Climate Change Committee

The Sixth Carbon Budget

Waste

This document contains a summary of content for the waste sector from the CCC's Sixth Carbon Budget Advice, Methodology and Policy reports.

Introduction

The Committee is advising that the UK set its Sixth Carbon Budget (i.e. the legal limit for UK net emissions of greenhouse gases over the years 2033-37) to require a reduction in UK emissions of 78% by 2035 relative to 1990, a 63% reduction from 2019. This will be a world-leading commitment, placing the UK decisively on the path to Net Zero by 2050 at the latest, with a trajectory that is consistent with the Paris Agreement.

Our advice on the Sixth Carbon Budget, including emissions pathways, details on our analytical approach, and policy recommendations for the waste sector is presented across three CCC reports, an accompanying dataset, and supporting evidence.

- **An Advice report**: *The Sixth Carbon Budget – The UK's path to Net Zero*, setting out our recommendations on the Sixth Carbon Budget (2033-37) and the UK's Nationally Determined Contribution (NDC) under the Paris Agreement. This report also presents the overall emissions pathways for the UK and the Devolved Administrations and for each sector of emissions, as well as analysis of the costs, benefits and wider impacts of our recommended pathway, and considerations relating to climate science and international progress towards the Paris Agreement. Section 9 of Chapter 3 in that report contains an overview of the emissions pathways for the waste sector.
- **A Methodology Report:** *The Sixth Carbon Budget – Methodology Report*, setting out the approach and assumptions used to inform our advice. Chapter 10 of that report contains a detailed overview of how we conducted our analysis for the waste sector.
- **A Policy Report:** *Policies for the Sixth Carbon Budget and Net zero*, setting out the changes to policy that could drive the changes necessary particularly over the 2020s. Chapter 9 of that report contains our policy recommendations for the waste sector.
- **A dataset** for the Sixth Carbon Budget scenarios, which sets out more details and data on the pathways than can be included in this report.
- **Supporting evidence** including our public Call for Evidence, 10 new research projects, three expert advisory groups, and deep dives into the roles of local authorities and businesses.

All outputs are published on our website (www.theccc.org.uk).

For ease, the relevant sections from the three reports for each sector (covering pathways, method and policy advice) are collated into self-standing documents for each sector. A full dataset including key charts is also available alongside this document. This is the self-standing document for the waste sector. It is set out in three sections:

1) The approach to the Sixth Carbon Budget analysis for the waste sector
2) Emissions pathways for the waste sector
3) Policy recommendations for the waste sector

Chapter 1

The approach to the Sixth Carbon Budget analysis for the waste sector

The following sections are taken directly from Chapter 10 of the CCC's Methodology Report for the Sixth Carbon Budget.[1]

Introduction and key messages

This chapter sets out the method for the waste sector's Sixth Carbon Budget pathways.

The scenario results of our costed pathways are set out in the accompanying *Advice report*. Policy implications are set out in the accompanying *Policy report*.

For ease, these sections covering pathways, method and policy advice for the waste sector are collated in *The Sixth Carbon Budget – Waste*. A full dataset including key charts is also available alongside this document.

The key messages from this chapter are:

- **Background**. Waste sector emissions, now including energy-from-waste (EfW) plants, accounted for 6% of UK GHG emissions in 2018 and were 63% below 1990 levels. Emissions have fallen significantly over the past two decades, due to reductions in waste being landfilled, although have not improved in the past few years due to a plateau in UK recycling and significant growth in fossil emissions from EfW plants.
- **Options for reducing emissions**. Mitigation options considered include reduced landfill methane generation (through waste prevention, recycling and banning biodegradable waste from landfill), reduced residual waste sent to EfW (through waste prevention, recycling), increased landfill methane capture and oxidation, improvements at wastewater treatment and compositing facilities, and installation of CCS on EfW plants.
- **Analytical approach**. Our analysis uses different potentials and costs in each sub-sector. The underpinning basis is BEIS' Energy and Emissions Projections. We model landfill methane falls due to landfill waste reductions and bans, before applying changes in landfill capture and oxidation rates. Industry data is used for wastewater and composting. Our EfW and CCS analysis comes from Element Energy modelling in Chapter 4, as do our assumptions on a circular economy and waste prevention potentials. Edible food waste reductions align with Agriculture sector analysis (Chapter 7). Resulting waste resource values feed into the Fuel Supply sector bioenergy & fossil waste supply analysis (Chapter 6).
- **Uncertainty**. We have used the scenario framework to test the impacts of uncertainties, to inform our balanced Net Zero Pathway. The key areas of uncertainty we test relate to landfill ban dates, recycling and waste prevention rates, and CCS roll-out timings.

We set out our analysis in the following sections:

1. Sector emissions
2. Options for reducing emissions
3. Approach to analysis for the Sixth Carbon Budget

1. Sector emissions

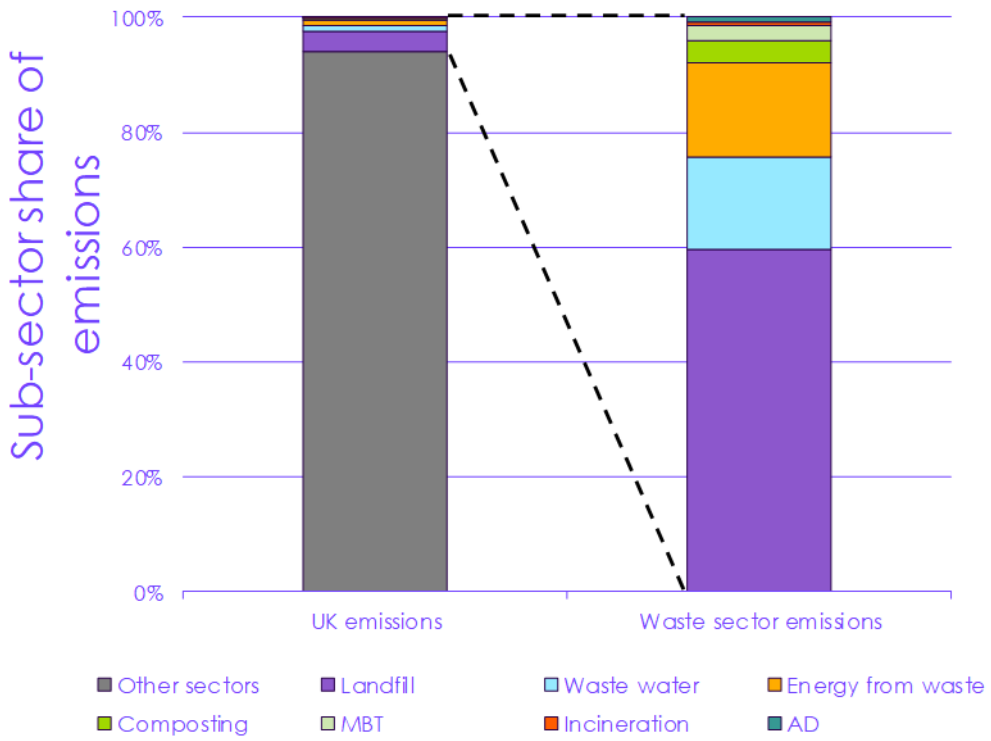
This section outlines the recent trends in waste emissions and their sources. For more detail, see our 2020 Progress Report to Parliament.[2]

a) Breakdown of current emissions

Based on the most recent year of official UK emissions data, total waste sector emissions (including energy-from-waste) increased by 3.7% from 2017 to 32.9 $MtCO_2e$ in 2018. Emissions from landfill increased by 2% to 19.6 $MtCO_2e$, emissions from wastewater were flat, and emissions from EfW plants increased 18% to 5.3 $MtCO_2e$. The waste sector, including energy-from-waste facilities, therefore comprised 6% of UK GHG emissions in 2018 (Figure M10.1). Landfill methane comprised the majority of waste sector emissions in 2018, followed by wastewater treatment and EfW plants.

Provisional GHG data for 2019 give sector emissions as 32.3 $MtCO_2e$, a 2% fall from 2018 levels. This is based on an estimate of a 2.4% fall for all CH_4 and N_2O sources, and no change in CO_2 emissions. However, these are likely to be updated.

Figure M10.1 Breakdown of waste sector emissions (2018)

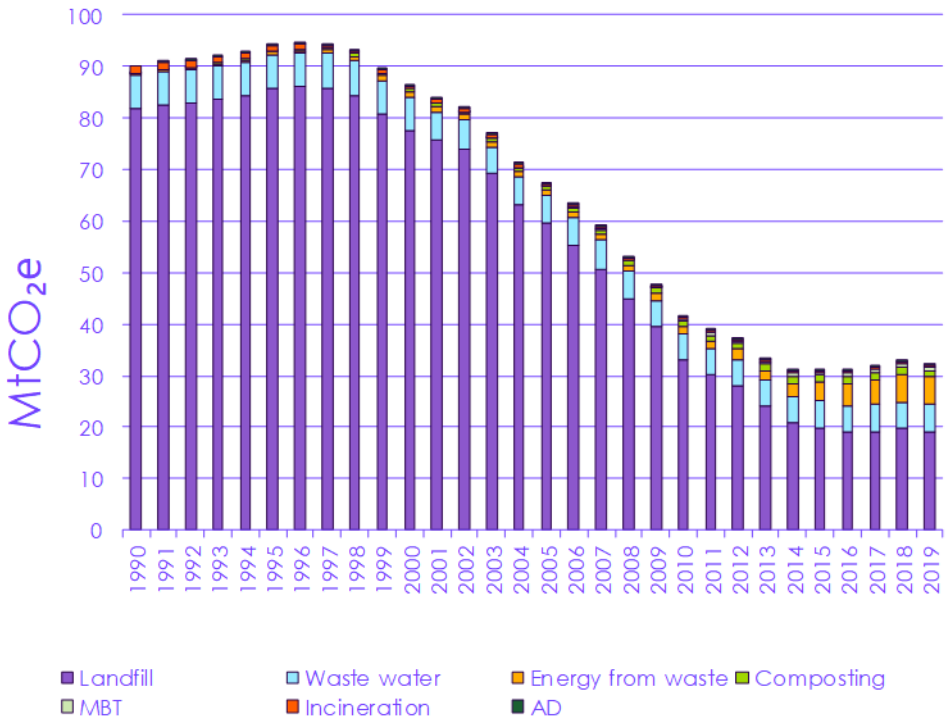


Source: BEIS (2020) *Final UK greenhouse gas emissions national statistics 2018.*
Notes: Total UK emissions in 2018 were 539 $MtCO_2e$/yr (AR5 basis, peatland revisions and IAS included). Waste sector emissions (including energy-from-waste) in 2018 were 32.9 MtCO2e/yr.

b) Emissions trends and drivers

The breakdown of waste emissions since 1990 is shown in Figure M10.2. Overall, emissions from the waste sector in 2018 were 61% lower than 1990 levels.

Figure M10.2 Breakdown of waste sector emissions (1990-2019)



Source: BEIS (2020) *Final UK greenhouse gas emissions national statistics 2018*; BEIS (2020) *Provisional UK greenhouse gas emissions national statistics 2019*.

Waste sector emissions rose with increases in landfill methane in the early 1990s, but since then have shown significant reductions. This is primarily due to falls in the amount of biodegradable waste being landfilled, driven by the UK's landfill tax diverting waste away from landfill. Landfill methane capture rates also increased significantly in the period up to the early 2010s, with policy support under the Renewables Obligation.

Wastewater treatment has seen modest improvements in emissions, as the UK population has increased but sewage treatment has shifted to improved anaerobic digestion systems. Minimal amounts of wastes (e.g. clinical & chemical wastes) are now incinerated without energy recovery.

