Greenhouse gas emissions in Winchester District: Part III

Estimates and trends (2005-2011)

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This report was commissioned by Winchester City Council from Winchester Action on Climate Change (WinACC). It presents a summary of emissions in Winchester District from 2005 to 2011. Like the commissioned reports of 2011 and 2012, it aims to assist Winchester Climate Change Programme Board to make informed decisions about, and to take actions on, reducing Winchester District's greenhouse gas emissions. The report also reviews progress towards the shared target of a 30% reduction in the carbon footprint of Winchester District by 2015 (relative to 2004) and identifies where greater improvements should be made in order to meet the target.

RECOMMENDATIONS

To reduce greenhouse gas emissions in Winchester District, and in particular to meet targets that have been set,

WinACC recommends:

- Action by organisations, both commercial and public sector, to reduce emissions from electricity and goods vehicles, both of which have increased since 2005 and currently together contribute 36% of the District's emissions.
- Action to encourage car drivers (28% of the District's emissions) to cut their emissions even more by using alternative modes of transport, which cause less emissions, and by other measures including,
    - A plan to "nudge" car drivers to drive less, use more efficient vehicles, and drive in a more environmentally friendly manner.

    - A requirement on all planners and projects to address the needs of walkers and cyclists before the needs of motorised transport, and of public transport before private cars.
    - Cycling to be presented as a form of transport rather than only as a leisure activity.

- To encourage rail travel by, for instance,
    - Action by the City and County Councils to reinforce the shift from private car to rail travel, in particular by pressing for increased rail capacity at Winchester town.
- To discourage air travel for leisure purposes.
- To implement those recommendations of WinACC's 2012 report which relate to emissions at sub-local authority level.

EXECUTIVE SUMMARY

This report is based on two premises: a) that climate change is largely caused by humankind's activities and b) that, to mitigate its effects and avoid exceeding 2℃ of warming, it is necessary to reduce greenhouse gas emissions now as a matter of urgency. Since most emissions come from burning fossil fuels, the report stresses areas where fossil fuel use can and should be reduced. The alternative approach, to expand the use of renewable energy as a way to replace fossil fuels, is not addressed here, but should be considered and implemented in parallel.

From 2005 until 2011, Winchester District performed less well in reducing its emissions compared to neighbouring local authorities and remained below average compared to all other local authorities in England. Of the seven main sources of emissions examined, five are unlikely to meet the target of a 30% cut by 2015 relative to 2004.

The commercial and business sector, including public bodies, needs to significantly cut its emissions from electricity and from goods vehicles, both of which have increased since 2005, if it is to meet the target.

Even though emissions from cars decreased by 12% their large (28%) contribution to total emissions means that efforts are required to reduce the number and even size of cars and to encourage lower annual mileages and more careful driving.

The number of passengers using Winchester railway station increased steadily since 2005. Passenger numbers at Southampton airport continued to decline since 2008.

Overall, but excluding emissions from land use (no times series figures available) and rail and air travel emissions (no accurate estimates exist), emissions in Winchester District reduced by approximately 13% between 2004 and 2011 (from an estimated 1272 thousand tonnes CO_2-eq to 1107 thousand tonnes CO_2-eq). A decrease of about 18% was required to be on target. This reduction estimate excludes the mostly harder-to-quantify sectors of food, consumer goods and services; the total reduction may have been less.

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INTRODUCTION

This report follows two earlier reports completed in 2011 and 2012 for the Winchester Climate Change Programme Board.[1] It brings up to date the greenhouse gas emissions data provided from several sources at Winchester District level. The 2012 report also explored electricity and gas emissions at sub-local authority level (Medium Level Super Output Areas); these are not revisited here.

The figures presented here are computed emissions from the use of electricity, gas, transport fuels and other fuels computed using published conversion factors. Most of the emissions cover all relevant greenhouse gases and are expressed in terms of the amount of carbon dioxide with an equivalent warming potential (CO_2-eq). The exception is land use changes, for which only carbon dioxide (CO_2) emissions are available. The background to the need to monitor emissions at local authority level, in the context of climate change and the UK government's stated emissions reduction targets, can be found in the 2011 report (referred to subsequently as Report I).

The need to reduce greenhouse gas emissions globally, and therefore nationally and locally, has been further strengthened by the findings of scientific research published since Report II in 2012. More extreme and more damaging weather events worldwide are now beginning to be attributed to climate change which is widely accepted to be largely anthropogenic (caused by humans) in origin. This adds urgency to work in Winchester District to reduce greenhouse gas emissions.[2]

Data availability

Table 1 lists the sources of energy and fuel consumption data which have been used and shows the date of the latest information.

The dataset previously called NI186, and now referred to as 'CO2 emissions within the scope of influence of Local Authorities', gives summaries of emissions per capita at local authority level[3] but it has not been used here for several reasons. First, emissions data depend on the use of factors to convert from energy or fuel used to carbon dioxide equivalent emissions and, in the case of electricity, these factors include significant year-to-year changes in the national energy mix used to generate electricity. Consequently it is hard to separate changes in emissions by local consumers from the effects of changes in the national electricity infrastructure whereas this is possible considering energy consumption figures alone.

Second, NI186 ignores emissions from the use of motorways. It does not attribute fuel consumption to particular classes of vehicle, as used here, but only to the type of road where the emissions are deemed to have occurred.

Third, NI186 data are published late in the year, usually in late August, at least 20 months after the end of the year in question and after this annual update has been completed (although unusually this year they were published in July). This is why other data sets, also published by the Department of Energy and Climate Change (DECC), have been used here.

Table 1. Sources of data available at Local Authority (LA) level which provided primary estimates of emissions for this investigation (grey cells)

Source	Year									
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
DECC LA summary[a]									publ July 2013	
DECC electricity[b]									publ March 2013	
DECC gas[c]									publ March 2013	
DECC road transport[d]									publ June 2013	
DECC other fuels[e]								publ Dec 2012		
Land use changes							Report dated 2010			

Trellis pattern = less reliable, experimental statistics
Blank cells = pre-2005: data not compatible with post-2005 data sets; post-2005: no data yet available.

a. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/211878/110713_Local_CO2_NS_Annex_B.pdf.
b. https://www.gov.uk/government/statistical-data-sets/regional-and-local-authority-electricity-consumption-statistics-2005-to-2011
c. https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/sub-national-gas-consumption-data. The 'gas year' runs from 1 October until 30 September
d. https://www.gov.uk/government/statistical-data-sets/road-transport-energy-consumption-at-regional-and-local-authority-level.
e. https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/sub-national-consumption-of-other-fuels

Data accuracy

Collecting accurate data on energy use and greenhouse gas emissions at local authority level is difficult. Estimates are frequently made based on incomplete or inappropriately classified data or by using models that necessarily have built-in assumptions. However, whatever the failings of a particular data set, to a large extent trends can be discerned with more confidence than can be given to individual estimates provided that there is consistency in the estimation process from year to year. For that reason the absolute accuracy of annual emissions presented here should be treated with some caution whereas the trends are likely to be closer to reality. A more detailed discussion is provided in reference 4.

Determining trends in the data

2004 was originally chosen as the baseline year for the shared target of a 30% reduction in greenhouse gas emissions by 2015, implying an average annual reduction of 3.2%. However, DECC recommends that its 2005 data, which are classed as National Statistics, should ideally be used as the baseline when making historical comparisons of the electricity and/or gas data because they are significantly more robust than the data from earlier years. For example, DECC advises that the pre-2005 gas consumption datasets should not be used for time series analysis, because changes in consumption recorded in the figures are mainly caused by improvements in data quality rather than by real changes in consumption.

So here DECC energy data, and for consistency all other data, have been plotted using 2005 as the reference year. Plots of emission reductions relative to a 2005 baseline will therefore indicate slightly lesser values, than if 2004 had been used, assuming that the District's energy consumption decreased between 2004 and 2005, as it did nationally. Nevertheless the directions of any consistent trends in the data will remain valid.

The effect of population changes

Energy use and emissions will depend to an extent on changes in the District's population. Winchester's population was 107,222 in 2001 and 116,600 in 2011 (ref.[5]), an average increase of 0.84% per annum, and this may have affected emissions. For example, in the six years from 2005 until 2011 the population would have increased by about 5.2%, assuming a uniform growth rate. The number of households increased from about 46,000 in 2001 to 46,900 in 2011, (ref.[6]) an increase of 2% over ten years, implying that the number of households may have increased by about 1.2% between 2005 and 2011. On the other hand industrial/commercial emissions will largely reflect the economic activity within the District.

Since the Winchester emissions target apparently relates to total emissions and not to *per capita* emissions, the possible influence of population and household changes is not mentioned further.

PRIMARY ESTIMATES OF EMISSIONS

Primary estimates of emissions are defined here as those that are derived from the metered use of electricity, gas, transport fuels, other fuels and land use changes. They are investigated at local authority (LA) level. Results for the sub-LA level (Medium Level Super Output Areas) up to 2010 were discussed in Report II.

Electricity

In England in 2011 electricity consumption accounted for 35% of the emissions from the seven main sectors reported here with the greater contribution (21%) coming from the industrial/commercial sector. Thus it is important to understand the sources and current trends of emissions from electricity in the District if effective measures are to be adopted to reduce local emissions.

DECC collects electricity data with the help of the electricity industry[7]. Annualised consumption data are generated by agents of the electricity suppliers, who collate/aggregate electricity consumption levels for each customer meter. Consumption data are then merged together to enable consumption data to be mapped to postcodes and aggregated to local authority and government office regions levels. The electricity consumption data are generated for two classes of user.[a] For the non-half-hourly data, an estimate of annualised consumption is based

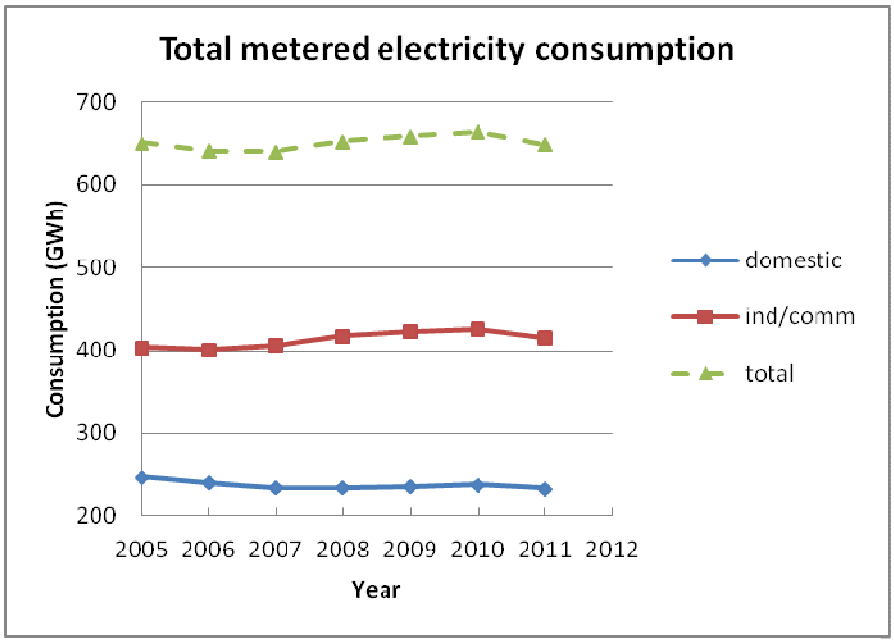


Figure 1. Metered electricity consumption in Winchester District (2005-2011). 1 GWh = 1,000,000 kWh.

