Highlights

Key Figures on Climate
France and Worldwide
2012 Edition

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Énergies et climat
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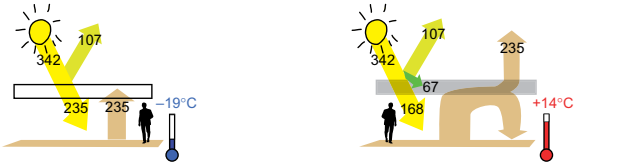
Contents

1.1 – The Greenhouse Effect

The Atmosphere's Role on the Greenhouse Effect

Energy flows, expressed in W/m² with or without greenhouse gases (GHG)

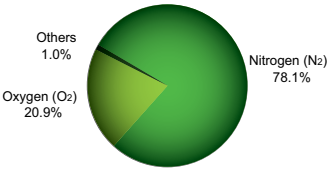


Source: adapted from IPCC, 1st working group, 2007.

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**.

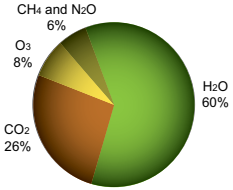
The Atmosphere and Greenhouse Gases

Composition of the dry atmosphere (% of volume excluding H_2O)



Source: IPCC, 1st working group, 2001.

Share of the main greenhouse gases in the reflection of radiation towards the surface (in W/m²)



N.B.: 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, currently plays the largest role in the greenhouse effect.

The rise in the temperature of the Earth's atmosphere over the industrial era corresponds to the **amplification of natural greenhouse phenomena by human activities.**

Characteristics of GHGs Influenced by Human Activity

	CO_2	CH_4	N_2O	HFC	PFC	SF_6
Atmospheric Concentration 2005	379 ppm	1,774 ppb	319 ppb	60.6 ppt	76.9 ppt	5.6 ppt
Lifespan in the Atmosphere	Between 2 years and thousand of years	12 years	114 years	Between 1 and 260 years	About 10,000 years	3,200 years
Global Warning Potenial (total over 100 years)	1	25	298	[124; 14,800]	[7,300; 12,200]	22,800
Sources in Human Activity	Burning of fossil fuels and tropical deforestation	Landfills, agriculture, livestock and industrial processes	Agriculture, industrial processes, use of fertilizer	Aerosols, refrigeration, aluminium smelting		
Change in Radiative Forcing Due to Anthropogenic Emissions since 1750 (W/m^2)	+1.66	+0.48	+0.16	+0.337		

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.

The Global Warming Potential (GWP) of a gas is the ratio between the energy reflected towards the surface over 100 years by 1 kg of this 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 heat the atmosphere equally over the century following their emissions.

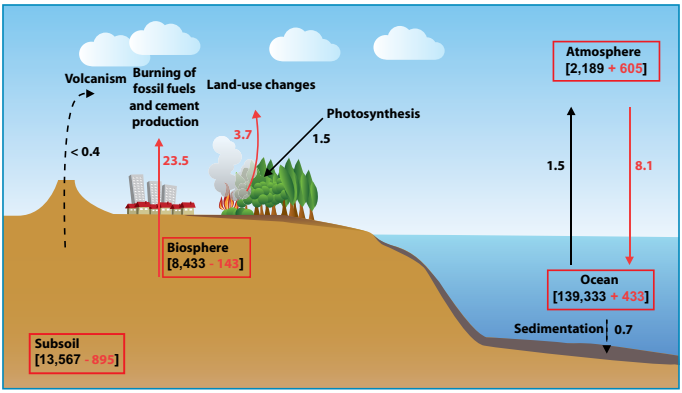
Radiative forcing (in W/m^2) quantifies, in relation to a year of reference (here 1750), the **changes in radiation**, or the energy reflected back towards the surface due to GHGs. A positive value indicates a positive contribution to warming and vice versa.

Although **CO_2** has **the smallest GWP** 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/m^2 since 1750, does not compensate for the positive radiative forcing of the six anthropogenic GHGs which reached +2.64 W/m^2.

1.3 – Stocks and Flows of GHGs: The Example of CO_2

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 allow the storage of carbon in different forms:

- **Atmosphere**: gaseous CO_2
- **Biosphere**: organic material and living things
- **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.

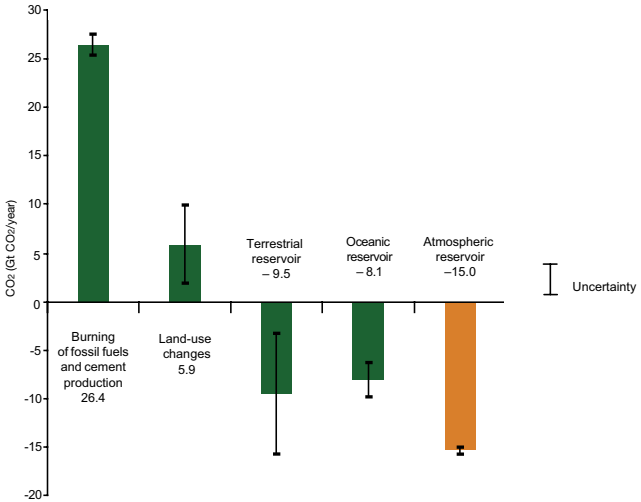
E.g.: the burning of fossil fuels (coal, petroleum…).

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**.

1.4 – Increase in Atmospheric GHG Levels

Imbalance between Emissions and Storage Capacity

Annual change in CO_2 by source, reservoir and the associated uncertainty



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

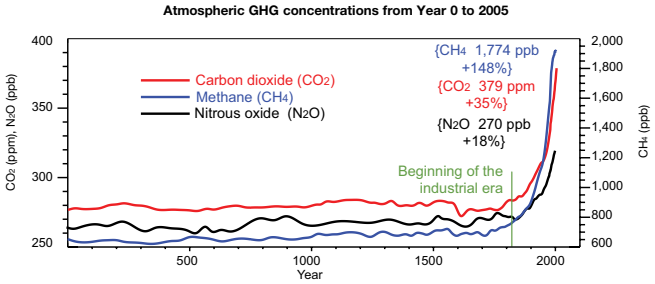
Source: IPCC, 1st working group, 2007.

Since the increase in industrial activities, terrestrial and oceanic reservoirs have absorbed half of the human-related emissions. The excess has been absorbed by the atmosphere, **inducing an increase in the concentration on GHGs**.

Forests are the largest terrestrial carbon reservoir. They store approximately 9.5 Gt CO_2e net emissions per year, equivalent to **30% of global GHG emissions**.

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

Historic Evolution of GHG Concentrations

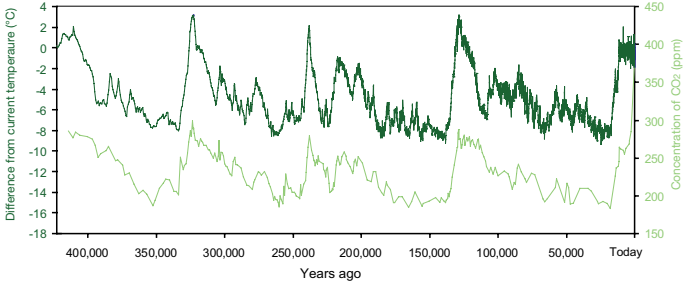


The figures in brackets indicate the atmospheric concentration of GHGs in 2005 and their growth rate between 1750 and 2005.

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 2010, atmospheric CO_2 concentration reached 390 ppm** (Source: NOAA, 2011). **It is 30% higher than the maximum level observed over the 450,000 years of weather records**.

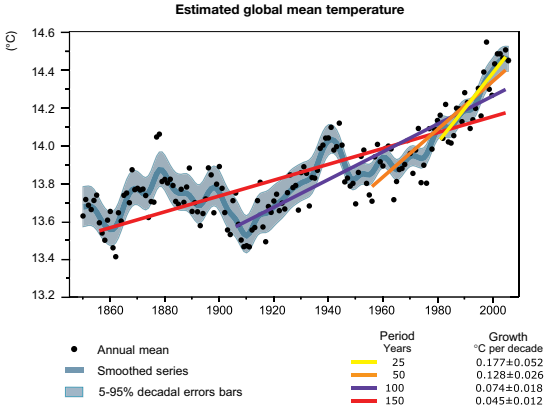
Correlation between temperature and CO_2 concentration in the atmosphere over the last 400,000 years



These results were obtained from the analysis of ice cores sampled at Vostok (Antarctica).
Source: World Data Center for Paleoclimatology, Boulder & NOAA Paleoclimatology Program.

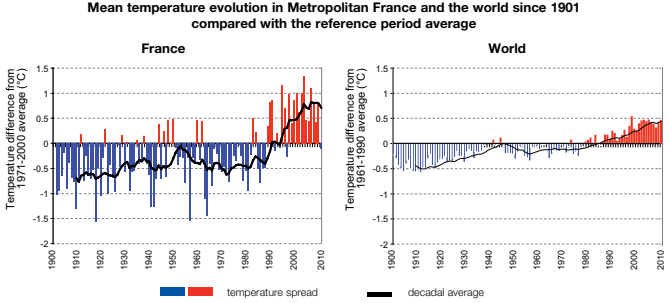
The variations in global temperature and CO_2 concentration are similar. If they are not fully understood, it is estimated that perturbing one of them leads to a perturbation of the other.

Estimated Global Temperature and Growth since 1850



Source: IPCC, 1st working group, 2007.

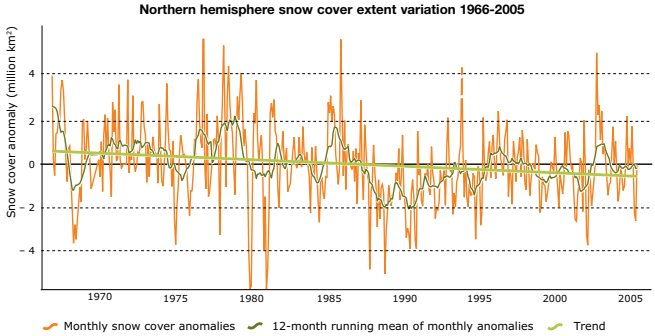
The global average temperature has increased by **+0.74°C over the last century**. Over **the last 25 years**, the growth rate of temperature has been **the highest of the entire century**.



