Highlights

Key Figures on Climate
France and Worldwide
2014 Edition

cdc climat research

Caisse des Dépôts GROUP

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

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

Service de l'observation et des statistiques

www.statistiques.developpement-durable.gouv.fr
www.cdcclimat.com/research

Key Figures on Climate France and Worldwide

Foreword

In line with previous editions, the 2014 edition of "Key Figures on Climate" has been prepared within the context of the 19th Conference of the Parties on Climate Change (COP19) held in Warsaw from the 11th to the 22nd of November 2013.

This latest version has been partially revised from the 2013 edition. In particular, data and figures extracted from volume one of the Intergovernmental Panel on Climate Change (IPCC) fifth Assessment Report, released in September 2013, have replaced the previous ones, dating from 2007. Moreover, a section has been added comparing GHG emissions results from "territorial" and "carbon footprint" approaches.

This publication, through its organization and the choice of covered topics, is aimed at informing the widest audience possible about climate change, its geophysical properties, causes and effects as well as the international policy frameworks established to limit its progression.

Authors

Medde - CGDD - SOeS
Sous-direction des statistiques de l'énergie
Frédéric Ouradou
Florine Wong

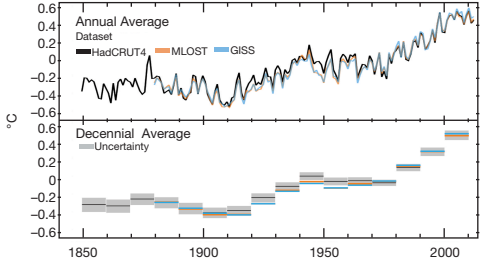
Medde - DGEC - SCEE
Observatoire national sur les effets du réchauffement climatique
Jérôme Duvernoy

CDC Climat Research
Romain Morel

1.1 Global Warming

Estimated Global Atmospheric Temperature since 1850

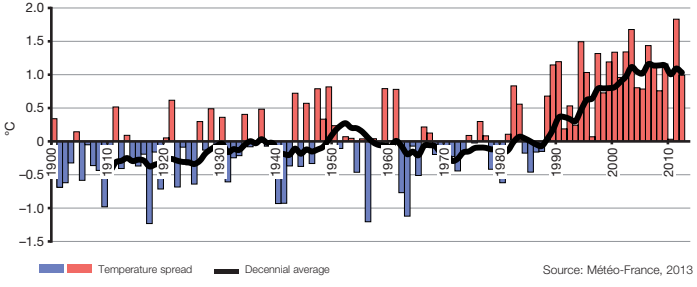
Estimated global mean temperature from 1850 to 2012 compared with the reference period average 1961-1990



Source: IPCC, 1st working group, 2013

> The global average temperature has increased by **0.89°C ±0.2°C** over the **1901-2012** period.
> In metropolitan France, the average temperature has increased by 0.7°C over the century in the northeastern part of the country. The increase is even larger in the southwestern part where it reached 1.1°C.

Mean temperature evolution in Metropolitan France since 1900 compared with the reference period average 1961-1990



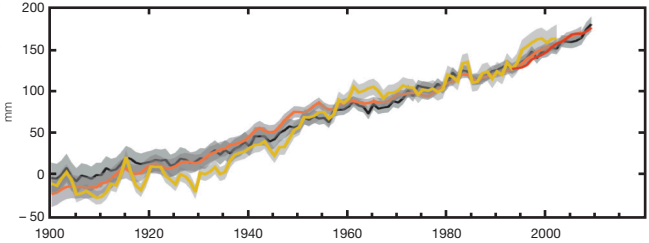
Source: Météo-France, 2013

> In metropolitan France, 2012 (+1°C compared with 1961-1990) followed a warm year (2011, +1.8°C) and a cool year (2010, +0.1°C). However, at the global scale, the last eighteen years (1995-2012) include seventeen of the eighteen warmest years since 1900.

> The average oceanic temperature also increased. Since 1970, the energy accumulated in oceans has been much higher than the energy absorbed by the earth and the atmosphere.

Continuous Increase in Sea Level since the 1900s

Global average sea level compared with the reference period average 1900-1905



Source: IPCC, 1st working group, 2013

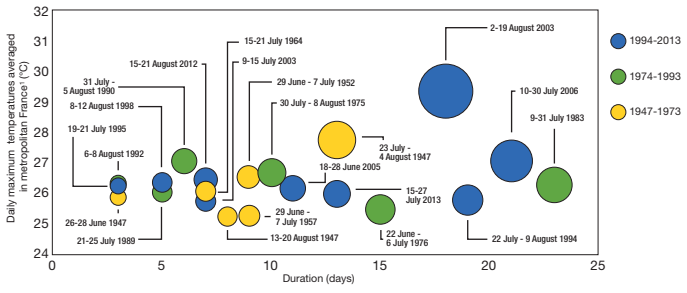
> The global average sea level increased by **1.7 ± 0.3 mm/year** over the **1901-2010** period.
> The rise in sea level has further increased during the last decades to reach **3.2 ± 0,4 mm/year** over the **1993-2010** period.

Extreme Weather Events

> A weather event is classified as extreme when it substantially exceeds baseline trends.

> Climate change modifies the frequency, intensity, scale, duration and time of occurrence of extreme events. It can push the extreme characteristics of these events (tornadoes, hurricanes, as well as heat waves or abnormally heavy rainfalls) to unprecedented levels.

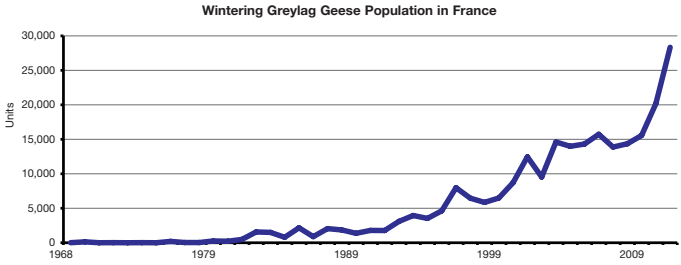
Heat waves in France between 1947 and 2013



1. The average is based on a selection of thirty cities in metropolitan France. The surface of each circle represents the intensity of the heat wave, which depends on its duration and its maximum temperatures.

Source: Météo-France, 2013

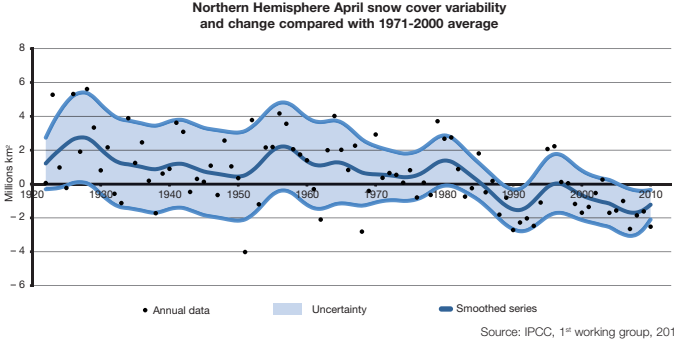
Wintering of Greylag Geese in France



Source: French Birds Protection League, 2012

> In the first half of the 20th century, the Greylag Goose *(Anser anser)* was crossing over France twice a year on the way to wintering grounds located principally in Spain.
> Climatic conditions, linked with climate change, now allow the geese to winter in France as well as in the southern part of the Scandinavian peninsula.

Melting Ice

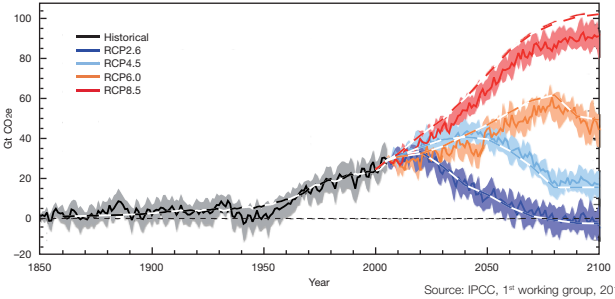


Source: IPCC, 1st working group, 2013

> In the Northern Hemisphere, the snow cover has decreased over the 20th century. The pace of this decline has increased for the last decades. The IPCC estimates that the spring snow cover has decreased by 8% in surface over the 1970-2010 period compared with the 1922-1970 period. The decline of the snow cover decreases the Earth's albedo – *i.e.* its ability to reflect solar energy – and thus contributes to rising temperatures.

IPCC Scenarios

Projection of fossil fuel emissions according to the IPCC's four GHG concentrations pathways (RCPs)

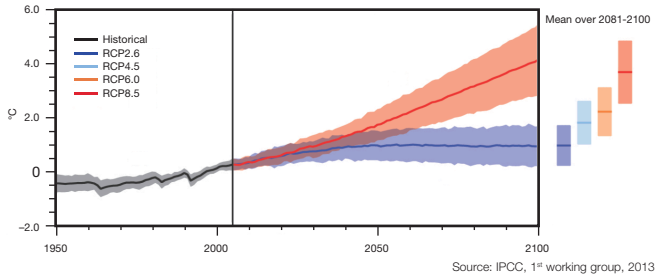


Source: IPCC, 1st working group, 2013

> The IPCC released its First Assessment Report (FAR) in 1990 and will release its complete fifth report (AR5) between 2013 and 2014. In each report, the IPCC publishes climate projections based on different scenarios. For the AR5, four Representative Concentration Pathways (RCPs) were chosen. Climate simulations and socio-economic scenarios were elaborated based on these pathways.

Projected Rise of Global Temperature

Projection of global average surface temperature change according to different RCPs

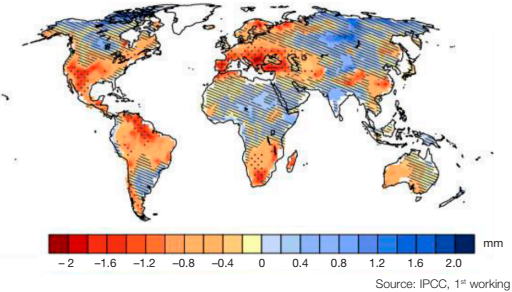


Source: IPCC, 1st working group, 2013

> RCPs produce different results. For instance, climate simulations using the RCP 4.5, which calls for a stabilization of the concentration of GHG emissions at 660 ppm eq. CO_2 after 2011, forecast a rise of the mean temperature by +1.8 ±0,5°C between 2081 and 2100.

Change of Soil Moisture at the end of the 21st century

Change in annual mean soil moisture between 2081 and 2100 compared with 1985-2005 period according to RCP 6.0

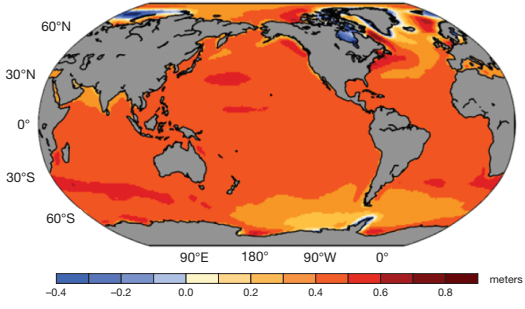


Source: IPCC, 1st working group, 2013

The soil moisture is the mass of water in all phases in the uppermost 10 cm of the soil.
Hatched areas indicate that the average expected change is small compared to typical climatic variations. Stippled areas indicate that the change is more important and there is a higher certainty of climate simulations.
Red areas have higher chance to be affected by increased periods of drought than today.