[a] Non-half-hourly meters include domestic and small/medium industrial/commercial customers, hereafter referred to as 'domestic' customers and half-hourly meters include larger industrial/commercial customers, hereafter referred to as 'industrial/commercial' customers. 'industrial/commercial' is a term used by DECC which can also include the public sector.

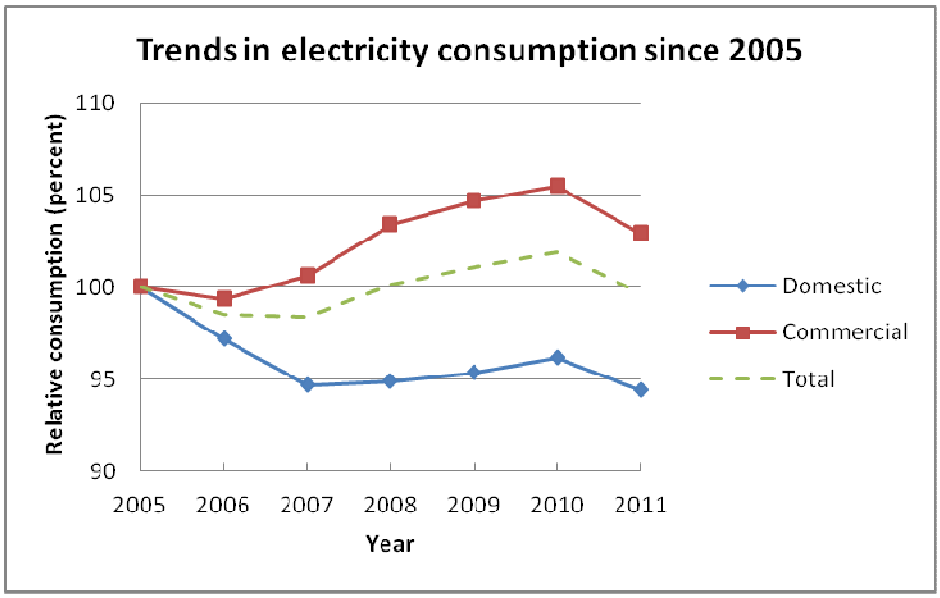


Figure 2. Relative consumptions in the domestic and commercial/industrial sectors since 2005 (2005=100).

on consumption recorded between two meter readings or, where two meter readings are not available, it is produced using historical information and knowledge of the customer's consumption 'profile'. The non-half-hourly data include both Ordinary and Economy 7 type tariffs. Larger domestic customers, defined as those usually consuming more than 100,000 kWh per year or, following specific validation, of those consuming over 50,000 kWh are reallocated to the industrial/commercial sector (this latter definition seems to apply in Winchester District where the average annual industrial/commercial consumption per meter has been about 74,000 kWh).

Fig.1 shows the metered electricity consumption in Winchester District from 2005-2011.

Although domestic consumption decreased by 6% overall, it increased slightly after 2007 and peaked in 2010; industrial/commercial consumption increased by 3% over the same period and also peaked in 2010. The average consumption per domestic meter decreased steadily by 10.5% between 2005 and 2011 ending up at 4700 kWh in 2011. The average consumption per industrial/commercial meter on the other hand has remained between 72,400 and 75,900 kWh for the whole period (essentially static within 5%) with only weak evidence of a downward trend.

Fig.2 shows the changes in electricity consumption relative to 2005. The overall change is almost exactly zero. The District's total consumption of electricity was only 3,000 kWh (0.4%) less in 2011 than it was in 2005!

Greenhouse gas emissions from electricity consumption are estimated using the relevant factor to convert from kWh to kg CO_2-eq published by Defra[a]/DECC for each year to be used in company reporting.[8] Until 2012 Defra/DECC stated that 'This factor changes from year to year, as the fuel mix consumed in UK power stations changes (as well as the net amount of imported electricity). Because these annual changes can be large (the factor depends very heavily on the relative prices of coal and natural gas as well as fluctuations in peak demand and renewables),

[a] Defra is the UK's Department for Environment, Food and Rural Affairs.

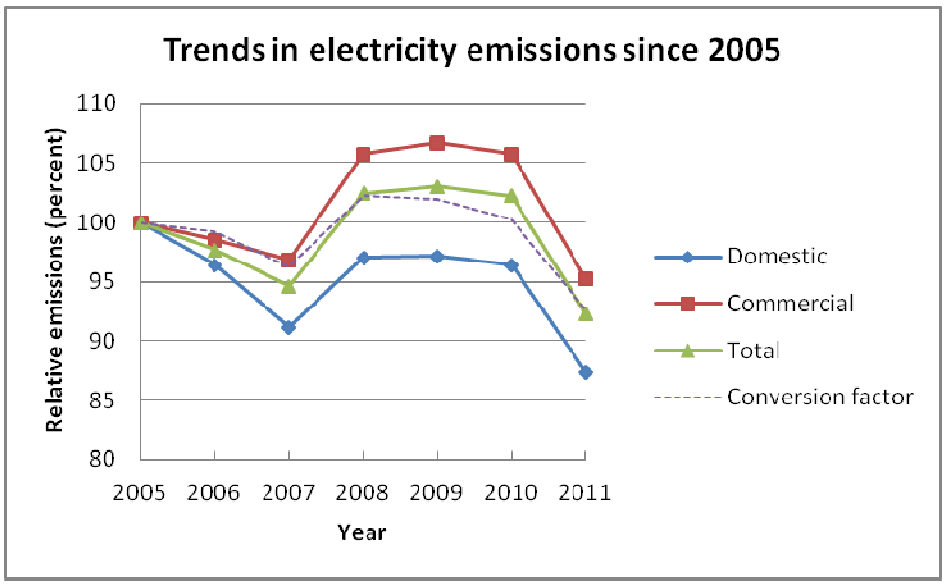


Figure 3. Trends in emissions relative to 2005 from the domestic and commercial/ industrial sectors showing the strong influence of annual changes in the conversion factor (2005=100).

and to assist companies with year to year comparability, the factor presented by DECC is the rolling average of the grid conversion factor over the previous five years.'

However, in 2013 a new system has been adopted by Defra/DECC which has done away with the rolling average and presents the relevant conversion factor for each year. Consequently any calculated emissions now include the year-to-year changes in the above factors which were previously largely smoothed out of the data. Further, for electricity, two factors are now presented. The sum of these factors, equal to CO_2-eq per kWh of electricity, allowing for losses (and emissions) in the transmission and distribution infrastructure, is the recommended factor to use[9]. It is equivalent to the factor used in Report II and has been used here to estimate trends in the total emissions (Fig.3).

Fig.4 presents a comparison of the earlier 5-year running average factors and the annual factors. It is evident from the irregular year-to-year variations in the latter that they may obscure any trends in emissions caused by the behaviour of consumers; they create too much 'noise'. Therefore, for electricity, we rely on plots of electricity consumption, as in Figs. 1 and 2, to determine trends. It is also evident from Fig.4 that there is a significant offset between the two sorts of conversion factor. In principle the rolling average for 2009 (0.59368), for example, should be the same as the average of annual factors for 2005-2009 (0.52242) but this is clearly not so and there is a 12% difference. Carbonsmart, consultants acting on behalf of Defra, were unable to explain this discrepancy. Nevertheless, to be consistent with the new Defra/DECC method of reporting electricity emissions, emissions have been calculated using the published annual factors. Consequently there will a discrepancy between values given in Report II and this report.

At the end of 2011 domestic emissions from electricity were about 113,000 tonnes and industrial/commercial emissions were about 201,000 tonnes giving a total of 314,000 tonnes CO_2-eq.

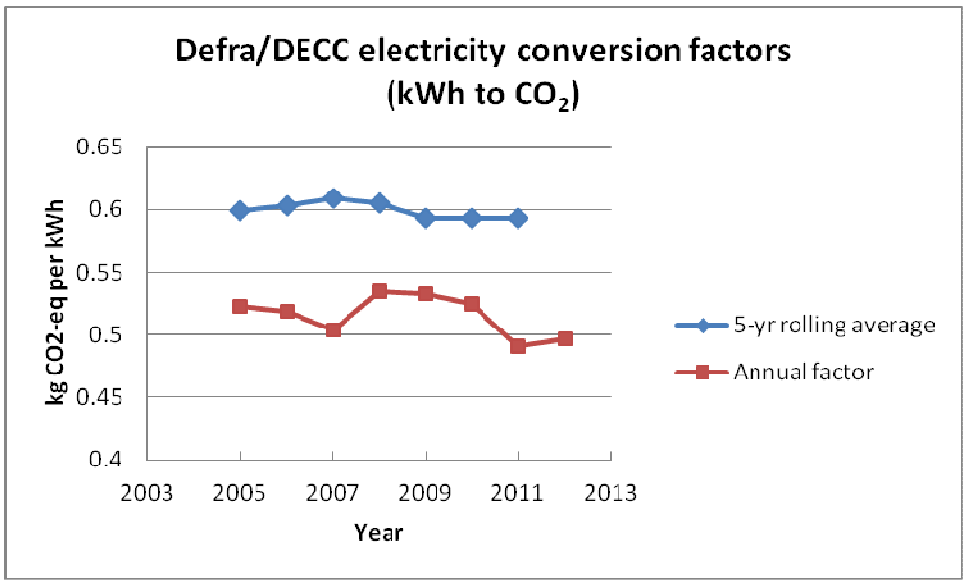


Figure 4. Comparison of Defra/DECC's 5-year running average conversion factors (2005-2010) and the new annual factors (2005-2011).

