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Incineration and Energy from Waste

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This briefing gives an overview of incineration of waste in Scotland in Energy from Waste (EfW) facilities. It provides information on waste trends and regulation of EfW, provides an overview of recent policy developments relevant to EfW in Scotland, and discusses the role of incineration in the context of Scotland's transition to a circular economy.

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Contents

Executive Summary

- Incinerators in Scotland are fitted with technologies that enable energy to be recovered from the treatment of waste, known as **Energy from Waste (EfW)**. EfW can be used to produce electricity only, heat only, or combined heat and power (CHP).

- From 31 December 2025, the landfilling of biodegradable municipal waste in Scotland will be banned, as part of the Scottish Government's actions to seek to transition to a circular economy and reduce waste-related Greenhouse Gas (GHG) emissions on the path to net zero. The upcoming ban, coupled with increasing landfill taxes and the waste hierarchy encouraging energy recovery over landfill, has been linked to the rise in incineration as waste is diverted away from landfill and to EfW facilities.

- Between 2011 and 2020 there was a 208% increase in total waste incinerated in Scotland - made up mainly of increases in both the incineration of household and similar waste (a 299% increase from 87,693 to 350,231 tonnes) and also a significant rise in wood waste used in biomass co-incinerators. In the same time period, the amount of waste being landfilled has significantly decreased.

- Scotland now has capacity to process over 1.1 million tonnes of municipal waste in operational EfW sites annually, with a further 2.5 million tonnes of capacity either under construction or in a planning stage. To put these figures into context, most recent waste data for 2018 shows 2.1 million tonnes of household and similar waste was generated.

- The increase in waste being treated in EfW facilities, and number of proposals for new sites, has been met with some concerns from stakeholders and parliamentarians, questioning the role EfW should play in Scotland's transition to a circular economy and net zero. Parliamentary scrutiny of the Scottish Government's Climate Change Plan update (CCPu) in particular raised concerns about the role of incineration in Scotland's transition to circular economy.

- Zero Waste Scotland has carried out lifecycle analysis to estimate the net GHG emissions per tonne of waste input for EfW compared to landfill. It estimated that sending one tonne of residual municipal waste to EfW in Scotland in 2018 emitted 246 $kgCO_2e$, 27% less emissions per tonne of waste than sending the waste to landfill [1] .

- At the same time, energy generation from the treatment of residual municipal waste in EfW plants was found to have a high carbon intensity compared to the grid average. Burning residual municipal waste in EfW plants in Scotland in 2018 had an average carbon intensity of 509 gCO_2/kWh, compared to the marginal electricity grid, which had an average carbon intensity of 270 gCO_2/kWh in the UK in 2018. Converting electricity-only EfW plants to CHP systems is estimated to reduce their carbon intensity by 30%.

- The Scottish Government has policies and regulations, across waste, climate change, environment and planning, which aim to ensure that EfW maximises energy recovered, does not cause significant harm to human health and the environment, and does not undermine the recycling and reuse of waste. However despite planning policies in place to encourage heat-offtake, most current EfW sites are electricity-only. The CCPu announced plans to consider measures to ensure new EfW plants are

more efficient and how waste infrastructure can be ‘future-proofed’ for carbon capture and storage (CCS).

- In its 2021/2022 Programme for Government, the Scottish Government announced that it would review the role of incineration in Scotland's waste hierarchy. The Scottish Government stated that the review will aim to consider "how emissions from existing incinerators can be reduced and residual heat may be reused; and consider the societal impacts of residual waste treatment, including health and community impacts".

- In November 2021, the Scottish Government appointed Dr Colin Church as the independent chair of the review [2] , and announced that planning authorities must now notify Scottish Ministers of any new applications or decisions involving incineration facilities, until the end of the review period [3] . In December 2021, the review team published a call for evidence on Energy from Waste and set out the scope of the independent review.

- Treating waste in EfW facilities is above landfill in the waste hierarchy which is embedded in environmental law and waste policy in Scotland, but below recycling, reuse and waste reduction. Approaches to waste management need to continue to move up this hierarchy in order for Scotland to transition to a circular economy.

Introduction

What is incineration and Energy from Waste (EfW)?

Incineration of waste which recovers energy is also termed **Energy from Waste (EfW)**. EfW is the process of generating energy in the form of electricity and/or heat from the treatment of waste. It is primarily used to refer to energy generated through incineration, but other non-thermal treatment technologies also exist which can recover energy from waste.

The Pollution Prevention and Control (Scotland) Regulations 2012 define incineration as referring to the thermal treatment of waste *either* by the burning of waste in the presence of oxygen (what is conventionally known as incineration) or using advanced thermal techniques that burn waste with little or no oxygen (gasification, pyrolysis and plasma processes).

Increases in incineration of waste in Scotland and incineration review

The total quantity of waste incinerated in Scotland in 2020 was 1.26 million tonnes, an increase of 38,000 tonnes (3.1%) from 2019, and an increase of 855,000 tonnes (208%) from 2011 [4] . This increase may reflect the start of an increasing trend as Scottish local authorities and waste management companies divert waste from landfill ahead of the forthcoming 2025 ban on biodegradable municipal waste being sent to landfill, and corresponds with new EfW sites becoming operational. It also relates to increasing landfill tax and more generally encouragement to move waste up the 'waste hierarchy' where energy recovery is ranked higher than disposal to landfill.

Amid rising stakeholder concerns that incinerators could undermine efforts to reduce Greenhouse Gas (GHG) emissions and increase recycling, the Scottish Government's 2021/2022 Programme for Government committed to review the role that incineration plays in Scotland's waste hierarchy. The Scottish Government stated that the review will [5] :

> “ Prioritise consideration of national capacity requirements for incineration, given the Scottish Government’s ambitious targets for waste reduction. The review will also have scope to consider how emissions from existing incinerators can be reduced and residual heat may be reused; and consider the societal impacts of residual waste treatment, including health and community impacts. The independent chair will determine the detailed shape of the review.”

There were calls on the Scottish Government to impose a moratorium on new incinerators prior to the review [6] [7] being concluded. In November 2021, the Scottish Government appointed Dr Colin Church (previously the CEO of the Chartered Institution of Wastes Management, and prior to that the Director of Environmental Quality at Defra) to chair the review [2] . The Government also announced that planning authorities must now notify Scottish Ministers of any new applications or decisions involving incineration facilities, until the end of the review period [3] .

In December 2021, the review team published a call for evidence and set out the scope of the review. This call is seeking evidence on five broad topics:

1. Given Scotland’s ambitions and current progress towards these, what capacity is

required to manage residual waste in Scotland?

2. What are the options for managing residual waste?
3. What are the economic, environmental and social trade-offs of those residual waste management options?
4. How do we decide where capacity should be located, and in what form?
5. What can be done to improve existing residual waste treatment facilities in terms of carbon performance and societal impact?

The review will consider the above in the context of the treatment of household and commercial and industrial waste streams, and will consider options for residual waste treatment beyond incineration. The review will not include the incineration of biomass for energy, treatment of healthcare and hazardous wastes, construction and demolition waste, or an in-depth review of health impacts of residual waste treatment options.

Briefing overview

This briefing provides an overview of the current status of EfW in Scotland, and puts EfW into the context of wider waste management policy and Scotland's transition to net zero and a circular economy. It summarises recent policy developments in this area, information about EfW sites in Scotland and how they are regulated and approved, and evidence on environmental impacts of EfW operations.

EfW technologies

Energy from waste is the process of generating energy in the form of electricity and/or heat from the treatment of waste. Incineration is a key EfW technology that is used to both reduce waste volume and gain energy from it. There are other technologies which enable energy to be generated from waste without the need to incinerate or thermally treat it (e.g. anaerobic digestion and landfill gas) - these are not generally referred to as 'energy from waste' although definitions and uses of the term can vary. This section provides information on key EfW technologies involving incineration or other thermal treatment which are the focus of this briefing.

Conventional incineration and Combined Heat and Power (CHP)

Incineration is an established technology in which waste is combusted (burned) in the presence of oxygen to produce hot gasses, which are then used to generate steam. The steam is used to move a turbine which generates electricity, or used directly to provide heat locally, or both - known as Combined Heat and Power or CHP.

In order to receive required environmental licences in Scotland, any new waste treatment plant needs to demonstrate that it can achieve **at least 20% energy recovery** (see energy recovery efficiency box below for further detail) as electricity only, electricity and heat, heat only or as exported fuel (energy) equivalent [8] .

Heat is a significant energy output of EfW plants and plants that can utilise or distribute heat locally can achieve greater energy efficiencies compared with electricity-only plants. SEPA state that where there are opportunities to effectively use energy from waste in the form of electricity and heat in a mature heat network infrastructure, high overall thermal efficiency levels in excess of 60% can be achieved [8] . For comparison, DEFRA states an efficiency range of between 20 - 27% for electricity-only waste incineration plants [9] . In addition to steam and heat, incineration produces produces carbon dioxide (CO_2) and any non-combustible materials (e.g. metals, glass) remain as a solid known as Bottom Ash .

Advanced Thermal Treatments (ATT)

An alternative to incineration, **gasification** and **pyrolysis** are Advanced Thermal Treatments (ATT) in which residual waste is thermally degraded in the presence of little oxygen (gasification) or no oxygen (pyrolysis). ATTs produce a mixture of gases (known as syngas) that can be combusted to generate steam. As with incineration, the steam can then be used to generate electricity and/or for heating if there is local demand. The production of syngas during ATT has a range of applications in addition to heat and power, including hydrogen production and production of industrial chemicals. DEFRA states an efficiency range of between 10-30% for gasification and pyrolysis plants depending on the specific energy system adopted [9] . Waste for ATT needs more pre-processing which increases the energy needs of the plant and lowers overall efficiency.

ATT is less widely utilised compared with conventional incineration in Scotland and across the UK, with currently only two operational EfW facilities using ATTs in Scotland (see EfW sites in Scotland). Globally, more established gasification and pyrolysis plants are in operation in North America, Japan and other European countries.

In terms of environmental impacts, a UK Government review of these technologies sets

out that one of the main benefits *claimed* by manufacturers for pyrolysis and gasification plant is that emissions of pollutants may be lower than those from incineration [9] . However, a comparative assessment of environmental impacts of EfW technologies is outwith the scope of this briefing.

