Government
Office for Science

Net zero society: Recent societal trends

Annex 1

March 2023

Foresight

Introduction

Uncertainties abound in how society will look in 2050 and what this will mean for the transition to net zero. To plan for a range of possible futures, it is useful to understand which net zero societal trends are changing, which appear static, and what underlying factors are driving these changes. This report sets out the research on recent societal trends identified during the evidence-gathering stage of the net zero society scenario development.

Net zero societal trends are defined in this report as activities undertaken by people and organisations that lead to changes in energy consumption and/or emissions. Related to this are 'drivers of change', which are the underlying patterns of societal and economic activity that drive demand and emissions. The relationship between these concepts is illustrated with some examples in Figure 1. This report does not aim to be comprehensive in its coverage of all relevant trends. Instead, it analyses an illustrative set of key net zero societal trends in four sectors of the UK economy: the built environment, travel and transport, work and industry, and food and land use. Where data are available, we provide analysis and illustrative graphs showing how the trend has developed over the last two decades. For each trend, we review relevant literature for potential underlying societal drivers and disruptors, including technological innovation, affordability, environmental awareness, or business reputation (summarised in Appendix 1). We have only included narrative on the key, high-level drivers that influence the selected trends. However, drivers that are not mentioned are often implicitly linked to these key drivers. For example, where we mention the state of the economy and household incomes, there is an implicit understanding that the level of income inequality and poverty are also important factors in determining these societal trends.

Introduction

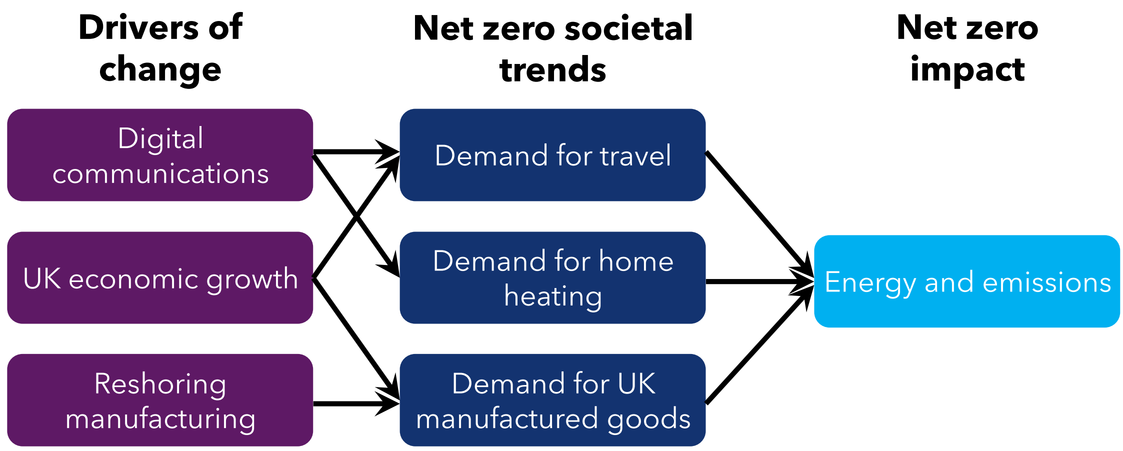

Figure 1. The relationship between drivers of change, net zero societal trends, and emissions

The trends outlined in this report are highly interconnected. For example, food production is driven by trends in both the work and industry sector and the food and land use sector. Often underlying drivers affect several trends at the same time. This report highlights such systemic effects and interdependencies and provides a baseline understanding of how the trends might change in the short-term.

The purpose of this report is to explore some historical relationships between drivers of change and their resulting net zero societal trends, which can then be used to inform our assumptions about the future relationships between these factors. Historical trends are not long-term projections. Instead, they inform our understanding of what has driven past changes as a context for developing future scenarios. They can provide insights into the speed and trajectory of future trends and indicate which signals we should pay most attention to. It is possible that there are already signals apparent in currently available data for some of the most significant trends of the future.

Please note that the research for this report was carried out up until early 2023 and, therefore, the report only considers trends and policy up until this time point.

The built environment

This section will focus on key trends affecting the built environment sector. These include home insulation rates, average indoor temperature, smart meter installations, household size and occupancy, house-building rates and heat pump installations. Key trends also include rooftop solar voltaic capacity, and non-residential floor area and energy efficiency measures.

2.1 Home insulation rates

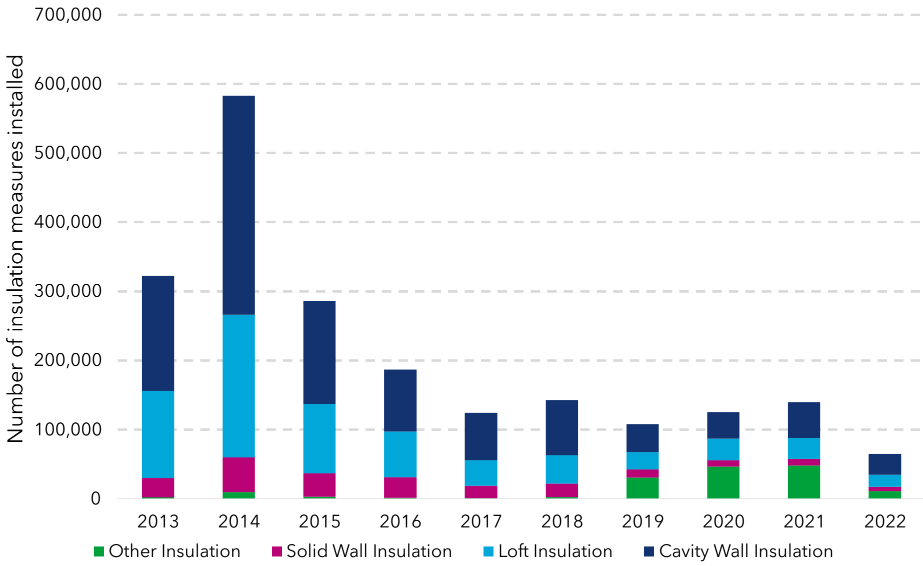

Figure 2. Home insulation installed, by measure, in Great Britain, 2013-2022[1]

Home insulation rates in Great Britain peaked in 2013–2014, coinciding with the end of government support measures such as Community Energy Saving Programme, which ran from October 2009, and Carbon Emissions Reduction Target, which ran from April 2008.[2] For example, cavity wall insulation rates fell by 77% between 2013 and 2020. Beyond policy support, one of the obvious key drivers of home insulation rates is the climate: for example, a threat of overheating was found to be an incentive for householders to insulate their homes.[3] Other drivers of home insulation include energy savings, improved thermal comfort, supportive peers, and structural and aesthetic improvements to a home.[4] In addition, there is emerging evidence that events focused on sustainable home retrofits can encourage more of such renovations.[5] Availability of local skills and established supply chains are essential, as lessons from the Green Homes Grant show.[88] Lack of relevant skills and materials can result in poor quality or incorrect application of insulation measures, for example damp and mould from solid wall insulation, putting other people off insulating their homes.[6]

2.2 Average indoor temperature

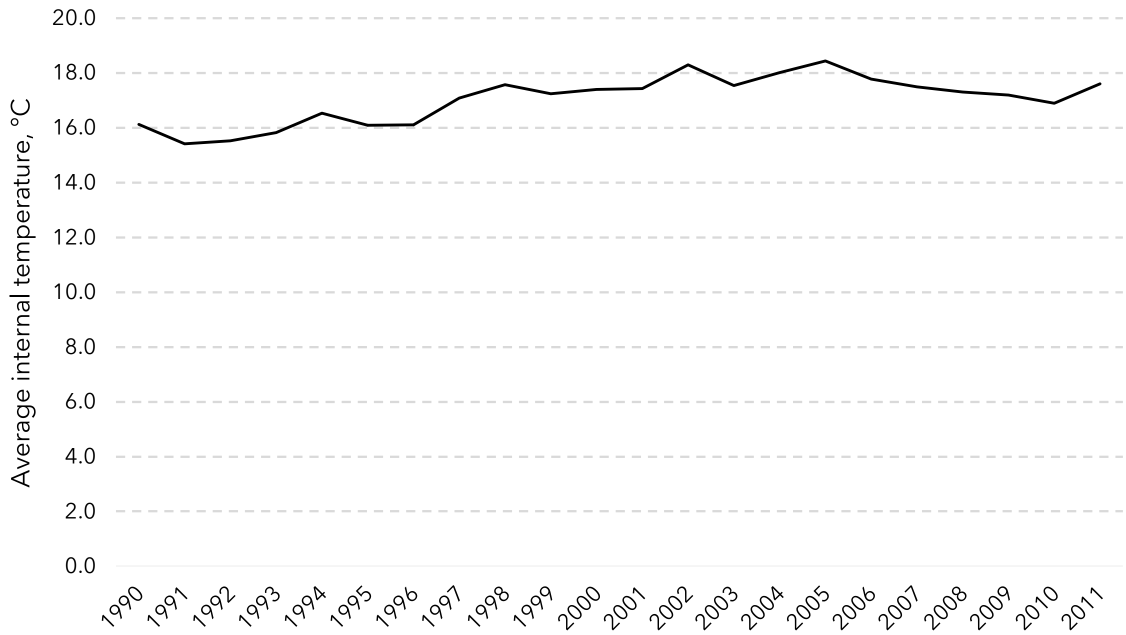

Figure 3. Average indoor temperature of a UK home, 1990-2011[7]

A report on housing energy published in 2014 showed that average indoor temperatures in winter steadily rose by 5.6°C between 1970 and 2011 (from 12°C in 1970 to 17.6°C). This trend took place alongside milder winters in more recent decades. Part of the increase was due to more housing having central heating,[7] although even in such housing the average internal temperatures rose by 4°C between 1970 and 2011 (from 13.7°C to 17.7°C). Likely drivers include more time spent indoors, shifting expectations of thermal comfort, and more efficient housing.[8] At the other end of the spectrum, indoor overheating in summer is correlated with house ownership, heating system type, and vulnerability of occupants: higher temperatures were observed in social housing than in mortgaged or owned dwellings, in dwellings with communal systems, and in dwellings with poorer or disabled occupants.[9] There is limited evidence on the association between energy prices and indoor temperatures, apart from in the USA during and after the 1970s fuel crisis.[8]

2.3 Smart meter installations

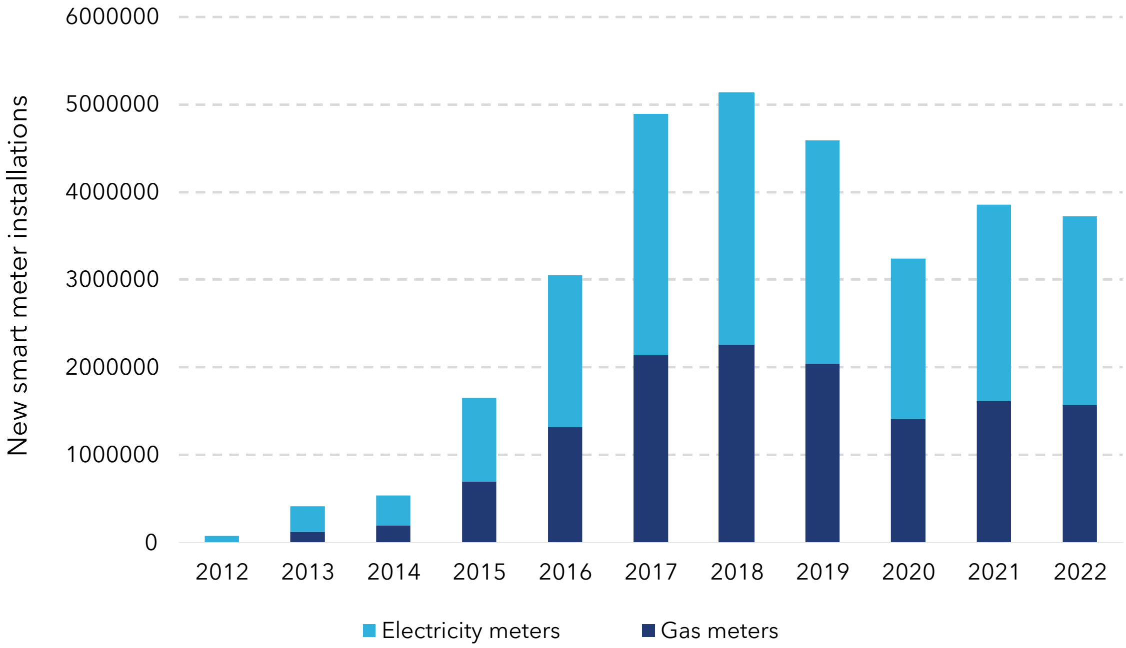

Figure 4. Number of smart gas and electricity meters installed in Great Britain, 2012-2022[10]

Installations of smart meters increased more than 65 times from 75,000 meters in 2012 to a peak of 5 million in 2018, falling to under 3 million meters in 2021. In total, more than 31 million smart meters have been installed over the past decade, achieving a 47% penetration rate.[11] Nearly 60% of the installations were electricity meters, with the rest being gas meters. There was a pause in the installations in 2020 due to COVID-19 restrictions, and the installation rate has not fully recovered since.[12] This may be due to the 'low-hanging fruit' principle; consumers who are most keen to have smart meters and properties that are easiest to fit meters in (such as standard construction houses) are reached quickly by installation schemes and there is a slowdown following this initial wave of activity.

