Highlights

Key Figures on Climate
France and Worldwide
2013 Edition

cdc climat research

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Ministère de l'Écologie, du Développement durable et de l'Énergie

Service de l'observation et des statistiques

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Key Figures on Climate France and Worldwide

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Foreword

The 2013 edition of "Key Figures on Climate" has been prepared within the context of the 18th Conference of the Parties on Climate Change (COP18) held in Doha from 26 November to 7 December 2012.

This latest version has been slightly revised from the 2012 edition. The layout of certain parts has been changed and some new indicators have replaced less relevant ones. This publication, through its organization and the choice of covered topics, aims to inform the widest audience possible about climate change, its mechanisms, causes and effects as well as international mechanisms established to limit it.

The panorama compiled in the five parts of this document is sometimes based on several sources, some of which are now relatively old but authoritative (e.g. IPCC 2007), and whose perimeters may vary according to the nature, origin and availability of information collected.

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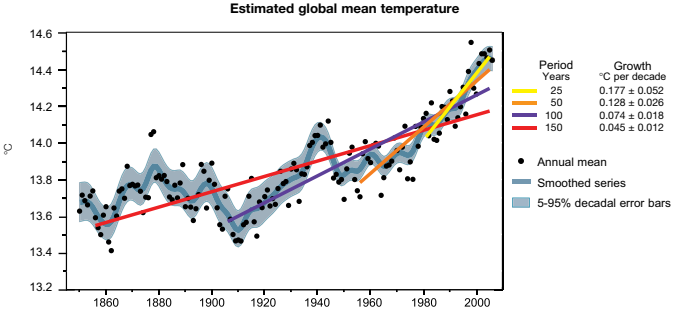
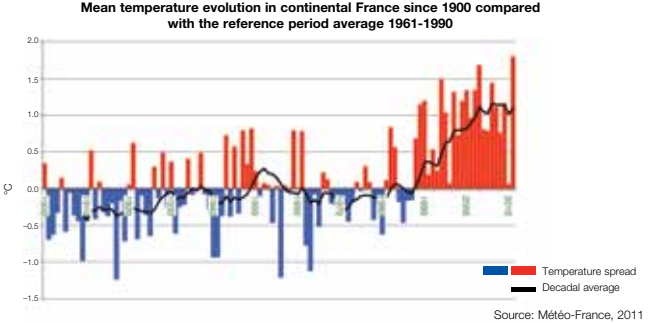
Estimated Global Temperature and Growth Rate since 1850



Source: IPCC, 1st working group, 2007

> The global average temperature has increased by **0.74°C** over the last century. Over the last 25 years, the rate of temperature growth has been the highest during the entire century.

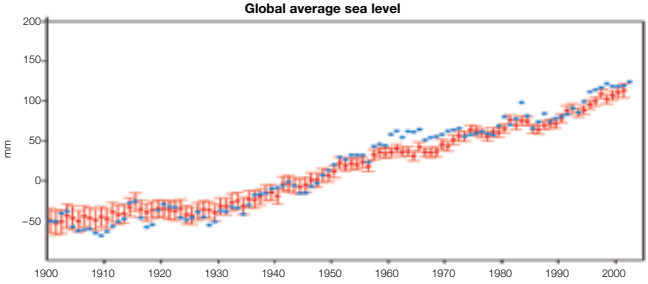
> In metropolitan France, the average temperature has increased by 0.7°C over the century in the north-eastern part of the country. The increase is even larger in the south-western part where it reached 1.1°C.



Source: Météo-France, 2011

> 2011 has been the warmest year on record in metropolitan France since 1900. At the global scale, the last seventeen years (1995-2011) include sixteen of the seventeen warmest years since 1900.

Continuous Increase in Sea Level since the 1900s



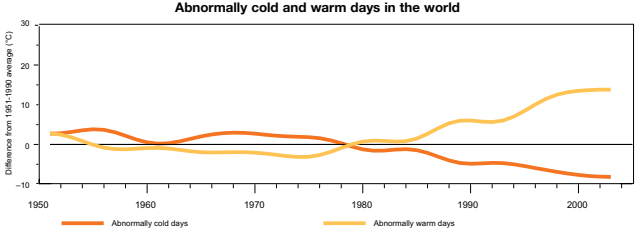
Red bars represent estimates and uncertainty from Church *et al.* (2004). Blue points represent estimates from Jevrejeva *et al.* (2006).

Source: *Les Climats du XXIe siècle,* n°3, 2012

> The global average sea level increased by 1.7 ± 0.2 mm/year between 1901 and 2009. The rise in sea level is further increasing in speed: it reached **3.2 ± 0.4 mm/year over the 1993-2011 period.**

Extreme Weather Events

> A weather event is classified as extreme when it substantially exceeds the baselines.
> Climate change modifies the frequency, intensity, scale, duration and time of occurrence of extreme events. It can bring these events (tornadoes, hurricanes, as well as heat waves or abnormally heavy rainfalls) to unprecedented levels.

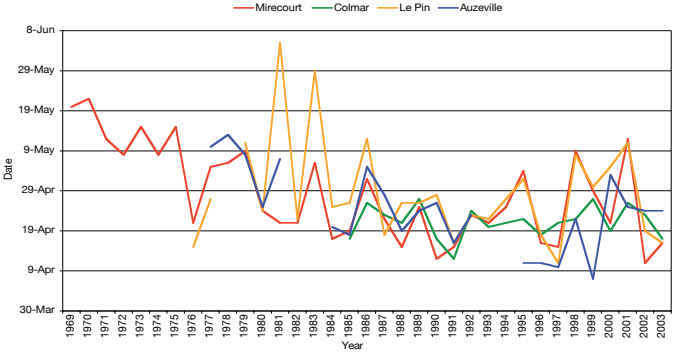


The baseline used is the mean of the indicator considered over the period 1951-1990. The orange curves represent the mobile averages per decade. All regions worldwide are not included due to insufficient data.

Source: IPCC, 1st working group, 2007

Annual Evolution of Seeding Dates

Evolution of corn seeding dates in four experimental units

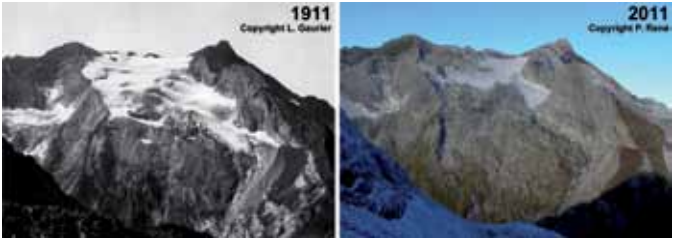


Source: INRA

> Observations show that the seeding dates for corn are increasingly earlier. Shortening physiological cycles also leads to earlier maturity and harvests.

Melting Ice

Compared pictures showing the evolution of the glacier of Ossoue (France)

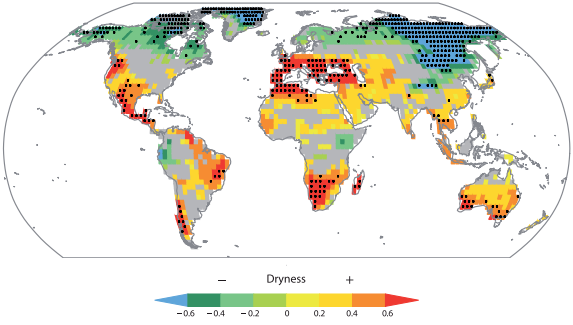


Source: Moraine (Pyrenean association of glaciology), 2011

> Since 1911, the diameter of the glacier of Ossoue has been shortened by 540 meters. In 100 years, its area has decreased from about 110 to 45 hectares, namely an area loss of 59%.

Change in Consecutive Dry Days (CDD)

Change in consecutive dry days 2081-2100



(CDD – precipitations under 1 mm)
The increased drought is represented by the yellow to red colors, drought mitigation by the green to blue colors.

Source: IPCC, SREX, 2012

> Climate extremes will have a significant impact on industries that are closely related to climate, such as access to water resources, agriculture and food production, forestry, health and tourism.

Consequences for France

Number of additionnal abnormally warm days in the future (IPCC A2 scenario)

Reference 1970 | Mean term 2055 | Long term 2085

Source: Drias, 2012

Projections of Sea Level Rise

In cm

Hypothesis	2030	2050	2100
Optimistic	10	17	40
Pessimistic	14	25	60
Extreme	22	41	100

Projections of sea level rise relative to the values of the late twentieth century, expressed in cm, depending on the assumptions surrounding climate change impacts.

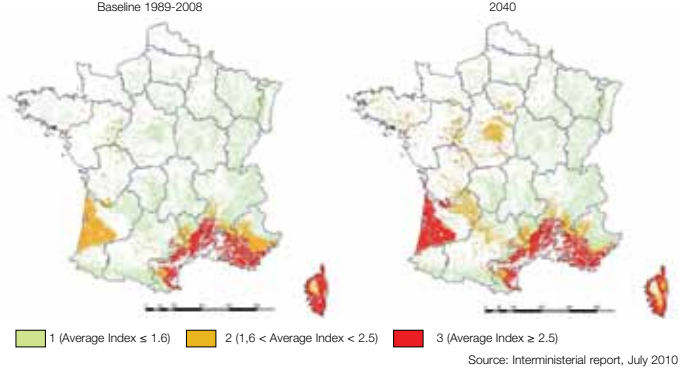
Source: Onerc, 2010

> The main drivers of growth in sea level are the thermal expansion and the melting of terrestrial ice (glaciers, polar ice caps, ...).

> The increase in sea level is likely to cause heavy migration of populations, since **80% of the humanity lives in coastal areas.**

Extension of Forest Fires Risk Areas

Sensitivity to summer forest fires of forest massifs (> 100 ha)



Source: Interministerial report, July 2010

> By 2040, areas sensitive to forest fires will extend in altitude and to the north. Moderately sensitive areas like the forest of Aquitaine will become very sensitive. Areas with historically little or no risk will be at moderate risk, such as the massifs of Sologne and the forest of Fontainebleau.

The Atmosphere's Role on the Greenhouse Effect

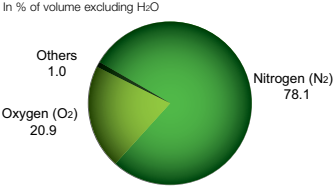
Energy flows, with or without greenhouse gases (GHGs)

Source: adapted from IPCC, 1st working group, 2007

> The sun supplies energy through its rays to the Earth which, in return, radiates an equal quantity of energy in the form of infrared radiation (IR). In the absence of greenhouse gases (GHGs), the temperature of the Earth would be -19°C.
> With GHGs in the atmosphere, a portion of the IR is reflected back towards the surface of the Earth. The Earth's temperature increases until the energy radiated is equal to that absorbed. The presence of GHGs leads to an increase in surface temperature, which then reaches +14°C. Increased GHG anthropogenic emissions imbalance the system and the equilibrium temperature increases. The increased forcing is estimated at + 2.81 W/m² in 2010 (source: National Oceanic and Atmospheric Administration).

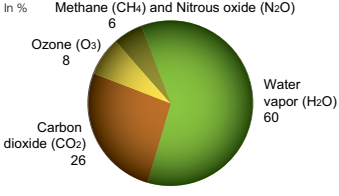
The Atmosphere and Greenhouse Gases

Composition of the dry atmosphere



Source: IPCC, 1st working group, 2001

Share of the main greenhouse gases in the reflection of radiation towards the surface



NB: proportions in the absence of clouds.
Source: Kiehl & Trenberth 1996

> GHGs other than water vapor make up **less than 0.1 % of the atmosphere.** Water vapor, which fluctuates from 0.4 % to 4 % in volume is the main greenhouse gas. It is natural and human activities have little impact on its fluctuations.
> However, during the industrial era, the development of human activities that emit GHGs, called anthropogenic, magnified the natural greenhouse effect, causing an increase in atmospheric temperature.

