RECENT ENERGY DEMAND AND ENERGY EFFICIENCY TRENDS IN FRANCE
(2000 – 2019)

ODYSSEE-MURE

NOVEMBER 2021

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Table of content

List of figures

List of tables

Introduction

As the socio-economic environment evolves in the face of increasing technological development, organizations are faced with energy problems in terms of consumption management.

In parallel to the evolution of the economic life, the agents evolve in an increasingly complex and changing environment. They are confronted today with other requirements and must meet several needs imposed by the environment in which they gravitate. Notably concerning their achievements of energy savings.

Let us recall of this fact, that within the framework of an intergenerational transfer and also protection of the environment the growing interest for the reduction of the energy consumption on the one hand and the realization of the energy savings on the other hand is of size today.

We thus make the choice to be interested in this axis by dividing our work on two chapters a first one which treats the subject of the demand of the energy and the analysis of the consumptions of the residential sector and the transport in France since 1990 until 2019. Then, a second chapter that will open on the issue of energy efficiency in France. And to answer the following question:

What is the pattern of energy demand and savings in France between 2000 and 2019?

In other words, in the face of the variation of the economic context, how does the final energy consumption in the different sectors (Industry, services, transport and residential) in France evolve and what are the measures of energy efficiency present in these same sectors.

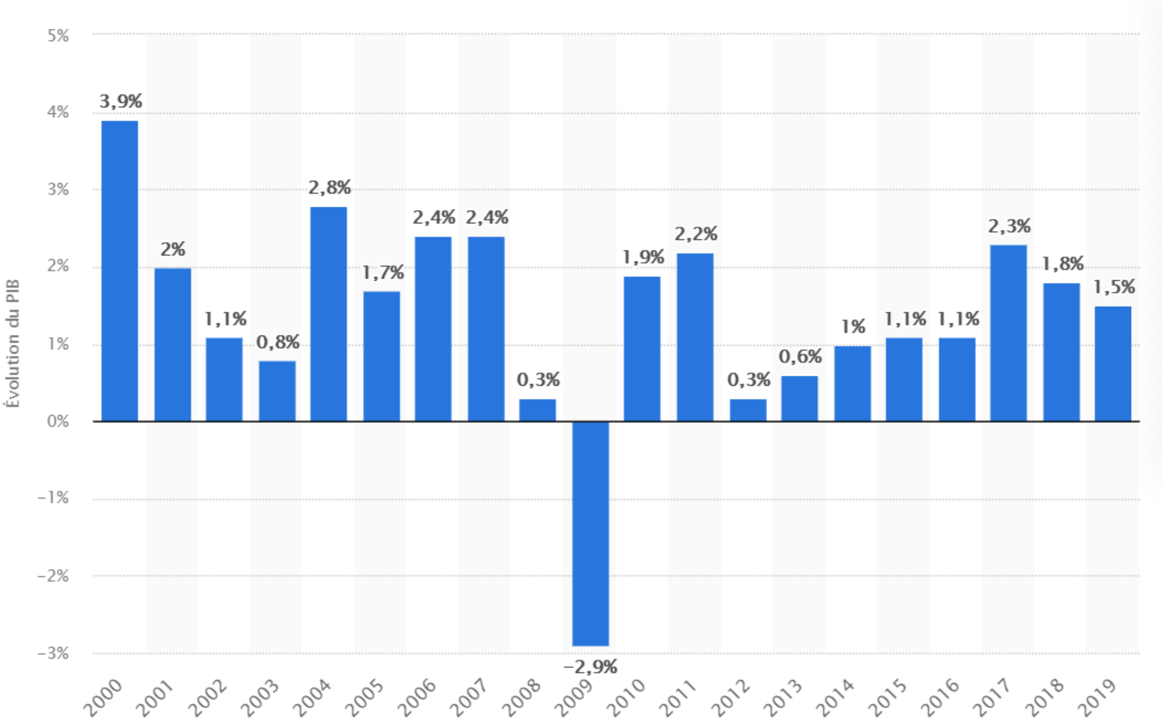
I.1 France's economic and energy context

I.1.1 The economic context

The global economic and financial crisis of 2008/2009 slowed down the French economy by creating a real break in different sectors of our economy (we talk about before and after the crisis). In 2017, GDP grew faster than in previous years, with a growth of 2.3% compared to the 0.6% observed in 2013 and 2014 (and 0.3% in 2012): the average growth rate was 0.7%/year over the period 2007-2019, compared to an average rate of 1.9%/year before the crisis (2000-2007).

In 2019 the GDP growth rate is 1.5%, the French economy is again facing a period of recession.

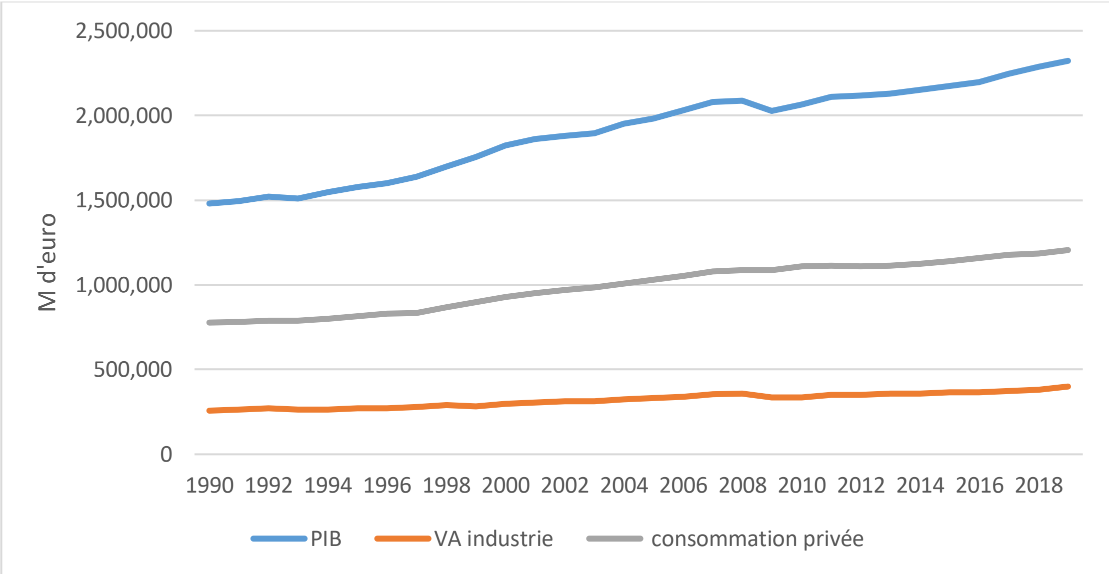
Figure 1 : Evolution of GDP in volume in France from 2000 to 2019



Source : Statista, https://fr.statista.com/statistiques/479446/evolution-annuelle-du-pib-en-volume-france/ .

Over the past 20 years, investment (Gross Fixed Capital Formation, GFCF) has driven economic growth, as has household consumption, which is accelerating even more sharply. Industrial production, measured by the value added of industry, has been rising slightly since the post-crisis period, as the following graph shows.

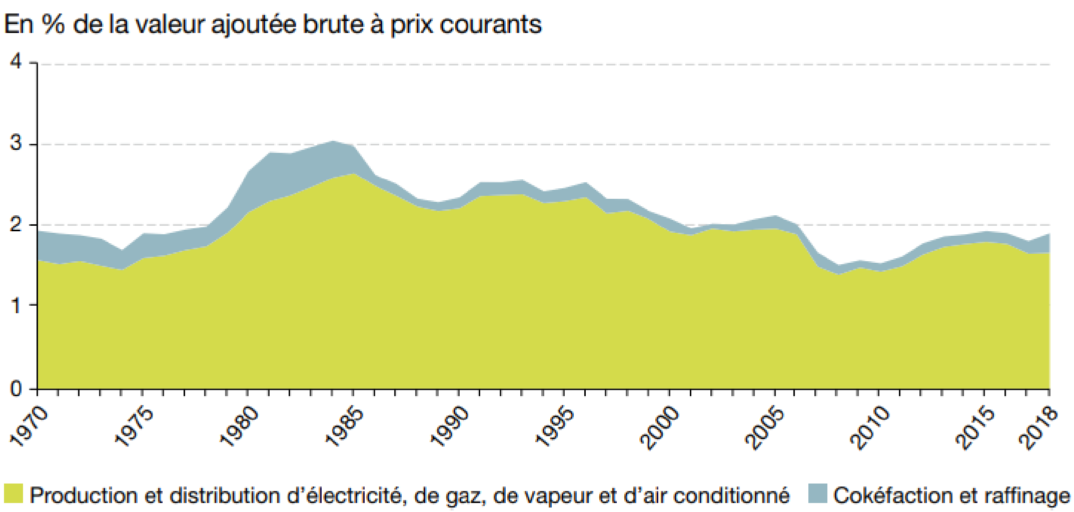
Figure 2 : Evolution of the components of economic growth in France



Source: ODYSSEE database

In 2018, the energy sector represents 2% of the value added in France. Households, businesses and administrations spent €153.5bn in 2017 to meet their energy needs. A household spent an average of €1,519 on energy for its home, of which a little less than a third was tax, and €1,386 on fuel, of which 59% was tax. In 2018, against a backdrop of rising international prices, energy accounted for €45bn of France's trade deficit.

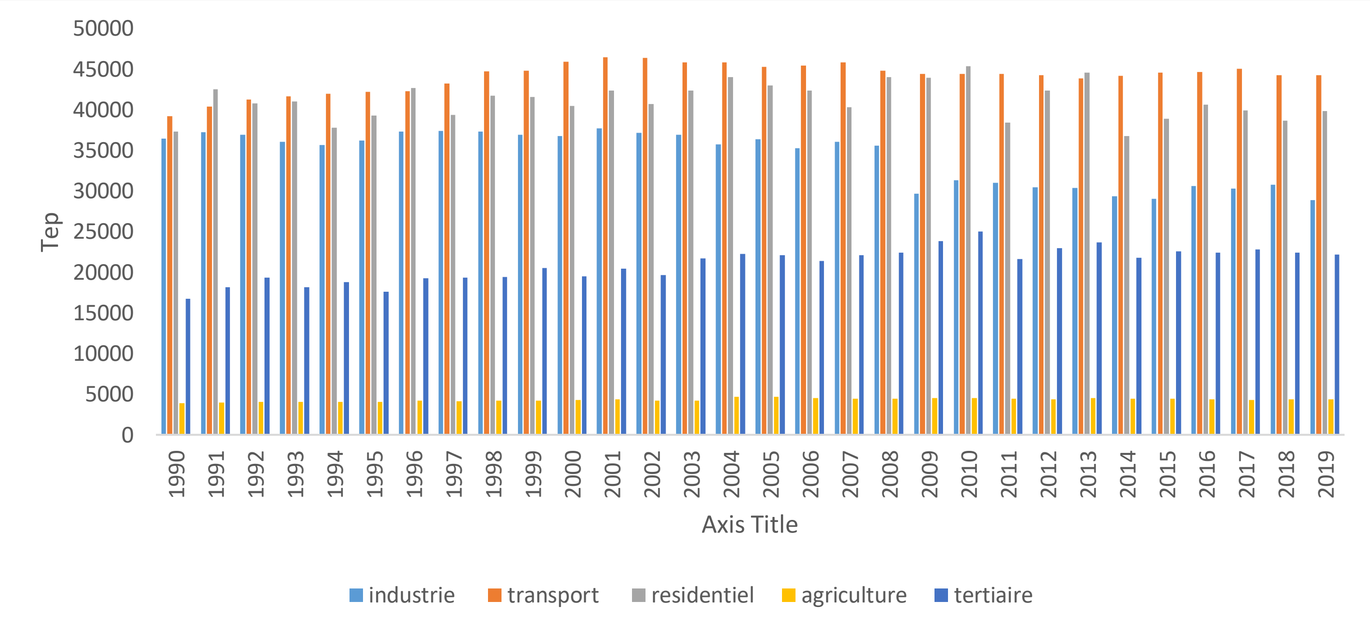
Figure 3 : Contribution of energy industries to GDP



Source : General Commission for Sustainable Development : Energy figure 2019.

The share of energy in value added has tended to increase since the late 2000s with the development of renewable energy. However, it fell in 2016 and 2017, due in particular to the decrease in the production of nuclear power plants. In 2018, this share returned to a level close to that observed in the early 1970s. After rising to 3% in the mid-1980s with the introduction of the nuclear power program, it declined over the following two decades.

Figure 4 : Final consumption trend by sector



Source: ODYSSEE database

Regarding final consumption, we note that the sectors with the highest consumption are the residential and transport sectors. We observe a very clear shift in the evolution of energy consumption before and after 2009 concerning the industry sector. One year after the economic and financial crisis which has especially impacted the industry sector: since 2010, the trend is still almost zero with the same consumption rate.

I.1.2 Policies et measures

France, through its national and European commitments, in particular those of the **Energy Transition Law for Green Growth (TECV)**1, is committed to fighting climate change more effectively and to strengthening its energy independence by better balancing its various sources of supply.

Titles I to VIII of this law are devoted to the building, transport, circular economy, renewable energy development, nuclear safety reinforcement sectors as well as to the simplification of procedures and the means to act together.

The main objectives of this law are:

- The reduction of GHG emissions by 40% between 1990 and 2030 and the division by 4 of GHG emissions between 1990 and 2050.
- The reduction of final energy consumption by 20% in 2030 and 50% in 2050 compared to 2012.

[1] Law published in the Official Journal on August 18, 2015

- The reduction of primary energy consumption of fossil fuels by 30% in 2030 compared to 2012.

32% renewable energy in final energy consumption in 2030, 40% in electricity production, 38% in final heat consumption, 15% in final fuel consumption and 10% in gas consumption,

Concerning nuclear energy, a gradual reduction is planned to limit the share of nuclear power in electricity production to 50% by 2025.

This law sets the objective of reducing the intensity of GHG emissions and atmospheric pollutants due to the transport of goods in the retail sector by at least 10% in 2020 (compared to 2010) and at least 20% in 2025.

For buildings, the law aims to create an energy performance objective for the entire housing stock by 2050, to fight against fuel poverty and to affirm the right of access to energy for all without excessive cost.

In accordance with the 2005 POPE law, France is committed to reducing final energy intensity to 2%/year by 2015 and to 2.5%/year by 2030. Similarly, greenhouse gas emissions must be divided by 4 (-75%) by 2050 (compared to 1990).

France's climate and energy strategy is anchored in two environmental laws, the Grenelle 1 law enacted on August 3, 2009 and the Grenelle 2 law of July 12, 2010. The main objectives of these two laws are the factor 4, with a division by 4 of greenhouse gas emissions by 2050 and the national translation of the European 3×20, with a target of 23% of renewable energy in 2020.

Sectoral objectives have also been defined, which will be presented in the different sections of this report.

The Energy Efficiency Directive 2012/27/EU (EED) establishes a common framework of measures for the promotion of energy efficiency in the European Union. It contributes to the goal of increasing energy efficiency by 20% by 2020. Under its National Energy Efficiency Action Plan (NEEAP, April 2014), France has set a dual target of reducing its energy consumption to 131.4 Mtoe of final energy and 236.3 Mtoe of primary energy in 2020 (compared to the current 155 Mtoe and 260 Mtoe respectively, a reduction of 15.2% and 9.1%).

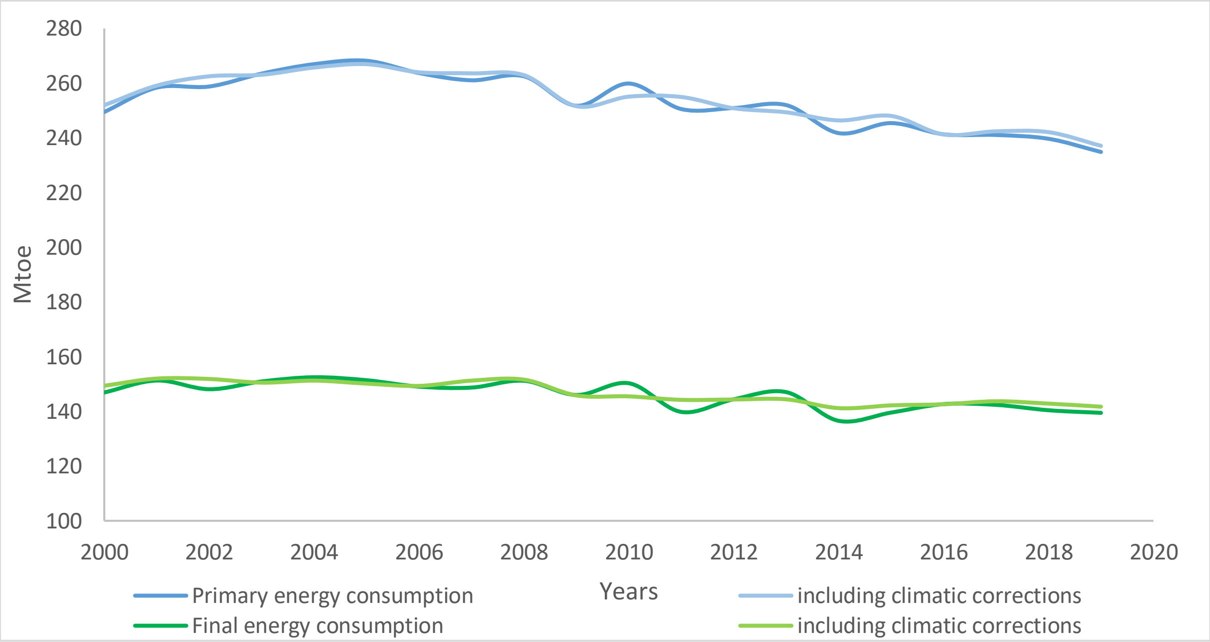
As part of the European strategy on the Energy Union, the European Commission presented a new policy and legislative package in November 2016 for the period 2021-2030 including, among other things: a proposal for a directive revising Directive 2012/27/EU on energy efficiency; a proposal for a directive revising Directive 2010/31/EC on the energy performance of buildings; and a proposal for a directive on the promotion of the use of energy from renewable sources for the period 2021-2030 (thus taking over from Directive 2009/28/EC covering the period 2013-2020).

I.1.3 Development of energy consumption

The total energy consumption in France (or primary energy, not temperature-corrected) declined 6% between 2000 and 2019, a fall from about 249 to 235 Mtoe in 2019 12 (**Figure 5**). Taking a closer look, the decrease has been pulled by the period after the financial recession (-11.8%), with 2014 as the lowest point after the drastic drop in 2009 due to the slump. Between 2000 and 2007 the variation remained stable. Peculiarly, the energy required by the end users (or final energy, not temperature-corrected) has varied between 140 and 152 Mtoe over 2000-2019.

The impact of weather fluctuations on energy consumption is shown by the different development of the actual and the climate-corrected consumption (**Figure 5**). Except for the colder years 2010 and 2013, the climate corrected primary and final energy consumptions are higher than the actual consumption. 2000, 2007 and 2014 are among the warmest years, and both 2015 and 2016 continued with this upward behaviour, making more meaningful the gap between temperature-corrected and the non-corrected consumption. This means that since 2014 the actual yearly consumption gradually decreases and moves further away from the expected consumption under the experienced weather conditions.

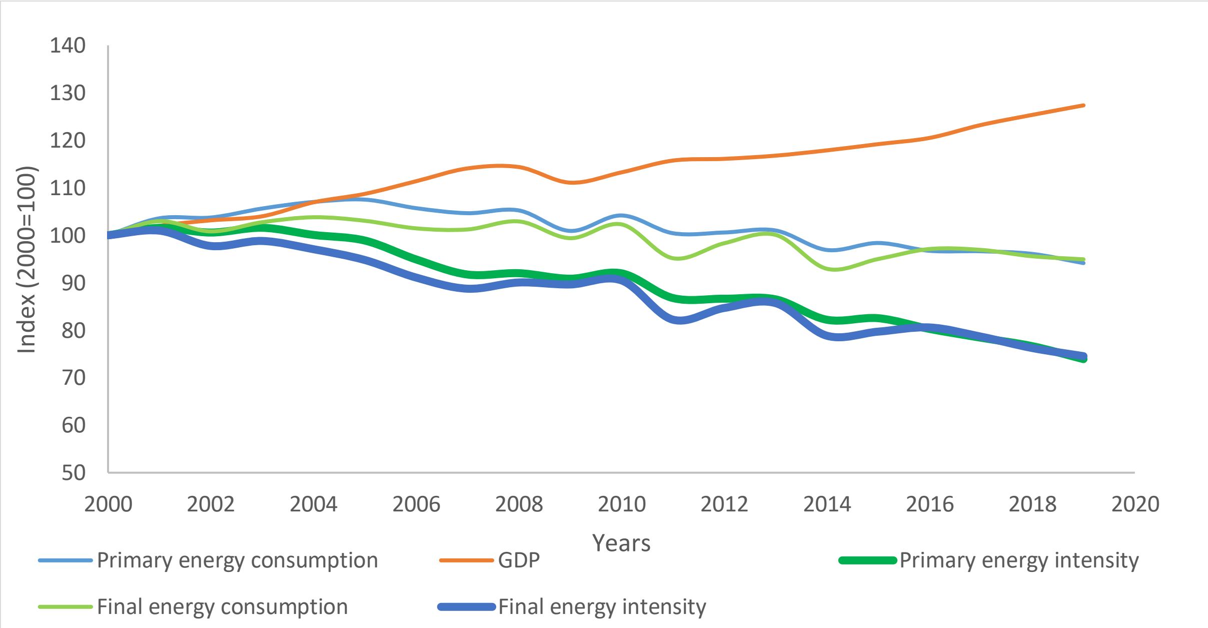
Figure 5 : Development of primary and final energy consumption in France (2000-2019)



Source: ODYSSEE database

Additionally, **figure 6** shows a larger decoupling between the GDP and the primary energy consumption from 2008. A higher economic growth was possible (1.4% yearly GDP increase since 2008) with a much lower progression of the primary energy consumption (-0.7% per year since 2008). Although 2015 and 2016 show a consecutive rise in energy consumption after the 2014 steep fall, but the decoupling trend is strengthened.

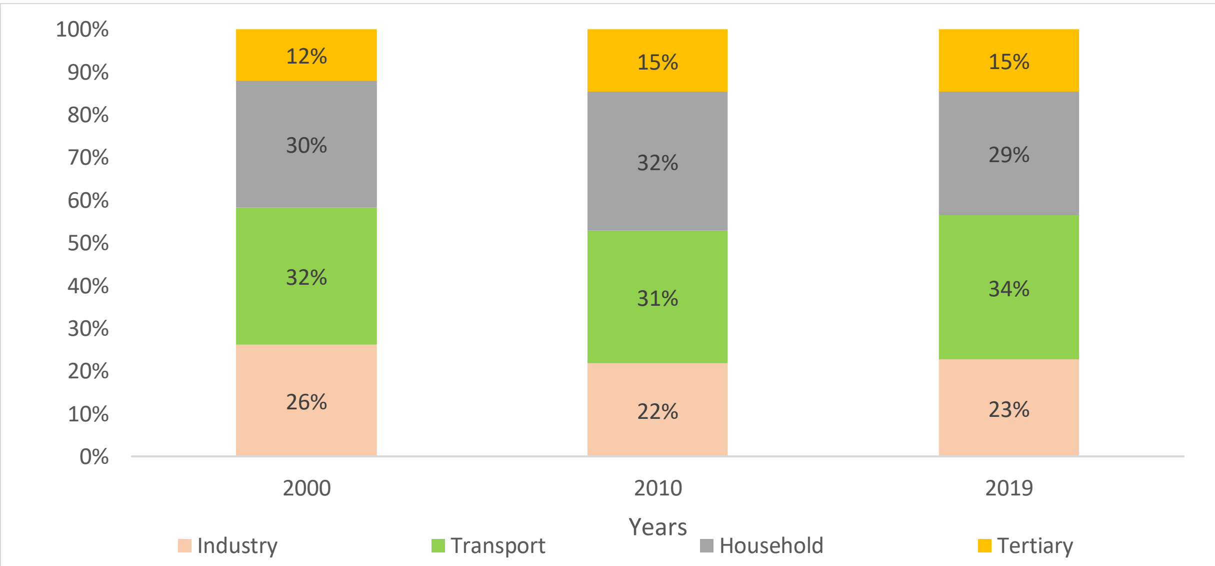
Figure 6 : Decoupling of energy consumption and GDP (2000-2019)



Source: ODYSSEE database

The transport and household sectors account for two-thirds of the final energy consumption with a relatively equal share. To their benefit, the industry sector has gone down by 3% during the past two decades **(Figure 7)**. However, there have been no fundamental changes since 2000. The variation of each sector has stayed at about 2 percentage points. Therefore, the three just mentioned sectors are of great importance for the analysis of energy efficiency.

Figure 7 : Final energy consumption by sectors in France (2000-2019)



Source: ODYSSEE database

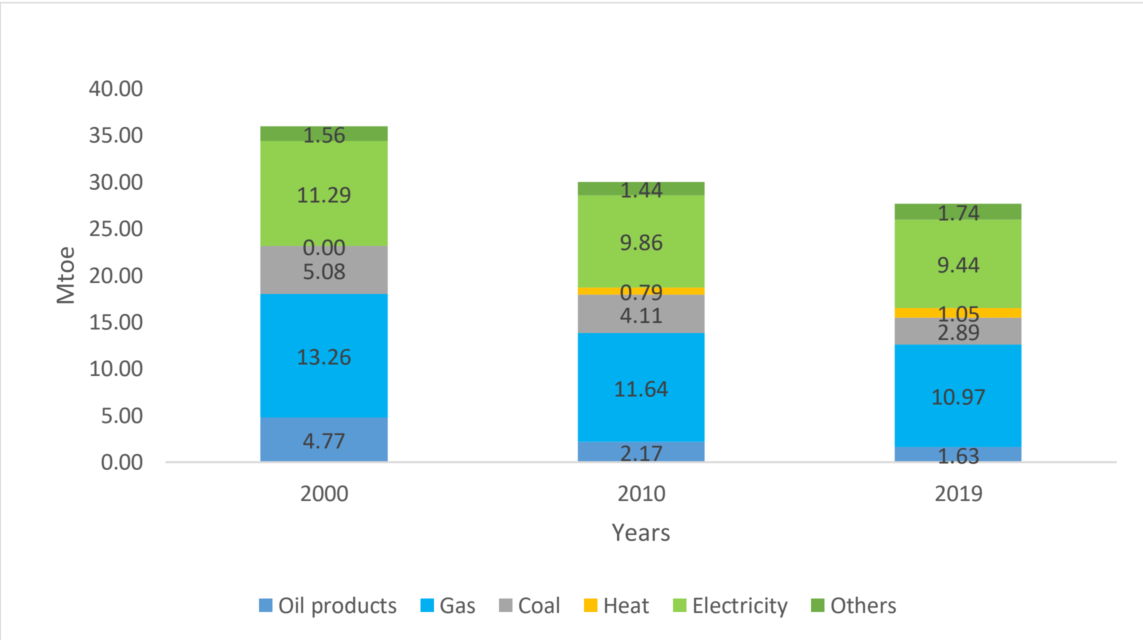
I.2 Energy efficiency in the Industry sector

I.2.1 Energy consumption

The share of the final energy consumption of the industry sector (Manufacturing, mining and construction) is still important (around (a 22% in 2019), amounting to 29.6 Mtoe, which is 20% lower than the 2000 consumption of 37.3 Mtoe **(Figure 8**). Today's consumption level was reached by an average yearly decrease of -1.2% from 2000. This trend was less marked between 2010 and 2019 with an average annual growth rate of - 0,8% just after the contraction of the economy in 2008 and 2009.

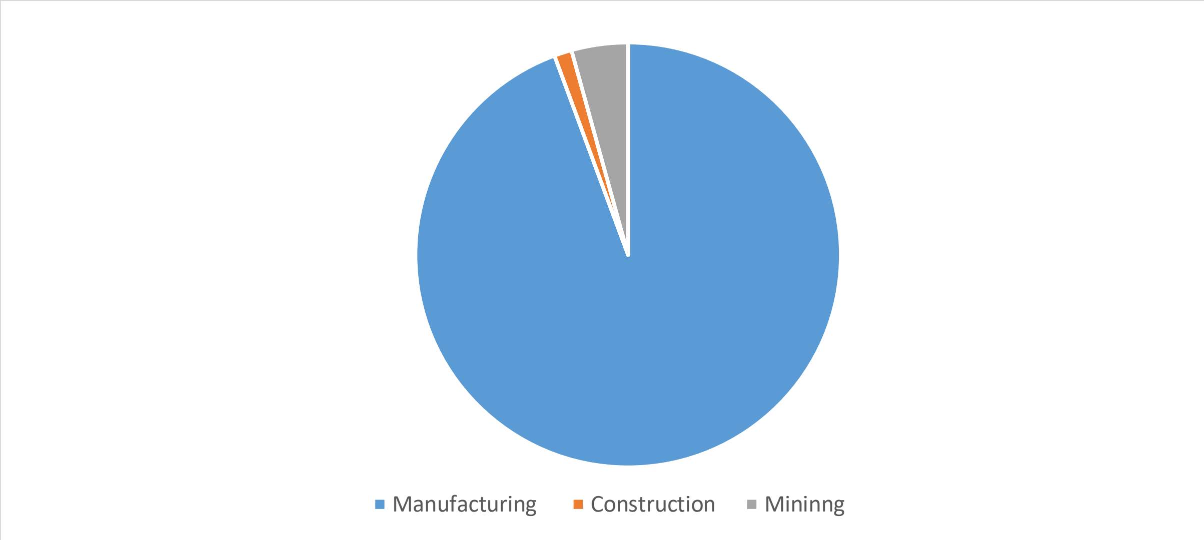
This decrease in consumption is obvious spdecially for fossil fuels which the market share dropped by 33% over the period, while electricity consumption decreased by -0,9%/year and the heat consumption increased. This downward trend is principally shaped by the manufacturing industry, which contributes about 94% (**figure 9**) of total final consumption in industry with 27.7 Mtoe in 2019. The lower-consuming, construction and mining industries reached a consumption level of 1.53 Mtoe and 0.39 Mtoe respectively.

