Drivers of increasing energy consumption in Europe and policy implications

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Abstract

Two years ago, the EU appeared to be well on the way to meeting its 2020 energy efficiency targets. 2014 final energy consumption was lower than in any year since the 1980s and lower than the level required in 2020. Since then, energy consumption has risen in two consecutive years and looks set to have kept on increasing. If these short-term trends continue, the 2020 targets will be missed. In this context, this paper analyses the drivers of recent increases in energy consumption, using index decomposition analysis breaking down changes in an aggregate indicator and assigning the effects to a number of predefined factors. We rely on a decomposition approach that is widely used across Europe and has been developed over more than 20 years as part of the Odyssee-Mure project. The paper also draws upon discussions at an expert workshop organised by the European Commission. The paper does identify areas where energy efficiency policies could be strengthened. We suggest that more ambitious policies are needed to drive improvements in building fabric and space heating efficiency, and that a greater focus on measurement, verification and enforcement of policies would improve the effectiveness of existing policies.

1. Introduction

Energy consumption trends in Europe have been studied by scholars over several decades. Understanding how and why energy consumption changes is highly relevant for energy efficiency policies and their design.

There is a rich literature on identifying the factors that drive energy consumption in the EU: Marrero and Ramos-Real (2013) assessed trends in energy intensity, i.e. the relationship between final energy consumption and GDP, focusing on industry, construction, services and agriculture. In their study they assess the drivers of changes in energy intensity in the EU15 from 1991 to 2005 pointing to structural changes and energy efficiency as key drivers. Focusing on a much shorter period (2001-2008) Fernández González et al. (2014) studied the factors behind the change in aggregate energy consumption in the EU-27, also identifying differences between member states. Their study showed that improvements in energy efficiency in the EU-27 were not enough to overcome the pressure of European economic activity on aggregate energy consumption. Looking at how energy trends influence future projections Smit et al. (2014) analysed the difference between two official EU baseline projections, PRIMES-2007 (pre-recession and pre-Climate and Energy Package) and PRIMES-2013 (post-recession and including the new policies of the Package). They found that the key factors in the differences between the two projections were the economic recession and the EU Climate and Energy Package. Showing that the EU as a whole already achieved their 2020 energy efficiency target in 2014, Bertoldi et al. (2016) evaluated energy consumption data for the period 2000-2014. Their assessment suggested that the EU was well on track to delivering its energy efficiency targets.

The most recent study assessing EU energy trends has been carried out by Reuter et al. (2019). Applying decomposition analysis to the EU28 and the period 2000-2015 they concluded that final energy consumption in the EU28 is primarily influenced by an increase in energy efficiency in industry followed by households. Similar to the Bertolid et al. (2016) study the results from Reuter et al. (2019) suggested that the 2020 targets were achievable given past improvements in energy efficiency.

However, in more recent years energy consumption in the EU28 has been increasing and it is now unlikely that the 2020 energy efficiency targets will be met. We are not aware of any published research that assessed the drivers behind this increase. This paper is addressing this issue and answers two overarching questions. The first question is: why is EU energy consumption growing? To answer this, the paper presents recent trends in primary and final energy consumption, focussing analysis on final energy consumption in the four main end-use sectors:

transport; industry; residential; and services. It examines trends in the drivers of energy consumption at sector and end-use level, including through the presentation of results from decomposition analysis using the Odyssee-Mure decomposition tool, which isolates efficiency gains over time (Odyssee-Mure, 2018).

The second overarching question is: what are the policy implications? Drawing upon the analysis of the first question, the paper presents recommendations for those planning to achieve future energy efficiency targets. The recommendations relate to policymaking, policy implementation, and the tracking of progress through both policy evaluation and final energy consumption modelling. This particularly important as various studies have shown that there is still significant potential for energy efficiency and reducing energy consumption in Europe (see Knoop and Lechtenböhmer (2017) for a comprehensive review).

2. Methodology

2.1 Data on energy consumption

The data on energy consumption used are obtained from Eurostat (European Statistical Office). Eurostat is a Directorate-General of the European Commission located in Luxembourg. Its main responsibilities are to provide statistical information to the institutions of the European Union (EU) and to promote the harmonisation of statistical methods across its member states and candidates for accession as well as EFTA countries. The methodology Eurostat employs for collecting energy data is described in detail on the Eurostat website (https://ec.europa.eu/eurostat/web/energy/methodology). National statistical authorities have a clear legal mandate to collect information for European statistical purposes. These data are compiled by Eurostat and published in various data tables.

2.2 Index decomposition analysis

Index decomposition analysis is widely used by researchers to understand changes in a specific variable. This is done by breaking down changes in an aggregate indicator and assigning the effects to a number of predefined factors. There is no consensus about the most appropriate decomposition methodology (Ang 2004) and this paper does not attempt to resolve the ongoing debate about this subject. We rely on a decomposition approach that is widely used across Europe and has been developed over more than 20 years as part of the Odyssee-Mure project. The Odyssee-Mure approach has been used to assess European (e.g. Reuter et al. 2019, 2017) and national energy trends (e.g. Norman 2017, Schlomann et al. 2014).

In order to identify and quantify the importance of the drivers of energy consumption the paper relies on analytical tools developed as part of the Odyssee-Mure project. Odyssee-Mure provide a decomposition tool to explain the variation in energy consumption over a given period. This tool allows decomposition into various explanatory factors, among which the most important ones are activity (economic output in the industry and services sectors, and passenger and freight travel in the transport sector), energy savings and, particularly in short-run analyses, the weather. Other factors are also included (e.g. population growth, larger dwellings, decreased household size and increased appliance ownership in the household sector, shifts between modes in the transport sector and changes in the structure of the industrial sector). The methodology of the decomposition tool is explained in detail in Odyssee-Mure (2017). The input data used by the decomposition tool are explained comprehensively in Odyssee-Mure (2016). The primary data behind the tool can be accessed through the Odyssee-Mure website (http://www.odyssee-mure.eu/).

2.3 Workshop

A workshop on energy consumption trends, hosted by the European Commission, Directorate General for Energy (DG ENER), Energy Efficiency Unit on 25th May 2018, provided direction on the elements of consumption upon which to focus, and the drivers upon which to concentrate research effort. The European Commission, motivated by the increase in energy in European Union energy consumption since 2014, assembled experts in the fields of energy efficiency to discuss recent trends in each of the main energy consuming sectors: transport, industry, residential and services. Participants included representatives of the European Commission including the Joint Research Centre, national energy ministries and agencies, international energy agencies, academia, research consultancies and energy companies.

