climate change
Scotland's centre of expertise connecting climate change research and policy

Implementing Scotland's landfill ban

Jack Stevens, Rachel Espinosa, Adi Prasad, Ricardo Energy & Environment
January 2022

http://dx.doi.org/10.7488/era/1777

Executive summary

Context

The Scottish Government has committed to ending the practice of landfilling biodegradable municipal waste (BMW) by 2025, in line with recommendations from the Climate Change Committee (CCC). The waste sector accounts for approximately 4% of Scotland's greenhouse gas (GHG) emissions,[1] with the degradation of biodegradable waste to landfill accounting for a large proportion of the waste treatment sector's GHG emissions.

The CCC also recommended that the ban on sending BMW to landfill be extended to include all biodegradable waste generated from non-municipal sources. In response to these recommendations, the Scottish Government has committed to extending the forthcoming ban on disposing of BMW to landfill to include biodegradable non-municipal wastes (BNMW). This is, however, subject to appropriate consultation and additional work to provide assurance around some specific waste streams[2].

The Scottish Government is working with local authorities to secure alternative treatment options for wastes encompassed by the ban. Effective delivery planning is required to ensure that residual waste treatment capacity is matched to the waste supply. This assessment considers the national residual waste capacity requirements to inform such delivery planning.

Research objectives

The project provides:

- An assessment of whether there is likely to be a gap in the capacity of facilities available within Scotland to treat Scotland's BMW in 2025 when the ban is implemented.
- A high-level summary of the impact of including BNMW within the ban.

[1] Scottish Government, greenhouse gas emissions 2018: estimates
[2] Scottish Government, securing a green recovery on a path to net zero: climate change plan 2018-2032 - update

- Potentially available options to deliver the ban, should a capacity gap be identified.
- Analysis of the impact on Scotland's GHG emissions with the BMW ban and the extended BNMW ban.
- An analysis of the likely calorific value (CV) of residual waste in 2025 under appropriate scenarios.

Three scenarios were modelled:

- **Scenario 1: Baseline** – where current performance would continue as 'business as usual'.
- **Scenario 2: Approaching targets** – where performance is improved beyond business as usual but only reaches half-way to the targets.
- **Scenario 3: Achieving targets** – where all applicable waste performance targets are met.[3]

Each scenario was broken down further into two (e.g., Scenario 1a and 1b) to allow for comparative analysis between the BMW and the extended BNMW landfill ban under the different scenarios.

Key findings

Capacity

A summary of the required capacity in 2025 for the materials within the scope of the BMW ('a' scenarios) and extended BNMW ('b' scenarios) landfill bans is shown in Table A.

Table A: Capacity summary in 2025 (in million tonnes)

2025 Capacity Summary	Baseline		Approaching Targets		Achieving Targets	
	Scenario 1a	Scenario 1b	Scenario 2a	Scenario 2b	Scenario 3a	Scenario 3b
Materials within scope of the landfill ban	0.61 Mt	0.66 Mt	0.13 Mt	0.18 Mt	-0.48 Mt	-0.43 Mt

Note: Positive values equate to a gap in treatment capacity and negative values equate to overcapacity and excess treatment capacity.

The treatment capacity needed to deliver compliance with the landfill ban largely depends upon the success of achieving the policy targets set by the Scottish Government. This ultimately impacts on the final quantities of waste needing diversion from landfill and treatment in 2025.

- A baseline/ 'business as usual' scenario (Scenario 1) results in a large gap in current and planned treatment capacity to deliver the BMW landfill ban (0.61 Mt) in 2025. This is exacerbated under the extended BNMW landfill ban (0.66 Mt) as more material is required to be diverted from landfill to alternative treatment facilities.

[3] Scottish Government, Managing Waste

- Under an approaching targets scenario (Scenario 2), there is still an estimated capacity gap in 2025 under the BMW landfill ban (0.13 Mt), which increases (to 0.18 Mt) under the extended BNMW waste landfill ban.
- In the scenario where all policy targets are achieved (Scenario 3), there is an estimated overcapacity due to the high impact of waste reduction measures on total waste requiring management. This results in a surplus treatment capacity (-0.48 Mt) in 2025 for the materials within the scope of the BMW landfill ban. This surplus treatment capacity reduces slightly (-0.43 Mt) under the extended BNMW landfill ban.

The extended BNMW landfill ban results in approximately 0.05 Mt of additional treatment capacity being required by 2025. The inclusion of this additional material, therefore, does not have a significant impact upon the capacity requirements when considered at a high level within this assessment.

In the scenarios where a capacity gap has been identified, the potential options to ensure compliance with the landfill ban could involve the development of further waste treatment infrastructure in Scotland or utilising capacity in different geographies whilst facilities are being developed.

Carbon modelling

Carbon modelling of the scenarios shows that the most significant reduction in carbon emissions results from increased contributions to waste reduction and recycling. It also shows that there are minor additional carbon emission savings expected from the inclusion of BNMW within the extended landfill ban. As extra efforts are made to divert materials from becoming waste in the first place, and with increased recycling, Scenario 3 results in the greatest carbon savings.

Calorific value

Calorific Value (CV) modelling showed an estimated marginal fluctuation in CV changes by 2025. However, as the analysis has been undertaken at a high level, more in-depth analysis is recommended to understand the impact of removing individual waste types for alternative or more specialist treatment. This could also include quantifying other potential influencing factors on waste composition such as, for example, the impact of Deposit Return Systems (DRS) and other policy initiatives.

Recommendations

The main recommendations are:

- Further investigation is recommended for individual waste types included within the scope of the BMW and BNMW landfill ban that may require specialist treatment. The resulting tonnage which may require specialist treatment should then be compared to the resulting waste quantities and treatment capacity requirements under each scenario.
- As more up-to-date data is released, close attention should be given to the progress in working towards the Scottish Government's policy targets to establish which of the scenarios presented is to be most likely in 2025.
- Close attention needs to be given to the current operational infrastructure post-2025, particularly those facilities nearing the end of their lifespan. This is to ensure that there is no unexpected drop-off in treatment capacity without sufficient planning to ensure pipeline facilities or other interim options (in the case of planned upgrade works) can pick up the capacity requirements.

- Potential 'buffer' or spare capacity may be required for any periods of planned or unplanned downtime at treatment facilities or unexpected changes in waste quantities.
- Further analysis is recommended to understand the impact of removing some waste types for alternative or more specialist treatment. This could also include other policy initiatives which may impact upon waste composition, such as DRS.

Contents

Glossary

Abbreviation	Definition
ATT	Advanced Thermal Treatment
BMW	Biodegradable Municipal Waste
BNMW	Biodegradable Non-Municipal Waste
CCC	Climate Change Committee
C&I	Commercial and Industrial
CV	Calorific Value
EfW	Energy from Waste
GDP	Gross Domestic Product
MBT	Mechanical Biological Treatment
MBT/Bio	Mechanical Biological Treatment with Biostabilisation (where the biostabilised output is destined for landfill)
MBT/RDF	Mechanical Biological Treatment with Refuse Derived Fuel (where a portion of the waste treated is diverted for use as RDF)
MSW	Municipal Solid Waste
Mt	Million Tonnes
RDF	Refuse Derived Fuel
RRC	Reuse, Recycling, Composting
SEPA	Scottish Environmental Protection Agency
SCM	Scottish Carbon Metric
ZWS	Zero Waste Scotland

1 Introduction

The Scottish Government has committed to ending the practice of landfilling biodegradable municipal waste (BMW) by the end of 2025, in line with recommendations from the Climate Change Committee (CCC). The waste sector accounts for approximately 4% of Scotland's greenhouse gas (GHG) emissions,[4] with the degradation of biodegradable waste sent to landfill accounting for a large proportion of the waste treatment sector's GHG emissions.

In addition, the CCC recommended that the ban on sending BMW to landfill should be extended to include all biodegradable waste. In response to these recommendations, the Scottish Government has committed to extending the forthcoming ban on sending BMW to landfill to include biodegradable non-municipal wastes (BNMW). This is, however, subject to appropriate consultation and additional work to provide assurance around some specific waste streams[5].

The Scottish Government is working with local authorities to secure alternative treatment options for wastes encompassed by the ban. Effective delivery planning is required to ensure that residual waste treatment capacity is matched to the waste supply. This assessment, therefore, aims to assess the national residual waste capacity requirements to inform delivery planning.

1.1 Project aims and scope

This project provides:

- An assessment of whether there is likely to be a gap in the capacity of facilities available within Scotland to treat Scotland's BMW in 2025 when the ban is implemented.
- A high-level summary of the impact of including BNMW within the 2025 ban.
- Potential available options to deliver the ban, should a capacity gap be identified.
- Analysis of the impact on Scotland's GHG emissions with the BMW ban and the extended BNMW ban.
- An analysis of the likely calorific value (CV) of residual waste in 2025 under appropriate scenarios.

2 Modelling approach

The modelling undertaken for this project was broken down into a four-stage approach which is outlined below, with further detail on each item provided within the following sections.

- Waste forecasting – examining how waste arisings may change in the future under different scenarios.
- Capacity gap modelling – examining how much waste is recycled and composted and, for the remaining waste quantities, how the available treatment infrastructure (current and planned) compares to these projected remaining waste quantities.
- Carbon modelling – examining the impacts of the modelled scenarios with relation to their associated carbon footprints.

[4] Scottish Government, greenhouse gas emissions 2018: estimates
[5] Scottish Government, securing a green recovery on a path to net zero: climate change plan 2018-2032 - update

- Calorific value modelling – examining the calorific value of the remaining residual waste under the modelled scenarios.

The approach is similar to that used in the Waste Markets Study[6] undertaken in 2018, which used 2016-2017 waste data to forecast future waste arisings, recycling and residual waste quantities. Whereas the previous Waste Markets Study examined exports to energy from waste (EfW) facilities and landfills outside Scotland, this report focuses on Scotland managing all its waste within Scotland. Additionally, this report uses more recent data (2018 data) and does not examine the opportunities and costs related to exporting Refuse-Derived Fuel (RDF), but it does consider the carbon implications of the modelling and examines the CV changes of the residual waste.

