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CLIMATE

Office of the Commissioner-General for Sustainable Development

Key figures on climate
France, Europe and Worldwide

EDITION 2018

I4CE INSTITUTE FOR CLIMATE ECONOMICS
Une initiative de la Caisse des Dépôts et de l'Agence Française de Développement

summary

Key figures on climate
France, Europe and Worldwide

Document edited by:
Service de la donnée et des études statistiques (SDES)

contributors

MB

Manuel **Baude**
Mtes-CGDD-SDES
manuel.baude@developpement-durable.gouv.fr

FXD

François-Xavier **Dussud**
Mtes-CGDD-SDES
francois-xavier.dussud@developpement-durable.gouv.fr

ME

Mathieu **Ecoiffier**
Mtes-CGDD-SDES
mathieu.ecoiffier@developpement-durable.gouv.fr

JD

Jérôme **Duvernoy**
Mtes-DGEC-ONERC
jerome.duvernoy@developpement-durable.gouv.fr

CV

Charlotte **Vailles**
I4CE-Institute for Climate Economics
charlotte.vailles@i4ce.org

Foreword

In line with previous years, the 2018 edition of "Key figures on climate" has been written in the context of the 22nd Conference of the Parties on Climate Change (COP 22) held in Bonn from 6 to 17 November 2017.

This latest version was updated relative to the 2017 edition. New data sources have been used for emissions factors and the part on the carbon footprint was futher developed. The part on climate policies notably deals with the Paris Agreement adopted in December 2015 at COP 21. Several data sets, displayed in graphs in this document are also available in tables on the web version.

— Sylvain Moreau
HEAD OF DEPARTMENT, SDES

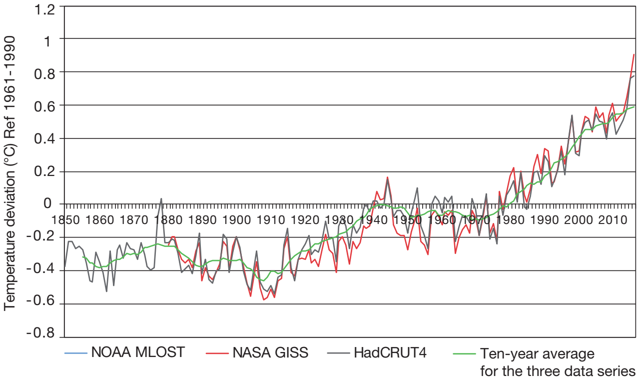
part 1

What is climate change?

— The concept of global warming refers to a sustainable increase of the planet average temperature. Additionally to the average sea level which has increased by more than 15 cm since 1900, numerous other indicators illustrate this warming.
The conclusions of the scientific community and notably of the International Panel on Climate Change (IPCC) meet general consensus on the causes of climate change. The natural climate balance is disrupted by anthropogenic GHG emissions (see glossary). The CO_2 atmospheric concentration – the main GHG – has increased by more than 40% since 1750, reaching the symbolic level of 400 parts per millions in 2015. Projections show that global warming could have a severe impact on sea levels or extreme weather events in the future.

Climate change observations

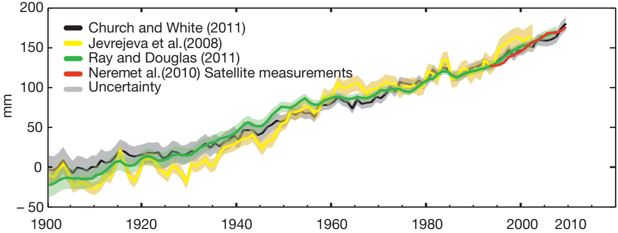
GLOBAL SURFACE TEMPERATURE CHANGE FROM 1850 TO 2016



Source: *NASA, NOAA, Hadley Center*

The increase in global average temperatures is very clear. The difference from the 1961-1990 reference period is far below zero until 1940, mostly negative until 1980, then the warming becomes more acute and the difference has almost always been positive since the early 1980's. The decade 2001-2010 was 0.21°C warmer than the decade 1991-2000 and was 0.48°C warmer than the 1961-1990 average. The year 2016, with an average temperature 1.1°C over pre-industrial levels, ranks first among the hottest years since 1850 on a global scale.

GLOBAL AVERAGE SEA LEVEL CHANGE COMPARED TO THE REFERENCE PERIOD 1900-1905

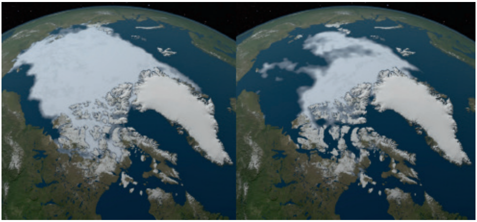


***Source:** IPCC, Working Group I, 2013*

The global average sea level rose by 1.7 ± 0.3 mm/yr over the period 1901-2010. The rise has been greater in recent decades, reaching 3.2 ± 0.4 mm/yr over the period 1993-2010.

ICE MELTING IN THE ARCTIC

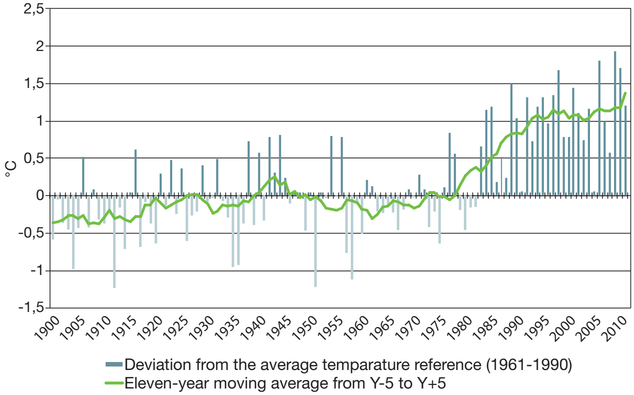
Arctic from space in summers: left 1984, right 2012



***Source:** NASA, 2013*

Arctics warms faster than other regions of the earth. In 2012, the minimum Arctic sea ice area was around half of the minimun area recorded in the 80's. Melting of continental ice in Greenland has doubled since the 90's , with a total average loss of 250 billion tons from 2005 to 2009, contributing to global sea level rise.

EVOLUTION OF THE AVERAGE TEMPERATURE IN METROPOLITAN FRANCE



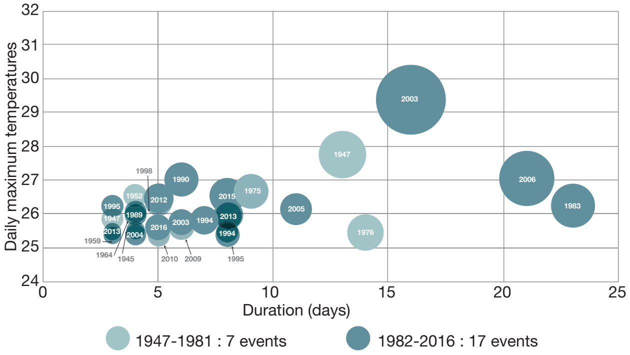
Source: *Météo-France, 2017*

As worldwide, the average temperature change in metropolitan France has shown a clear warming since 1900. The speed of this warming has been variable with a particularly pronounced increase since 1980. 2016 is again a warm year, 0.5°C above the reference 1981-2010 average. However, 2016 was not unusually hot in metropolitan France, it is the 10th warmest years on record since 1900, far behind 2014 (+1,2°C), 2011 (+1,1°C) et 2015 (+1,0°C).

EXTREME WEATHER EVENTS

A weather event (tornadoes, hurricanes, heat waves, heavy rainfalls) is classified as extreme when it significantly exceeds reference levels. Climate change modifies the frequency, intensity, scale, duration and time of occurrence of extreme events. It can push the characteristics of these events to unprecedented levels.

Heat waves in France - 1947-2016 period

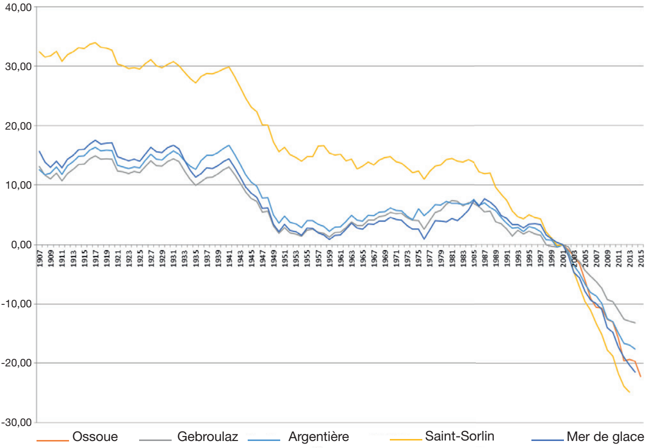


Note: the surface of each circle represents the intensity of the heat wave, which depends on its duration and its maximum temperature
***Source:** Météo-France, 2017*

At the French national level, the heat waves recorded since 1947 were twice as many over the last 34 years than over the previous period. This trend is also shaped by the occurrence of more severe events (duration, intensity overall) in recent years. Thus, the 4 longest heat waves and 3 among the 4 most intense waves occurred after 1981. The heat wave observed in France from 2 to 9 August 2003 is by far the most significant event over the observation period.

CHANGE IN THE MASS OF THE MAIN FRENCH GLACIERS

Cumulated mass balance (equivalent water meters)



Sources: *Association Moraine and Laboratoire de Glaciologie et Géophysique de l'Environnement - LGGE (CNRS – UJF - OSUG), 2017*

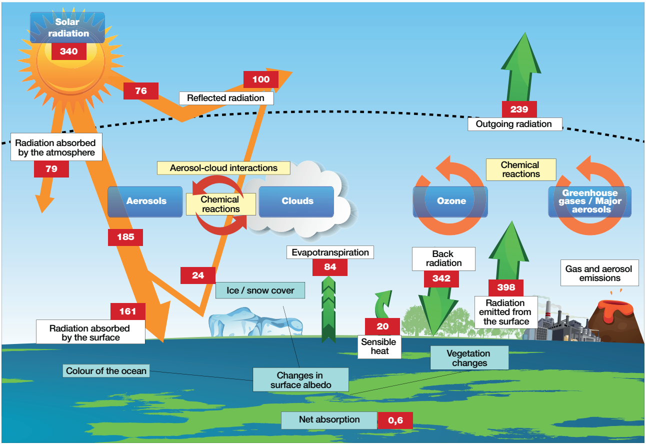
Glacier retreat is a common phenomenon across the main French mountains since 1990. However, glacial melting did not occur evenly throughout this period, with two phases of sharp decline: 1942-1953 and from 1985 onwards, separated by a period of relative stability. The significant loss of glacier mass recorded since 1982 is the result of a very significant increase in summer melting. This mass loss has become more pronounced since 2003.

This indicator illustrates the two aspects of climate variability: Short-term climate fluctuation (on a yearly basis) and long-term climate change (on a decade basis). The latter aspect allows for the observation of climate change.

Climate change causes

NATURAL GREENHOUSE EFFECT AND ITS PERTURBATIONS BY HUMAN ACTIVITIES

Current energy flows in W/m²



Sunlight provides the earth with energy. Part of this energy is directly or indirectly reflected back towards space, while the majority is absorbed by the atmosphere or by the earth's surface. The relatively warm temperatures at the earth's surface are due to GHGs that reradiate most of the surface radiation back to the earth.
***Source:** IPCC, Working group I, 2013*

Higher anthropogenic GHG emissions in the atmosphere increase the amount of energy reradiated to the earth. This results in an imbalance in the system, which causes the rise of the global temperatures. A change in radiation caused by a substance, compared to a reference year, is called radiative forcing. A positive radiative forcing value indicates a positive contribution to global warming. The total anthropogenic radiative forcing was + 2.55 ± 1.1 W/m² in 2013 compared to 1750.

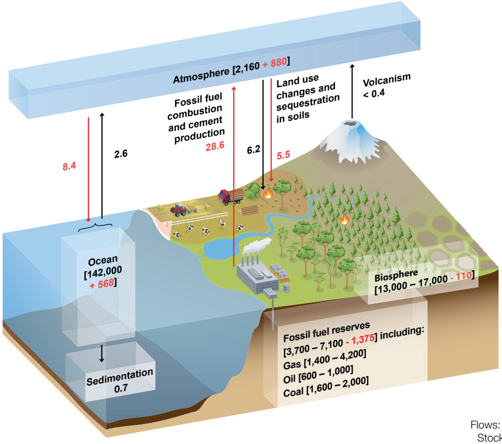
GREENHOUSE GASES

Water vapor excepted, GHGs make up less of 0.1% of the atmosphere. Water vapor, whose concentration in the atmosphere varies between 0.4% and 4% in volume, is the main GHG. Anthropogenic activities have little impact on the variations of its concentration but they have a strong impact on the concentration of other GHGs.

	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NF_3
Atmospheric concentration 2014 (in 2005 between brackets)	397 ppm (379 ppm)	1 823 ppb (1 774 ppb)	327 ppb (319 ppb)	> 157 ppt (> 49 ppt)	> 6,5 ppt (> 4,1 ppt)	8,2 ppt (5,6 ppt)	< 1 ppt
Global Warming potential (total over 100 years)	1	28-30	265	[1,4; 14 800]	6 630 ;11 100]	23 500	16 100
Anthropogenic sources	Fossil fuels combustion and tropical deforestation	Landfills, agriculture, livestock and industrial processes	Agriculture, industrial processes, use of fertilizer	Aerosols, refrigeration, aluminium smelting			Manufacture of electronic components
Change in radiative forcing due to anthropogenic emissions in 2014 since 1750 (W / m²) (in 2005 between brackets)	+ 1,91 (+1,66)	+ 0,50 (+0,48)	+ 0,19 (+0,16	+ 0,12 (+0,09)			

Global warming potential (GWP, see glossary) is the ratio between the amount of energy reradiated to the earth by 1 kg of a gas over 100 years and the amount that 1 kg of CO_2 would reradiate. It depends on the gases' concentrations and lifetimes. For example, 1 kg of CH_4 and between 28 and 30 kg of CO_2 will warm up the atmosphere by the same amount over the century following their emission. While CO_2 is the gas with the lowest global warming potential, it is also the one that has contributed the most to global warming since 1750, because the significant amounts emitted.

