Methodology

The climate emergency brake: an ambitious plan to cut UK methane emissions

green alliance…

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This methodology explains the analysis behind the estimated methane emissions savings from the interventions outlined in our report *The climate emergency brake: an ambitious plan to cut UK methane emissions*, published May 2025.

In general, we used government records on methane emissions from the National Atmospheric Emissions Inventory (NAEI), maintained by the Department for Energy Security and Net Zero (DESNZ). This splits methane emissions (measured as $ktCH_4$) into low level categories across sources and sectors, such as agriculture, energy and waste.

Since May 2025, the NAEI dataset has included annual emissions up to 2022. We used the data from 2020 as the baseline from which to estimate potential percentage reductions by 2030, in line with the aims of the Global Methane Pledge, of which the UK is a signatory.

It should be noted that detailed studies have found that the NAEI often underestimates methane emissions, especially in the oil and gas sector, and the relative ratio of emissions from different processes can be quite different to other datasets, such as the International Energy Agency's (IEA's) methane tracker, for example. A high level of uncertainty must be considered when using this emissions data and methane emissions from UK upstream oil and gas activities are likely to be underestimated in the NAEI.

More details of our detailed analysis are available on request.

Interventions in agriculture

Some of the following interventions were analysed as independent unrelated actions, but the impacts of some are dependent on others. For example, if methane suppressants and improved slurry management techniques are introduced, the effective savings from reducing the number of ruminant animals through a dietary shift and the growth of alternative proteins will be correspondingly lower. We accounted for this in our analysis, assuming the methane suppressants and better manure management effectively 'come first', followed by a reduction in livestock numbers.

1. **Forty per cent uptake of a methane suppressing feed additive for dairy cows**

We calculated that dairy cows are responsible for **35 per cent** of enteric emissions using the NAEI split of subsector emissions data, specifically the entries labelled 'dairy'.

We used the assumption, from our previous briefing discussing the evidence, that Bovaer/3-NOP can reduce enteric methane emissions by **30 per cent** when fed continuously to cows, although future products may be able to achieve higher efficacy.

We assumed that, by 2030, at least **40 per cent** of UK dairy cows can be fed additives to reduce methane emissions. This is essentially a proxy for how many mouthfuls of food a typical dairy cow ingests indoors vs outdoors in the UK.

The proportion of time a dairy cow is kept indoors will vary by farm and season, so this figure is not known exactly. However, estimates suggest that 20 per cent of UK dairy cattle spend little or no time on pasture, while conversations with farmers and industry bodies indicate that about 11 per cent of cows are housed indoors all year round.

We assumed that all dairy cows are fed indoors at least once a day whilst being milked, so could be fed methane suppressants at least once a day. Since the efficacy of the methane suppressing feed drops off after a few hours, we considered the uptake rate as a route to account for this to some extent.

We did not assume that 40 per cent of the UK herd is housed indoors all year round, nor that all cows are housed indoors for 40 per cent of the year, but effectively a combination of these adds up to 40 per cent.

We conservatively applied the methane reduction to 40 per cent of the UK herd. If products with a longer lasting efficacy enter the market that only need to be fed once a day, this uptake could reach 100 per cent of dairy cows.

We calculated the methane avoided by this intervention by multiplying the 40 per cent uptake by its 30 per cent efficacy and adjusted this based on dairy cows accounting for 35 per cent of enteric methane emissions. The resulting potential saving is 35.2ktCH_4, or 2.9 per cent of all agriculture and land use methane emissions.

We do not advocate, however, that the use of methane suppressants should be incentivised to the point that this drives cattle to be kept indoors more often.

2. Thirty per cent of cattle and pig farms use slurry acidification

Research shows that acidification of slurry to a pH of 5.5 has the potential to reduce methane emissions by up to **90 per cent**.

In this analysis, we conservatively assumed that **30 per cent** of stored slurry could be acidified by 2030. There is no reason this could not be higher, except, perhaps, the availability of acid.

In Denmark 20 per cent of slurry is acidified, but investment in acidification has historically been driven by ammonia reduction targets, with little incentive to reduce methane until the recently agreed carbon tax is implemented.

We calculated that slurry contributes **63.3 per cent** of manure management emissions. To do this, we calculated the manure, excreta and digestate emissions for different animals as per the NAEI detailed data.

