Scottish Government
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Waste Markets Study - Full Report

AGRICULTURE, ENVIRONMENT AND MARINE

social research

Executive Summary

Introduction

The Waste (Scotland) Regulations 2012 ban biodegradable municipal waste (BMW) from landfill in Scotland from the 1st of January 2021.[1] In preparation for the regulations coming into force, Eunomia Research & Consulting was commissioned by the Scottish Government to report on the current and future markets for the disposal and recovery of BMW. The aims of this work were:

- to consider the availability and costs of disposing of Scottish biodegradable municipal waste in other UK landfills or recovering energy in Energy from Waste (EfW) plants.
- to consider the opportunities and costs of recovering of Scottish biodegradable municipal waste by exporting the material as refuse derived fuel (RDF) to continental or Irish EfW facilities.

Overview of Waste Markets

Market Readiness

Despite the significant notice that has been provided of the ban, the alternative waste management options that will be needed may not be available at sufficient scale or at an affordable price at the point when the ban commences. Based on 2017 figures, fourteen local authorities, accounting for 55.5% of residual household waste (744k tonnes), have already made the financial investment to ensure solutions are in place before the ban. However, three authorities (7.6% of household waste – 99k tonnes) have long term solutions in place post 2021 but no firm interim solution and six authorities (13.3% of household waste – 177k tonnes) have an interim but no long-term solution secured. Nine authorities (23.6% of household waste – 315k tonnes) have no alternative arrangements in place.

Commercial waste operators do not appear yet to have made adequate preparations for the ban. Where strategies are in development, they are primarily focussed on transporting waste, either to landfill or treatment infrastructure in Northern England or into thermal treatment capacity abroad.

Capacity Modelling

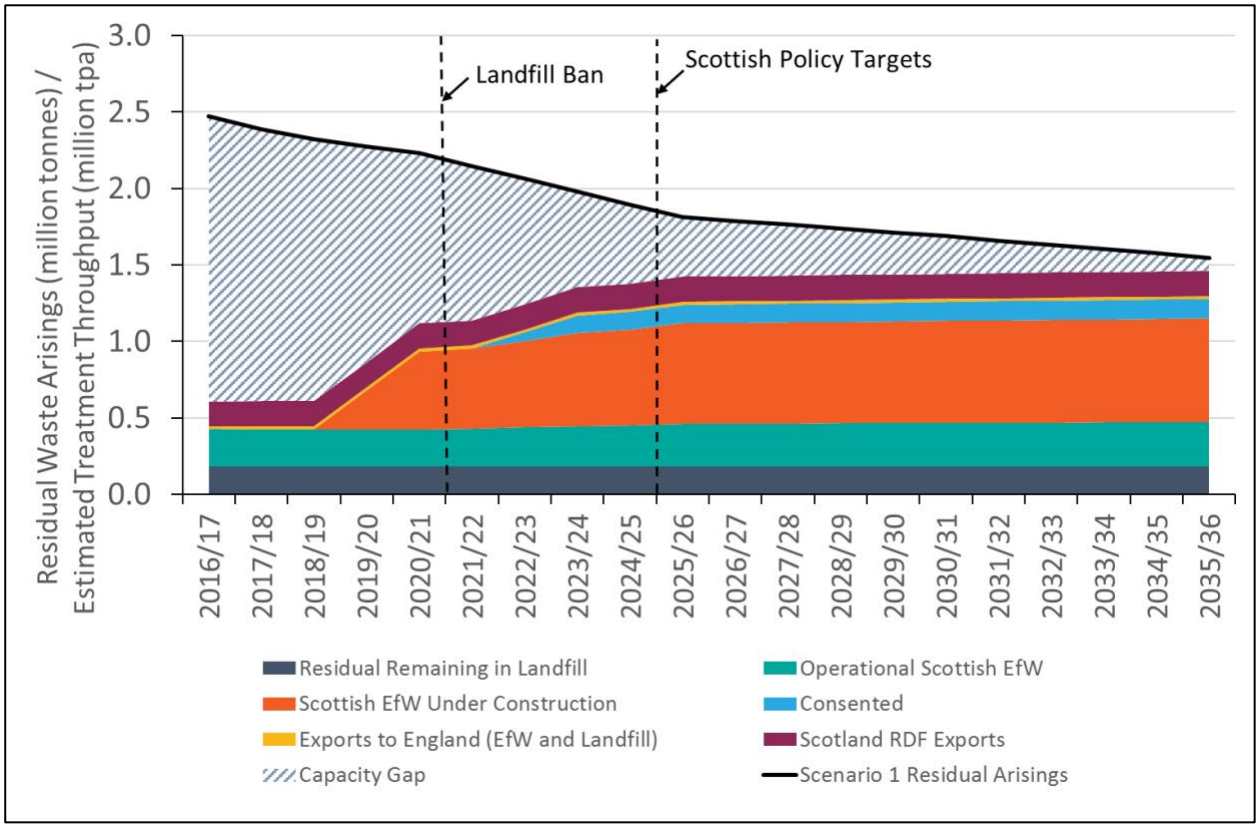
Eunomia's national level capacity modelling found that there will be insufficient residual waste treatment capacity in Scotland available to deal with waste

