Introduction and key messages

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Chapter 7: Progress reducing emissions from waste management and other non-CO_2 sources

Introduction and key messages

Outside of the agriculture sector, non-CO_2 emissions in the UK arise from a wide range of sources including waste, industry, transport, buildings and energy supply. These include methane (CH_4), predominantly arising from waste management, nitrous oxide (N_2O) and certain fluorinated gases (F-gases) including HFCs, PFCs, and SF_6.

Emissions data in the waste and other non-CO_2 sectors lag that for CO_2 by a year due to the longer time required to collate non-CO_2 emissions data. In this chapter, we focus on the latest data which show that in 2011, waste and other non-CO_2 emissions totalled 45 $MtCO_2e$, accounting for approximately 8% of total UK greenhouse gas emissions.

We have previously set out high-level assessments of abatement potential for waste and other non-CO_2 emissions (e.g. in our advice on the fourth carbon budget and on the 2050 target).

In our 2012 progress report we included an analysis of waste emissions and set out indicators against which future progress can be monitored. We also suggested that there was scope for emissions reductions beyond the Government's existing ambition, given further opportunities for waste prevention and recycling and other disposal methods such as anaerobic digestion and composting. We recommended that introduction of stronger levers to address the full potential for reducing waste emissions should be kept under review.

In this chapter we present latest evidence on emissions from waste, which accounted for 3% of total emissions in 2011, and consider policy developments to further reduce emissions.

We also bring together latest emissions data for other non-CO_2 emissions, arising in industry, transport, buildings and energy supply. Using the usual CO_2 equivalent metric based on the Global Warming Potential (GWP) over 100 years, other non-CO_2 emissions accounted for 5% of total greenhouse gas emissions in 2011. These non-CO_2 emissions have been continually monitored in our progress reports (e.g. in the overview and relevant sector chapters such as buildings and industry) but for the first time this year we set out indicators against which future progress can be monitored, with a focus on F-gases arising from industrial processes and buildings.

Our key messages are:

Waste emissions

- Waste emissions decreased by 3% in 2011, continuing a longer-term trend where emissions have fallen by 64% since 1990, largely due to reduced methane emissions arising from landfill sites.
- Landfill emissions have fallen due to reductions in the amount of biodegradable waste landfilled, driven by the landfill tax imposed to meet EU Landfill Directive targets. There has also been good progress to reduce waste generated by households and businesses and divert waste from landfill, through voluntary responsibility deals, information awareness campaigns and strategies to support anaerobic digestion.
- Further reductions in waste emissions could be supported through introduction of stronger levers, particularly targeting household food waste, which is likely to continue to be a major contributor to future landfill emissions. For example, households can be further encouraged to reduce waste arisings and increase recycling efforts. Local authorities can increase provision of separate food waste collection services, which can further unlock potential for producing energy through anaerobic digestion. The Government should also consider bans on major sources of biodegradable waste (e.g. food and textiles) from landfill on a case-by-case basis.

Other non-CO_2 emissions

- Other non-CO_2 emissions (from industry, energy supply, transport and buildings) fell by 4% in 2011, in line with the long-term trend which has seen emissions fall by 64% since 1990. This is mainly due to reduced emissions from industry and energy supply, caused by EU legislation to reduce emissions from industrial processes and reduced coal mining.
- Current policies are expected to lead to other non-CO_2 emissions falling by 50% by 2030 on current levels.
- There is potential to go further in reducing F-gas emissions than is currently being achieved under existing legislation.

We set out the analysis that underpins these messages in five sections:

1. Waste emissions: trends and drivers
2. Progress against waste indicators
3. Other non-CO_2 emissions: trends and drivers
4. Other non-CO_2 emissions: projections and abatement potential
5. Other non-CO_2 emissions: indicators of progress

1. Waste emissions: trends and drivers

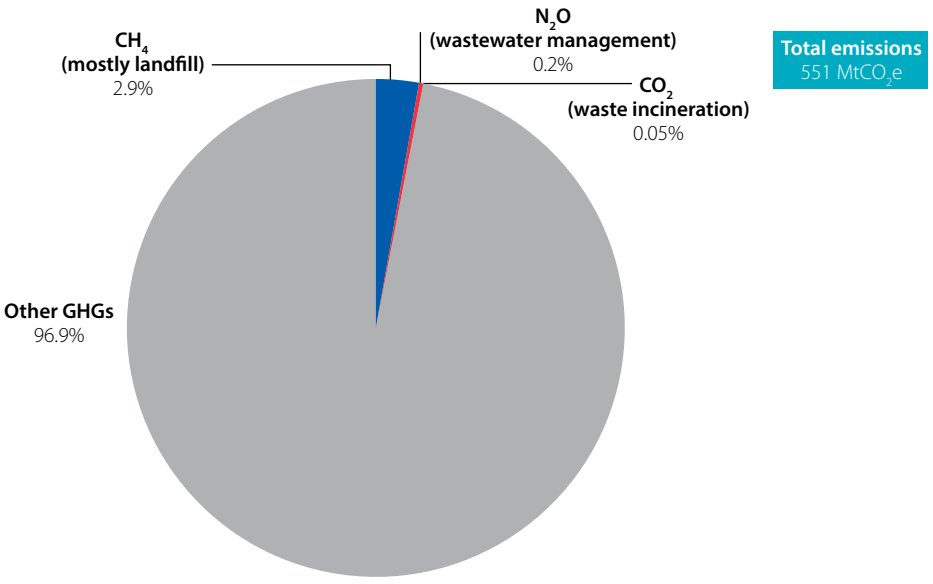
Emissions trends – methane, nitrous oxide, and CO_2

The waste emissions inventory was revised in 2012 to include a new separate time series of methane emissions arising from industrial wastewater treatment between 1990 and 2011.[1] Estimates for other sources of waste emissions remain unchanged. Due to the additional emission source, historic waste emissions reported in 2013 are slightly higher than previous estimates (e.g. 17.9 $MtCO_2e$ in 2010 versus previous estimate of 16.5 $MtCO_2e$). Therefore overall waste emission trends described below will differ slightly from those reported in our 2012 progress report.

Waste emissions were estimated to total 17.3 $MtCO_2e$ in 2011, accounting for just over 3% of total greenhouse gases in the UK (Figure 7.1). They are predominantly methane emissions which arise as biodegradable waste in landfill sites decomposes in the absence of oxygen.

- Methane emissions arising from landfill, accounted for 82% of waste emissions and fell 4% in 2011 (from 14.7 $MtCO_2e$ to 14.1 $MtCO_2e$). Overall landfill methane emissions have decreased by 67% since 1990.
- Methane and nitrous oxide (N_2O) emissions arising from wastewater treatment were 2.8 $MtCO_2e$ and increased very slightly in 2011.
- CO_2 emissions arising from incineration of wastes *without* energy recovery (e.g. clinical and sewage sludge) are small (0.3 $MtCO_2$ or 2% of total waste emissions) and fell 3% in 2011.