Electricity Summary:

- *Trends in emissions calculated from electricity consumption are not considered here because Defra/DECC's new annual conversion factors, which reflect changes in the energy mix and other factors, tend to obscure any changes in the behaviour of consumers. Consequently trends in electricity consumption need to be studied to form a view as to whether the District's consumers are helping to meet its target of a 30% reduction in emissions by 2015.*
- *Electricity consumption in the District in 2011, as in 2010, was divided in the ratio 36:64 between domestic and industrial/commercial sectors. This 'domestic' figure includes small and medium businesses (SMEs) using less than 50,000 kWh per year.*
- *Across the whole District since 2005 there has been no change in electricity consumption. Domestic consumption has decreased by 6% (about 1% per year). Industrial/commercial consumption, on the other hand, has increased by 3% (about 0.5% per year).*
- *Electricity emissions, calculated on the new basis of annual factors, were around 314,000 tonnes CO_2-eq in 2011.*

Natural gas

In England in 2011 gas consumption accounted for 28% of the emissions from the seven sectors reported here with the greater contribution (18%) coming from the domestic sector. Thus it is important to understand the sources and current trends of emissions from gas in the District if effective measures are to be adopted to reduce local emissions.

DECC provides weather-corrected gas consumption estimates for 2005-2011 at local authority and government office region level (Table 1).[7]

A company called xoserve provides annual estimates of consumption for all UK gas meters, based on two meter readings at least six months apart. The estimate is then adjusted to include a weather correction that reflects the observed warming trend, including year to year

fluctuations, over the last 17 years.[10] However, for around 4 million meters each year (approximately 18% of the total), no up-to-date annual estimate can be made because no new meter readings for those meters have been taken!

There is no reliable allocation of estimates between the domestic and industrial/commercial sectors for consumers with relatively low gas consumption. This is because the gas industry uses a crude 73,200 kWh per year level as the cut off point for defining customers as domestic or industrial/commercial. The implication of this is that nationally only around half a million businesses are allocated to the industrial/commercial sector, with around 2 million SMEs allocated to a sector which contains mainly domestic meters.

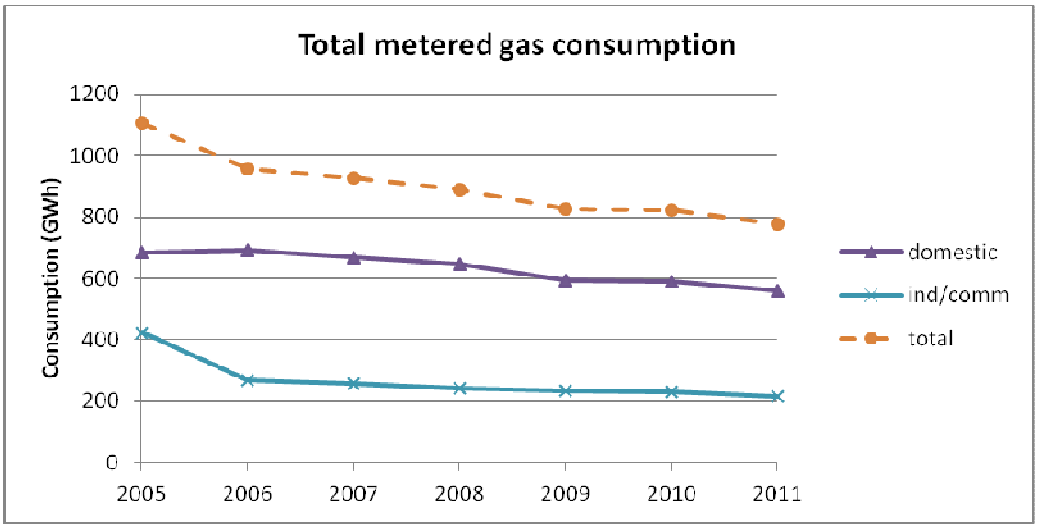


Figure 5. Metered gas consumption in Winchester District (2005-2011). Note that the domestic sector includes a large number of small and medium-sized businesses. 1 GWh = 1,000,000 kWh.

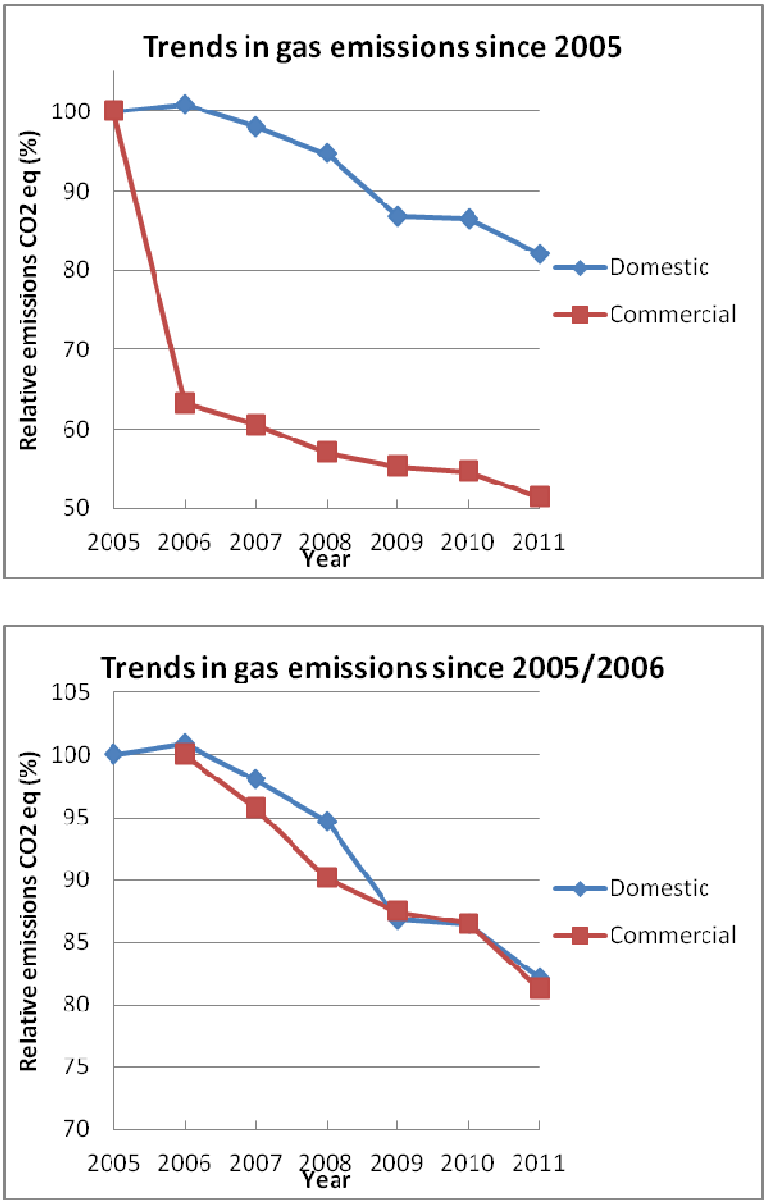
Table 2. Emissions from gas consumption in each sector since 2005.

Year	Domestic sector (thousand tonnes CO_2-eq)	Industrial/commercial sector (thousand tonnes CO_2-eq)	Total (thousand tonnes CO_2-eq)
2005	155	96	251
2006	157	61	218
2007	152	58	210
2008	147	55	202
2009	135	53	188
2010	134	53	187
2011	127	49	177

Total metered gas consumption for the two sectors is shown in Fig.5. The values for 2005 are suspect because the consumption by the industrial/commercial sector is inexplicably much higher than later values. Between 2005 and 2011, consumption in the domestic sector declined by 17.9%. Between 2006 and 2011, consumption in the industrial/commercial sector declined by the same amount. Although the number of domestic consumers increased by 8.9% the average consumption per meter fell by almost 25%. On the other hand, although the number of industrial/commercial meters decreased by 32% from 2006 to 2011, the average consumption

per meter rose by 18.9%. The reason for this change is unknown, although it seems likely that it is at least partly due to a reconfiguration of meters.

Figure 6. Relative changes in greenhouse gas emissions from the consumption of gas in Winchester District (2005-2011). The industrial/commercial emissions in 2005 were significantly higher than subsequently and have distorted the 'commercial' curve (top) and so it has been re-plotted relative to 2006 in the lower graph (2005 or 2006=100).



Emissions from gas consumption were calculated using DECC's net calorific value (CV) conversion factor of 0.22674 kg CO_2-eq/kWh for all years (Table 2).[11]

Emissions from both the domestic and industrial/commercial sectors have decreased significantly since 2005. When 2006 is used as the base year (Fig.6, bottom) for industrial/commercial emissions, because of the suspect figure for industrial/commerce in 2005, it is seen that both sectors follow very similar trends having decreased by almost 19%, or 4% per year, since 2006.

Gas summary:

- *Across the whole District in 2011 gas consumption was in the ratio 72:28 between the domestic and industrial/commercial sectors. The domestic sector includes SMEs using less than 73,200 kWh per year.*
- *Over the whole District since 2006 (ref.[12]) both domestic and industrial/commercial gas emissions decreased by around 19% (about 4.2% per year). At the end of September 2011 they stood at 177,000 tonnes CO_2-eq in total.*

Road transport

In England in 2011 road transport accounted for 27% of the emissions from the seven main sectors reported here. Thus it is important to understand the sources and current trends of road transport emissions in the District if effective measures are to be adopted to reduce local emissions. A very detailed survey of the District's emissions from road vehicles between 2008 and 2011 can be found in a separate WinACC report based on data sets provided by the DVLA and VOSA/MoT.[13]

This report uses DECC's estimates of fuel consumption by type of vehicle (bus, motorcycle, petrol car, diesel car, heavy goods vehicle (HGV), petrol light goods vehicle (LGV) and diesel LGV) for each local authority. The estimates are based on the local authority where the fuel was consumed rather than on where it was purchased or where vehicles are registered. The starting point for the work is information available from the National Atmospheric Emissions Inventory (NAEI) programme for Defra. The estimates are produced using CO_2 emissions data from NAEI, fuel consumption factors and traffic flow data from the Department for Transport. Fuel consumption factors are expressed in grams of fuel per kilometre, for each detailed vehicle class, and are taken from two distinct data sources: first, vehicle emissions test data provided by the Transport Research Laboratory (TRL) over different drive cycles from measurements on a limited sample of vehicles; and second, car manufacturers' data on CO_2 emissions and surveys with freight haulage companies on fuel efficiency of HGVs. DECC warns that 'The road transport estimates are modelled rather than real consumption estimates, and are based on the use of a number of different information sources. As a result the estimates are subject to potential modelling inaccuracies.'