In the early years of the scheme, the roll-out faced technological issues with first-generation smart meters losing their 'smartness' when switching supplier. The smart meter roll-out has been mainly driven by the government's target for energy suppliers to install smart meters in all residential and commercial properties by June 2025. Studies show that smart meters can reduce household electricity consumption by 3–9%,[13,14] and gas consumption by up to 22%.[15] In the latter case, standard energy use display was complemented with personalised messages that were actionable and framed around each household's values.[15] However, some evidence shows that energy-saving behaviour achieved through a one-off intervention, such as a smart-meter-based neighbourhood challenge, might not last.[16]

2.4 Household size and occupancy

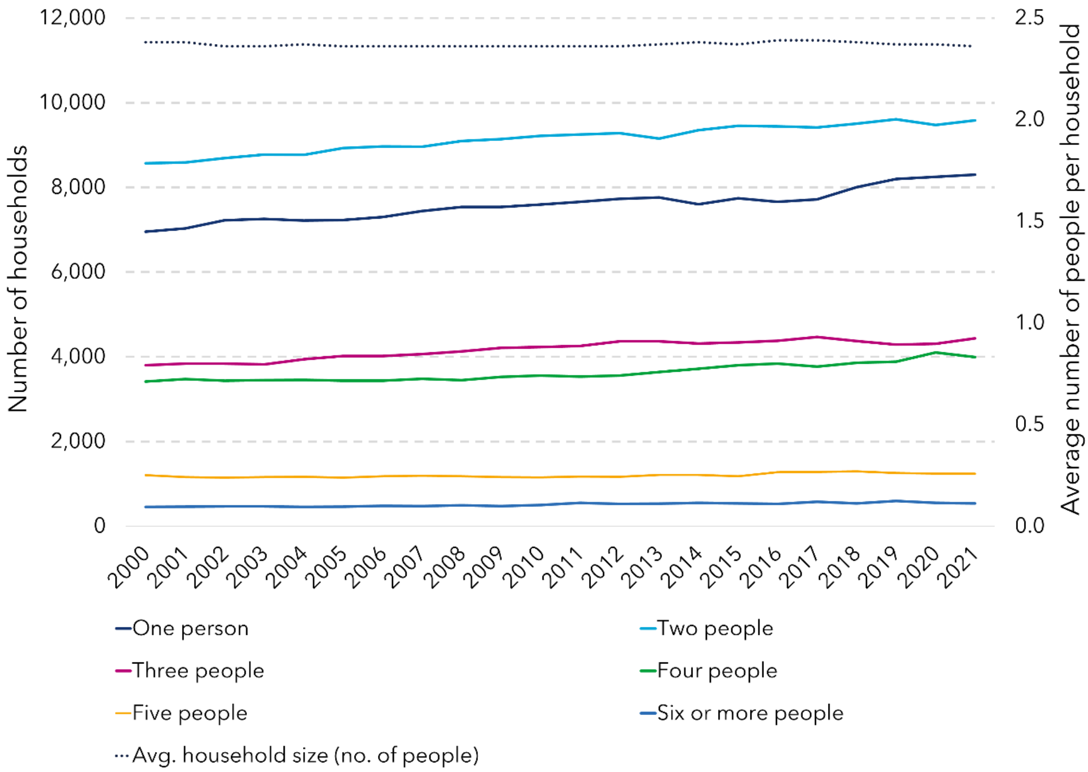

Figure 5. Average household size (dashed line) and number of households by household size (solid lines), in the UK, 2000-2021[17]

The average UK household size stayed at around 2.4 persons per household between 1996 and 2021, fluctuating by 1%. The total number of households rose by 18% from 24 million in 1996 to over 28 million in 2021.[18] There is a growing prevalence of solo living, with a 26% increase in the number of single-person households over the same period.[18] However, this trend holds only for older age groups, whereas the number of under-44-year-olds living alone decreased by 16% between 1997 and 2017.[19] This is partly driven by financial considerations, as living alone is more expensive per person than living in larger households. Household size is also somewhat cultural (for example, people who have migrated to the UK tend to live in larger households).[20] There has been a fast increase in multi-family households, by two-thirds over the past two decades, although from a low base.

2.5 House-building

There was a 7% annual reduction on average in the number of dwellings built for six years after the 2008 financial crisis. When the house-building activity picked up again, it grew by nearly 60% between 2013 and 2019, partly facilitated by changes in the planning system to ease conversion from non-residential to residential use.[21] The COVID-19 pandemic led to an 11% decrease in the number of new homes built in 2020 (216,000 homes) compared to the previous year (243,000 homes). As a longer-term trend, UK house-building has been slowed down by high prices on land, a complex planning system, and limited development of other vital infrastructures and facilities.[21] Another factor is the ailing construction sector, including its low productivity, limited innovation and poor-quality training.[22] At the same time, demographic changes have resulted in growing demand for new homes, with a growing number of households (a 6% increase between 2010 and 2020) and more people living alone (a 4% increase between 2010 and 2020).[18] While this has exerted an upward pressure on property prices,[23] government support for home-buyers has helped to sustain demand.

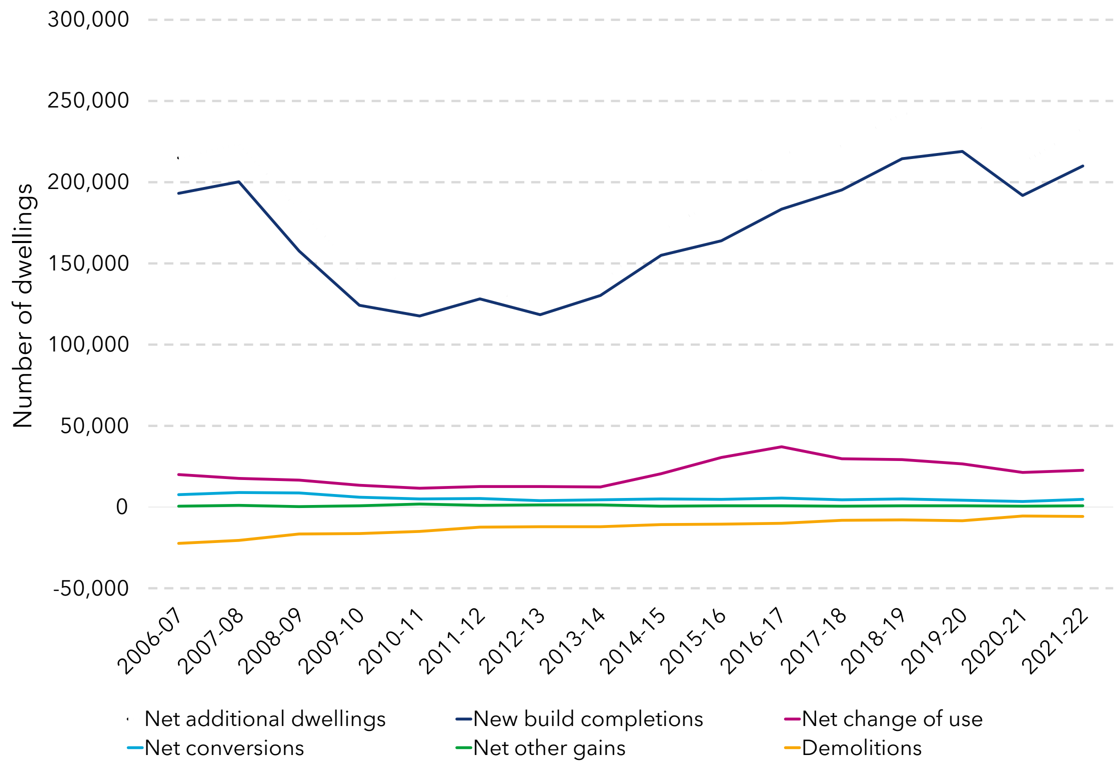

Figure 6: Net additional dwellings in England, 2006-2022[24]

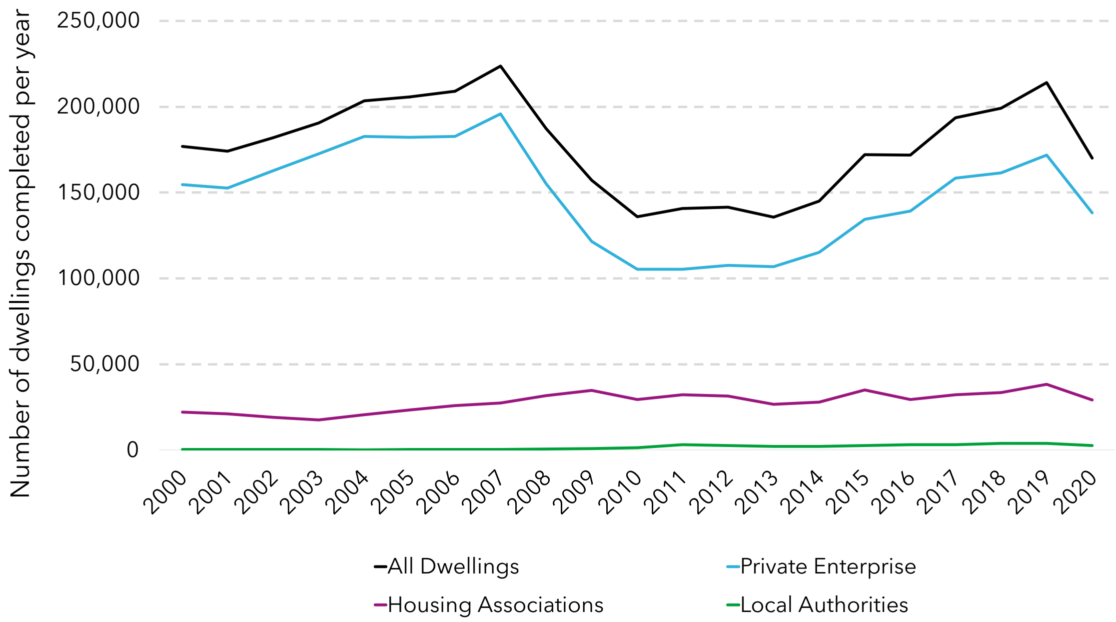

Figure 7: Permanent dwellings completed in the UK, 2000-2020[25]

2.6 Heat pump installations

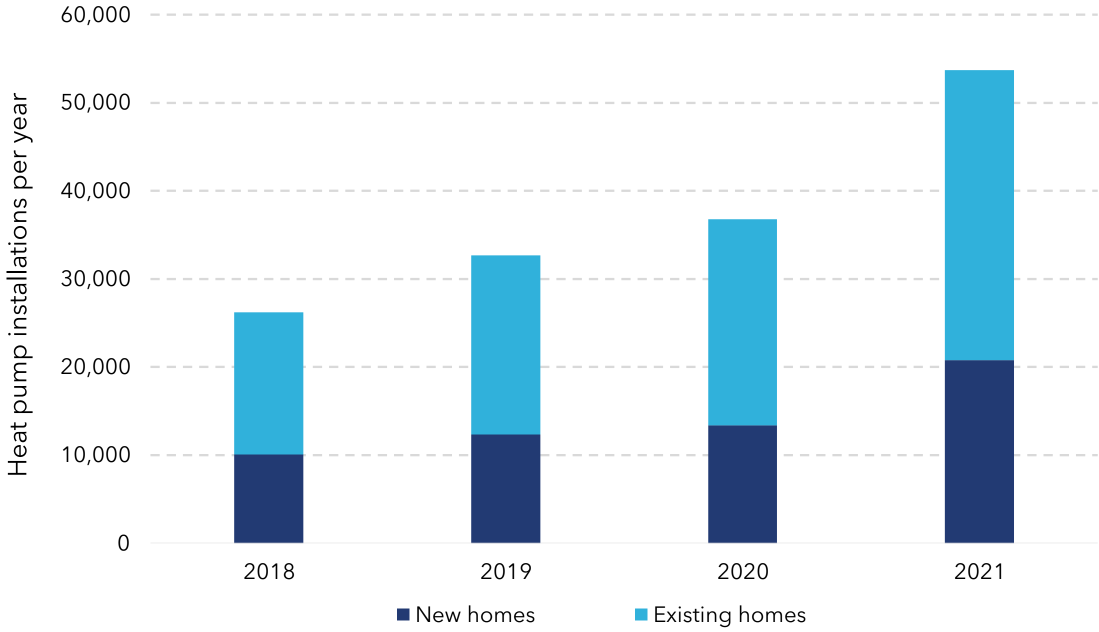

Figure 8. Heat pump installations in the UK, 2018-2021[26]. Data before 2018 is not available in this form.