Energy recovery efficiencies

Energy from waste plants are described in terms of an energy recovery efficiency which describes the amount of energy exported for use e.g. through electricity generation or local heat distribution relative to the amount of energy input required to run the facility. Energy recovery efficiencies are typically reported as a percentage.

Relationship of EfW with other waste management treatments - Mechanical Biological Treatment and anaerobic digestion

EfW facilities may use **Mechanical Biological Treatment (MBT)**, to pre-treat municipal solid waste prior to thermal treatment. MBT is a combination of physical (mechanical) treatment to recover recyclable components e.g. plastic, metal, and biological treatment to reduce the waste's biodegradability. Two of Scotland's operational EfW sites are fitted with MBT, providing a further source of energy and recovering resources prior to thermal treatment of waste.

The biological processes include decomposition in the presence or absence of oxygen - options include composting and anaerobic digestion. The three main outputs from an MBT plant are: recyclables –such as PET plastic that can be sent for recycling; low quality soil; and Refuse Derived Fuel (RDF), which is a mix of materials which can be used in incinerators or in some cement kilns [10] .

Anaerobic digestion is relevant in the context of Energy from Waste in relation to the processing of wet biomass waste (such as sewage sludge, animal manure and slurry and waste food). It uses bacteria in the absence of oxygen to break down organic matter in waste into "biogas' (predominately methane, CH_4), which can be used to generate electricity, supply heating (locally) or be directly injected into the gas grid. As anaerobic digestion recovers energy from the biodegradable component of waste, the resultant energy produced is renewable and therefore considered to be bioenergy.

EfW sites in Scotland and waste management requirements

Operational EfW sites and capacity

SEPA data lists six operational EfW sites in Scotland which accept Municipal Solid Waste (MSW) [11] - with a combined capacity to process **1.1 million tonnes (Mt) of MSW per year.** All of these operational EfW facilities generate electricity only, apart from one EfW site based on the Shetland Isles (Lerwick) which only generates and distributes heat locally. All other operational EfW sites, which only currently generate electricity, have the capacity for combined heat and power generation except for the Dundee site which would require extensive retrofit for heat offtake [11] .

Of the six operational EfW sites processing MSW, four use incineration to recover energy from waste and two sites use Advanced Thermal Treatments (ATT) in combination with Mechanical Biological Treatment (see technologies section for further explanation).

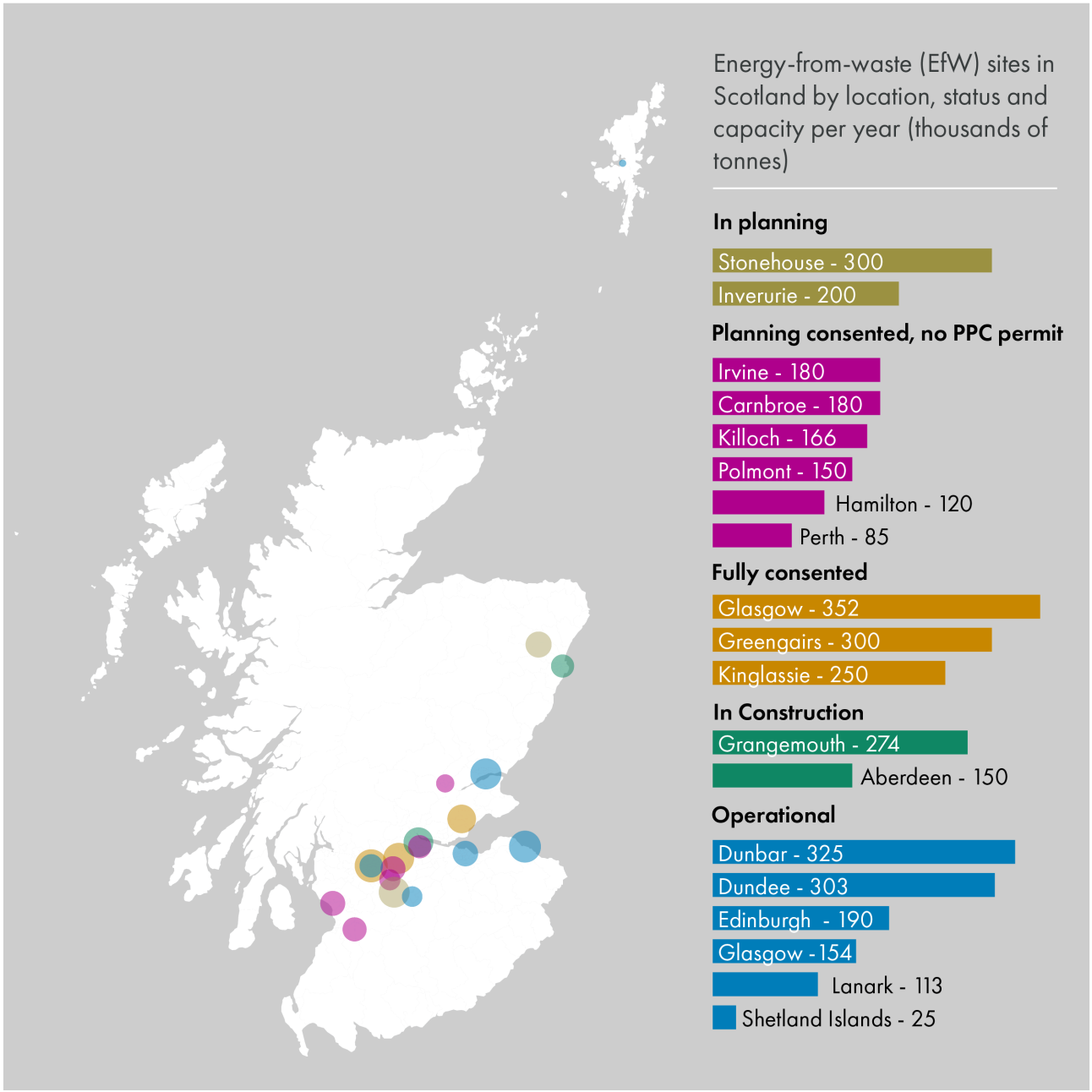
Facilities under construction, consented and in planning

At the time of writing, two EfW sites with a combined capacity to treat **424,000** tonnes of waste are currently under construction. A further three sites, with a combined capacity of 902,000 tonnes have received planning permission and environmental licences from SEPA but have yet to begin construction. Six sites, with a combined capacity to process 760,900 tonnes of waste have received planning permission but have yet to obtain the required environmental licenses from SEPA and two sites are still in planning, with a combined capacity of **500,000 tonnes.**

Sites under construction include the Ness Energy Project Residual Waste Treatment plant, being built by Aberdeen City Council, Aberdeenshire Council, and Moray Council to dispose of non-recyclable waste. The expectation is that this project will connect to the Torry District Heating Network, a European Regional Development Fund supported project which aims to connect 950 homes to a district heating scheme by 2025.

See Figures 1 and 2 below for a summary of sites in various stages of development and their corresponding capacity (in terms of annual processing of MSW).

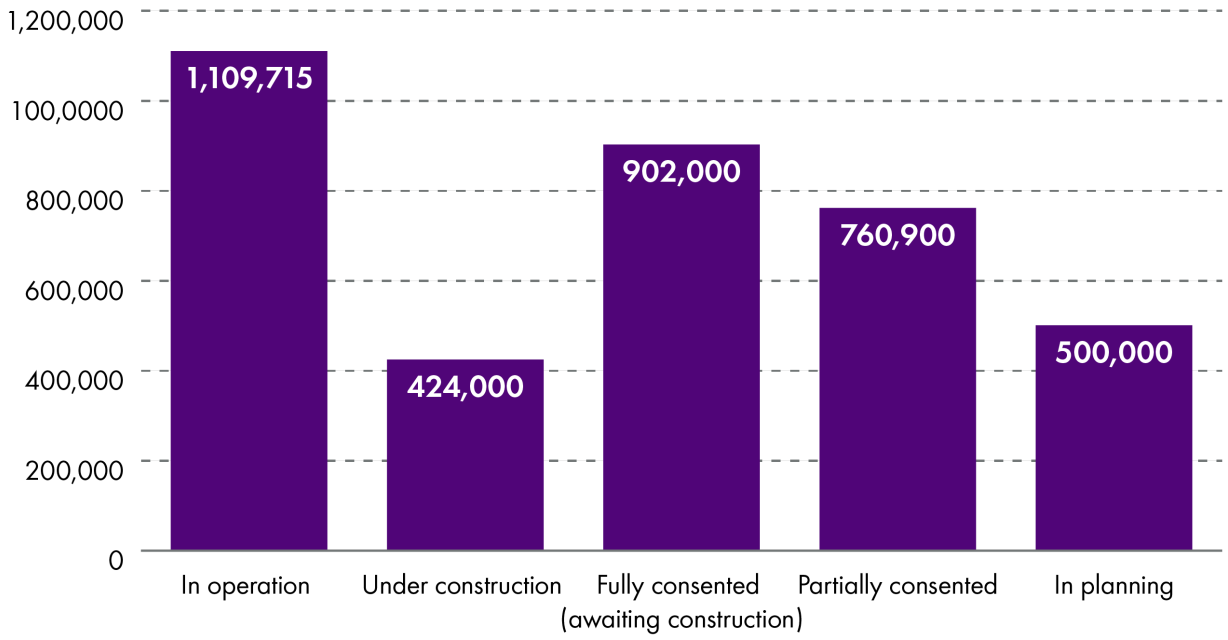
Figure 1. EfW sites processing MSW in Scotland by location, status and capacity per year (thousands of tonnes)



Data supplied by SEPA

Figure 2. Waste capacity (tonnes MSW per year) of EfW facilities in Scotland by operational, construction or planning status

Partially consented refers to sites which have gained planning permission, but have yet to gain the necessary environmental permits from SEPA.



Data supplied by SEPA

Waste management infrastructure capacity requirements

To ensure that all authorities in Scotland collectively plan for waste management facilities to meet the requirements of the Scottish Government's Zero Waste Plan (including the upcoming 2025 ban on Biodegradable Municipal Waste being sent to landfill), capacity shortfall is allocated to groups of local authorities or Strategic Development Plan (SDP) areas by the Scottish Government using data from SEPA [12] .

This information is intended to be used by local authorities in conjunction with Scottish Planning Policy to support the procurement or planning of waste infrastructure. The latest available figures (for 2018, published in December 2020) estimate that there is a total capacity shortfall for the management of unsorted waste (which includes EfW) of 1.01 million tonnes per year with the greatest shortfall within the Glasgow and Clyde Valley SDP planning area (see Table 1 below).

