Climate

Key messages

- Transport accounted for approximately 31% of all EU-27 GHG[1] emissions in 2023, including emissions from international aviation. Transport emissions increased by 25.3% from 1990 to 2023.
- Rising transport demand and the continued dominance of road transport more than offset improvements in energy efficiency and the uptake of alternative energies.
- Road is the largest contributor of GHG emissions in transport, accounting for 72.9% in 2023 (and 23.6% of all EU-27 GHG emissions in that year). Its contribution is expected to increase slightly until the mid-2030s.
- International aviation was the second largest source of GHG emissions in the EU-27 in 2023, with emissions rising 124% between 1990 and 2023. International navigation emissions increased by 21% in the same timeframe.
- Rail remains the lowest contributor of GHG emissions, with emissions falling 19.7% between 1990 and 2023 despite an increase in activity.
- GHG emissions from transport are projected to decrease by 29% in 2030 and by 66.7% in 2050 compared to 2021, due to current and planned EU policy measures.

Figure 1[2] shows direct GHG emission trends over time for different transport modes in the EU-27 (including emissions from international aviation). Between 1990 and 2019, GHG pollutants with a climate effect are covered by the air pollutants in transport indicator. However, emissions from those associated with electricity generation or fossil fuel extraction and manufacturing are not included in this analysis. Downward trends are observed for all modes of transport, except for domestic and international aviation.

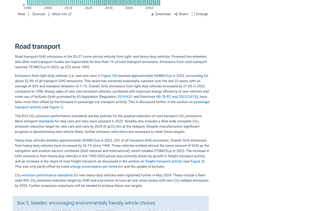
Transport GHG emissions are expressed in million tonnes of carbon dioxide equivalent ($MtCO_2e$). These peaked at approximately 1 $MtCO_2e$ in 2007 and fell with the 2008–2009 recession before reaching a second peak in 2019 at 1 $MtCO_2e$. Emissions then fell sharply to 899 $MtCO_2e$ in 2020 during the COVID-19 pandemic, a drop of 10 % compared to the previous year. In 2021, GHG emissions rebounded by 8.4 % to 974 $MtCO_2e$ and increased by 2.5 % to 998 $MtCO_2e$ in 2022. In 2023, they rose further to more than 1000 $MtCO_2e$ (an increase of 0.5 % compared to 2022).

Transport's share of total GHG emissions from the EU-27 has been steadily rising from 14.5% in 1990 to 28.4% in 2019. It accounted for approximately 31% of all EU-27 GHG emissions in 2023, a 2.7 percentage points higher than in 2022.

Projected emissions in Figure 1 correspond to those reported by Member States under Article 18 of the Regulation on the Governance of the Energy Union. Through this regulation, each Member State developed an integrated national energy and climate plan according to the (with additional measures) (WAM) scenario. This, as further explained in the Annex, includes policies and measures that were implemented or adopted at the time of reporting (mid-2023). Following the adoption of the 2030 climate and energy targets at the EU level, these plans suggest Europe's transport sector will still be emitting 29% less in 2030, with navigation as the major contributor (36.3%), followed by road transport (20.7%), aviation (29.6%) and rail (9.4%). The relative contribution of transport including international aviation to the EU-27's economy is expected to decrease slightly from 31% in 2023 to 24.5% in 2050.

Figure 1: GHG emissions in the EU-27 as reported to the United Nations Framework Convention on Climate Change (UNFCCC) and the EU's Greenhouse Gas Monitoring Mechanism

Absolutes ($MtCO_2e$) Shares — transport (%) Shares — total (%)



Road transport

Road transport GHG emissions in the EU-27 come almost entirely from light- and heavy-duty vehicles. Powered two-wheelers and other road transport modes are responsible for less than 1% of total transport emissions. Emissions from road transport reached 754 $MtCO_2e$ in 2023, up 0% since 1990.

Emissions from light-duty vehicles (i.e. cars and vans in Figure 1) reached approximately 504 $MtCO_2e$ in 2023, accounting for about 50.3% of all transport GHG emissions. This share has remained relatively constant over the last 10 years, with an average of 53% and standard deviation of 1.1%. Overall, GHG emissions from light-duty vehicles increased by 27.6% in 2021 and 2.2% in 2022, before falling by 0.5% in 2023. Emissions from heavy-duty vehicles and buses (i.e. trucks and buses in Figure 1) more than doubled between 1990 and 2019 ($MtCO_2e$), before falling by 10.6% in 2020 and 2021 and then rising by 2.1% in 2022 and 2023 (see Regulation (EU) 2019/631 and Directive 96/53/EC and 2002/49/EC), here fewer than offset by the increase in passenger car transport activity. This is discussed further in the section on passenger transport activity (see Figure 1).