Figure 7.1: Waste emissions as a share of all UK greenhouse gas emissions (2011)



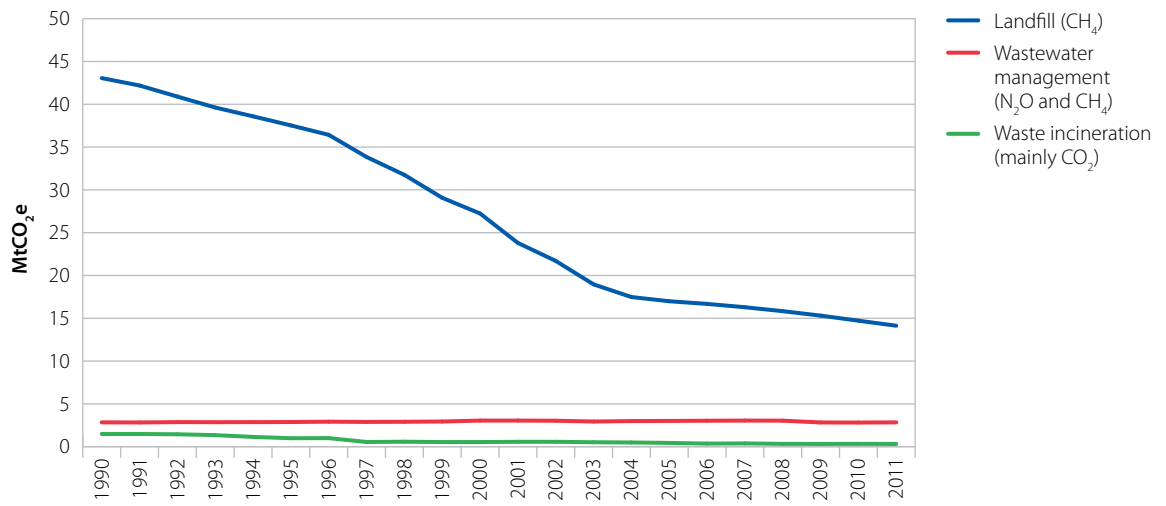
Source: NAEI (2013).
Notes: CH_4 = methane.

1 As recommend by the UNFCCC in its 2012 review of the UK inventory.

- There were also 1.8 $MtCO_2$ emissions arising from incineration of wastes *with* energy recovery, up 9% from 2010. These CO_2 emissions are allocated to the power rather than waste sector.

Overall waste emissions decreased by 3% in 2011, continuing a longer-term trend where emissions have fallen by 64% since 1990 (Figure 7.2).

Figure 7.2: Waste emissions by source (1990-2011)



Source: NAEI (2013).
Notes: CH_4 = methane.

Emissions drivers – methane

Methane arising from landfill sites, as food, paper and other biodegradable rubbish decomposes without oxygen, accounted for 90% of methane from the waste sector in 2011. The remaining 10% came primarily from wastewater treatment, as methane is produced from anaerobic decomposition of organic matter by bacteria in sewage facilities.

Landfill methane emissions are not directly measured but calculated based on data on: the quantity and composition of waste sent to landfill sites; assumptions on the properties of waste streams such as methane yield and decay rates (e.g. how much and over how many years methane is emitted as different types of waste degrade); as well as the properties of landfill sites (e.g. how much methane is captured and flared or used for energy generation rather than emitted into the atmosphere). There is imperfect understanding of methane yields and decay rates, which are affected by real landfill conditions and will therefore differ between and within sites. Given these uncertainties, the Government has estimated that landfill emissions could be 50% greater or lower than currently recorded in the inventory.[2]

Waste landfill emissions are in part determined by waste that was landfilled many years ago. For example, paper takes 12 to 17 years to emit half of its eventual total methane emissions. It is therefore important to consider longer-term as well as year-on-year changes in drivers of landfill methane emissions.

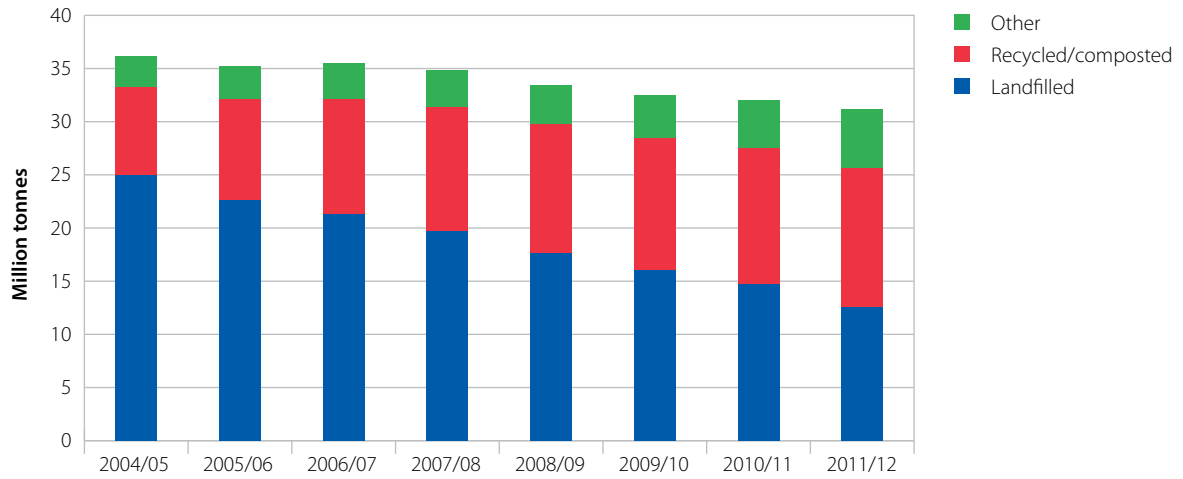
2 Ricardo-AEA (2013) *UK Greenhouse Gas National Inventory, 1990-2011, Annex 7.*

The three key drivers of methane emissions arising from landfill sites are: the amount of biodegradable waste generated in the UK; the amount of biodegradable waste that is landfilled; and the proportion of methane emitted by landfill sites that is captured or flared.

- **Waste arisings.** The latest Defra data on total waste arisings in the UK is for 2008 and shows an 11% decrease from 2004 levels. More recent Defra data suggest that municipal solid waste collected by local authorities fell by 3% in 2011/12, continuing a trend where waste collected by local authorities has decreased by 14% between 2004/05 and 2011/12 (Figure 7.3). Data on trends in biodegradable waste arisings are limited but Waste Reduction Action Programme (WRAP) data suggests that household food and drink waste has fallen by 13% since 2006, from 8.3 to 7.2 million tonnes (Mt). Reductions in waste have been driven by waste prevention and resource efficiency campaigns, voluntary responsibility deals and more recently the recession (Box 7.1).
- **Biodegradable waste sent to landfill.** This was reduced by an estimated 6% in 2011, continuing a longer-term trend where the amount of biodegradable waste landfilled has decreased by over 60% since 1990. These reductions have been driven by the UK landfill tax in place to meet EU Landfill Directive targets (Box 7.1). Limited data are available on how biodegradable waste is managed (e.g. proportion sent to landfill versus other treatments) but overall waste management statistics show an increasing trend towards treatment via recycling, composting, and other treatments including incineration, anaerobic digestion, and mechanical and biological treatment (Figure 7.3).
- **Methane captured at landfill sites.** Lifetime methane capture rates at landfill sites (or the proportion of methane that is captured rather than emitted) are assumed to average 75% (unchanged since 2005).

