carbone 4

The evolution of the French carbon footprint over the last 20 years
Are we really on the right path?

Editorial

How much greenhouse gas does the average French person emit? The answer seems simple: take the country's direct emissions, divide them by the total population, and you have the figure. As France's direct emissions have been practically stable since 1990 and the population is growing, per capita emissions are falling. Thus the Environment Ministry can periodically proclaim that we have good marks in the fight against climate change.

But in the era of globalisation things are not that simple. Many of the goods and services consumed in France are produced in other countries, and consequently we benefit from the consumption of these goods while the corresponding emissions are not visible in the country's direct emissions. This issue of The Carbon Letter suggests another approach: totalling up not only the country's direct emissions, but also all the emissions related to the manufacture of everything consumed in France, whether the production occurs in France or elsewhere. Surprise! It turns out that the work of reducing emissions is still ahead of us, in full. But without elaborating more, we leave you with the explanations given by the ECO2Climat team. Enjoy your reading!

Alain Grandjean and Jean-Marc Jancovici

How is the average carbon footprint calculated for a resident of France?

ECO_2Climat is the prime carbon indicator for final consumption in France, created at the initiative of television broadcaster TF1[1] and elaborated by Carbone 4. This indicator is designed to assess all greenhouse gas (GHG) emissions generated in day-to-day life by the average consumer in France, including food purchases, manufactured goods and services.

It also includes construction of the consumer's home, energy consumption and travel. This indicator therefore reflects, by design, all GHG emissions corresponding to final consumption in France.

Final consumption designates all goods and services that are used or consumed by households residing in the economic territory of France (including overseas departments, but not other overseas entities), regardless of how they are financed, and the public expenditures of government services.

This set therefore comprises:

- all direct household expenditures, whether for daily consumption or investment,
- all in-kind "social transfers" by government services to households (mainly health insurance reimbursements, and public expenditure for healthcare and education),
- all public expenditure for government functions: justice, defence, police, general administration.

The ECO_2Climat indicator is calculated monthly on the basis of figures from national accounts and published each month in the evening newscast on TF1 and in the free newspaper Metro.

As emphasised in the editorial, this indicator gives a figure that is distinct from the figure for direct GHG emissions in France which is published annually by CITEPA and used in the context of international climate negotiations.[2] The CITEPA figure, called the "national greenhouse gas inventory", covers emissions that occur on French territory, whether the final product is destined for consumption in France or for export. It does not include emissions generated abroad for the production of goods and services consumed in France.

Inversely, **the ECO_2Climat indicator measures only emissions related to consumption in France**. It includes emissions from Brazilian or German factories (and all others upstream of them) when they make a product slated for consumption in France, but does not include emissions of French factories (and all upstream production) when the latter manufacture goods for export.

- For example, emissions caused by the manufacture on French soil of cars or high-speed trains for export are not included in the ECO_2Climat indicator.
- Inversely, emissions generated for the production of computers bought in France, (from extraction of raw materials to final assembly) are included in our indicator, whereas they do not figure in total French emissions as calculated under the Climate Convention.

1 *directed at the time by Michel Floquet*
2 *www.citepa.org*

ECO_2Climat is thus the greenhouse gas equivalent of effective final consumption by households and government services as reported in national accounts.

The TF1 approach

" The broadcaster has undertaken a pedagogical approach. The ECO_2Climat figure materialises the key notion of GHG emissions, in the way that accident casualties materialise highway security or unemployment figures reflect the economy. The carbon indicator gives TF1 journalists a quantitative and stable reference to illustrate the impact of our production and consumption on greenhouse gas levels and on the resulting climate change.

Since December 2009 the news staff have produced monthly reports illustrating the fluctuations of the indicator, on automobile fuel purchases, home entertainment equipment, electricity consumption, home heating, food purchases, etc. In this way TF1 brings meaning to examples of more environmentally responsible consumption, showing in a positive and guilt-free way how citizen-consumers can have an effect on CO_2 emissions.
Now it is up to each of us viewers to forge our own opinion and eventually change our practices. "

Gilles Maugars, Director for social and environmental responsibility, TF1

" The day-to-day needs and concerns of people in France are our prime focus.
We therefore wanted this indicator to be built around concrete themes and designed to give insights on all aspects of common consumption. "

Anne de Coudenhove, Editor in chief, Evening newscast (8:00 p.m.), TF1

Do you know how much greenhouse gas is emitted per person in France ?