Manure and slurry methane emissions across livestock animal

	Dairy cows	Other cattle	Pigs	Other animals
Total manure, excreta and digestate emissions ($ktCH_4$)	77.93	45.38	20.31	7.98
Proportion of all manure management methane emissions (%)	51%	30%	13%	5%
Slurry as % of total manure management methane emissions by animal	85%	43%	50%	0%

To understand what proportion of manure emissions come from slurry, we used tables **A3.3.3** and **A3.3.5** from the UK's greenhouse gas (GHG) inventory annexes. These show the methane emission factors for manure management systems in the UK and the split of waste management by animal, respectively. The methane emissions factors were used as weightings of methane intensity. This resulted in the calculation in the third row of the table above, the proportion of manure management methane emissions from each type of livestock that come from slurry.

Multiplying the rows together and adding the results together found a total of 63.3 per cent of manure methane emissions come from slurry.

We calculated the methane emissions avoided by this intervention by multiplying the 90 per cent reduction potential by a 30 per cent in uptake and the 63.3 per cent of manure emissions from slurry, to estimate that 17.1 per cent of the 152ktCH_4 total methane manure emissions could be tackled in this way. The potential saving was calculated to be **26.0ktCH_4**, which is 2.2 per cent of all agriculture and land use methane emissions.

3. Thirty per cent of cattle and pig farms capture and use methane from slurry

To analyse the abatement potential of capturing and using the methane from slurry, we reused the assumptions above to assume the percentage of emissions from slurry. We propose that an additional 30 per cent of cattle and pig farms could use this technology, separate from the 30 per cent of farms that could treat slurry with acid. This, in effect, leaves 40 per cent of slurry untreated.

For this intervention we assumed an **80 per cent** effective methane capture rate, or reduction potential, for the Bennamann style slurry cover and capture system. We could not find any peer reviewed published research, nor any direct claims on methane capture rates from the manufacturer, demonstrating the precise capture vs leakage rate of these systems. This should be a subject of further study.

The potential saving was found to be **23.1ktCH_4**, or 1.9 per cent of all agriculture and land use methane emissions.

4. Overall dietary change reducing meat and dairy consumption by ten per cent

For this intervention, we modelled an average ten per cent reduction in meat and dairy consumption across the entire population between 2020 and 2030, in line with the Climate Change Committee’s seventh carbon budget.

We assumed that the production of meat and dairy in the UK also falls by a corresponding ten per cent and the methane emissions from enteric fermentation and manure management fall accordingly (after accounting for the reductions from the above interventions). We assumed the emissions from other agriculture and land use change stay the same, resulting in an overall reduction of 7.5 per cent across all agriculture and land use emissions, or **90.5ktCH_4**.

It is possible for UK meat and dairy production to fall without a corresponding change in consumption, or vice versa, through an alteration of import and export volumes. From a global climate change perspective, it does not matter if the emissions savings occur within the UK or elsewhere, but to demonstrate international leadership, it is essential that the UK can show that its domestic emissions are falling and are not simply being shifted to another country.

It is also crucial that the balance of land use changes so that there is more space for nature and tree planting, as outlined in the Climate Change Committee's seventh carbon budget advice, and in our report *Shaping UK land use* (2023). This can be supported by the Land Use Framework, which should set out the changes needed to deliver UK climate and nature goals alongside remaining at least as self-sufficient as the country is now. The Land Use Framework should be closely linked to the Environmental Land Management schemes (ELMs) in England, and equivalent farming subsidy regimes in devolved nations, such that farmers are supported to deliver public goods in the form of environmental improvements and earn a stable income.

The assumption that lower meat and dairy consumption can be matched by reduced production without affecting the UK's self-sufficiency breaks down when considering exports. We recognise that the UK is a net exporter of lamb and dairy products, whilst being a net importer of beef, chicken and pork. Overall, this could weaken the impact that dietary shift in the UK has on meat and dairy production. However, since the majority of our meat and dairy exports go to the EU, where diets are also shifting away from meat and dairy, we assume that overall demand for these products will continue to fall. However, since the majority of our meat and dairy exports go to the EU, where diets are also shifting away from meat and dairy, we assume that overall demand for these products will continue to fall.

We argue that avoiding excessive consumption of meat and dairy, and eating more fruit, vegetables and pulses could also be a route to greater self-sufficiency, provided policies aim to expand these industries at home. By increasing the consumption of foods that use relatively less land, the UK could become even more self-sufficient than it is at present, whilst requiring fewer imported animal feeds and fertilisers, and a smaller land footprint abroad.