3. Background

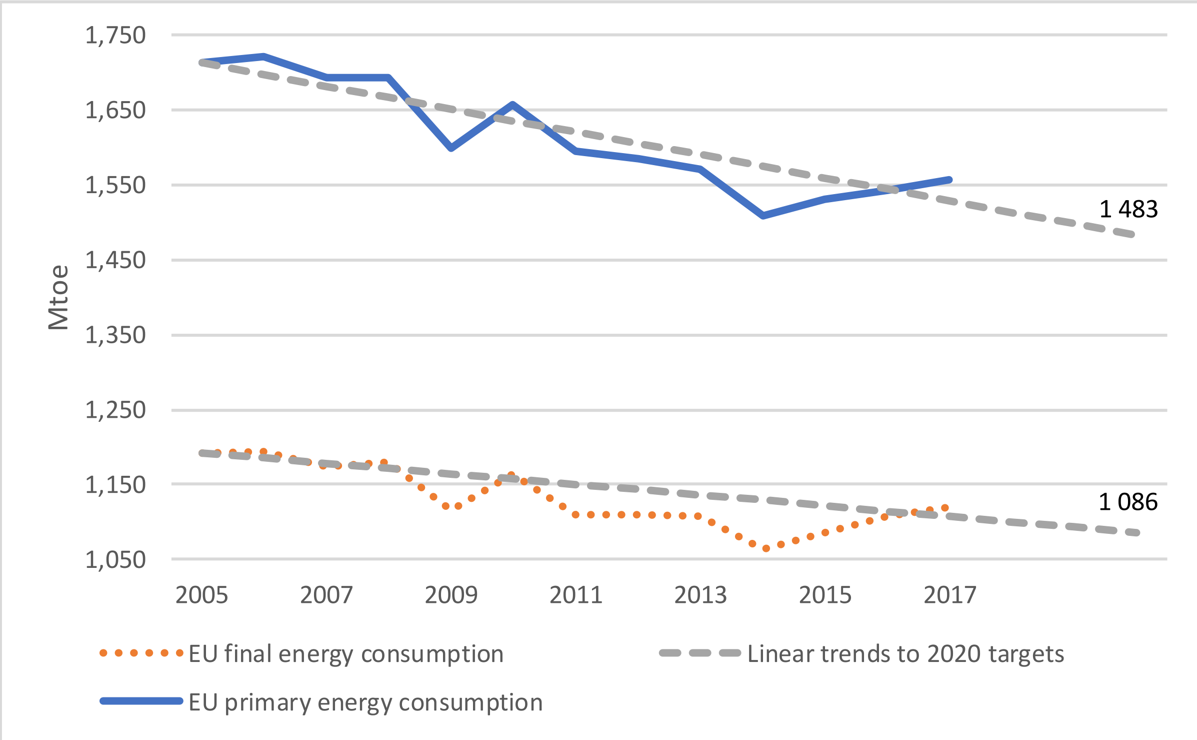
Between 2005 and 2014, European Union primary energy consumption (PEC) fell by 12 percent and final energy consumption (FEC) by 11 percent. 2014 FEC was below the level required by the EU's energy efficiency target in 2020, and PEC was well below the linear trend from 2005 to the 2020 target level.[1] In early 2017, faced

[1] The 2020 target involves lowering the EU's final energy consumption to at most 1086 Mtoe, and its primary energy consumption to at most 1483 Mtoe.

with the latest data from 2014, it would have been easy to be complacent and imagine that the 2020 targets would be easily achieved.

Two years later, the situation is very different. Between 2014 and 2016, FEC rose by 4.2 percent and PEC grew by 2.3 percent. To meet the energy efficiency targets, FEC must fall by an average of 0.5 percent per year and PEC by 1.0 percent per year between 2016 and 2020 (Figure 1). However, preliminary data suggest that both primary and final energy consumption rose again in 2017.[2]

Figure 1: EU primary and final energy consumption and linear trend from 2005 to 2020 targets



Source: Eurostat Energy Balance May 2018, http://ec.europa.eu/eurostat/documents/38154/4956218/ENERGY-BALANCES-May-2018-edition.zip/310265d9-6adf-45aa-ba41-2dce8e5f78eb

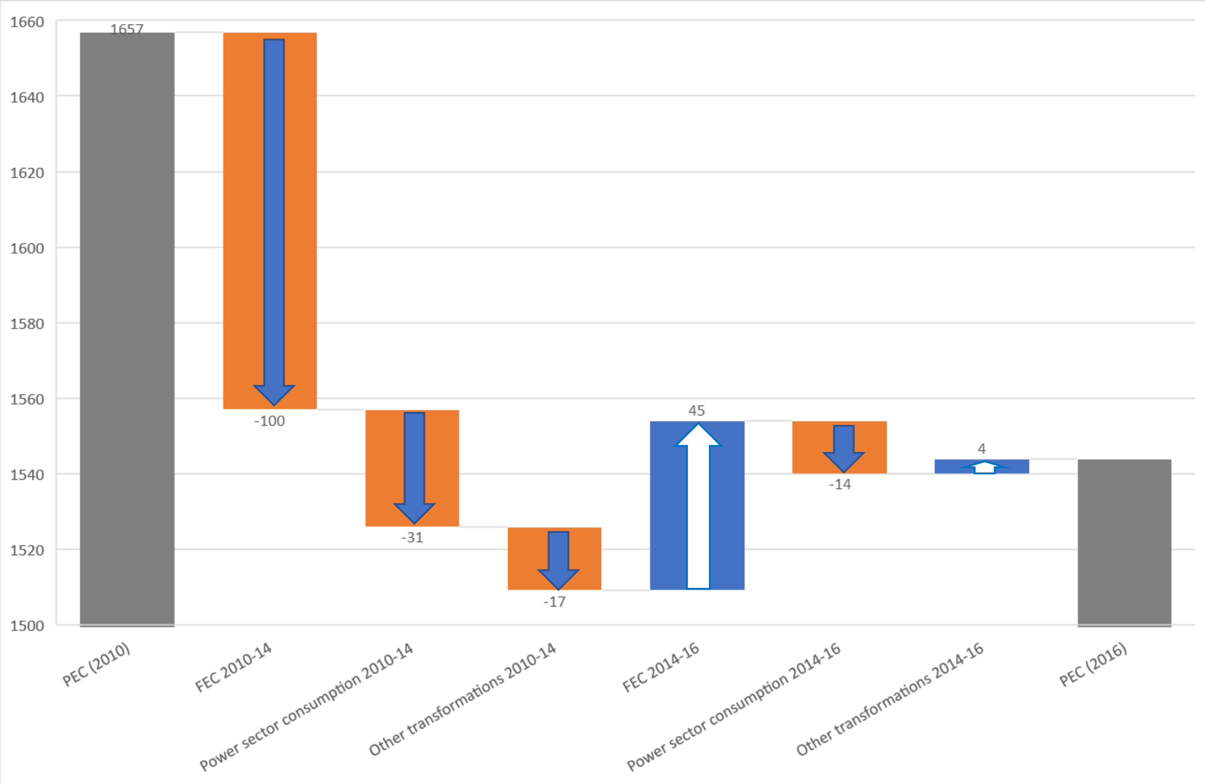
While both primary and final energy consumption have increased since 2014, it is the increase in FEC that is most interesting to analyse.[3] Changes in PEC can be decomposed into three key drivers: changes in FEC, changes in power sector energy consumption, and changes in other transformations (e.g., in refineries). Decomposition analysis reveals that changes in FEC have been driving the changes in PEC. Decreases in FEC between 2010 and 2014 put significant downward pressure on PEC, whereas increases in FEC between 2014 and 2016 put upward pressure on PEC at an almost equal rate (Figure 2).

On the other hand, power sector energy consumption fell at the same rate between 2014 and 2016 as between 2010 and 2014, owing in the main to fuel switching from coal to natural gas, driven by lower gas prices. Increases in renewable electricity generation continued to exert downward pressure on power sector energy consumption but not to the same extent as between 2010 and 2014.

