This briefing summarises the options for the treatment of residual waste (waste remaining once re-usable and recyclable materials have been extracted) in Scotland. The paper discusses treatment options with respect to their current and possible future application. It also explores the legislative setting within which these treatments operate. The briefing considers the impact work in this area will have on the quantities and types of material entering the residual waste stream.
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EXECUTIVE SUMMARY

Residual Waste is that which has been subjected to all reasonably practicable efforts to extract and recover re-usable and recyclable materials. It is likely to be composed of a variety of different types of material, which can be treated directly or broken down in pre-treatment facilities into mixed, biodegradable and non-degradable components. Treatment options for mixed waste include incineration, pyrolysis and gasification: these are thermal treatments, which help to recover energy from the residual materials. If residual waste is ‘pre-treated’, treatment options for recovered biodegradable components can include composting and anaerobic digestion which can stabilise and derive energy from the waste. Recyclable components recovered from residual waste may be used to produce low quality recycled outputs.

The Scottish Government has a vision for a zero-waste society where disposal is minimised and all waste is seen as a resource. Elaborating on the aims of the Waste (Scotland) Regulations 2012 and the Scottish Government’s Zero Waste Plan, the Scottish Environment Protection Agency (SEPA) note that legislation ‘aims to maximise levels of closed loop recycling in Scotland through the collection and processing of material resources back into new products and organic wastes back into nutrient cycles.’ The Waste (Scotland) Regulations 2012 require a reduction in quantities of waste sent to landfill by increasing recycling rates, removing biodegradable content from the mixed waste stream and optimising the recovery of materials and energy from residual waste prior to disposal.

Waste management policy and practice have changed significantly over the past fifteen years. The recent introduction of a high landfill tax rate, and the announcement of a large rate escalator over the 2008-2014 period, has seen an increase in the popularity of alternative treatments. Combined with increased pressure to reduce, reuse and recycle, the way in which residual waste is handled is being more carefully considered. Residual waste treatment options are important in reducing the amount of waste requiring disposal, as they offer the last opportunity in the current treatment schemes to capture materials and energy from waste before it is ultimately sent to landfill.

The use of residual waste treatment processes in Scotland is currently limited but increasing, as the disincentive to send material to landfill grows and the importance of resource recovery is promoted. In January 2013 there were 5 mechanical biological treatment plants for processing mixed residual waste, along with 2 incinerators and 1 gasification plant actively treating municipal waste in Scotland (SEPA 2013).

The Waste (Scotland) Regulations 2012 mark a significant shift from historic practices. The most appropriate approaches for dealing with residual waste will be needed to meet the ‘5% of all waste to landfill’ target by 2025. The Scottish Government considers that the selection and implementation of residual waste treatment options should be a significant part of the waste hierarchy and an area of national policy focus.
BACKGROUND

‘Residual Waste’ is the definition given to wastes which have been subjected to all reasonably practicable efforts to extract and recover re-usable and recyclable materials

The Scottish Government (2010) sees waste as a material that still has a value, and which is useable in place of costly new resources.

The Waste Hierarchy

The waste hierarchy, defined in the European Waste Framework Directive 2008 and illustrated in Figure 1, lists waste management options in order of environmental and economic priority, with disposal to landfill presenting the least preferable treatment option. Residual waste treatment presents the last opportunity in the hierarchy to extract use from waste before final disposal; therefore the effective handling of residual waste is important in reducing the quantities of material sent to landfill in Scotland.

Figure 1 - Waste hierarchy: after EU Waste Framework Directive (2008)

Legislative and industry bodies consulted by the Scottish Government (2011a) agreed that residual waste treatment options must align with the wider policy context for waste management: encouraging recycling and reuse behaviour and the progressive removal of biodegradable wastes from the waste stream. Policies with the potential to affect the residual waste stream and the operation of residual waste treatment technologies are summarised in Annex A. There are complimentary pieces of legislation to optimise recovery of materials and energy from any residual waste once easily collectable recyclables and biodegradable materials have been removed. These cover areas including immediate waste handling and disposal and the environmental and economic implications of generating renewable energy from waste.

There is broad agreement that while residual waste treatment is a useful and necessary stage of the waste hierarchy, it is economically and environmentally important to manage waste as far up the hierarchy as possible. Residual waste treatment should not be allowed to present a more attractive option than reduction, reuse or recycling, and provision should be made for improved capacity to take action at these earlier stages. Scotland’s Zero Waste Plan (Scottish Government 2010) stated that ‘the Scottish Government will introduce regulatory measures to support the delivery of landfill bans, by ensuring energy from waste treatment is only used to recover value from resources that cannot offer greater environmental and economic benefits through reuse or recycling.’ This measure was formally introduced in the Waste (Scotland)
Regulations 2012 and as a result residual waste treatment should only be developed to a capacity fit for, not exceeding, this purpose.

**LEGISLATIVE CONTEXT FOR RESIDUAL WASTE – THE WASTE (SCOTLAND) REGULATIONS 2012**

The legislative context for waste has changed significantly in the period following the publication of the EU Waste Framework Directive (2008), with the development of national legislation to meet or expand upon its core aims. The nature of residual waste production and treatment is expected to be strongly influenced by any legislation which affects the composition and/or quantity of material entering the residual waste stream.


Target recycling rates are set at 70%, with only 5% of all waste going to landfill, by 2025. Scotland has already made progress improving recycling rates. According to (SEPA 2013) in 2011, the Scottish recycling rate was 40.1% which was on a par with the EU average of 40% (Eurostat 2011) and a big improvement on the recycling rate recorded in 2000 which was 5%. The 2012 Regulations are designed to support a continual improvement.