5. Replacing 17 per cent of processed meat and dairy with alternative proteins

This measure would be in addition to the overall shift in consumption and production outlined in the previous measure of a ten per cent reduction in meat and dairy consumption. Many consumers may see eating more alternative proteins as part of a dietary shift away from meat and dairy, rather than a separate trend. By focusing on processed meat, we see this measure as one that can be driven as much by retailers and food manufacturers as by consumers.

To estimate the impact, we started by calculating the fraction of beef, lamb and dairy products that are 'processed' and relatively easy to replace with alternative proteins.

Volumes of beef and lamb consumption in different cuts and categories were taken from the AHDB household purchase data (beef, lamb, at 26 January 2025) looking at the preceding 52 weeks. We assumed that, for beef, the following categories are processed: mince, burgers and grills, sausages, sliced cooked meats and marinades. For lamb, the categories of mince, burgers and grills, sausages and marinades were considered processed. Everything else was considered unprocessed.

This resulted in a split of 33 per cent unprocessed beef vs 67 per cent processed and 80 per cent unprocessed lamb vs 20 per cent processed, according to household purchases. We assumed all dairy products are processed and could be replaced to some extent by alternative proteins.

We assumed that ambitious growth of the alternative protein industry could lead to 17 per cent of dairy consumption and 17 per cent of processed meat being replaced by 2030, compared to 2020. This is a third of the mid-ambition 2050 scenario explored in our previous report. Considering demand is expected to follow an s-curve growth trajectory, our assumptions on the scale of this measure are ambitious.

Again, it was assumed that a greater focus on the delivery of public goods would coincide with a fall in domestic dairy, beef and lamb production, through relevant measures in ELMs and the Land Use Framework. We also assumed that the overall trade balance is not significantly skewed towards processed or unprocessed meat and so there would be no significant carcass balance problem.

To estimate the fraction of emissions from enteric fermentation and manure storage that come from beef, lamb and dairy respectively, we studied the detailed breakdown of emissions in the NAEI. According to this, 78 per cent of all enteric and manure emissions come from cattle, and 17 per cent come from sheep. Of the emissions from cattle, 59 per cent come from the dairy sector while 41 per cent come from the beef sector.

Where it was unclear in the NAEI classification whether a subsector is primarily supplying dairy or beef (eg 'Bulls for breeding'), we assumed the emissions can be categorised as half dairy and half beef. This resulted in the following fractions of all enteric and manure emissions:

Enteric and manure emissions across sectors

Sector	Share of enteric and manure emissions
Sheep	17.2%
Beef	31.7%
Dairy	45.9%

Multiplying these emissions by the **17 per cent** potential uptake of alternative proteins across processed meat and dairy, and by the proportions of each which were considered processed, resulted in total emissions savings of 3.5 per cent from beef, 0.6 per cent from lamb and 7.7 per cent from dairy. This came to a total of 11.8 per cent of enteric and manure emissions, and **106ktCH_4** (after accounting for the impact of methane suppressants and better manure management), which is 8.8 per cent of all agriculture and land use methane emissions.

Interventions in energy

To estimate the abatement potential of different measures in oil and gas production and distribution, we used UK emissions data from NAEI, specifically extracting activities relating to the oil and gas sector using the Nomenclature for Reporting (NFR) coding groups. We used the categories 1B2a1 to 1B2c2ii under the NFR and Common Reporting Format (CRF) systems, international frameworks used to classify and report emissions data. Emissions from solid fuel sources and from the combustion of fuels were excluded from this analysis. All abatement analysis used 2020 as the baseline year.

Oil and gas production has steadily declined as reservoirs deplete and the UK moves towards alternative energy sources. By 2030, the North Sea Transition Authority projects that oil and gas production will have declined by 62 per cent, compared to a 2020 baseline.

According to our analysis of the breakdown of emissions sources in the NAEI, only 22.1 per cent of the total energy sector methane emissions come from the upstream extraction and processing, with the rest from refining, storage and transport. This split is likely to underestimate the emissions from upstream facilities, as per the discussion at the beginning of this methodology, but we have used it to be consistent with the rest of our analysis using the NAEI. The expected drop in methane emissions from natural decline in production is estimated as **23.4ktCH_4, or ten per cent** of energy sector methane emissions.