2.1 Modelled scenarios

Through discussion with the project steering group, the following scenarios were modelled:

- **Scenario 1: Baseline** – where current performance would continue as 'business as usual'.
- **Scenario 2: Approaching targets** – where performance is improved beyond business as usual but only reaches half-way to the targets.
- **Scenario 3: Achieving targets –** where all applicable waste performance targets are met.[7]

Each scenario was broken down further into two (e.g., Scenario 1a and 1b etc.) to allow for comparative analysis between the BMW and the extended BNMW landfill ban under the different scenarios. Table 1 outlines the details and key assumptions within each of these scenarios.

The Scottish Government's waste reduction and recycling targets encompass all three major waste sources (household, commercial and industrial (C&I), and construction and demolition (C&D)). This project focused only on Household and C&I waste for two reasons:

a) C&D waste is low in biodegradable content, which was the focus of this project.
b) C&D waste historically has very high recycling rates compared with Household and C&I waste.

Therefore, the modelling has sought to reach overall recycling targets without "assistance" from C&D recycling contributing to the overall recycling rates. This means that if C&D recycling is included, Scenarios 2 and 3 would likely exceed the predictions in this report.

[6] Scottish Government, Waste Markets Study, Full Report
[7] Scottish Government, Managing Waste

Table 1: Modelled scenario assumptions

	Baseline		Approaching targets		Achieving targets	
	Scenario 1a	**Scenario 1b**	**Scenario 2a**	**Scenario 2b**	**Scenario 3a**	**Scenario 3b**
Total waste arisings	No waste reduction, arisings follow the growth assumptions in section 0		Reduction in total waste arisings by 7.5% (compared to 2011 levels) by 2025		Reduction in total arisings by 15% (compared to 2011 levels) by 2025	
Food waste arisings	No food waste reduction target applied, follow the 'total arisings' trend		Reduction in food waste by 16.5% (compared to 2013 levels) by 2025		Reduction in food waste by 33% (compared to 2013 levels) by 2025	
Recycling and Composting	Recycling rate remains at current level (48.6% across household and C&I)		Recycle 59% of remaining waste by 2025		Recycle 70% of all remaining waste by 2025	
Waste to landfill	Current proportion of waste to landfill (36.7%) continues	Current proportion of waste to landfill (36.7%) continues	No more than 16-18% of remaining waste to landfill; diversion of all BMW from landfill (BMW landfill ban) by 2025	No more than 16-18% of remaining waste to landfill; diversion of all BMW and BNMW from landfill (extended BNMW waste ban) by 2025.	No more than 5% of remaining waste to landfill; diversion of all BMW from landfill (BMW landfill ban) by 2025	No more than 5% of remaining waste to landfill; diversion of all BMW and BNMW from landfill (extended BNMW waste ban) by 2025

3 Waste forecasting and capacity analysis

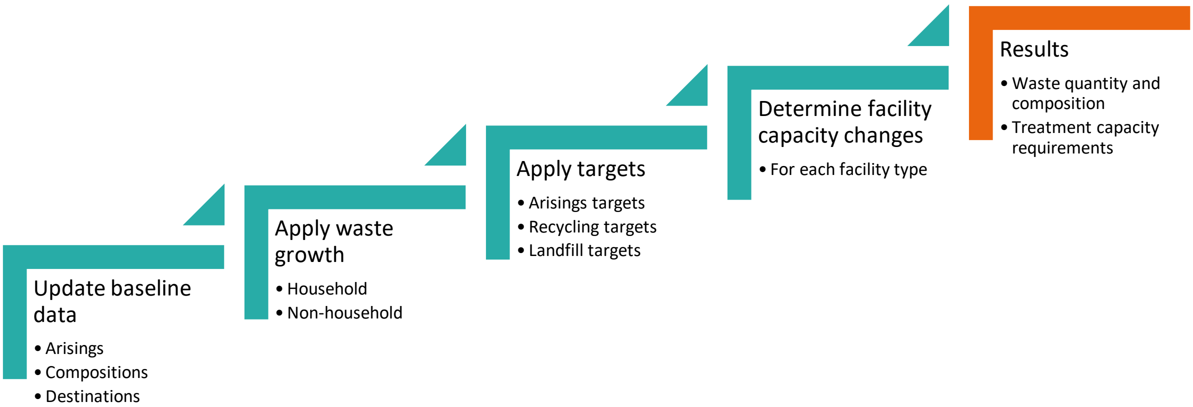
3.1 Modelling approach

For the waste forecasting and capacity modelling, Ricardo utilised an existing Residual Waste Model previously developed for the Scottish Government in 2015. This approach was undertaken as the model has already been verified and validated by the Scottish Government and provided trusted results.

The waste forecasting and capacity modelling approach is summarised in Figure 1. The existing model was updated with the latest available data, which relates to 2018[8], and is referred to as the 'baseline' year throughout this report. The relevant waste growth rates were then updated and applied to the baseline data. More detail is provided on these in Section 4.2.

Following the update to the baseline waste quantities and assumptions, a new component was added to the model to progress towards the waste targets outlined in Scenarios 2 and 3. Additionally, facility capacity information (facility type, status, year of commissioning, throughput capacity etc.) was reviewed and updated. More detail is provided in Section 4.3.

Figure 1: Waste Forecasting and Capacity Gap Modelling Approach



3.2 Data and assumptions

The existing Residual Waste Model relies upon numerous data sources and assumptions. These are provided in more detail in Appendix 1 with a summary below.

Waste arisings and recycling data was provided by SEPA, and growth assumptions were applied to the baseline year to examine changes in the years prior to the implementation of the ban (2018 to 2025). Following this, calculations were applied to consider the impacts of moving towards Scotland's waste reduction and recycling targets as per the details within each scenario listed in Table 1. SEPA provided guidance on the materials that would be included within the scope of each ban (BMW and BNMW) under its material categories. The projected waste quantities combined with the results of the infrastructure landscape research (Section 4.3) allowed for the comparison as to whether there would be sufficient treatment capacity when compared to the total residual waste quantities which have been presented in charts.

[8] It is acknowledged that 2019 data has become available after the analysis for this report was undertaken.

3.3 Infrastructure landscape

3.3.1 Approach

In addition to quantifying potential future waste tonnages under the different scenarios, an equally important task was to establish the available infrastructure treatment capacity. When overlaid with the waste quantities this allowed for analysis to determine whether a capacity gap might exist, where there is insufficient treatment capacity, when the ban is due to be implemented, or whether there is potential for there to be excess treatment capacity.

To identify suitable facilities, Ricardo utilised its own FALCON (Facilities, Arisings, Location, Contracts) database in addition to publicly available data and discussions with the steering group. To model the treatment capacity for each facility, the quantities of waste received at each facility were compared to the consented capacity, refined in discussion with the steering group. This enabled modelling of the true operational capacity of each facility. Whilst the total waste quantities a facility can accept will be consented through the planning and permitting process, the true throughput or processing capability of the facility may differ. This approach was therefore taken as a conservative approach to try and reflect the true operational capacity of the identified facilities.

Assumptions were also made relating to the lifespan of each facility from its first operational date. These assumptions are outlined in Table 2.

Table 2: Assumed lifespan of treatment facilities by technology type

Technology Type	Estimated Lifespan (Years)
Advanced Thermal Treatment (ATT)	20
Energy from Waste (EfW)	40
Mechanical Biological Treatment (MBT)	30

Within the study period of interest, to 2025 no current operational facilities are expected to close based upon the lifespan assumptions in Table 2. However, consideration will need to be given to aging infrastructure which could close or become unavailable in the future. This could be due to the need to modify and update equipment to ensure process efficiency and cost effectiveness, whilst also ensuring compliance with the latest regulatory requirements. Any alterations that could result in the closure or changes in a facility's size and capacity will need to be considered alongside new pipeline infrastructure potentially becoming available.

3.3.2 Operational facilities

A total of 12 operational facilities were identified which are currently managing these waste types. This includes MBT which is a pre-treatment operation with the resulting output from the facility requiring further treatment/disposal. The facilities are listed in Appendix 3.

The total modelled capacity of these facilities is approximately 1.32 Mt per year.

3.3.3 Pipeline facilities

Pipeline facilities within the development stage were also considered. Should these progress to completion and commercial operation, they could potentially change the infrastructure landscape.

Discussions with the steering group helped identify the facilities most likely to become operational by 2025. A total of 3 additional facilities were assumed to become operational by this date and these are outlined in Appendix 4. These would result in approximately 0.45 Mt per year of additional treatment capacity. These facilities are 'relatively secure' in the pipeline as they are already within the stages of construction or commissioning at the time of writing. However, it is still possible for delays to occur during the later stages of project development which could still impact upon pipeline infrastructure becoming operational. The modelled capacity for each facility was taken as 95% of the stated capacity, to factor in facilities ramping up to full operation and potentially becoming operational midway through the year. The modelled capacity was set at 50% for its first operational year, with 95% of the stated capacity modelled thereafter.

There are several other pipeline infrastructure projects within the early stages of development that have not yet reached key project milestones such as the start of construction. Whilst the analysis has focussed upon 2025, there is still the potential for additional infrastructure to be developed after that date, should key project milestones be met to reach commercial operation. This is difficult to quantify as not all projects that are currently proposed, achieved planning and/or permit consent will make it through to commercial operation.

3.4 Capacity gap analysis results

The following charts within this section present the findings from the capacity gap analysis under the different scenarios outlined.

The plotted lines on the charts show the remaining waste quantities from the baseline year in 2018 after reuse, recycling and composting (RRC) rates have been applied as summarised in Table 3.

Table 3: Baseline Waste Quantities, 2018

Baseline waste quantities (2018)	BMW landfill ban (Scenarios 1a, 2a, 3a)	Extended BNMW landfill ban (Scenarios 1b, 2b, 3b)
Total waste quantities	2.52 Mt	2.52 Mt
Waste quantities included within the scope of the ban	2.29 Mt	2.33 Mt
Waste quantities not included within the scope of the ban	0.24 Mt	0.19 Mt

The remaining baseline waste quantities are then projected into the future under the different scenario assumptions to establish what the remaining waste quantities may be when the ban is due to be implemented in 2025. The waste projections are plotted as a line on the following charts described below:

- Blue line – showing the overall remaining total waste quantities.
- Red line – this includes the waste quantities included within the scope of the BMW or extended BNMW landfill ban.

The resulting gap between the blue and red lines described above on the charts will be the resulting materials not included within the scope of the ban.