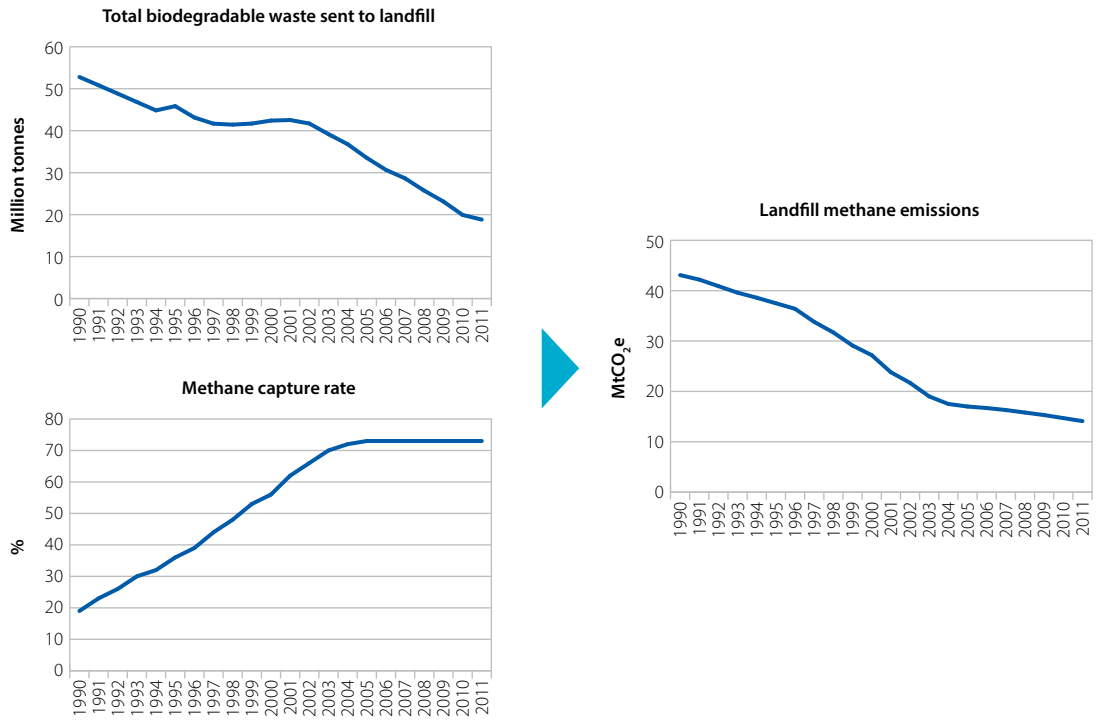
As a result, landfill methane emissions have decreased by 67% between 1990 and 2011 (Figure 7.4).

Figure 7.3: Local authority collected waste management in the UK (2004/05-2011/12)



Source: England: Defra (2013); Wales: StatsWales (2012); Scotland: SEPA (2012); Northern Ireland: DOENI (2012).
Notes: Compiled from various waste statistics databases; 'Other' includes incineration with/without energy recovery, mechanical and biological treatment and other treatments.

Figure 7.4: Total biodegradable waste sent to landfill, proportion of methane captured at landfill sites and methane emissions ($MtCO_2e$) from landfill (1990-2011)



Source: NAEI (2013).
Notes: These charts provide high-level overview of the key drivers accounting for reductions in landfill methane, which arises as various biodegradable waste streams decompose in landfills in the absence of oxygen. Emissions are a function of 1 minus the methane capture rate, and depend on the precise composition and historical timing of landfilled materials (e.g. each waste stream decays at a different rate and emits different levels of methane over time).

Success in reducing landfill emissions therefore reflects a combination of financial incentives introduced through the landfill tax, local authority and commercial/industrial actions in response to the landfill tax and other objectives, information and voluntary programmes for waste reduction and regulations to improve landfill management practices (Box 7.1).

As noted above and in greater detail in our 2012 progress report, considerable scientific and analytical uncertainty remains regarding the modelling of methane emissions (e.g. due to uncertain estimates of waste arisings, assumptions regarding methane yield and decay rates of waste streams, and the methane capture rate). We will continue to monitor any developments in the evidence base to improve the accuracy of waste emission estimates, including the Government working with the waste management sector to improve estimates of commercial and industrial waste and improving estimates of methane captured at UK landfill sites.

Box 7.1: Policy framework to reduce waste generation and landfill methane emissions

The UK landfill tax is currently the key policy driver to achieve targets under the 1999 EU Landfill Directive, which requires a 50% reduction in biodegradable municipal waste landfilled in the UK by 2013 relative to 1995 levels and a 65% reduction by 2020.

The landfill tax imposes a charge on landfill operators for each tonne of waste landfilled. Operators in turn pass on the costs as gate fees to local authorities and businesses, creating an incentive to reduce the waste they send to landfill either through waste prevention or diverting waste to other treatments (recycling, composting, recovery, and reuse). The tax has been increased from its initial rate of £7 per tonne to £72/t, and will rise to £80/t in 2014/15.

There are also a number of complementary approaches to encourage waste reduction, to increase recycling rates and to increase diversion of waste from landfill.

- **Waste reduction**
  - WRAP's **Love Food Hate Waste Programme** encourages voluntary reductions in food waste. It was introduced in 2007 and has had some success, with food waste generated by households falling by over 1 Mt (a 13% reduction) between 2006 and 2010.
  - The **Courtauld Commitment**, a voluntary responsibility deal to improve resource efficiency in the grocery retail sector, prevented 0.7 Mt of food waste between 2005 and 2009. The second phase (2009-2012) aimed to further reduce household food and drink waste by 4%, packaging waste by 10%, and supply chain product and packaging waste by 5% relative to 2009 levels. Much of this was achieved in the first year and a final evaluation of Phase 2 will be published in autumn of 2013. The third phase covers 2013-2015 and aims to reduce household food and drink waste by a further 5% from 2012 levels.
- **Diversion of waste** towards recycling and other treatments
  - **Household waste.** Partly incentivised by the landfill tax and until recently, the Landfill Allowance Trading Scheme (which set limits on the amount of biodegradable municipal waste that local authorities could send to landfill), local authorities have supported the sorting of waste through providing for recycling collection (and in some cases for separate food waste collection), encouraged composting and invested in waste treatment facilities.
  - **Commercial and industrial waste.** The UK has a statutory producer responsibility regime to reduce packaging and recently set new targets requiring producers to increase recovery rates of materials (e.g. paper/card, glass, aluminium, steel) from 74% in 2012 to 79% in 2017.
- **Methane capture and anaerobic digestion (AD).** A combination of permit conditions and financial incentives for capturing methane from landfill and anaerobic digestion (e.g. under the Renewables Obligation, Feed-in-Tariffs, and Renewable Heat Incentive) has driven investment to significantly increase capture of methane at landfill sites. The Government's 2011 AD Strategy and Action Plan aims to reduce barriers to uptake of AD in England.

Emissions drivers – nitrous oxide and CO_2

Nitrous oxide (N_2O) emissions in the waste sector arise primarily from wastewater treatment and are estimated based on the quantity of sewage sludge disposed, population levels, and protein consumption.

Overall N_2O emissions allocated to the waste sector decreased very slightly in 2011 (by -0.4%):

- The amount of sewage sludge treated increased 5% (mainly reflecting increasing population levels);
- In the absence of new information, per capita protein consumption has been assumed to be unchanged from 2010;

- However more sewage sludge was applied to agricultural lands in 2011 with associated emissions allocated to the agricultural sector, such that the share allocated to waste management has fallen.

CO_2 emissions from incineration of wastes *without* energy recovery are included in the waste sector inventory emissions and decreased 3% due to reductions in the amount of waste incinerated.

CO_2 emissions from incineration of waste *with* energy recovery are captured in the power sector (e.g. combustion of municipal solid waste). This has accounted for most waste incineration emissions since 1997 and is related to burning waste products that are produced from fossil fuels (e.g. plastics). Estimates of these emissions were revised upwards in 2012 using updated and improved emissions factors. The revised estimate for CO_2 emissions from incineration of wastes with energy recovery is 1.8 $MtCO_2$ in 2011, a 9% increase from 2010 which is likely to have been due to increased combustion of wastes with fossil fuel content.

Given the small magnitude of these emissions, our focus in monitoring progress in reducing waste emissions is on methane released from landfill sites.

2. Progress against waste indicators

Our indicator framework – set out last year in our 2012 progress report to Parliament – includes trajectories for emissions, biodegradable waste sent to landfill, the amount of methane captured at landfill sites and policies to drive progress.