Projections of Sea Level Rise

Projections of sea level rise in 2100 compared with the year 2000 according to RCP 2.6

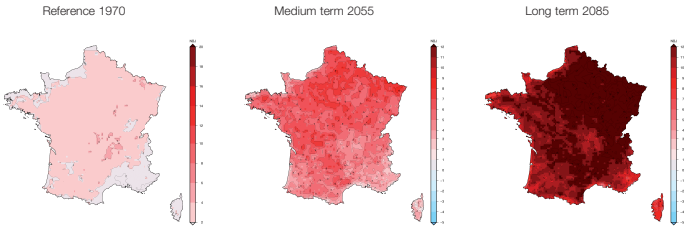


Source: IPCC, 1st working group, 2013

> The main drivers of growth in sea level are the thermal expansion and the melting of terrestrial ice (glaciers, polar ice caps...).
> The increase in sea level is likely to cause heavy migration of populations, since more than a billion people live in low-lying coastal regions.

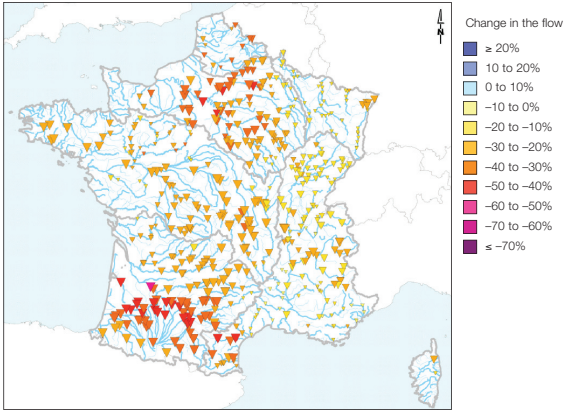
Consequences for France

Number of additionnal abnormally warm days in the future (2007 IPCC A2 scenario)



Source: Drias *les futurs du climat*, 2012

Change in the average annual flow of rivers between the 1961-1990 and 2046-2065 periods

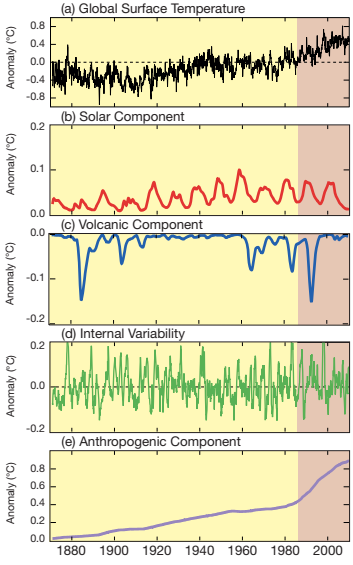


The larger the triangles, the more convergent the results of the different simulations are. Source: Project Explore 2070, Medde

> Overall, all river flows will be reduced. While low water levels will be more severe in the South, no significant change in floods is estimated. The temperature of surface waters will keep rising.

1.4 Factors Affecting the Global Temperature

Change in the Global Temperature since 1900 and Contributions of Natural and Anthropogenic Factors



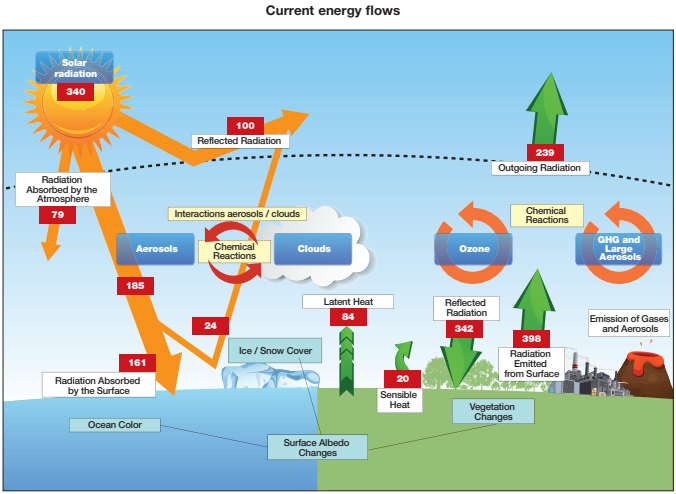
Source: IPCC, 1st working group, 2013

> A combination of natural and anthropogenic factors explains changes in global temperature:

- An internal variability, which explains change over a few years but does not contribute to a long term trend (for instance, the “El Niño” phenomenon);
- Volcanic activity, as aerosol emissions tend to decrease the temperature;
- Variations in solar activity;
- GHG emissions, which are the main anthropogenic contribution.

> According to the IPCC, the average rise in temperature since 1965 is mainly due to GHG emissions.

Role of the Atmosphere in the Greenhouse Effect



The sun supplies energy through its rays to the Earth. A portion of it is directly or indirectly reflected into space while the majority is absorbed by the atmosphere or the Earth's surface. The warmth at the surface of the Earth is principally due to greenhouse gases, which trap the main part of surface radiation.

Source: IPCC, 1st working group, 2013

Human Activities and the Greenhouse Effect

> Increased anthropogenic GHG emissions in the atmosphere augment the part of the energy reflected to the surface, destabilizing the system, and thus causing a rise of the Earth's temperature.

> The change of the radiation induced by an element, compared with a base year, is called radiative forcing. A positive **radiative forcing** indicates a positive contribution to global warming.

> Some human activities such as the emission of aerosols contribute to reducing the energy return towards the surface caused by GHGs but do not compensate it. In 2011, compared with 1750, this radiative forcing is estimated at **–0.45 ± 0.5 W m²**, while anthropogenic GHGs radiative forcing is **+2.83 ± 0,29 W/m²**. Thus, the total anthropogenic radiative forcing reaches **+2.3 ± 1.1 W/m²** in 2011 compared with 1750.

1.6 Greenhouse Gases

Greenhouse Gases

> GHGs other than water vapor make up less than 0.1% of the atmosphere. Water vapor, which fluctuates from 0.4% to 4% in volume, is the main greenhouse gas. It is natural and human activities have little impact on its fluctuations.

Anthropogenic Greenhouse Gases

	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NF_3
Atmospheric concentration 2011 (in 2005 between brackets)	391 ppm (379 ppm)	1,803 ppb (1,774 ppb)	324 ppb (319 ppb)	>119 ppt (>67 ppt)	>83 ppt (>79 ppt)	7.3 ppt (5.6 ppt)	<1 ppt
Lifespan in the atmosphere		~ 9 years	131 years	between 0.1 and 270 years	between 2,000 and 50,000 years	3,200 years	500 years
Global Warming potential (total over 100 years)	1	28-30	265	[1.4; 12,400]	[6,630; 11,100]	23,500	16,100
Anthropogenic sources	Burning of fossil fuels and tropical deforestation	Landfills, agriculture, livestock and industrial processes	Agriculture, industrial processes, use of fertilizer	Aerosols, refrigeration, aluminium smelting			Manufacture of electronic components
Change in radiative forcing due to anthropogenic emissions in 2011 since 1750 (W / m²) (in 2005 between brackets)	+1.82 (+1.66)	+0.48 (+0.47)	+0.17 (+0.16)	+0.02 (+0.01)	+0.05 (+0.05)	+0.004 (+0.003)	+0.0001

ppm = part per million, ppb = part per billion, ppt = part per trillion.

Source: IPCC, 1st working group, 2013

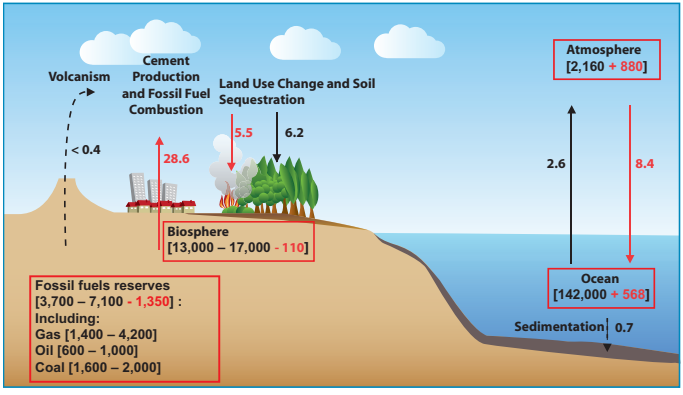
> **The Global Warming Potential (GWP)** is the ratio between the energy reflected towards the surface over 100 years by 1 kg of the gas and that which would be reflected by 1 kg of CO_2. The GWP depends on the concentration and lifespan of each gas. E.g.: 1 kg of CH_4 and between 28 and 30 kg of CO_2 would heat the atmosphere equally over the century following their release.

> **Ozone** – especially in the troposphere – is also a GHG whose radiative forcing increased by **+0.4 W/m²** since 1750.

> Ozone depleting gases governed by the Montreal Protocol (notably **CFCs** and **HCFCs**) are also GHGs. Their total radiative forcing increased by **+0.36 W/m²** since 1750.

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

Simplified CO_2 Cycle during the 2000s



This figure shows (i) between square brackets the size of the pre-industrial reservoirs in billions of tons of CO_2 equivalent in black and their variation over the 1750-2011 period in red ; (ii) arrows represent the annual carbon fluxes between reservoirs. Pre-industrial flows are in black. Flows linked with the development of anthropogenic activities between 2000 and 2009 are in red.

Source: based on IPCC, 1st Working Group, 2013

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

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

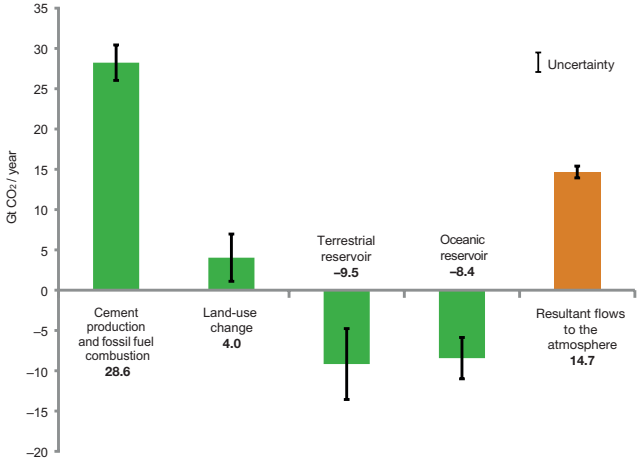
> Flows of carbon between these reservoirs constitute the natural carbon cycle which is disrupted by human activities which change the size of the flows or create new ones. E.g.: the burning of fossil fuels (coal, oil…).

> Over the 2000s, among the 340 billion tons of CO_2 (Gt CO_2) liberated by human activities from the biosphere and the lithosphere, 160 Gt have been absorbed by the atmosphere and 90 Gt by the oceans. The atmosphere is the most affected by human activities: the quantity of carbon absorbed has increased by 40% compared to the pre-industrial era.

1.8 Increase in Atmospheric GHG Levels

Imbalance between Emissions and Storage Capacity

Annual changes in CO_2 over 2000-2009 by source and by reservoir



Source: IPCC, 1st working group, 2013

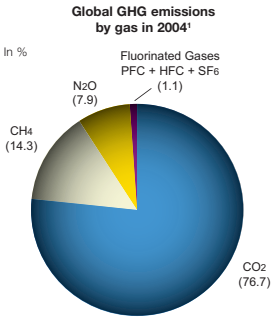
> Since the increase in industrial activities, the terrestrial and oceanic reservoirs have absorbed half of the human-related emissions. The remaining emissions persist in the atmosphere, which has led to **increased concentration of greenhouse gases**.

> Forests are the largest terrestrial carbon reservoir. They store approximately 9.2 Gt CO_2e net emissions per year, equivalent to 33% of global GHG emissions.