CARBON STOCKS AND GHG FLOWS: SIMPLIFIED CO_2 CYCLE IN THE 2,000S



Units:
Flows: $GtCO_2e/yr$
Stocks: $GtCO_2e$

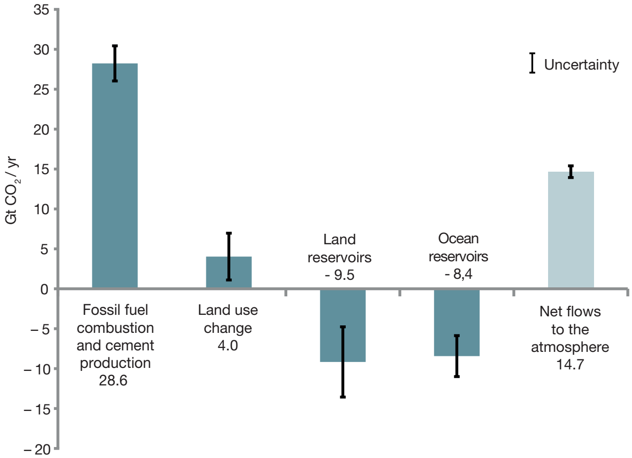
This graph shows: (i) in square brackets, the size of carbon stocks in pre-industrial times in billions of CO_2 tonnes equivalent in black and their change over the period 1750-2011 in red; (ii) as arrows, carbon flows between the stocks in billions of CO_2 tonnes equivalent per year. Pre-industrial flows are shown in black. Those from the development of anthropogenic activities between 2000 and 2009 are shown in red.
***Source:** based on IPCC, Working Group 1, 2013*

Four large reservoirs allow carbon to be stored in various forms:
- **Atmosphere:** gaseous CO_2;
- **Biosphere:** organic matter from living things including forests;
- **Ocean:** limestone, dissolved CO_2;
- **Subsoil:** rocks, sediment, fossil fuels.

Carbon flows between these reservoirs make up the natural carbon cycle, which has been disrupted by anthropogenic emissions of CO_2 that change the amounts exchanged or create new flows, such as the combustion of fossil organic carbon stocks.

IMBALANCE BETWEEN EMISSIONS AND CO_2 STORAGE CAPACITY

Net annual CO_2 flows towards the atmosphere by source and reservoir over the period 2000-2009



Source: *IPCC, Working Group I, 2013*

In the 2000s, of the 32.6 Gt of CO_2 annually released by human activities, the atmosphere absorbed 14.7, land reservoirs (biosphere and subsoil) 9.5 and the oceans 8.4. The atmosphere is the reservoir most affected by anthropogenic activities: the amount of carbon stored increased by nearly 40% compared to pre-industrial levels.

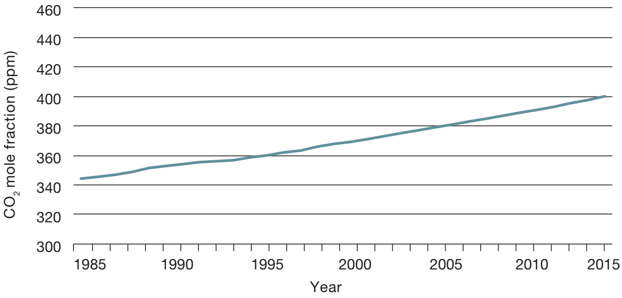
ROLE OF FORESTS IN THE CO_2 CYCLE

On a global scale, the biosphere is a net carbon reservoir mainly from forests, which concentrate 80% of the aboveground biomass and 50% of land-based photosynthesis. Sequestrations from the biosphere counterbalances around 19% of annual anthropogenic GHG emissions, about 10 $GtCO_2e$ (Dixon *et al*., 1994; Beer *et al*., 2010; IPCC, 2013; Canadell *et al*., 2007).

Deforestation causes GHG emissions through the combustion and decomposition of organic matter. These gross emissions account for 12% of GHGs from anthropogenic sources (IPCC, 2013).

In France, the net carbon sequestration in forest biomass is estimated to be around 50 Mt CO_2, or 12% of national fossil carbon emissions (excluding LULUCF, see glossary).

ATMOSPHERIC CO_2 CONCENTRATION

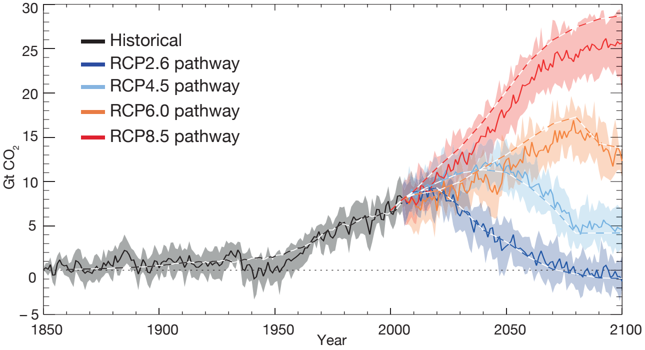


Source: *WDCGG under the authority of the WMO*

Since the development of industry, land and ocean reservoirs have absorbed half of anthropogenic emissions. The remaining emissions are still in the atmosphere, leading to an increase in the atmospheric concentrations of GHGs. In 2015 and for the first time, atmospheric CO_2 concentation, averaged on a global scale, reached the symbolic and significant threshold of 400 parts per million (ppm).

Scenarios et climate projections

PROJECTION OF EMISSIONS FROM FOSSIL FUELS ACCORDING TO THE IPCC'S FOUR REPRESENTATIVE CONCENTRATION PATHWAYS (RCP)



***Source:** IPCC, Working Group I, 2013*

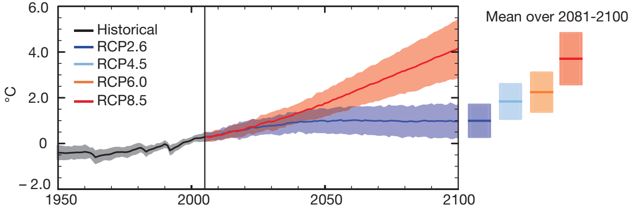
The IPCC published its First Assessment Report in 1990. Its fifth report (AR5) was published in its entirety end of 2014. For each publication, the IPCC communicates climate projections based on assumptions for the concentration of GHGs.

For the AR5, four Representative Concentration Pathways (RCP) were defined: **RCP2.6; RCP4.5; RCP6.0; RCP8.5**, from the most optimistic to the most pessimistic, named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (RCP8.5 corresponds to a situation with a radiative forcing of 8.5 W/m² in 2100.)

These pathways correspond to more or less drastic efforts to reduce global GHG emissions. Climate simulations and socio-economic scenarios are drawn up from these projections.

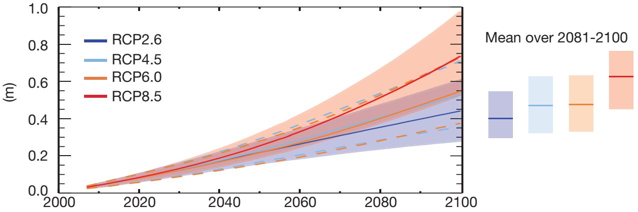
EVOLUTION OF TEMPERATURES AND SEA LEVELS IN THE IPCC'S CONCENTRATION PATHWAYS (RCPS)

Global average surface temperature change (relative to 1986–2005)



Source: *IPCC, Working Group I, 2013*

Global mean sea level rise (relative to 1986–2005)



Source: *IPCC, Working Group I, 2013*

Sea level rise is mainly caused by ocean thermal expansion and the melting of land-based ice (glaciers, polar ice caps…).

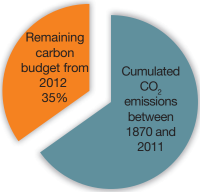
Sea level rise will probably cause massive migration flows, as over one billion people live in low-lying coastal areas.

Despite progress in recent years, ice melting forecast models still have wide margins of uncertainty.

CARBON BUDGETS AND TEMPERATURE RISE

Amont the four IPCC's concentration pathways, only the most ambitious, RCP 2.6, has a probability higher than 50% to limit the temperature rise to 2°C in 2100. The most conservative pathway RCP 8.5 has more than 50% chance of leading to a temperature rise higher than 4°C.

Carbon budget limiting to 2°C the raise in global temperatures



Total carbon budget giving a 66% probability to limit the raise in global temperatures to 2°C compared to pre-industrial levels :
2,900 $GtCO_2$

Source: *I4CE, based on IPCC, Working Group I*

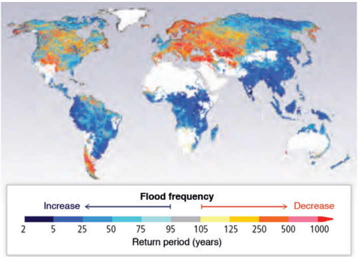
A carbon budget is the maximum amount of carbon that can be released into the atmosphere while keeping a reasonable chance of staying below a given temperature rise.

IPCC's simulations indicate that to have a probability higher than 66% to limit the raise in global temperatures to 2°C compared to pre-industrial levels, cumulated CO_2 emissions should be lower than 2,900 $GtCO_2$. Between 1870 and 2011, human activities already emitted 1,890 $GtCO_2$, which leaves a remaining carbon budget of 1015 Gt CO_2 from 2012. Taking into account CO_2 emissions between 2012 and today, the carbon budget which would give a 66% probability to limit the raise in global temperatures to 2°C will be exhausted within around 20 years, with current levels of CO_2 emissions.

The combustion of all current fossil fuel reserves would emit an amount of CO_2 much higher (3 to 5 times) than the carbon budget consistent with the 2°C limit (BP, 2017).

CONSEQUENCES ON A GLOBAL SCALE

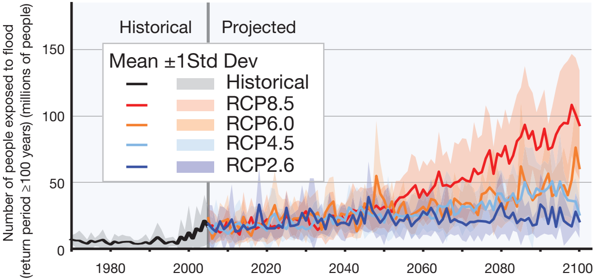
Change in river flood frequency in the world in the 2080's, based on the RCP 8.5 scenario



Note: change in the return period (years) for the 20th-century 100-year flood.
***Source:** IPCC, Working Group II, 2013*

According to the most pessimistic IPCC scenario (RCP 8.5), during the 21st century, river floods frequency will significantly increase in tropical areas (South America, Central Africa, South and South-East Asia). In some regions, the most severe floods, which used to occur every 100 years, could arise every 5 years. Combined with population growth, theses changes could greatly increase the impacts of floods on populations.

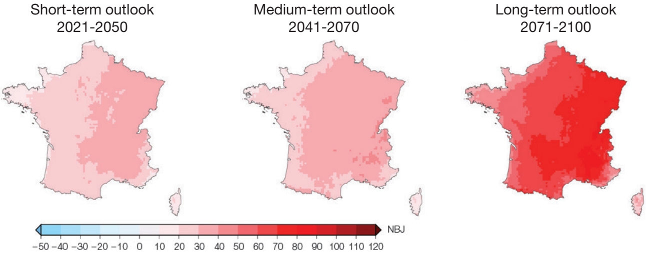
Global exposure to the 20th-century 100-year flood according to several IPCC scenario



***Source:** IPCC, Working Group II, 2013*

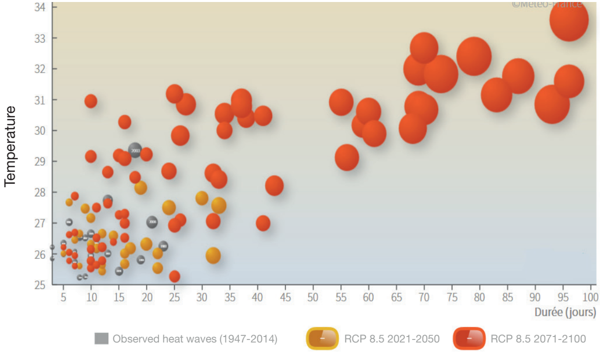
CONSEQUENCES FOR FRANCE

Number of additional days with abnormally high temperatures in the future (IPCC[1]'s RCP 4.5, 2014)



Source: *Drias les futurs du climat, 2014*

Heat waves: Observations and climate projections for two time frames (IPCC RCP scenarios)



Source: *Météo-France, Climat HD, 2017*

In France, the intensity and frequency of heat waves are expected to increase in the 21st century with a differentiated pace between the near future (2021-2050) and the end of the century (2071-2100). As a first step, the frequency of the events is projected to double around mid-century.

part 2

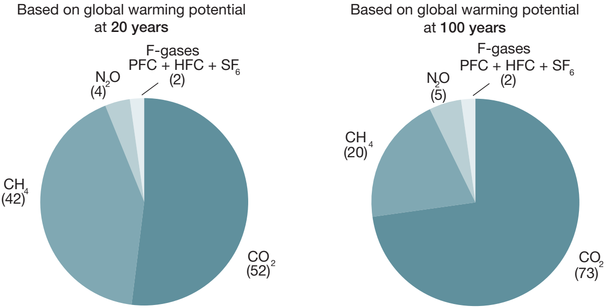
Which amounts of greenhouse gases are emitted globally?

— Anthropogenic GHG emissions reached 54 Gt CO_2e in 2013, with CO_2 emissions accounting for around 73% of this total. Global CO_2 emissions (excluding LULUCF) increased by more than 58% between 1990 and 2014, with trajectories very different depending on the countries. China is the biggest world emitter in 2015 with close to 30% of the total. When it comes to per capita CO_2 emissions, the situation is different. In countries such as the United States or Saudi Arabia, per capita emissions - more than 16 t CO_2 per year - are among the highest, while France is around the world average with emissions per capita around 5 t CO_2. Remarkably, 2015 saw a stabilization of global emissions, for the first time in 20 years it happened while the economy continued to grow.

Global overview of GHG emissions

GLOBAL DISTRIBUTION OF GHG EMISSIONS (INCLUDING LULUCF) BY GAS IN 2010

As %



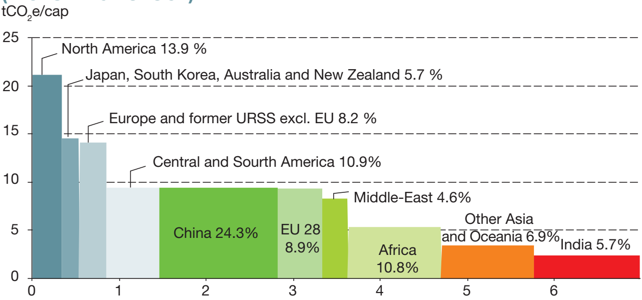
CO_2: Carbon dioxide; N_2O: Nitrous oxide; CH_4: Methane; HFCs: Hydrofluorocarbons; PFCs: Perfluorocarbons;
SF_6: Sulphur hexafluoride

***Source:** based on IPCC, Working Group III, 2014*

The Global Warming Potential (GWP) of a gas depends on the period over which it is calculated (*see page 12*). The GWP of methane is equal to 28 to 30 when calculated over 100, and is equal to 84 when calculated over 20 years. The GWP over 100 years is usually used in GHG emissions inventories. This metric lends more weight to persistent gases than to gases with a short lifetime. The use of the potential over 20 years shows the importance of methane emissions at this time frame.