Outcome indicators

Recognising opportunities to go further than the Government's ambition, we present our indicators as a range, reflecting scenarios where biodegradable waste sent to landfill is reduced at least in line with the Government's projections and potentially reduced close to zero by 2020. Our indicators were developed as a set of trajectories from 2007 (the last year before the first carbon budget) through to 2020, requiring the following:

- Landfill methane emissions fall by 30-50% from 2007 to reach 8-11 $MtCO_2e$ in 2020.
- The amount of biodegradable waste sent to landfill falls by 40-94% from 2007 levels of 29 Mt to reach no more than 17 Mt in 2020. Within this, food waste falls at least 35%, paper/card waste falls at least 46%, green waste falls at least 44% and wood waste falls at least 31%.
- At least 75% of methane is captured on average across UK landfill sites.

The reductions in landfill methane emissions set out above (section 1) are in line with our indicator trajectory, reflecting reductions in the overall amount of biodegradable waste generated in the UK. Reductions in biodegradable waste sent to landfill are also consistent with our trajectories. Based on available evidence, the 75% methane capture rate remains unchanged.

Policy milestones

In June 2011 the Government published a review of its waste policy in England, with the aim to put the UK on a path towards a 'zero waste' economy. While the landfill tax remains the key lever for reducing waste sent to landfill, the Waste Review included an Action Plan setting out further waste policy commitments or measures to consider to drive waste further up the 'waste hierarchy'[3]. Our policy milestone indicators cover actions identified in the Government's Waste Review and our recommendations for further actions.

National Waste Prevention Programme (WPP)

The Government is on track to launching its WPP to drive waste further up the waste hierarchy by helping businesses and households realise cost savings through waste prevention and resource efficiency. A call for evidence was launched in March 2013 to understand available data and barriers to reducing waste arisings in England and the programme will be launched by the end of December 2013, which we will evaluate in our 2014 progress report.

Consultation on wood waste landfill restriction and exploring potential for other material-specific landfill restrictions

The Government launched a consultation on wood waste landfill restrictions in 2012 (July to September). It concluded in February 2013 that it would not to pursue a ban at present given the additional costs likely to be incurred by businesses as well as evidence suggesting that wood waste sent to landfill will continue to decline under current policies (e.g. landfill tax and Environment Agency and WRAP efforts to manage wood waste). Moreover a cost-benefit analysis by Defra found negligible or negative benefits from diverting all wood waste from landfill (£0-50 million depending on the type of restriction), although uncertainty is attached to these estimates (e.g. if actual landfill methane capture rates are lower than what was assumed in the analysis, landfill methane emissions would be higher than currently estimated, and therefore the potential benefits of a restriction would be higher).[4]

This evidence was also used to support the Government's decision not to consider landfill restrictions for other materials at present.

However, there may be cost-effective opportunities for banning other types of biodegradable waste such as food or textiles from landfill. These should be considered on a case-by-case basis.

Consideration of such policies is important given that the European Commission has proposed phasing out landfilling progressively by 2020[5] and is currently consulting on adapting EU waste targets to reach this objective (June to September 2013). There has been recent progress in introducing landfill restrictions in other member states (e.g. Germany and Sweden). Scotland has also required the banning of landfilling biodegradable waste by 2021 under its Zero Waste Strategy, supported by Waste (Scotland) Regulations which were passed in Parliament in May 2012. Wales is also aiming to ban biodegradable waste from landfill by 2020.

3 Defined in the European Commission Waste Framework Directive as placing a priority on prevention, followed by re-use, recycling, energy recovery, and last of all disposal.
4 Defra (2013) *Wood Waste Landfill Restrictions in England: Call for Evidence Analysis.*
5 European Commission (2011) *Roadmap to a Resource Efficient Europe.*

We will continue to monitor efforts to move in this direction in the UK, including at the devolved level.

Agreeing responsibility deals with sectors specified in Waste Review

A number of responsibility deals have been launched by the Government since 2011 to encourage best practice, reduce waste and improve recycling rates in businesses. These include a Waste Management Responsibility deal to promote knowledge and recycling in businesses and a Direct Marketing deal, which aims to reduce direct marketing material through improving targeting, consumer awareness of opt-out schemes, and recycling rates.

Two key deals committed to in the Waste Review were further developed and launched in 2012:

- Building on achievements in Phase 1 and 2, Phase 3 of the **Courtauld Commitment** (2012-2015) was launched in May 2013 to reduce household food and drink waste by 5% and food and packaging waste by 3% (relative to a 2012 baseline). All major supermarkets have signed up and signatories currently represent 90% of the market. Meeting these targets would imply an overall 20% reduction in household food waste under the three phases between 2005 and 2015.
- A **Hospitality and Food Service Agreement** was launched in June 2012 with the aim to cut food and packaging waste by 5% from 2012 levels and increase food and packaging waste that is being recycled, sent to AD, or composted to 70% by 2015 (from an average of 45% today). The aim is to cover 25% of the market by food and drink sales (current signatories account for 20% of the market). First year progress against targets will be reported on in 2014.

We will continue to monitor delivery of these deals against objectives.

Improving estimates of methane captured from UK landfill sites

Recent field studies by Defra and the Environment Agency have supported the current assumption used by Government and in our indicators that on average 75% of methane is captured at landfill sites.[6] The studies, however, have found significant variation in methane emissions and surface methane oxidation across and within landfill sites. For example, in a recent Defra/Environment Agency pilot study[7] methane oxidation rates (or the proportion of methane that is not collected by landfill gas collection systems and is oxidised rather than released as methane) varied between 5% and 24% across nine landfill sites (under higher oxidation rates, fewer methane emissions are emitted into the atmosphere).

Regulatory guidance for landfill operators bases permit conditions on a target to collect at least 85% of the methane formed in landfills receiving biodegradable waste. Reducing variation by bringing sites in line with best practice could improve average capture rates and reduce emissions, although it is unclear whether this would be cost-effective across all sites. Improving

6 UK Greenhouse Gas National Inventory, 1990-2011 (2013).
7 NPL study for Defra (2012) *Measurements of Methane Emissions and Surface Methane Oxidation at Landfills: WR1125.*

methane capture rates and confidence in assumed estimates continue to be priorities for the Government and landfill operators.

Strengthening waste incentives through the waste chain

While the landfill tax is the key driver for reducing future waste emissions, we noted in our 2012 progress report that some parts of the waste chain may require direct regulation or additional incentives to encourage waste reduction and increased recycling. For example, in order to make landfill restrictions more cost-effective, further sorting and separate collection of waste streams for recycling, composting, AD and other treatment is required. We recommended that the Government explore scope to strengthen incentives throughout the waste chain using the full range of levers, for example by requiring separate collection of household food waste.

In the past year, recycling targets for English local authorities have been abolished based on the Government position that the landfill tax is a more effective driver for diverting waste from landfill.

However, there have been a number of encouraging developments in the past year by local authorities to support recycling and separate collection of waste streams, including:

- The Government's **Weekly Collection Support Scheme** (February 2012) provided £250 million to 90 councils to provide weekly waste collection services and deliver other environmental benefits. Some councils have used the funding to enhance recycling services, including providing for separate collection of food and other biodegradable wastes (e.g. textiles), and introducing recycling reward schemes. These efforts are estimated to send an additional 0.4 Mt of waste for recycling per year.
- The **Household Reward and Recognition scheme** provides a small amount of funding (£2 million between 2011 and 2013) to local authorities and community organisations to introduce or trial schemes that reward or recognise household recycling. Schemes will support development of the evidence base on environmental and financial costs and benefits of rewarding householders, with a particular focus on self-sustaining schemes (i.e. without central government funding).

We will monitor how these initiatives deliver and influence future waste policies.

In addition the number of local authorities providing for food waste collection continues to increase. In March 2013, 50% of English local authorities provided for collection of food waste (27% provided for separate collection while 23% provided for collection of food mixed in with garden waste). Food waste collection rates are higher in Scotland and Wales (56% of Scottish and 100% of Welsh local authorities provide for collection of food waste either via separate collection or mixed in with garden waste), with an average of 55% across the UK (up from 52% in 2012).[8] There is limited data on actual take up of food waste collection services by households and businesses.