Figure 8 : Energy consumption evolution by fuel type in industry sector (France, 2000-2019)



Source: ODYSSEE database

Figure 9 : Share of the manufacturing sector in the total energy consumption of industry (France, 2019)

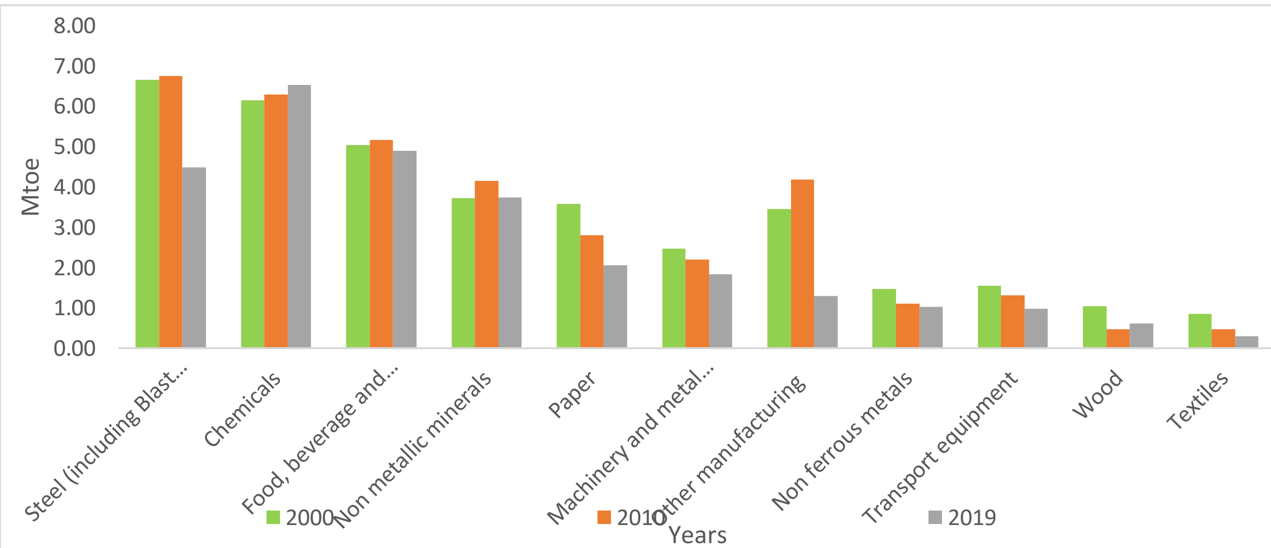


Source: ODYSSEE database

Over the period 2000-2019, energy consumption by sub-sectors did not change significantly (**Figure 10**). Primary metals and chemicals account for half of the consumption. The first one had decreased by 1.3% per year in the whole period but has accelerated since 2008, while the second acchieves a yearly increase of about 0.32% per year.

In addition to primary metals and chemicals, other energy-intensive branches such as non-metallic minerals, paper and food are also representative, and all together constitute almost the 80% of energy consumption in industry in 2019. The most interesting phenomena is that the energy consumption decreased in all sectors excepted chemical, particularly visible in two intensive branches from the post 2008 crisis level.

Figure 10 : Energy Consumption evolution by branch in the manufacturing sector

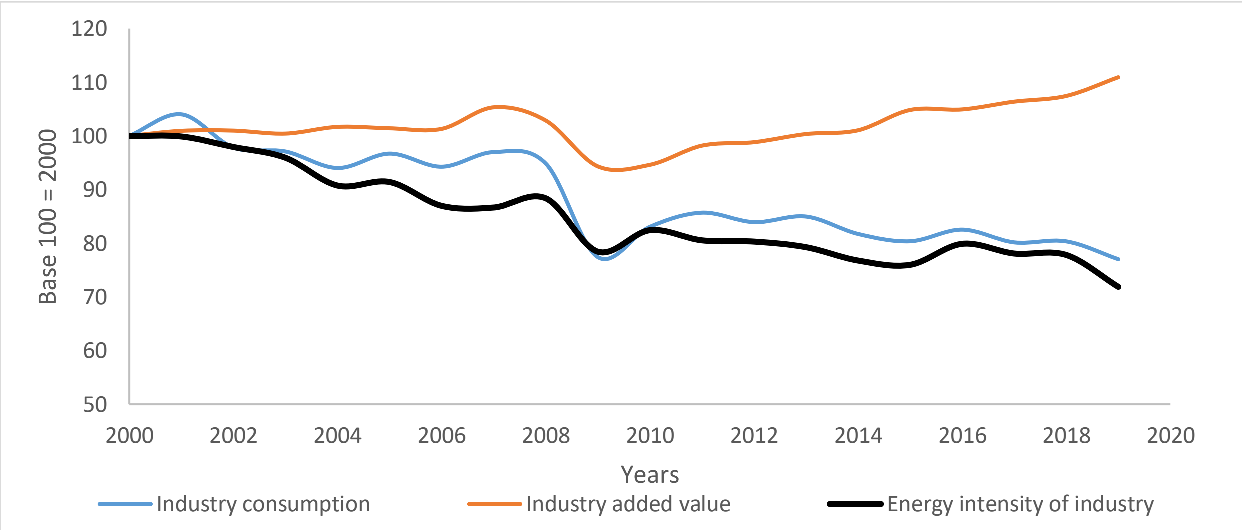


Source: ODYSSEE database

I.2.2 Energy productivity in the manufacturing sector

The overall energy productivity in the manufacturing sector can be evaluated through the evolution of the so-called" energy intensity ratio" described by the aggregate indicator of energy consumption compared to value added per branch. . Even though there is an expanding decoupling of these two variables (**Figure 11**), the energy intensity improved about 28% during the two last decades, with a remarkable impact of the 2008 crisis on the trend.

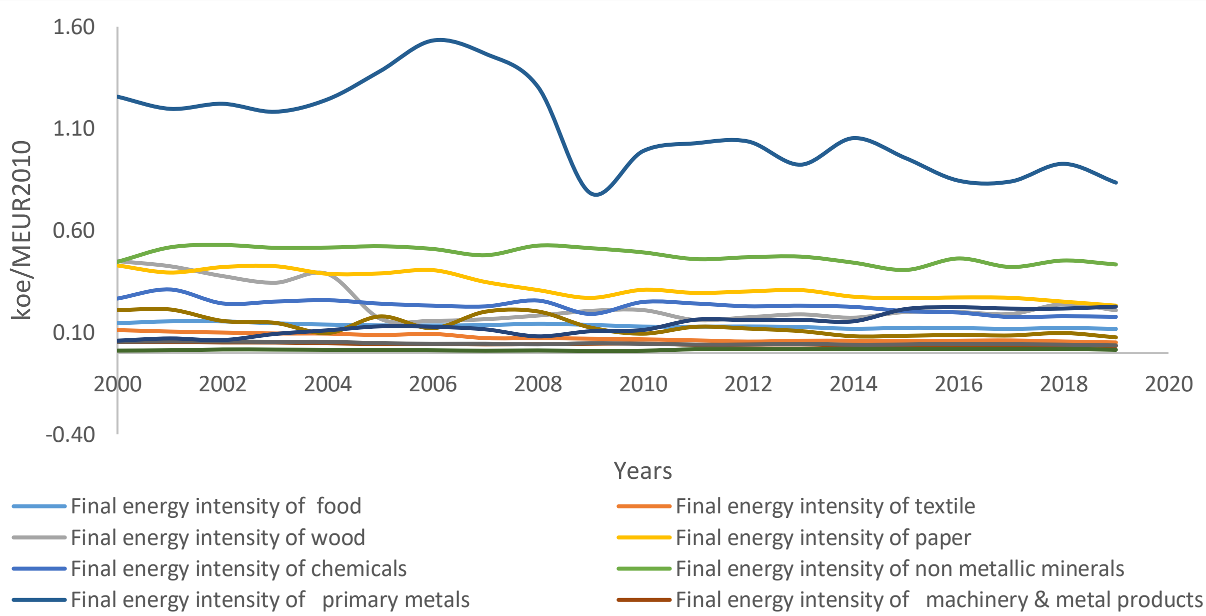
Figure 11 : Development of Energy Consumption and productivity in the industry sector (2000-2019)



Source: ODYSSEE database

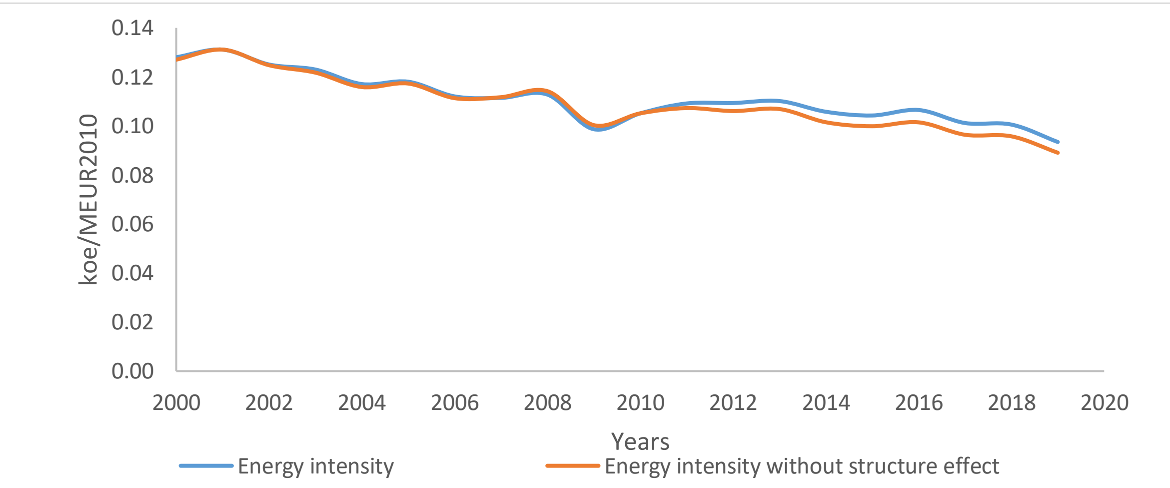
However, this indicator of energy intensity should be considered as a proxy of energy efficiency since its evolution encompasses the impact others factors such as the of structural changes which occurred among branches in particular towards light industries or the impacts other sectoral policies than energy efficiency (environmental norms for instance or delocalisation abroad). It is possible to clean out the energy intensity to some of these "others factors" in particular the structural changes between industrial branches (**Figure 12**). This can be shown by the energy intensity calculated within a constant structure of manufacturing. (**Figure 13**). The intensity at constant structure better reflects the predominantly technically induced efficiency changes in manufacturing since the impact of structural changes is removed. **Figure 13** shows the development of the structural change impact along the period 2000-2019.

Figure 12 : Energy intensity structural effect of the industry sector branches



Source: ODYSSEE database

Figure 13 : Evaluation of the impact structural change of themanufacturing sector on the energy intensity



Source: ODYSSEE database

In principle, the impact of the structural changes should be appreciated over a long time period since these changes develop slowly and have a long lasting effect due to the resilience of the infrastructure (i.e production line) in that economic sector. However strong and rapid structural effect may appear in a period of rupture such has the one observed in 2008 in France. Over the 2000-2008 period, no visible structural change have occurred in the French industry (or at least there was a compensation between sectors). Surprisingly enough is the absence of strong structural effects within the manufacturing sector caused by the 2008 crisis despites huge drop in production that have been observed.

For example, steel production dropped by 28% between 2008 and 2009 from 110.6 Mt to 7.7 Mt. For cement and glass production both dropped by 15% for the same period (from 21.4 Mt to 18.3 Mt and from 5.2 Mt to 4.4 Mt respectively) Finally the only period where some light structural changes are visible occurred during the post crisis recovery period of the crisis. They play a positive role in reducing the energy demand due to the more rapid development of light industries. However, we can consider this effect as very little contribution in the slowing down of the energy demand in the manufacturing sector.

I.2.3 Energy efficiency in the manufacturing sector

I.2.3.1 Energy efficiency policies in Industry

Energy efficiency policy in industry have been implement since the first oil shock and ones may say that the golden age of energy efficiency is behind us in industry. In fact, the energy efficiency potential in still important in that sector and continue to develop as far as new efficient technologies or processes penetrate the market. If the policy mix a certainly evolve as well as the sector coverage (ie SMEs), they are still important policies to support investments for efficiency in particular related to the EU directive (ETS and / or EED). Several policies targeting industry's energy consumption and CO2 emissions are included in the National Energy Efficiency Action Plans (NEEAP).

In the following paragraphs, some of the key energy efficiency policy measures are described.

Thanks to the French public investment bank (BPIfrance) small and medium-sized enterprises (SMEs) are eligible to two kind of loans, "Energy saving loan" & " Green loan" which are available for companies which want to improve their energy efficiency (installation of efficient equipment eligible to ESC scheme, work to bring them up to standard…), and the second to improve the environmental performance of their industrial processes or their products.

Also, the Heat Fund finances facilities for the production of heat from renewable energies (biomass, geothermal, solar, biogas, etc.) and district heating, as well as heat recovery projects (since 2015). During the period 2009-2017, it has supported more than 4,300 installations, and granted more than 1.7 billion euros of public aid representing a potential energy production of 2.15 Mtoe.

The European Directive 2012/27/EU on energy efficiency promotes the recovery of waste heat. Thus, ICPE (Classified Installations for the Protection of the Environment) installations with a total thermal capacity of more than 20 MW and located near a heating network are required to carry out a cost-benefit study in the case of substantial renovation or new installation.

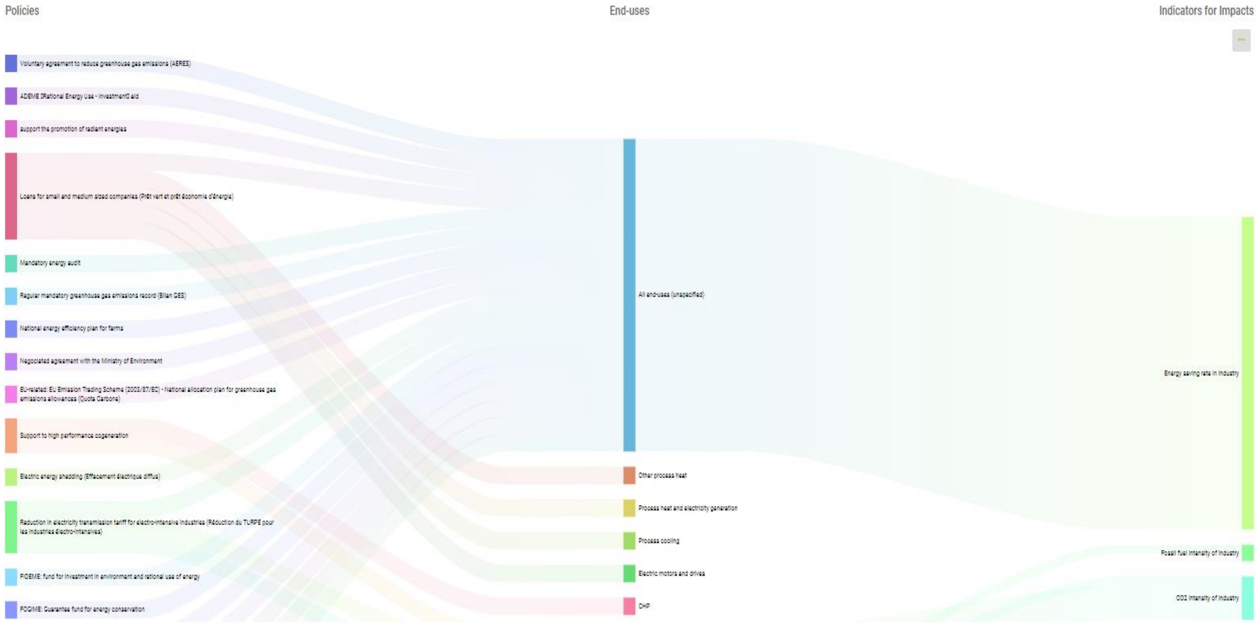
Managed by the French agency for energy and environment management (ADEME), the Heat Fund supports several types of projects.

The decarbonization of industry, in addition to meeting the climate challenge, is a performance lever for French industry in the medium term. This is why the France Recovery Plan includes an ambitious section dedicated to the decarbonization of industry and endowed with €1.2 billion by 2022, including €200 million from 2020.

ADEME is implementing this new support for industrial companies through investment grants.

The ”France Recovery plan”, allows accelerating the ecological, industrial and social transformations of the country.

Figure 14 : Policy mapper tool of the Mure database for industry



Source: MURE tools

The visual and clear overview of the list of policy measures per end-use, which is available in the Policy Mapper tool, prepares the ground for a deeper policy impact analysis (in terms of energy savings), including the overlap or reinforcing of measures within a policy package[4]. A combined impact can be calculated with the Policy Interaction facility for a package of measures based both on a matrix that contains the interaction among policy types and a semi-quantitative impact of each measure (low, medium, high) (**see figure 15 for more details**). These parameters are modifiable and in the example in **figure 15**, policy experts set them up.

Figure 15 : Industry measures and policies in France

Code	Country	Sector	Title	EU	Impact	NECPs	Article 7	Type	Starting Year	Ending Year
IND-FR1119	France	Industry	Voluntary agreement to reduce greenhouse gas emissions (AERES)	No	High	No	No	Others	2002	
IND-FR1122	France	Industry	Loans for small and medium sized companies (Prêt vert et prêt économie d'énergie)	No	Low	Yes	No	Financial	2010	
IND-FR1124	France	Industry	Mandatory energy audit	No	Low	Yes	No	Mandatory information	2015	
IND-FR1125	France	Industry	Regular mandatory greenhouse gas emissions record (Bilan GES)	No	Low	Yes	No	Mandatory information	2011	
IND-FR1128	France	Industry	EU-related: EU Emission Trading Scheme (2003/87/EC) - National allocation plan for greenhouse gas emissions allowances (Quota Carbone)	Yes	High	Yes	No	Market-based Instruments	2005	2030
IND-FR1129	France	Industry	Support to high performance cogeneration	No	Low	Yes	No	Financial	2001	
IND-FR1130	France	Industry	Electric energy shedding (Effacement électrique diffus)	No	Low	Yes	No	Mandatory standards	2014	
IND-FR1131	France	Industry	Reduction in electricity transmission tariff for electro-intensive industries (Réduction du TURPE pour les industries électro-intensives)	No	High	Yes	No	Fiscal	2016	
IND-FR1134	France	Industry	EU-related: - Minimum energy performances of boilers	No	Low	Yes	No	Mandatory standards	1994	
IND-FR1135	France	Industry	Motor Challenge Programme	No	Low	No	No	Others, Information/training	2002	
IND-FR4428	France	Industry	Recovery Plan - National Low-carbon strategy – Funds for industry Decarbonization - Energy efficiency component	No	High	Yes	No	General programme	2020	
IND-FR4429	France	Industry	Energy Saving Certificates (Certificats d'Economies d'Energie, CEE)	No	High	Yes	Yes	Market-based Instruments	2006	
IND-FR4430	France	Industry	EU-related: Promotion of the Use of Energy from Renewable Sources (Directive 2012/27/EC) - Heat Fund (Fonds chaleur) - Fatal heat component	No	High	Yes	No	General programme	2009	

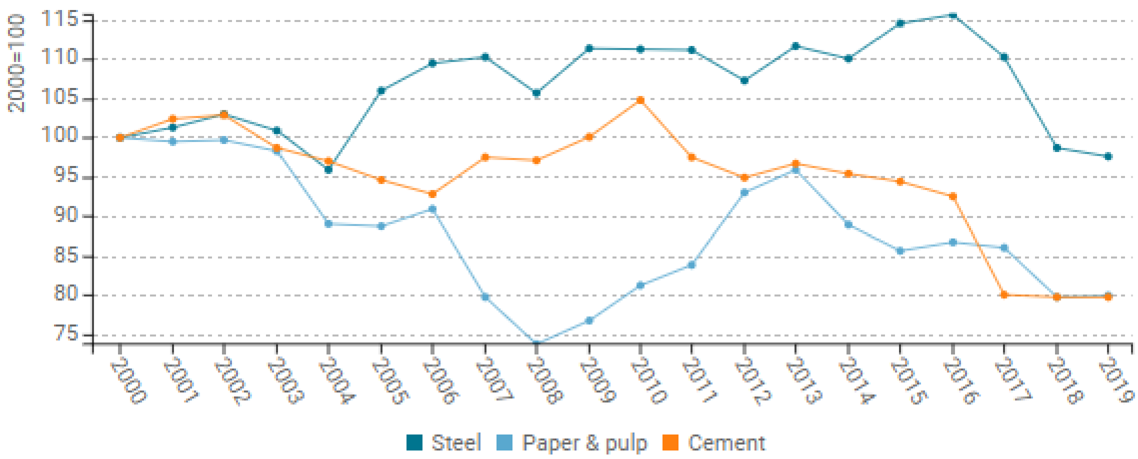
Source: MURE database

[4] Before defining whether the policies inside a package positively or negatively influence each other and promote or harm the energy savings of the commonly targeted end-use, the overview and information of those measures should be accessible and available in a structured way. The MURE's tool in charge of this: The Policy Mapper provides a clear visualization of policies aiming at the same-targeted end-use and relates them to the suitable energy efficiency indicators from the ODYSSEE database. The search is narrowed down to a clean policy overview by selecting a country, a sector and finally and a maximum of three energy uses. Including cross-cutting measures is optional. This tool is a key input of the Interaction Facility and together can contribute to the design of effective policy mixes.

I.2.3.2 Energy efficiency trends in the manufacturing sector

A more suitable and technical appraisal of energy efficiency trends should rely on the analysis of physical indicators (Toe/ton of product) rather than the economic indicator previously mentioned (The energy intensity). In the ODYSSEE data bases, we dispose on a breakdown of the manufacturing sector in 10 Branches[5]) Data availability allow us to carry out this analysis for selected products (crude steel, paper, cement) when the sector is **(Figure 16)**.

Figure 16 : Unit consumption of energy-intensive products



Source: ODYSSEE database

[5]Among this branches, we can find industries of : food, beverage, tobacco & textiles, clothing & wood industry & paper and printing & refining & chemicals & non metallic minerals & primary metals & machinery and metal products & transport equipment & other manufacturing including rubber and plastics.

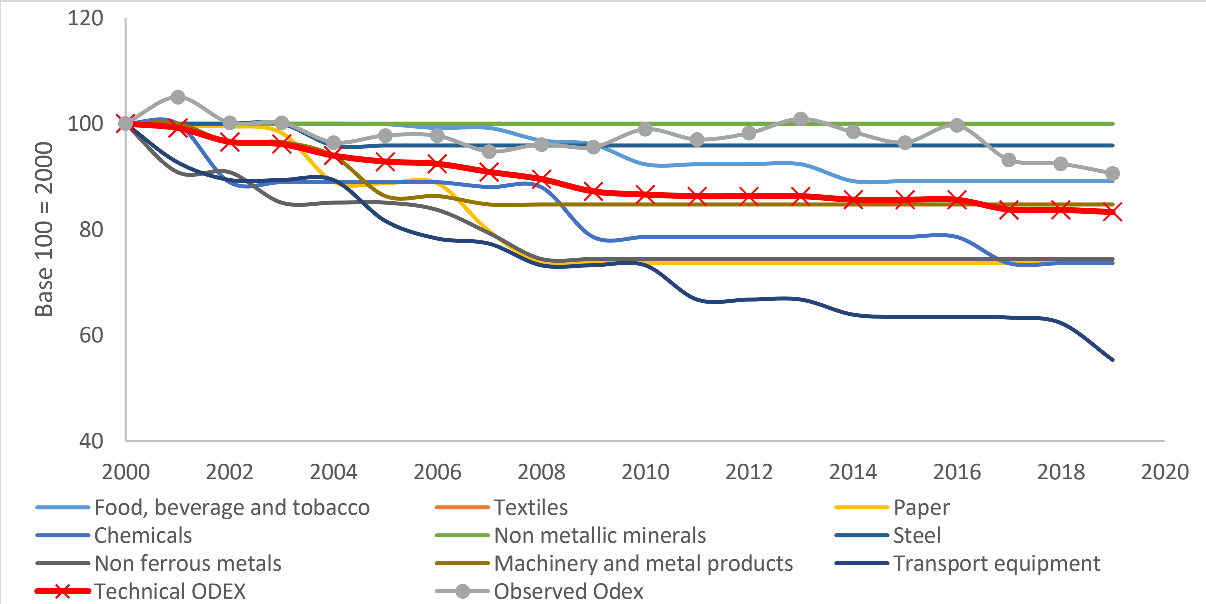
During the period 2000-2019, the unit consumption varied. Among the 5 energy intensive branches, the unit consumption of both cement and paper decreased by 1.2%/year. The steel industry, on the other hand, has experienced upward fluctuations, returning in 2019 to a level close to that of 2000. In fact, an increase was observed, especially in the case of steel, and this was mainly linked to business cycles. For cement and paper, unit consumption stagnates since 2018. The trend in unit consumption confirms the observation of rather modest energy efficiency improvement in industry, where only some branches showed a relevant fluctuation as the economy reactivated after the crisis. This was also a reversal of the trend during the 1990s, when both energy intensity and unit consumption of energy intensive products considerably decreased and an improvement in energy efficiency was observed.

It is possible to provide a sectoral evaluation of the technical efficiency progress based on the technical energy performances of the different branches which compose the manufacturing sector consumption products or at sectoral level using the Index of production energy efficiency index “ODEX”. It measures the efficiency development at the level of manufacturing branches and then aggregates this development to the whole sector (**Figure 17**). For the energy-intensive products (cement, steel, paper), the calculation is based on unit consumption per ton. For the other branches, the energy used per production index is used instead of added value, in order to exclude the impact of a changing value of products from the ODEX.

The fluctuating trend of the **observed total ODEX** (Red line) is due to the efficiency or inefficiency of equipment use and not to changes of equipment that are technically more or less efficient. That is why efficiency drastically drops in 2008, as equipments were not used at their rated capacity. In addition, part of energy consumption is independent of the production level. Under these conditions, it is difficult to assess the real technical energy progress. Therefore, the efficiency progress of the adopted technologies over the past 19 years is assessed by the **technical ODEX**, which shows an overall improvement in energy efficiency of 17% for the industry from the year 2000, the lowest among all sectors. However, it should be noted that after the 2008-2010 crisis the energy efficiency progress has substantially slowing down even stagnating. From 2000 to 2010 technical ODEX have decreased by 0.43%/year, and 0.96%/year from 2000 to 2019. This situation which is questionable and needs more investigations. It may results from a different factors such as intra-branches structural effect, change in the quality of products and lower impact of energy efficiency policies for instance.

The development within the industrial branches (**Figure 17**), however, varied significantly, both between the branches and over the whole period under review. There were some branches with a considerable energy efficiency progress (e.g. transport equipment, non-ferrous metals, paper and chemicals), and others with an increasing ODEX, i.e. a worsening of energy efficiency (e.g. steel, non-metallic minerals and food).

Figure 17 : Technical ODEX indicator by branch in industry

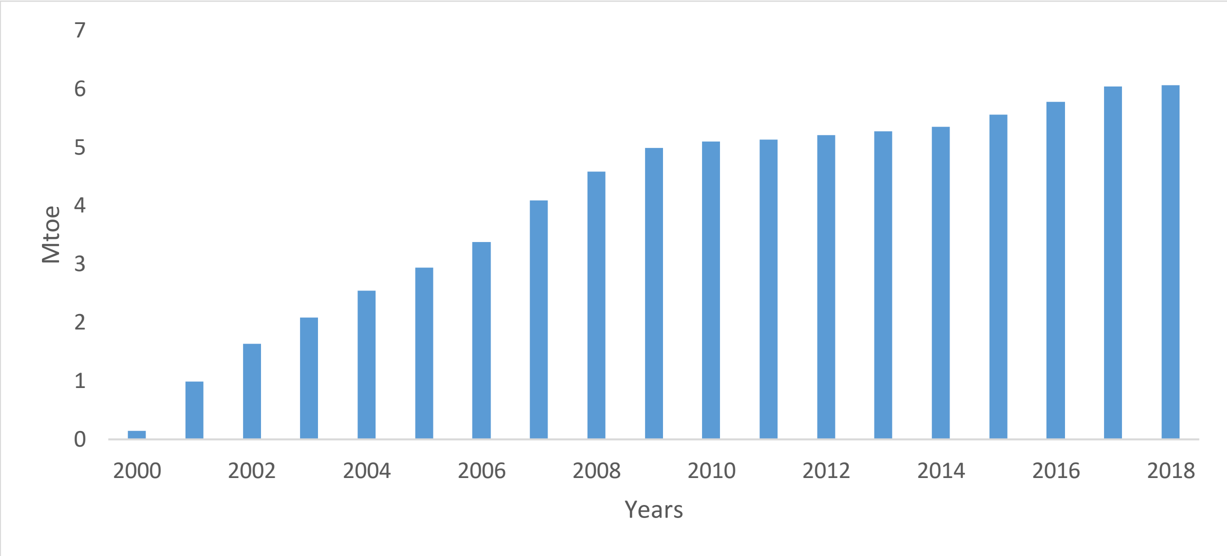


Source: ODYSSEE database

Directly derived from the technical ODEX, we can evaluate the amount of energy saving which have been delivered over the period. In 2019, the energy savings reach 6.1 Mtoe compared to the 2000 year reference corresponding to 20.6% of the 2019 consumption. In others terms, the final consumption of the manufacturing sector would have been 6.1 Mtoe higher without energy savings (**figure 18**).