More recently, waste sector emissions have fallen 46% over the period 2008-2018. However, progress has stalled since the mid-2010s. Landfill methane capture rates have peaked and are now declining. Recycling rates have plateaued in England, although Wales, Northern Ireland and Scotland have seen improvement in the past decade. With the significant decrease in landfilling, more local authority waste is now incinerated for energy than recycled or composted in England, and this has translated into increasing EfW emissions.

Waste sector emissions are primarily driven by the volumes of residual waste that end up in landfill or EfW facilities, which is in turn driven by UK consumption of products and food, combined with waste reduction programmes and reuse & recycling infrastructure. Wastewater emissions are more driven by population, the value of biomethane and water quality requirements.

2. Options for reducing emissions

Emissions reduction options have been explored within each sub-sector of the waste sector. These include:

- **Reduced landfill methane generation**. This is achieved via a combination of reductions in waste arisings, increased recycling rates, banning from landfill a list of key biodegradable wastes (paper/card, food waste, garden waste, waste wood and textiles) across municipal and non-municipal waste collections, as well as later bans on all landfilling of waste. Reductions in the amount of biodegradable material that is landfilled from the above actions will translate into reductions in the amount of landfill methane generated.
- **Increased landfill methane capture**, via a dispersed network of pipes inserted into the landfill, which collect landfill gas into a central location for use in generating heat, power or biomethane for gas grid injection.
- **Increased landfill methane oxidation** at the surface of landfill sites before emission to atmosphere as CO_2. This includes biocovers and biowindows, which are particularly suitable for lower-emitting sites and older sites. Most systems use compost as the filter medium.
- **Wastewater process improvements**. These measures involve the conversion of wastewater treatment plants to advanced anaerobic digestion systems (increasing the amount of biogas extracted and reducing methane emissions), as well as process optimisation improvements and leak identification using on-site emissions monitoring of CH_4 and N_2O. More innovative options include development and future installation of alternative wastewater treatment processes, such as membrane aerated biofilm reactors or partial nitrification-Anammox processes.
- **Composting forced aeration**. This involves use of pumped air to improve compost aeration and product quality, and avoid anaerobic conditions developing. It is estimated to be applicable to a third of compost facilities.
- **Reductions in residual waste sent to energy-from-waste,** achieved as above via increased recycling rates and reductions in waste arisings (including food waste), but also including changes in waste tonnages sent to landfill or exported. Waste reductions and recycling/AD/composting need to out-pace the bans on landfilling and export of wastes to avoid increased residual waste volumes being sent to EfW facilities.
- **Installation of CCS at energy-from-waste plants**, involving post-combustion carbon capture technology being installed at EfW plants and capturing 90-95% of the flue gas CO_2 for sequestration. EfW encompasses waste combustion, gasification and/or pyrolysis, for power (and heat) generation.

a) Summary of scenario choices

As a reminder from Chapter 3, section 9 of the *Advice Report*, the measures discussed in section 2 above are combined into the different scenarios as set out in Table M10.1 and Table M10.2.

Table M10.1
Waste scenario choices – waste reduction, recycling, energy-from-waste

	UK waste reduction, excluding food waste	UK per-capita edible food waste reduction		UK reuse & recycling rate		Residual waste allocated to jet fuel production		EfW plants installing CCS
	2037	2030	2050	2030	2050	2035	2050	2050
Balanced Net Zero Pathway	33%	52%	61%	68%	67%	0%	0%	100%
Headwinds	13%	52%	52%	68%	67%	0%	0%	100%
Widespread Engagement	33%	52%	71%	68%	79%	20%	70%	100%
Widespread Innovation	28%	52%	61% + 50% of inedibles	68%	67%	0%	0%	100%
Tailwinds	33%	52%	71% + 50% of inedibles	68%	79%	0%	0%	100%
Baseline	0%	27%	27%	52%	51%	0%	0%	0%

Notes: UK waste reductions are in-year versus a rising baseline of waste arisings. UK per-capita edible food waste reductions are measured (by WRAP) versus a 2007 base year for households and 2011 for business.

Table M10.2
Waste scenario choices – landfill, wastewater & composting

	Landfill bio-degradable ban	Landfill ban for all wastes	Landfill methane capture		Landfill methane oxidation		Wastewater GHG improvement		Composting GHG improvement
			2030	2050	2030	2050	2030	2050	2030
Balanced Net Zero Pathway	**2025**	**2040**	**71%**	**80%**	**10%**	**10%**	**21%**	**21%**	**23%**
Headwinds	2030	2050	68%	68%	10%	10%	21%	21%	23%
Widespread Engagement	2025	2035	68%	68%	10%	10%	21%	21%	23%
Widespread Innovation	2025	2040	80%	80%	15%	30%	21%	50%	23%
Tailwinds	2025	2035	80%	80%	15%	30%	21%	50%	23%
Baseline	None	None	60%	60%	10%	10%	0%	0%	0%

Notes: Some waste streams are banned from landfill earlier in the devolved administrations, see section 3(d) below. Wastewater improvements start ramping up from 0% in 2023, and composting improvements start from 0% in 2021.

Our baseline uses BEIS EEP 2019 modelling for "Existing Policies", with our own baseline derived for residual waste arisings and resulting EfW emissions based on the Waste sector analysis (Chapter 10).

This Baseline assumes growing waste arisings (roughly in-line with population and GDP), no further reductions in food waste from today and no other prevention, static recycling rates, and no installation of CCS on EfW plants. This leads to significant increases in EfW fossil CO_2 emissions. Regarding landfill, no landfill ban dates are set beyond those in existing DA policies, and methane capture and oxidation remain static, resulting in a slowly declining emissions trend for landfill methane. There are no improvements assumed in wastewater treatment or composting.

The exploratory scenarios assume different mixes and timings of measures to reduce waste sector emissions:

- **Headwinds** uses a similar approach to our analysis for the 2019 *Net Zero* advice, although with updates to add in new abatement measures in some sub-sectors. Changes mostly occur in the 2020s, but are more limited than in other scenarios.
  - Waste reductions align with conservative Manufacturing & Construction assumptions on product redesign, light-weighting, lifetime extensions and asset sharing.
  - Edible food waste reductions assume 2025 Courtauld Commitment[3] and 2030 UN SDG12.3 targets are met, but no further action after (this aligns with our Agriculture sector analysis).
  - Similarly, recycling is assumed to ramp-up to 56% for household and 74% for commercial & industry wastes by 2030 – this is 5 years earlier than the Waste & Resources Strategy – with no further improvement after 2030.
  - A later ban on the landfilling of biodegradable wastes in 2030, compared to 2025 in other scenarios, reflects a less ambitious rate of change in this scenario. Banning all landfill by 2050 is broadly in line with the Waste & Resources Strategy (some DAs act earlier).
  - No changes in landfill methane capture or oxidation rates are assumed, and only conservative improvements in wastewater and composting are considered to 2030. CCS is installed on EfW facilities from the late 2030s onwards.
- **Widespread Engagement** has much more ambition in terms of behaviour change than Headwinds, with more action during the 2020s and over the longer term.
  - This translates into high levels of waste prevention, aligning with the most ambitious Manufacturing & Construction assumptions, further significant reductions in food waste arisings post-2030 (this aligns with our Agriculture sector analysis), and further increases in recycling to 70% for household and 84% for commercial & industry wastes by 2050.*
  - Residual wastes are increasingly sent to waste-to-jet fuel plants for aviation from 2030, leading to significant falls in EfW utilisation.

* 84% reflects a likely maximum recycling rate for commercial & industry wastes, based on 16% of current non-household municipal wastes being non-recyclable, and 70% for households representing very significant progress from only ~45% in the UK today.

  - Greater action on prevention and recycling allows a 2035 date for banning all landfill (earlier in Wales), but an earlier date would be infeasible due to further EfW facilities being required.
  - Headwinds assumptions are taken for landfill methane capture & oxidation, wastewater and composting. CCS starts being installed on EfW facilities from 2040 onwards.

- **Widespread Innovation** focuses on new technical approaches to reducing emissions.
  - Non-food waste prevention aligns with mid-level Manufacturing & Construction assumptions, food waste reduction aligns with our Agriculture sector analysis, and recycling improves as in Headwinds.
  - While edible food waste reductions do not make as much progress to 2050 as in Widespread Engagement, the inedible fraction of food waste is also assumed to be reduced by 50% (e.g. through lab-grown meat and further selective breeding).
  - A full landfill ban in 2040 coincides with EfW plants starting to install CCS. Significant increases in landfill methane capture and oxidation by 2030 are achieved, and the wastewater industry shifts to higher cost, innovative technology options after 2030.
- **Tailwinds** combines the most ambitious measures in each of the above scenarios, with the difference that CCS is installed on EfW facilities starting from the late 2020s.

Our **Balanced Net Zero Pathway** sets sub-sector assumptions from within the range of the exploratory scenarios, with some values at the more conservative end of the scenario spectrum and others at the more optimistic end, but most generally in-between. These Balanced Net Zero Pathway choices have generally been made on the basis of cost-effectiveness and technical certainty:

- Waste prevention/reduction efforts (excluding food waste) are set in line with the Widespread Engagement scenario, aligning with the assumptions made in the Manufacturing & Construction sector analysis.
- Food waste reductions assume 2025 Courtauld and 2030 UN SDG12.3 targets are met, as in all other scenarios, and then further modest reductions to 2050 are assumed (between the Headwinds and Widespread Innovation scenarios). This aligns with our Agriculture sector analysis.
- Recycling efforts focus on the 2020s, with no further improvements assumed after 2030, as in Headwinds and Widespread Innovation. Achieving a UK-wide recycling rate significantly above 70% will require significant behaviour change. This choice on recycling is balanced by the more ambitious choices on waste prevention above, recognising that waste prevention and recycling have similar impacts in terms of reducing residual waste volumes (and hence downstream landfill and EfW emissions), and that recycling rates could improve further post-2030 if maximal action on waste prevention were not achieved.
- All EfW plants are assumed to install CCS by 2050, starting from the early 2040s. No residual waste is allocated to jet fuel production, as system GHG savings are unlikely to be significantly higher than if they were used in EfW with CCS.

- Key biodegradable waste streams are banned from landfill from 2025, with landfilling of all wastes stopping in 2040, as in the Widespread Innovation scenario. Landfill methane capture rates ncrease to 80% as in the Widespread Innovation scenario, but this occurs by 2050 instead of by 2030. Landfill methane oxidation rates remain unchanged, as this is more uncertain and higher cost than methane capture.
- Wastewater improvements are aligned to Headwinds and Widespread Engagement, with known technology rolled out by 2030. Further improvement beyond 2030 is not assumed, due to technical development uncertainty and likely significantly higher costs.
- Composting improvements are as in the other scenarios, given their very low cost.

b) Sector classifications

Note that with the CCC's current sector classifications, a major change from previous reports is the inclusion of energy-from-waste power generation facilities emissions within the CCC's Waste sector boundary.* This reclassification has been carried out due to the interdependencies of landfill and waste reduction & recycling policies on EfW emissions, and given the increasing importance of EfW emissions that would otherwise have been subsumed within power sector emissions data. These EfW facilities generate electricity and, in some cases, also heat.

