In 2025, France's greenhouse gas emissions are expected to fall by around 1%, mainly due to the decline in the activity of GHG-emitting industries

Every year, Citepa draws up an inventory of France's greenhouse gas (GHG) emissions on behalf of the Ministry of Ecological Transition, covering territorial emissions which fell by 1.8% in 2024 compared with 2023, according to the estimate published on 16 June 2025. In addition, the Statistical Data and Studies Deparment (SDES) and INSEE publish Air Emissions Accounts (AEA), which account for emissions from resident units whose classification of activity is modelled on that of the national accounts. For 2024, these emissions are expected to stand at around 400 million tonnes of CO_2 equivalent ($MtCO_2e$), down 0.9% on 2023. This rate of decline is below the level compatible with France's climate commitments – around -5% per year on average – and with the carbon budget for the new draft National Low-Carbon Strategy (SNBC-3).

The link between greenhouse gas emissions and economic activity is clearly established. Although a clear trend towards decoupling (i.e. a reduction in emissions for a given level of economic activity) has been observed in France and in all the advanced economies over the last 20 years, variations in emissions remain partly linked to economic fluctuations. By working at a detailed sectoral level, changes in emissions can be linked even more closely to changes in demand or production in certain sectors. For example, the drop in emissions from manufacturing industry in 2024 is mainly explained by the decline in industrial output in energy-intensive sectors, and does not reflect a reduction in carbon intensity. Conversely, the decline in emissions in the energy sector is not due to a drop in electricity production, but to greater decarbonisation of the electricity mix, made possible by a higher nuclear power plant operation rate.

The economic activity scenario in the *Economic Outlook* covers a large number of indicators at a relatively detailed sectoral level, which can be used to produce a forecast of France's greenhouse gas emissions in 2025 that is consistent with the economic activity forecast scenario in this *Economic Outlook*, by using past data to model the links between economic activity and emissions.

According to this forecast, France's GHG emissions in AEA format are set to decrease by 5.3 $MtCO_2e$ in 2025, corresponding to a reduction of 1.3%. This drop is mainly due to the economic downturn in GHG-emitting industries (chemicals, metallurgy, cement manufacturing, etc.), with manufacturing industry likely to contribute 0.8 points to the drop in emissions in 2025. However, the energy sector's contribution to the reduction should be smaller than in previous years. After two consecutive years of particularly sharp declines in fossil fuel power generation, due to the restarting of nuclear power stations and the upward trend in renewable power generation, the scope for further reductions is now limited. Direct household emissions, meanwhile, are expected to remain stable, with emissions linked to heating likely to fall as a result of the downward trend in the use of heating oil, although fuel consumption looks set to increase.

These trends remain forecasts, and are fragile for two reasons. Firstly, they are based on a macroeconomic scenario that is, by definition, uncertain, and secondly, they rely on assumptions used as the basis for estimating GHG emissions for a given economic activity, which are also sources of uncertainty. In addition, the forecast is conventionally based on the assumption that the end of the year will be in line with seasonal temperature norms. Autumn weather conditions are, by their very nature, a source of uncertainty for the forecasting of emissions linked to electricity production and heating, as well as for the activity of these same industries.

Clément Bortoli, Émilie Cupillard, Guillaume Roulleau

In 2024, France's GHG emissions in AEA format are likely to have amounted to 399.8 million tonnes of CO_2 equivalent, down 0.9% on 2023

In France, greenhouse gas emissions are measured by Citepa. Several concepts and formats for emissions data coexist, including emissions from activities in France ("UNFCCC" and "Secten" formats),[1] and emissions from resident units (Air Emissions Accounts "AEA" format). For their publication, INSEE and SDES favour this second concept, whose activity classification is based on the national accounting classification system. The levels of emissions in these two metrics are different, but their annual changes are closely correlated (► **Box** Sources). The main source of discrepancy between these two formats concerns the calculation of emissions associated with international transport, mainly air and maritime transport.

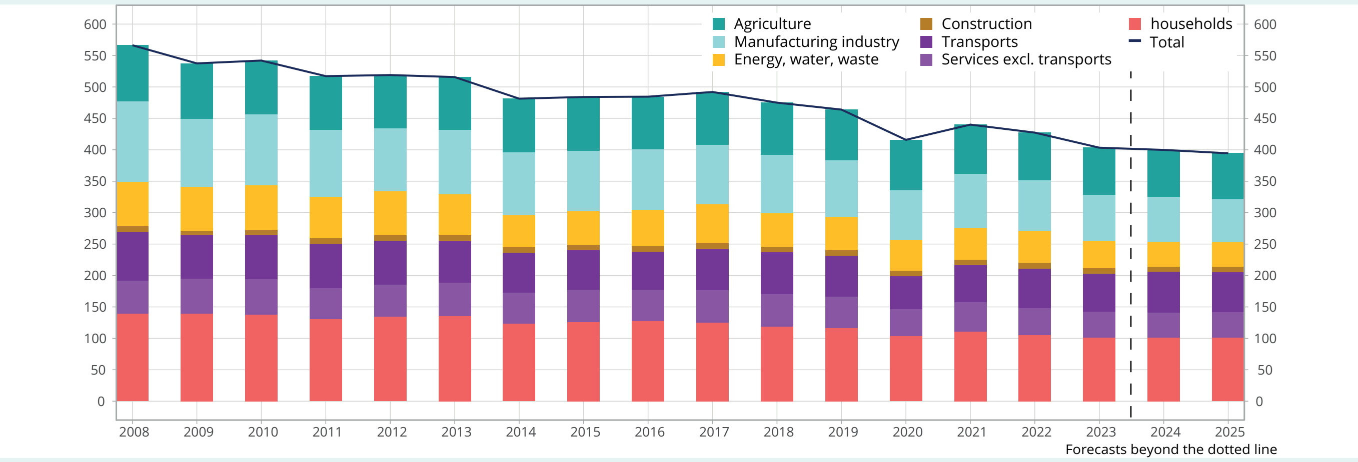
1 The UNFCCC (United Nations Framework Convention on Climate Change) GHG inventory is the international benchmark. The inventory in Secten (economic and energy sectors) format was developed by Citepa at the request of the French Ministry of Ecological Transition to provide clearer and more user-friendly information. The emission accounting rules in Secten format are identical to those for the inventory in UNFCCC format, and the national totals for the inventories in both formats are identical.

The global emissions of French resident enterprises are included in France's emissions in the "AEA" format, due to the principle of residence of the enterprises in question, but are not accounted for in Secten format because these emissions did not actually occur in the country. In the case of France, due to the existence of major air and maritime transport enterprises among the resident units, total resident emissions are structurally higher than in-country emissions. This data covers all greenhouse gases, mainly carbon dioxide (CO_2), but also includes other gases.[2] Emissions are measured in millions of tonnes of carbon dioxide equivalent ($MtCO_2e$).

In 2023, emissions in AEA format amounted to 403.4 $MtCO_2e$, according to the provisional estimate published by INSEE and SDES in November 2024. Household emissions accounted for 25% of total air emissions in AEA format, due to the use of private vehicles (16%) and gas- and oil-fired heating (8%). In terms of economic activity, manufacturing industry accounted for 18% of total emissions, generated mainly by three branches: the manufacture of non-metal materials, including cement (5%), metallurgy (4%) and chemicals (4%). The food processing and refining industries also contribute to these emissions but to a lesser extent. Agriculture also made a significant contribution to emissions (19%), particularly from cattle farming (around 10%), as did the transport sector[3] (15%), notably including emissions from air (4%) and sea (6%) transport, and from land freight (4%). The "energy, water and waste" branch was responsible for 11% of total emissions, half of which were generated by electricity production and half by the waste branch. The remaining emissions (12%) were mainly due to tertiary activities.

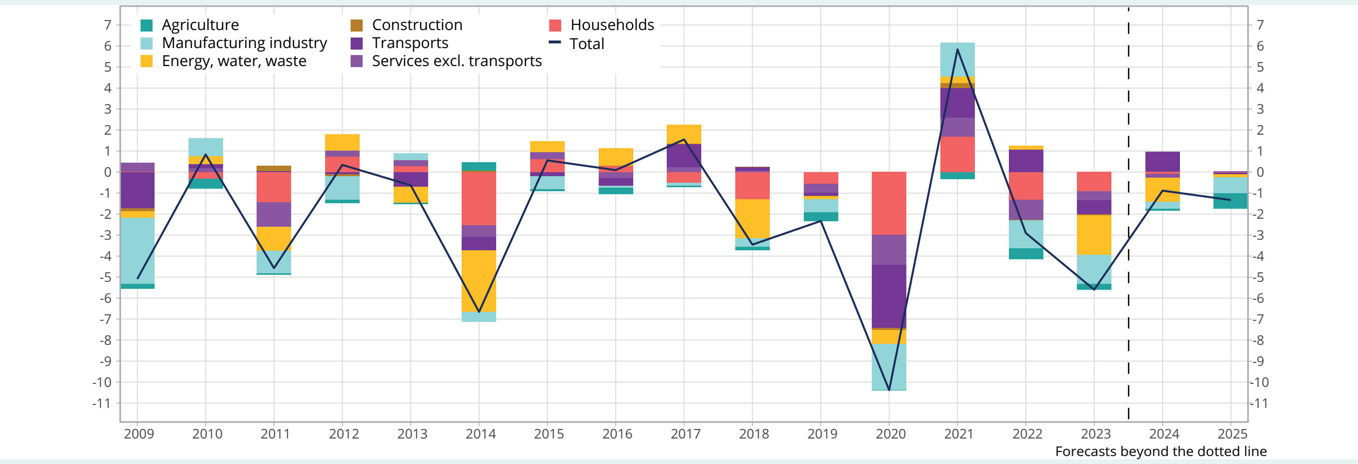
2 In 2023, carbon dioxide accounted for 77% of resident greenhouse gas emissions, methane 14%, nitrous oxide 6% and fluorinated gases 2%.
3 These emissions correspond to the activities of the "transport" branch in the national accounts. This only concerns transport services for hire or reward. AEA format relates emissions from other vehicles to each branch and to households (for emissions from private vehicles).