The level of energy saving achieved has fluctuated over the period. Before the crisis, the energy savings steadily increases followed by a 5 years post crisis stagnation meaning that no additional yearly saving have been made consequently to the crisis. This confirms that the energy demand and energy efficiency of the industrial sector are very responsive and can be hardly affected by the economic crisis. More damageable, in the recent period 2014-2019, the rhythm of yearly energy savings seems to be durably slowing down corresponding only to half of those achieved in the beginning of the 2000's years.

Figure 18 : Energy savings from industry since 2000 (technical savings)



Source: ODYSSEE database

I.2.3.3 Explanatory factors of the energy demand changes in the industry sector (2000-2010)

In the industrial sector, the decomposition analysis allow us to assess the relative contribution of 4 factors or drivers which shape the energy demand trend:

- The activity effect, measuring the effect of a change in the value added of tertiary
- Climatic difference
- The structural changes, measured by the change in the structure of the value added by branch
- Productivity effect, measured by the change in the ratio of the value added per employment
- The energy savings, due to a decrease in the energy consumed per employee by branch
- Other

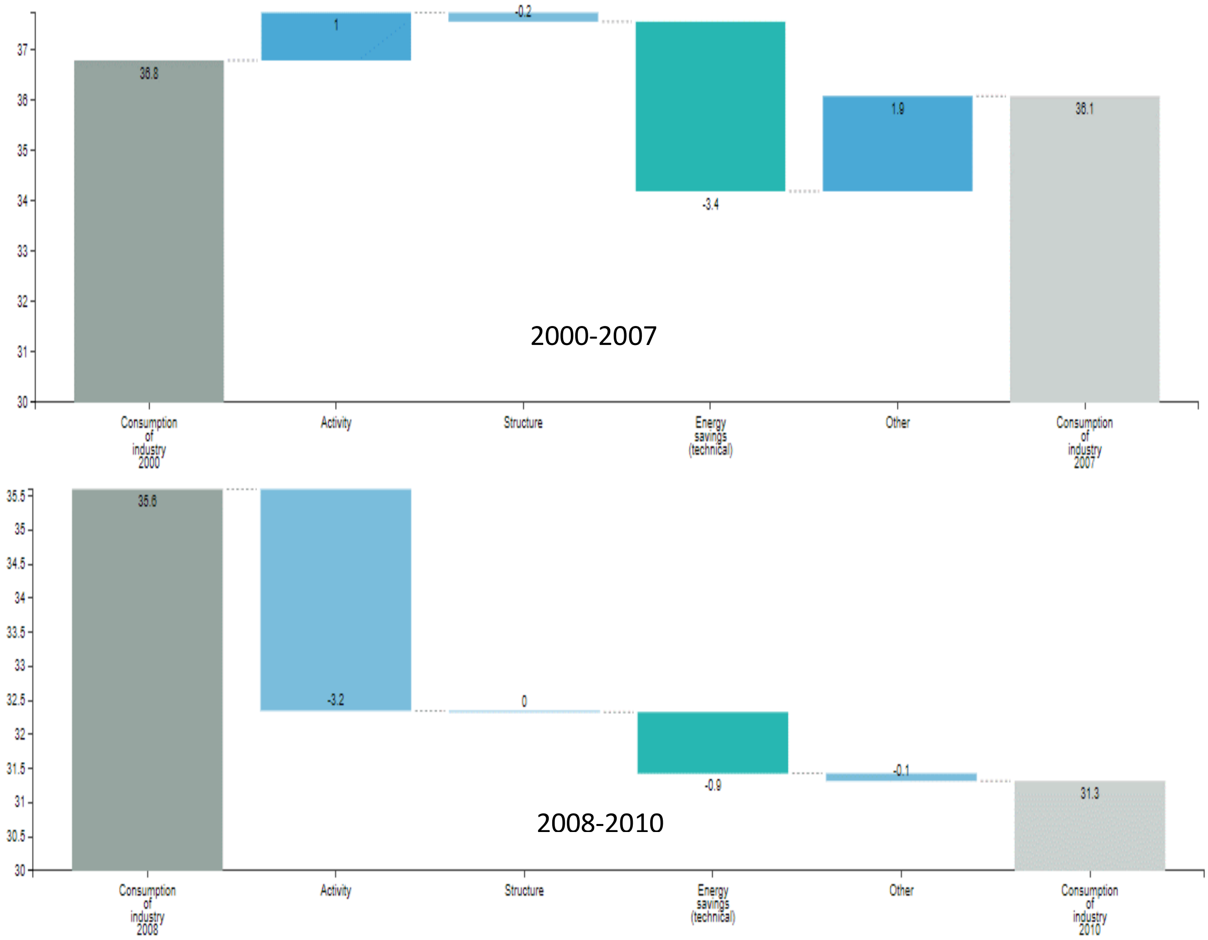
The decomposition of energy consumption confirms the progress in energy efficiency that was achieved in industry over the period 2000-2019. The relative contribution on energy demand of the four factors taken into account heavily depends on the period. Therefore, For the sake of the analysis, we have considered three periods over the two last decades.

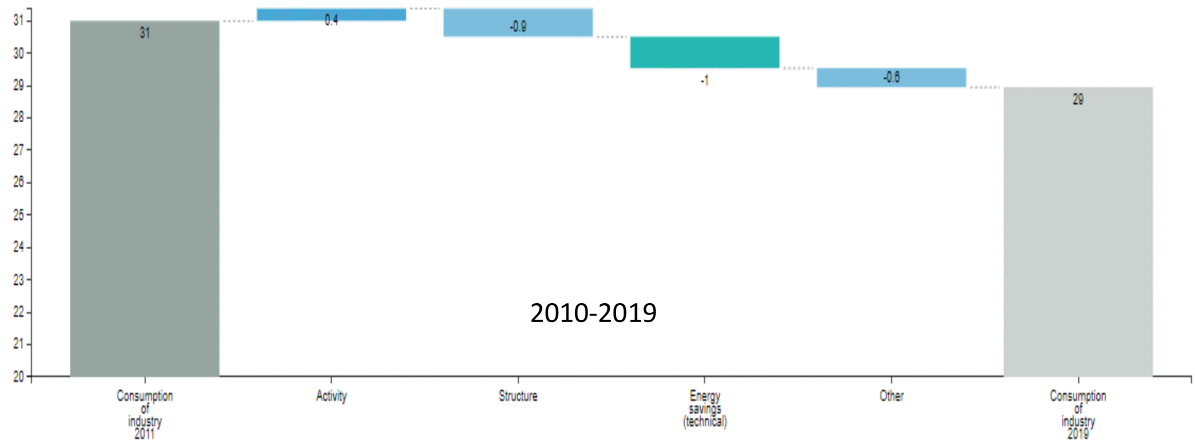
During the pre-2008 crisis period, the main explanatory factor has been the technical energy savings, which have contributed to reduce the consumption of (3.4 Mtoe). This has more than compensated the impact of the economic growth (1Mtoe). The second effect by importance, which have increased the energy consumption, is the “other” effect (+ (1.9 effect) due to inefficient operations which has offset 2/3 of the positive effect on energy demand reduction of the energy savings. Finally the impact of the structural changes towards less energy-intensive branches was negligible. The remaining difference, together with other effects (mainly negative savings due to inefficient operations), counteract the 3.4 Mtoe achieved technical savings from 2000 to 2007 and finally resulted in an energy consumption decrease of 0.7 Mtoe.

The 2008-2010 economic crisis has strongly depressed the final consumption in France (-4.3 Mtoe). Obviously, the most import impact of the downturn can be seen on the activity effect which have hardly decrease the energy demand of 3.2 Mtoe). Surprisingly, the drop of activity has not been accompanied by a structural effect which was negligible during the two years. The crisis also did not stop the achievement of energy savings but lowered the rhythm of improvement (- 0.9 Mtoe)

During in the last decade (2010-2019) (**figure 19c**), the energy demand has continued to decrease (2MToe) despites a slight recovery of the economy measured by the activity effect (1Mtoe). In fact during these 9 years no major changes can be observed and the energy saving contribution has been very deceiving

Figure 19 a, b, c, : Decomposition of final energy consumption in the industry for the periods 2000-2007, 2008-2010 and 2010- 2019





Source: ODYSSEE database

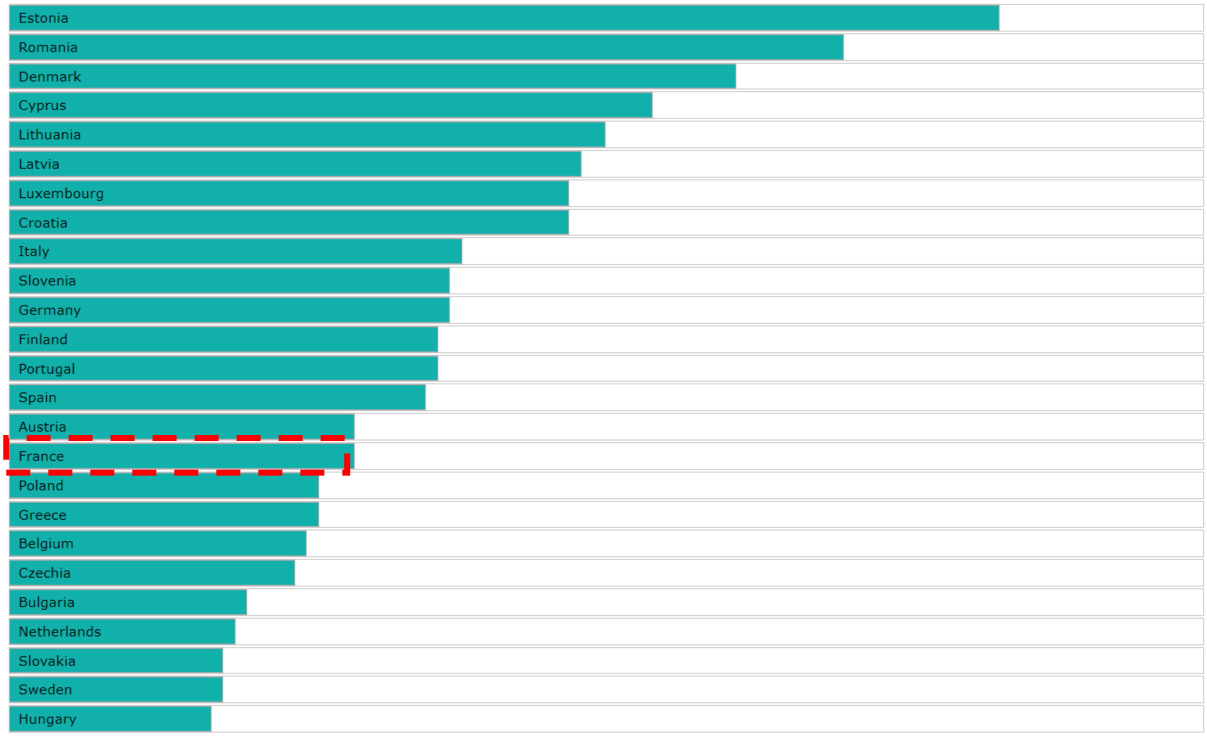
I.2.4 International benchmark on energy performances in the EU : The ranking of France

In industry the scoreboard on indicators relies on the following characteristics:

- The energy efficiency level,
- The energy efficiency progress,
- The energy efficiency policies,
- A combination of all these criteria.

As it can be seen from the **figure 20,** France is ranked 17th in the selection of 29 European countries. Table 1 provide a rough explanation of this position. Our energy performances trend is very slow compared to others countries (25th rank) which may be explained by the fact that France having started to implement policies since the 70s, it's becomes more difficult from French industry to perform rapid improvement anymore. However, our level of performances is just placed in the medium part of the scoreboard (18th rank). Further investigations at the level of industrial branches will be useful to better understating this situation particularly in the energy intensive industries (see below the case of the steel industry (**Figure 21**). However this "not so good" positioning may improve in the future since our policy mix in this sector (see description above in section 1.1)seems promising for taping the remaining energy efficiency potential (5th rank).

Figure 20 : Industry combined scoreboard



Source: ODYSSEE database; Scoreboard facility

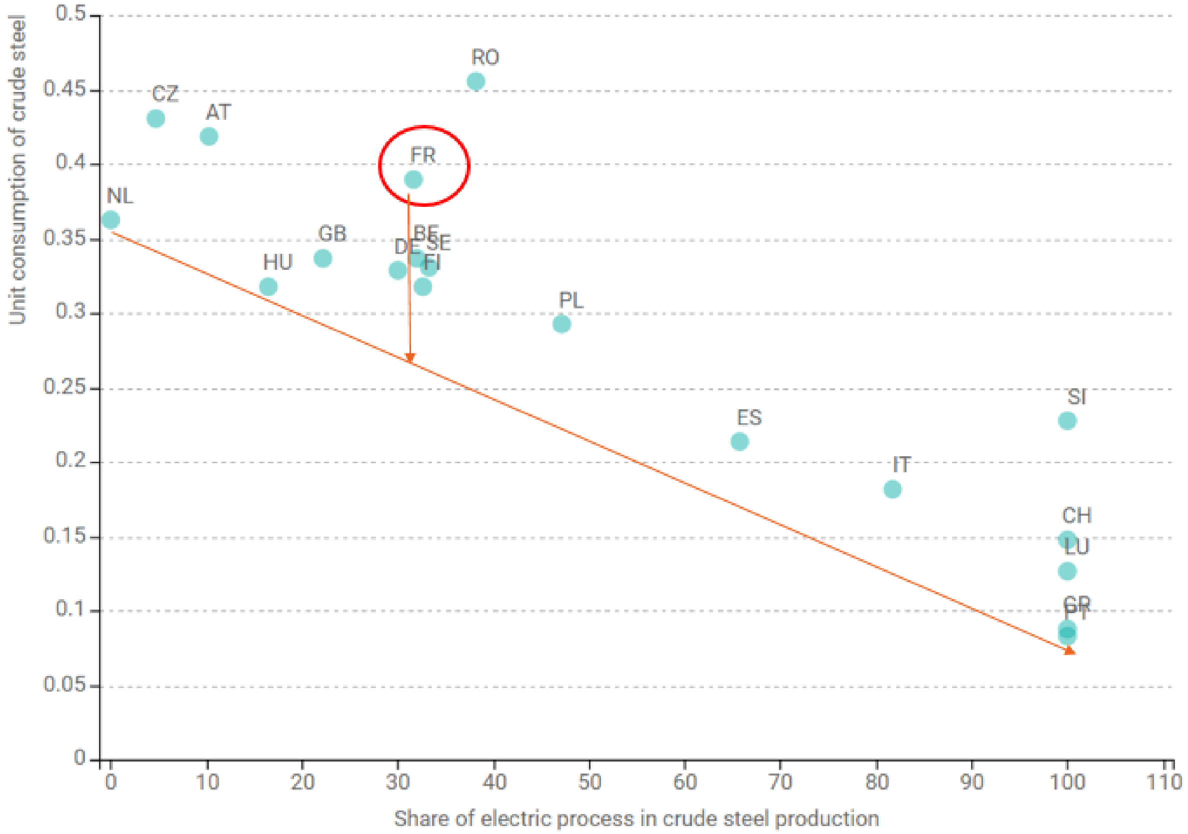
Table 1 : France industry sector position by critirea in the combined scoreboard

Ranking	Level	Trend	Policies	Combined
France	18 / 29	25 / 30	6 / 31	17 / 29
Highest score (benchmark)	Lithuania	Luxembourg	Finland	Estonia

Source: ODYSSEE database; Scoreboard facility

Comparing energy performances between countries at branch or product level is rather challenging because many factors can explain the differences at micro and macro level (process mix, product mix, quality of product, size of the company etc.). Such analysis is data demanding sometimes in confidential. We have investigate in 3 energy intensive industries of which the production is related to few products (steel, cement, paper. On purpose, we select the case of the steel industry (**Figure 21**). This graph shows the energy performances (toe/ton of steel) according to the share of the process mix used in each country between the oxygen and electric steel process. On average, the production of one ton of electric steel requires 5 times less energy than the oxygen-based process. (0.07 versus 0.37 toe/ton) as it can been seen from the benchmark of the best performances in Europe (the red line) . As it can be observed, on average the French steel industry is mainly relying on oxygen steel.

Figure 21 : Unit consumption of crude steel scoreboard



Source: ODYSSEE database

Steel is produced by two methods: electric steel and oxygen steel. There are countries with 100% production of electric steel like Slovenia and others with 100% production of oxygen steel like the Netherlands. France products 70% of oxygen steel and 30% of electric one. In figure 18, France consumption of steel is higher then other european countries which have the same share, as Germany, so an effort should be made to improve the efficiency and unit consumption of crude steel.

I.3 Energy efficiency in the Service sector

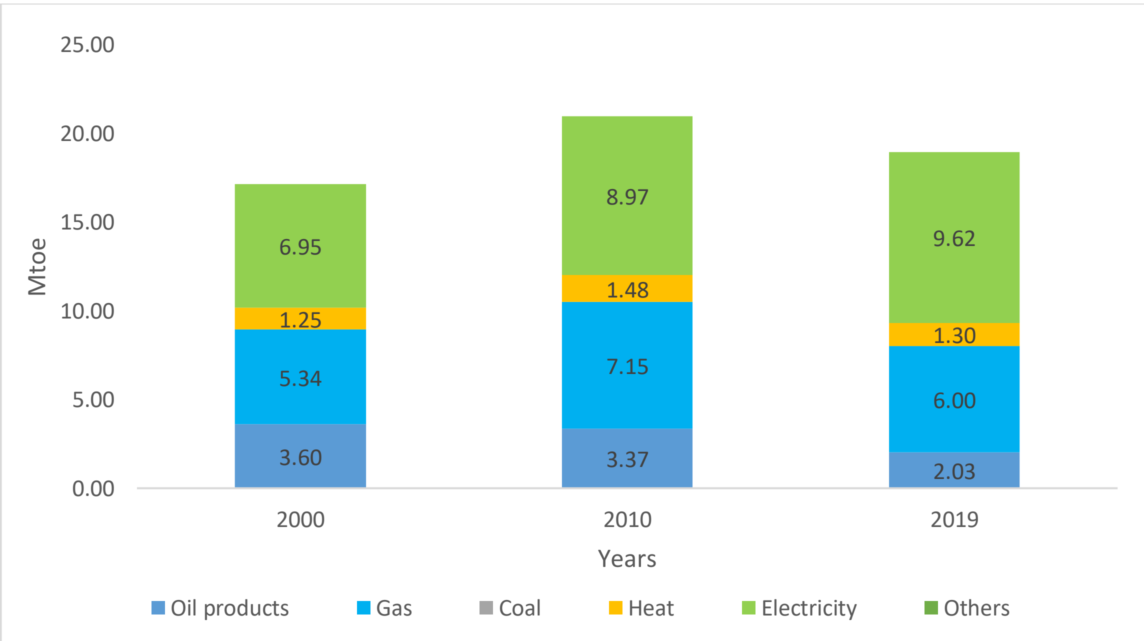
In 2019, the energy consumption of the tertiary sector accounted for 19.04 Mtoe, which is around 14.4% of total final energy consumption in France.

I.3.1 Energy consumption : Diminishing since the 2008 crisis

The total energy consumption in the service sector fluctuated between 16 and 20 Mtoe over the period 2000-2019 (**figure 22**). In fact, there has been an increase of 0.64% per year, which was mainly driven by the upward progression of consumption before 2008. From 2010 to 2019 consumption has dropped by 1.03%/year from 19.9 Mtoe to 18.2 Mtoe.

Significant variations of fuel type market share took place over the period. Clearly oil products and in a certain extent gas lost market share. At the opposite the electricity increased very rapidly whereas the heat consumption have remained stable, with a slight downward trend since 2008. The electricity and gas represent respectively 51% and 32% of the total energy consumption of the tertiary sector in France in 2019.

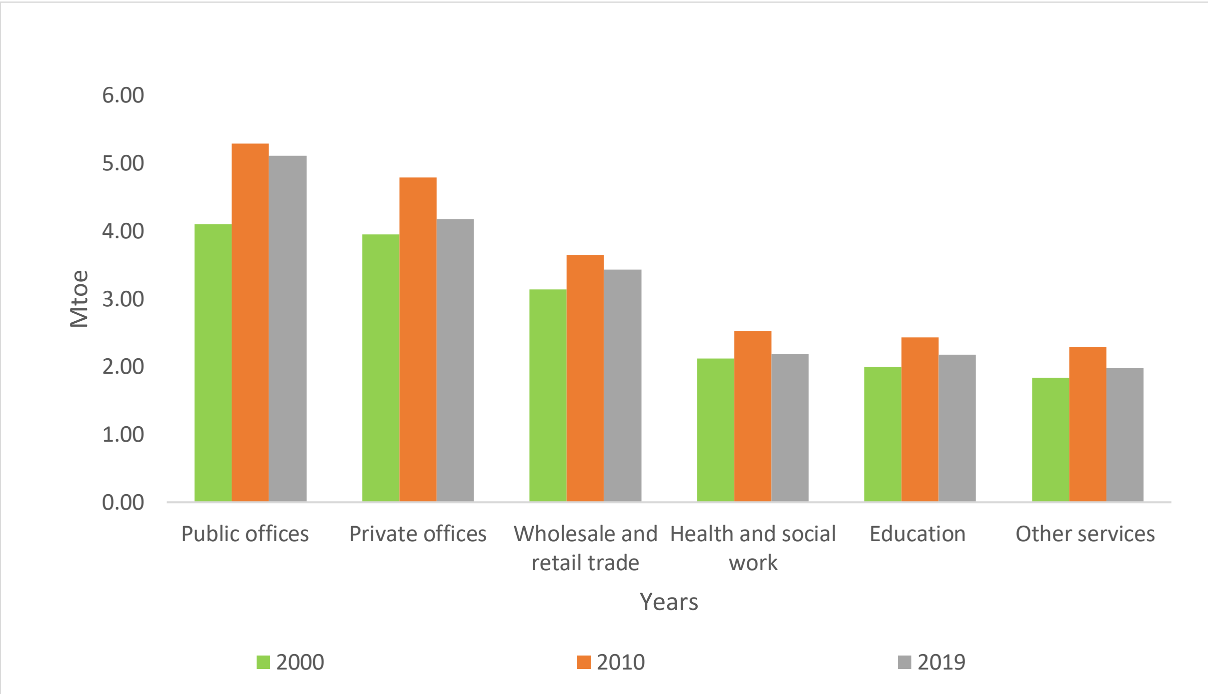
Figure 22 : Energy Consumption evolution by fuel type in Tertiary sector



Source: ODYSSEE database

In the past 19 years, the total energy consumption has followed the trend of the public offices, private offices and subsectors wholesale and retail, since they represent 67% of the energy consumption, with similar individual shares throughout the period (**Figure 23**). The consumption of the health and social work services, education and other services has remained steady over the period at a level of two to three Mtoe.

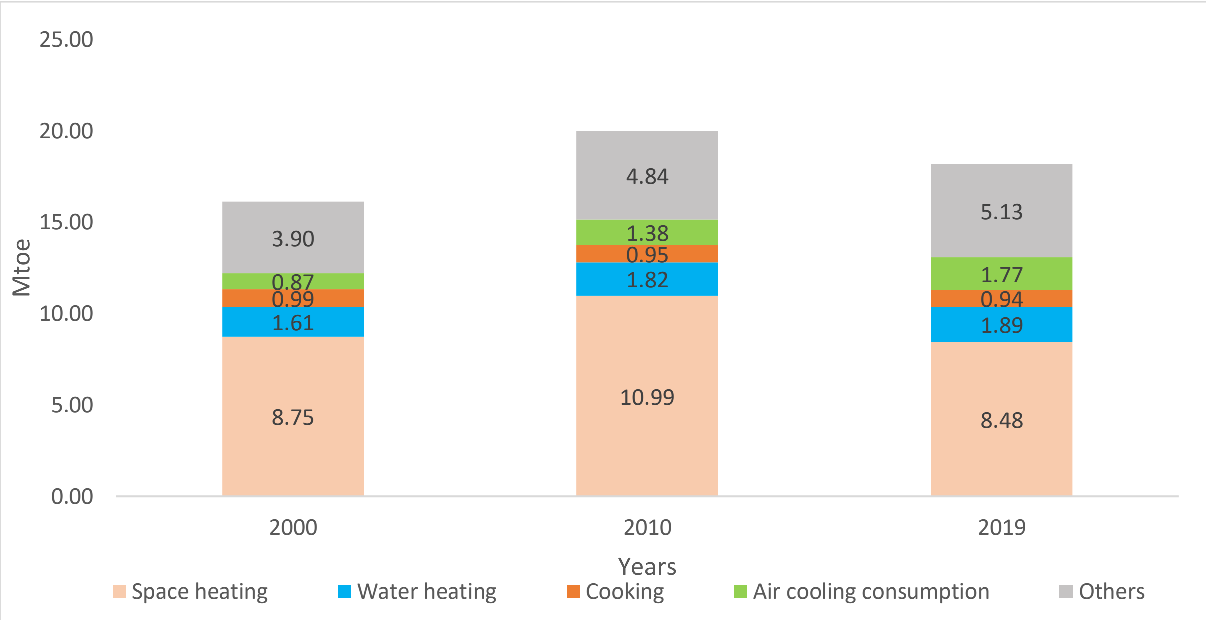
Figure 23 : Energy Consumption evolution by branches in Tertiary sector



Source: ODYSSEE database

Space heating is by far the largest energy end use of the tertiary sector but with a dramatic decrease since the Market share drop from 55% to 47% from 2000 and 2019 respectively (**Figure 24**). The second end use is the category "other electricity uses "such as lighting, ICT, computer, etc.) but excluding air conditioning. In detail within this category, electrical appliances consumption is growing rapidly. At the reverse, the lighting consumption is decreasing as far as efficient lighting (CFLs and LED) replace the incandescent lamps. It can be noted that air cooling consumption increase by 3.8% per year from 2000 to 2019, but it's consumption share remains low with only 10% in 2019. The impact of the development of data centers cannot be isolated for the moment from the category others.

Figure 24 : Energy Consumption evolution by end use in Tertiary sector



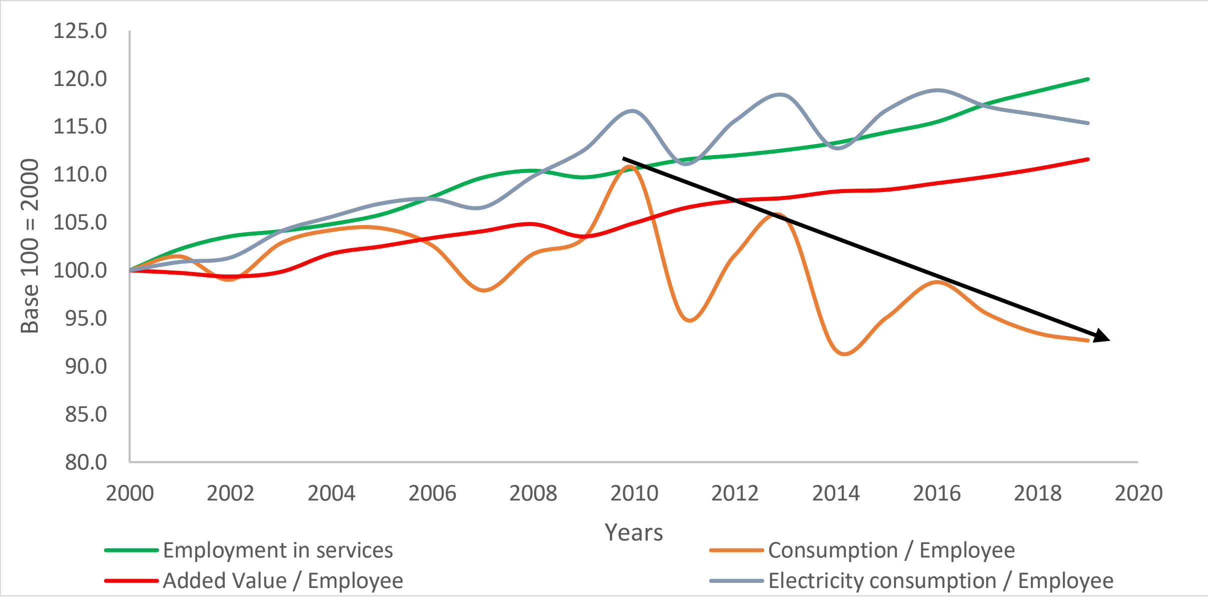
Source: ODYSSEE database

Services create the largest number of jobs in the economy during the last two decades (1% per year). However, this job creation has been accompanied by an improvement of the labour productivity (VA/employee) of around 0.5% per year. This labour productivity goes with a dramatic improvement of the consumption per employee particularly visible after the 2008 crisis (-18%).

However, this overall phenomenon results of two opposite trends: On one hand a rapid decrease for fossils fuels corresponding to the substitution towards electricity in space heating and large efficiency gains in space heating due to regulations and on the other hand and increasing electricity trend for electricity consumption per employee linked to a more important use of the use of electrical appliances as computer, photocopier, scan etc. (**Figure 25**).

However, since 2015, we notice a break in this upward trend where the electricity consumption/employee seems to decrease durably, probably linked to the combination of a beginning of saturation of electrical appliances ownership and a technical improvement of energy efficiency.