The EU's CO_2 emission performance standards are key policies for the gradual reduction of road transport CO_2 emissions (see Regulation (EU) 2019/631 and Directive 96/53/EC and 2002/49/EC). Since 2020, they require a 15% reduction in emission reduction target for new cars and vans by 2025 (gCO_2/km), before the 2030 target. Despite manufacturers' significant progress in decarbonising new vehicle fleets, further emission reductions are necessary to meet future targets.

Heavy-duty vehicles emitted approximately 212 $MtCO_2e$ in 2023, 20% of all transport GHG emissions. Overall, GHG emissions from heavy-duty vehicles have increased by 33.1% since 1990. This vehicle emitted almost the same amount of GHG as the entire aviation sector in the EU-27 (including international aviation) in 2023 (212 $MtCO_2e$ and 214 $MtCO_2e$, respectively). The increase was driven by a steady rise in HDV transport activity (tkm) over the past 30 years, which has only been briefly slowed by growth in the freight transport activity and an increase in the share of road freight transport, as discussed in the section on freight transport activity (see Figure 1). The latter was partly driven by lower energy consumption per tonne-km and the uptake of biofuels.

CO_2 emission performance standards for new heavy-duty vehicles were tightened further in May 2024. These include a then-new 90% CO_2 emission reduction target for buses and a provision to have all new urban buses with zero CO_2 tailpipe emissions by 2035. Further emissions reductions will be needed to achieve these new targets.

Box 5. Sweden: encouraging environmentally friendly vehicle choices

Considering long-term (1990–2050) and medium-term (2005–2023) changes in reducing GHG emissions from passenger cars, three Member States show decreasing trends. In order of progress made, these are Sweden, Finland and France. This is to be illustrated using data for Sweden, and reported in the EEA, aiming at transitioning away from fossil fuels and encouraging environmentally friendly vehicle choices.

The EEA database on climate policies and measures in Member States shows Sweden implemented an emission reduction obligation for petrol and diesel known as the 'fuel change' or 'pump' obligation, in conjunction with fuel tax reforms. This obliged fuel suppliers to reduce the GHG emissions from the fuels they supply by a specified percentage each year, with penalties for non-compliance. The obligation was first introduced for biofuels and was initially set at 2.66 % in 2009. It was increased in two-year lifts as fossil fuel equivalents.

This reduction obligation increased gradually until 2021 and remained at the same level the following year. In 2023, the Swedish Parliament lowered the reduction obligation to 6% for 2024-2026 and abolished reduction levels for 2027-2030. The government announced its intention to propose new levels for 2027-2030 and suggested that the reduction obligation should be considered to ensure Sweden's EU commitments are met.

Sweden has also introduced a bonus-malus system, which rewards or fees light vehicles with low carbon emissions, through the new, discontinued in 2022. All cars emitting more than a level 360 per year of vehicle taxes regardless of fuel type. Light petrol or diesel vehicles with high CO_2 emissions were subject to an increase in vehicle tax (malus) during the first 3 years, after which this tax is disregarded at the end of the vehicle's lifetime. Vehicles with low CO_2 emissions (green tax) Ethanol and gas-powered vehicles were exempt from the increased tax. The system was revised, effective 1 June 2022, with the introduction of a new scale for the bonus. The bonus and malus were subject to malus and emissions, and exceeding 120 grams per kilometre received a bonus of SEK 110 per gram.

Additionally, a support tax reduction was introduced for installation of green technology in 2021. Citizens were eligible for an income tax reduction based on the total cost of labour and equipment for installing grid-connected photovoltaic (PV) systems, storage systems for self-produced electricity and home charging stations for electric vehicles, among other installations. The reduction is of 50% of the cost for charging stations. The maximum reduction is SEK 50 000 per person, SEK 100 000 per property and SEK 1 500 000 per housing association. The scheme was extended to 2026.