This factor is taken into consideration in the analysis of the interventions below, where relevant. However, it was not applied to fugitive emissions from gas main pipelines, as these emissions are not expected to be influenced by changes in North Sea production.

Although gas consumption is likely to decline between 2020 and 2030, we do not anticipate any complete decommissioning of gas networks during this period. Gas will continue to flow through the pipelines and leaks will still occur.

6. Leak detection and repair

We identified specific activities across the oil and gas sector responsible for fugitive emissions which could be reduced from employing Leak Detection and Repair measures (LDAR), using the EEA air pollutant emission inventory as a guide to identifying and classifying each activity.

As such, emissions from offshore well testing, abandoned offshore wells, gas distribution mains and flaring and venting were excluded for this intervention which focuses on LDAR in upstream oil and gas production.

We used the assumption that under a continuous LDAR scenario, 90 per cent of fugitive emissions from leaks would be abated, based on the research from Ravikumar et al, 2020.

The potential of this measure is **4.3ktCH_4**, or 1.8 per cent of energy sector methane emissions.

7. End routine venting and flaring

According to the North Sea Transition Authority's 2024 emissions monitoring report, **50 per cent** of all venting and flaring from oil and gas facilities is considered 'routine'. We took the assumption that 50 per cent of all venting and flaring emissions from oil and gas facilities could be abated by ending routine venting and flaring by 2030.

The IEA has shown that technologies already exist to significantly reduce emissions from venting and flaring. One of the most effective is the installation of vapour recovery units in upstream oil production, which capture gas that accumulates in storage tanks and would otherwise be periodically vented to the atmosphere to prevent explosions.

This could save **5.7ktCH_4**, or 2.4 per cent of energy sector methane emissions.

8. Accelerate gas mains replacement completion by 2030

According to the UK's methane memorandum, replacing gas mains with plastic piping (rather than the current lead pipes, which have a high leakage potential) is expected to reduce methane emissions from gas distribution by **66 per cent** by 2032, relative to a 2014 baseline. Assuming that this replacement programme could be accelerated to complete by 2030, the reduction in emissions was estimated by calculating the difference between the volume of gas leaked from natural gas supplied in 2020 and the projected methane emissions from gas distribution in 2032. The latter was assumed to be 66 per cent lower than the 2014 estimate for distribution system leakage, based on data from the NAEI.

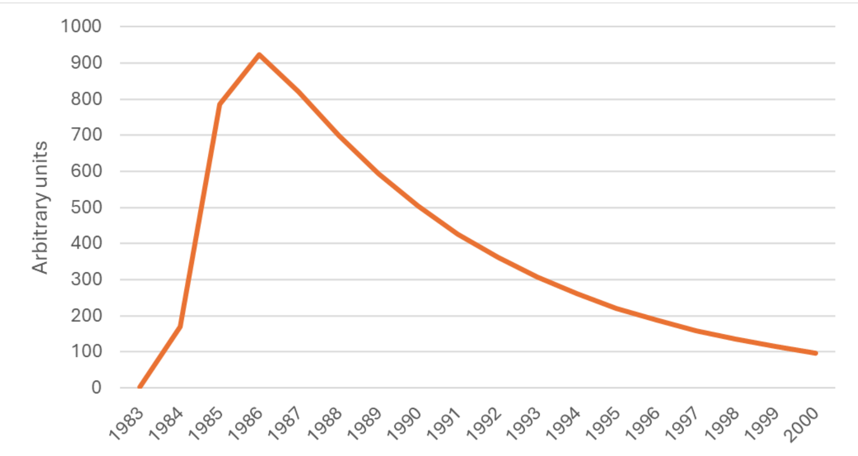
The result is that **75.6ktCH_4** could be saved by this measure, which is 35 per cent of the energy sector methane emissions in 2020.

Interventions in waste

For this sector we focused on the methane emissions from landfills. To estimate the potential of different policy interventions, we built an Excel model of the behaviour of methane emissions from landfills following the varying mass of waste disposals and different effective landfill gas capture rates.

This model used an exponential decay curve for waste disposed in any given year, as the material for anaerobic decay decreases with time. In addition, we included a delay using an s-curve for the first three to four years after disposal, as per the behaviour described in figure 2.3 of the World Bank ESMAP handbook for the preparation of landfill gas to energy projects in Latin America and the Caribbean.

