased, with emission levels 14 million tonnes below those of 2017. In addition, the use of renewable energy sources in electricity generation increased again in 2018, thus underpinning the ongoing decarbonisation trend in the sector.

Although less substantially than in the power sector, in 2018 GHG emissions also decreased in residential buildings, refrigeration and air conditioning, petroleum refining and agricultural soils. In particular, HFC emissions from refrigeration and air conditioning decreased for the fourth consecutive year since 2014. Carbon dioxide emissions from road transport remained broadly stable in 2018, compared with 2017, after four consecutive years of increases since 2013. This was a result of lower diesel consumption in passenger cars, where emissions decreased for the first time since 2012. The overall 2.1 % net decrease in total GHG emissions in 2018 was partly offset by higher emissions from manufacturing industries and construction.

In terms of fuels, there was a significant decrease in the use of fossil fuels in the energy sector — particularly solid fuels, but also gaseous (natural gas) and liquid fossil fuels. Based on Eurostat data [7], there was a decline in nuclear energy in 2018, in parallel with a strong increase in the use of renewable energy sources, both in terms of primary and final energy.

Overall, the energy intensity of the economy and the carbon intensity of energy production and consumption decreased again in 2018. These were largely driven by lower transformation losses and better energy efficiency on the one hand, and by the higher share of renewables in the fuel mix, compared to fossil fuels, on the other.

(6) Unless otherwise stated, total GHG emissions in this report exclude emissions and sinks from the land use, land use change and forestry sector, and include emissions from international aviation. Indirect CO_2 emissions from the atmospheric oxidation of methane (CH_4), carbon monoxide (CO), and non-methane volatile organic compounds (NMVOCs) are also included in the emission totals.

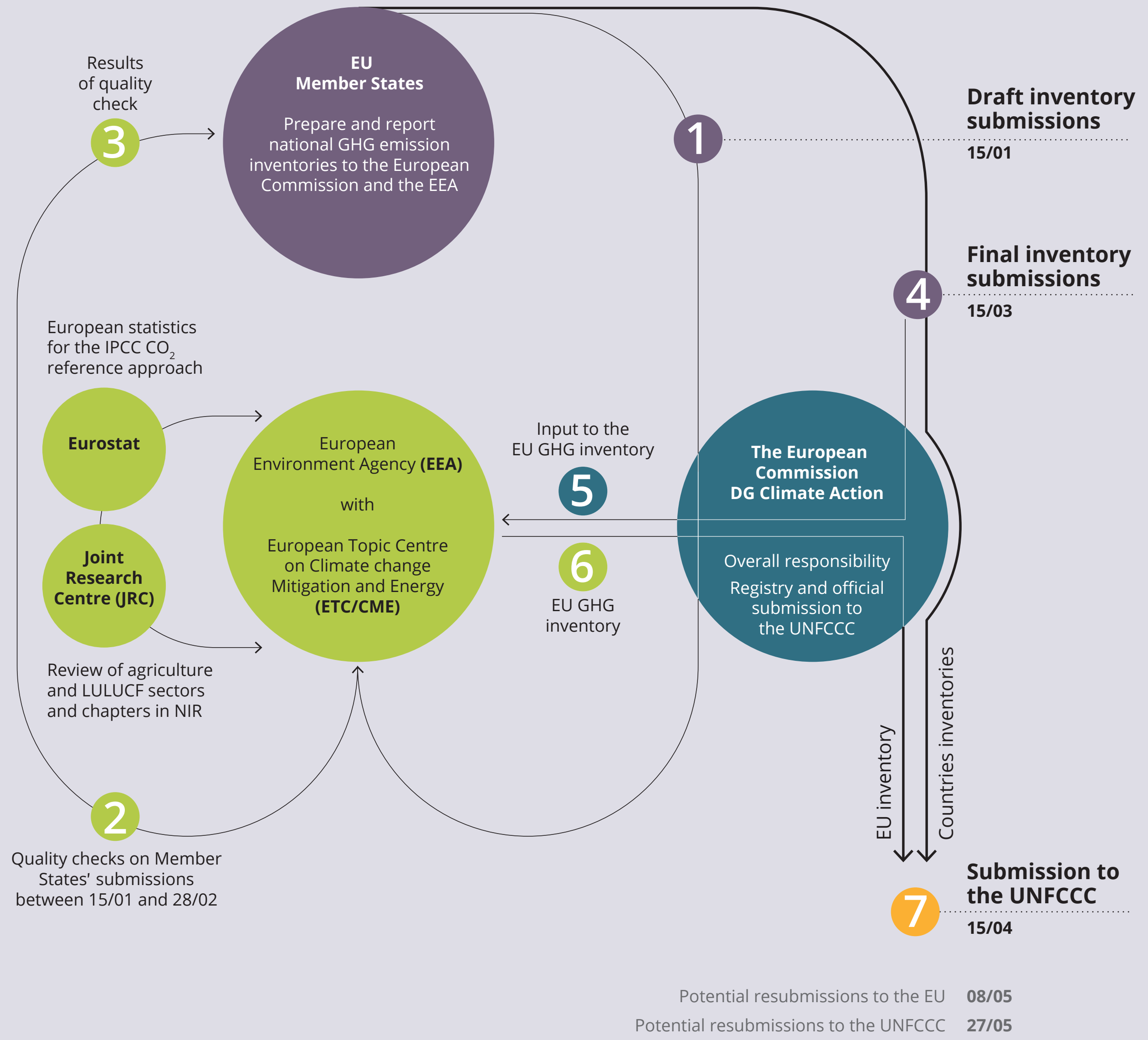
(7) Energy balances (nrg_bal), Eurostat; https://ec.europa.eu/eurostat/data/database

Box 1.1 Institutional arrangements for the preparation of the EU greenhouse gas inventory

In accordance with the EU's Monitoring Mechanism Regulation, an EU inventory system has been established to ensure the timeliness, transparency, accuracy, consistency, comparability and completeness of national inventories with regard to the EU GHG inventory. The EU GHG inventory is a collective effort between the different EU institutions involved in the preparation and quality assurance/quality control (QA/QC) of Member States' GHG inventories (Figure 1.1).

The main pillars of the system are: 1) a legal reporting basis that is fully consistent with international reporting requirements and an institutional basis (i.e. who does what, when and how); 2) the QA/QC programme (how we implement quality assurance and quality control procedures); and 3) the effective cooperation with EU Member States via a working group established by the European Commission, which meets regularly to discuss the ongoing preparation of the EU inventory, the review process and the implementation of improvements.

Figure 1.1 The EU's greenhouse gas inventory system



The three pillars of a robust EU monitoring, reporting and verification system for greenhouse gas inventories:	**Legal reporting basis**, fully consistent with the requirements of the UNFCCC and Kyoto Protocol (EU MMR - 525/2013)	**Institutional basis:** Union greenhouse gas inventory system and QA/QC programme [SWD(2013)308]	**Effective cooperation** between the EU and Member States via Working Group I of the Climate Change Committee 'Greenhouse gas inventories'

Source: EEA.

2 Overall greenhouse gas emission trends and key statistics

The 2015 Paris Agreement (8) sets out a global action plan to keep global temperature rise to well below 2 °C above pre-industrial levels and to drive efforts to limit the increase to 1.5 °C. It is the first multilateral agreement on climate change, covering almost all global emissions.

Based on data from the Joint Research Centre's (JRC) EDGAR database (9), the EU's total GHG emissions peaked in 1979, decreased until 1983 and increased again until 1989. The EU then followed a path of lower emissions in the early 1990s, in the aftermath of German re-unification and the restructuring of industry in eastern Europe. There have been several factors contributing to lower GHG emissions in the past three decades, including the strong uptake of renewable energy sources, the switch from coal to gas for heat and power generation, and improvements in energy efficiency. Structural changes in EU economies — leading to a less energy-intensive services sector — as well as the effects of economic recession have also contributed to lower GHG emissions in the EU. Finally, the effects of policies and measures helped to reduce emissions and provide the basis for further emission reductions in the future. Some of these factors will be analysed in more detail in the following sections.

In the past 28 years, total GHG emissions in the EU-27 plus the United Kingdom decreased by 1 330 million tonnes of CO_2e. The block emitted 4 392 million tonnes of CO_2e in 2018 — the lowest level since GHG inventory reporting to the UNFCCC — which is 23.2 % less than in 1990. The total reduction, including international navigation emissions, which are not included in the EU's current emission targets, over the 28-year period was 1 291 million tonnes of CO_2e or 22.1 % less than 1990 emission levels (Table 2.1).

Table 2.1 Percentage total greenhouse gas emission reductions in the past 28 years

Reporting scope	UNFCCC inventory	Kyoto Protocol	EU-target scope (2020 and 2030)	Information item (no agreed scope)
Sectoral scope	Total GHGs excluding LULUCF	Total GHGs (accounting rules for LULUCF)	Includes international aviation	Includes international aviation and international navigation
Reference year	1990	Fixed base year	1990	1990
Comparison year	2018	Average emissions 2013-2018	2018	2018
EU-27 plus United Kingdom	-25.2 %	-	-23.2 %	-22.1 %
EU-27 plus United Kingdom and Iceland (EU-KP)	-	-26.2 %	-	-
EU-27 (European Union)	-22.5 %	-	-20.7 %	-19.6 %

Note: Total GHG emission reductions in this table include all GHG gases not controlled under the Montreal Protocol, including also indirect CO_2 emissions from the atmospheric oxidation of CH_4, CO, and NMVOCs. Items that are colour-highlighted represent the relevant reductions according to the current reporting provisions under EU and international legislation at the time of publication of this report. The other emission reductions are presented for information purposes. There are specific accounting rules for LULUCF under the Kyoto Protocol and the EU 2030 target. The EU's base year emissions under the Kyoto Protocol are 5 875 692 700 tonnes of CO_2e, including GHG emissions from deforestation in 1990. Compliance will be calculated as the average emissions in the period 2013-2020 compared to the base year, taking into account the agreed accounting rules in the LULUCF sector.

Source: EEA.