The stacked columns on the charts show the total infrastructure capacity to treat these wastes, with the colour of column indicating the different facility and technology types. Pipeline infrastructure is then phased to come online at the predicted operational date. The predicted infrastructure capacity is consistent across all the scenarios.

Where the plotted lines exceed the top of the stacked columns and infrastructure capacity, marked on the charts as a dashed column, waste quantities are forecast to be greater than available infrastructure capacity (i.e., an estimated capacity gap). Where the plotted lines cut across the stacked columns and infrastructure capacity this indicates a potential surplus in treatment capacity.

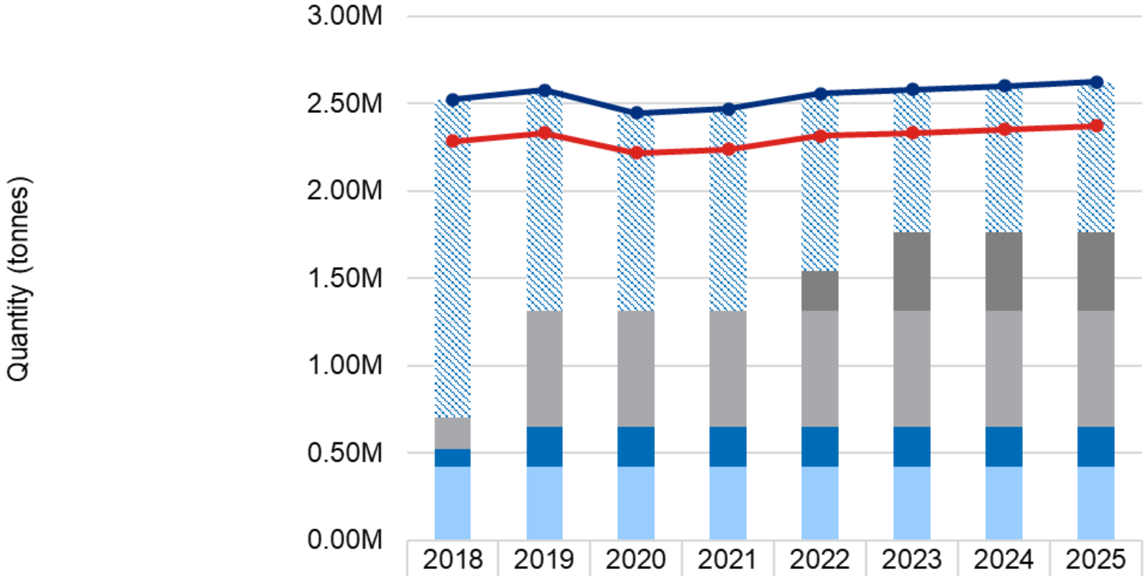
Landfill capacity has not been included within the charts. Therefore, in prior years (such as the baseline in 2018) the capacity gap noted would have likely resulted in most of these waste quantities being disposed of to landfill, with some smaller quantities being exported. In 2025, some waste quantities not included within the scope of the ban will, from a legislative point of view, still be able to be sent to landfill.

3.4.1 Scenario 1a and 1b – Baseline

Scenario 1a assumes that Scotland continues at its current performance levels and alongside the BMW landfill ban, with the results shown in

2. The baseline total waste quantities are estimated to increase to approximately 2.63 Mt in 2025. The materials included within the scope of the BMW landfill ban are also expected to increase from the baseline to 2.37 Mt in 2025. This is due to the increase in waste growth and stagnation of recycling rates as outlined within the scenario assumptions in Table 1.

Figure 2: Capacity gap analysis - Scenario 1a results (in tonnes)



	2018	2019	2020	2021	2022	2023	2024	2025
Capacity Gap: Materials inc. in BMW ban	1.58M	1.02M	0.91M	0.93M	0.78M	0.57M	0.59M	0.61M
Capacity Gap: Total Waste Quantities	1.82M	1.27M	1.13M	1.16M	1.02M	0.81M	0.84M	0.86M
EfW Pipeline Capacity	0.00M	0.00M	0.00M	0.00M	0.23M	0.45M	0.45M	0.45M
EfW Operational Capacity	0.18M	0.67M	0.67M	0.67M	0.67M	0.67M	0.67M	0.67M
ATT Capacity	0.10M	0.23M	0.23M	0.23M	0.23M	0.23M	0.23M	0.23M
MBT Capacity	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M
Total Waste Quantities	2.52M	2.58M	2.45M	2.47M	2.56M	2.58M	2.60M	2.63M
Materials inc. in BMW ban	2.29M	2.33M	2.22M	2.24M	2.32M	2.33M	2.35M	2.37M

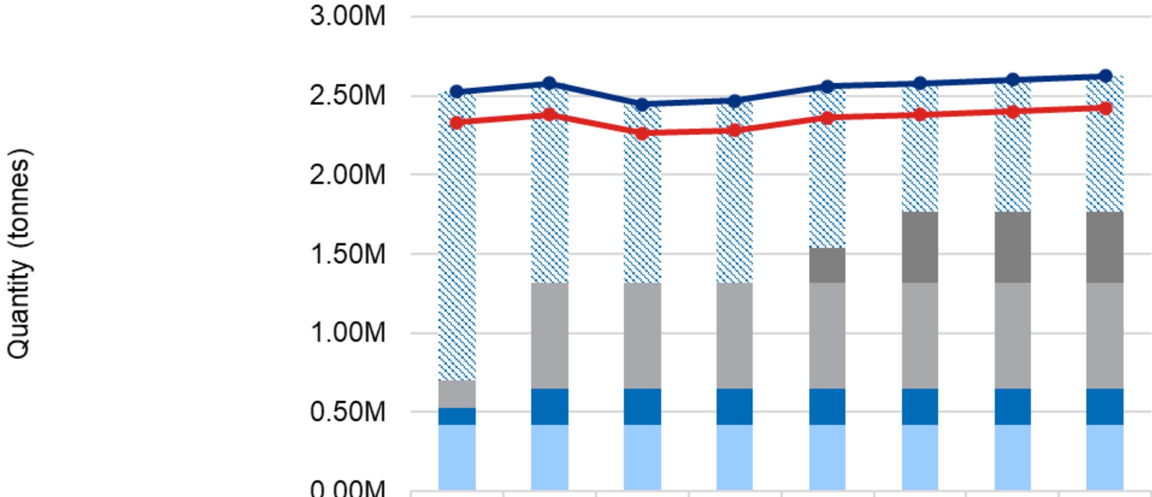
Under this scenario, the results indicate that a capacity gap will be evident when the ban is implemented in 2025. This capacity gap equates to:

- Approximately 0.61 Mt when considering the materials included within the scope of the BMW landfill ban.
- Approximately 0.86 Mt when considering the total waste quantities. However, this will include materials not included within the scope of the BMW landfill ban which, from a legislative perspective, could be sent to landfill.

This capacity gap is still evident in 2025, despite pipeline infrastructure due to become operational and phased in from 2022.

Scenario 1b assumes that Scotland continues with its current performance but alongside the extended BNMW landfill ban, with the results shown in Figure 3. The total waste quantities are the same in 2025 when compared to scenario 1a, although the materials included within the extended BNMW landfill ban have increased. This is an approximate increase of 0.05 Mt in 2025 which have increased over the projected period to approximately 2.42 Mt.

Figure 3: Capacity gap analysis - Scenario 1b results (in tonnes)



	2018	2019	2020	2021	2022	2023	2024	2025
Capacity Gap: Materials inc. in extended BNMW ban	1.63M	1.07M	0.95M	0.97M	0.82M	0.62M	0.64M	0.66M
Capacity Gap: Total Waste Quantities	1.82M	1.27M	1.13M	1.16M	1.02M	0.81M	0.84M	0.86M
EfW Pipeline Capacity	0.00M	0.00M	0.00M	0.00M	0.23M	0.45M	0.45M	0.45M
EfW Operational Capacity	0.18M	0.67M	0.67M	0.67M	0.67M	0.67M	0.67M	0.67M
ATT Capacity	0.10M	0.23M	0.23M	0.23M	0.23M	0.23M	0.23M	0.23M
MBT Capacity	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M
Total Waste Quantities	2.52M	2.58M	2.45M	2.47M	2.56M	2.58M	2.60M	2.63M
Materials inc. in extended BNMW ban	2.33M	2.38M	2.26M	2.28M	2.36M	2.38M	2.40M	2.42M

Under this scenario a capacity gap still exists and equates to:

- Approximately 0.66 Mt when considering the materials included within the scope of the extended BNMW landfill ban.
- Approximately 0.86 Mt when considering the total waste quantities.

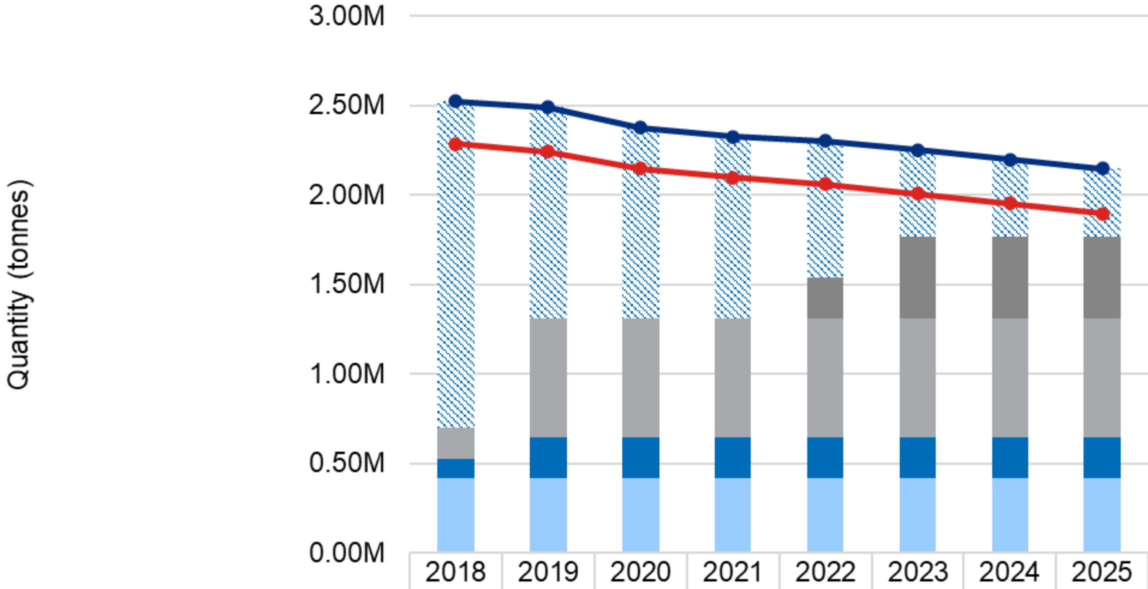
The capacity gap has increased slightly in 2025 when considering the materials included within the scope of the extended BNMW landfill ban when compared to scenario 1a. This is because more material is included within the scope of the ban and thus requiring diversion from landfill and alternative treatment.