The emissions of the six GHGs initially covered by the Kyoto Protocol increased by 80% since 1970 and by 45% since 1990, reaching 49 $GtCO_2e$ in 2010 and **54 $GtCO_2e$** in 2013.

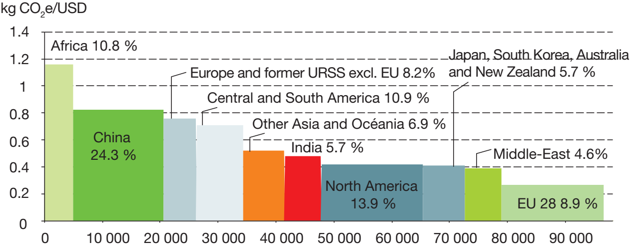
REGIONAL DISTRIBUTION OF GHG EMISSIONS PER CAPITA IN 2012 (INCLUDING LULUCF)



***Sources:** I4CE based on JRC EDGAR and World Bank, 2015*

In 2012, average emissions per capita in North America are more than eight times higher than in India. Besides, these values does not reflect the disparity within a geographical area (for example, in Middle-East, emissions per capita are more than 50 tCO_2e/inhabitant in Qatar, and less than 2 tCO_2e/inhabitant in Yemen), and within a country.

REGIONAL DISTRIBUTION OF GHG EMISSIONS PER UNIT OF GDP IN 2012

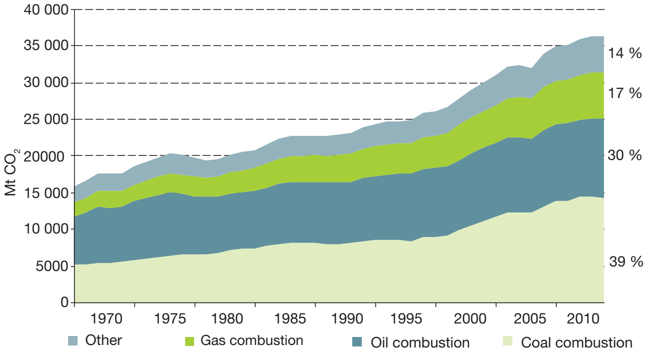


***Sources:** I4CE based on JRC EDGAR and World Bank, 2015*

In 2012, the carbon intensity of GDP is more than four times higher in Africa than in the EU, meaning that four times more GHGs are emitted per unit of economic output.

Global CO_2 emissions excluding LULUCF

GLOBAL CO_2 EMISSIONS BY FUEL

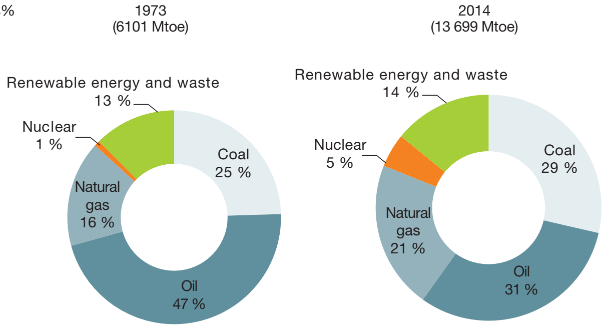


Note: emissions listed here are CO_2 emissions from fossil fuel use and industrial processes. This corresponds to total CO_2 emissions excluding LULUCF. They account for 85% of all global CO_2 emissions and 65% of GHG emissions
***Sources:** SDES from EDGAR, 2016, IEA, 2017*

In 2015, global CO_2 emissions excluding LULUCF (*see glossary*), amount to 36.2 billion tonnes. Close to 39% of those emissions are caused by coal combustion, 30% by oil combustion and 17% by natural gas combustion. Emissions related to industrial processes, such as cement production, represent 14% of the total. Compared to 2014, coal-related emissions have decreased while those related to oil and gas combustion have increased.

GLOBAL PRIMARY ENERGY MIX

As%



Source: *IEA, 2016*

The distribution of emissions by fuels can be linked to the global primary energy mix. In 2014, fossil fuels (coal, natural gas and oil) account for 81% of the global total primary energy supply. Oil remains the largest energy source at a global level but, between 1973 and 2014, its share in this mix fell by 16 points, in favour of gas (+ 5 points), nuclear power (+ 4 points) and coal (+ 3 points). Accounting for a 29% share of the energy mix, coal was the second largest energy source after crude oil in 2014. Yet, it ranked first in terms of CO_2 emissions as its emission factor is considerably higher than those of gas and oil (see page 75). Although global coal consumption greatly increased during the 2000's, it has been stagnant or even in decline for the last few years. While renewable energy generation used to increase at a rate close to total generation before 2010, its share in the world energy mix is now growing and reached 14% in 2014.

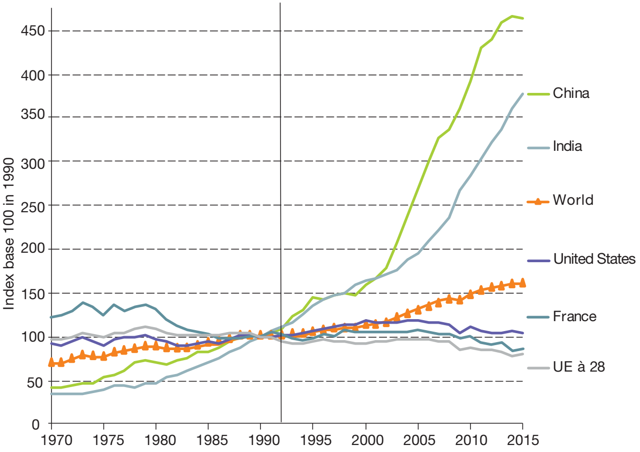
GEOGRAPHIC DISTRIBUTION OF GLOBAL CO_2 EMISSIONS (EXCL. LULUCF)

In Mt CO_2	1990	2014	2015	2015 share (%)	Change (%) 2015-2014	Change (%) 2015-1990
North America	**5 743**	**6 365**	**6 200**	**17,2**	**-2,6**	**+8,0**
of which: Canada	557	705	684	1,9	-3,0	+22,8
USA	5 008	5 317	5 177	14,4	-2,6	+3,4
Central and South America	**651**	**1 299**	**1 284**	**3,6**	**-1,2**	**+97,2**
of which: Brazil	221	506	486	1,3	-4,0	+119,9
Europe and former USSR	**8 448**	**6 265**	**6 216**	**17,2**	**-0,8**	**-26,4**
of which Russia	2 395	1 822	1 761	4,9	-3,3	-26,5
EU-28	4 386	3 424	3 470	9,6	+1,3	-20,9
Germany	1 021	773	778	2,2	+0,6	-23,8
Spain	230	246	263	0,7	+6,9	+14,3
France	383	323	328	0,9	+1,3	-14,4
Italy	429	337	354	1,0	+5,0	-17,5
United Kingdom	581	415	399	1,1	-3,9	-31,3
Poland	364	289	295	0,8	+2,1	-19,0
Sub-Saharan Africa	**530**	**942**	**942**	**2,6**	**-0,0**	**+77,8**
Middle East and North Africa	**956**	**2 545**	**2 616**	**7,3**	**+2,8**	**+173,8**
of which Saudi Arabia	168	487	506	1,4	+3,9	+200,9
Asia	**5 248**	**17 065**	**17 167**	**47,6**	**+0,6**	**+227,1**
of which: China	2 357	10 790	10 717	29,7	-0,7	+354,7
South Korea	270	612	610	1,7	-0,3	+125,9
India	663	2 349	2 469	6,8	+5,1	+272,4
Japan	1162	1285	1257	3,5	-2,2	+8,2
Océania	306	484	491	1,4	+1,6	+60,5
Annex I countries	14 996	13 794	13 544	37,6	-1,8	-9,7
Non-Annex I countries	6 885	21 171	21 373	59,3	+1,0	+210,4
International bunkers	626	1 119	1 145	3,2	+2,3	+82,8
World	**22 508**	**36 084**	**36 062**	**100,0**	**-0,1**	**+60,2**

Note: international bunkers are emissions from international aviation and shipping. They have been excluded from national totals (see glossary).
Source: *EDGAR, 2016*

In 2015, global CO_2 emissions slightly decreased (by 0.1%), a turnaround compared to the average yearly trend since 2000 (+2.5%). The United States (-2.6%) are the county contributing the most to this reduction, largely thanks to fuel-switching from coal to gas in electricity generation. In 2015 and for the second year in a row, India is the country displaying the strongest growth in emissions.

EVOLUTION OF GLOBAL CO_2 EMISSIONS BETWEEN 1970 AND 2015



Source: *EDGAR, 2016*

In 2015, Chinese emissions accounted for almost 30% of global CO_2 emissions. China is the first emitting country, followed by the United States (14.4%), the EU-28 (9.6% of the global total when counted as a block) and India (6.8%). Between 1990 and 2015, global CO_2 emissions increased by 58%. During this period, China contributed the most to the rise: its emissions were multiplied by 4.5. The second most significant contribution to global emissions growth comes from India where emissions increased by 272%. As for the United States, its emissions have been more or less stable (+3.4%) since 1990. During the same period, EU-28 emissions decreased by 20.9% and French emissions by 14.4%.

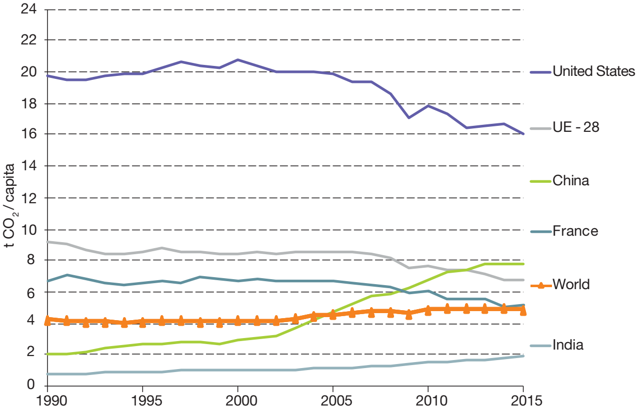
GLOBAL CO_2 EMISSIONS PER CAPITA (EXCL. LULUCF)

In t CO_2 / capita	1990	2014	2015	Évolution (%) 2015-2014	Évolution (%) 2015-1990
North America	**15,8**	**13,3**	**12,9**	**-2,6**	**-18,3**
of which: Canada	20,2	19,8	19,0	-3,9	-5,5
USA	19,8	16,6	16,1	-3,3	-18,8
Central and South America	**1,8**	**2,6**	**2,6**	**-1,2**	**+41,9**
of which: Brazil	1,5	2,5	2,3	-4,5	+59,2
Europe and former USSR	**10,0**	**6,9**	**6,9**	**-0,8**	**-31,3**
of which Russia	16,2	12,7	12,3	-3,4	-24,4
of which EU-28	9,2	6,7	6,8	+1,0	-25,8
of which: Germany	12,9	9,6	9,6	+0,5	-25,4
Spain	5,9	5,3	5,7	+7,3	-2,9
France	**6,7**	**5,1**	**5,1**	**+0,8**	**-24,0**
Italy	7,5	5,6	5,9	+5,2	-21,4
United Kingdom	10,2	6,5	6,2	-4,6	-39,5
Poland	9,5	7,5	7,6	+2,0	-19,8
Sub-Saharan Africa	**1,0**	**1,0**	**0,9**	**-2,7**	**-9,5**
Middle East and North Africa	**3,7**	**6,0**	**6,1**	**+0,9**	**+63,4**
of which Saudi Arabia	10,3	15,8	16,0	+1,7	+56,4
Asia	**1,8**	**4,3**	**4,4**	**+0,6**	**+143,6**
of which: China	2,0	7,8	7,8	-1,1	+281,8
South Korea	6,3	12,2	12,1	-0,7	+93,6
India	0,8	1,8	1,9	+3,9	+147,4
Japan	9,5	10,1	9,9	-2,1	+4,5
Océania	**13,9**	**16,0**	**16,2**	**+1,6**	**+17,0**
Annex I countries	**13,0**	**10,7**	**10,6**	**-1,8**	**-18,8**
Non-Annex I countries	**1,7**	**3,5**	**3,5**	**-0,5**	**+111,2**
World	**4,3**	**5,0**	**4,9**	**-1,2**	**+15,1**

Note: the figures here refer to the CO_2 emissions of a territory divided by its population. The average emissions due to the consumption of an inhabitant are calculated using a different approach (carbon footprint).
***Sources:** SDES from EDGAR, 2016, World Bank, 2017*

In 2015, global CO_2 emissions amounted to 4.9 t CO_2/capita on average, a decrease of 1.2% compared to 2014. The evolution was driven by the stabilization of global CO_2 emissions and a demographic growth of +1.2%. Emissions per capita were highest in North America (over 16 t CO_2/capita in the United States), in the Middle East and in Oceania. Chinese emissions per capita are now 7.8 t CO_2/ capita, 1.1% down in 2015 compared to 2014, above the French level of 5.1 t CO_2/capita and the average for the EU-28 (6.7 t CO_2/capita).

EVOLUTION OF GLOBAL CO_2 EMISSIONS PER CAPITA BETWEEN 1970 AND 2015



Sources: *SDES from EDGAR, 2016, World Bank, 2017*

Since 1990, global average emissions per capita have increased by 15%. While emissions per capita in non-annex I countries (*see glossary*) are still almost three times lower than in annex I countries, there is an ongoing catching-up process between those two groups of countries. For instance, since 1990, emissions per capita have been multiplied by more than 3.8 in China and by close to 2.5 in India. Simultaneously, CO_2 emissions per capita have significantly decreased in the EU (–26%) and to a lesser extent in the United States (–19%). Japan is at an intermediate stage, its emissions per capita are relatively high (10 t CO_2/ capita) and have remained quite unchanged since 1990. Unlike the situation in the main emerging countries, emissions per capita in Sub-Saharan Africa have not increased and remain around one ton of CO_2 per capita.

