Ressources, territoires, habitats et logement
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Infrastructures, transports et mer

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Highlights

Key Figures on Climate
France and Worldwide
2011 Edition

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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)

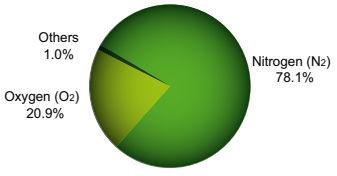
Source: after IPCC, 1st working group, 2007.

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**.

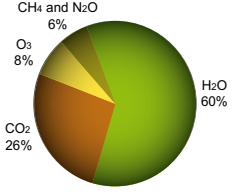
The Atmosphere and Greenhouse Gases

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)



Source: Kiehl & Trenberth 1996, National Center for Atmospheric Research.
N.B.: proportions in the absence of clouds.

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**.

1.2 – Humans and the Greenhouse Effect

Characteristics of GHGs Influenced by Human Activity

	CO_2	CH_4	N_2O	HFC	PFC	SF_6
Atmospheric Concentration 2005	379 ppm	1,174 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 Warming Potential (total over 100 years)	1	25	298	Between 124 and 14,800	Between 7,300 and 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/m²)	+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 per 1 kg of the gas and that which would be reflected by 1 kg of CO_2, used as a reference, over the same period. **The GWP depends on the concentration and lifespan of each gas**.
Ex.: 1 kg of CH_4 and 25 kg of CO_2, emitted at the same time, would heat the atmosphere equally over the century following their emissions.

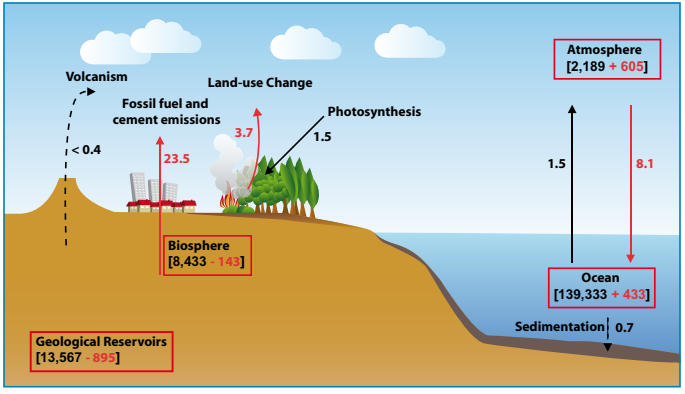
Radiative forcing quantifies, in relation to a year of reference (here 1750), the **changes in radiation**, or the energy reflected back towards the surface due to greenhouse gases. A positive value indicates a positive contribution to warming and vice versa.

Although **CO_2** has **the smallest global warming potential** of all greenhouse gases, it has nevertheless 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 greenhouse gases which reached +2.64 W/m².

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:

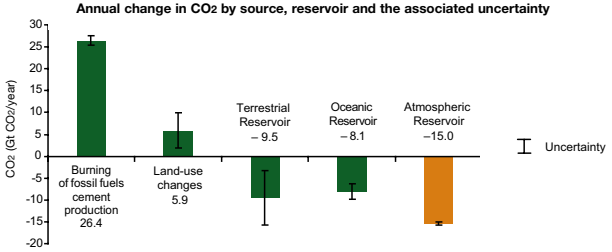
- **Atmosphere**: gaseous CO_2
- **Biosphere**: organic material and living things
- **Ocean**: calcium, dissolved CO_2
- **Subsoil**: rocks, sediments, fossil fuels

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 organic and 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

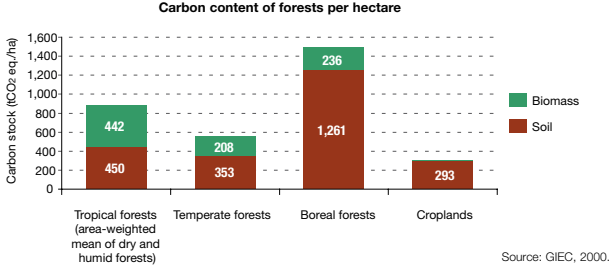


Emissions data from the burning of fossil fuels, the production of cement, the oceanic reservoir and the growth of the atmospheric reservoir are from the period 2000-2005. The terrestrial flows are for the 1990s. Emissions from the burning of fossil fuels and land-use change add up for half to the atmospheric reservoir and for about a quarter each the terrestrial and oceanic reservoirs.

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 therefore served to absorb the excess, which has led to **increased concentration of greenhouse gases**.

Importance of Forest Carbon



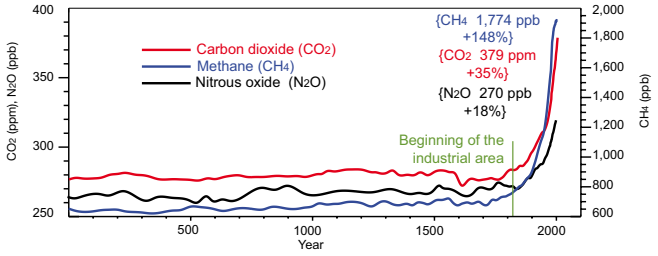
Source: GIEC, 2000.

Forests are the largest terrestrial carbon reservoir. They store approximately 9.5 Gt CO_2eq net emissions per year, equivalent to **30% of global GHG emissions**.

Deforestation leads to GHG emissions through **burning** and **decomposition** of organic matter, mainly in the form of CO_2. These gross emissions represent approximately 11% of yearly anthropogenic GHG emissions (Source: Van der Werf et al. 2009, Nature Geoscience).

1.5 – Concentrations and Temperatures

Historic Evolution of GHG Concentrations



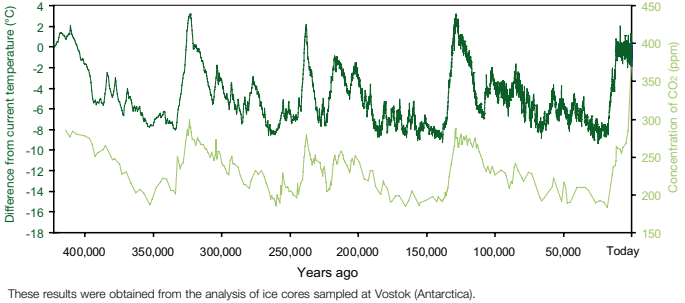
The figures in brackets indicate the atmospheric concentration of GHGs in 2005 and their percentage of growth between 1750 and 2005.

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 2008, atmospheric CO_2 concentration achieved 385 ppm**, 38% above pre-industrial level. (Source: World Meteorological Organisation, 2009).

Correlation between Temperature and CO_2 Concentration

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



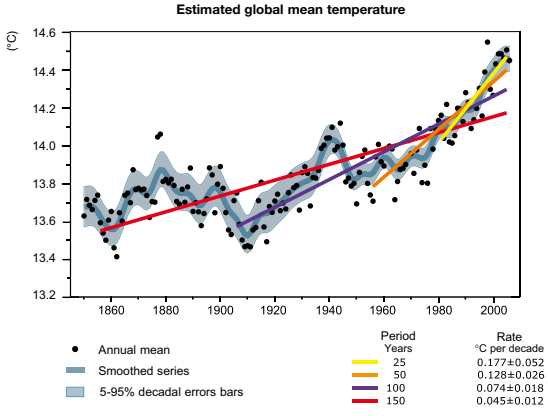
These results were obtained from the analysis of ice cores sampled at Vostok (Antarctica).

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

The variations in 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. The current **CO_2 concentration is 30% higher than the maximum observed over the 450,000 years of weather records**.

1.6 – Global Warming

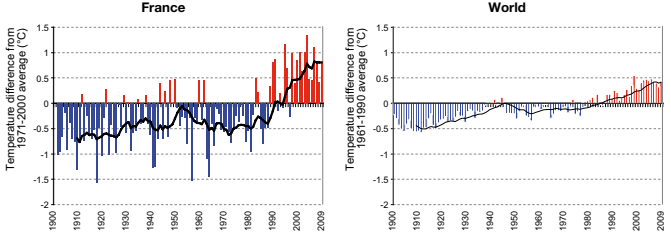
Estimated Global Temperature and Growth Rate since 1850



Source: IPCC, 1st working group, 2007.

The global average temperature has increased by approximately **+ 1 °C over the last century**. This **increase** is particularly apparent over **the last 25 years**, when the rate of temperature growth was **the strongest of the entire century**.

Mean temperature evolution in Metropolitan France and the world since 1901 compared with the reference period average



Source: Météo-France, 2010.

In France and in the world, **the temperatures of the last decade have systematically been above the average temperature of the reference period**. At the global scale, the last fifteen years (1995-2009) count fourteen of the fifteen warmest years since 1900.

1.7 – Warming Differentiated by Latitude

The expected increase in temperature varies according to latitude. The warming will be less in the tropics than at the poles. Equally, the increase in temperature in coastal regions is less 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 over a single century** (period from 1999-2099) are estimated:

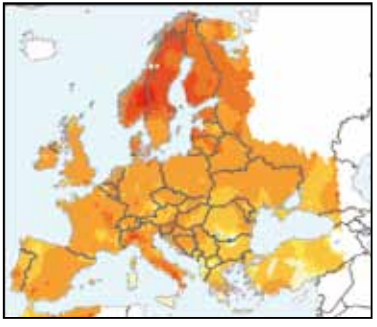
+ 3,5°C in Southern Europe
+ 2,5°C in Southeast Asia
+ 4,9°C in the Arctic (North Pole)
+ 3,2°C in Central America
+ 2,6°C in Southern Australia
+ 3.3°C In West Africa

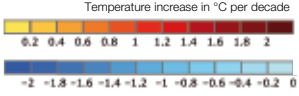
} For a **global increase of + 2,8°C** compared to the 1980-1999 period.

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.