Therefore, under scenario 1 and both the BMW and extended BNMW landfill bans, alternative treatment options would be required to allow compliance with the ban in 2025. The potential options for this are discussed within the conclusions in Section 4.5.

3.4.2 Scenario 2a and 2b – Approaching targets

Scenario 2a assumes that Scotland approaches its policy targets but only half-way to achieving them and alongside the BMW landfill ban, with the results shown in Figure 4. The total waste quantities from the baseline year decrease to approximately 2.15 Mt and approximately 1.90 Mt for the materials within the scope of the BMW landfill ban. This reduction is due to the waste reduction and increased recycling targets impacting on the remaining waste quantities.

Figure 4: Capacity gap analysis - Scenario 2a results (in tonnes)



	2018	2019	2020	2021	2022	2023	2024	2025
Capacity Gap: Materials inc. in BMW ban	1.58M	0.93M	0.84M	0.78M	0.52M	0.24M	0.19M	0.13M
Capacity Gap: Total Waste Quantities	1.82M	1.18M	1.06M	1.01M	0.76M	0.49M	0.43M	0.38M
EfW Pipeline Capacity	0.00M	0.00M	0.00M	0.00M	0.23M	0.45M	0.45M	0.45M
EfW Operational Capacity	0.18M	0.67M	0.67M	0.67M	0.67M	0.67M	0.67M	0.67M
ATT Capacity	0.10M	0.23M	0.23M	0.23M	0.23M	0.23M	0.23M	0.23M
MBT Capacity	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M
Total Waste Quantities	2.52M	2.49M	2.38M	2.33M	2.30M	2.25M	2.20M	2.15M
Materials inc. in BMW ban	2.29M	2.24M	2.15M	2.10M	2.06M	2.01M	1.95M	1.90M

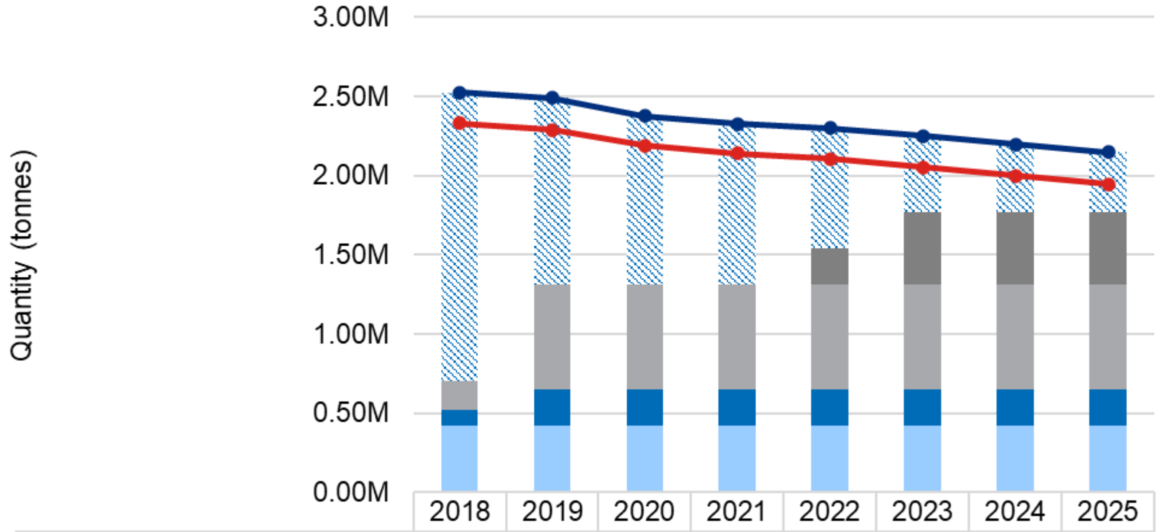
Under this scenario, despite a waste reduction being achieved when compared to scenario 1a, a capacity gap is still evident in 2025. This capacity gap equates to:

- Approximately 0.13 Mt when considering the materials included within the scope of the BMW landfill ban.
- Approximately 0.38 Mt when considering the total waste quantities.

Whilst this capacity gap is smaller when compared to the baseline in scenario 1a, alternative treatment options would still be required to allow compliance with the BMW ban in 2025.

Scenario 2b assumes that Scotland approaches its policy targets but only half-way to achieving them and alongside the extended BNMW landfill ban, with the results shown in Figure 5. The total waste quantities are the same in 2025 when compared to scenario 2a. However, the materials included within the extended ban have increased. This is again an approximate increase of 0.05 Mt in 2025 to approximately 1.95 Mt.

Figure 5: Capacity gap analysis – Scenario 2b results (in tonnes)



	2018	2019	2020	2021	2022	2023	2024	2025
Capacity Gap: Materials inc. in extended BNMW ban	1.63M	0.98M	0.88M	0.83M	0.57M	0.29M	0.23M	0.18M
Capacity Gap: Total Waste Quantities	1.82M	1.18M	1.06M	1.01M	0.76M	0.49M	0.43M	0.38M
EfW Pipeline Capacity	0.00M	0.00M	0.00M	0.00M	0.23M	0.45M	0.45M	0.45M
EfW Operational Capacity	0.18M	0.67M	0.67M	0.67M	0.67M	0.67M	0.67M	0.67M
ATT Capacity	0.10M	0.23M	0.23M	0.23M	0.23M	0.23M	0.23M	0.23M
MBT Capacity	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M
Total Waste Quantities	2.52M	2.49M	2.38M	2.33M	2.30M	2.25M	2.20M	2.15M
Materials inc. in extended BNMW ban	2.33M	2.29M	2.19M	2.14M	2.11M	2.05M	2.00M	1.95M

Under this scenario a capacity gap still exists and equates to:

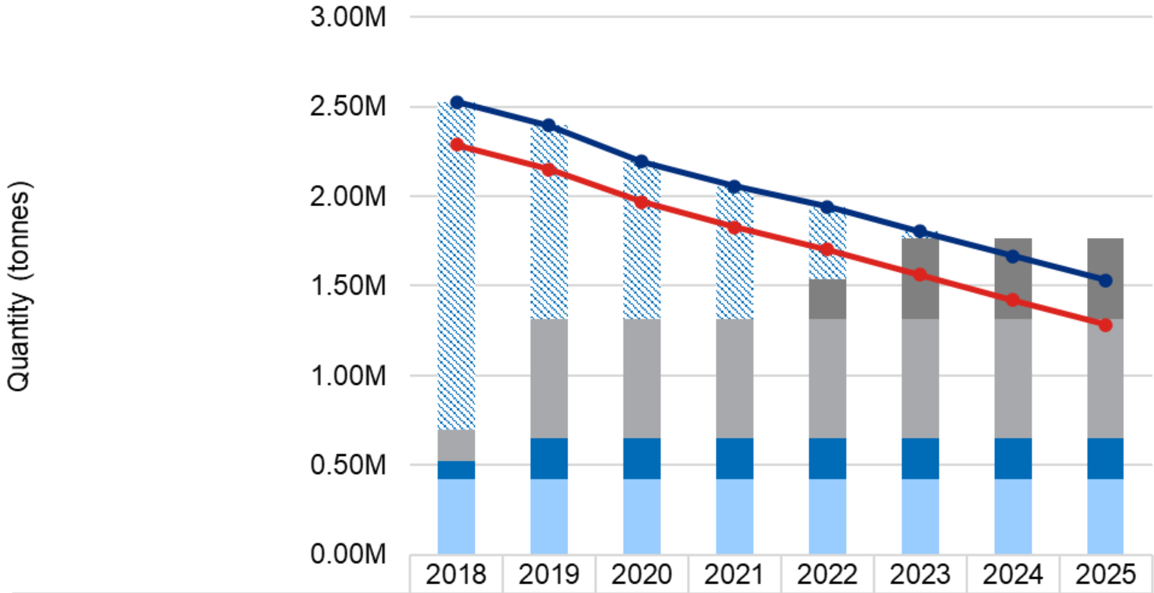
- Approximately 0.18 Mt when considering the materials included within the scope of the extended BNMW landfill ban.
- Approximately 0.38 Mt when considering the total waste quantities.

The capacity gap has increased slightly under this scenario as additional material is captured within the extended BNMW ban and thus requiring treatment.

3.4.3 Scenario 3a and 3b – Achieving targets

Scenario 3a models Scotland achieving all its policy targets alongside the current BMW landfill ban, with the results shown in Figure 66. The total waste quantities show a decrease from the baseline to approximately 1.53 Mt in 2025 within this scenario. This is as a result of achieving the waste reduction targets and increased recycling as outlined within the scenario assumptions. For the materials within the scope of the BMW ban, this decreases to approximately 1.28 Mt in 2025.