To ensure fairer access to charging infrastructure for those living in apartments and rented homes, the Swedish Energy Agency was tasked with SEK 10 000 in 2020. This supported two-level charging poles, which can charge two cars at once, among major roads to areas where it many residents. Public support covered up to 50 % of costs to encourage wider charging stations remained in operation for 5 years.

Sweden has also targeted biofuel mandates to support for advanced technologies. In 2022, it had the highest biofuel share among all Member States, at 29.3%, of which 19% is biofuel/electricity consumption of shipping. It is biodiesel from biogas. Meanwhile, the share of diesel and petrol in the overall fossil fuel mix was 19% and 21%, respectively. Sweden aims to reduce its GHG emissions by passenger GHG intensity of its fuels (including indirect land use change), the highest in the EU27 for the period 2005-2022.

Passenger transport activity

Powered two-wheelers (mopeds and motorcycles) accounted for 9MtCO$_2$e of GHG emissions in 2023, 26% lower than 1990 levels. Emissions from other road modes (i.e. buses and coaches) in the EU-27 in 2023 were 27% lower than 1990 levels. They represented just 0.9% of the GHG emissions from transport in 2023.

Overall, road transport emissions in 2023 included approximately 757MtCO$_2$e, representing 72.9% of all transport emissions and 22.3% of all EU-27 GHG emissions (including international bunkers). According to projections, emissions from the road transport sector will reach 754MtCO$_2$e in 2030 and 154MtCO$_2$e in 2050, corresponding to reductions of 27.9% and 84%, respectively, compared with 2021.

The Energy Performance of Buildings Directive has been revised. Among other things, this supports the transition towards the uptake of zero-emission vehicles. The Directive requires Member States to establish national policy frameworks that include, for example, provisions on providing low-fee and renovated buildings (to enable the installation of charging points at a later stage with minimal effort) and similar requirements on the number of recharging points which must be available in both residential and non-residential buildings. To support vehicle to grid (V2G) technologies, the Directive requires smart charging and bi-directional charging, where appropriate. This complements the Alternative Fuel Infrastructure Regulation (AFIR). The AFIR requires Member States to ensure sufficient publicly accessible charging and refuelling points to power zero-emission vehicles including infrastructure deployed under CEF. For example, AFIR requires infrastructure along major transport corridors (the TEN-T core network) to be deployed at regular intervals (e.g. electric fast chargers every 60km on major roads) and encourages smart and bidirectional recharging, where economically reasonable.

In addition to the measures already discussed, the sector is expected to be covered by ETS2, additional CO_2 emissions from fuel combustion in road transport and buildings from 2027 onwards. According to the EU ETS2 Directive, the ETS2 will cover emissions down by 42% by 2030 compared with 2005, thereby supporting the total emissions from buildings and road transport (and others). It will also address the social impacts of carbon pricing by allocating revenues from emissions trading to climate action, with a focus on vulnerable households and micro-enterprises.

Waterborne transport

Combined EU-27 GHG emissions from domestic and international navigation (including inland navigation) reached 129MtCO$_2$e in 2023, an increase of 1% since 1990. This trend follows a similar trajectory to total emissions (see Figure 1). Waterborne transport accounted for around 13% of total transport emissions in 2023 a share that has remained relatively stable since 1990. Emissions from navigation are projected to increase by 12% between 2021 and 2030, and by 36% between 2021 and 2050 in the same year. Notably, emissions from domestic navigation fell by around 28.3% (to 7MtCO$_2$e) from 1990 to 2023.

Regulation (EU) 2023/957 was adopted in 2023 and amended the monitoring, reporting and verification (MRV) system originally established by Regulation (EU) 2015/757. As of 2024, shipping companies must monitor and report emissions of not only CO_2, but also CH_4 and N_2O from ships above 5000 gross tonnage that call at any EEA port. From 2025 onwards, the MRV regulation's scope expands to include smaller general cargo ships with gross tonnage between 400 and 5000, as well as offshore ships of 400 gross tonnage and above. Additionally, as of 2024 the EU ETS applies to CO_2 emissions from ships of 5000 gross tonnage and above which are at or depart from ports within the European Economic Area, regardless of the vessel's flag. This system covers 100 % of the emissions produced while at berth within EEA ports, or travelling within the EEA, and 50 % of emissions produced on voyages that start or end outside the EEA. From 2025 onwards, the ETS will be covered by the EU ETS framework. The revised ETS Directive also requires revenues generated from auctioning maritime allowances to be directed towards decarbonising the maritime sector, including climate action and transformation of the sector. The FuelEU Maritime Regulation aims to support climate neutrality in maritime transport in the EU.