[1] Biodegradable waste is defined (in Regulation 2 (1) of the Regulations as "any waste capable of undergoing anaerobic or aerobic decomposition such as food, garden waste, paper and cardboard".
Municipal waste is defined (in Regulation 2 (1) of the Regulations as "waste from households as well as other waste which, because of its nature or composition, is similar to waste from households".

generated once the ban is put in place. The extent of this gap will depend on the level of recycling that is achieved.

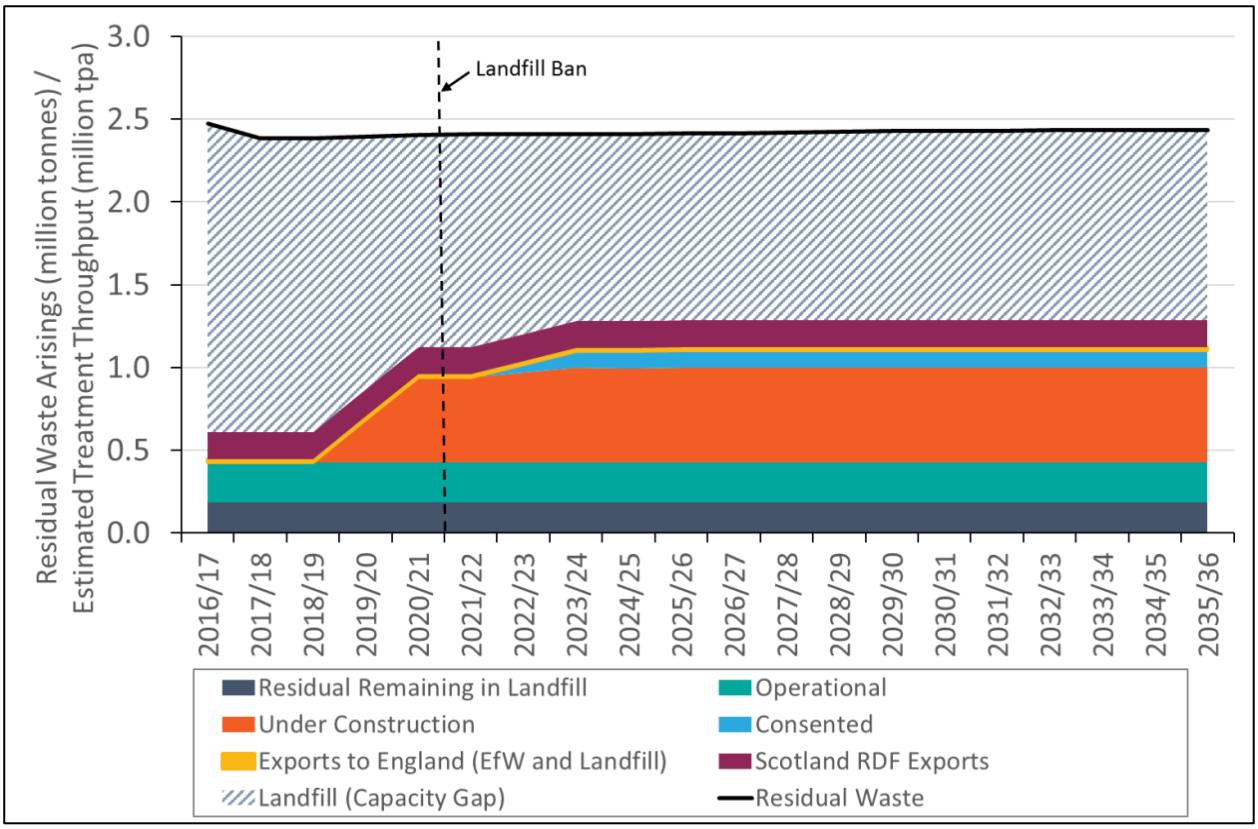
Two scenarios were modelled – Scenario 1, in which Scotland meets planned and likely recycling and waste prevention targets through to 2035; and Scenario 2, in which recycling remains at current levels and waste generation increases. In Scenario 1, at the point where the ban is introduced in 2021, Scotland has a shortfall of 1.01 million tonnes of treatment capacity compared with generation, falling to 0.09 million tonnes per annum by 2035.