Source: Météo-France, 2011.

In France and in the world, **the temperatures of the last decade have generally been above the average temperature of the reference period**. At the global scale, the last sixteen years (1995-2010) count fifteen of the sixteen warmest years since 1900.

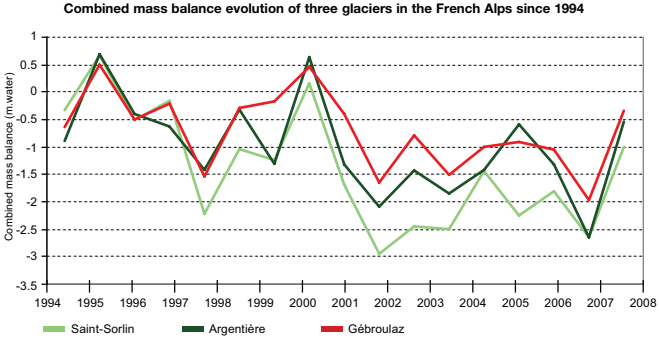
Decrease in Snow Cover



Snow cover anomaly refers to the difference between each monthly value and the annual mean.

Source: European Environment Agency, 2008, from NOAA and UNEP data.

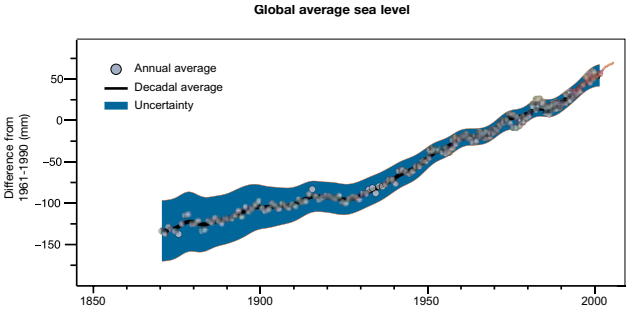
Melting Ice



Source: Laboratoire de glaciologie et de géophysique de l'environnement (LGGE), 2011.

The melting of Alpine glaciers has not been uniform over the period. **The falls in levels** of glacier mass (resulting from decreasing snowfalls in winter and increasing temperatures in summer) have been punctuated with **short phases of growth**.

Continued Increase in Sea Level since the 1870s



Source: IPCC, 1st working group, 2007.

Sea level rise will most likely lead to **migration of populations** living in flooded areas or who have no access to drinking water because of the salinization of essential groundwater resources.

The Various Causes of Increased Sea Level

Increase in sea level (mm/year) and contribution to mesured growth				
Causes	**1961-2003**		**1993-2003**	
Thermal Expansion	0.42 ± 0,12	23%	1.6 ± 0,05	52%
Melting of Glaciers and Polar Ice Caps	0.50 ± 0.18	28%	0.77 ± 0,22	25%
Melting of Glacial Cover of Greenland	0.05 ± 0.12	3%	0.21 ± 0,07	7%
Melting of Glacial Cover in Antarctica	0.14 ± 0.41	8%	0.21 ± 0.35	7%
Sum of contributions	1.1 ± 0.5	61%	2.8 ± 0.7	90%
Measured increase	1.8 ± 0.5	100%	3.1 ± 0.7	100%
Difference	0.7 ± 0.7	29%	0.3 ± 1.0	10%

Source: IPCC, 1st working group, 2007.

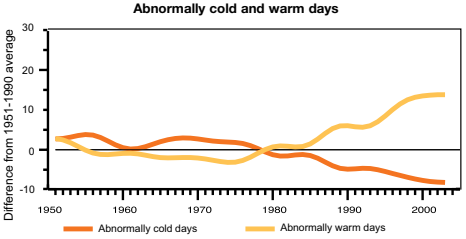
The principal factors of global sea level rise are **thermal expansion** and the **melting of terrestrial ice deposits** (glaciers, polar ice caps, snow cover, permafrost).

1.7 – Warming Differentiated by Latitude

Extreme Weather Events

A weather event is classified as extreme when it substantially exceeds a **base of reference**. Extreme events (tornadoes, hurricanes, as well as heat waves or abnormally heavy rainfall) are always unpredictable; it is **their increase in average frequency of occurrence or average intensity** that indicates climate changes.

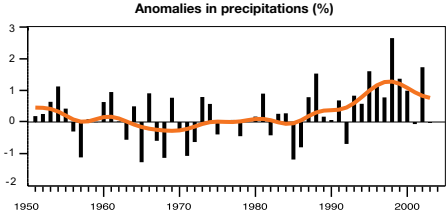
Temperature and Precipitation Extremes



The reference 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.

A day is considered abnormally cold (or warm) when the observed temperature is below (or above) the limit of 90% of the coldest (or hottest) temperatures recorded between 1951 and 1990.



The indicator used is the portion of rainfall abnormally high in terms of yearly precipitation. The black bars show the difference, in %, between this portion and the mean observed between 1951 and 1990. The orange curve shows the variations per decade. All regions worldwide are not included due to insufficient data.

Source: IPCC, 1st working group, 2007.

Projected Increase in Global Temperature

The expected increase in temperature varies according to latitude. The warming will be less in the tropics than at the poles and stronger in coastal regions than in inland.

With reasonable hypothetical conditions (continued levels of observed economic and demographic development and balance between fossil and renewable energy sources), the **increases in annual temperatures by the end of the century** are estimated as follows:

+3.5°C in Southern Europe
+2.5°C in Southeast Asia
+4.9°C in the Arctic (North Pole)
+3.2°C in Central America
+2.6°C in Southern Australia
+3.3°C in West Africa

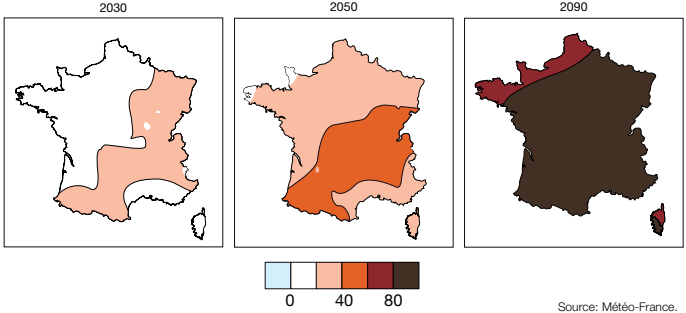
For a **global increase of +2.8°C** compared to the 1980-1999 period.

The regional temperatures' evolution is the median of all models' predictions under the A1B scenario of the IPCC.
The increase in global temperature is the mean of the models' predictions under the same scenario.

Source: IPCC, 1st working group, 2007.

Consequences for France

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

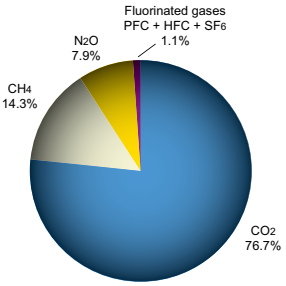


Source: Météo-France.

2.1 – Snapshot of Global Greenhouse Gas Emissions

Global GHGs by Type of Gas

Global GHG emissions by gas in 2004 (including LULUCF[1])



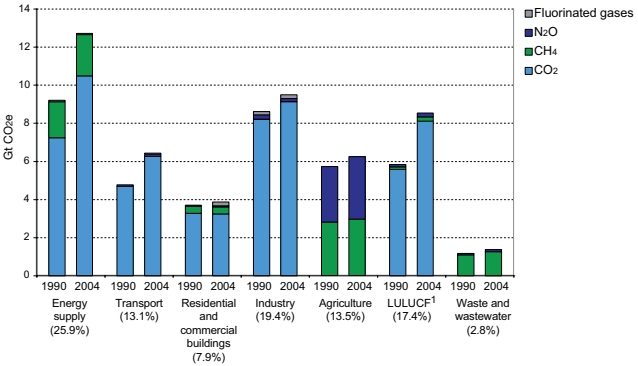
Source: IPCC, 3rd working group, 2007.

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 Gt CO_2e in 2004**.

1) Land Use, Land Use Change and Forestry (LULUCF).
2) Carbone dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulfur hexafluoride (SF_6)

Global GHG Emissions by Sector

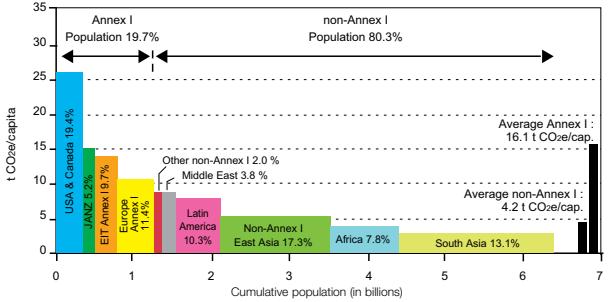
Evolution of global GHG emissions by sector between 1990 and 2004



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

Source: IPCC, 1st working group, 2007.

Regional Distribution of GHG Emissions[1] per Capita

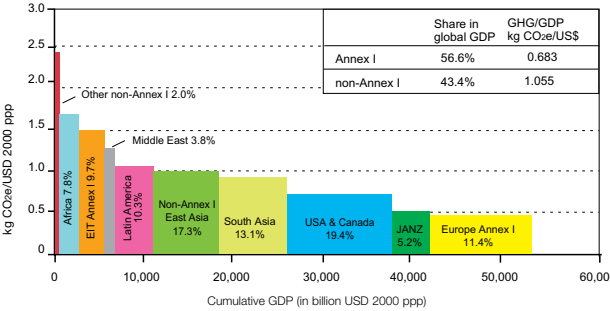


The percentage indicated for each region corresponds to its share in global GHG emissions.
EIT : Economies in Transition, JANZ: Japan, Australia, New Zealand.