(8) https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
(9) http://edgar.jrc.ec.europa.eu

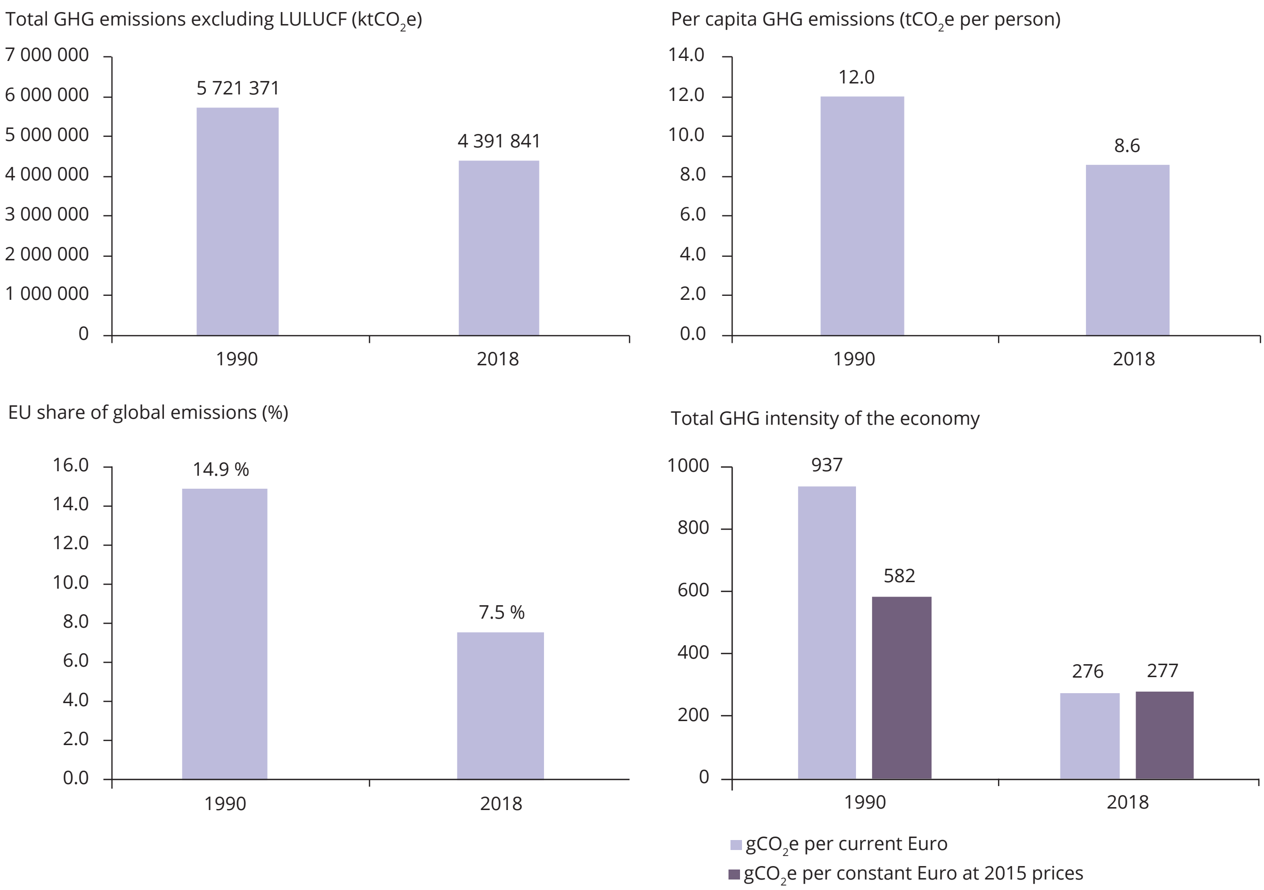
Excluding the United Kingdom, total GHG emissions decreased by 1 019 million tonnes of CO_2e, or 20.7 %, between 1990 and 2018, to reach 3 893 million tonnes of CO_2e in 2018. The reduction including international navigation over the 28-year period was 982 million tonnes of CO_2e, or 19.6 % below 1990 levels.

Based on data from the JRC's EDGAR database and the EEA's own calculations, the EU-27 plus the United Kingdom accounted for less than 8 % of global GHG emissions, down from 15 % in 1990. The average citizen emitted 8.9 tCO_2e in 2018, against 12.2 tonnes of CO_2e in 1990. These numbers also include international aviation and international navigation. GHG emissions per capita vary widely between European countries, partly reflecting differences in the fuel mix for the conversion of primary fuels to heat and electricity. In addition, the total GHG intensity of the economy halved in real terms between 1990 and 2018, reaching an average of 277 gCO_2e per Euro (Figure 2.1).

The European Union (i.e. excluding the United Kingdom) accounted for less than 7 % of global GHG emissions in 2018, down from 13 % in 1990. The average EU citizen emitted 8.7 tCO_2e in 2018, compared to 11.7 tonnes of CO_2e in 1990. Finally, the total GHG intensity of the EU economy has halved in real terms since 1990, reaching an average of 298 gCO_2e per Euro in 2018.

The EU is the sum of its Member States, most of which have reduced their emissions since 1990. Almost 50 % of the EU net decrease in emissions was accounted for by Germany and the United Kingdom (Table 2.2). The overall net GHG emission reductions by most Member States were partly offset by increased GHG emissions in a few of them. Table 2.2 also shows that, in spite of emissions increasing in some countries, all have improvements in the carbon intensity of energy production and consumption, as well as in the energy intensity of their economies in common during the period 1990-2018.

Figure 2.1 Key greenhouse gas emission statistics in the EU-27 plus the United Kingdom



Note: EEA calculations based on the 2020 EU GHG inventory submission to the UNFCCC (EEA); population statistics for EU (Eurostat), economic accounts (European Commission AMECO database), global population and economic statistics (World Bank); global estimates of CO_2 and GHG emissions (JRC EDGAR database). Total GHG emissions exclude emissions from LULUCF and include international aviation and indirect CO_2.

Source: EEA.

Table 2.2 Country comparison — climate mitigation variables and indicators by country

	Total GHG emissions in 2018 ($MtCO_2e$)	Change in total GHG emissions, 1990-2018 ($MtCO_2e$)	Change in total GHG emissions, 1990-2018 (percentage change)	GHG emissions per GDP in 2018 (PPS, EU=100)	GHG intensity of the economy in 2018 (gCO_2e per Euro)	GHG emissions per capita in 2018 (tCO_2e per person)	Change in the carbon intensity of energy 1990-2018 (percentage change)	Change in the energy intensity of the economy 1990-2018 (percentage change)
Austria	81.5	2.1	2.7 %	83	211	9.2	-20.6 %	-21.1 %
Belgium	123.6	-25.9	-17.3 %	105	269	10.8	-24.3 %	-32.2 %
Bulgaria	58.6	-43.9	-42.8 %	187	1045	8.3	-13.2 %	-54.7 %
Croatia	24.4	-8.0	-24.8 %	108	472	6.0	-15.1 %	-24.3 %
Cyprus	9.9	3.4	53.8 %	145	466	11.3	-1.5 %	-30.8 %
Czechia	129.4	-70.2	-35.2 %	153	623	12.2	-30.4 %	-49.7 %
Denmark	51.3	-21.3	-29.3 %	79	170	8.9	-33.8 %	-36.6 %
Estonia	20.2	-20.2	-50.0 %	214	775	15.3	-25.3 %	-63.4 %
Finland	58.8	-13.4	-18.6 %	110	252	10.7	-32.8 %	-24.8 %
France	462.8	-94.1	-16.9 %	76	197	6.9	-24.8 %	-27.2 %
Germany	888.7	-372.9	-29.6 %	100	266	10.7	-19.1 %	-42.2 %
Greece	96.1	-9.7	-9.2 %	150	520	9.0	-16.0 %	-16.7 %
Hungary	64.1	-30.4	-32.2 %	106	479	6.6	-26.7 %	-41.8 %
Ireland	64.2	7.7	13.6 %	80	198	13.2	-13.9 %	-67.0 %
Italy	439.3	-81.1	-15.6 %	86	249	7.3	-21.5 %	-12.9 %
Latvia	12.2	-14.4	-54.1 %	105	420	6.3	-30.7 %	-53.7 %
Lithuania	20.6	-27.8	-57.4 %	105	456	7.4	-20.7 %	-68.9 %
Luxembourg	12.4	-0.8	-5.8 %	89	206	20.3	-20.4 %	-52.0 %
Malta	2.7	-0.1	-3.9 %	64	215	5.5	-29.4 %	-65.7 %
Netherlands	200.5	-25.8	-11.4 %	103	259	11.6	-9.2 %	-36.4 %
Poland	415.9	-59.9	-12.6 %	175	836	11.0	-12.8 %	-63.1 %
Portugal	71.6	11.4	18.9 %	103	350	7.0	-10.4 %	-7.2 %
Romania	116.5	-132.3	-53.2 %	104	569	6.0	-17.4 %	-70.9 %
Slovakia	43.5	-30.1	-40.8 %	125	485	8.0	-34.6 %	-65.2 %
Slovenia	17.6	-1.1	-5.7 %	112	385	8.5	-18.6 %	-33.2 %
Spain	352.2	58.1	19.7 %	95	293	7.5	-15.6 %	-16.1 %
Sweden	54.6	-17.9	-24.7 %	51	116	5.4	-31.4 %	-41.9 %
United Kingdom	498.7	-311.0	-38.4 %	81	206	7.5	-25.5 %	-50.1 %
EU-27 plus United Kingdom	**4 391.8**	**-1 329.5**	**-23.2 %**	**97**	**276**	**8.6**	**-21.8 %**	**-38.4 %**
European Union	**3 893.1**	**-1 018.5**	**-20.7 %**	**100**	**289**	**8.7**	**-21.1 %**	**-36.2 %**

Note: The year 1990 is used as the reference year to show trends in GHG emissions on a comparable basis for all Member States and to assess progress towards the EU 2020 and 2030 targets. These data should not be used to assess the achievement of climate mitigation targets of individual Member States. GHG data are based on the 2020 GHG inventory submissions to the UNFCCC. The source of GDP data is the European Commission's AMECO database. Where gaps were present, gross domestic product (GDP) was estimated based on trends in the data reported to the World Bank. The purchasing power standard (PPS) is an artificial common currency unit that normalizes price level differences between countries. Underpinning energy and population data are from Eurostat. GHG aggregates exclude the LULUCF sector and include international aviation. The latter are excluded from the scope under the UNFCCC and Kyoto Protocol, but are included here because the EU's 2020 and 2030 targets include international aviation.

Source: EEA.

3 Sectoral trends and key emission sources

This section presents EU emission trends by sector from three different perspectives: 1) GHG emission trends as reported in national GHG inventories; 2) GHG emission trends in the EU ETS and Effort sharing sectors; and 3) GHG emission trends from the end-user perspective for the energy sector.