►1. Greenhouse gas emissions per sector in France (AEA format)
(in millions of tonnes of CO_2 equivalent)



Last point: 2023.
How to read it: in 2023, emissions amounted to 403.4 $MtCO_2e$; they are expected to stand at 399.8 $MtCO_2e$ in 2024.
Source: Citepa, SDES, INSEE, INSEE calculations.

►2. Contributions to greenhouse gas emissions in France, per sector
(annual change in %; contributions in points)



Last point: 2023.
How to read it: in 2023, observed emissions have declined by -5.6%; they are expected to fall by -0.9% in 2024.
Source: Citepa, SDES, INSEE, INSEE calculations.

The air emission figures in AEA format for 2024 are not yet known (they will be published in their provisional version in autumn 2025 and then in their final version in 2026). However, the data published by Citepa in Secten format can be used to calculate an approximation of these emissions for 2024 (►**Box** Methodology). In this way, France's emissions in AEA format in 2024 amounted to an estimated 399.8 $MtCO_2e$ (►**Figure 1**), down 0.9% on 2023 (►**Figure 2**). Electricity generation seems to have been a major contributor to this reduction, as its fossil fuel component reached an all-time low in 2024 due to the restarting of the numerous nuclear reactors shut down in 2022 for maintenance and inspection operations (notably due to stress corrosion phenomena). Other factors include an increase in renewable power generation and the excellent availability of hydro resources. To a lesser extent, emissions would also appear to have edged down in the manufacture of non-metal materials, due to the depressed activity in this branch. However, emissions from household activities (private vehicles and fossil heating) would appear to have remained virtually stable. The reduction in emissions from resident units (AEA format) seem to have been less pronounced than the decline in territorial emissions (Secten format), which fell by 1.8% in 2024, according to the Citepa "proxy" published on 16 June 2025. This difference can be explained by emissions generated abroad by resident transport units, which would seem to have been particularly dynamic in 2024.

France's climate commitments correspond to an average annual reduction of 16 to 20 $MtCO_2e$ by 2030

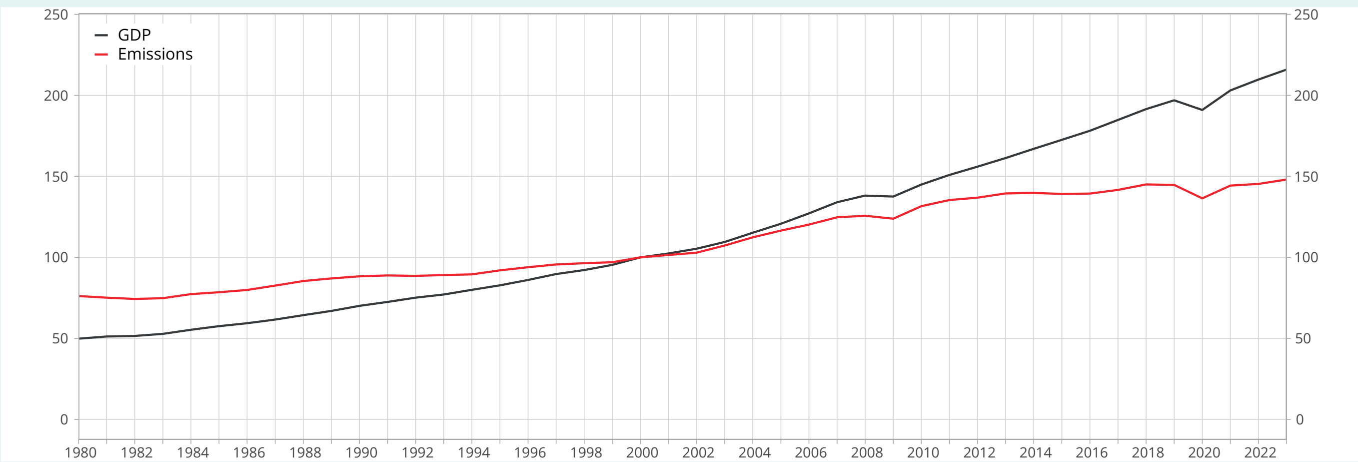
In December 2015, the COP21 conference culminated in the adoption of the Paris Agreement, which set long-term targets for climate change mitigation and adaptation, in addition to the definition of national policies by developed and developing countries. The European Union has set a new target of reducing its net emissions (emissions minus absorption by carbon sinks) by at least 55% between 1990 and 2030, and is committed to achieving climate neutrality by 2050 at the latest. France has adopted a national low-carbon strategy and carbon budgets to implement the transition towards a low-GHG economy. According to the ►**Haut Conseil pour le Climat (2024)**, France's commitments assume a reduction in emissions at an average annual rate of 16 $MtCO_2e$, while the draft new National Low-Carbon Strategy (SNBC-3) sets this reduction at around 5% per year.[4]

Emissions are simultaneously dependent on economic activity in certain sectors, on one-off factors such as severe weather, and on an overall decarbonisation trend

Human emissions are directly linked to economic activity. The "environmental Kuznets curve" (►**Grossman and Krueger, 1995**) hypothesises a bell curve of GHG emissions according to the stage of economic development. From a historical perspective, the transition from a predominantly agricultural economy to an industrial economy should significantly increase emissions, while the tertiarisation of the economy, accompanied by deindustrialisation, should tend to reduce the country's emissions. Empirically, over the long term, this is reflected by a decoupling of emissions and global GDP, i.e. a slower increase in emissions than in the level of GDP (►**Figure 3**). This decoupling is particularly prevalent in advanced economies (►**IEA, 2024**) and is partly due to their tertiarisation, but it should remain limited in developing economies (►**Cohen and al., 2022**).

4 The objectives of the National Low Carbon Strategy concern territorial emissions (Secten format). However, the changes in these emissions may occasionally differ from those for emissions from resident entities (AEA format) when the emissions generated abroad by resident transport units are subject to a particular trend, as was the case in 2024 for example.

►3. Level of global GHG emissions and global GDP
(level in base 100 in 2000)



Last point: 2023.
How to read it: in 2022, global GHG emissions are 45 points above the year 2000 level, while global GDP in real terms is 110 points above the year 2000 level.
Source: OECD, IMF, INSEE calculations.

However, in the short term, and even in the advanced economies subject to this decoupling, variations in emissions remain closely linked to the economic cycle. As in business activity, certain increases or reductions in emissions may therefore be “cyclical”. The ►Figure 4 thus points towards a causal link between variations in activity and those in emissions. The academic literature also highlights the fact that economic fluctuations have a significant direct short-term impact on emissions (►**Doda, 2014, Burke and al., 2015**). In addition, emissions from the residential and tertiary sectors are highly dependent on climate conditions (►**SDES, 2024**).

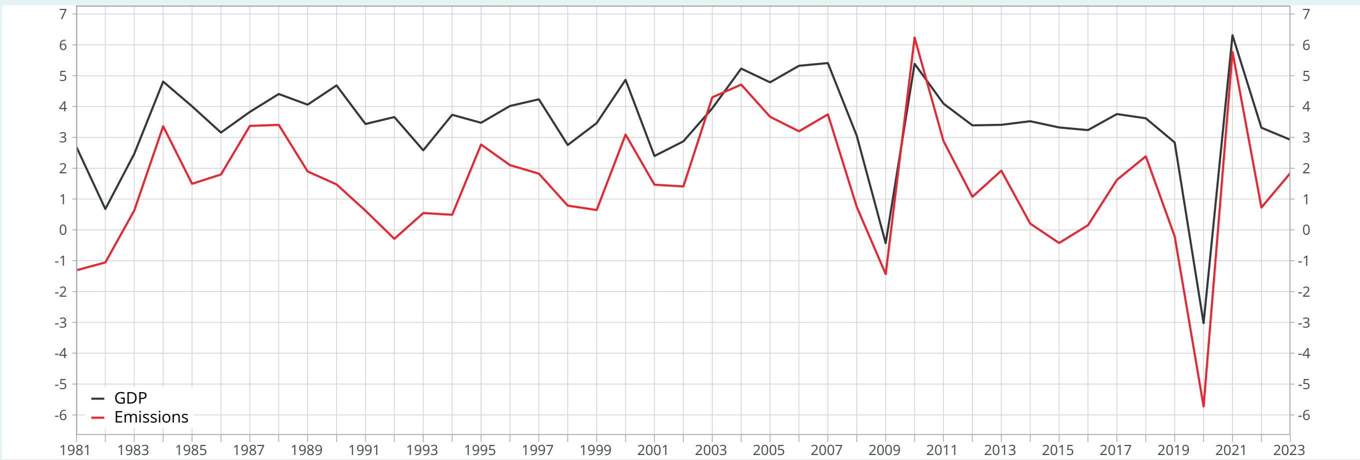
In France, this is clearly illustrated by the road transport sector. Emissions from vehicle use (road transportation of passengers, goods and household use of personal vehicles) are closely correlated with the distance travelled on the roads (►**Figure 5**), which is itself highly dependent on activity in industry and demand for goods, while fluctuating around a fairly linear decarbonisation trend.