The 2012 Regulations also require separate waste collections for recyclable and biodegradable waste and introduce a ban on the landfilling or incineration of materials collected separately for recycling by the end of 2013. Together these regulations are likely to have a significant impact on the future composition and quantity of Scotland’s residual waste stream.

As a result of the 2012 Regulations, the composition of residual waste from all sources will change significantly with increased recovery of recyclables and the segregated collection of different waste streams. This will influence the way in which the remaining material is most effectively treated.

In addition to legislation, a number of bodies note the importance of voluntary resource management agreements. WRAP has seen successes with its 'halving waste to landfill' signatory report for construction and demolition waste (Waste and Resources Action Programme 2010). Industrial and commercial waste forms a large part of the waste produced in Scotland, and significant action is required to ensure that legislation requiring the reduction of ‘all’ waste is met in this area. WRAP are also involved with a number of voluntary agreements ('responsibility deals') which work by stimulating businesses to come up with their own ways to solve problems.

**ECONOMIC PERSPECTIVES**

Waste management legislation aims to create a situation where ‘doing nothing’, or a ‘business as usual’ approach, would be economically damaging, leading to additional costs. The UK Landfill Tax in particular has acted as a strong incentive to divert material to alternative treatment options. In April 2012 landfill tax stood at £64 / tonne, increasing to a minimum floor price (until at least March 2020) of £80 / tonne in April 2014. Powers devolved to Scotland in the Scotland Act 2012 mean that from April 2015 the Scottish Parliament will be empowered to introduce and manage taxes on the disposal of waste to landfill, allowing more targeted implementation of the Waste (Scotland) Regulations 2012.
This high rate of landfill tax could result in making residual waste treatment an increasingly economically attractive option, especially if it appears to be a cheaper or easier route than rolling out comprehensive plans for separate waste collection and recycling. WRAP (2010) note that as waste is being actively prevented from entering landfill through economic disincentive, quantities of residual waste would increase significantly without sufficient infrastructure in place to reduce, reuse and recycle materials further up the hierarchy. A report by the Chartered Institute of Waste Managers (2011) contains focused sections on the economics behind residual waste, concluding that ‘to manage its waste sustainably and effectively, the UK needs to invest in waste management infrastructure immediately.’

Provision of treatment capacity at all stages of the hierarchy must, therefore, be appropriate and complimentary. Measures to prevent diversion of materials to residual waste treatment could include the capping of common residual waste treatments such as those producing energy from waste (EfW), or direct prohibition of materials which have the potential to be reused or recycled from entering the residual waste stream. A 25% cap on sending local authority collected municipal waste to EfW facilities formed part of the Scottish Government waste regulations until it was replaced by guidance on the handling of individual materials (paper, plastic etc.) to reduce the quantity which enters the residual waste stream, as proposed by the Zero Waste Plan (2010).

However, to avoid key recyclable materials that have not been separately collected from being incinerated the Waste (Scotland) Regulations 2012 require the best available techniques to be used to remove marketable recyclate (metals and hard plastics) from residual municipal waste prior to incineration. The Regulations specify that this should apply to existing Energy from Waste facilities from the end of 2015.

**RESIDUAL WASTE TREATMENT OPTIONS**

Residual waste may be treated directly from the waste stream with only minor preparation, or can be converted into other usable forms by pre-treatment processes. There are a number of final treatment options available for residual wastes. These are split into two categories:

- Pre-treatment options and subsequent processing measures for separated waste
- Techniques for directly treating mixed wastes.

The technical and environmental considerations of each are summarised in Annex B. Whilst pre-treatment is not a residual waste treatment option in itself, it plays an important part in the process and may allow the diversion of materials back ‘up’ the waste hierarchy for recycling and nutrient recovery.

Many techniques exist for exploiting the residual waste stream. These operate on a variety of scales with a number of different feedstock (materials which the process is able to use). The techniques are currently operating at differing levels of technical maturity, some having been widely used for residual waste treatment for many years, while others are less proven generally, either in the treatment of municipal waste, or specifically in the Scottish setting.

It should be noted that technology selection in residual waste treatment can be positively and negatively influenced by planning laws, environmental factors and social factors including public lobbying. SEPA considers that a comprehensive assessment of these treatment options, socially, economically and environmentally is central to determining the most effective and sustainable method(s) of residual waste treatment (Scottish Environment Protection Agency 2013).
PRE-TREATMENT

Pre-treatment options generally aim to remove a proportion (likely to be up to 15%) of residual recyclable materials from mixed waste streams. Stages of mechanical, biological or heat treatment are then used to break down the remaining waste in to Refuse Derived Fuels (RDF), for use in energy generation, and other stabilised products which, according to Defra (2007b), may be used to improve certain low quality soils, in the restoration of brown field sites, or for landfill cap restoration. These stabilised products have a low potential for breaking down in the environment, producing fewer greenhouse gas emissions than the original waste. These techniques are applied to mixed waste streams, and wastes which had been segregated at source prior to collection would not usually be treated using these processes. The feedstock is likely to consist of a mix of different waste types including biodegradable materials, plastics, textiles, metals and combustible and non-combustible composites (i.e. black bag waste).

MECHANICAL BIOLOGICAL TREATMENT (MBT)

MBT describes a series of processes which include the mechanical sorting of waste followed by a phase of biological treatment. The outputs from the process are recovered recyclables, a Refuse Derived Fuel (RDF) and a low quality, stabilised ‘compost-like’ output (CLO). Recyclables recovered from this process are of much lower quality than those from source-segregated waste, due to greater levels of mixing and increased potential for contamination with other materials. CLO is lower quality than compost produced from segregated biodegradable waste and SEPA (2013) recommends landfilling the product, requiring less volume and generating fewer methane emissions than landfilling of the original, untreated waste.