3.1 Emission trends by sector in greenhouse gas inventories

GHG emissions decreased in the majority of sectors between 1990 and 2018, with the exception of transportation (Figure 3.1). The largest decrease in emissions in absolute terms occurred in energy supply and industry, although agriculture, residential and commercial (i.e. buildings), and waste management have all contributed to the positive trend in GHG emissions since 1990. The figure also shows the increase in CO_2 emissions from bioenergy combustion. Although net removals from LULUCF increased over the period, the strong increase in CO_2 emissions from bioenergy highlights the rapidly increasing importance of bioenergy in replacing fossil fuel sources in the EU.

At the level of key emission sources reported in GHG inventories, the largest emission reductions took place in the manufacturing industries and construction, electricity and heat production, iron and steel production, and residential sectors (Table 3.1). The largest decrease in emissions in relative terms occurred in waste management, through reduced and better controlled landfilling. Emissions from HFCs (until recently) and road transport increased substantially over the 28-year period. International transport emissions have also increased signficantly since 1990 [10].

In terms of the main GHGs, CO_2 reductions contributed most to the reduction in emissions since 1990. Reductions in emissions from nitrous oxide (N_2O) and CH_4 have been substantial, reflecting inter alia:

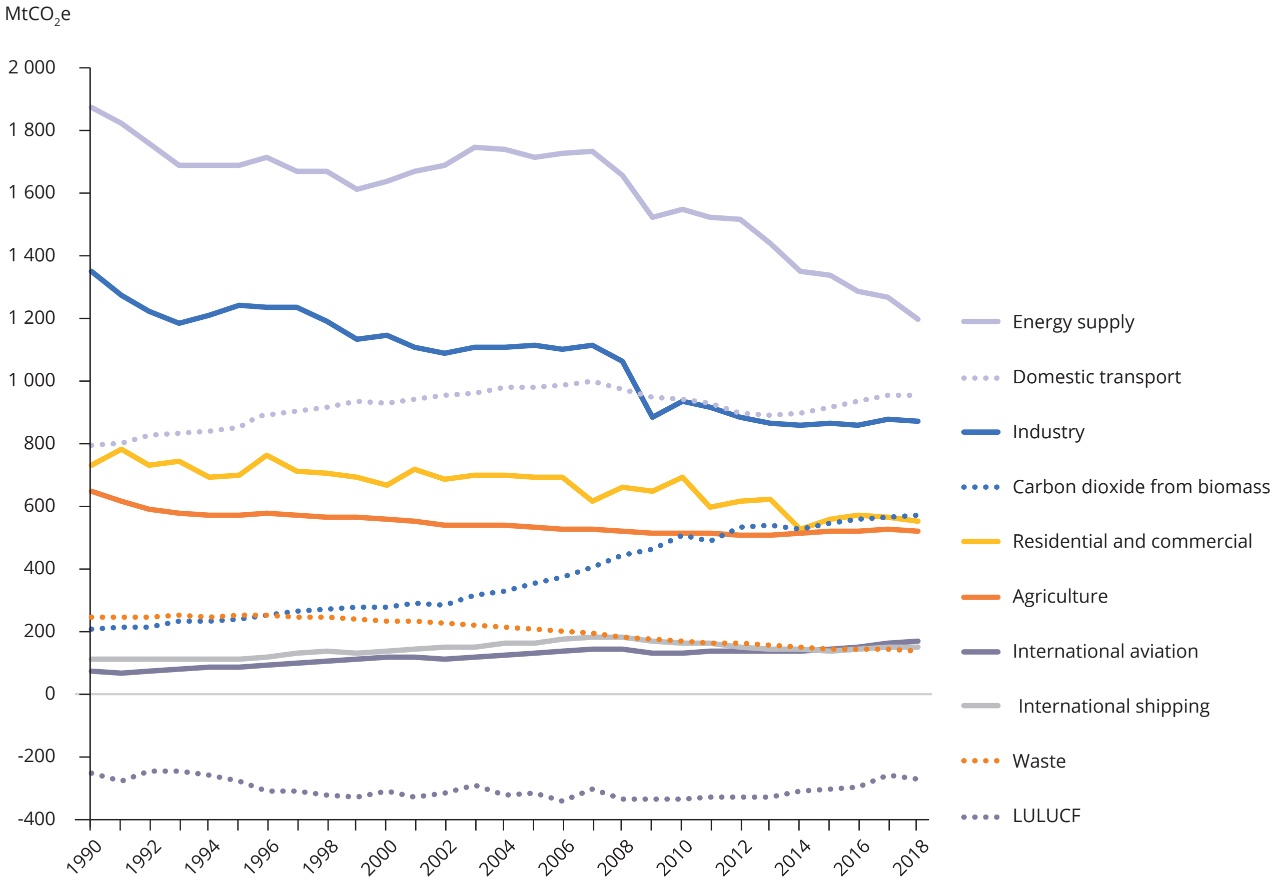
- for CH_4: lower levels of mining activities, improvements in technology and pipeline networks, lower agricultural livestock and enteric fermentation from cattle, lower emissions from managed biodegradable waste disposal on land and intensified separate collection, recycling and landfill-gas recovery; and
- for N_2O: reduced adipic and nitric acid production.

Although N_2O emissions from agricultural soils have decreased over the 28-year period, recent years have seen an increase in these emissions at the EU level, mostly due to the intensified use of inorganic fertilisers on cropland and grassland.

A combination of factors explains lower emissions in industrial sectors. These include improved efficiency and carbon intensity as well as structural changes in the economy, with a higher share of services and a lower share of more-energy-intensive industry in total GDP. The economic recession that began in the second half of 2008 and continued into 2009 also had a lasting impact on emissions from industrial sectors. Emissions from electricity and heat production have decreased strongly since 1990. In addition to improved energy efficiency, there has been a move towards less carbon intensive fuels. Between 1990 and 2018, the use of solid and liquid fuels in thermal stations decreased strongly, whereas natural gas consumption doubled, resulting in reduced CO_2 emissions per unit of fossil fuel energy generated. Emissions in the residential sector also represented one of the largest reductions at EU level. Energy efficiency improvements from better insulation standards in buildings and a less carbon-intensive fuel mix can partly explain lower demand for space heating in the EU as a whole over the past 28 years. Since 1990, there has been, on average, a warming of autumns/winters in Europe, although there is high regional variability.

(10) International aviation is included in the EU's 2020 and 2030 targets, although both international aviation and international navigation are excluded from the targets under the Kyoto Protocol.

Figure 3.1 Greenhouse gas emissions by main sector in the EU-27 plus United Kingdom



Note: The sectoral aggregations are: Energy supply: CRF 1A1 (energy industries) + 1B (fugitives); Industry: CRF 1A2 (manufacturing industries and construction) + CRF 2 (industrial processes and product use); Transport: CRF 1.A.3; Residential and commercial: CRF 1A4a (commercial) + CRF 1A4b (residential); Agriculture: CRF 1A4c (agriculture, forestry and fishing) + CRF 3 (agriculture); Waste: CRF 5 (waste); LULUCF: CRF 4 (LULUCF). International aviation, international shipping and CO2 biomass are Memorandum items, reported separately from other emission sources and sinks, and not included in national GHG inventory totals. CO_2 emissions from the combustion of biomass are not included in national GHG emission totals according to UNFCCC Reporting Guidelines. They are reported separately in GHG inventories as a Memorandum item. This is mainly to avoid double counting emissions from a reporting perspective. It should not be linked to sustainability and/or to carbon neutrality. The assumption is that harvesting does not outpace annual regrowth, and that unsustainable biomass production would show as a loss of biomass stock in the LULUCF sector.

Source: EEA.

The increase in HFC emissions used for refrigeration and air conditioning until 2014 was a negative side effect of the implementation of the Montreal Protocol on ozone depleting substances and the banning of CFCs, which were replaced by Kyoto HFCs. However, HFC emissions from refrigeration and air conditioning have decreased for the fourth consecutive year since 2014, as a consequence of the phase down and the system of annual quotas allocated to producers and importers of F-gases according to the EU F-gas Regulation ([11]). Emissions from road transportation also increased since 1990, both for passenger and freight transport, in spite of climate policies and the deployment of less carbon intensive and more efficent vehicles on the market. After the temporary decrease in transport emissions resulting from the 2008/09 economic crisis, emissions have continued to increase because of increasing transport demand. Moreover, the CO_2 emissions per km for newly registered vehicles has increased in the last two

([11]) For relevant information related to F-gases, see: *Fluorinated greenhouse gases 2019*, EEA Report No 20/2019 https://www.eea.europa.eu/publications/fluorinated-greenhouse-gases-2019; Emissions and supply of fluorinated greenhouse gases in Europe, EEA F-gas indicator, https://www.eea.europa.eu/data-and-maps/indicators/emissions-and-consumption-of-fluorinated-2/assessment-2.

Table 3.1 Change in absolute greenhouse gas emissions in the EU (Kyoto Protocol scope) by key source category, 1990-2018

Source category	$MtCO_2e$
Road transportation (CO_2 from 1.A.3.b)	172
Refrigeration and air conditioning (HFCs from 2.F.1)	86
Aluminium production (PFCs from 2.C.3)	-21
Cement production (CO_2 from 2.A.1)	-25
Agricultural soils: Direct N_2O emissions (N_2O from 3.D.1)	-25
Fluorochemical production (HFCs from 2.B.9)	-27
Fugitive emissions from oil and natural gas (CH_4 from 1.B.2)	-38
Fuels used commercial/institutional sector (CO_2 from 1.A.4.a)	-41
Enteric fermentation: Cattle (CH_4 from 3.A.1)	-44
Nitric acid production (N_2O from 2.B.2)	-46
Adipic acid production (N_2O from 2.B.3)	-57
Manufacture of solid fuels and other energy industries (CO_2 from 1.A.1.c)	-61
Fugitive emissions from solid fuels (CH_4 from 1.B.1)	-68
Managed waste disposal sites (CH_4 from 5.A.1)	-72
Iron and steel production (CO_2 from 1.A.2.a + 2.C.1)	-115
Fuels used residential sector (CO_2 from 1.A.4.b)	-134
Manufacturing industries (excluding iron and steel) (energy-related CO_2 from 1.A.2 excl. 1.A.2.a)	-248
Public electricity and heat production (CO_2 from 1.A.1.a)	-497
Memo items:	
International aviation (CO_2 from 1.D.1.a)	97
International navigation (CO_2 from 1.D.1.b)	38
Totals	
Total GHGs [excluding LULUCF, excluding international transport]	**-1 425**
Total GHGs [excluding LULUCF, including international aviation]	**-1 327**

Note: The table shows changes in emissions that have increased or decreased by more than 20 million tonnes CO_2e in the period 1990-2018. GHG emissions shown in this table include Iceland as they correspond to the scope of the EU's GHG inventory submission under the Kyoto Protocol.