Greenhouse gas emissions due to final consumption amounted to **10.5 tonnes CO_2 equivalent per person** on average in 2010. This figure represents in CO_2 equivalent the sum of all greenhouse gases (carbon dioxide, methane, nitrous oxide and fluorinated gases) released to the atmosphere in order to provide housing, passenger travel, consumer goods and services to a resident of France over one year.[3]

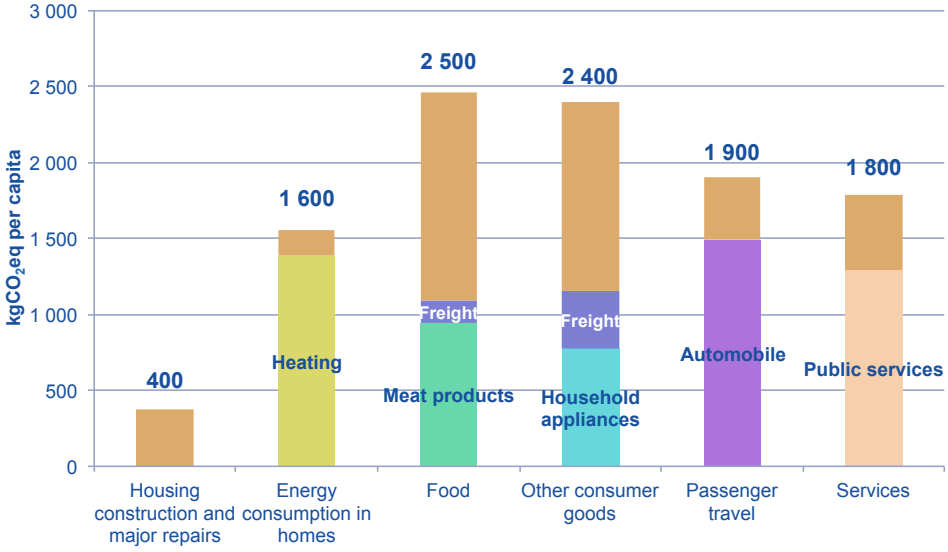


Figure 1 - *ECO_2Climat : Average GHG emissions per person in France in 2010*

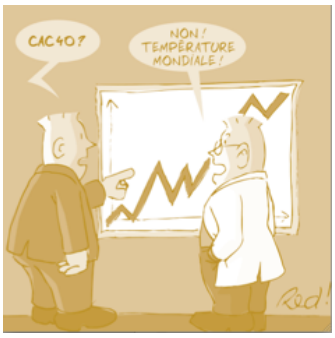
Which items generate the most impact ?

- The top-ranking category is **food, which represents close to one-quarter of emissions for the French population**, with a strong impact for meat consumption (38% of food expenditures).
- The second-ranking emissions category is the **purchase of manufactured goods**, for both current consumption and investment, excluding housing construction (23% of total emissions). This category includes clothing, household appliances, consumer electronic goods, cars, furniture, etc., much of which is manufactured abroad.
- The third category is **passenger travel**, at 18% of total emissions. Automobile travel accounts for 80% of emissions in this category. Although air travel is limited to a small fraction of the population – 1 in 4 people in France travels by plane each year[4] – and a low number of trips – 40 million individual personal trips – it represents 18% of the total GHG impact of travel. The remaining 2% represent the impact of public transport.

3 Each consumption category includes GHG emissions linked to business consumption: building construction and energy use for industrial, commercial and institutional buildings, shipping between companies, and all the goods and services consumed or transformed to make finished products.

4 French Environment Ministry, Direction du transport aérien (DTA) survey, 2000–2001

How has the ECO_2Climat indicator evolved over 20 years?



As measured by ECO_2Climat, total emissions for consumption in France have risen by 25% since 1990. Given that the population of France has risen by 11% over the same period, **per capita emissions have increased by 13%**.
Rising purchasing power has engendered an increase in per capita consumption of goods and services over the last 20 years, and thereby an increase in the consumption of energy required to transform raw materials into finished products, despite greater energy efficiency in industry.