Some emissions reduction options have been counted outside of the CCC's Waste sector, even if these emissions reductions are achieved via waste sector policy. For example:

- EfW facilities with CCS will be capturing and sequestering biogenic CO_2 alongside fossil CO_2, following the mixed biogenic/fossil composition of residual waste. This sequestration of biogenic CO_2 is counted within the CCC's engineered GHG removals sector, as a form of bioenergy with CCS (BECCS).
- Water utilities may plant trees in the UK, in order to offset their gross emissions and help achieve their industry-wide 2030 Net Zero goal, but this would be counted within CCC's Land Use, Land Use Change & Forestry (LULUCF) sinks sector.

These negative emissions options are discussed in greater detail in the LULUCF and engineered GHG removals sector (Chapters 7 and 12 respectively).

This CCC sector classification also means that while some EfW electricity and heat could be carbon negative on a lifecycle basis (e.g. if using CCS with a high enough capture rate), our waste sector analysis only considers the gross accounting CO_2 emissions from the use of waste in EfW, i.e. positive or nil emissions, but not negative emissions.

If an alternative accounting methodology were followed, the negative emissions from EfW with CCS plants could be counted within the waste sector emissions, but then these negative emissions would have to be excluded from the GHG removals sector to avoid double-counting. This accounting choice does not affect aggregate UK emissions.

* In terms of NAEI definitions, these Waste sector EfW facilities only include NAEI 1A1ai "Power stations" using "MSW", and do not include NAEI 1A1ai "Miscellaneous industrial/commercial combustion" of "MSW" which remains in the CCC's Manufacturing & Construction sector.

The waste sector will not achieve full decarbonisation by 2050. Even under the most ambitious scenarios, residual emissions remain from wastewater treatment, composting and landfill fugitive methane, as well as smaller sources of emissions from EfW (the 5% of fossil CO_2 not captured via CCS), clinical/chemical waste incineration without energy recovery, anaerobic digestion and mechanical biological treatment plants.

There is therefore an expectation that the waste sector will require an amount of GHG removals to be developed to offset its gross emissions (8 $MtCO_2e$/year in 2050 for the Balanced Pathway).

c) Analytical steps

The waste sector analysis for the Sixth Carbon Budget advice consists of the following steps:

- **Coverage.**
  - Emissions considered are CO_2, N_2O and CH_4.
  - Coverage is for UK, Scotland, Wales and Northern Ireland.
  - The waste sector is split into seven sub-sectors: Landfill, Wastewater, Incineration*, Composting, Anaerobic Digestion (AD), Mechanical-Biological Treatment (MBT), and Energy-from-waste (EfW).
- **Abatement measures** are split into seven types: reduced landfill methane generation, landfill methane capture, landfill methane oxidation, waste water improvements, composting improvements, residual waste reductions and EfW CCS. There is no abatement assumed in three sub-sectors: AD, MBT and Incineration.
- **Waste arisings.** Household and commercial & industrial (C&I) waste arisings are sourced from Defra statistics[4], projected to 2050 by Ricardo as in CCC's *Biomass in a low carbon economy* report. Hazardous waste is not separately modelled, and Construction & Demolition waste is not modelled.
- **Waste reductions** ramp up to 2037, following Manufacturing & Construction sector assumptions, then are held flat. Food waste reductions are modelled separately using WRAP data[5], meeting Courtauld 2025 and UN SDG12.3 goals to 2030, before any further scenario changes to 2050.
- **Recycling** rates are then applied, ramping up to 2025 and 2030, before any further scenario changes to 2050. Waste exports are phased out by 2030.
- **Landfill tonnages** of 31 different waste streams are scaled with total remaining waste tonnages, until being banned at specified dates in each DA.
  - These tonnages landfilled are fed into Ricardo's MELMod model for each DA, to calculate the amount of landfill gas generated.[6]
  - Landfill methane capture rates are then applied, plus an oxidation rate for the uncaptured methane, to derive fugitive methane emissions.

* Incineration sub-sector covers small amounts of clinical/chemical waste burnt without energy recovery. By contrast, the EfW sub-sector covers the large volumes of residual waste burnt to generate power (potentially also with heat).

  - Any increases in capture rates or oxidation rates are counted as abatement for these measures respectively, with the remainder of any GHG savings from the EEP 2019 baseline counted as being due to landfill bans and reduced landfilling (through waste reduction and recycling).

- **Residual waste** not landfilled is then allocated to EfW plants (or waste to jet fuel), with biogenic and fossil fractions varying over time due to the impact of landfill bans.* The baseline scenario has the largest amount of residual waste allocated to EfW plants, and so reductions in residual waste sent to EfW (due to prevention and recycling, less reductions in exports and landfilling) are accounted for as a GHG saving from the baseline. This is then before CCS is applied to EfW plants, as part of wider industrial Element Energy modelling (see Chapter 4 for details). Fossil CO_2 captured at EfW plants equate to further in-sector GHG savings, and biogenic CO_2 captured equates to GHG removals.

- **Biogas.** In addition to captured landfill gas, the following resources are calculated as biogas resources: sewage sludge (scaling with population, and the switch to advanced AD), livestock manures (scaling with Agricultural sector changes in livestock, and increasing collection rates), and food waste (with rising collection rate of the remaining waste after reductions). 2018 data is calibrated to ADBA sources.[7] Waste wood resources are estimated from Tolvik[8] data to 2022, then held flat. Used Cooking Oil is held fixed from Ricardo as in CCC *Bioenergy in a low carbon economy* report, and Tallow is scaled by Agricultural sector changes in livestock. These resources are fed into the Fuel Supply sector analysis.

- **Wastewater** and **composting**. In these sub-sectors, % improvements in GHG emissions are applied directly to the baseline from EEP 2019.

- **Energy consumption/generation**. With the exception of EfW, energy consumption in all waste sub-sectors is already fully accounted for within the Manufacturing & Construction and Non-domestic buildings sectors. However, EfW plants are not modelled within the Power sector, so the waste sector analysis includes power generation from EfW plants, using the residual waste sent to EfW and a fleet average 26% HHV electrical efficiency. The addition of CCS to EfW plants in Element Energy modelling (Chapter 4) results in a modest reduction in sector net electricity generation as well as sector consumption of low-carbon hydrogen to fuel the carbon capture equipment.

- **Costs.**
  - Data sources for costs in each sub-sector vary. Baseline investment and operating costs are only estimated for waste collection and recycling, with baseline data unavailable for other sub-sectors.
  - Composting aeration added costs of £11/tCO_2e from industry data, with 20-year lifetime and 6% discount rate. Landfill bio-window costs taken from Honace (2020), assuming 30 years at a 5% discount rate to derive £67/tCO_2e.[9]

* In addition to EfW, some residual niche fossil wastes from NAEI data (4 TWh/year of 'waste', 'waste oils', 'waste solvent' and 'scrap tyres'), are allocated to manufacturing, without variation between scenarios. Similarly, NAEI also gives 0.8 TWh/year of clinical/chemical waste used in waste incineration without energy recovery, and 0.5 TWh/year waste oils in power in 2018.

- Landfill methane capture costs of £12/tCO_2e are derived from BEIS (2020)[10], using the higher end of ranges, and 28 years at 6.1% discount rate.
- Additional wastewater costs of £204/tCO_2e to 2030, and £554/tCO_2e for more ambitious improvements after 2030 in some scenarios, come from Water UK. We have inferred investments from £/tCO_2e values using a 25-year asset lifetime and 3.5% industry discount rate, and assuming no change in operating costs. These municipal wastewater costs are applied to industrial wastewater treatment, given the lack of industrial wastewater data.
- Costs of waste collection and recycling derived from Defra's 2019 Impact Assessment[11], but compressing costs in time and scaling up total costs in line with increased recycling rates in our scenarios compared to English 2035 targets in Defra's "Option 3M" scenario. In the absence of other data, costs are assumed to scale up to cover the non-municipal waste sector, and scale down to devolved administrations (DAs) based on their smaller total tonnages and waste recycling ambitions (targets minus higher starting recycling rates). Further detail on DA recycling rates is given in section 3(d).
- The added costs of reduced landfill methane generation through higher recycling rates are £15-30/tCO_2e, depending on DA and scenario, which matches with the Defra IA.
- The costs of avoided EfW emissions from lower residual waste arisings are taken to be nil, given these waste collection and recycling costs are already accounted for in deriving landfill savings.
- The costs of installing CCS on EfW plants are calculated by Element Energy modelling, factoring in energy inputs and the location/distance to sequestration points, and are typically £140-260/tCO_2e.

The reason waste sector emissions cannot be reduced further than in our scenarios is due to a combination of technical potentials, current scientific uncertainty and cost.

- Maximum recycling rates are uncertain, and we assume a blended household/C&I rate up to just under 80% would be possible. We do not have scenarios with 100% recycling, as national rates of 70% are yet to be achieved anywhere in the world, and currently around 16% of UK waste is non-recyclable. Recycling rates also need to be seen in their context in the waste hierarchy - when recycling rates in our scenarios are combined with waste reduction efforts, the result is a 72-87% reduction in post-recycling waste tonnages in 2050 compared to the baseline (with the Balanced Pathway achieving 79% by 2050).
- Existing landfill characterisation is poor. We have ruled out going above 80% landfill methane capture, or 30% oxidation of fugitive landfill methane, on the basis that it is not clear yet whether this is technically possible, or what the associated costs would be. There is also huge heterogeneity in landfill sites, making it hard for any single solution to be generally applicable.

- Reducing wastewater treatment process emissions is highly capital-intensive, with average abatement costs rising to £400/tCO_2e when including the more novel technologies in Widespread Innovation. We limit costs in our scenarios, meaning that only a 50% reduction in methane and nitrous oxide emissions by 2050 is explored. Technology that could improve beyond 50% is only speculative at present.

d) Devolved administrations

The 2018 share of emissions from the NAEI and Element Energy modelling of the EfW fleet is used to apportion UK emissions to the devolved administration (DA) level. The following splits are used in the Baseline scenario, and held fixed over time:

- Landfill methane: 9.1% Scotland, 6.9% Wales, 4.3% NI, 79.8% England
- Wastewater, incineration, composting, AD & MBT: 6.5% Scotland, 4.7% Wales, 3.3% NI, 85.5% England
- EfW: 3.9% Scotland, 4.4% Wales, 2.0% NI, 89.8% England

In the exploratory scenarios and Balanced Pathway, landfill methane reductions are modelled for Wales, Scotland, England and Northern Ireland, based on waste reductions, recycling and landfill bans of different streams in each jurisdiction.

Household recycling data is reported annually by Defra, for the UK and devolved administrations (DAs).[4] Our analysis of recycling costs therefore starts from known 2018 household recycling rates of 45% in England, 43% in Scotland, 54% in Wales and 48% in Northern Ireland. From a combination of NAEI emissions data, industry expert approximations[12], surveys of recycling facilities[13] and older literature[14], we have inferred starting C&I recycling rate positions of 55% in England, 54% in Scotland, 58% in Wales and 43% in Northern Ireland. As discussed in section 3(e) below, C&I recycling rates are extremely uncertain.

In all our scenarios, we assume Scotland and Wales achieve their target 70% recycling rate by 2025. We assume England achieves 68% by 2030 (based on a 56% household waste recycling rate and 74% C&I waste recycling rate being achieved – this is Defra's 'Option M' scenario from their 2019 Impact Assessment,[15] brought forward by 5 years from 2035, with the non-household municipal recycling rate of 74% extended to all C&I waste). We assume that Northern Ireland also achieves the same recycling rates as England.