Source: EU GHG inventory submission to UNFCCC 2020, EEA.

years in the EU ([12]). This was because of more sales of gasoline cars relative to diesel, as well as bigger cars being sold on average in the EU. The transport sector represents a challenge for Member States and the achievement of the 2030 targets under the EU Effort sharing legislation, since transport accounts for about one third of emissions covered by the sectors where national mitigation targets apply.

Registrations of battery electric vehicles are, however, increasing rapidly. A typical electric car produces less greenhouse gases and air pollutants compared with petrol and diesel combustion engines over the entire vehicle life cycle ([13]). Increased use of electric vehicles together with further improvements in the carbon intensity of the fuel mix for electricity generation can lead to substantial reductions in GHG emissions in the transport sector.

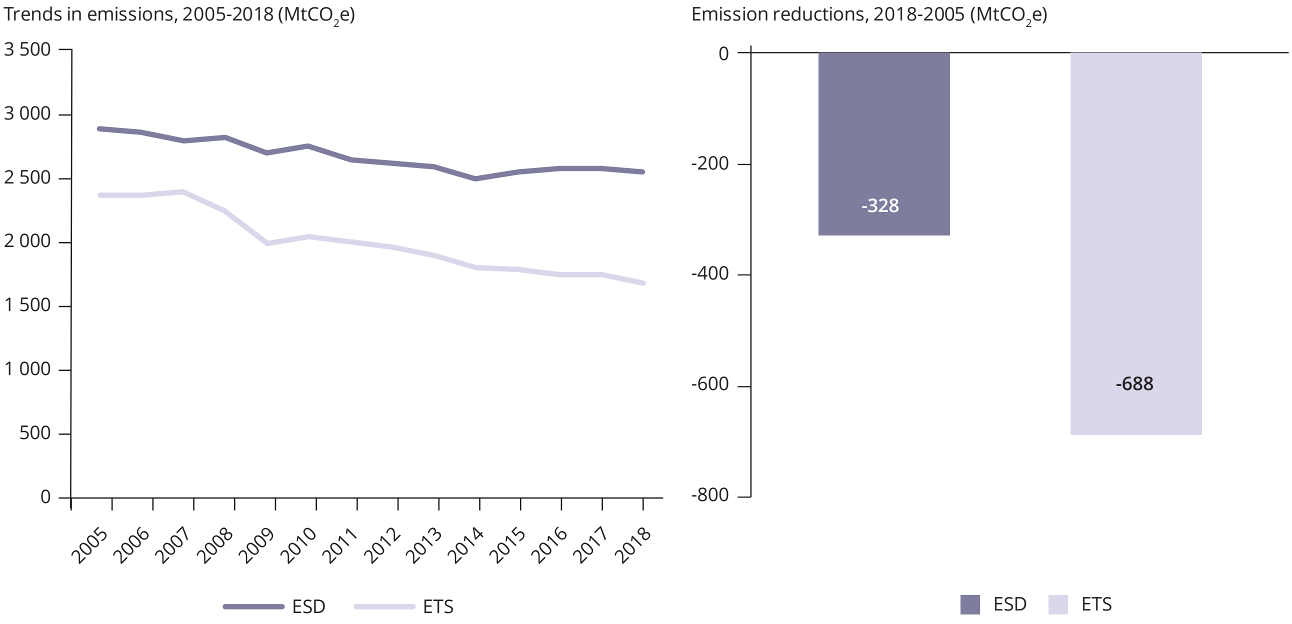
([12]) https://www.eea.europa.eu/highlights/average-co2-emissions-from-new
([13]) *Electric vehicles from life cycle and circular economy perspectives*, EEA Report No 13/2018; https://www.eea.europa.eu/publications/electric-vehicles-from-life-cycle.

3.2 Greenhouse gas emission trends in the Emissions trading system and the Effort sharing sectors

The EU's climate mitigation policy until 2020 is largely based on a distinction between GHG emissions from large stationary sources, which are currently governed by the EU ETS, and emissions from sectors covered by the Effort sharing decision (ESD) ([14]). Between 2005 and 2018, stationary emissions covered under the EU ETS have decreased more rapidly than those from sectors not covered (Figure 3.2). Of the net EU reduction in total GHG emissions between 2005 and 2018, two thirds were accounted for by the ETS, and one third by the sectors not covered under the ETS.

ETS emissions have decreased at a faster rate than non-ETS emissions, with the exception of the period between 2005 and 2007, when there was a strong consumption of hard coal and lignite for power generation. The reduction in emissions in the trading sectors between 2005 and 2018 doubled the reduction in emissions in the sectors covered by the ESD (Figure 3.2). Decreasing ETS emissions have been largely driven by lower emissions from combustion installations, mostly power plants. The emission reductions in power generation were due to a decrease in the use of hard coal and lignite fuels, better and more efficient installations and a substantial increase in electricity generation from renewables ([15]). Combustion installations remain the main source of emissions in the EU ETS

Figure 3.2 Greenhouse gas emissions in the Emissions trading system (excluding aviation) and Effort sharing sectors in the EU-27 plus the United Kingdom



Note: ESD emissions have been estimated from total GHG inventory emissions including indirect CO_2, and excluding domestic aviation, nitrogen trifluoride and verified emissions from stationary installations under the EU ETS. The ETS emissions for the years 2005-2012 reflect the current ETS scope, to allow for a consistent-trend comparison for the period 2005-2018.

Sources: GHG data viewer and EU ETS data viewer, EEA.

([14]) For the ETS, there is an overall decreasing cap for the period 2013-2020, which puts a limit on emissions from installations by setting the maximum amount of allowed emissions during the 8-year period. For the ESD sectors, there are binding annual greenhouse gas emission targets for Member States for the period 2013-2020. The sectors falling under the scope of the Effort sharing legislation currently represent about 60 % of total greenhouse gas emissions in the EU, and broadly include residential and commercial (buildings), transport, waste management, agriculture and the part of industry not covered by the ETS.

([15]) *Trends and projections in Europe 2019: Tracking progress towards Europe's climate and energy targets*, EEA Report No 15/2019; https://www.eea.europa.eu/publications/trends-and-projections-in-europe-1.

and represented two thirds of all emissions from stationary installations in 2018.

3.3 Energy related greenhouse gas emissions from the end-user perspective

Sectoral trends in GHG emissions have traditionally been based on the classification used in UNFCCC reporting. This internationally agreed reporting system requires Annex I Parties to estimate and report (territorial) GHG emissions using UNFCCC guidelines and IPCC methods.

GHG emissions for the energy sector consist of two main blocks: energy combustion and fugitive emissions. For reporting purposes, the main combustion categories are: energy industries, manufacturing and construction, residential, commercial and agriculture/fishing/forestry. This means that, for example, emissions from coal combustion installations to deliver heat and electricity to the residential sector are reported under energy industries, whereas emissions from the burning of coal in a stove by a household would be reported under emissions from the residential sector. The official sectoral breakdown used by the UNFCCC provides no information on emissions from energy industries by end user.

In 2012, the EEA published the report *End-user GHG emissions from energy — Reallocation of emissions from energy industries to end users 2005*–2010 ([16]). The report developed a methodology to redistribute emissions from the production of heat, electricity and refined oil products by energy-transformation industries to the final users of that energy (e.g. industry, transport, residential, commercial and agriculture) ([17]). This work is being updated during 2019 and 2020, and preliminary information is shown in Figure 3.3.

This approach helps improve the understanding of past GHG emission trends in the energy sector from the demand or end-user side using a comparable methodology for all countries. It can help policymakers target GHG emission reductions more effectively because the end-user approach provides additional information on the effect of sectoral energy demand on sectoral emissions.

Some additional benefits from this work are:

- The end-user approach provides additional information on the effect of energy demand or sectoral policies on GHG emissions that can be helpful in the context of the EU Effort sharing legislation. For example, more district heating from combined heat and power, replacing old stoves in households, or higher demand for electric-powered vehicles may drive emissions from non-trading sectors (where there are national targets) to trading sectors (governed by carbon prices). Thus, the end-user approach can provide additional information to evaluate the aggregate (direct and indirect) effects of sectoral policies and measures.

- The end-user approach also provides information on the effects on GHG emissions of cross-border trading of energy flows, such as electricity. These energy-trade effects can be very large in some countries and can also vary significantly from year to year. This can be relevant in the context of the Energy Union as it reflects the 'embedded carbon' or 'imported/exported energy-related emissions' within the EU area, or any other geographical boundaries selected.

- The end-user methodology can be applied to both GHGs and air pollutants (e.g. nitrogen oxides (NO_X) and sulphur oxides (SO_X) and this can be useful in the context of combined climate and air pollution policies.