Characteristics of GHGs Influenced by Human Activity

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
Atmospheric concentration 2010	389 ppm	1,808 ppb	323 ppb	96 ppt	82 ppt	7.0 ppt	< 1 ppt
Lifespan in the atmosphere	Between 2 years and thousand of years	12 years	114 years	Between 0.3 and 270 years	Between 1,000 and 50,000 years	3,200 years	740 years
Global warming potential (total over 100 years)	1	25	298	[12; 14,800]	[7,300; 12,200]	22,800	17,200
Anthropogenic sources	Burning of fossil fuels 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 since 1750 (W/m²)	+1.66	+0.48	+0.16	+0.017			

Notes: Ozone and water vapor omitted due to the complexity of their lifecycles.
ppm = part per million, ppb = part per billion, ppt = part per trillion.

Source: IPCC, 1st working group, 2007 and ESRL/NOAA, 2012

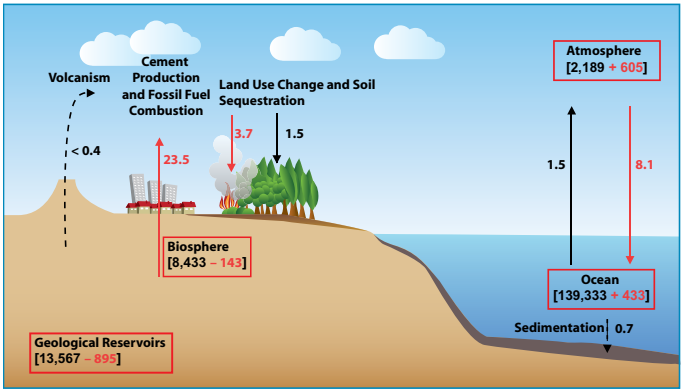
> **The Global Warming Potential (GWP)** is the ratio between the energy reflected towards the surface over 100 years by 1 kg of the gas and that which would be reflected by 1 kg of CO_2. The GWP depends on the concentration and lifespan of each gas. *E.g.:* 1 kg of CH_4 and 25 kg of CO_2 would heat the atmosphere equally over the century following their emissions.

> **Radiative forcing** (in W/m²) quantifies, in relation to a year of reference (here 1750), the **changes in radiation**, or the energy reflected by the atmosphere back towards the surface due to GHGs. A positive value indicates a positive contribution to warming and vice versa.

> Although CO_2 has the smallest global warming potential of all GHGs, it has contributed the most to global warming since 1750.

> Some human activities also contribute to reducing radiative forcing, most notably through the emissions of aerosols. However this negative radiative forcing, estimated at –1.20 W/m² since 1750, does not compensate for the positive radiative forcing of the six anthropogenic GHGs which reached +2.81 W/m² in 2010, increasing by 1.2% compared to 2009.

The Simplified CO_2 Cycle



This figure shows (i) as arrows, the carbon fluxes between reservoirs over the 1990-1999 period in billions of tonnes of CO_2 equivalent per year; (ii) between square brackets the size of the reservoirs in billions of tonnes of CO_2 equivalent and their variation over the 1750-2004 period. Pre-industrial reservoirs and flows are in black. Reservoirs' variations and flows induced by human activities since 1750 are in red.

Source: adapted from IPCC, 1st working group, 2007

> Four large reservoirs or "stocks" allow the storage of carbon in different forms:

- **Atmosphere:** gaseous CO_2;
- **Biosphere:** organic material and living things including forests;
- **Ocean:** calcium, dissolved CO_2;
- **Subsoil:** rocks, sediments, fossil fuels.

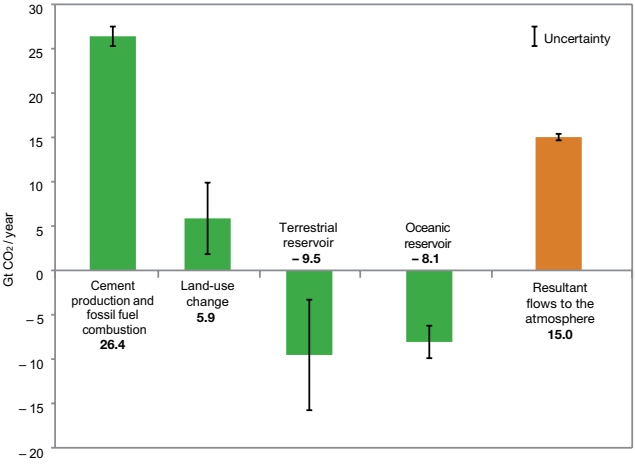
> Flows of carbon between these reservoirs constitute the natural carbon cycle which is disrupted by human activities which change the size of the flows or create new ones. *E.g.:* the burning of fossil fuels (coal, petroleum…).

> Of the 1,038 $GtCO_2$ liberated by human activities from the biosphere and the lithosphere, the atmosphere has absorbed 605 Gt and the oceans 433 Gt. The atmosphere is the reservoir which is the most affected by human activities: the quantity of carbon absorbed has increased by 30% compared to the pre-industrial era.

Increase in Atmospheric GHG Levels

Imbalance between Emissions and Storage Capacity

Annual changes in CO_2 by source, reservoir and their associated uncertainties



Emissions data from the burning of fossil fuels, the production of cement, the oceanic reservoir and the growth of the atmospheric reservoir are for the period 2000-2005. The terrestrial flows are for the 1990s.

Source: IPCC, 1st working group, 2007

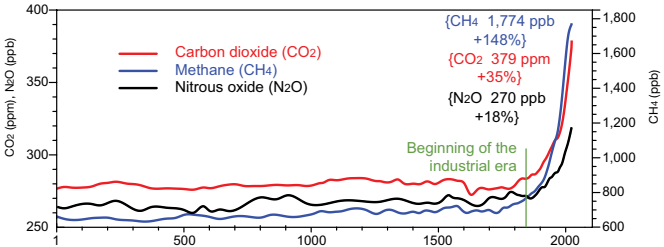
> Since the increase in industrial activities, terrestrial and oceanic reservoirs have absorbed half of the human-related emissions. The atmosphere has absorbed the other half, which has led to increased concentration of greenhouse gases.

> Forests are the largest terrestrial carbon reservoir. They store approximately 9.5 $GtCO_2e$ net emissions per year, equivalent to 30% of global GHG emissions.

> In France, carbon flow in forest biomass is estimated at 17.1 million tonnes of carbon per year, or 17% of national emissions of fossil carbon (INRA, 2006).

> Deforestation leads to GHG emissions through the burning and decomposition of organic matter. These emissions represent approximately 11% of yearly anthropogenic GHG emissions (source: Van der Werf *et al.* 2009, Nature Geoscience).

Historic Evolution of GHG Concentrations

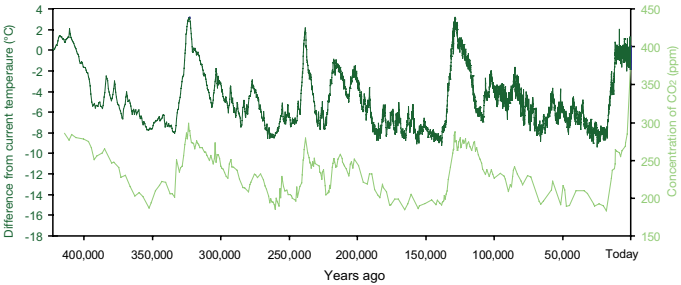


The figures in brackets indicate the atmospheric concentration of GHGs in 2005 and their growth rate between 1750 and 2005.

Source: IPCC, 1st working group, 2007

> The stable nature of concentrations before the industrial era shifted radically in 1750, exhibiting a strong increase in levels due to the intensification of human activities emitting large quantities of GHGs. In late 2011, atmospheric CO_2 concentration reached 391.4 ppm (source: NOAA, 2012). This is 30% higher than the maximum observed over the past 400,000 years of weather data.

Temperature and CO_2 concentration in the atmosphere over the past 400,000 years



These results were obtained from the analysis of ice cores sampled at Vostok (Antarctica).

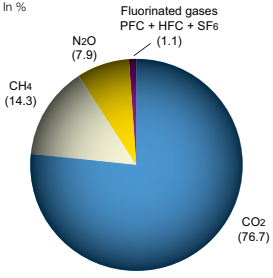
Source: World Data Center for Paleoclimatology, Boulder & NOAA Paleoclimatology Program

> The variations in global temperature and CO_2 concentration have a very clear correlation. If the causes are still poorly understood, it is believed that disrupt one of these two parameters leads to disrupt the other.

2.1 Snapshot of Global Greenhouse Gas Emissions

Global GHG Emissions by Type of Gas

Global GHG emissions by gas in 2004[1]



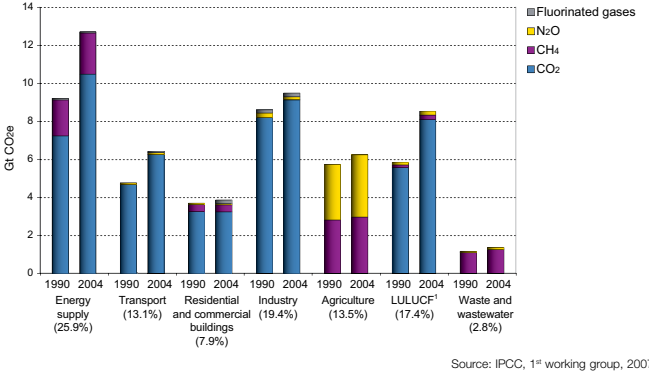
Source: IPCC, 3rd working group, 2007

> Emissions of the six greenhouse gases[2] covered by the Kyoto Protocol have increased by 70% since 1970 and by 24% since 1990, reaching **49 $GtCO_2e$ in 2004.**

1. Including emissions due to Land Use, Land Use Change and Forestry (LULUCF).
2. Carbon dioxide (CO_2), Nitrous oxide (N_2O), Methane (CH_4), Hydrofluorocarbons (HFC), Perfluorocarbons (PFC) and Sulfur hexafluoride (SF_6)

Global GHG Emissions by Sector

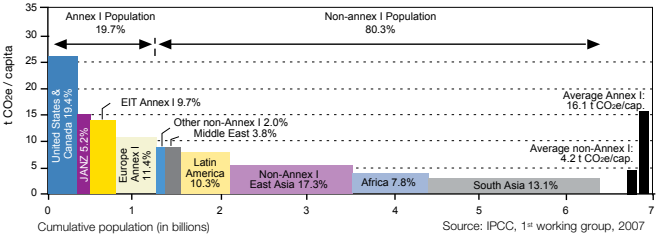
Evolution of global GHG emissions by sector between 1990 and 2004



Source: IPCC, 1st working group, 2007

The percentage indicated for each sector corresponds to its share in global GHG emissions in 2004.

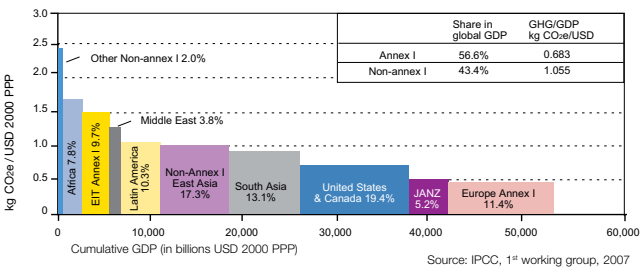
Regional Distribution of GHG Emissions[1] per Capita in 2004



The percentage indicated for each region corresponds to its share in global GHG emissions.
EIT: Economies in Transition, JANZ: Japan, Australia, New Zealand.

> In 2004, Annex I countries of the UNFCCC[2] represented **20% of the world's population**, 57% of global GDP and produced **46% of all the GHG emissions**. In Annex I countries, the average GHG emissions per capita was 16.1 t CO_2e, approximately four times that in non-Annex I countries.