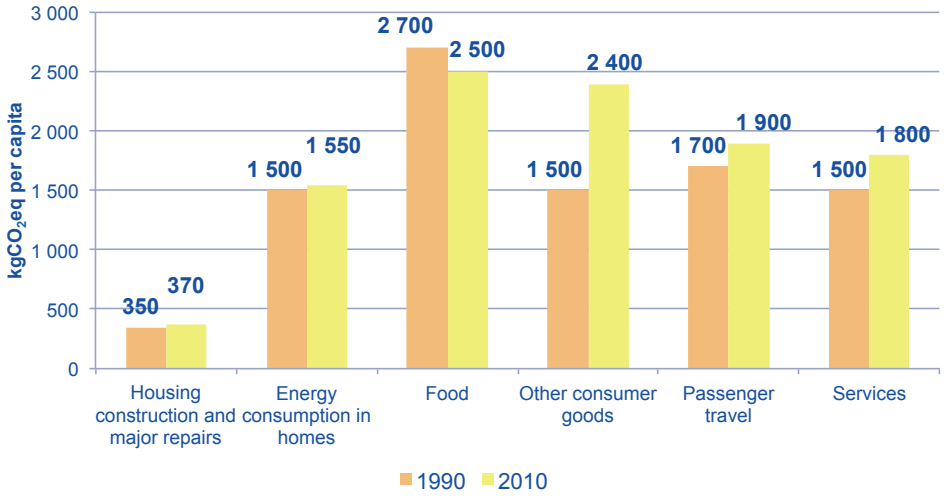


Figure 2 - *ECO_2Climat : Per capita GHG emissions in France, 1990 and 2010*

NB: Some calculations used here have been carried out using emission factors that have not been updated. They therefore do not reflect any eventual increase in energy efficiency over this period. Even so, the drop in real prices for many items goes hand in hand with an increase in CO_2 content per euro of expenditure and in many instances this effect is not reflected. In our estimate the uncertainty margin for the overall result is between 20% and 30%, but is not as high when it comes to the direction of this variation.

	Unité	1990	2010	Var
Per capita GHG emissions (ECO_2Climat)	tCO_2e/pers	9.3	10.5	+ 13 %
French population	Millions	58	65	+ 11 %
GHG emissions for France (ECO_2Climat)	Million tonnes CO_2 equivalent	539	676	+ 25 %
Final consumption expenditure per capita	Thousand euros (2010 value)	13.3	16.8	+ 26 %
Social transfers + public consumption expenditure[5]	Thousand euros (2010 value)	5.9	7.7	+ 31 %

Comparison with the national greenhouse gas emissions inventory

At the request of the Environment Ministry CITEPA acts as the National Reference Centre for atmospheric emissions. In this capacity the centre establishes the greenhouse gas emissions inventory for France (see page 2).
There is a significant difference between this inventory and the ECO_2Climat indicator: while ECO_2Climat shows an increase in emissions related to consumption in France, the CITEPA inventory reports a 10% drop in emissions between 1990 and 2010.[6]
What is the reason for this? Between 1990 and 2010 imports of finished products (electronic goods in particular) rose, and at the same time a part of France's production apparatus was delocalised to countries with low labour costs, with the result that **emissions within the French territory diminished, but the flow of imported carbon increased**.

Greenhouse gases are transported and mixed in the atmosphere, and the place of emission is of little importance when it comes to climate change.

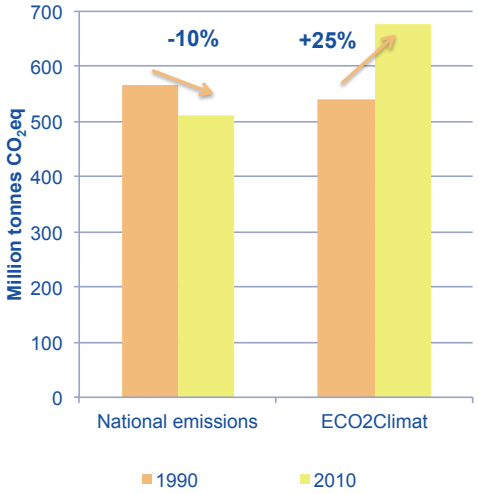


Figure 3 - *Comparison of national inventory and ECO_2Climat figures*

5 *Social transfers + public expenditures = public administration and central government expenditures that can be broken down per capita*
6 *Variation within the territory of metropolitan France*

Analysis of the main variations between 1990 and 2010

Home energy use per capita emissions up +3%

Emissions due to energy use have been nearly stable for the last 20 years; given the margin of uncertainty in the calculations, a variation of 3% is not significant.
The graph below shows GHG emissions per person and per type of energy consumed in homes between 1990 and 2010 :

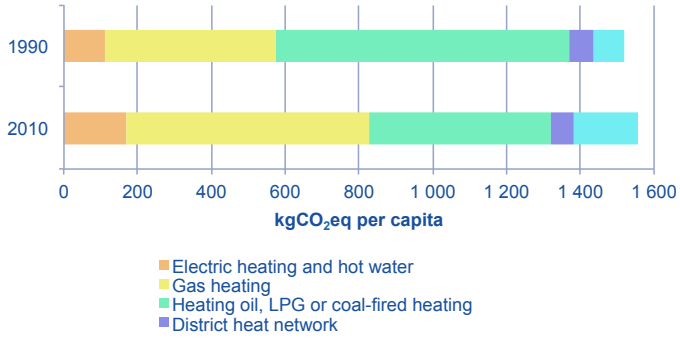


Figure 4 - *Per capita GHG emissions for home energy use*

It is important to note that overall home energy use grew by 14%, from 370 TWh in 1990 to 420 TWh in 2010, due to population growth and increasing urbanisation.
The stagnation of emissions while energy consumption was on the rise can be explained by two factors :

- energy consumption per square metre has dropped in housing, thanks to the better thermal performance of new housing units,
- home heating oil boilers have gradually been replaced by installations with lower greenhouse gas emissions, such as gas-fired or electric boilers.