MECHANICAL HEAT TREATMENT (MHT)

MHT is also referred to as ‘autoclaving’. Most MHT facilities carry out mechanical treatment followed by heat treatment using high pressure steam. As with MBT, recyclable materials can be recovered during the mechanical treatment step. The Refuse Derived Fuel (RDF) produced using MHT can also be used in energy generation. This process is frequently used to treat clinical waste but is not currently widely used in municipal waste treatment so is not discussed in significant detail in this paper.

OTHER TECHNIQUES/TREATMENTS

Biodegradable outputs recovered from pre-treatment may undergo additional treatment to recover nutrients. Anaerobic Digestion (AD) is an increasingly popular treatment and produces a solid organic residue, a run-off ‘liquor’ which can be used as a plant fertiliser, and biogas which can be burnt in conventional energy generation. Composting is also used to convert suitable biodegradable waste in to a soil improver. Materials recovered from pre-treatment are not ideal for AD treatment or composting as they tend to be mixtures of materials, containing a proportion of non-degradable components which reduce the quality of the outputs and the efficiency of the process. Recyclables such as plastics and paper recovered via pre-treatment can be sent to traditional recycling plants, but will produce a lower quality recycled product, of lower commercial value, than materials which have been pre-separated.

MIXED WASTE TREATMENT OPTIONS

Mixed residual wastes can be acquired directly through mixed / black bag waste collection, and can be shredded or undergo other minor processing prior to treatment, or be sent to a MBT or MHT facility. These wastes contain a mix of plastic, textiles, combustible composites, metals
and unrecovered biodegradable materials (Murphy et al 2004). The recyclable items are likely to be too fragmented or poor quality to warrant recycling, and are too well combined with biodegradable materials to allow reasonable separation. In these cases, where it is deemed that no further materials can be recovered, the waste can be sent to landfill or energy recovery. Incineration, pyrolysis and gasification are all thermal treatments, commonly referred to as Energy from Waste (EfW) processes. They use heat to liberate energy from residual wastes, which in turn is used for heating and electricity generation, and reduce the volume of waste for final disposal. Mixed waste treatments like these are most appropriately applied to residual material once all easily recoverable recyclables and biodegradables have been removed.

INCINERATION

Incineration, or co-incineration with traditional fuels such as a biomass (vegetable matter used as a source of energy), is currently used across the UK, EU and globally as a residual waste treatment option. The process involves the full, high temperature (>850°C), combustion of waste in controlled conditions, in the presence of oxygen, in a conventional furnace. Large-scale facilities are generally capable of handling a mixed waste feedstock, while smaller facilities may be designed to process a specific localised waste mix. Incineration results in a number of gaseous emissions including carbon dioxide, acid gases, dioxins and furans, heavy metals and particulates, which present the potential for negative climatic and environmental effects. Incineration also produces a stable, solid ash residue (representing ~10% of the original mass) which can be used as a secondary aggregate in construction applications dependent upon its chemical and physical properties, which relate to the original feedstock.

PYROLYSIS

Pyrolysis describes low temperature (400-800°C) processing in a zero, or low oxygen, environment. Classed as an ‘advanced thermal treatment’, it is not a widely implemented technology in waste treatment in Scotland but has been successfully applied to processes producing charcoal and generating energy from a variety of biomass fuels. Pyrolysis can operate on a mixed feedstock, with only non-combustibles such as metal and glass needing to be removed prior to treatment. Pyrolysis results in the production of combustible synthesis gas (syngas) which can be used in power generation, char and fuel oil. Char (representing ~90% reduction from the original mass) can be used as a Refuse Derived Fuel (RDF), soil improver or recycled (secondary) aggregate in construction applications depending upon its chemical and physical properties, which relate to the original feedstock.

GASIFICATION

Gasification describes high temperature (900-1400°C) processing in a low oxygen environment. Classed as an ‘advanced thermal treatment’, it is not a widely implemented technology in waste treatment in Scotland but has applications in the conventional fossil fuel industry, used in producing fuel gas from coal. Like pyrolysis, gasification can operate on a mixed feedstock, with only non-combustibles such as metal and glass needing to be removed prior to treatment. Gasification results in the production of combustible synthesis gas (syngas) which can be used in power generation. The residual char (representing ~90% reduction from the original mass) can be used as a recycled (secondary) aggregate in construction applications dependent upon its chemical and physical properties, which relate to the original feedstock.
ISSUES AND USE IN SCOTLAND

Most of the residual waste treatment technologies described in the previous section are not currently used on a large scale in Scotland, with around 4.4% of local authority collected municipal waste disposed of via incineration in 2010 (SEPA). Eurostat data shows that mainland Europe has much higher average rates of incineration, around 23% in 2011 in the EU27 (the 27 countries in the European Union (EU) on 1 January 2007). SEPA National Capacity Reports show that in Scotland incineration capacity increased between 2008 and 2010 from 536,512 to 644,642 tonnes / year (a rise of 20%). The nature of the data collected means that these figures only account for sites on which these techniques form the sole operation, not sites of multiple use where they form part of a suite of operational procedures. Data for other process cannot, therefore, be easily quantified. Incineration (and co-incineration), MBT and MHT are recognised technologies for residual waste treatment due to their relative simplicity, long history of use and the familiarity of operators and the public with these processes.

The location of residual waste sites currently treating municipal waste in Scotland is illustrated in Figure 2. Table 1 summarises the numbers of operational sites by treatment type.