Table 1: Additional operational waste management infrastructure capacity estimated to be required to meet Scottish Government targets (specifically to manage unsorted waste)

Region	Additional capacity needed to manage unsorted waste (tonnes)
Aberdeen City and Shire *	130,000
Glasgow & Clyde Valley *	305,000
Edinburgh and SE Scotland*	250,000
Tay cities (Dundee, Angus, Perth and North Fife)*	50,000
Argyll and Bute	15,000
Dumfries and Galloway	20,000
Highland	40,000
Moray	25,000
North, South and East Ayrshire	100,000
Shetland	5,000
Orkney	5,000
Eilean Siar	5,000
Stirling, Falkirk, Clackmannanshire	60,000
Total *Denotes strategic development plan area	**1,001,000**

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EfW policy context- Scottish waste policies and targets

The waste hierarchy

Waste management policy in Scotland seeks to move waste up the waste hierarchy, giving top priority to preventing waste and this is set out in law in the Environmental Protection Act 1990. Under the waste hierarchy, waste prevention and reduction through efficient use and reuse of resources, recycling and recovery of value should be prioritised in that order, with landfill or incineration a last resort. Where value is recovered via e.g. the recovery of energy, incineration sits higher in the waste hierarchy than disposal into landfill, which is at the bottom of the hierarchy (see Figure 3).

The Waste (Scotland) Regulations 2011 and the Waste Management Licensing (Scotland) Regulations 2011 place a duty on all persons who produce, keep or manage waste, including local authorities, to take all reasonable steps to apply the waste hierarchy.

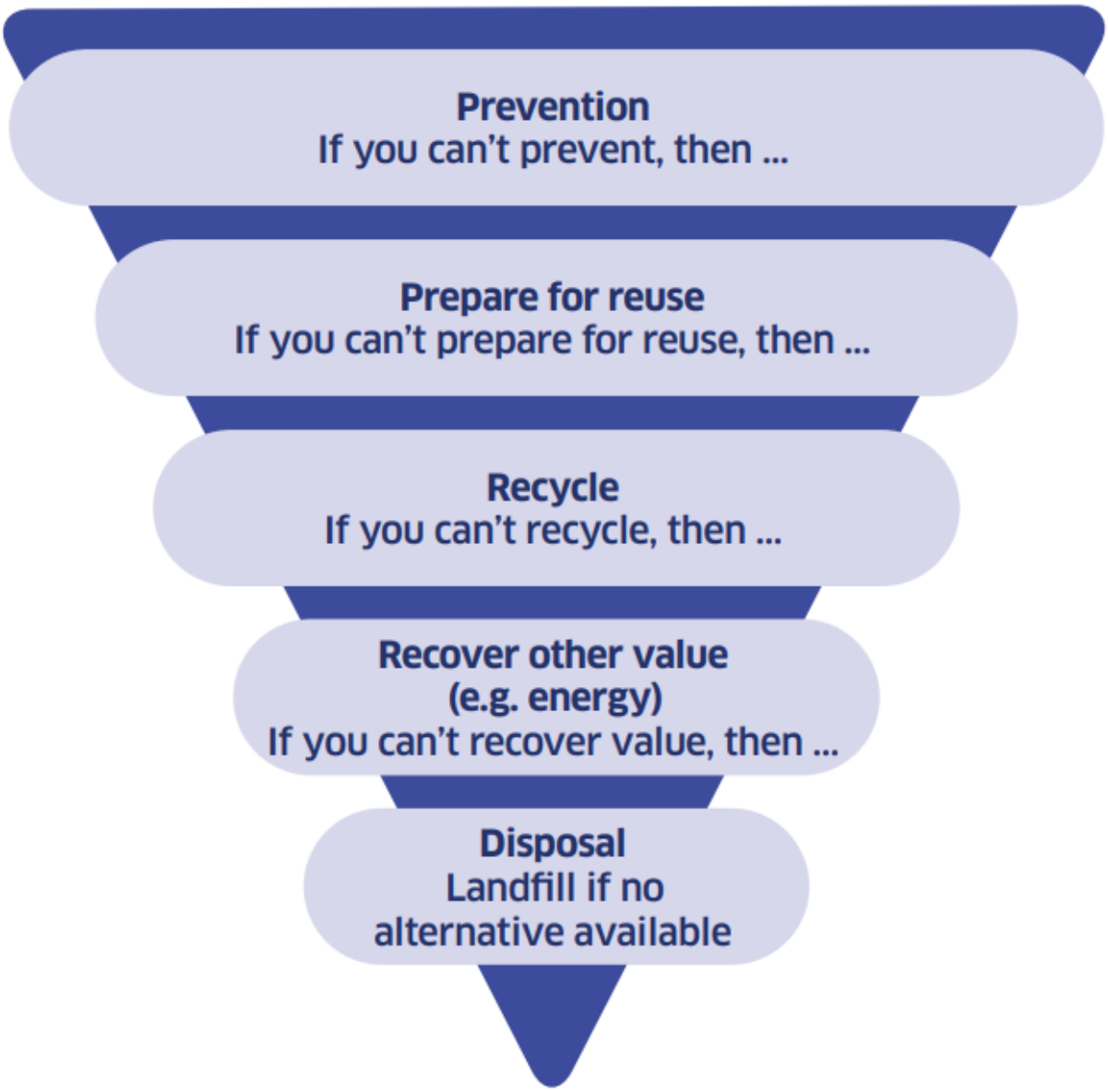
Waste targets

Current key Scottish Government targets in relation to waste and recycling are to, by 2025:

- reduce total waste arising in Scotland by 15% against 2011 levels
- reduce food waste by 33% against 2013 levels
- recycle 70% of remaining waste
- send no more than 5% of remaining waste to landfill
- end the landfilling of biodegradable municipal waste (BMW), a legal ban.

Figure 3. The waste hierarchy

Scotland's waste hierarchy, with stages in order of preference.



Scottish Government Climate Change Plan update

EfW in Scotland's Zero Waste Plan

Scotland's Zero Waste Plan set out the strategic direction for waste policy in Scotland in 2010. It states that EfW has an important role to play in meeting renewable energy targets and commits to ensuring that EfW is only used "for resource streams which cannot practicably offer greater environmental and economic benefits through reuse or recycling" [13] . This was legislated for through the Pollution Prevention and Control (Scotland) Regulations 2012, which limit incinerator inputs to residual wastes and other suitable waste types where treatment in incinerators is justified on environmental, health or safety grounds. These measures were intended to ensure that waste management in Scotland does not simply move 'one step' up the waste hierarchy from landfill to EfW without promoting measures further up the hierarchy.

EfW in Scotland's Climate Change Plan update

Scotland's waste targets outlined above are also a component of Scotland's 2020 Climate Change Plan update (CCPu). The CCPu states:

> “ In line with the waste hierarchy, our primary focus is on preventing waste and promoting the reuse of materials. However, we still need capacity to dispose of residual waste while we make the transition to a circular economy. In the context of the latest CCC recommendations and building on progress already made by the sector, we will consider measures to ensure new energy from waste plants are more efficient and how waste infrastructure can be ‘future-proofed’ for carbon capture and storage (CCS) technology.”

Carbon capture and storage (CCS) refers to technologies that capture and store carbon emitted from burning fossil fuels or at other emissions sources, preventing emissions from being released into the atmosphere. The Climate Change Committee (CCC) has indicated that coupling CCS with EfW will play an important role in reducing emissions from both the waste and bioenergy sectors [14] [15] . However, CCS technologies are still under development and there are currently no operational CCS facilities in the UK.

In the CCPu, the Scottish Government also committed to extending the ban on landfilling BMW to include biodegradable non-municipal wastes "subject to appropriate consultation and work to provide assurance around some specific waste streams". This was also in response to CCC recommendations on cutting emissions in the waste sector [14] .

The most recent (2021) CCC report on Scotland's progress states that "At this stage, it is difficult to assess the effectiveness of these measures or whether they will deliver the emissions cuts required" [16] . Recommendations include that the Scottish Government should work with the UK Government to develop a policy and funding framework to retrofit existing EfW plants with CCS from the mid-2020s, and ensure any new plants are all built ‘CCS-ready’.

During parliamentary scrutiny of the CCPu, the Environment, Climate Change and Land Reform Committee (ECCLR) heard concerns that the BMW landfill ban would divert waste to incineration, with questions raised about the extent to which this would deliver required emissions reductions. Concerns were also raised that this would lead to a 'lock in' to incineration which could undermine future incentives to reduce waste. There were calls for greater clarity on the role of EfW in the transition to a circular economy, and for coordination of public procurement processes [17] . The Committee also heard that public policy could assist in supporting greater use of heat recovery in EfW plants by e.g. supporting delivery of district heating infrastructure, and siting of EfW plants nearby heat demand through the planning system [17] .

In relation to the potential for CCS to be used to reduce emissions of EfW, concerns were raised about the time it will take before CCS technologies are operational [17] . ClimateXChange have stated that biomass paired with CCS is unlikely to be fully operational by 2030 [15] .

On the basis of these concerns, the ECCLR committee recommended that [18] :

- The Scottish Government review and coordinate the planning and procurement of

incineration capacity to avoid ‘lock-in’ to incineration including consideration of the strategic planning of EfW capacity in the development of the fourth National Planning Framework (NPF4).

- The Scottish Government consider what fiscal incentives may be required from 2025 to avoid over-reliance on incineration.