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

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

Global GHG Emissions by Gas

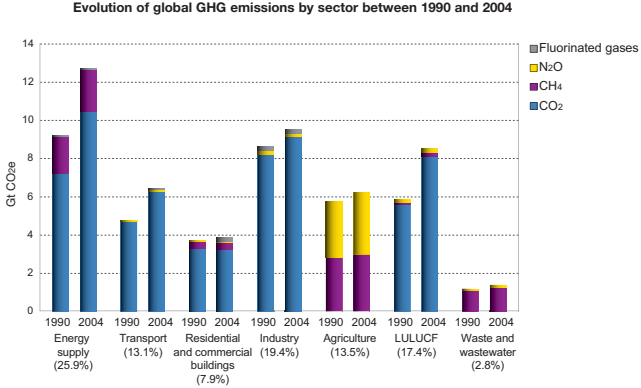


Source: IPCC, 3rd working group, 2007

> 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. Including emissions due to Land Use, Land Use Change and Forestry (LULUCF).
2. Carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulfur hexafluoride (SF_6).

Global GHG Emissions by Sector

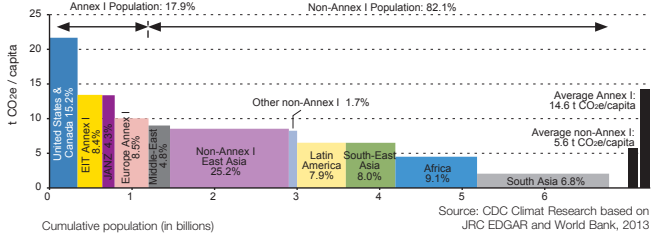


Source: IPCC, 3rd working group, 2007

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

2.1 Overview of Global GHG Emissions

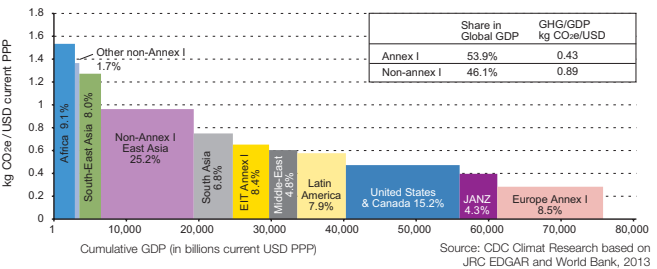
Regional Distribution of GHG Emissions[1] per Capita in 2010



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

> In 2010, Annex I countries of the UNFCCC[2] represented **18% of the world' population**, 54% of global GDP and produced **36% of all the GHG emissions**. In Annex I countries, the average GHG emissions per capita was 14.6 t CO_2e, approximately three times the average in non-Annex I countries. This gap has narrowed since 2004, when it was a factor four.

Regional Distribution of GHG Emissions[1] per Unit of GDP in 2010



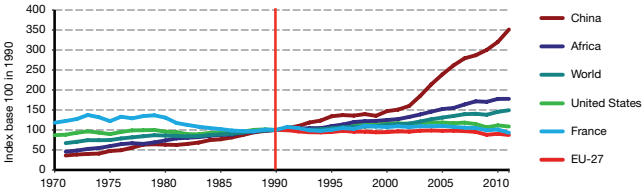
The percentage indicated for each region corresponds to its share in global GHG emissions.
EIT: Economies in Transition, JANZ: Japan, Australia, New Zealand.

> Measured in current USD, and adjusted for purchasing power parity (PPP), the production of one unit of GDP in the Annex I countries resulted in GHG emissions that were on average 50% 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.

Energy-related CO_2 Emissions Worldwide

CO_2 Emissions from Fuel Combustion Worldwide[1]



Source: International Energy Agency (IEA), September 2013

> In 2011, global CO_2 emissions from fuel combustion increased by 2,7%, reaching 31.3 billion tons of CO_2 (Gt CO_2). These emissions grew at a higher rate in emerging countries, particularly in China (+9.7%). With 8.0 Gt CO_2, this country is by far the biggest emitter ahead of the United States (5.3 Gt CO_2). In 2011, these two countries alone emitted 42% of the CO_2 due to fuel combustion.

In Mt CO_2

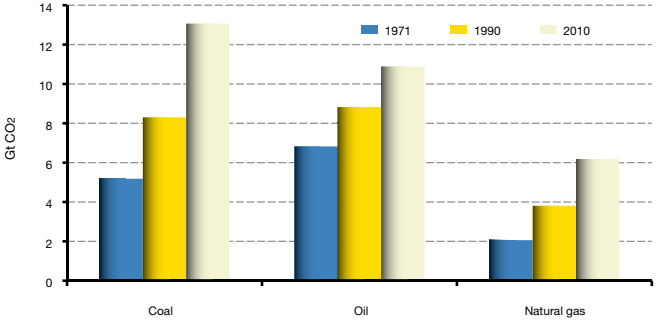
	1990	2010	2011	Share in 2011 (%)	Change (%) 2011/2010	Change (%) 2011/1990
North America	**5,562**	**6,375**	**6,249**	**19.9**	**–2.0**	**+12.4**
of which: Canada	428	528	530	1.7	+0.4	+23.7
USA	4,869	5,429	5,287	16.9	–2.6	+8.6
Latin America	**608**	**1,144**	**1,163**	**3.7**	**+1.7**	**+91.3**
of which: Brazil	192	389	408	1.3	+5.0	+112.1
Europe and former USSR	**7,937**	**6,482**	**6,490**	**20.7**	**+0.1**	**–18.2**
of which: EU-27	4,052	3,667	3,543	11.3	–3.4	–12.6
EU-15	3,082	2,978	2,853	9.1	–4.2	–7.4
of which: Germany	950	769	748	2.4	–2.8	–21.3
Spain	205	268	270	0.9	+0.9	+31.7
France	**353**	**357**	**328**	**1.0**	**–8.0**	**–6.9**
Italy	397	398	393	1.3	–1.4	–1.1
United Kingdom	549	482	443	1.4	–8.1	–19.3
12 new EU members	970	689	690	2.2	+0.1	–28.9
of which: Russia	2,179	1,577	1,653	5.3	+4.9	–24.1
Africa	**544**	**967**	**968**	**3.1**	**+0.1**	**+77.7**
Middle-East	**589**	**1,617**	**1,674**	**5.3**	**+3.5**	**+184.1**
Far East	**4,847**	**12,401**	**13,257**	**42.3**	**+6.9**	**+173.5**
of which: China	2,278	7,294	8,000	25.5	+9.7	+251.2
South Korea	229	564	588	1.9	+4.1	+156.3
India	582	1,710	1,745	5.6	+2.0	+199.7
Japan	1,062	1,138	1,186	3.8	+4.2	+11.7
Oceania	**282**	**427**	**427**	**1.4**	**+0.0**	**+51.3**
Annex I countries	**13,901**	**13,466**	**13,355**	**42.6**	**–0.8**	**–3.9**
Non-Annex I countries	**6,469**	**15,947**	**16,874**	**53.8**	**+5.8**	**+160.8**
International marine and aviation bunkers[2]	**619**	**1,096**	**1,114**	**3.6**	**+1.6**	**+80.0**
World	**20,989**	**30,509**	**31,342**	**100.0**	**+2.7**	**+49.3**

Source: International Energy Agency (IEA), September 2013

1. Emissions from fossil fuel combustion for final use (transport, heating, etc.) or intermediary use (production of electricity, oil refining, etc.). These emissions are assessed by the IEA on the basis of national energy balances. Differences in perimeters and methods of computation (in particular in emission factors) may be noted with chapters 3 and 4 whose data are taken from the inventories of GHG emissions transmitted to the UNFCCC.
2. International marine and aviation bunkers are excluded from national totals.

2.2 Energy-related CO_2 Emissions Worldwide

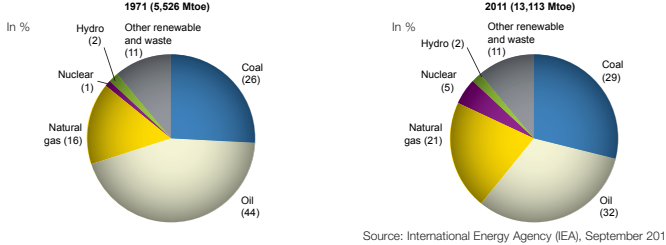
Change in Global Energy-related CO_2 Emissions by Fuel



Source: International Energy Agency (IEA), March 2013

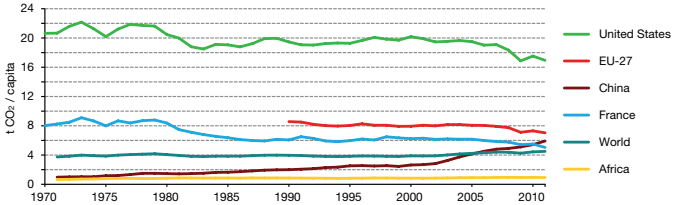
> Fossil fuels (coal, natural gas and oil) account for 82% of the global total primary energy supply (TPES) in 2011 (five points less than in 1971). In the EU-27, this figure drops to 74% and even 49% in France, due to the widespread use of nuclear generation. Worldwide, between 1971 and 2011, the share of oil in the energy mix fell by twelve points while the shares of both nuclear power and natural gas rose by five points respectively. In 2010, coal was the second energy source after oil, providing a quarter of the energy mix. Yet, it was the first CO_2 emitter (43%), because its emission factor is much higher than those of oil and gas (see page 33). The production of renewables has increased at the same pace as the TPES, so that its share in the global mix has not increased in forty years.

Global primary energy mix



Source: International Energy Agency (IEA), September 2013

Energy-related CO_2 Emissions per Capita Worldwide



Source: International Energy Agency (IEA), September 2013

> In 2011, energy-related CO_2 emissions per capita amounted to 4.5 t CO_2/capita. They declined in Annex I countries (–1.3%), while they continued to grow fast in non-Annex I countries (+4.5%). Thus, this indicator is now higher in China (5.9 t CO_2/capita) than in France (5.0 t CO_2/capita). In 2011, an inhabitant of the EU-27 emits an average of 7.0 t CO_2. A French person emits thrice less CO_2 than an inhabitant of the USA, and much less on average than an inhabitant of the other European countries.

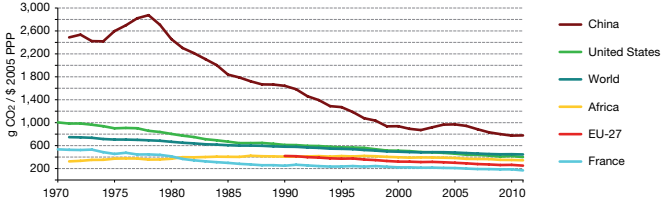
In t CO_2/capita

	1990	2010	2011	Change (%) 2011/2010	Change (%) 2011/1990
North America	**15.5**	**14.1**	**13.7**	**–2.7**	**–11.5**
of which: Canada	15.5	15.5	15.4	–0.7	–0.6
USA	19.5	17.5	16.9	–3.3	–12.9
Latin America	**1.7**	**2.4**	**2.4**	**+0.6**	**+42.2**
of which: Brazil	1.3	2.0	2.1	+4.1	+61.4
Europe and former USSR	**9.4**	**7.3**	**7.3**	**–0.3**	**–22.9**
of which: EU-27	8.6	7.3	7.0	–3.6	–17.9
EU-15	8.4	7.5	7.1	–4.6	–15.3
of which: Germany	12.0	9.4	9.1	–2.8	–23.6
Spain	5.3	5.8	5.9	+0.8	+11.4
France	**6.1**	**5.5**	**5.0**	**–8.4**	–16.9
Italy	7.0	6.6	6.5	–1.8	–7.6
United Kingdom	9.6	7.7	7.1	–8.8	–26.4
12 new EU members	9.1	6.7	6.7	+0.3	–26.5
of which: Russia	14.7	11.1	11.6	+4.9	–20.7
Africa	**0.9**	**0.9**	**0.9**	**–2.2**	**+7.7**
Middle-East	**4.5**	**7.6**	**7.7**	**+1.4**	**+72.0**
Far East	**1.6**	**3.3**	**3.5**	**+5.9**	**+109.8**
of which: China	2.0	5.4	5.9	+9.2	+196.5
South Korea	5.3	11.4	11.8	+3.3	+120.7
India	0.7	1.4	1.4	+0.6	+110.9
Japan	8.6	8.9	9.3	+4.4	+8.0
Oceania	**13.7**	**15.9**	**15.7**	**–1.3**	**+14.3**
Annex I countries	**15.1**	**17.7**	**17.4**	**–1.3**	**+15.1**
Non-Annex I countries	**1.6**	**2.9**	**3.0**	**+4.4**	**+89.4**
World	**4.0**	**4.4**	**4.5**	**+1.6**	**+13.5**

Source: International Energy Agency (IEA), September 2013

2.2 Energy-related CO_2 Emissions Worldwide

Energy-related CO_2 Emissions in relation to GDP Worldwide



Source: International Energy Agency (IEA), September 2013

> The amount of CO_2 released by the creation of one unit of GDP has decreased in all geographic areas between 1990 and 2010 (–23% worldwide), except in the Middle East (+27%). In China, this ratio has been halved since 1990. Yet, it remains high, as in Russia: in these two countries, one unit of GDP, expressed in $ 2005 PPP[1], leads to nearly 800 g of CO_2 emissions, while the global average is 446 g CO_2. In the EU-27, this indicator is rather low (251 g CO_2/$). With only 168 g CO2/$, France is the second best performer of the EU-27, behind Sweden, where both nuclear and hydraulics are also very developed.