Source: IPCC, 1st working group, 2007.

In 2004, Annex I countries of the UNFCCC[2] represented 20% of the world population, 57% of global GDP and produced 46% of all 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



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

Source: IPCC, 1st working group, 2007.

Measured in USD 2000, according to purchasing power parity (ppp), **the production of one unit of GDP in the Annex I countries resulted on average in GHG emissions 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.

2009 GHG Emissions in EU-27

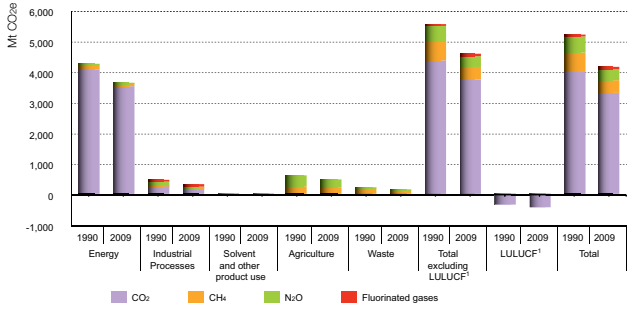
Unit: Mt CO_2e

Sector	Years	CO_2	CH_4	N_2O	Fluorinated gases	Total
Energy	1990	4,091.6	158.4	33.9	-	4,283.9
	2009	3,546.1	80.3	33.4	-	3,659.8
Industrial processes	1990	287.7	1.5	115.0	59.1	463.2
	2009	208.6	1.1	29.7	81.4	320.8
Solvent and other product use	1990	11.7	-	5.3	-	17.0
	2009	7.1	-	4.4	-	11.4
Agriculture	1990	-	249.1	361.4	-	610.5
	2009	-	202.7	273.3	-	476.0
Waste	1990	4.7	196.8	12.7	-	214.3
	2009	3.2	129.2	14.1	-	146.5
Total excluding LULUCF[1]	**1990**	**4,395.7**	**605.8**	**528.3**	**59.1**	**5,588.8**
	2009	**3,765.0**	**413.3**	**354.9**	**81.4**	**4,614.5**
LULUCF[1]	1990	–352.8	4.0	4.2	-	–344.6
	2009	–440.0	4.5	3.4	-	–432.1
Total	**1990**	**4,042.9**	**609.7**	**532.5**	**59.1**	**5,244.2**
	2009	**3,325.0**	**417.8**	**358.2**	**81.4**	**4,182.4**

Source: European Environment Agency, 2011.

European GHG emissions excluding LULUCF[1] decreased by 17% over the 1990-2009 period. They dropped by nearly 6 points between 2008 and 2009, partly as a consequence of the economic crisis.
Emission reductions reached 15% in the energy sector, 31% in the industrial processes sector, 22% in agriculture and 32% in waste treatment. **The net carbon sequestration in the agro-forestry sector has increased over the same period by 25%.**

GHG emissions by sector in EU-27



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

Source: European Environment Agency, 2011.

2009 GHG Emissions in France

Unit: Mt CO_2e

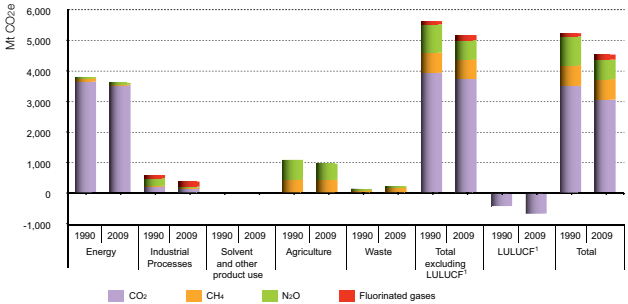
Sector	Years	CO_2	CH_4	N_2O	Fluorinated gases	Total
Energy	1990	365.5	10.5	3.7	-	379.8
	2009	353.3	2.9	4.4	-	360.7
Industrial processes	1990	24.3	0.2	24.6	10.0	59.1
	2009	17.3	0.1	3.9	16.4	37.6
Solvent and other product use	1990	2.0	-	0.1	-	2.1
	2009	1.1	-	0.1	-	1.2
Agriculture	1990	-	45.9	62.8	-	108.7
	2009	-	43.4	52.4	-	95.8
Waste	1990	1.7	9.9	1.6	-	13.2
	2009	1.8	18.6	1.6	-	22.0
Total excluding LULUCF[1]	**1990**	**393.6**	**66.5**	**92.7**	**10.0**	**562.9**
	2009	**373.5**	**65.0**	**62.4**	**16.4**	**517.2**
LULUCF[1]	1990	–42.6	1.2	1.7	-	–39.7
	2009	–67.1	1.7	1.5	-	–63.9
Total	**1990**	**351.1**	**67.7**	**94.4**	**10.0**	**523.2**
	2009	**306.3**	**66.7**	**63.9**	**16.4**	**453.3**

Source: European Environment Agency, 2011.

French GHG emissions excluding LULUCF[1] decreased by 6.4% between 1990 and 2009.

Emission reductions were 5% in the energy sector, 36% in industrial processes and 12% in agriculture. Emissions increased by 66% in the waste treatment sector. **The net increase in the agro-forestry carbon stock is 61% over the same period.**

GHG emissions by sector in France

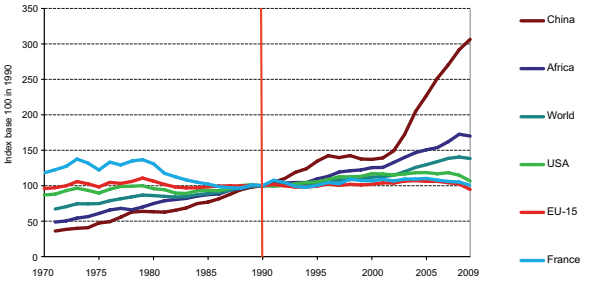


1. Land Use, Land Use Change and Forestry (LULUCF).

Source: European Environment Agency, 2011.

3.1 – Energy-related CO_2 Emissions

Energy-related CO_2 Emissions Worldwide[1]



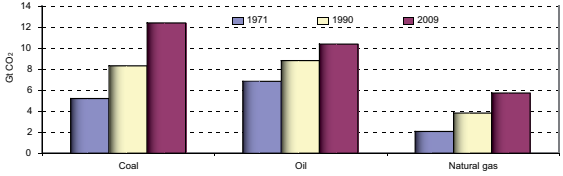
In Mt CO_2	1990	2008	2009	Share (%) in 2009	Change (%) 2008-2009	Change (%) 1990-2009
North America	**5,566**	**6,542**	**6,115**	**21.1**	**–6.5**	**+9.9**
of which: Canada	432	551	521	1.8	–5.5	+20.4
USA	4,869	5,587	5,195	17.9	–7.0	+6.7
Latin America	**610**	**1,062**	**1,039**	**3.6**	**–2.2**	**+70.5**
of which: Brazil	194	361	338	1.2	–6.6	+73.9
Europe and former USSR	**7,948**	**6,720**	**6,263**	**21.6**	**–6.8**	**–21.2**
of which: EU-27	4,052	3,868	3,577	12.3	–7.5	–11.7
EU-15	3,083	3,156	2,919	10.1	–7.5	–5.3
of which: Germany	950	804	750	2.6	–6.7	–21.1
Spain	206	318	283	1.0	–10.8	+37.7
France	**352**	**371**	**354**	**1.2**	**–4.4**	**+0.6**
Italy	397	435	389	1.3	–10.5	–2.0
United Kingdom	549	512	466	1.6	–9.0	–15.2
12 new EU members	969	713	657	2.3	–7.7	–32.2
of which: Russia	2,179	1,593	1,533	5.3	–3.8	–29.7
Africa	**545**	**941**	**928**	**3.2**	**–1.5**	**+70.1**
Middle-East	**590**	**1,523**	**1,574**	**5.4**	**+3.4**	**+166.7**
Far East	**4,811**	**11,192**	**11,639**	**40.1**	**+4.0**	**+141.9**
of which: China	2,244	6,549	6,877	23.7	+5.0	+206.5
South Korea	229	502	515	1.8	+2.7	+124.8
India	582	1,431	1,586	5.5	+10.8	+172.3
Japan	1,064	1,153	1,093	3.8	–5.2	+2.7
Oceania	**283**	**427**	**426**	**1.5**	**–0.1**	**+50.4**
Annex I countries	**13,908**	**13,913**	**13,012**	**44.9**	**–6.5**	**–6.4**
Non-Annex I countries	**6,444**	**14,493**	**14,972**	**51.6**	**+3.3**	**+132.3**
International marine and aviation bunkers[2]	**614**	**1,048**	**1,016**	**3.5**	**–3.1**	**+65.5**
World	**20,966**	**29,454**	**28,999**	**100.0**	**–1.5**	**+38.3**

Source: International Energy Agency, September 2011.

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 perimeter and methods of computation (in particular in emissions factors) with Chapter 4 are to be noted. Chapter 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 2009, energy-related global CO_2 emissions decreased by –1.5% due to the economic crisis. These emissions amounted to 29 billion tons of CO_2 (Gt CO_2). The drop affects all EU-27 countries (–7.5% on average), former EU-15 emissions being now lower than their 1990 level. However, emissions in certain countries continue to grow, such as in China (+5.0%). With an emission level close to 7 Gt CO_2, China is the biggest emitter ahead of the United States. In 2009, these two countries alone contributed to over 41% of global emissions of CO_2 from fuel combustion.

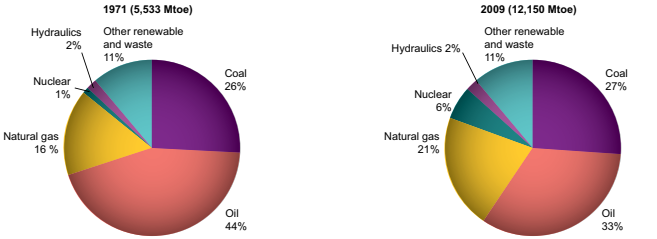
Change in Global CO_2 Emissions Related to Fuel Combustion



Source: International Energy Agency, October 2011.