For 2025, GHG emissions can be forecast using the economic activity scenario in the *Economic Outlook*

The *Economic Outlook* proposes a forecast scenario for economic activity in France in 2025 covering a large number of indicators at a relatively detailed sectoral level. This can be used to produce a forecast of greenhouse gas emissions from resident units in 2025 that is consistent with the economic activity forecast scenario, by modelling the links between economic activity and emissions based on past data.

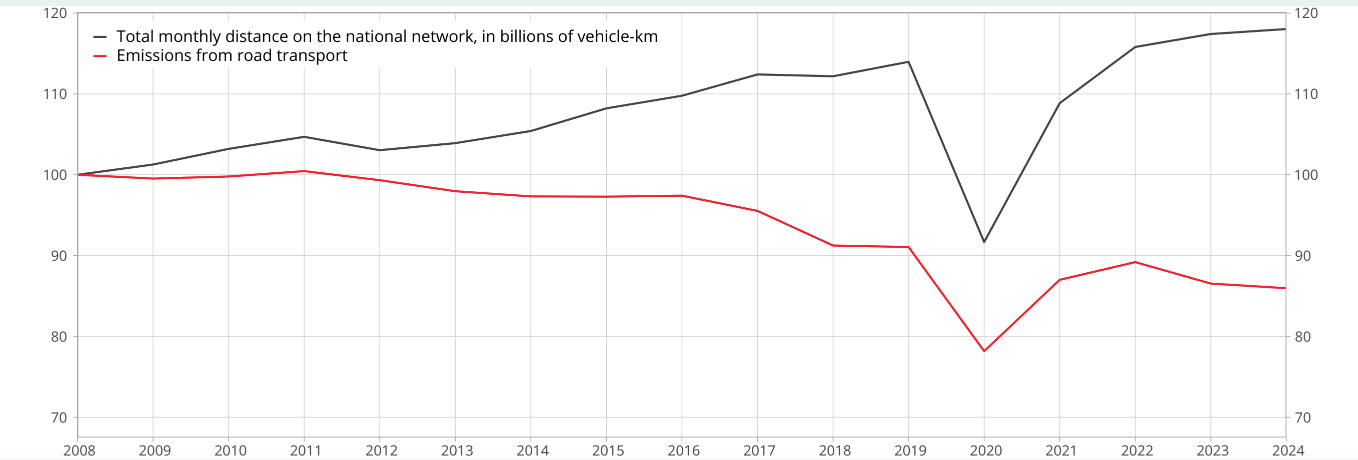
The cyclical monitoring of GHG emissions is clearly established as a topic of interest in the literature. Therefore, in addition to the quarterly barometer for France published by Citepa using the Secten classification (►**Box** Sources), other countries and institutions provide sectoral and sub-annual estimates of GHG emissions, generally on a quarterly basis, as in the Netherlands (►**Keller and Schenau, 2021**) and Sweden (►**SCB, 2016**).

►4. Changes in global GHG emissions and global GDP growth
(annual changes in %)



Last point: 2023.
How to read it: in 2022, global GHG emissions increased by 0.7%, while global growth reached 3.3%.
Source: OECD, IFM, INSEE calculations.

►5. Number of kilometres travelled and transport-related emissions
(base 100 in 2008)



Last point: 2024.
How to read it: in 2024, GHG emissions linked to road transport (from households and other institutional sectors) are expected to be 14 points below their 2008 level. The number of vehicle-km travelled on the entire road network is around 18 points above its 2008 level.
Source: Citepa, SDES, INSEE calculations.

Some projects also propose near-real-time monitoring of emissions, such as Carbon Monitor (▶Ke and al., 2023) and CarbonWatch, which use satellite data. In the majority of cases, these sub-annual estimates of emissions, including those by Citepa, are not based on direct information concerning the sector's GHG emissions (e.g. via the European Emissions Trading System), but on the latest available annual emissions, to which the changes in an infra-annual activity indicator (industrial production, energy generation, household petrol consumption, etc.) are applied, often assuming that the emission factors remain constant.[5]

With specific regard to emission forecasting, several modelling methods are proposed in the academic literature. Some of this literature adopts an approach that aims to forecast total GHG emissions directly, without aggregating sectoral emission forecasts. To capture non-linear relationships between economic variables (GDP, urbanisation, foreign trade, etc.) and the environment, these models often rely on complex statistical tools derived from statistical learning (▶Costantini and al., 2024). The forecasting period in this literature often corresponds to the medium/long term, i.e. five, ten or even fifteen years, compared with a much shorter period (several quarters) used in the *Economic Outlook*.

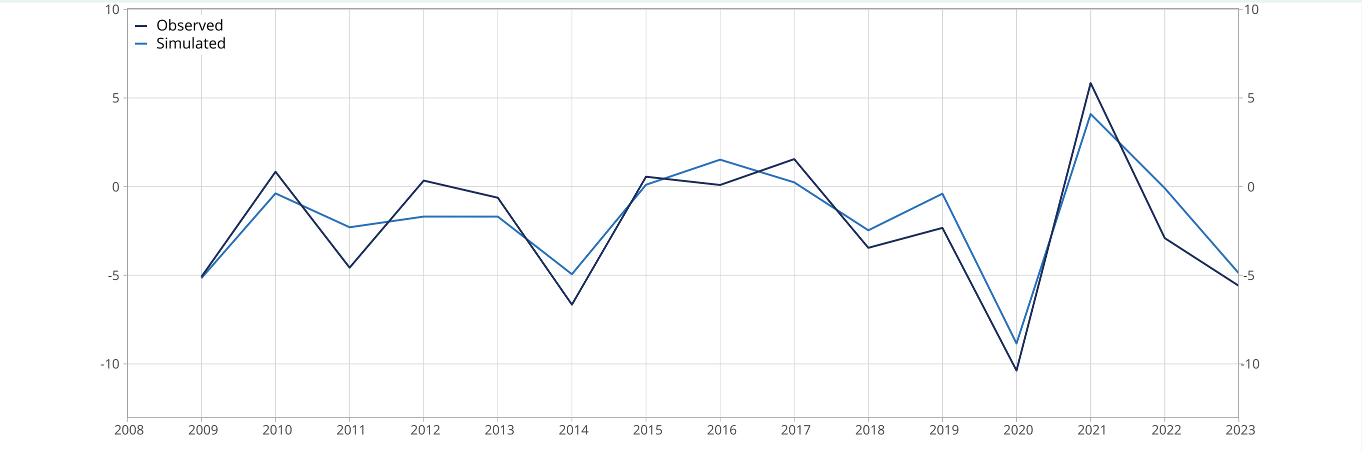
Other studies in the literature forecast emissions at sectoral level, but focus on a single sector such as transport (▶Javanmard and al., 2023; ▶Qiao and al., 2024) or energy (▶Bokde and al., 2021). Statistical learning tools are often used, and the forecasting period is generally medium to long term, or conversely very short term (sometimes just a few days). A final strand of the literature proposes the forecasting of total emissions by using a general equilibrium model, such as ThreeME in France (▶Reynès and al., 2021) to aggregate sectoral estimates, or via expert scenarios such as the ADEME (French Environment and Energy Management Agency) report entitled "Transition(s) 2050" (▶Ademe, 2024). These tools tend to be used more for public policy evaluation, as their results are more akin to long-term projections (over five-year, ten-year or even longer periods), rather than short-term forecasts as envisaged in this *Economic Outlook*.

The GHG emissions forecasting method proposed in this Focus for the various sectors is based on a two-stage approach (▶Box Methodology). First of all, it involves estimating the statistical relationships linking the past changes in the emissions from sectors with the changes in an activity indicator (the industrial production of a sector, household fuel consumption, etc.). These models, estimated on an annual basis, incorporate the elasticities of short-term emissions in relation to the corresponding activity. They also enable the implicit estimation of any decarbonisation trend gains in production processes, i.e. the capacity, for a given activity, to reduce the sector's GHG emissions. These models are then applied to sectoral activity forecasts for 2025 in order to calculate an annual forecast of GHG emissions.