Figure 25 : Consumption of the Tertiary sector per employee evolution & drivers



Source: ODYSSEE database

I.3.2 Energy efficiency policies in Tertiary sector

For the service sector, there are financial instruments pointing at energy efficiency such as the energy renovation tax credit for VSEs/SMEs which is included in France recovery plan and which benefit to support artisans, merchants and the self-employed in the ecological transition. This program started at 2021 for a budget of 200 million euros and can be requested by applying through the ADEME's platform AGIR.

Since the 1st July 2013, lighting installations of non-residential buildings have to be switched off during the night, in order to reduce both energy waste and light pollution. Energy savings resulting from this switching-off are expected to be in the range of 2TWh per year, allowing a CO2 emission reduction of 250 000 tons and representing a saving of 200 M€ according to the Ministry for the environment. The lighting union on its side estimates that energy savings resulting from this measure will be closer to 0.5TWh.

Within the framework of the France Recovery Plan**,** a selection of 4,200 projects has been approved in 2020 for 2.7 billion Euros for the energy renovation of government buildings, higher education, research and student life, and for a total recovery plan budget of 4 billion Euros, i.e. 15 million m²**.**

The government has given priority to the ecological and economic efficiency of the recovery.

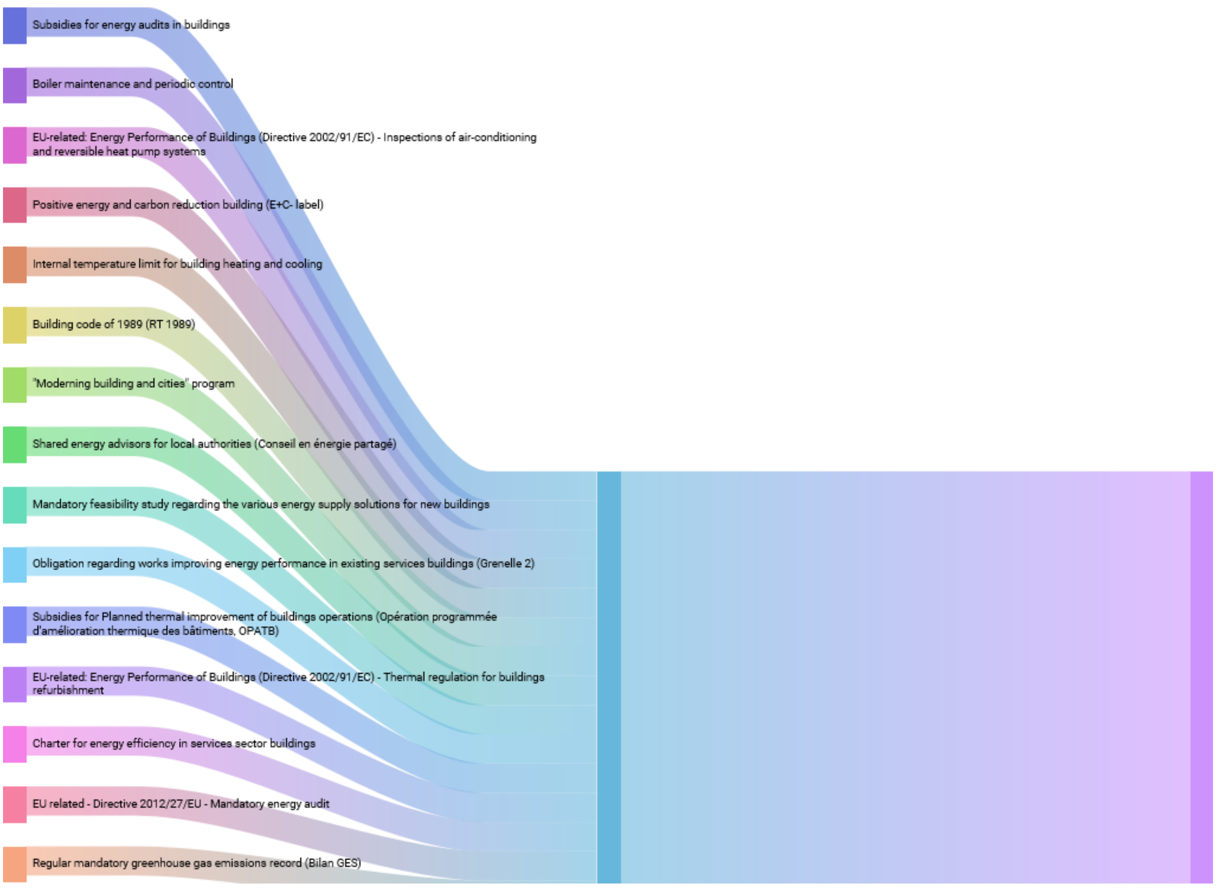
The projects were selected based on two essential criteria: their energy performance and the ability to implement the project quickly, thus promoting the revival of local economies and the construction sector. With an expected reduction of 400 to 500 GWhef at the end of the works, France Relance's investment will significantly reduce CO2 emissions and the carbon footprint of the State's building and will allow the creation of 20,000 jobs over 2021-2023**.**

Figure 26 : Tertiary sector measures and policies in France

Code	Country	Sector	Title	EU	Impact	NECPs	Article 7	Type	Starting Year	Ending Year
SER-FR1535	France	Services	Subsidies for energy audits in buildings	No	Medium	Yes	No	Financial	2000	
SER-FR1536	France	Services	Boiler maintenance and periodic control	No	Low	Yes	No	Mandatory standards	1998	
SER-FR1537	France	Services	EU-related: Energy Performance of Buildings (Directive 2002/91/EC) - Inspections of air-conditioning and reversible heat pump systems	Yes	Low	Yes	No	Mandatory standards	2002	
SER-FR1538	France	Services	Positive energy and carbon reduction building (E+C- label)	No	Low	Yes	No	Information/training	2007	
SER-FR1539	France	Services	Internal temperature limit for building heating and cooling	No	Medium	No	No	Mandatory standards	1974	
SER-FR1541	France	Services	"Moderning building and cities" program	No	High	Yes	No	Financial, Mandatory information	2008	
SER-FR1543	France	Services	Shared energy advisors for local authorities (Conseil en énergie partagé)	No	Low	No	No	Information/training	2009	
SER-FR1544	France	Services	Mandatory feasibility study regarding the various energy supply solutions for new buildings	No	Low	Yes	No	Mandatory information	2008	
SER-FR1546	France	Services	Subsidies for Planned thermal improvement of buildings operations (Opération programmée d'amélioration thermique des bâtiments, OPATB)	No	Medium	No	No	Financial, Information/training, Others	2003	
SER-FR1547	France	Services	EU-related: Energy Performance of Buildings (Directive 2002/91/EC) - Thermal regulation for buildings refurbishment	Yes	Medium	Yes	No	Mandatory standards	2008	
SER-FR1548	France	Services	Night-time switching-off of lighting in offices, shop windows and non-residential building facades	No	High	No	No	Mandatory standards	2013	
SER-FR1550	France	Services	Charter for energy efficiency in services sector buildings	No	Low	No	No	Others	2013	
SER-FR1551	France	Services	EU related - Directive 2012/27/EU - Mandatory energy audit	No	Low	Yes	No	Mandatory information	2015	
SER-FR1552	France	Services	Regular mandatory greenhouse gas emissions record (Bilan GES)	No	Low	Yes	No	Mandatory information	2011	
SER-FR1553	France	Services	Engaged territory , Ecological transition program (Programme TERRITOIRE ENGAGÉ TRANSITION ÉCOLOGIQUE)	No	Low	Yes	No	Others	2008	
SER-FR1554	France	Services	Refurbishment of central government buildings	No	High	Yes	No	Mandatory standards	2010	
SER-FR1555	France	Services	Building code of 2012 (RT 2012)	No	High	Yes	No	Mandatory standards	2013	
SER-FR1557	France	Services	High environmental quality certification for buildings (Certification Haute qualité environnementale, HQE)	No	Low	Yes	No	Information/training	1990	
SER-FR1558	France	Services	Minimum efficiency standards for fluorescent lamp ballasts	No	Medium	No	No	Mandatory standards	2001	
SER-FR1560	France	Services	EU-related: Energy Performance of Buildings (Directive 2002/91/EC) - Energy performance diagnosis (Diagnostic de performance énergétique, DPE)	Yes	High	Yes	No	Mandatory information	2006	
SER-FR1561	France	Services	EU-related: Eco-design requirements for energy-related products (Directive 2009/125/EC) - Minimum energy performances of boilers	Yes	Low	Yes	No	Mandatory standards	1994	
SER-FR4204	France	Services	Building code of 2020 (RE 2020)	No	High	Yes	No	Mandatory standards	2021	
SER-FR4206	France	Services	Programme to strengthen energy renovation support service (Programme SARE, Service d'Accompagnement à la Rénovation Energétique)	No	Low	No	No	Information/training	2020	
SER-FR4446	France	Services	Recovery Plan (Plan de Relance)	No	High	Yes	No	Mandatory standards	2020	
SER-FR4447	France	Services	Ecological transition and energy renovation of VSEs/SMEs - Energy renovation tax credit for VSEs/SMEs	No	Low	Yes	No	Fiscal	2021	
SER-FR4448	France	Services	Energy Saving Certificates (Certificats d'Economies d'Energie, CEE)	No	High	Yes	Yes	Market-based instruments	2006	
SER-FR4449	France	Services	Local Government Action for Energy Efficiency Program (ACTEE)	No	Low	Yes	No	Financial	2020	2023
SER-FR4450	France	Services	Investment plan for the dependent elderly housing sector (EHPAD) and inclusive housing	No	High	No	No	Financial	2021	2025
SER-FR4451	France	Services	Éco Energie Tertiaire (EET) - OPERAT (Observatory of performance performance, renovation and and actions in the service sector)	No	Low	No	No	Mandatory information	2019	

Source: Mure database

Figure 27 : Policy mapper tool of the Mure database for Tertiary sector



Source: Mure database

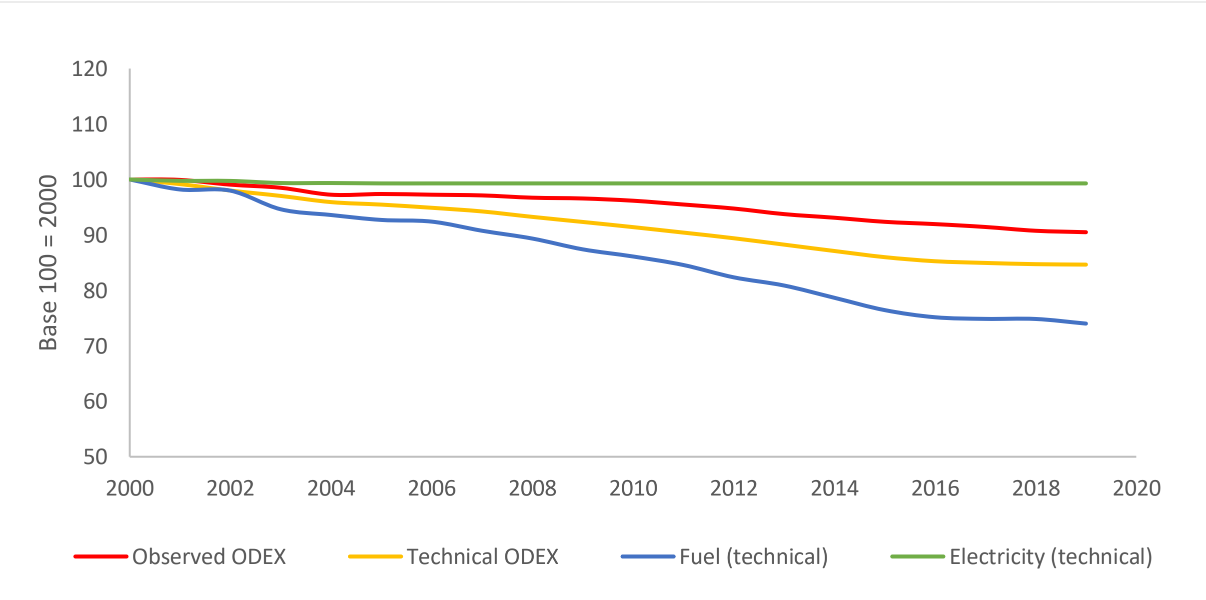
According to the policy mapper tool for the tertiary sector, a majority of policies and measures applies to all end-uses.

I.3.3 The energy productivity in the service sector

I.3.3.1 Energy efficiency and ODEX indicator

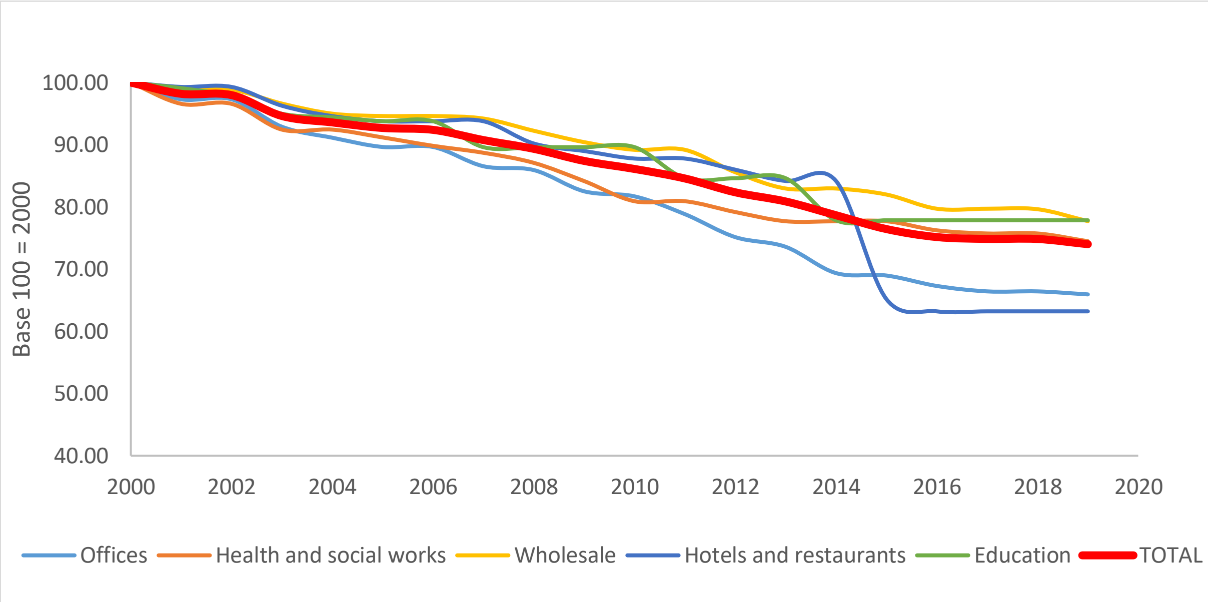
The so far achieved energy efficiency, related to the aggregate of unit consumption changes over time, has placed France in a disadvantageous stand in the Scoreboard for Energy Efficiency Level. However, the yearly evolution of the change in energy consumption seems satisfactory. **Figures 28 & 29** provides more information (four different ODEXs). As we have already noticed in the others sector the overall progress as it is measured by the observed index (Which contains climatic, behavioural, inefficient use of equipment and other effect) is slower than the technical energy efficiency one (10% compared with 15% respectively).

Figure 28 : ODEX indicator in Tertiary sector



Source: ODYSSEE database

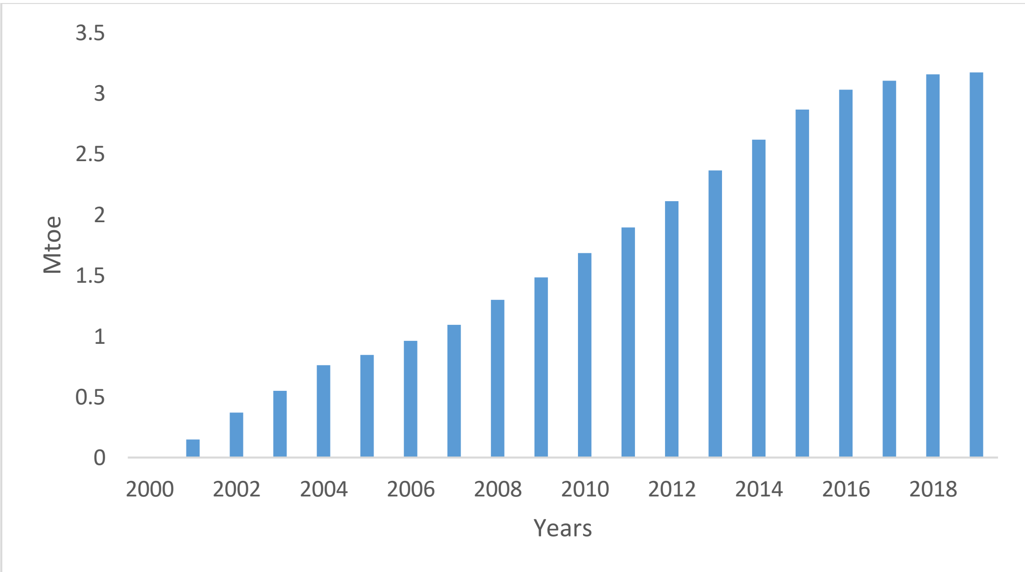
Figure 29 : Technical ODEX indicator by branches in Tertiary sector



Source: ODYSSEE database

Derived directly from the technical ODEX, we can calculate the amount of energy saved over the two last decades which culminates at 3.2 Mtoe in 2019, corresponding to 17% of the 2019 energy demand level in this sector (**Figure 30**).

Figure 30 : Energy savings from Services since 2000 (technical savings) in Tertiary sector



Source: ODYSSEE database

However, we observe a stabilization of the energy saving since the year 2016, but it is too early to conclude if this stagnation is a durable phenomenon and a rupture in the trend.

I.3.3.2 Explanatory factors of the energy demand variation in the service sector

The variation of the final energy consumption in services can be explained by:

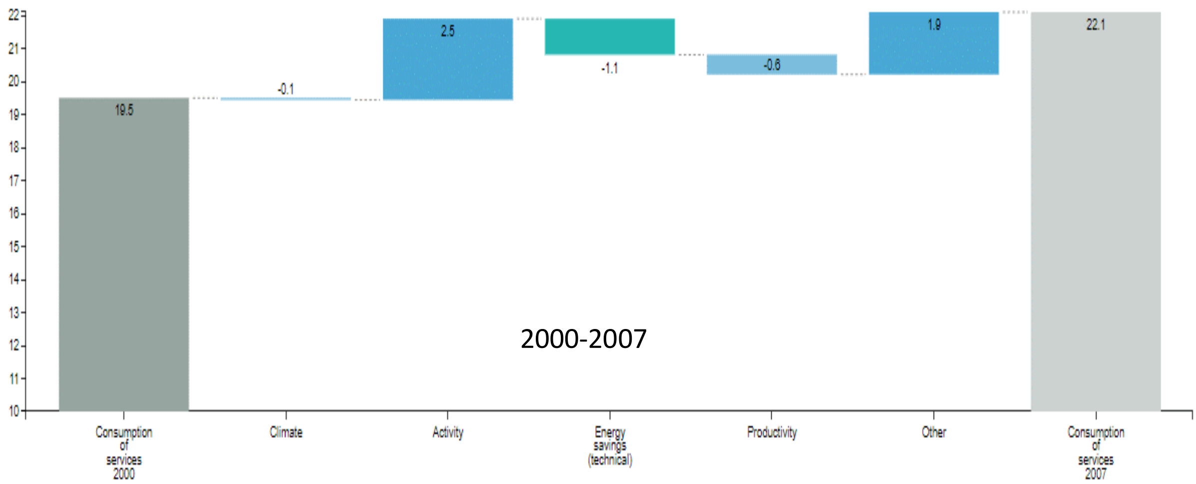
An activity effect, measuring the effect of a change in the value added of tertiary Climatic difference, a structural changes, measured by the change in the structure of the value added by branch the Productivity effect, measured by the change in the ratio of the value added per employee the Energy savings, due to a decrease in the energy consumed per employee by branch and other effects.

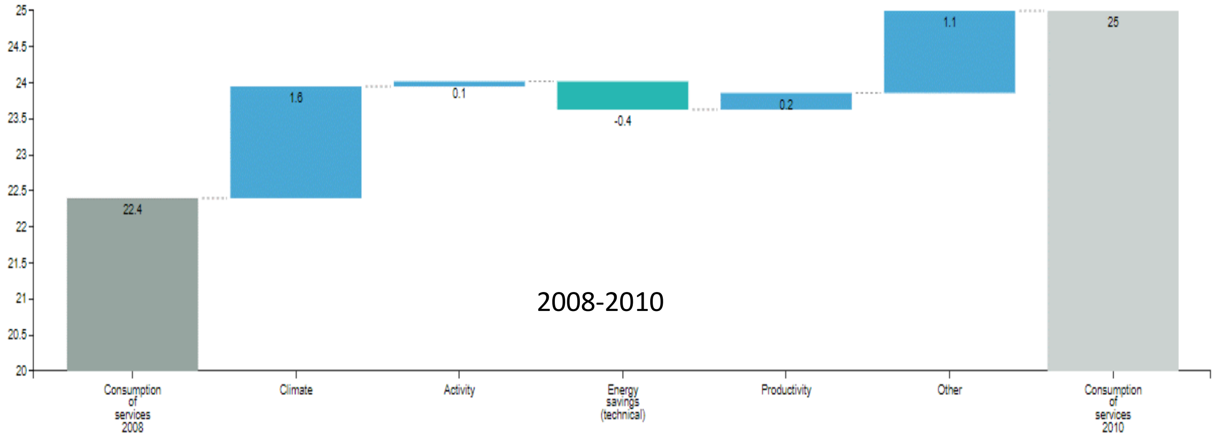
The drivers of final energy consumption changes in the service sector are displayed in **Figure 31**. In the period 2000-2019, the total consumption went up of 2.6 Mtoe, from 19.5 to 22.1 Mtoe. The relative contribution of each of the explanatory factors on the energy demand differs according to the period covered. However it is worthwhile noticeable that the energy savings effect has only partially (around the half) offset by the activity effect whatever the period considered. The productivity effect has only played a significant role afer the 2008 crisis and the the stuctural effect has been always negligible along the different period of analysis.

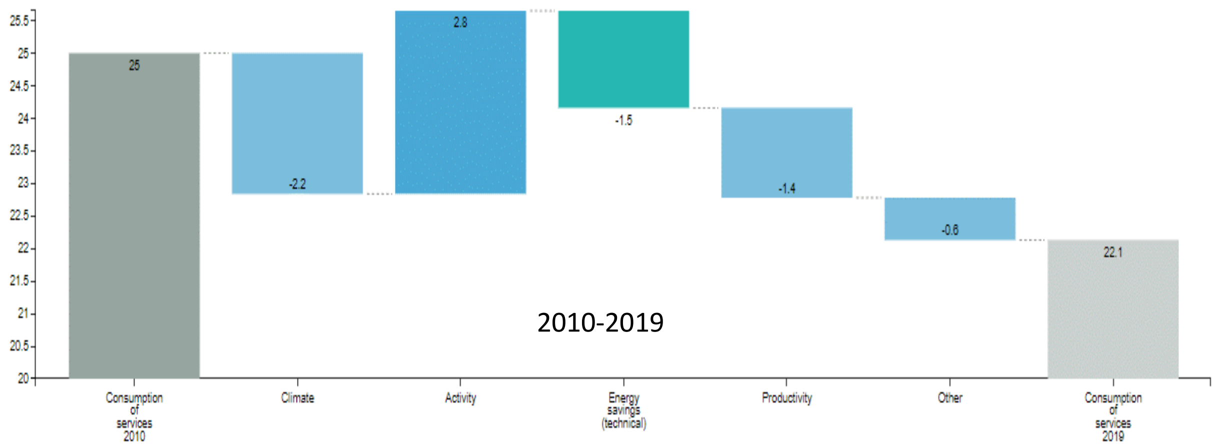
In detail, during the first period of analysis (2000 -2008), the activity effect, has highly contributed to an increase in energy consumption. Due to the energy savings which reached 3.2 Mtoe over all the period, it was less pronounced in the period from 2010. Weather fluctuations also contributed to a decreasing consumption from 2010, although it has no effect the overall the period.

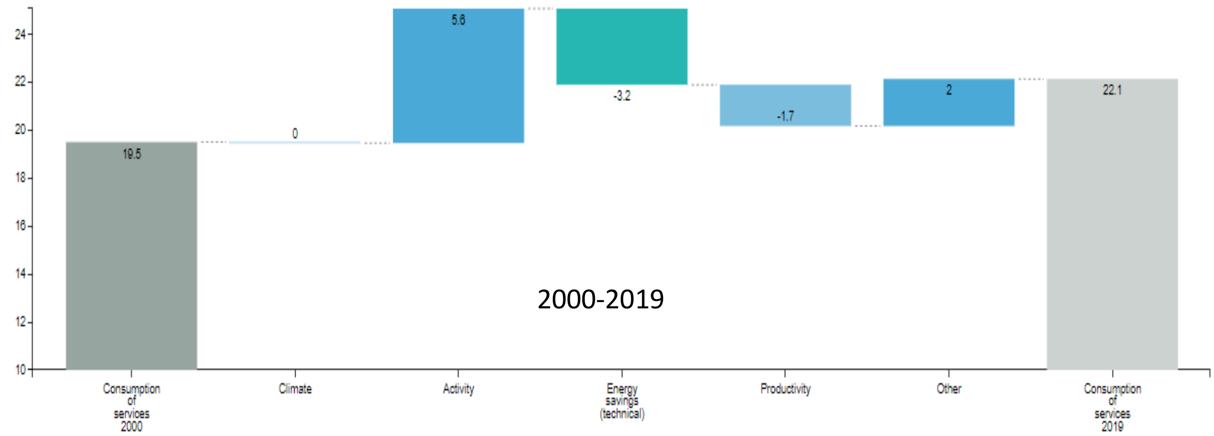
The increase in total consumption was mainly caused by the activity effect, which counteracted the decreasing effect of the other factors from 2000 to 2019. Overall, the productivity effect, which measures the change in the ratio of added value to employment, also had a reducing impact on energy consumption.

Figure 31 a, b, c, d : Decomposition of final energy consumption in the Tertiary sector for the periods 2000-2007, 2008 -2010, 2010-2019 and 2000-2019









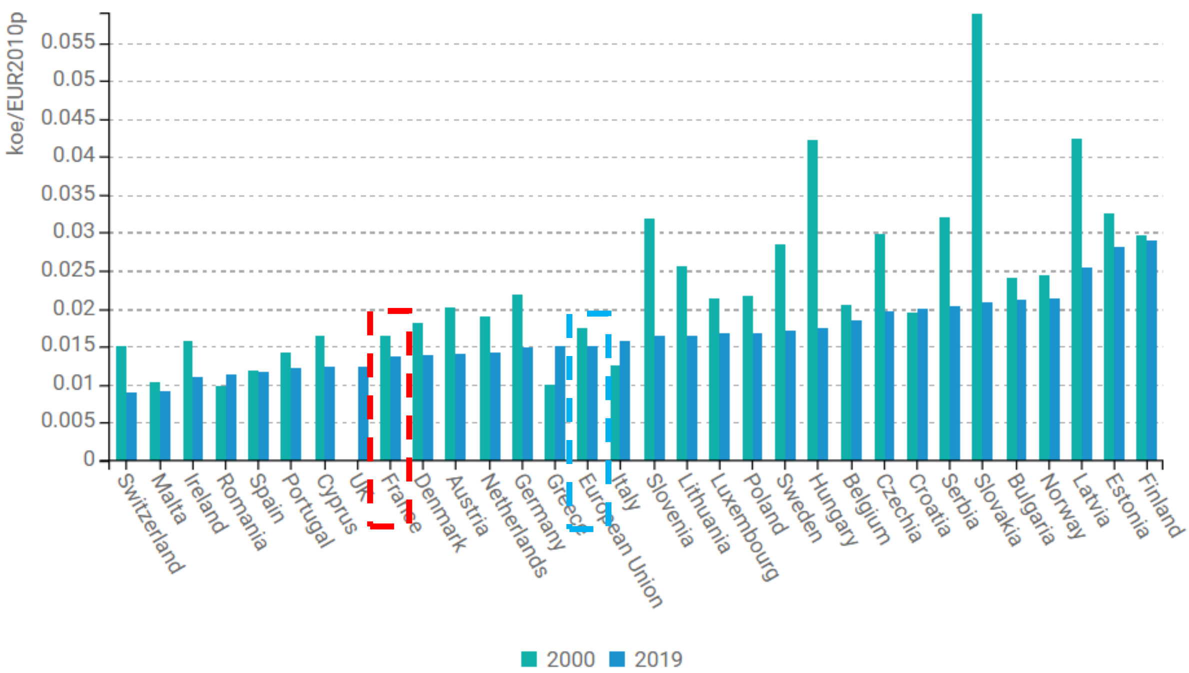
Source: ODYSSEE database

I.3.4 International benchmark on energy performances in the EU : The ranking of France

To pose a diagnosis of the ranking of France on energy efficiency in the tertiary sector, we dispose of two adjusted indicators: The energy intensity (Final consumption of the service sector divided by the Value Added of the tertiary sector in Koe/Euros2010 ppa) and the unit consumption per employee.

From an economic point of view, we perform the cross-countries comparison based on the on the energy productivity ratio (i.e. the energy intensity). The analysis of **Figure 32** delivers three messages: 1) Large discrepancies among countries partly due to climate (share of space heating) or the structure of the service sector, etc. with a factor 3 between Switzerland and Finland for instance but which is narrowing, 2); In all EU countries the energy productivity is increasing in all European countries) 3 France as a similar pattern as the EU average.