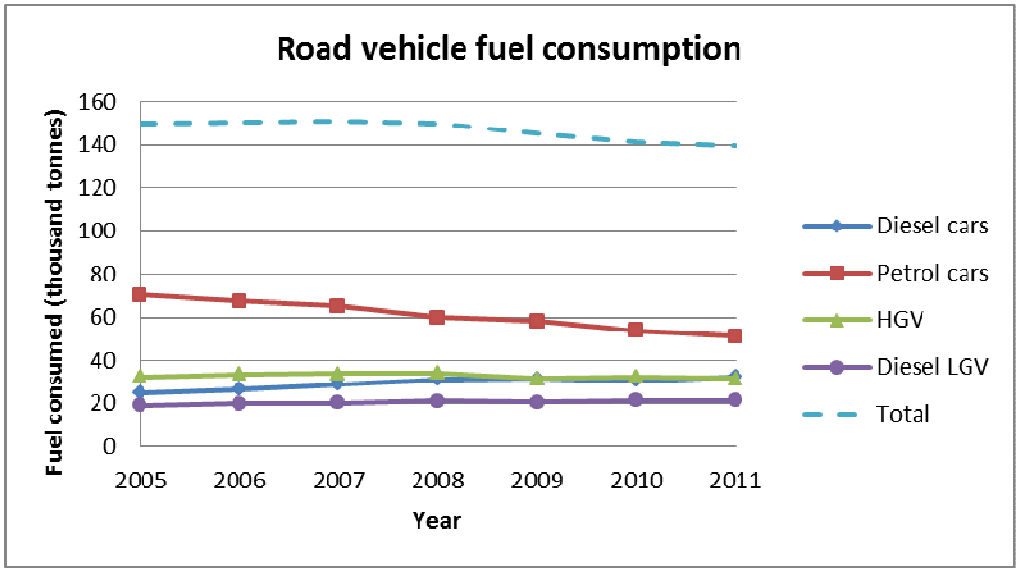


Figure 7. Fuel consumption by the four principal classes of road vehicle in Winchester District (2005-2011).

The principal classes of road vehicle that consume fuel are diesel and petrol cars, HGVs and diesel LGVs; they account for over 96% of all fuel consumed. The remainder includes buses, motorcycles and petrol LGVs.

Total fuel consumption for the four principal classes of vehicle in Winchester District is shown in Fig.7. Fuel consumption by goods vehicles has changed relatively little since 2005; HGVs peaked in 2008 and then dropped back and diesel LGVs have increased by 11.3%. Overall consumption by cars decreased by 12%; diesel cars increased by 31% whereas petrol cars reduced by 27.1%. Overall, total fuel consumption dropped by 6.8% between 2005 and 2011, mostly since 2008.

The CO_2 emissions from petrol and diesel engines were estimated assuming that a vehicle emits 2.32 kg CO_2 per litre of petrol and 2.66 kg CO_2 per litre of diesel.[14] The emissions of other greenhouse gases from most vehicles are negligible[15] although they are included here in estimating the CO_2-eq values. The emissions from all seven classes of vehicle are shown in Table 3. Unsurprisingly, when plotted against time they show very similar trends to the plots of fuel consumed (Fig.7).

Defra have recommended that 15% should be added to vehicle emissions rates quoted by manufacturers to allow for: the real world effects of using accessories, such as air conditioning, lights and heaters; vehicle payload (no allowance is made for passengers or luggage weighing over 25 kg); poor maintenance (tyre under inflation and maladjusted tracking); and gradients (tests effectively assume a level road).[16] Therefore the totals in Table 3 (right-hand most column) have been 'uplifted' by 15% to better represent the real world.

Table 3. Estimated greenhouse gas CO_2-eq emissions (thousands of tonnes) from road vehicles in Winchester District (2005-2011) using the factors described in the text to convert from fuel used to CO_2-eq emitted.

Year	Buses	Diesel cars	Petrol cars	Motor cycles	HGV	Diesel LGV	Petrol LGV	Total	Total +15%
2005	10.2	79.2	220.8	2.5	103.5	60.8	5.1	482.1	554.4
2006	10.1	85.0	211.1	2.5	107.6	63.5	5.1	484.9	557.7
2007	9.9	92.5	204.2	2.5	108.0	64.8	4.5	486.5	559.5
2008	10.0	100.2	188.1	2.6	109.5	67.1	4.1	481.6	553.8
2009	9.6	100.5	182.6	2.8	101.1	66.0	3.7	466.3	536.3
2010	9.6	98.3	168.9	2.2	103.1	68.6	3.4	454.2	522.3
2011	9.2	104.0	160.9	2.3	100.7	68.5	3.1	448.6	515.9

Fig.8 shows the changes in emissions from the four main classes of vehicle relative to 2005. Overall, total emissions were flat until 2008 and then decreased by 7.0%. The decrease in emissions from petrol cars was partly offset by a similar increase from diesel cars, reflecting trends in car numbers.[17]

Total emissions from goods vehicles (bus, HGV, petrol LGV and diesel LGV) increased up to 2008 and then dropped away, with a suggestion of a slight rising trend since 2009, ending 1.7% up. Total emissions from private vehicles (motorcycle, petrol car and diesel car) on the other hand have shown a steady decrease since 2005 ending 11.8% down (Fig.9). Overall the balance of emissions has changed with all private vehicles emitting 80% more than all goods

vehicles in 2005 but only 55% more in 2011. It should be noted that it is difficult to differentiate between changes brought about by driver behaviour (including distance driven although there is evidence that annual mileage has been decreasing by 1.25% a year in Hampshire since 2007 ref.[13]) and changes caused by advances in car design; these figures probably include both.

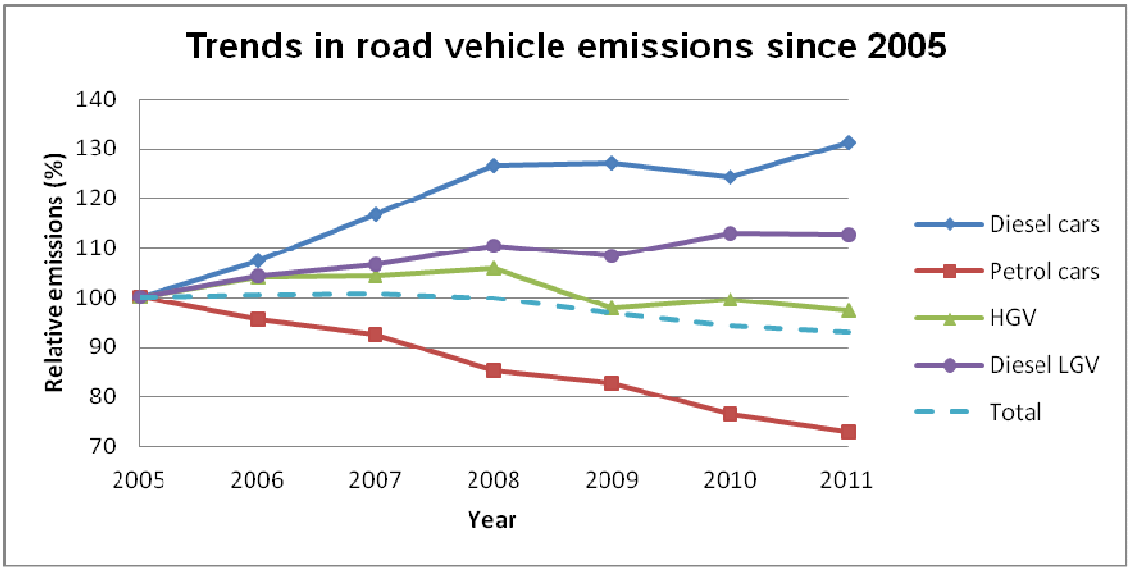


Figure 8. Trends in the emissions from the four main classes of road vehicle in Winchester District since 2005 (2005 = 100).

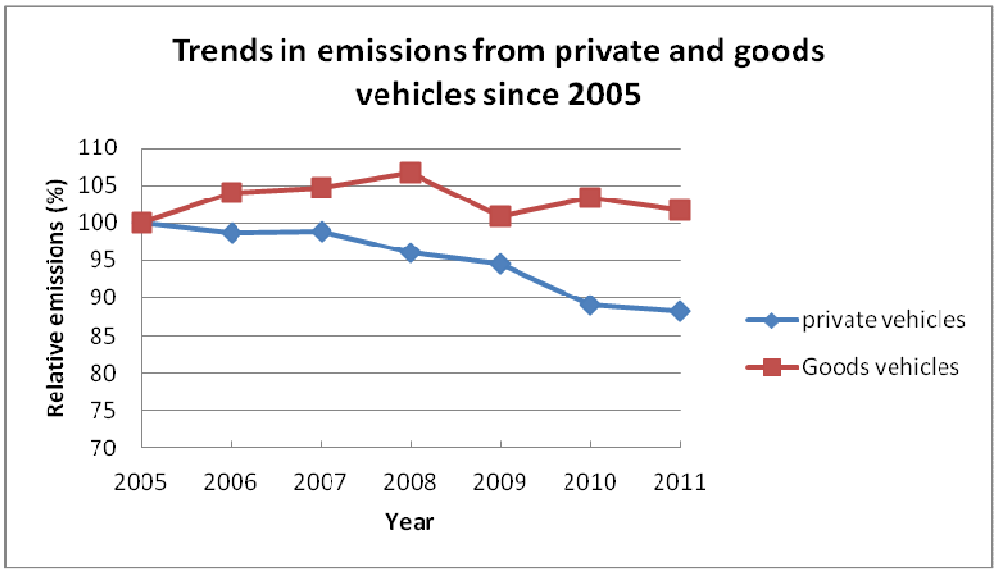


Figure 9. A comparison of trends in emissions from private vehicles and goods vehicles in Winchester District since 2005 (2005 = 100).

Road transport summary:

- *In Winchester District over 96% of road transport fuel is consumed by diesel and petrol cars, heavy goods vehicles and diesel light goods vehicles.*

- *The ratio of emissions from private vehicles to goods vehicles has changed from 1.8:1 in 2005 to 1.55:1 in 2011.*
- *Overall fuel emissions from road transport decreased by 7.0% between 2008 and 2011 (about 2.5% per year). Between 2005 and 2011 the emissions from private cars decreased by 11.8%. Although there was an increase in emissions from diesel cars, this was more than offset by a decrease from petrol cars as the relative numbers of diesel and petrol cars changed. However diesel LGVs increased their emissions by 12.6%.*
- *In 2011 the District's road transport emissions are estimated to have been around 516,000 tonnes of CO_2-eq which is about 46% of all emissions in the seven main sectors reported here.*

Other fuels

A DECC report in 2012 estimated the contributions of non-gas, non-electric and non-road transport energy consumption for 2005 to 2010 (Table 1; 2011 figures are not yet available). Previous DECC estimates for 2005 – 2009 were revised to take account of improvements in the methods used and to provide a time series that is consistent with the 2010 estimates.