[2] Early Eurostat estimates of the energy balances indicate that the primary and final energy consumption will rise slowly in 2017 as compared to 2016: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_balances_-_early_estimates

[3] PEC includes all gross inland energy consumption except that used for non-energy purposes, such as for producing plastics. FEC only includes energy consumed by end users, such as households and industry, and excludes energy used by the energy sector, e.g. the power sector and refineries.

Figure 2: Factors driving changes in EU primary energy consumption, 2010-16



Source: Odyssee-Mure, 2018, http://www.indicators.odyssee-mure.eu/decomposition.html.

The increases in FEC between 2014 and 2016 have been seen across all the main end-use sectors, with the biggest absolute increases in the transport and residential sectors (Table 1). However, the drivers of the increases are not uniform. Accordingly, the next section examines the picture at the whole economy level before turning to individual sectors.

Table 1. Increases in EU final energy consumption, million tonnes of oil equivalent (Mtoe), 2014 to 2016

Sector	Absolute increase (Mtoe)	Percentage increase
Transport	15.0	4.3%
Industry	0.9	0.4%
Residential	19.8	7.4%
Services	9.1	6.4%

4. Drivers of growth in final energy consumption

Many factors influence FEC, some of which such as economic growth, population growth, and outdoor air temperature are measured using well-established statistical techniques, while others, such as technical energy efficiency improvements, behavioural factors, and the impact of energy efficiency policies, are not.

Decomposition analysis makes it possible to identify the impacts of factors that can be measured; the remaining change in "adjusted energy" intensity is a proxy for energy efficiency improvements.[4] At the whole economy level, three factors are particularly relevant:

1. activity growth (increases in economic output by the industry and services sectors and increases in the amount of passenger and freight transportation);
2. energy efficiency improvements (changes in the energy intensity of end uses); and on a year-to-year basis

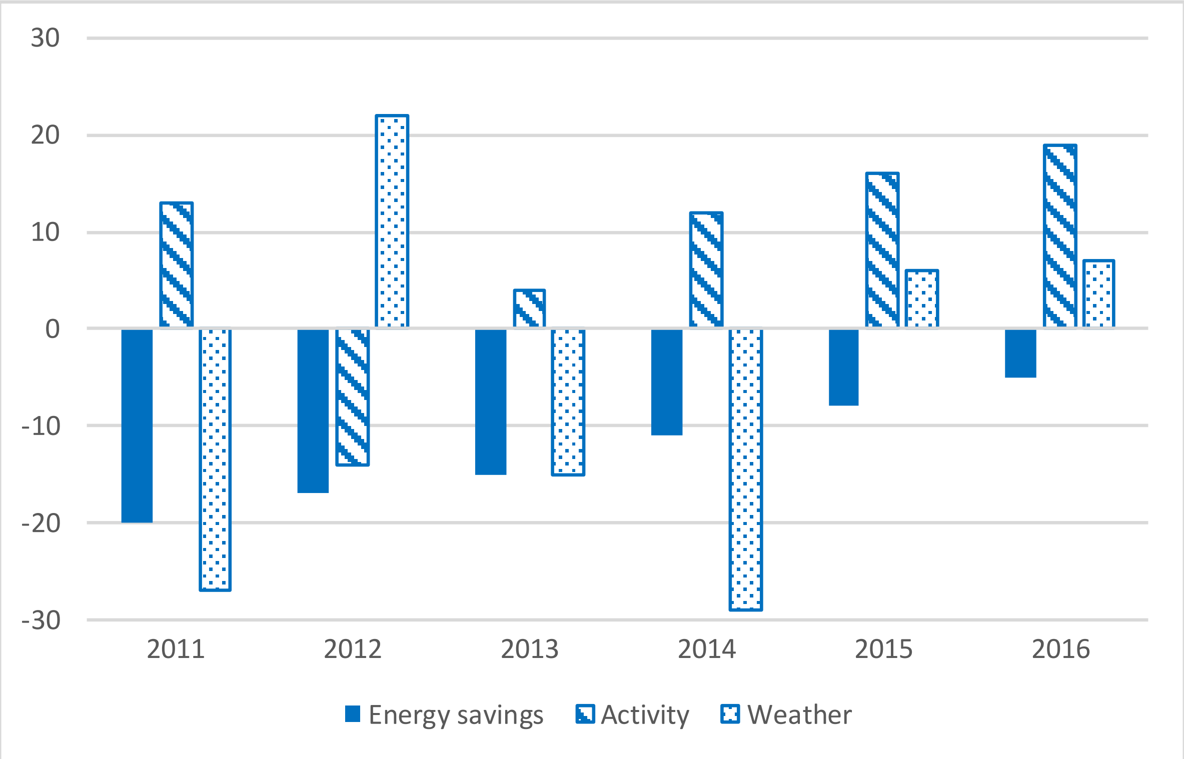
[4] The Odyssee-Mure project chooses to further distinguish between technical energy efficiency improvements and behavioural factors by assuming that technical efficiency gains cannot be reversed. This means that, where the adjusted energy intensity change is negative, this change is not ascribed to efficiency losses. Instead, it is allocated to behaviour change (e.g., higher indoor temperatures) or capacity utilisation (e.g., freight transport operating with smaller loads during periods of economic recession). The Odyssee-Mure methodology is discussed here: http://www.odyssee-mure.eu/publications/other/odex-indicators-database-definition.pdf.

3. the weather (changes in the severity of winter temperatures).

Previous studies have highlighted the importance of activity growth and energy efficiency as the two most important factors affecting energy consumption, particularly over long periods of 10 years or more (IEA, 2018). These studies tend to show that structural factors (changes in the relative size of industrial sectors and shifts between transport modes) have had a relatively small impact on changes in energy consumption. The impact of the weather is important on a year-to-year basis, particularly in regions such as the European Union with considerable variation in winter temperatures (Honoré, 2018). Over longer periods, the two dates between which the decomposition analysis is undertaken become progressively less important as factors that tend to accumulate over time take effect, notably economic output growth and energy savings.

Activity growth has picked up since the recession centred around 2012 and this is reflected in the whole economy decomposition, which shows activity growth exerting more upward pressure on energy consumption over time. The weather is an unpredictable variable, year-on-year, with the cold winter of 2012 exerting strong upward pressure on energy consumption and the mild winter of 2014 causing energy consumption to drop markedly, to its lowest level since the twentieth century. Since 2014, the weather has combined with activity growth to drive up energy consumption. Worryingly, energy efficiency gains (as estimated using the Odyssee-Mure decomposition tool) have become progressively smaller in each year of the current decade, meaning that the impact of economic growth and the colder weather in 2015 and 2016 was not offset to any great extent by improvements in efficiency (Figure 3). Previous studies have assumed that the magnitude of energy savings isolated by decomposition analysis are linked to the strength of energy efficiency policies (Reuter et al. 2019). While care should be taken when interpreting the energy savings implied by the decomposition, this analysis should provide policymakers with cause to consider the ambition and effectiveness of their energy efficiency policy frameworks.

Figure 3: Key factors driving changes in EU final energy consumption, 2010-16



Source: Odyssee-Mure, 2018, http://www.indicators.odyssee-mure.eu/decomposition.html.