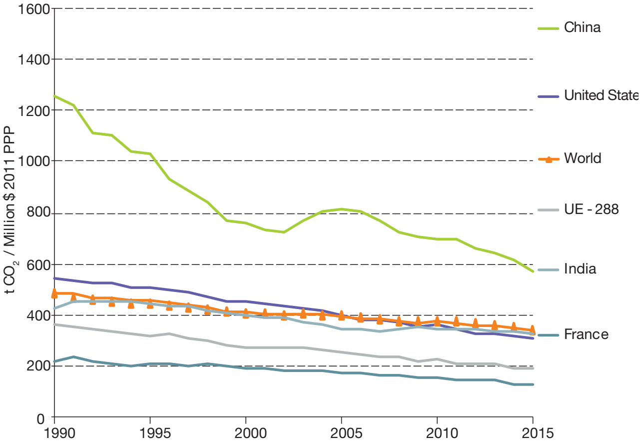
GLOBAL CO_2 EMISSIONS IN RELATION TO GDP (EXCL. LULUCF)

In t CO_2 / Million $ 2011 PPP	1990	2014	2015	Évolution (%) 2015/2014	Évolution (%) 2015/1990
North America	**567**	**353**	**335**	**-4,9**	**-40,9**
of which: Canada	641	463	445	-3,9	-30,5
USA	541	322	307	-4,9	-43,4
Central and South America	**201**	**183**	**181**	**-0,8**	**-9,7**
of which: Brazil	143	162	162	+0,1	+13,1
Europe and former USSR	**488**	**245**	**239**	**-2,3**	**-51,0**
of which Russia	783	502	503	+0,4	-35,7
of which EU-28	366	194	192	-0,7	-47,4
of which: Germany	408	219	217	-1,0	-46,9
Spain	245	167	173	+3,6	-29,7
France	**222**	**132**	**132**	**+0,2**	**-40,6**
Italy	246	166	173	+4,4	-29,6
United Kingdom	381	169	158	-6,2	-58,5
Poland	942	318	313	-1,6	-66,8
Sub-Saharan Africa	**409**	**278**	**269**	**-3,2**	**-34,1**
Middle East and North Africa	**323**	**350**	**351**	**+0,4**	**+8,9**
of which Saudi Arabia	290	318	319	+0,4	+9,9
Asia	**472**	**411**	**392**	**-4,6**	**-17,1**
of which: China	1 257	614	571	-7,0	-54,6
South Korea	520	361	351	-2,7	-32,6
India	430	336	329	-2,3	-23,5
Japan	318	284	276	-2,7	-13,1
Océania	**539**	**412**	**409**	**-0,8**	**-24,1**
Annex I countries	**499**	**301**	**290**	**-3,5**	**-41,9**
Non-Annex I countries	**404**	**359**	**346**	**-3,4**	**-14,3**
World	**483**	**350**	**339**	**-3,0**	**-29,8**

Note: GDP at constant prices converted to US dollars on a Purchasing Power Parity (PPP) basis for 2011 (see glossary)
***Sources:** SDES from EDGAR, 2016, World Bank, 2017*

The quantity of CO_2 emitted per unit of GDP keeps declining worldwide with a 3.0% decrease in 2015, the largest drop since 1990. This evolution is explained by the light decline in emissions and a global economic growth of 3%. There are strong disparities between countries with the highest values in China (570 t CO_2/ Million $) or in Russia. The United States (307 t CO_2/ Million $) or Japan are slightly below the global average, while the lowest values are in the EU (192 t CO_2/ Million $), in particular in France (132 t CO_2/ Million $).

EVOLUTION OF GLOBAL CO_2 EMISSIONS IN RELATION TO GDP BETWEEN 1990 AND 2015

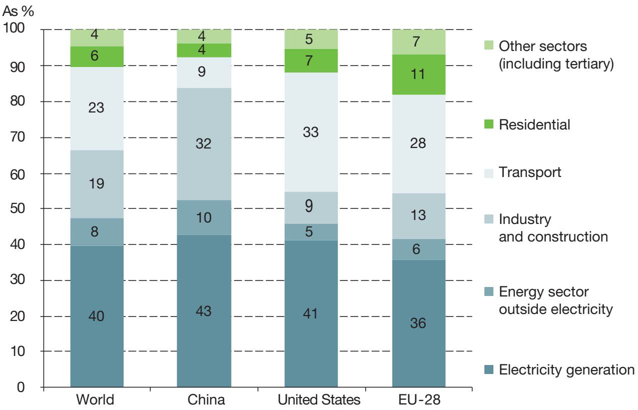


Sources: *SDES from EDGAR, 2016, World Bank, 2017*

The quantity of CO_2 emitted per unit of GDP shows the gradual decoupling of CO_2 emissions from economic growth. It has dropped by 29% worldwide since 1990 and has decreased in almost all countries. The main exceptions are oil-producing countries such as Saudi Arabia (+10%) or raw materials exporting countries like Brazil (+13%). China was the country that recorded the sharpest drop in 25 years, with emissions per unit of GDP down by more than half. The decline in CO_2 intensity in relation to GDP since 1990 is also significant in the EU (-47%) and in the United States (-43%).

Sectorial distribution of global CO_2 emissions

DISTRIBUTION OF CO_2 EMISSIONS FROM FUEL COMBUSTION FOR THE MAIN EMITTERS IN 2014



Source: *IEA, 2016*

Accounting for 40% of global energy-related CO_2 emissions, electricity generation was the first emitting sector in 2014. Coal-fired power plants alone are responsible for 31% of global emissions. Next are the transport sector and industry, respectively accounting for 23% and 19% of energy-related CO_2 emissions. In China, electricity generation (43%) and industry (32%) are responsible for a higher share of emissions than the global average. As for the transport sector, it is responsible of a higher share than the global average in the EU (28%) and in the United States (33%).

part 3

How much greenhouse gas is emitted in Europe and in France?

— Within the UNFCCC framework, the European Union and France report the greenhouse gases emitted on their territory. In 2015, the EU emitted 4 308 Mt CO_2e excluding LULUCF, representing a drop of 24% compared to 1990. In France, emissions excluding LULUCF reached 457 Mt CO_2e in 2015 and have decreased by 16% since 1990. In the EU, the energy sector is the first emitting sector while the transport sector contributes the most to French emissions. The footprint approach, complementary to the territorial approach, gives an estimate of GHG emissions arising from the consumption of French residents. In 2012, French consumption-based emissions were over 50% higher than territory-based emissions.

Overview of GHG emissions in Europe

EU-28 GHG EMISSIONS IN 2015

In Mt CO_2e

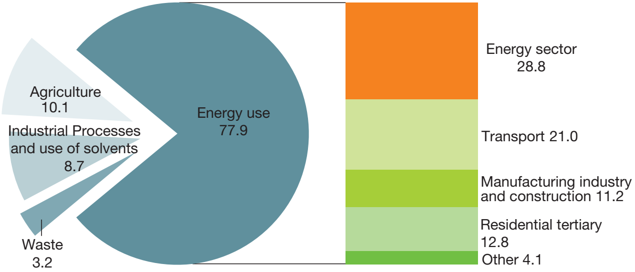
Source	Years	CO_2	CH_4	N_2O	F-gases	Total
Energy use	1990	4 111,6	193,9	31,0	0,0	4 336,6
	2015	3 241,2	87,4	29,4	0,0	3 358,0
Industrial processes and use of solvents	1990	325,3	1,8	117,9	71,9	516,9
	2015	243,4	1,6	11,0	117,9	373,9
Agriculture (excluding energy use))	1990	15,2	306,0	227,1	0,0	548,3
	2015	10,3	241,7	184,8	0,0	436,7
Waste	1990	5,2	226,7	9,0	0,0	240,9
	2015	3,2	125,3	10,8	0,0	139,3
Total excl. LULUCF	**1990**	**4 457,4**	**728,4**	**385,0**	**71,9**	**5 642,7**
	2015	**3 498,1**	**456,0**	**236,0**	**117,9**	**4 308,0**
LULUCF	1990	-251,7	6,9	13,1	0,0	-231,8
	2015	-323,6	5,0	13,7	0,0	-304,9
Total	**1990**	**4 205,7**	**735,3**	**398,1**	**71,9**	**5 410,9**
	2015	**3 174,4**	**461,1**	**249,7**	**117,9**	**4 003,1**

Note: the waste sector excludes waste incineration with energy recovery (included in “energy use”)
***Source:** EEA, 2017*

In 2015, European GHG emissions excluding LULUCF reached 4 308 Mt CO_2e of which 81% are CO_2 emissions and 11% are CH_4 emissions. European GHG slightly increased by 0.5% compared to 2014 and decreased by 23.7% over the period 1990-2015.

DISTRIBUTION OF GHG EMISSIONS (EXCL. LULUCF) IN THE EU IN 2015

As%



Source: *EEA, 2017*

In the EU, energy use was the main source of GHG emissions (78%) in 2015, followed by agriculture at around 10%. The largest GHG emitting sector was the energy sector (29% of emissions), ahead of transport (21%).

In 2015, EU GHG emissions have slightly increased, breaking the trend of the past 5 years. This evolution can be explained by a rebound of emissions in the residential-tertiary sector (+4.9%), consequence of a winter less mild than in 2015, and to a lesser extend by a rise of emissions in the transport sector (+1.9%). Between 1990 and 2015, the decline of GHG emissions is driven by significant decreases in the energy (-42%) and manufacturing industry (- 15%) sectors while the transport sector contributed to more emissions (+16%).

Overview of GHG emissions in France

GHG EMISSIONS IN FRANCE IN 2015

In Mt CO_2e

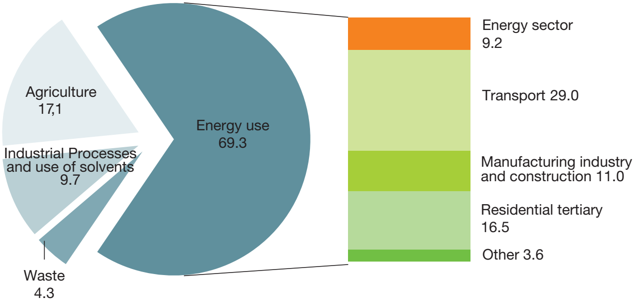
Source	Years	CO_2	CH_4	N_2O	F-gases	Total
Energy use	1990	364,5	12,6	3,2	0,0	380,3
	2015	310,2	2,9	3,7	0,0	316,9
Industrial processes and use of solvents	1990	31,1	0,1	23,8	11,8	66,8
	2015	22,9	0,0	1,3	20,3	44,5
Agriculture (excluding energy use))	1990	1,8	43,2	38,1	0,0	83,1
	2015	2,0	40,9	35,4	0,0	78,4
Waste	1990	2,2	13,7	0,9	0,0	17,4
	2015	1,5	15,0	0,8	0,0	19,5
Total excl. LULUCF	**1990**	**399,6**	**69,6**	**66,0**	**11,8**	**547,1**
	2015	**336,6**	**58,9**	**41,3**	**20,3**	**457,1**
LULUCF	1990	-29,8	0,9	2,4	0,0	-26,5
	2015	-39,1	1,1	2,2	0,0	-35,8
Total	**1990**	**369,7**	**70,6**	**68,4**	**11,8**	**520,59**
	2015	**297,5**	**60,0**	**43,5**	**20,3**	**421,32**

Source: *Citepa, 2017*

In 2015, French GHG emissions, excluding LULUCF, reached 457 Mt CO_2e, of which 74% are CO_2 emissions and 13% are CH_4 emissions. French GHG emissions increased by 0.8% compared to 2014 and dropped by 16.4% over the period 1990-2015.

DISTRIBUTION OF GHG EMISSIONS (EXCL. LULUCF) IN FRANCE IN 2015

As%



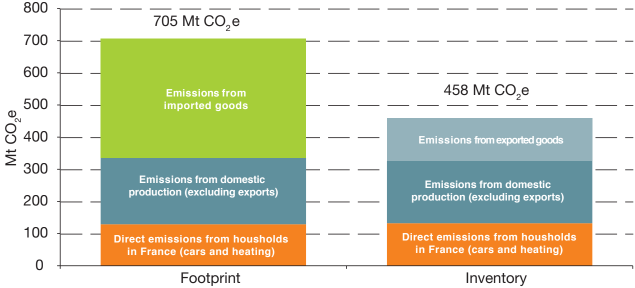
Source: *Citepa, 2017*

As throughout the EU, energy use was the main GHG emission source in France accounting for 70% of total emissions excluding LULUCF. However, unlike the EU average, the largest emitting sector in France is transport (29%), while the energy sector has relatively low emissions (9%), owing to the extent of nuclear electricity generation.

The rise in emissions between 2014 and 2015, is driven by a rebound of emissions in the residential-tertiary sector (+4.9%), consequence of a winter less mild than in 2015. Over the period 1990-2015, the evolution is similar to the rest of the EU, the sectors contributing the most to the reduction of French emissions are the manufacturing industry (-38%) and the energy (–25%) sectors.

Carbon footprint and emissions from imported goods

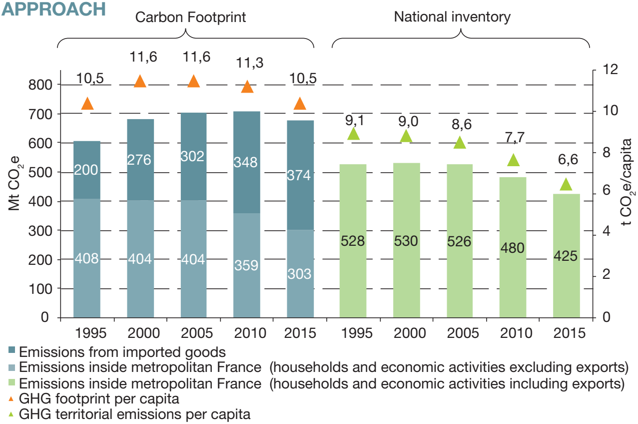
COMPARISON BETWEEN THE FOOTPRINT APPROACH AND THE TERRITORIAL INVENTORY APPROACH FOR METROPOLITAN FRANCE-2012



The inventory and the carbon footprint include the 3 main GHGs (CO_2, CH_4, N_2O)
***Sources:** SDES, 2017 from Citepa, Eurostat, Insee, Customs, IEA, 2016*

Two complementary methods allow to estimate a country pressure on global climate:
- National inventories account for GHGs physically emitted inside a country using a territorial approach. These national inventories are carried out each year according to UNFCCC guidelines.
- The carbon footprint approach accounts for emissions from final domestic demand in the country. It includes emissions from imported goods in addition to direct emissions from households (housing and cars) and from domestic production (excluding exports). Taking into account the 3 main GHGs, 75% of the footprint comes from CO_2 emissions, 19% from CH_4 and 6% from N_20. Compared to the inventory, the footprint gives a greater weight to CH4 emissions (19% against 13%), largely because of emissions from imported energy products.

EVOLUTION OF METROPOLITAN FRANCE'S GHG EMISSIONS ACCORDING TO THE TERRITORIAL APPROACH AND THE FOOTPRINT APPROACH

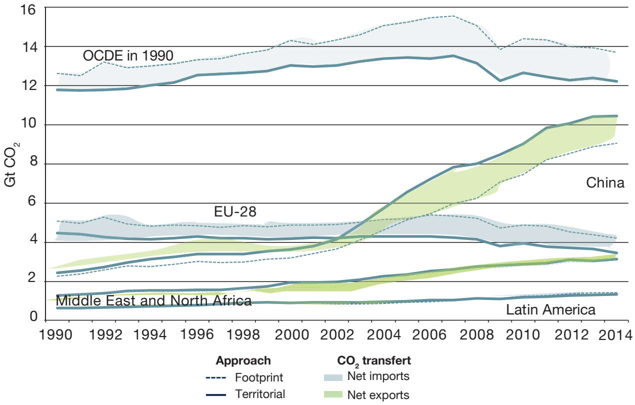


Note : The inventory and the carbon footprint include the 3 main GHGs (CO_2, CH_4, N_2O)

Sources: *SDES, 2017 from Citepa, Eurostat, Insee, Customs, IEA*

In 2015, the French carbon footprint (678 Mt CO_2e) is widely higher (+54%) than the inventory. The footprint is 11.7% higher than in 1995, notably emissions from imported goods increased by 76% over the same period.
However, if population growth is taken into account, the footprint calculated per capita in 2015 is almost the same as in 1995. Over this period, GHG emissions (CO_2, CH_4 et N_2O) inside metropolitan France decreased by 19.5% and the average emissions per capita by 27.8%. The carbon footprint per capita have been declining since 2005 after a period of increase while territorial emissions per capita have been steadily declining since 1995.