The fuels include domestic, industrial, commercial, agricultural and public administration use of coal and manufactured solid fuels (e.g. coke), petroleum consumed by railways and combined renewable energy sources, such as wood, and wastes.[18] The dataset excludes fuels consumed by international aviation, shipping and power stations, as this information cannot be allocated to regions and local authorities, and also data for heat sold which is already modelled at a UK level and accounts for a very small percentage of total energy use.[7] The total quantity of other fuels consumed in Winchester District in 2010 (30,800 tonnes oil equivalent) is equivalent to about 207,000 tonnes CO_2-eq.[19]

In 2013 DECC produced web-based tables of conversion factors[20] but these appear to be incomplete; for example, they do not currently (August 2013) contain factors for coal or coke. Therefore DECC's factors published in 2012 for 2010 are used here instead.[21]

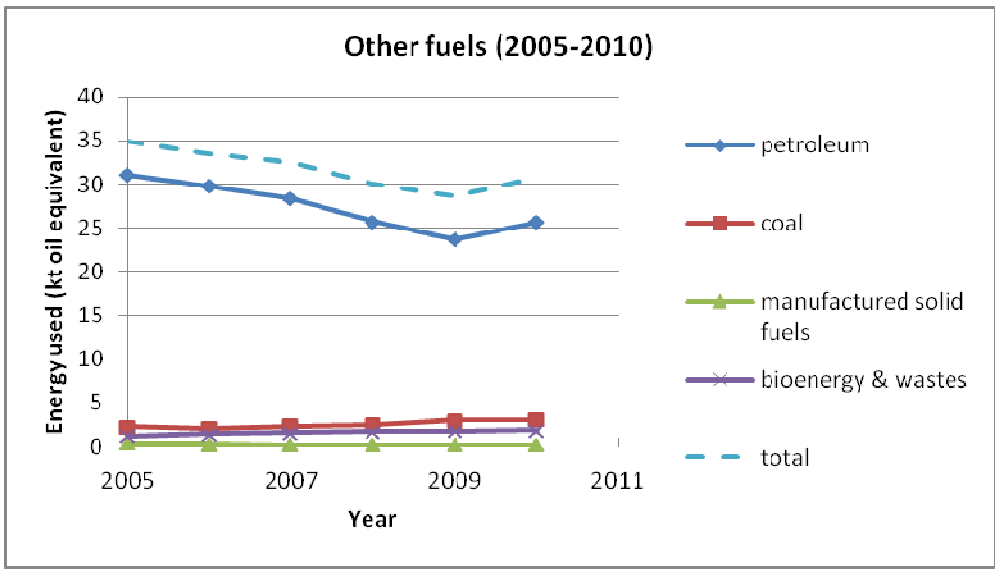


Figure 10. Emissions from four classes of other fuels in Winchester District between 2005 and 2010.

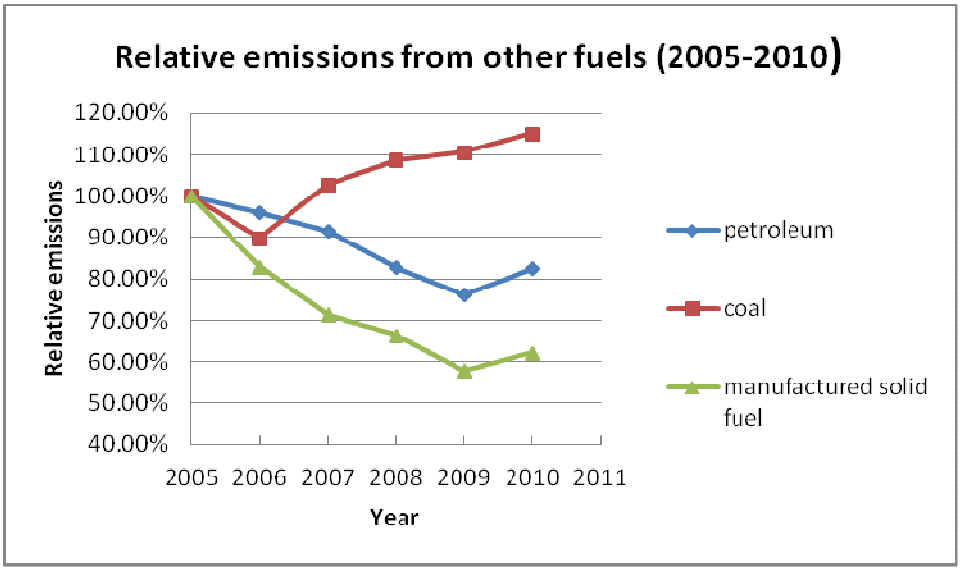


Figure 11. Trends in emissions from other fuels relative to 2005 (2005=100).

Fig. 10 shows trends in the energy consumed by using petroleum fuels[a], coal, manufactured solid fuels, and bioenergy and wastes. Overall there has been a decline of 11.7% in energy consumed in the other fuels sector since 2005, due mainly to the strong decrease in consumption of petroleum fuels. However the latter component increased markedly from 2009 to 2010 almost entirely due to a 15% increase in domestic consumption (heating oil) and an 8% increase in industrial/commercial consumption.

Fig.11 shows the changes in emissions from three of the four[b] components of other fuels relative to 2005. Although emissions from petroleum and coke decreased significantly between 2005 and 2009 they, and all other, components increased in 2010. Because the contributions from coke and coal are so small, the changes in total emissions relative to 2005 closely follow the petroleum curve (Fig.10).

Other fuels summary:

- *The emissions attributable to other fuels comprise about 207,000 tonnes CO2-eq. They declined between 2005 and 2010 by 11.7% (about 2.3% per year) but there has been a slight increase in emissions since 2009.*

Land use and changes in land use

Changes in land use can have important consequences for carbon dioxide sequestration and release into the atmosphere as well as for other greenhouse gases involved in agricultural activities. Green spaces in cities can equally 'lock up' carbon.

For example, a survey in Leicester concluded that an estimated 849,000 tonnes of CO_2 is stored within the above-ground vegetation of Leicester, equating to 11.6 kg CO_2/m^2 of urban area, with 97.3% of this carbon pool being associated with trees rather than herbaceous and woody vegetation.[22] The researchers concluded that current national estimates of this ecosystem service undervalue Leicester's contribution by an order of magnitude. It is worth noting that the

[a] Defined as any fuel produced in a refinery
[b] No conversion factor for waste is available.

carbon stored above ground in Leicester is only slightly less than that emitted annually by the production emissions of Winchester District!

There are clear environmental benefits to planting and preserving trees, both within and outside towns and cities, even though trees have long lifetimes that mean the annual uptake of carbon is relatively modest, and clear environmental benefits to using wood to a greater extent in construction and other projects, which ensures that the embodied carbon is not released for many years.

This is not the place to review how agriculture and land use can affect greenhouse gas emissions but Defra has published a useful document that does just that.[23] Activities that emit or sequestrate carbon are also listed in Table 1 of Hallsworth and Thomson (2010).[24] The latter authors map estimates of annual Land Use, Land Use Change and Forestry (LULUCF) sector emissions and removals at the local authority scale within the UK for 1990-2008. 2008 appears to be the latest year for which this information is available.

An estimate of the net impact of LULUCF have been taken from the colour-coded area representing Winchester District on a map published by DECC.[25] The District's emissions fall between the 20th and 40th percentiles of ranked land use emissions from all UK local authorities. The map indicates that land use changes in Winchester District caused between -350 and +580 tonnes of CO_2 to be emitted in 2011. This is a rough estimate that overlaps with the range of zero to 24,000 tonnes of CO_2 provided as a colour-coded estimate for Winchester District in Hallsworth and Thomson (2010). This latter figure omits emissions of non-CO_2 greenhouse gases that are produced by biomass burning during wildfires, the conversion of forest land to grassland or to settlements, and by nitrogen fertilisation of new forests. Emissions of methane and nitrous oxide are relatively small and together equated to around 1.7% of England's LULUCF emissions of CO_2 in 2009.[26] More details can be found in Report II. It appears reasonably certain that net annual LULUCF emissions in the District are less than 24,000 tonnes CO_2 and possibly considerably less.

No data are known to the author with which to study trends at local authority level although Hallsworth and Thomson (2010) state that a more detailed analysis of trends could be carried out in future reports.

Land use summary:
The net annual emissions from LULUCF within Winchester District are relatively small (estimated to be less than 24,000 tonnes CO_2). No data are available with which to study trends in LULUCF emissions.

SECONDARY ESTIMATES OF EMISSIONS

Secondary estimates of emissions are defined here as those that cannot be estimated solely from the metered use of fuels. In some cases they can be estimated partly from the metered use of fuels and so overlap with primary estimates of emissions.

The estate and operations of Winchester City Council

This section relies on measurements made by Winchester City Council (WCC) of the operation of its estate and transport. The measurements reported here were not specifically included in the estimate of Winchester's total emissions, to avoid double counting, but provide accurate

estimates of how well one particular sector in the District is performing. They also have the advantage of providing information up to the end of March 2013.

From April 2008 the UK government required local authorities to compile CO_2 emissions statistics for their estate and operations. These formed part of the National Indicator series statistics and were called NI185. From FY 2010/2011 the NI185 system was replaced by a requirement to collect equivalent data for the preceding fiscal year (1 April -31 March) by the end of July each year. The data cover scope 1, 2 and 3 emissions[27] and all greenhouse gases, expressed as CO2-eq. Data are not available for years prior to FY 2008/2009.

NI185 data for WCC for the four years from 2008/2009 until 2011/2012 were downloaded from the WCC website (Fig.12)[28] and data for 2012/2013 were obtained separately.[29] New regulations have created some changes in the time series since 2011/2012. Total emissions were between 4,000 and 4,600 tonnes CO2-eq each year[30] and decreased by 13% over the period. Scope 1 emissions decreased by 36.3% but this includes the effect of omitting 'van travel and distribution' from the last two years to follow new regulations; gas, the largest Scope 1 component, decreased by just 6.4% in the period following a large rise in emissions in 2012/2013. On the other hand, scope 2 emissions (electricity), which are by far the largest component of the Council's overall emissions, decreased by 12.5% partly the result of using a

Figure 12. Winchester City Council's 'NI185' emissions by scope from 2008/2009 to 2012/2013.