For bans on landfilling of waste streams, the following assumptions are made as inputs to Ricardo's MELMod landfill methane model:

- In England, scenarios follow the assumptions in Table M10.2.
- Scotland is assumed to ban landfilling of biodegradable municipal wastes from 2025, and follow the assumptions in Table M10.2 for non-municipal biodegradable waste (2025, or 2030 in Headwinds). Full landfill bans follow the assumptions in Table M10.2.
- Wales is assumed to ban the landfilling of all wastes from 2025.
- Northern Ireland scenarios follow the assumptions from Table M10.2, with the exception of municipal food waste which is already banned from landfill.

The DA splits for landfill methane emissions therefore vary over time, given the differing assumptions above. DA splits of EfW emissions also vary over time, since although residual waste resource estimates fed into the Element Energy modelling are at a UK level (aggregating waste reductions, recycling and DA-specific landfill bans of different waste streams), the Element Energy modelling chooses to deploy CCS in different regions at different times.* DA splits for wastewater, incineration, composting, AD & MBT are assumed to be held fixed over time in all scenarios.

As shown in Figure M10.3, the DA waste sector emissions decarbonise slightly faster than the UK as a whole, due to implementing higher recycling rates and earlier bans on landfilling of biodegradable material than in England, which leads to lower landfill methane and EfW emissions. 2040 sees a slight increase in emissions, due to banning of landfill pushing extra waste into the EfW market (in reality, this might be a phased transition to avoid these increases, or only conducted once CCS is deployed on EfW). The step-changes observed in the mid-2040s across the DAs are due to CCS modelling assumptions (Chapter 4) installing CCS on a region of EfW plants at one time. Given the smaller number of EfW plants in the DAs, this leads to steps, rather than the smoother curve seen for the UK from 2040, given the larger number of plants and regions to retrofit CCS than in the DAs.

Figure M10.3 Comparison of emission pathways for the UK, Scotland, Wales, Northern Ireland

Source: CCC analysis.
Notes: Waste sector GHG emissions for the Balanced Net Zero Pathway, including Energy from Waste (EfW) facilities, split into DAs, and re-based from 2020 levels.

* A future modelling refinement would be to consider DA-specific residual waste arisings (after DA prevention and recycling) as the resource available for EfW use in each of the DAs, although given the convergence in recycling rates assumed from 2030 across the UK, the current modelling assumption will not give a significantly different outcome for the CB6 period.

e) Uncertainties

Given waste will be still have residual gross emissions in 2050 (8 $MtCO_2e$/year in the Balanced Pathway), the following uncertainties may cause some changes in UK emissions in the near to mid-term, although these uncertainties will generally decline as sector emissions decline over time. The impact of waste uncertainties on Net Zero is therefore likely to be modest:

Uncertainties in the scenario analysis fall into the following main categories:

- **COVID-19**. Waste collection services have generally continued uninterrupted throughout the pandemic. However, with the increase in working and eating from home and increased online purchases, there has been a notable shift in waste arisings and recycling demands, with significant increases in household waste, and significant decreases in commercial & industrial wastes. This has presented challenges to Local Authorities. However, at a national level, given the main impact has been a shift in activity, we have not estimated any changes in waste arisings, recycling rates or emissions directly as a result of the pandemic. There remain uncertainties as to the final composition of the waste industry that will emerge post-COVID, due to the balance of household vs. commercial activity.

- **GDP/economic outlook.** We also have not attempted to calculate a longer-term reduction in waste arisings due to structural changes in GDP due to COVID-19.

- **Future arisings**. All scenarios have the same underlying baseline waste arisings to 2050, before waste reduction and recycling measures are applied, although there is some uncertainty over the amount of future growth in baseline waste arisings, particularly as the UK sets out to strike new trade deals globally and the long-term size of the manufacturing base in the UK is still uncertain. We have not modelled the impact of higher waste disposal costs on the amount of waste generated.

- **Water quality standards**. The strictness of standards that will be in place to 2050 in the UK are not yet known. Particularly strict water quality standards could favour or disincentivise the use of certain advanced waste water treatment processes over conventional processes.

- **Inventory uncertainties.** There are discussions ongoing about changes to NAEI's waste water inventory, to reflect improved data. There is also some uncertainty about landfill methane capture rates (and hence fugitive emissions vs. landfill gas for energy generation), given a discrepancy in the landfill gas power generation efficiencies assumed by NAEI and DUKES teams. Given the dominance of CH_4 and N_2O emissions in this sector, choices about GWPs will also have a particularly large impact.[16]

- **Commercial and industrial (C&I) waste.** Data on C&I waste arisings is uncertain, and UK data is only published every 2-3 years by Defra.[17] Even more uncertain is the overall recycling rate that applies to C&I waste – this data is not collected (some partial data is available for non-household municipal waste and packaging recycling). We have had to infer a current UK C&I recycling rate of 55% based on the $MtCO_2e$/year emissions from residual waste sent to EfW and Manufacturing, NAEI waste calorific values, and Defra data for UK C&I waste arisings, household waste arisings and household recycling estimates. Given the uncertainties in each of these factors, the actual UK C&I recycling rate may be between 40-60% (approximations in the literature for the DAs also fall within this range).

Since C&I wastes compromise the majority of UK waste, this data gap could significantly impact future sector emissions and costs, and therefore needs addressed.

- **Application of costs.** Costs for several of the waste sub-sectors are estimates based on literature sources or industry views, and are indicative of action in the sub-sector. There is likely to be a broad range of costs around our estimates, given differences in site size, location, existing equipment, cost of capital and lifetimes.

- **Modelling simplifications**: For simplicity, the modelling of various waste stream landfill bans in the four countries of the UK has been carried out by cutting off landfilling in the chosen year. In reality, there is likely to be a phase-out of landfilling in the years ahead of the ban, and potentially some small amount of non-compliance in the years after the ban, which would lead to a much smoother profile of residual waste availability – rather than the current spikes observed in e.g. 2025 and 2040 in the Balanced Net Zero Pathway. These spikes should be avoided, by significantly increased waste reduction and recycling/AD/composting efforts ahead of the landfill bans.

Endnotes

[1] CCC (2020) *The Sixth Carbon Budget – Methodology Report*. Available at: www.theccc.org.uk

[2] CCC (2020) *2020 Progress Report to Parliament*

[3] WRAP (2020) *The Courtauld Commitment*

[4] Defra (2020) *UK statistics on waste*

[5] WRAP (2020) *UK progress against Courtauld 2025 targets and UN Sustainable Development Goal 12.3*

[6] MELMod for the UK GHGI/NAEI for 2018, produced by Ricardo Energy and Environment on behalf of Defra

[7] ADBA (2020) *Biomethane: the pathway to 2030*

[8] Tolvik (2020) *UK Dedicated Biomass statistics - 2019*

[9] Honace (2018) *Landfill aftercare scoping study*, for Defra

[10] BEIS (2020) *Electricity generation costs*

[11] Defra (2019) *Consistent municipal recycling collections in England: Impact Assessment*

[12] Scottish Government (2019) *Waste markets study: full report*, based on Eunomia estimate

[13] WRAP Cymru (2020) *Commercial and Industrial Waste in Wales*

[14] WRAP Northern Ireland (2011) *Northern Ireland Commercial & Industrial (C&I) Waste Estimates*

[15] Defra (2019) *Consistent municipal recycling collections in England: Impact Assessment*

[16] All the analysis is conducted on an IPCC AR5 basis with carbon feedbacks, using 34 tCO_2e/tCH_4, and 298 tCO_2e/tN_2O.

[17] See ref 287.

Chapter 2

Emissions pathways for the waste sector

The following sections are taken directly from Section 9 of Chapter 3 of the CCC's Advice Report for the Sixth Carbon Budget.[1]

Introduction and key messages

Emissions from waste arise mostly from decomposition of organic matter in landfills, wastewater treatment processes and combustion of residual waste in energy-from-waste plants. Sector emissions can be reduced by 75% by 2050, through greater waste prevention, recycling, higher landfill methane capture rates, improvements to wastewater treatment and composting facilities, and adding CCS to energy-from-waste plants.

The evidence base on how to decarbonise the waste sector in the UK is more limited than the evidence available for other sectors. Our analysis has relied on data in BEIS's Energy and Emissions Projections pathways, Ricardo's MELMod landfill model, research by WRAP and Water UK, as well as internal analysis starting from and accelerating English and Devolved Administration announced policies. Further details are given in the Methodology Report.

This section is split into three sub-sections:

a) The Balanced Net Zero Pathway for waste

b) Alternative pathways for waste emissions

c) Investment requirements and costs

a) The Balanced Net Zero Pathway for waste

Our Balanced Net Zero Pathway sees waste sector emissions fall 75% from today's levels to reach 7.8 $MtCO_2e$/year by 2050. Around 80% of the abatement to 2035 is from waste prevention, increased recycling and banning biodegradable waste from landfill. By 2050, 30% of sector abatement comes from retrofitting CCS to the UK's fleet of energy-from-waste facilities. The additional 10% of emissions reductions comes from capturing more methane at landfills, reducing wastewater treatment emissions and improving composting (Figure A3.9.a).

Generating less waste, recycling more and not sending waste that can decay to landfill are the key pillars to reducing landfill emissions.

- **Waste prevention, recycling and landfill bans.** Edible food waste is reduced by just over 50% by 2030 (meeting UN SDG Target 12.3) and just over 60% by 2050, compared to 2007 levels. Compared to a steadily increasing baseline, a third of non-food waste arisings are prevented by 2037 via product redesign, light-weighting, extended lifetimes and asset sharing. Currently around 45% of all household waste is recycled in the UK, along with 55% of commercial & industrial waste. UK-wide recycling rates increase to a blended 70% by 2030 (with Wales and Scotland achieving this by 2025). Anaerobic digestion and composting play an important part in recycling food and garden wastes, helping enable a ban on all biodegradable waste going to landfill by 2025. Landfill methane emissions fall to 1.1 $MtCO_2e$/year by 2050.

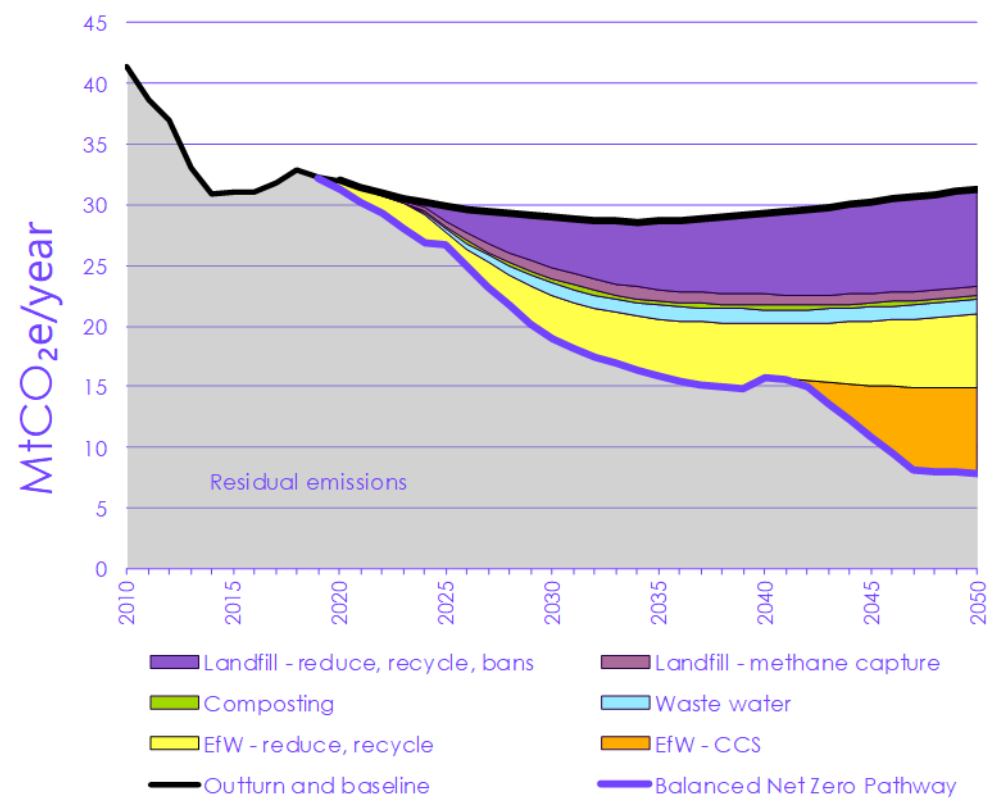
Energy-from-waste emissions can be constrained, before all plants fit CCS in the 2040s.