The Scottish Government responded (prior to announcing the review of incineration) that [19]:

> “ **'Lock-in' risk is being tracked through existing work.** For example, we are working to provide a centrally supported procurement solution to help remaining local authorities secure alternative solutions to comply with the forthcoming BMW ban, helping local authorities to consider whether to pool their waste and resources to secure the appropriate capacity for treatment of their residual waste. Through this collaborative procurement, we aim to ensure that expected reductions in residual waste (e.g. due to higher recycling rates) are taken into account when procuring energy from waste capacity. **This will avoid local authorities procuring more capacity than they are likely to require in the future, and send a clear signal to the market about how much capacity is required.** Contracts placed by local authorities are subject to thorough assessment and generally recent contracts have avoided the use of the types of contracts that require a minimum tonnage, reducing the risk of lock-in effects. **The NPF4 Position Statement is clear that we are exploring how NPF4 can promote the circular economy including the prioritisation of waste prevention, salvage, reuse and recycling of materials.** Encouraging the recovery of heat energy from waste facilities will also be considered. Further fiscal incentives (e.g. incineration tax) would need to be explored/considered, and potentially discussed with UK Government. (**emphasis added**)”

Fiscal measures to progress waste targets

In the CCPu, the Scottish Government also commits to developing a post-2025 route map to identify "how the waste and resources sector will contribute towards Scotland’s journey towards net zero in the period to 2030 and beyond". As part of this work, the Government outlines that it will "undertake a specific and focused piece of work to examine the range of fiscal measures used by other countries to incentivise positive behaviours and to develop proposals to go further in this area." The 2021-2022 Programme for Government went further and stated:

> “ consideration will also be given to the role of incineration and fiscal incentives, such as a waste tax, in the context of the planned waste route map and the Climate Change Plan, taking account of all waste targets and supporting a pathway to reducing waste sector emissions.”

The Scottish Government also calls on the UK Government to introduce further taxes to "influence behaviour; reduce consumption of unsustainable material; boost the competitiveness of recycled materials; and bring forward measures to influence global markets and reduce imported emissions."

In terms of existing fiscal mechanisms, **Scottish Landfill Tax (SLfT)** is paid on the disposal of waste to landfill, and is part of Scotland’s Zero Waste Plan to encourage the prevention, reuse and recycling of waste. SLfT is collected by Revenue Scotland, with enforcement by SEPA. The Scottish Government has stated its intention to use the SLfT

as an incentive to ensure that the transition to the 2025 ban on landfilling biodegradeable municipal waste proceeds at the necessary pace.

Some European countries have introduced **an incineration tax** to incentivise more reuse and recycling [20] . While the Scottish Government does not currently have the powers to introduce an incineration tax, the potential for such a tax has been debated in UK Parliament [21] . Other fiscal measures relevant to this area could include the potential for waste charges overseen by local authorities, or use of fiscal measures to reduce waste further up the waste hierarchy, for example by applying minimum charges on problematic items. The Scottish Government consulted on introducing powers for the introduction of such charges in 2019 as part of work on forthcoming circular economy legislation.

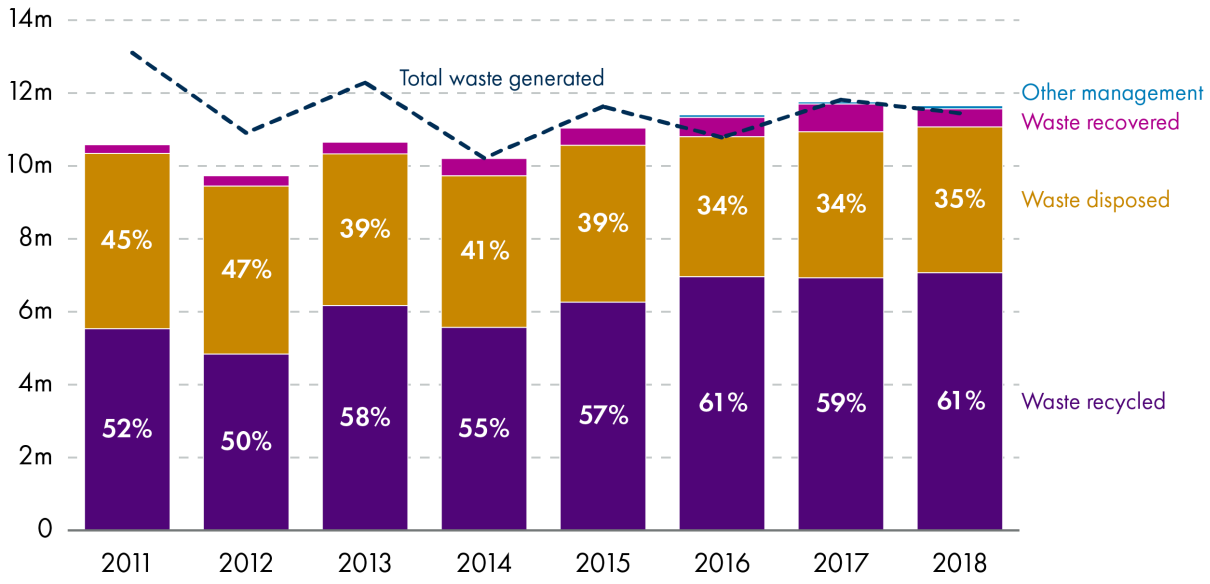
Waste trends and progress towards targets

What happens to waste in Scotland: recycled, disposed or recovered?

In 2018, Scotland produced **11.45 million tonnes of waste**, a reduction of approximately 13% in total waste generated since 2011 (see Figure 4). The majority of waste generated in Scotland is **recycled** (61%). A further 35% is **disposed** through landfill or waste inputs to incineration facilities that have not been certified to the R1 standard - which relates to a minimum level of energy efficiency. Of the remaining proportion, the majority is **recovered**, which includes waste inputs to co-incineration facilities and to incineration facilities that have been demonstrated to meet the R1 standard. Composting and Anaerobic Digestion of food and garden waste is included in the recycled category.

Figure 4. Waste generated annually in Scotland (tonnes) 2011-2018

Waste generated annually in Scotland (dashed line) and the percentage of waste processed either through recycling, disposal, recovery or other management. The total waste generated (dashed line) may differ from total waste processed as the techniques used to process waste may result in a lower or greater quantity (in tonnes) of waste output.



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*Publication of more recent waste data has been delayed by the SEPA cyber-attack. There may be a gap in some waste data until 2021 datasets are published in 2023.

Progress towards waste targets

In 2018, the recycling rate in Scotland was 60.7%, representing an increase of 8.7% in recycling since 2014. Whilst progress has been made with recycling towards the target of 70% by 2025, it has also somewhat flatlined over the past few years of available data. There was also a 2020 target to recycle 60% of household waste - however rates have also flatlined at around 45% and the CCC have stated that it looks unlikely this target will be met [16] (see Figure 5 below).

In 2020, Scotland sent 2.6 million tonnes (Mt) of waste to landfill, representing a reduction of over 4.4 Mt (63%) since 2005 [4] . Of this amount, 0.7 Mt was household waste, a reduction of 2.5 Mt (77%) since 2005 (see Figure 6 below). 32.1% of all waste was sent to landfill in 2018. There are currently no data on the progress towards reducing food waste although a review of progress is expected in 2022.

Between 2011 and 2020, the amount of biodegradable municipal waste sent to landfill has halved, with a significant drop between 2018 and 2019 [4] (see Figure 7). In 2020 the amount of BMW disposed to landfill was 691,000 tonnes, a decrease of 8,000 tonnes (1.1%) from 2019 [22] . The top two categories of BMW disposed of to landfill were mixed municipal waste which comprised (64% of the total) and other non-hazardous wastes from mechanical treatment of waste (20% of the total).

This reduction is considered to reflect the increased recycling rate over this period, escalating landfill tax [23] and preparations for the upcoming 2025 ban on BMW being sent to landfill - including diversion of landfill to incineration.

Figure 5: Progress with Scotland's overall and household recycling rate

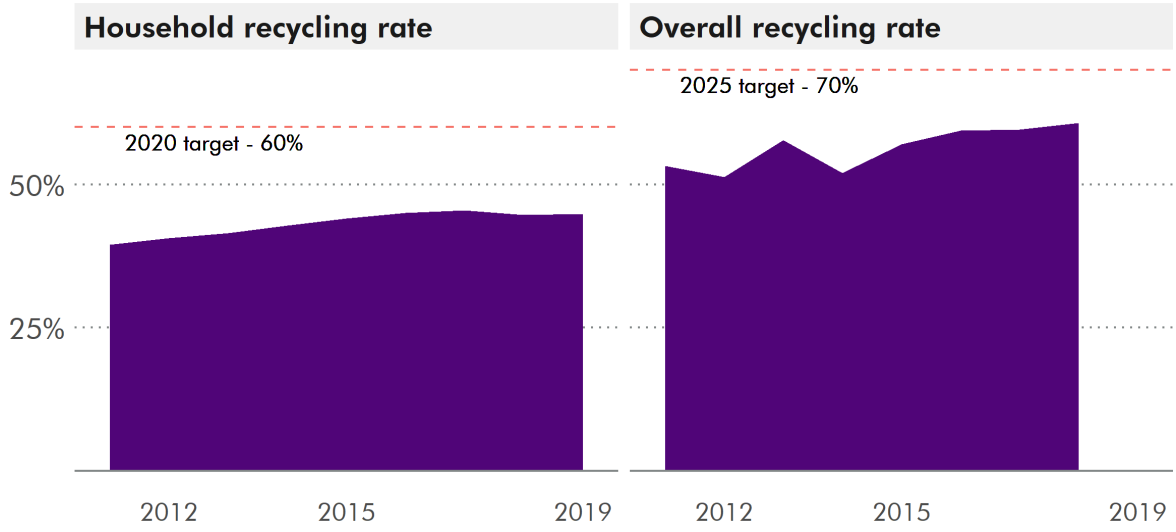

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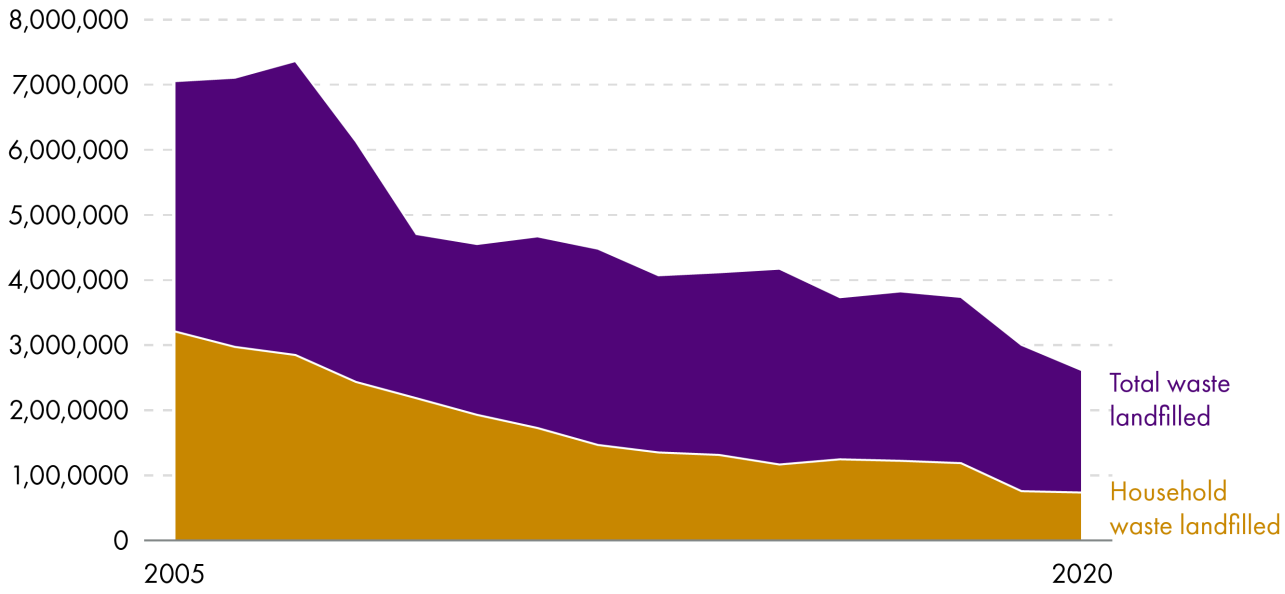
Figure 6: Total waste landfilled in Scotland from 2005-2020, and household waste landfilled (tonnes)