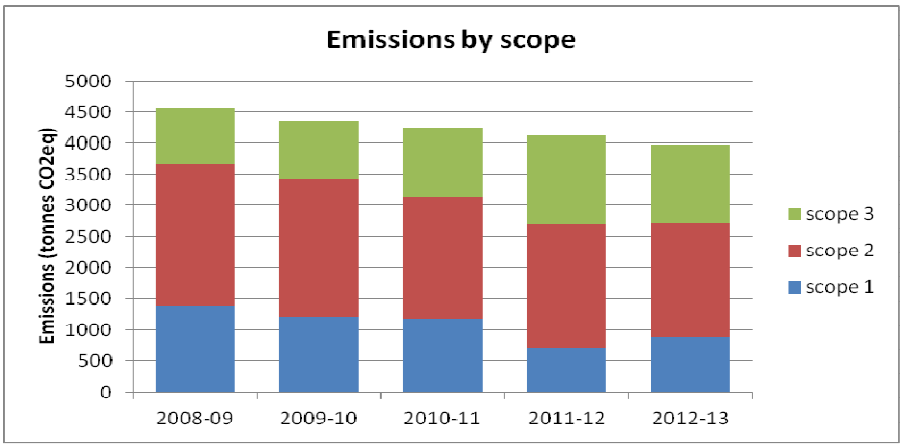
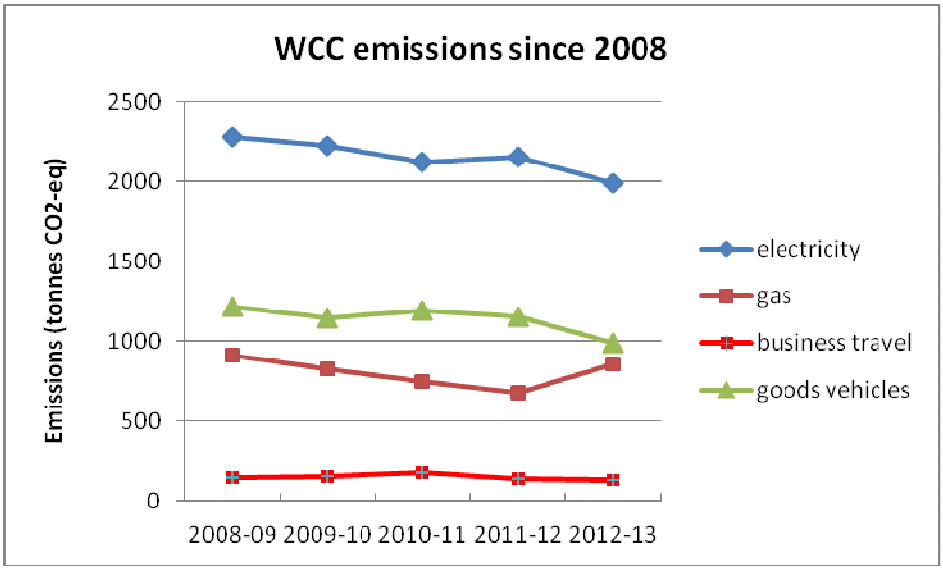


Figure 13. The principal components of Winchester City Council's 'NI185' emissions 2008/2009 to 2012/2013.



smaller conversion factor since 2010/2011 in line with the new regulations[a] (Fig.4). The year to year changes in the principal components of the Council's emissions are shown in Fig.13. Business travel was mainly by car and bus.

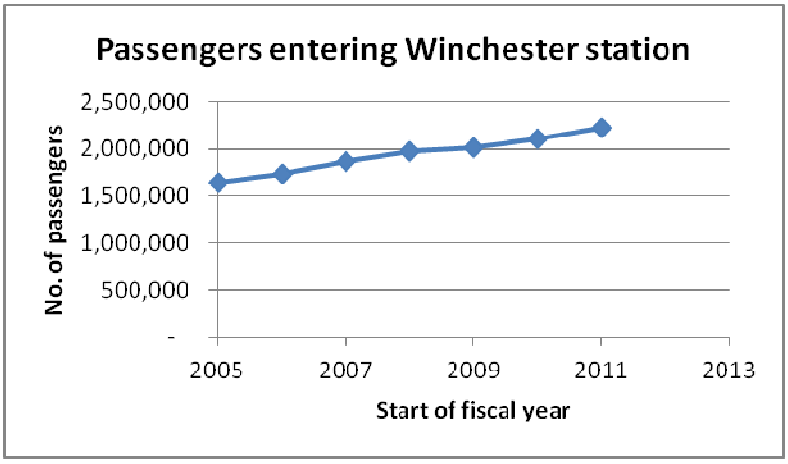
Winchester City Council summary:

- *WCC's 'NI 185' total emissions decreased by 13% from 2008/2009 to 2012/2013 (about 3.4% per year on average). Emissions from electricity consumption, around 50% of the total, decreased at approximately the same rate assisted, in part, by changes in the reporting regulations.*

Rail travel

The numbers of journeys starting and ending at UK railway stations are published annually by the Rail Regulator.[31] Winchester District contains four railway stations at Botley, Micheldever, Shawford and Winchester. Winchester is by far the busiest station by about a factor of thirty. 2,226,315 passengers entered Winchester in the year ending 31 March 2012. The number of passengers entering Winchester station increased by 35% between 2011/2012 and 2005/2006 (Fig. 14). This rate of increase in passengers is well in excess of the increase in the District's population in the same period.

Figure 14. Total number of passengers entering Winchester station from 2005/2006 until 2011/2012. The number of entries and exits in the published figures are identical.



I have not attempted to estimate the emissions associated with these passengers because I was unable to find statistics on journey lengths. Report II contains a brief discussion of possible emissions associated with rail travel from Winchester station.[1] The conclusion was that rail travel emissions are likely to contribute a relatively small amount compared to the likely emissions from flying or road transport yet the steady increase in the number of passengers indicates that emissions are being saved from other, more polluting, forms of transport.

Rail summary:

- *In spite of relatively high fares the number of passengers using Winchester station, and two of its three smaller neighbouring stations, continues to increase. Botley station experienced a slight drop in numbers in 2011/2012.*

[a] Before the new regulations were applied annual electricity consumption was little changed between 2008/2009 and 2011/2012. The apparent decrease since 2009/2010 is the result of Defra/DECC requiring the use of a smaller conversion factor.

Air travel

Although Southampton airport is the closest to Winchester District, people living in the District will clearly use other airports such as Bournemouth, Gatwick, Heathrow, Luton, Stansted and London City for their trips.

The Civil Aviation Authority[32] reports statistics by month and calendar year. The number of passengers departing from or in transit through Southampton airport increased relentlessly from 2002 to 2007 when it peaked at 1,965,422. Since 2007 numbers have declined apart from a small increase in 2011 that was not maintained in 2012 (Fig.15). This is not dissimilar to the national picture in which passenger numbers in 2012 were only slightly up, or even down in Q3, on the previous year.[33] The timing of the peak and the subsequent fall in numbers roughly coincides with the onset of the economic recession in 2008. Overall, the number of passengers passing through Southampton airport declined by 7.7% between 2005 and 2012.

The emissions associated with the flights from Southampton airport of passengers living in Winchester District are almost impossible to estimate although they were discussed in Report I.

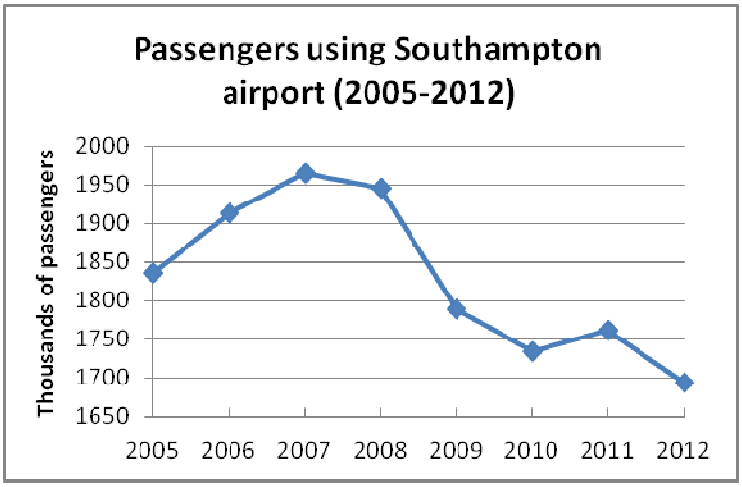


Figure 15. Plot of the number of departing and transit passengers at Southampton airport from 2005 until 2012.

Aviation summary:

- *The number of passengers using Southampton airport fell sharply after 2008 and, in spite of a small increase in 2011, numbers have continued to decline.*

SUMMARY OF RESULTS

Table 4 column 2 summarises the emissions that have either been identified above or, for rail and air transport, were estimated in Report I. Emissions from land use, land use changes and forestry (LULUCF) are omitted because they are uncertain and also relatively very small. All emissions are in CO_2-eq. Table 4 is our best estimate of the direct emissions caused by the District's residents and businesses. Indirect emissions from food, goods and services consumed within the District but produced elsewhere, which are thought to be almost equal in amount,[34] are not included.

Fig.16 presents the emissions in Table 4 column 3 as a pie diagram. This shows that 44% of emissions (domestic electricity and gas, and cars) are directly attributable to households, including some SMEs, and 36% to the industrial/commercial sector (electricity, gas and goods vehicles); the remaining 20% cannot readily be allocated between these two sectors.

Table 4. Summary of CO_2-eq emissions in Winchester District in 2011 with percentage contributions of all sectors and the seven main sectors.

Source of emissions	Emissions (thousands of tonnes of CO2-eq)	Emissions as percentage of total (%) All sectors	Emissions as percentage of total (%) 7 main sectors
Electricity ('domestic')	113	9.0%	10.2%
Electricity ('industrial/commercial')	201	16.0%	18.2%
Gas ('domestic')	127	10.1%	11.5%
Gas ('industrial/commercial')	49	3.9%	4.5%
Cars*	307	24.4%	27.7%
Goods vehicles*	198	15.7%	17.9%
Other fuels+	111	8.8%	10.0%
Rail transport**	15	1.2%	-----
Air transport**	136	10.8%	-----
TOTAL	**1258**	**100.0%**	**100.0%**

*After applying a 15% uplift (see text). The much smaller emissions from buses and motorcycles have been omitted from these figures for simplicity. + Latest figure is 2010 **Rough estimates from Report I.

It is clear from Table 4 column 3 and Fig.16 that the greatest emissions are attributable to cars and goods vehicles (40%), the domestic consumption of electricity and gas (19%) and the consumption of electricity by the industrial/commercial sector (16%). They are followed by other fuels, mainly non-transport petroleum, (9%) and air travel (11%) although the latter figure is only a rough estimate. Relatively small contributions are made by the gas consumed by the industrial/commercial sector and rail travel.

However the pie is sliced, all sectors of society make a substantial contribution to Winchester District's emissions. We shall investigate how these contributions have changed with time below.

However, if LULUCF emissions (for which no accurate annual figures are available) and rail and air travel emissions (for which no accurate estimates exist) are excluded, we obtain Table 4 column 4 and the pie diagram in Fig.17. Emissions in Winchester District from the first seven sectors listed in Table 4, reduced by 12.3% between 2005 and 2011 (from 1,263 thousand tonnes to 1,107 thousand tonnes of CO_2-eq; Fig.18). Although DECC do not recommend using local authority statistics for 2004 it is possible to estimate the 2004 emissions from the 2005 figure knowing that the UK's territorial emissions reduced by 0.7% between 2004 and 2005. Assuming the District's emission reductions between 2004 and 2005 were in line with the national average, this suggests that Winchester District's emissions for the seven principal sectors were 1272 thousand tonnes CO_2-eq in 2004 and that emissions reduced by 13% from 2004 to 2011.