Figure 2 - Existing residual waste treatment sites in Scotland (MBT / MHT locations unavailable), and 2b - proposed locations of EfW sites (points show localities, not precise geographical location) (SEPA 2013)

<p>| Table 1 – Residual waste treatment facilities active in 2012-2013 in Scotland (SEPA 2013) |
|--------------------|------|------|--------|-------|--------|</p>
<table>
<thead>
<tr>
<th>No. of sites</th>
<th>MBT</th>
<th>MHT</th>
<th>Incineration</th>
<th>Pyrolysis</th>
<th>Gasification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

A number of residual waste sites are currently under consideration in Scotland: as shown in Figure 2b, and Annex C, at least 11 new EfW sites are currently proposed, with 2 incinerators granted planning permission and permits but not yet at construction stage. A number of these proposals include advanced thermal treatment technologies as part of their operational portfolio. Data for development of new MBT and MHT facilities is unavailable.
It is a challenge to plan facilities which will perfectly cater for the future composition and quantity of residual waste, a problem recognised in reports by the Institution of Civil Engineers (2005, 2011) and a report by the Institution of Mechanical Engineers (2011). While the number of residual waste treatment facilities in Scotland is likely to rise, the Environmental Services Association (2004) and Zero Waste Scotland (2011) note that there are various factors controlling their scale. Quantitative restrictions on municipal waste inputs to EfW facilities are likely to be implemented, and the reduction of recyclables remaining in the waste stream due to increased pre-sorting will reduce the overall quantity of material available. As legislation progressively calls for the segregation of biodegradable wastes from the mixed waste stream, the eventual ban on sending segregated waste to landfill is expected to necessitate a significant increase in the requirement for recycling and biological treatment facilities, which would prevent the trickle-down of materials into residual disposal.

PRE-TREATMENT IN SCOTLAND

Pre-treatment is a contemporary option for maximising resource recovery from mixed waste where source segregation is not in place or has not been practicable, as is the case in a number of Scottish areas where recycling programmes are still being rolled-out and optimised. In the Scottish context, requirements for higher levels of source segregation, through the enforced introduction and expansion of local authority recycling schemes, and on-going separation of biodegradables are likely to reduce the long-term demand for pre-treatment facilities.

Pre-separation, while a useful interim technology, does not attract the full benefits of recycling and nutrient recovery from waste which are encouraged by current legislation. For example, the European Commission states in its (2008) Green Paper on the management of Biowaste in the EU:

‘Where bio-wastes (food and green waste) are collected and treated in open windrow\(^1\), in-vessel composters (IVC) or anaerobic digestion (AD) facilities the inputs to treatment processes count towards allied recycling and composting targets\(^1\).

Activities exempt from classification as recycling are energy recovery or reprocessing into materials that are to be used as fuels, or for backfilling operations, the engineered filling of voids on land, which is akin to landfill. ‘Biowastes’ resulting from MBT / MHT in Scotland do not count as ‘recycling’ in the same way as source segregated biodegradable wastes. SEPA’s concerns regarding the presence of contaminants from the mixed waste feedstock means that these materials cannot be used as nutrient sources or soil conditioners and must be landfilled (SEPA 2013). Treatment of source segregated materials is, therefore, in many ways preferable to the production of low quality compost like outputs (CLO), biologically stabilised waste or low-quality recyclable material from MBT or MHT facilities.

Refuse Derived Fuel (RDF) from pre-treatment facilities can be a useful product, used locally as a feedstock for energy generation in conventional and advanced thermal treatment facilities or providing a compact and unreactive physical format for transport within Scotland, or for international shipment. In recent years SEPA has received increasing numbers of applications from outside of Scotland to export RDF for incineration, often to countries lacking a sufficient supply of the fuel to maintain their current EfW sites.

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\(^1\) Windrow composting is used for processing garden waste, such as grass cuttings, pruning and leaves in either an open air environment or within large covered areas where the material can break down in the presence of oxygen.
MIXED WASTE TREATMENT OPTIONS IN SCOTLAND

Residual wastes are defined by the Scottish Government, and most professional bodies, as the remains after all reasonable efforts have been made to separate out recyclable materials. They only include other suitable waste types when justified on environmental, health or safety grounds. The Scottish Government (2010) has set out guidance to EfW facilities (incineration, gasification and pyrolysis) which it hopes should ensure that ‘Scotland does not simply move one step up the hierarchy from landfill to incineration’. This approach requires ‘equivalent treatment standards’ for all waste streams and sectors (household, commercial and industrial waste).

A publication by the Institution of Mechanical Engineers (2011) noted that residual waste treatments which produce energy could be important ‘on demand’ resources in future generation scenarios. The Scottish Government (2010) recognises the role of thermal treatment for mixed waste, but has advised that ‘the feedstock simply won’t be available in the future to feed large-scale plants or an extensive network of incinerators across Scotland.’ This statement surmises that, while worthy of consideration, expansion of EfW must be appropriately scaled in line with the wider waste plan for Scotland. Scotland’s Zero Waste Plan states that:

‘Energy from waste has an important role to play and could contribute up to 31% of Scotland’s renewable heat target and 4.3% of our renewable electricity target’.

Incineration is not widely seen by the public as an environmentally friendly treatment technique (SEPA 2006, ODPM 2004). SEPA (2007) note that ‘One of the main barriers to the use of thermal treatment in Scotland is the poor public perception of thermal treatment as a consequence of previous unpleasant experience with incineration technologies’. The Environment Agency (EA 2009) note that ‘there is significant public concern about the possible effects on health of compounds released from incinerators and co-ordinated opposition to planning applications to build them’. Friends of the Earth Scotland (2007) claim that incineration can waste natural resources, ‘crowd out’ recycling, reducing the incentive to minimise waste.