These forecasts are subject to two sources of error. Firstly, they are based on the statistical modelling of emissions, which automatically generates discrepancies in relation to the emissions actually observed. In other words, even if the activity indicators underlying the emission modelling were to be perfectly predicted, a deviation in relation to the observed emissions trends would persist. The ▶Figure 6 compares the GHG emissions simulated by modelling based on observed activity (▶Box Methodology) and the observed emissions over the 2008-2023 period. However, the standard deviation of forecast errors, at

5 Sweden stands out for the fact that its quarterly estimates of GHG emissions are not based primarily on activity indicators, but on a quarterly survey of energy and petroleum product consumption in industry.

▶6. Comparison between observed and model-simulated GHG emissions
(annual changes in %)



Last point: 2023.
How to read it: in 2023, observed GHG emissions fell by 5.6%, compared with -4.9% according to the model-based forecast.
Source: Citepa, SDES, INSEE calculations.

around 1.4%, is much lower than the standard deviation of observed emissions over the same period (around 4%), which suggests that the quality of the modelling is satisfactory. This first source of error is also accompanied by errors linked to the forecasting of the activity indicators themselves: by way of illustration, the standard deviation of errors in annual GDP growth forecasts in the *Economic Outlook* published in June since 2007[6] has been around 0.4 points.

In 2025, France's greenhouse gas emissions in AEA format are expected to fall by 1.3%, mainly due to the continuing economic downturn in energy-intensive industries.

In 2025, activity in the most highly emitting manufacturing industries (metallurgy, cement production and chemicals) is set to decline again. The business climate in these industries remains highly degraded (►**Figure 7**), down by more than 6 points compared with its long-term average, not least because Europe's energy-intensive industries continue to suffer from persistently unfavourable relative energy prices. The decline in emissions is expected to vary from one sector to another. In the chemicals and metallurgy sectors, emissions are expected to fall more sharply than in mineral products, particularly cement production. In H2, activity in this sector should benefit from the end of the downturn in new housing construction. As a result, emissions in the manufacturing industry are expected to fall by 4.3% in 2025 (►**Figure 8**), contributing -0.8 points to the total reduction in emissions.

However, in 2025, the energy sector will no longer be driving the reduction in GHG emissions. After ending 2024 at record levels, nuclear power generation is expected to fall slightly in H2 2025 and to stabilise thereafter, still at a relatively high level. Fossil fuel electricity generation, which has already fallen sharply over the last two years (-40% in 2023, followed by -46% in 2024), is set to stabilise at an all-time low, thereby making no further contribution to the reduction in emissions.

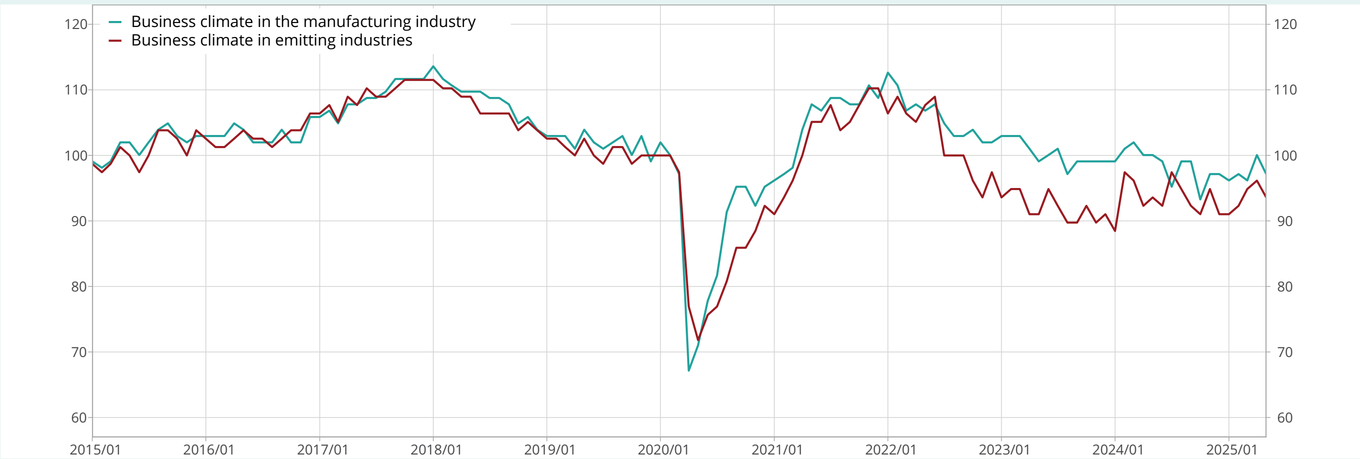
Emissions from the transport sector are likely to remain at a standstill in 2025. Although emissions from the aviation sector are expected to keep rising in 2025, albeit still below their pre-health-crisis level of around 10%, emissions from other transport activities (notably freight transport) are expected to drop, in the wake of a sluggish economy.

Finally, household emissions should remain stable. On the one hand, domestic heating-related emissions are expected to fall (-1.9%). Temperatures in H1 have been broadly comparable to those of last year, and the ban on installing or replacing an oil-fired boiler from 1st July 2022 has led to a downward trend in fuel purchases. On the other hand, household transport emissions are likely to increase (+0.9%) because the downward trend in fuel consumption should be temporarily offset by the stimulus provided by lower fuel prices in April and May 2025. These forecasts are based on consumption data available for the first four months of the year. For heating, they are also based on an assumption of severe weather in line with normal conditions for the end of the year, conventionally used in the *Economic Outlook.*

All in all, total emissions from resident units are expected to fall by 1.3% in 2025, after -0.9% in 2024.

6 Excluding the financial crisis in 2008 and the health crisis in 2020 and 2021.

►7. Business climate in emitting industries
(standard climates with mean 100 and standard deviation 10)



Last point: May 2025.
Note: for each sub-sector at level A38 of the NAF aggregated classification, a business climate was calculated by factor analysis based on the balances of opinion measured in the business tendency surveys. A climate for emitters was then calculated by weighting each sub-sector according to its weight in the GHG emissions of resident units for the year 2023.
How to read it: in May 2025, the business climate in manufacturing industry reached 97, compared with 94 for the climate for emitters.
Source: business surveys, INSEE.

►8. GHG emissions from French resident economic activities and direct household emissions, observed and forecast

(in $MtCO_2e$)

	Weight (in 2023)	2019	2020	2021	2022	2023	2024 (reconstitution)	2025 (forecast)	2025 (evol.)
Agriculture	18.6	80.9	80.3	78.7	76.4	75.1	74.7	73.2	-2.0 %
Manufacturing industry	18.2	90.1	79.1	85.6	79.5	73.3	72.1	69.0	-4.3 %
of which Chemicals-Pharmacy	*4.2*	*19.9*	*19.0*	*20.1*	*18.0*	*16.9*	17.2	*16.2*	*-5.8 %*
of which Food Industry	*1.9*	*10.0*	*9.0*	*9.3*	*8.3*	*7.5*	7.1	*7.0*	*-1.4 %*
of which Coking and Refining	*2.3*	*12.2*	*9.9*	*9.3*	*9.5*	*9.4*	9.1	*8.9*	*-2.2 %*
of which Metallurgy and metal product	*3.8*	*20.4*	*15.8*	*19.2*	*17.5*	*15.1*	15.4	*14.3*	*-7.1 %*
of which Mineral product (cement, rubber, plastics)	*4.5*	*20.6*	*18.6*	*20.4*	*19.7*	*18.3*	17.3	*16.7*	*-3.5 %*
of which Others industry products	*1.5*	*7.1*	*6.8*	*7.3*	*6.6*	*6.1*	6.0	*5.8*	*-3.3 %*
Energy, water, waste	10.8	52.6	49.4	50.6	51.4	43.7	39.1	38.5	-1.5 %
of which Extraction	*0.1*	*0.6*	*0.4*	*0.4*	*0.3*	*0.3*	0.3	*0.3*	*0.0 %*
of whichElectricity and gas	*4.7*	*26.6*	*23.9*	*25.8*	*26.4*	*18.8*	14.2	*13.6*	*-4.2 %*
of which Waste, water	*6.1*	*25.4*	*25.1*	*24.4*	*24.7*	*24.7*	24.6	*24.6*	*0.0 %*
Construction	2.1	8.9	8.0	8.9	8.9	8.5	8.5	8.5	0.0 %
Transports	15.0	65.7	52.8	58.8	63.4	60.6	64.4	64.1	-0.5 %
of which Aerial	*4.4*	*20.5*	*9.9*	*11.4*	*16.1*	*17.9*	18.5	*18.8*	*1.6 %*
of which Other transport activitiest	*10.6*	*45.3*	*42.9*	*47.4*	*47.3*	*42.7*	45.9	*45.3*	*-1.3 %*
Non-transport services	10.1	49.4	42.9	46.8	42.7	40.8	40.1	40.3	0.5 %
Households	25.1	116.3	103.3	110.6	105.1	101.2	100.9	100.9	0.0 %
of which Heating	*8.1*	*43.1*	*41.6*	*42.6*	*35.0*	*32.7*	32.4	*31.6*	*-2.5 %*
of which Transports	*16.2*	*69.8*	*58.5*	*64.8*	*66.8*	*65.3*	65.3	*66.1*	*1.2 %*
of which Other household activities	*0.8*	*3.3*	*3.2*	*3.2*	*3.2*	*3.2*	3.3	*3.2*	*0.0 %*
Total	**100.0**	**463.9**	**415.8**	**440.1**	**427.3**	**403.4**	**399.8**	**394.5**	**-1.3 %**

How to read it: in 2025, Emissions linked to energy production are expected to amount to 38.5 $MtCO_2e$ compared with 39.1 $MtCO_2e$ in 2024
Source: Citepa, SDES, INSEE, INSEE calculations.