The uptake of heat pumps in residential buildings increased by 36% between 2018 and 2020 (from 26,000 to 37,000 installations). The adoption has been slow in absolute terms, with the main reasons including a high upfront cost, the aesthetics of visible large pipes and fans, concerns about reliability and, more generally, lack of familiarity with the technology.[27] The disruptive nature of installation is another barrier, unless the current gas boilers and radiators are retrofitted rather than removed, which would be possible with hybrid heat pumps.[28, 29] Alongside new product design and affordable financing schemes, adoption drivers for other technologies such as electric cars and home retrofits might be relevant: for example, showrooms and eco-home events would allow people to observe and trial heat pumps, which might incentivise adoption.[28]

2.7 Rooftop solar photovoltaic capacity

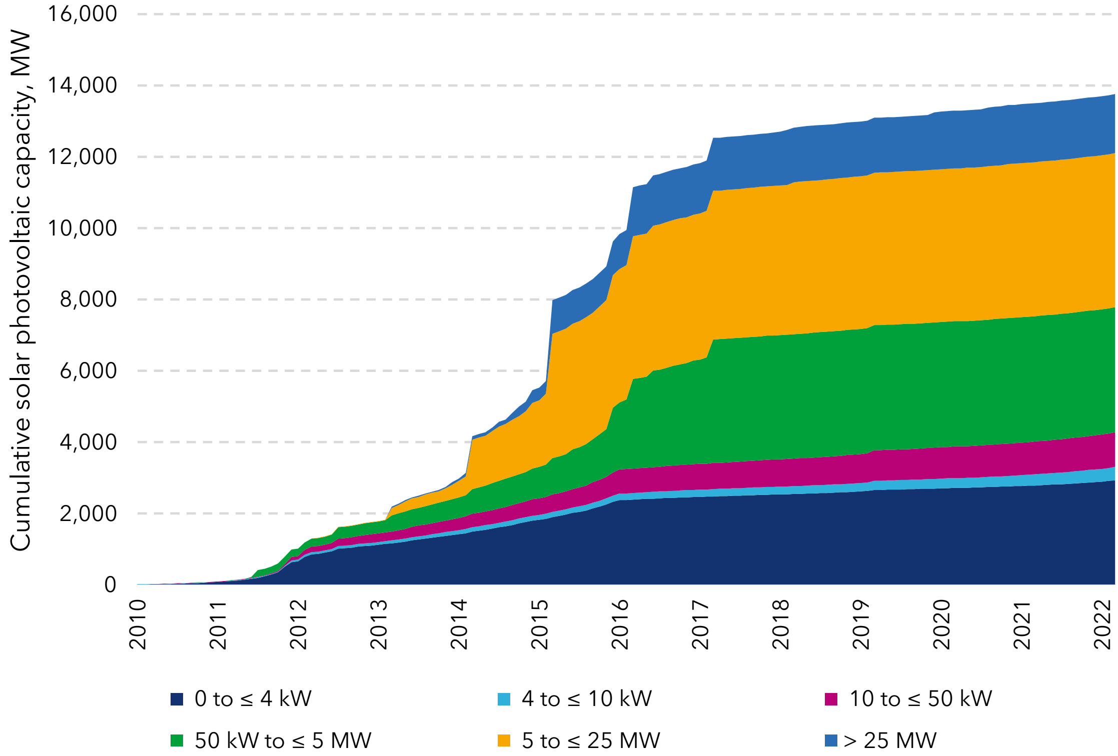

Figure 9. Cumulative solar photovoltaic capacity in the UK, 2010-2022 [30]

The cumulative capacity of rooftop solar photovoltaics (which are typically individually under 50kW) increased by around 260 times (from 16MW in 2010 to 4,200MW) by the end of 2021, when the cumulative number of installations reached more than a million. Rapid growth of the rooftop solar photovoltaic industry has been primarily incentivised by government support,[31] including the Smart Export Guarantee (SEG) and the Feed-in Tariff (FIT) scheme that the SEG replaced.[32] This support has mitigated the financial and other risks for households, which might otherwise slow down this trend.[33] In addition to the government incentives, the drivers of cost reductions in solar photovoltaics (solar PVs) have included availability of less expensive raw materials, increased imports of solar panels from China, innovations in the solar PV technologies, and the industry's own increased investment.[34] Non-financial drivers of residential solar PV installations include suitable climatic conditions, house orientation and rooftop space, aesthetics, and environmental awareness.[35]

2.8 Non-residential floor area

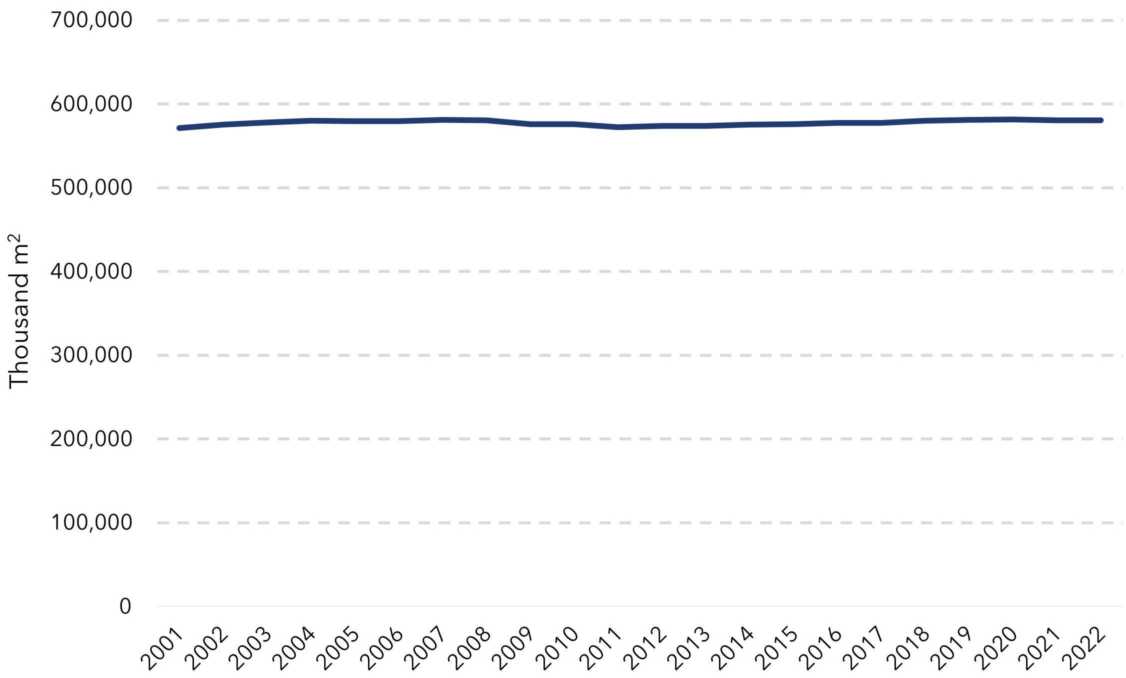

Figure 10. Total non-residential floorspace in England and Wales, 2001-2022[36]Data is from March 31st of that year.

The business floorspace in England and Wales increased by 2% between 2001 and 2021 (from 572 million square metres to 581 million square metres). The slow growth over the past two decades is primarily due to a 2% fall over a three-year period after the 2008 financial crisis and slow recovery afterwards. The state of the economy is correlated with commercial property prices. Property prices rise when: interest rates fall, alternative investments yield lower return, and/or foreign investment increases.[37] Some loss in business floorspace is driven by conversions to residential property,[38] a trend that might accelerate due to more people working from home and shopping online during and after the COVID-19 pandemic.

Footfall in city centres was already falling pre-COVID (by 4% between 2015 and 2019).[39] The sharp drop in footfall during the COVID-19 pandemic (around 90% at times) and subsequent recovery resulted in footfall in June 2021 being around three quarters of that in June 2019[39], with retail and hospitality floorspace being particularly affected.[55]

2.9 Non-residential energy efficiency measures

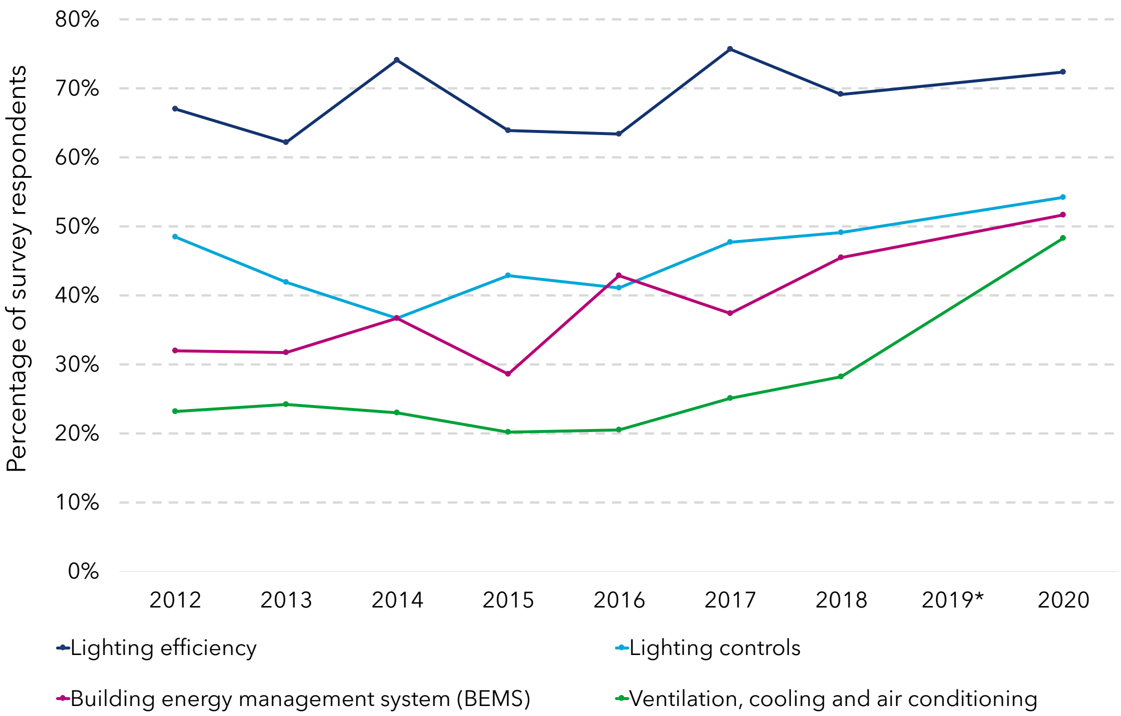

Figure 11. Energy efficiency measures installed in non-residential buildings in the UK, 2012-2020 (based on survey feedback from industry consumers and suppliers)[40] *More recent data and data for 2019 unavailable at time of research

Lighting efficiency dominated other energy efficiency measures in the non-residential sector: the number of public and private sector organisations reporting such improvements grew from 67% in 2012 to 72% in 2020. Here, the main driver has been government regulations for phasing out of incandescent lamps, halogens and later fluorescents.[41, 42] Installations of building energy management system (BEMS) increased from just under a third of surveyed organisations in 2012 to 52% in 2020. The number of organisations reporting new projects in ventilation, cooling and air conditioning increased from 28% in 2018 to 48% in 2020, predominantly to reduce the transmission of COVID-19. The number of organisations that installed heat pumps on their premises grew from a 2012–2018 average of 6% to 28% in 2020,[40] incentivised partly by the government's Public Sector Decarbonisation Scheme.[43] Factors that have been shown to expediate technological rollouts include government support, attractive balance of cost versus benefit, corporate social responsibility, and industry reputation.[44,45]

Travel and transport

This section considers societal trends relating to the travel and transport sector. These include loading factors for freight, traffic flow by transport mode, electric car sales and their market share, publicly accessible electric vehicle charging points, aviation demand and trips per person.