Wastewater emissions are hard to abate.

- **Carbon capture and storage (CCS) at energy-from-waste (EfW) plants.** Further growth in fossil emissions from UK energy-from-waste facilities is avoided due to prevention and recycling efforts, with EfW emissions staying relatively flat at 5-6 $MtCO_2e$/year until 2040. CCS is then fitted to 100% of plants starting in 2040 (when our scenario also bans all waste going to landfill, leading to a temporary uptick in emissions due to higher residual waste volumes). With the use of CCS, EfW emissions fall to 0.4 $MtCO_2e$/year by 2050.

- **Wastewater treatment improvements.** Process methane and nitrous oxide emissions from wastewater treatment are hard to mitigate. A combination of enhanced monitoring, operational measures and continued roll-out of advanced anaerobic digestion leads to a 21% improvement by 2030. Wastewater becomes the majority source of Waste sector emissions by 2050 (at 4.2 $MtCO_2e$/year).*
- **Landfill methane capture.** Even with banning key biodegradable waste streams from entering landfill, there will still be legacy methane emissions given the long decay time. More of this methane can be captured (for use in power or the gas grid), and capture rates increase from an estimated 68% in 2018 to 80% by 2050.
- **Composting improvements**. Use of pumped air to improve compost aeration and product quality at a third of sites by 2030, leading to a 23% improvement in methane and nitrous oxide emissions. Use of composting increases over time, so emissions return to 1.3 $MtCO_2e$/year by 2050.

Figure A3.9.a Sources of abatement in the Balanced Net Zero Pathway for the waste sector



Source: BEIS (2020) *Provisional UK greenhouse gas emissions national statistics 2019*; CCC analysis.

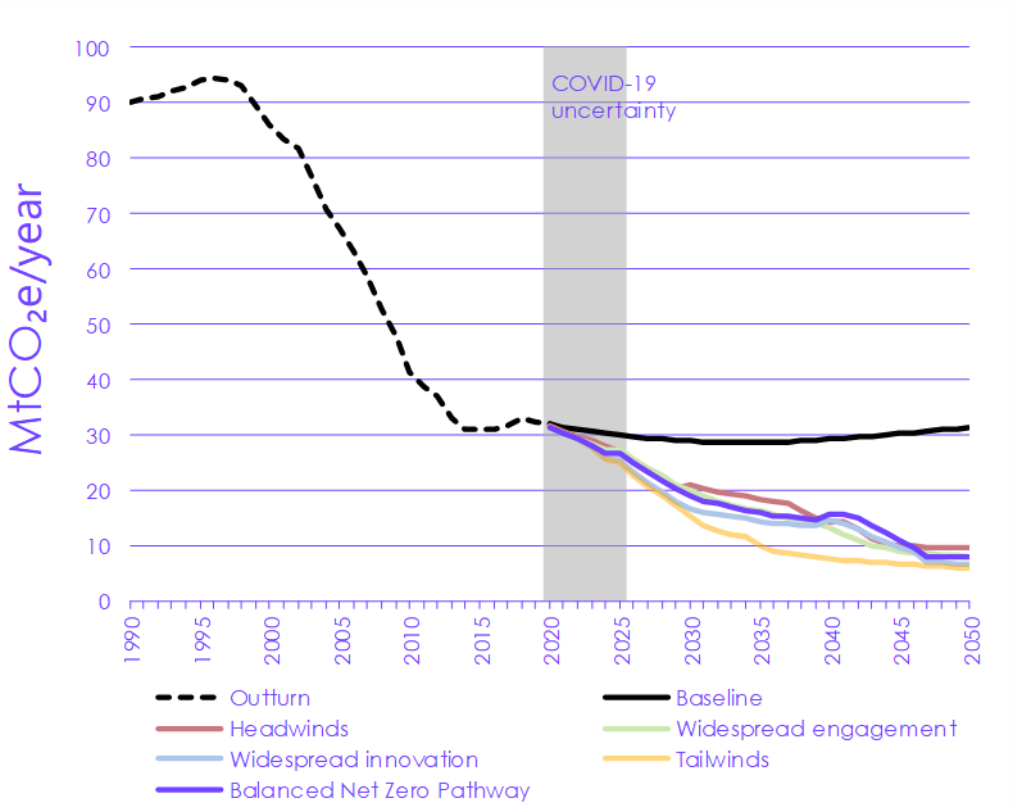
* Emissions from the spreading of sewage sludge or digestate to land are counted in the Land Use sector.

b) Alternative pathways for waste emissions

Each of our exploratory scenarios for the waste sector see emissions fall more than 70% from 2018 to 2050, with a range of residual emissions of 6.0-9.5 $MtCO_2e$/year in 2050 (Figure A3.9.b).

Emissions fell from 1997-2015 with less waste sent to landfill. The waste sector faces a challenge to get onto a low-carbon path after several years of limited progress.

Figure A3.9.b Emissions pathways for the waste sector



Source: BEIS (2020) *Provisional UK greenhouse gas emissions national statistics 2019*; CCC analysis.

Across the scenarios, we explore different contexts by varying the key timings, deployment of technologies and costs, and by exploring the impact of different levels of behaviour change (Table A3.9):

- **Headwinds**. Recycling rates follow the Balanced Pathway, although later landfill ban dates are implemented. There are no further reductions in food waste after 2030, and reductions in non-food waste are smaller, reflecting lower levels of behaviour change. Landfill methane capture rates remain unchanged from today.

Further improvements in recycling rates are possible, and more food waste can be avoided. Technology solutions can be implemented to further reduce landfill and wastewater emissions.

- **Widespread Engagement**. Households and businesses are prepared to recycle significantly more than they do today, with further increases in recycling after 2030, along with further reductions in food waste. All waste is banned from landfill at an earlier date of 2035, and landfill methane capture rates remain unchanged from today. Residual waste is increasingly allocated to jet fuel production instead of EfW incineration.

- **Widespread Innovation** achieves slightly smaller reductions in non-food waste than the Balanced Pathway, although it also targets reductions in inedible food waste (e.g. through lab-grown meat). Landfill methane capture and oxidation technologies are deployed during the 2020s, and wastewater treatment facilities install more novel technologies after 2030 to further reduce their emissions.

CCS could be installed on energy-from-waste plants starting from the 2020s, significantly reducing sector emissions.

- **Tailwinds** combines the highest waste prevention and recycling rates, the earliest landfill ban dates, and the highest technical improvements at landfill, compost and wastewater treatment sites. CCS also starts being installed on EfW plants much earlier, from the late 2020s. The result is emissions fall further and much faster than in the other scenarios.

Table A3.9
Summary of key differences in the waste sector scenarios

	Balanced Pathway	Headwinds	Widespread Engagement	Widespread Innovation	Tailwinds
Behaviour change and demand reduction	**51% fall in edible food waste by 2030 and 61% by 2050***	51% fall in edible food waste by 2030	51% fall in edible food waste by 2030 and 71% by 2050	51% fall in edible food waste by 2030 and 61% by 2050 (+50% fall in inedible food waste by 2050)	51% fall in edible food waste by 2030 and 71% by 2050 (+50% fall in inedible food waste by 2050)
	33% reduction in all waste by 2037 68% recycling by 2030**	13% reduction in all waste by 2037, 68% recycling by 2030	33% reduction in all waste by 2037 68% recycling by 2030 and 79% by 2050	28% reduction in all waste by 2037 68% recycling by 2030	33% reduction in all waste by 2037 68% recycling by 2030 and 79% by 2050
Landfill	**2025 ban on biodegradable wastes, 2040 full ban**	2030 ban on biodegradable wastes, 2050 full ban	2025 ban on biodegradable wastes, 2035 full ban	2025 ban on biodegradable wastes, 2040 full ban	2025 ban on biodegradable wastes, 2035 full ban
	80% CH_4 capture & 10% oxidation by 2050	68% CH_4 capture & 10% oxidation by 2050	68% CH_4 capture & 10% oxidation by 2050	80% CH_4 capture by 2030, 30% oxidation by 2050	80% CH_4 capture by 2030, 30% oxidation by 2050
Energy-from-waste	**CCS is fitted to 100% of EfW plants by 2050, starting from early 2040s**	CCS is fitted to 100% of EfW plants by 2050, starting from late 2030s	CCS is fitted to 100% of EfW plants by 2050, starting from early 2040s	CCS is fitted to 100% of EfW plants by 2050, starting from early 2040s	CCS is fitted to 100% of EfW plants by 2050, starting from late 2020s
Waste-water treatment	**Improves 21% by 2030**	Improves 21% by 2030	Improves 21% by 2030	Improves 21% by 2030, 50% by 2050	Improves 21% by 2030, 50% by 2050
Compost-ing	**Improves 23% by 2030**	Improves 23% by 2030	Improves 23% by 2030	Improves 23% by 2030	Improves 23% by 2030

* Measured from 2007 base year for household edible food waste, and 2011 for business edible food waste.

** Measured in-year from a baseline of increasing household and commercial & industry waste arisings

c) Investment requirements and costs

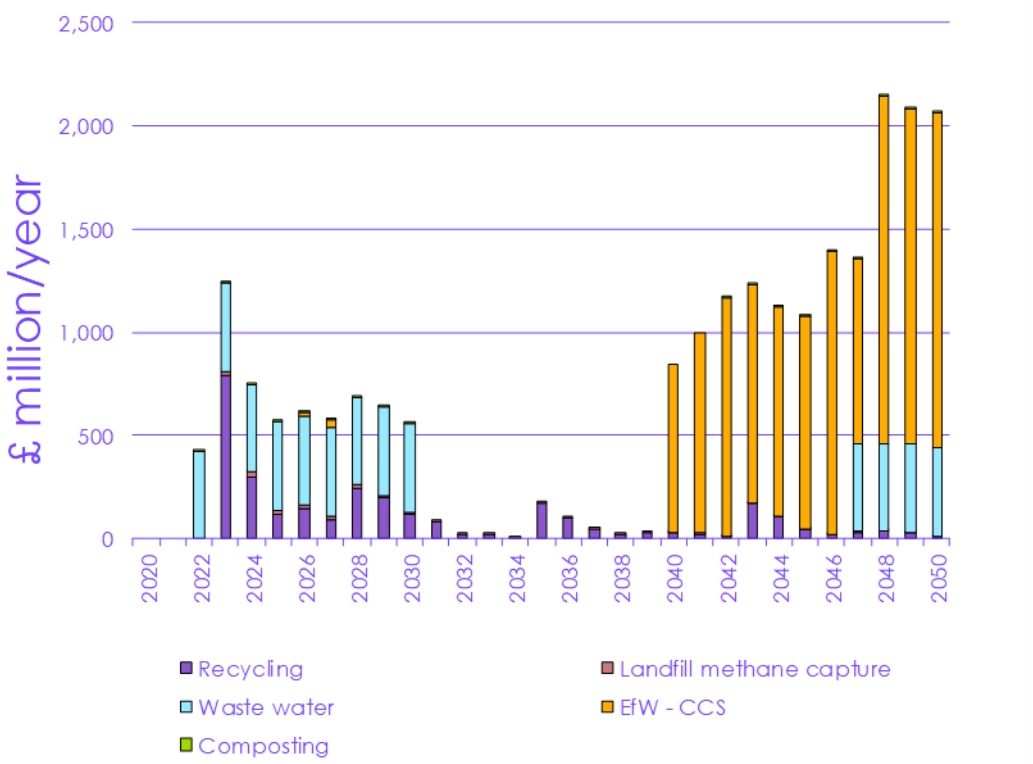
In our 2019 *Net Zero* report, we identified waste as a sector with potentially low cost GHG savings, based on recycling and banning biodegradable waste from landfill. Our sector categorisation and analysis has expanded to now include energy-from-waste plants, as well as abatement in the composting and wastewater sub-sectors. While some of these sub-sectors have much higher costs of abatement, our new estimates still suggest that reducing waste sector emissions is achievable as part of a cost-effective scenario towards the Sixth Carbon Budget and the UK's Net Zero objectives:

- In the Balanced Pathway, we estimate total added investment costs above the baseline of around £175 million/year in 2035 and £2,100 million/year in 2050 (Figure A3.9.c).

