ODYSSEE-MURE

Energy efficiency trends and policies in France between 2000 and 2022

Monitoring and analysis with the ODYSSEE and MURE databases

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Executive Summary

This report is studying energy consumption and efficiency trends and drivers in France from 2000 to 2022. It provides an overview of socio-economic and energy trends, while also examining energy efficiency progress through a range of indicators derived from the ODYSSEE database. This report explores the different explanatory factors that might contribute to sectoral trends in the residential, industrial, tertiary and transport sector.

The key finding is that, while GDP has been growing since 2000, both primary and final energy consumption have decreased by 17% and 12%, respectively, in 2023. This decoupling of energy consumption from economic growth indicates that the French economy is becoming less energy intensive. In 2023, it takes 30% less energy to produce one unit of economic output than in 2000.

While energy intensity of how efficiently energy resources are used to create economic output, it does not allow to disentangle efficiency improvements from structural and behavioural effects and can be biased by price dynamics. The ODYSSEE-MURE project developed a technical approach to measure energy efficiency based on an indicator aggregating unit consumption for a range of end-uses in all sectors.

Between 2000 and 2023, energy efficiency improved by 25% in France. The residential sector experienced the most significant gains, with a 36% improvement in 2023 compared to 2000. Meanwhile, the industrial, tertiary and transport sectors all saw efficiency improvements of around 20% over the same period. Without these progress and associated savings, the 2023 final energy consumption would have been nearly 40Mtoe, or 31%, higher. Energy savings due to efficiency represent the main driver of the variation in finale energy consumption between 2000 and 2023.

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Introduction

Energy efficiency plays a key role in the French and European transition towards a low-carbon future and has been part of energy management policies for decades. All Member States of the European Union commit to energy consumption reduction targets alongside their net-zero goal. This report analyses energy efficiency trends in France during the 2000 to 2022 period. Its goal is to assess the evolution of energy efficiency across each sector and identify the main drivers behind the changes and their relative contributions.

This report has been produced as part of the ODYSSEE-MURE project, which monitors trends in energy consumption and efficiency while assessing the effectiveness of energy efficiency policies by sector for EU countries, Switzerland, Norway, and Energy Community countries. The project relies on two databases: ODYSSEE, which collects energy data to compute energy efficiency and CO2 indicators, and MURE, which compiles and monitors energy efficiency measures implemented at EU or national level and their impact on energy consumption.

The ODYSSEE-MURE project is coordinated by ADEME with technical support from Enerdata and Fraunhofer. It is supported by LIFE-CET programme of the European Commission and is part of the activities of the EnR Club. A full description of both databases is available in the

This report is focusing on analysing energy efficiency trends in France from 2000 to 2022; with additional data for 2023 where available. It provides an overview of socio-economic and energy trends, while also examining energy efficiency progress through a range of indicators derived from the ODYSSEE database. The report then delves into sectoral trends, exploring the different explanatory factors that might contribute to these developments.

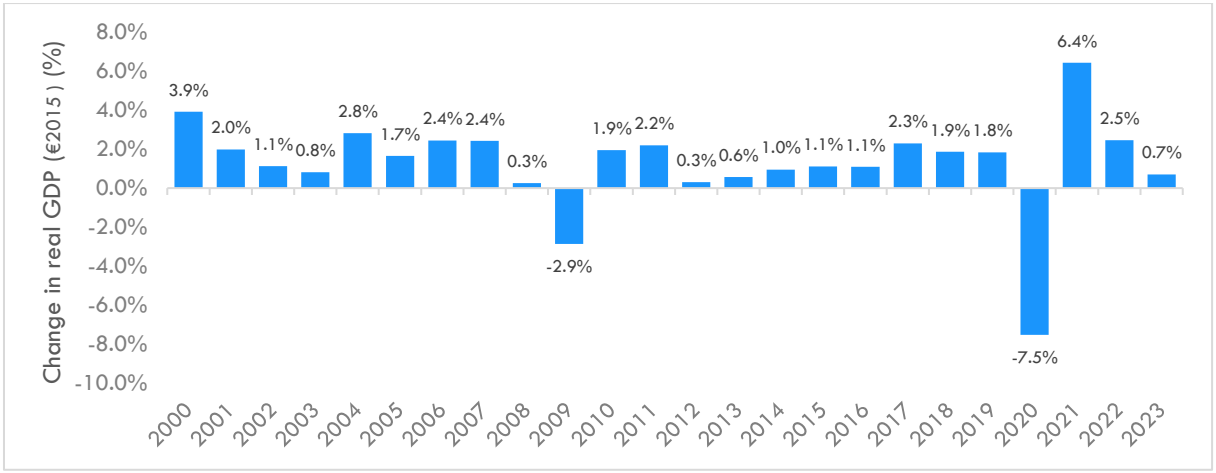
The report first describes the socio-economic context and the policy framework of the studied period. The second section presents overall energy efficiency trends in France and the last section goes through the trends for the four main energy consuming sectors: industry, transport, residential and service sectors.

1 Socio-economic context

1.1 Broader economic context

In the past two decades, two events have had a major impact on the French economy: the 2008 Financial Crisis, and the Covid-19 pandemic in 2020 and subsequent recovery in 2021, as shown by the recession in these years in **Figure 1**. In the years leading up to the pandemic, growth had been gradually recovering after a stagnation period since 2012, which can be partly attributed to austerity measures implemented in response to the European sovereign debt crisis. The 7.5% decline in gross domestic product (GDP) in 2020 marked the largest recession in the past four decades, while 2021 is also an outlier with a 6.4% growth rate largely fuelled by European recovery packages. The decreasing growth rate between 2022 and 2023 is difficult to characterise since it requires to disentangle short term effects due to the economic recovery following the pandemic from more structural trends.

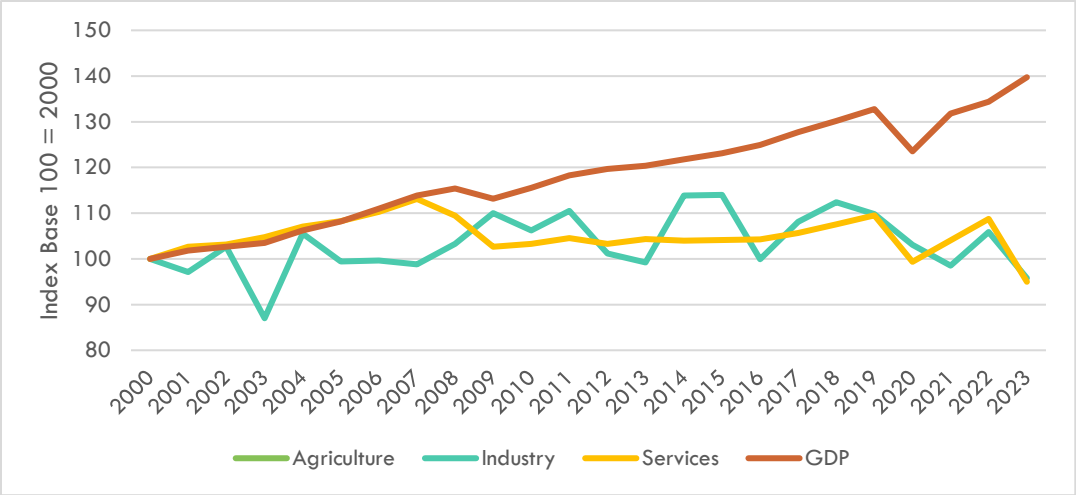
Figure 1 : Change in constant GDP (2000 – 2023)



Source: Eurostat

In France, the service sector makes up the largest share of GDP, with its value-added amounting to 72% of GDP in 2023, while the industrial sector represented 16% of GDP. Until 2008, the value-added of the industrial and service sector grew at the same rate, however, during the 2010s, the latter grew at a faster pace than the real GDP, showing the increasing shift towards a service-based economy (Figure 2). The dip in the trends in 2020 shows the impact of the Covid-19 pandemic and the subsequent economic catch-up phenomenon in 2021 and 2022, slowing down in 2023.

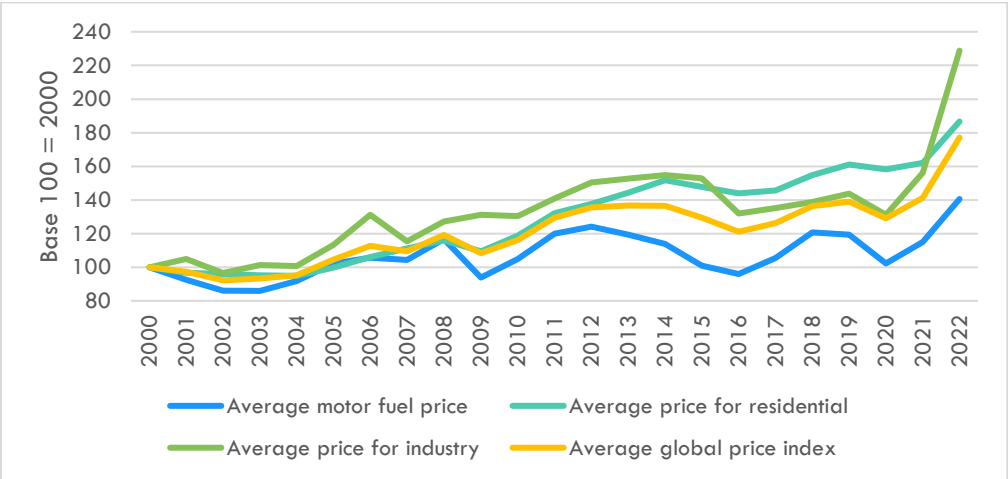
Figure 2 : Sectoral Added Values and GDP Growth in France (€2015)(2000–2023)



Source: Eurostat

Energy prices can have a significant impact on the level of energy consumption. The average price of energy has increased by 40% during the 2000-2021 period, or 2%/year on average (Figure 3), with fluctuations correlated with variations of international price of oil and gas. Due to the Russian invasion of Ukraine and its repercussion on natural gas prices, the average price of energy has increased by 30% in the EU. In France, the price increase was contained at 25%, thanks in part to the *bouclier tarifaire*. Fuels have had the smaller increase overtime with an average growth of 0,6%/year during the 2000-2021 period, before a 22% increase in 2022. The average price of energy in the residential sector increased by an average 2,3%/year between 2000 to 2021 before jumping by 15% in 2022. Meanwhile, prices for industry increased by a slightly lower average of 2,1%/year before an impressive 45% jump in 2022. Businesses were less protected during the energy crisis and were very impacted by the price spike.

Figure 3 : Energy prices by sector (2000-2022)



Source: Enerdata, Eurostat

Note: prices in €2015

1.2 Policy framework and targets

European Union Member States including France are committed to alleviate climate change through the reduction of their energy consumption and CO2 emissions. France through several major laws including the Energy Transition for Green growth Act of 2015, the Law for Mobility Organisation of 2019, the Energy and Climate Act of 2019, and the Climate and Resilience Act of 2021, has established a set of targets to reach before 2050 through policy actions spanning all sectors (building, transport, industry, etc).

These national laws are generally framed by EU directives setting targets for each member state. Indeed, in the context of the European Green Deal, the EU is committed to achieve carbon neutrality by 2050, with an interim target of reducing net CO2 emissions by 55% by 2030 compared to 1990. The EU has also set a goal of reducing final energy consumption by 38% and primary energy consumption by 40,6% compared to the 2007 Baseline scenario, enshrined in the Energy Efficiency Directive recast (EED)(2023/1791/EU). Article 8 of this Directive imposes the deployment of white certificates schemes, or alternative measures, in all EU countries to reach the energy consumption reduction targets, such as in France where a scheme is in place since 2006 (CEE, Certificats d'Economies d'Energie). While most EU members report several policies to the European Commission to comply with their energy consumption reduction objectives, France has been able to design its obligations scheme to reach its periodical targets.

Other European Directives are directly, through standards and norms, or indirectly, through transposition in national legislation, influencing energy use and efficiency across Member States. For instance, the Energy Performance of Buildings Directive (2024/1275/EU), recasted in 2024, is set to reduce emissions and energy consumption from all buildings and aim at achieving a decarbonize, zero-emission building stock by 2050. The Ecodesign Directive (ESPR) sets design requirements to minimize the life-cycle environmental impacts of the most energy and emissions intensive products.

Another EU wide legislation with large implications for energy efficiency is the EU Emission Trading System (ETS), a cap-and-trade system limiting the amount of CO2 emissions for obligated entities, including power plants and large industrial emitters mainly. ETS2, a new emissions trading, has been created in 2023 to address emissions from buildings, road transport and small industrial emitters. This second system is enlarging the scope of the ETS by providing an incentive to reduce emissions in sectors that were not previously obligated.

France has set its own targets and is committed to reduce its CO2 emissions by 40% between 1990 and 2030 and to reach carbon neutrality by 2050, or a 60% decrease compared to 1990. There is still a need to transpose in future legislation the Fit-for-55 EU target of a 55% reduction of CO2 emissions by 2030. The National Low-Carbon Strategy

(SNBC) adopted by decree in 2020, details sectoral pathways to transition towards a low-carbon economy and achieve carbon neutrality by 2050. The SNBC also defines carbon budget for 4-year periods with a decreasing emissions cap overtime. However, the SNBC assumes that in 2050 the carbon sinks will be able to absorb up to 80 MtCO2e of remaining emissions, while more recent studies have alerted on the diminishing capacity of French carbon sinks[1].

2 Overall energy consumption and efficiency trends

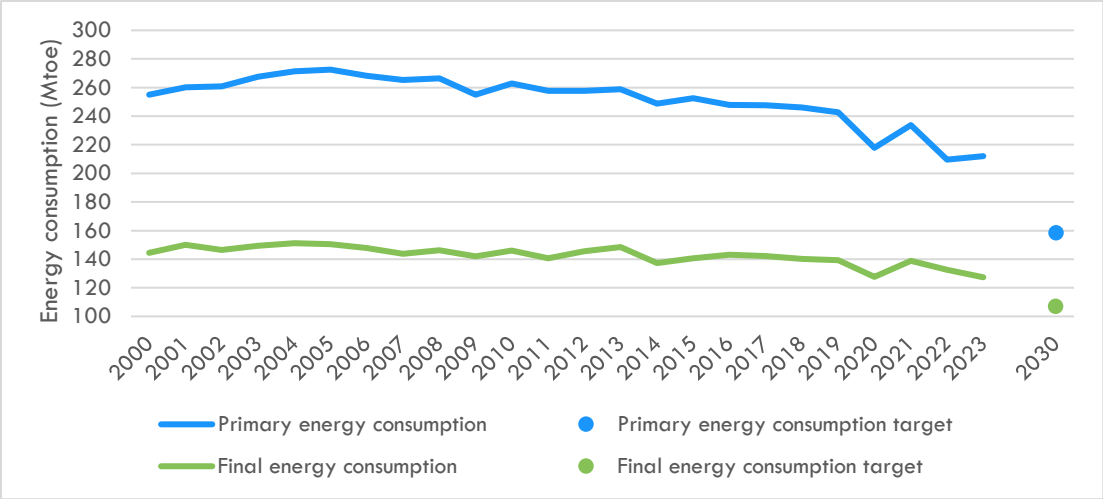
2.1 Total energy demand

Energy demand depends on the socio-economic context that defines firms' activity level and impacts households' level of consumption, on the average weather, on policies, and on behavioural change, among other factors. Energy demand can be assessed by analysing both primary energy consumption and final energy consumption[2].

Both primary and final energy consumption[3] have been decreasing since 2000, reaching 212,1 Mtoe and 127,3 Mtoe in 2023, corresponding respectively to a 17% and 12% reduction (Figure 4). Energy consumption is particularly correlated to changes in economic activity, with major recessions –such as those in 2008 and in 2020– corresponding to significant drops in energy consumption. Figure 4 also displays the France's 2030 energy consumption targets set under the EED. Achieving these targets will require a significantly faster reduction in energy consumption: from a yearly average of -0,9% between 2000 and 2022 to -3,4% per year for the 2022-2030 period for primary energy consumption, and from -0,4% to -2,65% for final energy consumption.

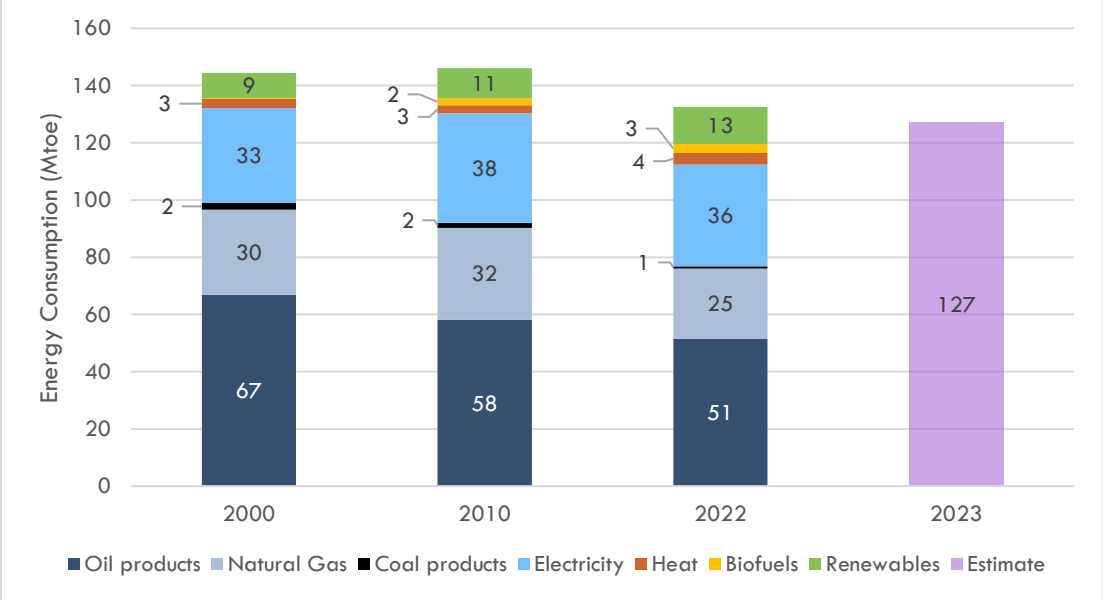
[1] https://www.hautconseilclimat.fr/wp-content/uploads/2024/06/HCC_RA_2024-web-1.pdf
[2] The former referring to all the energy sources, either fossil or renewable, supplied prior to any transformation, while the latter refers to energy actually consumed by end-users. Thus, final energy consumption corresponds to primary energy consumption diminished from all energy losses generated along the transformation chain (for instance due to the transformation of fossil fuel into electricity).
[3] Energy consumption with climatic corrections

Figure 4 : Primary and final energy consumption and 2030 targets



Source: ODYSSEE

Figure 5 : Final energy consumption by fuel type (2000-2023)



Source: ODYSSEE

Although final energy consumption has been decreasing by 12% over the period 2000-2023, trends differ by energy type, as can be seen in Figure 5. For the last three decades, fossil fuels have been accounting for the bulk of the final energy consumption in France. However, since 2000, oil consumption has decreased by more than 23%, from 67 Mtoe to 51 Mtoe in 2022, while oil products have remained the single largest contributor to the energy mix. The share of oil products in total final energy consumption has also shrunk from 46% in 2000 to 39% in 2022. Coal consumption has dropped by more than 85% on the same period and accounts for less than 1% of the total final energy consumption in 2022. Natural gas also has had a downward trajectory since 2000, reaching 25 Mtoe in 2022, or a 17% decrease. It should be noted that in 2022, natural gas use was particularly low due to the energy crisis triggered by the Russia-Ukraine conflict, which

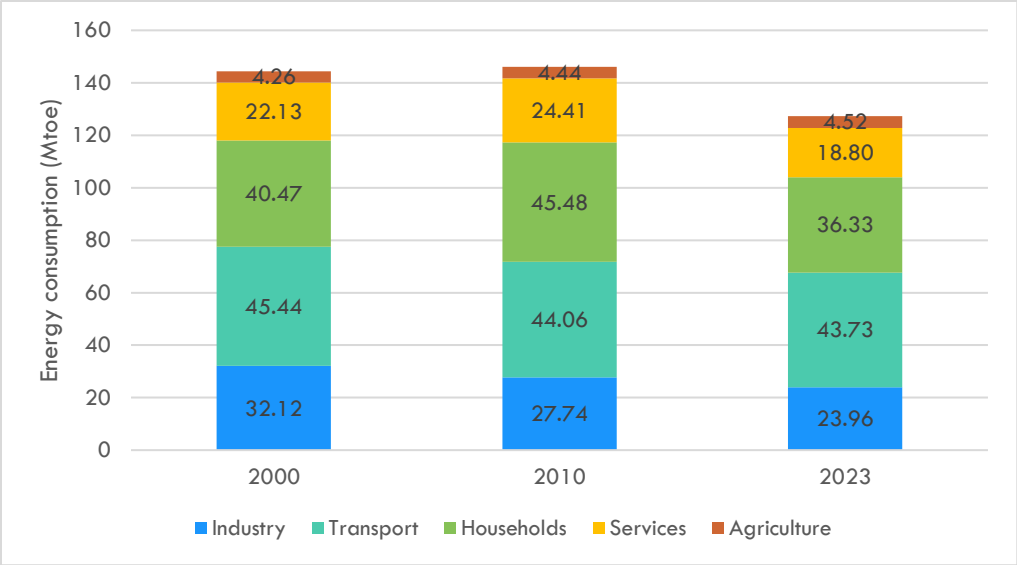
might not reflect the structural trend although the consumption of natural gas had been decreasing in the years before the pandemic.

On the other hand, other types of energy are making up a larger share of the final energy consumption in 2022 than in 2000. Electric consumption is higher at 36 Mtoe in 2022 than in 2000, but the consumption has been decreasing in the 2010s after peaking at 38 Mtoe in 2010. The share of electricity in final energy consumption declined, going from 23% of the total at the beginning of the period to 27% in 2022. On the same period, the consumption of heat grows slightly from 3 Mtoe to 4 Mtoe, while the share in total consumption stays relatively stable around 3%. The use of biofuels grew 10-fold since 2000 to reach 3 Mtoe in 2022. Finally, the use of other renewable fuels such as wood and biomass has also increased during the same period to reach 13 Mtoe in 2022 or 10% of the total final energy consumption.

2.2 Energy demand by sector

Final energy consumption breakdown by fuel end-use sector evolves based not only on their relative shares within the economic activity structure but also on sector-specific improvements in energy efficiency. Figure 6 shows that, although the overall final consumption has increased from 1990 to 2010 and then decreased in 2022, individual sector's consumption does not necessarily follow the same pattern. Namely, the transportation sector has seen its final energy consumption increase in level but also as a share of the overall consumption, amounting to 34% of the total in 2022 against 30% in 1990. The transportation sector represents the largest energy end-use in 2022. Industry final consumption has been decreasing since 2000 to reach 25 Mtoe or 19% of the total consumption. Final energy consumption in the service sector and in the residential sector has been increasing between 1990 and 2010 to decrease in 2022. Both sectors account for 43% of final energy consumption in 2022, compared to 48% in 2010. Overall, the variation of each sector's share in final energy consumption stayed below 3 percentage points, maintaining a similar balance among sectors from 2000 to 2022.

Figure 6 : Final energy consumption by sector (2000-2023)



Source: ODYSSEE, Eurostat

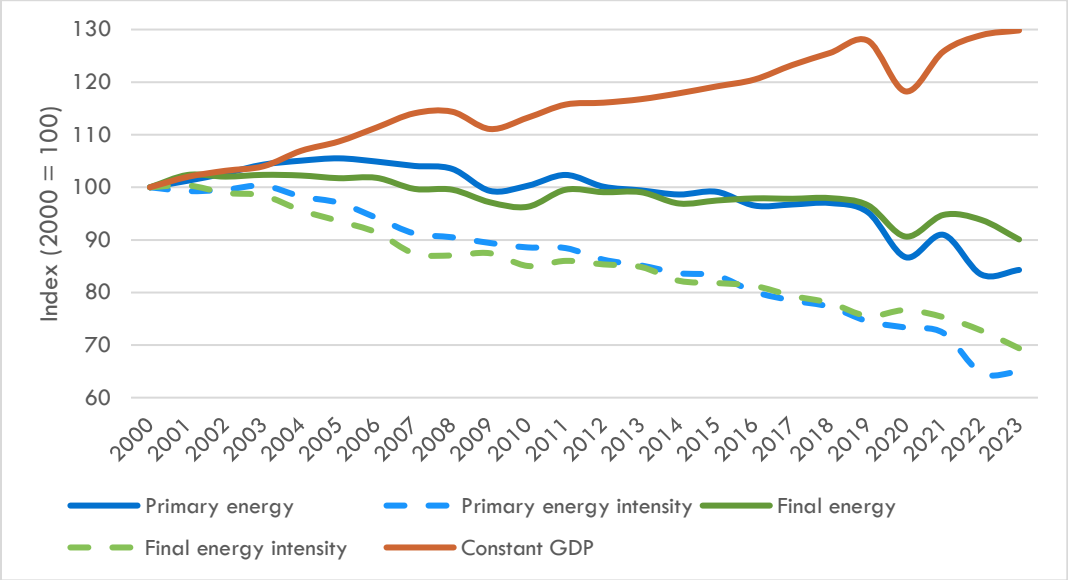
2.3 Energy intensity and structural effect

In the past two decades, GDP grew by 30%, while primary energy (or energy supply) and final energy (or energy demand) both declined, reaching 84% and 90% of their respective 2000 levels in 2023 (see Figure 7). This decoupling between energy consumption and economic growth shows that the French economy is becoming less energy intensive. Energy intensity is an "economic energy efficiency indicator" assessing the quantity of energy required to produce one unit of economic output or activity. A lower energy intensity means that overtime the same level of production of energy services can be reached with a smaller energy input. In other terms, the energy intensity can be considered as a measurement of a country's "energy productivity". Its variations can be explained in part by energy efficiency gains but also by changes in the monetary value attributed to a certain level of production. For instance, economic recession might lower the added value of certain sectors, thus decreasing the energy intensity ratio. Besides, energy intensity also reflects other factors, such as shifts across sector or product structure (e.g., from heavier to lighter, less energy-intensive industries) and behaviour changes (e.g., increased comfort in households), rendering it difficult to isolate the effects of energy savings alone.