At the same time another trend has pushed emissions in the opposite direction: the number of occupants per housing unit has decreased (see graph below) even as the average surface area has increased. In total, the surface area per occupant has risen by 22%.

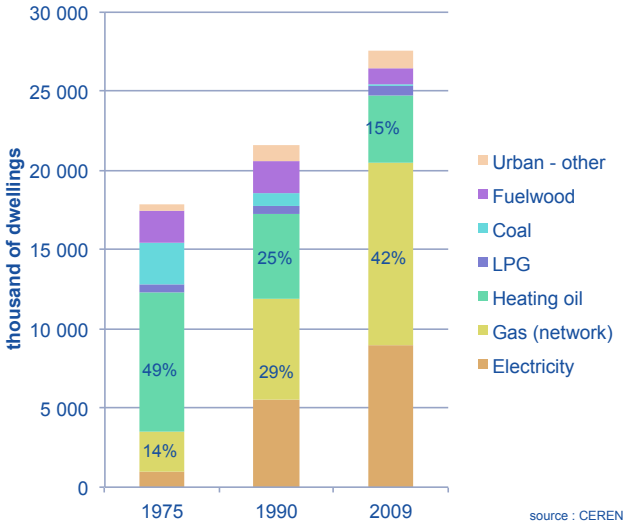


Figure 5 - *Primary residences by type of heating energy (single and multi-family)*

Specific electricity use (electricity for uses other than heating or hot water) has increased sharply over 20 years, and is up over 80% in terms of kWh per person. Despite the improved performance of certain appliances (refrigerators, washing machines) the profound transformation of audiovisual entertainment, the advent of new technologies, the development of home information technology and the new services that go along with them (Internet) account for the large increase in electricity consumption (LCD and plasma television screens, for instance, consume respectively 1.6 and 3.5 times as much electricity as cathode ray tube screens[7]).
The emission factor for electricity consumed in France also rose slightly during this period. The deregulation of the electricity market in Europe in recent years has led to more trade in electrical power between countries, with the result that France imported 37 TWh in 2010 compared to 6.6 in 1990. And in neighbouring countries – excepting Switzerland – between 50% and 90% of electricity is derived from natural gas or coal. The emissions for imported electricity are therefore much higher per kWh than for electricity generated in France (see La Lettre du Carbone, issue 1, devoted to electricity). The growth in imported electricity between 1990 and 2010 means that the overall emission factor for electricity consumed by French households is 18% higher in 2010 than in 1990.

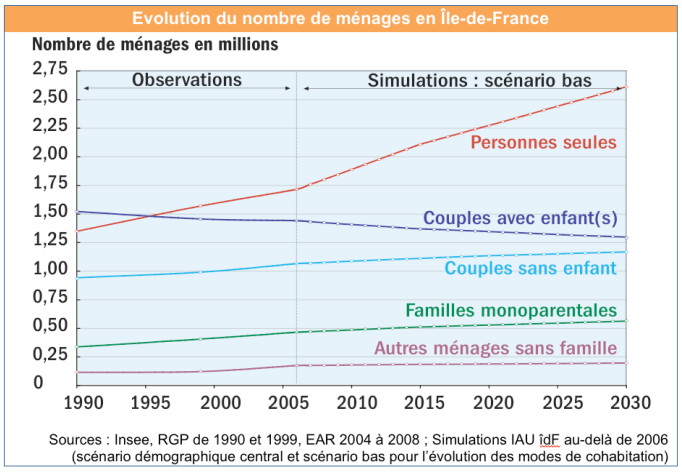


Figure 6 - *Composition of households in the Ile de France region*

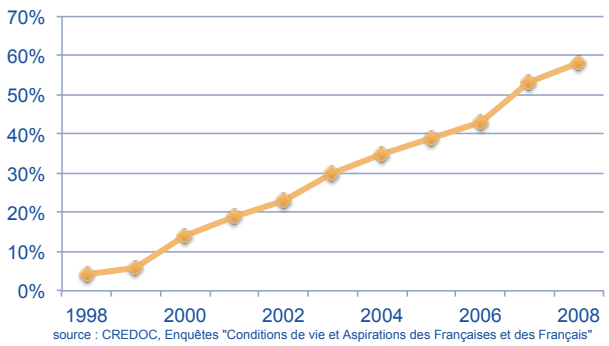


Figure 7 - *Proportion of over-18 population with home Internet connection*

7 *Enertech, "Maitrise des usages spécifiques de l'électricité dans le secteur résidentiel"*

Food
per capita emissions down by 8%

Greenhouse gas emissions linked to food purchases have fallen slightly. This is due primarily to the **drop in red meat consumption**.

The second-ranking category is dairy products (taken together beef and milk account for about half of food-related emissions). Dairy-product emissions have remained stable, but this masks two divergent trends: milk consumption has fallen, but this decrease has been compensated by higher consumption of processed milk products such as cheese and yoghurt.