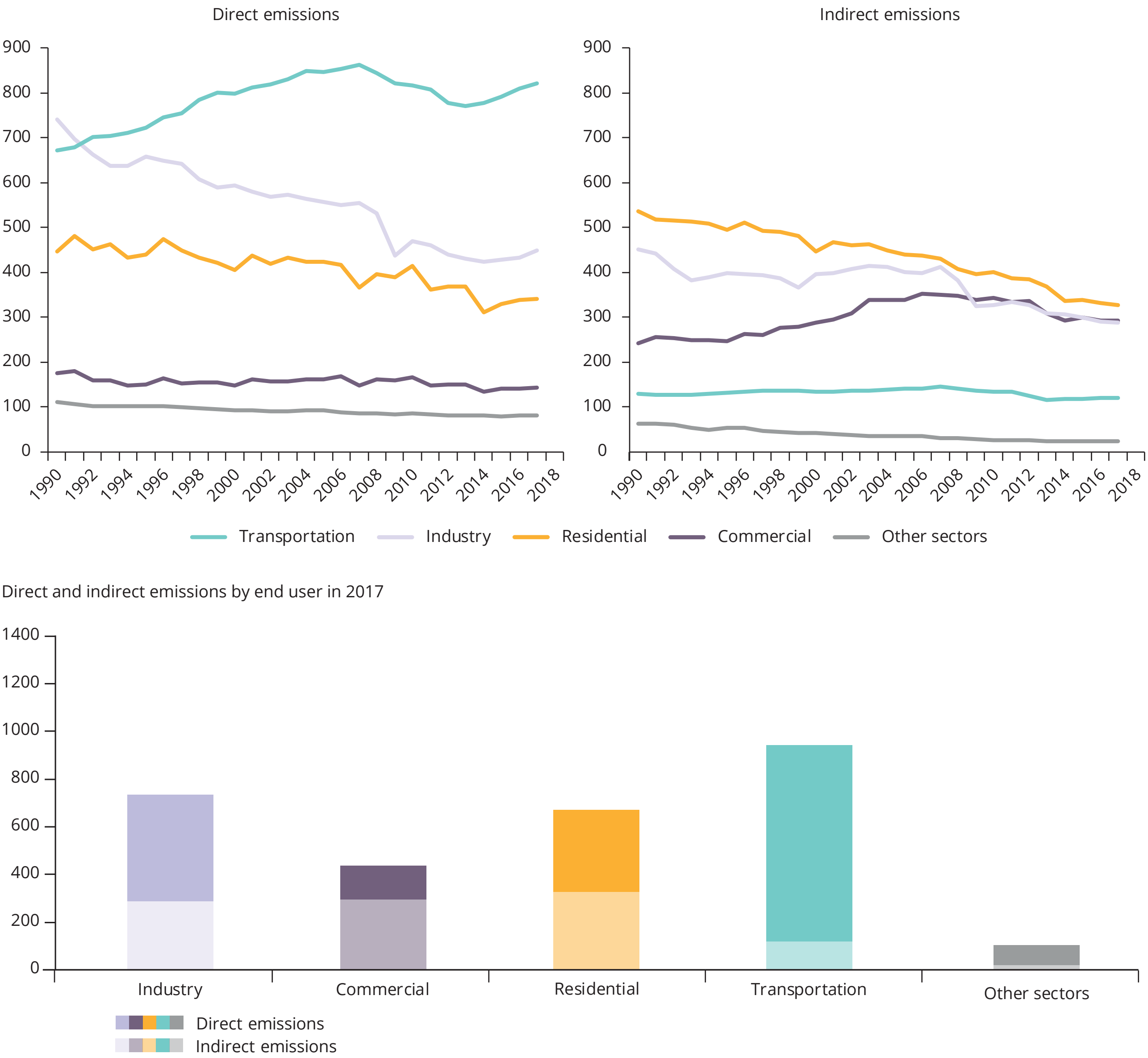
When emissions from energy supply are allocacted to the end-user sectors, the largest emission reductions in the period following the economic recession were, by and large, accounted for by industry (Figure 3.3). Over the whole time period since 1990, sectoral emission trends show that the largest energy-related emission reductions from the end-user perspective took place in industry and the residential sector. These include both direct emissions, as reported in GHG inventories, and distributed indirect emissions from the production of heat, electricity and petroleum products.

Figure 3.3 also shows that the largest energy emitter, on an end-user basis, remains transportation. The share of indirect emissions, which would, for example, include emissions from the electricity used by electric trains, is relatively small compared to the direct emissions in combustion engines. The progressive development of electric vehicles should result in a

([16]) EEA Technical report No 18/2012 https://www.eea.europa.eu/publications/end-user-ghg-emissions-energy.

([17]) This reallocation is done on the basis of Eurostat's energy balances and GHG inventories for the energy sector as reported to the UNFCCC. The method used in the re-allocation is Gaussian elimination applied to a system of simultaneous linear equations.

Figure 3.3 Energy-related greenhouse gas emissions by end user in the European Union, 1990-2017



Note: Data excludes the United Kingdom. The method is described in the EEA Technical report No 18/2012, *End-user GHG emissions from energy — Reallocation of emissions from energy industries to end users 2005–2010*.

Sources: EEA, based on GHG inventories reported to the EU and the EEA, and energy statistics reported to Eurostat (energy balances (nrg_bal)).

redistribution of emissions covered by the ESD to the EU ETS. The GHG emission savings would depend on several factors, including transport demand and the extent of further improvements in the carbon intensity (e.g. fuel mix in power generation) and transformation efficiency of electricity production.

The improvements in the carbon intensity of the EU economy have been particularly significant in the production of heat and electriciy. This also means that the indirect emissions allocated to end users would decrease over time assuming no changes in energy demand.

4 Key drivers of greenhouse gas emission reductions

This section analyses in more detail the key drivers that help explain why emissions in the EU have decreased since 1990.

4.1 Key findings from the analysis

The EU has reduced its GHG emissions since 1990 because of a combination of factors, inter alia:

- the effects of a number of policies, both EU and country-specific, including key agricultural and environmental policies in the 1990s, and climate and energy policies in the last two decades ([18]);
- the strong increase in the use of renewable energy sources for heat and electricity;
- the switch from coal to gas and a general move towards less carbon-intensive fossil fuels in heat and power generation;
- improvements in energy efficiency, both in transformation and end use — including energy savings;
- structural changes in European economies, with higher shares of the services sector and lower shares of the more energy-intensive industry sector in total GDP;
- although temporary, the effects of economic recession when it occurs;
- the milder winters experienced in Europe on average since 1990, which have reduced the demand for energy to heat households.

Although there has been good progress in reducing the GHG emissions intensity and decarbonising the EU economy, fossil fuels are still the largest source of emissions in the EU. Decarbonising the EU economy will require substantial and additional GHG emission reductions for the EU to become climate neutral by 2050.

4.2 An analysis of key drivers using decomposition analysis

Figure 4.1 breaks down the 28-year reduction in GHG emissions into several factors using the Kaya decomposition identity (see Box 4.1). The left side of Figure 4.1 shows the effects of different emission drivers on a cumulative basis between 1990 and 2018. The right side of Figure 4.1 shows shorter cumulative effects by selecting three different periods: 1990-2005, 2005-2015 and 2015-2030.

The factors that contributed positively to the net overall reduction in GHG emissions since 1990 were the lower carbon intensity of the energy system; the improved energy intensity of the EU economy; and the comparatively faster reduction in emissions in non-energy sectors. These three factors driving emissions down were partially offset by increases in the EU's population and in GDP per capita over the 28-year period.

Overall, the four main findings at EU level are:

- Higher GDP would usually lead to higher GHG emissions, other factors being equal, because economic growth is still essentially linked to an energy system that remains heavily dependent on fossil fuels in most European countries. Yet, the figure shows that emissions have decreased in parallel with increasing GDP, confirming that attempts to mitigate climate change do not necessarily conflict with a growing economy. The economic recession resulted in substantial emission reductions, particularly during the first commitment period of the Kyoto Protocol ([19]).

([18]) For relevant information on policies and measures reported by EU Member States, including, where available, the ex-ante and ex-post policy effects, see: the EEA PaMs data viewer, and the EEA PaMs database https://www.eea.europa.eu/themes/climate/national-policies-and-measures.

([19]) 'The role of economic growth and recession in GHG emission reductions in the EU', Section 7 of *Why did GHG emissions decrease in the EU between 1990 and 2012?*, published in 2014, http://www.eea.europa.eu/publications/why-are-greenhouse-gases-decreasing.

Box 4.1 Factors used in the decomposition analysis

The decomposition analysis used in Figure 4.1 is based on an extension of the original IPAT and Kaya identities, which are often used to illustrate the primary forces of emissions. IPAT or I = P x A x T, is an equation showing that environmental impact (I) is the product of population (P), affluence (A) and technology (T).

There are some limitations with this method, in particular whether the relationship between the variables in the equation is true by definition. Whereas one should avoid over-interpretation of the different effects, decomposition analysis can point to interesting findings, which can be explored further using other methods.

The chosen factors in Figure 4.1 are an extension of the Kaya identity. The decomposition analysis shown in this report is based on the Logarithmic Mean Divisia Index (LMDI) method. The equation is:

(y) [ln]GHG = (x1) [ln]POP + (x2) [ln]GDP/POP + (x3) [ln]PEC/GDP + (x4) [ln]GHG_en/PEC + (x5) [ln]GHG/GHG_en, where:

(y) GHG: total GHG emissions;

(x1) POP: population (population effect);

(x2) GDP/POP: GDP per capita (affluence effect);

(x3) PEC/GDP: gross energy intensity of the economy (energy intensity of GDP effect);

(x4) GHG_en/PEC: energy related GHG emissions in gross energy consumption (carbon intensity of energy effect);

(x5) GHG/GHG_en: total GHG emissions in energy related GHG emissions (non-energy sectors effect). It refers to how energy-related emissions (combustion) behave compared to non-energy related emissions (industrial processes, agriculture and waste sectors).

Source: EEA.

- The lower carbon intensity of energy (i.e. fewer GHG emissions to produce and use energy) has been a key factor underpinning lower emissions since 1990 and in all three periods considered. This positive trend has been a result of both the higher contribution from renewable energy sources in the fuel mix and the switch from the more carbon-intensive coal to the less carbon-intensive gas. The reduction in the carbon intensity of energy has also occurred in the context of lower electricity production from nuclear power stations since 2004.

- The decrease in the energy intensity of GDP was the largest contributing factor to lower GHG emissions from fossil fuel combustion. The lower energy intensity of GDP can be explained by improvements in energy efficiency (transformation and end-use, including energy savings) and the strong uptake of renewables, as well as by changes in the structure of the economy and a higher share of the services sector, compared to the more energy intensive industrial sector.