Finally the FuelEU Maritime Regulation (Regulation (EU) 2023/1805), applied from 1 January 2025, aims to increase the uptake of low- and zero-carbon fuels in maritime transport. It requires the GHG intensity (measured in gCO_2e/MJ) of energy used on board ships of and above 5,000 gross tonnage calling at EU ports to be reduced progressively. Articles 8 (monitoring plan) and 9 (modifications to the monitoring plan) are excluded. GHG intensity fell by 6% in 2025 and by 14.5% in 2030, relative to 2020, following 8 per incremento (certain exemptions apply until 2050). Reductions will be achieved from a reference value of 91.16 gCO_2e/MJ in 2020. The FuelEU Maritime Regulation is expected to lead to the uptake of low-carbon fuels, power supply (OPS) or alternative zero-emission technologies while at berth, as discussed further in the section on energy infrastructure.

Projections introduced at the start of this section suggest emissions from waterborne transport will reach 143MtCO$_2$e in 2030 and 118MtCO$_2$e in 2050. This corresponds to narrative of 4.4% (-6.5%) and -13.9% (-23.9%), respectively, compared to 2023 (2019).

Aviation

Aviation has seen the largest relative increase in GHG emissions among transport subsectors. GHG emissions from aviation (including international aviation) in the EU-27 were 124% higher in 2023 than in 1990, reaching 214 $MtCO_2e$ in 2023, and emitting 6.3 times more than domestic aviation. Aviation accounted for 7.5% of total transport GHG emissions in 2023, or approximately five percentage points since 1990. Although aviation emissions dropped to 64MtCO$_2$e due to the disruption of the COVID-19 pandemic, they rebounded relatively quickly to 2019 levels in 2021 and 2022. Aviation emission levels in 1990 and represented 13.1% of all transport emissions.

Notably, aviation CO_2 emissions within the EU-27 are covered by the EU ETS (specific provisions exist for outermost regions). Switzerland's proprietary system is linked to the EU ETS, while the UK system is independent. Emissions above the aviation cap (based on the average emissions between 2004 and 2006) are subject to a fee. Carriers such that the overall EU ETS cap is respected.

Aviation also contributes to global warming through mainstream beyond CO_2 emissions that are normally labelled as non-CO_2 effects. These are caused by the release of nitrogen oxides (NO_x), water vapour, particulate matter and contrails. The climate impact. This high variability results from the uncertainty of quantifying non-CO_2 effects being higher than those of CO_2 emissions. Non-CO_2 effects include, among others, the emission of climate-forcing pollutants and the formation of stable contrails. Regulation (EU) 2023/2405 (ReFuelEU Aviation) aims to increase the uptake of sustainable aviation fuels (SAF) and could be done quickly and cost-effectively. EU ETS rules for the aviation sector have been revised recently in Directive (EU) 2023/958. This implements a monitoring, reporting and verification (MRV) system for non-CO_2 effects in aviation through implementing Regulation (EU) 2024/2067. The aim will submit a report based on the MRV by 2027. If deemed appropriate after an impact assessment, the EC will produce a proposal to address non-CO_2 effects by 2028.

In addition to the EU ETS, the context of the Fit for 55 policy package, the ReFuelEU Aviation Regulation aims to gradually increase the uptake of sustainable aviation fuels (SAF). These can reduce aircraft GHG emissions by variable amounts, depending on the fuel's production pathway. The regulation requires fuel suppliers to ensure that SAF blending rates rise from 2% in 2025 and reaching 70% by 2050. From 2031, 1.7% of the fuel supplied by specific aviation fuel. Increasing to at least 35% by 2050. The revised ETS Directive also supports additional measures to electrify aviation and airbus to reduce emissions. Finally, the Alternative Fuel Infrastructure Regulation (AFIR) aims to support the uptake of SAF by climate action, energy transformations and addressing the social challenges of decarbonising aviation.