An important point to note is that decomposition analysis does not provide insights into the impact of the rebound effect on changes in energy consumption. The direct rebound effect, whereby energy efficiency improvements make energy services cheaper, leading to increases in their consumption, will reduce the efficiency gains that are estimated using decomposition analysis. Factors related to the rebound effect can be isolated where data are available, for example on variables such as product ownership, however quantifying the rebound effect is both very difficult and estimates are hotly disputed (Sorrell, 2007). The indirect rebound effect, whereby energy efficiency improvements both enable consumers to spend monetary savings on other goods and services and lead to reductions in energy prices, will manifest itself in increased activity levels. This paper, however, does not provide any evidence on the size or evolution over time of the rebound effect on activity levels and efficiency gains.

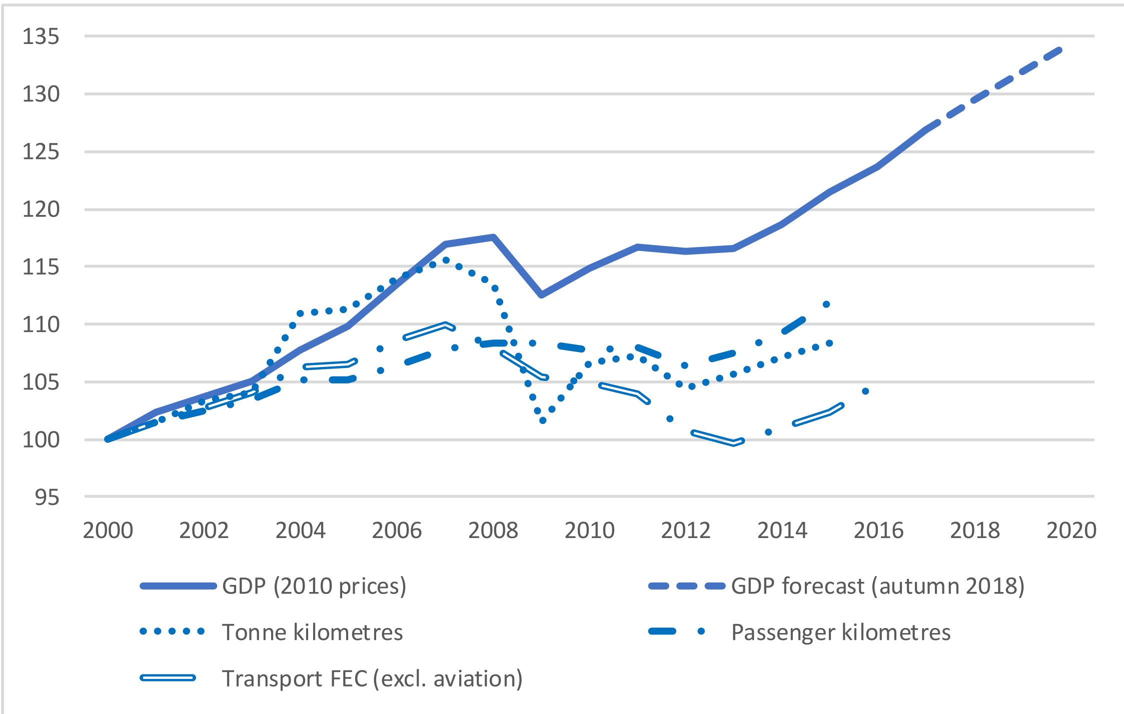
So far policy makers have neither identified an effective strategy to minimise the rebound effect (Vivanco et al. 2016) nor is there a consensus whether this would be desirable. Whilst the magnitude of the rebound effect from adopting energy efficiency measures in developed countries are now widely researched there is less evidence on the impact of increasing self-generated renewable energy. An ongoing research project in Germany is currently assessing the relevance of the rebound effect in this area (www.ee-rebound.de). However, there is not sufficient evidence to make any claims about the potential impact of the rebound effect on energy consumption in Europe and further research would be required to answer this question.

3.1 Drivers of growth in transport sector final energy consumption

The transport sector accounts for around one-third of EU28 FEC. Transport energy consumption (including air transport) is influenced by three main factors: transport activity levels (the amount of passenger kilometres (pkm) and freight tonne kilometres (tkm)); the modes of transport used; and the efficiency of those modes. Since 2012, increases in activity levels have been the dominant factor in the transport sector, while the split between transport modes has been reasonably stable and efficiency gains have been relatively small.

The increase in passenger and freight transport is strongly correlated with the health of the economy. Passenger kilometres fell between 2009 and 2012 and have been rising since then, reaching a new high of 4.7 trillion pkms in 2015. The increase of 2.6 percent in pkms in 2015 was the fastest growth rate in at least the last 20 years, a year in which gross domestic product (GDP) growth was accompanied by falling prices for diesel and gasoline. Freight transportation grew by 4 percent between 2012 and 2015 and, with the EU Commission forecasts predicting steady if slightly slowing growth to 2020 (European Commission, 2018), the likelihood is that transport activity will continue to push up energy consumption in the sector (Figure 4).

Figure 4: Indices of gross domestic product (GDP), activity and transport sector energy consumption



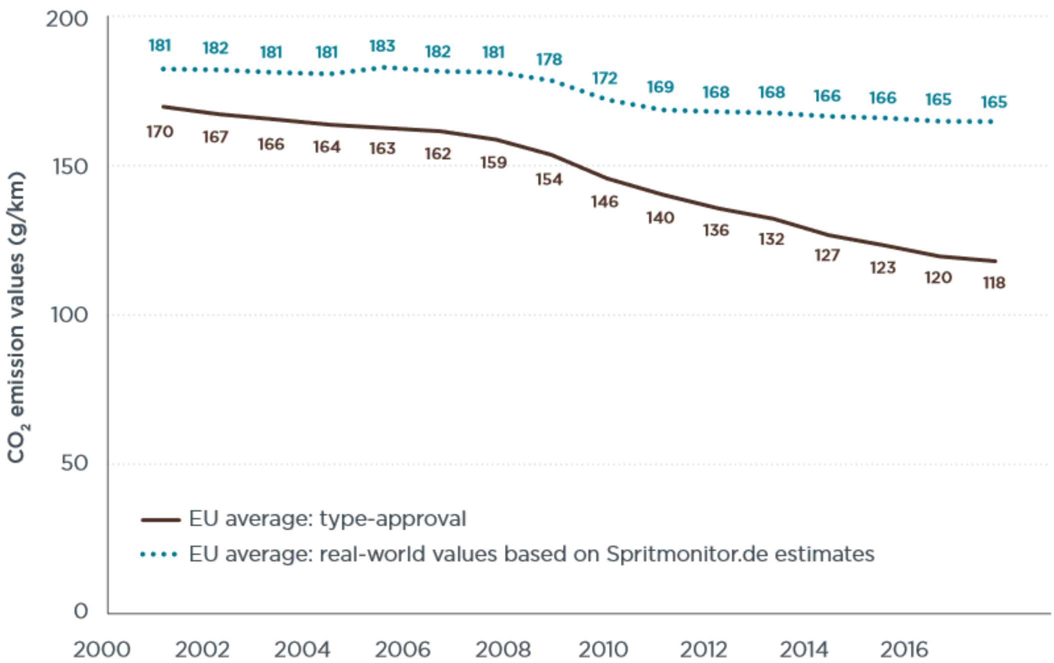
Sources: Eurostat GDP and main components, http://ec.europa.eu/eurostat/estat-navtree-portlet-prod/BulkDownloadListing?file=data/nama_10_gdp.tsv.gz; European Commission, European Economic Forecast Autumn 2018, https://ec.europa.eu/info/sites/info/files/economy-finance/ecfin_forecast_autumn_081018_overview_en.pdf; European Commission Statistical Pocketbook 2017, https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2017_en; and Eurostat Energy Balance May 2018, http://ec.europa.eu/eurostat/documents/38154/4956218/ENERGY-BALANCES-May-2018-edition.zip/310265d9-6adf-45aa-ba41-2dce8e5f78eb