Regional Distribution of GHG Emissions[1] per Unit of GDP in 2004



	Share in global GDP	GHG/GDP kg CO2e/USD
Annex I	56.6%	0.683
Non-annex I	43.4%	1.055

The percentage indicated for each region corresponds to its share in global GHG emissions.
EIT: Economies in Transition, JANZ: Japan, Australia, New Zealand.

> Measured in USD 2000, and adjusted for purchasing power parity (PPP), the production of one unit of GDP in the Annex I countries resulted in GHG emissions that were on average 35% lower than in non-Annex I countries.

1. Including Land Use, Land Use Change and Forestry (LULUCF).
2. United Nations Framework Convention on Climate Change.

2010 GHG Emissions in EU-27

In Mt CO_2e

Sector	Years	CO_2	CH_4	N_2O	Fluorinated gases	Total
Energy	1990	4,114.0	154.7	35.0	0.0	4,303.7
	2010	3,651.8	76.3	35.0	0.0	3,763.0
Industrial processes	1990	289.5	1.4	115.1	59.3	465.3
	2010	229.7	1.2	17.9	94.4	343.1
Use of solvents	1990	11.6	0.0	5.4	0.0	17.0
	2010	7.2	0.0	4.5	0.0	11.6
Agriculture	1990	0.0	248.7	345.0	0.0	593.7
	2010	0.0	198.6	263.0	0.0	461.6
Waste	1990	4.7	185.6	13.1	0.0	203.4
	2010	2.7	124.7	14.1	0.0	141.5
Total excluding LULUCF[1]	**1990**	**4,419.8**	**590.3**	**513.7**	**59.3**	**5,583.1**
	2010	**3,891.3**	**400.7**	**334.5**	**94.4**	**4,720.9**
LULUCF[1]	1990	−294.1	4.2	3.9	0.0	−286.0
	2010	−319.8	4.6	3.5	0.0	−311.6
Total	**1990**	**4,125.7**	**594.6**	**517.6**	**59.3**	**5,297.1**
	2010	**3,571.6**	**405.3**	**338.0**	**94.4**	**4,409.3**

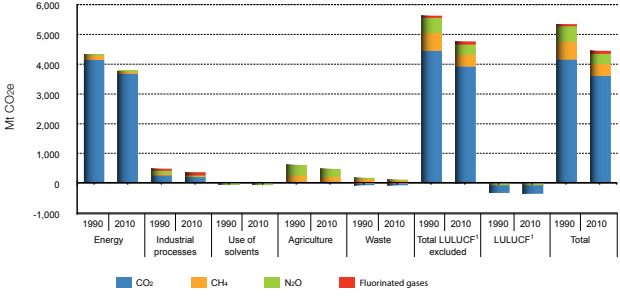
Source: European Environment Agency, June 2012

> **European GHG emissions excluding LULUCF[1] decreased by 15% over the 1990-2010 period.**

> Emission reductions reached 13% in the energy sector, 26% in the industrial processes sector, 22% in agriculture and 30% in waste treatment. The net carbon sequestration in the agro-forestry (LULUCF[1]) sector increased over the same period by 9%.

> EU emissions increased by 1% between 2009 and 2010. It is partly due to the effect of the economic recovery.

GHG emissions by sector in EU-27



1. Land Use, Land Use Change and Forestry (LULUCF).

Source: European Environment Agency, June 2012

2010 GHG Emissions in France

In Mt CO_2e

Sector	Years	CO_2	CH_4	N_2O	Fluorinated gases	Total
Energy	1990	366.9	10.5	3.7	0.0	381.1
	2010	362.5	3.1	4.4	0.0	370.0
Industrial processes	1990	24.3	0.1	24.6	10.0	59.0
	2010	17.4	0.1	2.2	17.9	37.5
Use of solvents	1990	2.0	0.0	0.1	0.0	2.1
	2010	1.1	0.0	0.1	0.0	1.2
Agriculture	1990	0.0	42.9	61.1	0.0	104.0
	2010	0.0	42.2	51.7	0.0	93.9
Waste	1990	1.7	9.5	1.6	0.0	10.0
	2010	1.4	17.0	1.3	0.0	17.9
Total excluding LULUCF[1]	**1990**	**395.0**	**62.9**	**91.0**	**10.0**	**559.0**
	2010	**382.5**	**62.4**	**59.6**	**17.9**	**522.4**
LULUCF[1]	1990	−22.4	1.2	1.8	0.0	−19.4
	2010	−35.5	1.8	1.5	0.0	−32.2
Total	**1990**	**372.6**	**64.1**	**92.8**	**20.1**	**539.6**
	2010	**347.0**	**64.2**	**61.1**	**35.7**	**490.1**

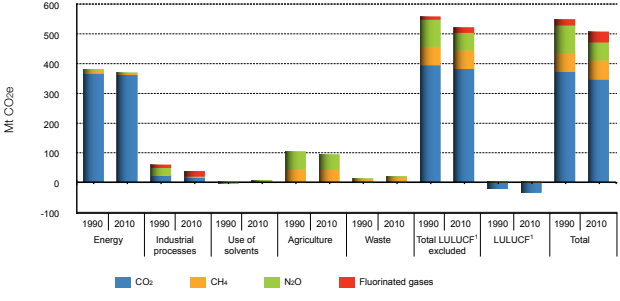
Source: Citepa, June 2012

> **French GHG emissions excluding LULUCF[1] decreased by 7% over the 1990-2010 period.**

> Emission reductions were 3% in the energy sector, 36% in industrial processes and 12% in agriculture. Emissions increased by 55% in the waste treatment sector. The net increase in the agro-forestry carbon stock is 66% over the same period.

> French emissions increased by 1% between 2009 and 2010.

GHG emissions by sector in France

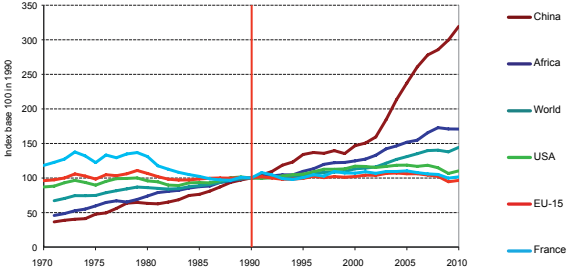


1. Land Use, Land Use Change and Forestry (LULUCF).

Source: European Environment Agency from Citepa, June 2012

3.1 Energy-related CO_2 Emissions

Energy-related CO_2 Emissions Worldwide[1]



Source: International Energy Agency, September 2012

In Mt CO_2

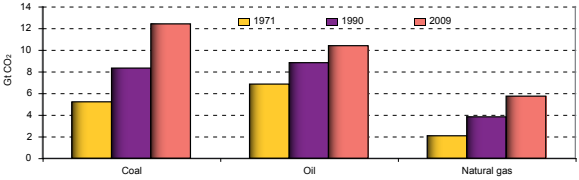
	1990	2009	2010	Share (%) in 2010	Change (%) 2010/2009	Change (%) 2010/1990
North America	**5,566**	**6,110**	**6,322**	**20.8**	**+3.5**	**+13.6**
of which: Canada	433	525	537	1.8	+2.1	+24.0
United States	4,869	5,185	5,369	17.7	+3.5	+10.3
Latin America	**609**	**1,058**	**1,135**	**3.7**	**+7.3**	**+86.3**
of which: Brazil	194	338	388	1.3	+14.7	+99.6
Europe and former USSR	**7,945**	**6,246**	**6,466**	**21.3**	**+3.5**	**−18.6**
of which: EU-27	4,050	3,571	3,660	12.1	+2.5	−9.6
EU-15	3,081	2,912	2,972	9.8	+2.1	−3.6
of which: Germany	950	747	762	2.5	+1.9	−19.8
Spain	205	282	268	0.9	−5.0	+30.7
France	**352**	**351**	**358**	**1.2**	**+1.8**	**+1.6**
Italy	397	389	398	1.3	+2.3	+0.3
United Kingdom	549	466	484	1.6	+3.9	−12.0
12 new EU members	969	659	688	2.3	+4.4	−29.0
of which: Russia	2,179	1,520	1,581	5.2	+4.0	−27.4
Africa	**544**	**931**	**930**	**3.1**	**−0.1**	**+70.8**
Middle-East	**591**	**1,547**	**1,616**	**5.3**	**+4.4**	**+173.5**
Far East	**4,861**	**11,622**	**12,348**	**40.7**	**+6.2**	**+154.0**
of which: China	2,289	6,858	7,311	24.1	+6.6	+219.4
South Korea	229	515	563	1.9	+9.2	+145.6
India	582	1,564	1,626	5.4	+4.0	+179.2
Japan	1,064	1,096	1,143	3.8	+4.3	+7.4
Oceania	**283**	**415**	**414**	**1.4**	**−0.2**	**+46.2**
Annex I countries	**13,907**	**12,973**	**13,398**	**44.2**	**+3.3**	**−3.7**
Non-Annex I countries	**6,494**	**14,956**	**15,833**	**52.2**	**+5.9**	**+143.8**
International marine and aviation bunkers[2]	**618**	**1,027**	**1,095**	**3.6**	**+6.6**	**+77.1**
World	**21,019**	**28,955**	**30,326**	**100.0**	**+4.7**	**+44.3**

Source: International Energy Agency, September 2012

1. Emissions from fossil fuel combustion for final use (transport, heating, etc.) or intermediary use (production of electricity, oil refining). These emissions are assessed by the International Energy Agency on the basis of national energy balances. Some differences in perimeters and methods of computation (in particular in emissions factors) with Chapters 2 and 4 are to be noted. Chapters 2 and 4 data are taken from the inventories of GHG emissions transmitted to the United Nations Framework Convention on Climate Change (UNFCCC).
2. International marine and aviation bunkers are excluded from national totals.

> In 2010, energy-related global CO_2 emissions rose sharply (+4.7%), offsetting the 2009 decrease (–1.7%). They culminate now at 30.3 billion tons of CO_2 (Gt CO_2). Trends are contrasted within the EU-27, depending on each country's economic situation. Emissions have dropped in Portugal (–9%), Greece (–7%) and Spain (–5%). However, they have jumped in Estonia (+26%), Sweden (+15%) and Finland (+14%). They also increase rapidly in China (+6.6%). With an emission level of 7.3 Gt CO_2, this country is the biggest emitter ahead of the United States. In 2010, these two countries issued 42% of the CO_2 due to fuel combustion.

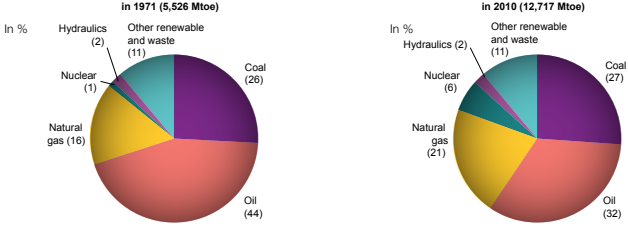
Change in Global CO_2 Emissions Related to Fuel Combustion



Source: International Energy Agency, October 2011

> Fossil fuels (coal, natural gas and oil) account for 81% of the global primary energy mix in 2010 (five points less than in 1971). In the EU-27, this figure drops to 75% and even 50% in France, due to the widespread use of nuclear generation. Worldwide, between 1971 and 2010, the share of oil in the mix fell by twelve points while the shares of both nuclear and gas raised by five points. In 2009, coal, which provided a quarter of the energy mix, was the second energy source after oil. Yet, it was the first CO_2 emitter (43%), because its emission factor is much higher than those of gas and oil (see page 31). The share of renewables in the global primary energy mix has not progressed in forty years.