As can be seen in Figure 7, both primary and final energy intensities have decreased by more than 30% in the last two decades, which means that less energy is needed to produce a unit of economic output. Although primary energy intensity has been decreasing slower than final energy intensity in the first decade, the trend is reversed since 2016. Indeed, the gap between final and primary energy intensity has been closing in since the mid-2010s, with the ratio going from 54% in 2014 to 61% in in 2023 (Figure

8). This is partly due to the decarbonization of the energy mix: as renewables account for a larger share of the production mix, less energy transformation is needed, resulting in a lower demand for primary energy to deliver the same amount of final energy. Besides, this can also mean that there are fewer energy losses in the system. The drop in primary energy intensity in 2022 is due to the 10% decrease in primary energy consumption between 2021 and 2022, likely impacted by the energy crisis of 2022 generated in part by Russia's war on Ukraine.

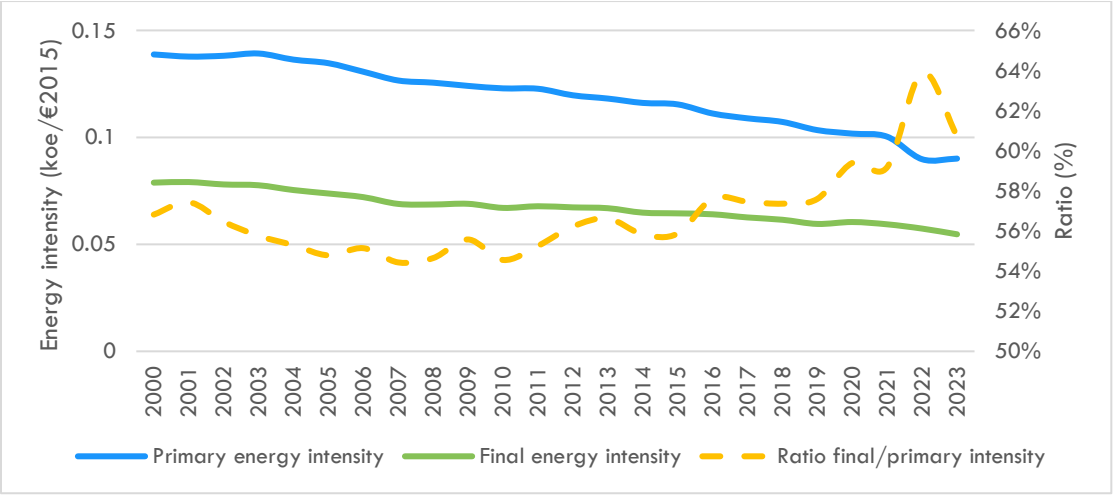
Figure 7 : GDP, energy consumption and energy intensities variations (2000-2023)



Source: ODYSSEE, Eurostat

Note: energy intensity with climatic corrections

Figure 8 : Primary and final energy intensities (2000-2023)

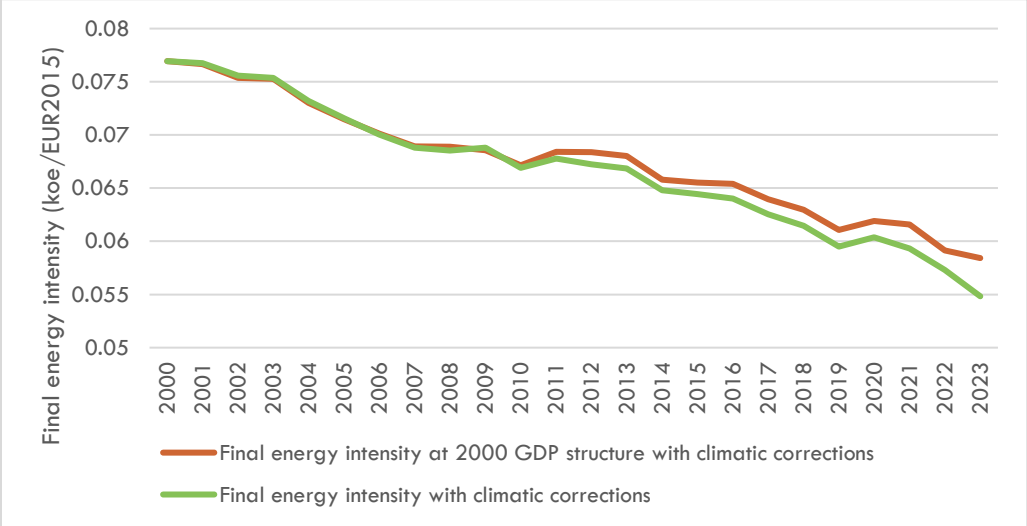


Source: ODYSSEE, Eurostat

Note: energy intensity with climatic corrections

Overall energy intensity also depends on the structure of GDP. Since different sectors contribute differently to the total economic output and have varying levels of energy intensity, changes in the sectoral distribution of GDP can impact the overall energy intensity. For instance, on average, producing 1 euro in the service sector requires 5,5 times less energy than in the industrial sector. Calculating the final energy intensity at real GDP as in Figure 9 allows to clean out these structural effects. Since 2010, the final energy intensity adjusted for structural effects has been higher than the actual intensity, indicating that the economy's shift toward less energy-intensive sectors has played a role in reducing overall final energy intensity. During the first decade, the structural changes in GDP have had no significant impact on energy intensity since the two lines overlap.

Figure 9 : Final energy intensity at real GDP structure (2000-2023)



Source: ODYSSEE, Eurostat

Note: energy intensity with climatic corrections

2.4 Energy efficiency trends

2.4.1 Energy efficiency index (ODEX)

Energy intensities provide a general sense of how well energy resources have been used to create economic output. However, they do not allow to disentangle energy efficiency improvements from other structural and behavioural effects. In addition, energy intensities can only be computed at a highly aggregated level (usually at the sectoral level), being limited by the availability of economic output statistics, which is why Figure 10 introduces another energy efficiency indicator, the ODEX, based on a more technical approach of energy efficiency savings.

***ODEX methodology*[4]**

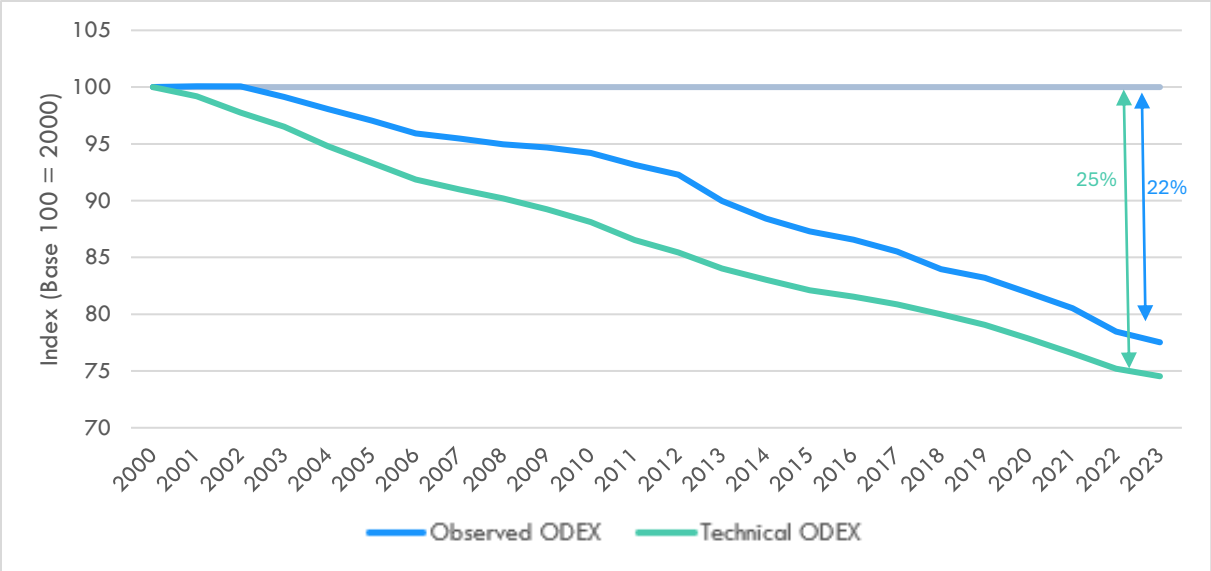
For each sector and for the whole economy, the ODYSSEE-MURE project calculates the ODEX to measure energy efficiency progress. The ODEX is a weighted average of 37 sub-sectoral indices of energy efficiency progress; sub-sector being industrial branches, service sector branches, specific end-uses for the residential sector and modes of transportation. These sub-sectoral indices allow to aggregate indicators of specific consumption for an array of energy end-uses, from toe per ton of steel produced in the industry, to kWh of energy/m2 of office building in the service sector, to kWh per household in the residential sector, and to litre of fuel per km in the transport sector. Each sub-sectoral index is then weighted by its share in total energy consumption of the sector to create an energy efficiency index at an aggregated level.

The ODEX is the sum of incremental savings, which means that energy efficiency gains are measured compared to the previous year. In addition, ODYSSEE also created a technical ODEX, where specific consumption for a given subsector will be kept constant instead of increasing if the case arises. Contrary to the technical ODEX, the observed ODEX indicator can increase, which means that there are negative energy efficiency improvements. This phenomenon is often observed during economic recession where the energy consumption does not decrease as fast as the economic activity when equipment is not used at their full working capacity, especially in the industry and in the freight sector. Here, the less efficient use of the equipment does not mean that the technical energy efficiency is decreasing and thus should not impact negatively the ODEX indicator.

Overall, both the observed and technical ODEX have been decreasing by more than 20% since 2000, with a slight reversal of trend after the subprime crisis for the observed ODEX. Overall, technical energy efficiency improved by 25% since 2000, or a 1,3% average annual rate of improvement. The difference between the technical and observed ODEX can be understood as a rebound effect of 3% in 2023. Indeed, the observed ODEX includes behavioural, productivity, and capacity effects, which can all lead to a reduction of the energy savings. Figure 11 shows that the picture is more nuanced when looking at sectoral indicators, with the residential sector presenting the largest energy efficiency gains at 64% of its 2000 level. Technical energy efficiency improved by approximately 20% in the industrial, service and transport sectors since 2000.

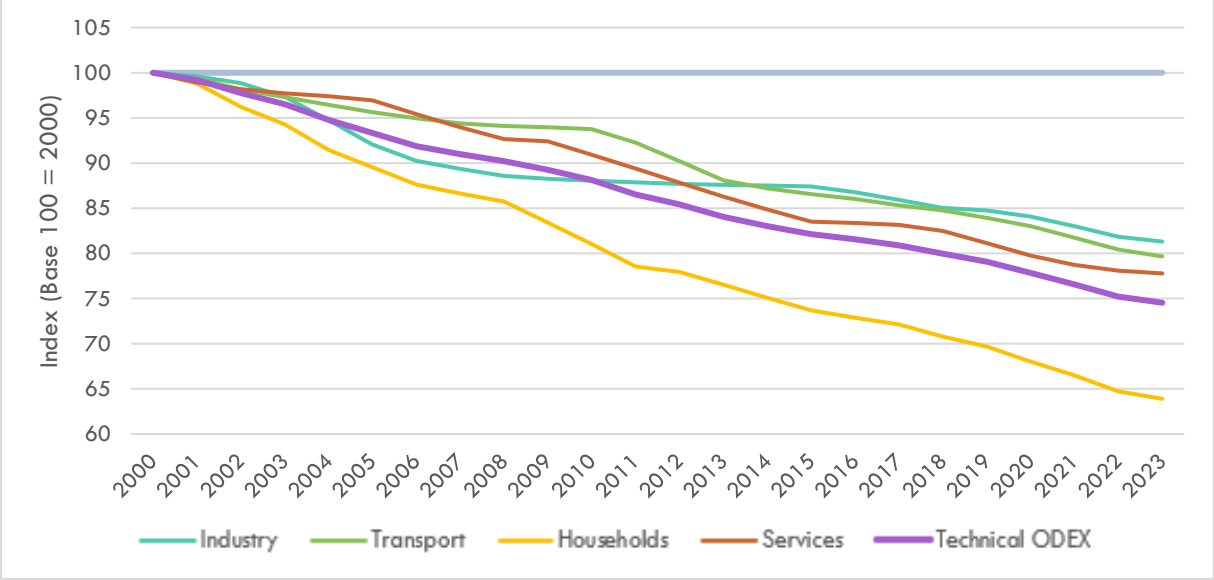
[4] https://www.odyssee-mure.eu/publications/other/odex-indicators-database-definition.html

Figure 10 : Observed and technical energy efficiency indexes (ODEX) (2000-2023)



Source: ODYSSEE

Figure 11: Observed and Technical ODEX by sectors (2000-2023)

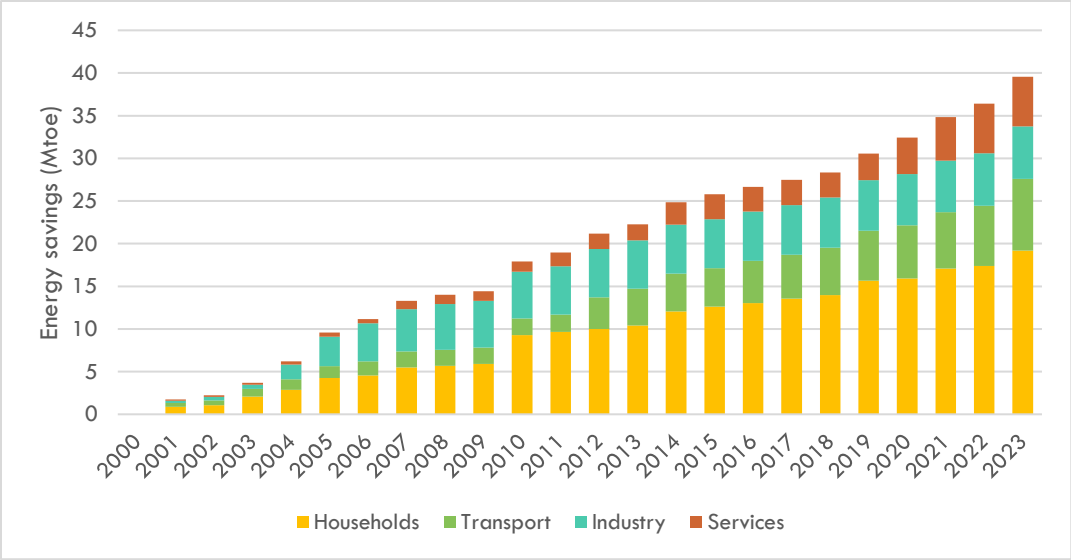


Source: ODYSSEE

2.4.2 Energy savings

Final energy savings are derived from the ODEX presented above. The savings shown in Figure 12 represent the annual savings cumulated since 2000. Without these energy savings, the 2023 final energy consumption would have been nearly 40 Mtoe higher. The bar chart shows that savings in the households' sector makes up the largest share of overall savings since 2010, with an average of 50% of total savings since 2010. The share of savings from the industrial sector has been decreasing in overall energy savings since the 2008 crisis, while savings from the services sector making up a growing share of the total in recent years. Finally, there is a jump in savings from the transport sector between 2011 and 2012, after which the sector makes up 20% of total savings on average.

Figure 12 : Final energy savings by sector (2000-2023)



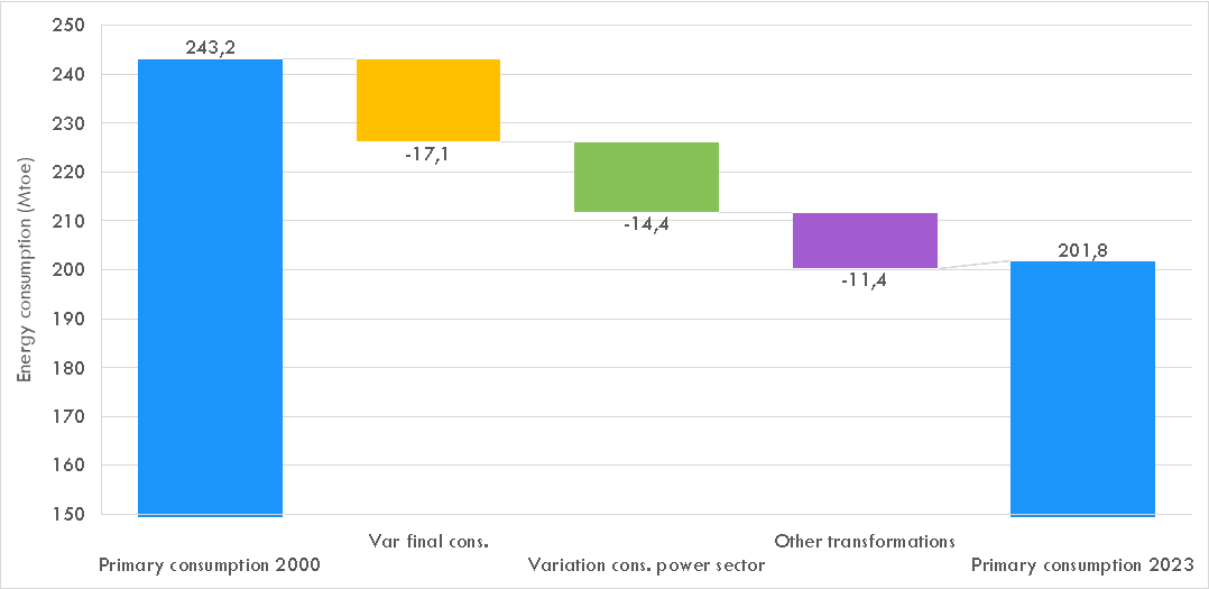
Source: ODYSSEE

2.4.3 Drivers of energy consumption

Looking at the different drivers of change in energy consumption along a given period allows to understand the contribution of energy efficiency gains compared to other explanatory factors. During the 2000-2023 period, primary energy consumption has decreased by 42 Mtoe (Figure 13). The decrease in primary energy consumption during can mainly be explained by the variation of the final energy consumption (-17,1 Mtoe), which means that the decrease in energy demand is driving the change in primary energy consumption. The net consumption of the power sector has also been decreasing by 14,4 Mtoe, which means that there has been a decrease in the amount of energy used for electric transformations. The rest of the variation between 2000 and 2023 can explained by the decreasing amount of energy used in other transformations happening outside of the power sector (e.g. energy used to extract fossil fuels).

As the main driver of the decrease in primary energy consumption, the variation in energy consumption of the power sector can be mainly explained by the changes in the power mix between 2000 and 2023, leading to a 12,6 Mtoe decrease in consumption (Figure 14). Indeed, the electric power mix in 2023 includes 29,9% of renewables, that have a 100% efficiency, compared to 13,5% in 2000. Net power imports also contribute to decrease the final consumption by 5,9 Mtoe. It should be noted that although power imports are lower in 2023 than in 2022, which was an exceptional year due to low power production by French nuclear plants, a significant share of them being in maintenance, there are still higher than in 2000. This factor alone has been able to balance the effect of the increase in power consumption (+6,5 Mtoe). The change in the thermal power mix (+1,8 Mtoe) led to an increase in consumption but overall, the gain of efficiency in thermal power plants (-4,3 Mtoe) cancels out this effect.

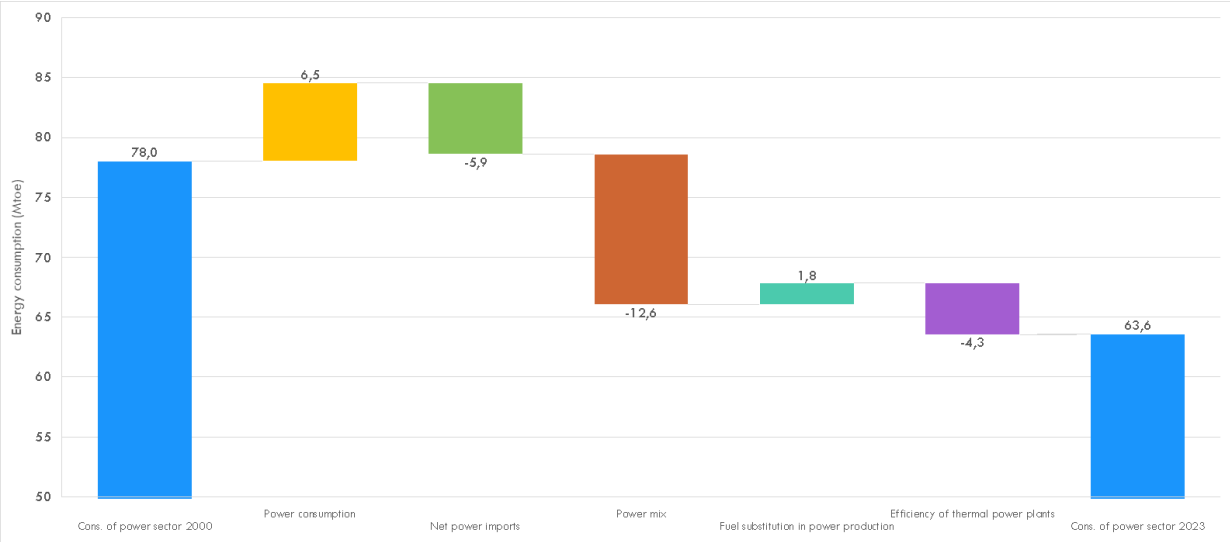
Figure 13 : Drivers of changes in primary energy consumption (2000-2023)



Source : ODYSSEE

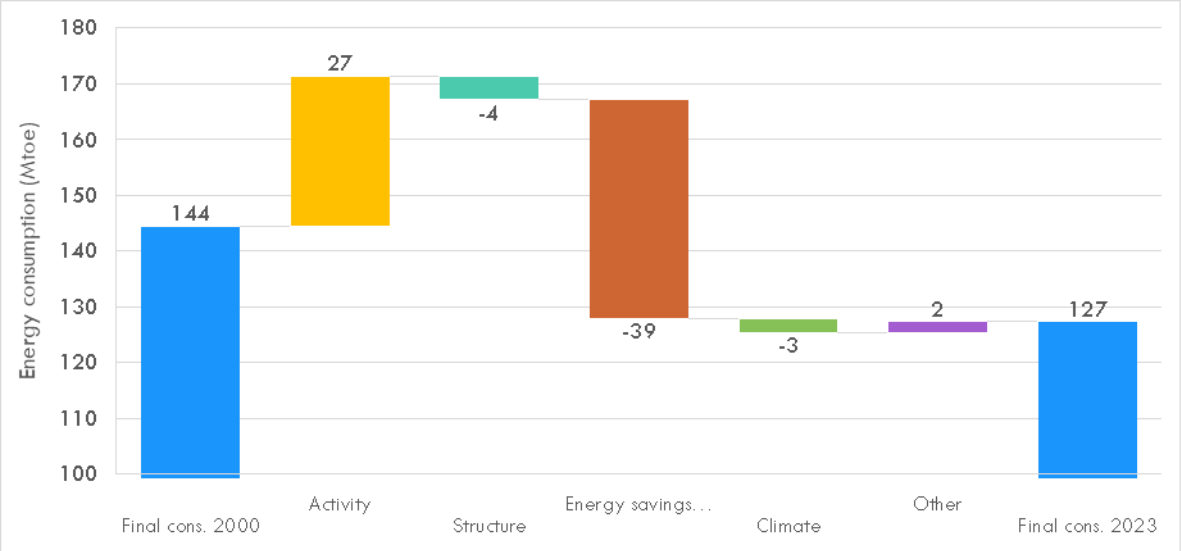
Finally, Figure 15 shows the drivers of change in the final energy consumption. Although the level of economic activity has significantly increased between 2000 and 2023, the higher final energy consumption it generates (+27 Mtoe) is compensated by other factors. Namely, the structural effect -(3 Mtoe) highlighted in Figure 9 leads to lower energy demand, due to the relatively lower weight of energy-intensive sectors. The relative climate for a certain year can also impact the final consumption, with 2023 being a relatively milder year compared to 2000, less energy is needed for space heating for instance (-3 Mtoe). The largest driver remains technical energy savings (-39 Mtoe) derived from the technical energy efficiency (ODEX) calculated by the ODYSSEE team. The “other” effect includes behavioural changes, inefficient use of equipment, and change in labour productivity.