A 2011 letter from Friends of the Earth Scotland to the Scottish Parliament Public Petitions Committee (Friends of the Earth 2011b) argues the strength of the environmental and economic case for prioritising waste prevention over incineration. SEPA state that contemporary incineration plants can comply with the necessary Waste Incineration Directive (2000) guidance which places mandatory limits on environmental and health impacts. The Chartered Institute of Wastes Management suggest that ‘the public need to understand it (incineration) is part of our energy solution and not just a cheap disposal option’ (CIWM 2012). Many countries use incineration successfully within their waste management programme and a relatively small treatment capacity would be sufficient to compliment waste disposal targets in line with current legislation.

There are on-going plans to expand the use of advanced thermal treatments (ATT) including pyrolysis and gasification for EfW. The National Waste Strategy Scotland (2003) suggests that using advanced treatments may offer reductions in potential risks to the environment and to human health compared to incineration. Additionally, ATTs frequently exploit a modular design, consisting of a number of smaller units which can be added or removed as necessary, and can operate at higher efficiency on a smaller scale than traditional incineration plants which Defra (2007a) claim could alleviate some planning and plant size concerns. They are also flexible in their input materials, and are therefore relatively resilient to changes in residual waste quantity and composition. There have been a number of economic and technical issues in the development of industrial-scale ATT plants in the UK (SEPA (2012) and Powrie (2010)) and a number of reports suggest that additional technical and economic investment would be required
to develop these technologies to mass market. HM Government's 2011 report on the Green Bank acknowledges that:

‘investments in the waste sector are needed to help the UK meet its landfill diversion targets, reduce greenhouse gas emissions and contribute to renewable energy targets. The aim of such investments is to reduce landfill volumes and related environmental costs and help to recover recycled materials or energy from waste.’

Defra state, in a 2007 report, that ATTs have the benefit of qualifying for Renewables Obligation Certificates (ROCs), green certificates which accredit renewable generating stations for the eligible renewable electricity they generate.

‘At present energy generated from mixed waste only qualifies for ROCs if it is through using advanced conversion technologies such as… gasification or pyrolysis.’

The current ROC bandings (UK Government 2013), valid until April 2017 include conventional EfW (incineration) only in accredited plants when it is used in the context of a Combined Heat and Power (CHP) scheme, generating electricity whilst also capturing usable heat from the process. Under the current banding levels ATT’s receive twice as many ROC credits per unit of energy generated as EfW with CHP. Banding levels for ROCs are reviewed every 4 years.

KEY ISSUES FOR TREATMENT OF RESIDUAL WASTE

There is no single solution to treating residual waste, with case studies from different locations proving the current efficacy of many different treatments. In many cases the combination of a number of treatment techniques may be the most effective option, as these techniques can be linked in to a wider treatment process scheme as illustrated in Figure 2. As an example, in evidence to the Scottish Parliament Rural Affairs, Climate Change and Environment Committee consideration of the draft Waste (Scotland) Regulations (2012) a Glasgow City Council representative stated:

‘in Glasgow, the solution is... a separation facility to extract the 18 per cent that is recyclable material; to anaerobically digest the biodegradable fraction; and to gasify the coarse fraction along with the digestate from the anaerobic digestion. Because the waste comes from a mixed-waste source, we cannot use the digestate as compost; instead we dry it and add it to the fuel in the gasifier’.

The mix of techniques employed depends upon the strength of regulatory incentives, as well as the possibility of funding opportunities and presence of infrastructure. Figure 3 from the Scottish Environmental Services Association (2012) illustrates a simplified waste flow system, where residual waste treatments are linked to other facilities in order to demonstrate their potential interconnectedness and interdependency.
The implementation of residual waste treatment processes is considered holistically by SEPA, SESA and other bodies involved in waste management, in the wider scheme of the legislative targets for resource management summarised in Annex A. The following sections summarise some of the main points.

Changes in waste composition

Waste handlers accept that there will be decreasing quantities of residual waste produced once inputs at all preceding levels of the waste hierarchy have been reduced. In future Zero Waste Scotland (2011) note that waste reception facilities will be dealing with lower total annual waste production figures, but will be required to recycle and perform residual waste processing on a larger proportion of this material. Legislative, industry and professional bodies recognise the need to plan to address these requirements now, and be able to consolidate the residual waste market over realistic time periods during which these changes are taking place, up to 2020 and beyond. The Scottish Government’s Report on Policies and Proposals (RPP1) noted that the need for a unified Scottish waste programme was identified in responses to the Scottish Government’s consultation on the Zero Waste Plan (Scottish Government 2010). Zero Waste Scotland was set up in 2010 as an umbrella programme to support this need and improve resource efficiency. The Scottish Government’s draft RPP2 highlights the need to move to a more circular model of resource use and economic growth that designs waste out of our economy. A disconnection between waste legislation and implementation of solutions can persist, as noted in the Zero Waste Scotland Programme Plan 2011-15:

‘there is wide variation in local waste delivery infrastructure which limits the scope for joined-up or national messages and increases confusion with consumers.’

One of the outlined goals of the Programme Plan is therefore defined as sending ‘less waste to landfill due to better public and cross-sector awareness and activity to prevent waste’.
The municipal waste stream will change significantly from its current composition if proposed strategic plans are adhered to. Stronger incentives to segregate wastes at point source will ensure that biodegradable and easily recyclable wastes are more effectively handled higher in the waste hierarchy. Detailed estimates of waste stream composition are central in developing an effective residual waste treatment infrastructure and providing relevant technologies at appropriate scales. Scotland’s Zero Waste Plan notes that the Scottish Government and SEPA need to collect more robust information about waste arisings and management than they do at present, which would support their ability to make decisions about the scale of facilities required to meet legislative targets. The Technical Annex to RPP1 discussed the need for policies to be implemented in the correct order. This may seem a simple statement, but in the case of this significant shift from historic practice it is important to ensure that the best alternative treatment routes for waste materials exist, and have the capacity to treat the quantity of waste that is likely to be generated, before imposing a ban on a particular waste stream going to landfill.