INTERNATIONAL COMPARISON OF CO_2 EMISIONS FROM FUEL COMBUSTION ACCORDING TO THE TWO APPROACHES



***Source:** I4CE from Global Carbon Budget, 2016*

Between 1990 and 2014, CO_2 emissions from fuel combustion increased by 4% in the OECD according to the territorial approach, and by 9% according to the footprint approach. In the EU 28, over the same period, they dropped by 23% according to the territorial approach but only by 17% with the footprint approach. In China, they have more than tripled according to both approaches. Emissions per capita in China are now higher than in the EU 28, with the territorial approach (7.6 tCO_2/capita in China against 6.8 tCO_2/capita in the EU 28). However, with the footprint approach, emissions per capita in China are 20% lower than in the EU 28, and more than 40% lower than the OECD average (6.6 tCO_2/capita in China, against 8.3 tCO_2/capita in the EU 28 and 11.2 tCO_2/capita on average in the OECD).

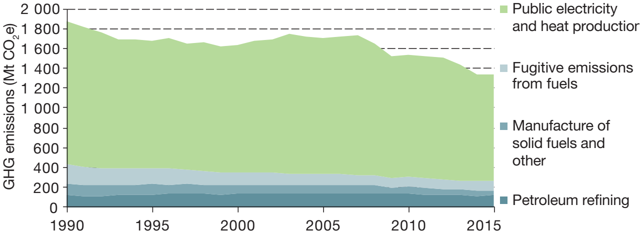
part 4

What is the sectoral distribution of GHG emissions in Europe and in France?

— European and French inventories enable a breakdown of GHG emissions by economic sectors and subsectors. In Europe and in France, the decline in emissions since 1990 has been the most significant in the manufacturing industry followed by the energy sector. Emissions in the residential and tertiary sectors have also been following a downward trend in the EU and to a lesser extent, in France. The transport sector is an exception as the level of emissions in 2015 was higher than in 1990, both in Europe and in France. However, since the mid 2000s, emissions have been on a decreasing trend in the transport sector at both levels. Emissions from LULUCF are negative, hence meaning that there is a net sequestration of CO_2 by biomass and soils.

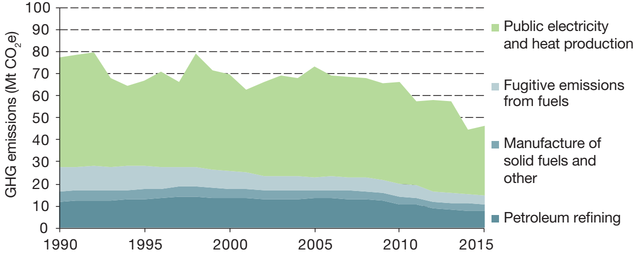
GHG emissions from the energy sector

GHG EMISSIONS FROM THE ENERGY SECTOR IN THE EU



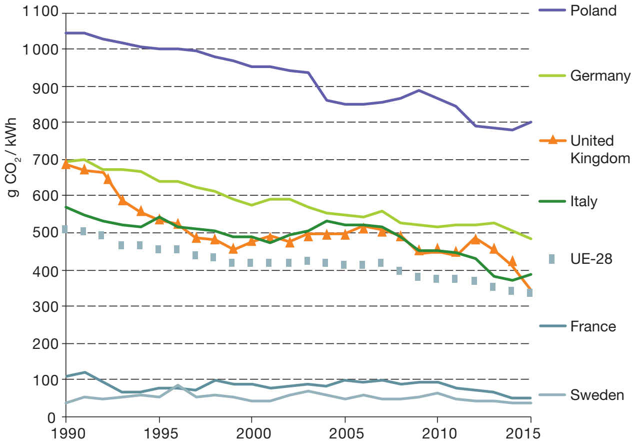
Note: public electricity and heat production includes waste incineration with energy recovery. Heat refers here to traded heat only.
***Source:** AEE, 2017*

GHG EMISSIONS FROM THE ENERGY SECTOR IN FRANCE



Note: public electricity and heat production includes waste incineration with energy recovery. Heat refers here to traded heat only. Including Overseas territories
***Source:** Citepa, 2017*

CO_2 EMISSIONS FROM THE GENERATION 1 KWH OF ELECTRICITY IN THE EU

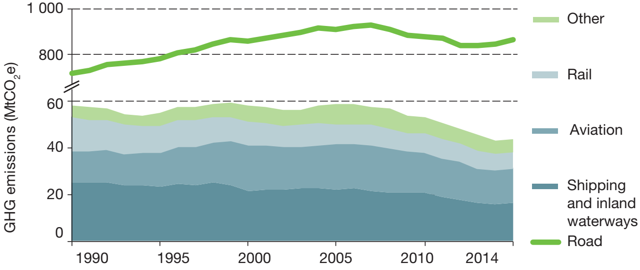


Note: cogeneration and autoproduction are included
***Source:** SDES from IEA, 2017*

Most of GHG emissions in the energy sector come from electricity and heat production, both in the EU (80% in 2015) and in France (68%). CO_2 emissions per unit of electricity generated vary greatly from one country to another in the EU-28, even if the downward trend since 1990 is common to almost all EU countries. They are very high (over 400 gCO_2/kWh) in countries where coal remains a major source for electricity production, such as Germany or Poland. They are lower in countries where renewable energy and/ or nuclear power have been significantly developed, such as France (76% nuclear and 11% hydro in 2015) and Sweden (46% hydro and 35% nuclear).

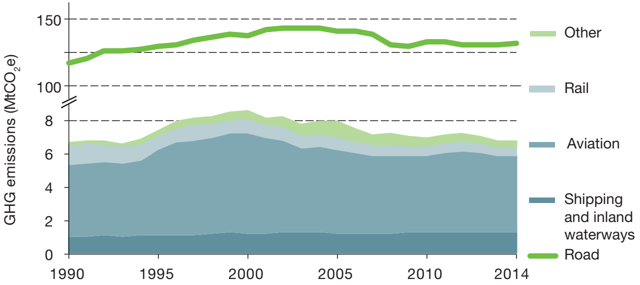
GHG Emissions from transport

GHG EMISSIONS FROM TRANSPORT IN THE EU



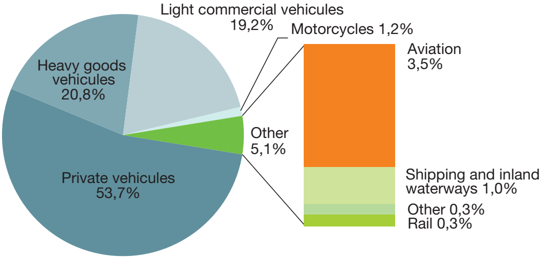
Note: emissions from international aviation and shipping are excluded.
***Source:** AEE, 2017*

GHG EMISSIONS FROM TRANSPORT IN FRANCE



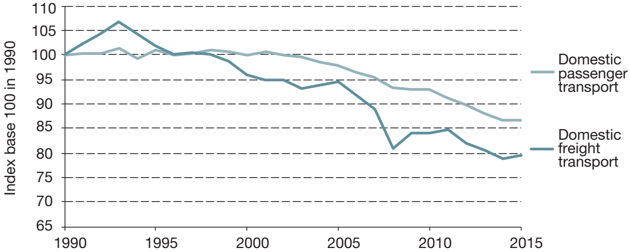
Note: emissions from international aviation and shipping are excluded. Emissions inside overseas territories and between metropolitan France and French overseas territories are included.
***Source:** Citepa, 2017*

GHG EMISSIONS BY TRANSPORT MODE IN FRANCE (INCL. OVERSEAS TERRITORIES)



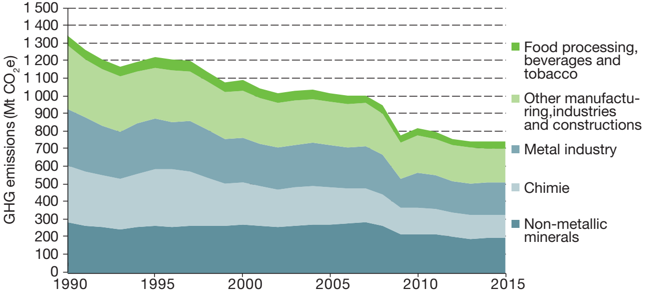
Source: *Citepa, 2017*

INTENSITY OF GHG EMISSIONS IN METROPOLITAN FRANCE



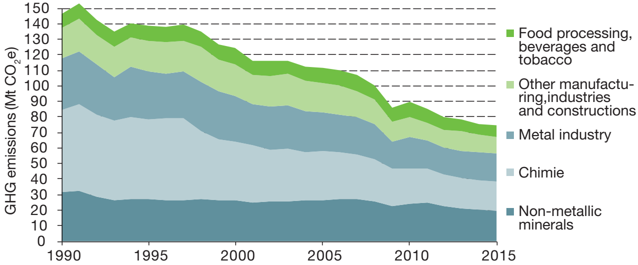
Note: the indicators used for freight and passenger transport are, respectively, GHG emissions per tonne-kilometre and GHG emissions per passenger-kilometre.
Source: *SDES, 2017*

GHG EMISSIONS FROM THE MANUFACTURING INDUSTRY AND CONSTRUCTION



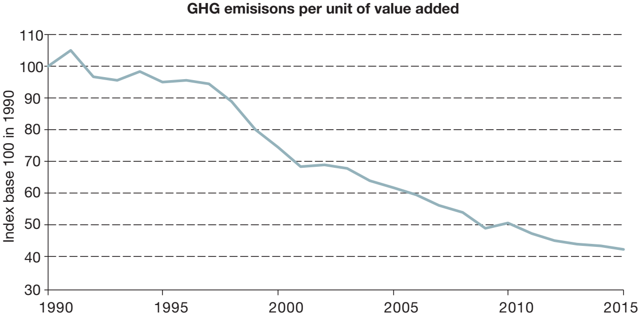
Note: emissions from each sector include energy-related emissions and emissions from industrial processes.
***Source:** AEE, 2017*

GHG EMISSIONS FROM THE MANUFACTURING INDUSTRY AND CONSTRUCTION IN FRANCE



Note: emissions from each sector include energy-related emissions and emissions from industrial processes. Overseas territories are included
***Source:** Citepa, 2017*

GHG EMISSIONS INTENSITY FROM THE MANUFACTURING INDUSTRY AND CONSTRUCTION IN FRANCE



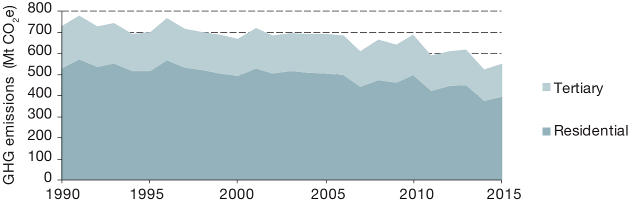
Sources: *SDES from Insee (value added), Citepa (GHG emissions), 2017*

Both in the EU and in France, most of GHG emissions of the manufacturing industry come from a few industrial branches producing CO_2-intensive products such as the metal industry, chemicals or the production of non-metallic minerals (cement, glass, lime...). For instance, in France, producing one ton of steel emits on average around 1.2 t CO_2, one ton of cement around 0.62 t CO_2 and one ton of glass 0.65 t CO_2 (*see page 75*).

Compared to 1990, emissions from the industry (including from industrial processes) have sharply dropped, both in the EU (-45%) and in France (-49%). All main industrial branches are concerned by this decrease. The economic crisis of 2008-2009 contributed to the drop in emissions, but most of it came from improvements in processes and energy efficiency gains. For example, emissions from the chemical industry fell by 64% between 1990 and 2015 in France. A strong reduction in N_20 emissions from the production of adipic and nitric acids played a large part in this evolution.

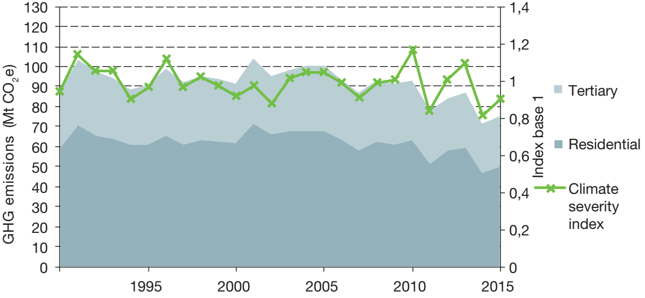
GHG emissions from the residendial and tertiary sectors

GHG EMISSIONS FROM THE RESIDENTIAL AND TERTIARY SECTORS IN THE EU



Source: *AEE, 2017*

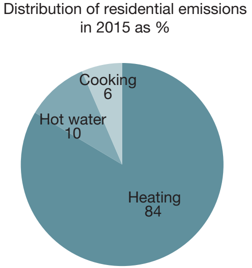
GHG EMISSIONS FROM THE RESIDENTIAL AND TERTIARY SECTORS IN FRANCE (INCL. OVERSEAS TERRITORIES)

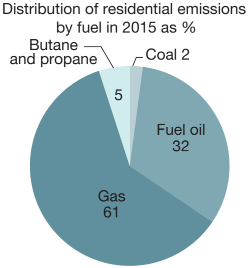


Sources: *Citepa, 2017, and SDES from Météo-France, 2017.*

Emissions from the residential and tertiary sectors vary depending on climate conditions. Temperatures were particularly mild in 1994, 2002, 2007, 2011 and 2014. This resulted in a reduction in heating consumption and thus in CO_2 emissions.

DISTRIBUTION OF CO_2 EMISSIONS FROM RESIDENTIAL BUILDINGS IN METROPOLITAN FRANCE

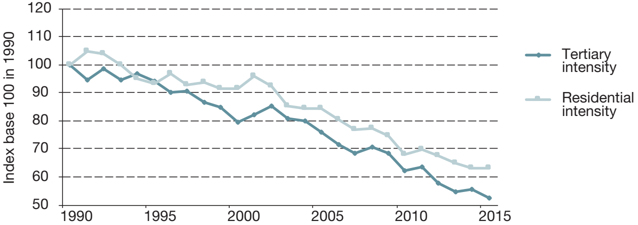




Note: only CO_2 emissions from fossil fuel combustion are taken into account. The carbon content of electricity is not measured.
***Source:** SDES, from Ceren, 2016*

Since 1990, natural gas have displaced coal and fuel oil for heating cooking, and hot water production in buildings. Combustion of natural gas now accounts for 61% of CO_2 emissions from residential buildings.