3.1 Loading factors for freight

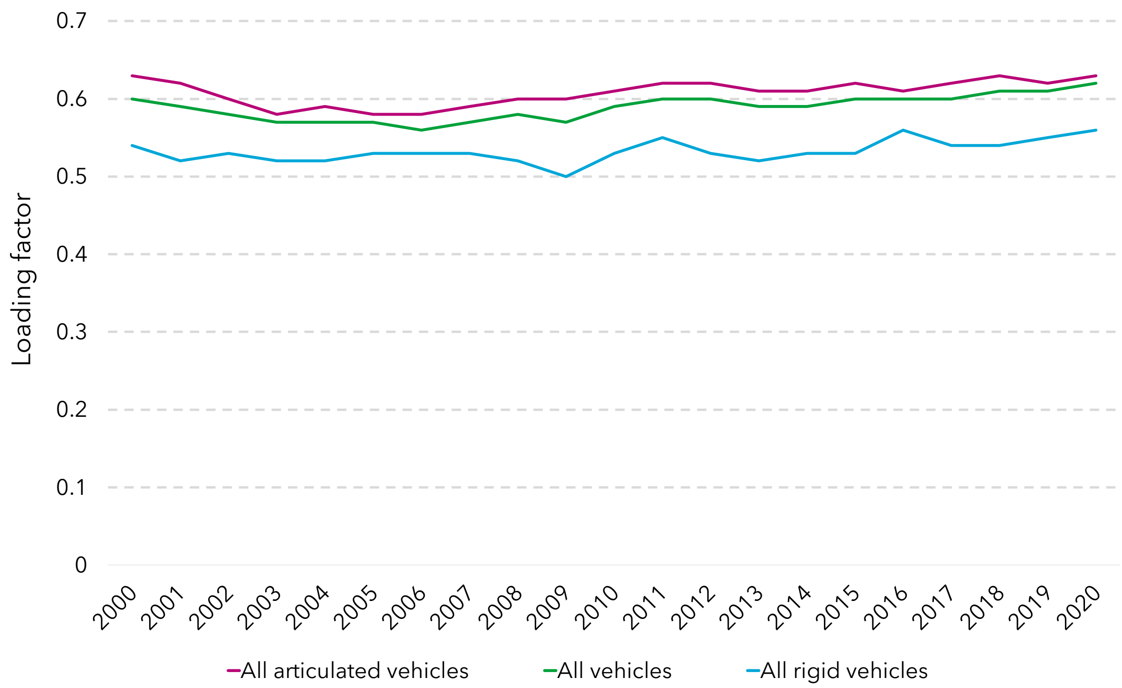

Figure 12. Loading factors for freight vehicles registered in Great Britain, 2000-2020[46]. More recent data cannot be compared with this data due to a methodology change.

A loading factor refers to how full a vehicle is when transporting goods, with the higher number indicating a more efficient use of each trip. Average loading factor is the ratio of the average load to total vehicle freight capacity. Over the past two decades, the UK's average loading factor for road freight was 0.59, reaching its highest level of 0.62 in 2020. There was a dip to 0.56-0.57 in the run up to and during the 2009 financial crisis. Some European countries, such as Germany and Spain, report road freight loading factors of above 0.7, suggesting that improvement is possible.[47] Loading factors depend on the cost of moving goods (including fuel prices), level of income (affecting how much people are prepared to pay for moving goods), and the ratio of local to long-haul freight (with the latter being more optimised and hence having higher loading factors).[48] Logistics measures such as urban consolidation centres, co-loading (i.e. 'ride sharing' for cargo), backhauling, and route optimisation can increase the loading factors.[49] Road pricing schemes, for example low-emission zones, can also improve the efficiency of road freight.[50]

3.2 Traffic flow by transport mode

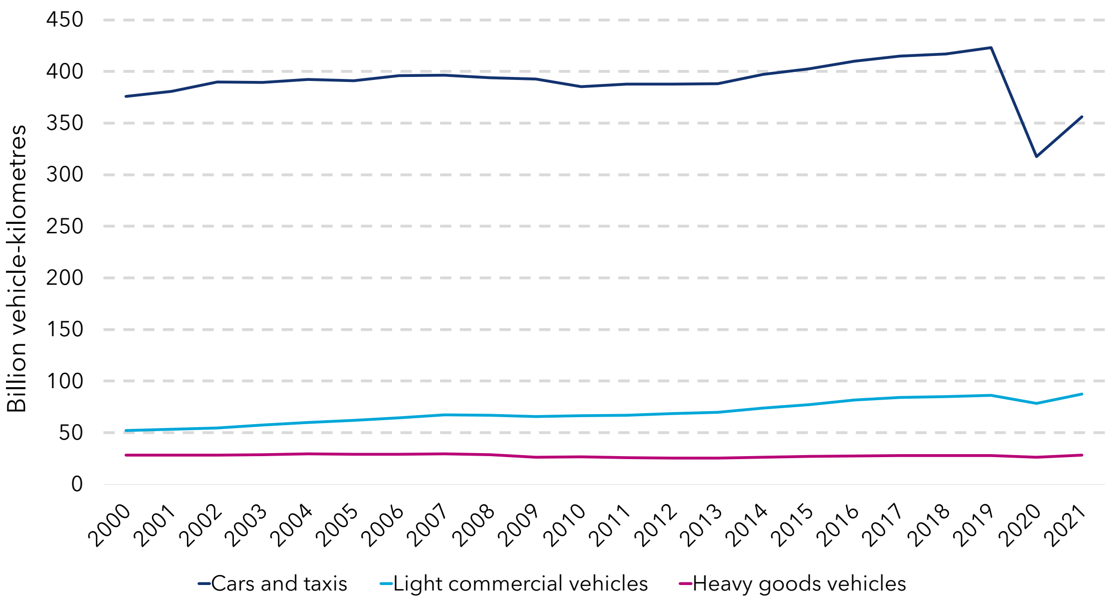

Figure 13. Traffic by vehicle type (vehicle kilometres) in Great Britain, 2000-2021[51]

Distance travelled by road vehicles, the most significant source of transport emissions, grew significantly up until 2020 (Figure 13). Car distance travelled and van traffic are influenced by incomes and vehicle operating costs.[52] In addition, the rapid growth of van traffic has trailed the rise of online shopping.[52] Cars and taxis dominate Great Britain's roads, on average accounting for just under 80% of all vehicle kilometres travelled by motor and pedal (Figure 14). In 2019, pre-pandemic, 423 billion vehicle kilometres were made by cars and taxis (falling by a quarter to 317 billion vehicle kilometres in 2020), compared to 5.8 billion vehicle kilometres by bicycles (rising by a third to 8.5 billion vehicle kilometres in 2020).[53] In terms of trips, demand for surface rail (excluding trams) has steadily increased since 2002, growing by around 60% by the beginning of 2020.[54] In the meantime, travel by other modes was either stable or slowly decreasing (implying that growth in car traffic is largely due to increasing trip lengths). When the COVID-19 pandemic struck in 2020, there was a marked drop in all travel except cycling and long walks (over a mile). While car travel decreased by more than a fifth in 2020 compared to the previous year, cycling distance travelled increased by 46% in 2020 compared with 2019.[55] Use of public transport, including national rail and urban mass transport systems, has not fully recovered since, with car travel rebounding faster.[55,56] In 2021, pedal cycle traffic decreased by 25% compared with 2020, and traffic from cars and taxis, and traffic from light commercial and heavy goods vehicles increased, suggesting some of the changes in transport seen in the pandemic have been reversing.[57] Travel trends directly impact carbon emissions, with higher private car use associated with higher emissions while higher active travel and public transport use is associated with lower emissions.

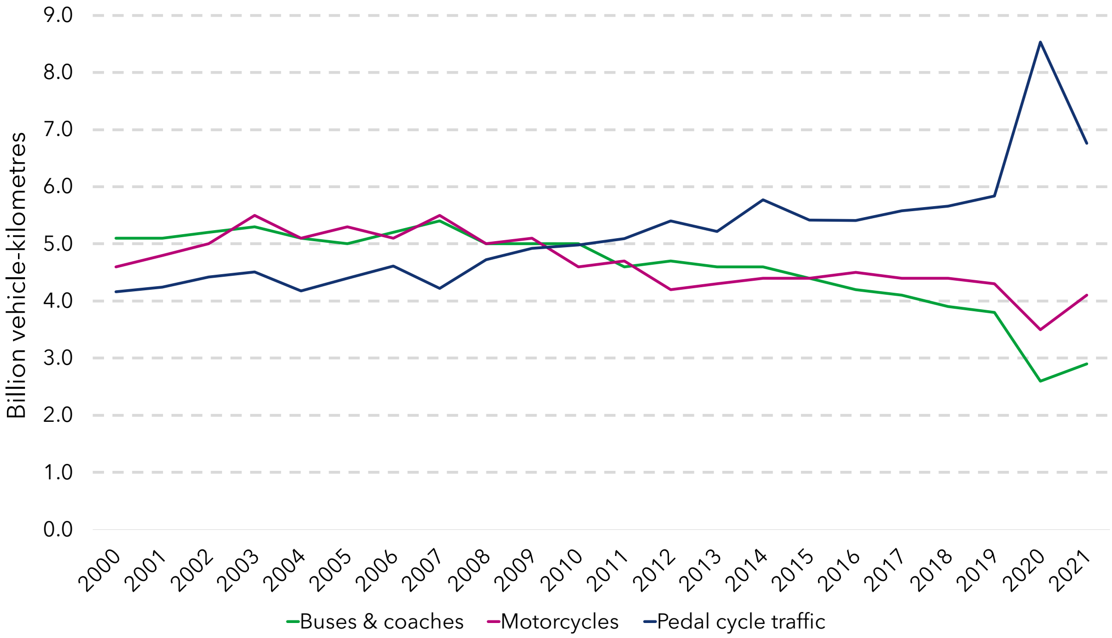

Figure 14. Traffic by vehicle type (vehicle kilometres) in Great Britain, 2000-2021[57,58]

3.3 Electric car sales and their market share

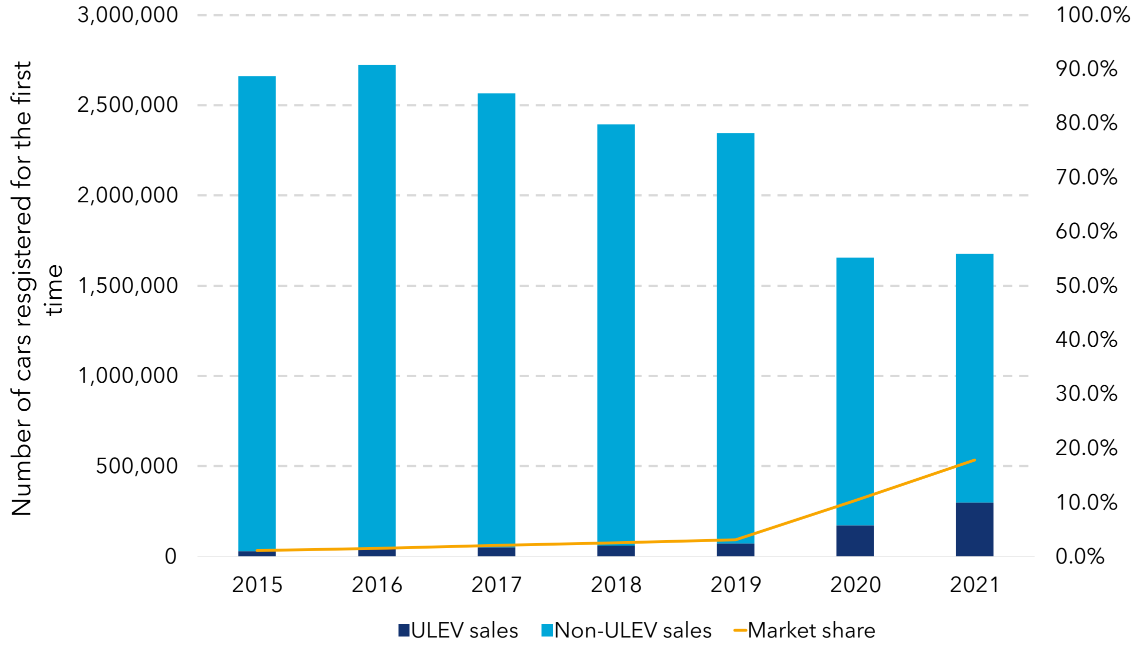

Figure 15. Number of new ULEV sales and market share of total car sales in the UK, 2015-2021[59,60]

The number of new ultra-low emission cars (ULEV) on UK roads increased six-fold, from around 30,000 cars (1% market share) in 2015 to almost 300,000 cars (18% market share) in 2021. The growth was particularly rapid for battery electric vehicles (BEV), whose sales increased more than ten-fold over this period, from 10,000 to 190,000 cars, quickly overtaking the sales of plug-in hybrid electric vehicles (PHEV). This was still dwarfed by sales of non-ULEV cars at nearly 1.7 million in 2020, although the number of such sales decreased by a third from more than 2.7 million cars sold in 2015. Among other considerations, ULEV sales depend on their range and cost, people's environmental awareness, and local availability of charging points. Global average BEV range extended from 211 to 338 km between 2015 and 2020, while PHEV range stabilised at around 56 km.[61] While global average battery prices fell by 6% between 2020 and 2021 (and by 89% between 2010 and 2021) in real terms, global average BHEV prices rose by 6% over the year, due to increased sales of more expensive cars, particularly in Europe.[62] In 2020 and

2021, the automotive industry, like many other sectors, was affected by supply chain challenges caused by the COVID-19 pandemic. Although this disruption might not persist beyond 2022, other supply chain challenges are likely to arise including a potential shortage of critical raw materials (such as lithium) for electric batteries, due to growing demand for such materials.[63]