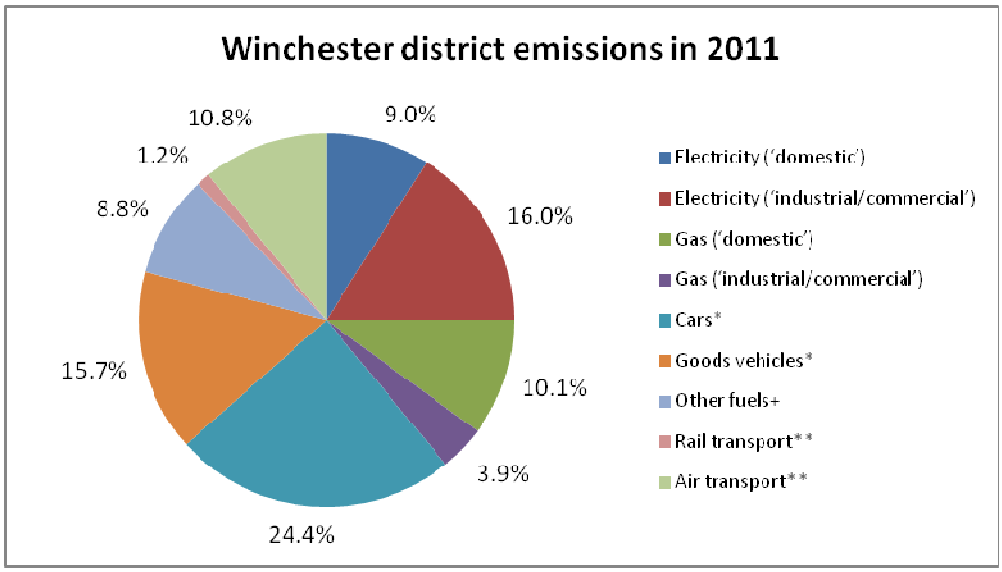


Figure 16. Pie diagram of estimated emissions of CO2-eq in different sectors of Winchester District for 2011. Total emissions from this set of sources are estimated to be 1,258 thousand tonnes CO2-eq. For an explanation of superscript symbols see Table 4.

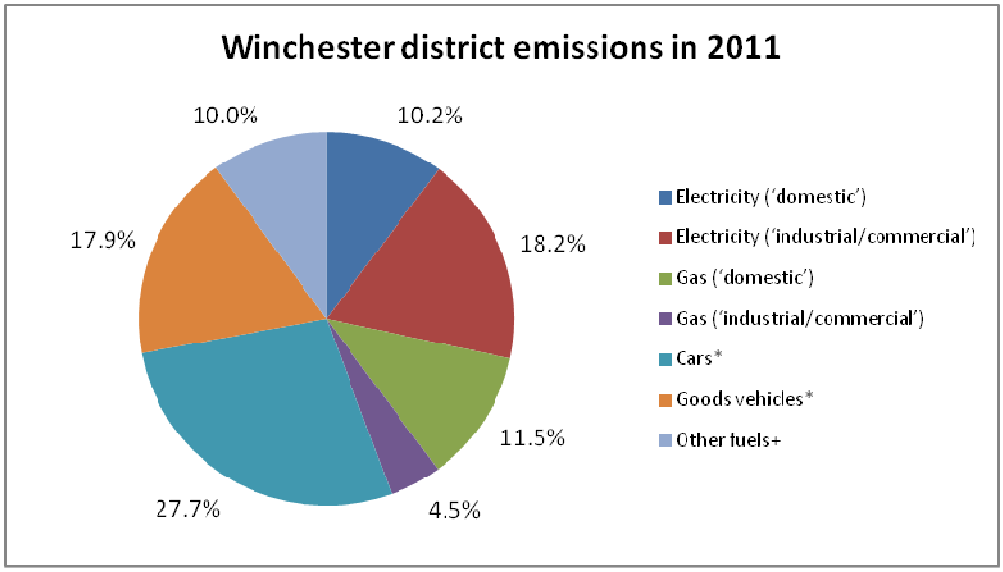


Figure 17. Pie diagram of estimated emissions of CO2-eq in the seven principal sectors of Winchester District for 2011. Total emissions from this set of sources are estimated to be 1,107 thousand tonnes CO2-eq. For an explanation of superscript symbols see Table 4.

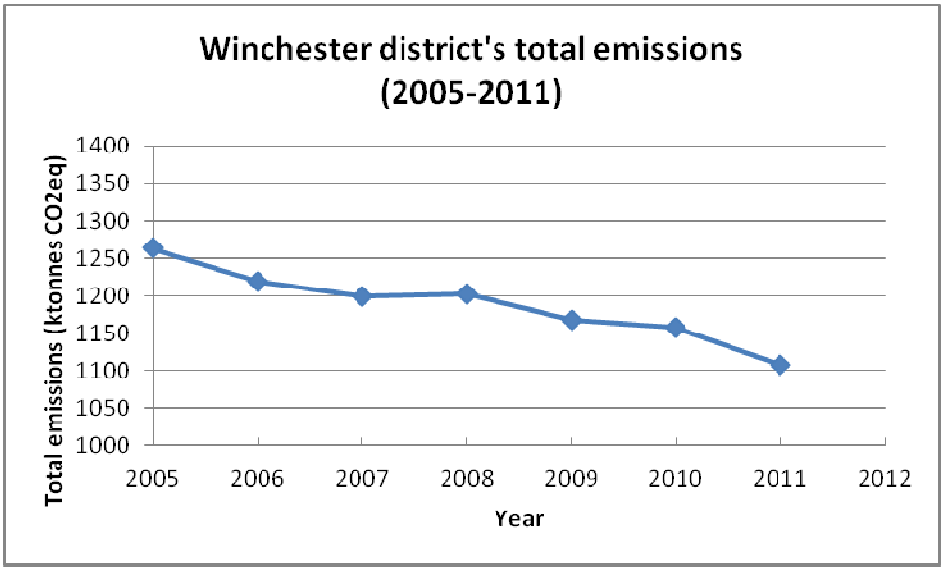


Figure 18. The estimated total emissions in 2011 in Winchester District from the seven principal sectors listed in Table 4 column 4.

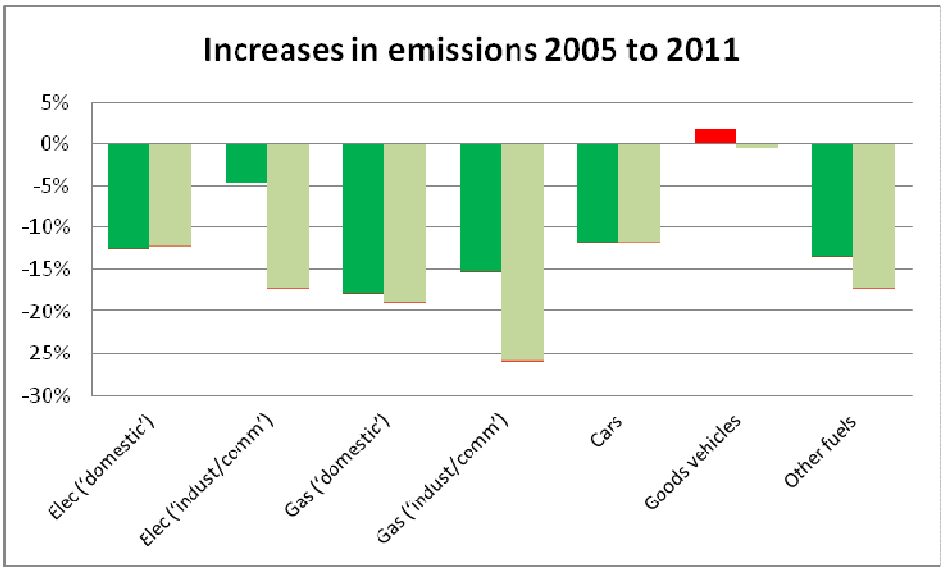


Figure 19. Summary of percentage changes in emissions from different sectors between 2005 and 2011 in Winchester District (dark green and red). Increases in emissions are shown in red (above the line) and decreases in green (below the line). The industrial/commercial gas figure for 2005 has been estimated from the average trend from 2006 to 2011 because the published 2005 figure is suspect. The lighter coloured bars represent average changes across all local authorities in England.

On average this equates to an annual reduction of 2.0% per year whereas an average reduction of 3.2% per year is required to meet the target of a 30% cut by the end of 2015 referred to 2004.

DISCUSSION

Fig.19 displays the percentage change in emissions over the 6-year period 2005-2011 for each of the first seven sectors listed in Table 4.

It is good news that emissions from the majority of sectors have decreased even though some of the reduction may have been driven by the recent economic situation or by changes in the national energy mix for electricity generation.[35] However, to meet Winchester's target of a 30% reduction by 2015, a reduction across all sectors is required of around 17.7% between 2005 and 2011. Only industrial/commercial and domestic gas and 'other fuels' come close to this figure although domestic electricity and cars are not far behind.

The sectors that most need to cut back their emissions if Winchester's 2015 target is to be met can be gauged by considering Figs. 17 and 19 together. Table 5 summarises the size of each sector and the degree to which it missed the target in 2011. A simple metric, calculated by multiplying the size of the sector by its shortfall from the desired 17.7% reduction in 2011, indicates the potential future contribution of each sector assumes that it is practical for each sector to contribute equally; this may not be so. The metric reveals that the worst sector by far is goods vehicles. Electricity consumption by the industrial/commercial sector is next worst, followed by car use. Domestic electricity (which includes 2,500 SMEs), gas and other fuels make a relatively small contribution.

Table 5. Summary of the contribution of each sector to meeting the 2005-2011 emissions reduction target and an estimate of the potential future contribution of each sector to meeting the 2015 target of a 30% reduction.

Source of emissions	Size of sector (%)	Reduction achieved in 2011 since 2005 (%)	Simple metric (col.2 x (17.7-col.3))	Future potential to contribute to meeting target
Electricity (domestic)	10.2	12.6	52	small
Electricity (industrial/commercial)	18.2	4.7	237	large
Gas (domestic)	11.5	17.9	-2	very small
Gas (industrial/commercial)	4.5	15.4	10	very small
Cars	27.7	11.8	163	moderate
Goods vehicles	17.9	-1.8	349	very large
Other fuels	10.0	13.5	42	small

HGVs and diesel LGVs consume fuel in the ratio 100:70 (Table 3). This suggests that both HGVs and diesel LGVs should be targeted in order to reduce emissions.

As shown in Report II, so-called superconsumers (those consuming more than 50,000 kWh per year) make a very large contribution to the electricity used by the industrial/commercial sector. Report II stated, 'At present the emissions of the 222 super consumers in Winchester District cannot be divulged by DECC because of its policy on data privacy. It would be helpful if this policy could be overturned.