Box 1: Sources and classifications of greenhouse gas emissions

In France, Citepa carries out an annual inventory of greenhouse gas emissions, expressed in millions of tonnes of CO_2 equivalent, on behalf of the Ministry of Ecological Transition

The aim of greenhouse gas (GHG) inventories is to quantify (in terms of the mass of substances emitted per year) the GHGs emitted within a country, and to link these emissions to human activities. The inventories reported by governments to the United Nations Framework Convention on Climate Change (UNFCCC) form the benchmark used for GHG emissions. These inventories are governed by internationally shared accounting and control rules. The Intergovernmental Panel on Climate Change (IPCC) is responsible for overseeing the rules governing calculations and the assessment of estimation procedures.

In France, Citepa produces an annual inventory of the country's greenhouse gas emissions on behalf of the Ministry of Ecological Transition. This inventory is compiled up to year N-2, while emissions for year N-1 are also the subject of a preliminary estimate ("proxy") published every year in June.

This inventory covers all greenhouse gases, mainly carbon dioxide (CO_2), but also includes methane (CH_4), nitrous oxide (N_2O) and fluorinated gases.[1] Emissions are measured in millions of tonnes of CO_2 equivalent ($MtCO_2e$). For this purpose, emissions excluding CO_2 are "converted" to CO_2 equivalent using a global warming potential (GWP) factor, which represents the impact of each type of GHG on the climate over a given time horizon, usually one hundred years (to take account of the different lifetimes of each substance), compared with CO_2 whose GWP is conventionally set at 1.

1 Hydrofluorocarbons (HFCs) and, more marginally, perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

Citepa also produces sub-annual estimates of greenhouse gas emissions for the current year. These estimates (not adjusted for seasonal variations) are produced on a monthly basis and published in the form of a barometer on a quarterly basis with a delay of around three months. Therefore, the March barometer corresponds to the publication of emissions for Q4 of year N-1 and therefore constitutes – even before the publication of the proxy in June – Citepa's first estimate of emissions for the full year N-1 (in the same way that, in national accounting, INSEE's quarterly accounts provide an initial estimate of activity for year N-1 before the provisional accounts).

GHG emissions can be published in several formats

These Citepa estimates relate to territorial emissions and are produced in "Secten" format (economic and energy sectors). This format, whose scope is identical to that of the inventory in UNFCCC format, was developed by Citepa at the request of the Ministry of Ecological Transition in order to provide clearer and more user-friendly information.[2]

Resident emissions, derived from air emissions accounts (AEA), differ from territorial emissions. This format has been developed internationally, as part of the System of Environmental Economic Accounting (SEEA), to facilitate the reconciliation of emissions data and macroeconomic statistics. The accounting system for AEA emissions is governed by a European regulation. This format is used by SDES and INSEE in their publications. These accounts are produced by Citepa on the basis of conventional national inventories. This format divides emissions associated with economic activity into 64 branches, based on the national accounts, to which emissions directly linked to household activities (mainly private vehicles and gas and oil heating) need to be added. For the transport sector, emissions in AEA format are calculated on the basis of the residency principle: the foreign emissions of "French resident" enterprises are included and those of foreign residents in France are excluded. Due to the existence of major international transport companies among French resident units, France's total air emissions in AEA format are higher than those within the meaning of the inventory.[3] Despite this difference in levels, the annual changes in emissions in both metrics are strongly correlated with each other. As a result, although emissions for 2024 in AEA format are not yet available, they can be gauged on the basis of emissions for 2024 in Secten format, which have already been estimated and published by Citepa for the production of the "proxy". ●

2 GHG emissions from the inventory in Secten format are allocated to the activities that emitted them, divided into six sectors (themselves subdivided into 70 sub-sectors): energy, manufacturing industry (including construction), residential-tertiary, transport, agriculture and waste. Finally, the absorption of GHGs by land use, land-use change and forestry ("LULUCF"), i.e. carbon sinks, which are estimated in the final annual inventories and proxies, but not in the quarterly barometer, can be subtracted from these emissions.
3 Furthermore, in terms of composition by activity, the Secten format encompasses all vehicle emissions in a separate "transport" sector, whereas the AEA format allocates emissions to each branch and to households according to vehicle ownership.

Box 2: Greenhouse gas emission forecasting methodology

In this study, GHG emissions from the various sectors are forecast on an annual basis, in two stages.

Firstly, changes in past emissions from sectors in the national inventory in AEA format are modelled on the basis of changes in economic activity in these sectors. In general, the models used are linear and can be used to estimate, on the one hand, the average elasticity of emissions in relation to the activity of the corresponding sector and, on the other hand, a constant (usually negative) that implicitly covers any gains in the emission efficiency of production processes, i.e. the ability, for a given activity, to reduce the sector's GHG emissions. This carbon efficiency, estimated by fixed effects in modelling, is particularly pronounced in French industry (► **Faquet, 2021**).

On the basis of these models, the various forecasts of sector activity or household consumption, published in the *Economic Outlook*, are then used to produce forecasts of changes in emissions for 2025. These changes are then applied to 2024 emissions. The air emission figures for 2024 in AEA format are not yet known (they will be published in the autumn), but they can be estimated from emissions in Secten format, published by Citepa, by exploiting the strong correlation between these two metrics.

The emissions data used to estimate the first-stage models is based on the annual national inventory available from 1990 to 2023, which was published by SDES and INSEE on 5 November 2024 as part of the augmented national accounts (▶ **INSEE, 2024**). The chosen forecasting models are used to associate the variation in emissions from each sector with an indicator of variation in activity provided in the *Economic Outlook*. These include industrial production indices (IPIs) for the most emission-intensive sectors and household consumption indicators for certain products, such as fuel, whose consumption correlates very closely with households' private vehicle emissions.

Formally, let E_a^j be the emissions of sector ***j*** for year ***a***, and Y_a^j the activity indicator (IPI, consumption for example) of sector ***j*** for year ***a***. Let ***β*** be the elasticity linking emissions and activity, and let ***α*** be the estimate of the linear trend related to carbon efficiency (in all estimated equations, ***α*** ≤ ***0***). The relative variation (expressed as a %, noted Δ) in emissions can then be estimated using the ordinary least squares method:

$$\Delta E_a^j = \beta \times \Delta Y_a^j + \alpha + \in_a \quad (1)$$

In the second stage, models are applied to the annual forecasts of economic activity or household consumption for 2025 from the *Economic Outlook*, as noted $\Delta \widehat{Y}_t^j$. The emissions forecast for 2025 can then be calculated. Formally:

$$\Delta \widehat{E}_{2025}^j = \widehat{\beta} \times \Delta \widehat{Y}_{2025}^j + \widehat{\alpha} \quad (2)$$

these changes are then applied to air emissions in 2024, which are themselves estimated on the basis of emissions in Secten format, published by Citepa.

Granularity of the forecast

GHG air emissions for the 1990 to 2023 period, published by SDES and INSEE on 5 November 2024, consist of GHG emissions from economic activities, which are themselves divided into 64 branches (NAF classification A64), and those due to household activities (travel in personal vehicles, oil or gas-fired heating, other activities).

To forecast emissions, economic activities were divided into fourteen sectors: chemicals and pharmaceuticals, metallurgy, manufacture of non-metal materials (including cement), refining, agri-food industry, remaining manufacturing industries (notably automotive, aeronautics and manufacture of capital goods), electricity, water and waste, mining, agriculture, construction, services excluding transport, air transport, and other transport (notably land and waterborne transport). The emissions of twelve of these fourteen branches were modelled.[1] The forecasting models used for these twelve sectors, as well as for the three types of household activity, are presented in the following sections.[2]

Chemicals and pharmaceuticals

The activities of the **chemical** industry (along with the pharmaceutical sector, which is marginal in terms of emissions) accounted for 4% of France's air emissions in 2023. The emissions forecasts are based on the IPI for the sector, which is extended in the forecast by the change in output in this sector in the scenario presented in the *Economic Outlook*. Activity in the chemicals sector is expected to deteriorate more strongly than activity in manufacturing industry as a whole in 2025, as shown firstly by the business climate in business surveys (▶ **Figure 7**), and secondly by the IPI observed over the first four months of 2025. According to this model, for a given level of activity, emissions from the chemical industry will drop by approximately 4% on average per year.

$$\Delta E_a^{Chimie} = \underset{(0,16)}{0,40} \times \Delta IPI_a^{CE} - \underset{(-0,70)}{3,50} + \epsilon_a$$

Estimation period=2000-2023
R^2=0.20

1 Emissions from the water and waste sector are not modelled, but stabilised in the forecast, as are those from the extractive industries, which are otherwise marginal.
2 The estimated coefficients are shown with their standard deviation.