3.4 Publicly accessible electric vehicle charging points

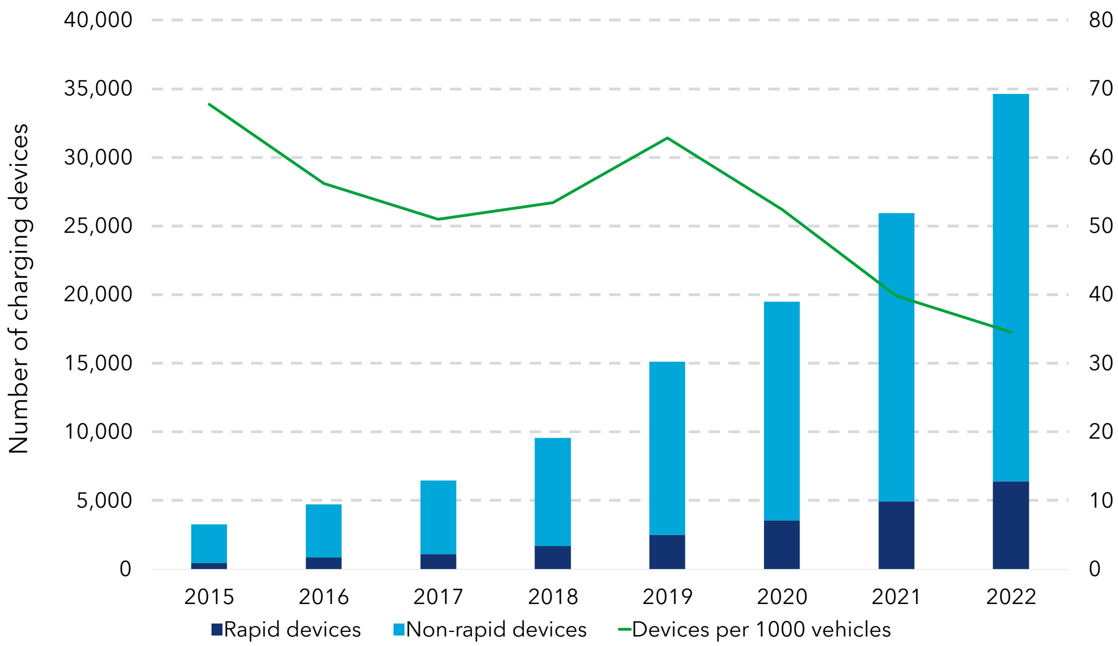

Figure 16. Publicly accessible EV charging devices and ratio to number of plug-in vehicles in the UK, 2015–2022, at the end of Q3 of each year.[64,65]

As of October 2022, there were 35,000 publicly accessible electric vehicle (EV) charging points in the UK, an 11-fold increase since October 2015. Around 18% of those were rapid devices, which can charge a car fully within 30–60 minutes.[66] On average, the public charge point network grew at over 41% per year, although it slowed down during the COVID-19 pandemic when the annual installation growth rate fell to 37% and 26% for rapid devices and all devices respectively. Accordingly, as sales of electric cars surged (see Figure 15), the ratio of charging points to the number of plug-in vehicles fell by a quarter (from 63 to 52 devices per 1000 vehicles) between October 2019 and October 2020. EV charging points are not equally distributed throughout the UK, with London providing 83 devices per 100,000 of population while the UK average is 36 devices per 100,000 of population.[67] Although there are several government grant schemes for installing EV charging infrastructure,[68] most devices have been installed by the private sector.[69]

3.5 Aviation demand

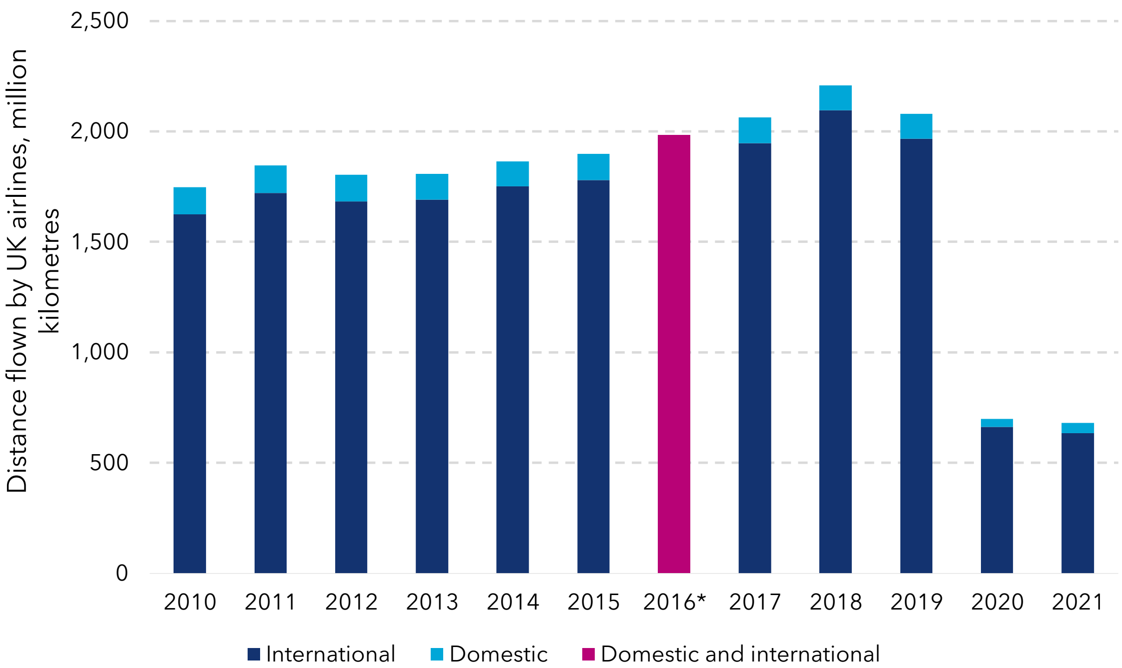

Figure 17. Aircraft kilometres flow by UK-registered airlines, 2010–2021[70] *International and domestic breakdowns were unavailable in 2016

Distance flown internationally grew by 20% between 2010 and 2019 (from 1,600 million km to nearly 2,000 million km), while domestic aircraft kilometres decreased by 10% over the same period (from 123 million km to 111 million km). Note that breakdown by international and domestic flights is not available for 2016. The total distance flown internationally and domestically dropped by 67% in 2020 compared to 2019 (because of the COVID-19 pandemic). Pre-pandemic, rising incomes and falling air fares have been the main drivers of increasing demand for aviation, both domestic and international.[71] Economic growth, which underlies rising incomes, is another strong predictor of aviation activity.[72] Beyond travel restrictions and health considerations during the COVID-19 pandemic, the latter has depressed demand for aviation through shifting leisure and business travel patterns,[73] with more homeworking[74] and domestic holidays.[75] However, domestic tourism in the UK exceeded international trips well before the pandemic and is not a new trend.[76]

3.6 Trips per person

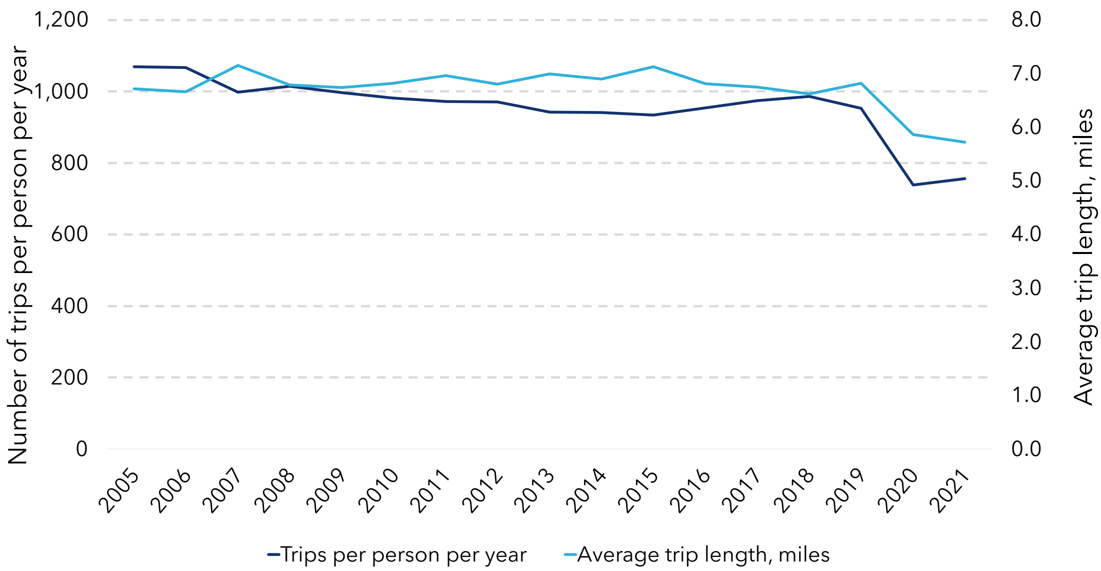

Figure 18. Number and average length of trips per person in Great Britain, 2005-2021[77]

The number of trips undertaken by individuals remained stable over the decade preceding the COVID-19 pandemic, at around annual 960 trips per person. Similarly, the average length of trips was stable at around 6.9 miles each. During 2020, due to COVID-19 and restrictions, the number of trips per person fell to around 740.The reduction in the number of trips was partly facilitated by the availability of teleconferencing technologies and broadband. While this drove down greenhouse gas emissions from transport,[78] the overall impact of remote working on emissions may be modest or even negligible (reductions in work travel may be outweighed by unpredictable increases in non-work travel and higher home energy use).[79] Working from home has the potential to relocate £3bn of hospitality spending per year from city centres to suburbs.[80]

Work and industry

This section considers trends relating to the work and industry sector. It specifically focuses on trade and spending, energy intensity, port traffic and non-hazardous construction and demolition waste.

4.1 Trade and spending

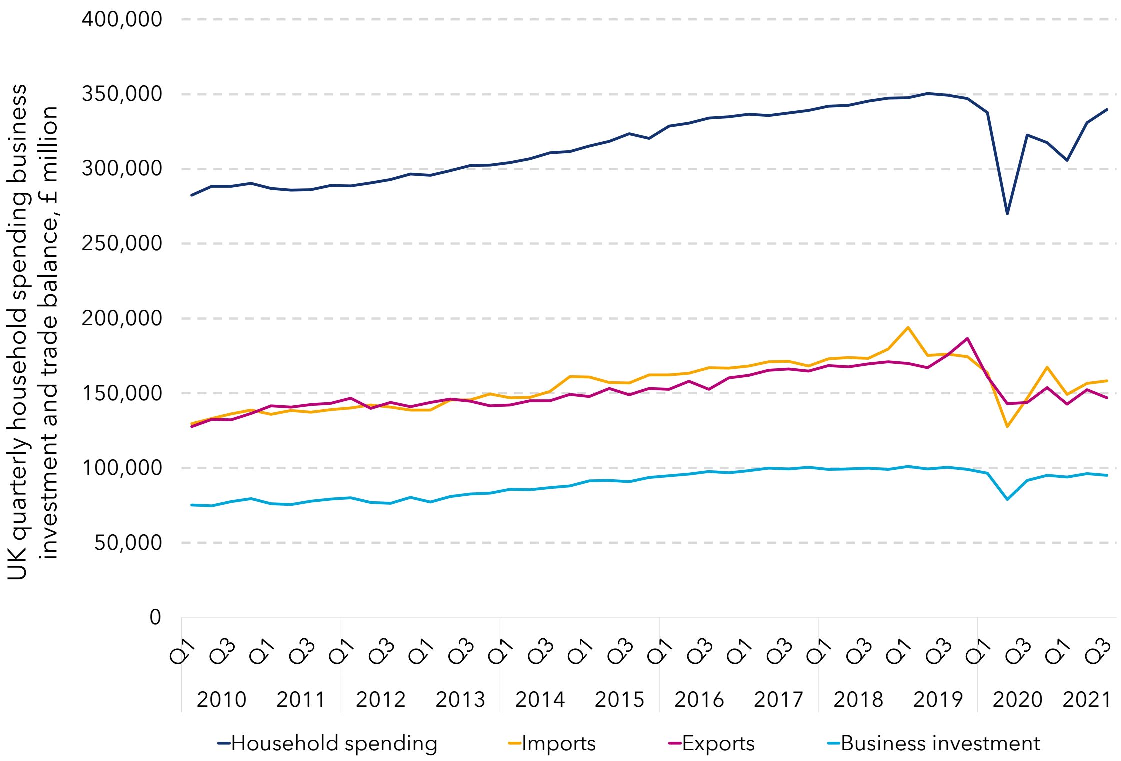

Figure 19. UK quarterly household spending, business investment and trade balance, 2010-2021[81]. More up to date data unavailable for all variables shown.