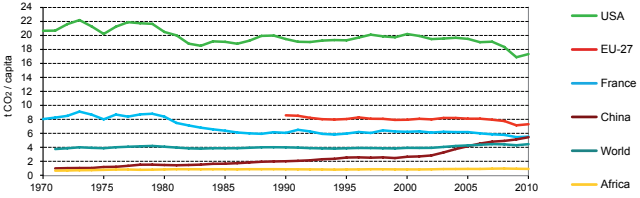
Global primary energy mix



Source: International Energy Agency, October 2012

3.1 Energy-related CO_2 Emissions

Energy-related CO_2 Emissions per Capita Worldwide



Source: International Energy Agency, September 2012

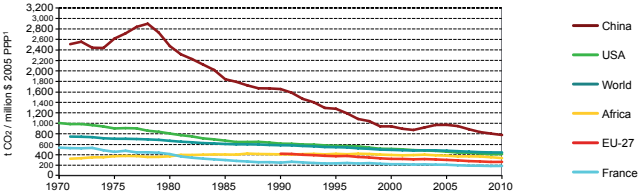
> In 2010, energy-related CO_2 emissions per capita in Annex I countries decreased by −1.9%. In non-Annex I countries, they continued to grow (+4.5%). However, the difference in level of development and a limited access to energy still limit emissions in Africa (0.9 t CO_2/capita). In China, this indicator is now nearly as high as in France (5.5 t CO_2/capita). In 2010, an inhabitant of the EU-27 emits an average of 7.3 t CO_2, 15% less than in 1990. A French emits thrice less CO_2 than an inhabitant of the USA, and much less on average than an inhabitant of the other European countries.

In t CO_2 / capita

	1990	2009	2010	Change (%) 2010/2009	Change (%) 2010/1990
North America	**15.5**	**13.6**	**14.0**	**+2.6**	**−9.9**
of which: Canada	15.6	15.6	15.7	+1.0	+0.6
United States	19.5	16.9	17.3	+2.7	−11.0
Latin America	**1.7**	**2.3**	**2.4**	**+6.2**	**+40.0**
of which: Brazil	1.3	1.7	2.0	+13.7	+53.2
Europe and former USSR	**9.4**	**7.0**	**7.3**	**+3.2**	**−22.6**
of which: EU-27	8.6	7.1	7.3	+2.2	−14.8
EU-15	8.4	7.3	7.5	+1.7	−11.4
of which: Germany	12.0	9.1	9.3	+2.1	−22.2
Spain	5.3	6.1	5.8	−5.3	+10.7
France	**6.1**	**5.4**	**5.5**	**+1.3**	**−8.9**
Italy	7.0	6.5	6.6	+1.8	−6.0
Utd Kingdom	9.6	7.5	7.8	+3.2	−19.0
12 new EU members	9.1	6.4	6.7	+4.5	−26.5
of which: Russia	14.7	10.7	11.2	+4.1	−24.1
Africa	**0.9**	**0.9**	**0.9**	**−2.4**	**+5.9**
Middle-East	**4.5**	**7.5**	**7.6**	**+2.1**	**+69.8**
Far East	**1.7**	**3.1**	**3.3**	**+5.2**	**+98.0**
of which: China	2.0	5.1	5.4	+6.1	+170.9
South Korea	5.3	10.6	11.5	+9.0	+115.4
India	0.7	1.4	1.4	+2.6	+102.5
Japan	8.6	8.6	9.0	+4.4	+4.2
Oceania	**13.8**	**15.7**	**15.4**	**−1.8**	**+11.5**
Annex I countries	**15.1**	**17.3**	**17.0**	**−1.9**	**+12.3**
Non-Annex I countries	**1.6**	**2.7**	**2.9**	**+4.5**	**+80.2**
World	**4.0**	**4.3**	**4.4**	**+3.6**	**+11.4**

Source: International Energy Agency, September 2012

Energy-related CO_2 Emissions in Relation to GDP Worldwide



Source: International Energy Agency, September 2012

> In every world area, the amount of CO_2 released in the creation of one unit of GDP, called the carbon intensity of the economy, has decreased between 1990 and 2010 (–24% worldwide), except in the Middle East (+29%). In China, this ratio has been halved since 1990. Yet, it remains high, as in Russia: in these two countries, one unit of GDP, expressed in $ 2005 PPP1, leads to nearly 800 g of CO_2 emissions, almost twice the global average. In the EU-27, particularly in the former EU-15, this indicator is rather low: 244 g CO_2/$, but 406 in the 12 new EU members. With only 186 g CO_2/$, France is the second best performer of the EU-27, behind Sweden, where both nuclear and hydraulics are very developed.

In t CO_2/million $ 2005 PPP[1]

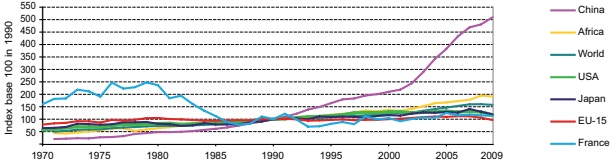
	1990	2009	2010	Change (%) 2010/2009	Change (%) 2010/1990
North America	**583**	**404**	**405**	**+0.2**	**–30.6**
of which: Canada	578	451	446	–1.1	–22.8
United States	611	410	412	+0.5	–32.5
Latin America	**271**	**253**	**256**	**+1.1**	**–5.5**
of which: Brazil	181	185	198	+6.7	+9.3
Europe and former USSR	**598**	**349**	**351**	**+0.7**	**–41.3**
of which: EU-27	420	262	263	+0.4	–37.2
EU-15	359	244	244	+0.1	–32.1
of which: Germany	462	283	279	–1.7	–39.7
Spain	267	227	216	–4.9	–19.1
France	**249**	**185**	**186**	**+0.3**	**–25.3**
Italy	295	242	243	+0.5	–17.5
Utd Kingdom	428	235	239	+1.7	–44.1
12 new EU members	907	399	406	+1.8	–55.3
of which: Russia	1,164	787	787	–0.0	–32.4
Africa	**408**	**352**	**336**	**–4.7**	**–17.6**
Middle-East	**492**	**628**	**635**	**+1.1**	**+29.2**
Far East	**602**	**530**	**521**	**–1.8**	**–13.4**
of which: China	1,653	803	776	–3.3	–53.0
South Korea	490	414	426	+2.9	–13.1
India	551	452	432	–4.5	–21.6
Japan	330	292	293	+0.3	–11.0
Oceania	**578**	**454**	**442**	**–2.6**	**–23.5**
Annex I countries	**550**	**362**	**364**	**+0.3**	**–33.9**
Non-Annex I countries	**596**	**509**	**501**	**–1.6**	**–15.9**
World	**581**	**444**	**443**	**–0.3**	**–23.7**

1. Purchasing power parity.

Source: International Energy Agency, September 2012

3.2 CO_2 Emissions due to Electricity Production

CO_2 Emissions due to Electricity Production[1]



Source: International Energy Agency, October 2011

> In 2009, global CO_2 emissions due to the production of electricity (including CHP plants) amounted to 11.8 billion tons of CO_2 (Gt CO_2). After rising steadily since 1971, these emissions began to shrink in 2008 (–1.7% in 2009). However, they remain almost 60% higher than in 1990. In the EU-27, these emissions reach 1.3 Gt CO_2, which represent a drop of –3% compared to its 1990 level. Germany, where coal accounts for 42% of the electricity mix, is responsible for a quarter of all the CO_2 released by EU-27 power stations. France only for 4%, although its production of electricity and heat makes 15% of European totals.

In Mt CO_2

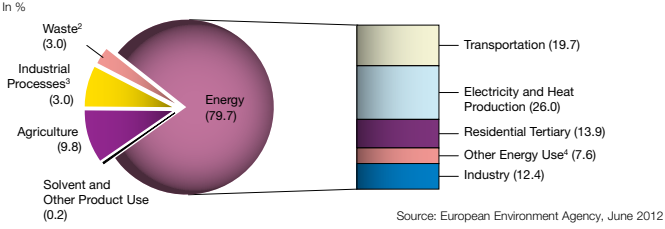
	1990	2008	2009	Share in energy related emissions in 2009 (%)[2]	Change (%) 2009/2008	Change (%) 2009/1990
North America	**2,029**	**2,638**	**2,411**	**38.1**	**–8.6**	**+18.8**
of which: Canada	100	122	102	19.1	–16.2	+2.6
United States	1,866	2,404	2,190	40.8	–8.9	+17.4
Latin America	**98**	**209**	**200**	**17.6**	**–4.6**	**+102.9**
of which: Brazil	12	41	30	7.7	–27.3	+146.5
Europe and former USSR	**3,376**	**2,790**	**2,578**	**39.9**	**–7.6**	**–23.6**
of which: EU-27	1,504	1,427	1,306	35.7	–8.5	–13.2
EU-15	1,014	1,076	980	33.0	–8.9	–3.4
of which: Germany	371	337	309	40.5	–8.5	–16.9
Spain	65	102	87	32.4	–14.4	+34.6
France	**46**	**53**	**52**	**14.6**	**–1.8**	**+13.3**
Italy	122	155	131	32.8	–15.8	+6.8
Utd Kingdom	214	197	175	36.1	–11.5	–18.2
12 new EU members	490	351	326	47.3	–7.2	–33.5
of which: Russia	1,162	874	813	51.4	–7.0	–30.0
Africa	**212**	**414**	**405**	**43.6**	**–2.0**	**+91.2**
Middle-East	**176**	**526**	**551**	**34.1**	**+4.8**	**+213.4**
Far East	**1,486**	**5,227**	**5,452**	**44.2**	**+4.3**	**+266.8**
of which: China	652	3,136	3,324	45.5	+6.0	+409.5
South Korea	55	230	251	44.6	+9.2	+358.1
India	235	805	856	52.6	+6.3	+264.3
Japan	364	474	434	38.0	–8.3	+19.3
Oceania	**130**	**229**	**230**	**55.5**	**+0.2**	**+77.1**
Annex I countries	**5,549**	**5,803**	**5,323**	**39.7**	**–8.3**	**–4.1**
Non-Annex I countries	**1,959**	**6,230**	**6,504**	**41.1**	**+4.4**	**+232.0**
World	**7,508**	**12,033**	**11,827**	**39.0**	**–1.7**	**+57.5**

Source: International Energy Agency, October 2011

1. Includes emissions related to electricity production (including CHP plants) as a main activity, and emissions in autoproducer plants. The latter produce electricity as a complement of another activity, industrial for instance. It should be highlighted that IPCC guidelines recommend to record emissions of autoproducers in the final sector which produced them and not in the electricity production sector. This is a reason why these figures are different from those of page 22.
2. Ratio between emissions due to electricity production (including CHP plants) and energy-related emissions (page 16).

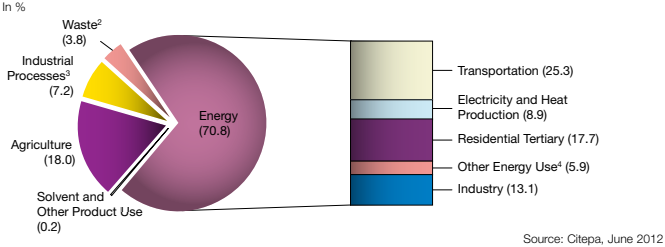
Fuel Combustion: the Largest Emitter of GHG

Distribution by Sources of GHG Emissions in the EU in 2010
(3,721 Mt CO_2e Excluding LULUCF[1])



Source: European Environment Agency, June 2012

Distribution by Sources of GHG Emissions in France in 2010
(522 Mt CO_2e Excluding LULUCF[1] and Including Overseas Departments)



Source: Citepa, June 2012

> Fuel combustion is the main source of GHG emissions: 80% of all emissions in Europe and 71% in France. At the EU level, the main emitter is the sector of heat and electricity production (26% of all emissions), followed by transportation (20%). Conversely, in France, the greatest emitter is transportation (25%), while heat and electricity production is a rather low emitter (9%) because of its primary nuclear production.