Observed temperature change in Europe 1976-2006





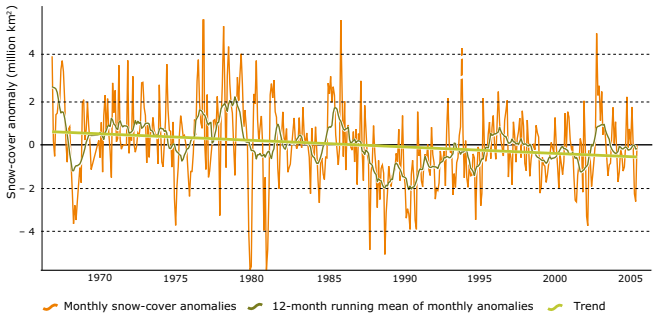
Source: European Environment Agency, 2008, from data of EU-FP6 ENSEMBLES Project and EC A&D Project.

There has been an increase in mean temperatures in Europe during the period 1976-2006. This evolution is not uniform: **the increase is greater in the North**.

1.8 – Consequences of Global Warming

Decrease in Snow Cover

Northern hemisphere snow cover extent variation 1966-2005

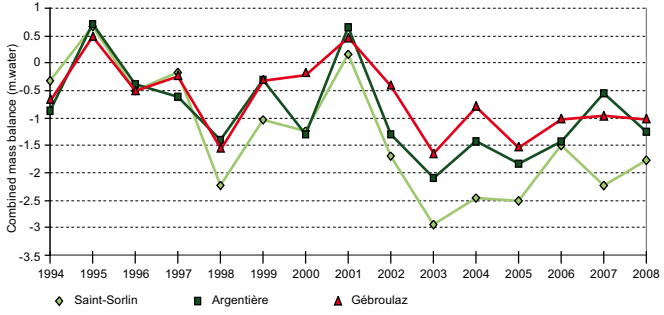


Snow-cover anomaly refers to the difference between each monthly value and the annual mean.

Source: European Environment Agency, 2008.

Melting Ice

Combined mass balance evolution of 3 glaciers from French Alps since 1994



Source: Laboratoire de Glaciologie et de Géophysique de l'Environnement (LGGE), 2010.

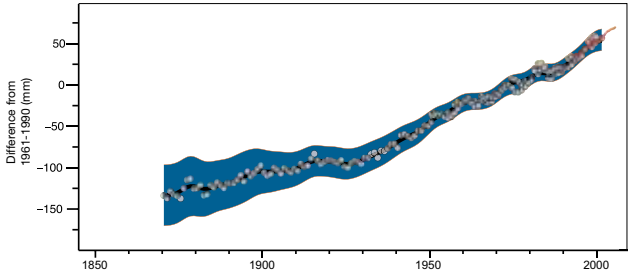
The run down of glacier mass from the Alps has not been uniform over the period. The **falls in levels** (as a result of winter with a small amount of snow and very hot summer) have been punctuated with **short phases of growth**.

1.8 – Consequences of Global Warming

Increase in Sea Level Worldwide

Global warming affects sea levels worldwide. Readings indicate a **continued increase** in levels since the 1870s.

Global average sea level



Source: IPCC, 1st working group, 2007.

Increases in sea level will most likely lead to **migration of population** 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 measured 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 of Antarctica	0.14 ± 0.41	8%	0.21 ± 0.35	7%
Sum of Contributions	1.1 ± 0.5	61%	2.8 ± 0.7	90%
Increase Measured	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.

Over a decade, the principal factors of growth of global sea levels are **thermal expansion** and the **melting of terrestrial ice deposits** (glaciers, polar ice caps, snow cover, permafrost).

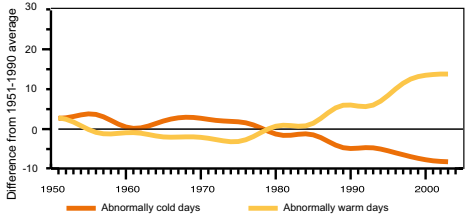
Extreme Weather Events

A weather event is classified as extreme when it substantially exceeds a **base of reference**. Extreme events are always unpredictable; it is **their increase in average frequency of occurrence or average intensity** that can indicate climate changes.

A number of weather events can be considered as extreme: tornadoes, hurricanes, as well as heat waves or abnormally heavy rainfall.

Temperature and Precipitation Extremes

Abnormally cold and warm days



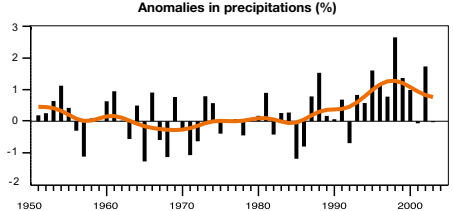
The reference used is the mean of the indicator considered over the period 1961-1990. The curves represent the mobile averages per decade. All regions worldwide are not included due to insufficient data.

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 1951-1990.

A decrease in the number of days abnormally cold and a growth in the number of days abnormally warm have been **noted since the 1990s**. **Anomalies** in precipitations have also been noted over the same time period.

Anomalies in precipitations (%)



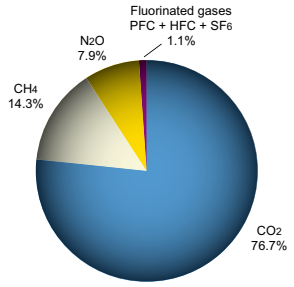
The indicator used is the portion of rainfall abnormally high in terms of yearly precipitation. This graphic presents the difference, in %, between this portion and the mean observed between 1961-1990. The orange curve shows the variations per decade. All regions worldwide were not included due to insufficient data.

Source: IPCC, 1st working group, 2007.

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.

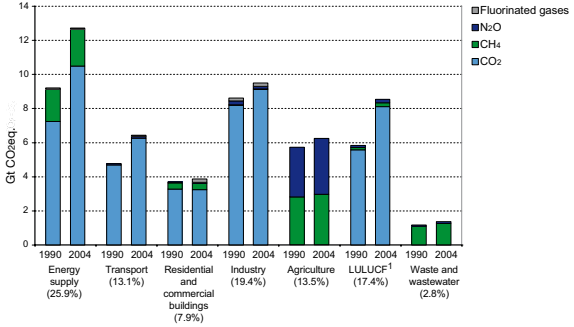
Emissions of the six greenhouse gases[2] covered by the Kyoto Protocol have increased by 70% since 1970 and by 24% since 1990, reaching **49 Gt CO_2eq. in 2004**.

CO_2 emissions, representing the ¾ of global emissions in 2004, have increased by 28% since 1990.

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

Global anthropogenic greenhouse gas emissions in 1990 and 2004



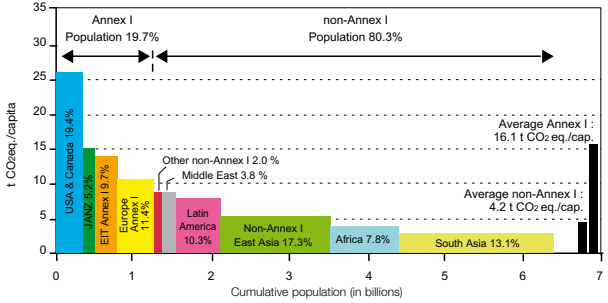
The percentage indicated for each sector corresponds to its share in global GHG emissions in 2004.

Source: IPCC, 1st working group, 2007.

The most significant increase since 1990 is attributed to **land use change and forestry (+48%)**, followed by **energy (+37%)** and **transport (+32%)**. The agricultural and industrial sectors each experienced an increase of 9% of their emissions since 1990. GHG emissions related to the use of buildings and to the waste sector have remained virtually stable.

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

Regional Distribution of GHG Emissions[1] per Capita

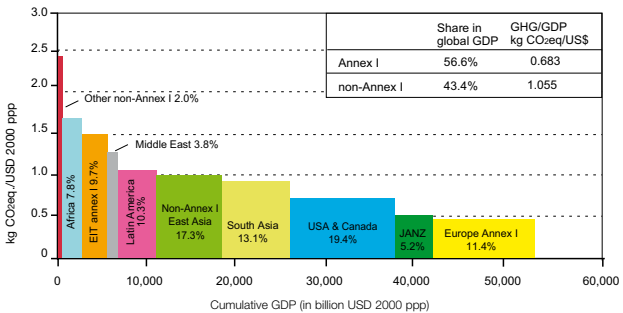


The percentage indicated for each region corresponds to its share in global GHG emissions.
EIT: Economies in transition, JANZ: Japan, Australia, New Zealand.

Source: IPCC, 1st working group, 2007.

In 2004, Annex I countries of the UNFCCC[2] represented 20% of the world's 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_2eq**, 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.

2.2 – European Panorama of GHGs

2008 GHG Emissions in EU-27 in Mt CO_2eq

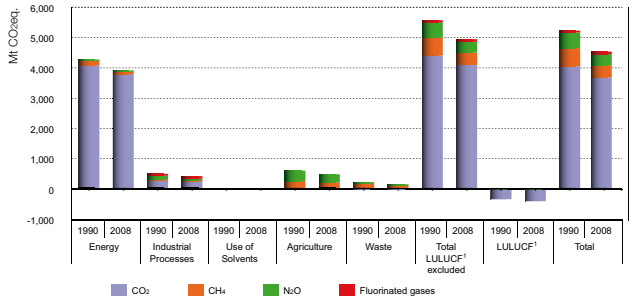
Unit: Mt CO_2eq

Sector	Years	CO_2	CH_4	N_2O	Fluorinated gases	Total
Energy	1990	4,076.6	156.8	34.1	-	4,267.4
	2008	3,787.3	84.9	34.8	-	3,907.0
Industrial Processes	1990	307.9	1.5	115.7	59.0	484.1
	2008	290.1	1.3	35.5	82.8	409.7
Use of Solvents	1990	11.4	-	5.1	-	16.5
	2008	8.1	-	4.1	-	12.3
Agriculture	1990	-	245.1	346.5	-	591.6
	2008	-	200.0	271.8	-	471.8
Waste	1990	4.9	190.3	12.3	-	207.4
	2008	3.3	121.8	13.8	-	138.9
Total LULUCF[1] excluded	**1990**	**4,400.7**	**593.6**	**513.7**	**59.0**	**5,567.0**
	2008	**4,088.8**	**408.0**	**360.1**	**82.8**	**4,939.7**
LULUCF[1]	1990	–352.5	4.3	4.4	-	–343.8
	2008	–417.9	4.7	3.4	-	–409.9
Total	**1990**	**4,048.2**	**597.9**	**518.1**	**59.0**	**5,223.2**
	2008	**3,670.9**	**412.7**	**363.5**	**82.8**	**4,529.8**

Source: European Environment Agency, 2010.