Rail

The rail sector has the lowest absolute GHG emissions (see Figure 1) (2) with approximately 0.8 $MtCO_2e$ in 2023. This is consistent with a highly electrified sector and the fact that rail emissions in the GHG emission inventory are only related to fuel combustion. Falling diesel consumption led to a 15.7% reduction in direct emissions from 1990 to 2020 (Figure 1), despite a 29.5% increase in electricity consumption (Figure 1). It is estimated that rail's share of total transport GHG emissions will remain relatively unchanged because N_2O mainly comes from biomass energy in power supply (Figure 1). Overall, rail accounted for 0.3% of the direct emissions from transport in the EU-27 in 2022.

Methane and nitrous oxide emissions

The following paragraphs consider the fractional and projected emissions of methane (CH_4) and nitrous oxide (N_2O). These GHGs are not covered by the air pollutants in transport indicator. In 2023, transport accounted for 1.4% of EU-27 CH_4 and N_2O that transport respectively accounted for approximately 0.13% and 0.41% of overall transport GHG emissions and 0.41% and 0.68% of the overall CH_4 and N_2O emissions in the EU-27, as measured in $MtCO_2e$.

CH_4 emissions also affect air pollution as they contribute to ground-level tropospheric ozone formation. Equally, N_2O has been identified as the most significant anthropogenic contributor to stratospheric ozone layer depletion. Estimating the emissions of these compounds through combustion processes is difficult. Hardly any emission standards exist for transport modes, except for the recently approved vehicle emissions and battery durability regulation (Euro 7), which specifically addresses non-CO_2 emissions from combustion engines. Between 1990 and 2023, CH_4 emissions fell by 37.5% and N_2O emissions by 25.6%. Both pollutants have seen a steady decline since 2000, mainly due to the introduction of three-way catalytic converters, which are challenging because N_2O mainly comes from biomass energy in power supply (OPS) or alternative zero-emission technologies while at berth, as discussed further in the section on energy infrastructure.

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Methane and nitrous oxide emissions

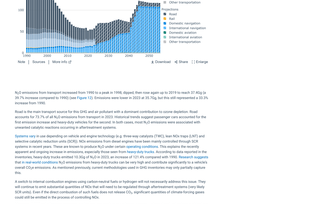
The following paragraphs consider the fractional and projected emissions of methane (CH_4) and nitrous oxide (N_2O). These GHGs are not covered by the air pollutants in transport indicator. In 2023, transport accounted for 1.4% of EU-27 CH_4 and N_2O that transport respectively accounted for approximately 0.13% and 0.41% of overall transport GHG emissions and 0.41% and 0.68% of the overall CH_4 and N_2O emissions in the EU-27, as measured in $MtCO_2e$.

CH_4 emissions also affect air pollution as they contribute to ground-level tropospheric ozone formation. Equally, N_2O has been identified as the most significant anthropogenic contributor to stratospheric ozone layer depletion. Estimating the emissions of these compounds through combustion processes is difficult. Hardly any emission standards exist for transport modes, except for the recently approved vehicle emissions and battery durability regulation (Euro 7), which specifically addresses non-CO_2 emissions from combustion engines. Between 1990 and 2023, CH_4 emissions fell by 37.5% and N_2O emissions by 25.6%. Both pollutants have seen a steady decline since 2000, mainly due to the introduction of three-way catalytic converters, which are challenging because N_2O mainly comes from biomass energy in power supply (OPS) or alternative zero-emission technologies while at berth, as discussed further in the section on energy infrastructure.

CH_4 emissions are expected to fall by 71.5% from 1990 to 2023 to 47.2 $MtCO_2e$ in 2030 and 19.1 $MtCO_2e$ in 2050. This corresponds to reductions of 13.9% in 2030 and 68.7% in 2050 compared to 2023. At the same time, CH_4 emissions from road transport are expected to decrease by 77.5% by 2050 compared to 2023. Projections also foresee an increase of up to 4.78Gg in CH_4 emissions from domestic aviation by 2050.

Figure 11: CH_4 emissions in the EU-27 reported to the UNFCCC and to the EU Greenhouse Gas Monitoring Mechanism

Absolutes (Gg) Shares — transport (%) Shares — total (%)



N_2O emissions from transport increased from 1990 to peak in 1998, dipped, then rose again up to 2019 to reach 37.8Gg in 2019 (a 20% increase compared to 1990) (see Figure 12). Emissions were lower in 2020 at 29.2Gg, but this still represented a 20.3% increase from 1990.