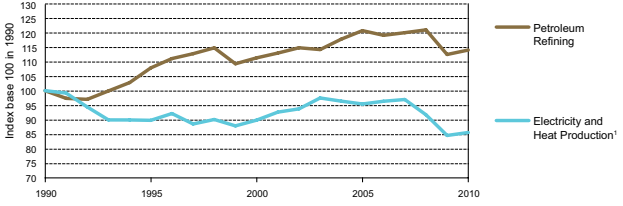
1. Land Use, Land Use Change and Forestry.
2. Excluding the incineration of waste with recuperation of heat (included in «Electricity and Heat Production»). See page 30.
3. Industry excluding fuel combustion. See page 30.
4. Other industries of energy (oil refining, transformation of solid mineral fuels and others), fugitive emissions and combustion of energy in the agriculture/forestry/fishing sector. See page 22.

4.2 GHG Emissions due to Energy Production and Conversion

GHG Emissions due to Energy Production and Conversion in the EU

In Mt CO_2e

	1990	2000	2005	2009	2010	2010/1990 (%)
Electricity and Heat Production[1]	1,436	1,290	1,370	1,214	1,229	−14
Petroleum Refining	118	131	142	132	134	+14
Solid Mineral Fuels[2] Conversion and Others	117	82	75	56	62	−47
Fugitive Emissions from Fuels[3]	152	109	90	77	76	−50
Total	**1,821**	**1,612**	**1,677**	**1,480**	**1,501**	**−18**



Source: European Environment Agency, June 2012

GHG Emissions due to Energy Production and Conversion in France (Including Overseas Departments)

In Mt CO_2e

	1990	2000	2005	2009	2010	2010/1990 (%)
Electricity and Heat Production[1]	47.7	44.7	50.8	44.4	46.3	−3
Petroleum Refining	12.1	13.8	13.6	13.1	12.0	−1
Solid Mineral Fuels[2] Conversion and Others	5.0	4.4	3.8	3.4	3.3	−34
Fugitive Emissions from Fuels[3]	9.6	8.0	5.3	5.0	4.7	−51
Total	**74.4**	**70.8**	**73.6**	**65.9**	**66.2**	**−11**

Source: Citepa, June 2012

1. Includes the incineration of waste with recuperation of heat.
2. Solid mineral fuels (coal and coal products). Emissions mainly linked to the activity of coking plants.
3. Mainly linked to the activities of extraction of fossil fuels (oil, gas and coal).

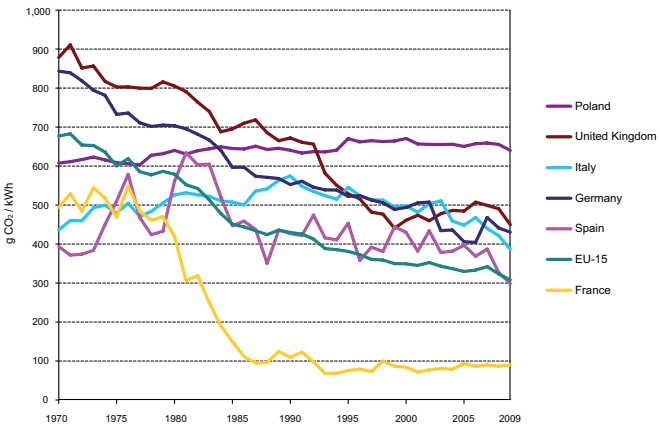
CO_2 Emissions per kWh of Electricity in the EU

In g CO_2/kWh

	1990	2000	2008	2009	Change (%) 2009/2008	Change (%) 2009/1990
EU-27	**n.a.**	**381**	**355**	**339**	**−4.5**	**n.a.**
EU-15	**430**	**349**	**323**	**308**	**−4.8**	**−28.4**
of which: Germany	553	494	441	430	−2.4	−22.1
Austria	245	180	185	163	−11.7	−33.3
Belgium	344	284	249	218	−12.5	−36.7
Spain	427	430	327	299	−8.5	−30.1
Finland	227	211	187	205	+9.8	−9.6
France	**109**	**84**	**87**	**90**	**+3.6**	**−17.7**
Italy	575	498	421	386	−8.3	−32.7
Netherlands	588	400	392	374	−4.5	−36.4
United Kingdom	672	461	490	450	−8.3	−33.1
Sweden	48	42	40	43	+7.7	−10.6
12 new EU members	**nd**	**517**	**506**	**487**	**−3.7**	**n.a.**
of which: Poland	641	671	656	640	−2.3	−0.1
Czech Republic	596	595	537	514	−4.3	−13.7

Source: International Energy Agency, October 2011

> Calculated per kWh, emissions of CO_2 vary widely among EU-27 countries. They are very high (more than 400 g CO_2/kWh) in countries where coal is an important source of energy, for instance in Germany and in some countries from Central and Eastern Europe. They are very weak in countries where renewables and/or nuclear are developed, like in France (nuclear 77%, hydraulics 11%), Sweden (hydraulics 48%, nuclear 38%), and, to a lesser extent, in Belgium (nuclear 52%).



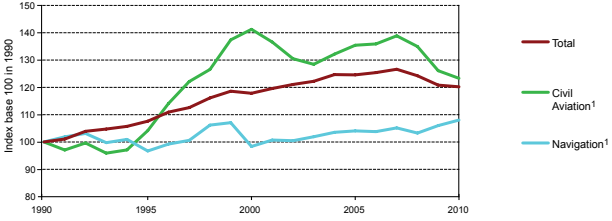
Source: International Energy Agency, October 2011

4.3 Transportation-related GHG Emissions

Transportation-related GHG Emissions in the EU

In Mt CO_2e

Transportation Sector	1990	2000	2005	2009	2010	2010/1990 (%)
Civil Aviation[1]	14	20	19	18	17	+23
Road Transportation	718	856	908	881	877	+22
Railways	14	10	8	7	7	−47
Navigation[1]	18	18	19	19	19	+8
Other	11	10	11	10	10	−11
Total	**775**	**912**	**964**	**935**	**931**	**+20**



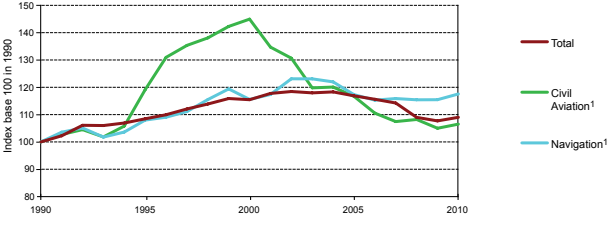
NB: road transportation is not represented on this figure for visibility reasons, since it almost duplicates the total line.
1. Includes domestic transport but excludes international transport.

Source: European Environment Agency, June 2012

Transportation-related GHG Emissions in France (Including Overseas Departments)

In Mt CO_2e

Transportation Sector	1990	2000	2005	2009	2010	2010/1990 (%)
Civil Aviation[1]	4.3	6.2	5.0	4.5	4.6	+7
Road Transportation	114.5	131.2	133.8	123.7	125.3	+9
Railways	1.1	0.8	0.6	0.5	0.5	−55
Navigation[1]	1.1	1.3	1.3	1.3	1.3	+18
Other	0.2	0.5	0.9	0.6	0.6	+152
Total	**121.2**	**140.0**	**141.7**	**130.6**	**132.2**	**+9**



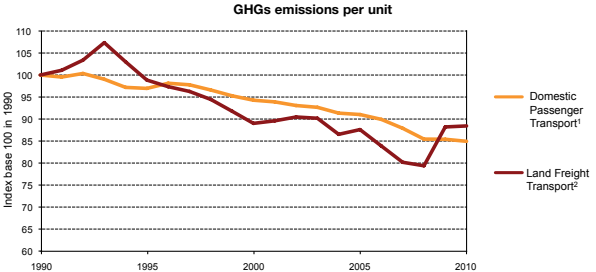
1. Includes domestic transport (and transport between Metropolitan France and Overseas Departments) but excludes international transport.

Source: Citepa, June 2012

GHG Emissions per Passenger-km and Metric ton-km in Metropolitan France

In index base 100 in 1990

	1990	2000	2005	2009	2010
Domestic Passenger Transport[1]	100	94.3	91.1	85.5	85.0
Land Freight Transport[2]	100	89.1	87.7	88.2	88.5

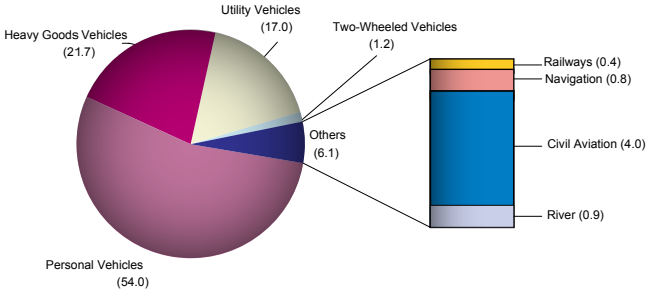


Source: Citepa, April 2012 and SOeS

1. GHG emissions per carried km-passenger.
2. GHG emissions per metric ton-km of freight.

GHG Emissions by Method of Transport[1] in Metropolitan France (133.2 Mt CO_2e in 2010)

In %



Source: Citepa, April 2012

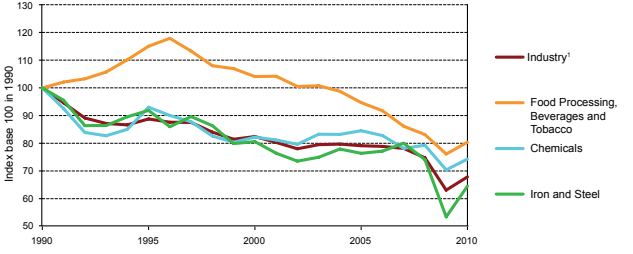
1. Includes domestic transport (excluding transport between Metropolitan France and Overseas Departments) but excludes international transport.

4.4 Industry-related GHG Emissions

GHG Emissions Related to Fuel Use in the Industrial Sector in the EU

In Mt CO_2e

Industrial Sector (includes building and civil engineering but excludes energy)	1990	2000	2005	2009	2010	2010/1990 (%)
Total	**861**	**710**	**682**	**544**	**585**	**−32**
of which: Iron and Steel	190	154	146	102	123	−35
Chemicals	133	109	113	94	99	−26
Food Processing, Beverages and Tobacco	53	55	50	41	43	−20

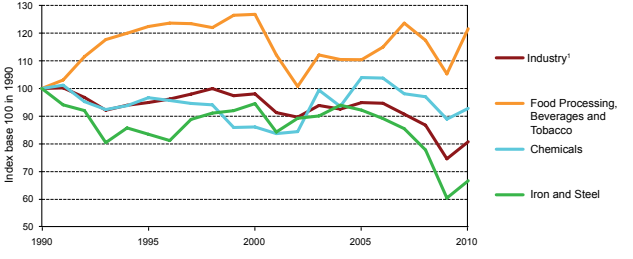


Source: European Environment Agency, June 2012

GHG Emissions Related to Fuel Use in the Industrial Sector in France (Including Overseas Departments)

In Mt CO_2e

Industrial Sector (Includes building and civil engineering but excludes energy)	1990	2000	2005	2009	2010	2010/1990 (%)
Total	**84.9**	**83.2**	**80.5**	**63.2**	**68.4**	**−19**
of which: Iron and Steel	18.6	17.6	17.1	11.2	12.4	−34
Chemicals	21.3	18.3	22.2	18.9	19.8	−7
Food Processing, Beverages and Tobacco	8.4	10.6	9.3	8.8	10.2	+22



1. Includes building and civil engineering but excludes energy.

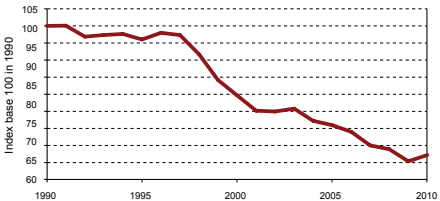
Source: Citepa, June 2012

Intensity of GHG Emissions in the Industrial Sector in France

In index base 100 in 1990

Industrial Sector (includes building and civil engineering but excludes energy)	1990	2000	2005	2009	2010
GHG emissions/value added	100	79.7	71.0	60.4	62.2