European GHG emissions excluding LULUCF decreased by 11.3% over the 1990-2008 period. This is due to a decline in CO_2 (-7%; -9% with LULUCF), methane and nitrous oxide emissions (-30% each).
Emission reductions reached 8% in the energy sector, 15% in the industrial processes sector, 20% in agriculture and 33% in the waste treatment sector. **The net carbon sequestration in the agro-forestry sector has increased over the same period by 19%**.

GHG emissions by sector in EU-27



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

Source: European Environment Agency, 2010.

2.3 – French Panorama of GHGs

2008 GHG Emissions in France in Mt CO_2eq

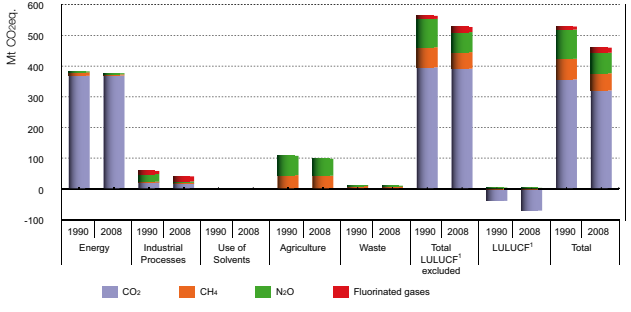
Unit: Mt CO_2eq

Sector	Years	CO_2	CH_4	N_2O	Fluorinated gases	Total
Energy	1990	368.1	11.2	3.2	-	382.6
	2008	369.0	3.8	3.8	-	376.6
Industrial Processes	1990	23.6	0.2	24.6	10.0	58.4
	2008	19.5	0.1	4.6	16.5	40.7
Use of Solvents	1990	2.0	-	0.1	-	2.1
	2008	1.2	-	0.1	-	1.3
Agriculture	1990	-	44.8	62.8	-	107.6
	2008	-	42.8	55.3	-	98.1
Waste	1990	2.0	9.3	1.4	-	12.6
	2008	1.6	7.4	1.4	-	10.4
Total LULUCF[1] excluded	**1990**	**395.7**	**65.5**	**92.0**	**10.0**	**563.2**
	2008	**391.2**	**54.1**	**65.2**	**16.5**	**527.0**
LULUCF[1]	1990	–39.1	1.3	3.1	-	-34.7
	2008	–70.8	1.9	1.5	-	-67.4
Total	**1990**	**356.6**	**66.8**	**95.1**	**10.0**	**528.5**
	2008	**320.4**	**56.0**	**66.7**	**16.5**	**459.7**

Source: European Environment Agency, 2010.

French GHG emissions excluding LULUCF1 decreased 6.4% over 1990-2008. This is due to a decline in CO_2 (-1%; -10% with LULUCF), methane (-18%) and nitrous oxide emissions (-29%).
Emission reductions were 2% in the energy sector, 30% in industrial processes, 9% in agriculture and 18% in the waste treatment sector. **The net increase in the agro-forestry carbon stock is 94% over the same period**.

GHG emissions by sector in France

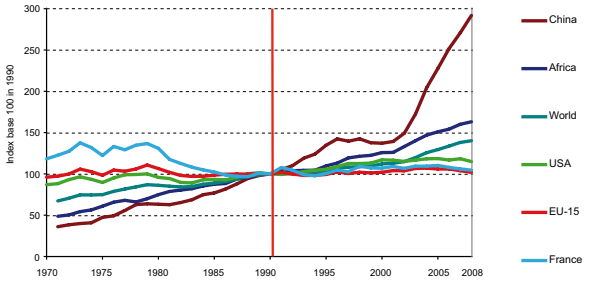


1. Land Use, Land Use Change and Forestry (LULUCF).

Source: European Environment Agency, 2010.

3.1 – Energy-related CO_2 Emissions

Energy-related CO_2 Emissions Worldwide[1]



In Mt CO_2	1990	2007	2008	Share (%) in 2008	Change (%) 2007 -2008	Change (%) 1990 -2008
North America	**5,566**	**6,751**	**6,555**	**22.3**	**-2.9**	**17.8**
of which: Canada	432	571	551	1.9	-3.5	27.4
USA	4,869	5,763	5,596	19.0	-2.9	14.9
Latin America	**605**	**1,024**	**1,068**	**3.6**	**4.3**	**76.7**
of which: Brazil	194	345	365	1.2	5.8	87.7
Europe and former USSR	**7,942**	**6,740**	**6,686**	**22.8**	**-0.8**	**-15.8**
of which: EU-27	4,054	3,930	3,850	13.1	-2.0	-5.0
EU-15	3,083	3,202	3,139	10.7	-2.0	1.8
of which: Germany	950	801	804	2.7	0.3	-15.4
Spain	206	344	318	1.1	-7.7	54.3
France	352	373	368	1.3	-1.4	4.5
Italy	397	441	430	1.5	-2.5	8.2
United Kingdom	549	521	511	1.7	-1.9	-7.0
12 new EU Members	971	727	710	2.4	-2.4	-26.9
of which: Russia	2,179	1,579	1,594	5.4	1.0	-26.8
Africa	**546**	**873**	**890**	**3.0**	**1.9**	**63.1**
Middle-East	**593**	**1,400**	**1,492**	**5.1**	**6.6**	**151.8**
Far East	**4,819**	**10,702**	**11,226**	**38.2**	**4.9**	**133.0**
of which: China	2,244	6,076	6,550	22.3	7.8	191.9
South Korea	229	490	501	1.7	2.2	118.6
India	591	1,338	1,428	4.9	6.7	141.6
Japan	1,064	1,242	1,151	3.9	-7.3	8.2
Oceania	**282**	**420**	**431**	**1.5**	**2.7**	**52.8**
Annex I countries	**13,905**	**14,241**	**13,904**	**47.3**	**-2.4**	**-0.0**
Non-annex I countries	**6,447**	**13,668**	**14,445**	**49.2**	**5.7**	**124.0**
International marine and aviation bunkers[2]	**613**	**1,036**	**1,033**	**3.5**	**-0.3**	**68.5**
World	**20,965**	**28,945**	**29,381**	**100.0**	**1.5**	**40.1**

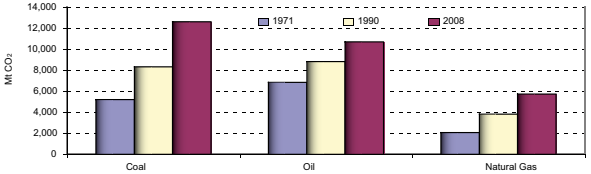
Source: IEA, October 2010.

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 emission 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 2008, energy-related global CO_2 emissions exceeded 29 billion tonnes (Gt) CO_2 (+40% since 1990). The annual growth rate of these emissions diminished from +3.3% in 2007 to +1.5% in 2008. China remains the first emitter before the United States. These two countries alone contributed to 41% of global CO_2 emissions related to fuel combustion in 2008.

In the EU, energy-related CO_2 emissions shrank by -5% in 2008 in relation to 1990 values. This is due to the 12 new EU member states (-27%), whose economies were restructured in the 1990's. Former EU-15 emissions increased from 1.8% since 1990 but decreased by 4.8% between 2004 and 2008. The crisis in countries with rapid economic growth like Spain, Ireland or Portugal was sound in 2008. The decrease of emissions in the United Kingdom (-7% since 1990) results primarily from a widespread fuel switch in electricity production from coal to natural gas.

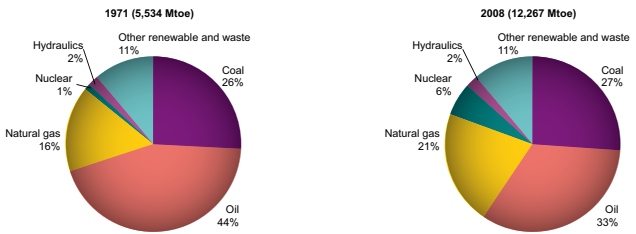
Change in Global CO_2 Emissions Related to Fuel Combustion



Source: IEA, October 2010.

Fossil fuels (coal, natural gas and oil) still represent **81% of the primary energy mix in 2008**, 5 percentage points less than in 1971. In the EU-27, this figure drops to 77% and even to 51% in France, due to the widespread use of nuclear generation. Worldwide, between 1971 and 2008, the oil share decreased by 11% whereas the shares of both nuclear and gas raised by 5%. The share of coal still represents a quarter of global energy mix. Coal is then the second energy source after oil, but it is the first CO_2 emitter (43%), because its emission factor is superior to that of oil and gas (see page 21).

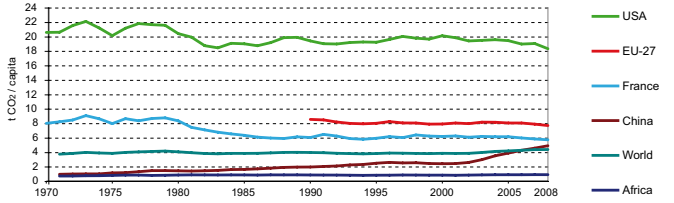
Global primary energy mix



Source: IEA, October 2010.

3.1 – Energy-related CO_2 emissions

Energy-related CO_2 Emissions per Capita Worldwide



Source: IEA, October 2010.

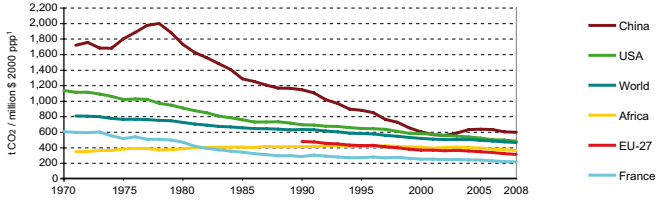
Between 1990 and 2008, the level of CO_2 emissions per capita lowered in Annex I countries and greatly increased in non-Annex I countries. Per capita emissions in China raised by more than 100%, to 4.9 t CO_2, and now exceed the world average (4.4 t CO_2). The difference in level of development and a limited access to energy sources restrain emissions in Africa (0.9 t CO_2 per capita).