Figure 1: Scenario 1: Recycling Target - Capacity Modelling



In scenario 2, residual waste generation increases marginally up to a total of 2.40 million tonnes at the time when the ban comes into effect and 2.43 million tonnes by 2035. This leaves a capacity gap of 1.28 million tonnes at 1 January 2021, which decreases slightly as new facilities come on stream through to 2023/24 before growth in waste arisings increases it to 1.15 million tonnes by 2035.

Figure 2: Scenario 2: Business as Usual - Capacity Modelling



The modelling examines two options available to deal with any capacity gap that may occur:

- Option 1: Scotland could make use of spare capacity in residual waste treatment facilities in England or continental Europe, or landfills in Northern England. The treatment facilities have substantial capacity, but much of this is already in use, making it challenging for Scottish waste collectors to secure capacity without incurring significant additional costs, particularly in the short-term post 2021. Consented English landfill capacity is finite, and if such sites receive Scotland's waste, the date when current landfill capacity in Northern England reaches capacity appears likely to move forward to as early as 2024 or 2025.
- Option 2: Scotland could construct its own additional treatment facilities, although it would not be feasible to bring on stream by 2021 sufficient capacity to bridge the capacity gap, meaning an interim solution would still be required.

Cost Implications for Scotland

Financial Costs

Scottish landfill disposal costs currently act as a cap on waste disposal costs in Scotland – alternative options must be able to compete with landfill on price. The

ban will mean that English landfill costs (inclusive of haulage) will replace Scottish landfill as the market cap post-2021 at least as long as capacity remains available. This is likely to create something of a shock to the market. While local authorities that have already secured a solution (rank 1 authorities) will not be affected by the policy, those with no solution in place (rank 4 authorities) – interim or otherwise – are likely to experience significant marginal costs in cash terms. The highest costs in the short term are likely to fall on a small number of authorities that have a long-term solution in place that comes in post-2021 but due to their location will have little option but to rely on the export market for a short interim period starting immediately after the ban (rank 2 authorities). Those with short term solutions in place that are yet to develop long term plans (rank 3 authorities) may be less affected as the market may well stabilise by the time they need to procure new solutions.

If Scotland builds additional thermal treatment capacity, this will result in a somewhat smaller increase in marginal cost per tonne than export options in the medium-term. However, as the market stabilises, the option to export may become more favourable.

Commercial waste collectors will also experience additional costs and disruption. Some operators may not be sufficiently financially robust to compete in the changed market, which may create costs and opportunities for local authorities as collectors of commercial waste.

Economic Costs

Table 1 presents the economic modelling results for the 2021-2030 period. Negative figures indicate a cost to Scotland, while positive figures represent an economic benefit to Scotland. Excluding consideration of waste minimisation and recycling, the ban will result in significant economic costs to Scotland due to the need to export an increased amount of residual waste – whether as an interim solution until new thermal treatment capacity comes online, or as a long-term solution. This has the effect of exporting revenue to English or continental landfill or treatment providers. The transition from landfill to alternative treatment will also result in a reduction in revenue to the Scottish Government as landfill tax receipts reduce. Uptake of alternative treatment solutions to comply with the ban will result in increased haulage distances, which contribute to the increase in costs and also give rise to additional emissions. This is offset by the emissions avoided through a reduction in waste sent to landfill, with environmental performance improving as 2030 approaches, resulting in an overall environmental benefit to Scotland.

The scale of these economic costs and impacts will depend on the extent to which waste minimisation and recycling targets can be met. The greater the recycling rate that can be achieved, the smaller the amount of residual waste that will need to be managed, lessening the economic impact upon Scotland.