Figure 14 : Drivers of variation in energy consumption of the power sector (2000-2023)



Source : ODYSSEE

Figure 15 : Drivers of variation in finale energy consumption (2000-2023)



Source : ODYSSEE

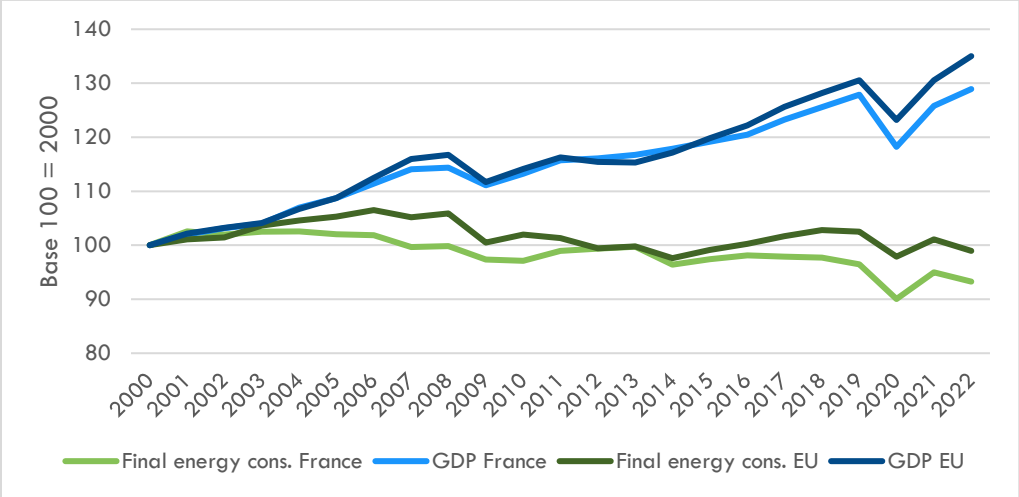
2.5 France's position in Europe

As a Member State of the European Union, France has to comply with all the Directives and mandatory targets defined by the European legislation. Thus, it can be informative to analyse France's characteristics and trends regarding energy consumption and efficiency against those of the European Union and other Member States. Final energy consumption in the EU is at a similar level at the beginning and at the end of the period, with periods of increases between 2000 and 2006 and from 2014 to 2019 (Figure 16). On the other hand, France's consumption has decreased by 7%, with a -0,5% decrease per year since 2006. In terms of GDP, the trends are increasing at a similar pace (around

1,9% per year) until 2015 where GDP starts growing slower in France compared to the European Union. Both France and the EU exhibit a decoupling between GDP growth and the evolution of final energy consumption, leading to a decrease of final energy intensity by 1,9% per year for France and 1,4% per year in the EU.

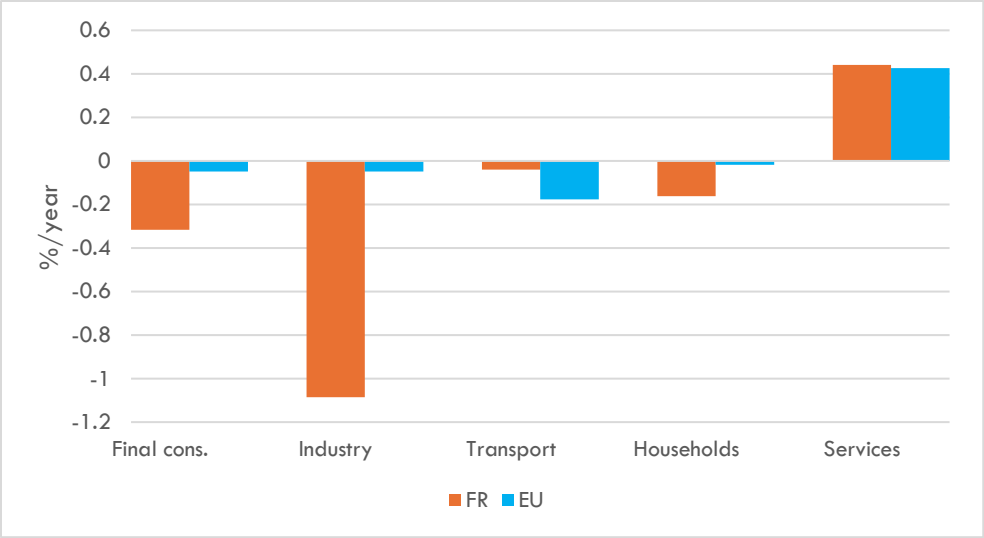
Final energy consumption in France has been declining at a faster rate of 0.3% per year compared to the European Union as a whole, where the decrease is 0.05% per year, as illustrated in Figure 17. The consumption trends for each sector are similar in France and in the EU in the overall direction but differ in terms of pace of change. The services sector is the only sector for which energy demand increased between 2000 and 2022 by more than 0,4% per year for both France and the EU. All the other sectors have seen their energy demand decrease on the same period. Interestingly, final energy consumption has decreased 20 times faster in France than in the EU as a whole. This phenomenon can be explained by the efficiency gains in the sector but also by the faster deindustrialisation of the French economy. Final energy consumption has decreased in the transportation sector but at a lower rate in France than in the EU. The energy demand for households has dropped by 0,1% per year in France, ten times faster than in the EU.

Figure 16 : Final energy consumption and GDP (France and EU)(2000 - 2022)



Source: ODYSSEE, Eurostat
Note: real GDP in €2015

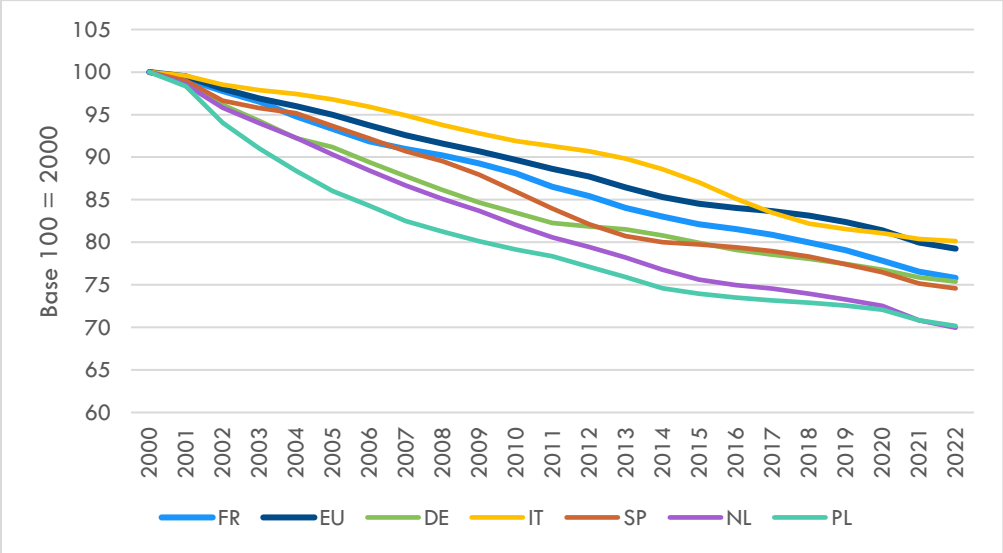
Figure 17 : Final energy consumption trends by sector (FR and the EU) (2000-2022)



Source: ODYSSEE, Eurostat

France's energy efficiency has improved faster than the EU average, which improved by 20% between 2000 and 2022, or 1%/year. Other large European countries such as Germany, Spain, the Netherlands and Poland were able to have larger energy efficiency gains over the same period (Figure 18). It seems that for most countries progress has been slower since 2013 but France presents a smoother trend overall. However, this graph serves only an indicator of the energy efficiency trends, as energy consumption levels vary by country, with Germany being the largest energy consumer in the EU.

Figure 18 : Technical ODEX (2000-2022)

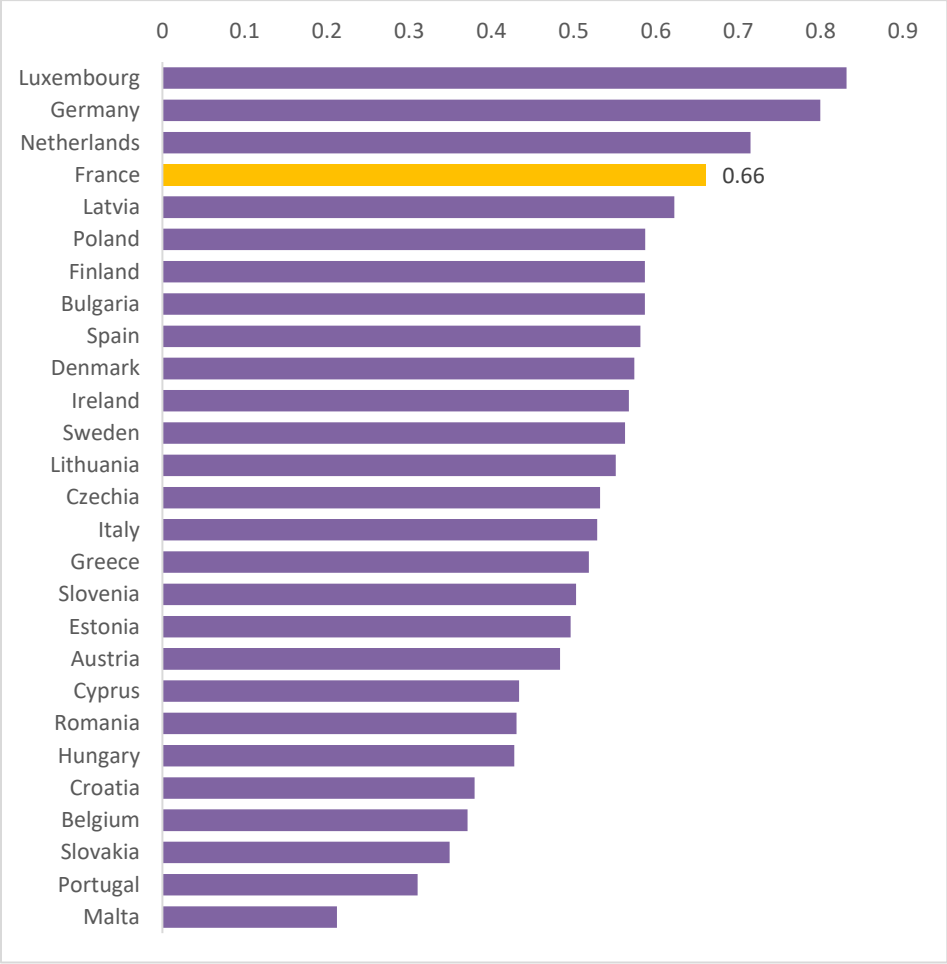


Source: ODYSSEE

The scoreboard produced by the ODYSSEE-MURE project ranking EU countries based on their energy efficiency score is based on a combination of three energy efficiency criteria and uses the principle of the OECD Composite Indicator methodology. In 2022, France appears at the 4th place in terms of energy efficiency score (Figure 19). It ranks below

Luxembourg, Germany and the Netherlands, which were all top of the board for one of the criteria while France has a more balanced profile with a similar score for all criteria (See Figure 67, Figure 68, Figure 69 in Annexe).

Figure 19 : 2022 Overall energy efficiency scoreboard



Source: ODYSSEE-MURE

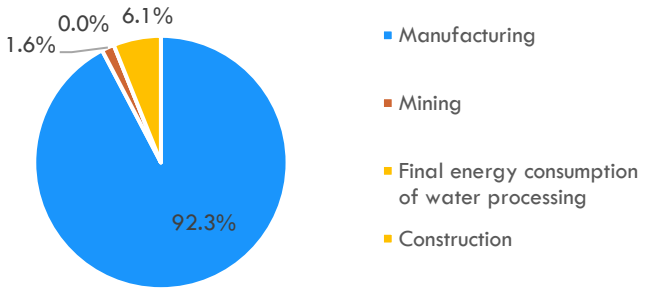
3 Sectoral energy efficiency trends

3.1 Industry

In 2022, the industrial sector (including the manufacturing, mining and construction branches) accounts for 25 Mtoe, or 19% of 2022 total final energy consumption, which is more than 20% lower than 2000 consumption of 32 Mtoe. Thus, energy consumption in the industrial sector has been decreasing faster than the overall final consumption, which is 8% lower in 2022 than in 2000. With the manufacturing sector accounting for 92% of the industry's energy consumption (Figure 20), the following sections concentrate primarily on energy trends within this branch. In addition, non-energy uses

of fuels are not included here although they can be important in some specific branch, such as the chemicals industry.

Figure 20 : Total final energy consumption by branch (2022)



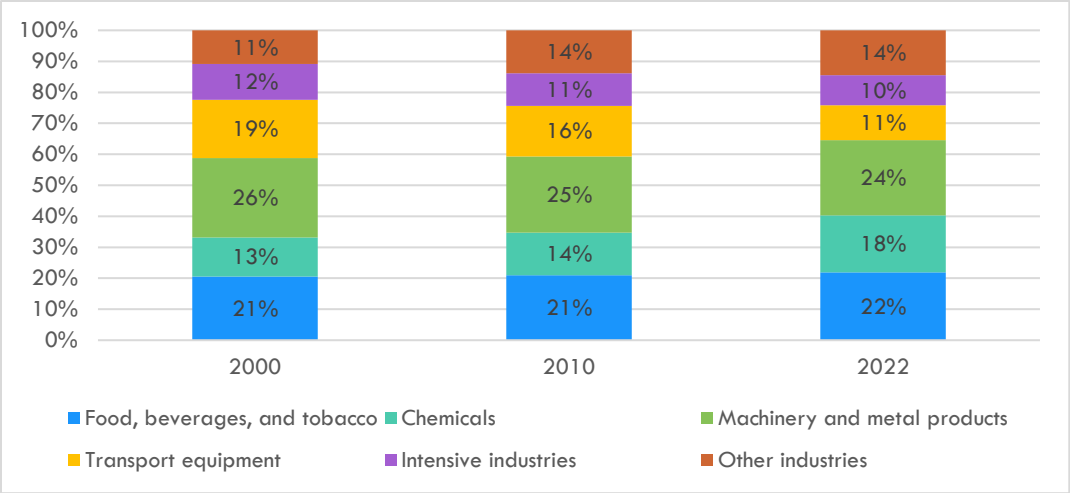
Source: ODYSSEE, Eurostat

3.1.1 Industry output

The industrial sector generated €382 billion of economic output[5] in 2022, up from €351 billion in 2000. The share of GDP generated by the industrial sector has been decreasing from 21% to 18% between 2000 and 2022. Focusing on the manufacturing sector, Figure 21 shows that the machinery (€50 million in 2022), food (€45 million), chemicals (€38 million) and transport equipment (€23 million) branches are generating the largest amount of economic outcome. Interestingly, while the share of the transport equipment branch has been decreasing from 19% of the total value added in 2000 to 11% in 2022, the chemicals branch has been following the opposite trend from 13% of the industry economic outcome in 2000 to 18% in 2022, reflecting structural changes in the industrial sector. Most of the other branches consistently amount to less than 5% of the total industry output. Overall, four branches generate a larger output in 2022 than in 2000: the value added of the chemicals sector increased by 63%, the wood branch by 32%, the food branch by 19%, and the machinery branch by 6%. The energy intensive industries, including steel, cement and paper among others, are only accounting for 10% of the value added in 2022.

[5] Values are in constant euros of 2015.

Figure 21 : Share of value added by branch of the manufacturing sector (2000-2022)



Source: Eurostat

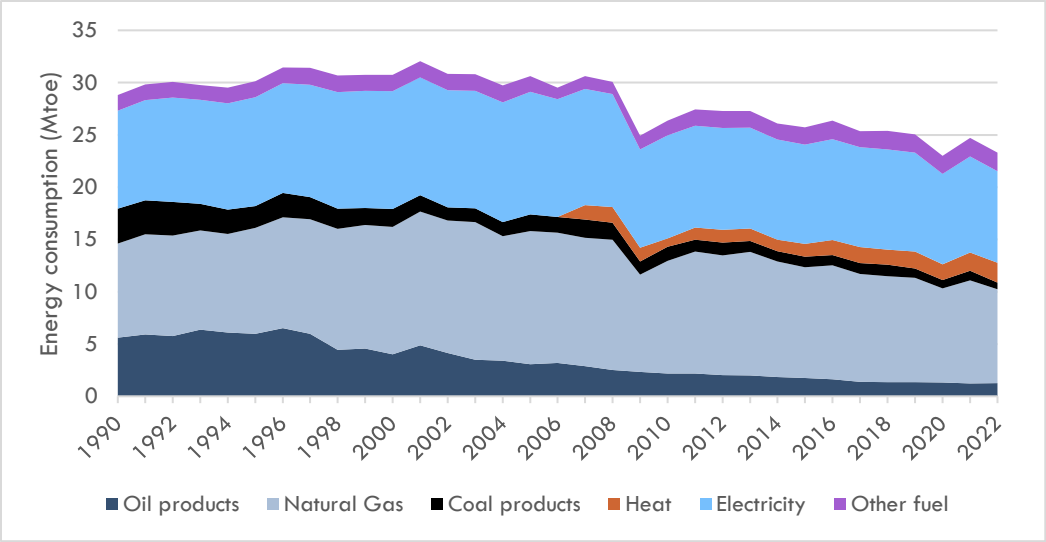
3.1.2 Energy consumption

Focusing on the manufacturing sector, Figure 22 shows the variation of final energy consumption by fuel type overtime. Between 2000 and 2022, the manufacturing sector's consumption has dropped by 24% or 7,4 Mtoe. There was an important break in the trend just after the subprime crisis due to the contraction of the economy and of the industrial sector in particular that led to 17% reduction in final energy consumption between 2008 and 2009.

The breakdown in fuel types shows that the fossil fuels share is decreasing in the final energy consumption of the manufacturing sector. In 2022, the manufacturing branch has been using 40% less fossil fuels than in 2000, with both coal and oil use decreasing by more than 60% on the same period. Electricity use has also been decreasing by 22% to reach 9 Mtoe in 2022. Heat as an energy source has been slowly building up in the final energy consumption since the mid-2000 and makes up 2 Mtoe in 2022 or 8% of the total energy consumption.

These changes in energy sources can be linked to an industry-wide shift towards cleaner fuels but can also be due to the evolution of the industry structure, with some branches seeing their relative share diminishing in the sectoral outcome and in the final energy consumption. For instance, the primary metals branch has seen its outcome drop by 16% between 2000 and 2022, while its energy use dropped by 42% on the same period. Meanwhile, their combined share in the manufacturing sector's value added amounted to 10% of the value added. It is also interesting to note that although machinery and transport equipment account for more than 35% of the manufacturing sector's value added in 2022, it only amounts to 10% of its final energy consumption.

Figure 22 : Final energy consumption by fuel type in the manufacturing sector (2000-2022)

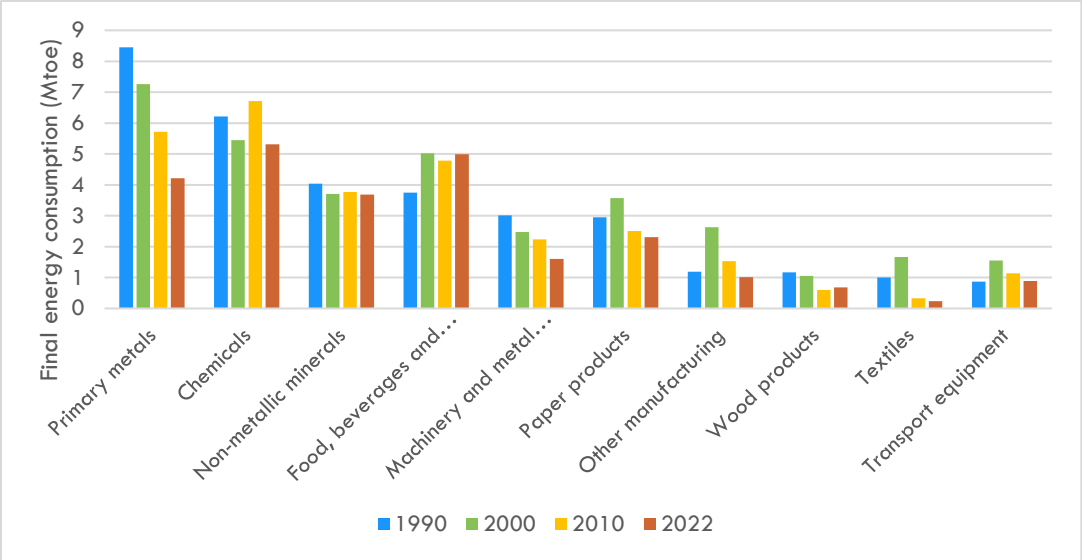


Source: ODYSSEE, Eurostat

As shown by Meanwhile, their combined share in the manufacturing sector's value added amounted to 10% of the value added. It is also interesting to note that although machinery and transport equipment account for more than 35% of the manufacturing sector's value added in 2022, it only amounts to 10% of its final energy consumption.

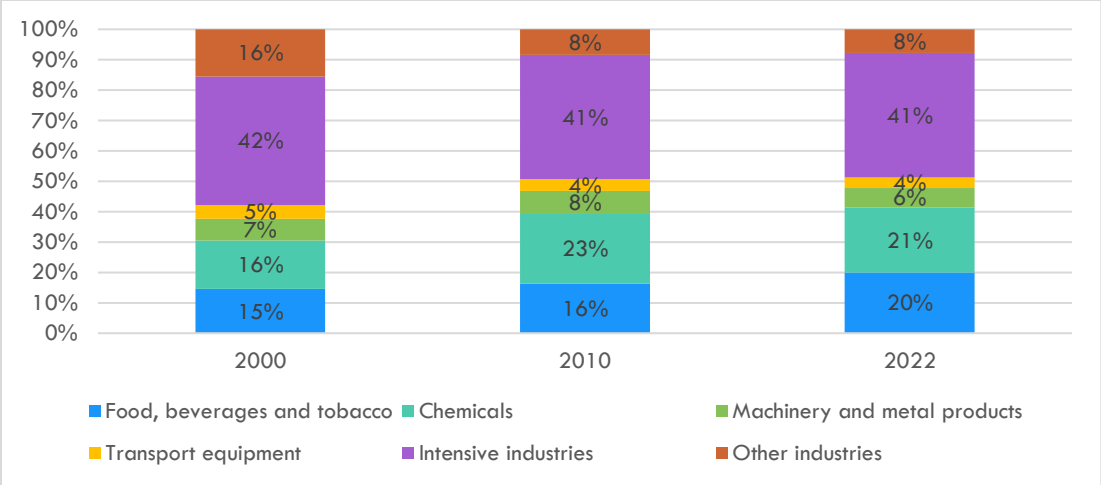
Figure 23, no branch has seen its energy consumption increase overtime during the 1990-2022 period. Interestingly, the structure of the manufacturing sector has stayed fairly similar over these two decades. Indeed, the energy intensive industries in 2000, namely the primary metals (7,3 Mtoe in 2000), chemicals (5,4 Mtoe), non-metallic minerals (3,7 Mtoe) and paper (3,6 Mtoe) branches totalling to 58% of final energy consumption (Figure 24), are still accounting for most of the energy consumption in 2022, adding up to 62% of the total consumption, or 16 Mtoe. Meanwhile, their combined share in the manufacturing sector's value added amounted to 10% of the value added. It is also interesting to note that although machinery and transport equipment account for more than 35% of the manufacturing sector's value added in 2022, it only amounts to 10% of its final energy consumption.