GHG emissions per unit of value added

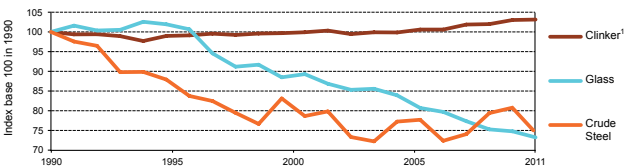


Source: Insee (value added), Citepa (GHG emissions)

Individual GHG Emissions of Selected Energy-Intensive Products in France

		1990	2000	2005	2009	2010	2011	2011/1990 (%)
Crude Steel	Production (Mt)	19.0	21.0	19.5	12.8	15.4	15.8	−17
	t CO_2/t steel	1.78	1.48	1.37	1.41	1.45	1.32	−26
Glass	Production (Mt)	4.8	5.5	5.6	4.5	4.6	5.0	+4
	t CO_2/t glass	0.70	0.62	0.59	0.52	0.52	0.51	−27
Clinker[1]	Production (Mt)	20.9	16.3	17.3	14.6	14.9	15.2	−27
	t CO_2/t clinker	0.87	0.86	0.86	0.88	0.89	0.89	+3

Specific CO_2 emissions



1. Constituent of cement that stems from the cooking of a mix of silica, oxid of iron and lime.

Source: Fédération Française de l'Acier (FFA), Fédération des Chambres Syndicales de l'Industrie du Verre (FCSIV), Syndicat Français de l'Industrie Cimentière (SFIC)

4.5 GHG Emissions in Other Sectors

Energy-related GHG Emissions in Other Sectors[1] in the EU

In Mt CO_2e

	1990	2000	2005	2009	2010	2010/1990 (%)
Total	**846**	**752**	**770**	**702**	**746**	**−12**
of which: Residential	520	479	491	441	476	−8
Tertiary	201	176	183	173	181	−10

Source: European Environment Agency, June 2012

Energy-related GHG Emissions in Other Sectors[1] in France (Including Overseas Departments)

In Mt CO_2e

	1990	2000	2005	2009	2010	2010/1990 (%)
Total	**100.6**	**104.0**	**111.5**	**102.7**	**103.2**	**+3**
of which: Residential	60.6	61.7	68.4	59.9	61.4	+1
Tertiary	29.1	30.7	31.2	31.7	31.1	+7

Source: Citepa, June 2012, and SOeS, according to Météo-France

> Emissions from the residential-tertiary sector depend on climatic conditions. Temperatures were particularly mild in 1994, 2000, 2002 and 2007. Therefore, heating energy consumption and thus GHG emissions were rather low. Conversely, the climate was exceptionaly cold in 1991, 1996 and 2010.

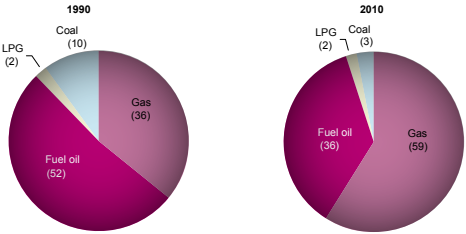
1. Direct emissions of sectors other than energy production and conversion, transportation and industry.

Contribution of each Energy to CO_2 Emissions Related to Heating[1] in Residential and Tertiary Buildings in Metropolitan France

Data corrected for climatic variations, in %

	1990	1995	2000	2005	2009	2010
Gas (excluding LPG)	36	42	47	52	57	59
Fuel Oil	52	48	45	42	38	36
Liquefied Petroleum Gas (LPG)	2	3	3	3	2	2
Coal	10	7	5	3	3	3

In %



Source: SOeS, according to Ceren

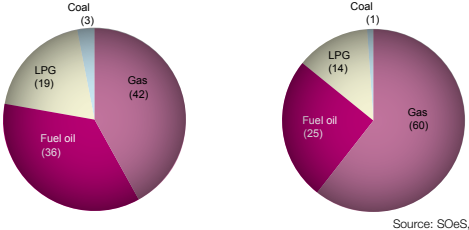
> Between 1990 and 2010, among fossil fuels, coal and fuel oil have been substituted for natural gas in the residential-tertiary sector. That explains the increase in natural gas contribution to CO_2 emissions.

Contribution of each Energy to CO_2 Emissions Related to Water Heating and Cooking[1] in Metropolitan France

In %

	1990	1995	2000	2005	2009	2010
Gas (excluding LPG)	42	48	48	55	60	60
Fuel Oil	36	30	30	27	26	25
Liquefied Petroleum Gas (LPG)	19	19	18	16	14	14
Coal	3	3	4	1	1	1

In %



Source: SOeS, according to Ceren

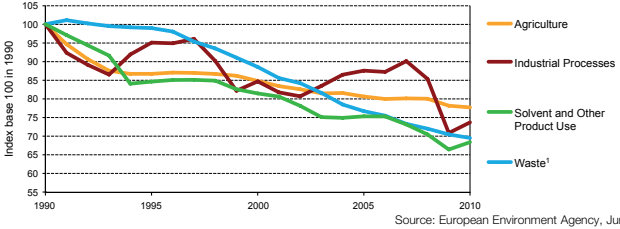
1. Only CO_2 emissions due to fossil fuels combustion are taken into account. Emissions related to electricity consumption are not measured.

4.6 GHG Emissions excluding Fuel Combustion

GHG Emissions Excluding Fuel Combustion in the EU

In Mt CO_2e

	1990	2000	2005	2009	2010	2010/1990 (%)
Total	**1,279**	**1,092**	**1,055**	**949**	**958**	**−25**
Agriculture	594	504	479	464	462	−22
Industrial Processes	465	394	408	330	343	−26
Waste[1]	203	180	156	143	142	−30
Solvent and Other Product Use	17	14	13	11	12	−32

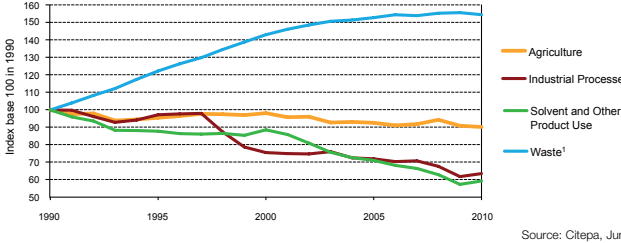


Source: European Environment Agency, June 2012

GHG Emissions Excluding Fuel Combustion in France (Including Overseas Departments)

In Mt CO_2e

	1990	2000	2005	2009	2010	2010/1990 (%)
Total	**177.9**	**166.8**	**159.9**	**152.2**	**152.4**	**−14**
Agriculture	104.0	102.1	96.4	94.6	93.9	−10
Industrial Processes	59.0	44.6	42.5	36.5	37.5	−36
Waste[1]	12.8	18.3	19.5	19.9	19.7	+55
Solvent and Other Product Use	2.1	1.8	1.5	1.2	1.2	−41



Source: Citepa, June 2012

1. Excludes the incineration of waste with recuperation of heat (included in "Electricity and Heat Production").

CO_2 Emissions Factors for Main Fossil Fuels

In t CO_2 / toe

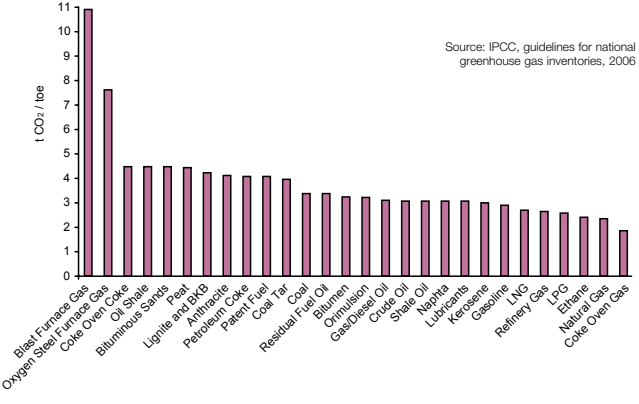
Patent Fuel	4.1	Refinery Gas	2.4
Anthracite	4.1	Natural Gas	2.3
Bitumen	3.4	Gas/Diesel Oil	3.1
Coal (Coking, Sub-bituminous, Other Bituminous)	4.0	Coal Tar	3.4
Coke Oven Coke	4.5	Shale Oil	3.1
Petroleum Coke	4.1	Kerosene	3.0
Gasoline	2.9	Lignite and BKB	4.2
Ethane	2.6	Lubricants	3.1
Residual Fuel Oil	3.2	Naphta	3.1
Liquefied Natural Gaz (LNG)	2.7	Orimulsion	3.2
Coke Oven Gas	1.9	Crude oil and Other	3.1
Oxygen Steel Furnace Gas	7.6	Bituminous Sands	4.5
Blast Furnace Gas	10.9	Oil Shale	4.5
Liquefied Petroleum Gas (LPG)	2.6	Peat	4.4

Source: IPCC, guidelines for national greenhouse gas inventories, 2006

> CO_2 emission factors indicate the average amount of CO_2 emitted during the combustion of given fuel for the production of a single energy unit (in this case, the ton oil equivalent - toe). The factor represents the ratio between the observed CO_2 emissions and the amount of energy used.

> The presented factors represent global averages and could differ from one country to another.

> The exceptional case of biomass fuels is not treated here: CO_2 emissions related to the combustion of biomass fuels are compensated by the absorption of CO_2 during the reconstitution of given fuel. If the reconstitution of the biomass fuel does not occur, the non-compensated emissions are recorded in LULUCF calculations (Land Use, Land Use Change and Forestry).



Source: IPCC, guidelines for national greenhouse gas inventories, 2006

5.1 The International Negotiations

The United Nations Framework Convention on Climate Change (UNFCCC)

> The UNFCCC, adopted in 1992 in Rio de Janeiro, aims at preventing dangerous human effects on the climate. The Treaty recognizes 3 principles:

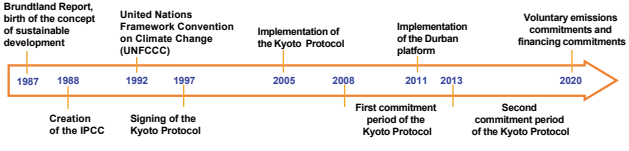
- **The precautionary principle:** lack of scientific certainty over climate change impacts shall not be used as a reason for postponing action.
- **The principle of common, but differentiated, responsibility:** any GHG emission has an impact on global warming but the most industrialized countries carry a greater responsibility for current GHG concentration.
- **The principle of the right to development.**

> Member countries of the UNFCCC meet at the end of each year for the "Conference of the Parties" (COP). During these conferences, major decisions are taken on the UNFCCC. The 18th COP takes place in Doha (Qatar) from 26 November to 7 December 2012.

The latest developments in international negotiations

> The Cancun (2010) and Durban (2011) Agreements established, particularly for post-2012 period:

- an objective of stabilizing the increase of the average temperature at no more than +2°C by the end of the century, as strongly recommended by the IPCC;
- the provision of funds by developed countries for mitigation and adaptation in developing countries. Financing should reach **100 billion US dollars per year by 2020**;
- a **second commitment period** under the Kyoto Protocol from 2013;
- the implementation of the **Durban platform** leading to a post-2020 international agreement by 2015;
- voluntary emissions reduction commitments for 2020 for countries that do not have commitments under the Kyoto Protocol.