Local authorities should consider further options for increasing separate collection of food waste and other recyclable materials and rewarding participation by households and businesses.

8 WRAP Household Kerbside Residual Waste Collections 2011/12, http://laportal.wrap.org.uk/Statistics.aspx

Strategies for food and paper/card waste

We previously recommended that specific strategies be developed for reducing food and paper/card waste given these waste streams are likely to be the biggest contributor to future landfill methane emissions (projected to comprise around 65% of emissions in 2020 and 2030).

The Government's position is that reductions in food waste and diversion of food waste from landfill towards other treatments are adequately covered by existing policies outlined above, including the landfill tax, the Courtauld Commitment, other responsibility deals, WRAP's Love Food Hate Waste Campaign, the Anaerobic Digestion Strategy and Action Plan, and the forthcoming Waste Prevention Programme. WRAP has also developed a Food Waste Resource Portal identifying up to date and relevant sources of data on different sources of food waste which could be used as feedstock for anaerobic digestion.

These policies have had success in reducing and diverting food waste from landfill. Household food and drink waste decreased by 13% between 2006 and 2010 and commercial/industrial food and drink waste levels were halved between 2002 and 2009.[9] We will continue to monitor the impact of these schemes.

However, it is not clear how these policies interact through the waste chain and across sectors, or whether in some areas players face weak incentives or existing policies are not effective. For example, household food waste, of which 60% is avoidable, continues to be the biggest contributor to UK food waste (7.2 Mt of a total 15 Mt in food waste) and we have previously noted that incentives for households to reduce waste may be limited given that they do not face the full costs of waste disposal.

We will monitor how these gaps are addressed in the Government's forthcoming Waste Prevention Programme and other waste policies. Government should ensure that current and forthcoming policies together provide appropriate incentives at each stage of the food waste chain and identify where new/stronger policies should be introduced as required to address areas where incentives appear weak or where progress is slow.

With regards to reducing paper/card waste, there has been good progress under existing policies:

- Paper collection rates are approximately 70%, in line with average rates across Europe. The Government has suggested that there may be practical limits to the amount of paper that can be collected for recycling[10], however higher collection rates may be possible. Industry data also suggests the UK has one of the highest recovered paper utilisation rates (the proportion of recovered paper used in relation to the amount produced is 87% compared to a Europe average of 51%).[11]
- Producer responsibility regulations require that packaging producers recover 70% of paper/card (covering the period 2012-2017).

9 WRAP Food Waste Resources Portal (2013), http://www.wrap.org.uk/content/food-waste-resources-portal
10 Government Response to the Fourth Annual Progress Report of the Committee on Climate Change: Meeting the Carbon Budgets – 2012 Progress Report to Parliament (October 2012).
11 Confederation of Paper Industries statistics (2013).

- Voluntary newspapers, magazines and direct marketing materials deals have met and exceeded recycling targets and Government is in process of developing successor deals.

We will continue to monitor paper/card waste prevention efforts and recycling rates and will identify any further opportunities for reductions and diversion. We recommend that the Government ensure that policies incentivise players across the waste chain (e.g. householders, businesses, and the public sector) to reduce paper/card waste and increase recycling efforts, introducing new/stronger policies as required.

Other policy developments

Anaerobic Digestion Strategy and Action Plan

Since launching its Anaerobic Digestion Strategy and Action Plan to tackle barriers and increase uptake of AD in England, the Government has: set up a £10 million loan fund to support new AD capacity; created an innovation fund to bring down costs of AD; identified potential sources of waste feedstock (through WRAP's Food Waste Resources Portal); and developed markets for digestate (an AD byproduct). The Green Investment Bank has also recently assessed development of the AD market and operational performance of UK facilities to improve industry and investor understanding of the sector.[12]

There has been good progress in AD in the UK, with the number of plants increasing from 78 to 112 in the past year (as of June 2013) and from 54 plants when the strategy and action plan was launched in June 2011. The number of plants specifically treating household and commercial/industrial waste (as opposed to agricultural waste) has increased from 48 to 66 in the past year, with an estimated capacity to handle 4 million tonnes.[13] The Government will report on annual progress on its AD Strategy and Action Plan in July 2013.

Devolved administrations

Waste management is a devolved issue, with each of the devolved administrations developing waste strategies and legislating waste measures. Stronger policy frameworks are in place in Wales and Scotland to encourage recycling by households and businesses. Both have set recycling targets for 2025 (70%). Scotland has also banned the landfilling of biodegradable material by 2020 and is requiring local authorities to roll-out separate food waste collection services by the end of 2013, to be completed by 2015. Wales aims to divert all municipal biodegradable waste from landfill by 2020 and is the only UK country where food and/or food and green waste is collected separately by every local authority. Northern Ireland has set a household recycling/reuse target of 50% by 2020, with a proposal to increase the rate to 60%.

12 Green Investment Bank (2013) *Anaerobic Digestion Market Report.*
13 Biogas Portal, http://biogas-info.co.uk/

3. Other non-CO_2 emissions: trends and drivers

Emission trends

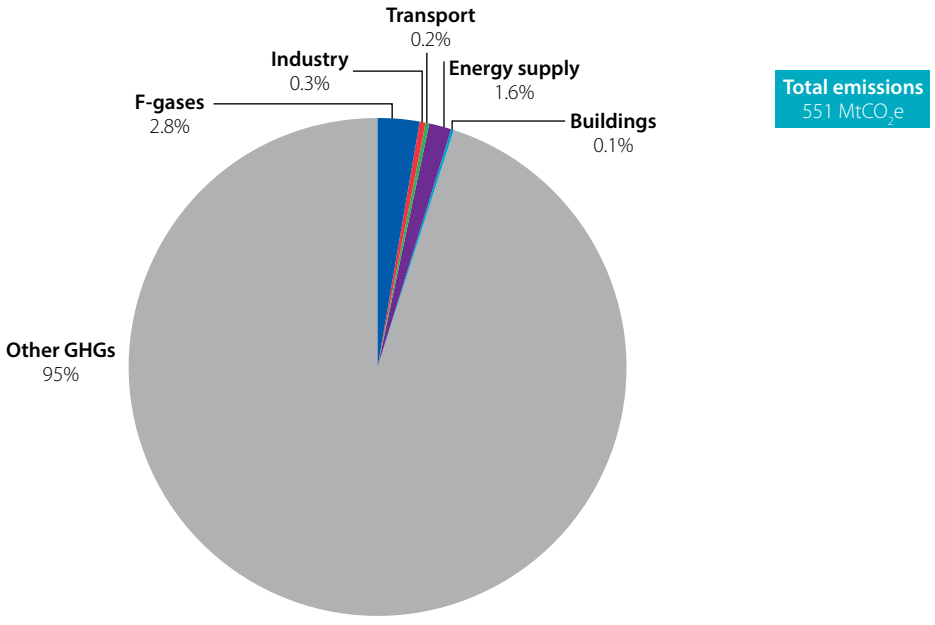
Other non-CO_2 emissions in the UK comprise emissions of methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (F-gases) that are not covered by either the agriculture or waste sectors. They include emissions from industry, energy supply, residential buildings and transport. Other non-CO_2 emissions total 28 $MtCO_2e$ in 2011 (approximately 5% of all UK greenhouse gas (GHG) emissions, Figure 7.5).

The biggest contributors to these emissions are F-gases, which account for approximately 60% of all other non-CO_2 emissions. They relate primarily to emissions from the use of F-gases as coolants in refrigeration and air conditioning. The remaining emissions come from fugitive methane and nitrous oxide emissions in the energy supply sector (32%) and nitrous oxide emissions from industry (6%) and transport (4%). Given that transport emissions are such a small proportion of total other non-CO_2 emissions, and are expected to remain fairly constant to 2030, our focus in monitoring trends is on F-gas, energy supply, and industry emissions.