Figure 23 : Final energy consumption by branch of the manufacturing sector (1990-2022)



Source: ODYSSEE

Figure 24 : Total final energy consumption of the manufacturing sector by branch (2000-2022)



Source: ODYSSEE, Eurostat

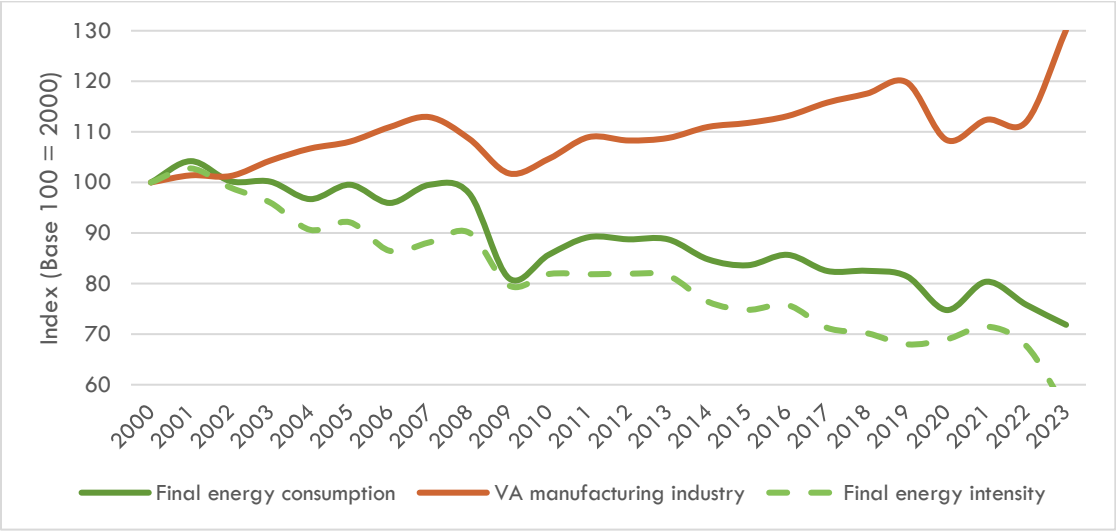
3.1.3 Energy intensity

Despite the manufacturing industry's output increasing by 10% in two decades, the energy consumption of the sector has been decreasing twice as fast, leading to a decrease in final energy intensity of 32% compared to 2000 as shown in Figure 25. Energy intensity for industry is the ratio between the final energy used and the value added of the sector, which can be understood as an economic measure of energy efficiency. The final energy intensity of the manufacturing sector depends on its structure evolution overtime, and especially on the weight of Energy-Intensive Industries (EIIs), as can be seen in Figure 24.

The impact of both the 2008 crisis and Covid 19 pandemic can be clearly identified in both output and energy consumption trends. Interestingly, the Covid 19 pandemic did

not led to a drop in final energy intensity since energy consumption did not drop as abruptly as the industry economic output. The rebound after the Covid19 recession in 2021 actually led to an increase in final energy intensity in the manufacturing sector before dropping below 2020 level in 2022.

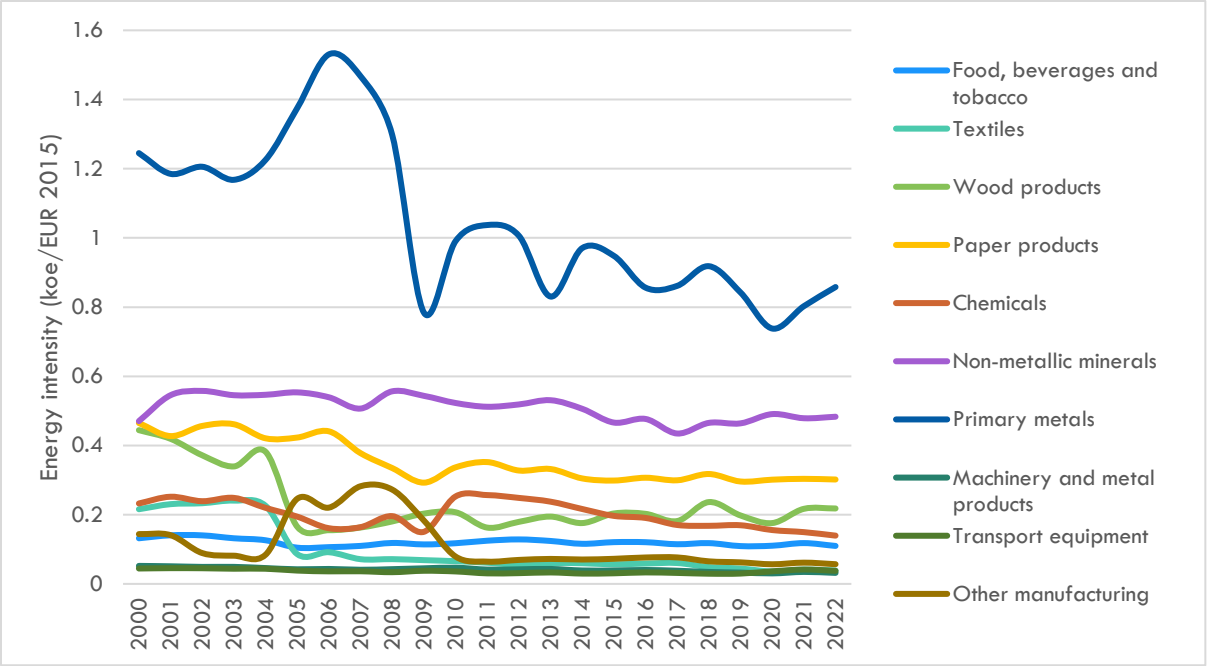
Figure 25 : Value added, final energy consumption and final energy intensity of the manufacturing industry (2000-2023)



Source: ODYSSEE, Eurostat

The picture differs by branch as can be seen in Figure 26. It is obvious that the primary metals energy intensity is significantly higher than the rest of the branches, with 0,9 toe of energy needed to produce a euro of economic output in 2022, or ten times more than the energy intensity of the manufacturing industry as a whole. The primary metals branch, that notably includes steel production, also accounts for more than 15% of the manufacturing energy consumption, thus these variations explain the changes in overall final energy intensity. Here, it is clear that in the wake of the 2007-08 financial crisis, there was a massive drop of primary metals' energy intensity after a period of high intensity between 2004 and 2008. Interestingly, energy consumption dropped starting in 2008 with the production index of the branch, while the value added actually increased significantly in 2009 compared to 2008 (see Annexe). The non-metallic minerals branch, including cement production, has the second highest energy intensity over the 2000-2022 period, with a stable trend averaging at 0,5toe/€. The paper sector has seen its intensity drop by nearly 35% between 2000 and 2022, while still being the third most intensive sector at the end of the period.

Figure 26 : Final energy intensity by branch (2000-2022)



Source: ODYSSEE, Eurostat

3.1.4 Energy efficiency trends

3.1.4.1 Policies to support energy efficiency

Energy efficiency in the industrial sector has been supported by public policies since the first oil shock in the 1970s. Currently, 11 policies are implemented in this sector. The four following ones are deemed to have the largest impact.

The **EU Emissions Trading System (ETS)** established in 2005 is a European carbon credit scheme designed to reduce CO2 emission of polluting entities including power plants and energy-intensive industrial firms. The ETS sets a cap on emissions and obligated operators buy or receive emissions allowances for free, that they can trade on the marketplace if needed, until the end of the year where they have to surrender enough allowances to cover their actual emissions. The price of these allowances incentivises emissions reductions and promotes innovation in energy efficiency and low-carbon solutions. In France, more than a thousand entities are subjected to the ETS emitting 84MTCO2 in 2022. Industrial sites participating in the system account for 80% of France's industrial emissions. The fourth phase of the ETS going from 2020 to 2030, targets a 62% decrease in CO2 emissions by 2030.

The **Heat Fund** established in 2009 supports projects for the production of heat from renewable energies or recovered waste heat. During the period 2009-2022, the fund has financed more than 7,145 installations and granted more than 3.7 billion euros of public aid generating 42.6 TWh/year of additional energy production from renewable energy and recovery. The annual budget allocated to the fund has been growing since its first instalment to reach €520 million in 2022. Funding is allocated through call for projects

managed by ADEME and can cover up to 30% of investment cost for waste heat recovery projects.

In the wake of the Covid19 pandemic and energy crisis linked to the Russia-Ukraine conflict, investment plans were launched by the government to support economic activity and sustain investments, including in decarbonizing industries. The €100 billion **2020 Recovery plan** includes a €1.2-billion package dedicated to the decarbonisation of industry, with call for projects specifically targeted at energy efficiency investments. Continuing the dynamic engaged with the Recovery plan , the **France 2030 plan** deploys 54 billion euros of investment over 5 years to enhance industrial competitiveness and develop new technologies. To encourage industrials to commit to decarbonise their activity and reduce their energy use, the Ministry of the Industry signed 32 Ecological Transition contracts covering the 50 most emitting industrial sites in France, where industrials precise their 2030 and 2050 decarbonisation targets.

The **Energy Saving Certificates** scheme implemented since 2005 can benefit industries improving their energy efficiency. In 2022, 17% of all ESC were delivered for industrial entities likely for installing heat recovery systems which was part of the actions accounting for the most energy savings.

3.1.4.2 Measuring energy efficiency with product unit consumption

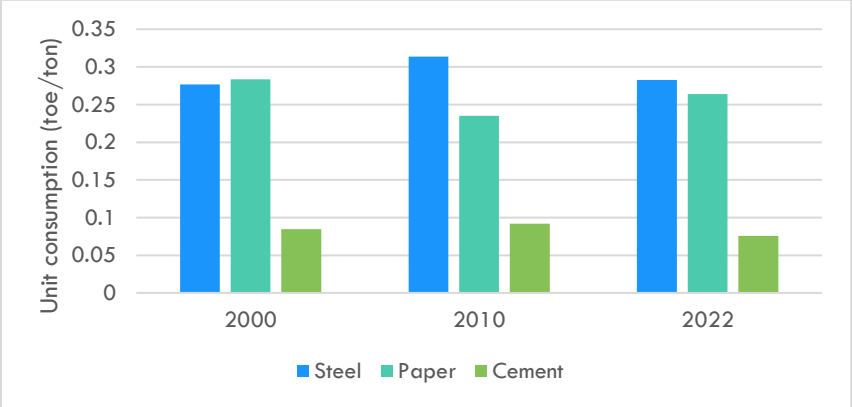
For a better understanding of energy efficiency progress in the manufacturing industry, this section relies on a technical approach where the energy consumption is compared to a physical production index for each branch, instead of its added value. For energy-intensive products such as cement, steel, and paper, the unit energy consumption per ton is used to measure technical efficiency. Each sectoral energy efficiency index (ODEX) is then aggregated at the manufacturing industry level, taking into account its weight in the final energy consumption of the sector. Thus, the branches with the largest energy consumption are the most significant drivers of the manufacturing industry ODEX variations.

Steel, cement, and paper are part of the most energy-intensive products in the industrial sector and their respective branches weighs 45% of the final energy consumption of the manufacturing sector in 2022. There are two main ways to produce steel: by melting scrap steel in electric arc furnaces or making it from scratch by melting iron ore in a blast furnace, which is the most energy- and emissions- intensive way and the most frequent production process in France contrary to other European countries. Steel's unit consumption is, after a peak in 2010, higher in 2022 than in 2000 with a ratio of 0,28toe/ton (Figure 27).

Cement energy consumption is concentrated in the clinker making process, which requires high heat in the kilns and in turns require a large quantity of energy. However,

cement's unit consumption has decreased by 10% between 2000 and 2022. Similarly, paper's unit consumption is 7% lower in 2022 than in 2000.

Figure 27 : Unit consumption of energy intensive products (2000-2022)



Source: ODYSSEE

3.1.4.3 Technical energy efficiency in the manufacturing sector (ODEX)

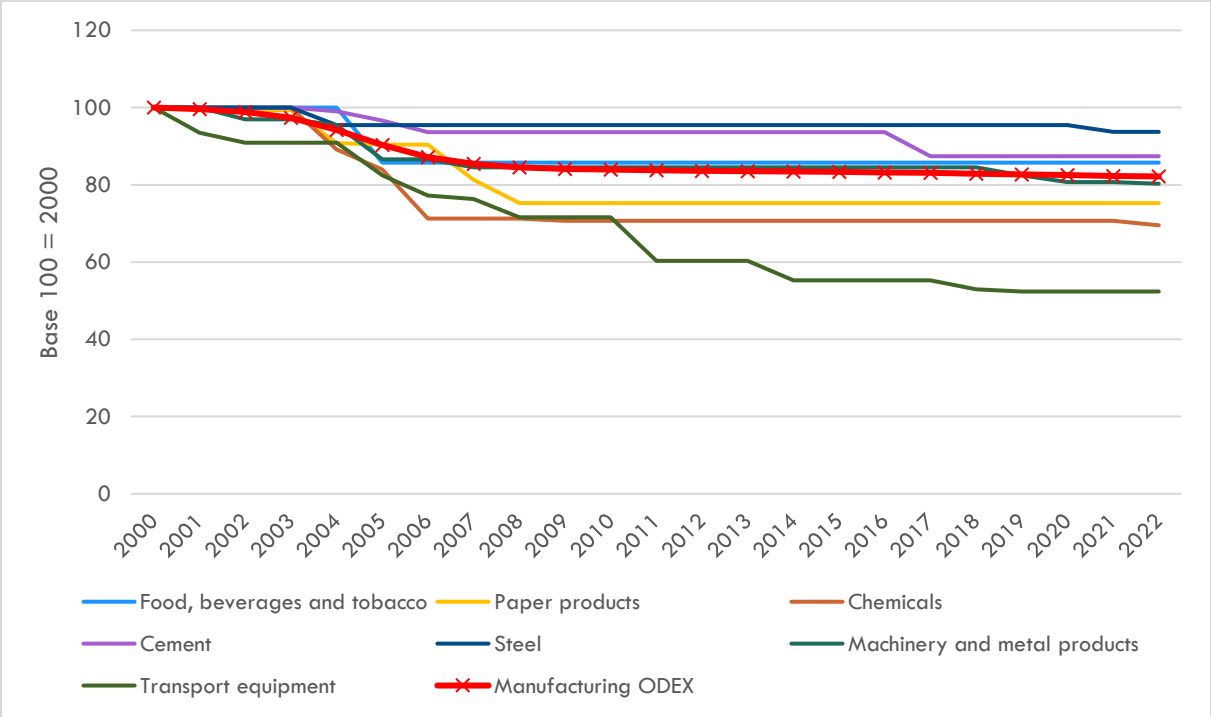
The manufacturing industry ODEX (technical energy efficiency index) has decreased by 18% since 2000, which means the sector is 18% more energy efficient in 2022 than in 2000 (

Figure 28).

The disaggregated index by subsector shows disparities in rate and scale of energy efficiency gains. Overall, most branches do not show significant energy efficiency progress after 2008. Interestingly, the non-metallic minerals branch shows no improvement in terms of energy efficiency between 2000 and 2022. This trend impacts heavily the sectoral ODEX since non-metallic minerals account for on average 14% of the manufacturing sector's final energy consumption. Similarly, the gains in the steel industry, weighing for 15% of the 2022 final energy consumption, are limited to 6% on the same period. There seems to be no significant energy efficiency gains in the food industry, another large share of the manufacturing final energy intensity, since 2005. The chemicals branch, which weighs 19% of the final energy consumption on average, has its ODEX 30% lower in 2022 than in 2000 but most of the gains have been accrued before 2007.

The transport vehicles branch seems to be the only subsector where there have been more spread-out energy efficiency gains. Indeed, the index is still decreasing during the 2010 decade. The "other" branch has the most significant gains however, since it is a composite branch including all of the remaining sectors, it is difficult to have a better understanding of the trend.

Figure 28 : Technical ODEX in the manufacturing industry by branch (2000-2022)

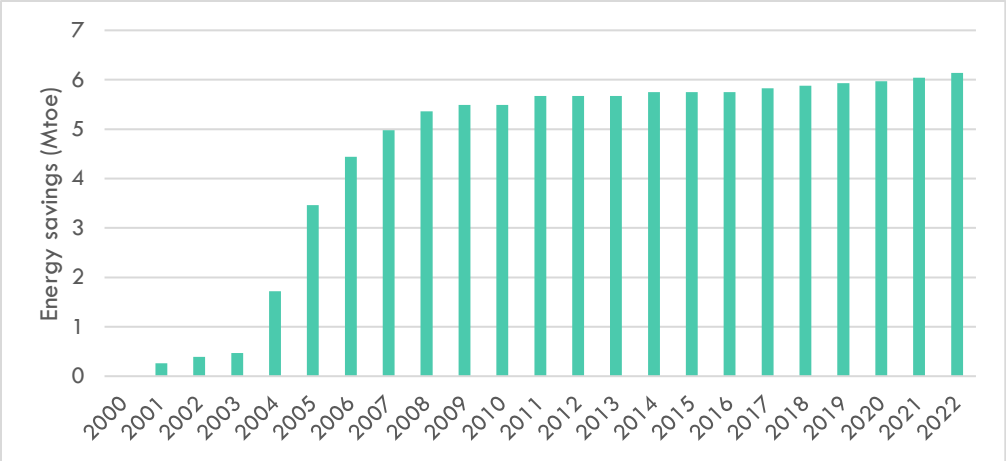


Source: ODYSSEE

The technical ODEX shows that the manufacturing industry as a whole is 18% more energy efficient in 2022 than it was in 2010 (Figure 28**Erreur ! Source du renvoi introuvable.**). The branch-level indices show disparities in rate and scale of energy efficiency gains. The chemicals branch seems to have achieved the largest gains in terms of energy efficiency, reaching 60% of its 2010 level in 2022, while also being one of the largest energy consumers of the manufacturing industry at 21% of the final energy consumption. The machinery and transport equipment branches both achieved close to 30% of energy efficiency gains. Other energy intensive branches such as the steel and cement industry both achieved close to a 20% gain in energy efficiency. The food branch has seen no significant improvement between 2010 and 2020, while its share in the sector's final energy consumption increased during the same period.

Directly derived from the technical ODEX, technical energy savings can be calculated for the 2000-2022 period. Figure 29 shows the additional annual technical energy savings in the industrial sector from 2000 to 2022. Without energy efficiency progress, the final energy consumption of the manufacturing sector would have been 6,1 Mtoe higher in 2022. As shown with the ODEX graph, most of the savings appear to have happened in the mid-2000s, with a 10-fold increase between 2003 and 2007. After 2010, additional annual savings are below 1% on average. The slow pace of energy efficiency progress in the industrial sector for the last decade calls for investigation on the cause of such a trend. With limited policies deemed to have a large impact on energy efficiency in the industrial sector, it also seems to be calling for additional or reformed public policies targeting these aspects.

Figure 29 : Cumulated yearly energy savings from the industrial sector since 2000



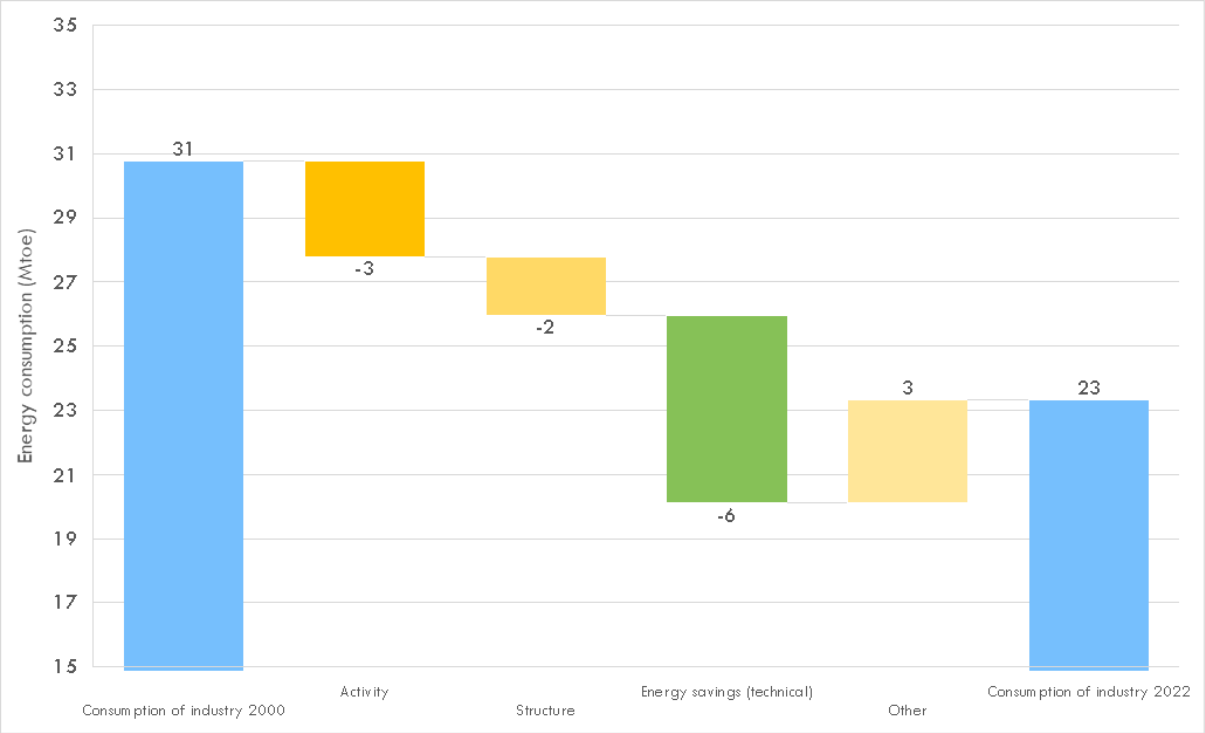
Source: ODYSSEE

3.1.4.4 Drivers of consumption variation in the manufacturing sector

Taking into account the technical energy savings estimated based on the ODEX, it is possible to explain the variation in final energy consumption in the manufacturing sector between 2000 and 2022 as the combination of several drivers (Figure 30). The energy consumption is -9 Mtoe lower in 2022 than in 2000 for the manufacturing sector. Most of this can be attributed to energy savings delivered in the different branches of the sector (-6 Mtoe). However, the drop in the economic activity level, measured by the change in value added of the manufacturing sector between the two dates, accounts for a -3 Mtoe decrease. Structural effects also play a role in the lower energy consumption (-2 Mtoe) with some energy-intensive branches receding in the French industrial sector (e.g. the steel industry).

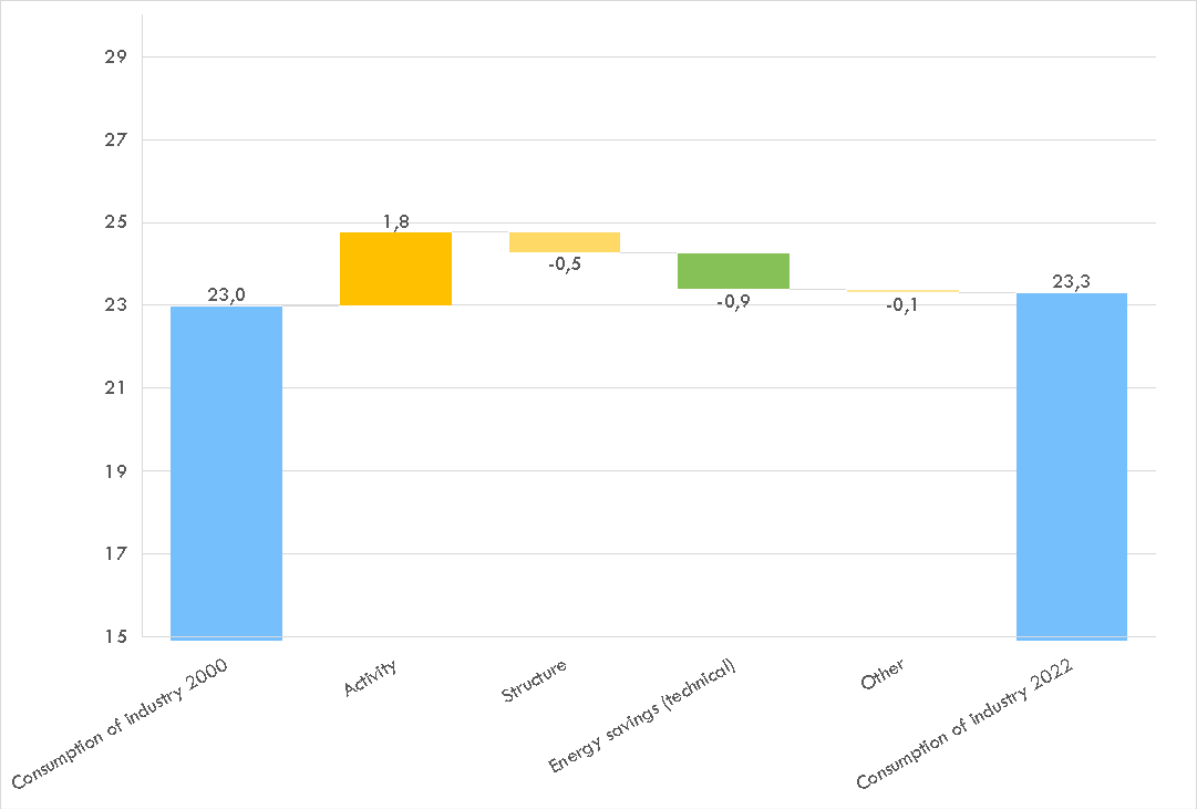
Since this analysis is focusing on explaining the difference between two dates, the relative contribution of the four explanatory factors heavily depends on the period chosen. Indeed, focusing on the period 2020 to 2022 (Figure 31), corresponding to the Covid19 pandemic and subsequent recovery period, the increase in activity level (+1,8 Mtoe) seems to be the main driver of change. However, the economic recovery effect is partially compensated by the structural effect (0,5 Mtoe) and by energy savings (0,9 Mtoe) in the manufacturing sector. This leads to the final energy consumption being slightly higher in 2022 than in 2020.