Changes in the share of transportation energy consumption between different modes have not had major impacts on energy consumption in recent years. However, air travel has been growing at a faster rate than any other mode, notably since 2013 (European Commission (DG MOVE) Statistical Pocketbook, 2017). On average, planes use more fuel per pkm than any other transport mode, while high-speed rail is seven times more efficient on an energy per pkm basis on routes which are likely to have comparable travel times (International Energy Agency, 2017). A continuation in this trend would put further upward pressure on transport energy consumption.

Energy efficiency gains have been relatively small over the current decade. This is in part owing to a lack of policy intervention in the freight sector until recent Heavy-Duty Vehicle legislation[5] which has yet to have an impact. The lack of progress in the passenger vehicle sector comes despite the average carbon dioxide emissions targets that manufacturers must meet across their sales of new vehicles. Real world emissions from new light-duty vehicles have decline by significantly less than the targets would imply. The disparity between real-world emissions and type-approval emissions generated by test laboratories has grown markedly since 2007, when real-world emissions were on average 16 percent higher. In 2016, the gap stood at 40 percent (Figure 5).

The effectiveness of new vehicle carbon dioxide targets in driving efficiency gains has been further undermined by the continuing increase in the popularity of larger vehicles such as sports utility vehicles (SUVs). The increase in new vehicle registrations more generally should have a positive impact on efficiency, as more efficient vehicles replace older, less efficient stock. However, the increasing concentration of new registrations in the SUV segment, which accounted for 26 percent of all new vehicle sales in 2016, is putting upward pressure on transport sector FEC. This resulted despite the targets being set in terms of average grams of carbon dioxide per kilometre across a manufacturer's sales. SUVs have a larger wheel base, meaning that, as they increase their market share, manufacturers targets soften to accommodate changing consumer preferences for bigger vehicles, leading to more energy consumption across the new vehicles fleet.

Figure 5 Real-world vs type-approval CO2 emission values of new EU passenger cars



Source: ICCT White Paper, From Laboratory to Road (2017), https://www.theicct.org/sites/default/files/publications/Lab-to-road-2017_ICCT-white%20paper_06112017_vF.pdf drawing upon Spritmonitor.de real world estimates and European Environment Agency type-approval data.

3.2 Drivers of growth in industry sector final energy consumption

The industry sector accounts for around one-quarter of EU final energy consumption. Industry sector energy consumption is influenced by activity levels (output growth), industrial structure (shifts in production between and within industry subsectors), and the efficiency with which energy is used. During the recent upturn in economic growth, industrial sector energy consumption has remained fairly flat, as the impact of production increases has been offset by efficiency gains and the structure of the sector has changed very little. This pattern is similar to the situation seen in the period of growth between 2003 and 2007, immediately prior to the great financial crisis.

The pick-up in industrial production volumes since 2013 has been accompanied by only a very small rise in energy consumption. The relative unresponsiveness of energy consumption to rising production is typical of the pattern seen in recent years. In the current century, only in the recovery year of 2010 did industry sector energy consumption rise by more than 2 percent and overall sector energy consumption had fallen by 17 percent by 2016, whereas production had risen by 7 percent. Nevertheless, a 3.4 percent increase in industrial production in 2017 is likely to have pushed up sector consumption a little (Figure 6).

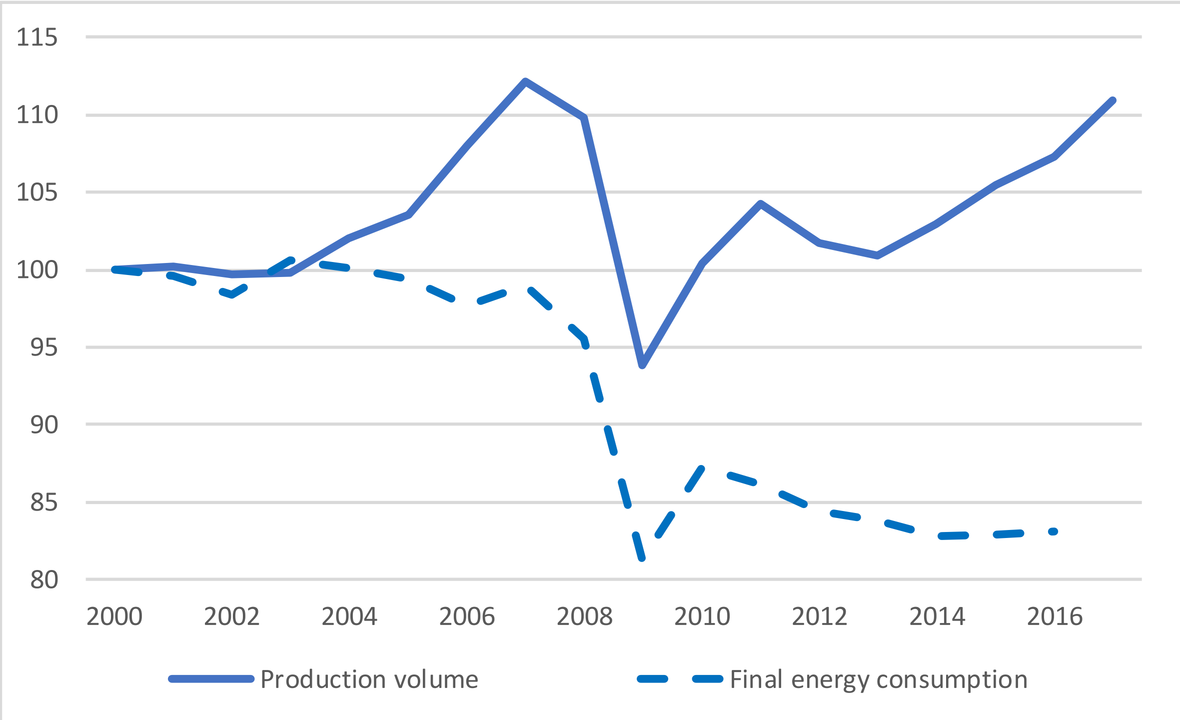
[5] CO_2 emission standards for heavy-duty vehicles in the EU were proposed in 2018 by the European Commission. The proposed targets would take effect during the 2020s: https://ec.europa.eu/clima/policies/transport/vehicles/heavy_en

Amongst the industrial sectors, production growth since 2013 has been strongest in the relatively less energy-intensive transport equipment subsector. The chemicals sector and the non-metallic minerals sector also expanded production by more than 10 percent between 2013 and 2017. Overall, structural change appears to be having a relatively benign impact on energy consumption, with all industrial sectors expanding in 2017.