Overall other non-CO_2 emissions fell 2% in 2011. They have fallen 64% between 1990 and 2011 (Figure 7.6). Within this:

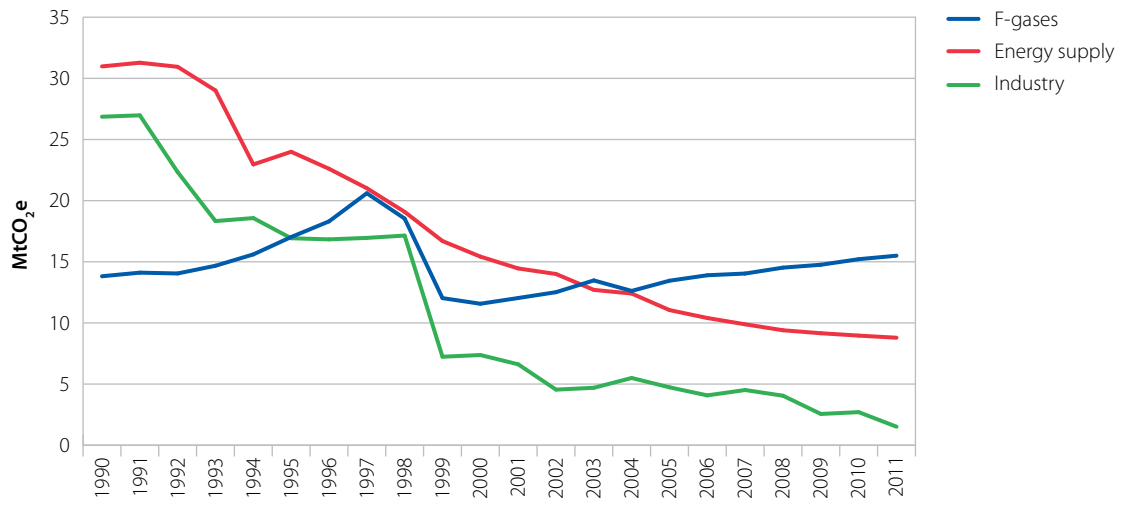
- F-gas emissions rose 2% in 2011 to 15.5 $MtCO_2e$ and have risen 12% overall since 1990.
- Emissions of methane and nitrous oxide from the energy supply sector fell 2% in 2011 to 8.8 $MtCO_2e$ and have fallen 72% since 1990.
- Nitrous oxide emissions from industry fell 44% in 2011 to 1.5 $MtCO_2e$ and have in total fallen by 94% since 1990.

Figure 7.5: Other non-CO_2 emissions as a share of all UK GHG emissions (2011)



Source: DECC (2013) *Final emissions estimates 2011.*

Figure 7.6: Other non-CO_2 emissions by source (1990-2011)



Source: DECC (2013) *Final emissions estimates 2011.*

We now consider the drivers of these changes in more detail.

Emissions sources and drivers – F-gases

F-gas emissions arise from three types of fluorinated gases; hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). These gases are emitted in industrial processes and buildings in very small amounts but have high global warming potentials (between 140 and 23,900 times that of CO_2) and long atmospheric lifetimes.

- HFC emissions make up the largest proportion of F-gas emissions. Since the Montreal Protocol was ratified in 1989 HFCs have been used as substitutes for ozone-depleting substances (ODS) such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). HFCs are therefore now used in applications which previously used CFCs and HCFCs, such as refrigeration and air conditioning equipment, foams, aerosols and fire extinguishers. HFCs are emitted during the manufacture, lifetime and disposal of these applications.
- PFC emissions arise mostly from use in industrial processes such as aluminium production and manufacture of semiconductors. PFCs are also used as solvents, fire fighting agents and refrigerants.
- SF_6 emissions arise from use in industrial applications such as magnesium casting and photovoltaic manufacture. They are also used in sound-proof windows and switchgear equipment.

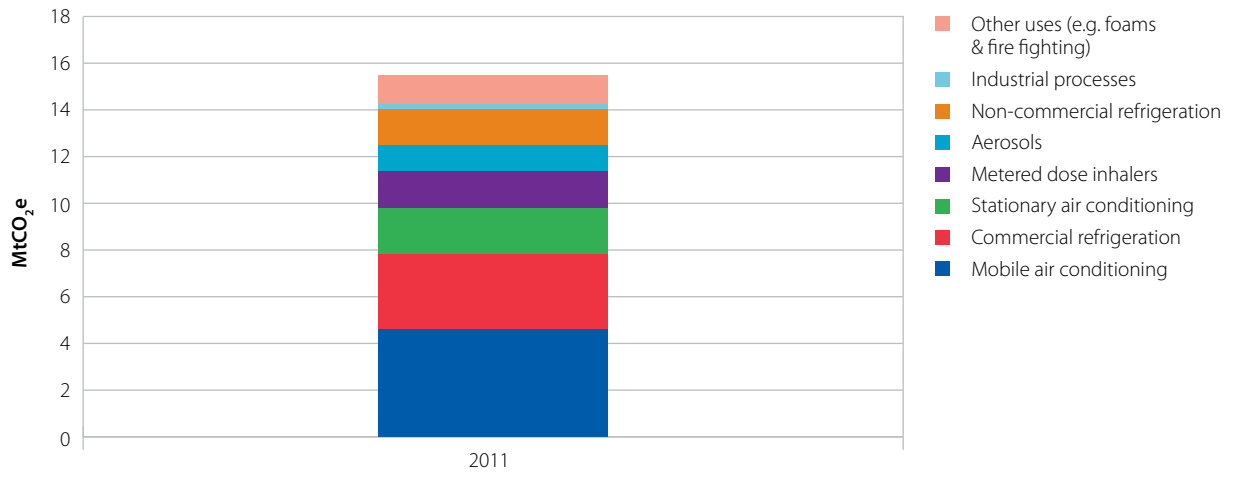
Overall F-gas emissions have been rising since 1990 mainly due to their use as a replacement for ozone-depleting substances (ODS). The increase has also been driven by growth in demand for products such as air conditioning units.

In response, the EU has introduced policies to reduce F-gas emissions (Box 7.2). These are having some effect in controlling the biggest contributors to UK emissions of F-gases (Figure 7.7):

- **Mobile air conditioning**[14] **(MAC) emissions** fell by 1.3% in 2011 to 4.6 $MtCO_2e$. This reduction is being driven by the MAC directive which came into effect in 2011 and which restricts the use of F-gases in new cars. This has reversed the historical trend of increased emissions arising from the phase out of ozone-depleting CFCs and increased demand for air conditioning in vehicles.
- **Commercial refrigeration emissions** increased 2% in 2011 to 3.2 $MtCO_2e$. This is a much lower rate of growth than the average 12% per year over the last decade. The higher rates historically were due to F-gases being used to replace ODS under the Montreal Protocol. As ODS have now been completely replaced by F-gases, the current increase in emissions is being driven by increased demand for refrigeration. The F-gas regulation (which attempts to reduce leakage and use of F-gases) may also be limiting the increase in F-gases from this sector.
- **Stationary air conditioning emissions** increased 10% in 2011 to 2 $MtCO_2e$. As ODS have been completely replaced by F-gases, this increase is also being driven by increased demand. These emissions are also covered under the F-gas regulation.
- **Inhaler emissions** increased by 1% in 2011 to 1.6 $MtCO_2e$, driven by population growth.

We consider options for stronger policy measures to reduce F-gases in section 4 below.