Figure 30 : Drivers of energy consumption variation in the manufacturing sector (2000-2022)



Source: ODYSSEE

Figure 31: Drivers of energy consumption variation in the manufacturing sector (2020-2022)



Source: ODYSSEE

3.2 Transport

Transport is the sector accounting for the largest share of final energy consumption, with 34% of the total consumption or 45 Mtoe in 2022. The sector includes both passenger transport and goods transport and takes into account all modes of transportation (road, rail, water, air[6]).

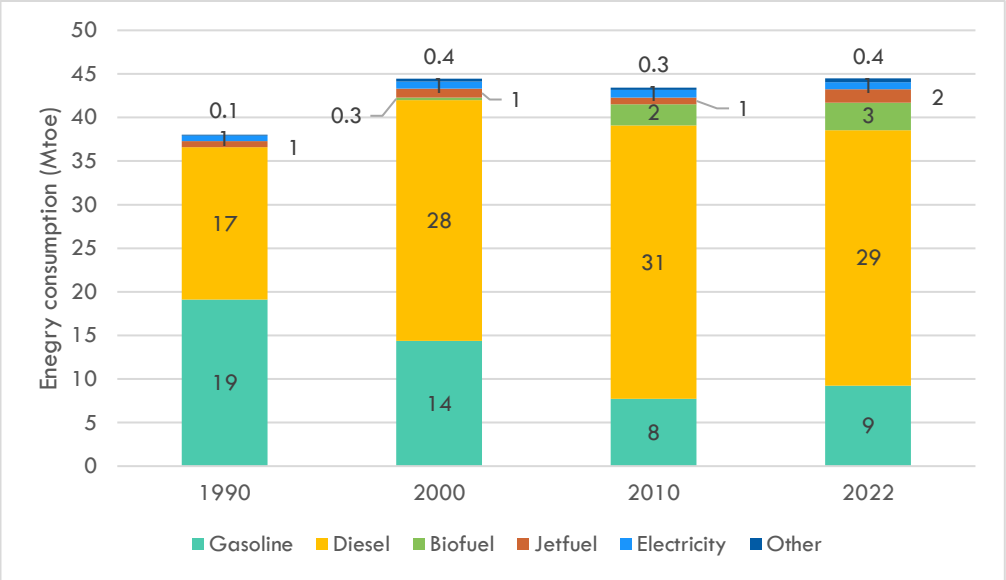
3.2.1 Energy consumption

The final energy consumption of the sector stays steady overtime, with a 1% decrease between 2000 and 2022 (Figure 32). During the 1990s, the consumption had been steadily increasing 3,7% per year on average to reach 44,8 Mtoe in 2000. It should be noted that this trend is largely driven by road transport as it accounts for 93% of final energy consumption in 2022, slightly below its average of 94% on the 2000-2022 period (Figure 33). Hence, the following paragraphs will put special emphasis on road transportation. The share of domestic air transport has increased by 52% to account for 4% of total final energy consumption in 2022. Water transport has been hovering over 1% of the transport sector's energy consumption since 2000, while rail transportation consumption has been decreasing by 30% on the same period.

Diesel has been the main fuel in the transport sector since 2000, its share in the total increasing from 62% in 2000 to 72% in 2022, influenced by the favourable taxation in place. The use of diesel has been decreasing in the total since 2013 to reach 66% in 2022. The amount of gasoline in the energy consumption has been decreasing from 50% of the total energy used in 1990 to 21% in 2022. Interestingly, the share of gasoline has been augmenting both in gross consumption and relative to other fuels since 2013. The amount of jet fuel (only used for domestic air transport) has been increasing for the entire period to reach 1,5 Mtoe in 2022 or 3% of the total. The amount of biofuel in transportation has increased tenfold since 2000, likely driven by regulations mandating the blending of biofuel with diesel and gasoline in the sector. In contrast, electricity consumption has remained steady at around 2% of the sector's total final energy use for the past two decades, despite the rapid growth of the electric car market in recent years.

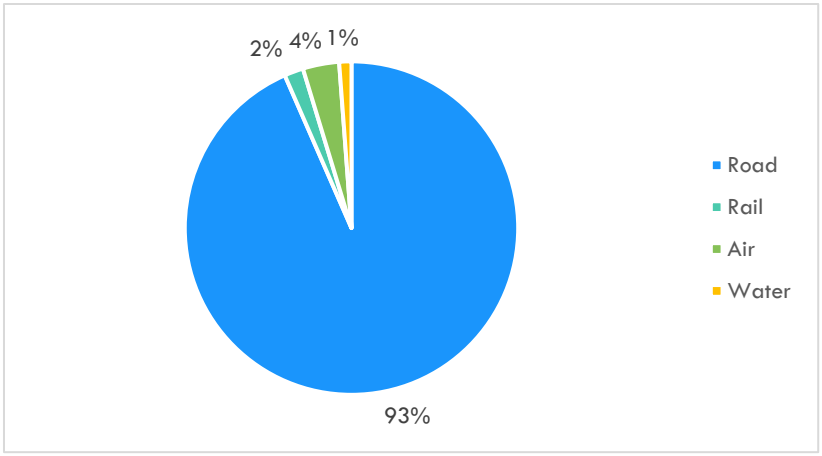
[6] International air transport is not included in the analysis unless otherwise specified.

Figure 32 : Final energy consumption by fuel type in the transport sector (1990-2022)



Source : ODYSSEE, Eurostat

Figure 33 : Mode share in total final energy consumption of the transport sector (2022)



Source: ODYSSEE, Eurostat

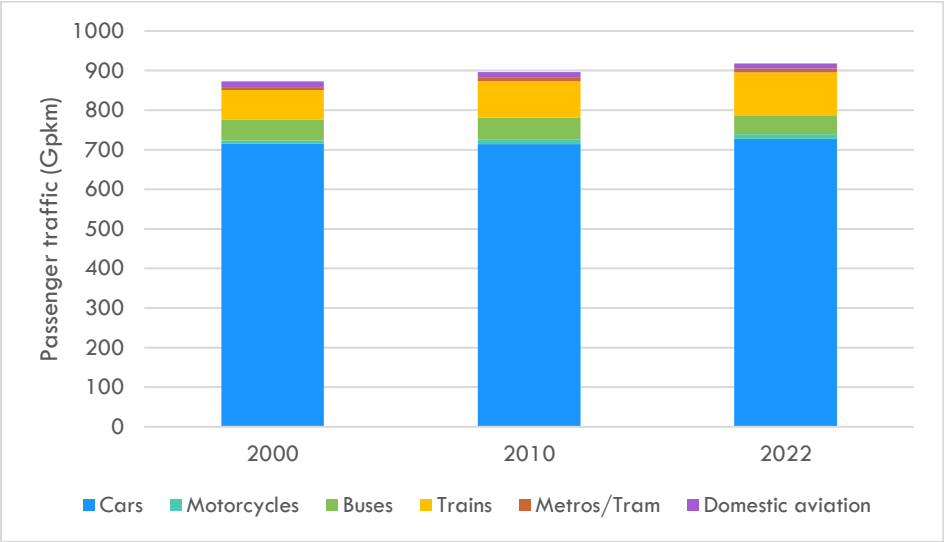
3.2.2 Trends in traffics

Passenger traffic measured in passenger kilometres has been increasing for most of the 2000 to 2022 period for all modes of transport, with an overall 8% increase in all traffic (Figure 34). The overall trend in passenger traffic is dominated by road transport that has occupied 88% of the total annual passenger traffic on average, 92% of which being from passenger cars.

In 2022, traffic has been higher than in 2000 for all transport modes, with trains being the only mode of transport with a higher traffic after than before the pandemic. The 46% increase in metros and tram traffic in 2019 compared to 2000 is likely due to growing ridership in existing metro system and the development of urban train systems in new cities in the past two decades. The increase in motorcycles traffic seems to be plateauing for most of the 2010 around 11 billion pkm. After increasing for much of the

period, bus passenger traffic in 2022 is 10% lower than in 2020, failing to return to pre-pandemic levels. Similarly, domestic air passenger traffic had been increasing during the 2010s before suffering from the pandemic effect. Car use has seen less significant changes than other means of transport until the pandemic where traffic dropped 15% under its 2000 level.

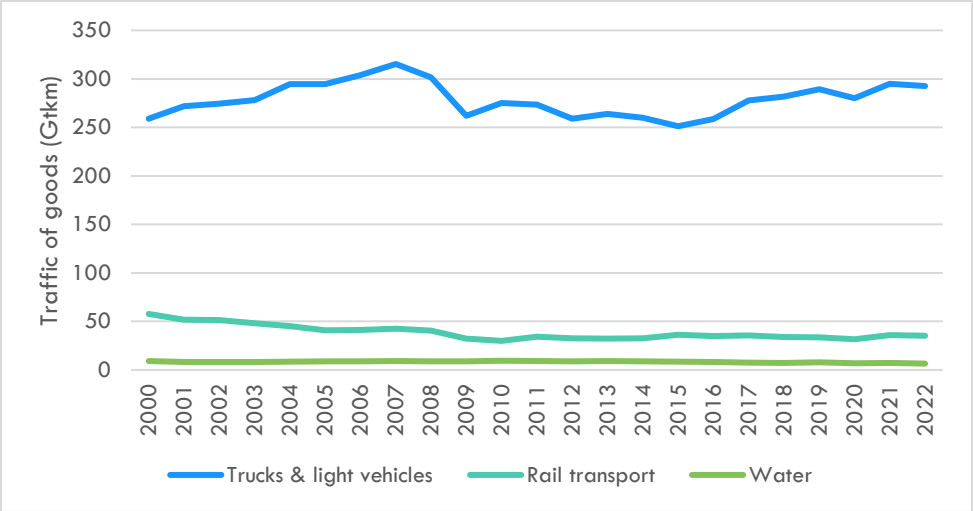
Figure 34 : Passenger traffic by mode of transport (2000- 2022)



Source: SDES

Road transport also largely dominates the transport of goods as can be seen in Figure 35. Although the overall traffic of goods has increased by 3%, trucks & light vehicles traffic has increased by 13% between 2000 and 2022 in particular due to the deregulation of the sector. Road transport traffic increased by more than 50 Gtkm between 2000 and 2007, while rail transport was decreasing, before decreasing back to its 2000 level after the subprime crisis before rising again from 2016 onwards. Over the 2000 to 2022 period, traffic through both rail and water has decreased by 37%, accounting for 13% of goods traffic in 2022 compared to 21% in 2000.

Figure 35 : Traffic of goods by modes of transport (2000-2022)



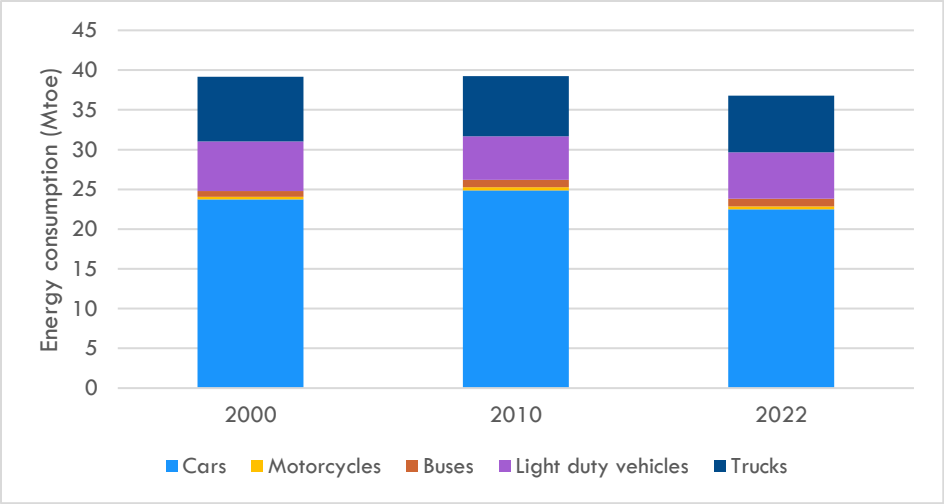
Source: SDES

3.2.2.1 Road transport

Road transport accounts for most of the passengers and goods traffic. Although, the transport sector's final energy consumption has been steady between 2000 and 2022 (less than one percent decrease), road transport has seen its energy consumption decrease from 39,2 Mtoe to 36,8 Mtoe (-6%) on the same period (Figure 36). Even though energy consumption has declined, the repartition among vehicle types has been relatively steady for the entire period, with cars accounting for 62%, light duty vehicles for 15% and trucks 20% of the road transport consumption on average.

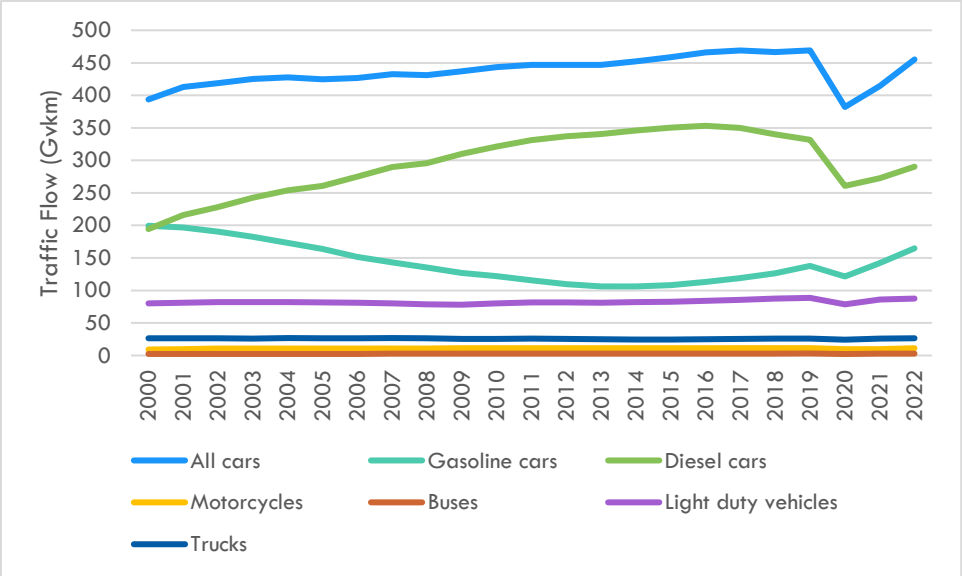
Focusing on road traffic, cars are, by far, the main type of vehicles occupying the road according to Figure 37, with a 16% increase of the traffic measured in vehicles/kilometres between 2000 and 2022. Interestingly, diesel cars traffic has been increasing for most of the period (+82% between 2000 and 2016 traffic) while gasoline cars have followed the opposite trend (-47% between 2000 and 2014 traffic). This increase of the share of diesel car in traffic, which have a lower specific consumption factor than gasoline powered cars, has influenced the reduction in energy consumption of road transport. Since the end of the 2010s, both gasoline cars and diesel cars trends have shifted in the opposite direction. This fuel substitution can be explained partly by the growing concerns related to the rate of fine particles emitted by diesel cars. Motorcycles and buses traffic has also risen by more than 20% between 2000 and 2022.

Figure 36: Road transport final energy consumption by type of vehicles (2000, 2010, 2022)



Source: SDES

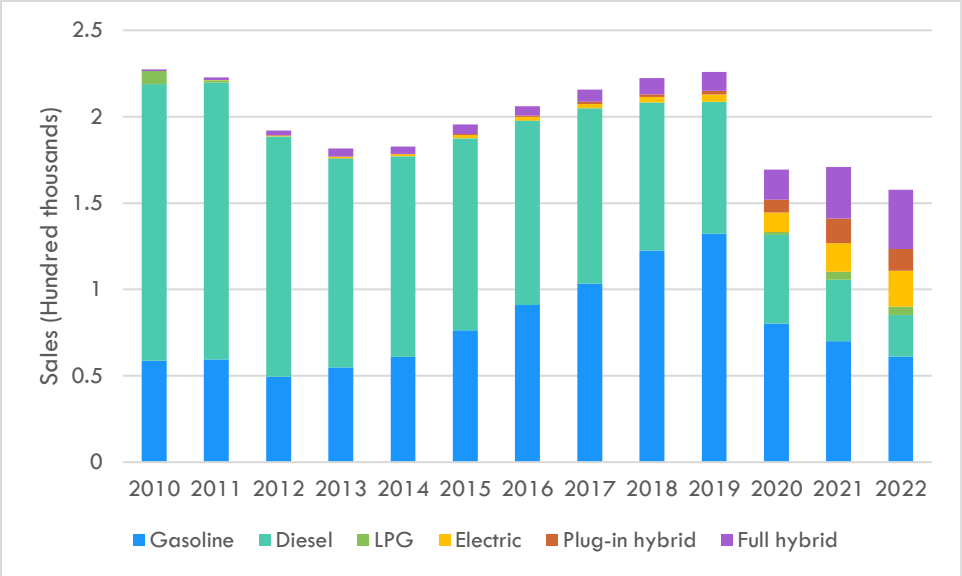
Figure 37: Traffic flow by vehicle type measured in vehicles/kilometres (2000-2022)



Source: SDES

The stock of vehicles and thus the overall energy consumption is influenced by the performance of new vehicles entering into the market. Figure 38 shows that the sales of new vehicles decreased by 31% between 2010 and 2022. While the first half of the period was the Age of the diesel car, gasoline cars started being the most popular type of new vehicles from 2017 onwards. This chart also highlights the higher penetration of low-carbon vehicles since 2020, with electric and hybrid cars accounting for 43% of the sales in 2022.

Figure 38 : Sales of new vehicles by type (2010 - 2022)



Source: SDES

3.2.3 Energy efficiency trends

3.2.3.1 Policies to support energy efficiency

The decrease of the energy demand in the transport sector after 2010 should be highlighted. Certainly, the implementation of policies contributes to this trend. In the MURE database 37 ongoing measures are documented for France. Among them, we will focus on a selection of the "high" impact measures.

Some transport policies in place in France are directly transposed from European Directives and standards. Road vehicles entering the market have to follow requirements regarding their CO2 and other air pollutants emissions levels and regarding the related labelling. It also set EU fleet-wide CO2 emissions targets. These European regulations are setting the **standard** (CO2/km) for all Member States towards a less carbon intensive fleet.

In addition, EU legislation is also impacting the level of **tax on energy** and especially on fuel by defining a minimum level of taxation. The price of fuels for end-users thus depend on the level of taxation, which impacts drivers' vehicle usage. Since 2014, the tax on fuel for transport includes a carbon component, which was at first supposed to increase overtime, making it more relevant to environmental policy.

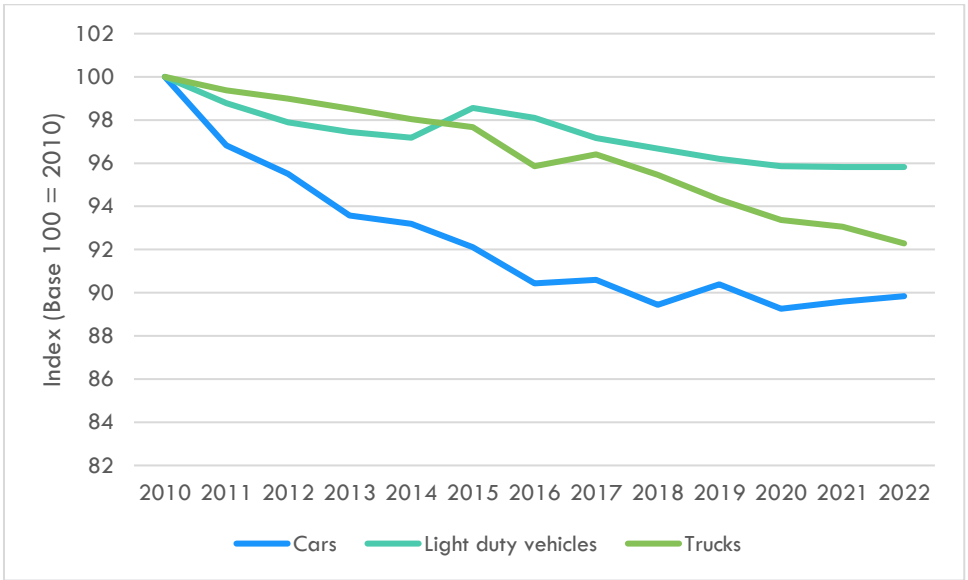
One of the most impacting measures in France is the **Bonus-Malus scheme** which was introduced in 2008 with the objective to reduce the average emissions of the vehicle fleet. The two-sided fiscal and financial scheme is incentivising the purchase of cleaner vehicles through and penalising the purchase of CO2- and energy-intensive vehicles with a tax. This scheme also addresses energy poverty by adapting the level of subsidy to the car customer's level of income.

Focusing on goods transport, the **Voluntary Engagement for the Environment** programme supports actors of the sector to decarbonise fleets and supply chains. This programme enrols shipping companies and other actors in logistics chains and provide them with technical support to reach their decarbonisation goals. This scheme is entirely voluntary and relies on participants own goals to achieve results.

3.2.3.2 Unit consumption trends

A good indicator of technical energy efficiency for transport is the evolution of vehicles specific consumption overtime. Figure 39 shows that the specific consumption in litres per kilometres (including both gasoline and diesel consumption for passenger cars) was lower across all vehicle types in 2022 compared to 2010. This trend is driven by new vehicles entering the market with improved specific consumption with new cars being 15% more efficient in terms of litres per kilometres in 2022 compared to 2010. The speed of improvement depends on both the specific consumption of new vehicles entering the market and the replacement rate of older, less efficient vehicles. The specific consumption for passenger cars is decreasing faster than for trucks or light duty vehicles. However, the trend is stagnating from 2016 onward, likely due to gasoline cars accounting for the majority of new vehicles from 2017 onwards, while the sales of diesel vehicles used to dominate the market for most of the 2010s. A second important factor explaining the rebound of the specific consumption is the increasing share of SUV generally gasoline powered.

Figure 39 : On-road specific consumption by vehicle type (2010-2022)

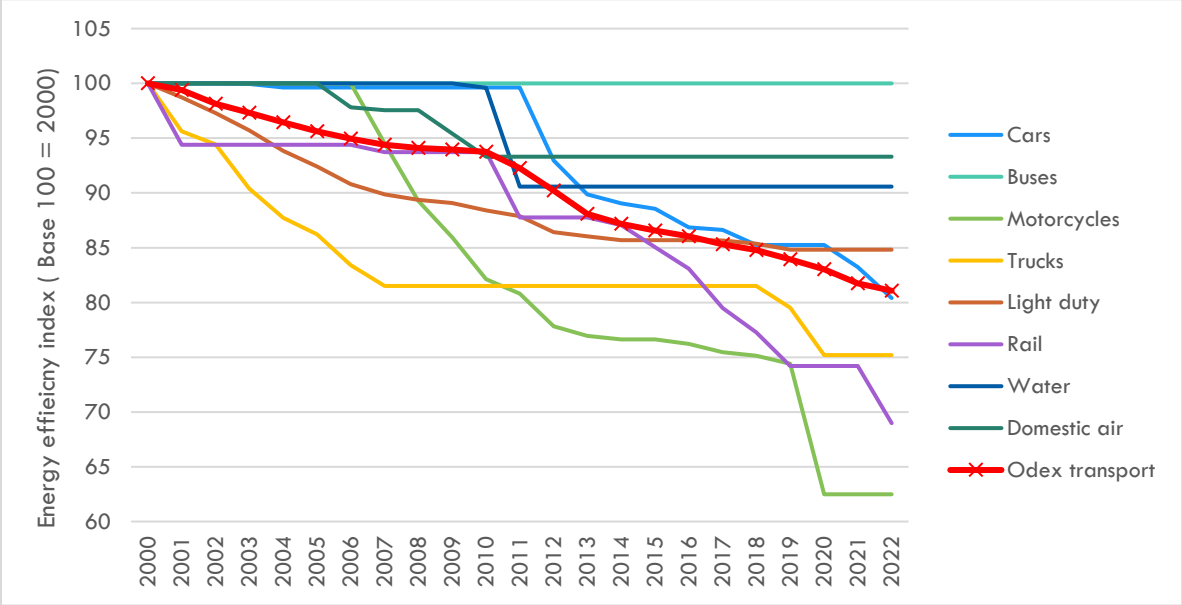


Source: ODYSSEE

3.2.3.3 Technical energy efficiency trends in the transport sector (ODEX)

Overall, there was a 19% gain in energy efficiency in the transportation sector in France between 2000 and 2022 as measured by the technical ODEX[7], corresponding to an average yearly improvement of 1%/year (Figure 40). With cars accounting for the largest share of transport energy consumption, the ODEX is mainly driven by this mode's technical improvements which happen mostly during the 2010s. Trucks and light duty vehicles energy efficiency gains are visible in the first half of the period, with trucks technical efficiency improving by 19% between 2000 and 2007, and light duty vehicles by 10% on the same period. Energy efficiency progress for the 2000-2022 period, led to an estimated 7 Mtoe of cumulated yearly energy savings in 2022 (Figure 41).