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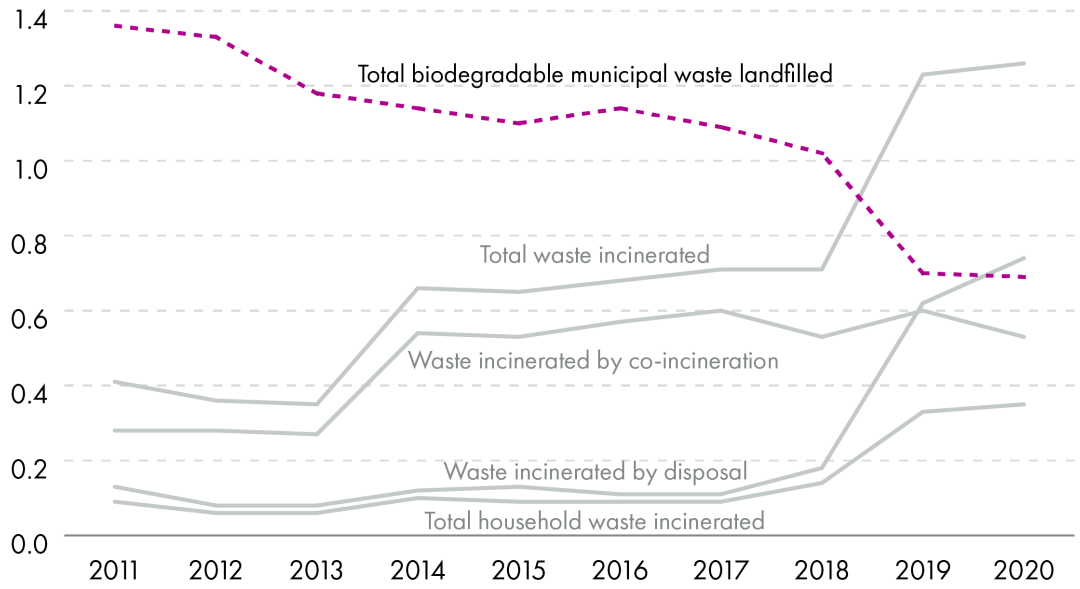
Incineration trends

Over the same period in which total BMW landfilled has decreased, there has been an increase in incineration in EfW facilities in Scotland [24] (see Figure 7 below). More recent increases are largely due to more household and similar wastes being incinerated, and longer-term increases are also driven by a significant rise in co-incineration of waste wood from construction. Scotland is a net importer of waste wood for incineration.

- The total quantity of total waste incinerated in Scotland in 2020 was 1.26 million tonnes, an increase of 38,000 tonnes (3.1%) from 2019, and an increase of 855,000 tonnes (208%) from 2011 (bearing in mind this started from a low baseline).
- The incineration of household and similar waste increased from 87,693 to 350,231 tonnes between 2011 and 2020, a 299% increase. Between 2019 and 2020 the incineration of household and similar waste increased from 330,368 to 350,231 tonnes, a 7% increase.
- The waste material category with the highest amount incinerated in 2020 was wood waste, which comprised 32.8% (415,000 tonnes) of the total waste incinerated. Household waste comprised 27.7% (350,231 tonnes) of the total.

Figure 7: Waste incinerated in Scotland 2011-2020 (in million tonnes)



SEPA

Classification of incineration

The thermal treatment of waste in Scotland is classified on the basis of whether the operation's sole purpose is for the processing of waste (co-incineration versus incineration) and whether the operation has been accredited as meeting EU energy efficiency standards of an energy recovery facility, known as R1 accreditation. R1 accreditation is voluntary but is a requirement if Scottish EfW facilities intend on importing waste from EU Member states [8] .

Facilities that are not accredited to R1 standards are classified as **incineration by disposal**, whereas those which are accredited are classified as **incineration by recovery**. **Recovery by co-incineration** refers to waste incinerated/thermally treated at a facility that normally generates energy from incineration of non-waste sources (such as coal, gas or biomass) [25] .

Figure 7 above also shows the split between waste incinerated by disposal and by co-incineration between 2011 and 2020. There was no incineration recorded as incineration by recovery in this period as during this time no municipal waste incinerators in Scotland had been accredited to the R1 energy efficiency standard. At the time of writing one site is now understood to be accredited (Viridor Dunbar).

GHG emissions from waste

In 2019, emissions from waste represented around 3% of Scotland's total GHG emissions, compared to approximately 8% in 1990 (see Figure 8). The majority of GHG emissions from the waste sector are the result of methane released from landfill sites, which represented 78% of waste-related emissions in 2019 (1.4 $MtCO_2e$) [26] [27] . There has been a 74% reduction in waste-related emissions between 1990 to 2019, primarily achieved by an increase in landfill methane being captured and used for energy, a reduction in biodegradable waste going to landfill, and increases in recycling [28] .

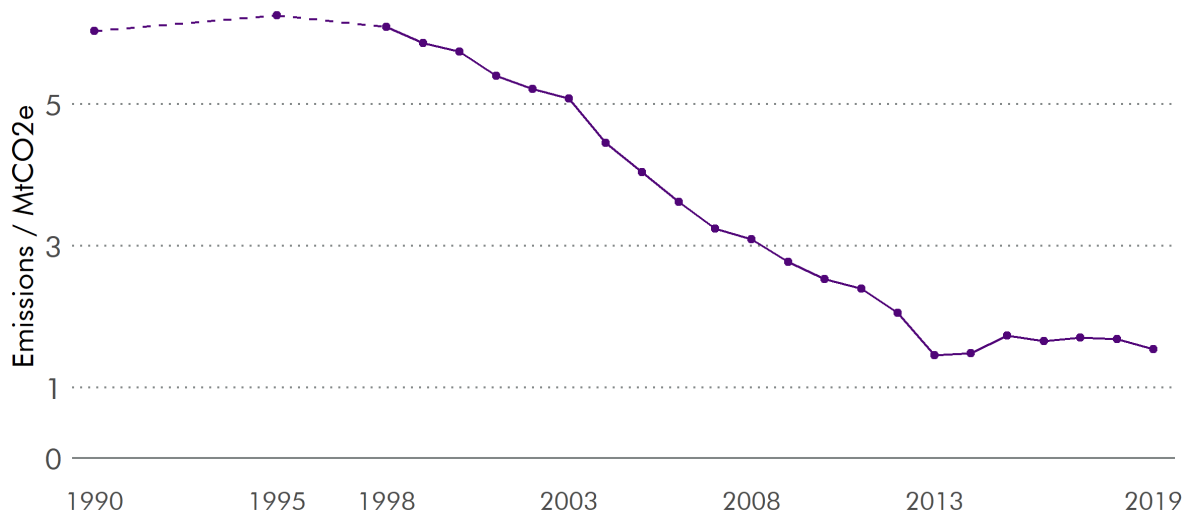
It should be noted however that emissions from EfW may be classed as energy emissions e.g. in the energy 'envelope' of the Climate Change Plan rather than as emissions from the waste sector. Care should be taken in interpreting waste GHG emissions data, as emissions can move between categorisations (from waste to energy) by shifting from landfill to EfW.

The CCC recognises this challenge with reporting and monitoring waste emissions data in its most recent (2021) progress report on Scotland, and, also "Noting the issue of rising emissions from incineration and EfW", has asked the Scottish Government to report emissions from EfW plants separately from power sector emissions from other sources, to make it easier to track these emissions [16] .

More information on climate impacts of EfW compared to landfill is provided later in the briefing.

The CCPu aims to reduce emissions from waste to 0.9 million tonnes of carbon dioxide equivalent ($MtCO_2e$) by 2025, and 0.7 $MtCO_2e$ by 2030, from a current figure of approximately 1.9 $MtCO_2e$ [29] .

Figure 8. Emissions from waste 1990-2019 (not including EfW plants)



NAEI

Ban on landfilling biodegradable municipal waste by 2025

As described above, a factor that has been linked to the increase in incineration of waste in Scotland is the forthcoming ban on landfilling biodegradable municipal waste in 2025.

From 31st December 2025 the landfilling of biodegradable municipal waste (see box below) will be banned, set out in law by the Landfill (Scotland) Regulations 2003, as amended by the Waste (Scotland) Regulations 2012 and the Waste (Miscellaneous Amendments) (Scotland) Regulations 2020. As well as reducing the amount of waste

landfilled, the purpose of the ban is to extract remaining resource value from the residual waste stream and to reduce GHG emissions from landfill [30] .

The ban means that any BMW that cannot be recycled or reused will instead need to be diverted to other waste management streams. BMW will instead need to:

1. Be sent to an EfW facility for thermal treatment (either incineration or an advanced thermal treatment); or
2. Be pre-treated to reduce the biodegradability of waste before it is sent to landfill; or
3. Be exported to another country.