In 2008, an inhabitant of the EU-27 emitted on average 7.7 t CO_2, a drop of -10% in comparison to 1990 level. This decrease is mainly due to the drop in emissions observed in Eastern countries. In comparison, the EU-15 had seen its CO_2 emissions per capita slowly decrease by -5.7% between 1990 and 2008. With only 5.7 t CO_2 released, France emits thrice less than United States or Australia per capita and remains easily below the European average.

In t CO_2 per capita	1990	2007	2008	Change (%) 2007 -2008	Change (%) 1990 -2008	Population in 2008 (millions)
North America	**15.5**	**15.3**	**14.7**	**-3.8**	**-4.8**	**444.4**
of which: Canada	15.6	17.3	16.5	-4.6	5.9	33.3
USA	19.5	19.1	18.4	-3.8	-5.6	304.5
Latin America	**1.7**	**2.2**	**2.3**	**3.2**	**35.7**	**462.0**
of which: Brazil	1.3	1.8	1.9	4.7	46.2	192.0
Europe and former USSR	**9.4**	**7.7**	**7.6**	**-1.2**	**-19.3**	**881.0**
of which: EU-27	8.6	7.9	7.7	-2.5	-10.0	498.7
EU-15	8.4	8.1	7.9	-2.5	-5.7	395.4
of which: Germany	12.0	9.7	9.8	0.5	-18.3	82.1
Spain	5.3	7.7	7.0	-9.1	32.1	45.6
France	6.1	5.9	5.7	-2.0	-5.2	64.1
Italy	7.0	7.4	7.2	-3.3	2.5	59.9
United Kingdom	9.6	8.5	8.3	-2.5	-13.3	61.4
12 new EU Members	9.1	7.0	6.9	-2.4	-24.4	103.3
of which: Russia	14.7	11.1	11.2	1.2	-23.7	141.8
Africa	**0.9**	**0.9**	**0.9**	**-0.4**	**5.0**	**984.3**
Middle-East	**4.5**	**7.2**	**7.5**	**4.3**	**66.9**	**198.5**
Far East	**1.6**	**2.9**	**3.0**	**3.8**	**84.3**	**3,691.9**
of which: China	2.0	4.6	4.9	7.2	149.9	1,332.6
South Korea	5.3	10.1	10.3	1.9	92.8	48.6
India	0.7	1.2	1.3	5.3	80.0	1,140.0
Japan	8.6	9.7	9.0	-7.3	4.7	127.7
Oceania	**13.7**	**16.5**	**16.7**	**1.0**	**22.2**	**25.8**
Annex I countries	**11.8**	**11.2**	**10.9**	**-2.8**	**-7.8**	**1,274.9**
Non-Annex I countries	**1.6**	**2.6**	**2.7**	**4.3**	**69.3**	**5,413.0**
World	**4.0**	**4.4**	**4.4**	**0.3**	**10.3**	**6,687.9**

Source: IEA, October 2010.

Energy-related CO_2 Emissions in Relation to GDP Worldwide



Source: IEA, October 2010.

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 since 1990 (-27% worldwide)**, except in the Middle East (+19%). In China, the large drop observed between 1990 and 2008 (-48%) hides a trend towards an increase of this indicator between 2002 and 2005 (+5% a year). This shift is directly related to China's strong economic growth and the induced increasing energy needs that have been met essentially through the use of coal. In spite of a strong reduction since 1990 (-32%), this ratio stands at a very high level in Russia: a unit of GDP, expressed in $ ppp[1], leads to about one tonne of CO_2 emissions. In the EU-27, particularly in former EU-15, this indicator is rather low compared with the other areas of the world: 0.29 kg CO_2 per $, but 0.47 in the 12 new EU members. With only 0.21 kg CO_2 per $, France is the second best among EU-27, after Sweden, where both nuclear and hydraulics are very developed.

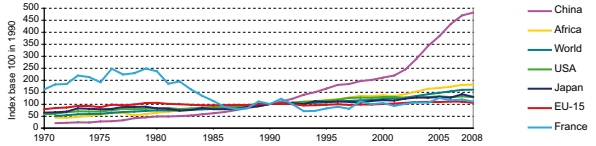
In t CO_2 / million $ 2000 ppp[1]	1990	2007	2008	Change (%) 2007 -2008	Change (%) 1990 -2008	GDP in 2008[2]
North America	**661**	**485**	**469**	**-3.4**	**-29.1**	**13,984**
of which: Canada	660	546	525	-3.9	-20.4	1,049
USA	689	493	477	-3.3	-30.9	11,742
Latin America	**286**	**273**	**271**	**-0.7**	**-5.1**	**3,937**
of which: Brazil	201	220	221	0.7	10.3	1,648
Europe and former USSR	**678**	**416**	**406**	**-2.4**	**-40.2**	**16,485**
of which: EU-27	473	316	307	-3.0	-35.2	12,543
EU-15	404	292	285	-2.5	-29.6	11,033
of which: Germany	549	345	342	-0.9	-37.7	2,352
Spain	316	317	290	-8.5	-8.2	1,095
France	279	214	210	-1.8	-24.7	1,751
Italy	319	279	275	-1.5	-13.7	1,562
United Kingdom	459	284	277	-2.4	-39.7	1,842
12 new EU Members	1,035	502	470	-6.4	-54.6	1,510
of which: Russia	1,430	1,010	965	-4.4	-32.5	1,651
Africa	**407**	**368**	**356**	**-3.2**	**-12.5**	**2,499**
Middle-East	**770**	**907**	**916**	**1.0**	**18.9**	**1,630**
Far East	**563**	**461**	**457**	**-0.9**	**-18.7**	**24,551**
of which: China	1,142	598	593	-0.9	-48.1	11,054
South Korea	511	440	440	0.0	-13.9	1,139
India	419	332	331	-0.4	-20.9	4,310
Japan	371	343	320	-6.7	-13.7	3,598
Oceania	**655**	**548**	**552**	**0.8**	**-15.7**	**679**
Annex I countries	**621**	**433**	**420**	**-3.2**	**-32.4**	**33,137**
Non-Annex I countries	**588**	**473**	**470**	**-0.6**	**-20.1**	**30,729**
World	**628**	**469**	**460**	**-1.9**	**-26.8**	**63,866**

1. Purchasing power parity.
2. in billion $ 2000 ppp.

Source: IEA, October 2010.

3.2 – CO_2 Emissions due to Electricity Plants Production Including CHP Plants

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



Source: IEA, October 2010.

In 2008, global CO_2 emissions from the production of electricity (CHP plants included) reached 12 billion t CO_2 (Gt CO_2). After a growth between 4% and 6% per year from 2003 to 2007, these emissions were almost stable between 2007 and 2008. **In 2008, emissions are 60% higher than in 1990.** China alone is responsible for half of this increase, its emissions quintupling over this period. In the EU-27, these emissions reached 1.4 billion t CO_2, of which 1.1 billion stemmed from the former EU-15. Germany, where coal represents nearly 50% of the electric mix, is responsible for a quarter of all CO_2 released by EU-27 power stations; France, only 3.6%, while at the same time its production of electricity and heat makes 15% of European totals.

In Mt CO_2	1990	2007	2008	Share in emissions linked to energy in 2008 (%) [2]	Change (%) 2007 -2008	Change (%) 1990 -2008	Heat and electricity produced in 2008 (TWh)
North America	**2,029**	**2,716**	**2,637**	**40.2**	**-2.9**	**29.9**	**5,411.5**
of which: Canada	100	129	119	21.7	-7.3	19.7	660.6
USA	1,866	2,459	2,403	42.9	-2.3	28.8	4,492.1
Latin America	**99**	**199**	**216**	**20.2**	**8.4**	**119.2**	**1,069.6**
of which: Brazil	12	33	41	11.3	26.6	238.9	464.1
Europe and former USSR	**3,370**	**2,832**	**2,761**	**41.3**	**-2.5**	**-18.1**	**8,054.8**
of which: EU-27	1,504	1,479	1,409	36.6	-4.7	-6.3	4,017.0
EU-15	1,014	1,115	1,061	33.8	-4.8	4.6	3,324.9
of which: Germany	371	357	337	42.0	-5.5	-9.2	764.5
Spain	65	117	101	31.9	-13.2	57.0	311.1
France	46	55	51	13.8	-7.4	10.1	614.0
Italy	122	142	147	34.2	3.8	19.9	368.6
U. Kingdom	214	203	195	38.2	-3.8	-8.7	400.2
12 new EU Members	490	364	348	49.0	-4.3	-28.9	692.1
of which: Russia	1,162	877	874	54.8	-0.4	-24.8	2,684.7
Africa	**212**	**382**	**384**	**43.2**	**0.7**	**81.4**	**620.7**
Middle-East	**172**	**488**	**530**	**35.5**	**8.7**	**208.5**	**771.2**
Far East	**1,497**	**5,109**	**5,223**	**46.5**	**2.2**	**249.0**	**7,635.7**
of which: China	652	3,060	3,137	47.9	2.5	380.8	4,210.9
South Korea	55	219	230	45.8	4.9	318.8	499.9
India	245	749	804	56.3	7.3	227.6	830.1
Japan	364	512	472	41.0	-7.8	29.7	1,081.8
Oceania	**130**	**228**	**237**	**54.9**	**3.6**	**81.9**	**301.2**
Annex I countries	**5,545**	**5,944**	**5,785**	**41.6**	**-2.7**	**4.3**	**14,141.9**
Non-Annex I countries	**1,962**	**6,011**	**6,203**	**42.9**	**3.2**	**216.1**	**9,722.9**
World	**7,508**	**11,954**	**11,988**	**40.8**	**0.3**	**59.7**	**23,864.7**

Source: IEA, October 2010.