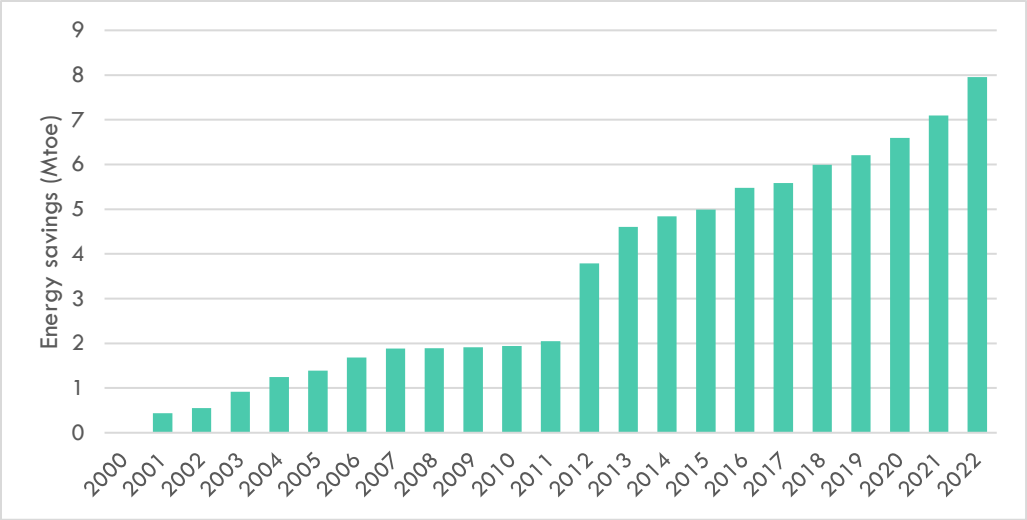
Figure 40 : Technical ODEX by transport modes (2000-2022)



Source: ODYSSEE, SDES

[7] Here, ODEX weights efficiency gains for 8 modes of transportations (cars, buses, motorcycles, trucks, light-duty vehicles, rail, water, and domestic air) according to their share in transport energy consumption. Transport efficiency is estimated based on the change in the unit consumption index, with the most relevant physical unit being used for each mode (e.g. koe/pkm for passenger cars and koe/tkm for trucks).

Figure 41: Cumulated yearly energy savings for the transport sector (2000-2022)



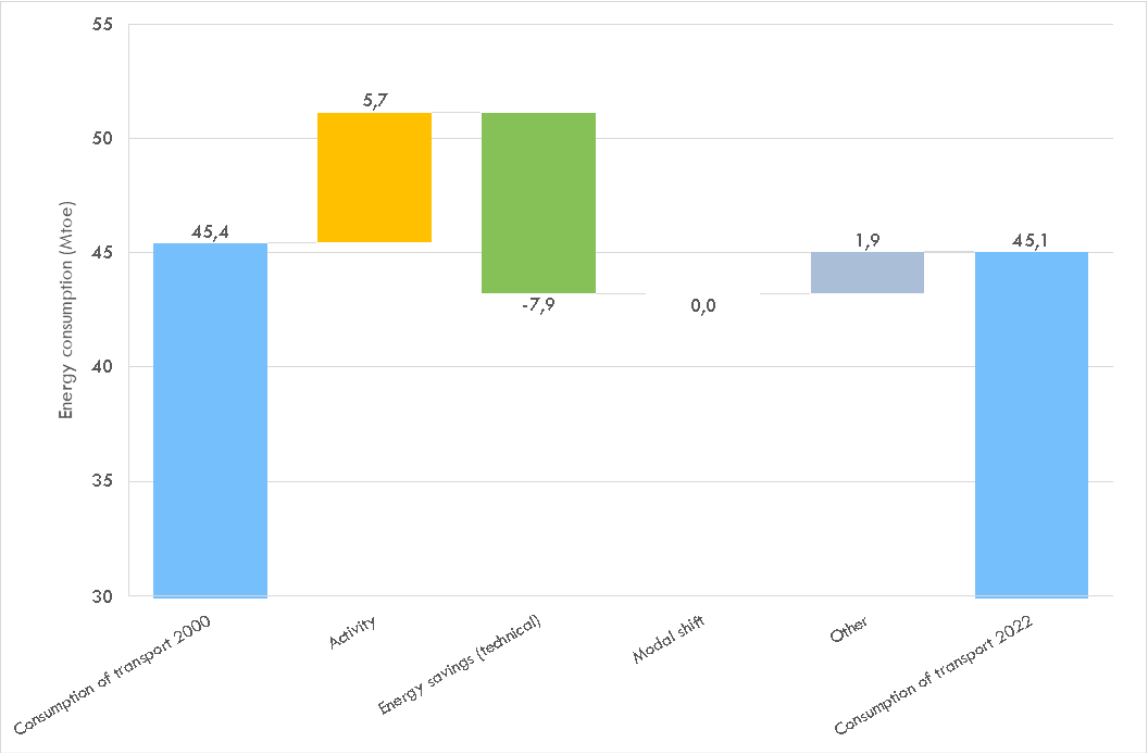
Source: ODYSSEE

3.2.3.4 Drivers of consumption variation in transport

As shown in Figure 42, the transport sector's energy consumption is similar in 2000 and 2022. However, the increase in activity during the same period, in both passengers and goods traffic, would have led to a 5,7 Mtoe increase in energy consumption. As seen above, the share of each mode of transport in final energy consumption has not significatively changed between the two dates, meaning that modal shift has not been a significative driver of change for the entire sector. Actually, passenger modal shift led to a slight decrease of the energy consumption while for goods transport, the shift to road transport led to a slight increase in consumption, both compensating at the sectoral level.

Energy efficiency is the main factor contributing to shape the energy demand trends leading to energy savings (-7,9 Mtoe). The factor "other" which counterbalances the technical energy savings by increasing energy demand by +1,9 Mtoe can be attributed to a lower loading ratio for transports of goods or a lower number of passengers per vehicles.

Figure 42 : Drivers of consumption variation in transport (2000-2022)



Source: ODYSSEE

3.3 Residential sector

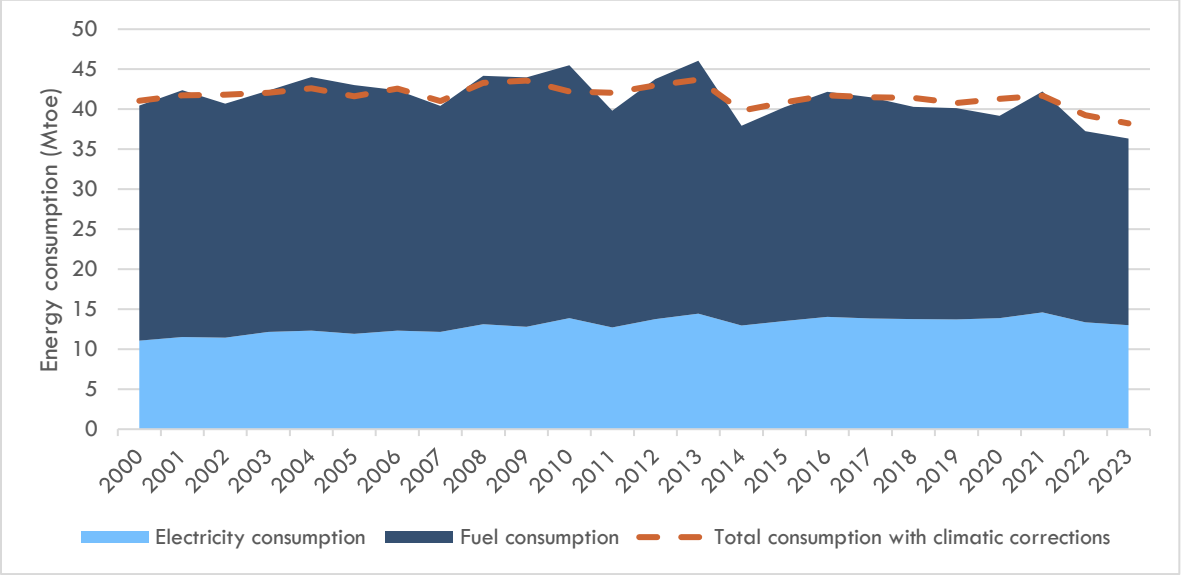
3.3.1 Energy consumption

Overall, energy consumption of the residential sector, at constant climate, declined by 7% between 2000 and 2023, landing at 38 Mtoe (Figure 43). Notably, the share of electricity in the overall energy consumption has increased from 27% in 2000 to 36% in 2023, replacing oil consumption. Energy consumption in households also varies with climatic conditions with the amount of heating or cooling needed not being the same in relatively warmer or cooler conditions than usual.

In the residential sector, households are using energy for heating their homes, for the sanitary water they use, for cooking food, for lighting and all their electrical appliances, large and small including air conditioning. These multiple end-uses contribute differently to overall energy consumption, with heating accounting for the largest share on average (Figure 44). However, this share has been declining from 76% in 2000 to 68% in 2023. This means that energy demand for heating has decreased faster than the sector's energy consumption over the same period. Water heating is consuming more energy in 2023 than in 2000, making up 10% of the total consumption in 2023. Cooking as an end-use has a relatively low and stable share. It is using 12% less energy in 2023 than in 2000. On the other hand, the amount of energy used for electrical appliances

and lighting has increased by 26% between 2000 and 2023, with its share in the total consumption going from 11% of the total to 16%.

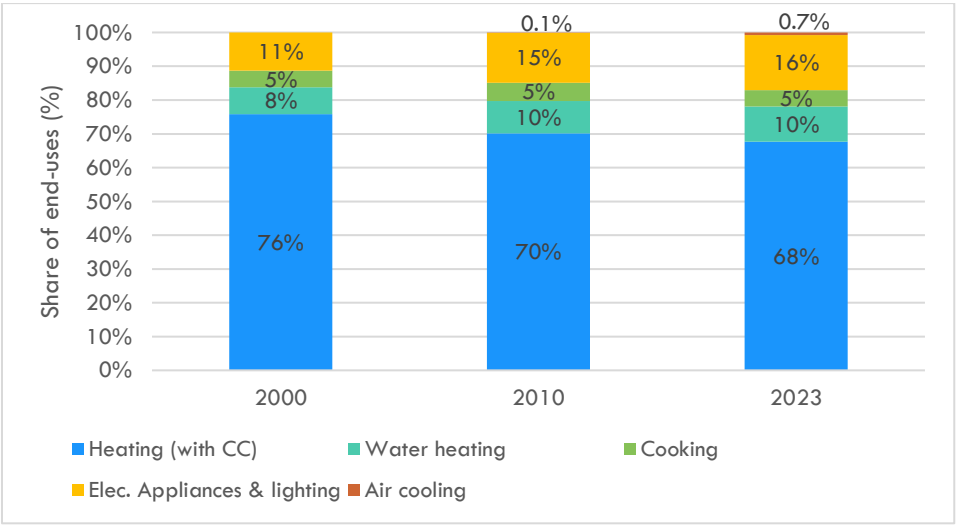
Figure 43 : Final energy consumption in the residential sector (2000-2023)



Source: ODYSSEE

Note: Final energy consumption for all end-uses.

Figure 44 : End-use share in final energy consumption of the residential sector (2000, 2010, and 2023)

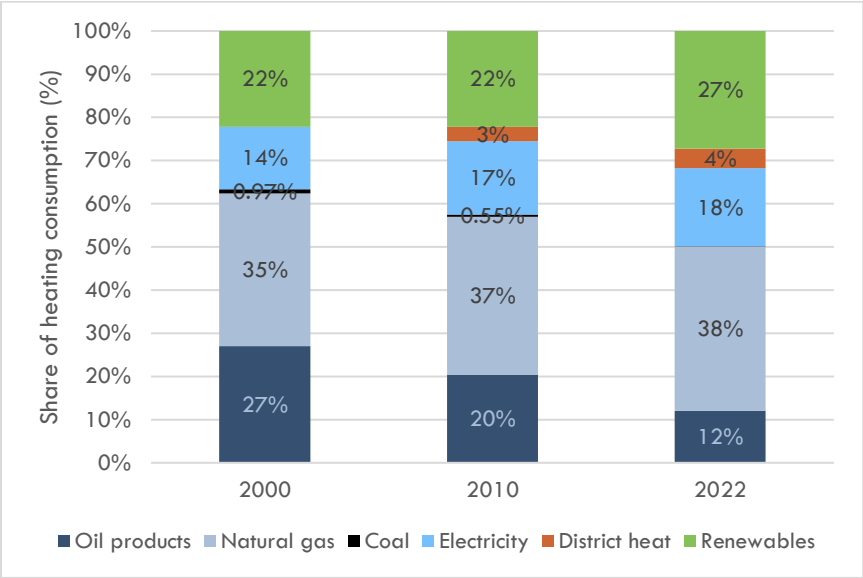


Source: ODYSSEE

Space heating represents the main energy end-use for households and its decrease overtime can be tied to changes in the fuel mix. Indeed, in 2000 space heating mostly relied on fossil fuels, with oil products, natural gas and coal summing up to 19 Mtoe or 63% of heating energy consumption (Figure 45). More than 58% of dwellings were equipped with a boiler powered on fossil fuels in 2000. However, the replacement of old boilers with new, more efficient and low-carbon equipment resulted in half of all households using low-carbon energy for space heating by 2022. This trend is largely due to the replacement of oil and coal boilers, whereas natural gas use weighs slightly more

in total consumption in 2022 than in 2000. Low-carbon fuels contributed to half of households space heating energy consumption in 2022, with wood pellets accounting for 27% of the total, electric heating 18% and district heating 4%. With the most energy-intensive boilers being replaced with more efficient equipment, space heating consumption dropped during the 2000 to 2022 period.

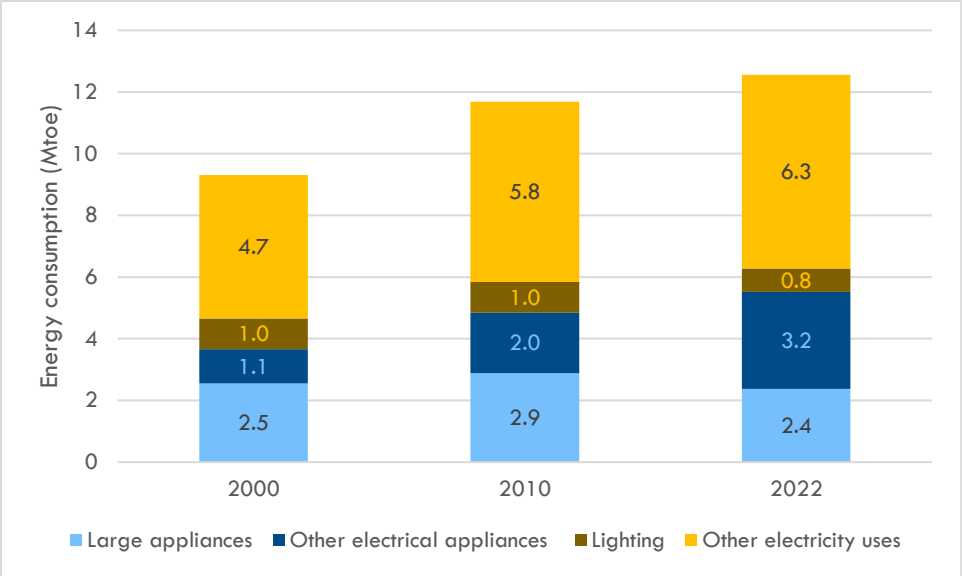
Figure 45 : Final energy consumption for space heating by fuel types (2000-2022)



Source: Eurostat, CEREN

Electrical appliances and lighting represent the second largest share in households' energy consumption with 5,9 Mtoe in 2022, 35% above its 2000 level (Figure 46). The demand for lighting stayed stable overtime while the final consumption for electrical appliances, both large and small, has increased by 40% during the 2000-2022 period. The total electricity demand for large appliances, including refrigerators, freezers, washing machines, etc, is lower in 2022 than in 2000, and has been decreasing every year since 2009. This is likely due to the impact of European policies on specific consumption of large appliances (EPBD, Ecodesign, etc). In the meantime, the electricity consumption associated with small electrical equipment, including phones, computers, etc, has nearly tripled.

Figure 46 : Final electricity demand by end-use (2000-2022)



Source: ODYSSEE

3.3.2 Energy efficiency trends

3.3.2.1 Policies to support energy efficiency

As the second largest sector in terms of energy consumption and the largest in terms of energy savings, the residential sector weighs heavy in France's pathway towards its energy reduction targets. Being the sector with the largest energy efficiency improvement, there is no denying that policies in place in France have had an impact on the trend. The MURE database includes 37 ongoing measures as of December 2024. This report is presenting some "high" impact policies.

Similarly to other sectors, energy efficiency policies applied in France are often transposed from EU legislation such as the **Energy Performance in Buildings Directive** recast, which sets targets to achieve a zero-emissions building stock by 2050, and the **Ecodesign Directive**, which sets requirements for most energy related appliances performance.

Building codes are key regulations for buildings energy efficiency. They establish minimum requirements regarding the characteristics of buildings including their energy performance and, as of the **RE2020**, their environmental impact and their adaptability to climate change. They have a significant impact on new buildings energy efficiency, but a lesser effect on the overall performance of the building stock, depending on the rate of new construction.

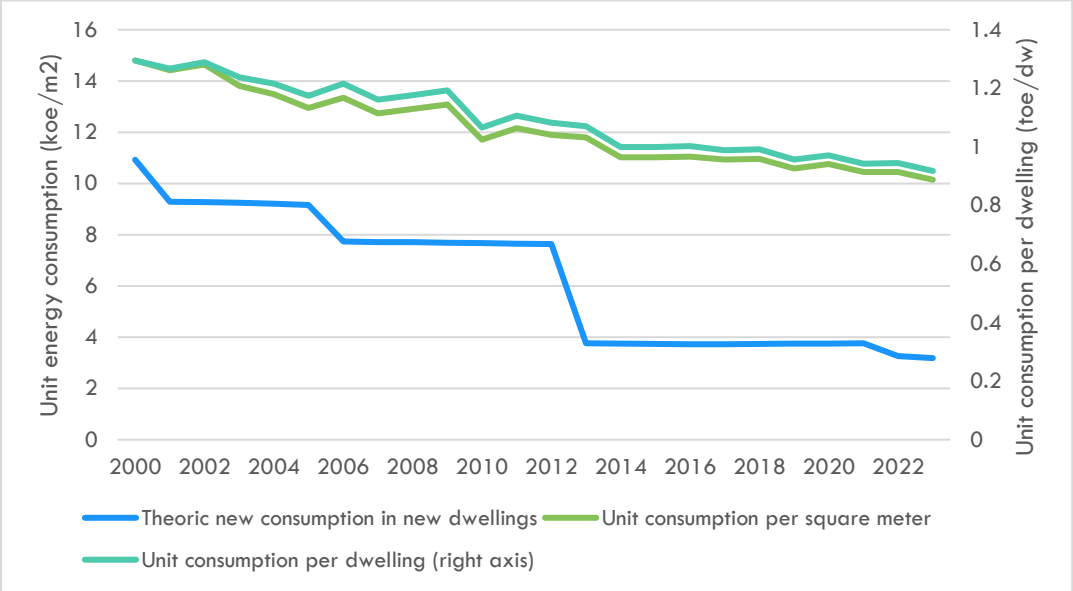
Another regulatory measure which is believed to have a large impact on residential buildings, is the **rental bans for low energy class dwellings**. A gradual rental ban will be imposed on the worst-performing segment of the building stock to strongly incentivise owners to carry out renovation work aimed at reducing energy consumption.

In order to support owners undertaking energy-efficient renovations, the **MaPrimeRénov' subsidy scheme** has been established in 2020. The scheme is accessible to all households, but the level of support is significantly higher for applicants facing energy poverty. MaPrimeRénov' subsidises among other, the replacement of energy-intensive boilers, the insulation of dwellings or full energy-efficient renovations.

3.3.2.2 Measuring energy efficiency with unit consumption

The final energy consumption associated with space heating has decreased by 1,5% per year since 2000 (Figure 47).

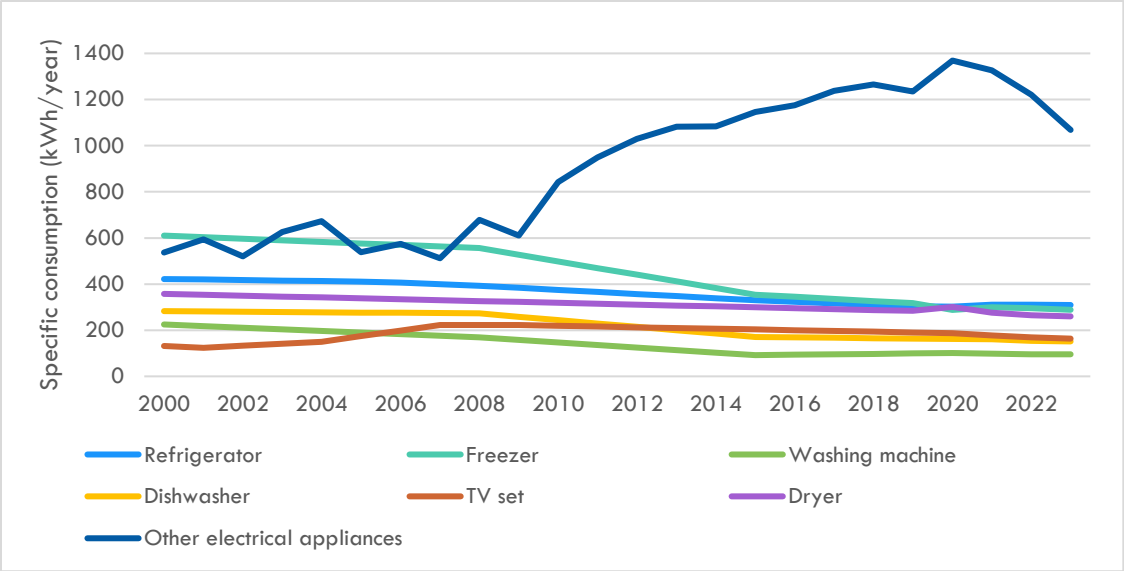
Figure 47 : Unit consumption of space heating (2000-2023)



Source : ODYSSEE

Large appliances, such as fridges and dishwashers, which use to account for most of that end-use in 2000, have seen their average consumption drop by 27% during the 2000-2023 period (Figure 48). Indeed, large electrical appliances are more energy efficient in 2023, except for TV sets whose consumption has increased by 24%, especially driven by the expanding size of TV screens at the beginning of the 2000s. The average energy consumption per dwelling for other appliances, including smaller electric equipment and electronics, has doubled between 2000 and 2023. This can be explained by the greater number of electronics owned per households, specifically mobile phones and laptops. Notably, after increasing for most of the period, the average dwelling consumption for other appliances has been decreasing by 22% since 2020.

Figure 48 : Specific consumption of electrical appliances (2000-2023)

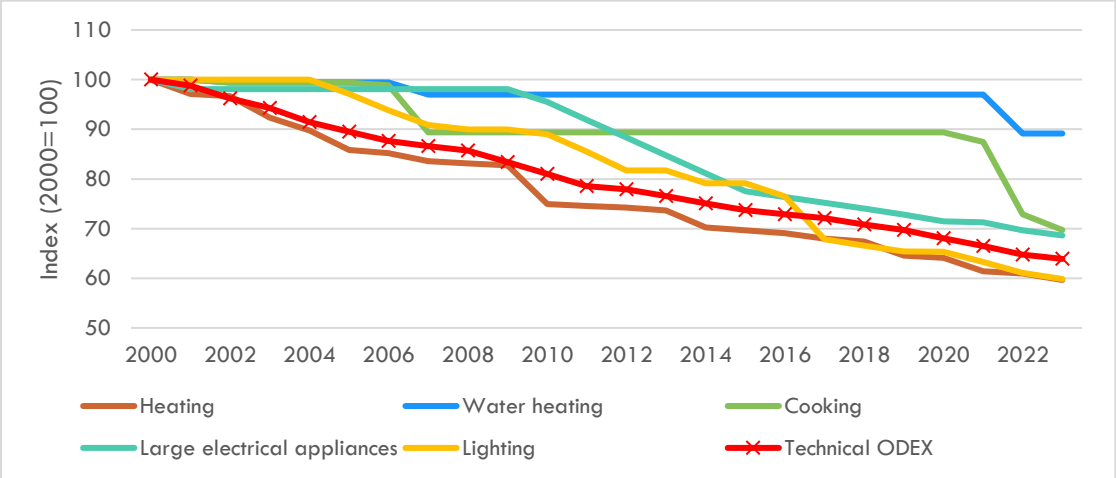


Source: ODYSSEE

3.3.2.3 Technical energy efficiency trends in the residential sector (ODEX)

To estimate energy efficiency progress in the households sector, the technical ODEX shown in Figure 49 is built on the unit consumption of five end-uses (heating, water heating, cooking, lighting and large electrical appliances) weighted by their respective share in the overall final consumption of the sector. Overall, the residential sector is 36% more efficient in 2023 than in 2000, with the trend being mainly driven by improvements in space heating efficiency (41% on the same period) as the largest contributor to the sector's energy consumption. Lighting efficiency also improved by more than 40% likely due to the banishment of incandescent lamps and the penetration of more efficient LDCs and LEDs. Large appliances efficiency, estimated based on the average unit consumption of five pieces of equipment (refrigerators, freezers, washing machines, dishwashers, TVs), has seen significant improvements since 2009.