Source: CDC Climat Research

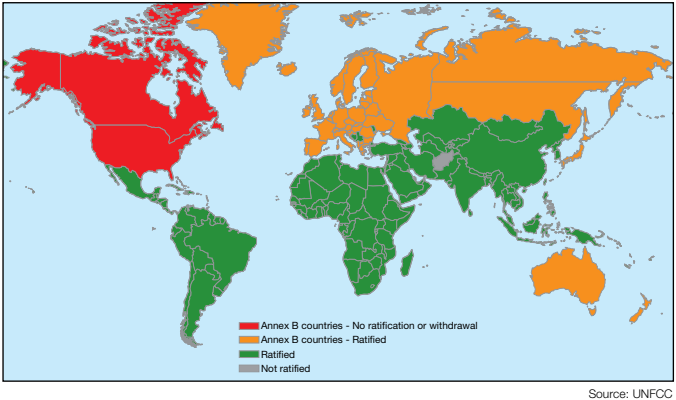
The objectives of the Kyoto protocol

> The emissions of the 40 most industrialized countries (listed in Annex B of the Protocol) are to be reduced by at least **5% between 2008 and 2012** compared to 1990 levels. The target is differentiated by country.
> **Six GHGs induced by human activity** are included: CO_2, CH_4, N_2O, HFC, PFC, SF_6. From 2013, NF_3 is also included.
> Non-Annex B countries have no set objectives.

Implementation of the Protocol

> **Signed in 1997, the Protocol was implemented in 2005**. The requisite quorum of at least 55 countries representing a minimum of 55% of Annex B emissions in 1990 was thus achieved in November of 2004 after the ratification of the Protocol by Russia.
> The United States has not ratified the Protocol and therefore is not subject to the fixed reduction objectives for 2008-2012. In December 2011, Canada withdrew from the Kyoto Protocol. This withdrawal is effective from December 2012. Canada will thus not be obligated to respect its target under the first commitment period of the Kyoto Protocol.
> In Durban, in 2011, member parties agreed on the extension of the Protocol beyond 2012. There will thus be **a second commitment period of the Kyoto Protocol**.

State of Kyoto Protocol ratification as of 30 September 2012



Source: UNFCC

5.3 The Flexibility Mechanisms under the Kyoto Protocol

Kyoto, a Flexible Protocol

> To assist Annex B countries in achieving their emissions reduction objectives, the Protocol includes three mechanisms:

1. An international carbon market for Annex B countries. Each one receives **Assigned Amount Units (AAUs)** equivalent to its GHG emissions objective. Countries can sell AAUs to other countries.

2 & 3. The **Clean Development Mechanism (CDM)** and the **Joint Implementation (JI)** allow countries to fund emissions reduction projects outside of their national territories.

> To **comply**, Annex B countries must submit as many AAUs and carbon credits as their emissions between 2008-2012.

> The UNFCCC Secretariat oversees the functioning of these mechanisms, through the **International Transaction Log (ITL)**.

The Clean Development Mechanism (CDM): The Investment of Annex B Countries in Developing Countries

> An Annex B country, or a project-developer based in an Annex B country, invests in a project reducing GHG emissions **in a non-Annex B country**. A **Certified Emission Reduction (CER)** would be issued for each tonne of GHG emissions avoided, expressed in CO_2 equivalent.

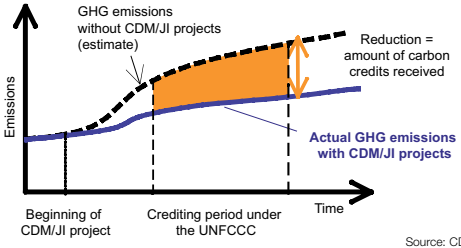
CDM projects must be approved and registered by the UNFCCC Secretariat. Emissions reductions have to be verified by independent consultants.

Joint Implementation (JI): Reduction Projects within Annex B Countries

> JI projects are being funded and hosted by **Annex B countries**. They generate an **Emission Reduction Unit (ERU)** for each tonne of GHG emissions avoided, expressed in CO_2 equivalent.

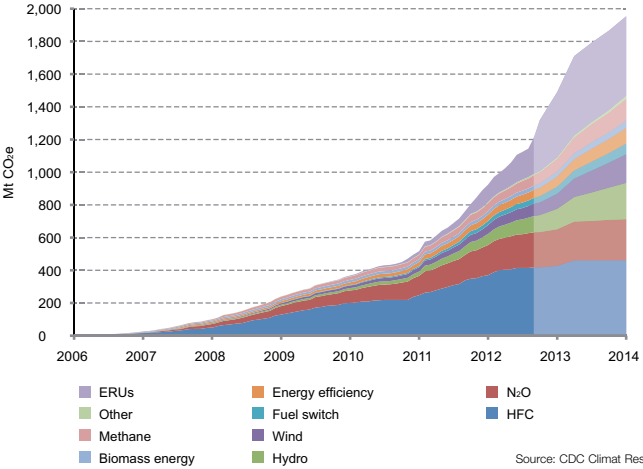
Project Mechanisms of the Kyoto Protocol

Principle of a project mechanism (CDM or JI)



Source: CDC Climat Research

Issuance and forecast issuance of EU ETS-eligible Kyoto offsets



Source: CDC Climat Research

> As of 1st September 2012, the project mechanisms of the Kyoto Protocol had led to the issuance of more than 1.2 billion credits, representing an equivalent amount of avoided tonnes of CO_2e emissions. By the end of 2013, it is expected that this figure will approach two billion.

5.4 The Tradable Permit Market

> The global target of GHG emissions reduction by 5% under the Kyoto Protocol was shared between the Annex B countries according to their economic development and potential to reduce emissions.

> Eastern European countries received more AAUs than their actual emissions to help them "catch up" with the level of development of other Annex B countries. This surplus is often referred to as "hot air."

Country	Kyoto objectives for 2008-2012 (in %)[1]	Yearly average of AAUs received over 2008-2012 (in millions)	Yearly average emissions over 2008-2010 (including credits and debits under LULUCF)		Distance to Kyoto objective (in % points)
			in Mt CO_2e	Evolution (in %)[1]	
EU-15	**−8**	**3,924**	**3,787**	**−11**	**3**
Bulgaria	−8	122	62	−53	45
Czech Republic	−8	179	138	−29	21
Estonia	−8	39	19	−55	47
Hungary	−6	108	67	−42	36
Latvia	−8	24	10	−60	52
Lithuania	−8	45	21	−58	50
Poland	−6	530	382	−32	26
Romania	−8	256	126	−55	47
Slovakia	−8	66	46	−35	27
Slovenia	−8	19	19	−8	0
Australia	8	592	573	5	3
Belarus[2]	−8	128	89	−36	28
Croatia	−5	30	29	−9	4
Iceland	10	4	4	19	−9
Japan	−6	1,186	1,202	−5	−1
Kazakhstan	0	n.p.	255	−29	29
Liechtenstein	−8	0	<1	7	−15
Monaco	−8	0	<1	−15	7
Norway	1	50	52	4	−3
New Zealand	0	62	54	−12	12
Russia	0	3,323	2,059	−38	38
Switzerland	−8	49	53	0	−8
Ukraine	0	921	386	−58	58
Total[3]	**−4**	**11,656**	**9 434**	**−22**	**18**
United States	−7	not participating	6804	10	−17
Canada[4]	−6	558	706	19	−25

n.p. = not published by the UNFCCC yet.
1. Compared to the reference year, generally 1990. 2. AAUs will be received once its inclusion in Annex B is completed.
3. Excluding Kazakhstan for which the AAU allocation has not been published yet. 4. Canada withdrawn from the Kyoto Protocol in 2011.
EU Countries, Non-EU Annex B Countries, Non-ratifying Countries.

Source: UNFCCC, 2012.

> From 2008, Annex B countries can exchange AAUs, on the condition that they possess at any given moment at least 90% of all AAUs allocated, or five times their last GHG emissions inventory.

The Objectives of European Member States

> During the Kyoto Protocol negotiations in 1997, the European Union (EU) was allowed to **share its total objective of – 8% among its 15 member countries**. Since then, the EU has added 12 new members, who, except for Cyprus and Malta, also have Kyoto Protocol commitments.

Country	Kyoto objectives for 2008-2012 (in %)[1]	Yearly average of AAUs received over 2008-2012 (in millions)	Yearly average emissions over 2008-2010 (including credits and debits under LULUCF[2])		Distance to Kyoto objective (in % points)
			in Mt CO_2e	Evolution (in %)[1]	
Austria	–13.0	69	83	4.4	–17.4
Belgium	–7.5	135	132	–9.7	2.2
Denmark	–21.0	55	66	–5.3	–15.7
Finland	0.0	71	70	–1.8	1.8
France	0.0	564	522	–7.5	7.5
Germany	–21.0	974	931	–24.4	3.4
Greece	25.0	134	124	16.0	9.0
Ireland	13.0	63	61	9.2	3.8
Italy	–6.5	483	495	–4.2	–2.3
Luxembourg	–28.0	9	12	–9.3	–18.7
Netherlands	–6.0	200	205	–3.8	-2.2
Portugal	27.0	76	70	17.0	10.0
United Kingdom	–12.5	682	364	25.5	–10.5
Spain	15.0	333	61	–15.4	19.4
Sweden	4.0	75	597	–23.5	11.0

1. Compared to the reference year, usually 1990
2. Land Use, Land Use Change and Forestry.

Source: UNFCCC, 2012

Post-Kyoto European Climate Policy

> The European Council in March 2007 announced its so-called "3x20" climate targets for 2020. These aimed to:

- reach a 20% share of **renewable energy** in energy consumption,
- improve **energy efficiency** by 20%,
- reduce **GHG emissions** by 20% compared to 1990. If a satisfactory international agreement is signed, this objective would increase to **–30%**.

> **The Energy/Climate legislative package of March 2009** establishes specific policies to reach these goals and distributes them to the members states (which may adopt more restrictive emission regulations if they wish).

> A key element of the European climate policy will be the continuation of the **European Union Emissions Trading Scheme (EU ETS)**, introduced in 2005 on the same principles as the international market created by the Kyoto Protocol.

5.6 The European CO_2 Market (EU ETS)

How the EU ETS Works

> Since 2005, the EU ETS sets a cap to the CO_2 emissions of about 11,400 industrial installations. These installations are accountable for nearly 50% of the European Union's CO_2 emissions.

> These industrial installations have to return each year as many allowances (1 allowance for 1 ton of CO_2 emitted) as their verified emissions of the previous year. From 2008, EU ETS installations have also been allowed to use Kyoto offset credits (CERs or ERUs) up to a limit of 13.5% of their allocation on average.

Annual EU ETS calendar

Source: CDC Climat Research

Covered Sectors

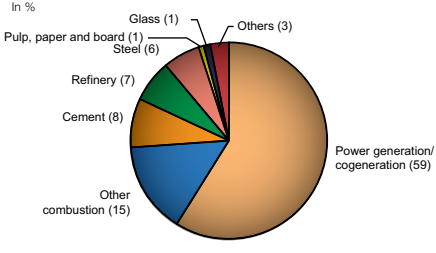
> Currently the EU ETS only covers CO_2 emissions.

> The energy sector (power and heat production, refinery, coke furnaces) is the largest sector in the EU ETS. Electricity producers alone receive approximately **50% of total allocations.**

> The aviation sector has been included in 2012. From 2013 onwards, the emissions of N_2O and SF_6 from the chemical and aluminum sectors are also covered.

> In 2008, **Norway, Iceland** and **Liechtenstein** joined the other 27 European member states in participating in the EU ETS. **Croatia** will join it in 2013.

EU ETS emissions by sector in 2011



Source: CITL, CDC Climat Research

Allowance Allocation

> During the two first periods of the EU ETS – the "trial phase" of 2005-2007, and 2008-2012, which is the Kyoto commitment period – EU ETS-covered installations receive an annual allocation of emissions allowances, generally free of charge, which has been fixed by **National Allocation Plans (NAP)**, established under the supervision of the European Commission.
> In phase 3 (2013-2020), the allocation of allowances will be centralized and determined by the European Commission. The emissions reduction target of the EU ETS sectors has been fixed at –21% for the 2005-2020 period **(–1.74% per year)**.