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 23.
2. Ratio between emissions due to electricity production (CHP plants included) and energy-related emissions (see page 16).

3.3 – CO_2 Emission Factors

CO_2 Emission Factors for the Principal Fossil Fuels

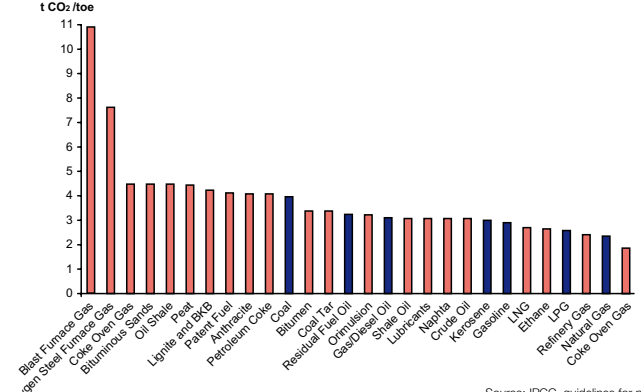
Fuels	Unit: t CO_2/toe
Patent Fuel	4.1
Anthracite	4.1
Bitumen	3.4
Coal (Coking, Sub-bituminous, Other Bituminous)	**4.0**
Coke Oven Coke	4.5
Petroleum Coke	4.1
Gasoline	**2.9**
Ethane	2.6
Residual Fuel Oil	**3.2**
Liquefied Natural Gaz (LNG)	2.7
Coke Oven Gas	1.9
Oxygen Steel Furnace Gaz	7.6
Blast Furnace Gas	10.9
Liquefied Petroleum Gases (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, the petroleum equivalent tons or tep) for the given fuel. 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.

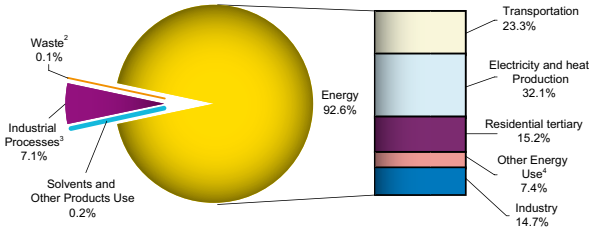
The exceptional case of biomass fuels is not treated here: CO_2 emissions linked to the combustion of biomass fuels are compensated by the absorption of CO_2 during the reconstitution of given fuel. If the reconstitution of the biomass fuel does not occur, the non-compensated emissions are recorded in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



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

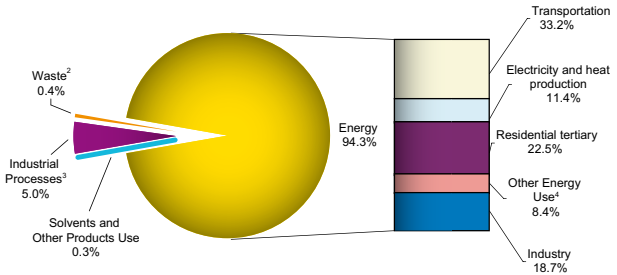
4.1 – Fuel Combustion: the Largest Emitter of CO_2

Distribution by Sources of CO_2 Emissions in the EU in 2008 (4,089 Mt CO_2 Excluding LULUCF[1])



Source: European Environment Agency, June 2010.

Distribution by Sources of CO_2 Emissions in France in 2008 (391 Mt CO_2 Excluding LULUCF[1] and Including Overseas Departments)



Source: European Environment Agency according to CITEPA, June 2010.

Fuel combustion constitutes the main source of CO_2 emissions: 93% of all emissions in Europe and 94% in France. At the EU level, the main emitter is the sector of heat and electricity production (32% of all emissions), before transport (23%). Conversely, in France, the greatest emitter is transport (33%), while heat and electricity production is a rather low emitter (11%) because of a primary nuclear production.

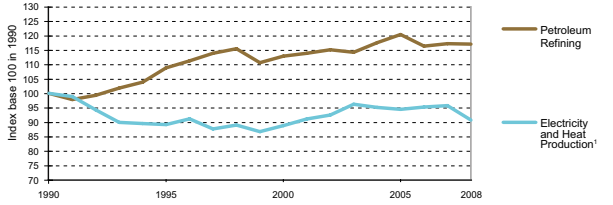
1. Land Use, Land Use Change and Forestry.
2. Excludes the incineration of waste with the recuperation of heat (included in "Electricity and Heat Production"). See page 31.
3. Industry excluding fuel combustion. See page 31.
4. Other industries of energy (oil refining, transformation of solid mineral fuels and others), fugitive emissions and combustion of energy in the agriculture/forestry/fishing sector. See page 23 for the two first sources of emission and page 29 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	2004	2005	2006	2007	2008	1990/2008
Electricity and Heat Production[1]	1,450	1,286	1,379	1,369	1,381	1,388	1,314	-9%
Petroleum Refining	114	129	135	138	133	134	134	17%
Solid Mineral Fuels[2] Conversion and Others	108	75	70	67	66	70	65	-40%
Fugitive Emissions from Fuels[3]	20	20	20	20	20	20	19	-7%
Total	**1,693**	**1,510**	**1,603**	**1,594**	**1,600**	**1,612**	**1,533**	**-9%**

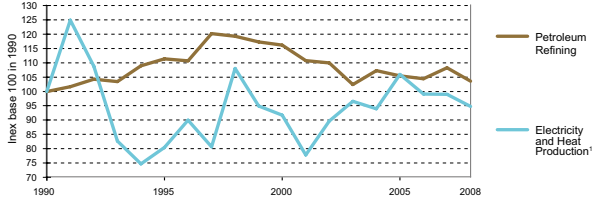


Source: European Environment Agency, June 2010.

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

Unit: Mt CO_2

	1990	2000	2004	2005	2006	2007	2008	1990/2008
Electricity and Heat Production[1]	47.2	43.3	44.4	50.1	46.8	46.8	44.8	-5%
Petroleum Refining	13.2	15.4	14.2	14.0	13.8	14.3	13.7	+4%
Solid Mineral Fuels[2] Conversion and Others	5.0	4.5	4.0	3.8	3.8	3.7	3.6	-27%
Fugitive Emissions from Fuels[3]	4.5	4.2	4.0	3.9	4.2	3.7	4.2	-7%
Total	**70.0**	**67.4**	**66.6**	**71.7**	**68.6**	**68.5**	**66.3**	**-5%**



Source: European Environment Agency according to CITEPA, June 2010.

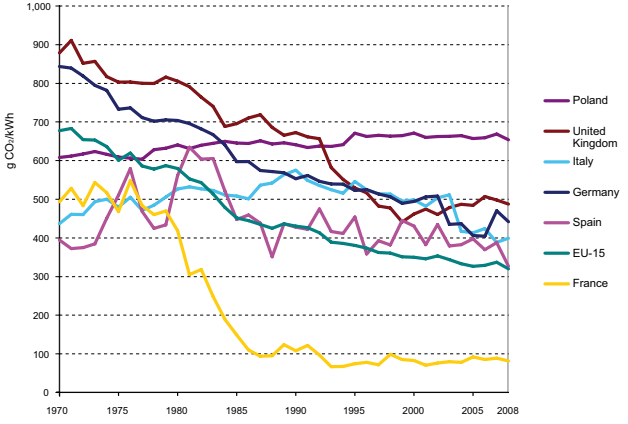
1. Includes the incineration of waste with recuperation of heat.
2. Solid mineral fuels (coal and coal products). Emissions mainly linked to the activity of coking plants.
3. Mainly linked to activities of extraction of fossil fuels (oil, gas and coal).

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

g CO_2 / kWh	1990	2000	2005	2006	2007	2008	Change (%) 2007-2008	Change (%) 1990-2008
UE-27	**NA**	**381**	**355**	**358**	**368**	**351**	**-4.8**	**NA**
UE-15	**430**	**349**	**326**	**328**	**336**	**319**	**-5.1**	**-25.7**
of which: Germany	553	494	405	404	470	441	-6.1	-20.2
Austria	245	180	219	215	196	183	-6.6	-25.3
Belgium	344	284	271	260	253	249	-1.5	-27.7
Spain	427	430	397	369	387	326	-15.8	-23.7
Finland	227	211	193	241	229	187	-18.2	-17.6
France	109	84	93	87	90	83	-8.1	-24.2
Italy	575	498	413	424	388	398	+2.8	-30.6
Netherlands	588	400	387	394	399	392	-1.8	-33.4
United Kingdom	672	461	484	506	497	487	-2.1	-27.5
Sweden	48	42	44	48	40	40	-0.3	-17.3
12 new EU members	**NA**	**517**	**495**	**501**	**521**	**503**	**-3.4**	**NA**
of which: Poland	641	671	657	659	668	653	-2.2	+2.0
Czech Republic	596	595	524	526	557	544	-2.3	-8.7

Source: IEA, October 2010.

Calculated per kWh, emissions of CO_2 are very variable among EU-27 countries. They are very high in countries where coal is an important source of energy, like in Germany and in some Eastern countries. They are weak in countries where renewables and/or nuclear are developed, like in France (nuclear 74%, hydraulics 11%), Sweden (hydraulics 44%, nuclear 43%), and, to a lesser extent, in Belgium (nuclear 55%).

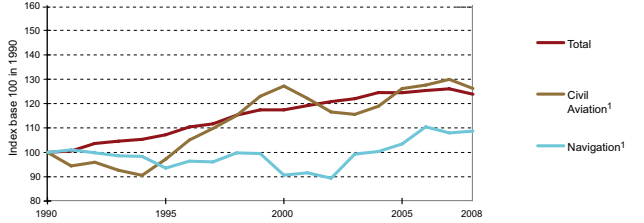


Source: IEA, October 2010.