Household spending is the largest source of consumption in the economy, accounting for around 60% of the gross domestic product (GDP) and is around three times larger than business spending. Trade balance gives additional information about the demand for goods and services produced in the UK and about imported goods and services consumed here. While it is important to note that the balance of goods to services will affect the intensity of energy and emissions consumption, these aggregate metrics are still a useful first order indicator of overall consumption. In Figure 19, the values are in constant prices (accounting for inflation) to be able to compare the statistics across several years. Overall, between 2010 and 2021, household and business spending and imports increased by 20–26%, while exports of goods and services grew more slowly by 15%. However, all of these factors stalled in recent years, with business investment and exports broadly flat since around 2017, and household expenditure significantly impacted by the pandemic. During this period, imports to the UK normally exceeded its exports, with an average annual trade deficit of £3.6bn per year. The trade statistics were volatile in 2020 and 2021, so the recent trends need to be interpreted with caution.[82] COVID-19 restrictions led to a dip in the values during the second quarter of 2020, although exports were less affected (an 11% drop) than the other three indicators (an 18–21% drop). In 2021, imports from non-EU countries overtook EU imports.[82][83]

4.2 Energy intensity

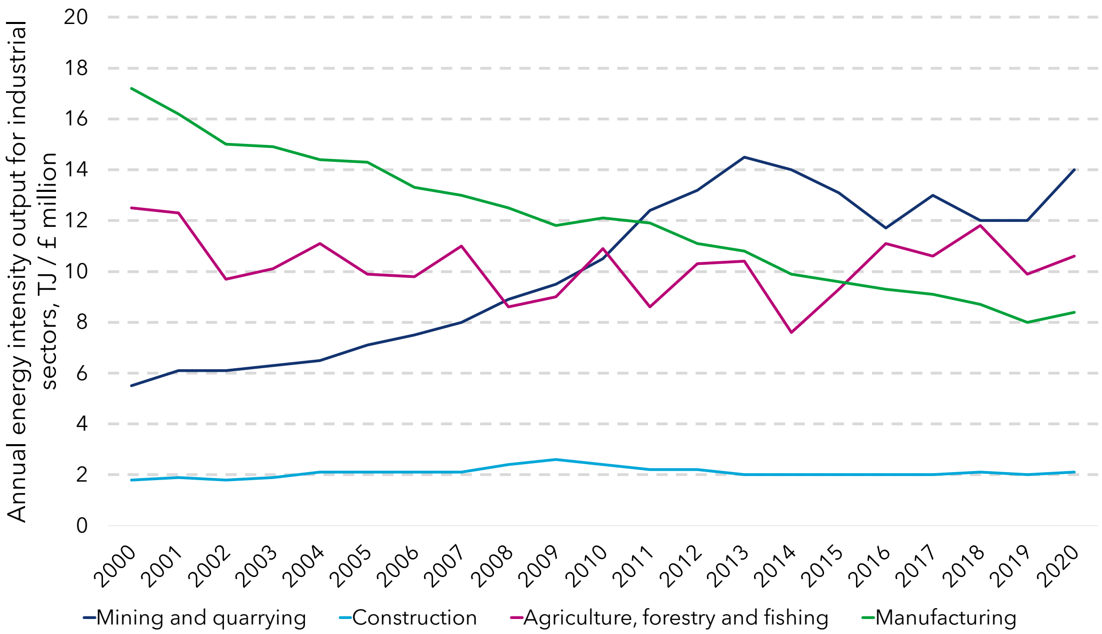

Figure 20. Annual energy intensity of output for industrial sectors, 2000-2020[84]

Energy intensity is a measure of how much energy is required by a country or sector's industrial output. High energy intensity means a higher cost associated with converting energy into industrial output (usually defined by GDP). Low energy intensity means a lower cost associated with converting energy into industrial output.

The energy intensity of manufacturing decreased by 51% between 2000 and 2019 (from 17.2 TJ/£ million to 8.4 TJ/ £million). The decrease was mainly caused by the changing structure of the UK's economy and, through offshoring energy-intensive industries (such as iron and steel, chemicals, and textiles and leather). Only around a third of the reduced energy use was attributable to improvements in energy efficiency.[85] Technological innovation is one of the primary drivers of such improvements, including waste heat recovery through new cooling systems.[86] A more recent tendency in the manufacturing sector towards reshoring might have increased the energy intensity of the total industrial output by changing the structure of the sector.[87]

Most sub-sectors show falling energy intensities over time, except mining and quarrying (increased by 150% between 2000 and 2020) and electrical engineering (increased by 17% since 2000). The available data do not explain whether the changes in the subsectors occurred mainly as a result of improved process efficiencies or switching to less energy-intensive activities within the subsectors.[88] Some of the improvement may be due to past policies in energy efficiency[89] as well as product and construction standards.[90]

4.3 Port traffic

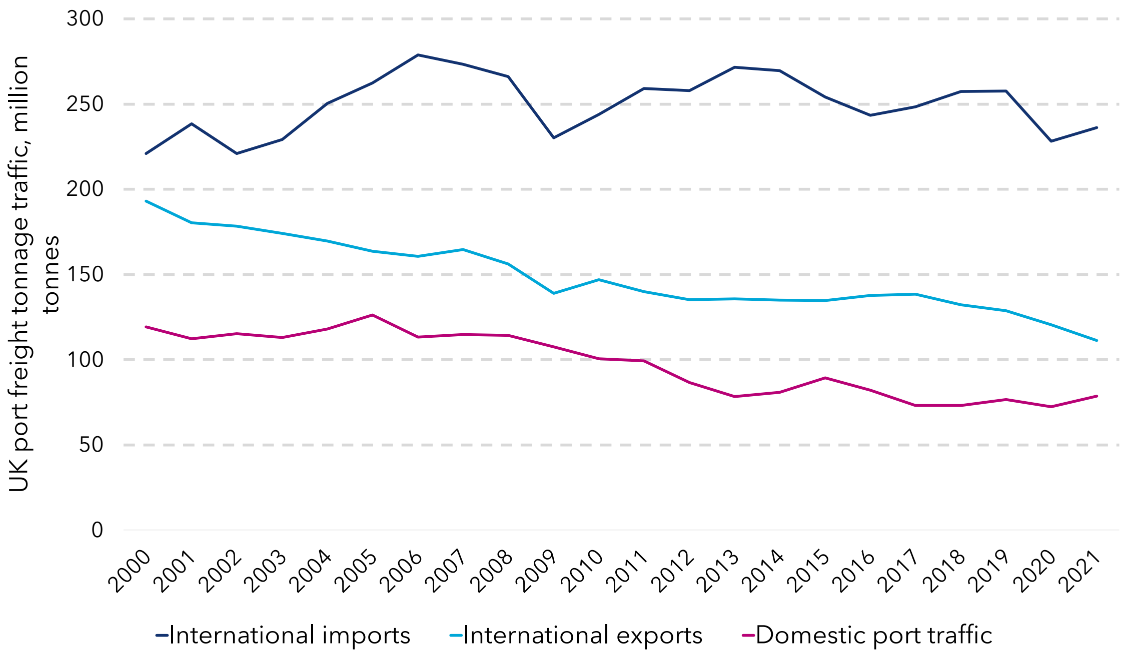

Figure 21. UK annual international and domestic port freight tonnage traffic, 2000-2021[91]

Unlike Figure 19, which shows the UK imports and exports of both goods and services in monetary terms, Figure 21 displays the imports and exports of goods by weight through UK ports only. Between 2000 and 2019, import flow through the UK's ports increased by 17%, while exports dropped by a third from 193 to 129 million tonnes. In 2020, imported tonnage was almost double that exported. The volume of domestic shipping continued its long-term decline, decreasing by around 24%, from 119 million tonnes in 2000 to 90 million tonnes in 2020, with a moderate uptick. Although not shown in the chart, there is evidence that during the COVID-19 pandemic, when lockdown restrictions particularly affected demand for oil products and crude oil, total shipping activity further declined, with a 9% fall between 2019 and 2020.[91] Container traffic also reversed its upward trend, which started in 2012, and fell by 7% between 2019 and 2020. In addition, the latest data on the cost of shipping shows that, after Brexit, shipping to UK ports became more expensive than to EU ports,[92] which may be contributing to the recent decline of the UK freight. Longer-term economic trends, such as offshoring the country's manufacturing, partly explain why the UK continues to import more than it exports. However, there is some evidence of accelerated reshoring among UK manufacturing companies since the

2008 financial crisis, which would affect port traffic.[87] Unlike offshoring which is mainly driven by lower input costs abroad, reshoring decisions are motivated by access to a skilled workforce, technologies and innovation, and by lower supply chain risks.[87]

4.4 Non-hazardous construction and demolition waste

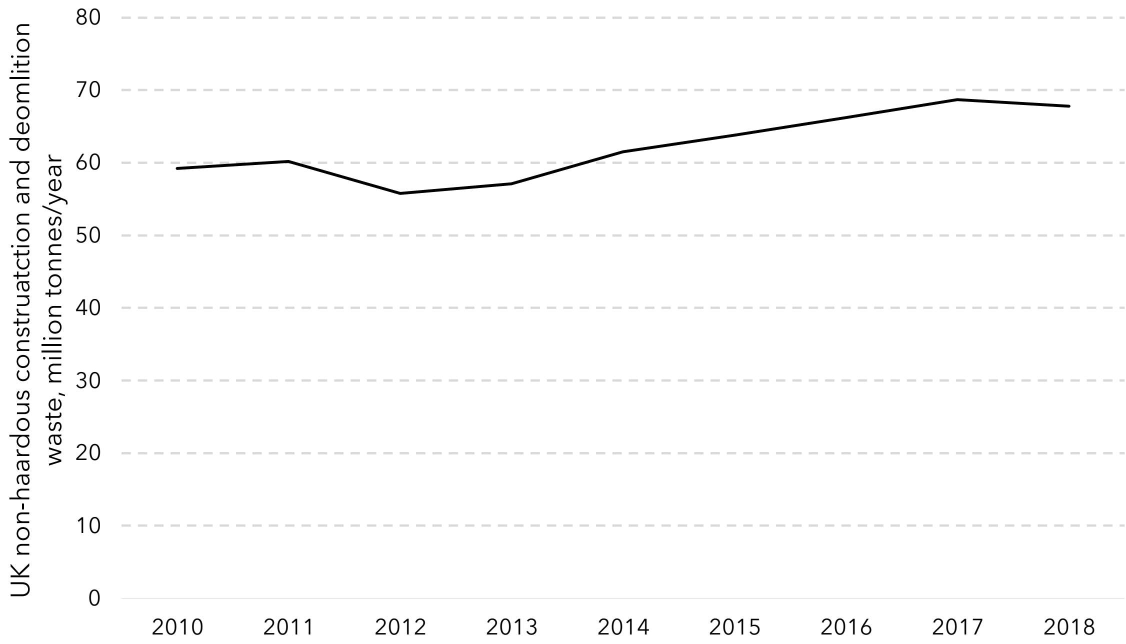

Figure 22. UK non-hazardous construction and demolition waste generated per year, 2010-2018[93]. More recent data is not available for the whole of the UK.

Construction and demolition waste in the UK increased by 15% between 2010 and 2018 (from 59 million tonnes to 68 million tonnes). At the time of researching, more recent data for the UK were not available. This trend is driven predominantly by construction rates (with a 16% increase in the housing stock in England over the past two decades)[94] which are in turn affected by economic growth, demographics and property prices. While it is mainly the extraction, processing and use of materials and products that lead to greenhouse gas emissions,[95,96] the end-of-life stage of these materials and products can contribute up to a quarter of embodied emissions.[97] Embodied emissions have received little attention compared to operational performance of buildings, despite accounting for around 44% of a building's total emissions.[98] Waste from construction and demolition is affected by the lifespan of buildings and structures, reuse and recycling rates, and other circular economy measures that the industry is increasingly adopting. Such measures include material substitution (for example, of wood for concrete), lightweighting, and recycling of materials.[99,100]

Food and land use

This section considers trends relating to the food and land use sector. These include calories consumed, food waste, meat-free diets, afforestation and energy crop production.