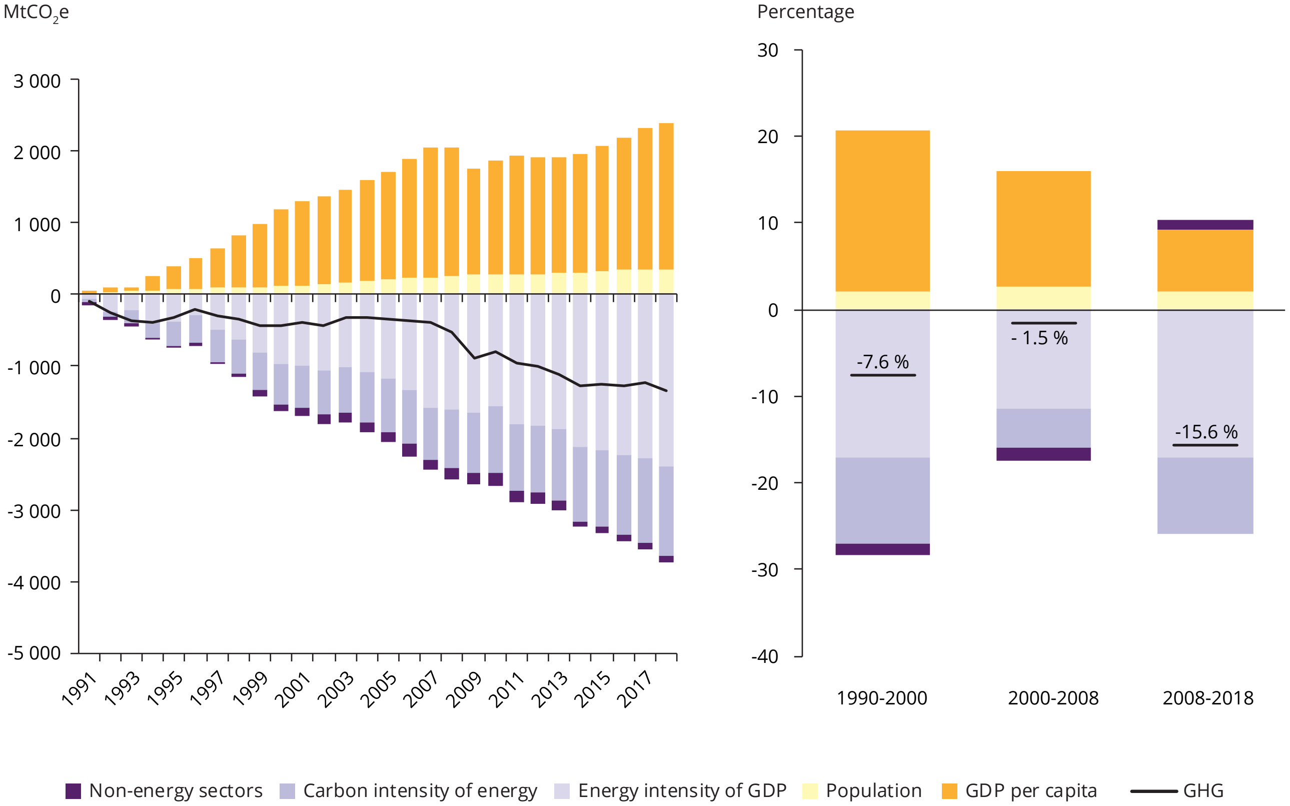
- The largest emission reductions in the first two decades up to the 2009 economic recession occurred in the non-energy sectors, whereas in the period 2008-2018, energy-related emissions from both production and consumption decreased faster than non-energy emissions. Although the effects of the non-energy sectors shown in the decomposition analysis appear to be modest, the actual emission reductions observed in industrial processes and product use, agriculture and waste management have been substantial since 1990.

Overall, the same factors driving emission reductions in the past are also expected to play a key role in the future, although to a different degree ([20]). Whereas the EU is on track to achieve its 20 % GHG reduction target by 2020, more efforts to reduce GHG emissions will be needed to achieve its reduction target of at least 40 % by 2030 ([21]). These results suggest that efforts should, together with lower energy intensity and higher efficiency, concentrate on further improving the carbon intensity of energy production and consumption.

([20]) *The European environment — state and outlook 2020: knowledge for transition to a sustainable Europe* (SOER 2020), https://www.eea.europa.eu/publications/soer-2020.

([21]) See the EEA's 2019 *Trends and Projections in Europe* report https://www.eea.europa.eu/publications/trends-and-projections-in-europe-1; and the Member States' GHG projections database https://www.eea.europa.eu/data-and-maps/data/greenhouse-gas-emission-projections-for-6.

Figure 4.1 Drivers of greenhouse emission reductions in the EU-27 plus the United Kingdom: cumulative and period-comparison decomposition analysis, 1990-2018



Note: Based on the 2020 EU GHG inventory to the UNFCCC. The decomposition analysis is based on the logarithmic mean Divisia index (LMDI). The bar segments show the changes associated with each factor alone, holding the other respective factors constant.

Source: EEA.

Some additional insights regarding the explanatory factors in Figure 4.1 are outlined in the following sub-sections.

4.2.1 *Economic growth, employment and emission reductions*

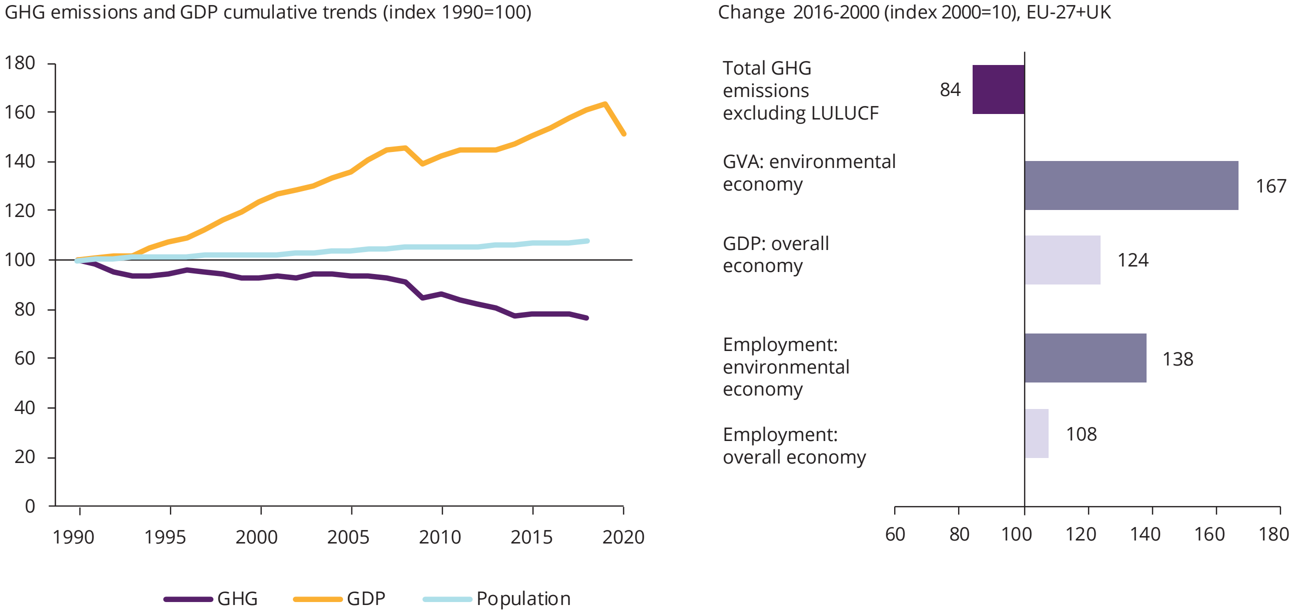
There has been a substantial improvement in the GHG emissions intensity of the EU economy since 1990. GHG emissions decreased by 23 % and GDP increased by 60 % between 1990 and 2018 (Figure 4.2, left side). In addition, the population in the EU plus the United Kingdom increased by 35 million between 1990 and 2018. GHG intensities of Member States have both decreased and converged since 1990. One reason for this convergence is the strong growth in the use of renewable energy sources in most Member States and a clear move towards less carbon intensive fuels.

However, the reliance on coal, gas and oil remains high at EU level and the economy continues to be, by and large, based on fossil fuels. It is worth highlighting that EU economies have grown and emissions have decreased alongside a growing share of renewables, less carbon intensive fuels in the energy mix and improvements in energy efficiency. Yet, to break the link between GDP and GHG emissions, more substantial improvements in energy efficiency and carbon intensity will be needed, which will enable the EU to meet its 2030 and 2050 objectives ([22]).

Figure 4.2 (right side) shows that jobs and value added linked to environmental activities outperformed jobs

([22]) 'The economy and the link to GHG emissions', Section 6 of *Analysis of key trends and drivers in greenhouse gas emissions in the EU between 1990 and 2015* — EEA Report No 8/2017, https://www.eea.europa.eu/publications/analysis-of-key-trends-and.

Figure 4.2 Greenhouse gas emission intensities in the EU plus the United Kingdom: GHGs, GDP and employment



Source: EEA, based on GHG inventories reported to the EU and the EEA, and population, employment and economic and environmental accounts reported to Eurostat.

and value added in other sectors of the economy. Eurostat estimates that, between 2000 and 2016, the gross value added in the environmental economy increased by 67 %, compared with a 24 % increase in the overall economy ([23]). In addition to the positive effects on economic growth, Eurostat also estimates that, in the EU, about 1.3 million more people were working in the environmental economy in 2016. This represents an increase of 38 % compared with 8 % for the overall economy ([24]).

The above suggests that both the economy and society can benefit from better environmental conditions and climate change mitigation, and thus it is important to think of these interactions when setting new policy objectives in order to achieve maximum benefits.