Figure 6: Capacity gap analysis - Scenario 3a results (in tonnes)



	2018	2019	2020	2021	2022	2023	2024	2025
Capacity Gap: Materials inc. in BMW ban	1.58M	0.84M	0.65M	0.51M	0.16M	-0.20M	-0.34M	-0.48M
Capacity Gap: Total Waste Quantities	1.82M	1.08M	0.88M	0.74M	0.40M	0.04M	-0.10M	-0.23M
EfW Pipeline Capacity	0.00M	0.00M	0.00M	0.00M	0.23M	0.45M	0.45M	0.45M
EfW Operational Capacity	0.18M	0.67M	0.67M	0.67M	0.67M	0.67M	0.67M	0.67M
ATT Capacity	0.10M	0.23M	0.23M	0.23M	0.23M	0.23M	0.23M	0.23M
MBT Capacity	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M
Total Waste Quantities	2.52M	2.40M	2.19M	2.06M	1.94M	1.80M	1.67M	1.53M
Materials inc. in BMW ban	2.29M	2.15M	1.97M	1.83M	1.70M	1.56M	1.42M	1.28M

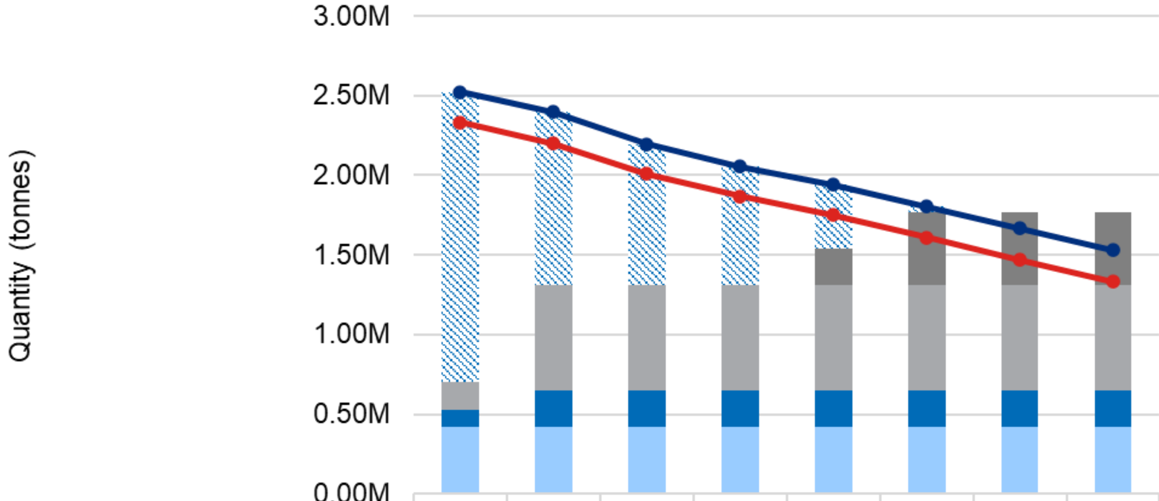
Under this scenario, a potential overcapacity is estimated (marked as negative values within Figure 6 and below) in 2025. This overcapacity equates to:

- Approximately -0.48 Mt when considering the materials included within the scope of the BMW landfill ban.
- Approximately -0.23 Mt when considering the total waste quantities.

Under this scenario where all policy targets are achieved, the results indicate that there would be surplus treatment capacity providing all pipeline treatment infrastructure becomes operational.

Scenario 3b assumes that Scotland achieves all its policy targets alongside the extended BNMW landfill ban, with the results shown in Figure 7. The total waste quantities decrease at the same rate outlined in scenario 3a when projected to 2025. However, with the increase in materials covered by the scope of the extended ban, there is an increase of approximately 0.05 Mt in additional material in 2025 which equates to approximately 1.33 Mt.

Figure 7: Capacity gap analysis - Scenario 3b results (in tonnes)



	2018	2019	2020	2021	2022	2023	2024	2025
Capacity Gap: Materials inc. in extended BNMW ban	1.63M	0.88M	0.70M	0.56M	0.21M	-0.16M	-0.30M	-0.43M
Capacity Gap: Total Waste Quantities	1.82M	1.08M	0.88M	0.74M	0.40M	0.04M	-0.10M	-0.23M
EfW Pipeline Capacity	0.00M	0.00M	0.00M	0.00M	0.23M	0.45M	0.45M	0.45M
EfW Operational Capacity	0.18M	0.67M	0.67M	0.67M	0.67M	0.67M	0.67M	0.67M
ATT Capacity	0.10M	0.23M	0.23M	0.23M	0.23M	0.23M	0.23M	0.23M
MBT Capacity	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M	0.42M
Total Waste Quantities	2.52M	2.40M	2.19M	2.06M	1.94M	1.80M	1.67M	1.53M
Materials inc. in extended BNMW ban	2.33M	2.20M	2.01M	1.87M	1.75M	1.61M	1.47M	1.33M

Under this scenario an overcapacity still exists in 2025 and equates to:

- Approximately -0.43 Mt when considering the materials included within the scope of the extended BNMW landfill ban.
- Approximately -0.23 Mt when considering the total waste quantities.

The modelled overcapacity has reduced slightly to approximately -0.43 Mt in 2025. This is due to the additional quantities of material needing to be diverted away from landfill under the extended BNMW landfill ban. However, under this scenario there is still an estimated surplus in treatment capacity to cover the extension of the ban. This is, however, reliant upon Scotland meeting all its policy targets as outlined within the scenario modelling assumptions of Table 1.

3.5 Capacity gap conclusions

A summary of the capacity requirements in 2025 for the materials within the scope of the BMW (scenarios 'a') and extended BNMW (scenarios 'b') landfill bans are shown in Table 4. The capacity requirements are also shown for the total waste quantities, which include materials that, from a legislative point of view, would still be able to be sent for landfill for which the landfill capacity has not been accounted for.

Table 4: Capacity summary in 2025 (in million tonnes)

2025 Capacity Summary	Baseline		Approaching Targets		Achieving Targets	
	Scenario 1a	Scenario 1b	Scenario 2a	Scenario 2b	Scenario 3a	Scenario 3b
Total waste quantities	0.86 Mt	0.86 Mt	0.38 Mt	0.38 Mt	-0.23 Mt	-0.23 Mt
Materials within scope of the ban	0.61 Mt	0.66 Mt	0.13 Mt	0.18 Mt	-0.48 Mt	-0.43 Mt

Note: Positive values equate to a gap in treatment capacity and negative values equate to overcapacity and excess treatment capacity.

The treatment capacity requirements needed to deliver compliance with the ban largely depend upon the success of achieving the policy targets set by the Scottish Government. This ultimately impacts on the final quantities of waste needing diversion from landfill and treatment in 2025. This is evident in Table 4, which highlights that a baseline scenario (scenario 1) results in a large capacity gap to deliver the BMW landfill ban (0.61 Mt) in 2025. This then increases under the extended BNMW landfill ban (0.66 Mt) as more material is required to be diverted from landfill to alternative treatments.

In the scenario where all policy targets are achieved (scenario 3), there is an estimated overcapacity due to the large impact on waste reduction measures which results in a surplus treatment capacity (-0.48 Mt) in 2025 for the materials within the scope of the BMW landfill ban. This surplus treatment capacity reduces slightly (-0.43 Mt) under the extended BNMW landfill ban as additional treatment capacity is taken up by the additional waste quantities included within the scope of the extended ban.

When approaching the policy targets at half-way (scenario 2), there is a capacity gap estimated for 2025 under the BMW landfill ban (0.13 Mt) which increases (0.18 Mt) under the extended BNMW landfill ban.

The progress towards these policy targets is therefore key to determine the future treatment capacity requirements.

The analysis is based upon 2018 data as the baseline for future projections. As more recent data becomes available, the situation should be reviewed. More up-to-date data may alter the predictions of the future waste quantities, composition and the estimated treatment capacity required in 2025 and thereafter.

In terms of the extended BNMW landfill ban, this results in approximately 0.05 Mt of additional treatment capacity being required by 2025. The inclusion of this additional material is therefore not a significant impact upon the capacity requirements when considered at a high-level within this assessment. However, further investigation may be required to establish the most suitable treatment method for certain materials or waste types. This study assumes that all sorting residues are within the scope of the BMW landfill ban. However, it should be possible to separate out the non-municipal fraction that would not be covered by the BMW ban. This would however be caught by the extended BNMW landfill ban.

In the scenarios where a capacity gap has been identified, the potential options to ensure compliance with the ban could include:

- Development of further waste treatment infrastructure. This would need to be carefully managed to ensure facility sizes adequately meet the future capacity requirements. As discussed within the analysis findings, this will be dependent upon Scotland's success in meeting the Scottish Government's policy targets.

  The vast majority of pipeline waste treatment infrastructure is based upon thermal treatment technology, notably incineration / EfW. Conventional incineration technology is well established within the UK and whilst facilities will have slight variances in the exact technologies to be employed (e.g., moving grate, fluidised bed etc.) incineration is considered a well proven technology. In terms of waste feedstock, most incineration facilities can accept wide ranging materials if they are within a suitable CV range (discussed in Section 6).

  Whilst none are currently within the pipeline, there are other more emerging thermal treatment technologies such as pyrolysis and gasification. Pyrolysis is a process in which the waste feedstock is exposed to high temperature in the absence of oxygen. Gasification follows a similar process but with the addition of limited and controlled amounts of oxygen. Both these technologies are commonly referred to as Advanced Thermal Treatment (ATT) technologies. Whilst there are two operational ATT facilities within Scotland further deployment would require careful consideration concerns over the performance of this technology. In terms of waste feedstock, the technology also generally requires a more consistent set of materials with most facilities including a pre-treatment element to control the feedstock going into the process.

  MBT is the treatment of waste by both mechanical and biological means which can be undertaken through different processes. Whilst no current pipeline facilities are planned, there are operational MBT facilities within Scotland which employ different technologies. The biological process employed at an MBT facility most commonly involves mechanical processing followed by one or more of:
    - In-vessel composting (IVC).
    - Biological drying (Biodrying).
    - Anaerobic digestion (AD).

  Typically, MBT technology provides a pre-treatment approach with a significant proportion of the waste then requiring disposal to landfill or via energy from waste facilities. Further deployment of MBT facilities would also have to be carefully considered given concerns about the reliability and performance of the technology.

  There are some waste types that might not be suitable for the technologies described above, such as sludges for example. These materials may require the development of more specialist treatment methods. The higher tiers of the waste hierarchy should also not be overlooked to establish whether waste types requiring treatment could not be first reduced, reused or recycled. This would ultimately result in more carbon savings which could also be a factor in determining the best treatment method (as discussed with the findings in Section 5). This is, therefore, recommended for further investigation as materials requiring different treatment methods would also need to be reflected within the high-level capacity analysis. For example, where a capacity gap has been stated, this could be to a lesser extent if some of the waste types need alternative treatment methods. Alternatively, where overcapacity has been stated, this may not be a true reflection if some of the waste types still need treatment via an alternative method.