5.1 Calories consumed

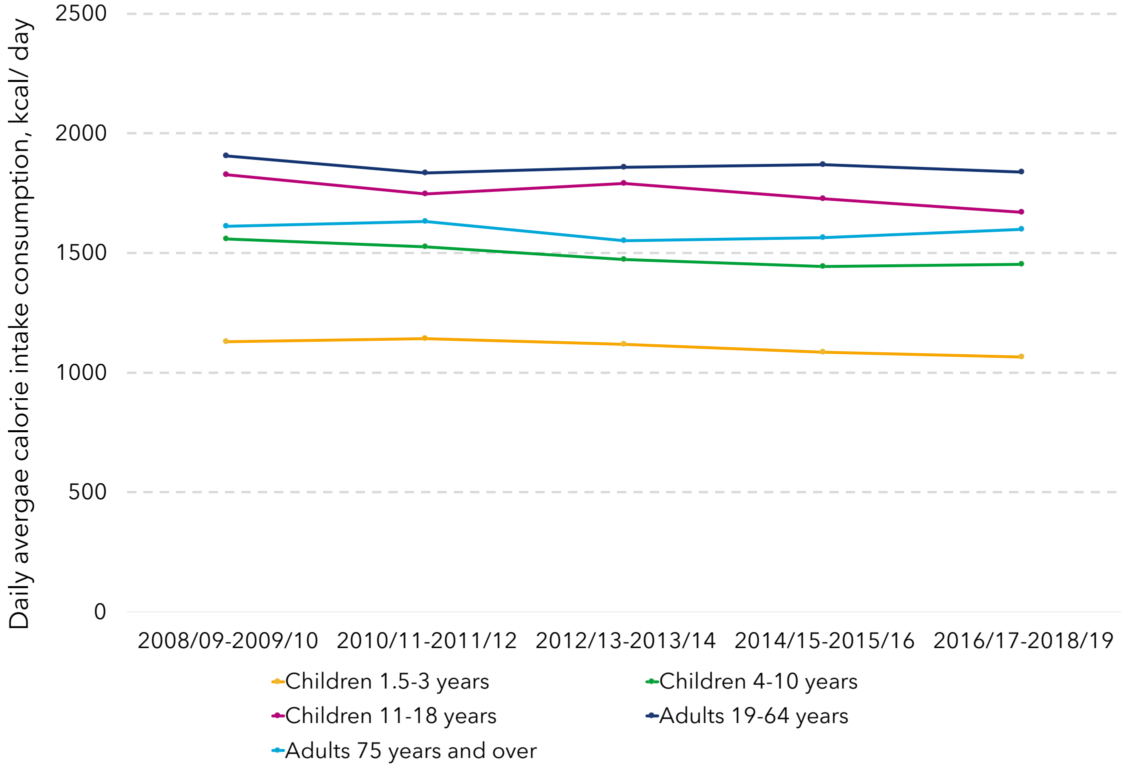

Figure 23. UK daily average calorie consumption by age group, as reported in years 1 to 11 of the National Diet and Nutrition Survey[101]. More recent data from the survey is not available

The UK's reported consumption of calories fell by an average of 5% across all age groups between the 2008–2010 and 2016–2019 survey years. These numbers should be taken with caution, as there is evidence to suggest that the UK population's calorific intake was 30–50% higher than reported.[102] During the COVID-19 pandemic, total reported energy intake and meat consumption did not change, but consumption of fish decreased.[103] However, another study estimates that calorie intake during the pandemic increased by 10–15%.[104] The calorie underreporting in the official statistics is important, as the nation's calorie consumption affects emissions both upstream and downstream (impacting how much food we grow and associated transport as well as how much food is wasted). Intake (and reporting) of calories is affected by a range of individual and systemic factors including age, sex, food availability and prices. Technological changes in food manufacturing in the past several decades have made calories more available and cheaper.[105]

5.2 Food waste

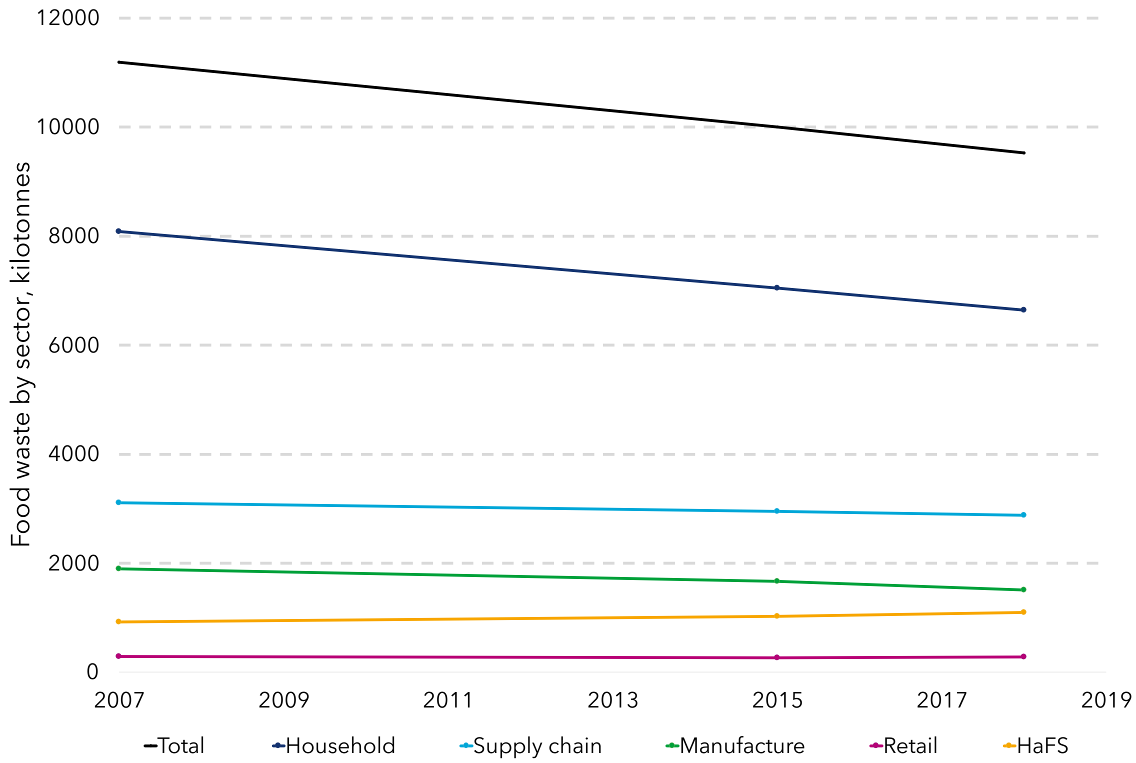

Figure 24. UK food waste by sector, 2007-2018[106], from a 2020 report by WRAP. (HaFS = hospitality and food service). More recent data in the same format not available.

Total post-farm food waste in the UK decreased by 15% between 2007 and 2018 (from 11 million tonnes to just under 10 million tonnes). Around 70% of the total was household food waste, with the rest arising from the post-farm supply chain. Food waste from households fell almost three times faster than that from the supply chain over the same period. Some of the factors that might have affected the rapid decrease include raising awareness, improvements in food labelling and packaging, more access to separate food waste collections, and changes in income and food price.[106] Other likely reasons for the reduction in food waste from households include a post-recession fall in consumer spending and growing basic competence in cooking and food management.[107] Within the food supply chain, manufacturing was responsible for 16% of the total food waste in 2018 (at just under 2 million tonnes), with the hospitality and food service sector (HaFS) generating 12% of the total food waste. The rest of the food waste arose from retail (3% of the total food waste). By product group, the volume of waste is highest in the cereal category (just under a third is wasted) and vegetables and starchy roots (around a quarter is wasted).[108] To reduce food waste, manufacturers and retailers increasingly measure their food waste and work with charities to distribute products that would otherwise be wasted. The hospitality & food service sector is more fragmented and complex, so presents challenges in both measuring and reducing their food waste.

5.3 Meat-free diets

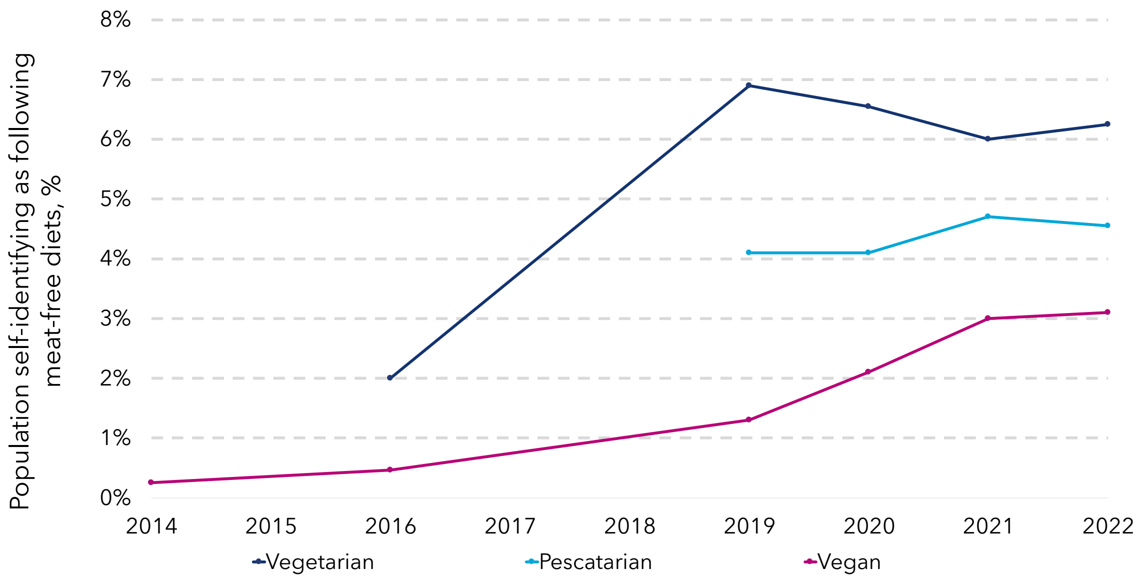

Figure 25. Percentages of the UK population self-identifying as following meat-free diets, 2014–2022[109]

The number of people reporting that they follow a meat-free diet increased by 11% between 2016 and 2022, reaching more than 7 million people. Among them, the number of vegetarians grew the fastest: from 2% to 6% of the population over the same period. However, a more recent slice of this data, between 2019 and 2022, shows a decrease in the number of vegetarians (by 9% from 4.6 million to 4.2 million people) and rapid growth in the number of vegans albeit from a low base (by 143% from just under 1 million to more than 2 million people). There are notable differences by age, with a quarter of generation Z currently on a meat-free diet, compared to 12–13% for generation X and baby boomers.[109] Considerations of ethics, health and environment are the main drivers of switching to plant-based diets, while the main barriers include concerns about cost and convenience of such diets.[110, 111] Social aspects such as role models and support by peers and family members also affect people's likelihood of becoming vegan or vegetarian.[111]

5.4 Afforestation

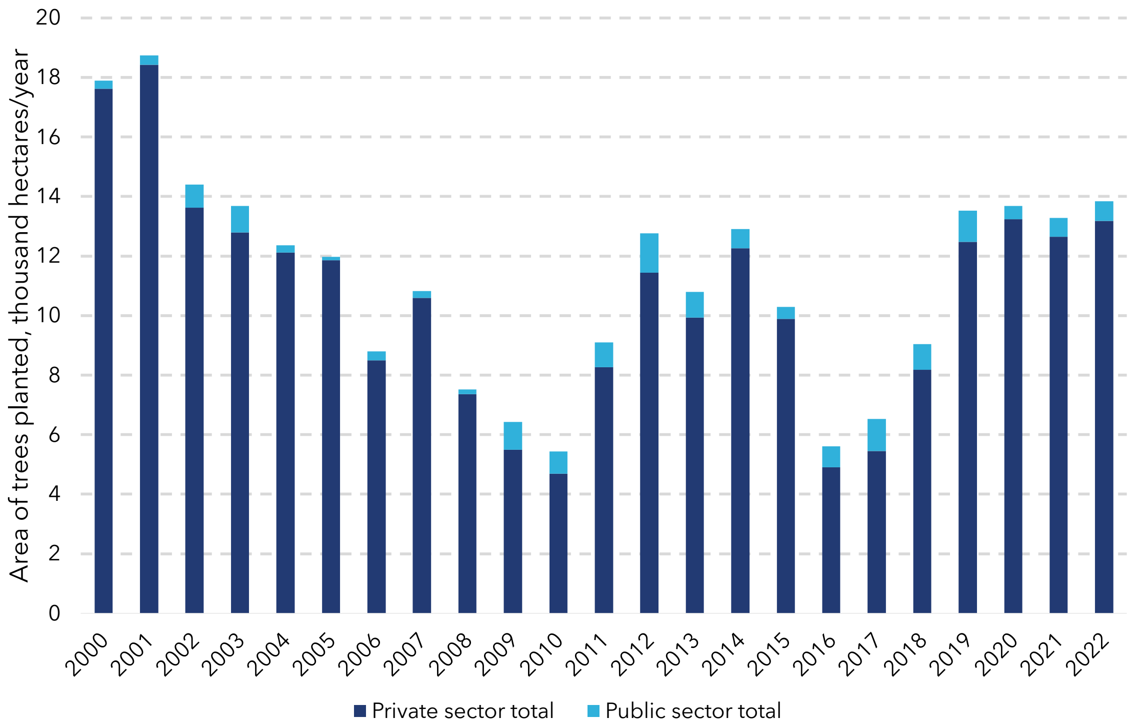

Figure 26. **Area of trees planted per year in the UK, 2000-2022 (2022 data is provisional)**[112]

Between 2000 and 2021, almost 260,000 hectares of woodland was planted by both the private sector and UK government agencies (including Forestry England, Forestry and Land Scotland, Natural Resources Wales, and Forest Service). Government agencies planted on average 600 hectares per year, while the private sector planted around 17 times that. There were notable fluctuations in the annual afforestation rates by the private sector, with peaks in 2014 (12,000 hectares) and 2020 (13,000 hectares) and troughs in 2010 and 2016 (around 5000 hectares). Scotland was responsible for the spikes in tree-planting, mainly due to improved application and funding processes for such projects.[113] Despite these increases, the total area being afforested each year decreased by around 25% from 18,000 hectares in 2000 to 13,000 hectares in 2021. Overall, the afforestation has been incentivised by woodland creation targets and funding supplied by national governments and Local Authorities. Carbon offsetting schemes through tree-planting have recently gained popularity, although their effectiveness at storing carbon in the long term is still being investigated.[114] Another potential future driver of afforestation is trade in forest products: the UK currently imports 80% of forest products,[115] so using and exporting more of its native forests could incentivise creating more woodland to compensate for this.