**Technology and infrastructure**

The 11 currently proposed EfW treatment facilities in Scotland, if built would have a combined capacity of 1.77 million tonnes. SEPA (2013) conclude that ‘it would be safe to assume that Scotland as whole does not need all of these developments to go ahead to meet its zero waste ambitions’.

CIWM note in their 2011 report ‘Rubbish to Resource’, that for the UK to meet European landfill diversion targets, ‘we need to build 8.8 million tonnes of new residual waste treatment capacity by 2020’. A UK Government (2011) report suggests that £15 billion must be invested in the waste sector across the UK by 2030 in order to meet all national and regional targets. It is important to ensure that waste producers incorporate the full cost of waste disposal in to decisions; measures including landfill tax should encourage the development of sustainable waste management options. This economic perspective is especially significant if development costs fall heavily on the private sector.

The number, size, spread and specificity of facilities will be determined by waste stream demands and economic and social controls. SEPA Waste Datasheets for 2009, 2010 and 2011 demonstrate that most current waste management sites offer a number of treatment processes. One aspect of the Scottish Government’s evidence to the Rural Affairs, Environment and Climate Change Committee (2012a) evidence relates to this:

‘there is still a question mark over what the shape of the infrastructure that emerges will be. Will it involve a few larger plants or a number of smaller plants in different places? That is for a combination of the local authorities and the market to determine.’

The potential for integration of residual waste treatment with other complimentary technologies is also widely discussed by Defra (2013) and the Scottish Government (2009). Proposals include twinning EfW processes with cogeneration / combined heat and power (CHP) or district heating systems, which could efficiently use waste heat, or generated heat from thermal treatment.

Experience from other countries has illustrated the problems with assessing required capacities for EfW facilities. Refuse Derived Fuel is exported from Scotland to Sweden, Germany and the Netherlands, due to a surplus of EfW facilities in these countries, a lack of suitable EfW facilities in Scotland and the high cost of landfill in the UK. In 2012 SEPA approved eight export notifications (2012-2013) for RDF totalling 724,408 tonnes of which 11,050 tonnes were shipped in 2012.
Friends of the Earth Scotland noted, in their consultation response to ‘Implementing Scotland’s Zero Waste Plan’ (2011a), that most incineration proposals require long-term contracts. This risks ‘locking in’ local authorities to contracts requiring substantial supplies of waste or RDF. They agree that a long term perspective must be taken and only as much incinerator plant capacity is approved as is verifiably able to be fed by the amounts of residual waste that are envisaged in the mid to long term.

Legacy

Legislation referred to in this briefing covers the period up to 2025, therefore requiring users of residual waste facilities, which may have operational lifetimes of 10-25 years, to appropriately predict and provide for the future challenges of the sector. The Scottish Government (2010) highlights the need to consider how the options for treatment chosen now will be relevant in the future, to understand the inputs to, and requirements from, the residual waste stream, and intelligently assess how these are likely to change up to 2020. This is necessary in order to draw sensible conclusions, tied to the lifetime of plants and duration of funding and operating contracts which may also include decommissioning or reappropriation. Escalating legislation should be carefully considered, as facilities meeting current legislative requirements for residual waste treatment will not necessarily meet those required by 2015, 2020 or 2025.

The phasing out of waste and the movement towards a zero waste society is considered by the Scottish Government (2010, 2012) and European Parliament and Council (2008a) a necessary strategic move to ensure a sustainable future for waste management. It is critical to ensuring the development of a sustainable society: reducing environmental impact, reducing energy use in manufacturing and reprocessing, reducing the need to exploit primary sources of minerals, reducing dependence on fossil fuels and reducing the amount of environmental pollution caused by landfill. The scale and nature of election of residual waste treatment options has the potential to influence all of these factors, and should be considered a significant part of discourse on future environmental issues and resource management.
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  - Gasification and Pyrolysis
  - Anaerobic Digestion
  - In-Vessel Composting
  - Open Windrow Composting
  - Large Thermal Treatment

  - Gasification
  - Pyrolysis
  - Incineration
  - Landfill
  - Anaerobic Digestion
  - In-Vessel Composting
  - Open Windrow Composting


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## ANNEX A – LEGISLATIVE CONTEXT

### Table 1 – Chronological summary of waste legislation targets

<table>
<thead>
<tr>
<th></th>
<th>End of 2013</th>
<th>End of 2015</th>
<th>End of 2020</th>
<th>End of 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Collection guidance</strong></td>
<td>Businesses: separate food waste (if over 50kg/week) and dry recyclables collections* (Scottish Government Target)</td>
<td>Businesses: separate collection for all food waste* (Scottish Government Target)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local authorities: Full food waste</td>
<td>Removal of metals and dense plastics from residual waste** (Scottish Government Target)</td>
<td>Ban on biodegradable municipal waste to landfill (Scottish Government Target)</td>
<td>Cap at 5% of all waste to landfill (Scottish Government Target)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Re-use and recycling of 50% waste by weight from household waste and similar (paper, metal, plastic and glass) (EU Waste Framework Directive)</td>
<td>70% recycling / composting and re-use of all waste (Scottish Government Target)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>60% recycling / composting and re-use of household waste (Scottish Government Target)</td>
<td></td>
</tr>
<tr>
<td><strong>Target / Cap</strong></td>
<td>Ban on mixing, landfill or incineration of segregated wastes (Scottish Government Target)</td>
<td>Cap at 1.8 million tonnes of biodegradable municipal waste to landfill (EU Landfill Directive)</td>
<td>Cap at 1.8 million tonnes of biodegradable municipal waste to landfill (EU Landfill Directive)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50% recycling / composting and re-use of household waste (Scottish Government Target)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cap at 1.8 million tonnes of biodegradable municipal waste to landfill (EU Landfill Directive)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Businesses involved in food production, food retail or preparation ** Applies to existing facilities, for new facilities this comes in to effect on commencement of the regulations