Figure 7.7: F-gas emissions by source (2011)



Source: DECC (2013) *Final emissions estimates 2011.*

14 Mobile air conditioning (MAC) refers to air conditioning units in vehicles.

Box 7.2: EU policy framework to reduce F-gas emissions

There are currently two EU policies in place to reduce F-gas emissions:

- The Mobile Air Conditioning (MAC) Directive was introduced in 2008 and came into effect in 2011. It prohibits the use of F-gases with a global warming potential more than 150 times greater than carbon dioxide (CO_2) in air conditioning units in new types of cars and vans introduced from 2011 and in all new cars and vans produced from 2017.
- The F-gas Regulation introduced in 2006 covers all other key applications in which F-gases are used with the aim to:
  - Improve the prevention of leaks from equipment containing F-gases. Measures comprise: containment of gases and proper recovery of equipment; training and certification of personnel and of companies handling these gases; labelling of equipment containing F-gases; and reporting on imports, exports and production of F-gases.
  - Avoid F-gases in some applications where alternatives with lower global warming potentials (such as CO_2 and ammonia) are cost-effective. Measures include restrictions on the marketing and use of certain products and equipment containing F-gases.

Source: The European Commission

Emissions drivers – methane and nitrous oxide emissions arising from energy supply and industry

The remaining other non-CO_2 emissions include fugitive methane emissions arising in energy supply processes and methane and nitrous oxide emissions arising mainly from production of nitric and adipic acid.

- **Energy supply:** Non-CO_2 greenhouse gases emitted in this sector include methane and nitrous oxide . They are caused by fugitive emissions during the production, storage, distribution and combustion of fossil fuels. The largest sources of fugitive emissions in 2011 included:
  - Coal mine methane emissions, which fell 5% in 2011 to 2 $MtCO_2e$. This was driven by the continued decrease in UK coal production (since 1990 emissions have fallen 89%, in line with a fall in total UK coal output of 80%).
  - Natural gas supply methane emissions also fell 5% in 2011 to 4 $MtCO_2e$. This was driven by a fall in leakage rates from the natural gas supply network due to continued replacement of gas pipes and improved detection of leaks (which have led to emissions falling 51% since 1990).
  - N_2O emissions from power stations increased 0.3% in 2011 to 0.9 $MtCO_2e$. This may have been driven by a slight increase in coal power generation in 2011.
- **Industry:** Methane and nitrous oxide emissions also arise from certain industrial processes. The biggest contributor historically has been N_2O emissions arising from production of nitric and adipic acid. However the installation of abatement equipment at plants has greatly reduced emissions such that emissions of N_2O from adipic acid production are now zero and emissions from nitric acid were only 0.2 $MtCO_2e$ in 2011 having fallen from 1.3 $MtCO_2e$ in 2010. The remaining 1.3 $MtCO_2e$ of industrial non-CO_2 emissions came from other industrial processes, industrial combustion and off-road machinery.

Overall non-CO_2 emissions from energy supply and industry have fallen significantly since 1990 and continued to fall in 2011.

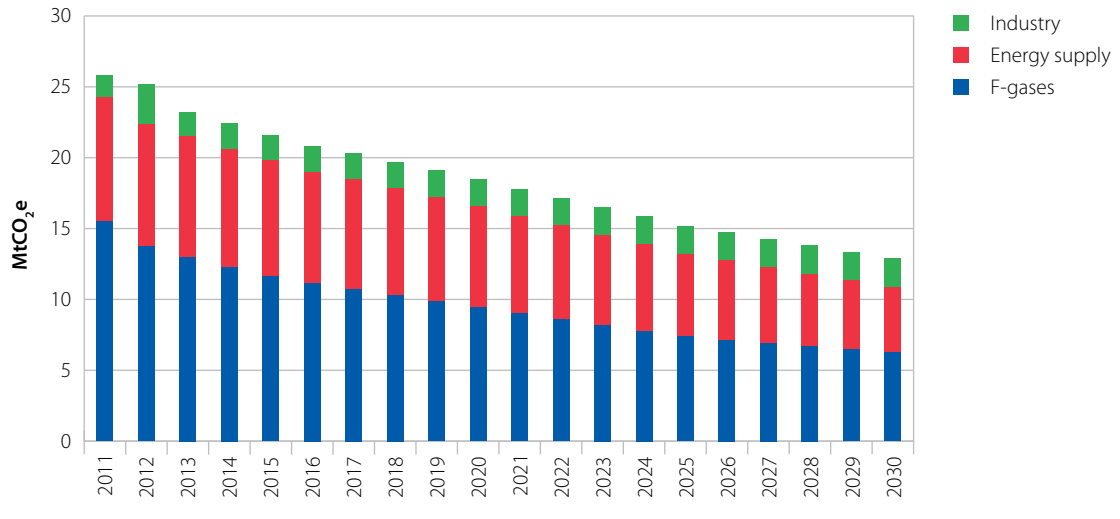
4. Other non-CO_2 emissions: projections and abatement potential

Emission projections

In DECC's central projections, emissions of non-CO_2 gases excluding agriculture and waste are expected to fall 50% by 2030 relative to 2011 levels (Figure 7.8). This primarily reflects reductions in energy supply and F-gas emissions, with emissions from industry expected to remain fairly flat:

- Emissions from F-gases are expected to fall by 61% by 2030 to 6 $MtCO_2e$:
  - Mobile air conditioning emissions are projected to reach zero by 2030. This is being driven by the EU MAC directive which has already seen a decline in emissions in 2011.
  - Refrigeration emissions and stationary air conditioning emissions are expected to fall by 70% by 2030. This is being driven by the F-gas regulation which will lead to a continued reduction in leakage rates of F-gases and replacement of F-gases with much lower GWP alternatives.
  - F-gas emissions from industrial processes, such as aluminium production, are projected to fall by 50% by 2015 and then remain flat to 2030. The fall to 2015 is mainly due to the closure of the Lynemouth aluminium plant in 2012 which accounts for 80% of UK aluminium production.
  - Emissions of F-gases from medical inhalers are projected to increase slightly due to population growth.

Figure 7.8: Projected emissions of other non-CO_2 (2011-2030)



Source: DECC (2012) *Updated emissions projections.*

- Emissions from energy supply are projected to fall by 45% to 5 $MtCO_2e$ in 2030. The two main drivers of this decrease are:
  - Methane emissions from coal mining falling 78% to 0.4 $MtCO_2e$ in 2030, reflecting further anticipated reductions in UK coal mine production.
  - Methane emissions from natural gas leakage falling 36% to 2.5 $MtCO_2e$ in 2030. These emissions are projected to decline due to a 30 year programme (started in 2002) to reduce leakage from the gas distribution network.
- Industry emissions are expected to remain fairly constant out to 2030 at approximately 1.5 $MtCO_2e$.

These reductions would result in 2030 emissions of approximately 13 $MtCO_2e$ and are expected to occur without further efforts to reduce emissions. We now consider whether more can be achieved.

Further abatement potential – F-gases

There is potential for further reductions in F-gas emissions by replacing remaining F-gases with alternative compounds. A 2010 AEA study for Defra[15] showed that there are currently much lower GWP alternatives to HFCs, some of which are commercially available and some of which are in development:

- In refrigeration and air conditioning there are several options including hydrocarbons which are already in the market, as well as CO_2 and Hydrofluoroolefins (HFOs) which are in development.
- Metered dose inhalers, which are currently used in the UK, can be replaced with dry powder inhalers which have been a known technology for over 20 years and are more widely used in some countries than in the UK.
- Currently replacements for HFCs in aerosols are not widely used in the UK. However HFOs are already being used as a replacement, with only small modifications to equipment required, in the EU.

The main barriers to further uptake of these alternatives are higher costs, whether directly or through costs of replacing existing systems. If these replacements are used they could lead to HFC emissions being reduced by a further 1 $MtCO_2e$ in 2030.