Fossil fuels (coal, natural gas and oil) **account for 81% of the global primary energy mix in 2009** (five points less than in 1971). In the EU-27, this figure drops to 76% and even 51% in France, due to the widespread use of nuclear generation. Worldwide, between 1971 and 2009, the share of oil in the mix fell eleven points while the shares of both nuclear and gas raised by five points. Coal provides a quarter of the energy mix (stable). It is the second energy source after oil, but the biggest contributor to CO_2 emissions (43%), due to its high emission factor (see page 31).

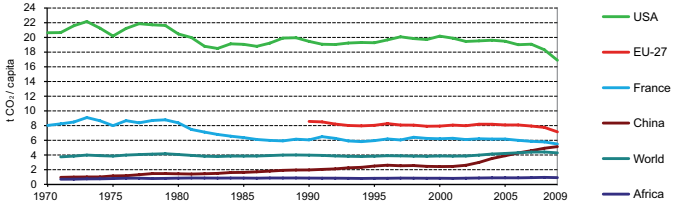
Global primary energy mix



Source: International Energy Agency, October 2011.

3.1 – Energy-related CO_2 Emissions

Energy-related CO_2 Emissions per Capita Worldwide



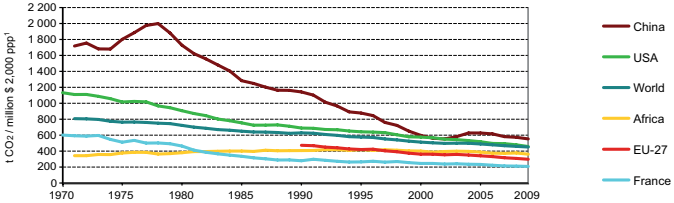
Source: International Energy Agency, September 2011.

In 2009, CO_2 emissions per capita in Annex I countries shrank by –6.9%. In non-Annex I countries, they continued to grow (+2.0%) despite a significant slowdown. The difference in level of development and a limited access to energy still limit emissions in Africa (0.9 t CO_2 / capita). In 2009, an inhabitant of the EU-27 emmited an average of 7.1 t CO_2, 17% less than in 1990. A French emits thrice less CO_2 than an inhabitant of the USA, but much less on average than an inhabitant of the other European countries.

In t CO_2 / capita	1990	2008	2009	Change (%) 2008-2009	Change (%) 1990-2009
North America	**15.5**	**14.7**	**13.6**	**–7.3**	**–12.1**
of which: Canada	15.6	16.5	15.4	–6.7	–1.2
USA	19.5	18.3	16.9	–7.8	–13.2
Latin America	**1.7**	**2.3**	**2.2**	**–3.3**	**+29.3**
of which: Brazil	1.3	1.9	1.7	–7.4	+34.2
Europe and former USSR	**9.4**	**7.6**	**7.1**	**–7.1**	**–24.8**
of which: EU-27	8.6	7.8	7.1	–7.8	–16.6
EU-15	8.4	8.0	7.4	–7.9	–12.7
of which: Germany	12.0	9.8	9.2	–6.4	–23.5
Spain	5.3	7.0	6.2	–11.4	+16.9
France	**6.1**	**5.8**	**5.5**	**–4.9**	**–9.3**
Italy	7.0	7.3	6.5	–11.1	–7.7
United Kingdom	9.6	8.3	7.5	–9.6	–21.4
12 new EU members	9.1	6.9	6.4	–7.8	–29.9
of which: Russia	14.8	11.2	10.8	–3.7	–26.8
Africa	**0.9**	**1.0**	**0.9**	**–3.7**	**+7.4**
Middle-East	**4.5**	**7.7**	**7.8**	**+1.2**	**+73.6**
Far East	**1.6**	**3.0**	**3.1**	**+3.0**	**+89.8**
of which: China	2.0	4.9	5.1	+4.5	+161.2
South Korea	5.3	10.3	10.6	+2.5	+97.7
India	0.7	1.3	1.4	+9.3	+100.2
Japan	8.6	9.0	8.6	–5.0	–0.3
Oceania	**13.8**	**16.5**	**16.1**	**–2.1**	**+16.9**
Annex I countries	**11.8**	**10.9**	**10.2**	**–6.9**	**–14.2**
Non-Annex I countries	**1.6**	**2.7**	**2.7**	**+2.0**	**+73.5**
World	**4.0**	**4.4**	**4.3**	**–2.7**	**+7.8**

Source: International Energy Agency, September 2011.

Energy-related CO_2 Emissions in Relation to GDP Worldwide



Source: International Energy Agency, September 2011.

In every region, the amount of CO_2 released in the creation of one unit of GDP, called the carbon intensity of the economy, **has decreased since 1990 (–28% worldwide)**, except in the Middle East (+26%). In China, this ratio has been halved since 1990. It remains high in Russia: one unit of GDP, expressed in $ ppp[1], leads to one kg of CO_2 emissions. In the EU-27, particularly in the former EU-15, this indicator is rather low: 0.28 kg CO_2 / $, but 0.45 in the new EU members. With only 0.21 kg CO_2 / $, France shows the second best performance of the EU-27, behind Sweden, where both nuclear and hydraulics are very developed.

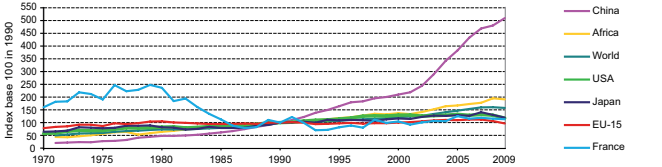
In t CO_2 / million $ 2000 ppp[1]	1990	2008	2009	Change (%) 2008-2009	Change (%) 1990-2009
North America	**661**	**470**	**453**	**–3.7**	**–31.5**
of which: Canada	660	526	510	–3.1	–22.7
USA	689	479	457	–4.5	–33.6
Latin America	**287**	**268**	**262**	**–2.2**	**–8.5**
of which: Brazil	201	218	204	–6.4	+1.9
Europe and former USSR	**681**	**408**	**398**	**–2.2**	**–41.5**
of which: EU-27	473	309	298	–3.5	–37.0
EU-15	404	286	277	–3.4	–31.6
of which: Germany	549	342	334	–2.1	–39.1
Spain	316	290	269	–7.3	–15.0
France	**279**	**212**	**208**	**–1.8**	**–25.4**
Italy	319	280	264	–5.6	–17.3
United Kingdom	460	280	267	–4.4	–41.8
12 new EU members	1,033	472	453	–4.0	–56.2
of which: Russia	1,467	959	1,002	+4.4	–31.7
Africa	**407**	**376**	**362**	**–4.0**	**–11.1**
Middle-East	**4,5**	**7,7**	**7,8**	**+1.2**	**+73.6**
Far East	**562**	**451**	**447**	**–0.9**	**–20.5**
of which: China	1,142	573	553	–3.5	–51.6
South Korea	534	441	452	+2.5	–15.4
India	412	337	347	+2.9	–15.8
Japan	368	322	322	+0.0	–12.5
Oceania	**643**	**535**	**528**	**–1.3**	**–17.8**
Annex I countries	**621**	**421**	**409**	**–2.7**	**–34.1**
Non-Annex I countries	**589**	**467**	**461**	**–1.2**	**–21.6**
World	**629**	**460**	**451**	**–1.8**	**–28.2**

1. Purchasing power parity.

Source: International Energy Agency, September 2011.

3.2 – CO_2 Emissions due to Electricity Production

CO_2 Emissions due to Electricity Production
(Including CHP plants)[1]



Source: International Energy Agency, October 2011.

In 2009, global CO_2 emissions from the production of electricity (including CHP plants) **amounted to 11.8 billion tons of CO_2** (Gt CO_2). After rising steadily since 1971 and a stagnation in 2007, emissions fell by –1.7% in 2009. In 2009, emissions are almost 60% higher than in 1990. China is responsible for 62% of this increase with its emissions having grown fivefold. In the EU-27, these emissions reached 1.3 Gt CO_2, a drop of –3% compared to 1990 level. Germany, where coal represents 42% of the electricity mix, is responsible for a quarter of all CO_2 released by EU-27 power stations; France, only 4%, although its production of electricity and heat accounts for 15% of European totals.

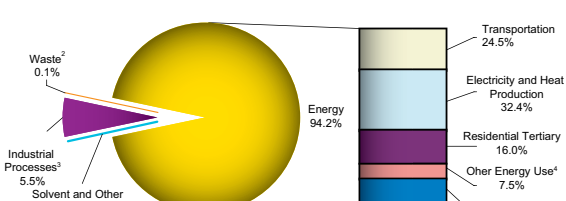
In Mt CO_2	1990	2008	2009	Share in emissions linked to energy in 2009 (%)[2]	Change (%) 2008-2009	Change (%) 1990-2009
North America	**2,029**	**2,638**	**2,411**	**39.4**	**–8.6**	**+18.8**
of which: Canada	100	122	102	19.6	–16.2	+2.6
USA	1,866	2,404	2,190	42.2	–8.9	+17.4
Latin America	**98**	**209**	**200**	**19.2**	**–4.6**	**+102.9**
of which: Brazil	12	41	30	8.9	–27.3	+146.5
Europe and former USSR	**3,376**	**2,790**	**2,578**	**41.2**	**–7.6**	**–23.6**
of which: EU-27	1,504	1,427	1,306	36.5	–8.5	–13.2
EU-15	1,014	1,076	980	33.6	–8.9	–3.4
of which: Germany	371	337	309	41.2	–8.5	–16.9
Spain	65	102	87	30.7	–14.4	+34.6
France	**46**	**53**	**52**	**14.8**	**–1.8**	**+13.3**
Italy	122	155	131	33.6	–15.8	+6.8
United Kingdom	214	197	175	37.5	–11.5	–18.2
12 new EU members	490	351	326	49.5	–7.2	–33.5
of which: Russia	1,162	874	813	53.0	–7.0	–30.0
Africa	**212**	**414**	**405**	**43.7**	**–2.0**	**+91.2**
Middle-East	**176**	**526**	**551**	**36.5**	**+4.8**	**+213.4**
Far East	**1,486**	**5,227**	**5,452**	**46.8**	**+4.3**	**+266.8**
of which: China	652	3,136	3,324	48.3	+6.0	+409.5
South Korea	55	230	251	48.7	+9.2	+358.1
India	235	805	856	54.0	+6.3	+264.3
Japan	364	474	434	39.8	–8.3	+19.3
Oceania	**130**	**229**	**230**	**53.9**	**+0.2**	**+77.1**
Annex I countries	**5,549**	**5,803**	**5,323**	**40.9**	**–8.3**	**–4.1**
Non-Annex I countries	**1,959**	**6,230**	**6,504**	**43.4**	**+4.4**	**+232.0**
World	**7,508**	**12,033**	**11,827**	**40.8**	**–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-based emissions (page 16).