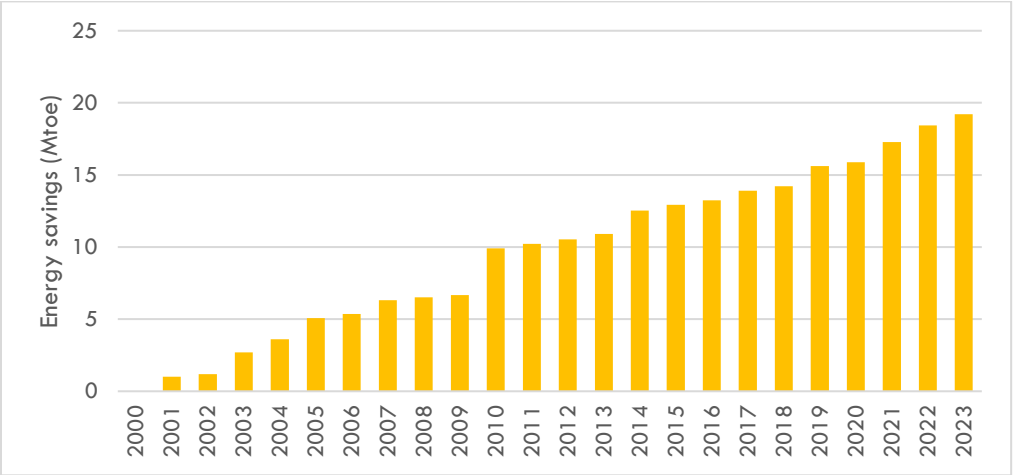
Figure 49 : Technical ODEX for the households' sector by end-uses (2000-2023)



Source : ODYSSEE

The residential sector is responsible for the largest cumulated annual energy savings since 2000 compared to the other sectors, with 19 Mtoe of savings in 2023 (Figure 50). Most of these savings can be attributed to the progress made in space heating, which has been driving energy efficiency in the sector.

Figure 50 :Cumulated annual energy savings in the residential sector (2000-2023)

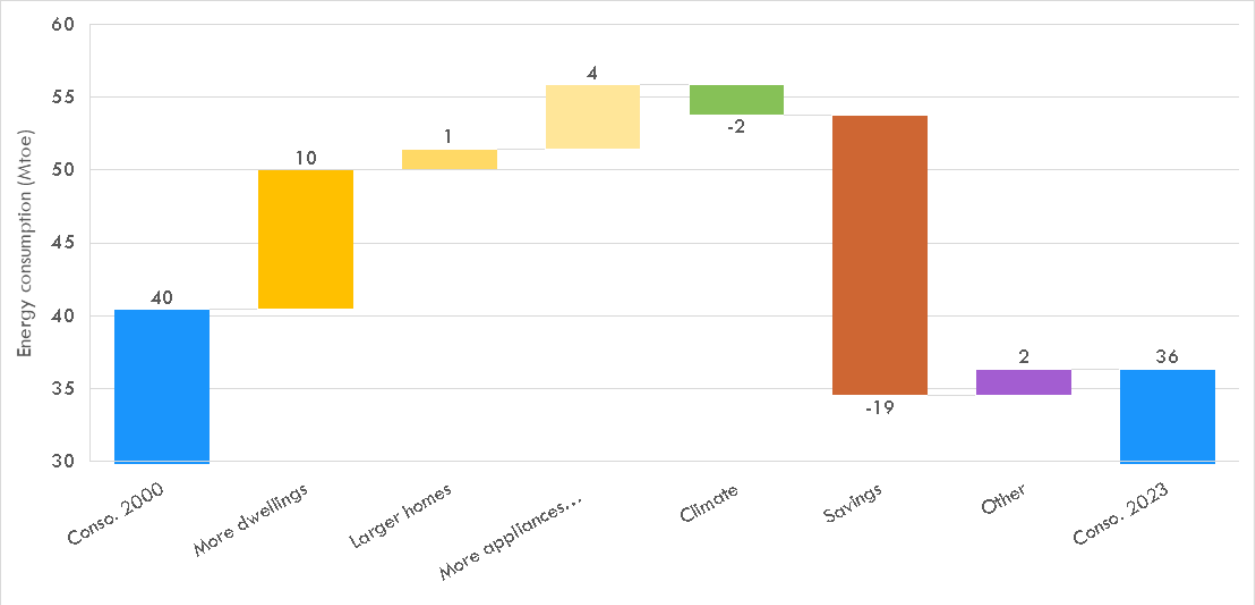


Source : ODYSSEE

3.3.2.4 Drivers of consumption variation in the residential sector

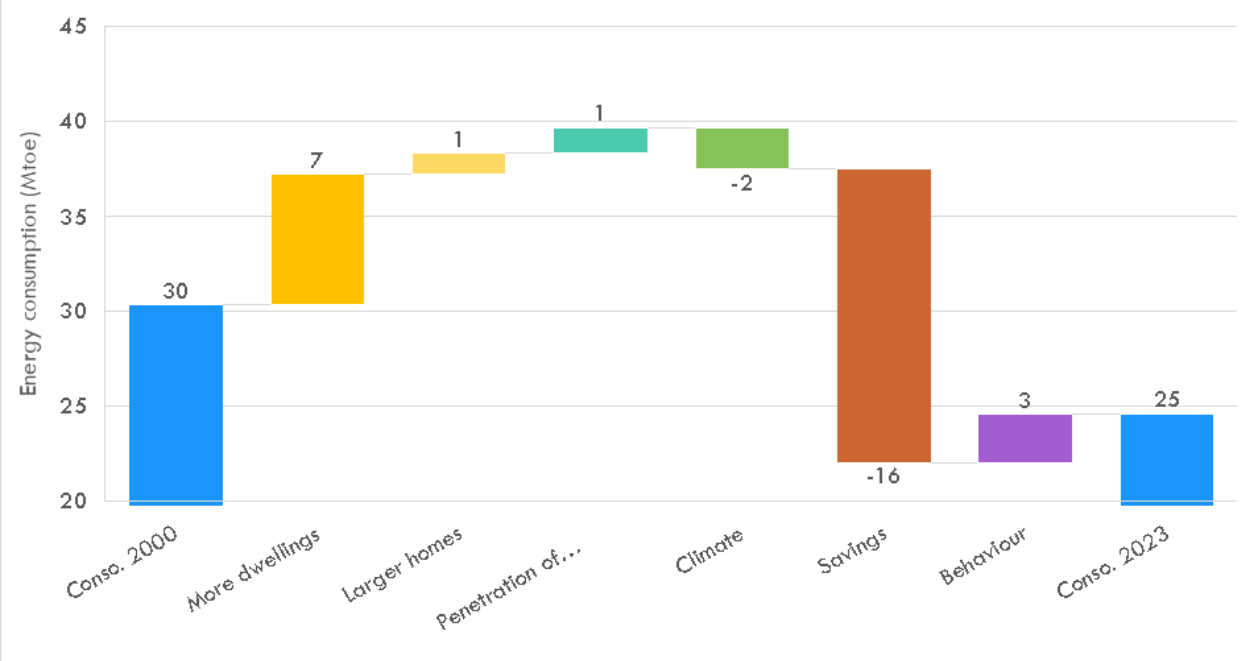
Demographic and socio-economic factors have pushed up the energy demand in the residential sector (Figure 51). Indeed, the number of dwellings increasing by 24% on average should have led to a +10 Mtoe increase in energy consumption between 2000 and 2023. In addition, dwellings are 3% larger on average in 2023 than in 2000, which implies a +1 Mtoe additional energy consumption in 2023. The high electrical appliances ownership rate led to a+ 4 Mtoe increase in energy demand. This effect is primarily driven by the substantial increase in electronics ownership, whose energy consumption has doubled over the period, while large appliances ownership has stayed similar. Energy savings led to a -19 Mtoe decrease in energy demand, more than compensating the raise in demand from socio-economic drivers.

Figure 51: Drivers of consumption variation in the residential sector (2000-2023)



Source: ODYSSEE

Figure 52 : Drivers of consumption variation for space heating (2000 - 2023)



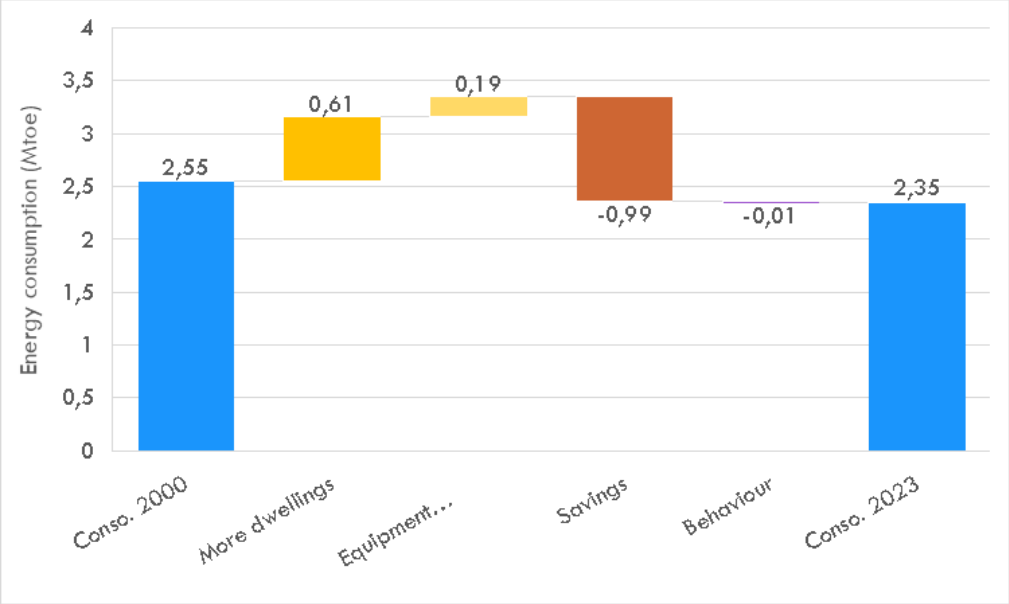
Source : ODYSSEE

As space heating accounts for most of the residential sector's final consumption, the drivers of change in Figure 52 are fairly similar to the changes in the overall residential sector. The energy demand is correlated with the number and size of dwellings, leading to a +8 Mtoe increase between 2000 and 2023. The increasing penetration of central heating in France (comfort effect) also led to an increase in energy demand. Energy savings and the relatively milder climate in 2023 compared to 2000 led to a decrease in

energy demand. The remaining effect can be likened to the effects of behavioural changes (longer heating periods, higher indoors temperature) on energy demand.

Large appliances have seen their final energy consumption decrease between 2000 and 2023 (Figure 53). Here again, the energy demand is driven by the increasing number of dwellings entering the market. Although households tend to have only one large appliance per type per dwelling (e.g. washing machine, refrigerator), the equipment rate has increased between 2000 and 2023 leading to a slight increase in energy demand. Energy savings have more than compensated the raising energy demand thanks in part to efficiency norms and labels regulating the production.

Figure 53 : Drivers of consumption variation for large appliances (2000-2023)



Source : ODYSSEE

3.4 Service sector

3.4.1 Energy consumption

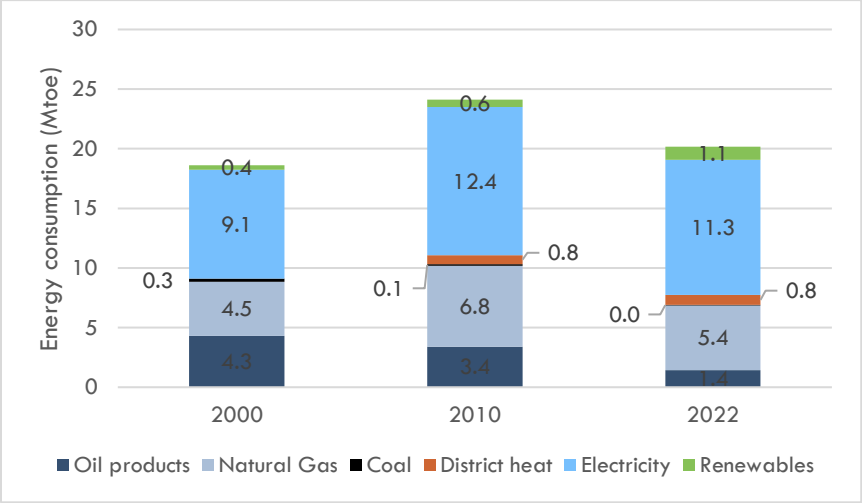
With a 35% increase in value added between 2000 and 2022, the services sector has been the main driver of GDP growth since 2000, with its share reaching 80% of the total outcome in 2022[8], up from 77% in 2000. After reaching a maximum in 2010, the final energy consumption of the sector decreased to 20 Mtoe in 2022, slightly above the 2000 level (Figure 54). Thus, final energy consumption is only 11% higher in 2022 than in 2000.

For the entire period, electricity has been the main energy carrier in the service sector, accounting for 49% of the final consumption in 2000 and 56% in 2022 (Figure 54). Fossil fuels account for 49% of the final energy consumption in 2000, while they only account

[8] This section is focusing on the period 2000 to 2022 due to missing data for 2023 at the time of publication.

for 34% of the total at the end of the period. The weight of each energy carrier in the final consumption is also influenced by the distribution of energy demand across various end-uses (see Figure 55).

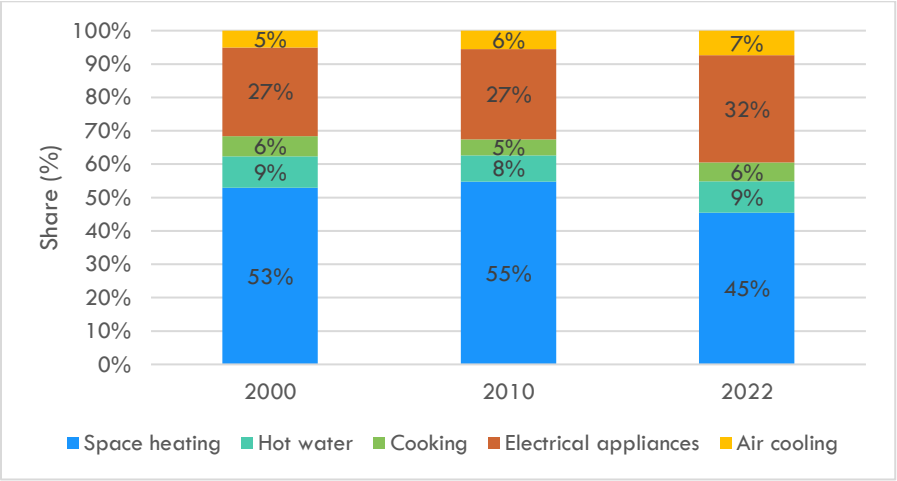
Figure 54 : Final energy consumption in the service sector by fuel (2000, 2010, 2022)



Source: Eurostat

Similarly to the residential sector, space heating account for the largest driver of energy demand in services, even though its share decreased overtime from 53% of the demand in 2000 to 45% in 2022 (Figure 55). Meanwhile, the energy demand related to electric appliances has been increasing by 1%/year, from 27% of the total in 2000 to 32% in 2022. This can be explained by the increasing rate of equipment in services similarly to the residential sector, implying a higher energy consumption for the growing number of electrical appliances for all branches.

Figure 55 : Final energy consumption of the service sector by end-uses (2000, 2010, 2022)

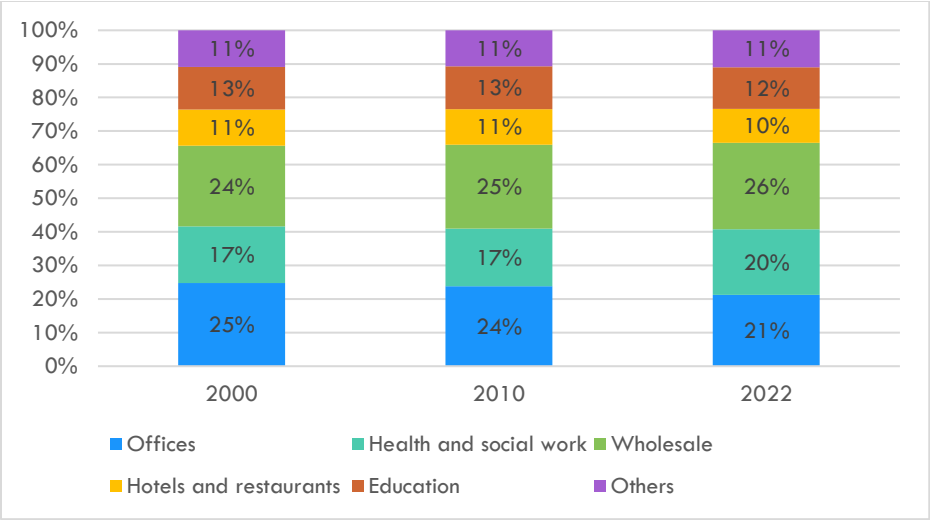


Source: ODYSSEE

The share of each branch in the final energy consumption of services stayed, for the most part, relatively stable overtime (Figure 56). Offices and wholesale are accounting for the half of the energy demand, with a slight decrease to 47% of the demand in 2022,

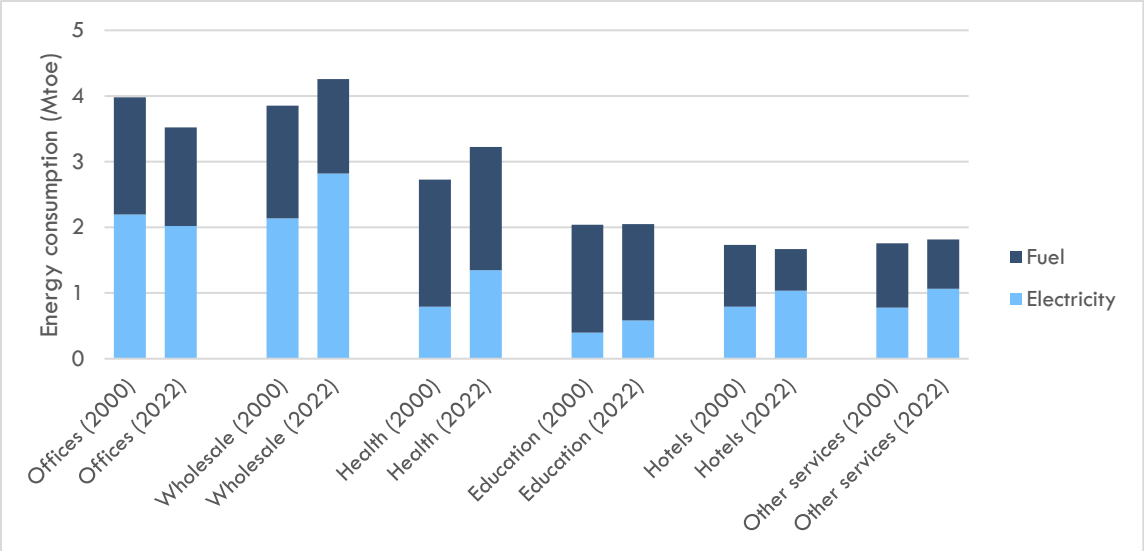
mostly imputable to the reduction in the offices share. The six services branches considered here exhibit different pattern related to the evolution of their energy demand overtime (Figure 57). While both the employment rate and the surface area occupied by buildings in the services sector have been growing between 2000 and 2022, offices have seen their energy consumption decrease by 11%, mainly driven the lower fuel demand in 2022. The wholesale and health branches have seen their energy demand increase by 11% and 18%, respectively. This translates into an increase of electricity demand for both branches, while there is a slight reduction of fuel use. For hotels and restaurants, and education, the energy demand stayed relatively stable, with a higher share of electricity in final energy consumption.

Figure 56: Final energy consumption in the service sector by branch (2000, 2010, 2022)



Source: ODYSSEE

Figure 57 : Final energy consumption by fuel by branch in the service sector (2000, 2022)

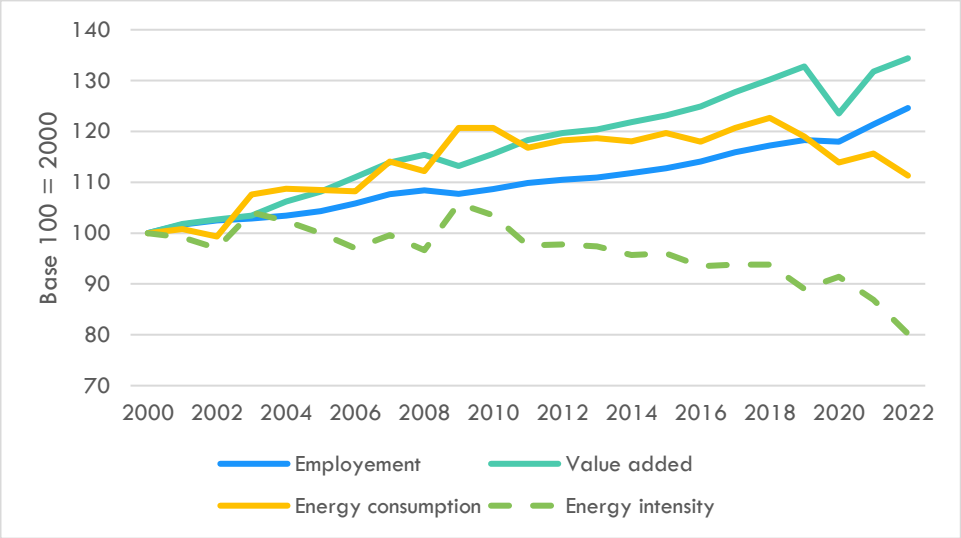


Source: ODYSSEE

3.4.2 Energy intensity

While both the activity level and the final energy consumption of the sector have increased overtime, the growth in energy demand is lower than the sector's value added, with the energy trend slowing down after 2010 while the upward activity trend keeps steady (Figure 58). Consequently, the energy intensity of the sector is decreasing on a long-term basis. In particular, the intensity has been improving by 1,2% per year since 2010.

Figure 58 : Energy intensity of the service sector (2000-2022)



Source: ODYSSEE

3.4.3 Energy efficiency trends

3.4.3.1 Policies to support energy efficiency

The service sector is facing similar issues regarding energy efficiency than the residential sector, with space heating of buildings being the main energy consuming end-use. In order to reduce the impact of the sector, policies are in place in France, of which 27 can be found in the MURE database. Some of these measures are also coming from transposed EU legislation. On top of the Directives relevant for buildings (EPBD, EcoDesign, etc), the **Energy Efficiency Directive** requires Member States to renovate each year 3% of the total public building stock. This section presents some measures with a "high" impact in terms of energy efficiency in the service sector.

Service buildings are regulated by **building codes** setting requirements regarding the energy performance, environmental impact and adaptability to climate change. In addition, in case of important building renovation, a **mandatory thermal insulation** has to be carried out for service buildings.

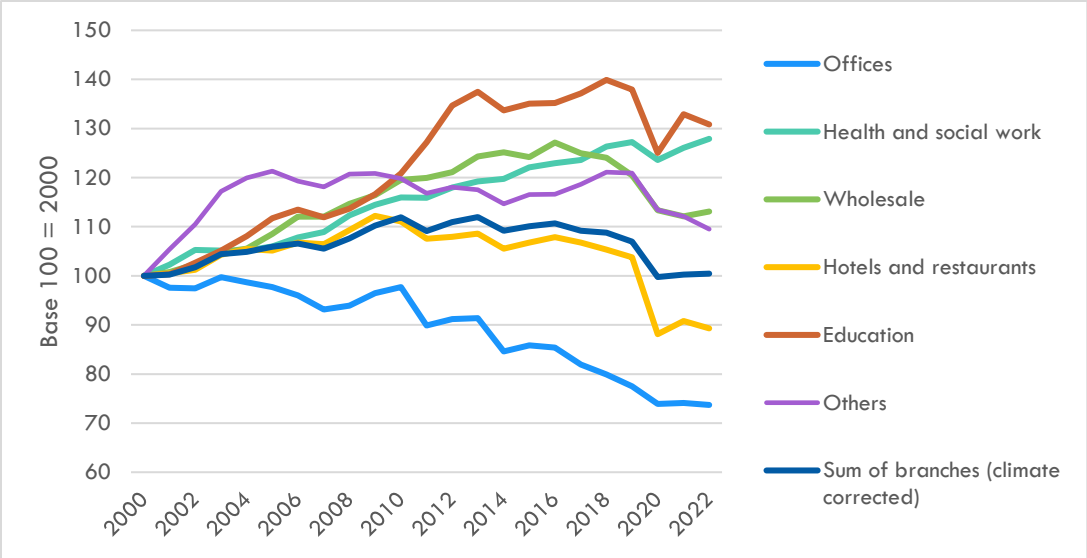
All service buildings are also subjected to the **Eco-Energy Service decree**, a regulatory obligation that commits the sector to achieve energy efficiency gains with final energy consumption reduction targets set at 40% of savings by 2030, 50% by 2040, and 60% by 2050 compared to 2010 levels. This obligation applies to close to 80% of the service sector's building stock including public buildings. The same legislation mandates that obligated entities report their progress against meeting their energy reduction target on the online **OPERAT public platform**, which will enable the monitoring of the targets' achievement by all stakeholders.