Efficiency improvements (as calculated using the Odyssee-Mure decomposition tool) have picked up since 2013 too, following a period of relative stagnation between 2007 and 2013. It is these efficiency improvements that have been largely responsible for offsetting the impact of higher industrial production levels. The return to an efficiency improvement of around 2 percent per year, similar to that seen before 2007, may well be owing to increased investment levels seen during periods of economic growth. Investment leads to the replacement of older, less efficient equipment with newer more efficient versions, driven in part by minimum standards for the efficiency of motor driven systems and other equipment.

The extent to which policy, through standards, audit requirements, carbon pricing, and other national programmes such as sector voluntary agreements, has led to efficiency improvements is unclear and deserves further analytical attention.

Figure 6 Indices of EU industrial production volumes and final energy consumption

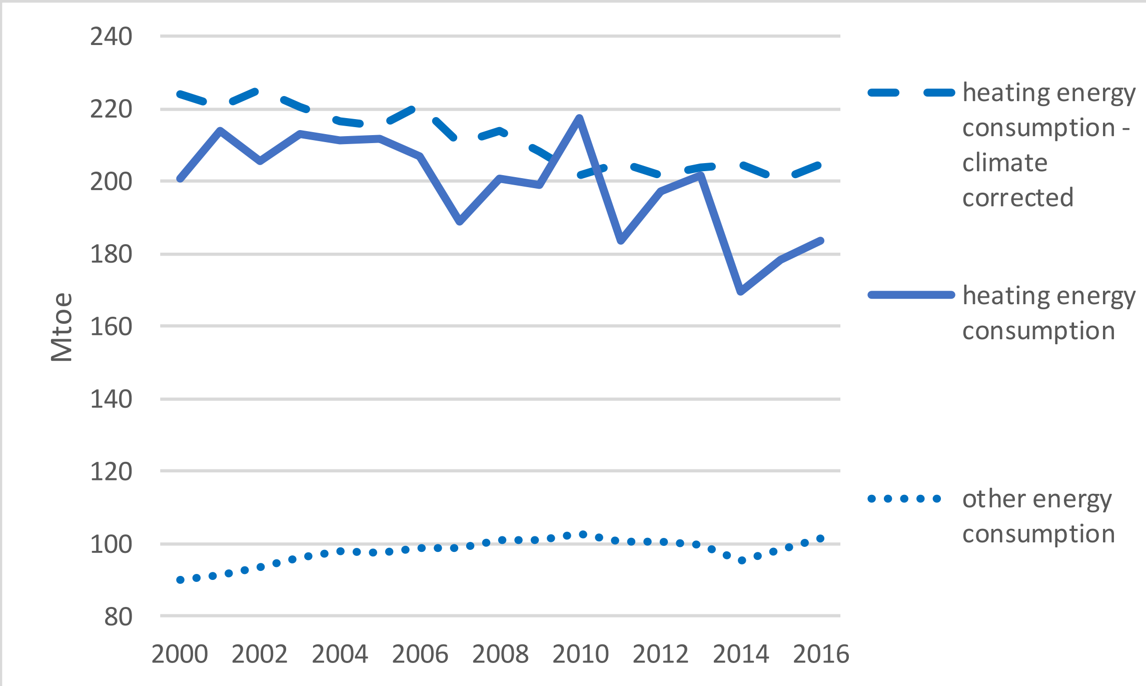


Note: Production volumes for NACE (Nomenclature for economic activity in the EU) codes B and C: mining & quarrying and manufacturing.
Source: Eurostat Production in Industry, http://appsso.eurostat.ec.europa.eu/nui/setupDownloads.do?p=6d425b62-a7cf-4471-8415-da35339f2f87-1532191555478; and Eurostat Energy Balance May 2018, http://ec.europa.eu/eurostat/documents/38154/4956218/ENERGY-BALANCES-May-2018-edition.zip/310265d9-6adf-45aa-ba41-2dce8e5f78eb

3.3 Drivers of growth in residential sector final energy consumption

The residential sector accounts for around one-quarter of EU final energy consumption. Residential sector energy consumption is influenced by demography, lifestyle factors, the efficiency with which energy is used, and the weather.

Figure 7 EU residential space heating energy consumption and other energy consumption



Source: Eurostat and Odyssee-Mure data supplied by European Commission

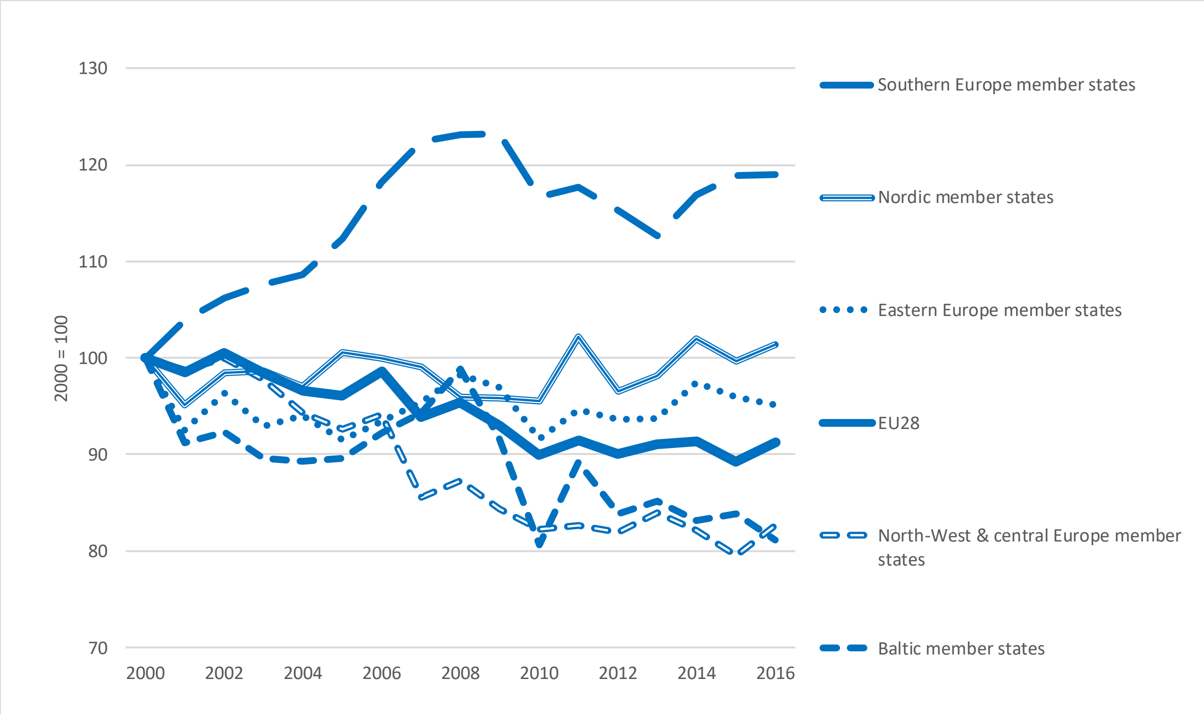
Amongst these factors, the weather has by the far the biggest impact on a year-to-year basis, given that around two-thirds of residential energy consumption is used for space heating, and winter temperatures can vary considerably. The data on space heating final energy consumption consist of the energy content of the fuels directly combusted, such as natural gas, oil products and solid fuels, and the electricity consumed by heating equipment. The ambient heat captured from the environment by buildings and heat pumps is not included in these data.