Figure 32 : Energy intensity of the tertiary sector in EU countries (2000-2019)

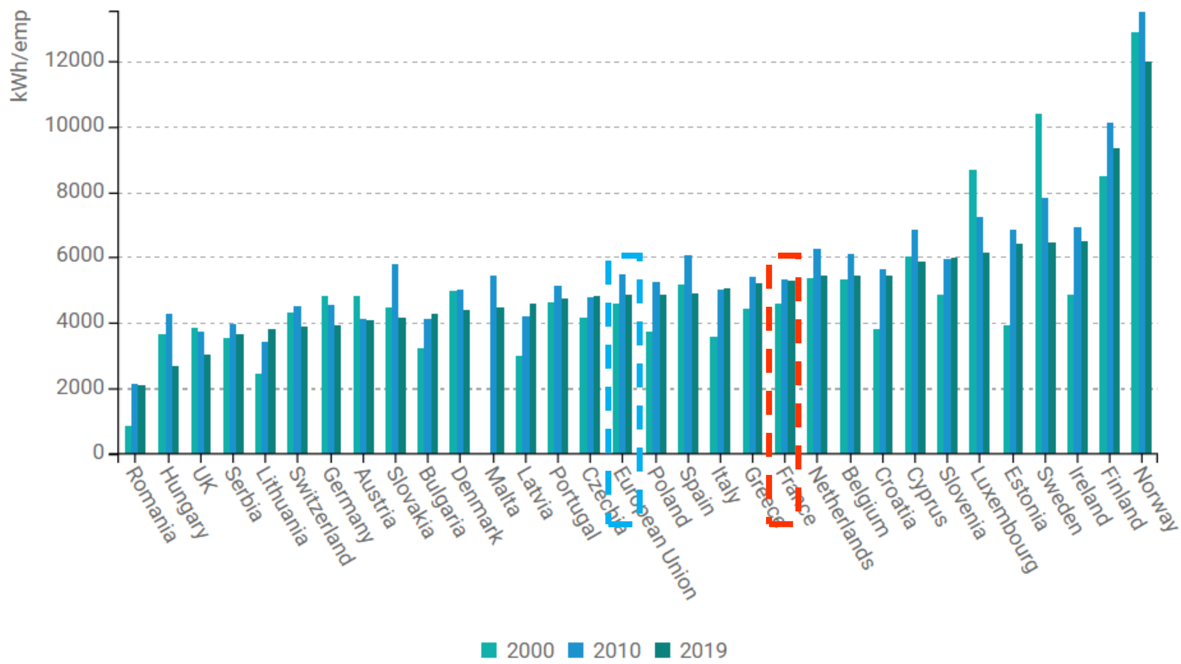


Source: ODYSSEE database

Due to the difference in the climate among countries and its impact on the space heating (or air conditioning) consumption, the most relevant benchmark should refer on electricity consumption.. **Figure 33** presents the electricity consumption per employee. Intuitively, we may assume that there is no particular reason for having a large discrepancy among countries in the level of electrical appliances uses in the service sector. This is not the case since this indicator strongly varies among European countries by a factor 6 for instance between Romania and Norway (2000 kwh/employee and 12000kWh/Emp respectively) (**Figure 33**). The second important information is that the electricity consumption per employee increases in around 2/3 of EU countries.

However, we observe a significant decrease in Sweden, Luxembourg, Hungary, Austria and Germany, while France is in the European average. The ranking of France is quite deceiving since 2/3 of EU countries shows better energy performances in that sector.

Figure 33 : Electricity consumption per employee in EU countries for the Tertiary sector



Source: ODYSSEE database

<u>However, Overall France scores</u> among the top ten countries, Thanks to the impact of policies which is judged good (rank4/31) Table 2.

Table 2 : Ranking of France in the ODYSSEE-MURE combined scoreboard for the tertiary sector

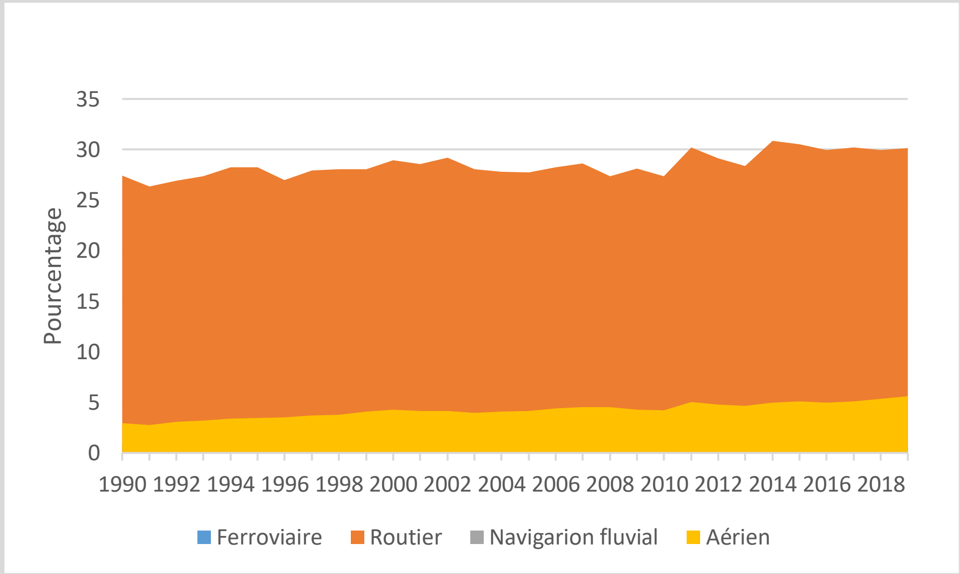
Ranking	Level	Trend	Policies	Combined
France	24 / 31	18 / 31	4 / 31	10 / 31

Source: ODYSSEE database

I.4 Energy efficiency in the Transport sector

I.4.1 Energy consumption

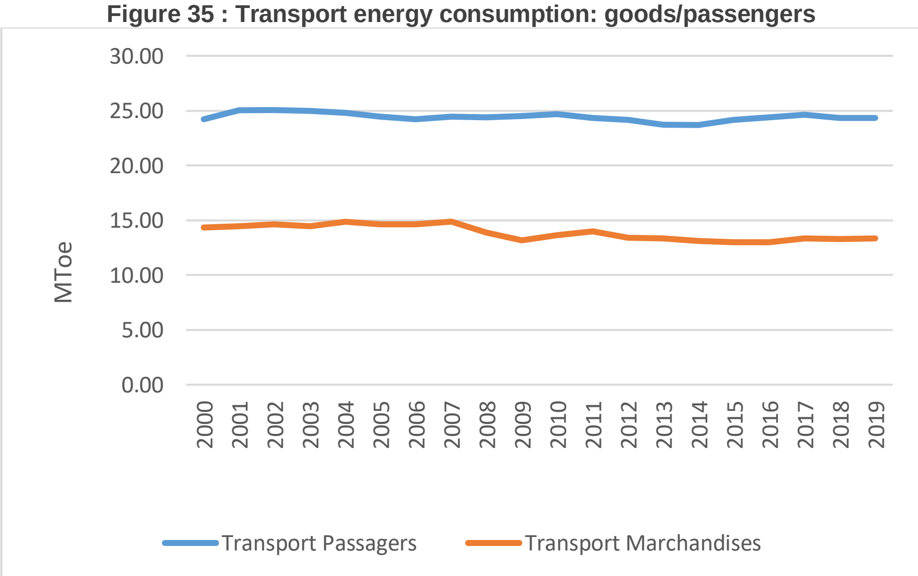
Figure 34 : Share of transport modes in final energy consumption



Source: ODYSSEE database

The road mode is the leading energy-consuming mode in the residential sector in France and its weight in total final consumption has risen from 26% in 1990 to 31% in 2019. Air transport is in second place, accounting for just over 5% of consumption in 2019. The share of road and river transport has remained relatively stable over time.

Figure 35 : Transport energy consumption: goods/passengers

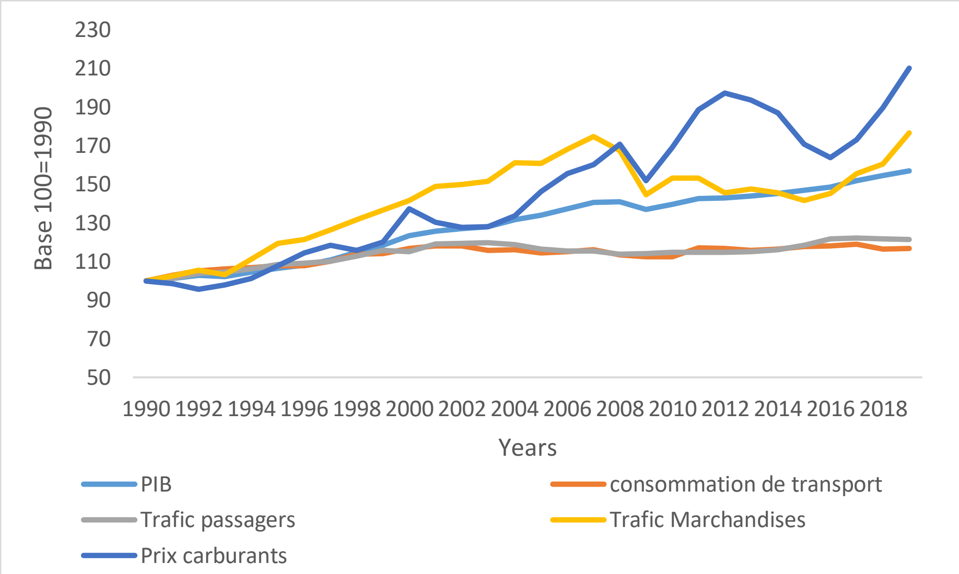


Source: ODYSSEE database

The consumption of passenger transport has been almost stable over the last two decades at 25 Mtoe, representing 63% of total transport consumption in 2019.

As for the consumption of goods transport, it has slightly decreased. It should be noted that the economic crisis of 2008 affected the consumption of goods, but it did not affect passengers.

Figure 36 : Evolution of consumption, traffic and GDP

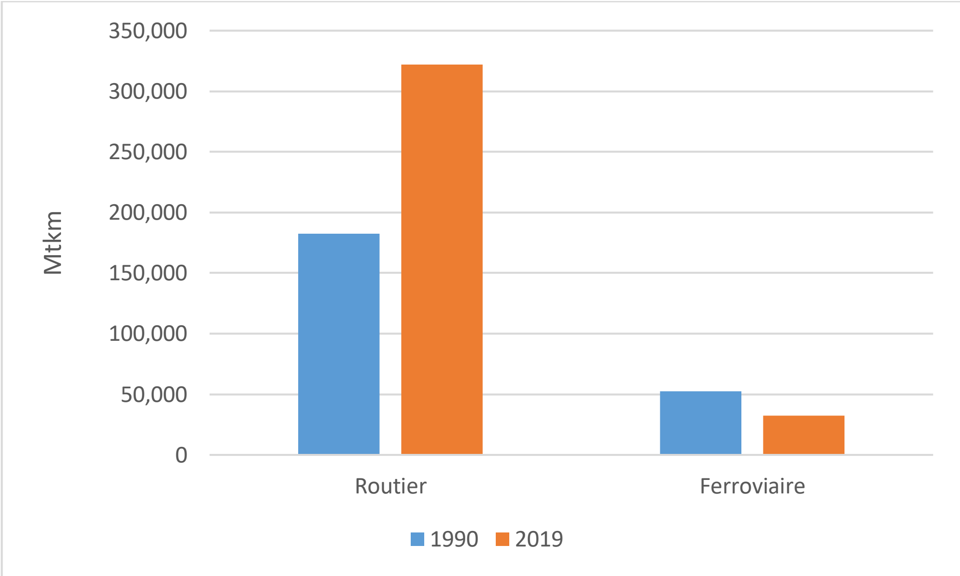


Source: ODYSSEE database

Consumption increased until 2000 with a rate of 10% After 2000 there is a very slight downward trend. Since 2008, there has been a downward trend in the consumption of the transport sector (-0.4%/year). During the previous decade (1990-2000), transport consumption had grown by an average of 1.2%/year. Between 2000 and 2007, consumption grew less rapidly, by an average of 0.7%/year.

The decline in consumption since 2007 has taken place in a context of relatively high prices until 2012 and a decline in freight traffic (-3.3%/year) and a slowdown in passenger traffic (0.6%/year, compared to 1.3%/year between 1990 and 2000). Since 2000, growth in transport consumption has decoupled from GDP growth. As a result, the ratio of transport consumption to GDP has decreased by 1%/year.

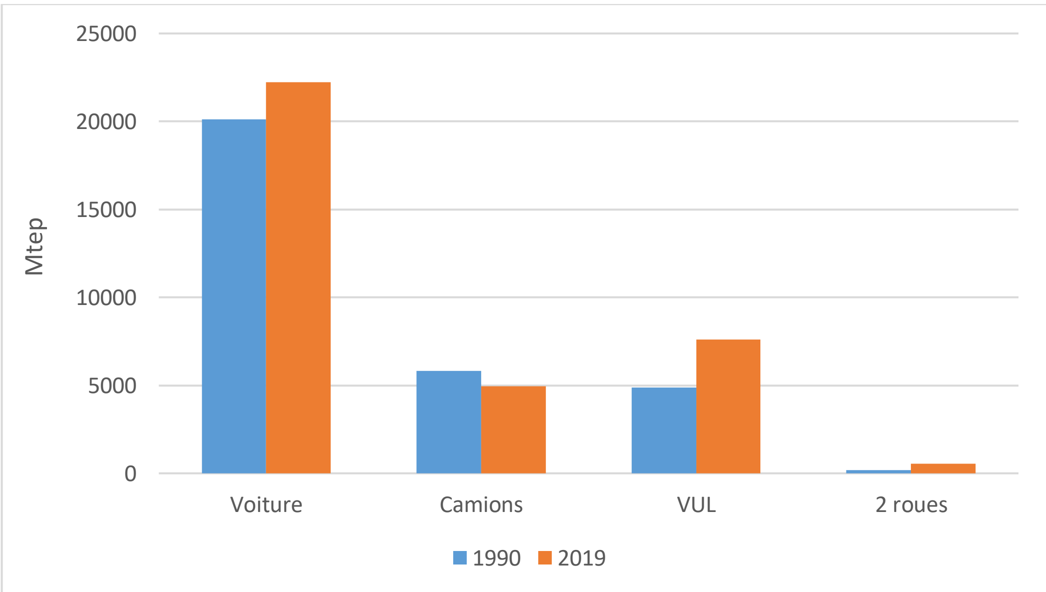
Figure 37 : Evolution of domestic road and rail freight traffic (Mtkm)



Source: ODYSSEE database

Domestic road traffic increased by 35% between 1990 and 2019, while rail traffic decreased by 11%.

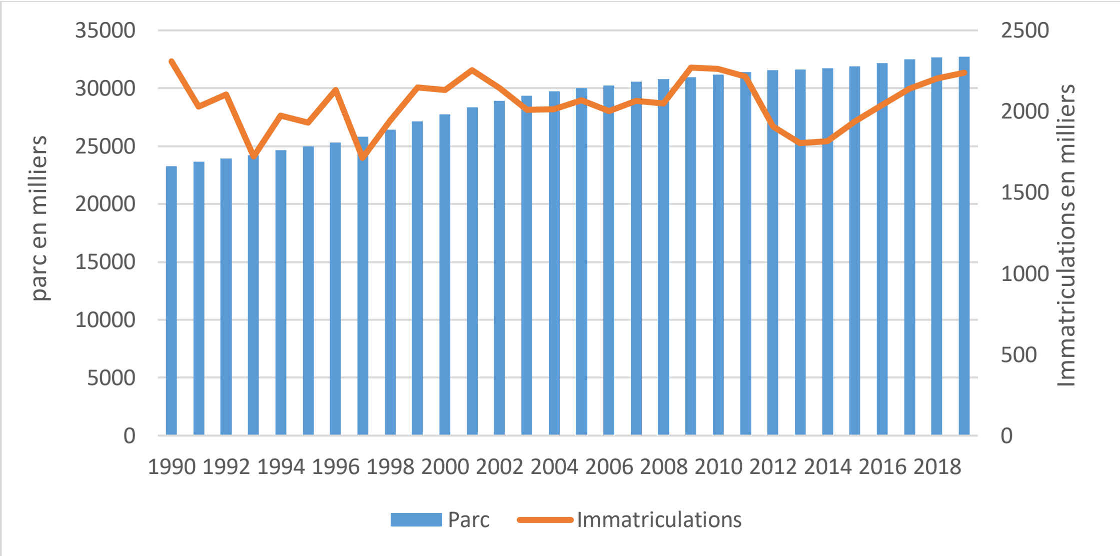
Figure 38 : Evolution of consumption in transport by type of vehicle



Source: ODYSSEE database

The different types of road transport vehicles (cars, LCVs, 2-wheelers) have generated an increase in final energy consumption between 1990 and 2019. On the other hand, the consumption of trucks has decreased by 5% between this period.

Figure 39 : Evolution of car fleets and registrations



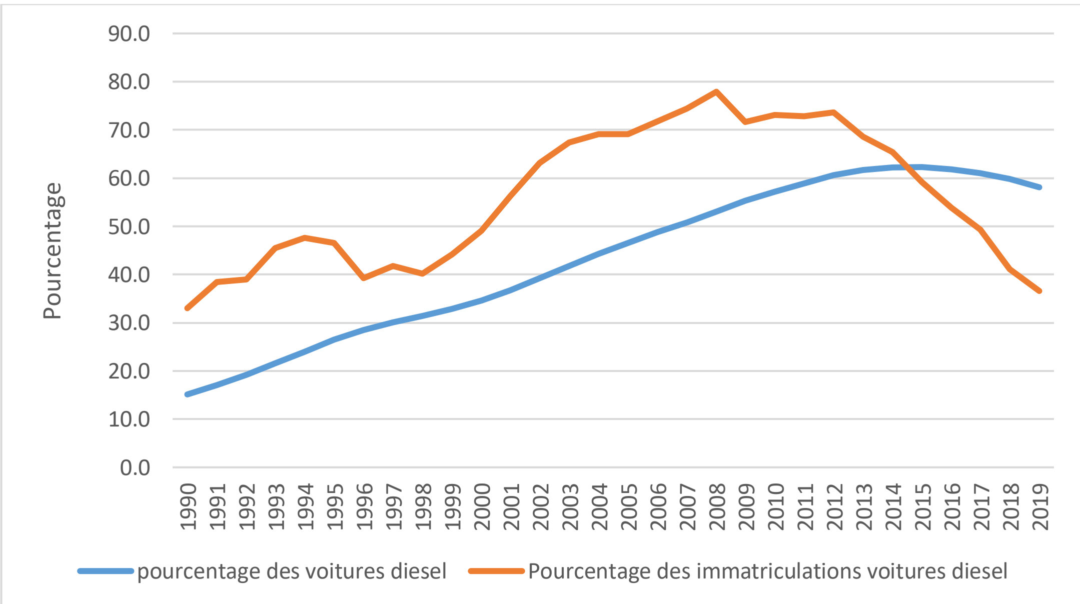
Source: ODYSSEE database

A fairly rapid trend growth of the fleet (average annual growth rate) until 2010 which was slowed down since the crisis until 2017 accompanied by a stabilization of the fleet of cars since 2016.

The registrations have returned in 2019 to the pre-crisis level but the fluctuation is quite strong depending on the economic situation.

It should be remembered that the follow-up of registrations is a good indicator of technical progress in the global car fleet.

Figure 40 : Decline in the dieselisation of the car fleet in France



Source: ODYSSEE database

A break in diesel registrations was observed in 2008, since the dieselisation rate in 2018 has returned to that of 1990, after having peaked at 80% in 2008.

This effect of the drop in the diesel fleet can also be seen, but with a reaction time of around 3 to 4 years. Thus, the peak of dieselization of the fleet appears in 2015.

France's transport sector policies and objectives :

Transport is an important part of the Energy Transition for Green Growth Act (TECV), with the objectives of Axis 3 (develop clean transport)[8] :

- Reduction of GHG and air pollutant intensity by at least 10% in 2020 and at least 20% in 2025 compared to 1990;
- Reduction of CO2 emissions from the French car fleet (176 gCO2/km in 2006 to 120 gCO2/km in 2020);
- 1,500 km of new public transport lines between 2010 and 2020 (excluding the Ile-de-France);
- 25% non-road and non-air freight by 2022 (14% in 2006);
- 2,000 km of additional high-speed lines between 2006 and 2020;
- 2 million electric and hybrid vehicles on the road in 2020;
- Deployment of 7 million charging points for electric vehicles by 2030;
- Establishment of a "reference standard" for fuel consumption (2 l/100 km);
- Obligation for car rental companies, cab and VTC operators to acquire 10% of low-emission vehicles when renewing their fleet;
- All or part of the costs incurred by an employee travelling by bicycle between his or her home and workplace will be taken into account by the employer.

The measures implemented in this sector are mainly aimed at supporting modal shift by encouraging non-road freight (25% by 2022) and improving the energy efficiency of transport modes. In particular, the ecological bonus-malus has enabled France to have in 2015 one of the lowest CO2 emitting new vehicle markets in Europe (around 111 gCO2/km in 2015[9]). France is in fifth place, just after the Netherlands (1st with 101g) and Greece, Denmark and Portugal (all three tied with 106g)[10].

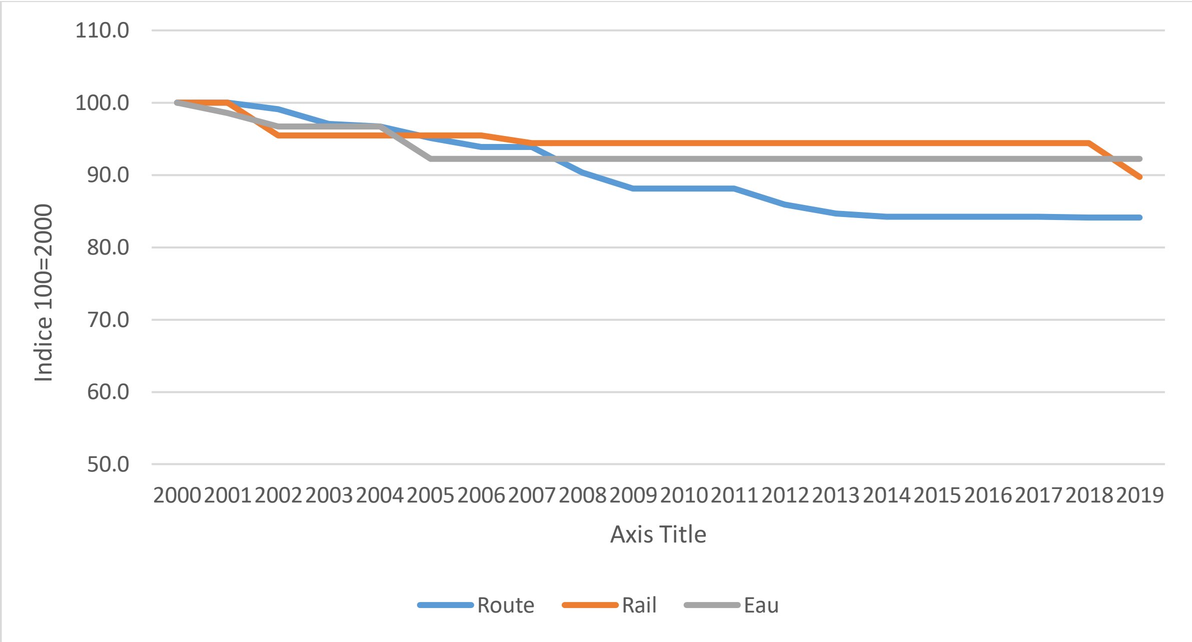
On the passenger side, the measures concern the technical improvement of vehicles, the development of high-speed lines and dedicated public transport (TCSP).

[8] http://www.developpement-durable.gouv.fr/Developper-les-transports-propres,41392.html

[9] A new bonus/malus was introduced in France on January 1, 2017, including new scales: http://www.ademe.fr/particuliers-eco-citoyens/financer-projet/vehicule/bonus-malus-ecologique-2017

[10] Source ADEME brochure, Evolution du marché, caractéristiques environnementales et techniques des véhicules particuliers neufs vendus en France, Chiffres clés édition 2016, http://www.ademe.fr/evolution-marche-caracteristiques-environnementales-techniques-vehicules-particuliers-neufs-vendus-france

Figure 41 : Evolution of the technical energy efficiency index (ODEX tec) by transport mode

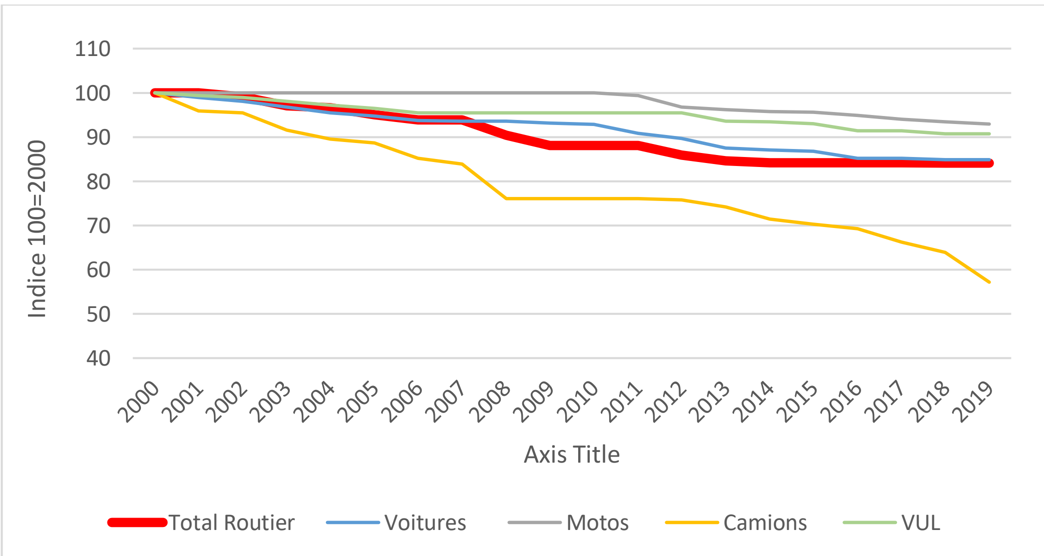


Source: ODYSSEE database

The energy efficiency index shows a fairly linear (stable) trend between 2000 and 2019 for the water and rail modes. For the river mode, we observe a decrease in the index in 2004 followed by a stabilization until 2009 indicating the technical progress in this mode.

In the rail mode, we observe an evolution parallel to that of the river mode except for the last 2 years where there has been a significant decrease of 5%. While for the road mode we note a gain of almost 18% over the period 2000-2020, but as in all other modes over the recent period, we note a stabilization.

Figure 42 : Evolution of the technical energy efficiency index (ODEX technical) by type of road vehicle



Source: ODYSSEE database

This figure shows the evolution of the index for the main types of road vehicles. The overall energy efficiency of road transport has improved by 17% over the previous two decades. While this improvement trend has been broadly linear, since 2012 there has been a stagnation in energy efficiency. This can be explained by the weight that the trend of cars represents in the global index (cars represent half of the consumption of road transport). Thus, it is the stagnation of the progress of energy efficiency of cars that explains the stagnation of road transport.

The most significant and encouraging result in road transport concerns trucks. There has been a gain of more than 40% over the last 20 years, with an acceleration since 2016.

The improvement in the performance of light commercial vehicles follows the trends observed in cars, but with more degraded results (-10%) over the last 20 years.

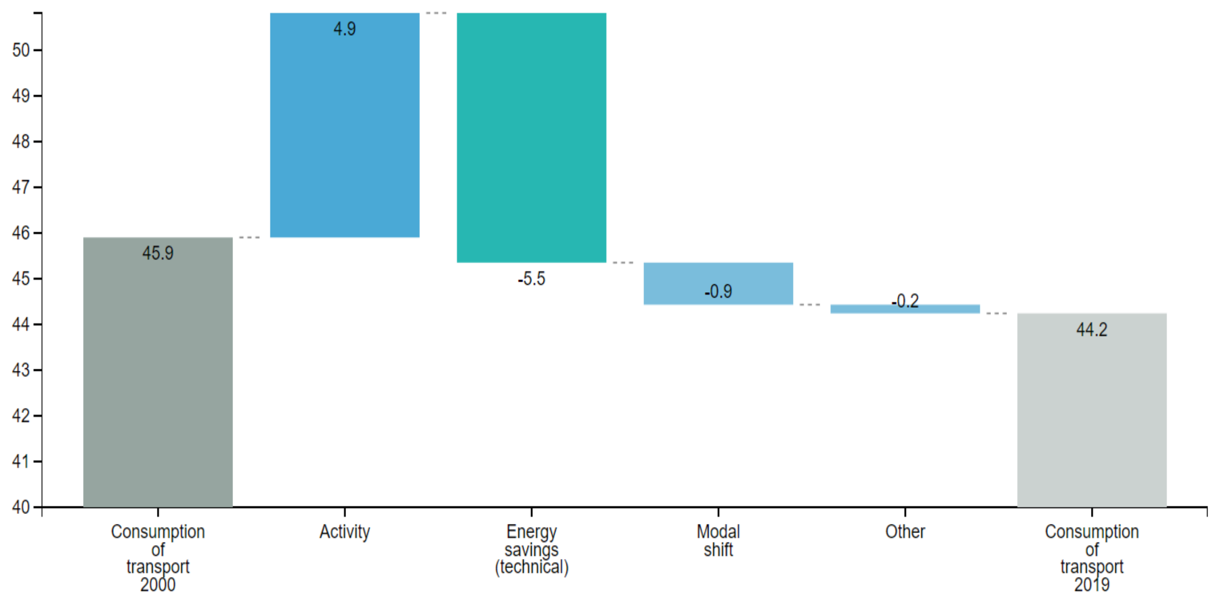
The change in energy consumption in transport is influenced by :

The change in domestic passenger traffic and freight traffic ("activity effect"), technical energy savings (i.e., changes in the efficiency of cars, trucks, airplanes, etc)

Modal shift for domestic transport, i.e. the change in the share of each mode of transport in total traffic.