3.4.3.2 Measuring energy efficiency with unit consumption

To appreciate energy efficiency gains in services, one can look at the final energy consumption by employee. Electricity demand is depending mostly on electric appliances use, thus final electric consumption is likely correlated to the number of employees and their labour productivity. Figure 59 shows that the unit electric consumption has been increasing for most services branch compared to 2000. Offices are the only branch where the electricity demand by worker has been decreasing for the entire period, reaching 25% of its 2000 level in 2022.

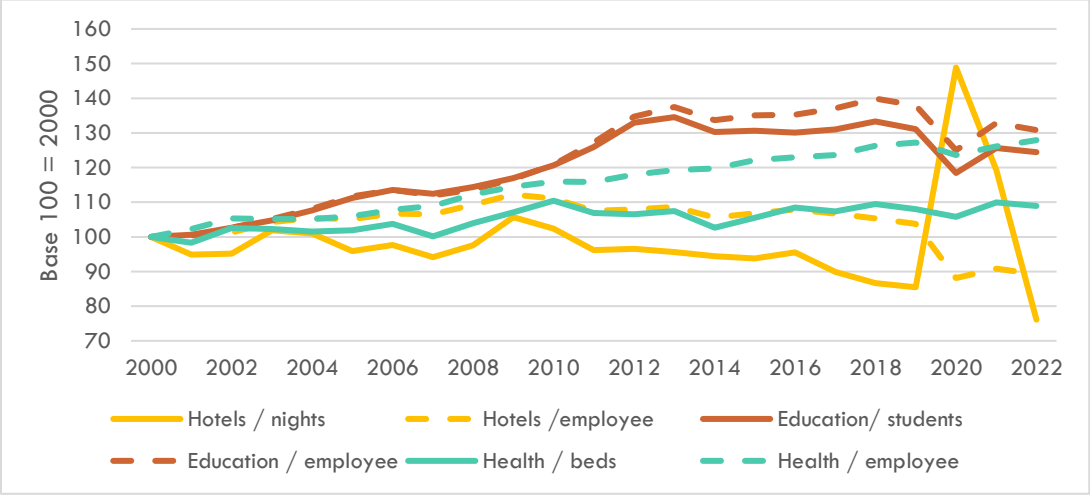
For the wholesale, health and education branches, electricity demand per employee has been increasing for most of the period, with the final consumption reaching 30% of its 2000 level in 2022 for the education branch. Similarly, for hotels and restaurants electric unit consumption has been increasing until the turn of the decade before stagnating during the 2010s. The large drop in efficiency in 2020 can be explained by the massive closure of touristic, commercial and education establishments during the Covid19 pandemic. It should be noted that for activities welcoming customers on site, such as hotels and restaurants, the unit consumption by capacity indicator is lower than the indicator by employee (Figure 60). Hotels are effectively more efficient when considering electric consumption by nights booked. Similarly, electricity efficiency for health and education services shows a smoother increase when looking at the unit consumption by capacity (e.g. bed or students) rather than the employee unit consumption.

Figure 59 : Electric consumption by employee by branch (2000-2022)



Source: ODYSSEE

Figure 60 : Electric consumption by employee and by capacity (2000-2022)



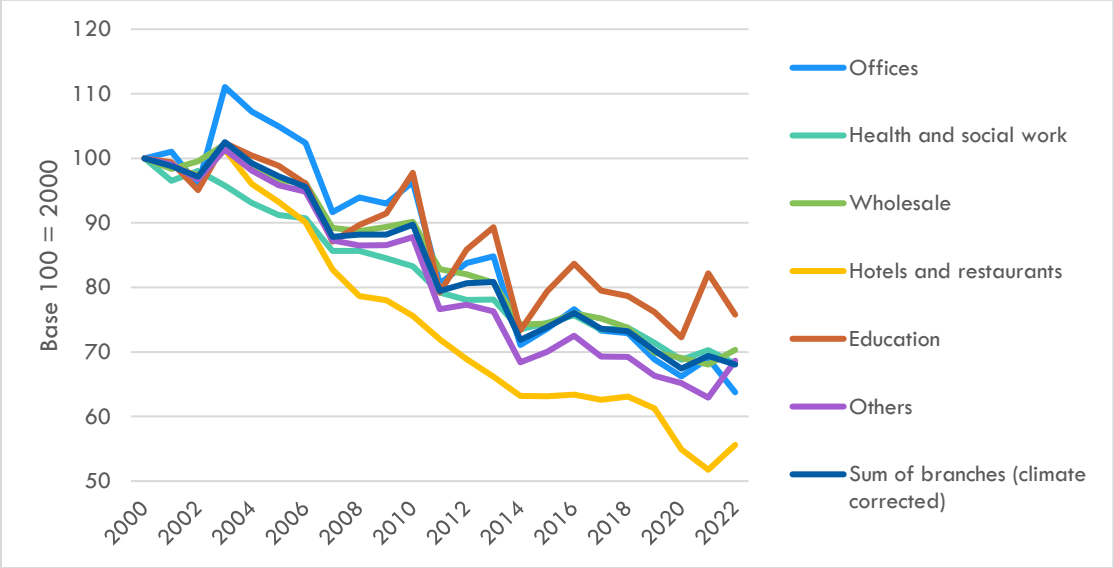
Source: ODYSSEE

Note: capacity refers to nights booked for hotels, students enrolled for the education branch, and number of beds available in the health branch.

Final fuel consumption in services is mainly used for space heating. Thus, the unit consumption of fuel per square meter of service buildings would be a good energy efficiency indicator for this end-use. While fuel demand in services has only decreased by 15% between 2000 and 2022, Figure 61 shows that the consumption of fuel per square meter of buildings has decreased by 30% on the same period. This change in fuel consumption might be due partly to the replacement of old boilers with new and more efficient ones and the overall electrification of space heating in service buildings. It

appears that hotels and restaurants were able to become more efficient compared to the other branches, in terms of fuel use per square meter between 2000 and 2022.

Figure 61 : Fuel consumption by square meter by branch (2000-2022)

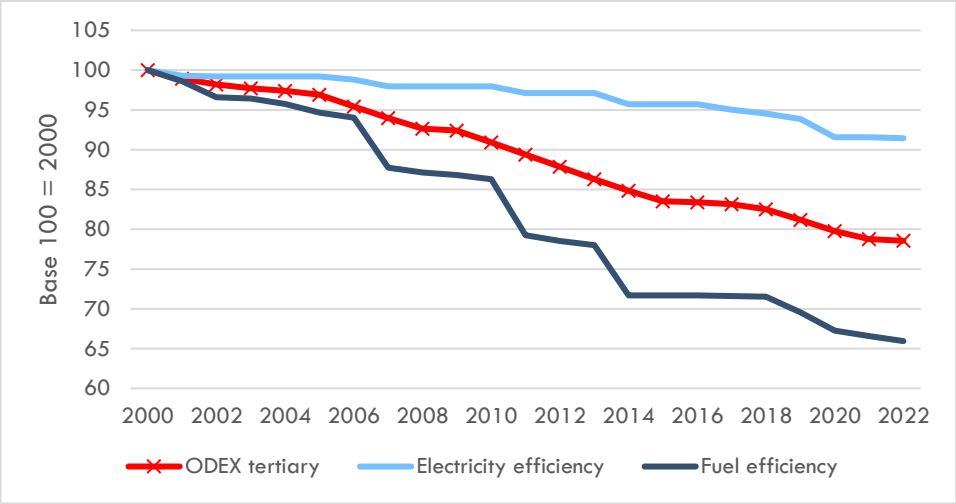


Source: ODYSSEE

3.4.3.3 Technical energy efficiency in the service sector (ODEX)

The energy efficiency index for services is built based on the electricity consumption per employee and on the fuel consumption per square meter. These two indicators are calculated for the 6 branches and combined into a single ODEX that estimates energy efficiency gains in the sector. According to Figure 62, energy efficiency in services improved by 21% between 2000 and 2022. This is mainly due to large gains of more than 30% in terms of fuel consumption per square meter of service buildings. However, although some branches saw their unit electric consumption slightly increase overtime, the overall technical electricity efficiency decreased on the same period to 91% of its 2000 level.

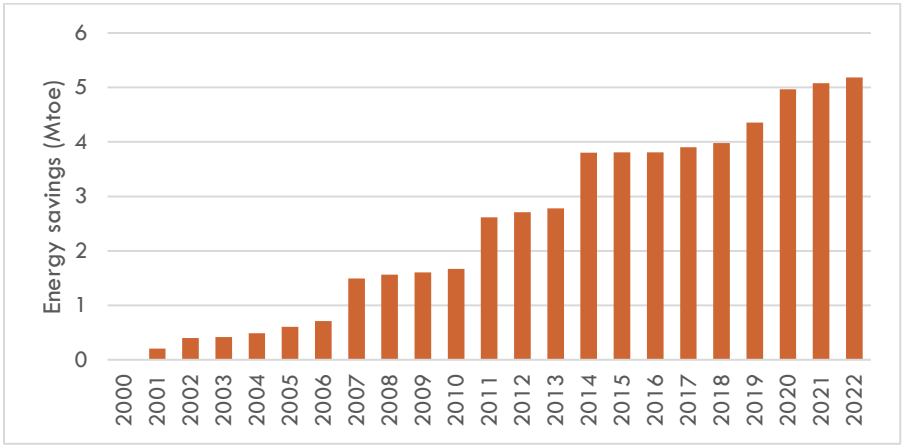
Figure 62 : Technical energy efficiency index for the service sector (2000-2022)



Source: ODYSSEE

These improvements in both electricity and fuel efficiency generated energy savings cumulating to 5,2 Mtoe in 2022 for the entire 2000-2022 period. As the smallest energy consumer, the service sector inherently makes smaller savings compared to other sectors.

Figure 63 : Cumulated annual energy savings in the service sector (2000-2022)

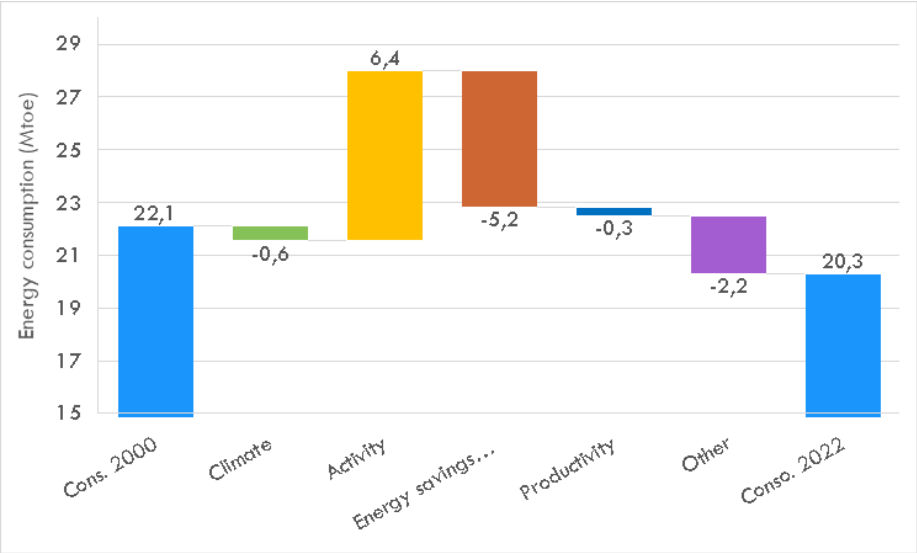


Source : ODYSSEE

3.4.3.4 Drivers of consumption variation in the service sector

As noted earlier, overall energy consumption in the service sector has fallen below its 2000 level after peaking in 2010. Figure 64 shows that the activity surplus between 2000 and 2022 has been the main driver of change in final energy consumption, with a +6,4 Mtoe increase. However, the sector's energy savings amounted to -5,2 Mtoe during the same period. Other factors have conducted to a lower energy consumption in 2022 than in 2000. For instance, the milder climate led and the relatively lower productivity, measured in value added per employee, led to a total -0,9 Mtoe decrease in consumption. The other category accounts mainly for the impact of behavioural effects on final energy consumption (-2,2 Mtoe).

Figure 64 : Drivers of consumption variation in the service sector (2000-2022)



Source : ODYSSEE

Annexe

The ODYSSEE database contains more than 180 indicators to help with monitoring and evaluating energy efficiency and CO2 emissions trends in all the sectors. This database encompasses several types of indicators, calculated at a macro-economic, sectoral, or sub-sectoral levels, with specific breakdowns by industry branch and by end-use for the building sector. The main indicators are:

- **Energy and CO2 intensities**, which relate the energy used (or CO2 emissions) by sector to macro- economic variables (GDP, value added, etc.).
- **Specific energy consumption** (or CO2 emissions), which measures the energy efficiency progress by comparing consumption to physical units (e.g. consumption per ton of steel, per car or per dwelling, gCO2/km).
- **Energy efficiency indices** (ODEX) evaluating energy efficiency progress by sectors and for the whole economy.
- **Energy savings** or the amount of energy saved through energy efficiency improvements measured by the ODEX.
- Adjusted indicators, which allow the **comparison** of indicators across countries (adjustments for differences in climate, general price level, fuel mix, industry and economic structure).
- Indicators of **diffusion**, which monitor the market penetration of energy-efficient technologies and practices.
- **Benchmark indicators**, which compare specific energy consumption of energy intensive products among countries.

Five data facilities are publicly accessible on the ODYSSEE page of the website (Figure 65). They are designed to provide an easy-to-use interface for policymakers, interested parties and non-expert users. The five specific data facilities are:

- **Key indicators**: enables the user to display 30 key energy efficiency indicators on a map showing country ranking.
- **Market diffusion**: monitors the progress in the market penetration of energy efficient technologies.
- **Decomposition**: displays the various factors behind changes in energy consumption in a given period (e.g. activity changes, structural changes, behaviour, efficiency improvement).
- **Comparison**: compares of the energy efficiency performance of a country with selected others by adjusted indicators.
- **Energy saving**: overview of historical and projected energy savings as compared to targets to be achieved.

Figure 65 : Data facilities for ODYSSEE

Source: https://www.odyssee-mure.eu/

The MURE database provides an overview of the most important energy efficiency measures in the EU Member States, Norway, Switzerland, and Energy Community Contracting Parties (Albania, Bosnia-Herzegovina, Montenegro, North Macedonia, Kosovo, Serbia, Georgia, Moldova and Ukraine). The database is structured by final energy consumption sectors (household, service, industry and transport) and also includes a general cross-cutting section. At the sectoral level, the focus is on single policy measures whereas programmes comprising several measures are mainly described in the cross-cutting section. The homogeneity of measure descriptions over sectors and countries is ensured by detailed guidelines. All measures are classified by key characteristics such as:

- their **status** (completed, on-going or proposed);
- their **date of implementation** and completion;
- their **policy type** (Mandatory information, mandatory standards, financial, fiscal, information/training, market-based instruments, others, general programme);
- the **targeted end-uses** and the main **actors** involved by the policy measures;
- their **semi-quantitative impact** (low, medium or high impact, based on quantitative evaluations or expert estimates);
- The way they address **energy poverty**;
- The way they include **energy sufficiency** components.

MURE provides two policy facilities (Figure 66) helping to showcase the data:

- **Successful policies**: aims at identifying successful and promising energy efficiency policies.
- **Policy mapper**: provides a visualisation of all policies addressing energy efficiency for a given end-use associated to the most relevant energy efficiency indicators.

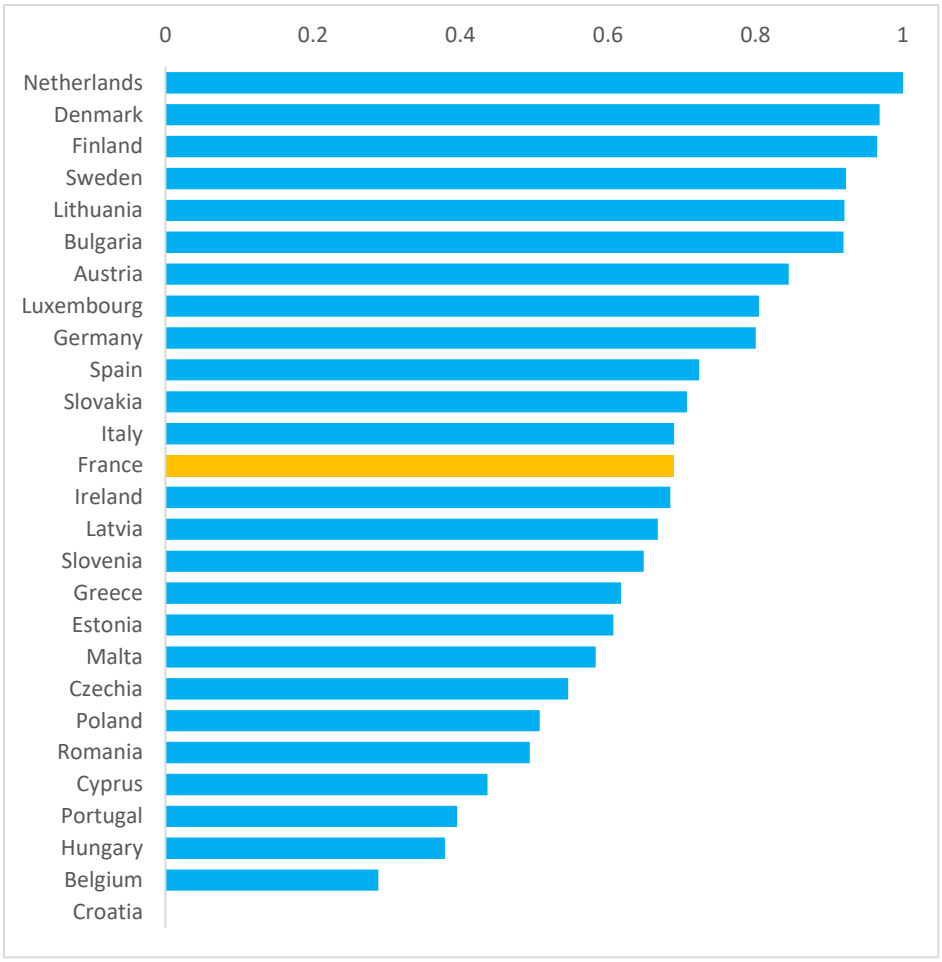
Figure 66 : Data facilities for MURE

Source : https://www.odyssee-mure.eu/

The **energy efficiency scoreboard**[9] is another data tool creating country rankings based on different energy efficiency criteria including energy efficiency level, energy efficiency progress and energy efficiency policies using information from both ODYSSEE and MURE databases. The 2022 scoreboard is presented in Section I.

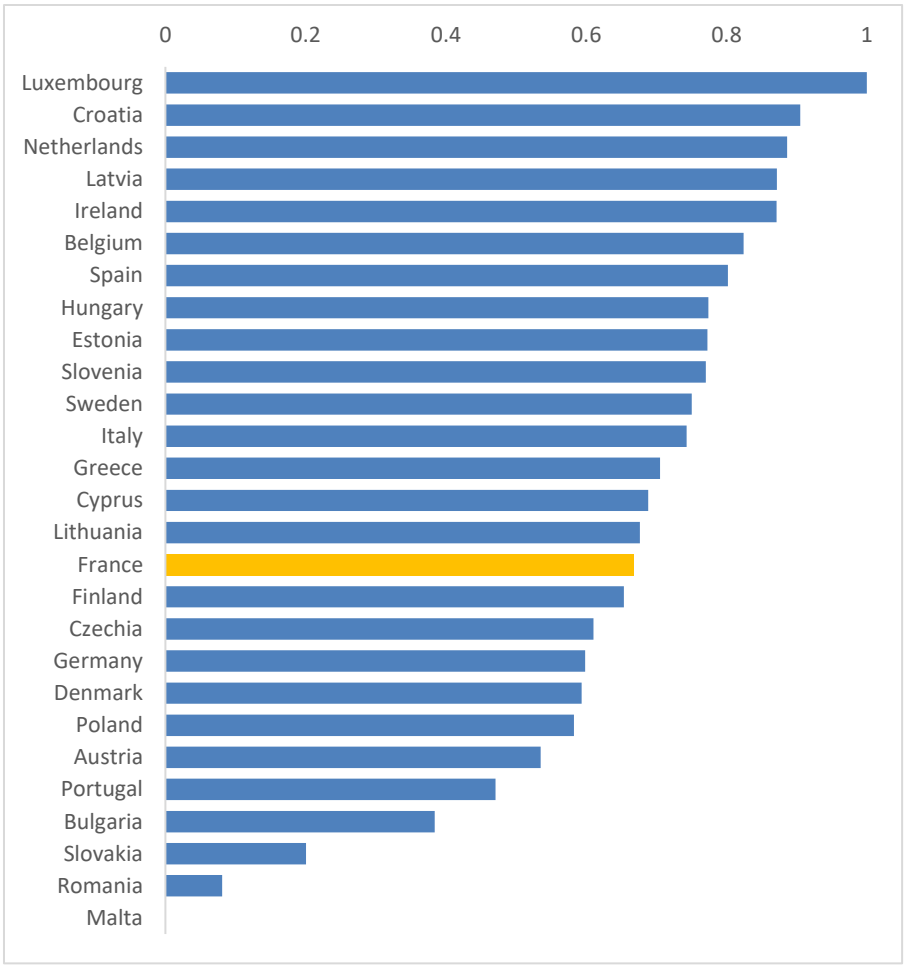
[9] https://www.odyssee-mure.eu/data-tools/scoring-efficiency-countries.html

Figure 67 : 2022 Energy efficiency level scoreboard



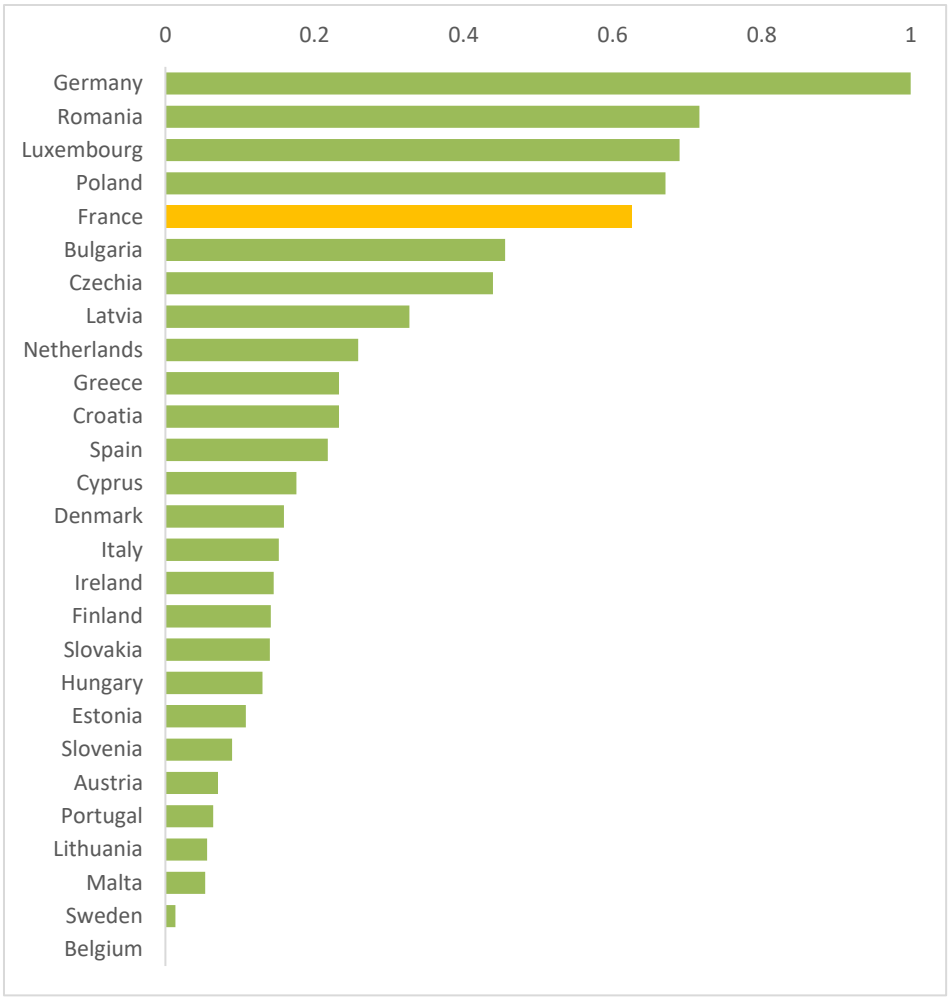
Source: ODYSSEE-MURE

Figure 68 : 2022 Energy efficiency progress scoreboard



Source: ODYSSEE-MURE

Figure 69 : 2022 Energy efficiency policy scoreboard



Source: ODYSSEE-MURE