- **EU Waste Framework Directive:** sets out separate collection for key waste materials such as paper, metal, plastic and glass. It also advises minimum recycling targets to be achieved by 2020 and establishes the waste hierarchy. Scotland’s waste policy is strongly influenced by the European Waste Framework Directive.
- **Landfill tax:** aims to discourage landfill in the long-term by making other disposal options more economically competitive. By 2014 the landfill tax will have reached £80/tonne.
- **Producer Responsibility Directives:** (e.g. Courtauld Commitment for retail packaging) require specific waste streams to be collected and recycled to defined targets. This includes wastes like batteries which are problematic to recycle.
- **Renewable Energy Obligation:** includes the potential for capped quantities of residual wastes to be accredited as fuel sources in the generation of renewable energy.
- **UK Landfill Directive:** aims to significantly reduce biodegradable waste in the municipal waste stream sent to landfill through segregated collection for separate treatment.
- **Waste (Scotland) Regulations**: implement the objectives of the Zero Waste Plan. Requires source segregation and separate collection of business waste by 2014. Bans the landfill of biodegradable material by 2021 and ensures that only certified residual waste is available for Energy from Waste (EfW) treatment.

- **EU Waste Incineration Directive (WID) (2006/76/EC)**: provides mandatory guidance for emissions control and environmental regulations for energy and EfW incinerators.

- **Scotland’s Zero Waste Plan**: promotes the importance of the waste hierarchy in waste reduction and commits Scotland to recycle 70% of all waste by 2025.
## ANNEX B - TECHNICAL AND ENVIRONMENTAL CONSIDERATIONS

<table>
<thead>
<tr>
<th>Technical Considerations</th>
<th>Incineration</th>
<th>Pyrolysis</th>
<th>Gasification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inputs</strong></td>
<td>Mixed waste</td>
<td>Mixed waste</td>
<td>Mixed waste</td>
</tr>
<tr>
<td><strong>Outputs</strong></td>
<td>Recoverable heat, Bottom ash</td>
<td>Recoverable heat, Syngas, Bottom ash, Char</td>
<td>Recoverable heat, Syngas, Bottom ash</td>
</tr>
<tr>
<td><strong>Scale (tonnes per year)</strong></td>
<td>&lt;90,000 – 600,000</td>
<td>50,000 (proposed)</td>
<td>50,000 (proposed)</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Size (hectares) / Siting</strong></td>
<td>&lt;1-5ha Traditional commercial / industrial areas</td>
<td>1-2ha Mixed use sites. Commercial / industrial areas</td>
<td>1-2ha Mixed use sites. Commercial / industrial areas</td>
</tr>
<tr>
<td><strong>Operating in Scotland</strong></td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Lifetime (years)</strong></td>
<td>20-25</td>
<td>20-25</td>
<td>20-25</td>
</tr>
<tr>
<td><strong>Working time</strong></td>
<td>Up to 24hrs, 7 days per week</td>
<td>Up to 24hrs, 7 days per week</td>
<td>Up to 24hrs, 7 days per week</td>
</tr>
</tbody>
</table>

## Environmental Impacts

<table>
<thead>
<tr>
<th>Environmental Impacts</th>
<th>Incineration</th>
<th>Pyrolysis</th>
<th>Gasification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Traffic</strong></td>
<td>Access for large numbers of HGVs</td>
<td>Access for large numbers of HGVs</td>
<td>Access for large numbers of HGVs</td>
</tr>
<tr>
<td><strong>Air emissions (potential)</strong></td>
<td>Acid gases, dioxins + furans, heavy metals, particulates: reduced using air pollution</td>
<td>Acid gases, dioxins + furans, heavy metals, particulates: reduced using air pollution</td>
<td>Acid gases, dioxins + furans, heavy metals, particulates: reduced using air pollution</td>
</tr>
<tr>
<td><strong>Dust</strong></td>
<td>Low risk if properly managed</td>
<td>Low evidence load (likely to be similar to incineration)</td>
<td>Low evidence load (likely to be similar to incineration)</td>
</tr>
<tr>
<td><strong>Odour</strong></td>
<td>Low risk if properly managed</td>
<td>Low evidence load (likely to be similar to incineration)</td>
<td>Low evidence load (likely to be similar to incineration)</td>
</tr>
<tr>
<td><strong>Noise</strong></td>
<td>Likely from process operations</td>
<td>Noise from vehicles and processing</td>
<td>Noise from vehicles and processing</td>
</tr>
<tr>
<td><strong>Litter</strong></td>
<td>Low risk if properly managed</td>
<td>Low risk if properly managed</td>
<td>Low risk if properly managed</td>
</tr>
<tr>
<td><strong>Water resources</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Aesthetic</strong></td>
<td>Large structures may affect sensitive viewpoints</td>
<td>Large structures may affect sensitive viewpoints</td>
<td>Large structures may affect sensitive viewpoints</td>
</tr>
<tr>
<td><strong>Public concern</strong></td>
<td>Public concern with emissions</td>
<td>Insufficient evidence: immature technology</td>
<td>Insufficient evidence: immature technology</td>
</tr>
</tbody>
</table>
* Incineration, pyrolysis and gasification figures from 2013. Many waste treatment sites carry out more than one waste activity: this figure is an underestimate as it does not take into account the sites which only include the named treatment as part of their process.
## ANNEX C - PROPOSED ENERGY FROM WASTE SITES