Other effects, i.e. behavioral effects and "negative economies" in freight transport due to low capacity utilization.

Figure 43 : Decomposition of final energy consumption in the Transport sector (1990-2019)



Over the period 2000-2019, energy consumption decreased from 45.9 Mtoe in 2000 to 44.2 Mtoe in 2019.

After the residential sector, the transport sector is the one that has achieved the most energy savings, up to 5.5 Mtoe. This is explained by a significant activity effect of 4.9 Mtoe corresponding to an increase in road traffic linked to the income of households concomitantly with the growth in goods traffic linked to economic growth.

At the same time, energy savings of about 5.5 Mtoe have more than offset the effect of economic growth.

This growth in activity effect was accompanied by the effect of changes in the modal split between traffic types (the change in modal split led to a very slight decrease in consumption, the changes in modal split over the 20 years had practically no influence on the change in energy demand).

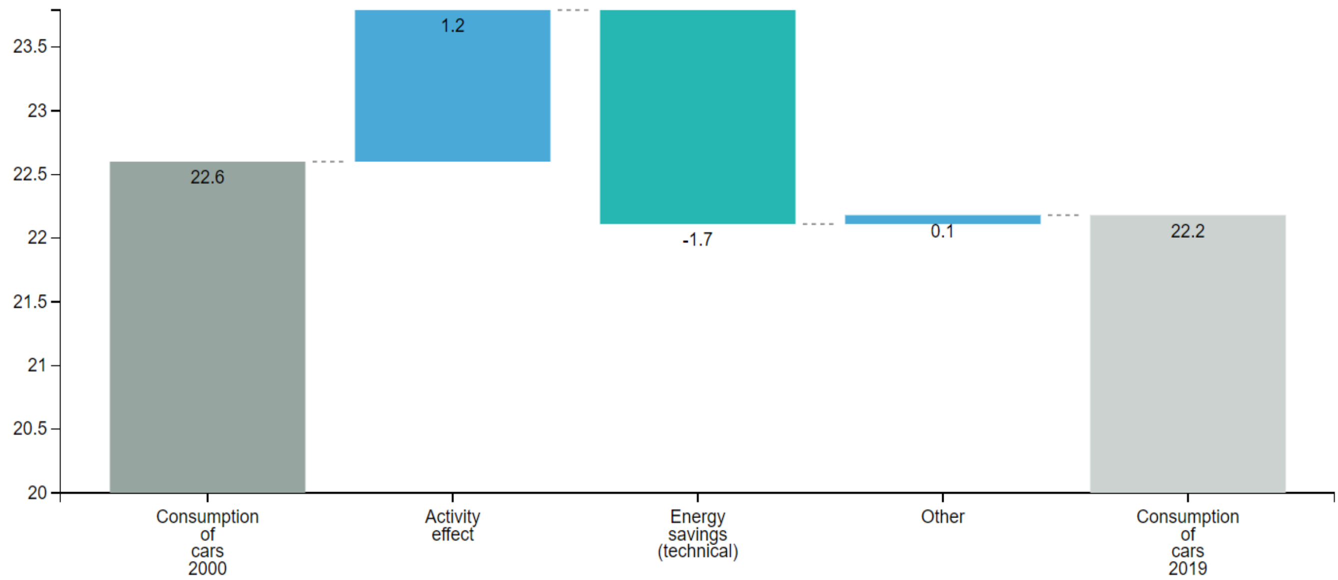
The resultant management or behavior such as the loading rate of trucks had very little effect on the variation of demand over the period concerned. This effect is slightly negative 0.9 (the less consumptive modes (trains) have proportionally grown more than the other modes (cars and airplanes) and the behavioral effect has been negligible over the period.

- For the modal split, we can show that the main part of this modal split is linked to passenger traffic which represents -0.7 while freight is -0.2.

- We can show that the activity effect linked to the traffic activity, the freight traffic had more impact than the growth of the passenger traffic 2.7 / 2.3.

- The energy savings have been much more realized in freight traffic (3.4 for freight traffic against 2 for passenger traffic).

Figure 44 : Explanatory factors of the variation in car consumption (1990-2019)



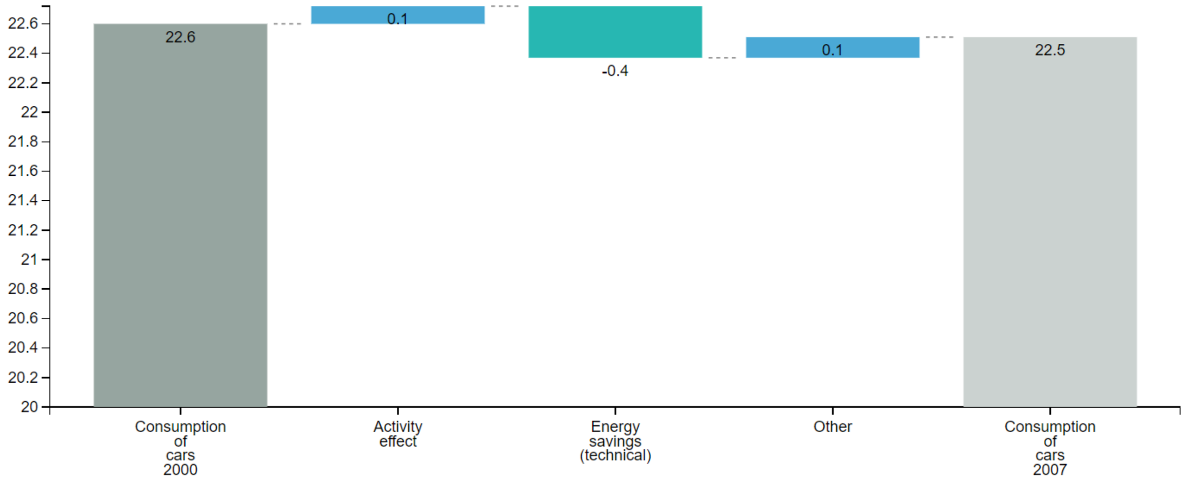
Since cars consume about half of the energy balance for transport, we will analyze the respective contribution of the explanatory factors of the variation in energy consumption of cars.

Over the last 20 years, the most significant result is probably that France has succeeded in stabilizing its car consumption, which has even decreased slightly over the period (22.2 Mtoe in 2019 versus 22.6 Mtoe in 2000).

This good result can be explained by the important contribution of energy savings (-1.7 Mtoe) which cancelled out the impact of traffic growth measured by the activity effect (+1.2 Mtoe).

An analysis by sub-periods shows the contributions of the two main explanatory effects: energy savings and activity effect. We can clearly distinguish 3 sub-periods where the compensations between these two effects have played out very differently.

Figure 45 : Explanatory factors of the variation in car consumption 1990-2007



A first period from 2000 to 2007 (before the crisis) where the energy consumption of cars was stable corresponding to an activity effect measured by car traffic in passenger-kilometers (+0.1Mtoe) while there were some energy savings of 0.4Mtoe.

Figure 46 : Explanatory factors for the variation in car consumption in 2007-2008

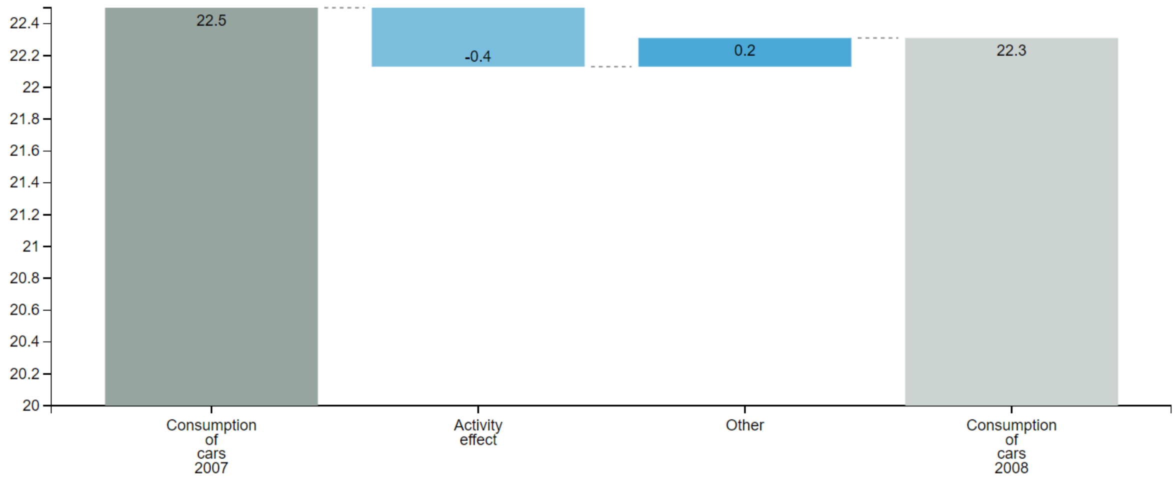
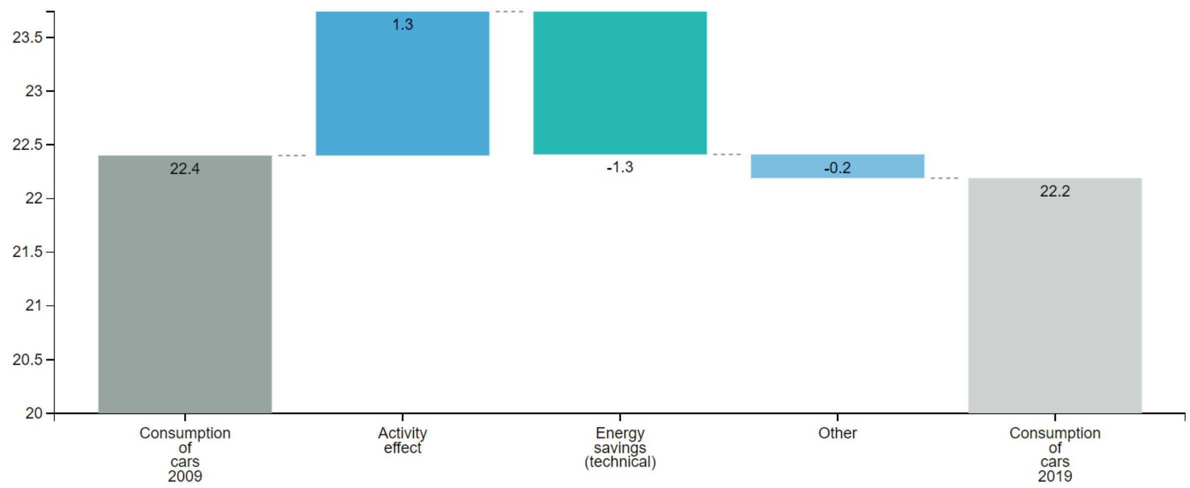


Figure 54 illustrates very well the impact of the 2007-2008 crisis on the variation of energy demand. This demand naturally fell due to the contraction of car traffic linked to the very sharp drop in mileage during the recession (activity effect -0.4 Mtoe). Another interesting phenomenon is that the economic recession has generated energy savings of about 0.2 Mtoe, which is difficult to explain.

Figure 47 : Explanatory factors of the variation in car consumption 2009-2019

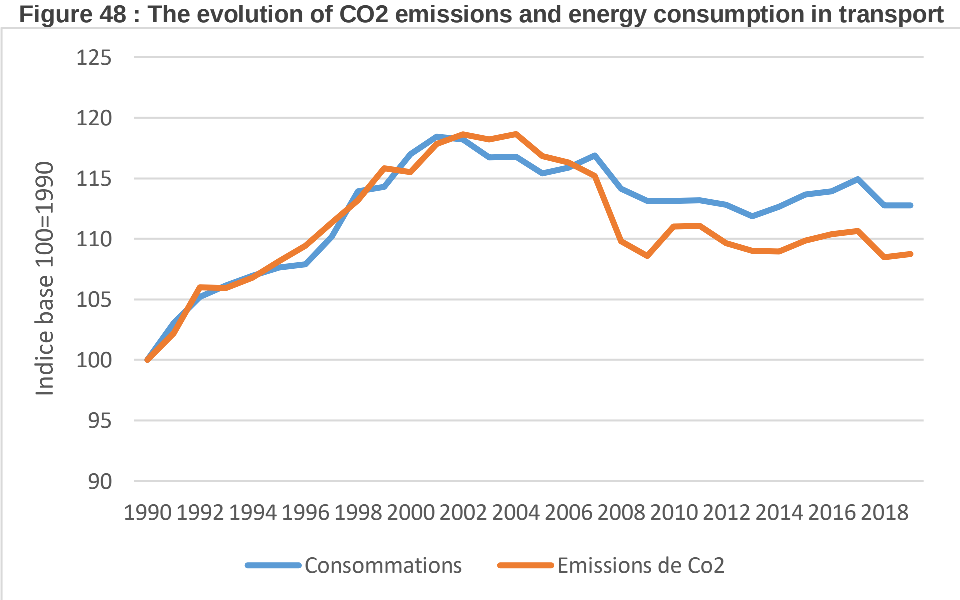


After the crisis, we observe a catching up of the car traffic, in particular an increase of the mileage which pushed the consumptions up by 1,3 Mtoe (activity effect); at the same time this new growth of the fleet has favored an accelerated renewal of the car fleet generating technological energy savings.

CO2 savings in the transport sector

CO2 emissions up by 20 Mt between 1990 and 2019, from 120 to 131 MtCO2.

Figure 48 : The evolution of CO2 emissions and energy consumption in transport

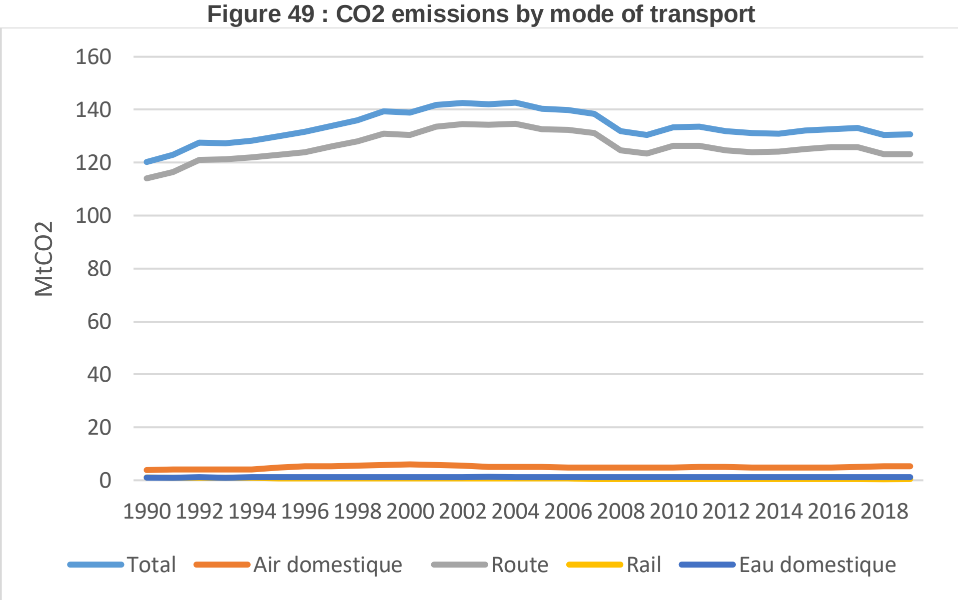


Source: ODYSSEE database

We notice that energy consumption is increasing faster than CO2 emissions in transport. This is probably due to the penetration of biofuels, whose CO2 content is statistically considered as zero.

If emissions have grown very strongly from 90 to 2000. A break in the trend was observed until the 2008 crisis, which caused a cyclical drop in CO2 emissions. Since then, the results are quite alarming insofar as CO2 emissions in 2018 are at the same level as in 2008.

Figure 49 : CO2 emissions by mode of transport



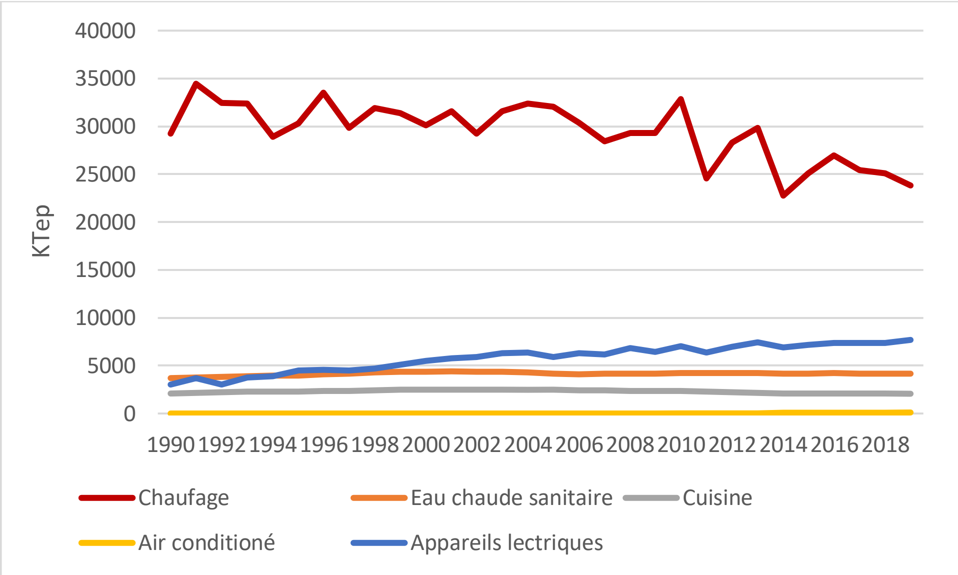
Source: ODYSSEE database

I.5 Energy efficiency in the Household sector

The largest share of final energy consumption in the residential sector is for heating. It was 0.4 Mtoe lower in 2019 than in 2000. On the one hand, three main factors have contributed to the increase in energy consumption over the period - more housing.

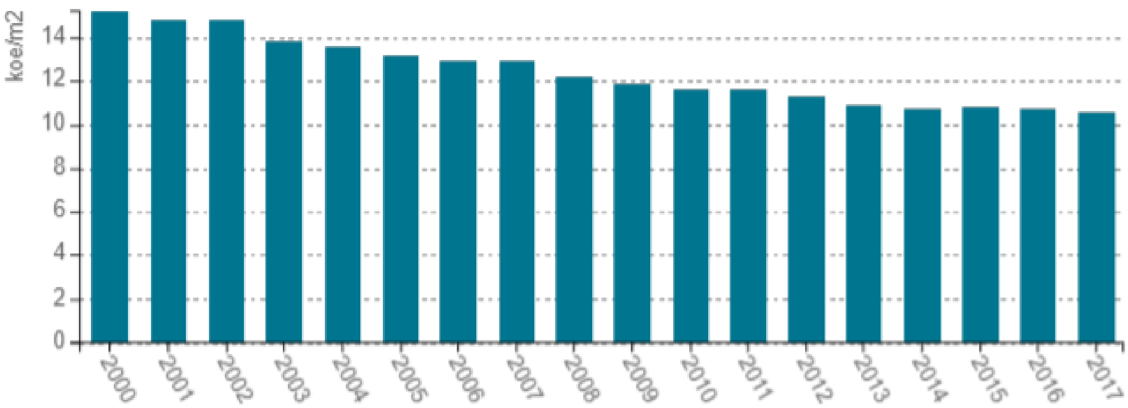
After heating, the other end uses of the residential sector have followed more or less the same trend over the last 30 years **(Figure 50)**.

Figure 50 : Share of consumption of different types of use in the household sector



Source: ODYSSEE database

Figure 51 : Energy consumption for space heating per m²

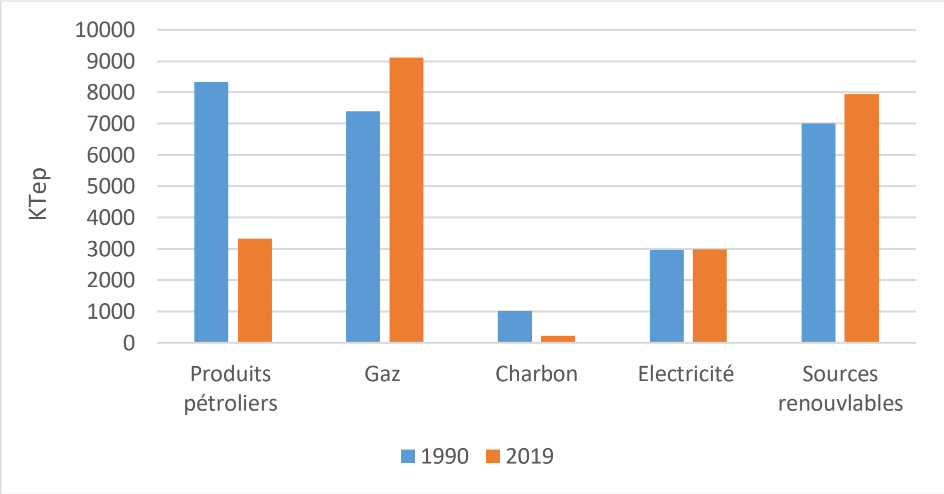


Source: ODYSSEE database

In 2017, space heating accounted for 67% of the sector's consumption, electrical appliances 18%, water heating 10%, and cooking 5%.

Water heating (10%) and cooking (5%). While electrical appliances have increased by 5 percentage points since 2000 with a trend of +1.8%/year, the share of consumption for space heating has dropped by 10 percentage points over the period. On the other hand, energy consumption for cooking and water heating also decreased by -0.2%/year and -1.1%/year respectively. Energy consumption in the residential sector has thus decreased by about 0.2% per year since 2000, thanks in particular to efforts made in the end-use of space heating.

Figure 52 : Evolution of consumption by form of energy for heating between 1990 and 2019



Source: ODYSSEE database

Concerning the primary energy sources used in the heating of the residential sector it is presented in the graph above.

We notice the evolution of the primary sources of heating between 1990 and 2019. There is a clear decrease in the use of petroleum products and coal and an increase in the use of gas and renewable energy sources while electricity consumption has remained constant over the last 30 years.

To assess energy efficiency trends, we have two complementary approaches: an approach that can be described as economic with reference to the analysis of energy productivity trends. This will be observed from monetary indicators: energy intensities.

This approach has the merit of being simple in terms of data collection (consumption divided by GDP or VA), but it is more difficult to interpret in terms of progress in energy efficiency because it also includes many other effects:

Example effect of structure of the economy, industry, and impact of other policies example environmental.

This aggregate measure of energy efficiency via the energy intensity indicator can be considered simply as a proxy for energy efficiency. It is the most widely used indicator because it is the simplest to construct.

This is why evaluators have developed a complementary approach that is more detailed and closer to a measure of technical energy efficiency, in other words a more engineering approach.

In this case, physical energy efficiency indicators are preferred:

(Tep / tons of steel, Litre/100Km, Electricity consumption/employee, KWH/ refrigerator).

This detailed analysis can also provide aggregate indicators (such as energy intensity): energy efficiency indices and the approach to the decomposition of energy demand according to explanatory factors; among these factors we will look at the evolution of energy savings.

The change in household energy consumption is explained by:

The difference in climate between these two dates ("climate");The change in the number of occupied dwellings ("more dwellings"); The change in the number of appliances ("more appliances per dwelling" for electric appliances and central heating); Change in the average floor area per dwelling ("larger dwellings"); Energy savings: these correspond to technical savings, i.e., gross savings adjusted for negative savings due to inefficient behaviors, and are derived from the technical ODEX;Other effects (mainly change in heating behaviors). Climate corrections are made on the basis of national degree day data (Eurostat for the EU).

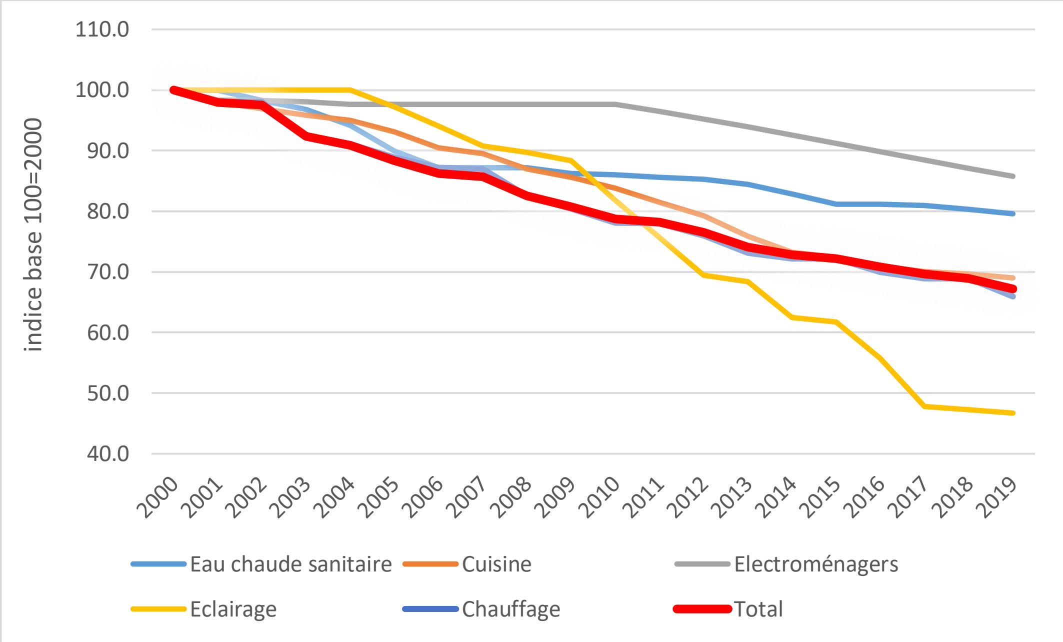
France's residential policies and objectives

Buildings represent the largest final energy consumption in France, and the consumption of thermal uses represents the majority of the consumption of the residential sector. Even if the unit consumption of dwellings for thermal uses has been decreasing on average since 1990, there is still a very high potential for energy savings in this sector, mainly through the renovation of the existing stock. For these reasons, the residential sector is a priority target in European and national policies. The main European Directives and national objectives targeting the residential sector are listed below (and detailed in the Annexes of this report):

- Directive 2010/31/EU on the energy performance of buildings EPBD2 (reinforces Directive 2002/91/EC).
- Directive 2002/91/EC on the energy performance of buildings EPBD 1 (Energy Performance of Buildings Directive), Directive 2010/30/EU on labelling (updates Directive 92/75/EEC).
- Directive 2009/125/EC on the ecodesign of energy-related products ErP (Energy-related Products) (repeals Directive 2005/32/EC known as the EuP Directive - Energy-using Products).
- Energy renovation plan for housing (PREH) adopted in October 2013

Many of the energy efficiency measures and actions listed in the NEEAP target the residential sector in particular.

Figure 53 : Evolution of the technical energy efficiency index (ODEX technical) by type of use



Source: ODYSSEE database

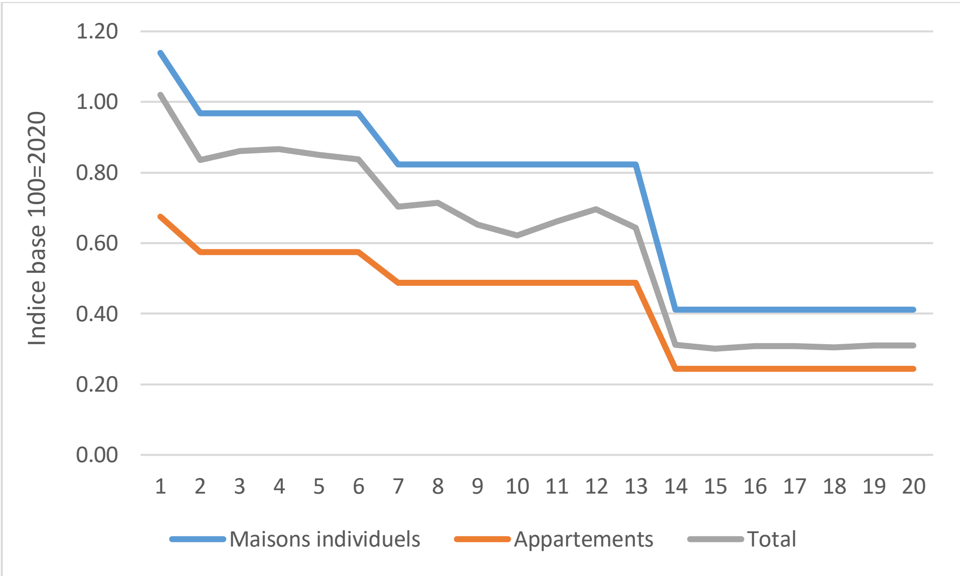
This figure shows the evolution of the energy efficiency index by type of use in the residential sector. Over the last 20 years, we notice:

- At the most global level, the energy efficiency in the residential sector, all uses included, is around, and we notice a slight slowdown in energy efficiency over the last years despite the different policies in the sector.

- Heating (the most important use in the residential sector) has experienced a trend evolution over the whole period of about 32%.

- It is in lighting that there have been the fastest and most significant gains (50%). These good results are certainly to be put to the benefit of the substitution of incandescent lamps by energy-saving lamps or LED, linked to the implementation of European policies of labels and standards.