Front-loaded investment in the 2020s will be required to realise a biodegradable waste landfill ban by 2025.

- However, investment starts early in the 2020s, as robust action is taken on recycling (new vehicles, bins and downstream infrastructure) costing £100-800 million/year in order to ban biodegradable waste from landfill, as well as £430 million/year for rolling out advanced anaerobic digestion at municipal and industrial wastewater sites.

Figure A3.9.c Breakdown of waste sector additional investment

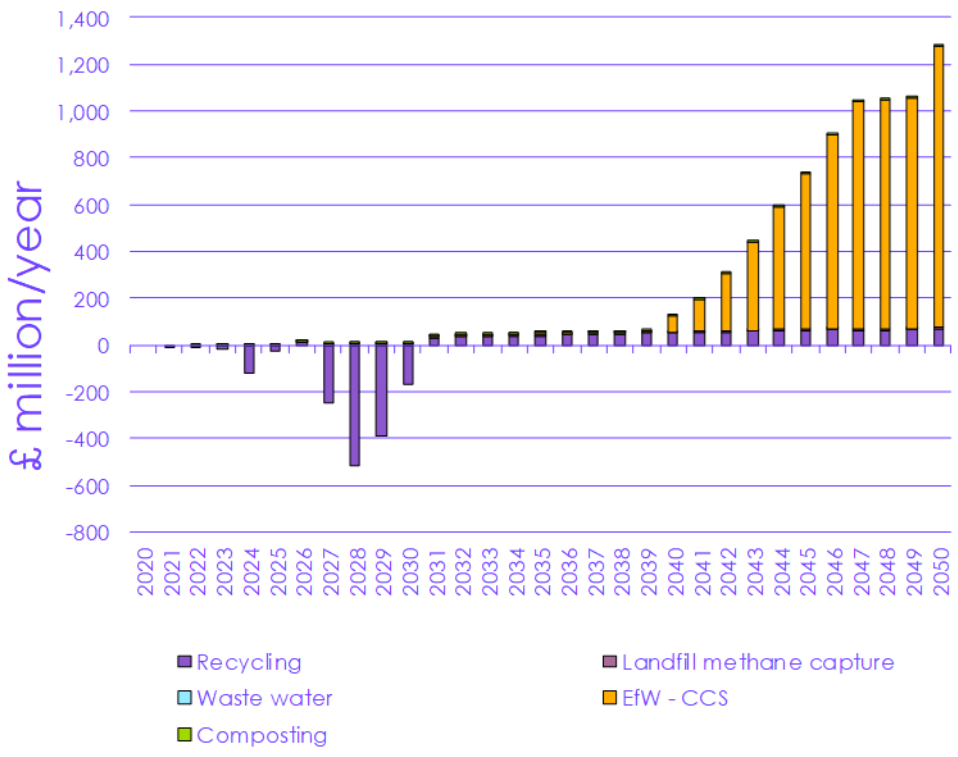


Source: BEIS (2020) *Provisional UK greenhouse gas emissions national statistics 2019*; CCC analysis.
Notes: Additional investment in Balanced Net Zero Pathway compared to the baseline, due to costs of new equipment for landfill methane capture, compost forced aeration, (municipal and industrial) waste water advanced AD, and new waste collection and recycling infrastructure.

- By the 2030s, there is no assumed further increase in recycling rates or wastewater improvements, so waste collection vehicle fleet turnover is the main cost. From 2040, the majority of added investment is retrofitting CCS to all the UK's remaining EfW plants, along with wastewater equipment replacement.
- We estimate total added operating costs above the baseline of around £50 million/year in 2035 and £1.3 billion/year in 2050 (Figure A3.9.d). However, during the 2020s, reduced total waste arisings, fewer collections of residual/black bin-bag waste from households and businesses, and improved quality and consistency of collected recyclable materials leads to cost savings* that can outweigh the added transition costs. Larger businesses are likely to increase recycling rates earlier and at lower cost, whereas smaller businesses face higher costs and are likely to be slower, leading to some marginal net long-term costs from 2030. From 2040, the installation of CCS on EfW plants leads to increased energy and labour costs, dominating waste sector added operating costs.

Cost savings are possible via reduced volumes of residual waste to collect and collection of higher quality recyclable materials. CCS will add significant costs to EfW plants.

Figure A3.9.d Breakdown of waste sector additional operating costs



Source: CCC analysis.
Notes: Additional operating costs in Balanced Net Zero Pathway compared to the baseline, due to costs of operating new equipment for CCS at EfW plants, landfill methane capture, composting forced aeration, and new waste collection and recycling infrastructure. No additional operating costs are assumed for wastewater treatment.

* This analysis excludes the cost savings from local authorities and waste management companies paying less landfill tax (currently £650 million/year is paid).

- For comparison, baseline costs (investment plus operations combined) are estimated at approximately £8.6 billion/year for solid waste handling across the UK, so the added costs of recycling and banning biodegradable waste from landfill are estimated at under 10%. The added investment in municipal wastewater treatment (excluding industrial wastewater) would add £4 a year to each UK household water bill during the 2020s.
- Reducing emissions from UK waste comes at an average cost of around £70/tCO_2e, although there is significant variation between sub-sectors, with wastewater abatement having very high costs compared to low cost methane capture and composting improvements.
- Reducing waste emissions will also produce benefits with improved air, soil and water quality, and recreational benefits from faster return of landfill sites to other uses. Lower landfill methane generation results in less methane captured for energy generation, although this decline is compensated for via increased use of anaerobic digestion for food wastes, sewage sludge and animal manures.

Endnotes

[1] CCC (2020) *The Sixth Carbon Budget – The Path to Net Zero.* Available at: www.theccc.org.uk

Chapter 3

Policy recommendations for the waste sector

The following sections are taken directly from Chapter 9 of the CCC's Policy Report for the Sixth Carbon Budget.[1]

Table P9.1
Summary of policy recommendations in waste

Waste reduction and recycling	• **Develop further policies to accelerate the Resources & Waste Strategy for England**, introducing greater ambition for efficiency in manufacturing and construction, material substitution for more sustainable alternatives, and reduction in consumer demand for products. Similar focus to be applied in Wales, Scotland and Northern Ireland with their respective circular economy strategies. • **Mandatory business food waste reporting** to be introduced by 2022, building on WRAP's existing voluntary scheme. • **Accelerate investment plans for local authorities to put in place universal municipal waste recycling collections**, along with downstream recycling, composting and anaerobic digestion (AD) facilities. • **Set a target for a 68% recycling rate by 2030 covering all wastes in England** via the Environment Bill, and announce new policies to meet this target. **Northern Ireland to set a 70% target for 2030**. Scotland and Wales to set new targets for 2030 that go beyond their 70% targets for 2025. • **Composting facilities should be incentivised to install forced aeration** as a method of reducing on-site emissions.
Landfill and exports	• Legislate for (in England via the Environment Bill, and in Wales, Scotland and Northern Ireland via new legislation) and **implement a ban on landfilling of all biodegradable municipal and non-municipal waste from 2025**. There must be sufficient recycling/composting/AD treatment capacity made available before the ban comes into force, so that significant increases in energy-from-waste are avoided. • **Phase out exports of waste by 2030.** • Long-term plans should be announced for **eventual diversion of all wastes from landfill**, but with a date conditional on sufficient action on reduction, re-use and recycling, and installation of CCS at energy-from-waste plants, to avoid a surge in fossil emissions when the ban comes into force. • Announce policies and funding for **increased methane capture and oxidation** at landfill sites, to significantly decrease fugitive landfill methane emissions.
Wastewater	• **Ofwat should include decarbonisation as one of its core principles**, to assist the water industry's goal of decarbonising by 2030, and the need to roll out advanced AD systems. • Innovation funding should be committed to development and **demonstration of novel wastewater treatment process** that achieve a step change improvement in direct process emissions. • Outside of the municipal wastewater sector, **industrial wastewater plants should be incentivised** to reduce their process emissions.
Energy from waste	• Examine the impact of waste reduction & recycling targets on the **utilisation of (and need for further) energy-from-waste plants**. Issue guidance notes to align local authority waste contracts and planning policy to these targets. • New waste conversion plants (including incineration, gasification & pyrolysis facilities) **must be built with carbon capture and storage (CCS) or 'CCS ready'.** • **Existing plants should start retrofitting CCS from late 2020s onwards, with 2050 a backstop date for full CCS coverage.** This will require either use of GHG thresholds for generated power & heat (could be set as part of the UK's new Bioenergy Strategy), access to CCS incentives to lower the costs of capture (particularly for smaller facilities further from CCS clusters), and/or carbon taxation (either taxes or inclusion in a UK ETS). Regional retrofit timings should be aligned with BEIS' CCS infrastructure plans.

The circular economy requires moving away from landfill and energy-from-waste, towards prevention, re-use and recycling.

Good progress has been made in decarbonising waste in the past three decades, mainly through landfill taxes reducing waste sent to landfill. However, recent years have seen sector emissions stalling, with increases in energy-from-waste plant emissions. Achieving significant future emission reductions in the waste sector requires a step-change towards a circular economy, moving away from landfill and energy-from-waste and towards a reduction in waste arisings and collection of separated valuable resources for re-use and recycling. This applies at local, regional and national levels.

Without substantial increases in policy ambition, and new policies in a range of areas, waste will become an increasing share of emissions and could still have substantial emissions by 2050. Given lead-times for changing waste management practices without a risk of unintended consequences, the waste sector requires new policy urgently.

Waste policy is mainly devolved, and there are different starting points and targets across the UK.

In this chapter, we set out the set of policy measures consistent with meeting our Balanced Net Zero Pathway across the UK, while recognising that waste policy is a devolved matter and there are different starting points across the UK. Different targets and regulations have been established in England and each devolved administration.

- **Wales** is setting a leading example with long-term circular economy proposals, plus 70% recycling and significant action on food waste by 2025.
- **Scotland** has a similar set of 2025 goals to Wales, although implementation of some prior measures has been delayed.
- **England** is legislating via the Environment Bill for more consistent recycling collections, and targeting 65% municipal recycling and below 10% municipal waste landfilled by 2035.
- **Northern Ireland** is at an earlier pre-legislative stage but is proposing similar targets to England.