Modelled behaviour of methane generation for a single year of waste disposal in 1982



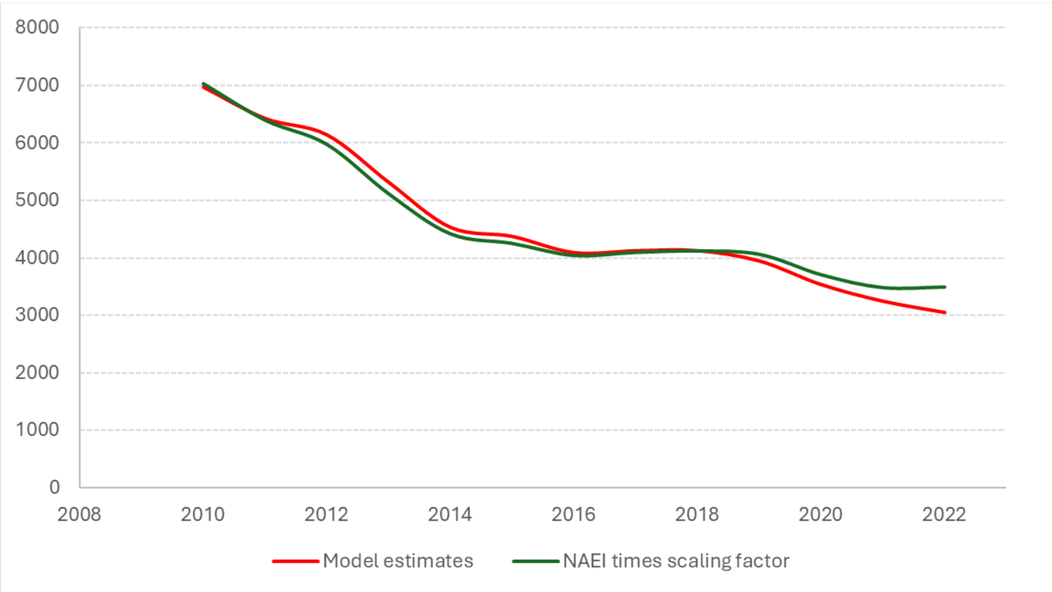
The s-curve has the formula $\frac{1}{(1+e^{-2(t-2)})^3}$ where t is the time since the waste was deposited, in years.

The exponential decay curve has the formula $M(e^{-\lambda(t-1)} - e^{-\lambda t})$ where M is the mass of waste deposited, t is the time in years since the waste was deposited, and λ is the decay constant = 0.165.

The decay constant was discovered through a trial and error approach. Modelled methane emissions were generated using different decay constants and compared against published waste sector methane emissions from the NAEI, after applying a landfill gas capture fraction and scaling by an arbitrary scaling factor of 7.2, to best match the arbitrary units of the model with the published emissions records (this is essentially an estimate of the scaling factor between mass of waste entering landfill in and the mass of methane emitted).

As the analysis focuses solely on percentage changes in methane emissions, relative to a 2020 baseline, the use of arbitrary units does not affect the outcomes. Despite the simplicity of this model, a reasonably good fit to the observed data was achieved.

Comparison between modelled methane emissions and NAEI data



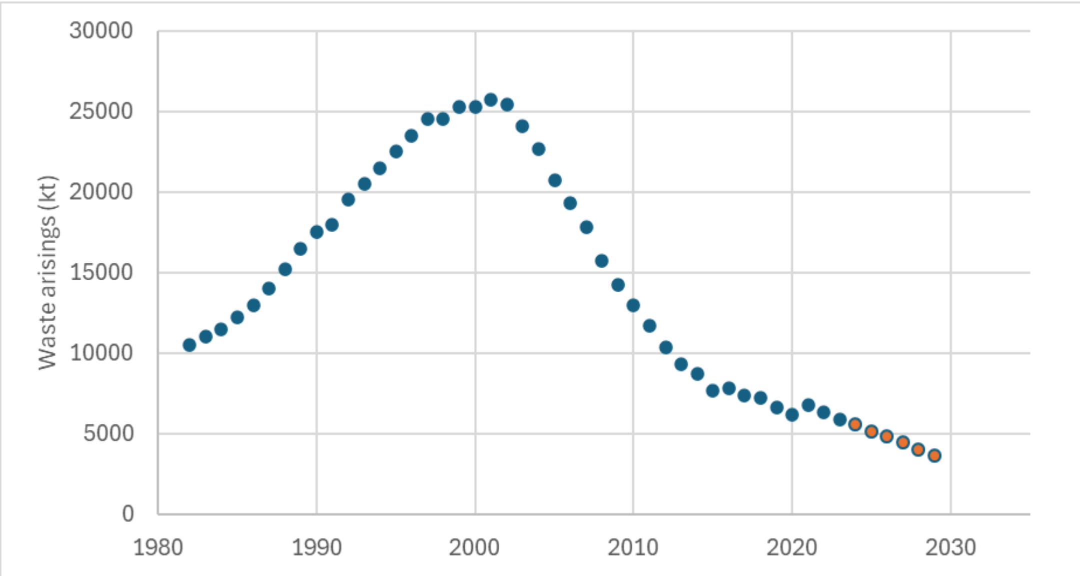
The effective capture rates of landfill gas in each year were taken from table A3.5.4 of the [UK GHG inventory annexes](). Methane generation in any given year was calculated as the sum of methane generated from all previous years, adjusted by the fraction remaining after accounting for landfill gas capture.