In Option 2, the economic costs of the policy are mitigated by building additional new incinerator capacity in Scotland, which in later years reduces the amount of

waste (and therefore revenue) that is exported. It also helps to limit haulage distances.

Analysis of the allocation of economic impacts shows that waste collectors – both local authorities and private collection contractors – will incur the greatest costs. Hauliers and exporters will see an economic benefit.

Under both scenarios, Option 1 sees economic costs being incurred throughout the time period evaluated, as waste continues to leave Scotland in significant quantities throughout. Under Option 2, once the new treatment facilities come onstream in 2025, there is no longer an annual economic cost to Scotland each year, but the economic benefits achieved are not sufficient to outweigh the costs incurred between 2021 and 2024.

The environmental modelling takes account of treatment emissions that occur within Scotland; thus, options in which material is exported for treatment may look environmentally favourable.

Table 1: Economic Modelling Results

Industry		**NPV (£m)**			
		Scenario 1: Option 1	**Scenario 1: Option 2**	**Scenario 2: Option 1**	**Scenario 2: Option 2**
Public Authorities		-853	-842	-1,132	-1,114
Waste Collectors		-770	-713	-953	-879
Haulage	Household	54	44	70	52
	C&I	34	21	41	24
Exporters	Household	46	43	58	51
	C&I	102	55	126	63
Scottish Treatment/Landfill Providers	Household	464	649	648	897
	C&I	-61	312	-71	420
Total Economic		**-984**	**-430**	**-1,213**	**-486**
Total Environmental		**40**	**16**	**57**	**37**
COMBINED TOTAL		**-943**	**-414**	**-1,156**	**-449**

Note: figures may not sum to the totals due to rounding.

Conclusions

Despite the lead-time since the ban was announced in 2012, insufficient residual waste treatment capacity has been brought through into development to meet the expected level of need in Scotland. The availability of capacity in the UK and European export markets to take Scotland's waste is likely to be limited in the short term as demand for waste treatment in these markets currently outstrips supply. More capacity may become available in the longer term as increases in recycling may result in supply outstripping demand.

In the short term, the ban is likely to lead to a significant rise in residual waste treatment costs for organisations that have not already secured a long-term contract, as the price of local landfill will no longer restrict gate fees and there will be greater reliance on exports, whose price will be likely to be set by reference to the next cheapest option – typically, landfill in England.

Over time, the market is likely to stabilise at a price a little above the current level. Prices will be lower in the medium term if additional incineration capacity is built in Scotland, though in the longer term export may be more favourable. Costs will be lower if high levels of recycling are achieved.

It should be noted that this study focuses on the impact of the ban on the cost and benefits of the disposal of residual waste. The impact upon waste reduction, reuse and recycling is not considered. The likely substantial economic and environmental benefit that might be expected from the increase in reuse and recycling is therefore not reflected in these results.

Contents

Introduction

Scotland's vision is for a zero waste society, as articulated in 2010's Zero Waste Plan. One measure adopted by the Scottish Government towards achieving this goal is a ban on the disposal of biodegradable municipal waste (BMW) from landfill from the 1st January 2021, which was introduced by Regulation 4(2)(a) of the Waste (Scotland) Regulations 2012. This ban applies to a wide range of waste types including the following European Waste Codes (EWC):

- 20 02 01 – Biodegradable waste
- 20 03 01 – Bulky waste
- 20 03 01 – Mixed municipal waste
- 19 12 10 – Combustible waste (Refuse Derived Fuel - RDF)
- 15 01 06 – Mixed packaging.

A full list of EWC codes affected by the ban can be found in Appendix 1. Diverting biodegradable materials from landfill is likely to result in environmental benefits, especially if the result is a boost to recycling as waste producers look to avoid residual treatment costs. However, there is a risk that, despite the significant notice that has been provided of the ban, the alternative waste management options that will be needed may not be available at a sufficient scale or at an affordable price at the point when the ban commences.

The aims of this study are:

- To consider the availability and costs of disposing of Scottish biodegradable municipal waste in other UK landfills or recovering energy in Energy from Waste (EfW) plants.
- To consider the opportunities and costs of recovering of Scottish biodegradable municipal waste by exporting the material as refuse-derived fuel (RDF) to continental or Irish EfW facilities.