Whilst there are pipeline facilities identified within the earlier stages of development interim measures may be needed to allow for the development of these facilities as this can take time. Further assessment is also recommended to ensure that these facilities can handle the expected waste types requiring treatment to ensure that any future capacity can be best utilised.

- An alternative, or interim, measure could be to utilise surplus treatment capacity in different geographies such as other areas of the UK or through pre-processing operations to turn waste into refuse derived fuel (RDF) for export. This would be dependent upon the waste type, with those requiring more specialist treatment potentially being diverted to more specialist treatment infrastructure elsewhere. This would require the receiving facility (or facilities) to have adequate spare capacity. Landfilling of material caught under the ban in Scotland could also be an option in other parts of the UK, although this may only be a short-term option and may be considered inappropriate as it would negate the environmental objectives of the ban

This assessment has been undertaken at a high-level and the following influencing factors must be borne in mind:

- The analysis is focused on the national level. Regional capacities have not been considered, which may be an option to investigate further should additional treatment infrastructure be required. As an example, the economics (and carbon emissions) of transporting waste from rural or isolated areas to the nearest treatment facility may need to be considered.
- The analysis assumes that all treatment infrastructure is operational for 100% of the time, whereas there will be periods of planned and unplanned downtime. Therefore, in any scenario where there is surplus treatment capacity to some extent a sufficient 'buffer' may be required should there be any prolonged periods of unplanned downtime at any one or more facility. The lifespan of currently operational facilities should also be discussed closely with industry post 2025 to ensure there is no unexpected drop in operational capacity.
- The analysis assumes that the facilities identified will only manage waste quantities generated within Scotland. For example, this high-level analysis does not quantify any waste tonnages being managed that are from England, or other waste types not included within the assessment such as small quantities of hazardous waste.
- Waste quantities included within the analysis are potentially within medium to long-term contracts, particularly for local authority waste and the impact of this has not been included within the analysis. For example, a particular facility may not be able to accept other waste quantities as it is contractually obliged to manage the tonnage from a certain provider.
- Market drivers such as gate-fees will also be an influencing factor in determining alternative treatment solutions.

4 Carbon modelling

Carbon modelling was undertaken to provide analysis of the impact on Scotland's GHG emissions with the BMW and the extended BNMW landfill ban.

4.1 Method

The carbon modelling used the outputs from the waste arisings forecasting to estimate the carbon impacts of each scenario. The carbon modelling method is summarised below:

1. Recycled, Reused and Composted (RRC) materials are multiplied by their respective carbon emission factors.
2. Residual materials are multiplied by the carbon emissions factors corresponding to the types of facilities used e.g., EfW, landfill etc.
3. Materials not included in the ban are multiplied by a landfill emission factor.
4. The results are added together to determine the total carbon emissions for the scenario.
5. Carbon emissions are quantified in terms of carbon dioxide equivalent (CO_2eq), representing the global warming potential of different greenhouse gases.

4.2 Data and assumptions

4.2.1 Material destinations

Where there is surplus treatment capacity for the materials included in the ban, the assumption is that materials are processed through the facilities listed below in the following priority order[9]:

1. Mechanical Biological Treatment with Biostabilisation (MBT/Bio).
2. Energy from Waste (EfW).
3. Refuse-Derived Fuel generation (RDF).
4. Advanced Thermal Treatment (ATT).
5. Mechanical Biological Treatment, with Refuse Derived Fuel generation (MBT/RDF).

Where there is insufficient facility capacity for materials included in the ban, the excess materials are assumed to be processed through EfW[10].

Materials excluded from the scopes of the bans are assumed to be disposed of to Landfill.

4.2.2 Emission factors

Wherever possible, the latest available Scottish Carbon Metric (SCM) emission factors[11] have been used to calculate carbon impacts. The household waste factors are shown in Appendix 5.

There was no SCM factor for MBT or ATT of residual waste, so this factor was developed using data from WRATE, IPCC and BEIS. These factors are shown in Table 5.

[9] Based on guidance from ZWS
[10] Based on guidance from the Steering Group
[11] SCM 2018 Emission Factors

Table 5: Emission factor assumptions

	Mechanical Biological Treatment, with Refuse-Derived Fuel (MBT/RDF)	Mechanical Biological Treatment, with Biostabilisation (MBT/Bio)	Advanced Thermal Treatment (ATT)
Emission Factor Used	-341.7 kg CO_2-eq/tonne	68.9 kg CO_2-eq/tonne	-341.7 kg CO_2-eq/tonne[12]

Where emissions factors are presented as a negative kg CO_2eq, such as for recycling, the SCM incorporates the contribution that recycling provides by 'avoiding' emissions that would have otherwise been generated from manufacturing new products from virgin materials. These 'avoided emissions' are considered as gains and are calculated as negatives for presenting carbon results.

Whilst the SCM does include these benefits from emissions avoidance, from a carbon accounting perspective these benefits would fall in scope 3, otherwise known as indirect emissions that occur in the value chain. From a carbon accounting perspective, the entity that generates the waste typically cannot record these avoided emissions as deductions when calculating their footprint. Rather, the benefits are recorded by the entity that purchases and uses the recycled products. However, since the purpose of this report is to provide an overall picture of the 'whole system' of carbon, the avoidance benefits have been included. As a result the carbon modelling analysis does not provide a detailed illustration of the impact of these scenarios on Scotland's waste emissions envelope as set out in the Climate Change Plan update.

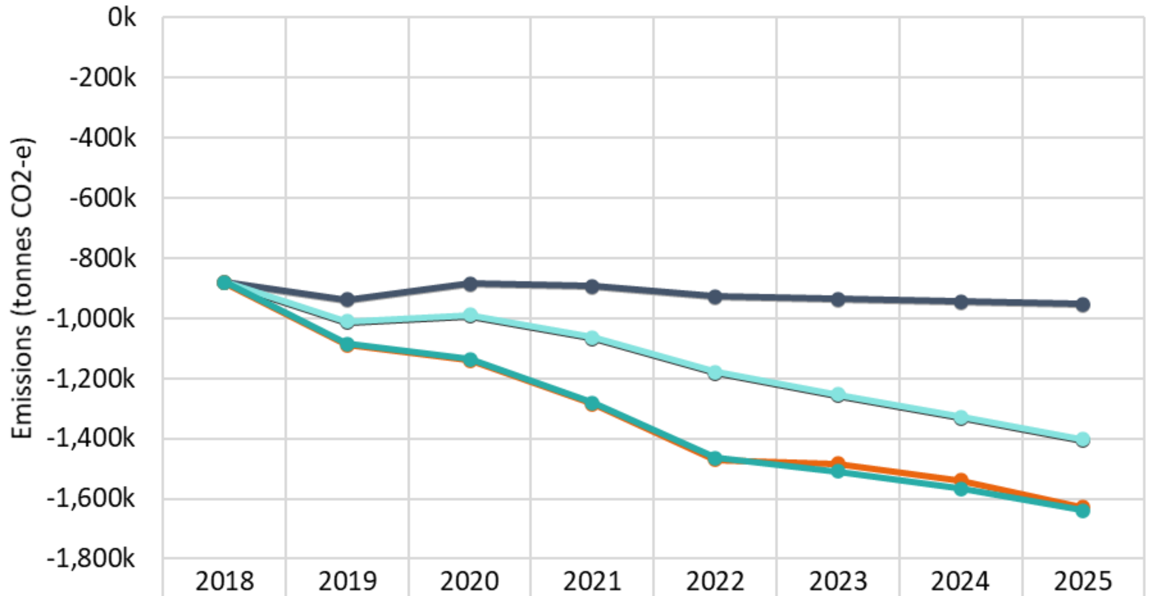
4.3 Carbon modelling results

The results from the carbon analysis are shown in

[12] The ATT facilities used follow a similar process flow to MBT/RDF

Figure 8, with each plotted line showing the carbon emissions for each year under all of the scenarios.

Figure 8: Carbon results overview*



	2018	2019	2020	2021	2022	2023	2024	2025
Sc 1a	-883k	-943k	-888k	-897k	-932k	-940k	-948k	-957k
Sc 1b	-880k	-939k	-884k	-893k	-928k	-936k	-944k	-953k
Sc 2a	-883k	-1,015k	-993k	-1,068k	-1,183k	-1,257k	-1,332k	-1,407k
Sc 2b	-880k	-1,010k	-989k	-1,064k	-1,178k	-1,253k	-1,327k	-1,403k
Sc 3a	-883k	-1,089k	-1,141k	-1,286k	-1,470k	-1,484k	-1,539k	-1,629k
Sc 3b	-880k	-1,085k	-1,136k	-1,282k	-1,465k	-1,509k	-1,566k	-1,640k

* negative numbers reflect emissions avoided compared to manufacturing new products using virgin materials rather than implying the waste sector is a net emissions sink.

The results indicate that:

- **Baseline: Scenarios 1a and 1b** - These two scenarios portray business as usual, with a small reduction in emissions reflecting slight improvements from waste reduction and recycling rates. For this reason, emissions remain broadly steady.
- **Towards Policy Targets: Scenarios 2a and 2b** - These two scenarios depict partial progress towards the waste reduction and recycling targets, resulting in the emissions falling between Scenarios 1 and 3 pathways.
- **Achieving Targets: Scenarios 3a and 3b** - These two scenarios have the greatest amount of waste reduction and highest recycling rates; these two factors combine to produce the lowest carbon emissions.

4.3 Carbon conclusions

The carbon modelling results demonstrate the corresponding reduction in carbon emissions that would be expected to be seen from an increased contribution from waste reduction and recycling. As extra efforts are made to divert material from waste in the first place and then to recycle more, through the scenarios, carbon emissions are reduced, as demonstrated in scenarios 3a and 3b. There is a slight difference between the BMW landfill ban and the extended BNMW landfill ban in 2018 due to the slight difference in materials covered under the different bans and the assumptions outlined in Section 0. The inclusion of the extended BNMW landfill ban only has minimal carbon saving impacts, because the expansion of the ban only results in the capture of an additional 0.05 Mt of waste.

5 Calorific value modelling

CV modelling was undertaken to provide a high-level analysis of residual waste in 2025 under a range of scenarios.