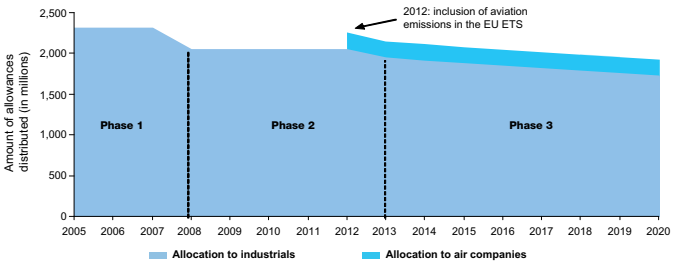
Fewer and Fewer Free Allocations

> The share of auctioned allowances in the allocation **was 0.13 % in phase 1 and 3.6% in phase 2**. In 2013, the share of auctioned allowances will be extended to:

- 100% of the allocation for power generators excluding temporary exemptions for eight countries from Central and Eastern Europe
- 20% of the emissions cap for other sectors, but steadily increasing to 70% in 2020 and 100% in 2027.

> Free allocations are set thanks to benchmarks. Industrial sectors and subsectors that are identified to be exposed to a significant risk of carbon leakage[1] by the European Commissions will receive 100% of free allocation by 2020.
> Ultimately, at least 50% of allowances will be auctioned from 2013 and **up to 75% in 2027**.
> Countries may decide to pool the organization of auctions but the resulting revenue will be managed by each state.

Evolution of total EU ETS allowance allocation



Source: CDC Climat Research, from European Commission data

1. Carbon leakage is defined as relocations in order to avoid carbon regulation.

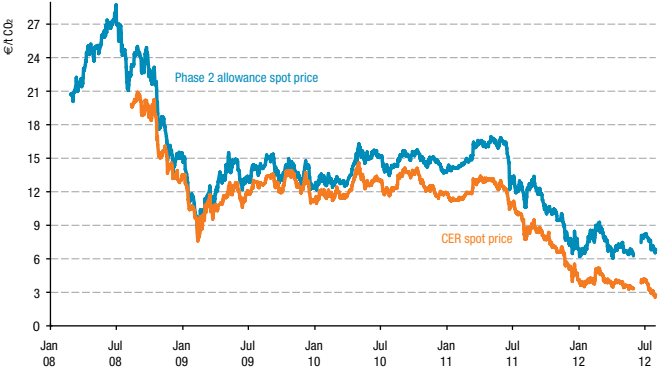
5.7 The Carbon Price in the EU ETS

Trading CO_2 Allowances

> Allowances are tradable: a company emitting more than its allocation can purchase allowances on the market. Conversely, a company which reduces its emissions can sell its unused allowances. The decision depends upon the carbon price on the market. Emissions reductions will therefore occur where they are the least costly.

> CO_2 buyers and sellers exchange either through bilateral contracts – **"over-the-counter" trades** – or through **exchange platforms**, electronic portals which publicly list prices and quantities.

CO_2 Price History



Note: In June 2012, Bluenext was closed for a number of days, accounting for the break in the curve. Source: BlueNext

> **Spot prices** are for immediate delivery of allowances or CERs; **forward prices** represent the current price of allowances or CERs delivered at a later date.

> The allowance price is driven by economic context, energy policies as well as modifications in market regulations.

National Climate Policy: the Case of France

Long Term Targets

> France has one of the lowest GHG emissions, per capita and per GDP unit, amongst the industrialized economies. This is due to the large share of nuclear energy in its electricity generation mix. In line with the IPCC recommendations, France sets a national objective of reducing its GHG emissions by four by 2050 compared to 1990.

> The consultation process set up by the Grenelle de l'Environnement lead to ambitious targets to promote the decarbonization of the French economy. If all of the Grenelle's targets are to be met, the emissions reduction in France would reach 23.4% between 2005 and 2020. It would be –23.6% between 2005 and 2020 for non EU ETS sectors, meaning France would overshoot its –14% target set in the EU's Energy-Climate Package. In 2011, renewable energies represented 13.1% of energy consumption.

Main Policies and Measures in Place

> **Energy sector:**
- Energy saving certificates (ESC) targeting a 345 TWh cumac[1] saving by 2013; as of 31 July 2012, a total of 6,680 decisions were issued to 1,046 beneficiaries for a volume of 301 TWh cumac;
- Implementation of the EU's eco-design, the carbon labeling and the EU ETS Directives;
- Boiler scrapping bonus: 12,000 boilers have been replaced in 2011 saving the equivalent of 80 GWh/year;
- Development of renewable energies.

> **Buildings sector:**
- New 2012 thermal regulation in new buildings, with the expansion of low energy consuming buildings with consumption below 50 kWh/m^2/year on average;
- "Sustainable development" tax credit extended until 2015, Zero Interest Eco-Loans to give private individuals incentives to renovate existing buildings and VAT discount for thermal renovations;
- Upgrading of the most energy-consuming social houses and commitment to upgrade public buildings. The first batch of loans has helped the financing of 100,000 social houses since 2009.

> **Transport sector:**
- Bonus-malus on new vehicles in August 2012 has placed a subsidy on the purchase of vehicles emitting less than 105 gCO_2/km and a tax if the vehicle emits more than 141 gCO_2/km; hybrid vehicles benefit from a special measure;
- Eco-tax per kilometer for heavy trucks by mid-2013;
- Infrastructure development program for low carbon transport; for instance, a target of building 2,000 kilometers of high speed railways by 2020.

1. TWh cumulated and discounted: unit of measure for energy savings induced by a given action. Yearly energy savings are summed up and discounted over the lifespan of the action.

Examples of Emission Factors

Transport

Traveling 1,000 km (approximately round trip Paris-Amsterdam) results in:

> **0.21 tCO_2 by car (french average), 213 gCO_2/km**[1] Increasing the number of passengers proportionately reduces emissions.

> **0.31 tCO_2e in plane** with an aircraft at 75% capacity. The shorter the flight, the more GHGs it emits per kilometer as takeoff and landing are proportionately more intensive in fuel use[1].

> **0.07 tCO_2e by train.** However, rail emissions depends on the energy source. In France, emissions are lower (9 gCO_2/km) as electricity is produced principally from nuclear energy[1].

Electricity Production and Consumption

A standard 250 MW-capacity power plant operating baseload (i.e. 8,000 h/year) releases:

> **1.7 $MtCO_2$/year** for a coal-fired power plant (0.87 tCO_2/MWh, corresponding to a thermal efficiency rate of 40%)[2].

> **0.72 $MtCO_2$/year** for a gas power plant (0.36 tCO_2/MWh, corresponding to a thermal efficiency rate of 55%)[2].

> **1.5 tCO_2/year** are emitted by power consumption of a European household[2], 3 for lighting, heating and electrical appliances consumption in house.

Industry

A typical steelworks producing 1Mt of steel per year emits on average:

> **1.8 $MtCO_2$/year** for a **classical steel chain** (1.8 tCO_2 per ton of steel)[3].

> **0.5 $MtCO_2$/year** for an **electric steel chain** (recast waste) (0.5 tCO_2 per ton of steel corresponding to the indirect emissions due to electricity)[3].

Among other industries that emit CO_2:

> **0.35 $MtCO_2$/year** for a typical cement plant producing 500 000 tons/year (0.7 tCO_2 per ton of cement)[4].

> **0.09 $MtCO_2$/year** for a typical glass plant producing 150 000 tons/year (0.6 tCO_2 per ton of glass)[5].

Forestery and agriculture

> **580 tCO_2e** are issued per hectare of tropical forest from deforestation (burning and decomposition)[6]. Agriculture emits on average in France:

> **3 tCO_2e/year per dairy cow** due to enteric fermentation[7].

> **0.5 tCO_2e/year per pig** due to of its dejections[7].

1. Source: Ademe, Base carbone. 2. Source: AIE. 3. Source: European Commission. 4. Source: Cement Sustainability Initiative. 5. Source: Fédération des chambres syndicales de l'industrie du verre. 6. Source: IPCC. 7. Source: Citepa.

AAU:
Assigned Amount Unit.

Allowance:
Accounting unit for the emissions trading systems. Represents one tonne of CO_2.

Annex I and Annex B Countries:
UNFCCC Annex I countries are the developed countries and those in transition towards a market economy. They make up the majority of the Annex B countries of the Kyoto Protocol who have accepted fixed reduction objectives.
The only deviations are the following: Croatia, Liechtenstein, Monaco and Slovenia are part of the Annex B; Belarus and Turkey are not.

Anthropogenic activities:
Induced by human activities (industry, agriculture, etc.)

CER:
Certified Emission Reductions, tradable carbon credit stemming from emission reductions in CDM projects.

CDM:
Clean Development Mechanism.

CO_2 equivalent:
Method of measuring greenhouse gases based on the global warming potential of each gas relative to that of CO_2.

ERU:
Emission Reduction Unit, tradable carbon credit stemming from emission reductions in JI projects.

Fuel Switch:
Switching from a high-emissions fuel to a lower-emissions fuel.

GDP:
Gross Domestic Product. Measure of the wealth created by a country. This measure in purchasing power parity (ppp) allows for meaningful comparison between countries.

GHG:
Greenhouse gas

International Shipping:
Sector gathering the emissions of international aviation and maritime transport.

IPCC:
Intergovernmental Panel on Climate Change. Research group led by the World Meteorological Organization and by UNEP (United Nations Environment Program), charged with organizing the synthesis of scientific research on climate change.

JI:
Joint Implementation.

LULUCF:
Land Use, Land Use Change and Forestry.

toe:
Ton of oil equivalent. Unit of measure of energy.

UNFCCC:
United Nations Framework Convention on Climate Change.

Units

1T 1 trillion	**1G** 1 billion	**1M** 1 million
1 ppm 1 part per million	**1 ppb** 1 part per billion	**1 ppt** 1 part per trillion

Energy Units

See: “Les chiffres clés de l’énergie édition 2012 - Repères”, published by the SOeS.

Useful Links

Adaptation Portal
National Observatory on the Effects of Global Warming ..... *www.onerc.gouv.fr*

Ademe
French Environment and Energy Management Agency ..... *www.ademe.fr*

CDC Climat Research ..... *www.cdcclimat.com/research*

CITEPA
Centre interprofessionnel technique d'études
de la pollution atmosphérique ..... *www.citepa.org*

Climate Economics Chair
CDC Climat & Paris-Dauphine University ..... *www.climateeconomicschair.org*

Drias les futurs du climat
Météo-France, IPSL, CERFACS ..... *www.drias-climat.fr*

European Commission ..... *http://ec.europa.eu*
CITL - Community International Transaction Log ..... *http://ec.europa.eu/environment/ets*
Directorate General for Climate Action ..... *http//ec.europa.eu/dgs/clima*

EEA
European Environment Agency ..... *www.eea.europa.eu*

IEA
International Energy Agency ..... *www.iea.org*

IPCC
Intergovernmental Panel on Climate Change ..... *www.ipcc.ch*

MEDDE
Ministry of Ecology,
Sustainable Development and Energy ..... *www.developpement-durable.gouv.fr*
Department of the Commissioner General
for Sustainable Development – SOeS ..... *www.statistiques.developpement-durable.gouv.fr*
General Directorate for Energy and Climate ..... *www.developpement-durable.gouv.fr/energie*

NOAA
National Oceanic and Atmospheric Administration ..... *www.noaa.gouv*

Paris-Dauphine University – CGEMP
Center of Geopolitics of Energy and Commodities ..... *www.dauphine.fr/cgemp*

UNEP - Risø ..... *www.uneprisoe.org*

UNFCCC
United Nations Framework Convention on Climate Change ..... *http://unfccc.int*

WRI
World Resources Institute ..... *www.wri.org*

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