We extended the model backwards to include waste disposed of in 1982. As per the model, by 2020 waste from the early 1980s was having very little impact on emissions. Estimates for mass of waste sent to landfill are less accurate pre-1980, so we did not generate data going back any further.

The model must be supplied with estimates for mass of waste disposed of in each year. The waste arisings from 1982 to 1994 were estimated by a backwards extension of the 1995-2000 trend, taking account of GDP trends over that period. The arisings from 1995 to 2009 were estimated by backwards extension of the 2010 recorded arisings, following the trend seen in figure 1 of C Fletcher et al, 2018. The arisings from 2010 to 2022 were the recorded Biodegradable Municipal Waste (BMW) to landfill, taken from table 2 (BMW to landfill) of the UK statistics on waste 2024 dataset.

We projected the mass of waste going to landfill through to 2030, assuming it followed the existing decline seen in recent years, but with no implementation of an outright ban on biodegradable waste.

Known, estimated and projected mass of waste sent to landfill



In this model, we projected that landfill gas capture rates will decline from 2027 onwards, as Renewables Obligation subsidies disappear and landfill operators switch to flaring instead. As we explore in our briefing, the lost incentive for generating renewable electricity from landfill gas is likely to lead to a significant drop in capture rates. The average rate could fall by ten percentage points, to 48 per cent, by 2030.

Although this model is simple, it allows us to predict the impacts of interventions which interact with each other, by adjusting both the mass of waste entering landfills and the landfill gas capture rate.

The base case model predicted that, because of existing policies which are driving down the mass of waste entering landfills, by 2030 there will be a reduction of **160ktCH_4**, or 25 per cent of 2020 waste sector methane emissions.

9. Near elimination of organic waste entering landfills from 2028

To analyse this intervention, we adjusted the mass of waste entering landfills in the years 2028 and 2029 in our model. We assumed that the mass of biodegradable waste landfilled will drop to 1,000 kt in 2028 and to 200 kt in 2029. Rather than zero, we assumed a very small amount of biodegradable waste would still enter landfills, perhaps in regions where alternative routes are scarce, or in the event of major disruptions occurring in the livestock sector.

The impact of a landfill ban in 2028 is minimal in 2030 due to the s-curve delay in methane generation from newly deposited waste. The estimated saving is **3.7ktCH_4**, or 0.6 per cent of 2020 waste sector methane emissions.

10. Maintain capture rates at 58 per cent and ban organic waste from 2028

Instead of allowing landfill gas capture rates to fall, if subsidies were maintained at sufficient levels to continue capturing 58 per cent of landfill gas, alongside introducing the planned 2028 ban on organic waste entering landfill, our model estimated that a total of **71.3ktCH_4** could be saved, on top of the baseline scenario. This represents an effective additional saving of 11.3 per cent of 2020 waste sector methane emissions.

Note that this scenario is not discussed in our report, to avoid readers imagining that such savings could be achieved on top of the savings available for the intervention outlined below (in effect, the potential savings could be one of the other, but not both).

11. Increase capture rates to 80 per cent and ban organic waste from 2028

If the average landfill gas capture rate could be increased to 80 per cent across all landfill sites and the 2028 ban is implemented, our model estimated that 220ktCH_4 could be saved, on top of the baseline scenario. The effective impact of such policy interventions would then be 34.8 per cent of 2020 waste sector methane emissions.

For more information, contact Liam Hardy or Matilda Dunn