In t CO_2 / million $ 2005 PPP[1]

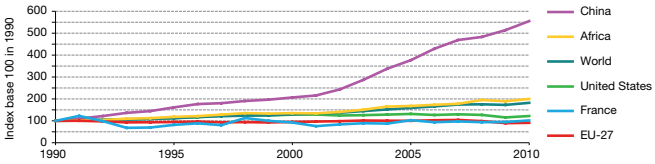
	1990	2010	2011	Change (%) 2011/2010	Change (%) 2011/1990
North America	**582**	**409**	**392**	**–3.9**	**–32.6**
of which: Canada	572	439	430	–2.2	–24.9
USA	611	418	400	–4.3	–34.6
Latin America	**270**	**256**	**249**	**–2.7**	**–7.5**
of which: Brazil	179	197	202	+2.2	+12.7
Europe and former USSR	**595**	**351**	**343**	**–2.3**	**–42.3**
of which: EU-27	419	264	251	–4.9	–40.2
EU-15	358	244	230	–5.5	–35.8
of which: Germany	462	280	264	–5.6	–42.8
Spain	267	216	217	+0.5	–18.7
France	**249**	**186**	**168**	**–9.8**	**–32.8**
Italy	295	243	239	–1.7	–19.0
United Kingdom	421	236	215	–9.0	–49.0
12 new EU members	910	407	396	–2.7	–56.5
of which: Russia	1,164	782	786	+0.5	–32.5
Africa	**408**	**349**	**344**	**–1.5**	**–15.7**
Middle-East	**491**	**628**	**621**	**–1.1**	**+26.5**
Far East	**605**	**540**	**545**	**+0.9**	**–10.0**
of which: China	1,643	774	778	+0.5	–52.7
South Korea	490	427	429	+0.5	–12.6
India	551	460	439	–4.5	–20.3
Japan	324	288	302	+4.8	–6.9
Oceania	**576**	**459**	**446**	**–3.0**	**–22.7**
Annex I countries	**548**	**365**	**355**	**–2.6**	**–35.2**
Non-Annex I countries	**599**	**517**	**516**	**–0.2**	**–13.8**
World	**580**	**450**	**446**	**–1.0**	**–23.2**

1. Purchasing power parity.

Source: International Energy Agency (IEA), September 2013

CO_2 Emissions due to Electricity Production Worldwide

CO_2 Emissions due to Electricity Production[1] Worldwide



Source: International Energy Agency (IEA), March 2013

> In 2010, global CO_2 emissions due to electricity generation (including CHP plants) reached 11.3 Gt CO_2. They have been rising steadily since 1990, by +3% per year on average. However, in the EU-27, these emissions shrank by –9% over the same period, amounting to 1.1 Gt CO_2 in 2010. Germany, where coal accounts for 44% of the electricity mix, is responsible for a quarter of all the CO_2 released by EU-27 power stations. France accounts only for 2% of the European CO_2 emissions, although its production of electricity represents 17% of the European total.

In Mt CO_2

	1990	2009	2010	Share in energy-related emissions in 2010 (%) [2]	Change (%) 2010/2009	Change (%) 2010/1990
North America	**2,026**	**2,381**	**2,511**	**40.2**	**+5,5**	**+23,9**
of which: Canada	99	108	113	21.4	+4,6	+14,6
USA	1,864	2,154	2,274	43.0	+5,6	+22,0
Latin America	**98**	**208**	**235**	**20.2**	**+12,8**	**+138,9**
of which: Brazil	12	30	45	11.0	+49,2	+264,1
Europe and former USSR	**2,152**	**1,858**	**1,884**	**29.0**	**+1,4**	**–12,4**
of which: EU-27	1,266	1,131	1,151	32.5	+1,7	–9,0
EU-15	947	874	885	31.0	+1,3	–6,5
of which: Germany	332	273	287	38.4	+5,2	–13,7
Spain	65	87	71	26.4	–17,6	+10,5
France	**44**	**41**	**45**	**13.6**	**+7,6**	**+1,8**
Italy	122	119	121	30.9	+2,4	–0,9
United Kingdom	214	169	173	39.0	+2,2	–19,0
12 new EU members	320	258	266	38.6	+3,4	–16,7
of which: Russia	440	398	397	24.0	–0,0	–9,6
Africa	**212**	**401**	**423**	**43.7**	**+5,5**	**+99,9**
Middle-East	**179**	**561**	**596**	**35.6**	**+6,1**	**+233,1**
Far East	**1,411**	**5,099**	**5,467**	**41.2**	**+7,2**	**+287,3**
of which: China	581	2,987	3,227	40.3	+8,0	+455,3
South Korea	55	237	265	45.1	+11,6	+383,0
India	235	857	876	50.2	+2,2	+272,8
Japan	363	434	463	39.0	+6,6	+27,3
Oceania	**130**	**216**	**210**	**49.1**	**–2,6**	**+62,0**
Annex I countries	**4,414**	**4,623**	**4,790**	**35.9**	**+3,6**	**+8,5**
Non-Annex I countries	**1,794**	**6,103**	**6,522**	**38.7**	**+6,9**	**+263,5**
World	**6,208**	**10,726**	**11,312**	**36.1**	**+5,5**	**+82,2**

Source: International Energy Agency (IEA), March 2013

1. Includes emissions related to electricity generation (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 generation sector. This is a reason why these figures are different from those of page 24.
2. Ratio between emissions due to electricity generation (including CHP plants) and energy-related emissions (page 15).

3.1 Overview of GHG Emissions in Europe

2011 GHG Emissions in EU-27

In Mt CO_2e

Sector	Year	CO_2	CH_4	N_2O	Fluorinated gases	Total
Energy	1990	4,108.5	154.1	34.1	0.0	4,296.8
	2011	3,507.4	74.3	32.3	0.0	3,614.0
Industrial Processes	1990	281.8	1.3	115.3	59.2	457.7
	2011	226.1	1.1	13.2	91.3	331.7
Solvent and Other Product Use	1990	11.7	0.0	5.0	0.0	16.7
	2011	6.9	0.0	3.2	0.0	10.1
Agriculture	1990	0.0	250.3	349.3	0.0	599.6
	2011	0.0	192.5	268.5	0.0	461.0
Waste[1]	1990	4.9	185.4	13.3	0.0	203.6
	2011	3.1	116.2	14.2	0.0	133.4
Total emissions excluding LULUCF[2]	**1990**	**4,407.0**	**591.2**	**517.0**	**59.2**	**5,574.4**
	2011	**3,743.4**	**384.1**	**331.4**	**91.3**	**4,550.2**
LULUCF[2]	1990	–264.1	4.6	4.6	0.0	–254.9
	2011	–298.3	4.5	3.7	0.0	–290.1
Total	**1990**	**4,142.9**	**595.9**	**521.6**	**59.2**	**5,319.5**
	2011	**3,445.1**	**388.6**	**335.1**	**91.3**	**4,260.1**

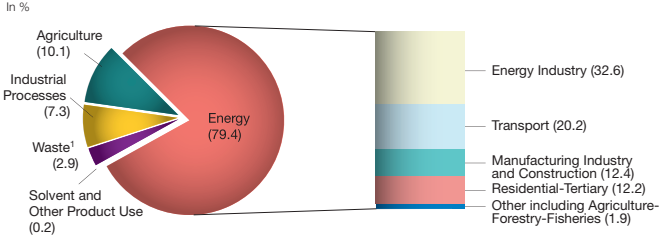
Source: European Environment Agency, June 2013

> **GHG emissions excluding LULUCF[2] in Europe decreased by 18% over the 1990-2011 period.**

> At the EU level, energy use is the main source of GHG emissions (79%). The main emitter is the energy industry (33%), followed by transportation (20%).

> EU emissions decreased by 3.3% between 2010 and 2011. It is mainly due to the warm winter which reduced the needs for heating.

Distribution by sources of GHG emissions in the EU in 2011 (4,550 Mt CO_2e excluding LULUCF[2])



Source: European Environment Agency, June 2013

1. Excluding the incineration of waste with recuperation of heat (included in "Energy industry"). See page 32.
2. Land Use, Land Use Change and Forestry.

2011 GHG Emissions in France

In Mt CO_2e

Sector	Year	CO_2	CH_4	N_2O	Fluorinated gases	Total
Energy	1990	369.0	10.5	3.8	0.0	383.3
	2011	337.6	2.7	4.1	0.0	344.4
Industrial Processes	1990	24.2	0.1	24.6	10.1	58.9
	2011	18.0	0.1	1.2	16.8	36.1
Solvent and Other Product Use	1990	2.0	0.0	0.1	0.0	2.1
	2011	1.0	0.0	0.1	0.0	1.1
Agriculture	1990	0.0	39.0	60.5	0.0	99.6
	2011	0.0	38.2	53.0	0.0	91.2
Waste[1]	1990	1.7	9.3	1.6	0.0	12.6
	2011	1.4	10.2	1.3	0.0	12.8
Total emissions excluding LULUCF[2]	**1990**	**397.0**	**58.9**	**90.5**	**10.1**	**556.4**
	2011	**358.1**	**51.1**	**59.6**	**16.8**	**485.5**
LULUCF[2]	1990	–25.8	1.2	1.8	0.0	–22.8
	2011	–47.7	1.6	1.4	0.0	–44.6
Total	**1990**	**371.2**	**60.1**	**92.3**	**10.1**	**533.6**
	2011	**310.3**	**52.7**	**61.1**	**16.8**	**440.9**

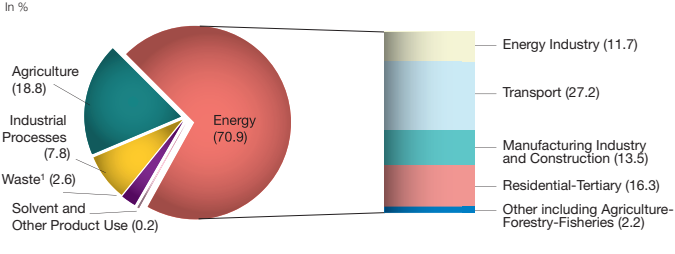
Source: Citepa, June 2013

> **GHG emissions excluding LULUCF[2] in France decreased by 13% over the 1990-2011 period.**

> As the EU, energy use is the main source of GHG emissions in France (71%). On the other hand, in France, transportation is the most emitting sector (27%), while the energy industry is a rather low emitter (12%), because of the primary nuclear production.