Transportation-related CO_2 Emissions in the EU

Unit: Mt CO_2

Transportation Sector	1990	2000	2003	2004	2005	2006	2007	2008	1990/2008
Civil Aviation[1]	17	22	20	21	22	22	22	22	+26%
Road Transportation	705	843	879	897	895	900	906	890	+26%
Railways	14	9	9	9	8	8	8	8	-45%
Navigation[1]	20	18	20	20	21	22	22	22	+9%
Other	11	9	9	9	10	10	9	10	-11%
Total	**767**	**901**	**937**	**956**	**955**	**962**	**968**	**951**	**+24%**



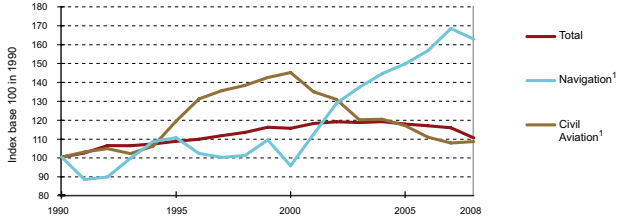
1. Includes domestic transport (and transport between Metropolitan France and Overseas Departments) but excludes international transport.

Source: European Environment Agency, June 2010.

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

Unit: Mt CO_2

Transportation Sector	1990	2000	2003	2004	2005	2006	2007	2008	1990/2008
Civil Aviation[1]	4.2	6.2	5.1	5.1	5.0	4.7	4.6	4.6	+8%
Road Transportation	110.8	127.1	130.9	131.2	129.7	129.1	127.8	121.5	+10%
Railways	1.1	0.8	0.7	0.7	0.6	0.6	0.6	0.6	-45%
Navigation[1]	1.7	1.6	2.3	2.4	2.5	2.7	2.9	2.8	+63%
Other	0.2	0.5	0.7	0.8	1.0	0.7	0.6	0.6	x2.8
Total	**118.0**	**136.1**	**139.7**	**140.3**	**138.8**	**137.7**	**136.4**	**130.1**	**+10%**



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

Source: European Environment Agency according to CITEPA, June 2010.

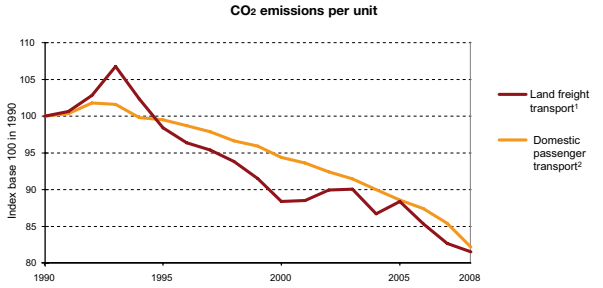
4.3 – Transportation-related CO_2 Emissions

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

Unit: index base 100 in 1990

Index of CO_2 emissions per unit[1]	1990	2000	2004	2005	2006	2007	2008	1990/2008
Domestic passenger transport[1]	100.0	94.4	90.0	88.6	87.4	85.4	82.1	-18%
Land freight transport[2]	100.0	88.4	86.7	88.3	85.3	82.6	81.5	-19%

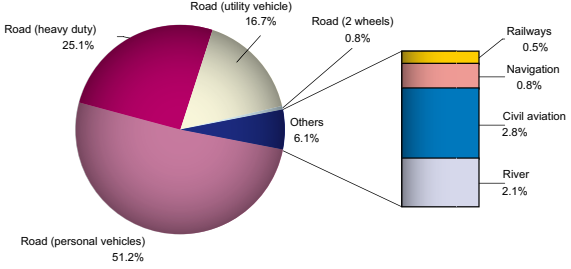
1. Emission of CO_2 per carried km-passenger.
2. CO_2 emissions per metric ton-km of freight.



Source: CITEPA/format SECTEN, April 2010 and SOeS.

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

CO_2 Emission by Method of Transport[1] in Metropolitan France (126.4 Mt CO_2 in 2008)



Source: CITEPA/format SECTEN, April 2010.

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

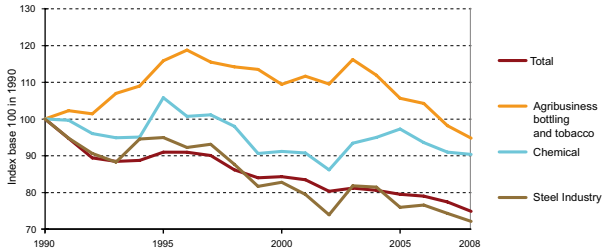
4.4 – Industry-related CO_2 Emissions

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

Unit: Mt CO_2

Industrial sector[1]	1990	2000	2004	2005	2006	2007	2008	1990/2008
Total	802	676	646	637	633	620	600	-25%
of which: steel industry	146	121	119	111	112	108	105	-28%
chemical	91	83	87	89	85	83	82	-10%
agribusiness, bottling and tobacco	42	45	46	44	43	41	39	-5%

1. Including building and civil engineering but excluding energy.



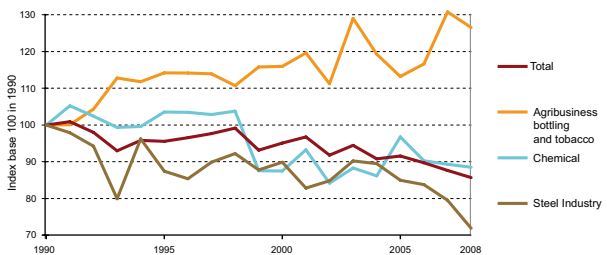
Source: European Environment Agency, June 2010.

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

Unit: Mt CO_2

Industrial sector[1]	1990	2000	2004	2005	2006	2007	2008	1990/2008
Total	85.3	81.1	77.5	78.1	76.5	74.8	73.1	-14%
of which: steel industry	19.3	17.3	17.3	16.4	16.1	15.3	13.9	-28%
chemical	19.9	17.4	17.1	19.2	17.9	17.7	17.6	-12%
agribusiness, bottling and tobacco	8.9	10.4	10.7	10.1	10.4	11.7	11.3	+27%

1. Including building and civil engineering but excluding energy.



European Environment Agency according to CITEPA, June 2010.

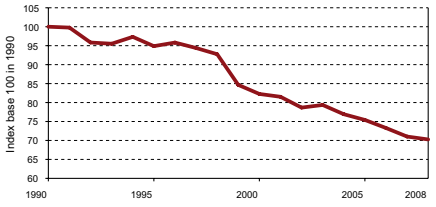
4.4 – Industry-related CO_2 Emissions

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	2004	2005	2006	2007	2008	1990/2008
CO_2 emissions / Value added	100.0	82.3	76.9	75.4	73.3	71.0	70.3	-29.7%

Index of CO_2 emissions per unit

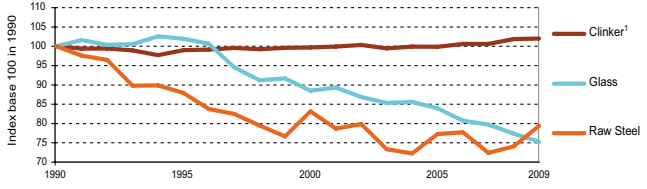


Sources: INSEE (value added), CITEPA (CO_2 emissions).

Individual CO_2 Emissions of Selected Energy-Intensive Products in France

	1990	1995	2000	2004	2005	2006	2007	2008	2009
Raw Steel									
Production (Mt)	19.0	18.10	21.0	20.8	19.5	19.9	19.3	17.9	12.8
t CO_2 / t steel	1.78	1.57	1.48	1.29	1.37	1.38	1.29	1.32	1.41
Glass									
Production (Mt)	4.8	5.08	5.5	5.7	5.6	5.7	5.6	5.2	4.5
t CO_2 / t glass	0.70	0.71	0.62	0.60	0.59	0.56	0.56	0.54	0.52
Clinker[1]									
Production (Mt)	20.9	16.5	16.3	17.2	17.3	17.7	18.0	16.9	14.6
t CO_2 / t clinker	0.87	0.86	0.86	0.86	0.86	0.87	0.87	0.88	0.88

Specific CO_2 emissions



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

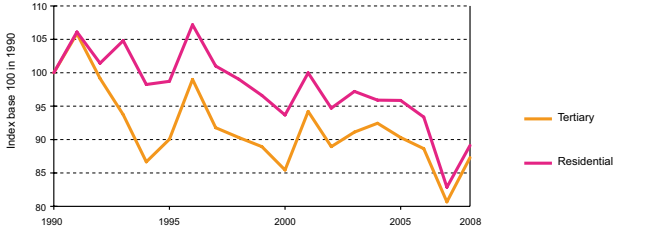
Sources: Fédération Française de l'Acier (FFA), Fédération des Chambres Syndicales de l'Industrie du Verre (FCSIV), Syndicat Français de l'Industrie Cimentière (SFIC).

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	2004	2005	2006	2007	2008	1990/2008
Total	**815**	**731**	**754**	**749**	**729**	**657**	**704**	**-14%**
of which: residential	499	467	478	478	466	413	444	-11%
tertiary	201	172	186	182	178	162	176	-13%



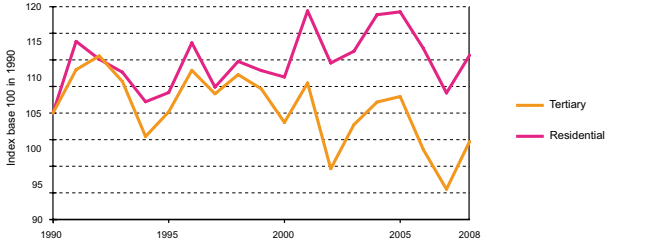
Source: European Environment Agency, June 2010.

Emissions from the residential-tertiary depend on climatic conditions: in the years 1994, 2000, 2002 and 2007, temperatures were particularly mild (severity index below 0.9), so that heating consumption and emissions were rather low.

Energy-related CO_2 Emissions in Other Sectors in France[1] (Overseas Departments Included)

Unit: Mt CO_2

	1990	2000	2004	2005	2006	2007	2008	1990/2008
Total	**95**	**99**	**106**	**107**	**100**	**93**	**99**	**5%**
of which: residential	55	59	65	66	62	57	61	11%
tertiary	29	28	29	30	27	25	27	-5%



Source: European Environment Agency according to CITEPA, June 2010.