5.5 Energy crop production

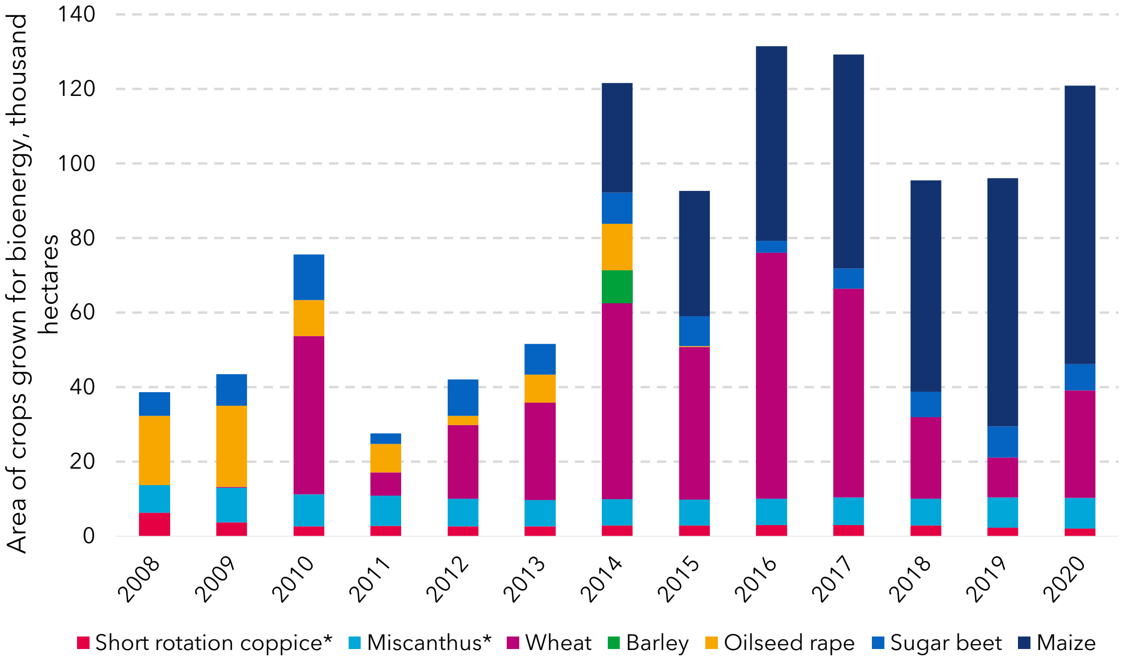

Figure 27. Total area of crops grown for bioenergy in the UK, 2008-2020[116](*Short rotation coppice and Miscanthus data are for England only). More recent data is not available.

Energy crops are plants used for bioenergy production. These crops are grown and then processed into fuels (including bioethanol, biodiesel or biogas). The two main types of perennial energy crops produced in England (where such statistics are systematically collected) are short rotation coppice and Miscanthus (a highly productive grass species able to grow in relatively cold conditions). The area occupied by these two crops was around 10,000 hectares in 2020, an increase of 5% since 2015. Miscanthus generally took up between 70% and 80% of that area, and the number of Miscanthus growers increased by 73% from 409 to 708 over the same period. By contrast, the number of growers planting short rotation coppice fell by 15% from 361 to 306. Another perennial potentially valuable for bioenergy, short rotation forestry, is not yet being planted at scale.[88] The main UK food crops grown for energy purposes include wheat, barley, and sugar beet for bioethanol, oilseed rape for biodiesel, and maize for anaerobic digestion.[117] Maize has become particularly dominant, with its area increasing from 29,000 hectares in 2014 to 75,000 hectares in 2020, incentivised by the UK government support for biogas production.[118] Availability of land might be a constraint on the UK's expansion of energy crops, particularly if more expensive cropland is used rather than grassland.[119] However, growing demand for clean energy might make this use of land increasingly competitive with food crops and livestock.

Conclusion

Achieving a net zero society is a complex challenge that will entail both technological advances and societal changes. To further our understanding of the latter, this report has analysed some of the key societal trends relevant to the UK's emissions over the past two decades.

Before the COVID-19 pandemic, emerging trends included battery electric vehicle (EV) sales rising ten-fold between 2015 and 2020, smart meter installations rising more than 65 times between 2012 and 2018, and publicly accessible EV charging points rising six-fold between 2015 and 2020 – all from a low base. Another rapidly changing trend was cumulative capacity of rooftop solar photovoltaics, which increased by 260 times between 2010 and 2021. Moving in the opposite direction, home insulation rates fell by 70% between 2013 and 2020. Most of these trends were driven by government support, or by its withdrawal, although growing environmental awareness and other factors did play a role. More recently, some trends were immediately disrupted by the pandemic (such as travel), while others might be affected in the long run (such as the use and construction of offices and homes).

The analysis in this report shows that well understood drivers of many societal trends continue to be important, including government policies, the state of the economy, and the cost and performance of low emission choices. Less anticipated drivers include supply chain disruptions, availability of critical raw materials (such as lithium for batteries) and parts (such as chips for cars), and showrooms and eco-home events fostering familiarity with new technologies (such as for EVs, retrofits and heat pumps).

This report has also highlighted the important systemic interactions between the trends, for example floor area demand affects emissions from construction and space heating, and food consumption affecting both demand for travel and land use. Many of the net zero societal trends are influenced by 'super-drivers' spanning multiple areas of society. Figure 28 below shows interdependencies involving drivers such as environmental awareness, economic growth, and demographics. For example, environmental awareness significantly affects trends from electric vehicle sales to food waste to home insulation rates, whilst demographic changes are strongly correlated with trends in calorie consumption, household size and trade.

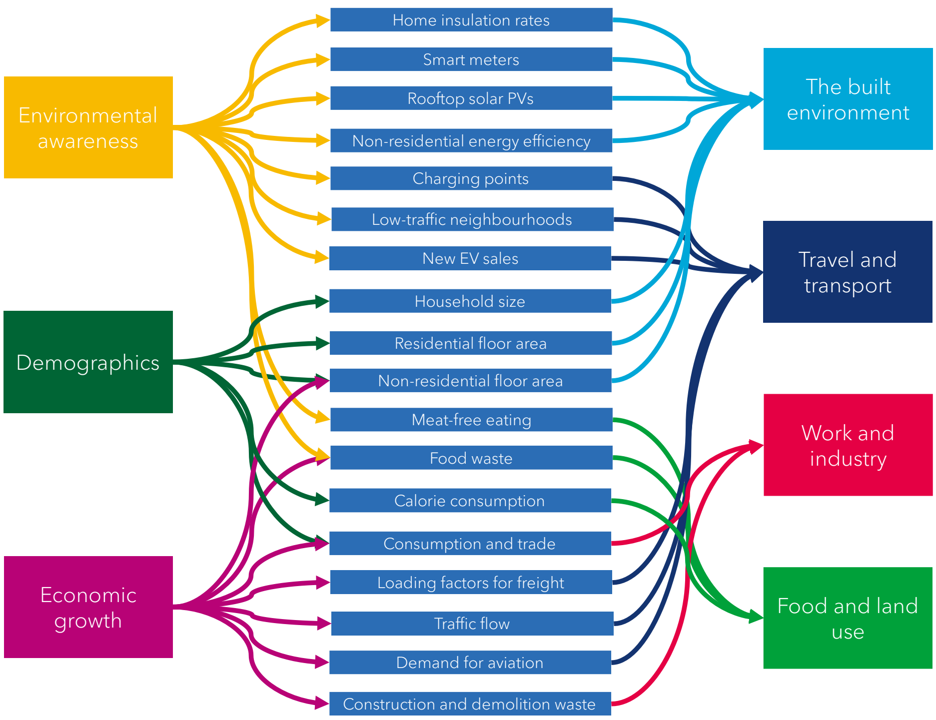

Figure 28. Societal drivers affecting the largest number of trends across the four sectors

This paper has allowed us to explore a sample of historical relationships between drivers of change and the resulting net zero societal trends. This analysis was used within the net zero society foresight project to inform our assumptions about the future relationships between these factors for use in the creation of our detailed future societal scenarios.

Appendix 1. Key net zero societal trends and their drivers in four sectors of the UK economy

Key trend by sector (The built environment)	***Responsibility***	***Type of trend***	***Underlying driver***	***Figure numb er***
Home insulation rates	Individual; business	Technology-driven behaviour	environmental awareness; government funding; climate (e.g. threat of overheating); energy savings; thermal comfort; supportive peers; improvements to home; eco-home events; availability of skills and materials	2
Average indoor temperature of a home	Individual	Purely behavioural	climate; time spent indoors; expectations of thermal comfort; more efficient housing; house ownership; heating system type; vulnerability of occupants	3
Smart meter installations	Individual; business	Technology-driven behaviour	environmental awareness; government targets; technological issues	4
Household size and occupancy	Individual; business	Technology-driven behaviour	property prices; demographics	5
Residential floor area	Business	Technology-driven behaviour	property and land prices; demographics; complex planning system; development of other local facilities; state of construction sector	6; 7
Heat pumps installed in homes	Individual; business	Technology-driven behaviour	cost; environmental awareness; climate; government funding; aesthetics; performance concerns; lack of familiarity with technology; disruptive nature of installation	8
Rooftop solar PV installed	Individual; business	Technology-driven behaviour	cost; environmental awareness; climate; government funding; technological innovation	9

Appendix 1: Trends by sector

Non-residential floor area	Business; local authority	Technology-driven behaviour	economic growth; property prices; interest rates; return on alternative investments; foreign investment; demographics; working from home practices; footfall in city centres; conversions to residential	10
Non-residential energy efficiency measures	Business	Technology-driven behaviour	environmental awareness; regulatory standards; cost; payback period; corporate social responsibility; climate; government funding	11

Key trend by sector (Travel and transport)	***Responsibility***	***Type of trend***	***Underlying driver***	***Figure number***
Loading factors for freight	Business	Technology-driven behaviour	trade; economic growth; fuel prices; level of income; ratio of local to long-haul freight; availability of freight consolidation centres; co-loading; road pricing schemes	12
Traffic flow by transport mode	Individual; business	Technology-driven behaviour	economic growth; cost of travel	13; 14
New electric car sales	Individual; business	Technology-driven behaviour	environmental awareness; cost; performance; number of charging points; supply chain risks	15
Publicly accessible charging points	Business; local authority	Technology-driven behaviour	environmental awareness; electric car sales; government funding; local authority support; density of local population	16
Demand for domestic and international aviation	Individual; business	Technology-driven behaviour	economic growth; cost of travel; leisure patterns; business travel; health considerations (COVID-19)	17
Commuting trips per person	Individual; business	Technology-driven behaviour	property prices; teleconferencing tech and broadband quality; transport infrastructure	18

Key trend by sector (Work and industry)	***Responsibility***	***Type of trend***	***Underlying driver***	***Figure number***

Appendix 1: Trends by sector

Household and business consumption and trade balance	Individual; business	Technology-driven behaviour	economic growth; trade; consumer preferences; business practices related to circular economy; cost of goods; inflation (cost of living); availability of new products; demographics; supply chain risks	19
Energy intensity of industrial subsectors	Business	Technology-driven behaviour	technological innovation; process efficiency; regulatory standards; offshoring/ reshoring	20
Port freight traffic	Business	Technology-driven behaviour	trade; demand for goods; manufacturing costs in UK and abroad; shipping costs; offshoring/ reshoring; access to skills and technologies; supply chain risks	21
Construction and demolition waste	Business	Technology-driven behaviour	economic growth; construction rates; reuse and recycling rates; lifespan of buildings and structures	22

Key trend by sector (Food and land use)	***Responsibility***	***Type of trend***	***Underlying driver***	***Figure number***
Calorie consumption	Individual	Purely behavioural	demographics; health; food prices; food availability; technological innovation	23
Food waste	Individual; business	Technology-driven behaviour	economic growth; food prices; environmental awareness; food labelling and packaging; access to separate food waste collections; basic competence in cooking and food management; (retail) food waste measurement; (retail) distributing food to charities	24
Meat-free eating	Individual	Purely behavioural	environmental awareness; campaign groups; availability of vegetarian/vegan foods; food prices; convenience; taste; supportive peers; celebrity role models	25
Afforestation rates	Business; local authority	Technology-driven behaviour	government funding; local authority support; offsetting schemes; native forest products for export	26

Area of bioenergy crops	Business; local authority	Technology-driven behaviour	demand for bioenergy; availability of land and water; government targets; government funding	27

Acknowledgements

This report was produced by Maria Sharmina (University of Manchester) and members of the GO-Science foresight project team (Heather Ballard and Emily White) as part of the net zero society foresight project.

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