> French emissions decreased by 5.6% between 2010 and 2011.

Distribution by sources of GHG emissions in France in 2011 (486 Mt CO_2e excluding LULUCF[2])

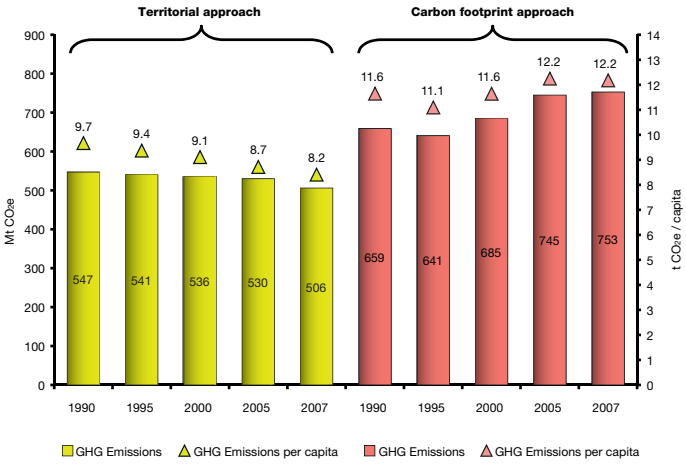


Source: European Environment Agency, June 2013

1. Excluding the incineration of waste with recuperation of heat (included in "Energy industry"). See page 32.
2. Land Use, Land Use Change and Forestry.

3.3 Carbon Footprint and Emissions from Imported Goods

GHG Emissions in France according to the Territorial Approach and the Carbon Footprint Approach in 2009



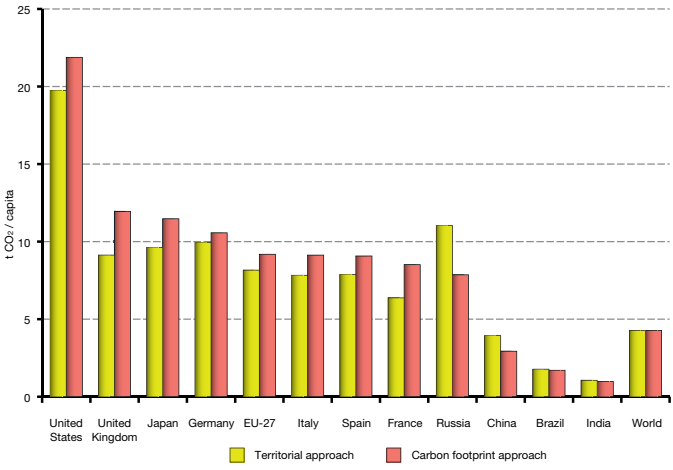
Source: IEA, Citepa, DGDDI, Eurostat, Insee, SOeS calculations (carbon footprint approach), UNFCCC (territorial approach, 2009 version of the national GHG emissions inventory)

> In the Territorial Approach, chosen by the Kyoto Protocol, GHG emissions are accounted for where they are emitted. In the Footprint Approach, emissions related to the final domestic demand are assessed, by adding emissions induced by imported products and by deducting those incurred by products manufactured on the domestic territory and exported.

> In 2007, according to the Territorial Approach, France emitted 506 million tons of CO_2 equivalent (Mt CO_2e) of GHG (CO_2, CH_4 and N_2O), *i.e.* 8.2 tons per capita. These emissions dropped by 7% compared to their 1990 level. However, with the Foootprint Approach, they amount to 752 Mt CO_2e in 2007, *i.e.* 12.2 tons per capita.

> Territorial emissions represented in 2007 only 67% of the Footprint Approach emissions, compared to 83% in 1990. This evolution is due to the expansion of the French service sector, and in contrast, to the decline of industry and agriculture, which are big emitters of respectively CO_2 and methane (CH_4). As such, a growing part of emissions related to the French domestic demand is imported.

Comparison of Worldwide CO_2 Emissions according to the Territorial Approach and the Carbon Footprint Approach in 2005



Source: OECD

> In 2005, the EU-27 CO_2 emissions amounted to 8.2 tons of CO_2 per capita according to the Territorial Approach, but 9.2 tons when using the Footprint Approach, which takes into account emissions from imported products — a ratio of 89%. In the United Kingdom and France, this ratio is lower, around 75%. The gap between the two measures can be explained by the size of the services sector, which is a lower emitter than industry, in both countries. Conversely, in China and Russia, this ratio is higher than 130%. This confirms its role as the "world factory" for the first one and the importance of the energy sector, which is a big emitter of CO_2, in the second one.

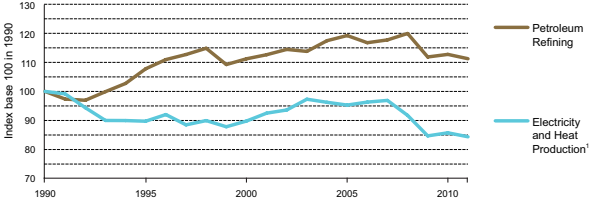
> On a global scale, emissions amount to 4.3 tons of CO_2 per capita. This total figure is, by definition, identical in both approaches.

4.1 GHG Emissions from Energy Industry

GHG Emissions from Energy Industry in the EU

In Mt CO_2e

	1990	2000	2005	2010	2011	2011/1990 (%)
Electricity and Heat Production[1]	1,435	1,288	1,367	1,229	1,210	–16
Petroleum Refining	118	131	141	133	131	+11
Solid Mineral Fuels[2] Conversion and Others	115	83	77	66	65	–43
Fugitive Emissions from Fuels[3]	154	110	93	79	78	–49
Total	**1,822**	**1,612**	**1,678**	**1,507**	**1,484**	**–19**



Source: European Environment Agency (EEA), June 2013

GHG Emissions from Energy Industry in France
(including Overseas Departments)

In Mt CO_2e

	1990	2000	2005	2010	2011	2011/1990 (%)
Electricity and Heat Production[1]	47.3	44.3	50.3	46.5	38.3	–19
Petroleum Refining	12.0	13.7	13.5	11.7	11.4	–5
Solid Mineral Fuels[2] Conversion and Others	5.0	4.3	3.8	3.3	3.2	–35
Fugitive Emissions from Fuels[3]	9.7	7.6	5.0	4.4	4.1	–58
Total	**74.0**	**69.9**	**72.7**	**65.9**	**57.0**	**–23**

Source: Citepa, June 2013

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

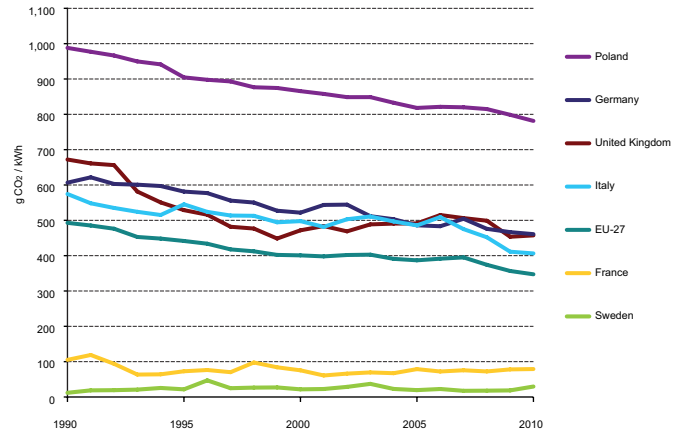
CO_2 Emissions per kWh of Electricity in the EU

In g CO_2/kWh

	1990	2000	2009	2010	Change (%) 2010/2009	Change (%) 2010/1990
EU-27	**493**	**401**	**357**	**347**	**–2.6**	**n.a.**
EU-15	**442**	**362**	**321**	**310**	**–3.2**	**–29.8**
of which: Germany	607	522	467	461	–1.2	–24.0
Austria	238	170	158	188	+19.2	–21.0
Belgium	347	291	218	220	+0.7	–36.7
Spain	427	430	297	238	–19.8	–44.3
Finland	188	173	190	229	+20.8	+21.8
France	**105**	**75**	**78**	**79**	**+1.3**	**–24.7**
Italy	575	498	411	406	–1.2	–29.3
Netherlands	607	477	420	415	–1.2	–31.7
United Kingdom	672	472	453	457	+0.9	–31.9
Sweden	12	22	19	30	+58.6	+149.0
12 new EU members	**752**	**648**	**576**	**577**	**+0.2**	**nd**
of which: Poland	988	866	799	781	–2.2	–20.9
Czech Republic	744	728	588	589	+0.1	–20.8

Source: International Energy Agency (IEA), March 2013

> Calculated per kWh, emissions of CO_2 vary widely among EU-27 countries. They are very high (more than 400 g CO_2/kWh) in countries where coal is an important source of energy, for instance in Germany and in some Eastern countries. They are lower in countries where renewables and/or nuclear are developed, like France (nuclear 76%, hydro 11%) and Sweden (hydro 45%, nuclear 39%).



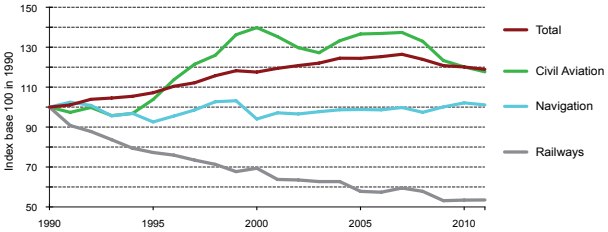
Source: International Energy Agency (IEA), March 2013

4.2 GHG Emissions from Transportation

GHG Emissions from Transportation[1] in the EU

In Mt CO_2e

Mode of Transport	1990	2000	2005	2010	2011	2011/1990 (%)
Civil Aviation	14	19	19	17	16	+18
Road Transportation	718	855	908	877	869	+21
Railways	14	9	8	7	7	–47
Navigation	19	18	19	19	19	+1
Other	10	9	10	9	9	–6
Total	**774**	**910**	**963**	**930**	**921**	**+19**



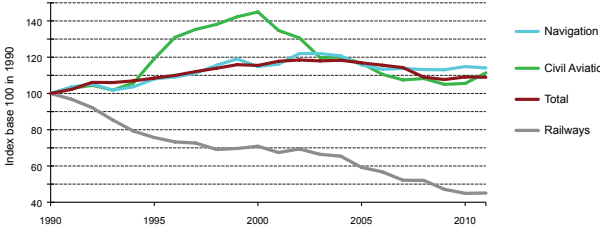
NB: road transportation is not represented on this figure for visibility reasons, since it almost duplicates the total line.

Source: European Environment Agency (EEA), June 2013

GHG Emissions from Transportation[2] in France (including Overseas Departments)

In Mt CO_2e

Mode of Transport	1990	2000	2005	2010	2011	2011/1990 (%)
Civil Aviation	4.3	6.2	5.0	4.5	4.8	+11
Road Transportation	114.5	131.2	133.8	125.4	125.0	+9
Railways	1.1	0.8	0.6	0.5	0.5	–55
Navigation	1.1	1.2	1.3	1.2	1.2	+14
Other	0.2	0.5	0.9	0.5	0.5	+133
Total	**121.2**	**140.0**	**141.7**	**132.2**	**132.0**	**+9**



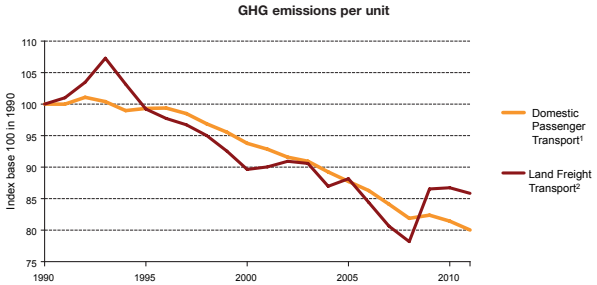
1. Excludes international transport.
2. Includes transport between Metropolitan France and Overseas Departments, but excludes international transport.