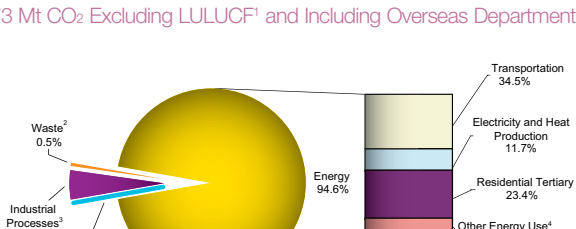
4.1 – Fuel Combustion: the Largest Emitter of CO_2

Distribution by Sources of CO_2 Emissions in the EU in 2009
(3,765 Mt CO_2 Excluding LULUCF[1])



Source: European Environment Agency, June 2011.

Distribution by Sources of CO_2 Emissions in France in 2009
(373 Mt CO_2 Excluding LULUCF[1] and Including Overseas Departments)



Source: European Environment Agency according to CITEPA, June 2011.

Fuel combustion is the main source of CO_2 emissions: 94% of all emissions in Europe and 95% in France. At the EU level, the main contributor is heat and electricity production (32% of all emissions), followed by transportation (25%). Conversely, in France, the biggest emitter is transportation (35%), while heat and electricity production is a rather low emitter (12%) because of its primary nuclear production.

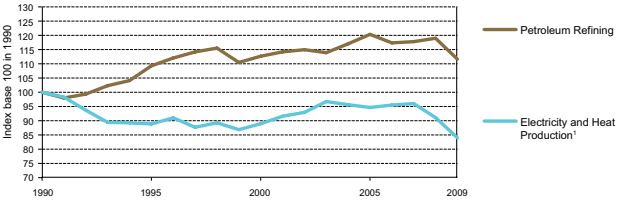
1. Land Use, Land Use Change and Forestry.
2. Excluding the incineration of waste with recuperation of heat (included in «Electricity and Heat Production»). See page 30.
3. Industry excluding fuel combustion. See page 30.
4. Other industries of energy (oil refining, transformation of solid mineral fuels and others), fugitive emissions and combustion of energy in the agriculture/forestry/fishing sector. See page 22 for the two first sources of emission and page 28 for the third one.

4.2 – CO_2 Emissions due to Energy Production and Conversion

CO_2 Emissions due to Energy Production and Conversion in the EU

Unit: Mt CO_2

	1990	2000	2005	2008	2009	1990/2009
Electricity and Heat Production[1]	1,451	1,290	1,373	1,321	1,218	–16%
Petroleum Refining	114	128	137	135	127	+12%
Solid Mineral Fuels[2] Conversion and Others	112	77	69	65	54	–52%
Fugitive Emissions from Fuels[3]	21	20	20	20	19	–8%
Total	**1,697**	**1,516**	**1,599**	**1,541**	**1,418**	**–16%**

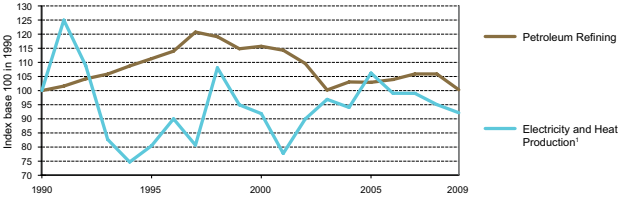


Source: European Environment Agency, June 2011.

CO_2 Emissions due to Energy Production and Conversion in **France** (Including Overseas Departments)

Unit: Mt CO_2

	1990	2000	2005	2008	2009	1990/2009
Electricity and Heat Production[1]	47.2	43.4	50.2	44.9	43.5	–8%
Petroleum Refining	12.9	15.0	13.3	13.7	13.0	+0%
Solid Mineral Fuels[2] Conversion and Others	4.8	4.3	3.8	3.6	3.3	–31%
Fugitive Emissions from Fuels[3]	4.5	4.4	4.0	4.2	3.9	–14%
Total	**69.5**	**67.1**	**71.2**	**66.4**	**63.7**	**–8%**



Source: European Environment Agency according to CITEPA, June 2011.

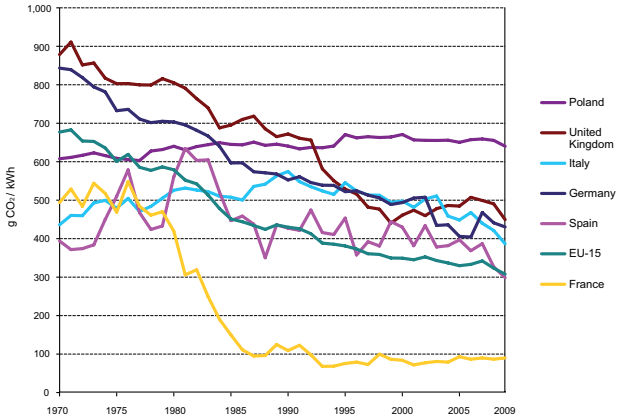
1. Includes the incineration of waste with recuperation of heat.
2. Solid mineral fuels (coal and coal products). Emissions mainly linked to the activity of coking plants.
3. Mainly linked to activities of extraction of fossil fuels (oil, gas and coal).

CO_2 Emissions per kWh of Electricity in the EU
(Including CHP Plants)

In g CO_2 / kWh	1990	2000	2008	2009	Change (%) 2008-2009	Change (%) 1990-2009
EU-27	**nd**	**381**	**355**	**339**	**–4.5**	**nd**
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**	**nd**
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 in countries where coal is an important source of energy, as in Germany and in some Eastern countries. They are much lower in countries where renewable and/or nuclear are developed, for example in France (nuclear 77%, hydraulics 11%), Sweden (hydraulics 48%, nuclear 38%), and, to a lesser extent, in Belgium (nuclear 52%).



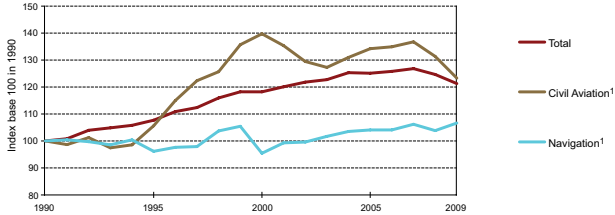
Source: International Energy Agency, October 2011.

4.3 – Transportation-related CO_2 Emissions

Transportation-related CO_2 Emissions in the EU

Unit: Mt CO_2

Transportation Sector	1990	2000	2005	2008	2009	1990/2009
Civil Aviation[1]	14	20	19	19	17	+23%
Road Transportation	703	842	895	892	868	+23%
Railways	14	9	8	8	7	–49%
Navigation[1]	18	17	19	18	19	+7%
Other	10	9	10	10	9	–9%
Total	**759**	**897**	**950**	**946**	**921**	**+21%**



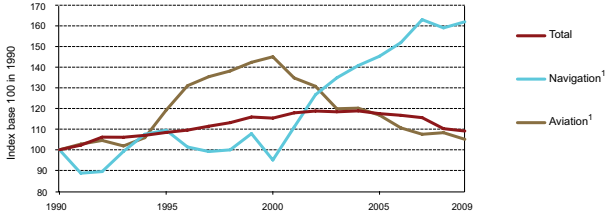
1. Includes domestic transport (and transport between Metropolitan France and Overseas Departments) but excludes international transport.

Source: European Environment Agency, June 2011.

Transportation-related CO_2 Emissions in France
(Including Overseas Departments)

Unit: Mt CO_2

Transportation Sector	1990	2000	2005	2008	2009	1990/2009
Civil Aviation[1]	4.2	6.2	5.0	4.6	4.5	+5%
Road Transportation	110.8	127.1	129.7	121.6	120.4	+9%
Railways	1.1	0.8	0.6	0.6	0.5	–50%
Navigation[1]	1.8	1.7	2.5	2.8	2.8	+62%
Other	0.2	0.5	0.9	0.6	0.6	x2.8
Total	**118.1**	**136.2**	**138.7**	**130.2**	**128.8**	**+9%**



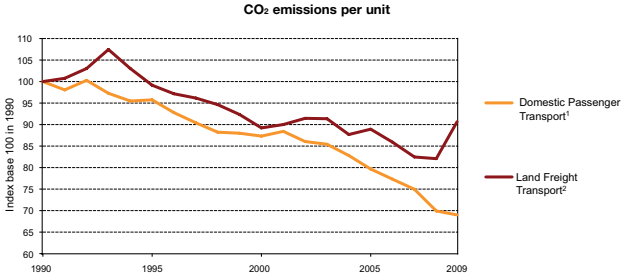
1. Includes domestic transport (and transport between Metropolitan France and Overseas Departments) but excludes international transport.

Source: European Environment Agency according to CITEPA, June 2011.