Demographic and lifestyle factors have tended to push up residential energy consumption over time. As populations have increased, the number of dwellings has grown more quickly, the average amount of floor area per dwelling has risen, indoor temperatures have increased, and appliance ownership has grown. However, these factors, where they can be measured, have been fairly weak during the current decade, with lower population growth and building construction and slow appliance ownership growth until the pick-up in consumer spending in 2014. Natural gas and electricity prices rose significantly over the first half of the current decade too, suggesting that it is unlikely that comfort taking, in the form of higher indoor temperatures, had a particularly strong impact on energy consumption during this period.

The large fall in residential energy consumption between 2010 and 2014 can be almost entirely explained by the difference in winter weather conditions in these two years, with 2010 having an extremely cold winter and 2014 a very mild winter. Similarly, the increase in residential energy consumption since 2014 has coincided with progressively colder winters. Indeed, between 2010 and 2016, weather-corrected space heating consumption has barely changed (Figure 7). This suggests that energy efficiency progress has been sufficient merely to offset the relatively weak demographic and lifestyle trends in the current decade (Odyssee-Mure, 2018), with the weather accounting for almost all of the difference in residential space heating consumption since 2010.

The stability of EU28 weather-corrected space heating consumption is in stark contrast to the previous decade, during which there was a fall of 10 percent in this series. At the regional level, different trends for weather-corrected energy consumption emerge, but in most cases, most of the significant changes occurred prior to 2010, with more stable patterns appearing during the current decade. In the older member states of northwest and central Europe, weather-corrected heating energy consumption fell by 18 percent between 2000 and 2010, since when it has remained at or around the same level. In southern Europe, weather-corrected heating energy consumption increased by 23 percent between 2000 and 2009. Following a period of reduced consumption during the great financial crisis and subsequent recession, this measure of consumption had recovered by 2016 to be 19 percent higher than in 2000 (Figure 8).

Figure 8 EU weather-corrected residential space heating energy consumption by region



Source: Eurostat and Odyssee data supplied by the European Commission.

The older member states of northwest and central Europe accounted for 60 percent of EU28 heating energy consumption in 2016 and were the main drivers of the fall in weather-corrected space heating consumption during the decade to 2010. Germany saw the biggest fall in this measure of consumption during this period (30 percent). The German reductions appear to have been driven by the switch from the use of heating oil to other more efficient heat carriers, particularly natural gas and district heating. This decade also saw the market for condensing gas boilers grow, meaning that new boilers were replacing significantly less efficient models. Since 2007, the shift away from oil has slowed considerably – in 2000, the share of heating oil in residential heating consumption in Germany stood at 36 percent. By 2007, its share had fallen to 25 percent, while it was still at 24 percent in 2013. Across the EU, the shift away from heating oil also occurred in the period to 2010.[6] Without another shift towards more efficient heating technologies, such as heat pumps, and a significant increase in the renovation rate of the existing EU building stock, weather-corrected space heating energy consumption appears likely to remain fairly flat. The current renovation rate, estimated to be around 1.2 percent per year (Zebra 2020, 2018), appears to only be fast enough to offset the impacts of demography and lifestyle changes. The heat pump market did pick up in 2015 and 2016, growing at 13% and 12% per year respectively (EHPA, 2018). However, growth will have to quicken considerably to have a transformative effect on the efficiency of EU space heating; in 2017, less than 2% of EU final energy demand for space heating and cooling was met using heat pumps (EHPA, 2019).

Residential energy consumption for end-uses other than space heating also increased between 2014 and 2016, at a rate not seen since the early 2000s. This increase followed a decade from 2004 to 2014, during which consumption remained fairly flat. The increase in energy consumption since 2014 does not appear to be driven by the consumption of large household appliances. The increase in the number of large appliances (fridges, freezers, dishwashers, washing machines, and dryers) was strong between 2000 and 2010 but has not re-emerged as an important factor since 2014. Meanwhile, the efficiency of large appliances has continued to improve, and the recent pick-up in consumer spending should have sped up the turnover of the stock of large appliances, improving efficiency levels.

With the energy consumption of large appliances and lighting declining, the relative importance of smaller appliances to residential (and service sector) energy consumption is increasing. These devices and equipment – e.g., computers, coffee makers, phone chargers, home security systems, escalators – do not consume large amounts of energy individually, but in aggregate they are becoming more important as the number of electricity-using products increases and their functionality expands. Both large and small appliances, including lighting, are now being sold with the capability to be connected (the "Internet of Things"), meaning that they are both

[6] Odyssee database, http://www.indicators.odyssee-mure.eu/energy-efficiency-database.html

performing more functions and, at least to some extent, are always on, drawing additional power to ensure that they are able to communicate with other devices on the network (McMahon, 2018). The extent to which new functionality will enable more energy savings, as a result of the ability to use interconnected devices as part of a smart system, to offset the increases in energy consumption required to power them is a matter of debate (Connected Devices Alliance, 2018). The United States Department of Energy estimates that primary energy consumption from "miscellaneous plug loads" will increase by 13 percent between 2016 and 2030 in the United States and by double that amount in the services sector. A similar increase in the EU would put upward pressure on energy consumption and may be behind the uptick in energy consumption in non-heating energy consumption between 2014 and 2016.

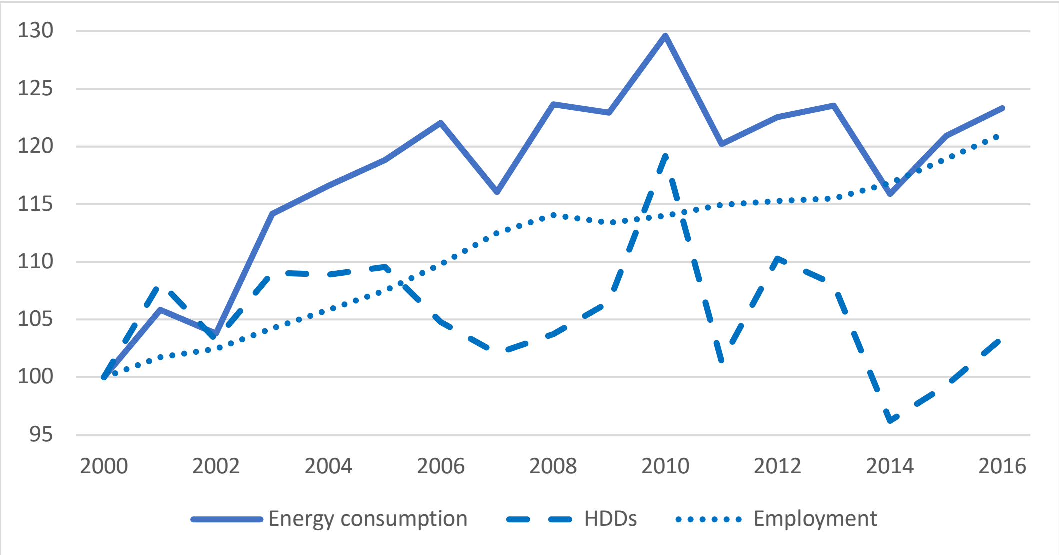
3.4 Drivers of growth in services sector final energy consumption

The services (or tertiary) sector accounts for around one-sixth of EU final energy consumption. Service sector energy consumption is influenced by activity levels within the sector, the efficiency with which energy is used, and the weather. Energy efficiency impacts are difficult to observe in the sector, owing to the paucity of data availability across all countries.