Key policy gaps are banning biodegradable waste from landfill, and addressing growing energy-from-waste emissions.

Existing policy frameworks are therefore mainly focused on consistent collections, reuse and recycling efforts, food waste prevention, and some reductions in landfill. The largest policy gap remains preventing biodegradable municipal and non-municipal waste entering landfill. An early ban date of 2025 needs large-scale recycling infrastructure investment brought forward. Growing energy-from-waste plant emissions also need to be addressed, where possible through accelerating waste prevention and recycling efforts, and where necessary installation of carbon capture and storage (CCS).

Our recommendations are based on an assessment of existing policies and announcements, a review of evidence and updating our existing findings set out in our UK 2020 *Progress Report*, 2020 *Scottish Progress Report*, and 2020 *Welsh Progress Report*.

This Chapter is in three sections:

1. Challenges for waste policy and strategy
2. Existing policy and planned publications
3. Key policy changes needed

1. Challenges for waste policy and strategy

The waste sector faces a number of challenges, including diffuse sources and incomplete data, locational and quality variations, a growing population, time lags, long-term contracts and the current lack of carbon capture and storage (CCS) infrastructure in the UK.

- Waste emissions are generally diffuse, dominated by methane and nitrous oxide, and spread across a large number of actors and diverse supply chains. Data regarding commercial & industrial waste recycling is very poor, and the industrial wastewater sector is not well characterised.
- There can be large differences between local authorities as to what materials can currently be recycled, and variations in the quality of materials collected for recycling. Space for additional bins at properties can be limited. Some wastes also cannot currently be recycled or are hazardous.
- Waste volumes are often tied into long-term waste management contracts, making it difficult or expensive to quickly change course and prioritise other uses.
- The UK has a growing population, and so a growing requirement for wastewater treatment, and without action, potentially greater consumption of goods leading to more waste.

Policy benefits can take decades to be fully realised.

- Biodegradable material sent to landfill today will still be producing methane in several decades – policy benefits can therefore take significant time to be fully realised. This makes near-term action all the more important.
- Many new energy-from-waste (EfW) plants are under construction and have been granted planning permission, which if built without CCS will likely significantly increase sector emissions.

The circular economy cuts across multiple departments.

- Policy on developing a circular economy needs to be developed across multiple Government departments, particularly involving manufacturing and construction sectors, as well as areas such as agriculture and transport.

2. Existing policy and planned publications

As waste is largely a devolved matter, we discuss developments at a UK level first, before discussing England and each of the devolved administrations in turn. This section summarises the findings from our 2020 UK *Progress Report*, *Scottish Progress Report*, and our forthcoming *Welsh Progress Report*.

a) UK

The Circular Economy Package sets targets of >65% recycling and <10% landfill into law.

The UK published the Circular Economy Package (CEP) in August 2020,[2] which introduces a revised legislative framework, transposing across EU 2020 CEP measures. This package:

- Identifies steps for waste reduction, to ensure better compliance with the waste hierarchy.
- Establishes a long-term path for waste management and recycling, with 2035 targets across the UK of at least 65% municipal recycling, and below 10% municipal waste sent to landfill.[3]
- Bans separately-collected plastic, metal, glass and paper from being landfilled unless it has gone through treatment and is the best environmental outcome.[4]

Waste reduction policies have been relatively modest to date, focusing mainly on plastics, with a new tax on plastic packaging with less than 30% recycled content from April 2022.[5] Support is also provided to campaigns targeting behavioural change (for example, "Love Food Hate Waste").

In the wastewater sector, UK water utilities have committed to achieving zero net emissions by 2030 (counting the savings from the industry's exported biomethane, and removals measures such as tree planting). A 2030 Routemap has been published as an industry-led initiative.[6] BEIS have consulted on a Green Gas Support Scheme to increase the injection of biomethane into the gas grid, which will improve anaerobic digestion prospects beyond the Renewable Heat Incentive.[7]

b) England

The Environment Bill will improve re-use and recycling over 2023-35.

The Environment Bill currently going through Parliament will establish several new policy levers to tackle waste in England:

- Extended Producer Responsibilities on packaging.
- Deposit Return Schemes for drinks containers.
- Provision of resource efficiency information.
- Mandating consistent collections of separate recyclable/compostable materials from households and businesses (starting in 2023 and fully rolled out by 2035). These streams include food waste, plastics, paper and card, metal packaging and glass, plus garden waste collection from households.
- Establishment of binding long-term targets for England, potentially for resource productivity and residual waste targets (with the latter measuring reductions in per capita tonnages sent to landfill or incineration).[8]

Together these reforms aim to achieve Defra's 2019 *Resources & Waste Strategy* (RWS) target of a 65% recycling rate by 2035 in England, now set in law via the CEP. In August 2020, Defra consulted on an updated Waste Management Plan for England. This did not introduce new policies, but reflects the RWS. In September, England also legislated to ban the supply of plastic straws, stirrers & cotton buds.[9]

Government has also committed to mandatory food waste reporting for businesses, and to update their Waste Prevention Programme.

Following on from the RWS, Government has also committed to:

- Introduce mandatory food waste reporting by food businesses in England. A consultation will be held in late 2020 or early 2021.
- Publish an updated Waste Prevention Programme that will focus on efforts at the top of the Waste Hierarchy.

The RWS also set out the following proposals, but these are yet to be enacted in legislation or translated into policy:

- Ban food waste from landfill by 2030, with an aspiration to ban other biodegradable waste by the same date.
- An intention to work towards zero avoidable waste being landfilled by 2050.

c) Scotland

Scotland's Circular Economy Package is ambitious, with strong measures on waste reduction, but has been delayed.

The Scottish Government proposed several 2025 targets in *'Developing Scotland's circular economy'* but this is not being taken forward in this legislative session due to COVID-19, although may be reintroduced in 2021.[10] These 2025 targets include:

- A 70% recycling rate for all wastes (with households achieving a 60% recycling rate by 2020).
- A 15% reduction in total waste (against 2011 levels).
- A 33% reduction in food waste (per capita against 2013 levels), following the *Food waste reduction: action plan*.
- No more than 5% of all waste being sent to landfill.

In conjunction with the Convention of Scottish Local Authorities, the Scottish Government has also committed to evaluating the Household Recycling Charter and its Code of Practice and to form a steering group to change the way Scotland tackles waste and recycling. Zero Waste Scotland has provided a total of £7.5 million since 2015 to eight Councils in support for transition to Charter-compliant waste and recycling collection services.

A landfilling ban on biodegradable municipal waste is in force, but has delayed.

1.02 million tonnes of biodegradable municipal waste were landfilled in 2018.[11] Scotland's previous commitment to ban the landfill of biodegradable municipal waste by 2021 has been delayed to January 2025, as many local authorities lacked sufficient processing infrastructure and would have been forced to export their waste.[12] Although some local authorities had made significant progress towards the 2021 target, this delay will lead to fewer avoided landfill methane emissions.

The Scottish Government is proposing centrally supported procurement and use of the Scottish Landfill Tax to ensure the transition occurs by 2025. The 2020-21 *Programme for Government* also allocates a £70 million fund to the improvement of local authority refuse collection infrastructure. The introduction of a national Deposit Return Scheme for drinks containers has also been delayed until 2022.

d) Wales

Wales' Beyond Recycling strategy has both long-term goals and ambitious near-term targets.

Wales currently recycles 62.8% of municipal waste today, which is one of the highest recycling rates globally. In December 2019, the Welsh Government consulted on a new circular economy strategy '*Beyond Recycling*'.[13] This contains a number of ambitious near-term and longer-term targets:

- A 'zero waste' goal for 2050, aiming to phase out residual waste to landfill and incineration (an effective 100% recycling rate from all sectors).
- Development of minimum preparation for re-use targets for Local Authorities, and prioritising re-used and remanufactured content in the goods that the public sector procures.
- A 50% reduction in food waste by 2025, against a 2006-07 baseline, and looking to go further after 2025.

Business recycling collections are already being improved, with bans on landfilling or incineration of some collected materials.

- 70% recycling of all waste by 2025, as well as statutory local authority recycling targets at the same level. A £6.5 million fund is available for local authorities and public bodies to increase their recycling rates. Improved waste collections for Welsh businesses are also being implemented,[14] with bans on the landfilling or incineration of specified separately collected recyclable materials.

If all successfully enacted, the above goals would substantially reduce future waste sector emissions. Wales currently has a target of an 80% reduction in waste sector emissions by 2020, and 92% by 2030, compared to 1990 levels. However, the 2020 target looks extremely challenging, given the latest 2018 data of a 62% reduction and little change since 2016.* Wales' Landfill Allowance Scheme, which focused on reducing landfill of biodegradable municipal waste, also ended in March 2020.

Wales' current '*Towards Zero Waste*' strategy from 2010 has similar recycling targets, along with targets for <10% of municipal waste to be landfilled by 2020, and <5% by 2025.[15] These existing targets may be built on or superseded by other metrics when Wales' final circular economy strategy is published.

e) Northern Ireland

The Department of Agriculture, Environment & Rural Affairs (DAERA) consulted on its 2019 Waste Prevention Programme '*Stopping Waste in its Tracks*' in early 2020.[16] However, this was an interim extension of existing actions, rather than proposing new policies or targets. Northern Ireland's Landfill Allowance Scheme, which focused on reducing landfill of biodegradable municipal waste, also ended in March 2020.

Northern Ireland are proposing new targets that match the ambition of the Circular Economy Package to 2035.

A discussion document on the '*Future of recycling and the separate collection of waste of a household nature in Northern Ireland*' was published in June 2020.[17] The proposed targets match the CEP, with a municipal recycling rate of 65% by 2035 (with interim targets of 55% by 2025, 60% by 2030) and less than 10% of municipal waste going to landfill by 2035. A consultation response is now pending. Northern Ireland's 2013 waste management strategy '*Delivering Resource Efficiency*' is due to be revised as a result.[3]

* Data given based on the UK's current National Inventory methodology (IPCC AR4 GWPs, and a waste sector classification that does not include energy-from-waste plant emissions).

Other recent announcements and plans include:

- £23 million provided to local government to improve recycling services and facilities. To date, seven projects have been supported totalling £3.5 million.[18]
- DAERA consulted on the reform of the producer responsibility system for packaging and the introduction of a deposit and return scheme for drinks containers in 2019. Further consultation is planned in 2021.
- DAERA is also currently developing an '*Environment Strategy for Northern Ireland*', due to be published for consultation in March 2021.

3. Key policy changes needed

Waste sector emissions will become increasingly important to UK Net Zero by 2050. Policy needs developed in multiple areas.

Without substantial increases in policy ambition, and new policies in a range of areas, waste will become an increasing share of emissions and could still have substantial emissions by 2050. Given lead-times for changing waste management practices without a risk of unintended consequences, the waste sector requires new policy urgently.

In this section, we set out the set of policy measures consistent with meeting our Balanced Net Zero Pathway across the UK, while recognising that waste policy is a devolved matter and there are different starting points across the UK.

Develop further policies to accelerate the transition to a circular economy.

- Following on from the Resources and Waste Strategy for England, introduce greater ambition for efficiency in manufacturing and construction, material substitution for more sustainable alternatives, and reduction in consumer demand for products.
- Similar policies to be followed in Wales, Scotland and Northern Ireland with their respective waste strategies. For example, Scotland should reintroduce their Circular Economy Bill in the next Parliament, setting out specific plans for material efficiency, including material substitution, to reduce emissions through reduced demand.

Food waste policy needs to align with agricultural policy.

Food waste remains one of the biggest source of emissions in the sector. Action is needed in businesses and households.