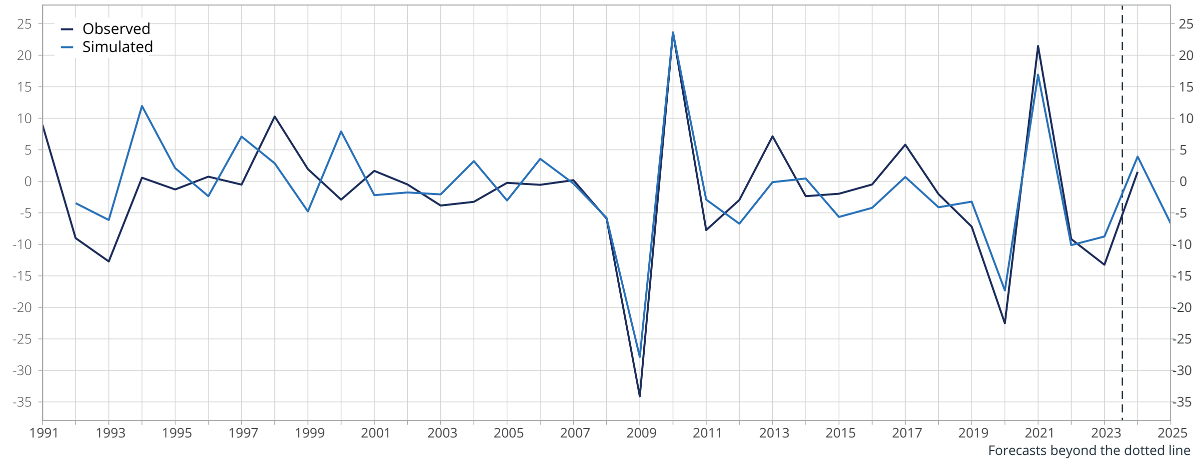
Metallurgy and manufacture of metal products

Emissions from the **metallurgy and manufacture of metal products** branch also accounted for 4% of France's air emissions in 2023. Within this sector, metallurgy accounts for almost all of the emissions, despite only accounting for a third of the value added. The emissions forecast for the entire industry is therefore based on the IPI for metallurgy alone (**►Figure A1**), with changes in the IPI for the manufacture of metal objects not taken into account. The IPI for metallurgy is extended in the forecast by the changes in this sector's output in the *Economic Outlook* scenario. As in the chemical sector, activity in the metallurgy sector is forecast to deteriorate more than activity in manufacturing industry as a whole, as reflected by enterprises' responses to INSEE's business tendency surveys (**►Figure 7**). Finally, the delay in the emissions series is added to the model, with the constant not being significant.

$$\Delta E_a^{Métall.} = \underset{(0{,}12)}{1{,}1} \times \Delta IPI_a^{C24} - \underset{(0{,}09)}{0{,}2} \times \Delta E_{a-1}^{Métall.} + \epsilon_a$$

Estimation period=1990-2023
R^2=0.74

►A1. Observed, simulated and forecast annual change in emissions from metallurgy sector
(annual changes in %)



Last point: 2023.
Note: the 2024 point corresponds to the approximate estimate of emissions from resident units (AEA format), based on data published by Citepa, covering territorial emissions.
How to read it: in 2023, observed emissions fell by -13%, whereas the model predicted a reduction of -9%.
Source: Citepa, SDES, INSEE, INSEE calculations.

Non-metal materials

The manufacture of **non-metal mineral** products is expected to account for 5% of France's air emissions in 2023. This branch includes the manufacture of rubber and plastic products, on the one hand, and the manufacture of other non-metal materials, notably cement, on the other. However, it is the latter that accounts for almost all of the industry's emissions, despite only accounting for around half of its value added. Total emissions for the branch are therefore modelled without taking account of changes in the IPI for the manufacture of plastic and rubber products, and only considering changes in the IPI for other non-metal materials (including cement, which generates high levels of emissions). This IPI is extended in the forecast by changes in output in this sector in the *Economic Outlook* scenario. Although the sector's activity in the first four months of 2025, as measured by the IPI, was worse than activity in the manufacturing industry as a whole, the non-metal mineral product manufacturing sector should benefit in H2 from the end of the downturn in new housing construction, as this sector is its main client.

$$\Delta E_a^{Mat.\ non-métal.} = \underset{(0{,}13)}{0{,}61} \times \Delta IPI_a^{C23} - \underset{(0{,}75)}{1{,}1} + \epsilon_a$$

Estimation period=1990-2023
R^2=0.42

Food industry

The **agri-food industry** accounted for 2% of air emissions in France in 2023. The forecast for these emissions is based on the sector's IPI, extended by the sector's output in the Economics Outlook scenario. To take account of the many ups and downs in the emissions series, the modelling adds a delay. Lastly, since the observed emissions in this sector over the last three years have been systematically lower than those forecast by the model (potentially due to the drop in emissions linked to refrigeration gases, known as "HFCs", which have recently been subject to stricter regulations, notably under the Kigali Agreement in 2016), a buffer of around -1.5 points has been added to the forecast for 2025.

$$\Delta E_a^{Agro-alim.} = \underset{(0,7)}{1,6} \times \Delta IPI_a^{C1} - \underset{(0,22)}{0,42} \times \Delta E_{a-1}^{Agro-alim.} - \underset{(1.05)}{3,00} + \epsilon_a$$

Estimation period=2000-2023
R^2=0.18

Refining

The **refining** industry also accounted for 2% of France's air emissions in 2023. Emissions modelling is based on the sector's IPI, extended by the sector's output in the *Economic Outlook* scenario.

$$\Delta E_a^{Raff.} = \underset{(0,07)}{0,4} \times \Delta IPI_a^{C2} - \underset{(0.87)}{3,88} + \epsilon_a$$

Estimation period=2008-2023
R^2=0.69

Other manufacturing industries

The **other manufacturing branches** are grouped together for the forecasting of their emissions. These include the manufacture of capital goods, transport equipment (particularly automotive and aeronautical), textiles, wood, paper and cardboard, furniture and other manufacturing industries not classified elsewhere. Taken together, these branches accounted for less than 2% of France's air emissions in 2023. The modelling is based on the IPI for the woodworking, paper and printing industries, which accounts for around 40% of the aggregate emissions. Changes in production in the other sectors are not taken into account. The IPI for the woodworking, paper and printing industries is extended in the forecast by the changes in this sector's output forecast in the *Economic Outlook*. In addition, an endogenous delay is added to the model. The constant is not significant. Lastly, as the observed emissions over the last three years have been systematically lower than those forecast by the model, a -2 points adjustment has been added to the forecast for 2025.

$$\Delta E_a^{autres\ Indus.} = \underset{(0.38)}{1,0} \times \Delta IPI_a^{CC} - \underset{(0.22)}{0,66} \times \Delta E_{a-1}^{autres\ Indus.} + \epsilon_a$$

Estimation period=2010-2023
R^2 =0.49

Production of electricity, gas, steam and air conditioning

The **production of electricity, gas, steam and air conditioning** accounted for around 5% of France's air emissions in 2023. Two economic indicators are used to forecast emissions in this sector:

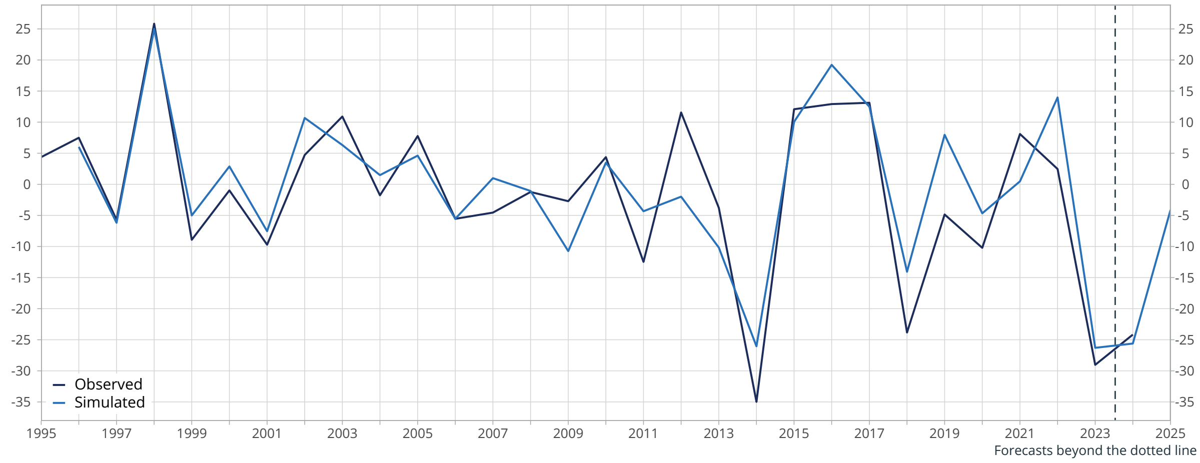
• fossil fuel electricity generation published by RTE (French electricity transmission network), which is used to model emissions from the French electricity mix. This is extended in the forecast, assuming that the end of 2025 will be in line with normal seasonal temperatures and taking account of the downward trend in the carbon content of the electricity mix over the last few years;