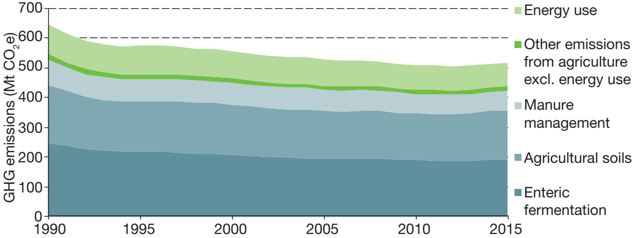
CO_2 INTENSITY FOR THE RESIDENTIAL AND TERTIARY SECTORS IN FRANCE



Note: emissions from the tertiary sector are divided by the value added of the tertiary sector (excluding transports) while emissions from residential buildings are divided by the total surface of occupied buildings. Emissions are climate corrected.
***Source:** SDES from Insee, 2016*

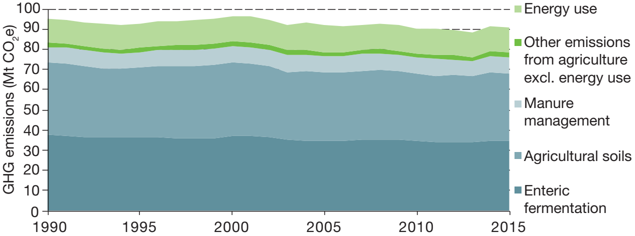
GHG emissions from agriculture, forestry and land use

GHG EMISSIONS FROM AGRICULTURE IN THE EU



Source: *AEE, 2017*

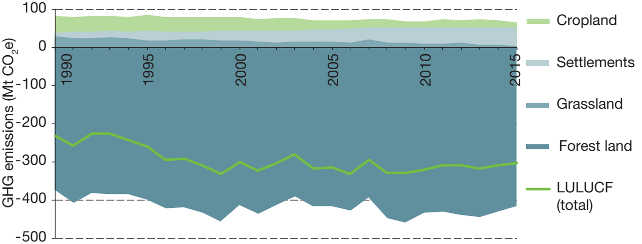
GHG EMISSIONS FROM AGRICULTURE IN FRANCE (INCL. OVERSEAS TERRITORIES)



Source: *Citepa, 2017*

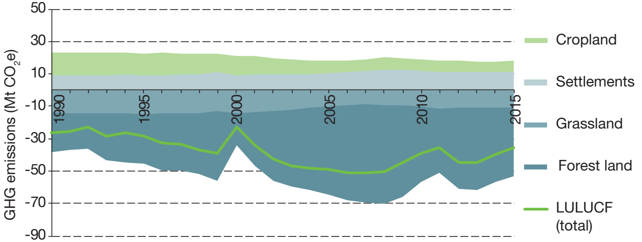
Agriculture differs from other economic sectors as most of the GHG emissions are not energy-related. The main GHGs sources are CH_4 emitted by livestock (enteric fermentation) and N_2O emitted by agriculture soils and linked to the nitrogen cycle.

GHG EMISSIONS FROM LULUCF IN THE EU



***Source:** AEE, 2017*

GHG EMISSIONS FROM LULUCF IN FRANCE (INCL. OVERSEAS TERRITORIES)

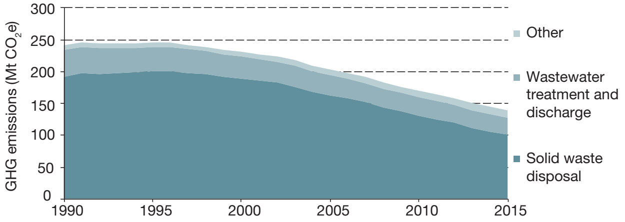


***Source:** Citepa, 2017*

Emissions from Land Use, Land Use Change and Forestery (LULUCF) are negative in both the European Union and France. This means that LULUCF activities sequester more GHGs than they emit. This sequestration is mainly due to the growth of forests while artificialisation of land cover contribute to more GHG emissions.

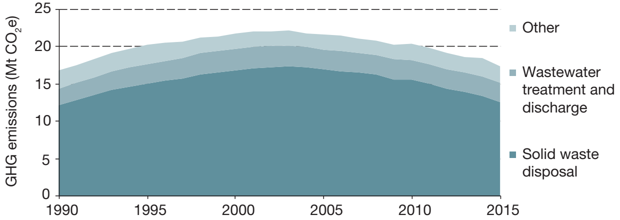
GHG emissions from waste management

GHG EMISSIONS FROM WASTE MANAGEMENT IN THE EU



Note: emissions from waste incineration with energy recovery are not included (included in "energy sector").
***Source:** AEE, 2017*

GHG EMISSIONS FROM WASTE MANAGEMENT IN FRANCE



Note: emissions from waste incineration with energy recovery are not included (included in "energy sector"). Overseas territories are included
***Source:** Citepa, 2017*

GHG emissions from waste management are mostly made of methane, emitted during the decomposition of waste in landfills. These emissions have been decreasing in Europe since the mid 90's and in France since the mid 2000's.

partie 5

Which climate policies in the world, in Europe and in France?

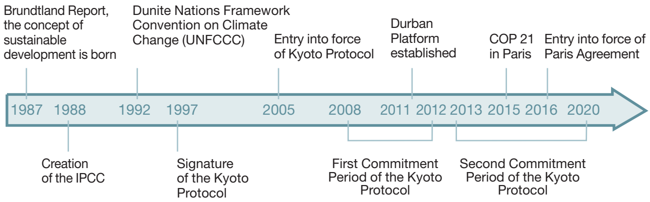
— COP 21 led to the adoption of the Paris agreement in December 2015, which implies pledges to limit GHG emissions both for developped and developing countries. The European Union set a 40% emissions reduction target in 2030 compared to 1990 levels as well as climate policies based in particular on an emissions trading system. Carbon pricing mechanisms are set in the world, notably to reorient financial flows. France adopted a climate plan, a national low carbon strategy and carbon budgets to implement the transition to a low carbon economy.

International negotiations

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

The UNFCCC, first international treaty aiming at preventing dangerous human interference with the climate system, was adopted in 1992 in Rio de Janeiro. It recognizes 3 principles:
- **a precautionary principle**: lack of full scientific certainty on the impacts of climate change shall not be used as a reason for delaying action;
- **the principle of common but differentiated responsibility**: all GHG emissions have an impact on global warming but the most industrialized countries carry a greater responsibility for the current concentration of GHGs;
- **the principle of the right to development**: climate actions shall not have a negative impact on the priorities of developing countries, including a sustainable economic growth and the fight against poverty.

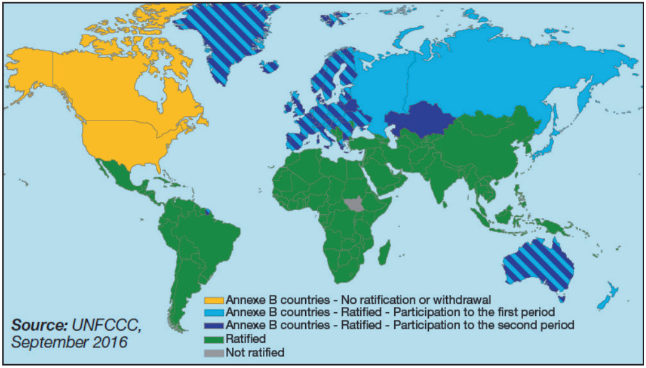
Countries that are party to the UNFCCC meet at the end of each year for the "Conference of the Parties" (COP). Major UNFCCC decisions are made during these conferences. The 23rd COP will be organised from 6 to 17 November 2017, in Bonn (Germany), and Fiji will hold the Presidency.



KYOTO PROTOCOL

The Kyoto Protocol was the first outcome of international negotiations on climate. It was agreed in 1997 and entered into force in 2005 after being ratified by Russia. It achieved the quorum of 55 States representing 55% of emissions from industrialized countries (listed in Annex B of the Protocol) in 1990.
The Protocol applies a top-down approach, and sets to Annex B countries an objective to reduce GHG emissions by roughly **5% between 2008 and 2012 relative to 1990 levels.**
Targets are binding and differentiated by country, but no emissions reductions objectives apply for Non-Annex B countries.
Amongst Annex-B countries, only the United States have not ratified the Protocol, and Canada withdrew from the Protocol in December 2011.
In 2011, at COP17 in Durban (South Africa), Parties agreed to continue the Protocol for a second period of commitment from 2013 to 2020. Those countries that announced a commitment for the second period represented 13% of global emissions in 2010.

Status of ratification of the Kyoto protocol



Paris agreement

PARIS APPROACH

In contrast to the Kyoto Protocol, the Paris Agreement applies a bottom-up approach.

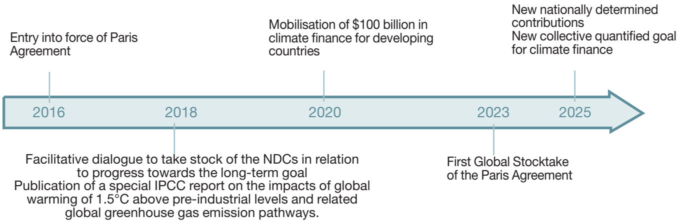
The Agreement sets a global objective of long-term GHG emissions reductions, but affords Parties flexibility in determining their own climate commitments, in the form of Nationally Determined Contributions (NDCs, see glossary). NDCs describe national efforts to fight against climate change, in the form of climate mitigation or adaptation objectives, based on their national circumstances. By guaranteeing that different climate priorities were represented, this approach was able to engage both developed and developing parties, and achieve a final consensus.

The efforts of non-state actors (cities, regions, companies, investors, civil society) were recognised by the COP21 Decision, to insist on their role in the dynamic of the Agenda of Solutions. The dialogue between non-state actors and the negotiations process rests in particular on the NAZCA (for Non-State Actor Zone for Climate Action) portal which brings together the commitments to action by non-states actors and should evaluate their progress in the future.

In particular, a new partnership to reinforce the dynamic of non-state actors was born at COP22 in Morocco, the “Marrakech Partnership for Global Climate Action”, on the initiative of the High-level Champions for climate.

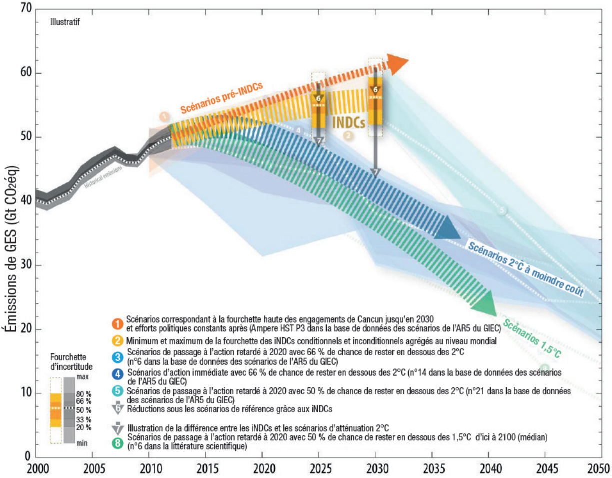
CONTENT OF THE PARIS AGREEMENT

On December 12th 2015 at COP21 in Paris, the text known as the Paris Agreement was adopted by the UNFCCC, it entered into force on November 4th 2016. It was one month after reaching the threshold of Parties which deposited their instruments of ratification (55 Parties representing at least 55% of global emissions.) For the first time, both developing and developed country Parties have binding commitments under the Convention.
The bottom-up NDC process successfully received **162 submissions** representing **190 country pledges**.
The key objectives of the Paris Agreement are threefold:
Mitigation
- To contain the rise of global mean temperatures "well below 2°C above pre-industrial levels" by 2100 and to pursue efforts to **limit warming to 1.5°C**.
- To **reach global peaking of GHG emissions** as soon as possible.
- To achieve **net-zero emissions** before the end of the century.
Adaptation
- To enhance support and capacity building for adaptation and loss & damage.
Finance
- To make finance flows consistent with climate objectives.
- **To mobilise at least $100 billion in climate finance** annually, from developed to developing countries between 2020 and 2025.
The Agreement introduces a Transparency Framework; it enhances cooperation at every level between public and private stakeholders. It includes a "**ratcheting mechanism**" to ensure that Parties do not decrease climate ambition over time.



IMPACT OF INDCS ON GLOBAL GHG EMISSIONS

Comparison of 2025 and 2030 global emissions levels resulting from iNDCs' implementation and other scenarios



***Source:** UNFCCC Synthesis report, 2016*

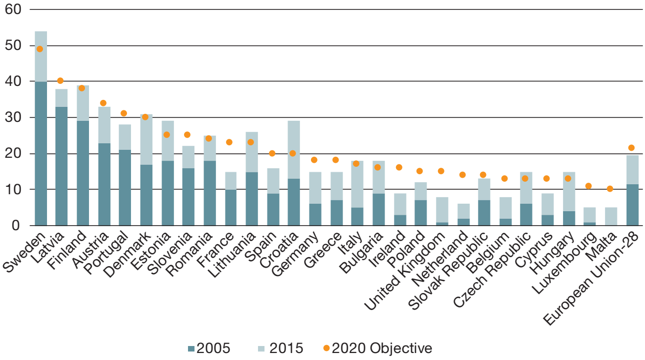
The UNFCCC has published a Synthesis Report that aggregates information from all iNDCs (for "intended Nationally Determined Contributions", which referred to Parties' contributions before the Agreement entered into force) submitted by April 2016.
This report concluded that, taking into account implementation of all iNDCs, GHG emissions are expected to increase between 34-53% by 2030 relative to 1990 levels. Per capita emissions are on the contrary are expected to decrease by 10% between 1990 and 2030.
Thus, iNDCs in their current form appear to be insufficient in meeting the 2°C-1.5°C objectives of the Paris Agreement. Reaching these objectives is still possible but will require drastically increasing the ambition as soon as possible.

Commitments of the European Union

CLIMATE AND ENERGY PACKAGE 2020

The Climate and Energy Package sets three targets for 2020, known as "20-20-20":
- A **20% cut in GHG emissions** from 1990 levels;
- A **20% share of renewables in EU gross final consumption of energy.** This objective is translated into a national binding target for each Member State;
- A **20% improvement in energy efficiency.** This objective corresponds to a 20% decrease in primary energy consumption compared to the Baseline scenario defined in 2007 (*see glossary*).