As a general rule consumption of processed foods has risen to the detriment of fresh products.

Emissions related to food-product **logistics** have increased by 7% per capita. Logistics includes emissions from transport, which have not changed much, but also the distribution sector, where emissions have risen by 20%. Distribution emissions include the construction of retail stores, their energy consumption, refrigerant fluid losses in the cold supply chain and the manufacture of packaging.

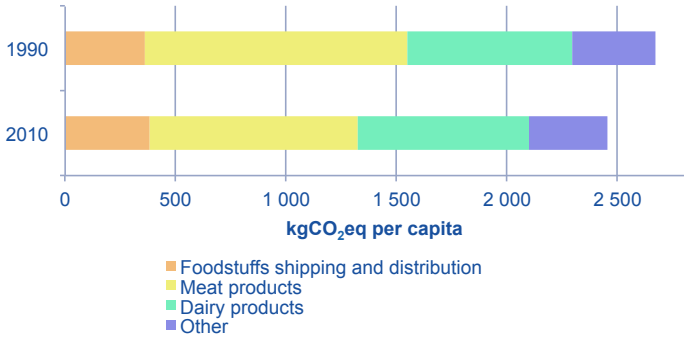


Figure 8 - *Per capita GHG emissions related to food*

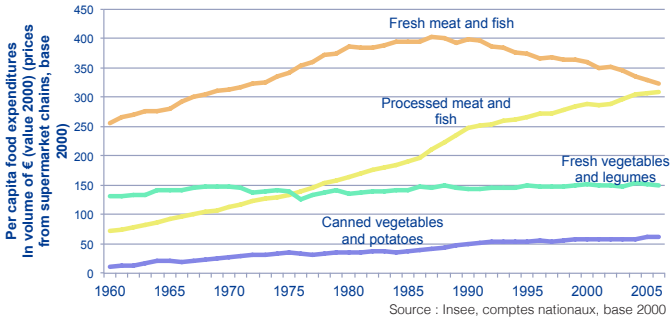


Figure 9 - *Trends in food expenditures*

The good news is that the total tonnage of **packaging** has not risen at the same pace as overall consumption. This is due to the lower unit weight for plastic bottles, and the substitution of glass for plastic bottles (53% of household packaging is used for beverages).[8]

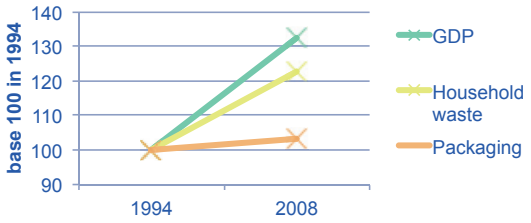


Figure 10 - *Increase in packaging tonnage, household waste tonnage and GDP in volume between 1994 and 2008*

Manufactured goods
per capita emissions up 60%

This category comprises emissions from the production of manufactured goods consumed by French households, regardless of the country of production.

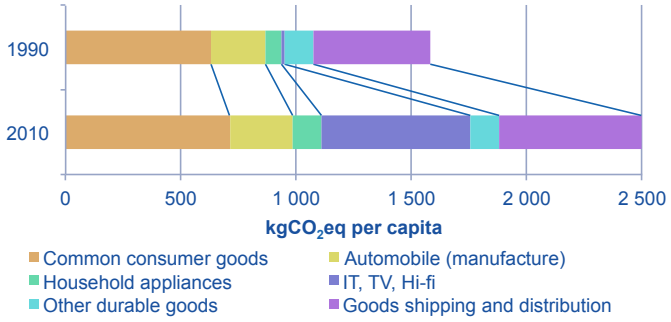


Figure 11 - *GHG emissions for consumer goods (other than foodstuffs)*

These emissions, which stood at slightly over half of food-related emissions in 1990, are now at the same level. All types of goods have contributed to this increase, but those most implicated are information and communication technologies, encompassing television sets and accessories (DVD players, among others), communication devices (telephones, modems, ADSL boxes, etc.) and all other electronic goods that process information. Emissions in

8 *"Analyse environnementale de l'évolution des tonnages d'emballages ménagers en France entre 1997 et 2006 sur 8 marchés de produits de grande consommation", Ademe/CNE/Eco-emballages.*

this category are due to the manufacture of these devices and not to their use (electricity for use is reported under home energy use).

The portion of household budgets devoted to information and communication technologies rose from an average 1.7% in 1960 to 5% in 2010. Growth in consumption of information and communication devices has been very strong since 1990, rising by 13.2% in volume per year, as opposed to 1.9% for consumption in general.[9] This uninterrupted growth (without equivalent in other areas of consumption) was driven by sales of personal computers starting in 1995, and then bolstered by the spread of flat-screen TVs at the end of the 1990s and the explosion of mobile phones and Internet (the number of Internet users in France shot up from 150,000 in 1995 to 34 million in 2009).