• household consumption of the distribution of steam and air conditioning, which is used to model emissions from urban heating systems, included in this branch. In the forecast (►**Figure A2**), this consumption is extended by the actual home energy consumption of households in the *Economic Outlook* scenario, which is a more aggregated series.

$$\Delta E_a^{elec} = \underset{(0.05)}{0{,}5} \times \Delta RTE_a^{fossil} + \underset{(0.22)}{0{,}62} \times \Delta Conso_a^{D35B} + \epsilon_a$$

Estimation period=1995-2023
R^2=0.78

►A2. Observed, simulated and forecast annual change in emissions from the electricity, gas, steam and air conditioning production sector
(annual changes in %)



Last point: 2023.
Note: the 2024 point corresponds to the approximate estimate of emissions from resident units (AEA format), based on data published by Citepa, covering territorial emissions.
How to read it: in 2023, observed emissions fell by -29%, whereas the model predicted a reduction of -26%.
Source: Citepa, SDES, INSEE, INSEE calculations.

Waste, decontamination and wastewater treatment

Emissions linked to the waste, **decontamination and wastewater treatment** branches accounted for 6% of France's air emissions in 2023, which have remained virtually constant since 2013 (fluctuating between 24.3 and 25.4 $MtCO_2e$). These emissions are assumed to be stable in the forecast.

Mining and quarrying

Emissions from **mining and quarrying activities** in France are negligible: they are assumed to be stable in the forecast.

Construction

Emissions from **construction** accounted for around 2% of total emissions in France in 2023. These emissions are linked both to the sector's own activity and to the use of fuel-consuming commercial vehicles.[3] The forecast is therefore based both on the sector's output (as defined by the INSEE national accounts) and on household fuel consumption, whose dynamics are assumed to be similar to those of consumption by professional vehicles in the industry.

$$\Delta E_a^{Constr.} = \underset{(0,2)}{0{,}6} \times \Delta Prod_a^{FZ} + \underset{(0,1)}{0{,}4} \times \Delta Conso_a^{C2} + \epsilon_a$$

Estimation period=2012-2023
R^2=0.9

3 As a reminder, in terms of composition by activity, the AEA format attaches vehicle emissions to each branch and to households, unlike the Secten format, which groups together all vehicle emissions in a separate "transport" sector.

Agriculture

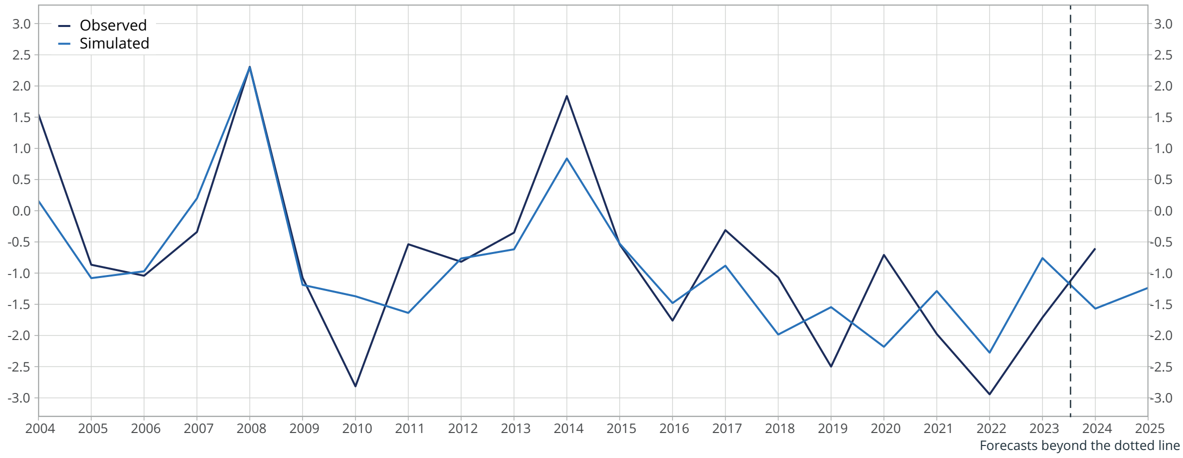
The agricultural sector accounts for a significant proportion of air emissions in France (almost 20% of emissions in 2023). Emissions are generated by livestock farming (59% of the sector's emissions), cultivation (27% of emissions) and, more marginally, the use of agricultural machinery (around 14% of emissions).[4]

Emissions from livestock are mainly due to methane generated by enteric fermentation. The size of the cattle herd (data from AGRESTE, the Statistical Office of the French Ministry of Agriculture) appears to be a relevant explanatory variable for modelling livestock farming emissions. In the forecast, based on the downward trend, the change in the size of the cattle herd is modelled by ARIMA. With regard to crop cultivation, where the emissions are mainly generated by the use of fertilisers and agricultural equipment, emissions are forecast on the basis of agricultural crop production (within the meaning of the national accounts). Finally, a constant is added to the model (►**Figure A3**).

$$\Delta E_a^{AZ} = \underset{(0{,}11)}{0{,}53} \times \Delta Cheptel_a^{Bovins} + \underset{(0{,}06)}{0{,}2} \times \Delta Prod_a^{AZ} - \underset{(0{,}20)}{0{,}61} + \epsilon_a$$

Estimation period=2004-2023
R^2=0.7

►A3. Observed, simulated and forecast annual change in emissions from the agriculture sector
(annual changes in %)



Last point: 2023.
Note: the 2024 point corresponds to the approximate estimate of emissions from resident units (AEA format), based on data published by Citepa, covering territorial emissions.
How to read it: in 2023, observed emissions fell by -1.7%, whereas the model predicted a reduction of -0.8%.
Source: Citepa, SDES, INSEE, INSEE calculations.

Emissions from services excluding transport

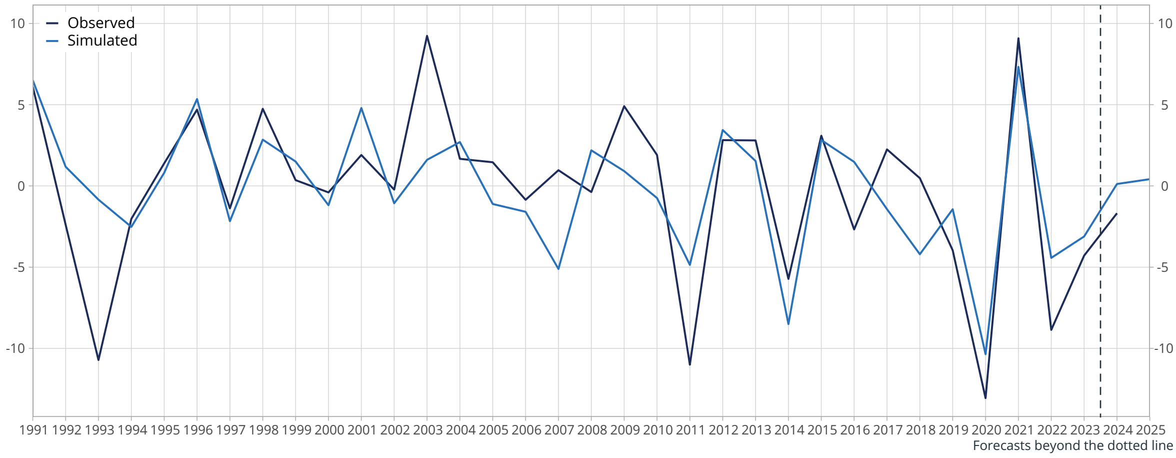
Services excluding transport accounted for 10% of air emissions in France in 2023, a relatively modest share compared with their weight in GDP (almost 60%). These emissions are mainly associated with the heating of non-residential buildings (excluding electricity) and the use of commercial vehicles. The forecasting model (►**Figure A4**) consists in estimating emissions from services (excluding transport) on the basis of total household emissions (see below) because the determinants of these two sources of emissions are closely correlated (mainly heating and fuel consumption).

$$\Delta E_a^{Service} = \underset{(0{,}16)}{0{,}95} \times \Delta E_a^{HH} + \epsilon_a$$

Estimation period=1990-2023
R^2=0.53

4 This breakdown of emissions is not available in the AEA classification and is derived from the Secten classification.

►A4. Observed, simulated and forecast annual change in emissions from services excluding transport
(annual changes in %)



Last point: 2023.
Note: the 2024 point corresponds to the approximate estimate of emissions from resident units (AEA format), based on data published by Citepa, covering territorial emissions.
How to read it: in 2023, observed emissions fell by -4.3%, whereas the model predicted a reduction of -3.1%.
Source: Citepa, SDES, INSEE, INSEE calculations.