Source: Citepa, June 2013

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

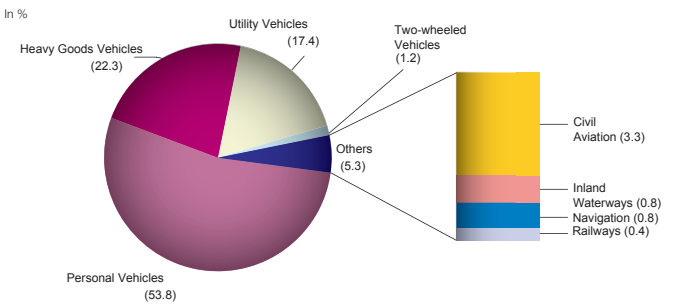
In index base 100 in 1990

GHG emissions per unit	1990	2000	2005	2010	2011
Domestic Passenger Transport[1]	100	93.8	87.7	81.4	80.0
Land Freight Transport[2]	100	89.6	88.2	86.7	85.8



Source: Citepa, June 2013 and SOeS

GHG Emissions by Transportation Mean[3] in Metropolitan France (132.0 Mt CO_2e in 2011)



Source: Citepa, June 2013

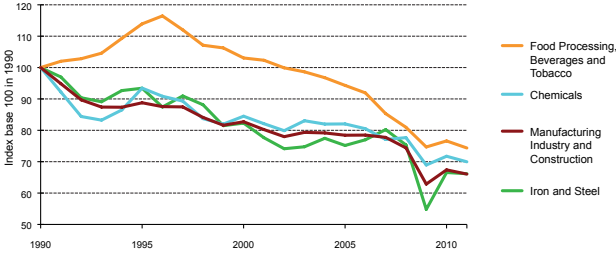
1. GHG emissions per carried km-passenger.
2. GHG emissions per metric ton-km of freight.
3. Includes transport inside Metropolitan France only.

4.3 GHG Emissions from Manufacturing Industry and Construction

GHG Emissions from Manufacturing Industry and Construction in the EU

In Mt CO_2e

Manufacturing Industry and Construction	1990	2000	2005	2010	2011	2011/1990 (%)
Total	**854**	**706**	**670**	**576**	**564**	**–34**
of which: Iron and Steel	184	152	139	123	122	–34
Chemicals	132	111	108	94	92	–30
Food Processing, Beverages and Tobacco	54	56	51	41	40	–26

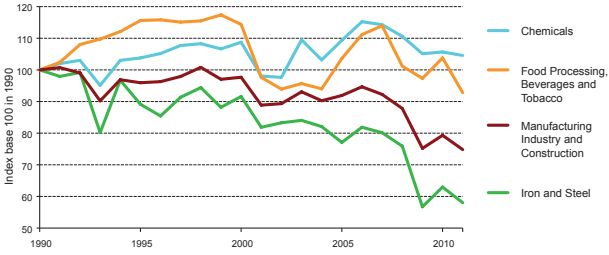


Source: European Environment Agency (EEA), June 2013

GHG Emissions from Manufacturing Industry and Construction in France (including Overseas Departments)

In Mt CO_2e

Manufacturing Industry and Construction	1990	2000	2005	2010	2011	2011/1990 (%)
Total	**87.4**	**85.4**	**80.4**	**69.4**	**65.4**	**–25**
of which: Iron and Steel	22.5	20.6	17.3	14.2	13.0	–42
Chemicals	19.9	21.7	21.8	21.0	20.8	+5
Food Processing, Beverages and Tobacco	9.3	10.6	9.6	9.7	8.6	–7



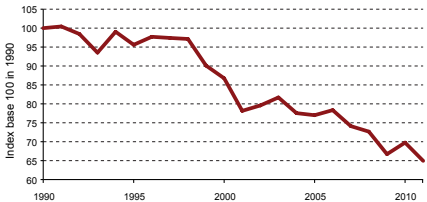
Source: Citepa, June 2013

Intensity of GHG Emissions from Manufacturing Industry and Construction in France

In index base 100 in 1990

Manufacturing Industry and Construction	2000	2005	2010	2011
GHG Emissions / Value Added	86.8	77.0	69.8	64.9

GHG Emissions per Unit of Value Added

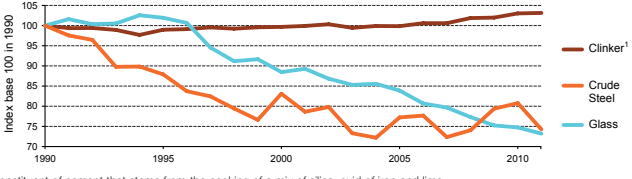


Source: INSEE (value added), Citepa (GHG emissions), June 2013

GHG Emissions from a Selection of Energy-Intensive Products in France

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

Specific CO_2 Emissions



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

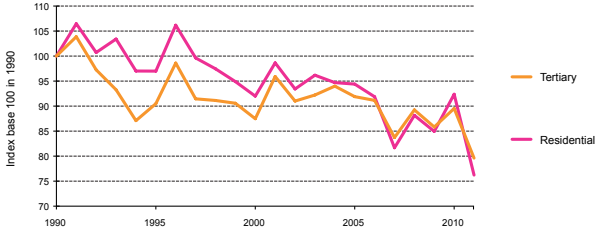
Source: Fédération Française de l'Acier (FFA), Fédération des Chambres Syndicales de l'Industrie du Verre (FCSIV), Syndicat Français de l'Industrie Cimentière (SFIC)

4.4 GHG Emissions from Other Sectors

GHG Emissions from Other Sectors[1] in the EU

In Mt CO_2e

	1990	2000	2005	2009	2010	2010/1990 (%)
Total	**847**	**752**	**773**	**751**	**645**	**–24**
of which : Residential	520	479	491	481	397	–24
Tertiary	201	176	185	180	160	–20
Agriculture-Forestry-Fisheries	96	85	85	80	78	–19

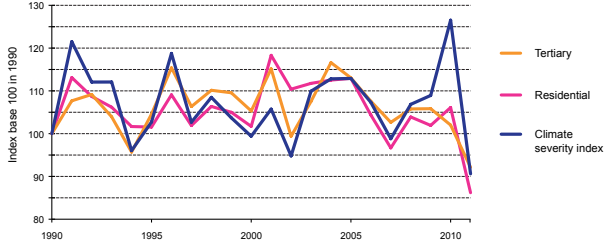


Source: European Environment Agency (EEA), June 2013

GHG Emissions from Other Sectors[1] in France (including Overseas Departments)

In Mt CO_2e

	1990	2000	2005	2010	2011	2011/1990 (%)
Total	**100.6**	**104.0**	**113.2**	**105.1**	**89.9**	**–11**
of which : Residential	60.6	61.6	68.4	64.3	52.2	–14
Tertiary	29.1	30.7	32.9	29.7	26.8	–8
Agriculture-Forestry-Fisheries	10.9	11.7	11.9	11.1	10.9	–1



Source: Citepa, June 2013, and SOeS, according to Météo France

> Emissions from the residential-tertiary sector depend on climatic conditions. Temperatures were particularly mild in 1994, 2002, 2007 and 2011. Therefore, heating energy consumption and thus GHG emissions were rather low. Conversely, the climate was exceptionaly cold in 1991, 1996 and 2010, leading to higher emissions.

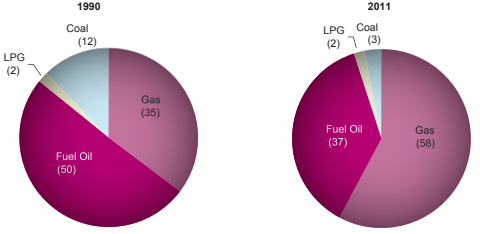
1. Direct emissions from sectors other than energy industry, transportation and manufacturing industry and construction.

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

In %

	1990	1995	2000	2005	2010	2011
Natural Gas	35	42	45	52	59	58
Fuel Oil	50	46	45	42	37	37
Liquefied Petroleum Gas (LPG)	2	3	3	3	2	2
Coal	12	9	6	3	3	3

In %



Source: SOeS calculations, according to Ceren

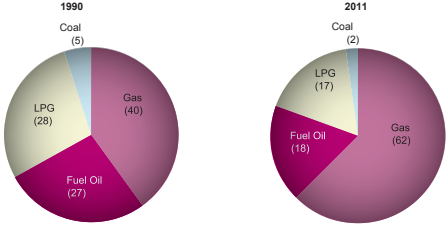
> Over the period, among fossil fuels, coal and fuel oil have been substituted for natural gas in the residential-tertiary sector. This explains the increase of the contribution of natural gas to CO_2 emissions.

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

In %

	1990	1995	2000	2005	2010	2011
Natural Gas	40	42	45	54	61	62
Fuel Oil	27	28	28	23	19	18
Liquefied Petroleum Gas (LPG)	28	26	24	21	18	17
Coal	5	4	3	2	2	2

In %



Source: SOeS calculations, according to Ceren

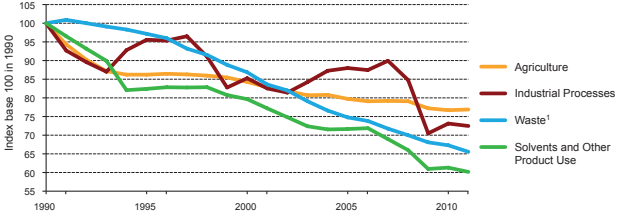
1. Only direct CO_2 emissions from fossil fuels combustion are taken into account. Emissions due to electricity consumption are not measured.

4.5 GHG Emissions excluding Fuel Combustion

GHG Emissions excluding Fossil Fuel Combustion in the EU

In Mt CO_2e

	1990	2000	2005	2010	2011	2011/1990 (%)
Total	**1,278**	**1,086**	**1,045**	**942**	**936**	**–27**
Agriculture	600	505	478	460	461	–23
Industrial Processes	458	390	403	335	332	–28
Waste[1]	204	177	152	137	133	–34
Solvent and Other Product Use	17	13	12	10	10	–40

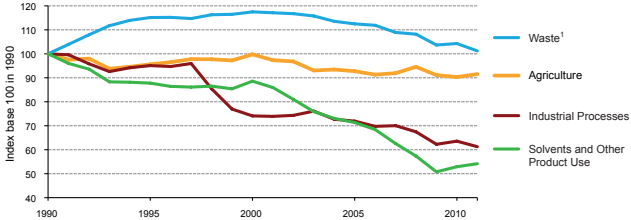


Source: European Environment Agency (EEA), June 2013

GHG Emissions excluding Fossil Fuel Combustion in France (including Overseas Departments)

In Mt CO_2e

	1990	2000	2005	2010	2011	2011/1990 (%)
Total	**173.2**	**159.7**	**150.4**	**141.6**	**141.1**	**–19**
Agriculture	99.6	99.3	92.3	89.9	91.2	–8
Industrial Processes	58.9	43.6	42.4	37.5	36.1	–39
Waste[1]	12.6	14.8	14.2	13.2	12.8	+1
Solvent and Other Product Use	2.1	1.8	1.5	1.1	1.1	–46



Source: Citepa, June 2013

1. Excludes the incineration of waste with recuperation of heat (included in “Energy Industry”).

CO_2 Emission Factors for Main Fossil Fuels

In t CO_2/toe

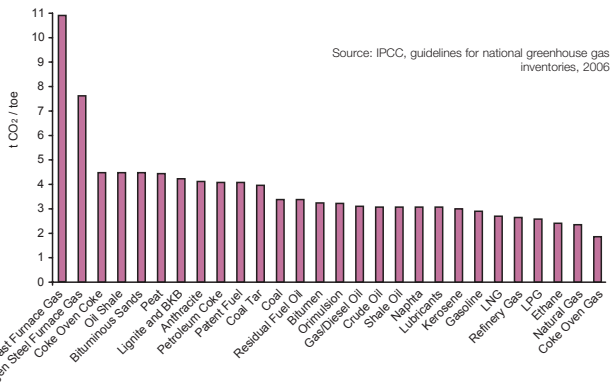
Patent Fuel	4.1	Refinery Gas	2.4
Anthracite	4.1	Natural Gas	2.3
Bitumen	3.4	Gas/Diesel Oil	3.1
Coal (Coking, Sub-bituminous, Other Bituminous)	4.0	Coal Tar	3.4
Coke Oven Coke	4.5	Shale Oil	3.1
Petroleum Coke	4.1	Kerosene	3.0
Gasoline	2.9	Lignite and BKB	4.2
Ethane	2.6	Lubricants	3.1
Residual Fuel Oil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

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

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

> These factors are global averages and can differ from one country to another.