The decision to ban BMW going to landfill was informed by 2010 Scottish Government-commissioned research which outlined that both the timing and sequencing of landfill bans was an important consideration to avoid an over-supply to other residual waste facilities, such as EfW facilities. The research concluded that:

> " EfW has an important role to play and can make a positive contribution to both renewable energy and climate change targets. However, in order to achieve the high levels of prevention, reuse and recycling outlined in the Zero Waste Plan it is imperative that materials that could be reused or recycled are not directed to mixed waste treatment facilities such as EfW facilities."

What is Biodegradable Municipal Waste?

The legal definition of Biodegradable Municipal Waste (BMW), set out in the Landfill (Scotland) Regulations 2003 is "municipal waste that is also biodegradable" with biodegradable waste defined as:

"any waste capable of undergoing anaerobic or aerobic decomposition such as food, garden waste, paper and cardboard" and municipal waste defined as: "waste from households as well as other waste which because of its nature or composition is similar to waste from households". This includes wastes from the retail and hospitality sector.

The ban applies to both public and private sectors managing waste covered by the ban. If BMW waste has undergone a treatment process to the extent that it is no longer biodegradable, it will not be categorised as BMW and will not be subject to the landfill ban. The main affected waste stream here is residual 'black bag' waste from homes and businesses.

Original ban delayed from 2021 to 2025

Under the Waste (Scotland) Regulations 2012 the landfilling of BMW was originally banned with effect from 1st January 2021. However, in 2019, the Scottish Government announced that this would be delayed until 31st December 2025 [31] - given legislative effect in the Waste (Miscellaneous Amendments) (Scotland) Regulations 2020.

The extension was based on research indicating that compliance with the ban would not be possible without reliance on export which "might not be wholly consistent with the aims of the ban, which seeks to divert waste from landfill" [32] . The report additionally stated that

it would be 'highly unlikely' that the additional thermal treatment capacity needed would be operational in advance of the 2021 date [32] .

The Climate Change 2019 monitoring report expands on this, stating that (emphasis added):

> " Significant progress has already been made towards the ban... **Despite this further progress, it is clear that full compliance by 2021 will not be possible without significant reliance on export options, including landfill in England, with consequent environmental impact and additional financial implications for local authorities.** The additional 4 years will allow for procurement, development, planning and building of waste processing infrastructure, over and above that which is already in the pipeline."

The Scottish Government also stated in 2019 that it would "support a positive, centrally co-ordinated intervention to help the remaining local authorities procure solutions for the remaining tonnage of waste and Scottish Landfill Tax will be used to provide a further incentive to ensure that transitional work proceeds at the necessary pace". [31] .

Progress towards the ban (including CCC advice)

The most recent Climate Change Monitoring Report, published in May 2021, stated that it was 'too early to say' whether Scotland was on track to meet the target of ending the landfilling of BMW by 31 December 2025. The Scottish Government has commissioned research through ClimateXChange to assess Scotland's residual waste treatment capacity needs up to 2025, and also the impact of extending the ban to include non-municipal biodegradable waste [33] (a CCC recommendation). The Scottish Government stated in November 2021 that information on residual waste treatment capacity needs up to 2025 will be published independently of the incineration review [34] .

In its most recent (2021) progress report on Scotland, the CCC recommend that the Scottish Government should implement the 2025 landfill ban and extend this ban to also cover biodegradable non-municipal waste by 2025. They state that individual local authorities "should move faster where possible (from 2021 onwards)" and that early investment is required to fully deliver on this target, along with Scotland's 70% recycling rate, 15% total waste reduction and 33% food waste reduction targets for 2025 [16] .

Related policy: food waste

As food waste forms a key component of the biodegradable content of municipal waste, Scotland's food waste policies also have a role to play in progress towards the ban. There was an estimated 987,890 million tonnes [35] of food waste in 2013, the baseline year for the target to reduce food waste by 33% by 2025.

Scotland's Food Waste Reduction Action Plan sets out actions to drive progress towards the 33% target by 2025 and support the upcoming 2025 ban on BMW being sent to landfill. The Action plan is focused on preventing food waste through improved monitoring and reporting of food waste, sector leadership, public engagement, and where prevention is not possible, optimising use of the bio resource through promoting food waste segregation, and identifying barriers to food waste reuse and recycling. A review of progress towards the 33% target and an updated Action Plan is expected to be published during 2022.

Planning and regulatory requirements

EfW operations are regulated to control emissions of GHGs and other airborne contaminants to ensure that human health and environmental impacts are minimised. EfW operations are also regulated with the aim of ensuring that recycling efforts are not undermined, by controlling what can be incinerated in thermal treatments and also to ensure a minimum level of efficiency.

SEPA plays an important role in consenting new EfW sites, in the initial planning stage as a statutory consultee and in the issuing of environmental licences. **SEPA's position on EfW is that [8] :**

- Scotland needs to generate less waste, recycle more and safely maximise the use of the resources left in residual waste.
- Appropriately located and well managed energy from waste facilities that meet modern requirements such as the standards contained in the EU Industrial Emissions Directive, should not cause significant pollution of the environment or harm human health.
- Facilities to recover energy from waste have a part to play in a national network of waste management facilities.
- Treating waste to generate energy should not be at the expense of actions taken to prevent or recycle waste.
- Recovering energy from waste can contribute to a balanced energy policy where the energy generated is recovered as far as practicable using combined heat and power schemes in compliance with Best Available Techniques (BAT).

Planning permission and Scottish Planning Policy

All new EfW developments must seek planning permission from the relevant local authority. Under the Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017 all waste disposal installations for the incineration or chemical treatment of non‑hazardous waste with a capacity exceeding 100 tonnes per day also require an Environmental Impact Assessment (EIA) [36] . The purpose of the EIA is to assess the likely significant environmental effects arising from a proposed development.

SEPA are a statutory consultee in the planning process, and provide advice on whether the proposed plant will likely be given a permit and comply with the Thermal treatment of Waste Guidelines 2014.

Scottish Planning Policy (SPP) sets out that proposed EfW developments should identify where heat sources and demand are situated close together and where heat networks and energy centres would be appropriate. The Scottish Government provide further guidance to planning authorities on EfW through a Planning Advice Note (PAN 63), in place since 2013. Suggested areas of focus for local authorities include to use heat maps to identify long-term waste streams and buildings where there are long term high heat demand to identify logical locations for EfW plants, and to ensure heat plans are submitted with EfW proposals.

Given all current operational EfW sites processing MSW in Scotland are electricity-only with the exception of one (although there are more plans for heat offtake for sites in the planning system - see EfW sites), it is unclear if existing planning policy has had a significant impact on enabling or ensuring heat offtake from EfW sites.

EfW in the draft National Planning Framework 4

The National Planning Framework (NPF) is a long-term plan for Scotland that sets out where development and infrastructure is needed to support sustainable and inclusive growth. A consultation draft of the fourth NPF (NPF4) was published in November 2021. The draft contains a number of policies relevant to EfW, and a wider zero waste policy which aims to support development that reflects the waste hierarchy, prioritising the reduction and reuse of materials.

Draft NPF4 states that development proposals which involve the recovery of EfW should only be supported where the proposal:

“

- is in a location identified or supported by the local development plan;”
- is consistent with climate change mitigation targets and in line with circular economy principles;”
- can demonstrate that a functional heat network can be created and provided within the site for appropriate infrastructure to allow a heat network to be developed and that wherever possible, potential local consumers have been identified;”
- is supported by a heat and power plan, which demonstrates how energy recovered from the development would be used to provide electricity and heat, including the scope to efficiently distribute heat to sites which have a long-term high heat demand and where consideration is given to methods to improve the sustainability of the facility, such as carbon capture and storage;”
- complies with the Thermal Treatment of Waste Guidelines published by SEPA;”
- supplies a decarbonisation strategy aligned with Scottish Government decarbonisation goals and be refused where the strategy is insufficient; and”
- delivers demonstrable community benefits if the energy from waste proposal would treat waste from an area wider than the local authority.”

NPF4 will replace SPP which sets out current planning policy for EfW developments. The draft recognises that an independent review of the role that incineration plays in Scotland’s waste hierarchy is underway and states that "Any emerging outcomes will be taken into account in the finalised version" of NPF4.

Pollution Prevention Control (PPC)

An EfW facility requires both planning permission and an environmental permit - PPC licence - under the Pollution Prevention and Control (Scotland) Regulations 2012 (PPC regime) issued by SEPA before it can operate.

The practical implications of the PPC regulations are that plants:

- Are designed, equipped and operated using Best Available Techniques and conform to the requirements of the Industrial Emissions Directive (2010/75/EC) ("IED" -- transposed into Scottish Law under the PPC regulations, now part of retained EU law) to ensure that no significant pollution is caused.
- Only recover energy from waste which has been subject to all reasonably practicable measures to recover materials for recycling e.g. recyclable metals and plastics.
- Ensure that the recovery of energy takes place with a minimum level of energy efficiency.

PPC regulations require a **noise impact assessment** and air modelling to investigate the potential effects of emissions to the atmosphere. Any application for a PPC permit for an EfW plant will also require a **Human Health Impact Assessment** and must take into account the Thermal Treatment of Waste Guidelines 2014.

As part of these requirements, operational EfW facilities must complete an annual Scottish Pollutant Release Inventory (SPRI) which is published after verification by SEPA. Plants which fail to meet reasonable expectations of environmental performance can have their license revoked [8] .

The role of (and future alignment with) EU law on EfW and waste

A significant proportion of waste regulation in Scotland (as with many areas of environmental regulation) is derived from EU law, and remains the basis for much regulation in this area via retained EU law. SEPA is also currently implementing revised EU Best Available Techniques (BAT) conclusions (essentially revised technical standards) for Waste Incineration, published in 2019, which further tighten emissions standards.

EfW facilities in Scotland may also continue to apply for R1 status, demonstrating they meet energy efficiency standards set by the EU and outlined in the WFD.

The Scottish Government has also consistently maintained that it will seek to continue to align with EU standards where possible (e.g. as stated in the 2021-22 Programme for Government). This suggests that any future developments in EU law or standards in relation to Energy from Waste or industrial emissions are likely to influence standards in Scotland.