CO_2 Emissions per Passenger-km and Metric ton-km in Metropolitan France

Unit: index base 100 in 1990

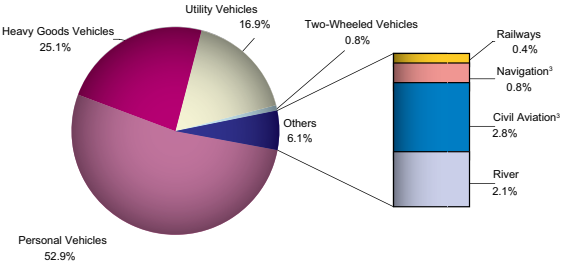
Index of CO_2 emissions per unit	1990	2000	2005	2008	2009
Domestic Passenger Transport[1]	100	87.3	79.7	69.9	69.0
Land Freight Transport[2]	100	89.2	88.9	82.1	90.7



Source: CITEPA/SECTEN format, May 2011 and SOeS.

1. Emission of CO_2 per carried km-passenger.
2. CO_2 emissions per metric ton-km of freight.

CO_2 Emissions by Method of Transport in Metropolitan France (125.1 Mt CO_2 in 2009)



Source: CITEPA/SECTEN format, May 2011.

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

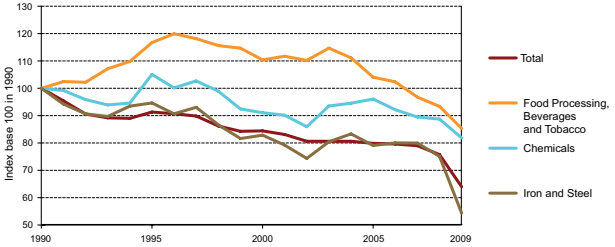
4.4 – Industry-related CO_2 Emissions

CO_2 Emissions Related to Fuel Use in the Industrial Sector in the EU

Unit: Mt CO_2

Industrial Sector[1]	1990	2000	2005	2008	2009	1990/2009
Total	820	692	654	621	524	–36%
of which: Iron and Steel	148	123	117	111	80	–46%
Chemicals	90	82	87	80	74	–18%
Food Processing, Beverages and Tobacco	41	46	43	38	35	–15%

1. Including Building and Civil Engineering but excluding Energy.



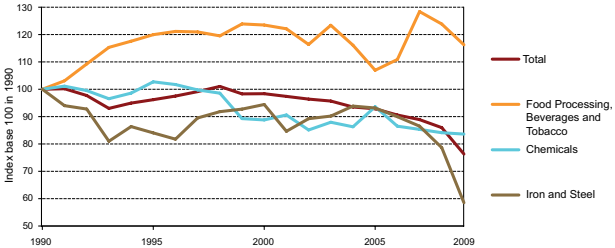
Source: European Environment Agency, June 2011.

CO_2 Emissions Related to Fuel Use in the Industrial Sector in France (Including Overseas Departments)

Unit: Mt CO_2

Industrial Sector[1]	1990	2000	2005	2008	2009	1990/2009
Total	**82.2**	**80.9**	**76.4**	**70.7**	**62.7**	**–24%**
of which: Iron and Steel	18.3	17.2	17.0	14.4	10.7	–41%
Chemicals	19.4	17.2	18.2	16.3	16.2	–16%
Food Processing, Beverages and Tobacco	8.5	10.5	9.1	10.5	9.8	+16%

1. Including Building and Civil Engineering but excluding Energy.



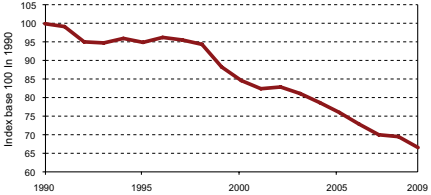
Source: European Environment Agency according to CITEPA, June 2011.

Intensity of CO_2 Emissions in the Industrial Sector in France

Unit: index base 100 in 1990

Industry (including Building and Civil Engineering but excluding Energy)	1990	2000	2005	2008	2009
CO_2 emissions / value added	100	84.7	76.1	69.6	66.7

CO_2 emissions per unit of value added

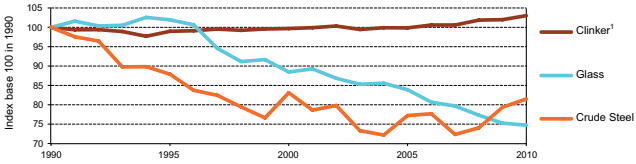


Source: INSEE (value added), CITEPA (CO_2 emissions).

Individual CO_2 Emissions of Selected Energy-Intensive Products in France

		1990	2000	2005	2008	2009	2010
Crude Steel	Production (Mt)	19.0	21.0	19.5	17.9	12.8	15.4
	t CO_2 / t steel	1.78	1.48	1.37	1.32	1.41	1.45
Glass	Production (Mt)	4.8	5.5	5.6	5.2	4.5	4.6
	t CO_2 / t glass	0.70	0.62	0.59	0.54	0.52	0.52
Clinker[1]	Production (Mt)	20.9	16.3	17.3	16.9	14.6	14.9
	t CO_2 / t clinker	0.87	0.86	0.86	0.88	0.88	0.89

Specific CO_2 emissions



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

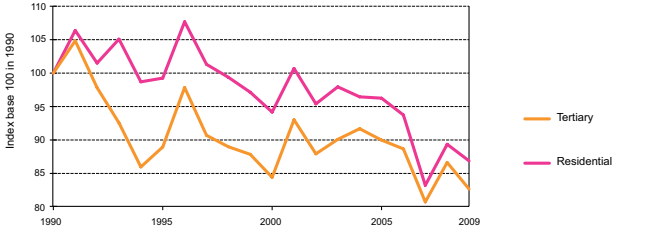
Source: Fédération Française de l'Acier (FFA), Fédération des Chambres Syndicales de l'Industrie du Verre (FCSIV), Syndicat Français de l'Industrie Cimentière (SFIC).

4.5 – CO_2 Emissions in the Other Sectors

Energy-related CO_2 Emissions in Other Sectors[1] in the EU

Unit: Mt CO_2

	1990	2000	2005	2008	2009	1990/2009
Total	**816**	**734**	**753**	**705**	**683**	**–16%**
of which: Residential	497	468	478	444	432	–13%
Tertiary	205	173	185	178	169	–17%



Source: European Environment Agency, June 2011.

Energy-related CO_2 Emissions in Other Sectors[1] in France

(Including Overseas Departments)

Unit: Mt CO_2

	1990	2000	2005	2008	2009	1990/2009
Total	**95.7**	**100.4**	**109.9**	**101.0**	**98.0**	**+2%**
of which: Residential	56.0	60.1	66.8	60.1	58.4	+4%
Tertiary	28.9	28.7	31.6	29.8	28.9	–0%

Source: European Environment Agency according to CITEPA, June 2011, and SOeS according to Météo-France.

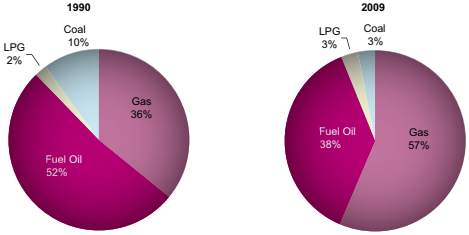
Emissions from the residential and tertiary sectors depend on climatic conditions. Temperatures were particularly mild in 1994, 2000, 2002 and 2007 (climate severity index below 0.9). Therefore, heating consumption and CO_2 emissions were rather low.

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

CO_2 Emissions Related to Heating in Residential and Tertiary Buildings in Metropolitan France

Unit: %

Data corrected for climatic variations	1990	1995	2000	2005	2008	2009
Gas (excluding LPG)	36	42	46	52	56	57
Fuel Oil	52	48	45	42	39	38
Liquefied Petroleum Gas (LPG)	2	3	3	3	3	3
Coal	10	7	5	3	2	3



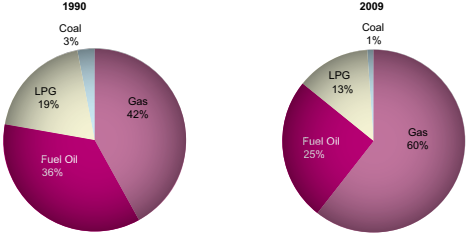
Source: SOeS according to CEREN.

Between 1990 and 2009, among fossil fuels, coal and fuel oil were substituted by natural gas in the residential and tertiary sectors. That explains the increase in natural gas contribution to CO_2 emissions.

CO_2 Emissions Related to Water Heating and Cooking in Metropolitan France

Unit: %

	1990	1995	2000	2005	2008	2009
Gas (excluding LPG)	42	48	50	56	60	60
Fuel Oil	36	30	30	27	25	25
Liquefied Petroleum Gas (LPG)	19	19	18	16	14	13
Coal	3	3	3	1	1	1



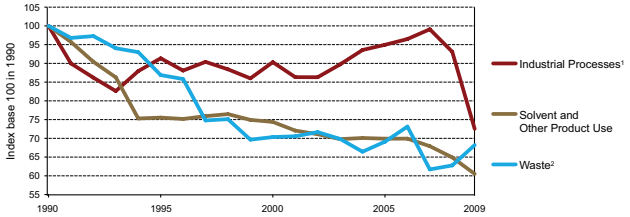
Source: SOeS according to CEREN.

4.6 – CO_2 Emissions excluding Fuel Combustion

CO_2 Emissions Excluding Fuel Combustion in the EU

Unit: Mt CO_2

	1990	2000	2005	2008	2009	1990/2009
Total	**304.1**	**271.8**	**284.6**	**278.3**	**218.9**	**–28%**
Industrial Processes[1]	287.7	259.8	273.2	267.8	208.6	–27%
Solvent and Other Product Use	11.7	8.7	8.2	7.6	7.1	–39%
Waste[2]	4.7	3.3	3.3	3.0	3.2	–32%

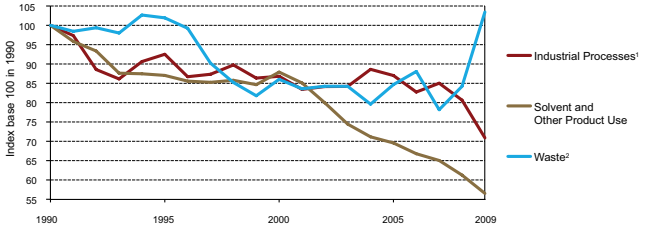


Source: European Environment Agency, June 2011.