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Capacity (tonnes)</th>
<th>Technology</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viridor Waste Management Ltd</td>
<td>East Lothian</td>
<td>300,000</td>
<td>Moving Grate</td>
<td>Planning and Permit Granted</td>
</tr>
<tr>
<td>Sita UK Ltd</td>
<td>Perthshire</td>
<td>60,000</td>
<td>Moving Grate</td>
<td>Planning and Permit Granted</td>
</tr>
<tr>
<td>Covanta</td>
<td>North Lanarkshire</td>
<td>300,000</td>
<td>MRF &amp; Moving Grate</td>
<td>Planning Granted – PPC App Submitted</td>
</tr>
<tr>
<td>Scotgen Ltd</td>
<td>South Lanarkshire</td>
<td>150,000</td>
<td>MRF &amp; Gasification</td>
<td>Planning Granted – PPC App Submitted</td>
</tr>
<tr>
<td>Levenseat Recycling Ltd</td>
<td>West Lothian</td>
<td>60,000</td>
<td>MBT &amp; Gasification</td>
<td>Planning Granted – No Permit App</td>
</tr>
<tr>
<td>Shore Energy Ltd</td>
<td>North Lanarkshire</td>
<td>160,000</td>
<td>Autoclave &amp; Pyrolysis</td>
<td>Planning Granted – JR pending</td>
</tr>
<tr>
<td>Combined Power &amp; Heat Highlands</td>
<td>Highlands</td>
<td>100,000</td>
<td>Moving Grate</td>
<td>Planning Granted – Public inquiry pending</td>
</tr>
<tr>
<td>Peel Environmental</td>
<td>Glasgow</td>
<td>250,000</td>
<td>MRF &amp; Moving Grate</td>
<td>Planning Application Submitted</td>
</tr>
<tr>
<td>Glasgow City Council</td>
<td>Glasgow</td>
<td>200,000</td>
<td>MBT &amp; Gasification</td>
<td>Pre-Planning Application Submitted</td>
</tr>
<tr>
<td>Sita UK Ltd</td>
<td>Aberdeenshire</td>
<td>80,000</td>
<td>MBT &amp; Gasification</td>
<td>Pre-Planning Application Scoping</td>
</tr>
<tr>
<td>Edinburgh and Midlothian Councils</td>
<td>Midlothian</td>
<td>200,000</td>
<td>No Decision</td>
<td>Outline Planning Permission</td>
</tr>
</tbody>
</table>
ANNEX D – WASTE ARISINGS IN SCOTLAND

Total waste arisings in Scotland were 16.86 million tonnes in 2010, down from 17.11 million tonnes in 2009 (SEPA 2009, 2010, 2011). Commercial waste in 2010 totalled 4.70 million tonnes (down from 4.89 million tonnes in 2009) and Industrial waste (including construction and demolition (C&D)) totalled 9.39 million tonnes in 2010, around the same as the 2009 figure of 9.40 million tonnes. Most commercial and industrial waste is not collected by local authorities, and adherence to regulations on this part of the waste stream will generally be the responsibility of private operators. SEPA reports total Scottish Local Authority Collected Municipal Waste (LACMW), which consists of household and some commercial waste, in 2010/11 was 3.14 million tonnes, following a downward trend from 3.20 million tonnes in 2009/10 and 3.30 million tonnes in 2008/09. Local authority targets for recovery, recycling and composting from ‘municipal waste’ are based on the LACMW component of the waste stream. Table 1 below sets out the summary picture.

Table 1 – SEPA –waste arisings in Scotland (million tonnes)

<table>
<thead>
<tr>
<th>Year</th>
<th>Household</th>
<th>Commercial</th>
<th>Industrial (including C&amp;D)</th>
<th>Total</th>
<th>LACMW</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>2.82</td>
<td>4.89</td>
<td>9.40</td>
<td>17.11</td>
<td>3.20</td>
</tr>
<tr>
<td>2010</td>
<td>2.77</td>
<td>4.70</td>
<td>9.39</td>
<td>16.86</td>
<td>3.14</td>
</tr>
</tbody>
</table>

Source: SEPA Waste Data Digest

Historically landfill was the favoured option for waste disposal due to low cost and easy availability of suitable sites, but it poses a number of environmental and societal problems. The Scottish Government’s second draft Report on Proposals and Policies (RPP2) for meeting Scotland’s emission reduction targets states that ‘potent greenhouse gases’ are produced by the uncontrolled breakdown of organic waste in landfill. SEPA attest other environmental risks including water and land contamination (Scottish Government 2013). In 2010/11 SEPA reported that after the removal of recoverable and recyclable materials approximately 1.94 million tonnes of residual LACMW were disposed of: 95% was landfilled and the remainder ‘incinerated with energy recovery’ (a residual waste treatment discussed in the ‘Treatment Options’ section of this report). 4.56 million tonnes of controlled waste (waste subject to legislative control in handling or disposal) was landfilled in Scotland 2010. About 36% of the waste landfilled in Scotland originated from households and the remainder was produced by commerce and industry (SEPA 2012).

Compared to EU levels of municipal recycling and composting, with an average of 40% in the EU27 reported by Eurostat (2011), Scotland achieves moderate treatment figures. The EU average is skewed by a few nations with very low reported rates of recycling and composting, but countries including Germany, Austria, The Netherlands and Belgium treat considerably more than 50% of their waste in this way. Despite this, the 40.1% Scottish rate reported in 2011 was a significant step change from the 5% rate reported in 2000 (SEPA 2013).
RELATED BRIEFINGS

SB 12/18 The Waste (Scotland) Regulations 2012 16 March 2012

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