- Policy should include immediate low-cost measures to reduce food waste (e.g. target setting in the public and private sectors, redistribution of surplus food), measures to 'nudge' consumers towards best practice and mandating of separate food waste collection. Changes in dietary preferences and behaviour change to lower meat and dairy consumption will also impact the composition of food waste collections.
- Mandatory business food waste reporting will help achieve reductions in food waste, alongside reductions in household food waste.

Biodegradable waste should be banned from landfill by 2025.

Banning biodegradable waste from landfill from 2025 is a priority, and should be achieved via prevention, re-use and recycling, not via more energy-from-waste.

- A ban on key biodegradable wastes, across municipal and non-municipal sectors, to include at least paper and cardboard, food, textiles, wood and garden wastes. Achieving this ban would decrease the tonnage of biogenic material entering landfill by at least 85% by 2025 from 2018 levels.* Where Local Authorities are able to move faster than 2025, they should be incentivised to do so.
- This ban will require waste prevention, re-use and recycling efforts (including AD and composting) to be significantly ramped-up, and should not be met by increased waste exports or a significant (more than 20%) increase in EfW emissions.†

* This is not 100%, due to the presence of biogenic material in other less well categorised waste streams that would continue to enter landfill after 2025.

† Although biodegradable waste streams are being banned from landfill, there is some fossil carbon in these streams, and so increases in EfW emissions should be limited to a maximum of 20% above 2018 levels.

The Environment Bill is an important step, but timelines need to be more ambitious, particularly on business recycling.

An expansion in Scottish EfW capacity occurred ahead of their original 2021 biodegradable municipal waste ban date, and a repeat of this should be avoided (across the UK), due to the risk of locking-in increased EfW fossil emissions.

- While the Environment Bill will assist in removing several important biodegradable wastes from English residual waste streams, reducing the amount of biodegradable waste that is landfilled, this will only happen in stages over 2023-35. This timeline, and the RWS proposed landfill ban on food waste and potentially other biodegradable wastes from 2030 (which are yet to legislated for), will lead to significantly higher landfill methane emissions over the period to 2050 than in our Balanced Pathway.

Exporting of waste from the UK should stop by 2030, but full landfill waste bans should not be rushed.

Waste exports should be phased out by 2030.

- Governments should work towards banning the export of waste from the UK by 2030. Current UK export volumes are falling mainly due to the increase in UK energy-from-waste plants, but this goal should be achieved via prevention and recycling.
- Banning all landfill will lead to further modest reductions in landfill methane emissions. However, achieving the RWS aspiration of zero avoidable waste being landfilled by 2050 in England needs careful planning. Similar caution will be required in the DAs if implementing full landfill bans.
  - If full landfill bans are imposed without accompanying improvements in prevention or recycling, and before CCS is widely available, this could substantially increase waste volumes going to EfW and increase sector emissions by several $MtCO_2e$/year.
  - A full ban should only be enacted once residual volumes have been significantly lowered and CCS installed on remaining EfW plants.*

Recycling rate ambitions need to be raised.

England should target 68% recycling by 2030 – household, commercial and industrial shares of this are achievable.

- England should target 68% recycling across all wastes by 2030.
  - Experience from Wales and Northern Ireland indicates that it is feasible for England to achieve a 56% household recycling rate by 2030 (similar to Wales today), from its current 45% position.†
  - The non-household municipal waste sector has significant potential for improvement.[19] RWS/CEP targets in England require 74% non-household municipal recycling by 2035 (up from 30-40% today). Defra have proposed costs be spread over 12 years, focusing on cheaper action at larger businesses first before later more expensive action for smaller businesses. Achieving 74%, or close to this level, by 2030 could be feasible with more support for smaller businesses during the mid/late-2020s, instead of during the 2030s.

* Our Tailwinds and Headwinds scenarios both achieve full landfill bans (in 2050 and 2035 respectively) without emissions increases, due to sufficient CCS being in place and sufficient prior action on prevention and recycling.

† Wales and Northern Ireland have been able to achieve high household recycling rates of 54% and 48% in 2018, having both started at only 5% twenty years ago.

  - With other commercial & industrial waste* outside of the municipal sector also achieving 74% by 2030, this would lead to a combined English recycling rate of 68% by 2030. There may be potential to go further in the long-term as well, and we understand work is ongoing with WRAP to assess the options and costs. Ambitious new goals should be consulted on.

Northern Ireland should target 70% recycling by 2030, driven by business recycling improvements.

- Northern Ireland should target 70% recycling across all wastes by 2030.
  - Evidence from WRAP shows 'it is possible to achieve and surpass a municipal recycling rate of 65% in Northern Ireland well before the target date of 2035', with non-household municipal sectors potentially achieving over 80%.[20]
- Wales and Scotland should ensure compliance with their 2025 targets, and set new 2030 targets.
  - By targeting 2025 for 70% recycling of all wastes, Wales and Scotland are already well ahead of the rest of the UK. Both countries need to formalise their 2025 targets in legislation, with funding committed for the required infrastructure. Scotland is also starting from a lower recycling rate, and progress will need to be carefully monitored.
  - Both countries should set out proposed recycling rate targets for 2030 that go beyond 70%.

Statutory targets for Welsh local authorities, and available central funding, were key to driving progress in Wales.

- Best practice and successful implementation lessons should be shared. An important reason for Welsh recycling success has been the setting of statutory recycling targets for local authorities. Welsh Government support has also been made available for increasing recycling rates (e.g. Circular Economy Funding). Scotland, England and Northern Ireland should assess the potential benefits of following a similar statutory approach.
- Waste recycling policy over time should evolve away from just weight-based measures, and focus more on carbon and resource supply chains. While weight-based targets still have an important role given the large improvements needing to be made, there should be increasing focus on recycling of wastes that reduce national carbon footprints and improve resource security. For example, food, textile, metal and plastic wastes only made up 9% of Scotland's waste by weight in 2016, but accounted for 49% of waste carbon impacts (and food waste is particularly important).[21]

Energy-from-waste emissions continue to grow, but need to be constrained by waste prevention, re-use and recycling, and over time further mitigated via carbon capture and storage.

- EfW fossil GHG emissions in 2018 were 5.3 $MtCO_2e$/year. Achieving the Balanced Pathway will require waste prevention, re-use and recycling efforts to keep EfW emissions approximately flat over time (between 5-6 $MtCO_2e$/year) before CCS starts being retrofitted to plants.†
- New circular economy measures, prevention and recycling targets need to be translated into their impact on regional residual waste arisings, and these findings communicated to Local Authorities.

* Industrial wastes have a comparable composition to non-household municipal waste (since commercial waste makes up two thirds of C&I waste), although industrial waste tends to be purer, so industrial recycling rates are currently estimated to above those for non-household municipal waste.

† Our other exploratory scenarios stay within 4.5-6.5 $MtCO_2e$/year of EfW emissions before CCS is applied.

- Guidance should be issued to help align Local Authority waste contracts and planning policy to the expected improved residual arisings trajectories. For example, in Wales, energy-from-waste plants will have to be phased out by 2050 to achieve Welsh Zero Waste targets (no waste sent to landfill or incineration).

EfW emissions could rise significantly over the coming years if all approved plants built.

- If EfW plants under construction and granted planning approval in the UK were all built, and plant utilisation rates remain unchanged, this would add 3-10 $MtCO_2e$/year to UK emissions. To prevent this major increase, either a substantial fraction – potentially a majority – of the EfW plant pipeline will have to remain unbuilt, EfW fleet utilisation rates will have to fall, or else carbon capture and storage (CCS) will need to be installed on plants from the mid/late-2020s onwards to mitigate the additional emissions.
  - Falling EfW utilisation rates may only be possible in some cases via renegotiation of waste management contracts, in order to prioritise prevention and recycling efforts instead. Government support to assist Local Authorities will likely be required.
  - Government policy could also focus on EfW emissions, either through carbon taxation or inclusion in a UK ETS, and/or providing incentives for CCUS to be installed.

New EfW plants should be built with CCS, or CCS-ready in areas soon to have CO_2 infrastructure.

  - For those plants not yet under construction, new energy-from-waste plants (and plant expansions) should only be constructed in areas confirmed to soon have CO_2 infrastructure available, and should be built 'CCS ready' or with CCS.
- EfW policy should cover all waste facilities generating energy, whether by combustion, gasification, pyrolysis or similar methods. Any plants that produce jet fuel from residual waste should also install CCS.

Incentives for landfill operators to reduce methane emissions are required.

There is now no incentive for landfill operators to install methane capture equipment (beyond wholesale power prices).

- With the closure of the Renewables Obligation in 2017 to new entrants, one of the primary incentives for landfill methane capture in the UK was removed. The latest evidence from the NAEI shows that methane capture rates have recently been falling. If this trend continues, this will significantly increase fugitive landfill methane emissions.
- Policy is needed to fill this gap, to provide incentives for landfill operators to invest in increasing methane capture rates over time, even when sites are shut to new waste and gas volumes are decreasing. This could be emissions-based policy via Defra rather than energy policy via BEIS.
- Funding is also required for demonstrating the methane oxidation potential and applicability of biocovers and biowindows at a range of different UK landfill types, and assessing how these technologies might interact with tree planting on older landfill sites.

Wastewater decarbonisation needs to be embedded into the sector's investment framework.

Ofwat should have decarbonisation of the wastewater sector as a core principle.

- Ofwat should include sector decarbonisation as one of its core principles, as the capital costs of continuing to roll out advanced Anaerobic Digestion systems (and more expensive novel technology after 2030) need to be met.

- Research, development and deployment funding should be committed by the mid-2020s to develop and demonstrate novel treatment processes that achieve a step change improvement in direct process emissions.
- Outside of the municipal wastewater sector, industrial wastewater process emissions are large and need tackled, whether via carbon pricing, regulation or manufacturing policy levers.

Composting facilities should be incentivised to install forced aeration.

- This method of reducing on-site emissions will also have benefits of improving product quality and consistency. Although aeration is a low-cost solution, the composting sector faces competition from peat, and any additional costs on the sector should only be imposed after peat has been banned for horticultural use in the UK (as recommended in Chapter 7).

Waste data need improvement.

Waste sector data is in places poor, and requires improvement.

- Energy-from-waste data are only available in the National Atmospheric Emissions Inventory at a UK level. Collection of devolved administration data should occur to allow reporting of DA-level estimates, given their increasing importance.
- Commercial & Industry waste data are currently uncertain, particularly for recycling rates. Efforts via the Waste Tracking programme should be built on, so as to be able to annually report C&I waste arising tonnages in England and each DA, and more accurate estimate recycling rates.

Endnotes

[1] CCC (2020) *Policies for the Sixth Carbon Budget and Net Zero*. Available at: www.theccc.org.uk

[2] *The Waste (Circular Economy) (Amendment) Regulations 2020*

[3] Defra, DAERA, Scottish Government, Welsh Government (2020) *Circular Economy Package policy statement*

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[5] HMRC (2020) *Introduction of a new plastic packaging tax*

[6] Water UK (2020) *Net Zero 2030 Routemap*

[7] BEIS (2020) *Future support for low carbon heat*

[8] Defra (2020) *Environment Bill - environmental targets*

[9] *The Environmental Protection (Plastic Straws, Cotton Buds and Stirrers) (England) Regulations 2020*

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[12] Scottish Government (2019) *Climate Change Plan: monitoring report 2019*

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[16] DAERA (2020) *Waste Prevention Programme for Northern Ireland 2019*

[17] DAERA (2020) *Discussion on the "Future Recycling and Separate Collection of Waste of a Household Nature in Northern Ireland"*

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