5.1 Method

The CV modelling used the outputs from the waste forecasting modelling to estimate the CV of the remaining residual waste. The method involved multiplying the quantity of each material in the composition of residual waste with its corresponding CV assumption, then dividing by the total amount of residual waste tonnes to determine a weighted average.

This method provides an indicative CV per kilogram of residual waste, but this is an average value that will vary between different locations that generate residual waste.

5.2 Data and assumptions

WRATE[13] CV's were used wherever possible, as these values are widely used in research. The residual waste materials were aligned with the most suitable WRATE material. There were two material streams within the residual waste composition where assumptions were required:

- Household and similar wastes
- Mixed and undifferentiated materials

For both material streams, the tonnes were re-allocated proportionally across the remainder of the residual waste stream, in liaison and agreement with the steering group.

---

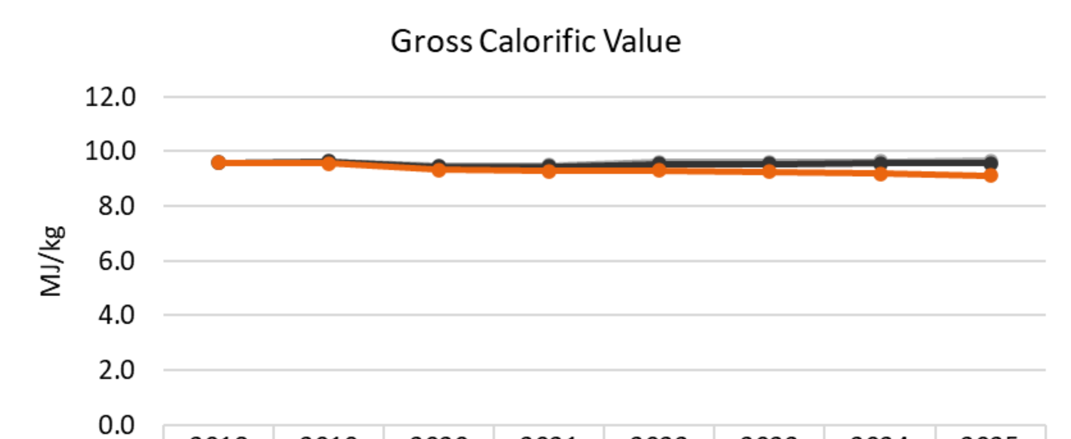
[13] WRATE

5.3 Calorific value results

The results of the CV modelling under each scenario is presented in the figures below. These show the gross (

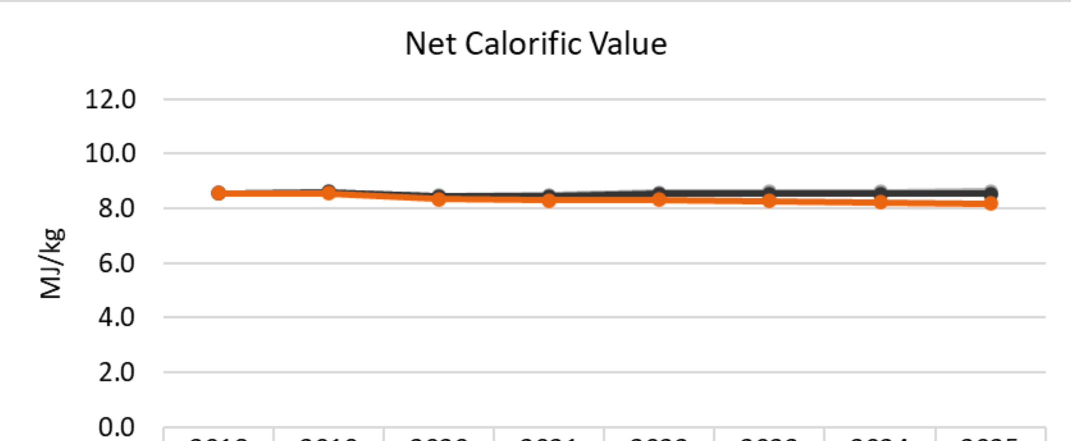
Figure 9) and net (Figure 10) CV. The difference between net and gross CV is the latent heat of vaporisation of the water content in the fuel. The latent heat of vaporisation represents the energy needed for the water to change state, from liquid to vapour (or vice versa).

Figure 9: Gross Calorific Value Results



	2018	2019	2020	2021	2022	2023	2024	2025
Sc 1	9.6	9.6	9.5	9.5	9.6	9.6	9.6	9.7
Sc 2	9.6	9.6	9.4	9.5	9.5	9.6	9.6	9.6
Sc 3	9.6	9.6	9.3	9.3	9.3	9.3	9.2	9.1

Figure 10: Net Calorific Value Results



	2018	2019	2020	2021	2022	2023	2024	2025
Sc 1	8.6	8.6	8.5	8.5	8.6	8.6	8.6	8.6
Sc 2	8.6	8.6	8.4	8.4	8.5	8.5	8.5	8.5
Sc 3	8.6	8.6	8.3	8.3	8.3	8.3	8.2	8.2

The results show a slight reduction in the gross and net CV in Scenario 3. In terms of value change, this amounts to a reduction of 0.4 MJ/kg to an average of 8.2 MJ/kg net calorific value by 2025. In Scenarios 1 and 2 there is a marginal fluctuation in CV with minimal change in 2025.

5.4 Calorific value conclusions

The significance of calculating CV in this analysis relates to the suitability of the remaining waste to processing through a range of treatment technologies. Changes in CV are most significant for EfW and ATT technologies as the combustion and/or ATT (gasification, pyrolysis etc.) processes operate best within specific ranges of net CV to aid the combustion process. The typical CV range that is accepted for a modern EfW facility is:

- Lower range value of ~7.5 to 8 MJ/Kg (Net CV)

- Upper range value of ~11 to 12.5 MJ/Kg (Net CV)

Based upon the findings of the estimated calorific values, the results suggest that EfW would remain a viable option for the remaining waste quantities, although with the CV in the lower end of the typical range.

As this analysis has been undertaken at a high-level, more in-depth analysis is recommended to understand the impact of removing particular waste types for alternative or more specialist treatment. This could also include quantifying other potential influencing factors on waste composition. As an example, this could include the impact of Deposit Return Systems (DRS) and other policy initiatives.

6 Conclusions and recommendations

The key findings for the project are summarised below under each individual aim.

An assessment of whether there is likely to be a gap in the capacity of facilities available within Scotland to treat Scotland's BMW in 2025 when the ban is implemented.

- The required treatment capacity in 2025 is largely dependent upon the success in achieving the Scottish Government's policy targets. This is due to the impact these policies will have, such as through waste reduction and increased recycling, on the remaining waste quantities requiring treatment.
- Under the baseline and approaching (half-way achievement) of policy targets, a capacity gap is estimated where there would not be sufficient treatment infrastructure. Where policy targets are achieved, there would be potential overcapacity with surplus treatment capacity.
- Further investigation is recommended on waste types included within the scope of the BMW and BNMW landfill ban that may require more specialist treatment. The resulting tonnage which may require other treatment options should then be compared to the resulting waste quantities and the treatment capacity requirements under each scenario.
- As more up-to-date data becomes available, close attention should be made to the progress towards the Scottish Government's policy targets to establish which of the scenarios presented would be most likely in 2025.

A high-level summary of the impact of including BNMW within the 2025 ban.

- Including BNMW would result in approximately 0.05 Mt of additional material requiring treatment in 2025.
- However, further assessment may be needed to establish the most suitable treatment method for some waste types.

Potential available options to deliver the ban, should a capacity gap be identified.

- Development of additional waste treatment infrastructure to make up any shortfall in capacity. There is currently additional incineration / EfW capacity within the early stages of pipeline development.
- Alternative or interim measures could include utilising surplus treatment capacity in other geographies, subject to there being sufficient spare capacity and their suitability to manage the waste types.
- Further investigation is recommended for particular waste types which may require more specialist treatment methods and the resulting impact of this on the capacity requirements.
- Close attention needs to be made to the current operational infrastructure post 2025, particularly those facilities nearing the end of their lifespan. This is to ensure that there is no unexpected drop-off in treatment capacity without

sufficient planning to ensure pipeline facilities or other interim options (in the case of planned upgrade works) can pick up the capacity requirements.
- Potential 'buffer' or spare capacity may be required for any periods of planned or unplanned downtime at treatment facilities or unexpected changes in waste quantities.

<u>Analysis of the impact on Scotland's GHG emissions with the BMW ban and the extended BNMW ban.</u>

- The inclusion of BNMW within the ban has a minor impact on carbon emissions as it only results in the capture of an additional 0.05 Mt of waste.
- The largest carbon emission savings are found within Scenarios 3 and 2 where there is increased waste reduction and higher recycling rates.

<u>An analysis of the likely CV of residual waste in 2025 under appropriate scenarios.</u>

- There is a minimal change in gross and net CV under each scenario assessed.
- Further analysis is recommended to understand the impact of removing some waste types for alternative or more specialist waste treatment. This could also include other policy initiatives which may impact upon waste composition such as DRS.

7 Appendices

Appendix 1 – Data and assumptions

Appendix 2 – Materials included within the scope of the bans

Appendix 3 – Operational treatment infrastructure

Appendix 4 – Pipeline treatment infrastructure

Appendix 5 – Scottish Carbon Metric (2018)

Appendix 1: Data and assumptions

Arisings, composition and destinations

The waste arisings and compositions are based upon 2018 data from the Scottish Environmental Protection Agency (SEPA)[14,15]. The arisings data excludes hazardous waste, as advised by the project steering group. The waste destinations (i.e., how much of each material is recycled, landfilled etc.) was derived using SEPA data for household waste[5] and the Scottish Carbon Metric (SCM) data from Zero Waste Scotland for commercial and industrial waste[16].

The resulting baseline waste quantities for 2018 were applied consistently across all the modelled scenarios for the baseline year.

Waste growth

The following growth assumptions were applied consistently to all scenarios:

- Household waste arisings - growth as per the Scottish Government population projections[17].
- Commercial and Industrial (C&I) waste arisings - growth as per estimated Scottish GDP growth[18].