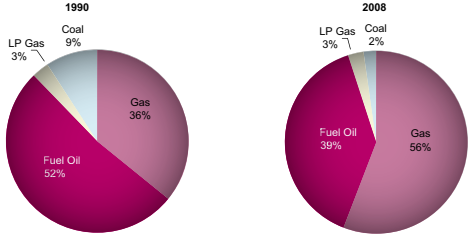
1. Direct emissions of sectors other than energy production and conversion, transportation and industry.

4.5 – CO_2 Emissions in the Other Sectors

Distribution by Fuel Type of Emissions Related to Heating in Metropolitan France

Unit: %

	1990	1995	2000	2004	2005	2006	2007	2008
Gas (excluding LP Gas)	36	42	46	51	52	52	54	56
Fuel Oil	52	48	46	43	42	42	41	39
LP Gas	3	3	4	3	3	3	3	3
Coal	9	7	5	3	3	3	3	2



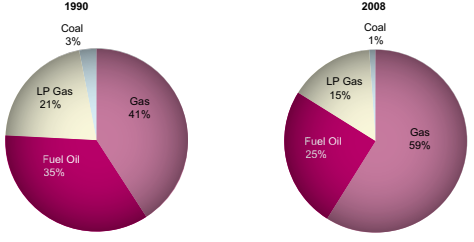
Source: SOeS according to CEREN.

Between 1990 and 2008, among fossil fuels, coal and fuel oil have been substituted for natural gas in the residential / tertiary sectors. That explains the increase in natural gas contribution to CO_2 emissions.

Distribution by Fuel Type of Emissions Related to Water Heating and Cooking in Metropolitan France

Unit: %

	1990	1995	2000	2004	2005	2006	2007	2008
Gas (excluding LP Gas)	41	47	49	53	55	57	57	59
Fuel Oil	35	29	29	29	27	26	26	25
LP Gas	21	21	19	17	17	16	15	15
Coal	3	3	3	1	1	1	1	1



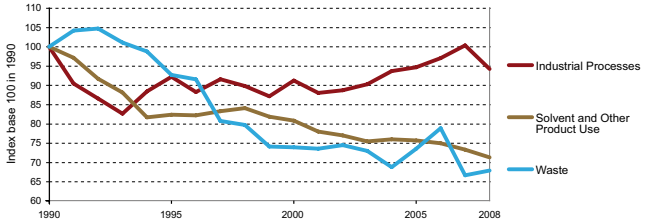
Source: SOeS according to CEREN.

4.6 – CO_2 Emissions excluding Fuel Combustion

CO_2 Emissions Except Fuel Combustion in the EU

Unit: Mt CO_2

	1990	2000	2004	2005	2006	2007	2008	1990/2008
Total	**324,2**	**293,7**	**300,4**	**303,7**	**311,2**	**320,6**	**301,5**	**-7%**
Industrial Processes[1]	307,9	280,8	288,4	291,4	298,8	309,0	290,1	-6%
Solvent and Other Product Use	11,4	9,2	8,7	8,6	8,6	8,4	8,1	-29%
Waste[2]	4,9	3,6	3,4	3,6	3,8	3,2	3,3	-32%

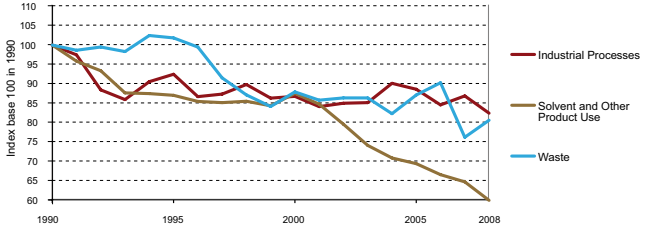


Source: European Environment Agency, June 2010.

CO_2 Emissions Except Fuel Combustion in France (Overseas Departments Included)

Unit: Mt CO_2

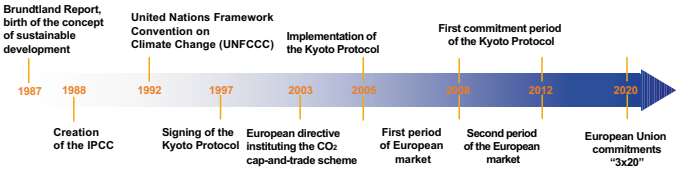
	1990	2000	2004	2005	2006	2007	2008	1990/2008
Total	**27,6**	**24,0**	**24,3**	**24,0**	**23,1**	**23,3**	**22,2**	**-19%**
Industrial Processes[1]	23,6	20,5	21,3	20,9	20,0	20,5	19,5	-18%
Solvent and Other Product Use	2,0	1,7	1,4	1,4	1,3	1,3	1,2	-40%
Waste[2]	2,0	1,7	1,6	1,7	1,8	1,5	1,6	-19%



Source: European Environment Agency according to CITEPA, June 2010.

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

A Major Step in Increasing International Awareness



The United Nations Framework Convention on Climate Change

The UNFCCC, **adopted in 1992** in Rio de Janeiro, is the first international treaty addressing climate change with an aim to prevent dangerous human effects on the climate.

The Treaty recognizes **3 principles**:

- The **precautionary principle**: lack of scientific certainty shall not be used as a reason for postponing cost-effective measures.
- The **principle of common, but differentiated, responsibility**: each signatory country recognizes the effects of its GHG emissions on global warming. The most industrialized countries carry a greater responsibility accrued by their earlier development and historically higher emission levels.
- The **principle of the right to development**: measures will take into consideration the right to economic development of every country.

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.

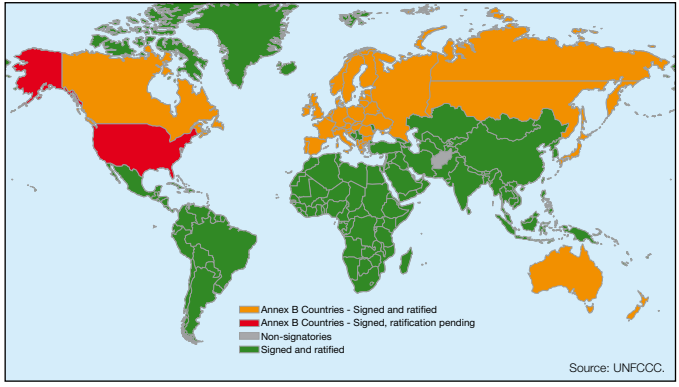
Non-Annex B countries have no set objectives.

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 ratify the Protocol and therefore are not subject to the fixed reduction objectives for 2008-2012.

State of Kyoto Protocol ratification as of 30 September 2010



Kyoto, a Flexible Protocol

To aid Annex B countries in achieving their 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 fixed under the Protocol. Countries can sell AAUs to other countries.

2 & 3. The **Clean Development Mechanism (CDM)** and the **Joint Implementation (JI)** allow countries to fund emissions reductions outside of their national territory against the issuance of **tradable carbon credits**.

Annex B countries must submit as many AAUs and carbon credits as they have 2008-2012 emissions to be **compliant**.
The UNFCCC Secretariat oversees the functioning of the system, through the **International Transaction Log (ITL)**. Each Annex B country is obligated to develop a standardized national registry connected to the ITL.

The global reduction of GHGs by 5% foreseen by the Kyoto Protocol is **divided between the countries** according to their economic development and potential to reduce emissions. This arrangement is referred to as **burden sharing**.

During the Kyoto Protocol negotiations, Eastern European countries benefited from low reduction objectives, allowing them to "catch-up" with the level of developpement of other Annex B countries. Their AAU allowances are substantially higher than their real emission levels. This surplus is called "hot air."

Country	Kyoto objectives for 2008-2012 (in %)*	Yearly average of AAUs received over 2008-2012 (in millions)	2008 emissions (LULUCF excluded)		Distance to Kyoto objective (in % points)
			in Mt CO_2eq	Evolution (in %)*	
EU-15	-8	3,924	3,970	-6	-2
Bulgaria	-8	122	74	-42	34
Czech Republic	-8	179	141	-28	20
Estonia	-8	39	20	-50	42
Hungary	-6	109	73	-36	30
Latvia	-8	24	12	-56	48
Lithuania	-8	46	24	-51	43
Poland	-6	530	396	-30	24
Romania	-8	256	146	-47	39
Slovakia	-8	66	49	-34	26
Slovenia	-8	19	21	5	-13
Australia	8	592	550	31	-23
Belarus**	-8	117	91	-35	27
Canada	-6	558	734	24	-30
Croatia	-5	34	31	-1	-4
Iceland	10	4	5	43	-33
Japan	-6	1,186	1,282	1	-7
Kazakhstan	0	n.p.	246	-24	24
Liechtenstein	-8	<1	<1	15	-23
Monaco	-8	<1	<1	-11	3
New Zealand	0	62	75	23	-23
Norway	1	50	54	8	-7
Russia	0	3,323	2,230	-33	33
Switzerland	-8	49	53	1	-9
Ukraine	0	921	428	-54	54
Total* **	**-5**	**12,147**	**10,460**	**0**	**-4**
United States	-7	not participating	6,925	13	-20

Source: UNFCCC, 2010.

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.

International AAU Exchange Market

From 2008, Annex B countries can **exchange AAUs** for the 2008-2012 period, on the condition that they possess at any given moment at least **90% of all AAUs allocated for the 2008-2012 period**, or the equivalent in AAUs to five times their last GHG emissions inventory.

AAUs can be placed in reserve, that is carried over to the second period of the Kyoto Protocol (post-2012). The **carbon credits coming from the CDM and JI mechanisms** can be equally placed in reserve in each country up to a total of 2.5% of the initial quantity of AAUs allocated.

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**. He receives a **Certified Emission Reduction (CER)** 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.

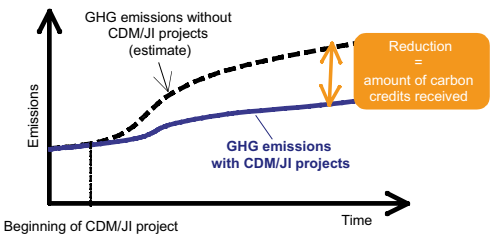
Almost 2.9 billion tonnes of emissions could be avoided by 2012 thanks to the CDM. More than three quarters (81%) will take place in Asia, 13% in South America and only 4% in Africa. Projects dealing with the destruction of industrial gases like **HFCs and N_2O** (24% of the total credits expected by 2012) are being caught up by projects developing **renewable energies** (36% of expected credits) or improving **energy efficiency** (11% of expected credits).