Notably, although this does not directly relate to EU standards, the EU excluded EfW facilities from its 2019 EU Sustainable Finance Taxonomy Report which includes a list of economic activities considered to have the potential to make a substantial contribution to climate change mitigation in order to guide investment. The background provided on the decision well illustrates tensions in EfW policy at the moment:

“ On waste incineration with energy recovery (waste-to-energy, WtE) experts’ opinions differed on whether this would be an appropriate environmentally sustainable activity offering a substantial contribution to climate mitigation. On the one hand, there were arguments against the inclusion of WtE. These highlighted the large portion of waste currently incinerated that could be recycled, the reliance of some individual Member States on the incineration of municipal waste, and the risk that further increasing capacities risk overcapacity and could result in lock-in effects. This would in turn discourage more reuse and recycling, options higher in the waste hierarchy. On the other hand, it was emphasized that WtE has a role to play even in an increasingly circular economy as not all residual waste can be reused or recycled.”

Social and environmental impacts of EfW

Social and environmental implications of EfW sites relevant to policy-making, strategic planning and individual consenting and permitting decisions may include:

- **Climate implications** - The incineration of waste generates GHGs, mainly CO_2 as well as N_2O (nitrous oxide), NOx (oxides of nitrogen) NH_3 (ammonia) and organic C, measured as total carbon. Climate considerations include how to maximise efficiency through technology type, heat offtake, fuel supply and complex issues of how EfW might have knock-on effects for or interact with other waste management or circular economy decisions e.g. how EfW is prioritised in relation to waste reduction and recycling measures;
- **Air quality implications** with any associated health implications. Incineration produces a range of pollutants released through flue gases which have the potential to damage the environment and human health and the location, construction and operation of sites may have local implications for communities;
- **Other local potential issues or considerations** around siting of infrastructure, noise, odour, and knock-on effects on traffic. This could include socioeconomic dynamics around where waste infrastructure is sited in relation to communities, for example.

It is worth bearing in mind, in terms of considering the overall and comparative merits and social and environmental impacts of EfW as an approach to waste management, that **landfill sites** also have climate, air quality and local environmental implications. Net impacts of the waste management choice need to be considered as a whole. Research published in 2010 set out for example that socially deprived areas of Scotland were disproportionately exposed to municipal landfills and had been since at least 1981 [37] .

The broader context is the opportunity to further avoid environmental or social impacts through moving further up the waste hierarchy, away from the need for disposal through both EfW and landfill, and towards recycling, reuse and reduction.

Climate impacts of EfW

As discussed, the forthcoming 2025 ban on landfilling BMW is expected to divert municipal waste away from landfill to incineration in EfW facilities and this trend can already be observed. However, as EfW plants still emit carbon dioxide, questions have been raised by stakeholders and in the Scottish Parliament about how much benefit is gained from diverting waste from landfill to EfW and how EfW fits into net zero goals in the long-term [38] , particularly given the need to plan infrastructure which can have long time horizons.

As discussed earlier in the briefing, between 2010 and 2019, SEPA reported that CO_2 emissions from it's regulated waste sites increased by 76%, partly due to an increase in the incineration of waste [39] . However during the same time period, methane emissions from landfill have decreased.

Zero Waste Scotland published a review in 2021 examining the potential climate change impacts of treating residual municipal waste in EfW plants, compared with landfill and

other low-carbon sources of energy - by modelling scenarios which could meet the 2025 BMW landfill ban [1] **.** It carried out lifecycle analysis to estimate the net GHG emissions per tonne of waste input for EfW against landfill as an alternative management option. **It found that sending one tonne of residual municipal waste to EfW in Scotland in 2018 emitted 246 kgCO_2e, 27% less than sending a tonne of waste to landfill.**

At the same time, the energy generated from the burning of residual municipal waste in EfW plants was found to have a high carbon intensity compared to the grid average. The report estimated that **burning residual municipal waste in EfW plants in Scotland in 2018 had an average carbon intensity of 509 gCO_2/kWh**. The average carbon intensity for electricity-only incinerators and gasifiers was 524 gCO_2/kWh. This average was nearly twice as high as the carbon intensity of the UK marginal electricity grid average, which was 270 gCO_2/kWh in 2018. The carbon intensity of the only heat-only incinerator operating in Scotland in 2018 was 325 gCO_2/kWh, reflecting its higher efficiency, although this was still higher than the carbon intensity of the UK marginal heat average of 267 gCO_2/kWh. The report states that converting electricity-only EfW plants to CHP reduces their carbon intensity by 30% but "not below the carbon intensity of alternative energy sources".

Modelling of different waste disposal scenarios in the report suggests that theoretically the greatest emissions savings can be made if residual waste is subject to biostabilisation prior to landfill, and CHP is utilised in EfW rather than electricity only (see Figure 9 below). Biostabilisation is a process of degrading the biodegradable content of residual waste prior to landfilling, resulting in an output which, when landfilled, produces lower GHG emissions than untreated waste. In summary, the report found [1] :

1. **EfW had a lower carbon intensity than landfill (based on current waste compositions)**, but the EfW carbon intensity was still significantly greater than marginal carbon intensity of electricity generated from the Scottish and UK grid.

2. **Converting EfW plants to combined heat and power (CHP) improves their efficiency** and reduces their carbon intensity.

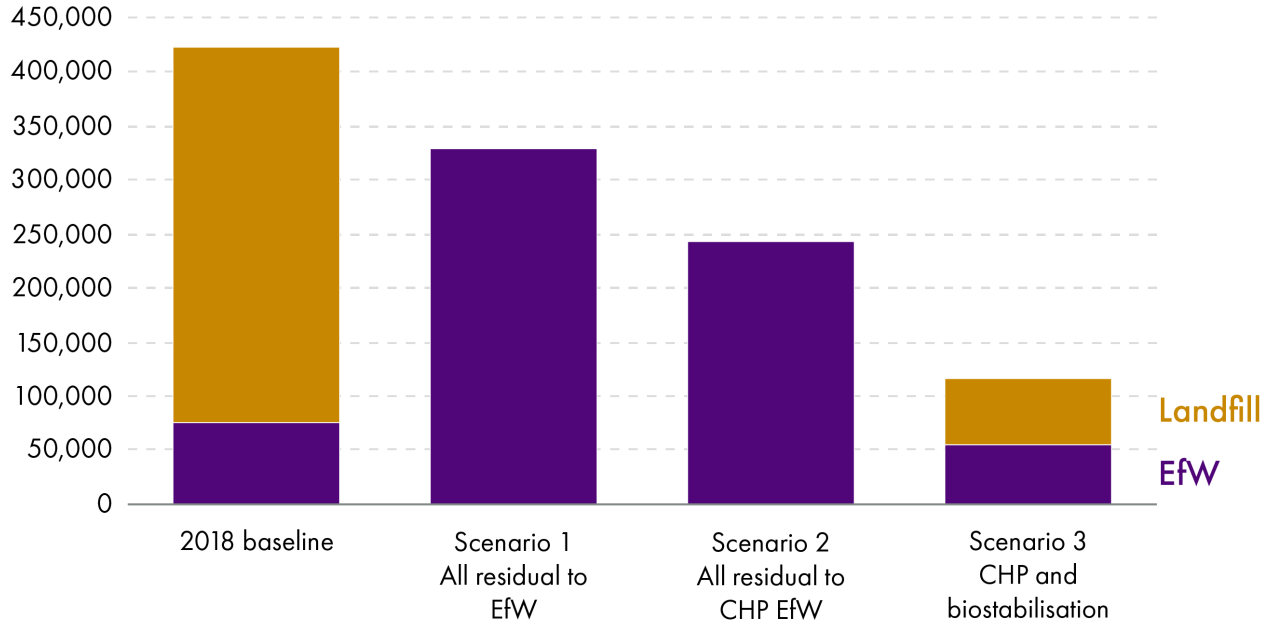
3. **Emissions from incineration and landfill are highly sensitive to waste composition**; the greater the plastic content of the residual waste incinerated, the greater the carbon intensity. For example a greater proportion of plastic (and corresponding lower proportion of biodegradable waste) in residual waste, results in higher carbon emissions per tonne incinerated, and reduced carbon emissions if landfilled.

4. **Further reducing the carbon impacts of EfW will require additional measures**, such as the use of biostabilisation.

The report is also caveated that whilst biostabilisation can significantly reduce the biodegradable content of landfilled waste, resulting in emissions savings, figures presented are indicative, based on a theoretical assessment of what could be achieved through biostabilisation, and require further research. The report states that "Such technologies offer an alternative means of meeting the BMW ban to incineration. Whilst such plants exist in Europe, there are no such reference plants in Scotland".

The report also stresses that climate change is not the only consideration when assessing the relative merits of EfW vs other options such as landfill - land use change and local land, air and water pollution should also be considered.

Figure 9. Estimated annual emissions of three scenarios for meeting the BMW ban by managing residual municipal waste in 2018 (tCO2e/year)



Zero Waste Scotland [1]

Air quality and human health impacts

As stated, an EfW facility requires a permit under the Pollution Prevention and Control (Scotland) Regulations 2012 (PPC regime) before it can operate. This means that plants must be designed, equipped and operated using Best Available Techniques and conform to requirements of the Industrial Emissions Directive - transposed into Scottish law under the PPC regulations, now part of retained EU law. PPC regulations require air modelling to investigate the potential effects of emissions to the atmosphere and any application for a PPC permit for EfW will also require a Human Health Impact Assessment.

NGOs raise the importance of strict controls on new incinerators in relation to air pollution and human health. Friends of the Earth Scotland states:

> " The chemicals given off by incineration have to be very carefully controlled and even then toxin particulates, heavy metals and dioxins are released. Failure to properly control emissions, can be dangerous to human health, especially for vulnerable groups like infants, pregnant mothers and people with underlying health conditions."

Greenpeace has raised concerns that waste incinerators are more likely to be built in the UK's most deprived neighbourhoods, although information provided by the Scottish Government in Parliament in September 2021 regarding location of current operational incinerators suggests this is not currently the case in Scotland.

Greenpeace also raise concerns that there may be pressure for the UK Government to weaken standards in the post EU-exit environment. Air quality is a devolved area, but the Scottish Government has provisionally agreed a Common Framework on air quality with the UK Government which may indicate a future approach to alignment with EU standards

such as those in the Industrial Emissions Directive. The Scottish Government has consistently maintained that it wishes to continue to maintain or exceed EU environmental standards.

A 2020 academic review of health studies related to impacts of EfW emissions (including those undertaken in the UK) concluded that whilst there was a lack of evidence, limited evidence suggests that well-designed and operated EfW facilities using sorted feedstock are critical to reduce potential adverse health (cancer and non-cancer) impacts, due to lower hazardous combustion-related emissions, compared to landfill or unsorted incineration [40] .