A very large upstream industrial structure is needed to make electronic devices (television sets, computers, telephones, tablets and all the electronic equipment now built into other products such as cars and home appliances). Minerals (iron, copper, cadmium, coltan, etc.) must be extracted in mines all around the world and for some materials the per-kg energy costs are extremely high. The production and processing of electrical grade silicon, for instance, calls for a great deal of energy. Specialised glasses must also be made and many other products are derived from petroleum or mineral-based chemicals (the chemical industry is the largest industrial energy consumer, absorbing 8% of world energy). Lastly, the production process is highly distributed, with each factory handling a specific task; this entails a lot of goods transport, including a significant share of air freight. As an example, the manufacture of a 31-inch flat-screen TV causes 1.8 tonnes of CO_2 equivalent emissions, equal to 17% of the annual carbon footprint of one person in France. In short, when we talk about the virtual nature of information technology, we generally forget that the manufacture of the physical devices used (computers, screens, network electronics and cable, civil engineering works etc.) is far from virtual! Several calculations carried out by Carbone 4 show that replacing paper by electronic documents does not necessarily lead to lower emissions.

What should be observed is that the spread of electronic devices has not caused a rise in the inventory of French national emissions. Nearly all electronics-related emissions are **imported emissions** that occur outside of the French territory, mainly in Asian countries where the upstream industries (chemicals, metallurgy, components) are located and where coal is the dominant source of electricity (it should be remembered that coal-fired power plants emit nearly 20% of global GHG emissions, all gases and sources taken into account). As mentioned above, the place of emission is of little importance in terms of the greenhouse effect.

Emissions related to shipping of consumer goods

Before they are sold consumer goods are transported from the point of assembly to the point of purchase.[10] For the most part they are shipped by boat: this mode of transport accounts for 96% of tonne.kms for products delivered to France, but only 55% of GHG emissions. Indeed emissions per tonne.km are much lower for boats than for trucks, not to mention aeroplanes. Globalisation has led to a massive increase in maritime shipping, which ensures the bulk of international trade.[11] For road transport, the drop in unitary fuel consumption (-27%) has in large part counterbalanced the per capita increase in shipping (+45%). But despite greater energy efficiency, the growth in air traffic, which was multiplied by 2.5, has caused a clear increase in GHG emissions due to air freight.

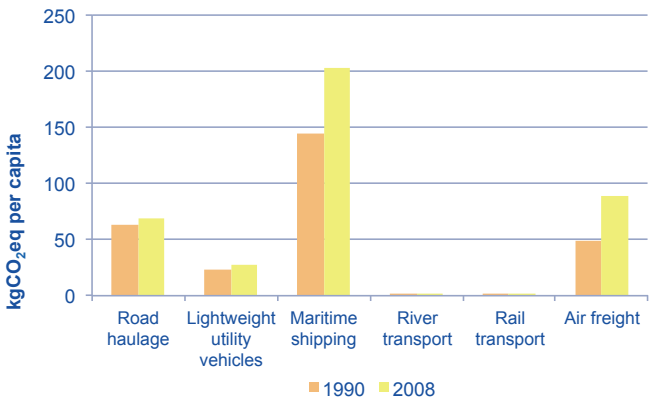


Figure 12 - *GHG emissions for shipping of consumer goods (other than foodstuffs)*

9 When prices rise, currency is depreciated over time. To correct for this effect trends in terms of value (evaluated at current cost, without correction for inflation) are distinguished from trends in terms of volume (evaluated with a correction to eliminate the effect of inflation by calculating annual consumption at the price of the preceding year). For each basic category the quantities for the year are multiplied by the price of the year before. The direct effect of price fluctuations, upwards or downwards, are thereby erased.

10 Emissions due to shipping between companies before the final assembly phase are taken into account in the emission factor for the final product itself.

11 Transport of hydrocarbons, which represent 50% of maritime freight in tonnage, is not included in the shipping of consumer goods but is integrated directly into the emission factors of the hydrocarbons.

Passenger travel per capita emissions up 11%

Per capita emissions due to automobiles, that often come to mind when discussing travel, have not significantly increased over the last 20 years. The increase in vehicle emissions from private cars over this period is mainly due to the increase in population.
A detailed analysis of automobile travel does however reveal several contradicting trends :

- average unitary fuel consumption of vehicles has fallen by 16%, due in part to the rising proportion of diesel engines and in part to greater vehicle energy efficiency, which has gone from 8.2 litres/100 km to 6.9 litres/100 km,[12]
- on average cars travel 4% less in distance per year (12 800 km per car in 2010) due to a relative increase in the number of short trips,
- vehicle ownership has increased by 20% per capita since 1990,
- the increasing use of automobile air conditioning causes greater emissions of refrigerant gases with high climate warming potential (15% of new vehicles were equipped with air conditioning in 1995, 90% en 2005).[13]