CO_2 Emissions Excluding Fuel Combustion in France
(Including Overseas Departments)

Unit: Mt CO_2

	1990	2000	2005	2008	2009	1990/2009
Total	**28.1**	**24.4**	**24.0**	**22.3**	**20.2**	**–28%**
Industrial Processes[1]	24.3	21.1	21.2	19.6	17.3	–29%
Solvent and Other Product Use	2.0	1.7	1.4	1.2	1.1	–43%
Waste[2]	1.7	1.5	1.5	1.5	1.8	+3%



Source: European Environment Agency according to CITEPA, June 2011.

1. Industry excluding fuel combustion.
2. Excluding the incineration of waste with recuperation of heat (included in «Electricity and Heat Production»).

CO_2 Emissions Factors for the Principal Fossil Fuels

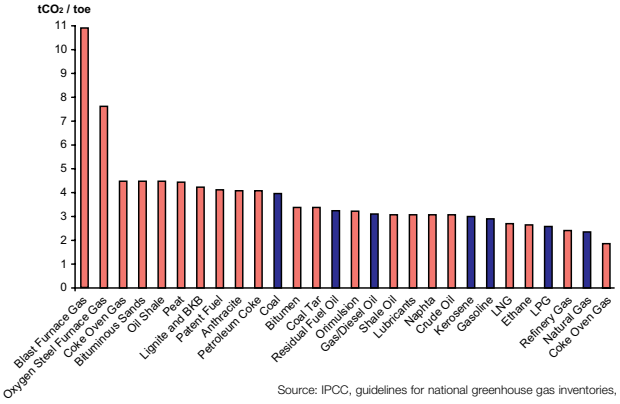
Fuels	tCO_2 / toe
Patent Fuel	4.1
Anthracite	4.1
Bitumen	3.4
Coal (Coking, Sub-bituminous, Other Bituminous)	**4.0**
Coke Oven Coke	4.5
Petroleum Coke	4.1
Gasoline	**2.9**
Ethane	2.6
Residual Fuel Oil	**3.2**
Liquefied Natural Gas (LNG)	2.7
Coke Oven Gas	1.9
Oxygen Steel Furnace Gas	7.6
Blast Furnace Gas	10.9
Liquefied Petroleum Gas (LPG)	**2.6**
Refinery Gas	2.4
Natural Gas	**2.3**
Gas/Diesel Oil	**3.1**
Coal Tar	3.4
Shale Oil	3.1
Kerosene	**3.0**
Lignite and BKB	4.2
Lubricants	3.1
Naphta	3.1
Orimulsion	3.2
Crude Oil and Other	3.1
Bituminous Sands	4.5
Oil Shale	4.5
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 production of a single energy unit (in this case, one tonne of oil equivalent - toe) for a given fuel. The factor represents the ratio between the measured CO_2 emissions and the amount of energy used.

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

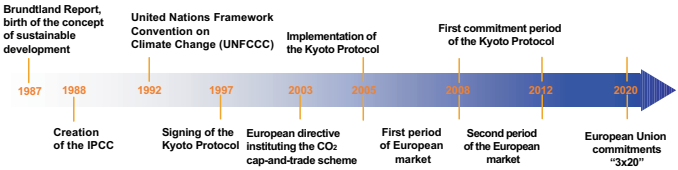
The exceptional case of biomass fuels is not treated here: CO_2 emissions related to the combustion of biomass fuels are compensated by the absorption of CO_2 during the reconstitution of the given fuel. If the reconstitution of the biomass fuel does not occur, the non-compensated emissions are recorded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



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

5.1 – The Kyoto protocol

A Major Step in Increasing International Awareness



The United Nations Framework Convention on Climate Change

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 of current GHG concentration.

- The **principle of the right to development**.

The Kyoto Protocol

The Kyoto Protocol, **adopted in 1997**, established the targets and mechanisms necessary to implement the UNFCCC.

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.

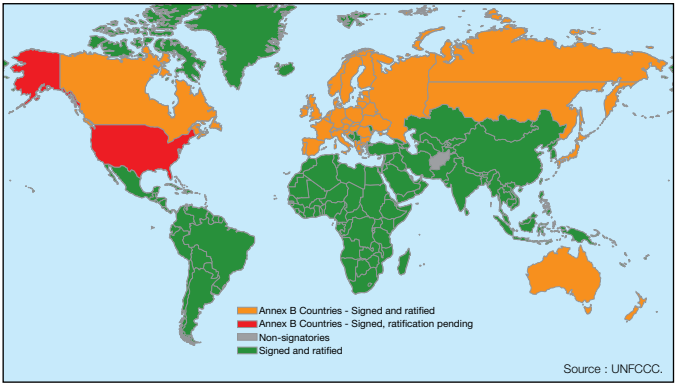
Non-Annex B countries have no set objectives.

Implementation of the Protocol

Signed in 1997, the Protocol should be ratified by at least 55 countries representing a minimum of **55% of Annex B emissions in 1990.** This quorum was achieved in November of 2004 after the ratification of the Protocol by Russia which allowed **its implementation in 2005.**

The **United States did not ratified the Protocol** and therefore are not subject to the fixed reduction objectives for 2008-2012.

State of Kyoto Protocol ratification as of 30 September 2011



Kyoto, a Flexible Protocol

To assist the 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 as many **Assigned Amount Units (AAUs)** as 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)**.

5.2 – The Tradable Permit Market

The global target of GHG emissions **reduction** by 5% under the Kyoto Protocol is 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 called "hot air."

Country	Kyoto objectives for 2008-2012 (in %)*	Yearly average of AAUs received over 2008-2012 (in millions)	2009 emissions (LULUCF excluded)		Distance to Kyoto objective (in % points)
			in Mt CO_2e	Evolution (in %)*	
EU-15	**-8**	**3,924**	**3,728**	**-12**	**4**
Bulgaria	-8	122	59	-55	47
Czech Republic	-8	179	133	-32	24
Estonia	-8	39	17	-59	51
Hungary	-6	108	67	-42	36
Latvia	-8	24	11	-60	52
Lithuania	-8	45	22	-57	49
Poland	-6	530	377	-33	27
Romania	-8	256	131	-52	44
Slovakia	-8	66	43	-41	33
Slovenia	-8	19	19	-4	-4
Australia	8	592	546	30	-22
Belarus**	-8	117	88	-35	27
Canada	-6	558	678	15	-21
Croatia	-5	34	29	-8	3
Iceland	10	4	5	36	-26
Japan	-6	1,186	1,138	-10	4
Kazakhstan	0	n.p.	290	-28	28
Liechtenstein	-8	< 1	< 1	15	-23
Monaco	-8	< 1	< 1	-11	3
New Zealand	0	62	71	16	-16
Norway	1	50	51	3	-2
Russia	0	3,323	2,169	-35	35
Switzerland	-8	49	52	-2	-6
Ukraine	0	921	370	-60	60
Total* **	**-4**	**12,207**	**10,084**	**-21**	**17**
United States	-7	not participating	6,608	14	-21

Source: UNFCCC, 2011.

n.p. = not published by the UNFCCC yet.
* Compared to the reference year, generally 1990. ** AAUs will be received once its inclusion in Annex B is completed.
*** Excluding Kazakhstan for which the AAU allocation has not been published yet.
EU Countries, Non-EU Annex B Countries, Non-ratifying Countries.

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 for the 2008-2012 period,** or five times their last GHG emissions inventory.

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.

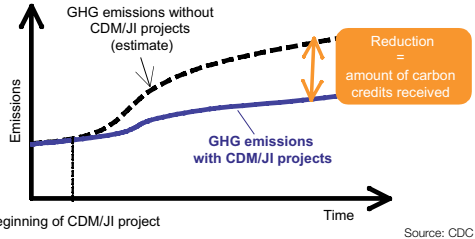
CDM projects must be **approved and registered by the UNFCCC Secretariat.**

Emissions reductions have to be verified by independent consultants.

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

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

Principle of a project mechanism (CDM or JI)



Source: CDC Climat Research.

Potential for emissions reductions through CDM and JI mechanisms

		CDM	JI
Principle of a project mechanism (CDM or JI)	**Maximum** (source: Unep-Risoe)	2.7	0.6
	CDC Climat Research estimate	1.1	0.3
Sectoral and geographical origin of offsets expected by 2012		80% in Asia, 14% in South America; barely 4% in Africa. 27% from projects of industrial HFC, PFC and N_2O destruction; 18% from methane projects. Increasing share of renewable energies (35%) and energy efficiency projects (11%)	70% in Russia and Ukraine. 32% from methane projects, 19 % from projects of industrial HFC, PFC and N_2O destruction, and 28% from energy efficiency improvement.

5.4 – Other Initiatives to Reduce Emissions

The Cancun Summit Commitments

The Cancun Agreements established:

- an objective of **stabilizing the increase of the average temperature at no more than +2°C by the end of the century**, strongly recommended by the IPCC;

- the provision of funds by developed countries for mitigation and adaptation in developing countries. Financing should reach **30 billion US dollars by 2012 then increase to 100 billion US dollars per year by 2020**;

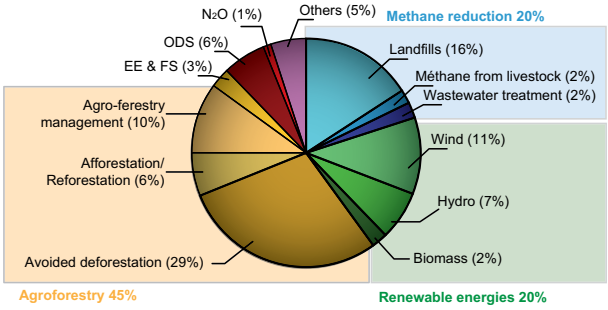
- **voluntary emissions reduction commitments** for 2020.