Share of renewables in the Member States' gross final energy consumption
As%



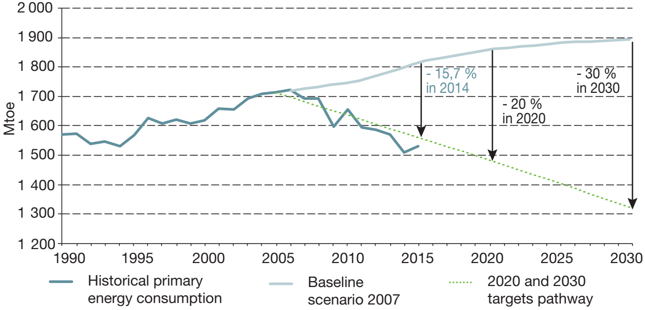
Source: *Eurostat, 2017*

CLIMATE AND ENERGY PACKAGE 2030

At a meeting on 23-24 October 2014, the European Council agreed on the 2030 climate and energy framework for the EU, which sets three targets for 2030:
- A **40% cut in GHG emissions** from 1990 levels;
- A **27% share of renewables** in EU gross final consumption of energy;
- A **27% improvement in energy efficiency**, which means a 27% decrease in primary energy consumption compared to the Baseline scenario defined in 2007.

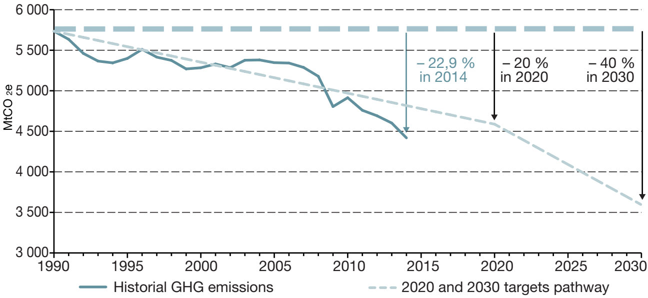
The legislatives texts of the 2030 Climate and Energy Package are currently under negotiation. The European Comission published in November 2016 several legislative proposals on renewable energy sources, energy efficiency, the organization of the electricity maket and the governance of the Energy Union. The proposal for a revised Energy Efficiency Directive increases to 30% the 2030 objective for energy efficiency.

EU-28 primary energy consumption evolution and targets to 2020 and 2030



Source: *Eurostat and European Commission*

EU-28 GHG emissions evolution and targets to 2020 and 2030



Source: *Eurostat and European Commission*

EFFORT SHARING

The two main policy instruments to achieve the emissions reduction targets are the **European Union Emissions Trading System** (EU ETS, *see page 62*) and the **Effort Sharing Decision (ESD)**, which sets national emissions reduction targets for non-ETS sectors.

The 20% emissions reduction target by 2020 compared to 1990 translates into a **21% reduction from 2005 levels** for the EU ETS and a **10% reduction compared to 2005** for other sectors.

The 40% emissions reduction target by 2030 compared to 1990 translates into a **43% reduction from 2005 levels for the EU ETS** and a **30% reduction compared to 2005** for other sectors.

The Commission published in July 2016 a proposal to revise the Effort Sharing Directive to divide the objective between Member States for the post-2020 period.

The EU ETS

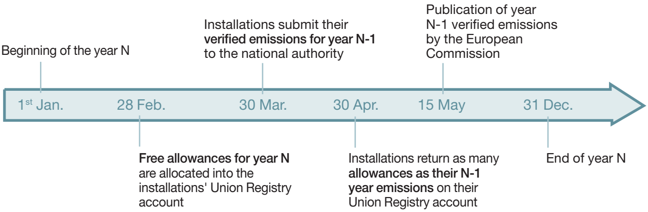
PRINCIPLE

The European Union Emissions Trading System (EU ETS) was created in 2005 with the aim of setting an annual cap on the emissions from heavy energy-using installations (power stations and industrial plants) and is now in its third phase (2013-2020).

Under the cap, installations receive or buy allowances which they can trade with each other. Every year, they have to surrender a number of allowances (1 allowance = 1 tonne of CO_2) equal to their verified emissions of the previous year.

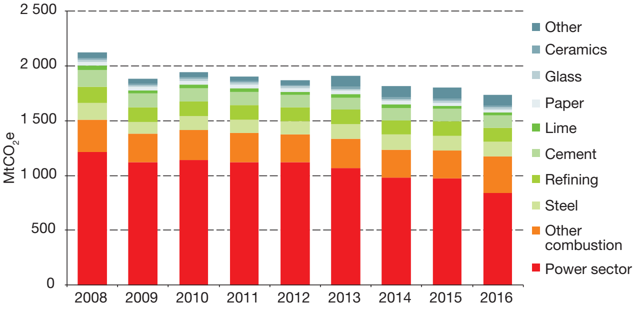
Since 2013, new sectors and new GHGs have been included in the EU ETS. It covers now 11,600 power stations and industrial plants installations in the EU and other countries of the European Economic Area (Norway, Liechtenstein and Iceland), as well as airlines operating between these countries, which represents about 45% of total GHG emissions.

EU ETS annual calendar



PRINCIPLE

Sectoriel GHG emissions under the EU ETS in phases II and III



Source: *I4CE based on EU TL data*

ALLOCATION OF ALLOWANCES

During the first two phases of the EU ETS (2005-2007, the pilot phase and 2008-2012, the first Kyoto commitment period), covered installations received every year the majority of their allowances for free, as set in the National Allocation Plans (NAP), established under the supervision of the European Commission.

In phase III (2013-2020), the allocation of allowances is centralised at the level of the European Commission.

EU ETS sectors (excluding aviation) have a 21% emissions reduction target by 2020 compared to 2005 levels, which corresponds to an annual decrease of the cap by a linear reduction factor of 1.74% of the average total number of allowances issued annually in 2008-2012.

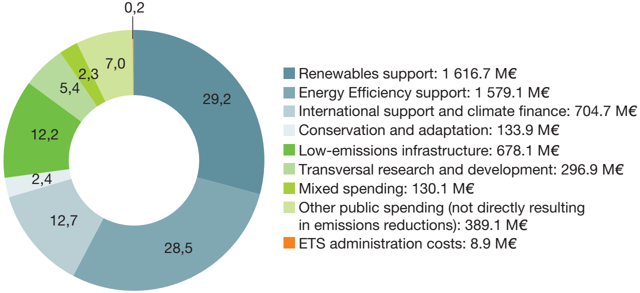
FEWER AND FEWER FREE ALLOCATIONS

The share of allocations auctioned was 0.19% in phase 1 and 3.6% in phase 2. Since 2013, auctioning has become the default allocation method. Have to be auctioned :
- 100% of the allocation for power generators, with a temporary exception in eight countries in Eastern and Central Europe;
- 20% of the allocation for manufacturing industry in 2013, a share progressively increasing to 70% in 2020.

Free allocations are set according to benchmarks of carbon intensity. Sectors and subsectors deemed to be exposed to a risk of carbon leakage (transfer of production to other countries with laxer emission constraints) receive 100% of the benchmark-based allocation until 2020.

Auctions may be pooled but the revenues are managed by Member States.

ETS revenue spending by EU Member States (2013-2015)
As%



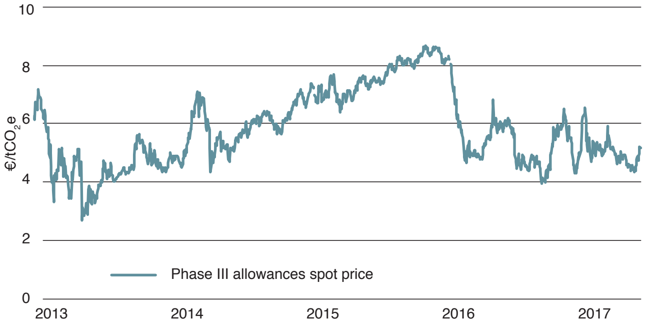
Source: *I4CE, May 2016*

TRADING CARBON ALLOWANCES

Allowances are tradable : an installation emitting more than its allocation may purchase allowances on the market, while installations which reduce their emissions can sell their unused allowances. Emissions are thus theoretically cut where it costs least to do so.

The trading of allowances is done **over-the-counter** i.e through bilateral contracts between industrials, or on **market platforms**, electronic portals which publicly list prices and amounts traded.

HISTORICAL PRICE OF ALLOWANCES



Source: *ICE Futures Europe*

The spot price is the price at which allowances can be sold for immmediate delivery; futures prices correspond to prices defined in contracts for a delivery at a later date specified in the contracts.

ALLOWANCES SURPLUS

Low prices on the EU ETS (*see page 65*) are the consequence of the allowances surplus which has built up since 2009.

While the EU ETS is on track to meet its 2020 objectives, this surplus undermines the credibility of the price signal for low-carbon investments.

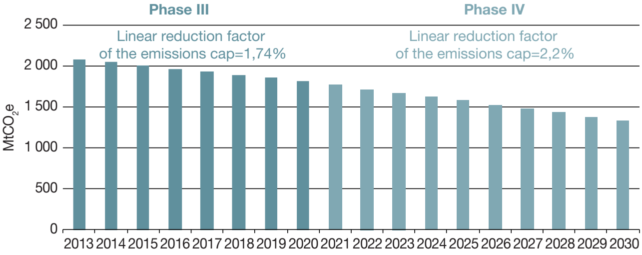
EU ETS REFORM FOR PHASE IV (2021-2030)

A first step of the reform was the backloading measure, which consisted in postponing the auctioning of 900 million allowances from 2014-2016 to 2019-2020.

A second step will be the establishment of the Market Stability Reserve (MSR) in 2018, whose objective is to regulate the long-term surplus by applying thresholds on the total amount of allowances circulating in the market.

The revision of the directive will notably set the linear reduction factor by which the emissions cap is reduced annually. The Commission recommended to change this linear factor from 1.74% to 2.2% after 2020.

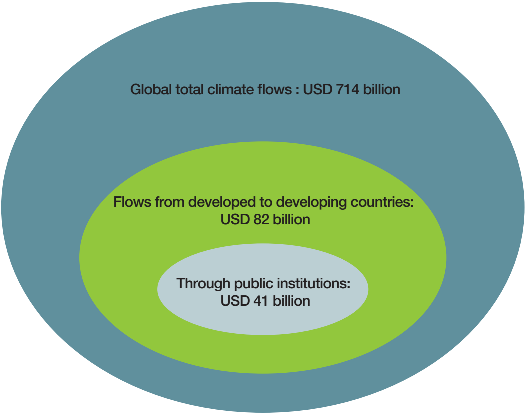
Evolution of the EU ETS emissions cap (2013-2030)



Sources: *I4CE, from European Commission, 2017*

Climate finance

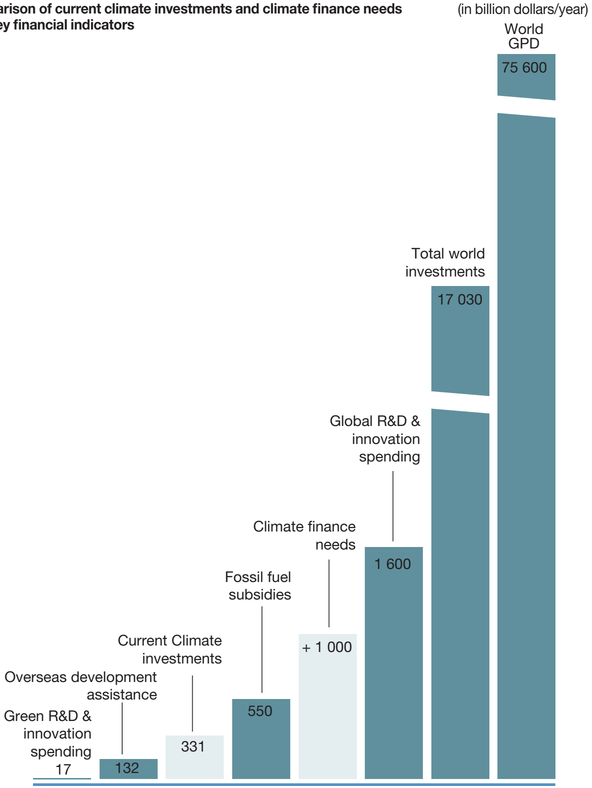
ESTIMATION OF GLOBAL FINANCE FLOWS (2013-2014 AVERAGE)



Note: on average over 2013-2014, annual climate finance flows amounted to USD 714 billion, including USD 82 billion to developing countries.
***Source:** 2016 biennial assessment and overview of climate finance flows, UNFCCC*

Climate finance encompasses all the financial flows which enable the implementation of actions with a positive impact in terms of mitigation (GHG emissions reductions) or adaptation to climate change. Depending on the definition and the organization, distinctions can be made according to the level of impact and whether it is a shared benefit or the main purpose of the financed action.

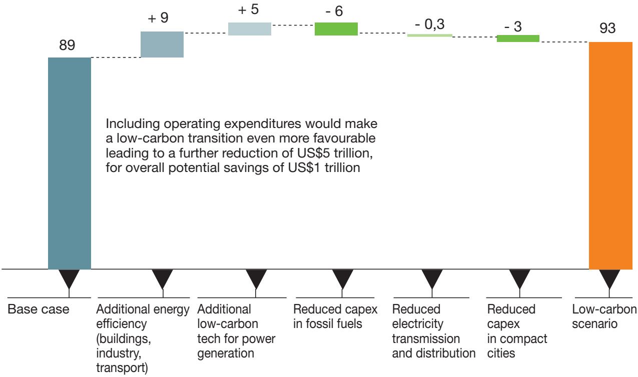
Comparison of current climate investments and climate finance needs with key financial indicators



Note: the definition for climate finance used here is slightly different from the one used on the previous page.
***Sources:** I4CE, May 2015 from A E, 2015, World Bank, 2013, UNFCCC, 2014, Climate Policy Initiative, 2014 and OECE, 2013*

GLOBAL INVESTMENT REQUIREMENTS, 2015 TO 2030

US$ trillion, constant 2010 dollars

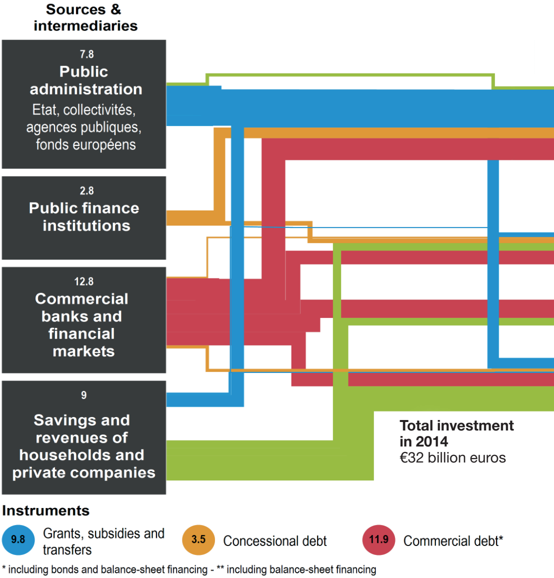


Note: among other differences, compared to the business-as-usual scenario, the low-carbon scenario would need 9 trillion USD of addditional investments in energy efficiency. The uncertainty on the figures is significative.
***Source:** New Climate Economy, 2016*

Achieving the 2°C target requires raising significant amounts – in the order of magnitude of one or several trillion dollars annually until 2030 – across all sectors, both for energy use and energy production. However, any scenario based on a continuation of current needs would require significant investments, regardless of the climate constraint.