> Biomass fuels are not treated here: CO_2 emissions related to the combustion of biomass fuels are supposedly 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).



5.1 International Negotiations

United Nations Framework Convention on Climate Change (UNFCCC)

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

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

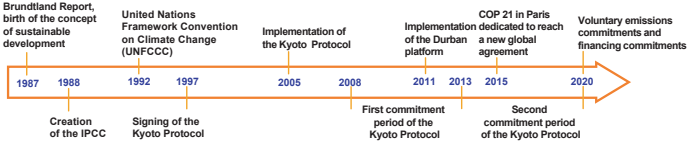
> Member countries of the UNFCCC meet at the end of each year for the "Conference of the Parties" (COP). During these conferences, major decisions are taken on the UNFCCC. The 19th COP takes place in Warsaw (Poland) from the 11th to the 22nd of November 2013.

Latest Developments in International Negotiations

> The Cancun (2010), Durban (2011) and Doha (2012) agreements established that:

- the increase of the average temperature should be contained at a maximum of **+2°C** by the end of the century, as the IPCC strongly recommended ;
- developed countries will provide funds for mitigation and adaptation in developing countries. Financing should reach **100 billion US dollars per year** by 2020;
- **a second Commitment Period** under the Kyoto Protocol will be established between 2013 and 2020;
- the **Durban platform** leading to a post-2020 international agreement must be enforced by 2015;
- countries that do not have commitments under the Kyoto Protocol will commit to voluntary emissions reduction for 2020.

> The 21st COP, in 2015, will take place at Paris-Le Bourget, in France.



Source: CDC Climat Research

> **Signed in 1997, the Protocol was implemented in 2005.** The requisite quorum of at least 55 countries representing a minimum of 55% of Annex B emissions in 1990 was thus achieved in November of 2004 after the ratification of the Protocol by Russia.

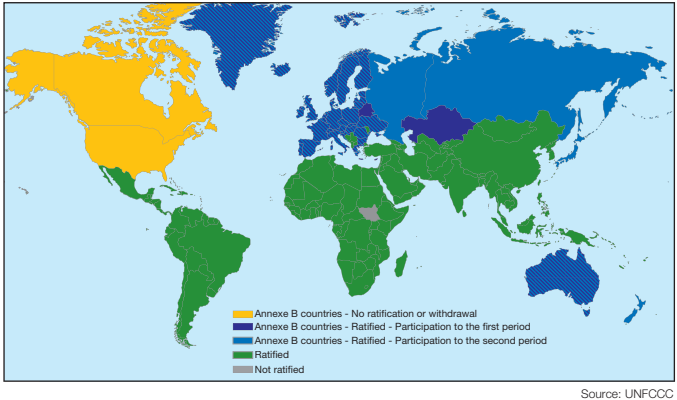
> When the Kyoto Protocol was signed, the emissions of the 40 most industrialized countries (listed in Annex B of the Protocol) are to be reduced by at least **5% between 2008 and 2012** compared to 1990 levels. The target is differentiated by country. Non-Annex B countries have no set objectives.

> **Six GHGs induced by human activity** are included: CO_2, CH_4, N_2O, HFCs, PFCs, SFs. From 2013, NF_3 is also included.

> The United States has not ratified the Protocol and therefore is not subject to the fixed reduction objectives for 2008-2012. In December 2011, Canada withdrew from the Kyoto Protocol. This withdrawal was effective from December 2012. Canada was thus not be obligated to respect its target under the first Commitment Period of the Kyoto Protocol.

> In Durban, in 2011, member parties agreed on the extension of the Protocol beyond 2012. There will thus be **a second Commitment Period of the Kyoto Protocol**. (see p. 39).

State of Kyoto Protocol ratification as of 30 September 2013



Source: UNFCCC

5.3 The Flexibility Mechanisms under the Kyoto Protocol

Kyoto, a Flexible Protocol

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

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

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

> To comply, Annex B countries must submit as many AAUs and carbon credits as their cumulated verified emissions all over one period (between 2008 and 2012 for the first period).

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

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

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

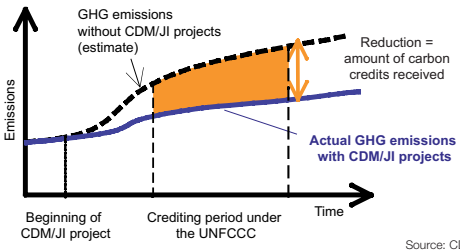
> CDM projects must be approved and registered by the UNFCCC Secretariat. Emissions reductions have to be verified by independent consultants.

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

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

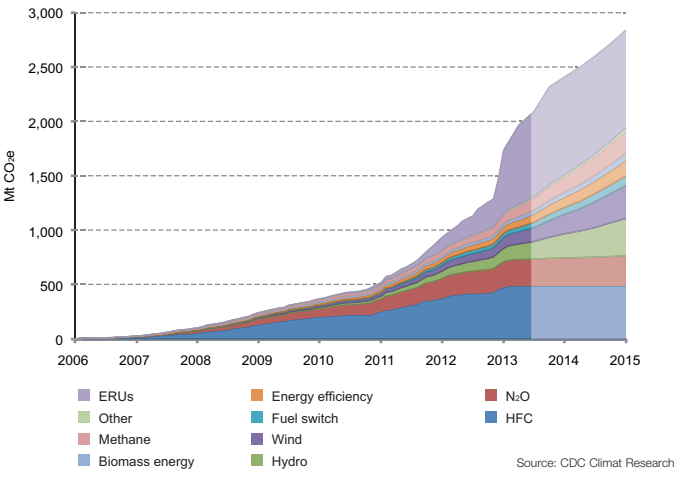
Project Mechanisms of the Kyoto Protocol

Principle of a project mechanism (CDM or JI)



Source: CDC Climat Research

Issuance and forecast issuance of EU ETS-eligible Kyoto offsets



Source: CDC Climat Research

> As of 1st September 2013, the project mechanisms of the Kyoto Protocol had led to the issuance of more than two billion credits, representing an equivalent amount of avoided tonnes of CO_2e emissions.

5.4 Tradable Permit Market during the First Period

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

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

Country	Kyoto objectives for 2008-2012 (in %)[1]	Yearly average of AAUs received over 2008-2012 (in millions)	Yearly average emissions over 2008-2011 (including credits and debits under LULUCF)		Distance to Kyoto objective (in % points)
			in Mt CO_2e	Evolution (in %)[1]	
EU-15	**–8**	**3,924**	**3,731**	**–13**	**5**
Bulgaria	–8	122	62	–53	45
Czech Republic	–8	179	135	–30	22
Croatia	–5	30	28	–10	5
Estonia	–8	39	20	–54	46
Hungary	–6	108	67	–42	36
Latvia	–8	24	10	–60	52
Lithuania	–8	45	21	–58	50
Poland	–6	530	383	–32	26
Romania	–8	256	122	–56	48
Slovakia	–8	66	46	–37	29
Slovenia	–8	19	19	–8	0
Australia	8	592	573	5	3
Iceland	10	4	4	18	–8
Japan	–6	1,186	1,216	–4	–2
Liechtenstein	–8	0	<1	6	–14
Monaco	–8	0	<1	–16	8
Norway	1	50	52	5	–4
New Zealand	0	62	56	–10	10
Russia	0	3,323	2,103	–37	37
Switzerland	–8	49	51	–4	–4
Ukraine	0	921	389	–58	58
Total	**–4**	**11,528**	**9,088**	**–24**	**20**
Uniteds States[2]	–7	n.a.	6,769	10	–17
Canada[3]	–6	n.a.	704	18	–24
Belarus[4]	–8	n.a.	89	–36	28
Kazakhstan[4]	0	n.a.	260	–28	28

EU Countries, Non-EU Annex B countries, Annexe B countries for which the Kyoto Protocol is not applyed for the first period.

1. Compared to the reference year, generally 1990. 2. USA Did not ratified the Protocol 3. Canada withdrawn from the Kyoto Protocol in 2011.
4. Amendments integrating the Belarus and the Kazakhstan into the Annex B are not ratifyed yet and then are not applyed yet.

Source: UNFCCC, 2013

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

Second Commitment Period of the Kyoto Protocol

> The rules of the second period of the Kyoto Protocol (2013-2020) were finalized in Doha in 2012. Japan, Russia and New Zealand have announced they would not participate in the second Commitment Period of the Kyoto Protocol (KP-CP2). Countries that have announced a commitment to the KP-CP2 represent 13% of global emissions in 2010.

> Part of the rules decided in Doha have the aim to reduce the impact of hot air during the second period. One of these rules constrains countries to adopt emissions targets that do not imply an increase of emissions compared to the 2008-2010 levels. This rule jeopardize the final participation of the Belarus, the Kazakhstan and the Ukraine to the KP-CP2 ; even if, for the latter, the surplus of allowances accumulated during the first period would offset the impact of these new rules.

> A new system simplifies the formalities for countries wishing to increase their ambition during the period.

> To be implemented, these provisions must be ratified by at least 75% of countries that have ratified the Kyoto Protocol.

In %

Country	Commitment KP-CP1 (2008-2012) compared to base-year[1]	Commitment KP-CP2 pledged by countries (2013-2020) compared to base-year[1]	Commitment KP-CP2 pledged by countries (2013-2020) compared to 2008-2010 emissions	Commitment KP-CP2 compared to base-year[1] after applying new rules	Commitment KP-CP2 compared to 2008-2011 emissions after applying new rules and carrying-over surplus[2]
Australia	+8	–0.5	–5	–0.5	–3
Belarus[3]	n.a.	–12	+37	–36	+ 1
Croatia[4]	–5	–20	–12	–20	–8
EU-27[5]	–7.9	–20	–2	–20	0
Iceland[4]	10	–20	–33	–20	–32
Kazakhstan[3]	n.a.	–5	+34	–29	–2
Liechtenstein	–8	–16	–22	–16	–20
Monaco	–6	–22	–8	–22	–1
Norway	+1	–16	–19	–16	–20
Switzerland	–8	–15.8	–16	–15.8	–13
Ukraine	0	–24	+81	–58	+85[6]
Total	**–6**	**–18**	**+5**	**–24**	**+ 5**
Total excl. EIT[3]	**–6**	**–18**	**–2**	**–18**	**–1**

Source: CDC Climat Research based on UNFCCC, 2013

1. Compared to the reference year, generally 1990.
2. The surplus is calculated with 2008-2011 emissions applied over five years.
3. Economies in Transition. Here, only non-EU countries are included. The participation of Belarus, Kazakhstan and Ukraine is still uncertain.
4. For KP-CP2, Croatia and Iceland will fulfill their commitments jointly with the EU in accordance with Article 4 of the Kyoto Protocol.
5. The EU-27 countries have differentiated commitments under the KP-CP1. The provided data therefore aggregates those of the concerned countries. According to the European Climate and Energy Package, countries are not allowed to use their surplus of AAUs for 2013-2020.
6. This percentage is valid only if Ukraine reviews its KP-CP2 commitment to make it match with its 2008-2010 emissions level.