In 2012 the European Commission proposed that the current F-gas Regulation be strengthened and updated through introduction of a phase-down mechanism, and bans on certain uses:

15 AEA (2010) *HFC consumption and emissions forecasting.*

- A phase-down mechanism would involve a gradually declining cap on the placement of F-gases (in tonnes of CO_2 equivalent) on the market in the EU, with a freeze in 2015, followed by a reduction from 2016 leading to sales in 2030 at only 21% the level of those from 2008 to 2011. This will lead to producers of products and equipment which previously used F-gases switching to alternative technologies where feasible.
- Bans would prevent the placing of F-gases on the market in several subsectors between 2015 and 2020 where technologies currently exist for a full replacement.

These policies appear to be deliverable given Defra and EC[16] evidence. Together they are expected to reduce F-gas emissions in the EU by around 70% in 2030 compared to current emissions (this compares to reductions of 60% expected in the UK under current policies). Furthermore companies such as Coca-Cola and Unilever have committed to the replacement of F-gases on a more ambitious timescale than the EC proposal (for example Coca-Cola are committed to buying only HFC-free equipment by 2015). The US and China have also recently agreed a phase down in the use of HFCs.

We therefore recommend that the Government should support the EC proposal as a minimum and should consider going further given the existence of cost-effective alternatives, with more rapid phase out of some uses of these gases.

5. Other non-CO_2 emissions: indicators of progress

Our indicator framework generally comprises emissions trajectories, trajectories for key drivers of emissions, and policy milestones to strengthen incentives for implementation of measures to reduce emissions.

Extension of this framework to include other non-CO_2 emissions requires trajectories for F-gas emissions, energy supply emissions and industry emissions. We will monitor progress against the following trajectories:

- F-gas emissions fall 33-45% from 2007 levels to reach 9.3-7.5 $MtCO_2e$ in 2020. Given the potential to reduce F-gas emissions beyond current government projections, this range encompasses scenarios where emissions are only reduced in line with current projections and where they are reduced to 4 $MtCO_2e$ in 2030 in line with abatement potential identified in the Defra analysis, and potentially deliverable under the EC proposals.
- Energy supply emissions fall 25% on 2007 levels to reach 7 $MtCO_2e$ in 2020, in line with Government projections.
- Industry emissions fall 47% on 2007 levels to reach 1.4 $MtCO_2e$ in 2020, in line with current projections.

The main policy milestone for other non-CO_2 will be the update of the current F-gas regulation which should be finalised by the end of 2013. We will monitor development of this at both the UK and EU levels to ensure that it is rigorous enough to deliver the required cuts in emissions.

16 European Commission (2011) *Preparatory study for a review of Regulation (EC) No 842/2006 on certain fluorinated greenhouse gases.*

Key findings

- Waste emissions fell by **3% in 2011**, and are now 64% below 1990 levels. This is largely due to reduced methane emissions from landfill, driven by reductions in the amount of biodegradable waste sent to landfill and an improved rate of methane capture at landfill sites.
- There has been **good progress** to reduce waste generated by households and businesses and to reduce waste from landfill through **voluntary responsibility deals, information awareness campaigns**, and **strategies to support anaerobic digestion**.
- Further reductions in waste emissions could be supported through **stronger levers**, particularly **targeting household food waste**.
- The Government should **consider bans on major sources of biodegradable waste** from landfill on a **case-by-case basis**.
- **Non-CO_2 emissions** arising from industry, transport, buildings and energy supply fell **4% in 2011**, continuing a longer-term trend where emissions fell 64% since 1990.
- Other non-CO_2 emissions are likely to decrease **50% by 2030** on current levels under **current policies**.
- **Further reductions in F-gas emissions** could be achieved under stronger policies.

Table 7.1: The Committee's waste and other non-CO_2 indicators

WASTE AND OTHER NON-CO_2 SOURCES		Budget 1	Budget 2	Budget 3	2011 trajectory	2011 Outturn
Waste						
Headline indicators						
Emissions (indicative % change from 2007)*						
CO_2e emissions		-9%	-22% to -33%	-32% to -50%	-7%	-12%
GHG and source emissions (% change in $MtCO_2e$ against 2007)	Landfill – CH_4*	-10% to -15%	-25% to -37%	-36% to -56%	-7%	-13%
	Wastewater treatment – N_2O*	-5%	-2%	+2%	-6%	+3%
	Incineration – total CO_2*	No more than 25%			-20%	-18%
Drivers (indicative % change from 2007 levels)**						
Biodegradable waste sent to landfill	2007 = 29 Million tonnes (Mt)	-30% (20 Mt)	-38% to -84% (18 Mt to 4.5 Mt)	-39% to -97% (17 Mt to 1 Mt)	-25% (21 Mt)	-30% (19 Mt)
Percentage of methane captured at landfill sites	2007 = 75%**	75%	75%	75%	75%	75%
Policy Milestones						
Develop National Waste Prevention Programme			End 2013			December 2013 (call for evidence launched March 2013)
Agree responsibility deals with sectors specified in Waste Review (waste management, paper, packaging, hospitality, textiles, Courtauld 2 successor)		Different timetables for various sectors; ongoing work to 2015				Ongoing; Courtauld (3 May 2013), Hospitality/Food Service deal (June 2012)
Explore scope to strengthen incentives through the waste chain			Publish findings during Budget 2			Ongoing research, including trialling of reward/recognition trial schemes by local authorities
Launch consultation on wood landfill restriction		Autumn 2012				Completed, with decision (February 2013) not to pursue wood waste landfill ban

Table 7.1: The Committee's waste and other non-CO_2 indicators

WASTE AND OTHER NON-CO_2 SOURCES	Budget 1	Budget 2	Budget 3	2011 trajectory	2011 Outturn
Policy Milestones (continued)					
Review case for material-specific landfill restrictions	2012/2013 Parliament session				Decision not to pursue other bans at present based on wood waste evidence
Improve estimates of methane captured and explore opportunities for capturing more methane from landfill	Ongoing				EA and Defra preliminary and pilot studies (December 2012) support 75% assumption; ongoing research to narrow variation within/ across sites
Develop specific food and paper/card waste strategy		End 2013			Current/forthcoming policies sufficiently address food and paper/card to be set out in greater detail
Other drivers					
Total waste arisings: total waste generated (Mt) broken down by source (municipal and commercial/industrial sectors) and type.					
Waste management: amount, proportion and type of waste (Mt) sent to landfill and to alternative treatments (e.g. recycling/composting, energy from waste, MBT); municipal recycling rates.					
Separate collection: number/percentage of local authorities providing for separate collection of food waste; percentage of food waste sent to treatment via AD.					
General: We will monitor work to improve emissions data (e.g. estimates of activity data, methane yields and decay rates) as well as costs/environmental benefits of landfill diversion options.					

Table 7.1: The Committee's waste and other non-CO_2 indicators					
WASTE AND OTHER NON-CO_2 SOURCES	**Budget 1**	**Budget 2**	**Budget 3**	**2011 trajectory**	**2011 Outturn**
Other non-CO_2 emissions					
Headline indicators					
Emissions (indicative % change from 2007)					
F gas emissions (HFCs, PFCs, SF_6)	-2%	-23%	-39% to -50%	n/a	-1.9%
Energy supply emissions (CH_4, N_2O)	-9%	-19%	-31%	n/a	-44%
Industry emissions (CH_4, N_2O)	-11%	-49%	-49%	n/a	-1.9%
Policy Milestones					
Update to the EC's F-gas regulation to make it fit for purpose		End 2013			

* Methane emissions trajectories reflect a range of emissions reductions from the Government's projections to close to full diversion of biodegradable waste from landfill. Other greenhouse gas trajectories are based on Government projections.

** An average methane capture rate of 75% is assumed across UK landfill sites.

Note: Numbers indicate amount in last year of budget period (i.e. 2012, 2017, 2022).

Key: Headline indicators Implementation indicators Milestones Other drivers