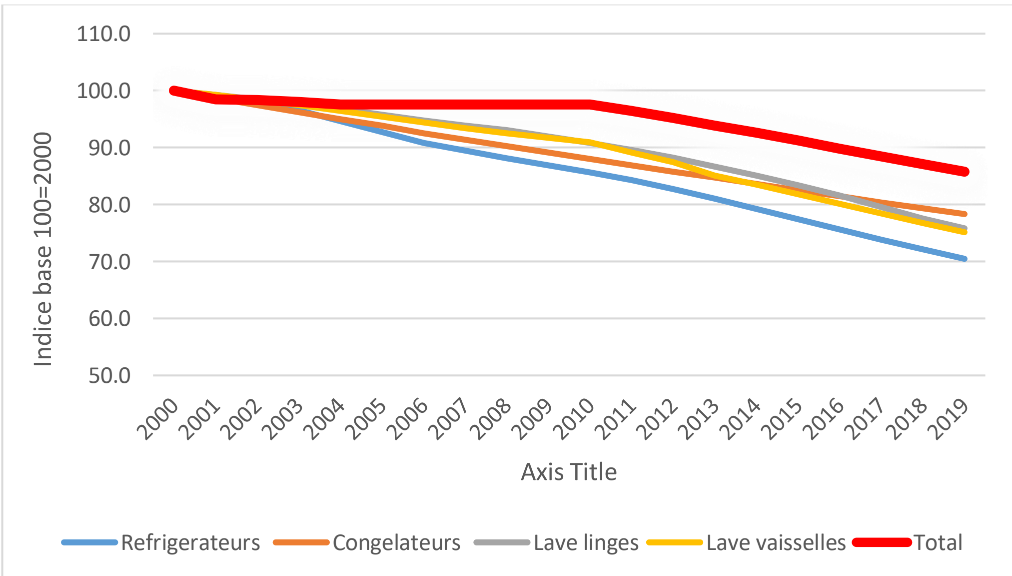
Figure 54 : Evolution of energy performance of new housing by type



Source: ODYSSEE database

The following graph illustrates the evolution of the energy performance of new housing by type, we note a fairly linear trend between 2000 and 2012 and then a great improvement in energy efficiency that affects the 2 types of new housing cited (individual houses, apartment). The latter results from the two thermal regulations in 2000 and 2012.

Figure 55 : Evolution of the technical energy efficiency index for electrical appliances



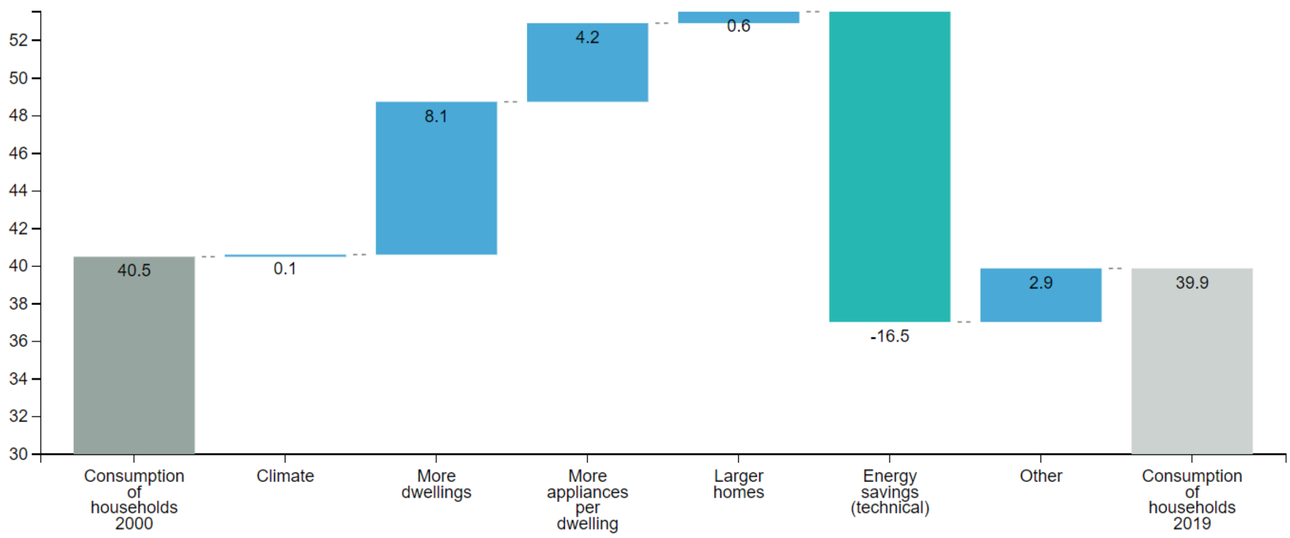
Source: ODYSSEE database

We have selected the evolution of specific unit consumptions for the 5 most electricity consuming household appliances. This is reflected by the ODEX in Figure 20. The following changes can be observed over the period 2000-2019:

- In total, the overall ODEX of household appliances has improved by about 14%, there was a break in 2010 after the crisis, which roughly corresponds to the updating of the European directive on household appliances (Ecodesign), after 10 years of stabilization the energy performance of equipment has improved trend.

- Refrigerators (the most energy-consuming appliance in a household) have seen the fastest improvement in energy performance of all energy-intensive appliances (30%).

Figure 56 : Explanatory effects of the Variation of consumption in the residential sector 1990 -2019

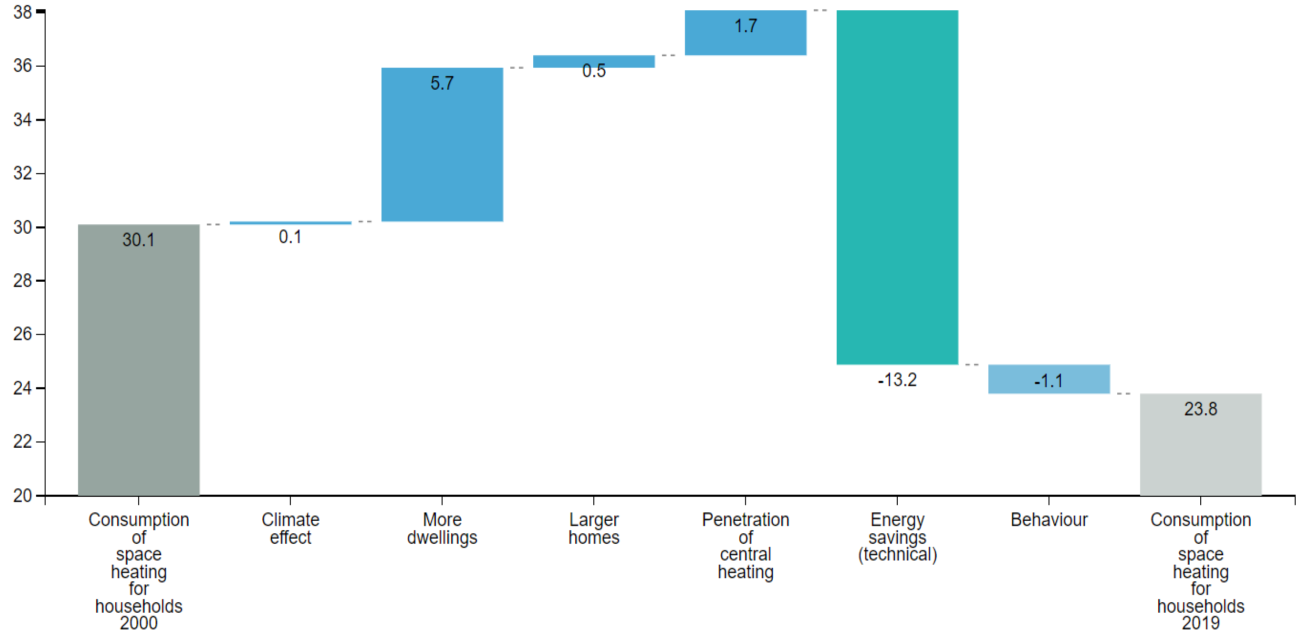


Over the period 2000 to 2019, the consumption of the residential sector is almost stable (from 40.5 Mtoe to 39.9 Mtoe).

The residential sector which is the one that realizes the most energy savings up to 16.5 Mtoe this is explained by an effect housing stock of 8.1 Mtoe corresponding to an increase in the stock related to household income and demographics that goes along with the growth of household appliances also links to household income that increases the rate of equipment in electrical appliances and multi equipment (brown products and white products and Tic) (number of appliances per household). At the same time or the energy savings achieved are about 16.5 Mtoe and have therefore more than offset the effect of economic growth.

This growth of the activity effect is accompanied by the effect of behavioral changes (the change is mainly related to the change of heating) and which led to lower consumption, the changes in behavior over the 20 years has influenced the change in demand of 2.9 Mtoe. While heating represents nearly 60% of the consumption, we will analyze the results of this usage more closely.

Figure 57 : Explanatory factors of the variation in heating consumption in the residential sector 1990 - 2019



Given that heating represents the first consumption of the residential sector. We observe a first important effect which pushes the consumptions up by 5,7 M TOE this is due to the demographic push and to the growth of the incomes of the households. In addition, the preference of the French for larger dwellings, also linked to household income, can only contribute to the increase in consumption over the period.

Its 3 effects linked to the socio-economic factor have been more than offset by a very large volume of energy savings 13.2 Mtoe this important result is largely due to the implementation of many energy efficiency policies related to the European directive example (label and standard Eco designates)

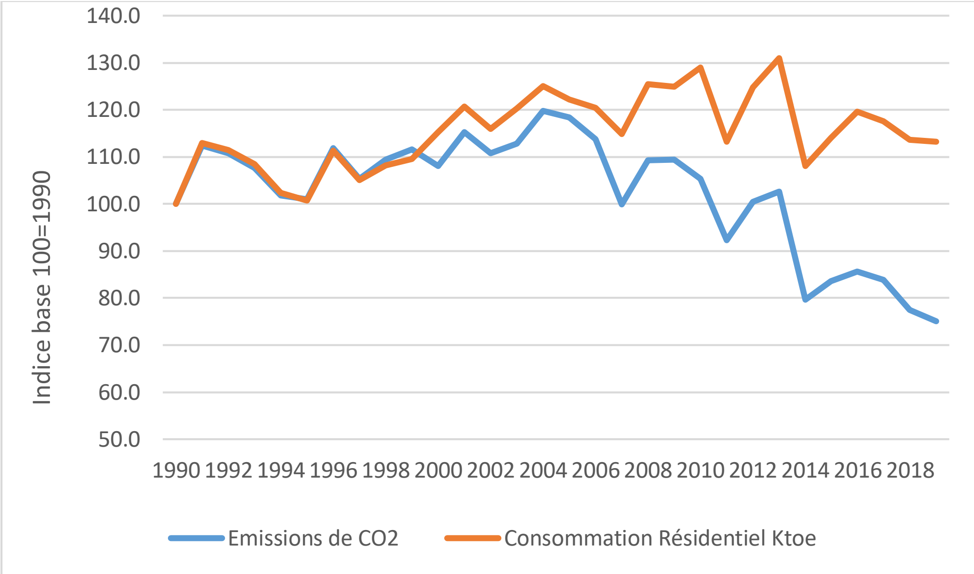
For the record, the resultant climate has very little effect on the variation of demand, while the penetration of heating plants has had an effect.

CO2 savings in the residential sector

CO2 savings mainly due to energy savings

Direct and indirect CO2 emissions from the residential sector have decreased by 22 Mt since 1990 (or 13%). All other things being equal, they should have increased by more than 16 Mt, due to the increase in the number of primary residences. But they have mainly decreased due to CO2 savings estimated at 38 Mt since 1990, of which 55% come from energy savings. The rest of the CO2 savings comes from inter-energy substitutions, notably from oil heating to gas or to heat pumps or wood stoves.

Figure 58 : Evolution of CO2 emissions and energy consumption in the residential sector



Source: ODYSSEE database

CO2 emissions are increasing faster than energy consumption in the residential sector.

II .1 The economic approach: measuring energy productivity through energy intensity

II.1.1 Measuring energy productivity through energy intensity

Definition of energy intensity :

Energy intensity is a measure of the energy efficiency of an economy. It is an indicator calculated as the quotient of energy consumption to gross domestic product. It is usually expressed in tons of oil equivalent (toe) per million euros of GDP.

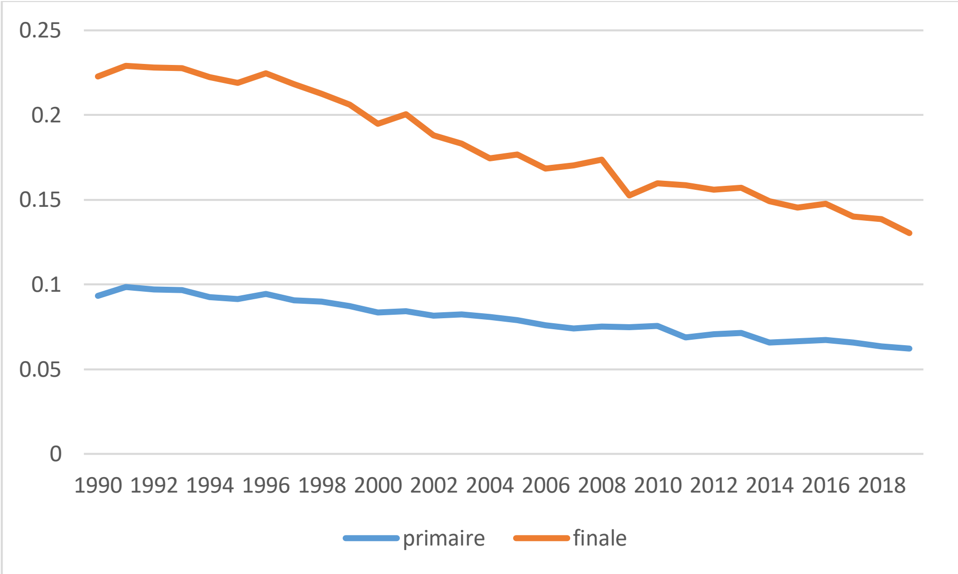
After three decades of declining trends in the world, energy intensity (energy consumption per unit of GDP, which is also an index of waste), the latter has experienced an increase in 2010 following the decline in energy prices due to the crisis of 2008.

Initially, we selected two energy intensity indicators:

Primary energy intensity (the most commonly used) and final energy intensity. These indicators are a ratio between energy consumption (final or primary) and GDP. To be correctly analyzed in terms of evolution, energy intensity must be calculated at constant GDP (e.g. base year=2014) in order to correct for inflation. It is therefore expressed in toe/euro.

Figure 8 presents the evolution of the final and primary energy intensity indicators for France over the period 1990-2019.

Figure 59 : Evolution of final and primary energy intensities



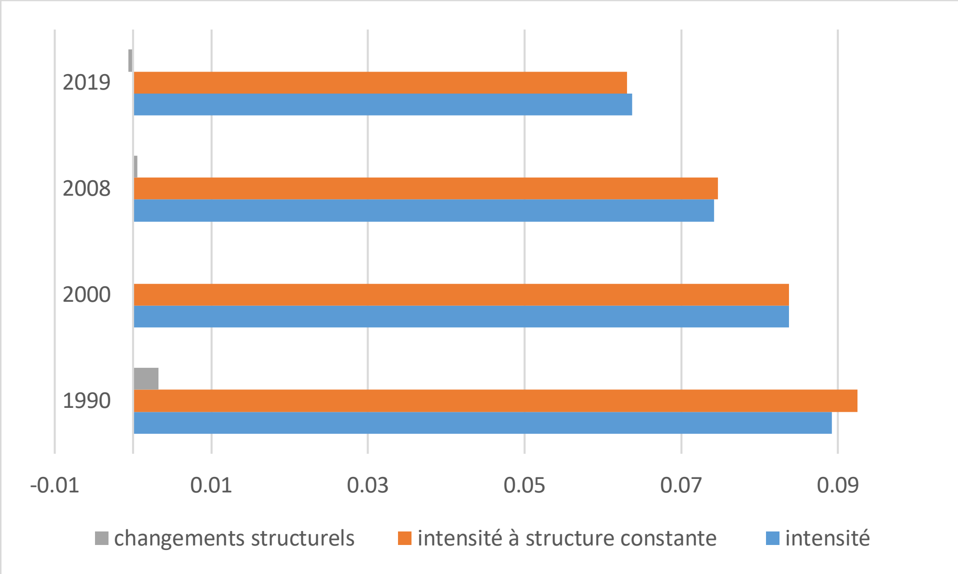
Source: ODYSSEE database

It can be seen that primary energy intensity is decreasing less rapidly than final energy intensity. This gap results from the loss of efficiency in the energy transformation sector. Despite the penetration of combined cycle gas power plants and renewable energies in the production of electricity (wind and solar), the growth of nuclear power consumption is degrading the overall performance of the energy transformation sector.

Since 2008, the decrease in energy intensity is essentially due to structural changes in the economy, linked mainly to a greater, contribution of the tertiary sector and the least energy-intensive industries[6] to GDP; the decrease in the energy intensities of the sectors (energy productivity gains) explains the rest of the variation in energy consumption. If we look more precisely at each year of this period 2008-2019, we see that the situation evolves quite differently from year to year; structural changes have had a strong impact especially in 2009 and 2019.

6 The share of value added of the tertiary sector in GDP rose from 68% to 72% between 1990 and 2013, at the expense of industry, which fell by 3 points (from 20% to 17%). The tertiary sector is about 7 times less energy intensive than industry.

Figure 60 : Details of the impact of structural changes between 1990 and 2019



Source: ODYSSEE database

However, the estimation of traditional energy intensities that relate energy consumption to a monetary value (e.g. GDP, VA, private consumption) can be improved by calculating a constant structure energy intensity, i.e. by removing the impact of structural changes between contributing components of GDP and industrial branches. On the other hand, it is still difficult to isolate the impact of other factors that are not related to energy efficiency (more than one third of energy consumption) and factors not related to energy efficiency (more appliances, more cars).

II.2 Technical and economic approach

II.2.1 Measuring energy efficiency through Energy Efficiency Indices

The ODYSSEE database provides a variety of indicators of specific consumption, measured in physical units, at a detailed level:

- By subsector in industry (e.g. toe/ton for steel, cement) and services (e.g. kWh/employee, /per m2/per bed...),

- By end-use/appliance for households (e.g. toe/m2 for heating, kWh/household for electrical and AC appliances...)

- By mode of transport/vehicle type for transport (e.g. km/l or pkm for cars, toe/tkm for freight, etc.)

These detailed indicators can be used to assess energy efficiency progress at the sub-sector, end-use and transport mode levels.

For households, we can get, for example, different trends in energy efficiency: 1.5%/year for refrigerators and 2.3%/year for heating. The question is what are the overall energy efficiency improvements for households? This is the objective of the energy efficiency index, called "ODEX".

ODEX methodology

Box 1 : Principle of the ODEX calculation

ODEX is calculated as follows:

- First, by expressing trends in specific energy consumption by end-use or subsector as an index of change.

- Second, by calculating a weighted average index for the sector based on the share of each end-use/sub-sector in energy consumption, the end-use/sub-sector in the sector's energy consumption.

Example with two subsectors:

- Change in specific consumption from 100 to 85 for the first sub-sector and from 100 to 97.5 for the second

- Share of consumption of 60% and 40% respectively

The weighted average index is 0.6(85/100) +0.4* (97.5/100) = 90*

An ODEX value of 90 means a 10% energy efficiency gain.

ODEX measures energy efficiency progress by major sectors (industry, transportation, households, services) and for the economy as a whole (all end-use consumers).

For each sector, the index is calculated as a weighted average of sub-sectoral indices of energy efficiency progress, where the sub-sectors are industrial branches, service sector branches, household end-uses or transport modes.

- The subsector indices are calculated from changes in specific energy consumption indicators, measured in physical units and selected to provide the best proxy for energy efficiency progress from a policy evaluation perspective. In addition, the use of indices allows different units to be combined for a given sector, e.g. kWh/appliance, ktoe/m2, toe/household.

- The weighting used to obtain the weighted aggregate is the share of each sub-sector in the total energy consumption of the sector.

Table 3 below provides a fictitious example of a calculation for households with only 2 end-uses, in which energy efficiency gains are measured relative to the previous year. The energy efficiency index is set to 100 for the base year (e.g. 2015) and successive values are obtained by multiplying the value at t-1 by IEt /IEt -1 multiplying the value at t-1 by IEt /IEt -1. The index at year t thus accumulates the progress in energy efficiency since the base year of energy efficiency since the base year. In this example, ODEX equals 88.6 in 2018, which means that energy efficiency improved by 11.4% between 2015 and 2018[7]

Tableau 3 : Fictitious example of ODEX calculation for households

Consommation énergétiques spécifiques	**2015**	**2016**	**2017**	**2018**
Chauffage (tep/logement) (index)	0.85 (100)	0.83 (98)	0.82 (96)	0.82 (96)
Eclairage (kWh/logement) (index)	300 (100)	290 (97)	260 (87)	250 (83)
Consommation énergétiques				
Chauffage(Mtep) (%)	20 (50)	22 (52)	25 (56)	26 (54)
Eclairage (Mtep) (%)	20 (50)	22 (52)	25 (56)	26 (54)
Indice de l'efficacité énergétique				
Chauffage	100	98	96	96
Eclairage	100	97	87	83
Total	100	97,4	90,9	88,6

Source : realised by author

[7] 11.4%= (1-(88.6/100)*100)

ODEX indicators are a better proxy for assessing energy efficiency trends by sector (e.g., industry, households, transportation, services) and for all end-use consumers.

II .2.2 Measuring energy efficiency through energy savings

The analysis of energy savings by sector (industry, residential, tertiary) is done over the period 1990-2019. However, in this report we propose an estimate of the consumption of the main branches in 2019 using data from the Odyssey-Mure database after updating.

Energy Savings Methodology

The principle of calculating energy savings is to break down the variation in energy consumption between two years (by sector, by use, by type of housing, by industry, by mode of transport, etc....) into two main components: a quantity effect and a unit consumption (or emissions) effect, the latter being used to measure the energy (or CO2) savings.

$$\Delta\, \boldsymbol{C}_{t,t-1} = \boldsymbol{EQ}_{t,t-1} + \boldsymbol{ECU}_{t,t-1}$$

With : C; variation of consumption between two dates, t et t-1

EQ : Quantity effect

EC : Unit consumption effect (or energy savings)

The term "energy savings" (also known as the unit consumption effect) is the result of a "convention" dictated by constrained choices, particularly with respect to data availability. Thus, the reader is invited to interpret with caution "energy savings achieved" between sectors or sub-sectors when the guiding variables are not the same for these sectors/sub-sectors. In particular, beware of conclusions that may be misinterpreted, as the increase in unit consumption, also called "diseconomy", may be negatively connoted. We must systematically analyze what is "hidden" behind the "unit consumption" effect.

The quantity effect in year t measures the impact of the variation in the number of elements of a module Q (number of dwellings, car fleet, etc.) on its energy consumption between a year t and the previous year t-1. It is calculated by multiplying this variation by the level of unit consumption (UC) in year t-1. Added to the actual consumption, the "quantity" effect measures the virtual level of energy consumption that would have been observed in year t if the unit energy consumption had not changed from the previous year. It measures the impact of economic and population growth on energy consumption. The quantity effect of a sector is calculated as the sum of the quantity effects of each module.

$$EQ_{t/t-1} = \Delta Q_{t/t-1} * CU_{t-1}$$

The unit consumption effect, which is used to measure energy savings, measures the impact of the variation in unit consumption between two years (t and t-1) at the level of the different consumption modules. It is calculated by multiplying this variation by the level of activity in year t. The unit consumption effect of a sector is calculated as the sum of the unit consumption effects of each of the modules.

$$ECU_{t/t-1} = \Delta C_{t/\ t-1} - EQ_{t/\ t-1}$$

Since the sum of the effects between t and t-1 is strictly equal to the variation in consumption between t and t-1, the unit consumption effect can also be calculated as the difference between the variation in consumption and the quantity effect (**see Figure 61**). The main equations by sector are given in Table 4 below.

If the information allows, the "unit energy consumption" effect can be split into several effects:

- A technological effect, which measures the savings achieved through improved energy performance of the equipment and techniques used; these savings are irreversible.

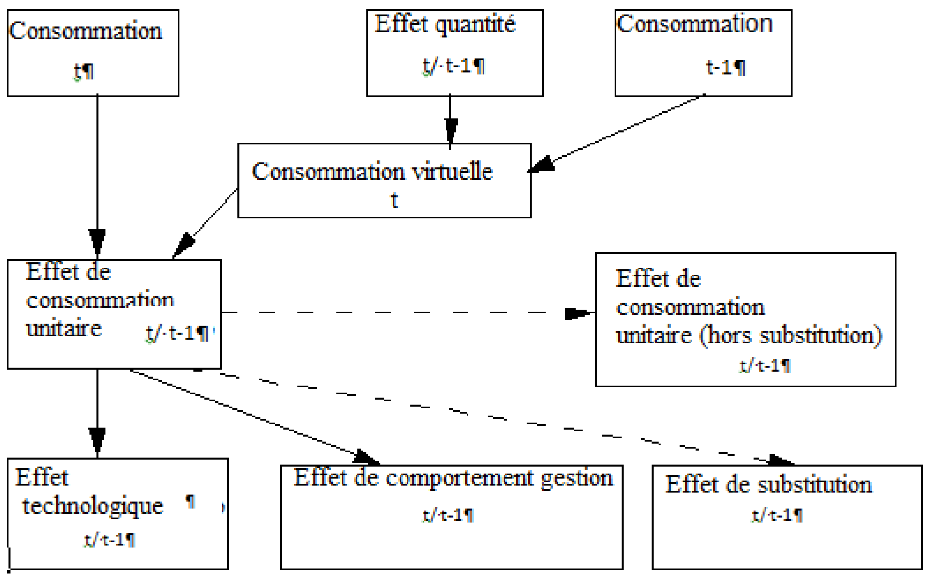
- A substitution effect, which measures the energy savings achieved through an improvement in the average efficiency of energy use due to energy substitution.

- A behavior-management effect, which measures the energy savings achieved through more sober behavior or better energy management; these savings are reversible and therefore quite volatile from one year to the next. This effect is often calculated by difference. All effect calculations are expressed in terms of energy and CO2.

The various effects are calculated incrementally, taking the previous year (t-1) as a reference. By cumulating the savings made each year since 1990, we calculate the savings made in year t compared to 1990.

The diagram below shows the principle of calculating energy savings.

Figure 61 : Presentation of the effects calculation method



Note: virtual consumption obtained by combining the quantity effect (between year t and t-1) and the consumption of year t-1

Table 4 summarizes the different factors used to calculate the energy savings in the different sectors.

Table 4 : Equations for calculating energy savings by sector

Sector/modes/uses	Equations
Industry **Energy-intensive industries (cement, steel, aluminum, paper and cardboard, ethylene, chlorine, fertilizers, sugar, glass)(1)** **Other industries (2)**	(1) $EQ_{t/to} = \Delta Prod_{t/t-1}$ (Mt) $* CU_{t-1}$ (2) $EQ_{t/to} = \Delta IPI_{t/t-1} / IPI_{t-1} * C_{t-1}$ $ECU_{t/to} = \Delta C_{t/t-1} - EQ_{t/t-1}$
Transport • **Cars, buses, motorcycles (1)** • **Truck, Light Commercial Vehicle (LCV), merchant rail (2)** • **Passenger rail (3)** • **Air (4)**	(1) $EQ_{t/} = \Delta$ Parc $_{t/t-1}$ x CU t-1 (2) $EQ_{t/to} = \Delta$ tkm $_{t/t-1}$ x CU t-1 (3) $EQ_{t/to} = \Delta$ pkm $_{t/t-1}$ x CU t-1 (4) $EQ_{t/to} = \Delta$ pas aérien$_{t/t-1}$ x CU t-1 $ECU_{t/to} = \Delta C_{t/to} - EQ_{t/to}$

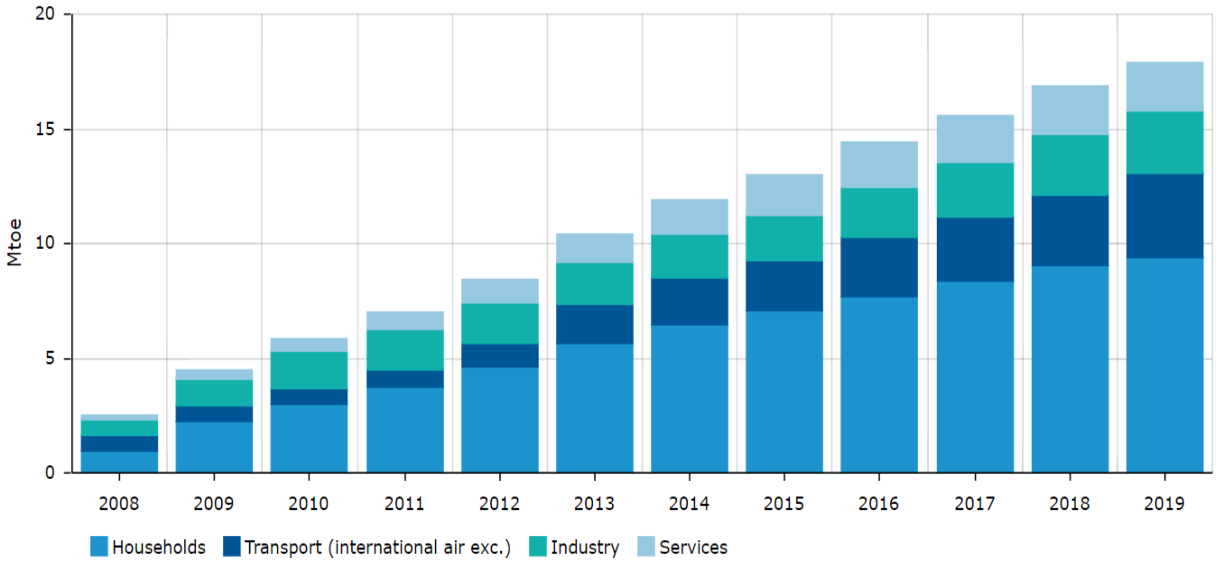
Households - Heating - Cooking/Hot water - Specific electricity (excluding large appliances)	$EQ_{t/to} = \Delta$ parc $_{t/t-1}$ x CU t-1 $ECU_{t/to} = \Delta E_{t/to} - EQ_{t/to}$ Breakdown by type of heating, date of construction of dwellings
Tertiary By branches, uses	$EQ_{t/to} = \Delta$ emp $_{t/t-1}$ x CU t-1 $EQ_{t/to} = \Delta$ surface $_{t/t-1}$ x CU t-1 (usage chauffage) $ECU_{t/to} = \Delta C_{t/t-1} - EQ_{t/t-1}$

With E: energy consumption; Prod, physical production in Mt, IPI, Index of Industrial Production; Park: vehicle or housing stock; tkm: freight traffic in Gtkm; pkm: passenger traffic in Gpkm; empl: Employment; area: heated area in m2.