5.6 European Union's Commitments

Objectives of European Member States for the First Period

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

Country	Kyoto objectives for 2008-2012 (in %)[1]	Yearly average of AAUs received over 2008-2012 (in millions)	Yearly average emissions over 2008-2011 (including credits and debits under LULUCF[2])		Distance to Kyoto objective (in % points)
			in Mt CO_2e	Evolution (in %)[1]	
Austria	–13.0	69	82	4.3	–17.3
Belgium	–7.5	135	128	–11.8	4.3
Denmark	–21.0	55	66	–6.1	–14.9
Finland	0.0	71	69	–3.0	3.0
France	0.0	564	506	–10.2	10.2
Germany	–21.0	974	927	–24.8	3.8
Greece	25.0	134	121	13.0	12.0
Ireland	13.0	63	59	5.6	7.4
Italy	–6.5	483	489	–5.4	–1.1
Luxembourg	–28.0	9	12	–8.0	–20.0
Netherlands	–6.0	200	202	–5.4	–0.6
Portugal	27.0	76	73	21.5	5.5
Spain	15.0	333	353	21.8	–6.8
Sweden	4.0	75	60	–16.4	20.4
United Kingdom	–12.5	682	589	–24.5	12.0

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

Source: European Commission and UNFCCC, 2013

Burden Sharing and Bubbling

> Under the Kyoto Protocol, the European Union makes a commitment on behalf of all the countries composing it at the time of adoption of the text (15 countries for the first commitment period, 27 countries for the second period). It is its own responsibility to then distribute this commitment among its member countries. For the first period, this was done in the so-called "burden sharing" directive adopted in 2002.

> This flexibility offered to the EU is called "bubbling". Within the EU, a surplus of allowances and credits for one country can offset a deficit for another. In this case, the EU as a whole will be deemed compliant.

The Energy/Climate Package

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

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

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

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

In %

Pays	Objectives		Share of energy from renewable sources in gross final consumption of energy in 2005
	Member State GHG emission limits in 2020 compared to 2005 GHG emissions levels for non EU-ETS sectors	Target for share of energy from renewable sources in gross final consumption of energy in 2020	
Austria	–16	34	23
Belgium	–15	13	2
Bulgaria	20	16	9
Cyprus	–5	13	3
Czech Republic	9	13	6
Denmark	–20	30	17
Estonia	11	25	18
Finland	–16	38	29
France	–14	23	10
Germany	–14	18	6
Greece	–4	18	7
Hungary	10	13	4
Ireland	–20	16	3
Italy	–13	17	5
Latvia	17	40	33
Lithuania	15	23	15
Luxembourg	–20	11	1
Malta	5	10	0
Netherlands	–16	14	2
Poland	14	15	7
Portugal	1	31	21
Romania	19	24	18
Slovakia	13	14	7
Slovenia	4	25	16
Spain	–10	20	9
Sweden	–17	49	40
United Kingdom	–16	15	1

Source: European Commission, 2009

5.7 The European Carbon Market (EU ETS)

How the EU ETS Works

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

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

Annual EU ETS calendar

Source: CDC Climat Research

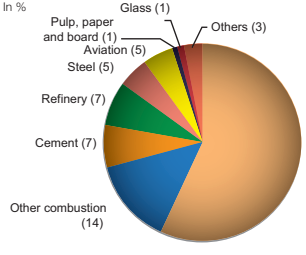
Covered Sectors

> Initialy, the EU ETS only covered CO_2 emissions. From 2013 onwards, the emissions of N_2O and SF_6 from the chemical and aluminum sectors are also covered.

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

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

EU ETS emissions by sector in 2012 (total : 1,887 Mt CO_2)



Source: CITL, CDC Climat Research

Allowance Allocation

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

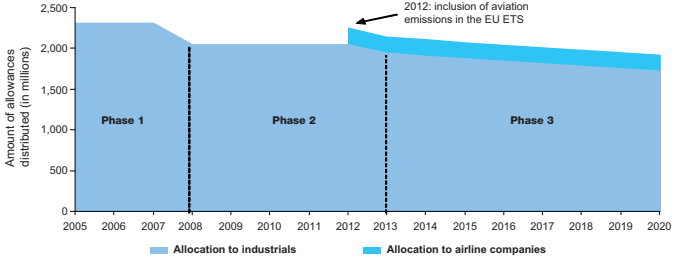
Fewer and Fewer Free Allocations

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

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

> Free allocations are set according to benchmarks. Industrial sectors and subsectors that are identified to be exposed to a significant risk of carbon leakage[1] by the European Commission will receive 100% of free allocation by 2020.
> Ultimately, after the "backloading" decision, revising the auction calendar and voted in July 2012, at least 30% of allowances will be auctioned from 2013 and **up to 75% in 2027**.
> Countries may decide to pool the organization of auctions but the resulting revenue will be managed by each state.

Evolution of total EU ETS allowance allocation



Source: CDC Climat Research, from European Commission data

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

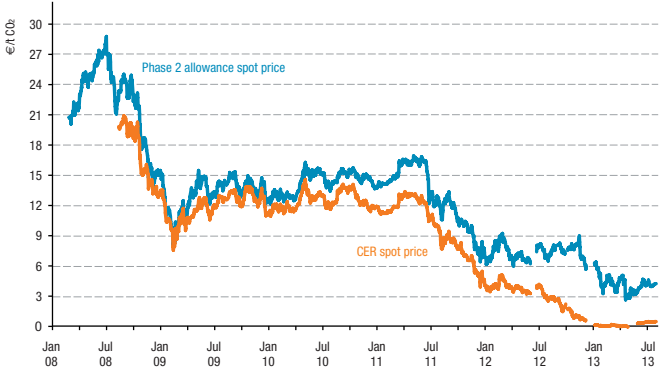
5.8 Carbon Price in the EU ETS

Trading Carbon Allowances

> European Union Allowances (EUAs) 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 and when they are the least costly.

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

Carbon Price History



Note : Breaks in the curve are due to temporary closure of exchange platforms and of the registry. Source: BlueNext, ICE

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

> The allowance price is driven by the economic context, energy policies as well as modifications in market regulations. The Kyoto credits (CERs and ERUs) are close to reach their threshold of maximal use (see page 42). That explains the decorrelation with the prices of EUAs from 2012.

Long-Term Targets

> France has one of the lowest GHG emissions per capita as per GDP unit, amongst the industrialized economies. This is due to the major share of nuclear energy in its electricity generation mix. In line with the IPCC recommendations, France sets a national objective of dividing its GHG emissions by four by 2050 compared to 1990. In 2011, the country's GHG emissions were 10% lower than 1990 levels.

> The consultation process set up by the Grenelle de l'Environnement lead to ambitious targets to promote the decarbonization of the French economy. If all of the Grenelle's targets were met, the emissions reduction in France would reach **23.4%** between 2005 and 2020. It would be –23.6% between 2005 and 2020 for non EU ETS sectors, meaning France would overshoot its –14% target set in the EU's Energy/Climate Package. In 2012, renewable energies represented **13.7%** of the French final energy consumption.

Main Policies and Measures

> **Energy sector:**
- Energy saving certificates (ESC) targeting a 345 TWh cumac[1] saving between 2010 and 2013 and at least 200 TWh cumac per year after. As of the 31st of July 2013, a total of 8,065 décisions were issued to 1,161 beneficiaries for a volume of 405 TWh cumac ;
- Implementation of the EU's eco-design, the carbon labeling and the EU ETS Directives;
- Boiler-scrapping bonus: 12,000 boilers have been replaced in 2011 saving the equivalent of 80 GWh/year;
- Development of renewable energies.

> **Buildings sector:**
- New 2012 thermal regulation for newly-built buildings, with the generalization of low energy buildings with a consumption below 50 kWh/m²/year on average;
- "Sustainable development" tax credit extended until 2015, Zero Interest Eco-Loans to give private individuals incentives to renovate existing buildings and VAT discount for thermal renovations;
- New investment plan for housing witha target of 500,000 renovated houses per year. It includes notably an acceleration in the renovation of social housing with a target of 120,000 renovations per year from 2017.

> **Transport sector:**
- Stronger bonus-malus on new vehicles that subsidizes on the purchase of low-emitting vehicles (less than 105 gCO_2/km in 2013) and taxes the purchase of high-emitting vehicles (more than 136 gCO_2/km in 2013). Hybrid vehicles benefit from a special measure.

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

Examples of Emission Factors

Transport

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

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

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

> **0.07 tCO_2e by train.** Rail emissions depends on the energy source. In France, emissions are low (9 gCO_2/km) since electricity is mainly produced by nuclear plants[1].

Electricity Production and Consumption

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

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

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

1.5 tCO_2/year are emitted by each European household[2, 3] for lighting, heating and electrical appliances at home.

Industry

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

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

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

Among other industries that emit CO_2:

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

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

Forestry and Agriculture

> **580 tCO_2e** are issued per hectare of tropical forest from deforestation (burning and decomposition)[6].

Agriculture emits on average in France:

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

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

Energy

> Main fuels emission factors are on page 33.

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

Glossary of Terms

AAU:
Assigned Amount Unit.

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

Annex I and Annex B Countries:
UNFCCC Annex I countries include 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 targets.
The only deviations are the following: Croatia, Liechtenstein, Monaco and Slovenia are part of the Annex B; Belarus and Turkey are not.

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

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

CDM:
Clean Development Mechanism.

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

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

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

GDP:
Gross Domestic Product. Measure of the wealth created by a country over a given period. Measured in purchasing power parity (ppp), it allows for acurate comparison between countries.

GHG: Greenhouse gas

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

IPCC:
Intergovernmental Panel on Climate Change. Research group led by the World Meteorological Organization and by the UNEP (United Nations Environment Program), responsible for establishing a compendium of scientific research on climate change.

JI: Joint Implementation.

KP-CP1 / KP-CP2:
Respectively the first and second Commitment Period of the Kyoto Protocol

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

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

Energy Units

See: “Les chiffres clés de l’énergie édition 2013 - Repères”, published by the SOeS.

Useful Links

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

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

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

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

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

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

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

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

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

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

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

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

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

UNEP - Risø ..... *www.uneprisoe.org*

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

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

The figures and data whose source is "IPCCC, 1st Working Group, 2013" are extracted from *Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. It concerns especially the Figures SPM.1 (p.2 of the present *Highlights*), SPM.3 (p.3), 4.19 (p.4), 6.25 (p.5), SPM.7 (p.5), 12.23 (p.6), 13.20 (p.6) and FAQ5-1.1 (p.8) of the report.

Commissariat général
au développement durable – SOeS
Tour Voltaire
F-92055 La Défense Cedex
email: diffusion.soes.cgdd@
developpement-durable.gouv.fr

Direction générale de l'énergie
et du climat – SCEE
Grande Arche, Paroi Nord
F-92055 La Défense cedex
email: scee.dgec@
developpement-durable.gouv.fr

CDC Climat Research
47 rue de la Victoire
F-75009 Paris
email: research@cdcclimat.com

www.developpement-durable.gouv.fr

ISSN : 2115-7634