4.2.2 Improvements in the carbon intensity of the energy system

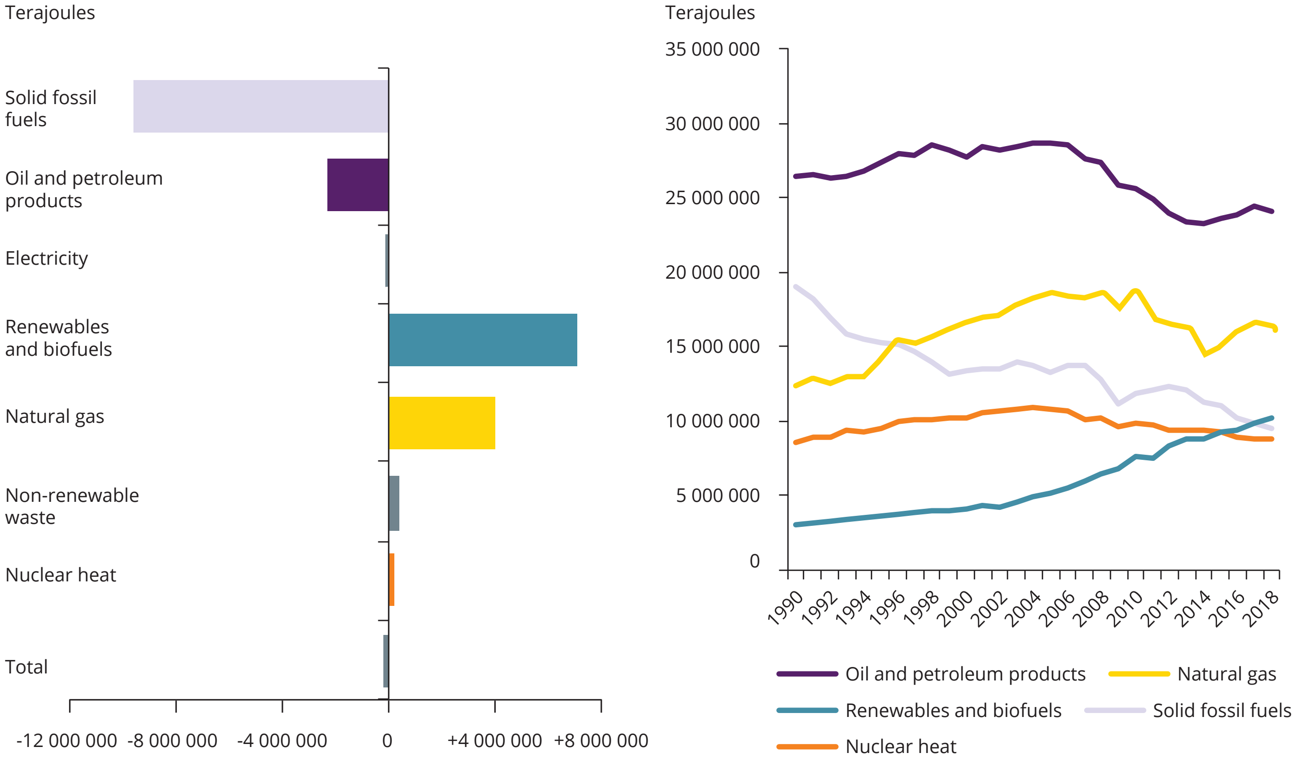
The lower carbon intensity of energy was a key factor underpinning lower emissions, in spite of a decline in nuclear electricity production in recent years. The lower carbon intensity was due to both the higher contribution from renewable energy sources in the fuel mix, and the switch from the more carbon-intensive coal to the less carbon-intensive gas (Figure 4.3).

The figure shows two clear developments: the first trend is that coal consumption has decreased considerably and rather steadily over the 28-year period since 1990. The second clear trend is the increase in the use of renewable energy sources, mostly bioenergy and wind, which offsets around 75 % of the decrease in solid fuel use at EU level. Natural gas consumption has also increased compared with 1990.

Although total energy consumption in terms of primary energy has remained relatively stable, the changes in the energy mix have had a substantial effect on total GHG emissions. The average CO_2 emission factor for coal and lignite in the EU was, on average, 103 tonnes of CO_2e per terajoule in 2018. The emission factor for liquid fuels was 73 tCO_2/Tj and for gaseous fuels it was 56 tCO_2/Tj. This means that coal releases over 80 % more CO_2 than gas to deliver the same amount

([23]) Environmental economy — statistics on employment and growth, Eurostat.
([24]) According to Eurostat, these jobs are related to preventing and reducing pollution of the environment as well as preserving and maintaining the stock of natural resources. The increase in the number of environmental jobs is mainly attributed to the management of energy resources, particularly for the production of energy from renewables and the production of equipment and installations for heat and energy savings.

Figure 4.3 Improved carbon intensity from a less carbon intensive energy mix



Source: EEA, based on energy statistics reported to Eurostat (energy balances (nrg_bal)).

of energy. The EU average implied emission factor for fossil fuels (i.e. excluding bioenergy) decreased from 79 tCO_2/Tj in 1990 to 73 tCO2/Tj. This means that the carbon intensity of fossil fuel production has improved in the last three decades. In addition, there has been a very large increase in the use of renewable energy sources, including bioenergy and other renewables, such as wind and solar. The rapid increase in renewable energy technology has been due to dedicated policies and measures and falling costs ([25]). These improvements have reduced the carbon intensity of the energy system even further.

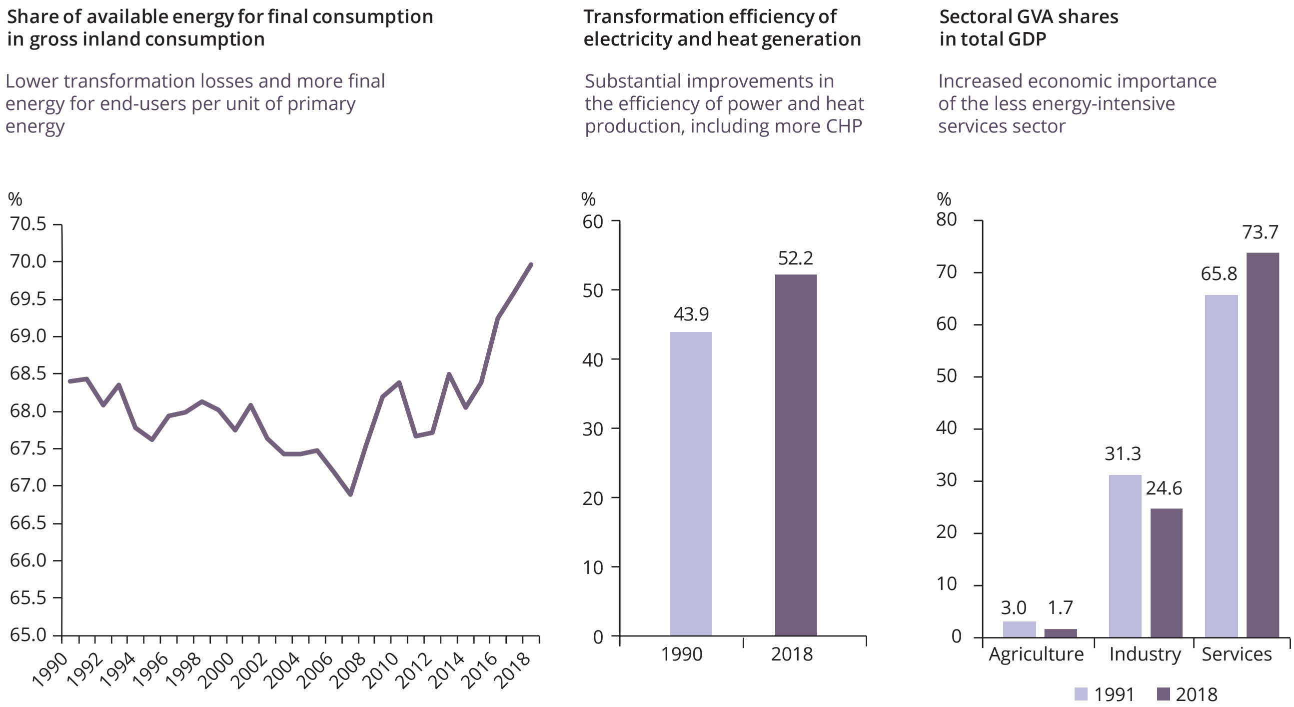
4.2.3 Improvements in the energy intensity of the economy

The decrease in primary energy intensity was the largest contributing factor to lower GHG emissions. The lower energy intensity of GDP can be explained by improvements in energy efficiency (transformation and end-use) and the strong uptake of renewables, as well as by changes in the structure of the economy and a higher share of the services sector compared to the more energy intensive industrial sector.

Figure 4.4 shows three charts to explain some of the key drivers of improvements in the energy intensity of the EU economy since 1990. First, the share of available energy to final users has increased relative to the primary energy required, resulting in lower transformation losses and lower GHG emissions. Second, the energy efficiency in the transformation of heat and electricity in thermal power stations — which remains the largest source of emissions in the EU — has improved significantly because of more efficient combined cycle gas turbines and better heat utilisation in combined heat and power plants. Third, the structural changes in the EU economies, including economic restructuring and a move towards the services sector compared to the more

([25]) EEA, *Renewable energy in Europe 2019 — Recent growth and knock-on effects*, https://www.eea.europa.eu/themes/energy/renewable-energy/renewable-energy-in-europe-2019.

Figure 4.4 Energy intensity of the economy, energy efficiency and economic structure



Source: EEA, based on energy statistics reported to Eurostat (energy balances (nrg_bal)). Gross value added from the European Commission's Ameco database.

energy-demanding industry sector have also led to lower GHG emissions ([26]).

The decrease in the energy intensity of GDP is expected to remain a key factor in the transition to carbon neutrality, which requires continued improvements in transformation and end-use energy efficiency. This can be done via energy savings from the technology and consumer perspectives as well as from the improved energy efficiency of the transformation process.

4.2.4 The role of non-energy sectors

The largest emission reductions occurred in the energy sector, both in transformation and in consumption by final users. Although the effect may appear modest compared to the carbon intensity and energy intensity effects mentioned above, emissions from non-energy sectors have decreased slightly faster than emissions from energy sectors over the 28-year period. The emission reductions observed in industrial processes, agriculture and waste management have been substantial since 1990.