Road is the main transport source for this GHG and air pollutant with a dominant contribution to ozone depletion. Road accounts for 72.1% of all N_2O emissions from transport in 2023. Historical trends suggest passenger cars are expected to be the first emission increase and heavy-duty vehicles for the second. In both cases, most N_2O emissions were associated with unwanted catalytic reactions occurring in three-way catalysts.

Systems vary in use depending on vehicle and engine technology (i.e. three-way catalysts (TWC), lean NO_x traps (LNT) and selective catalytic reduction (SCR)). Each of these systems has its own N_2O emission factor, which depends on the systems in recent years. There are trends to reduce fuel consumption under operating conditions. This is particularly relevant, apparent and ongoing increases in emissions, especially those seen from heavy-duty trucks. According to data reported in the Inventories, heavy-duty trucks emitted 15.6g of N_2O in 2020, an increase of 131.4% compared with 1990. Research suggests that in real-world conditions N_2O emissions from heavy-duty trucks can be very high and contribute significantly to a vehicle's total CO_2 emissions. As mentioned previously, current Euro VI emission standards for heavy-duty vehicles do not regulate this.

A switch to internal combustion engines using carbon-neutral fuels or hydrogen will not necessarily address this issue. They will continue to emit substantial quantities of NO_x that will need to be regulated through aftertreatment systems (very likely SCR) until. Even if the direct combustion of such fuels does not release CO_2, significant quantities of climate-forcing gases could still be emitted in the process of controlling NO_x.

Moreover, if SCR units become common in other sectors, such as waterborne transport, where diesel technology is ubiquitous, N_2O emissions could rise substantially. Other technologies, such as LNT, are also likely to emit N_2O under certain conditions. Of note, unlike NO_x emissions (NO_2 and NO), which are regulated at the same time, systems could be calibrated to minimise the emissions of some compounds at the expense of others. In the case of hydrogen (H_2) as an energy carrier, the gas itself can unintentionally slip into the atmosphere during combustion or in the production and transport processes. While H_2 is not a direct GHG, it affects atmospheric chemistry by impacting the lifetime of other GHGs, namely methane, ozone and water vapour. Ultimately, this has an overall climate warming effect.

Waterborne transport was responsible for 13.5% of all N_2O emissions across all transport sectors in 2023, equating to 4.8Gg (81.3% of which was due to international navigation). Emissions have increased by 7.3% in the period 1990–2023.

Aviation contributed to 10.9% of overall N_2O emissions from transport in 2023, with 3.9Gg (82.1% coming from international transport). Emissions for the sector have risen by 20.3% since 1990.

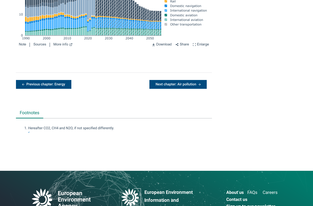
N_2O emissions are expected to fall, mainly driven by a smaller contribution from road transport. Road transport N_2O emissions are projected to fall by 77.5% by 2050 compared with 2023 (see Figure 12). Meanwhile, emissions from the combustion of both navigation and aviation is also expected, with a decrease of 23.6% and 23.2%, respectively, by 2050 compared with 2023.

Box 6. Greece and Finland: consistently reducing methane and nitrous oxide emissions in road transport

Greece and Finland are achieving reductions in both CH_4 and N_2O over the long term (1990-2020) and short term (2022-2025) in road transport. Both countries emphasised a shift to cleaner transport alternatives, including electrification and public transport improvements, in national decarbonisation plans that target methane and nitrous oxide emissions in addition to CO_2. These Member States have also committed to phasing out older diesel vehicles and implemented early policies supporting biofuels, biogas and renewables in the transport system. These actions have likely contributed to lower emissions of methane and nitrous oxide.

Figure 12: N_2O emissions in the EU-27 reported to the UNFCCC and to the EU Greenhouse Gas Monitoring Mechanism

Absolutes (Gg) Shares — transport (%) Shares — total (%)



← Previous chapter: Energy
Next chapter: Air pollution →

Footnotes

1. Hereafter CO2, CH4 and N2O, if not specified differently

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Air pollution
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Acronyms