Air transport

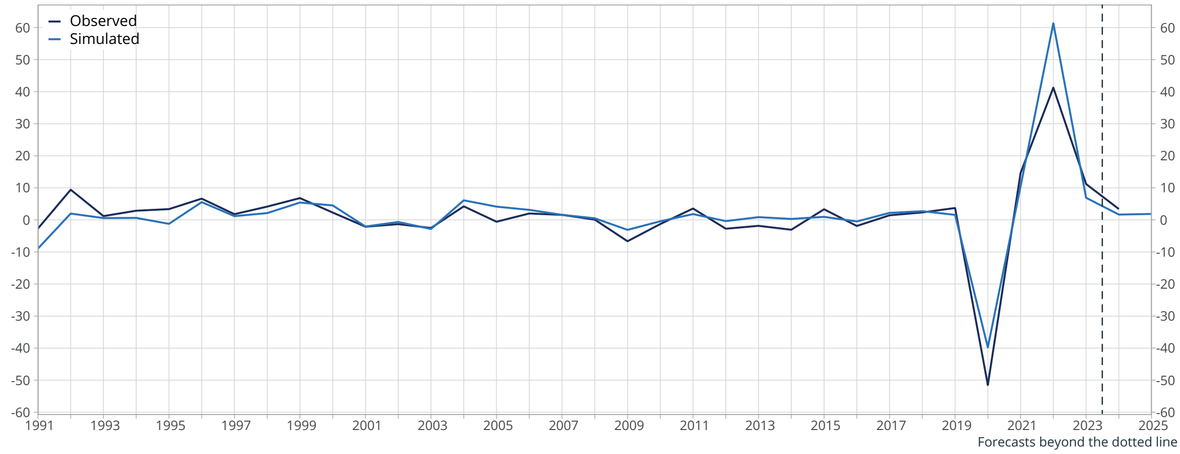
Air transport accounted for 4% of France's air emissions in 2023. The sector's emissions forecast is based on the household consumption of air transport services in the national accounts (►**Figure A5**). This consumption corresponds to journeys made entirely in France, or departing from France (regardless of the air carrier's country of residence). Conversely, the emissions of this sector in the AEA classification correspond to those of resident airlines and, in theory, do not depend on the country of departure of the flight, even if, in practice, the two values are linked. Consequently, a 10% increase in household consumption leads to a 6% increase in emissions, all other factors remaining equal, and 60% of the variance in the change in emissions over the estimation period is explained by the change in consumption. For the forecast, the series is extended by forecasts of changes in the consumption of air transport services published in the *Economic Outlook*, which is slightly more vigorous than the forecast for household consumption of all transport services.

$$\Delta E_a^{H51} = \underset{(0{,}12)}{0{,}60} \times \Delta Conso\_ménages_a^{H51} - \underset{(0{,}69)}{1{,}21} + \epsilon_a$$

Estimation period[5]=1991-2019
R^2=0.6

5 Emission data for the air transport sector in AEA format is only available from 2008 onwards. A retropolation was carried out using Secten data (national and international flights), available since 1990 and showing an almost perfect correlation with data in AEA format over the 2008-2023 period.

►A5. Observed, simulated and forecast annual change in emissions from the air transport sector
(annual changes in %)



Last point: 2023.
Note: the 2024 point corresponds to the approximate estimate of emissions from resident units (AEA format), based on data published by Citepa, covering territorial emissions.
How to read it: in 2023, observed emissions increased by 11.2% whereas the model predicted an increase of 6.9%.
Source: Citepa, SDES, INSEE, INSEE calculations.

Other transport

All other transport sectors (notably land and water) accounted for 11% of France's air emissions in 2023. The change in these emissions is modelled on the basis of the total change in GDP. The two values prove to be correlated: a 10% increase in GDP leads to an 11% increase in emissions, all other factors remaining equal, and slightly more than 30% of the variance in the change in emissions over the estimation period is explained by the change in GDP. In addition, an indicator corresponding to the 2009-2019 period has been added to the regression: while emissions from this sector seemed to have fluctuated according to the economic cycle around a constant level during the 1990s and 2000s, and once again since 2019, a significant downward trend in emissions occurred during the 2010s, which was identified by this indicator.

$$\Delta E_a^{HX} = \underset{(0{,}34)}{1{,}14} \times \Delta PIB_a^{FR} - \underset{(1{,}78)}{2{,}6} \times dummy\_2009\_2019 - \underset{(1{,}07)}{1{,}98} + \epsilon_a$$

Estimation period=1991-2023
R^2=0.35

Household emissions

Household emissions accounted for 25% of France's air emissions in 2023. They are mainly generated by the gas- and oil-fired heating of residential buildings (one third) and by the use of private cars (two thirds).

Changes in emissions linked to **household heating and cooling systems** are modelled by their gas consumption and heating oil consumption, with no fixed effect. In the forecast, the gas series is extended by the home energy consumption of households forecast in the *Economic Outlook*. This forecast is conventionally based on an assumption of normal weather conditions for the rest of 2025. The heating oil series is adjusted downwards by around -3 points over the year compared with the forecast for the home energy consumption of households, to take account of the downward trend in this type of heating due to the ban on the installation or replacement of oil-fired boilers from 1st July 2022.

$$\Delta E_a^{HHEAT} = \underset{(0{,}13)}{0{,}50} \times \Delta Conso_a^{D35B} + \underset{(0{,}14)}{0{,}45} \times \Delta Conso_a^{Fioul} + \epsilon_a$$

Estimation period[6]=1991-2023
R^2=0.72

6 Household heating and cooling-related emissions data in AEA format is only available from 2008 onwards. A retropolation was carried out using Secten data, available since 1990 and showing an almost perfect correlation with data in AEA format over the 2008-2023 period.

Changes in emissions from private household transport are modelled by household fuel consumption and a constant (► **Figure A6**). For forecasting purposes, the series is extended by the household consumption of refined products forecast in the *Economic Outlook*. Consumption is following a downward trend as a result of the increased use of electric and hybrid engines in the vehicle fleet, but reacts cyclically to prices.

$$\Delta E_a^{HTransport} = \underset{(0{,}06)}{0{,}85} \times \Delta Conso_a^{C2} - \underset{(0{,}29)}{0{,}57} + \epsilon_a$$

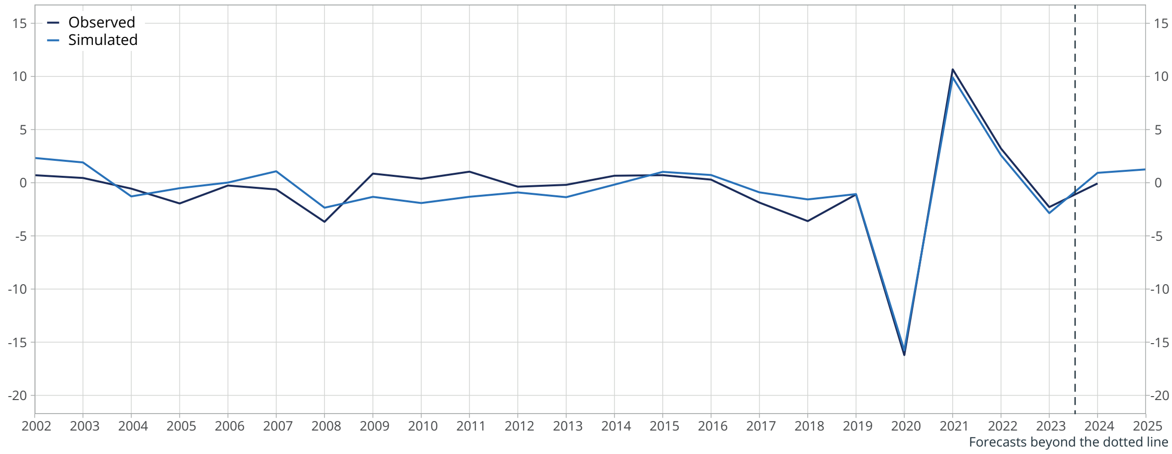
Estimation period[7]=2000-2023

R^2=0.91

7 Emissions data linked to private household transport in AEA format is only available from 2008 onwards. A retropolation was carried out using Secten data, available since 1990 and showing an almost perfect correlation with data in AEA format over the 2008-2023 period.

► A6. Observed, simulated and forecast annual change in household transport emissions

(annual changes in %)



Last point: 2023.
Note: the 2024 point corresponds to the approximate estimate of emissions from resident units (AEA format), based on data published by Citepa, covering territorial emissions.
How to read it: in 2023, observed emissions fell by -2.3%, whereas the model predicted a reduction of -2.9%.
Source: Citepa, SDES, INSEE, INSEE calculations.

Household emissions from neither heating nor private transport are marginal (less than 1% of France's air emissions in 2023). They mainly correspond to domestic waste and burning, in addition to wastewater. These emissions have been virtually stable since 2019 (between 3.2 and 3.3 MtCO_2e) and are expected to remain that way in the short term. ●

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