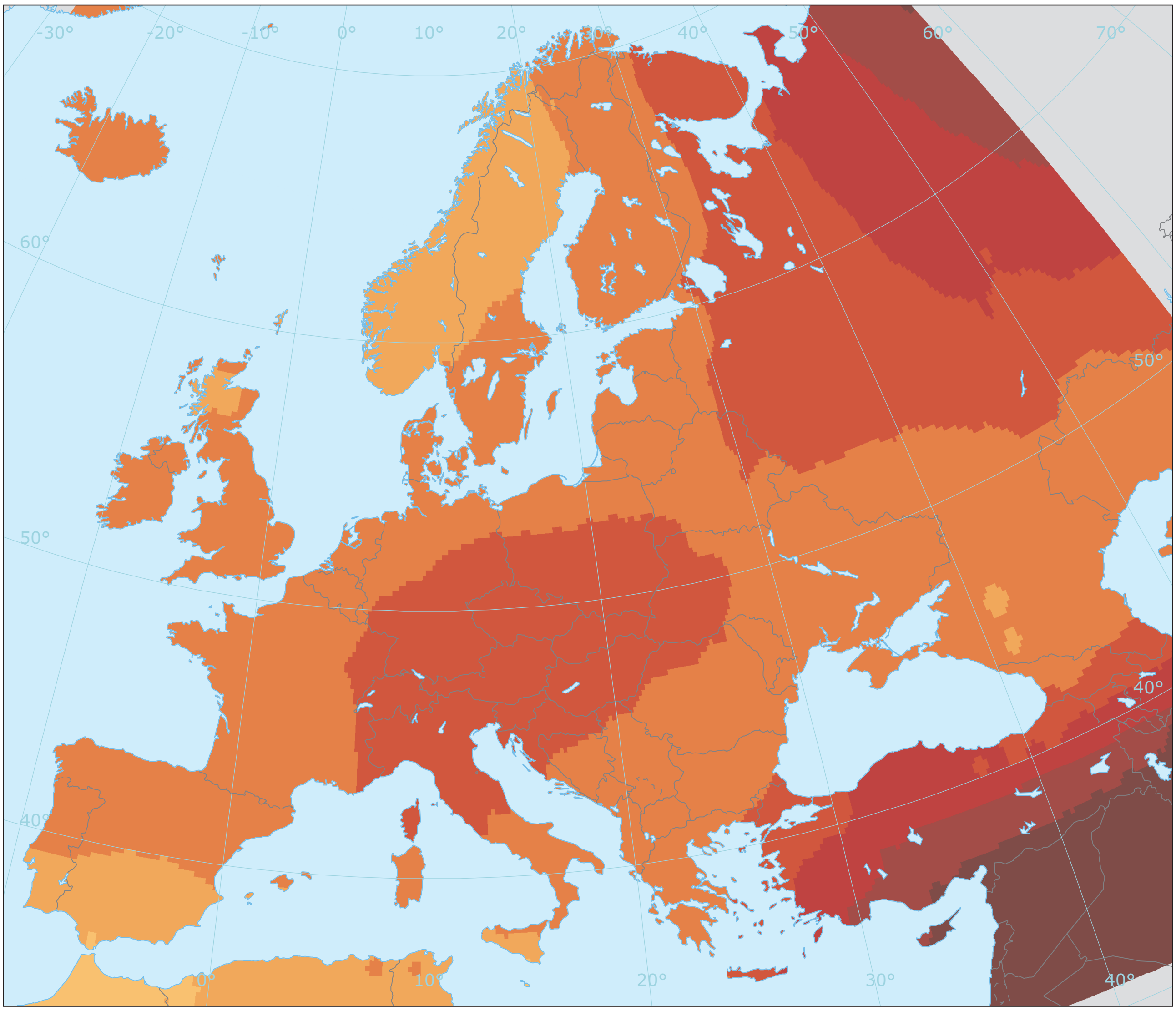
These reductions affected both CH_4 emissions from waste management and agriculture livestock, as well as N_2O emissions from industrial processes and from agricultural soils. Emissions from F-gases have increased compared with 1990 levels, although the latest trends regarding refrigeration and air conditioning are positive. The most important emission reductions in the non-energy sectors, mostly affecting non-CO_2 GHGs, are shown in Table 3.1.

([26]) As mentioned in SOER 2020 (https://www.eea.europa.eu/soer-2020), there are various reasons for the lower share of industry in Europe. Industry can close down, become more efficient or relocate to other countries. Carbon footprint statistics (consumption-based approach) can be useful for assessing the impact of domestic economic activities abroad and for the analysis of emission trends. Yet the assessment of progress towards GHG mitigation targets used here is consistent with how the targets have been defined and agreed both domestically and internationally (production-based approach). Also, while Europe may be indirectly generating some of the emissions elsewhere for final consumption in Europe — via imported products — a share of Europe's own emissions can also be linked to final consumption of European goods outside Europe — via EU exports.

4.2.5 Warmer winter conditions in Europe

It is worth highlighting that, notwithstanding the different trends per country and region, warmer winters are another factor in lower GHG emissions in Europe. Europe has become warmer (Map 4.1), especially during winters, and this has contributed to lower fuel use and emissions because of the lower demand for space heating. Better insulation standards and retrofitting in buildings has also contributed to lower demand for heating and emissions.

Map 4.1 Warmer winters and lower demand for heating



Reference data: ©ESRI

Trends in annual temperature across Europe between 1990 and 2019

°C/decade

0-0.05, 0.05-1, 0.1-0.15, 0.15-0.2, 0.2-0.25, 0.25-0.3, 0.3-0.35, 0.35-0.4, 0.4-0.45, 0.45-0.5, > 0.5, Outside coverage

0, 500, 1 000, 1 500 km

Source: EEA.

There is also a clear positive correlation between heating degree days (HDDs) and fuel use and emissions from the residential sector. According to Eurostat data ([27]), the current demand for heating in Europe is below its long-term average (defined as 1980-2004). An EEA analysis on heating and cooling showed that HDDs decreased by 6 % between 1981 and 2017, compared with the period 1950-1980, with the largest decrease observed in northern Europe. In parallel, cooling degree days (CDDs) increased on average by 33 % in the same period, with the largest increase in southern Europe ([28]). Because temperatures in Europe are projected to increase, the trends in lower HDDs and higher CDDs are also expected to continue, if not accelerate.

([27]) Cooling and heating degree days by country — annual data (nrg_chdd_a), Eurostat, https://ec.europa.eu/eurostat/data/database.
([28]) Heating and cooling degree days, EEA indicator CLIM 047, https://www.eea.europa.eu/data-and-maps/indicators/heating-degree-days-2/assessment.

5 Further emission reduction needs

Over the past 28 years, the EU has reduced its GHG emissions due to a combination of factors. As explained in Chapter 4, these factors include, inter alia: the effects of EU and national policies and measures, the strong increase in the use of renewables, a switch from coal to gas for power generation, improvements in energy efficiency and structural changes in the EU economies. These, combined, have led to improvements in the carbon intensity of energy production and consumption and a lower energy intensity of the economy. Although to different degrees, all EU Member States have shown improvements in these two variables during the 28-year period. In particular, the rapid increase in renewable energy throughout Europe has helped reduce emissions by replacing fossil fuels to meet energy demand. Section 2 also showed that the EU has achieved substantial improvements since 1990, and that these include not only lower GHG emissions, but also lower GHG emissions per capita and lower GHG emissions of the EU economy as a whole.

In spite of the good progress in reducing GHG emissions and decarbonising the EU economy, substantial GHG emission reductions will be needed for the EU to become a climate neutral economy by 2050.

The objective of achieving net zero greenhouse gas emissions by mid-century is part of the European Green Deal ([29]) and was endorsed by the European Council in December 2019 ([30]). The Green Deal also includes the proposal for the first European Climate Law ([31]) that would make climate neutrality by 2050 legally binding. The 2050 climate neutrality objective is also part of the EU's long-term strategy ([32]) to the UNFCCC as part of article 4, paragraph 19 of the Paris Agreement, submitted in March 2020.

For instance, the effort to achieve net-zero emissions by 2050, with the information we have so far and not assuming potential emission offsets from emission removals, could imply an almost tripling of the mitigation efforts achieved to date in a sustained manner during the next 30 years (see Table 5.1, including the note about limitations). Long-term green investments can be instrumental for sustainable growth and the achievement of climate goals.

Improved energy efficiency and carbon intensity, with an increasing role for renewables in the energy mix, will help reduce the CO_2 footprint of the energy sector. But all sectors of the economy, including industrial processes and product use, agriculture, forestry and land use as well as waste management, would have to contribute to the objective of climate neutrality by 2050.

([29]) Communication from the Commission, The European Green Deal, https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en.

([30]) According to IPCC, 'net zero emissions' are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specified period. Where multiple greenhouse gases are involved, the quantification of net zero emissions depends on the climate metric chosen to compare emissions of different gases (such as global warming potential, global temperature change potential, and others, as well as the chosen time horizon). Climate neutrality is a concept of a state in which human activities result in no net effect on the climate system. See glossary from the IPCC Special Report on Global Warming of 1.5 ºC, https://www.ipcc.ch/sr15/chapter/glossary.

([31]) Commission proposal for a Regulation of the European Parliament and of the Council establishing the framework for achieving climate neutrality and amending Regulation (EU) 2018/1999 (European Climate Law), https://ec.europa.eu/clima/policies/eu-climate-action/law_en.

([32]) Long-term low greenhouse gas emission development strategy of the EU and its Member States, https://unfccc.int/documents/210328.

Table 5.1 Effort to meet EU targets and objectives, compared with 1990 emissions ($MtCO_2e$)

	GHG level	Total reduction	Number of years	Annual reduction
Year 1990	5 721	-	-	-
Year 2018	4 392	-1 330	28	-47
2020, 20 % target/1990	4 577	-1 144	30	-38
2030, 1st NDC 40 % target/1990	3 433	-2 289	40	-57
Meeting the 2030 target taking into account already-achieved (by 2018) reductions	3 433	-959	12	-80
2050 EU objective, between 80 %/1990	1 144	-4 577	60	-76
and 95 %/1990	286	-5 435	60	-91
Meeting the 95 % objective taking into account already-achieved reductions	286	-4 106	32	-128
Meeting the objective of climate neutrality by 2050	Net zero GHG emissions	Net GHG emission reduction also depends on emissions removals	32	-

Notes: The GHG emission numbers in this table represent the available information (as of 8 May 2020) on the geographical scope, targets and objectives regarding climate change mitigation in the European Union. The numbers in this table also include the United Kingdom, as part of the EU's 2020 GHG inventory submission under the UNFCCC and the Kyoto Protocol. The European Union and its Member States are currently discussing an increased level of ambition that would be part of the EU's revised National Determined Contribution by 2030 and that would also be consistent with the objective of climate neutrality by 2050. Given these uncertainties, the information in this table should not be considered final or pre-empt any ongoing discussions taking place during 2020. In addition, the role of the LULUCF sector has not been included in these calculations. The LULUCF sector is included in the 2030 target under the 'no-debit' accounting rules, which requires each Member State to ensure that accounted CO_2 emissions from LULUCF are fully compensated by an equivalent removal of CO_2. However, Member States can use up to 280 million CO_2 credits over the period 2021-2030 to comply with their national effort sharing targets. The European Council of October 2009 supported the EU objective, in the context of necessary reductions according to the IPCC by developed countries as a group, to reduce emissions by 80-95 % by 2050 compared to 1990 levels. Climate neutrality, or net-zero GHG emissions by 2050, can also be achieved by increasing carbon sinks and not by reducing GHG emissions alone. The main purpose of this table is to show that emission reduction efforts will have to increase substantially in the next three decades at a rate that is likely to triple the emission reductions achieved since 1990.

Source: EEA.

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