Voluntary Offsets

Voluntary offset consists, for **businesses**, **individuals** or **public actors**, of buying carbon credits corresponding to all or part of their GHG emissions.

The carbon credits used are sourced from emission reduction projects more diverse than those present in the CDM and JI mechanisms. For example, the **agriculture and forestry sector** is more represented.

Distribution of voluntary credits OTC transactions worldwide in 2010 by project type (Total = 55 Mt CO_2e)



Note: EE & FS = energy efficiency and fuel-switch;
ODS = ozone-depleting substances.

Source: Ecosystem Marketplace, 2011.

5.5 – The European Union's Commitment

The Objectives of European Member States

During the Kyoto Protocol negotiations in 1997, the European Union (EU) was allowed to **share its objective of -8% total reduction 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 %)*	Yearly average of AAUs received over 2008-2012 (in millions)	2009 emissions (LULUCF** excluded)		Distance to Kyoto objective (in % points)
			in Mt CO_2e	Evolution (in %)*	
Austria	-13.0	69	80	2.0	-15.0
Belgium	-7.5	135	124	-13.0	5.5
Denmark	-21.0	55	62	-12.0	-9.0
Finland	0.0	71	66	-6.0	6.0
France	0.0	564	517	-9.0	9.0
Germany	-21.0	974	920	-25.0	4.0
Greece	25.0	134	123	19.0	6.0
Ireland	13.0	63	62	14.0	-1.0
Italy	-6.5	483	491	-5.0	-1.5
Luxembourg	-28.0	9	12	-11.0	-17.0
Netherlands	-6.0	200	199	-6.0	0.0
Portugal	27.0	76	75	26.0	1.0
Spain	15.0	333	368	29.0	-14.0
Sweden	4.0	75	60	-17.0	21.0
United Kingdom	-12.5	682	570	-26.0	13.5

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

Source: UNFCCC, 2011.

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).

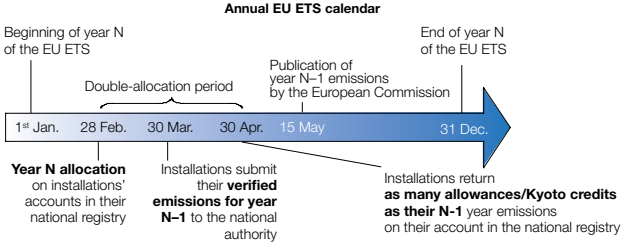
A key element of the European climate policy will be the extension of the **European Union Emissions Trading Scheme (EU ETS)**, introduced in 2005 on the same principles as the international market created by the Kyoto Protocol.

5.6 – The European CO_2 Market (EU ETS)

How the EU ETS Works

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.



Source: CDC Climat Research.

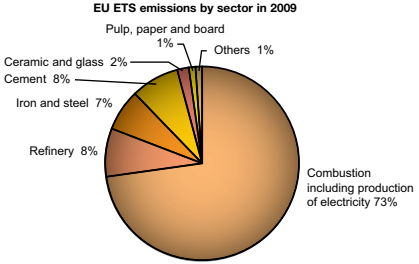
Covered Sectors

Currently the EU ETS only covers **CO_2 emissions**.

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

The **aviation** sector will be included from 2012. From 2013 onwards, the emissions of N_2O and SF_6 from the chemical and aluminum sectors will also be covered.

In 2008, **Norway, Iceland** and **Liechtenstein** joined the other 27 European member states in participating in the EU ETS.



Source: European Commission.

The Allowance Allocation

During the two first periods of the EU ETS – the "trial phase" of 2005-2007, and 2008-2012, which is the first 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)**, 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 is **0.13 % in phase 1 and 3.6% in phase 2**. In 2013, the share of auctioned allowances will be extended to:

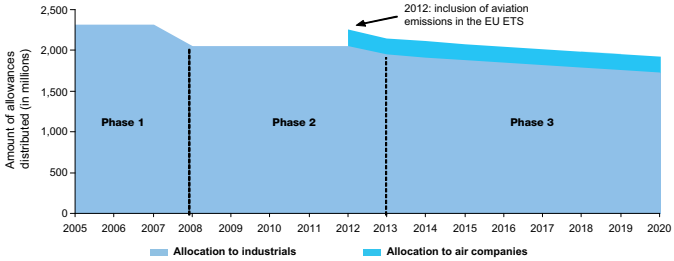
- 100% of the allocation for power generators

- 20% for other sectors, but steadily increasing to 70% in 2020 and 100% in 2027.

Exemptions are made for sectors at risk of losing competitiveness to international competitors that are not subject to carbon pricing.

Ultimately, **at least 50% of all allowances will be auctioned from 2013 and up to 75% in 2027**. The revenue of the auctions, which will be managed by each state, should reach a minimum of 15 to 20 billion euros per year from 2013 onwards.

Evolution of total EU ETS allowance allocation



Source: CDC Climat Research, from European Commission data.

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

Source: BlueNext, ECX, Point Carbon.

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.

During the first phase, the allowance **allocations exceeded the total emissions** of covered installations. **As the European Commission banned the banking of allowances** to phase 2, **the price of the first period allowances collapsed during 2006/07**, converging to zero by the end of the trial period.

In 2008, the ban was lifted. Thus, together with the tightening of allocations in the second and the third periods (2008-2012 & 2013-2020), prices for allowances have been maintained and stayed relatively stable, despite the economic crisis since 2008.

5.8 – States 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 led 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**, i.e. –23.1% between 1990 and 2020, or –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 addition, France adopted in July 2011 its first **National Adaptation Plan** which includes 230 concrete measures for the 2011-2015 period.

Main Policies and Measures in Place

Energy sector:

- **Energy saving certificates (ESC)**. Targeting a 345 TWh cumac* saving by 201;
- Implementation of the EU's **eco-design, the carbon labelling and the EU ETS Directives**;
- **Development of renewable energies** to 23% of final energy consumption in 2020, in particular through the financing of the "Renewable Heat Fund" receiving more than one billion euros over 2009-2013.

Buildings sector:

- **New 2012 thermal regulation** in new buildings, with the expansion of low energy consuming buildings with a primary energy consumption below 50 kWh/m^2/year on average;
- **"Sustainable development" tax credit** and **Zero Interest Eco-Loans** to give private individuals incentives to renovate existing buildings. More than 5.5 million households benefited from these measures between 2005 and 2009. By the end of 2010, the ZIE loans had helped the financing of 150,000 thermal renovations.
- **Upgrading** of the most energy-consuming social houses and commitment to upgrade State's 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 2011 which has placed a bonus on the purchase of vehicles emitting less than 111 gCO_2/km and a tax if the vehicle emits more than 150 gCO_2/km;
- **Eco-tax per kilometer** for heavy trucks by mid-2013 from 2012;
- **Infrastructure development** program of for low carbon transport; for instance, a target of building 2,000 kilometers of high speed railroads by 2020.

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

CO_2 Key Figures

Transport

To travel 1,000 km (about a round trip Paris-Amsterdam), one will lead to the issuance of:

- **0.18 t CO_2 with a car** (french average), 176 g CO_2/km. A small cylinder emits 0.12 t CO_2 (120 g CO_2/km)[1]. Increasing the number of passengers proportionately reduces emissions.
- **0.27 t CO_2 by plane**, with an aircraft filled by 75%. The shorter the travel is, the more CO_2 it emits by kilometer because takeoff and landing have a higher fuel consumption[1].
- **0.04 t CO_2 by train** (on average in Western Europe). Emissions of a train depends on the energy source. In France, emissions are lower (0.009 t CO_2 / 1,000 km) since electricity is produced mainly from nuclear energy[1].

Electricity Production and Consumption

A power-plant type with a capacity of **250 MW** operating in base (8,000 h/year) issues:

- **1.7 Mt CO_2/year for a coal-fired plant** (0.87 t CO_2/MWh, corresponding to a thermal efficiency rate of 40%)[2].
- **0.72 Mt CO_2/year for a gas power plant** (0.36 t CO_2/MWh, corresponding to a thermal efficiency rate of 55%)[2].

1.5 t CO_2/year are emitted by **power consumption** of a **European household**[2, 3] for lighting, heating and electrical appliances consumption in house.

Industry

An average steelworks producing **1 Mt of steel** per year emits on average:

- **1.8 Mt CO_2/year for a classical steel chain** (1.8 t CO_2 per ton of steel)[2].
- **0.5 Mt CO_2/year for an electric steel chain** (recast waste) (0.5 t CO_2 per ton of steel corresponding to the indirect emissions due to electricity[2].

Among other CO_2-emitting industries:

- **0.35 Mt CO_2/year for a cement-type producing** 500,000 tons/year (0.7 t CO_2 per ton of cement)[4].
- **0.09 Mt CO_2/year for a glass-type producing** 150,000 tons/year (0.6 t CO_2 per ton of glass)[5].

Forestry and agriculture

- **580 t CO_2e** are issued **per hectare of tropical forest from deforestation** (burning and decomposition)[6].

Agriculture emits on average in France:

- **3 t CO_2e/year per dairy cow** because of enteric fermentation[7].
- **0.5 t CO_2e/year per pig** because of its dejections[7].

1. Source: Ademe, bilan carbone
2. Source: IEA
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

Glossary of Terms

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:
Human induced 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.

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

Energy Units

See: "Les chiffres clés de l'énergie édition 2011 - Repères", published by the SOeS.

Useful Links

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

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

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

CITEPA
Centre Interprofessionnel Technique d'Études
de la Pollution Atmosphérique ..... *www.citepa.org*

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*

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

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

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

MEDDTL
Ministry of Ecology, Sustainable Development,
Transport and Housing ..... *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*

Paris-Dauphine University - CGEMP
Center of Geopolitics of Energy and Raw Materials ..... *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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