Data availability restricts the depth of analysis that can be undertaken. Time series data by services subsector are not available, meaning that structural changes within the sector cannot be adequately observed, with the sector treated as a whole in most analyses. Space heating is estimated to account for the largest share of overall energy consumption (44 percent in 2015), followed by "other electric uses" (24 percent), which includes information technology.

Given the non-energy intensive nature of the outputs produced by the services sector, employment in the sector is a better indicator than gross value added when examining the impact of activity on energy consumption. Periods of strong employment growth have been associated with periods of rising energy consumption (2002-07 and 2014-16). Given the strong link between employment and services sector energy consumption (Figure 9), continued strong growth in employment would be expected to push up consumption further. At the same time, a warm winter, such as that experienced in 2014, could cause consumption in the sector to fall (Figure 9).

Figure 9: Indices of EU tertiary sector energy consumption, employment, and heating degree days (HDD)



Source: Eurostat Energy Balance May 2018, http://ec.europa.eu/eurostat/documents/38154/4956218/ENERGY-BALANCES-May-2018-edition.zip/310265d9-6adf-45aa-ba41-2dce8e5f78eb and Eurostat data supplied by the European Commission.

4 Conclusion and Policy Implications

If the EU economy grows as forecast, it is unlikely that the 2020 energy efficiency targets will be met. Economic uncertainty, caused by Brexit, tensions over international trading arrangements and the slowdown of Chinese economic growth, does present risks to the EU economy. An economic downturn would put the EU back on track to meeting its efficiency targets; similarly, an extremely warm winter in 2020 could reduce space heating consumption enough to enable targets to be met. Whether these exogenous factors push energy consumption up or down, it is almost certainly too late to produce additional energy savings from energy efficiency policies before the end of 2020, over and above what is already expected to be delivered from existing and planned policies. Instead, there are a number of actions that could be taken to reduce the likelihood that, in 2029, economic growth does not put at risk the achievement of the 2030 targets.

4.1 Upping policy ambition levels

The realisation in 2018/19 that the 2020 energy efficiency targets may not be achieved highlights the need for policymakers to plan now to succeed in meeting the 2030 targets. Energy efficiency gains occur incrementally and require investment over sustained periods to achieve results. Much of the energy efficiency policy framework is well-understood: minimum energy performance standards drive out the least efficient technologies from markets and programmes, while energy company obligations can drive the uptake of the most efficient technologies available. The experience with space heating in the 2000s is a case in point. Sustained investment in condensing boilers, replacing significantly less efficient gas boilers and in some cases oil boilers, delivered large reductions in energy consumption.

The analysis in this paper identified the lack of progress in reducing weather-corrected space heating energy consumption since 2010. It is crucial to bring forward investment in the next wave of space heating efficiency gains. That means significantly increasing the building renovation rate, which implies substantial amounts of investment. It also requires uptake of more efficient heating systems such as heat pumps in countries where they are currently not deployed at scale. Fortunately, public funding is becoming available through the increasing volume of EU Emissions Trading System auction revenues. Allocating these receipts to the public funding of building renovations, allied with new policies to bring forward private investment, would provide the boost that is needed to the building renovation sector (Wiese et al. 2018). Policy innovations might include differentiated property sales taxation, raising the issue at a point when renovation is most likely (Jahn and Rosenow 2017); regulation on private landlords to improve the energy efficiency of properties before being able to rent them out (Steuwer et al. forthcoming); and allowing property renovation loans to be collected through local taxation or energy bills (IEA, 2017). Finally, many EU countries are in the process of adopting Energy Efficiency Obligations as part of their compliance with the Energy Efficiency Directive (EED). If implemented well, this instrument can save significant amounts of energy economically and targets can be increased relatively quickly once the schemes are up and running (Rosenow et al. 2019).

4.2 Monitoring, verification, and evaluation

Understanding the extent of energy efficiency gains is only possible if data are available to measure energy consumption at end-use level. Data are particularly scarce in the services sector where estimates rely on irregular and partial surveys. Allocating funding to the collection of data on service sector energy consumption by end-use and type of business or organisation would enable a greater understanding of where the opportunities and barriers to the uptake of energy efficiency exist in the sector.

Furthermore, understanding the relationship between energy efficiency policy and the EU's energy efficiency targets requires more policy monitoring, verification, and evaluation. As has been seen in the new passenger vehicle market, real-world verification of the energy efficiency and pollutants emitted by vehicles can identify disparities between the intended effect and reality of policy implementation. A similar effect has been found for many low-carbon technologies in the building sector with expected savings lagging behind actual savings, a phenomenon which has become known as the 'performance gap' (McElroy and Rosenow 2018). Recognising this for passenger cars, under the 2030 target regime, the Commission is required to assess the feasibility of real-world emissions tests in 2027 and put in place an enforcement mechanism as of 2030. The sooner real-world testing is introduced for a much wide range of energy efficiency measures, the better.

There is also evidence suggesting that savings reported by Member States to the European Commission may be overly optimistic for a variety of other reasons. Analysis of the notifications as part of Article 7 of the EED shows that a significant share of savings may not be additional or are at risk not being delivered in practice (Rosenow et al. 2016). Much of this has to do with the relatively weak evaluation, monitoring and verification framework in Europe. Analysis by Schlomann et al. (2015) illustrates that this is largely a result of the lack of binding rules for monitoring and verification at the EU level that provide sufficient detail and clarity to Member States. This lack of clarity provides potential loopholes and does not result in a consistent approach to monitoring and verification across the EU. Member States adopt different approaches to calculate their energy savings and report on their methodologies in different ways. This may be well justified, since some calculation approaches are better suited to some policies than others. However, as a result of this flexibility, the energy savings that are notified by Member States, and the information reported on methodologies, are not fully consistent or comparable at an EU level. This inconsistency presents uncertainty about whether the EU is on track to deliver its target and reduces confidence in the savings that are claimed at an EU level. Clearer guidance and additional tools can help to reduce the uncertainties in this area to ensure reported savings materialise in reality. Various efforts are currently under way to support Member States with their evaluation, monitoring and verification approaches.

Finally, given the nature of the energy efficiency targets, being set in absolute energy consumption terms, it would be sensible to monitor the progress of all the variables of importance to meeting the targets and to model energy consumption under different scenarios. Understanding how energy consumption is likely to evolve under different economic outlooks (as already modelled by the European Commission's Economic and Financial Affairs Directorate-General), weather scenarios, and rates of energy efficiency progress would enable policymakers to understand the likelihood of meeting 2030 targets sufficiently far ahead to enable remedial action to be taken if necessary.

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