The Climate Change Programme Board could consider asking local superconsumers, many of whom are probably readily identifiable from local knowledge, to publish the steps they are taking to reduce their emissions. For a start, all but three of the ca. 50 publicly accessible buildings discussed in the section on Display Energy Certificates consume enough electricity each year to be classed as a superconsumer (more than 50,000 kWh/year). This is around 20% of all

superconsumers. Some of these buildings reduced their emissions between 2008 and 2010 (Table 12) which suggests that it may be the non-publicly accessible buildings that are more responsible for the increase in emissions by superconsumers'.

Although cars are not as far 'off target' as goods vehicles, WinACC's proposed parking strategy should provide a way to reduce emissions from cars even more, as should the proposed development of a coherent public transport strategy and walking strategy to complement the recently agreed cycling strategy.

Greater savings in emissions from the domestic electricity sector might be achievable by a campaign to better insulate homes with electric heating, to replace filament bulbs, and even CFLs, by LED lamps and to 'switch off at the wall' when appliances are on stand-by.

Comparing Winchester District's emissions in 2011 with neighbouring local authorities and nationally

Winchester District's emissions can be compared with those of neighbouring local authorities on the basis of national rankings (Table 6).[36]

Table 6. Comparison of ranked emissions per capita for different sectors from Winchester District and neighbouring local authorities. '80-100' indicates that the emissions of an authority fell in the 80%-100% band of all ranked authorities i.e. it was in the band with the highest emissions. The number in parentheses for each column denotes the figure number consulted in the source document.

Local Authority	Total CO_2 per cap excluding LULUCF (5)	Domestic CO_2 per cap (6)	Industrial/ commercial CO_2 per cap (7)	Transport CO_2 per cap (8)	LULUCF CO_2 per cap (9)
Winchester	80-100	60-80	60-80	80-100	20-40
Test Valley	60-80	60-80	40-60	80-100	60-80
East Hants	40-60	60-80	20-40	60-80	0-20
Basingstoke & Deane	60-80	40-60	60-80	80-100	60-80
Eastleigh	0-20	0-20	20-40	20-40	40-60

Table 6, column 2, shows that Winchester District has higher emissions per capita than any of its neighbouring local authorities. LULUCF is the only sector in which Winchester District is in a lower emissions category than one or more of its neighbours. Except for LULUCF, Eastleigh Borough Council has consistently lower emissions.

Fig.19 compares the changes in seven sectors in Winchester District's emissions between 2005 and 2011 with those achieved on average in LAs in England according to DECC's Sub-National Energy Consumption statistics.[37] Winchester's reductions are below average in all seven sectors. The sectors which lag most behind the national average reductions in emissions are consumption of electricity and gas by the industrial/commercial sector. Overall, Winchester District's emissions from the seven sectors fell by 12.3% between 2005 and 2011 whereas on average LAs in England registered a 16.0% drop.

CONCLUSIONS

The figures presented here are based on a variety of assumptions and modelling methods and are subject to uncertainties. For electricity and gas consumption, DECC also use a misleading nomenclature of 'domestic', which actually include SMEs, and 'industrial/commercial', which includes public organisations, as explained above. These limitations need to be borne in mind when assessing some of the results presented here.

The principal findings of this report, based on the latest data available, mostly relate to calendar year 2011 or FY 2011/2012, or to trends or changes in greenhouse gas emissions since 2005, and are,

1) Winchester District has higher per capita emissions than any of its neighbouring local authorities (Basingstoke & Deane, Test Valley, East Hampshire and Eastleigh). The District also has above average emissions when compared to all the local authorities in England.

2) The District's emissions can be presented in several ways. Considering the seven principal sectors alone (Fig.17), 49% of emissions come from households (domestic electricity and gas consumption and private cars), 41% from the industrial/commercial sector, including public bodies (electricity, gas and goods vehicles) and 10% cannot be allocated (other fuels). Or, 28% of emissions come from electricity, 16% from gas, 46% from transport and 10% from other fuels.

3) A simple metric has been used to indicate which of the seven sectors investigated in detail are currently furthest from achieving the target of a 30% reduction in emissions by 2015 relative to 2004.

4) The sector that was performing least well, up to 2011, was goods vehicles, which includes both diesel light goods vehicles (LGVs) and heavy goods vehicles (HGVs) roughly in the ratio 7:10. This sector contributed to just under 18% of the district's emissions in 2011. Between 2005 and 2011 emissions from HGVs decreased by 2.7% and emissions from diesel LGVs increased by 12.6%. Consequently there was no decrease in overall emissions from goods vehicles at any time from 2005 to 2011 and the sector's emissions ended up just under 2% higher in 2011 than they were in 2005.

5) Electricity consumption by the industrial/commercial sector, which also includes public bodies, was the second worst performing sector. It contributed 18% of the District's emissions in 2011 and accounted for 64% of all electricity consumption in the District in 2011. Further, between 2005 and 2011, consumption by the industrial/commercial electricity users increased by 3%. These figures exclude around 2,500 businesses using less than 50,000 kWh per year which are counted within the domestic sector.

6) Winchester City Council, when compared on the same basis with the rest of the industrial/commercial sector in which it falls, caused essentially the same emissions from electricity in 2011/2012 as it did in 2008/2009 but there appears to have been a slight decrease in emissions since 2011/2012. The emissions from public buildings, which are included in this sector, are reviewed in Report II.

7) Emissions from cars was the third worst performing sector, mainly because the sector contributes just under 28% of all the District's emissions, even though the emissions reduced by

almost 12% in the period 2005-2011. Presumably this means that the sheer number and even size of cars swamped the decrease in emissions attributable to technological improvements, annual mileage reductions and, possibly, more careful driving.

8) In spite of relatively high fares, the number of passengers using Winchester station between 2005/2006 and 2011/2012 continued to increase at an average rate of around 7% per year.

9) The number of passengers using Southampton airport fell sharply after 2008. Following a slight increase from 2010 to 2011 passenger numbers continued to fall in 2012.

In conclusion, although its emissions had fallen approximately 13% in 2011 since 2004, Winchester District, has performed less well compared to neighbouring local authorities and to remain below average compared to all other local authorities in England. To be on track to reach the 30% reduction in emissions by 2015 emissions should have fallen by 18%. The business sector, including public bodies, has made the least progress in reducing emissions; its emissions from goods vehicles and electricity consumption increased slightly.

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[4] http://www.decc.gov.uk/assets/decc/11/stats/climate-change/4194-sectoral-uncertainties-in-the-uk-ghg-inventory-.pdf

[5] http://www3.hants.gov.uk/factsandfigures/key-facts/kf-winchester.htm#pop and Table P07, 2011 census results, ONS.

[6] Table H01, 2011 census results.

[7] DECC guidance note from DECC (2013). Sub-national consumption statistics: Methodology and guidance booklet. London, DECC**:** pp.69 and Defra/DECC (2013). 2013 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting: Methodology paper for emissions factors. London, Defra/DECC**:** pp.111.

[8] Values for 2005-2009 inclusive are given in Table 3c in Defra/DECC (2011). 2011 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting. London, Defra/DECC**:** pp.102.

[9] Anon. (2013). A Comparison of Emissions Factors for Electricity Generation. London, DECC**:** pp.9.

[10] Allowance is made for the fact that more gas is burned in cold winters, and *vice versa*, by adjusting emissions according to the number of heating degree.days recorded each winter.

[11] Conversion factor for 2010 from Table 1d in Defra/DECC (2012). 2012 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting. London, Defra/DECC**:** pp.54. Carbonsmart do not provide a conversion factor for 2011.

[12] 2006 is used in preference to 2005, see earlier explanation.

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[16] Page 23, para.52 in Defra/DECC (2011). 2011 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting: Methodology paper for emissions factors. London, Defra/DECC**:** pp.102.

[17] Fig.5a in Whitmarsh, R. B. (2012). Vehicles registered within Winchester District (2008-2011) and their carbon dioxide emissions. Winchester, WinACC**:** pp.27.

[18] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66005/7359-sub-nat-cons-other-2005-2010.pdf

[19] 1 tonne oil equivalent = 11,630 kWh (Carbon Trust). Conversion from kWh to kg CO_2-eq depends on the fuel (see Defra/DECC (2013). 2013 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting. London, Defra/DECC**:** pp.111). This calculation ignores the contribution of renewables and wastes. Figures are not yet available for 2011.

[20] http://www.ukconversionfactorscarbonsmart.co.uk/

[21] Defra/DECC (2013). 2013 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting. http://www.ukconversionfactorscarbonsmart.co.uk/.

[22] Davies, Z. G., J. L. Edmondson, et al. (2011). 'Mapping an urban ecosystem service: quantifying above-ground carbon storage at a city-wide scale.' Journal of Applied Ecology (doi: 10.1111/j.1365-2664.2011.02021.x).

[23] Anon. (2013). Agricultural Statistics and Climate Change 4th Edition. London, Defra**:** pp.137.

[24] Hallsworth, S. and A. Thomson (2010). Mapping Carbon Emissions & Removals for the Land Use, Land Use Change & Forestry Sector (Final Report to AEAT). Penicuik, Midlothian, Centre for Ecology and Hydrology**:** pp.17.

[25] Anon. (2013). Local Authority CO_2 emissions estimates 2011: Statistical Summary and UK Maps. London, DECC**:** pp.38.

[26] Thomson, A. M., S. Hallsworth., et al. (2011). Emissions and Removals of Greenhouse Gases from Land Use, Land Use Change and Forestry (LULUCF) for England, Scotland, Wales and Northern Ireland: 1990-2009, Centre for Ecology & Hydrology**:** pp.17.

[27] Scope 1 covers Direct emissions (natural gas and Council's transport fuels), Scope 2 covers Indirect emissions (electricity) and Scope 3 covers Other indirect emissions (waste, grounds maintenance contracts, Park & Ride buses, staff business travel)

[28] http://www.winchester.gov.uk/data/council-energy-carbon-management/ .

[29] Pers. Comm. Simon Howson, Winchester City Council, 4 September 2013.

[30] The figures have been revised since September 2012 when the average total emissions were around 3000 tonnes (Report II).

[31] http://www.rail-reg.gov.uk/server/show/nav.1529

[32]http://www.caa.co.uk/default.aspx?catid=80&pagetype=88&pageid=3&sglid=3

[33] http://www.caa.co.uk/docs/80/AviationTrends_Q1_2013.pdf

[34] http://www.resource-accounting.org.uk/downloads/south-east/winchester

[35] See comment on UK's emissions in para.5 by Committee on Climate Change at Anon. (2012).Consumption-Based Emissions Reporting: Government Response to the Committee's Twelfth Report of Session 2010-12 - Energy and Climate Change at http://www.publications.parliament.uk/pa/cm201213/cmselect/cmenergy/488/48804.htm.

[36] Anon. (2013). Local Authority CO2 emissions estimates 2011: Statistical Summary and UK Maps. London, DECC: pp.38.

[37] http://www.decc.gov.uk/en/content/cms/statistics/energy_stats/regional/regional.aspx