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

JI projects are being 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.

Over 400 million tons of emissions could be avoided through JI projects by 2012. Three quarters will take place in Russia and Ukraine. Most of the emissions reductions deal with methane fugitive emissions, HFC and N_2O industrial gases and the improvement of energy efficiency (25%, 25% and 20%, respectively, of the total credits expected by 2012).

Principle of a project mechanism (CDM or JI)



Source: CDC Climat Research.

5.4 – Other Initiatives to Reduce Emissions

The Copenhagen and Cancún Summits Commitments

International climate negotiations in December 2009 in Copenhagen had to determine emissions reductions targets for the post-2012 period. An in principle agreement was concluded which provides for:

- 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 by developed countries of **funds** for mitigation and adaptation climate policies 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.

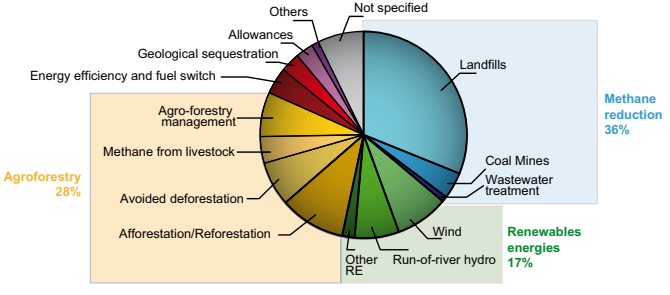
In December 2010, the Cancún Summit resulted in a set of decisions that allow the inclusion of the Copenhagen advances into the UN framework, with only the Bolivian vote against.

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 2009 by project type (Total = 51 Mt CO_2eq)



Source: Ecosystem Marketplace, 2010.

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 out 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 %)*	Yearly average of AAUs received over 2008-2012 (in millions)	2008 emissions (LULUCF** excluded)		Distance to Kyoto objective (in % points)
			in Mt CO_2eq	Evolution (in %)*	
Germany	-21.0	974	958	-22.2	1.2
Austria	-13.0	69	87	10.8	-23.8
Belgium	-7.5	135	133	-7.1	-0.4
Denmark	-21.0	55	65	-7.2	-13.8
Spain	15.0	333	406	42.3	-27.3
Finland	0.0	71	70	-0.3	0.3
France	0.0	564	527	-6.4	6.4
Greece	25.0	134	128	23.1	1.9
Ireland	13.0	63	67	23.0	-10.0
Italy	-6.5	483	541	4.7	-11.2
Luxembourg	-28.0	10	12	-4.8	-23.2
Netherlands	-6.0	200	207	-2.4	-3.6
Portugal	27.0	76	78	32.2	-5.2
United Kingdom	-12.5	682	632	-18.5	6.0
Sweden	4.0	75	64	-11.7	15.7

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

Source: UNFCCC, 2010.

Post Kyoto European Climate Policy

The European Council in March 2007 announced its so-called "3 x 20" 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.

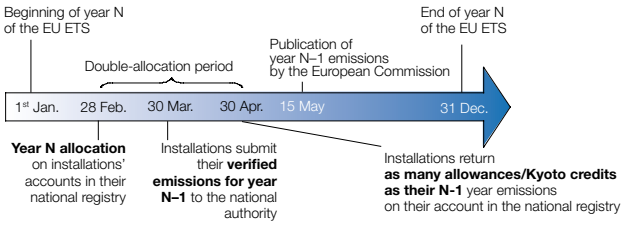
5.6 – The European CO_2 Market (EU ETS)

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 tonne 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

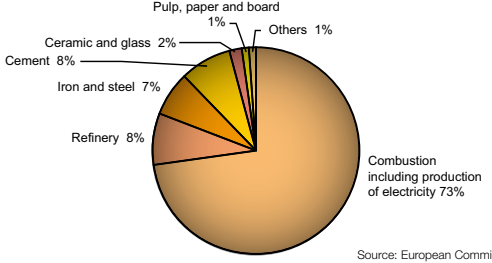


Source: CDC Climat Research.

Covered Sectors

Currently the EU ETS only covers CO_2 emissions.
The energy sector (power and heat production, refinery, coke furnaces) is the most important sector of the EU ETS. Electricity producers alone receive approximately **50% of total allocations**.
The **aviation** sector will be included from 2012. From 2013 on, 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.

EU ETS emissions by sector in 2009



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 each country's **National Allocation Plan (NAP)**, under the supervision of the European Commission.

In the EU ETS phase 3 (2013-2020), the allocation of allowances will be centralized in the hands of the European Commission. The **emissions reduction target of EU ETS sectors has been fixed at -21% for the 2005-2020 period** (-1.74% per year). This target could become more ambitious if a satisfactory international agreement is signed.

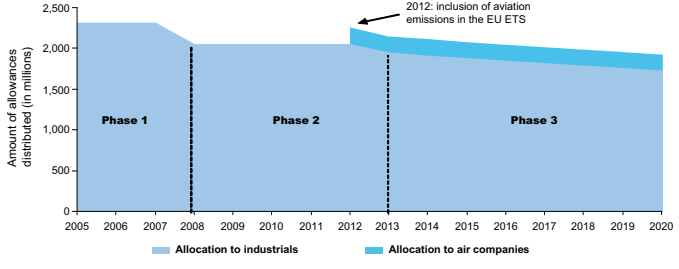
Fewer and Fewer Free Allocations

Until 2012, the share of **auctioned allowances** in the allocation is very small: **0.13% in phase 1 and 3.6% in phase 2**. As of 2013, the auctions will be extended to:
- 100% of the allocation to power generators
- 20% of the allocation other sectors', but increasing steadily to 70% in 2020 and 100% in 2027.

In principle, exemptions to auctions are for sectors at risk of losing competitiveness on international markets to competitors without carbon pricing. Any free allocation will be allocated based on standardised EU-wide best emissions performance benchmarks.

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 starting in 2013.

Evolution of total EU ETS allowance allocation



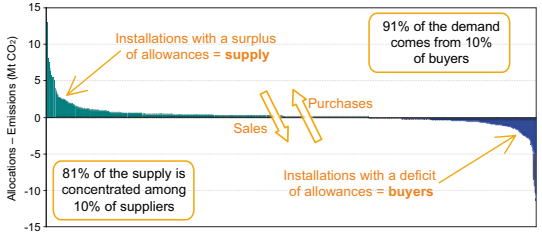
Source: CDC Climat Research, from European Commission data.

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**.

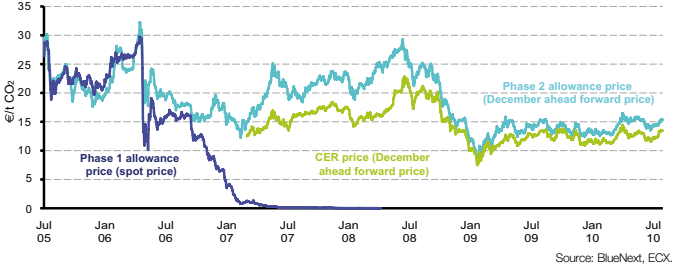
CO_2 buyers and sellers exchange either through bilateral contracts – **"over-the-counter" trades** – or through **exchange platforms**, electronic portals which publicly list prices and quantities.

Net position of EU ETS installations in 2009



Source: CDC Climat Research, based on CITL data.

Price Curves



Source: BlueNext, ECX.

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 amount of allowances **allocated exceeded the total emissions** of covered installations. As **the European Commission has forbidden the banking of allowances** to phase 2, **the price of first period allowances collapsed during 2006/07**, converging to zero by the end of the trial period.

From 2008, this constraint will be lifted. Thus, with the tightening of allocations to installations during second and the third periods (2008-2012 & 2013-2020), a significant price for allowances has been maintained, despite the effect of the economic crisis beginning in 2008.

Long Term Targets

France is one of the lowest GHG emitting industrialized economies in terms of emissions per capita and GDP. This is due to the large share of nuclear energy in its electricity generation mix. In line with the IPCC recommendations, France set a national objective of **dividing GHG's 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 for the decarbonization of the whole French economy.

If all the Grenelle's targets were met, the **reduction in GHG emissions in France would reach 21.8% between 2005 and 2020**, i.e. -22.8% between 1990 and 2020. This reduction would be 18.3% between 2005 and 2020 for non EU ETS sectors, meaning France would overshoot its -14% target set in the EU's Energy-Climate Package.

Main Policies and Measures in Place

Energy sector:

- **Energy saving certificates (ESC)** targeting a 345 TWH saving by 2013;
- Implementation of the **EU's eco-design and EU ETS directives**;
- **Development of renewable energies** to 23% of final energy consumption in 2020, in particular through the financing of a "Renewable Heat Fund" receiving one billion euros over 2009-2011.

Buildings sector:

- **New thermal regulation** in new buildings, with the expansion of low energy consumption buildings with a primary energy consumption below 50kWh/m^2/year on average;
- **"Sustainable development" tax credit** and **Zero Interest Eco-Loans** to give private individuals incentives to renovate existing buildings. As of end of March 2010, the ZIE loans had helped the financing of 100 000 thermal renovations.
- Program of **renovation of the more energy-consuming social housing sites** and commitment to **renovate State-owned buildings**. A first budget allowed for the renovation of 100,000 social houses in 2009 and 2010.

Transport sector:

- **Bonus-malus on new vehicles** which has placed a bonus on the purchase of vehicles emitting less than 120 gCO_2/km and a tax if the vehicle emits more than 150 gCO_2/km;
- **Eco-tax per kilometer** for heavy trucks 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.

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_2eq 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_2eq 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_2eq** are issued **per hectare of tropical forest from deforestation** (burning and decomposition)[6].

Agriculture emits on average in France:

- **3 t CO_2eq/year per dairy cow** because of enteric fermentation[7].
- **0,5 t CO_2eq/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 2010 - 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*