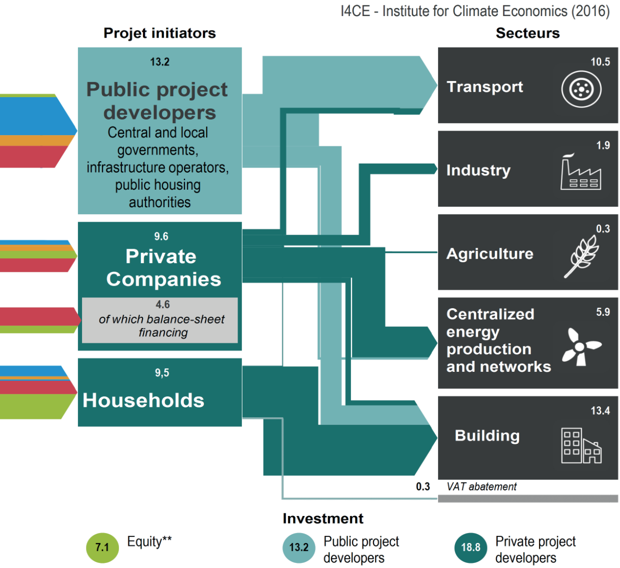
The difference between a business-as-usual scenario and a low carbon scenario is mainly about the distribution of investments. Indeed, higher investments are necessary in low carbon technologies and energy efficiency in a low carbon scenario, but lower investments are required in fossil fuels production for instance.

LANDSCAPE OF CLIMATE FINANCE IN FRANCE IN 2014 (IN BILLION CURRENT EUROS)



Source: *I4CE, Landscape of climate finance, 2016 edition*

In 2014 in France, investment contributing to GHG mitigation is estimated at up to **€32bn** across the five sectors displayed on the right side of the diagram. This investment was initiated by public and private project developers, who were most often considered to be the end-owners of the assets created. For example, **households** realized a majority of their investments in the residential (building) sector, whereas **private companies** invested primarily in transports and energy production.



Note: the Landscape only represents financial flows which correspond to effective investments. Some public subsidies, such as VAT reduction for energy efficiency in buildings, or feed-in tariffs for renewable energy, are not represented in this diagram.

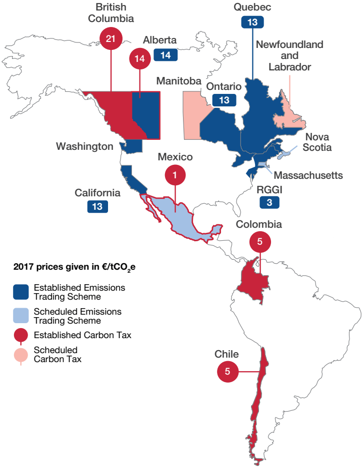
To finance these investments, project developers resorted to four principal types of instruments: 1) **grants, transfers and subsides**; 2) **concessional debt** at interest rates, tenure or volume preferential to typical market conditions; 3) **commercial market debt**; 4) and **equity** or own funds. **Balance-sheet financing**, which is used by private companies, is represented as a combination of commercial debt company-wide and equity.

Carbon pricing in the world

To prompt economic operators to invest more in clean energy and low carbon technologies and less in carbon-intensive technologies, some governments have decided to give an economic value to the emission of one tCO_2e.

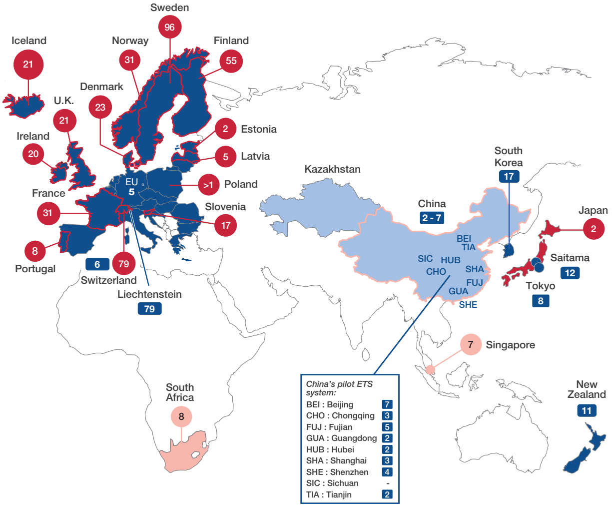
Several economic instruments exist in the policy toolkit to create a carbon price. Some of them target prices (taxes), others target the level of emissions (ETS).

Carbon pricing world map in September 2017



More than **40 countries** and **25 cities, states and provinces** have implemented or consider carbon pricing mechanisms (World Bank). Amongst them are big emitters such as China, South Korea, Europe, South Africa, Japan and Mexico.

In 2017, around 8 $GtCO_2e$ or 15% of global GHG emissions are covered by an explicit carbon price.



***Source:** I4CE, 2017*

Member State Climate Policies: the case of France

By the energy transition for green growth Act published in August 2015, France has committed to reducing its greenhouse gas emissions by 40% between 1990 and 2030 and to dividing them by four between 1990 and 2050. The climate plan, launched on the 6th of July 2017, calls for more ambitious actions to speed up the implementation of the Paris Agreement. In particular, it aims at achieving zero net GHG emissions by 2050. In line with these new targets, the French national low-carbon strategy (SNBC) and the multi-annual energy plan (PPE) will be revised before the end of 2018.

The SNBC, published by a decree of November 2015, includes cross-sectoral recommendations to implement the transition to a low-carbon economy and, beyond emissions reductions within the territory, calls for a reduction of the carbon footprint of France.

A carbon budget is the maximum amount of greenhouse gas emissions nationally released. It defines the trajectory of emission reductions for successive periods of 4 and 5 years.

Annual Average emissions (in Mt CO_2e)	**2013**	**1st carbon budget (2015-2018)**	**2nd carbon budget (2019-2023)**	**3rd carbon budget (2024-2028)**
All sectors	492	442	399	358

Source: *Decree No. 2015-1491 of 19 November 2015 concerning national carbon budgets and the national low-carbon strategy*

The multiannual energy plan, published in October 2016, sets out the objectives and priorities of public authorities in their management of various forms of energy, in line with the SNBC and the carbon budgets.

Examples of emission factors

CO_2 EMISSION FACTORS OF THE MAIN FOSSIL FUELS

Coal (coke, sub-bituminous or other bituminous)	4,0 t CO_2/oe	Lignite (lower grade coal)	4,2 t CO_2/oe
Diesel or crude oil	3,1 t CO_2/oe	Liquefied petroleum gas (LPG)	2,6 t CO_2/oe
Motor gasoline	2,9 t CO_2/oe	Natural gas (methane)	2,3 t CO_2/oe

Source: *IPCC, 2006*

CO_2 emission factors indicate the amount of CO_2 emitted when a given fuel is combusted to produce one unit of energy (here in toe). The specific case of biomass is not covered here: CO_2 direct emissions from the combustion of biomass are considered to be compensated by the assimilation of CO_2 during the growth of the plant. If this is not the case, any uncompensated emissions are recorded in the LULUCF sector.

EMISSION FACTORS FROM EVERYDAY ACTIVITIES

The concept of emissions factors can be extended to cover activities of businesses and households. They are calculated by relating GHG emissions from an activity to a measure of this activity.

Sector	Emissions factors	Details
Transport	172 g CO_2/km by car	French average in 2015, one passenger/vehicule. Increasing the number ofpassengers proportionately reduces these emissions
	132 g CO_2/km/passenger by plane	Average on a Paris-Marseille flight (660 km). The shorter the trip, the higher the emissions per kilometre, as take-off and landing use proportionately more fuel.
Electricity generation	0,87 t CO_2/MWh for a coal-fired power station	Efficiency rate of 40%
	0,36 t CO_2/MWh for a gas-fired power station	Efficiency rate of 55%
Industry	1,8 t CO_2/ton of steel	Oxygen pathway (non-recycled raw steel)
	0,62 t CO_2/ton of cement	World average in 2014, per ton of cement-equivalent
Forestry and agriculture	5,2 t CO_2/dairy cow per year	Emissions from enteric fermentation and manure management
	580 t CO_2/ha of deforested tropical forest	World average in the 2000's. Emissions related to the combustion and decomposition of organic matter.

Sources: *ADEME, Cement Sustainability Initiative, CITEPA, SDES*

Carbon footprint of some everyday objects and actions

The methodology rests on a "lifecycle" approach and accounts for different phases linked to the activity of each emissions factor. For example, for one kilometer by car, the emissions factor takes into account direct emissions due to fuel combustion, but also emissions from the fuel extraction and refining, its transport and distribution, as well as emissions linked to the fabrication of the car.

Transport

- Personal car fueled with gasoline – average horsepower : **259 g CO_2e/km**
- High-speed train (France): **3.69 g CO_2e/passenger.km**
- Subway (Paris): **5.70 g CO_2e/passenger.km**
- Plane - 180-250 seats, flight of 0-1000km: **293 g CO_2e/passenger.km**

Food

- Meal - classic (with beef): **4.52 kg CO_2e/meal**
- Meal - classic (with chicken): **1.11 kg CO_2e/meal**
- Meal – vegetarian: **0.45 kg CO_2e/meal**

Electronics

- Desktop computer – with a flat screen: **1280 kg CO_2e/computer**
- Laptop - 14,1 inches: **202 kg CO_2e/ appareil**
- Smartphone: **30 kg CO_2e/phone**

Communication

- 1email: **4 g CO_2e/unit**
- 1 email with attachments: **35 g CO_2e/unit**
- 1 tweet: **0,02 g CO_2e/unit**
- 1 internet query: **6.65 g CO_2e/unit**

Source: *resource centre for greenhouse gas accounting, ADEME.*

Glossary

Annex I country and Annex B country: Countries from the UNFCCC's Annex I are made up of developed countries and countries in transition to a market economy (former USSR mainly). With some minor differences, they are the countries from Annex B of the Kyoto Protocol, which aims to establish binding quantified commitments.
Anthropogenic: Relating to human activities (industry, agriculture, etc.).
CO_2 equivalence (CO_2e) : Method of measuring greenhouse gases based on the warming effect of each gas relative to that of CO_2.
Emissions allowance: Accounting unit of the trading system. Represents one tonne of CO_2.
ETS : Emissions Trading System.
Fossil fuel reserves : Quantities of gas, oil and coal recoverable from known reservoirs with the existing technologies and economic conditions.
GDP: Gross Domestic Product. Measure of the wealth generated by country over a given period. Measured in purchasing power parity (PPP), it allows for meaningful comparisons between countries.
GHG: Greenhouse gases: gaseous components of the atmosphere, both natural and anthropogenic, which absorb and re-emit infrared radiation.
GWP : Global warming potential. It allows a comparison to be made of the contributions of different greenhouse gases to global warming for a given period. The period chosen is usually 100 years but is sometimes taken at 20 years to better estimate the short-term effect of some gases.
NDC : Nationally Determined Contributions. iNDCs describe national policies planned against climate change. It can include adaptation or attenuation objectives.
International bunkers: Emissions from international aviation and maritime transport.
IPCC: Intergovernmental Panel on Climate Change. Research group led by the World Meteorological Organization and the United Nations Environment Programme, responsible for reviewing scientific research on climate change.
LULUCF: Land Use, Land Use Change and Forestry.
Scenario Baseline 2007: This scenario prepared by the Technical University of Athens proposes projections of the EU energy system until 2030. It takes into account policies implemented by members States until the end of 2006.
Solid fuels : Coal and its derivatives. Emissions from the transformation of solid fuels are mainly made of emissions from coke production
toe: Tonne of oil equivalent. Unit of measure for energy.
UNFCCC: United Nations Framework Convention on Climate Change.

Useful websites

Ademe - Agence de l'environnement et de la maîtrise de l'énergie - French Environmental and Energy Management Agency
www.ademe.fr
Resource centre for greenhouse gas accounting
http://www.bilans-ges.ademe.fr/
EEA - European Environment Agency
www.eea.europa.eu
IEA - International Energy Agency
www.iea.org
UNFCCC - United Nations Framework Convention on Climate Change
http://unfccc.int
I4CE - Institute for Climate Economics
www.i4ce.org
Citepa - Centre interprofessionnel technique d'études de la pollution atmosphérique-Interprofessional Technical Centre for Studies on Air Pollution
www.citepa.org
European Commission. Directorate-General for Climate Action
https://ec.europa.eu/clima/
EUTL - European Union Transaction Log.
http://ec.europa.eu/environment/ets
Drias les futurs du climat - Météo-France, IPSL, CERFACS.
www.drias-climat.fr
IPCC -Intergovernmental Panel on Climate Change
www.ipcc.ch
MTES - Ministère de la Transition écologique et solidaire - French Ministry for the Ecological and Inclusive Transition
https://www.ecologique-solidaire.gouv.fr/
General Directorate for Sustainable Development – SDES
www.statistiques.developpement-durable.gouv.fr
Climat Plan
http://www.gouvernement.fr/action/plan-climat
National low-carbon strategy (SNBC)
https://www.ecologique-solidaire.gouv.fr/index.php/strategie-nationale-bas-carbone
Multiannual energy programming (PPE)
https://www.ecologique-solidaire.gouv.fr/programmations-pluriannuelles-lenergie-ppe
NOAA - National Oceanic and Atmospheric Administration
www.noaa.gov
Météo France Climat HD
http://www.meteofrance.fr/climat-passe-et-futur/climathd
Onerc - National Observatory for the Impacts of Global Warming in France
www.onerc.gouv.fr
Université Paris-Dauphine – CGEMP – Centre of Geopolitics of Energy and Raw Materials
www.dauphine.fr/cgemp
Climate Economics Chair
www.chaireeconomieduclimat.org

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This publication, through its structure and choice of topics, aims to inform as wide a readership as possible about climate change, its mechanisms, causes and effects, as well as the measures that have been implemented to limit it, on an international, European and French scales. In particular, it gives detailed statistics on greenhouse gas emissions in the world, in Europe and in France.

Key figures on climate
France, Europe and Worldwide

Office of the Commissioner-General for Sustainable Development

Service de la donnée et des études statistiques – SDES
Tour Séquoia – 92055 La Défense cedex
Contact : diffusion.sdes.cgdd@developpement-durable.gouv.fr

Direction générale de l'énergie et du climat – SCEE
Tour Séquoia – 92055 La Défense Cedex
Contact : scee.dgec@developpement-durable.gouv.fr

I4CE – Institute for Climate Economics
24 avenue Marceau – 75008 Paris
Contact : contact@i4ce.org

www.statistiques.developpement-durable.gouv.fr

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