Energy savings per sector

ODYSSEE Savings: Energy savings represent the effect of a reduction in unit consumption in up to 30 sub-sectors or end-uses. They are calculated year by year with reference to the previous year ("new annual savings"). The savings shown in the graph represent the cumulative annual savings over a period ("cumulative new energy savings"). They correspond to "technical energy savings" and are derived from the technical ODEX, an indicator that measures energy efficiency progress by sector. Negative savings, mainly due to deterioration in energy efficiency during recessions when plants and trucks are not operating at full capacity, are excluded. More information on ODEX.

Figure 62: Evolution of energy savings in France by sector



Source: ODYSSEE database

In 2019, energy savings amount to 18M TOE, in other words, if France had not made any energy savings, it would have consumed 18M more than in 2008. Globally, this trend of energy savings is growing every year without any major change (without any break periods) (2008 is a reference year; post crisis year)

In observing that a very high proportion of energy savings have been achieved in the housing sector so in 2019 it represents 9.3 out of 18 more than half and these have been achieved primarily in the household sector essentially in heating and electricity specific this is brought closer to the efficiency policy related to European regulation as LEPBD (buildings directive) and the Eco-design (for labels and standards on household appliances)

The second sector of savings is the transport in the total contribution is 3.7 million TOE in 2019.

This encouraging result, although insufficient in view of the level of consumption of the sector, begins to reap the result of technical progress driven by public policy (labels and CO2 standards and the bonus-malus for cars) 3.7 / 30 which makes 10% of the consumption of transport in 2019.

Energy savings amount to 2.7 Mtoe, or 6% of consumption. They are relatively weak compared to the one that this sector knew in the 90s.

Finally, energy savings in the services sector are relatively low at 2 Mtoe, which is probably due to the weakness of energy efficiency policies in this sector.

Energy savings by the decomposition method

Box 2 : Decomposition method

The decomposition of the change in final energy consumption is calculated by combining the sectoral decomposition, i.e., adding the contribution of the different drivers by end-use sector (industry, transport, households, services, and agriculture) into broad categories, as follows:

Activity: change in value added in industry, services and agriculture, traffic in transport, number of dwellings and appliances, and dwelling size for households;

Structural effects: industry (and services), modal shift in transport.

Energy savings ("technical");

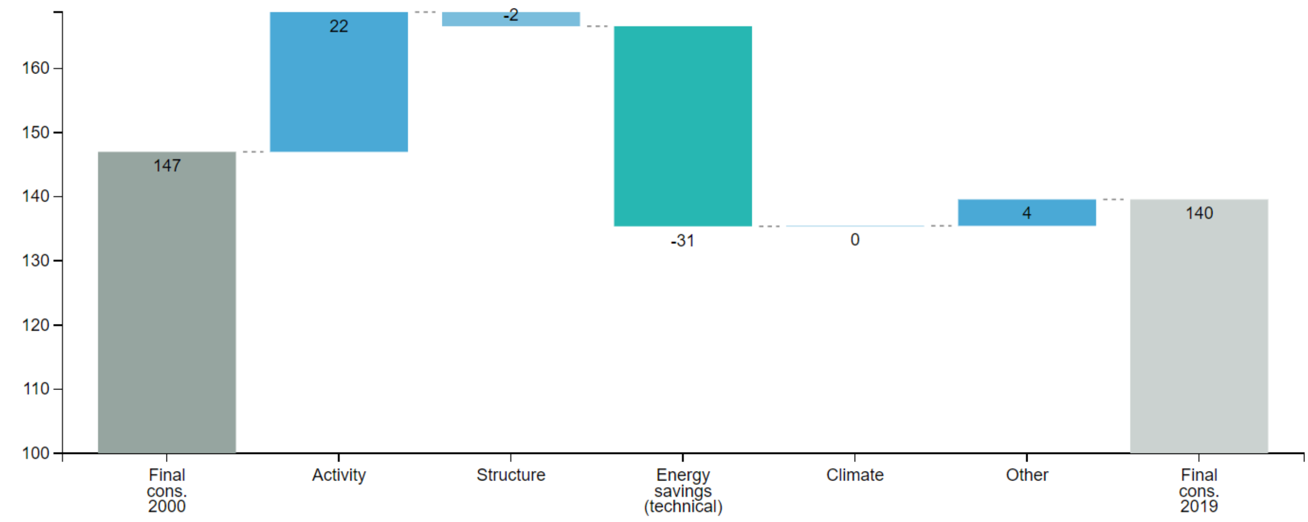
Climate effect: households and services

Other effects: household behavior, product value in industry, labor productivity in services, and "negative" savings due to inefficient operations in industry and transport.

Energy savings are technical savings, i.e., gross savings adjusted for negative savings due to inefficient operation of facilities or behavior. Energy savings are derived from the ODEX, an indicator that measures energy efficiency progress by major sector and for the economy as a whole (all end-use consumers).

For each sector, ODEX is calculated as a weighted average of subsectoral indices of energy efficiency progress; subsectors being industries du secteur industriel ou des services, des utilisations finales pour les ménages ou des modes de transport.

Figure 63 : Decomposition of final energy consumption in France for all sectors (1990-2019)



Over the last 20 years, final energy demand has decreased by 7 Mtoe (140 in 2019 / 147 in 2000).

We observe that the amplitude of the explanatory effects are very variable as well as their orientations, the economic growth and the income of the households as well as the demographic push pushed the consumptions up by 22 Mtoe (activity effect).

At the same time, this economic growth has led to structural effects. This growth of the activity effect was accompanied by the structural effect of more services and less industry or more light industry and less heavy industry. In total, this effect measured by the structure effect played very little role over the period (- 2Mtoe).

The technical progress of energy efficiency policies and energy can generate technical energy savings of the order of 31 Mtoe, this impressive result shows that the energy savings achieved have more than cancelled out the effect of economic growth on energy demand.

Changes in user behavior (others) and company management have had very little effect over the period (4 million), with a very slight deterioration as consumption increased.

Energy savings in the transportation sector using the decomposition method

Box 3 : Methodology for calculating energy savings in transport sector

The savings in the transport sector are measured in 8 modes: cars, trucks, light commercial vehicles (LCVs), buses, two-wheelers, air, rail (passenger, freight) and inland navigation. For road modes, energy savings are calculated on the basis of consumption, fleet and traffic of French vehicles (domestic transport of vehicles registered in France).

Energy savings can be broken down into 3 effects:

A technological effect, which measures the impact of improved vehicle performance;

A mileage effect related to the variation in the annual distance traveled by vehicles;

A "behavior-management" effect, linked to driver behavior, which is calculated by balance.

The technology effect measures the impact on fuel consumption of changes in the technical specifications of vehicles, expressed in terms of the conventional fuel consumption of new vehicles (as given by the manufacturers) and their penetration in the total fleet.

The behavior-management effect measures the impact on fuel consumption of changes in driving behavior and car use.

Box 3 : Climate corrections

The interest of calculating consumption "corrected for climatic variations" consists in calculating what consumption would have been if temperatures had been "normal", i.e. equal to those of a reference period. Consumption series that better reflect changes in consumer behavior are thus obtained (definition of energy consumption corrected for climatic variations in the Ministry's Energy Balance).

The CEREN and the Bilan de l'Energie do not have the same degree days. The Bilan proposes reference degree-days equal to 1966, corresponding to the period 1986-2015. On the CEREN side, a new "normal year" is adopted from 2014 (1900°D) taking as "normal" the reference temperature of Météo-France. For the previous years, it was asked to make the "normal year" evolve by smoothing to take into account the "global warming" between 1975, 1995 and 2014 (normal in 1975 = average 1961-1990, that is to say 2231°J and normal in 1995 = average 1984-2004 that is to say 2033°J). The analysis of energy consumption in the residential sector is made with data from CEREN.

The energy savings in the residential sector are calculated at the level of the whole sector from the savings by use (heating, hot water, cooking, specific electricity). For heating, the savings are calculated at the level of the main residences, distinguishing :

The type of housing (houses / apartments) ;

The year of construction (before/after 1975);

The different energies (oil, gas, electricity, LPG, coal, wood, other)

The type of heating (individual heating/collective heating).

II.3 Scoreboard (European energy efficiency scoreboard)

The objective of the European Energy Efficiency Scoreboard is to evaluate and score the energy efficiency performance and policies of the European Union countries as well as other countries such as Norway, Serbia, Switzerland and the United Kingdom, by country and by sector (households, transport, industry and services).

The scores are calculated on the following components of energy efficiency:

- the level of energy efficiency,

- energy efficiency progress (i.e. energy efficiency trends)

- energy efficiency policies,

- the overall energy efficiency score, which is a combination of these three components.

For each of these three criteria, each country receives a score between 0 and 1 based on a series of indicators (extracted from the ODBC) and energy policies (extracted from the MURE database).

II.3.1 France's score on the European energy efficiency scoreboard

Tableau 5 : France's score on the energy efficiency scoreboard by sector

		Level	Trend	Policies	Combined
Overall	France	12 / 29	17 / 29	2 / 31	5 / 29
	Highest score (benchmark)	Lithuania	Greece	Estonia	Switzerland
Industry	France	18 / 29	25 / 30	6 / 31	17 / 29
	Highest score (benchmark)	Lithuania	Luxembourg	Finland	Estonia
Transport	France	8 / 30	12 / 30	2 / 31	1 / 30
	Highest score (benchmark)	Romania	Greece	Ireland	France
Households	France	15 / 30	14 / 30	2 / 31	3 / 30
	Highest score (benchmark)	Finland	Netherlands	Estonia	Switzerland
Services	France	24 / 31	18 / 31	4 / 31	10 / 31
	Highest score (benchmark)	Romania	Slovakia	Estonia	Switzerland

At the most global level, combining all 3 criteria, France is in 5th position but is in 3rd position in the EU. A more detailed analysis shows that France is the best rated in terms of impact of energy efficiency policies. However, the results are much less convincing in terms of results, since France is ranked 13th in terms of energy efficiency level and trend.

However, the results are very dependent on the sector. Thus, France is in first place in the transport sector but in last place in the industry sector. We also note the good performance in the residential sector, but this is essentially due to our good position in terms of implementation of the best policies, but with disappointing results in terms of achieving energy efficiency, ranking 15th.

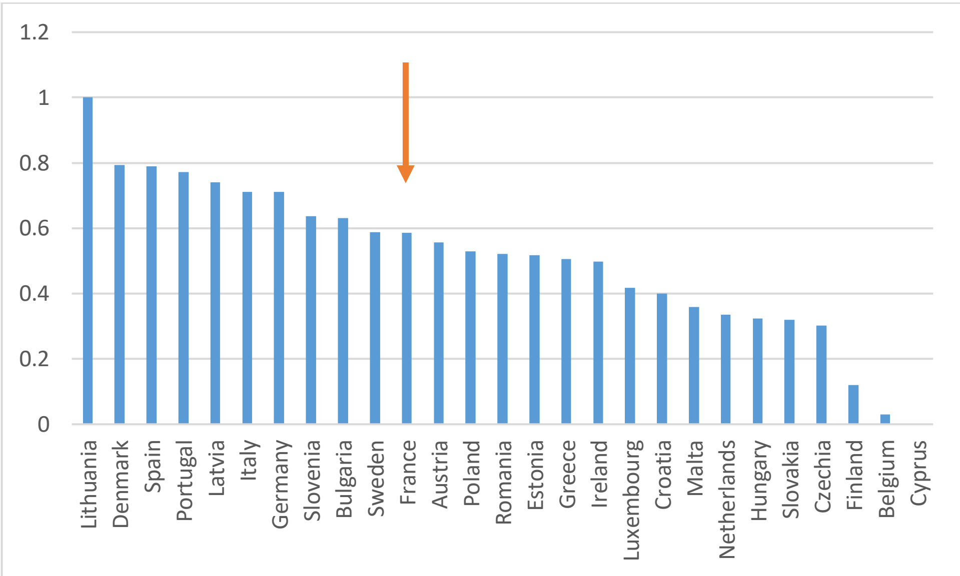
The following graphs illustrate the position of France compared to all other European countries.

And it will be available in the annex the scoreboard scale extracted from Odyssey.

All sectors scoreboard of European countries by level

This graph shows the ranking of countries in terms of energy efficiency level. Each country is given a score between 0 and 1 based on a series of indicators.

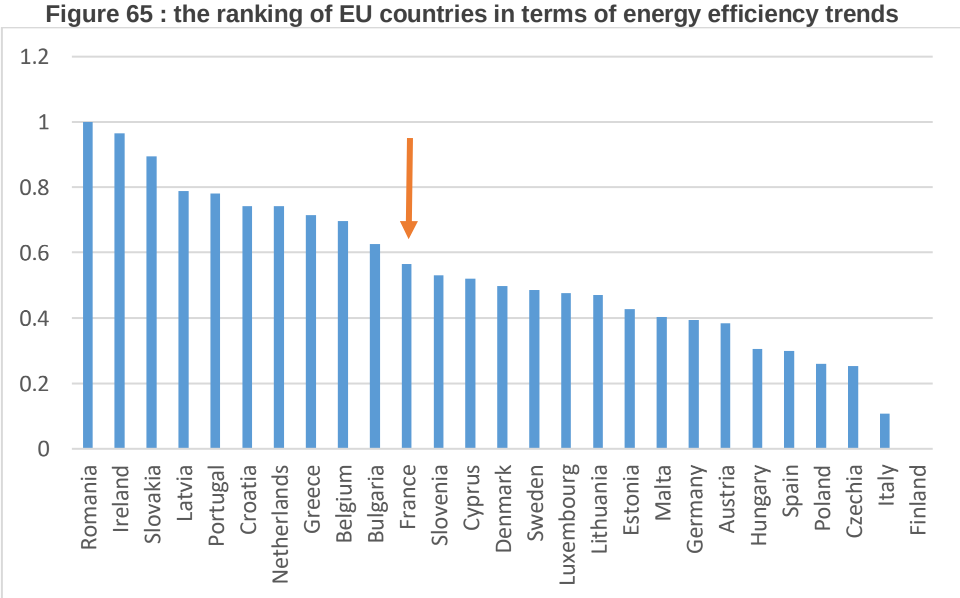
Figure 64 : the ranking of EU countries in terms of energy efficiency level



Scoreboard of all sectors in European countries by trends

This graph shows the ranking of countries in terms of energy efficiency trends. Each country is given a score between 0 and 1 based on a series of indicators.

Figure 65 : the ranking of EU countries in terms of energy efficiency trends



II.4 Developpment of energy efficiency trends

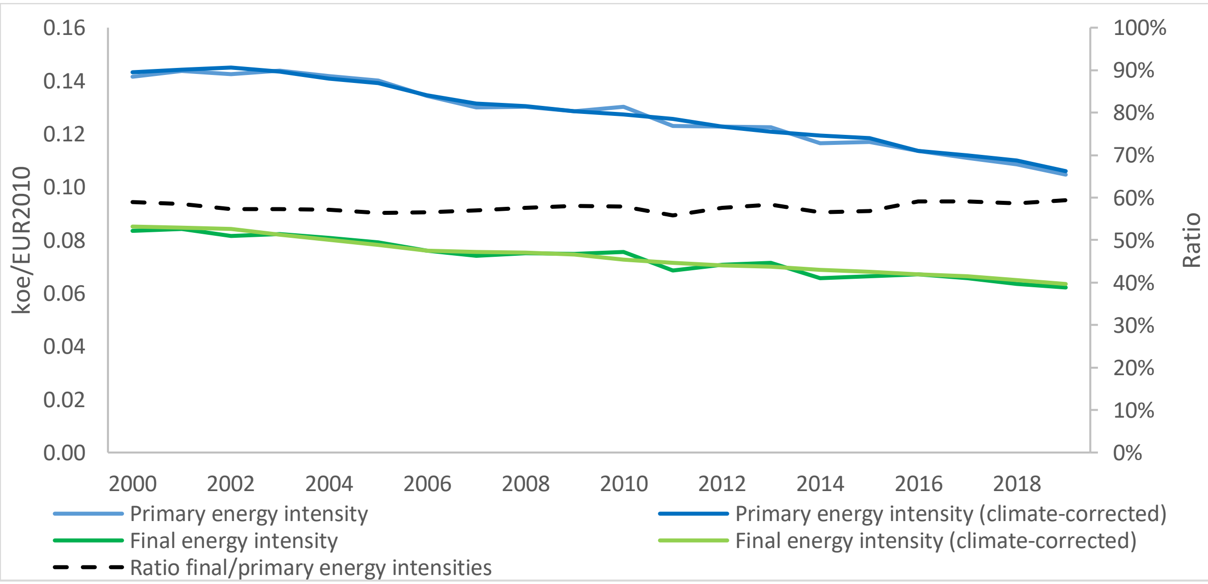
Energy intensity

France's overall energy efficiency from an economic viewpoint is next characterized through the primary and final energy intensities, i.e. the ratio between the energy consumption and the GDP. The reverse of this ratio or the "energy productivity" is also a measure of how well the energy resources are being used. The effects of economic growth from 2000, as measured by GDP, are removed from the indicator in order to avoid the impact of inflation. Likewise, the weather fluctuations are taken out through the temperature-corrected intensities for the residential and tertiary sectors.

Since 2000, the temperature-corrected primary and final energy intensities have had a yearly descending progression of 1.58% and 1.53% respectively. The strong fluctuations in the economic development due to the financial and economic crisis and the subsequent revival of the economy had an impact on the energy intensity. In 2009, the main year of the recession, the final energy intensity even began to increase, which was mainly caused by developments in the industrial sector.

On average, the energy intensity variation between the primary and the final energy intensities became more pronounced after 2008 (**Figure 63**). This certainly led the ratio between them to climb just under 60% and to acquire an upward tendency. Behind this behaviour lay the improvement in power generation efficiency linked to the important penetration of wind and solar power as replacements of less efficient energy conversion technologies like thermal or nuclear power[11].

Figure 66 : Development of primary and final energy intensities in France (2000-2019)



Source: ODYSSEE database

[11] Thermal and nuclear power generation have average efficiencies below 40% and of 33%, while solar and wind have a 100% efficiency. https://www.iea.org/statistics/resources/questionnaires/faq/

Energy efficiency progress : ODEX indicator

Although the overall energy intensities described above already take into account the impact of short-term weather fluctuations and changes in activities, clearly capturing energy efficiency improvements is limited by many structural effects across the different energy consumption sectors (e.g. sector or product structure in the industrial and tertiary sectors) and several comfort effects (e.g. larger living area per household, higher room temperature, larger appliances).

In addition, energy intensities which are based on monetary activities at a highly aggregated level (i.e. total GDP or added value of a sector) only give a limited understanding of the pure energy efficiency developments. ODYSSEE tackles these limitations by providing a re-aggregated energy efficiency indicator called "ODEX". This index is obtained by aggregating the unit consumption changes at detailed levels (by sub-sector or end-use), observed over a given period. The unit consumption variation is measured in terms of a ratio that use physical instead of monetary activities, which is more suitable to evaluate pure energy efficiency trends (see e.g. Farla et al., 1998; Farla and Blok, 2000; Neelis et al., 2007).

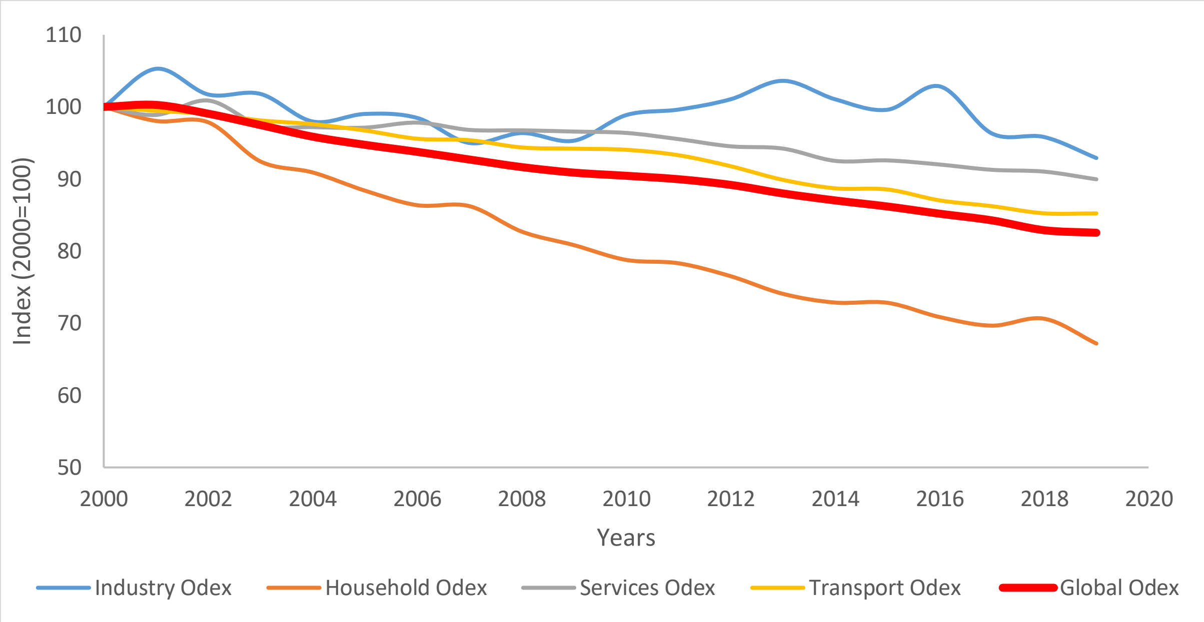
ODYSSEE went further in isolating the pure energy efficiency evolution. Even all effects considered, apparent (or observed) energy efficiency could increase from year to year, resulting in negative energy efficiency improvement. However, the pure technical energy efficiency should not be reverse, as it is not likely that private consumers and companies are acquiring less efficient equipment from a technical point of view. They can however underutilize it, what leads to a less efficient consumption (mainly in the industry).

With the intention to provide better proxy of technical energy efficiency progress, the observed ODEX is cleaned from effects of equipment's less efficient use as well as from strong fluctuations linked to of statistical errors, imperfect climatic corrections and influence of business cycles. The "technical" ODEX is the result of these adaptations.

According to the development of the observed ODEX indicator **(Figure 67)**, in the year 2019, the global ODEX in France was 83 which represents an improvement of 17% on the overall energy efficiency since the base year 2000, or 1.0% per year on average.

However, the pace of progress has slowed down since the economic recession: the annual gain has dropped from 1.1% per year between 2000 and 2007 to 0.87% per year thereafter. This post-crisis stagnation of the energy efficiency progress was mainly caused by the reversal in development in industry and it was triggered by a drop in equipment's capacity utilization. Its energy efficiency worsened during and after the recession, what levelled off the gains so far obtained.

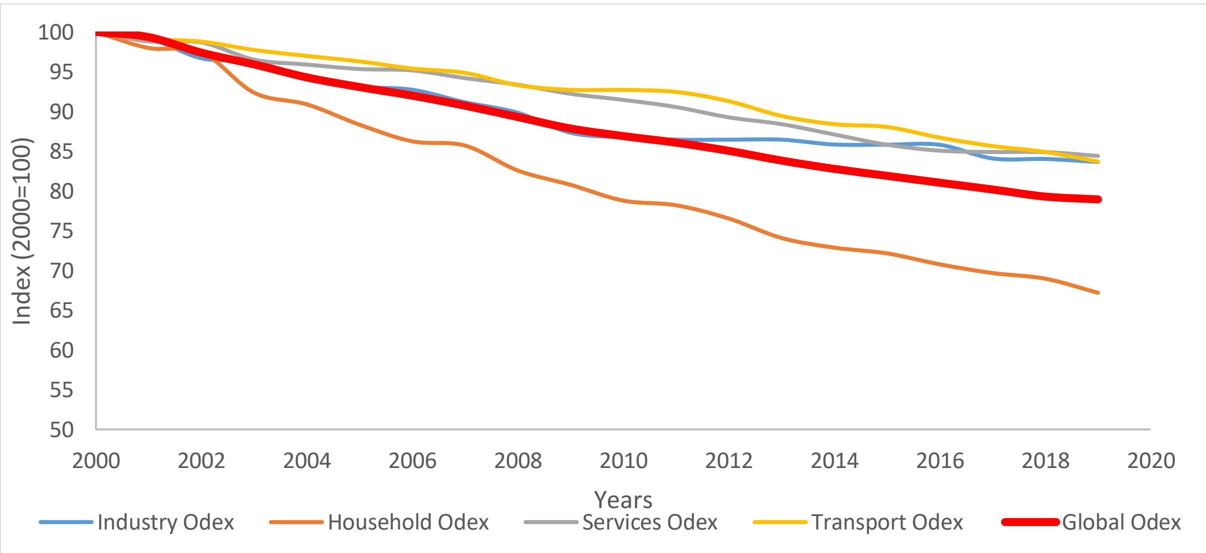
Figure 67 : Development of the observed energy efficiency index (ODEX), 2000-2019



Source: ODYSSEE database

Free from the inefficient use of equipment, the technical ODEX indicator reveals in **Figure 64** that between 2000 and 2019 the energy efficiency progress in France has steadily improved by 1.24% per year and 21% over the period.

Figure 68 : Development of the technical energy efficiency index (ODEX), 2000-2019



Source: ODYSSEE database

This report analyses the development of the energy efficiency in Germany at the level of the overall economy and all final energy consumption sectors between the years 2000 and 2019. It also explores the reasons behind France's position in the Combined Scoreboard for Energy Efficiency, one of the decision-support tools of the ODYSSEE-MURE European project.

France has achieved economic growth while improving efficiency. This decoupling is larger from 2008, with an increase in GDP of 1.4% per year and a decrease in primary energy consumption of around 0.7% per year since 2008. This report brings to light some relevant reasons of France's stand on the targets achievement, besides outlining the country's performance on energy efficiency compared to other countries, with the use of several types of energy efficiency bottom-up indicators presented by sector and end-use.

In 2019, France was placed 5th in the Combined ODYSSEE-MURE Scoreboard, a joined evaluation of the current energy efficiency level, the efficiency development over time (or trend) and the energy savings due to implemented efficiency-related policies. According to the breakdown of the overall ranking (Table 5), it becomes clear that the positive results of the deployed policies have leveraged the total scores. Regarding policy results, France is ranked among the top five countries in each of the studied sectors (household, services, transport and except for industry,6th). In general, this might be an evidence of the solid policy package that France has deployed with the NEEAP, NAPE and Climate Action.

On the contrary, the energy efficiency level moves back to the rather average 12th position (out of 29), where the household sector becomes the matter of concern, due to its 15th post respectively in the sector-specific ranking and to its high importance in the energy consumption in France. The energy efficiency level is susceptible to further detriment by the slow evolution in efficiency, mainly in the services and industry, a high consuming sector likewise. France's lowermost position (17th/29) in the scoreboard for energy efficiency trend is clearly influenced by the industry's penultimate stand regarding energy efficiency trend in the sectoral results (25th/30).

The variation in consumption observed from 1990 to 2019 can be explained by two opposing factors; on the one hand, a growth or activity effect ("quantity effect") that would have contributed to increasing consumption to 147 MTOE in 2019, and on the other hand, energy savings (31 MTOE) from 2000 to 2019 attributable to decreases in unit energy consumption of the various sectors and uses.

In addition, after analyzing the first effect, which is presented under energy consumption. We will discuss the second effect, energy savings in a second chapter and the contribution of the two sectors (transport and residential) in the quantity effect and the unit consumption effect.

The cumulative energy savings since 1990 come largely from the residential sector, followed by transport. For this reason, most of our work is focused on these two sectors. We note changes in trends in energy consumption and savings over the period, particularly since 2008 with the economic and financial crisis that has deeply affected the country.

Finally, this work can serve as a reference for the analysis of the post-crisis period of Covid-19.

Refrences

ADEME, Rapport National (Edition 2017).

Commissariat Général au développement durable, Chiffres clé de l'énergie (Edition 2019).

ADEME, Sectoriel Profile (Edition 2018).

Odyssée-Mure, Energie Profile (Edition 2020).

ADEME, Chiffres-clés Évolution du marché, caractéristiques environnementales et techniques

Véhicules particuliers neufs vendus en France, (Car labeling).

OCDE, Études économiques de l'OCDE France, (Edition Avril 2019).

Annex