It states that "Poorly fed WtE [waste to energy] facilities may emit concentrated toxins with serious potential health risks, such as dioxins/furans and heavy metals; these toxins may remain problematic in bottom ash as a combustion by-product". Most modelling estimates that electricity (per unit) generated from EfW generally emits less health-relevant air pollutants than from combustion of fossil fuels e.g. coal - although this comparison arguably has less relevance in Scotland where coal-generated electricity has come to an end. The study concluded that "rigorous assessment" of both the EfW technology and the waste feedstock to be used is necessary when planning sites, in order to protect human health.

Health Protection Scotland and SEPA jointly published a report in 2009 on the Incineration of Waste and Reported Human Health Effects [41] . Key findings included:

- There are limitations on the evidence for a number of reasons, including that much research was carried out during periods where incinerator standards were less strict.
- The range of health outcomes covered in literature is wide including: cancers, respiratory illness, birth outcomes, congenital malformations and infant mortality.
- For waste incineration in general, the evidence for an association with (non-occupational) adverse human health effects is inconsistent and inconclusive.
- Some more recent work suggests that there may have been an association between some airborne emissions (particularly dioxins) from industrial, clinical and municipal waste incinerators in the past (before more stringent regulatory requirements) and some forms of cancer. However, this evidence is not conclusive.
- The magnitude of any health effects on residential populations living near incinerators in the past, if it occurred, is likely to have been very small.
- Due to stricter legislative controls and improved technology, levels of airborne emissions from incinerators should be lower now than in the past. Any risk to human health associated with newer incinerators, operated within current regulations which are based on a precautionary approach, is likely to be minimal.
- It is possible that in the future the number of incinerators or throughput of incinerators may rise, and consequently airborne emissions could increase. When new incinerators are planned, especially if there are vulnerable populations nearby, or in localities where there are other sources of similar airborne emissions (including other EfW sites, road traffic and other industrial sources), there will remain a need to take account of background ambient air quality in assessing the potential impact of a new facility.

EfW and the circular economy

As well as considering the climate and other social and environmental implications of different disposal scenarios e.g. EfW vs landfill, an important part of the debate about EfW is how it fits into a long-term transition to a circular economy. This raises complex questions around how policies on EfW interact with policy ambitions to increase and maximise demand reduction, reuse and recycling - i.e. actions further up the waste hierarchy. Concerns are often phrased around the potential for 'lock-in' to incineration infrastructure which might undermine those efforts.

Key Scottish Government commitments and areas of policy development in relation to the wider transition to a circular economy include the forthcoming Deposit Return Scheme, collaboration with the UK Government on producer responsibility schemes (e.g. on packaging), a commitment to a forthcoming Circular Economy Bill, and policy development in specific waste management areas such as on food waste and textiles. More information can be found in the SPICe Environment Subject Profile and Scottish Government commitments set out in the Climate Change Plan update - which notably also include a commitment to a routemap for how 2025 waste targets will be met, and to explore the potential for fiscal measures in this area.

There is a challenge for policy-makers in considering how these various policy efforts interact or align, and pull together towards a more circular economy, including policies on EfW. The most recent CCC advice to the Scottish Government on waste recognises this dynamic, for example recommending that the Government implement measures to ensure the 2025 landfill ban is "delivered primarily through improved waste prevention, resource efficiency and recycling" [16] .

Giving evidence to the Net Zero, Energy and Transport Committee on 28 September 2021, Zero Waste Scotland's Chief Executive Iain Gulland recognised that whilst incinerators may have a short-term role, there needed to be an "exit strategy" [38] :

> “ [D]isposing of waste whether through incineration or landfill is, as we keep saying, part of the old linear economy system. We need to decouple ourselves from that and think more aggressively about different strategies to reduce, reuse, repair and remanufacture materials at a much faster rate and in a more strategic way. Instead of just handing this to the 32 local authorities, we need a much more collaborative approach as a nation. Our waste system has, to some extent, fragmented, with 32 authorities that take a variety of approaches and a number of waste management companies in the middle. As a small country, if we really want to realise some of our ambitions with regard to our resources, we need a much more collaborative and joined-up approach to harnessing those resources for economic as well as climate gains.”

Friends of the Earth Scotland (FoES) has expressed concerns about incineration [42] , stating that:

> “ Incinerators including energy-from-waste plants, should not be used as an alternative to recycling and reducing waste. Any new incinerator that is built in Scotland now will lock us into years of wasting resources by burning them, and further environmental damage. Incinerators also create a barrier to moving to a circular economy as there is a demand for waste that could be reused, recycling or remanufactured, all of which is critical if we are to limit our reliance on the planet’s resources and tackle the climate crisis.”

FoES have also called for a moratorium on building new incinerators in Scotland to on the basis that "incineration wastes valuable resources, incineration pollutes and incineration is bad for climate change." [42] .

The Marine Conservation Society has expressed that they do not support the construction of new waste incinerators in the UK [43] , stating that:

> “ Incineration does not support the circular economy, which is not only about recycling products at the end of life, but also about designing the products at the start of life for their end of life. By further increasing incineration capacity we actively discourage changes in behaviour, both on the part of the consumer and producer, to reduce resource usage (such as a reduction in single use plastic) and disincentivise a push for increased recycling rates. To encourage a circular economy, incentives on recycling should ensure that the cost of recycling is not higher than that of incineration (as is the case for a number of councils at present).”

Some other stakeholders stress however that even in the context of the transition to a circular economy, there is still a need for sufficient waste management infrastructure in the meantime, including EfW, as a means of dealing with residual waste.

The Chartered Institution of Water and Environmental Management (CIWEM) has stated it's view that policy should focus on driving reuse and eco-design as opposed to towards recycling and energy from waste [44] . However, CIWEM have expressed that "energy recovery from waste has a legitimate role to play in meeting renewable energy objectives for truly residual waste (that which cannot be reused or recycled)." [45]

The Scottish Environmental Services Association, a waste industry body, also emphasise that EfW continues to have a significant role to play in waste management, stating in 2021 that [46] :

> “ With Scotland continuing to face a residual waste treatment capacity gap, the Scottish Government should conclude its EfW review as quickly as possible so as not to delay or deter investment in much needed waste treatment infrastructure. EfW is the only viable and bankable alternative to landfill for the treatment of Scotland’s non-recyclable waste...”

EfW's contribution to the energy sector

In a 2010 report to the Scottish Government it was estimated that EfW (including thermal treatments *and* anaerobic digestion) using combined heat and power (CHP) could provide up to **2.0 terawatt hours (TWh)** of useful heat and **0.90 TWh of electricity** per year [47] , equivalent to 3% of Scotland’s total heat and electricity demand in 2010.

Energy recovered from the biological material within waste through EfW (which constitutes approximately 50% of MSW [28] [48]) is considered as bioenergy and is a renewable source of energy. In 2020, the installed electricity capacity of EfW operations treating the **biodegradable** component of MSW through EfW was 1400 MW, representing an increase of 108% since 2014 [49] .

There are currently no specific data available for the energy generated in Scottish EfW facilities either from the biodegradable or the non-biodegradable components of MSW. Available data on electricity generation from 'bioenergy' is published by the UK Government, which includes generation from landfill gas, EfW, anaerobic digestion and co-firing with fossil fuels, so does not disaggregate EfW.

Policy on heat networks

Under the Climate Change (Scotland) Act 2009, Scottish Ministers must prepare and publish a plan for (a) promoting energy efficiency, wherein 'energy efficiency' can include "surplus heat from electricity generation or other industrial processes for district heating or other purposes".

The CCPu commits to creating the conditions to secure growth of heat networks and to put in place Local Heat & Energy Efficiency Strategies for all of Scotland by the end of 2023. The Heat Networks (Scotland) Act 2021 aims to encourage greater use of heat networks in Scotland by providing a framework for the designation and consenting of heat networks and heat network zones.

The Scottish Government published a Draft Heat Networks Deliver Plan in November 2021, which states that **surplus or waste heat is rarely fully utilised in Scotland.** Whilst EfW facilities are required to prepare plans identifying opportunities for local use of heat, and there are examples of actual heat recovery (Lerwick) and plans for heat offtake at other sites, significant amounts of heat go unused. The Plan states:

> “ A key reason that heat is not recovered is that there are insufficient commercial opportunities to incentivise recovery, in particular the lack of potential heat customers and absence of an adjacent heat network. Equally, there are no legal requirements and limited incentives to recover and use surplus or waste heat. We will make available to local authorities, by Winter 2022/23, further information on the availability of surplus or waste heat to support the identified of heat network zones and the development of LHEES [Local Heat and Energy Efficiency Strategies]. In addition, next year we will engage with stakeholders and as relevant consult on whether there is need for further measures to increase the utilisation of surplus or waste heat.”

Conclusion

Waste policy is a rapidly developing area as the Scottish Government seeks to transition towards a circular economy and reduce waste-related emissions to meet its target of net zero by 2045, guided by the principles of the waste hierarchy.

One of the key Scottish Government actions that aims to help meet these goals, is a legal ban on biodegradable municipal waste being sent to landfill from 2025. In order to comply with the ban, local authorities have procured additional incineration capacity in Energy from Waste facilities to process residual waste that cannot be recycled or reused. Scotland now has capacity to process over 1.1 million tonnes of waste in it's operational EfW sites, with a further 2.5 million tonnes of capacity either under construction or in a planning stage.

Growing capacity has been reflected in the amount of waste incinerated in Scotland, which has increased by 208% between 2011 and 2020, with incineration of household waste increasing 299% (albeit from a low baseline).

There is a potential tension here, between having sufficient capacity by 2025 to meet the terms of the ban, and not having so much incineration capacity that it is inconsistent with residual waste arisings beyond 2025 as more progress is made towards a circular economy.

The rise in treatment of waste in EfW facilities and development of new sites has been met with a range of views, questioning the role EfW should play in Scotland's transition to a circular economy and net zero. These concerns are often based on whether incineration will undermine longer-term efforts to increase recycling and reuse, and the environmental impact of diverting waste from landfill to incinerators.

While the Scottish Government has a number of policies and regulations in place that are designed to minimise impacts of EfW, and had further committed in the CCPu to consider measures to ensure new EfW plants are more efficient, concerns led to the Government commissioning an independent review. The review is expected to examine how incineration fits into Scotland's waste hierarchy and how its impacts compare to other treatment of residual waste options.

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