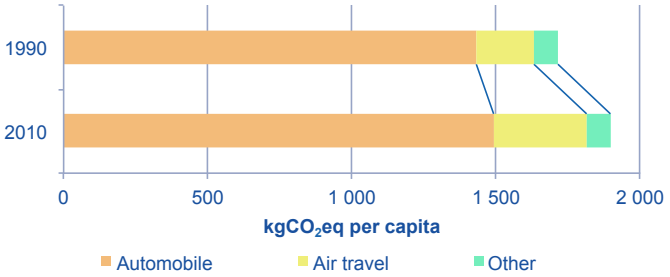


Figure 13 - *Per capita GHG emissions for passenger travel*

All told, emissions for automobile travel have increased by 4% over the last 20 years.
The increase in travel-related emissions is therefore almost exclusively due to the increase in air travel, itself due to a very steep drop in real prices.
Figure 14 shows that in 1980 a Paris-Singapore flight costed 734 hours of the minimum-wage pay in France. In 2005 the same flight costs between 80 and 120 hours of the minimum wage, or seven times less in real terms than in 1980 !

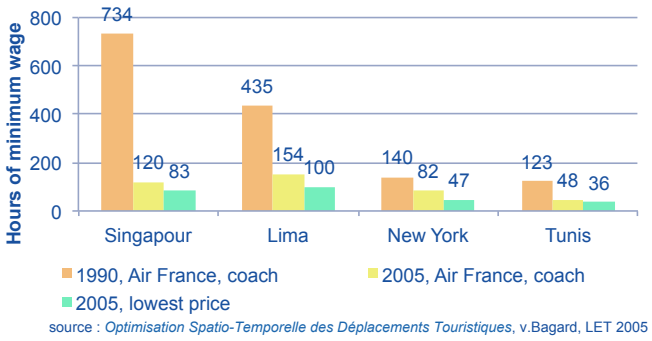


Figure 14 - *Cost of air travel*

This graph is an excellent illustration of the fact that **the real price of energy** (i.e. the amount of work required to purchase one unit of energy) **has greatly diminished in the space of two generations**.

Services per capita emissions up 19%

The emissions found in this category include both direct emissions of buildings used to provide services (schools and healthcare facilities as well as military barracks, court buildings and banks, to include an example of a private-sector service) and emissions due to the goods and services purchased by service providers (for example drugs and scanner equipment in hospitals) and which are "incorporated" into the carbon content of the final service. Public services represent over 70% of the GHG impact of services consumed by households in France.
The 19% increase of the last 20 years is due to a **large increase in healthcare expenditures** (including household and public administration expenditures) which caused healthcare-related GHG emissions to double between 1990 and 2010. In 1990 per capita emissions for healthcare came to 220 kg CO_2 eq per year while in 2010 they amounted to 405 kg CO_2 eq.
The graph below outlines the evolution of per capita emissions by type of service in France.

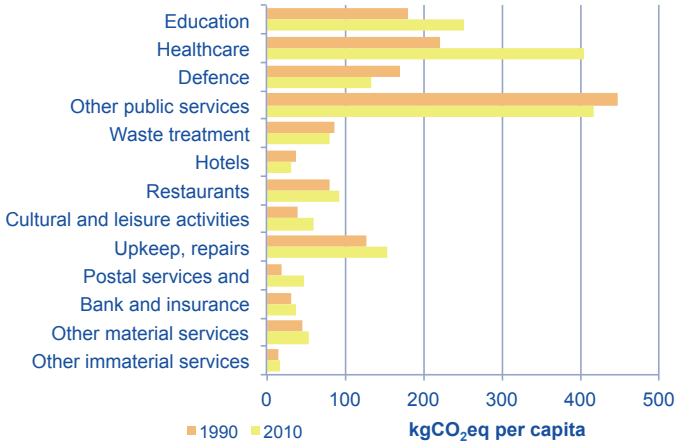


Figure 14 - *Per capita GHG emissions for public and private-sector services*

12 SOeS, "Les comptes des transport en 2010"
13 http://www.arehn.asso.fr/dossiers/clim/climatisation.html

And when broken down by socio-economic category ?

It is well known that as living standards rise, so does consumption. Quite logically this also means that **as standards of living rise carbon footprints grow larger**. The more products and services one buys, the more one takes part in the processing of the planet's resources, using lots of energy to do so and the greater the pressure one exerts on the environment. The contrast between socio-economic categories is less stark for the distribution of GHG emissions, however, than for income. Indeed, people have to eat whether they have high income or not, and food represents one-quarter of the ECO_2Climat indicator. Furthermore, savings, which have no GHG emissions in our calculations, are greater for high-income households.