Waste reduction targets

Scottish Government waste reduction targets have been based on 2013 data[19] for food waste targets and 2011 data for total waste arisings targets[20]. Ricardo liaised closely with the steering group to confirm assumptions around particular material streams in the baseline data, in preparation for the scenario modelling, as follows:

1. **Food waste arisings reduction target**: SEPA indicated that the quantity of food waste in the published 2013 SEPA data (246k tonnes in the 'Animal and mixed food waste' material line) was too low. SEPA suggested that additional food waste could be contained within the 'Household and similar wastes' material line, which totalled 2.37M tonnes in the same year. SEPA proposed a re-allocation of this hidden food waste from the 'Household and similar wastes' material line to

[14] SEPA, Waste Data for Scotland
[15] SEPA, Household Waste Data
[16] ZWS Scottish Carbon Metric 2018 Carbon Metric Factors 2018 and Carbon Metric Tonnages 2018
[17] Scottish Government Statistics, Population Projections (2018 baseline)
[18] Scottish Fiscal Commission, January 2021
[19] SEPA, Waste from all sources, 2018, Table 2
[20] SEPA, Waste Data for Scotland (waste from all sources) Table 1 and business waste by economic sector

the 'Animal and mixed food waste', to the amount of 753k tonnes. This figure has been derived from the estimated 1 Mt of total food waste in 2013[21] minus the amount already in the 'Animal and mixed food waste' material line. This proportion[22] of 'hidden food waste' was used to determine the estimated total amount of food waste (identified and hidden) in 2018, in order to model the total food waste reduction to meet 2025 targets.

2. **Total waste arisings reduction target**: this has been calculated for all waste except food waste to avoid double counting the food waste reduction performance to meet the target summarised above. As such, food waste arising reductions were modelled first, followed by total waste arisings (minus food waste) reductions. For all four scenarios that are modelled to reach specific targets (1a, 1b, 3a, 3b), it was found that applying the food waste reduction target on its own meant that the total waste arisings reduction target was met in its' entirety. This is because of the high total waste arisings in 2011, (the year that the total waste arisings reduction target is based on), compared to the baseline year (2018) for this analysis. For this reason, the total waste arisings reduction target was not applied to any of the scenarios.

As mentioned in Section 4.2.1, SEPA recommended that various commercial and industrial materials be re-allocated as household waste arisings. For this reason, the modelling examined total waste reduction targets, instead of separate targets for household waste and C&I waste.

Food waste arisings reduction targets are summarised in Table 6 and total waste arisings reduction targets are summarised in Table 7.

Table 6: Food waste arisings reduction targets

	Achieving Targets		**Approaching Targets**	
	Scenario 3a	**Scenario 3b**	**Scenario 2a**	**Scenario 2b**
Baseline food waste arisings (2018)	Total: 1.0M tonnes[23]			
Food waste target (2025)	Total: 670k tonnes[24]		Total: 835k tonnes[25]	

[21] Scottish Government, Managing Waste – Food Waste
[22] Hidden food waste made up an estimated 31.8% of the 'Household and similar wastes' material line in 2013. It was assumed that this proportion would be consistent over the time period examined.
[23] 423k in the 'Animal and mixed food waste' material line, 605k in the 'Household and similar wastes' material line
[24] 33% lower than 2013 food waste arisings (1.0M tonnes)
[25] 17.5% lower than 2013 food waste arisings (1.0M tonnes)

Table 7: Total waste arisings reduction targets

	Achieving Targets		Approaching Targets	
	Scenario 3a	**Scenario 3b**	**Scenario 2a**	**Scenario 2b**
Baseline total waste arisings (2018)	Total: 5.2M tonnes			
Total waste target (2025)	Total: 5.5M tonnes[26]		Total: 5.9M tonnes[27]	

Recycling targets

Scenario 1 examines the achievement of the all waste recycling target (70% by 2025), and Scenario 3 examines achievement of 'halfway to the recycling target' (59% by 2025). The baseline recycling rate for household and C&I waste is 48.6% (2018), so in order to meet the targets of Scenarios 1 and 3, assumptions were required to determine which materials would be expected to have greater recycling rates in the future. SEPA provided guidance on material groups that were deemed to have a higher potential for recycling, and the recycling rates for these materials were increased in order to meet the overall targets. Based on guidance from SEPA, it was assumed that the recycling rates of the following materials would increase in order to meet the overall targets:

- Household waste:
  - Household and similar wastes
- Commercial and Industrial waste:
  - Used oils
  - Chemical wastes
  - Plastic wastes
  - Wood wastes
  - Textile wastes
  - Animal faeces, urine and manure
  - Other mineral wastes

Materials included in the bans

SEPA provided advice on the materials to be included in the current BMW landfill ban and the extended biodegradable non-municipal waste ban. Details on which materials were included within the scope of these two bans are provided in Appendix 2.

[26] 15% lower than 2011 total arisings minus food waste (6.4M tonnes)
[27] 7.5% lower than 2011 total arisings minus food waste (6.4M tonnes)

Appendix 2: Materials included within the scope of the bans.

X = material category included in the respective ban.

Material	Household Waste		C&I Waste	
	BMW Landfill Ban	Extended BNMW landfill Ban	BMW Landfill Ban	Extended BNMW landfill Ban
Spent solvents		X		X
Acid, alkaline or saline wastes				
Used oils	X	X		X
Chemical wastes				
Industrial effluent sludges		X		X
Sludges and liquid wastes from waste treatment	X	X		X
Health care and biological wastes				
Metallic wastes, ferrous				
Metallic wastes, non-ferrous				
Metallic wastes, mixed ferrous and non-ferrous				
Glass wastes				
Paper and cardboard wastes	X	X	X	X
Rubber wastes				
Plastic wastes				
Wood wastes	X	X	X	X
Textile wastes	X	X	X	X
Waste containing PCB				
Discarded equipment (excluding discarded vehicles, batteries and accumulators wastes)				
Discarded vehicles				

Material	Household Waste		C&I Waste	
	BMW Landfill Ban	Extended BNMW landfill Ban	BMW Landfill Ban	Extended BNMW landfill Ban
Batteries and accumulators wastes				
Animal and mixed food waste	X	X	X	X
Vegetal wastes	X	X	X	X
Animal faeces, urine and manure	X	X	X	X
Household and similar wastes	X	X	X	X
Mixed and undifferentiated materials	X	X	X	X
Sorting residues	X	X	X	X
Common sludges	X	X		X
Mineral waste from construction and demolition				
Other mineral wastes				
Combustion wastes				
Soils				
Dredging spoils		X		X
Mineral wastes from waste treatment and stabilised wastes				

Appendix 3: Operational treatment infrastructure

Facility Name	Technology	Modelled Capacity (tpa)	Operational Year
Dunbar ERF	EfW	300,000	2019
DERL (Baldovie)	EfW	150,000	1994
Lerwick EfW	EfW	26,000	2000
Millerhill	EfW	189,500	2019
GRREC	ATT	123,000	2019
Levenseat	ATT	105,000	2018
Levenseat (Forth by Lanark)	MBT	250,000	2006
Eco Deco Dumfries	MBT	70,000	2006
Avondale	MBT	70,000	2005
Dalinlongart Compost	MBT	10,000	2001
Moleigh, Kilmore	MBT	10,000	1998
Lingerton Compost	MBT	10,000	2001

Appendix 4: Pipeline treatment infrastructure

Facility Name	Technology	Modelled Capacity (tpa)[1]	Operational Year[1]
Dundee ERF	EfW	105,000	2022
Earlsgate Energy Centre	EfW	205,000	2022
Aberdeen Recycling & Energy Recovery	EfW	143,000	2022

[1] *First operational year modelled at 50% capacity to factor in a ramp up of operations and facilities entering operations midway through the year.*

Appendix 5: Scottish Carbon Metric (2018)

Scottish Carbon Metric Factors for Household Waste, 2018

Material Type (WSR)	Household (kgCO₂eq per tonne of material)				
	Generated	Recycled/Composted	Incinerated	Landfilled	Other diversion
Acid, alkaline or saline wastes	0	0	0	0	0
Animal and mixed food waste	3,744	-18	-3	989	21
Animal faeces, urine and manure	0	0	0	0	0
Batteries and accumulators wastes	12,107	-579	0	0	0
Chemical wastes	1,321	4,039	388	0	0
Combustion wastes	0	0	0	8	-4

Material Type (WSR)	Household ($kgCO_2eq$ per tonne of material)				
	Generated	Recycled/Composted	Incinerated	Landfilled	Other diversion
Common sludges	0	0	0	0	0
Discarded equipment (excluding discarded vehicles, batteries and accumulators wastes)	1,754	-181	47	4	0
Discarded vehicles	6,850	-1,623	328	0	0
Dredging spoils	0	0	0	0	0
Glass wastes	1,210	-755	54	4	0
Health care and biological wastes	0	0	179	420	0
Household and similar wastes	3,208	-653	388	452	21
Industrial effluent sludges	0	0	0	0	0
Metallic wastes, ferrous	2,922	-1,771	0	0	0
Metallic wastes, mixed ferrous and non-ferrous	3,893	-2,540	47	4	-2,493
Metallic wastes, non-ferrous	12,946	-9,964	0	0	0
Mineral waste from construction and demolition	21	2	47	3	0

Material Type (WSR)	Household (kgCO2eq per tonne of material)				
	Generated	Recycled/Composted	Incinerated	Landfilled	Other diversion
Mineral wastes from waste treatment and stabilised wastes	0	0	0	0	0
Mixed and undifferentiated materials	1,895	-1,212	-27	107	0
Other mineral wastes	0	0	0	0	0
Paper and cardboard wastes	882	-547	-118	499	0
Plastic wastes	3,185	-537	1,824	4	0
Rubber wastes	3,100	-514	1,729	0	0
Sludges and liquid wastes from waste treatment	0	0	0	0	0
Soils	0	1	0	1	0
Sorting residues	0	0	0	0	0
Spent solvents	0	0	0	0	0
Textile wastes	20,444	-5,828	216	571	0
Used oils	1,401	-725	0	0	0
Vegetal wastes	0	-51	-21	214	21
Waste containing PCB	0	0	0	0	0
Wood wastes	516	-288	-180	861	0

climateXchange

Scotland's centre of expertise connecting climate change research and policy

info@climatexchange.org.uk
+44(0)131 651 4783
@climatexchange_
www.climatexchange.org.uk

ClimateXChange, Edinburgh Climate Change Institute, High School Yard, Edinburgh EH1 1LZ