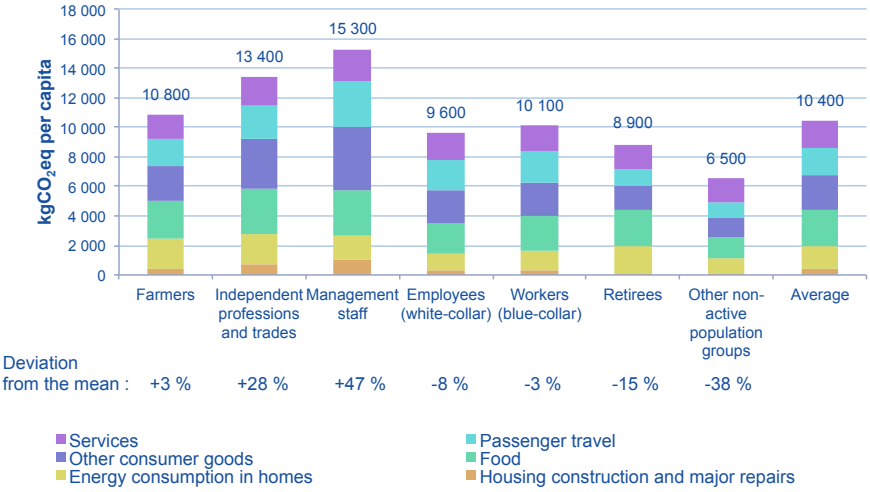
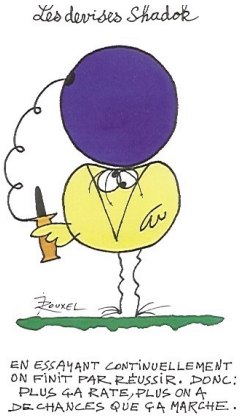


Figure 15 - *Per capita GHG emissions by socio-economic group*

NB : In the above assessment GHG emissions for public services are evenly distributed across all socio-economic groups, and not in proportion to income tax paid. This choice can be contested from a methodological point of view, as many studies show that recourse to education and healthcare services is proportionally greater per capita as income increases.

How can we meet the challenge of the transition to a low-carbon economy ?

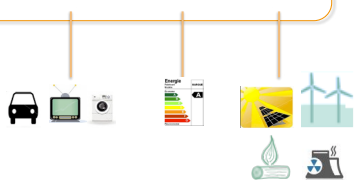


If we want to limit the rise in global temperature to an increase of 2°C by 2100, emissions in 2050 will have to be more than halfed compared to emissions in 1990. In light of the increase in emissions over the last 20 years, this means cutting world emissions in 2010 by a factor of 2.6. In a world where the population will rise by 30% to reach 9 billion people in 2050, **each individual carbon footprint will have to level out at 2.2 tonnes CO_2 eq**.

Meanwhile, we generally want to consume more. Japanese economist Yoichi Kaya has summed up the problem in the following equation :

The Kaya equation per person

$$CO_2/person = \frac{Services}{Population} \times \frac{Energy}{Services} \times \frac{CO_2}{Energy}$$

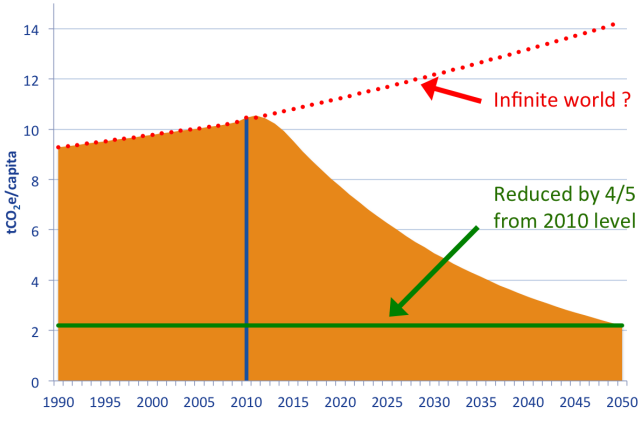


- **Service per person** : this represents our purchasing power. Most people hope to see their purchasing power increase by at least 2% per annum, which will multiply this ratio by 2.2 over 40 years. We will use this as the basis for our estimation.

If global GHG emissions are to be divided by 2.6 in 2050, and taking population growth and the increase in purchasing power into account, the ratio of energy to services and of CO_2 to energy must both be cut by a factor of 10. This means, for example, reducing each ratio by two-thirds.

- **Energy per service** : this is the number of kWh needed to make a product or provide a service (for example a transport service). Worldwide this ratio improved by 30% between 1970 and 2005. This is what is commonly known as energy efficiency. Reducing this ratio by two-thirds in 40 years means improving a lot faster than in the past !

- **CO_2 per energy input** : this reflects the energy mix (all energies, not just electricity!) used by people. This ratio improved by only 10% in 35 years (1970–2005). Reducing this ratio by two-thirds supposes a massive penetration of "no-carbon" resources in the energy mix.



An immense challenge awaits us – we must get to work, and quickly…

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