The report presents:

- an analysis of the current waste markets for Biodegradable Municipal Waste (BMW) in Scotland, Rest of the UK and Europe and the likely short to medium term trends including the current Scottish EfW pipeline;
- an assessment of the availability of capacity in these markets to take material from Scotland in the short and medium term;
- an examination of the logistical and environmental impacts of using these alternative markets in the short and medium term; and
- an assessment of the likely costs of disposal or recovery of material in this way.

All data and analysis presented are correct as of December 2018.

Progress Towards Addressing the Ban

In order to understand the progress being made by local authorities towards addressing the ban, the Scottish Environment Protection Agency (SEPA) surveyed all Scottish local authorities in December 2017. Scottish waste managers also collated detailed information on each council's readiness, including current waste collection/processing/contractual arrangements, tonnage, forward plans for EfW processing and anticipated capacity gaps for possessing household waste in line with the ban. Interviews undertaken by Eunomia in September 2018 with Scottish local authorities and waste management operators provided further updates and clarification on top of the survey results, and also yielded information regarding the progress being made by the private sector to adapt to the ban.

Based on the surveys and interviews, local authorities were classified according to their 'state of readiness' into one of four categories.

- Rank 1: Policy Compliant – 14 authorities have, or will have, a policy compliant solution in place prior to the ban coming into effect. This equates to 744k tonnes (55.5%) of household residual waste landfilled based on 2017/18 waste flows.
- Rank 2: Secure Post Ban Solution, Uncertain Interim Solution – 3 authorities have procured a policy compliant long-term solution that won't be ready in time for the ban. However, no secure interim solution is in place. This equates to 99k tonnes (7.6%) of 2017/18 household residual waste.
- Rank 3: Uncertain Post Ban Solution, Secure Interim Solution – 6 authorities have short to medium term solutions in place but have an uncertain long-term solution or are currently in the early stages of procuring their solution. This equates to 177k tonnes (13.3%) of 2017/18 household residual waste.
- Rank 4: No solution – 9 authorities don't currently have policy compliant solutions in place, and are not yet procuring a solution. This equates to 315k tonnes (23.6%) of 2017/18 household residual waste.

The surveys indicate that, while slightly more than half of Scotland's household residual waste has a policy-compliant solution in place, there are risks for many authorities. This may result in some authorities facing difficulties in finding compliant solutions, or being exposed to higher costs.

The commercial and industrial waste collection market in Scotland is primarily served by a handful of large collection contractors, namely Biffa, Viridor and William Tracey. There are numerous smaller local enterprises operating at a regional level, with local authorities also participating in the market – non-household waste collected by councils is excluded from the local authority household waste figures listed above.

Interviews held with five commercial waste contractors in September 2018 suggest that few have developed specific plans to prepare for the ban. Where strategies are in development, they are primarily focussed on transporting waste, either to landfill or treatment infrastructure in Northern England or into thermal treatment capacity abroad. In areas of Scotland where this is likely to necessitate significant additional haulage, it can be expected to push up the overall cost of managing commercial and industrial residual waste.

A number of companies raised concerns about limited capacity south of the border to cope with additional waste from Scotland. Landfill capacity may well decline in the years prior to the implementation of the policy, as some sites may close earlier than expected as demand for landfill in England falls. The risks are likely to be greatest for smaller contractors that are not vertically integrated through collection, transfer and /or treatment and disposal services, as they may find it particularly hard to access capacity outside Scotland.

Some companies were concerned that the ban could result in some parts of the sector engaging in fraud. One possibility was that waste might be erroneously re-categorised from banned to non-banned EWCs as material passes through transfer station and pre-treatment infrastructure, so as to evade the ban.

Capacity Modelling

Capacity modelling was undertaken to understand the availability of treatment capacity to treat residual waste defined as waste affected by the landfill ban from 2021.

Methodology

Modelling Approach

To assess the longer-term trends in residual waste arisings and treatment capacity a time series model was developed with 2016/17 as the baseline year extending to 2035/36. The model firstly seeks to establish the total residual waste arisings affected by the ban. In parallel, we establish the treatment capacity that is already operational, under construction or has a high degree of certainty of reaching financial close. Comparing the two provides an understanding of the availability of treatment infrastructure to meet Scotland's needs (i.e. whether capacity outstrips demand or vice versa) over the short, medium and long term.

Modelling Total Residual Waste Arising

In order to understand the national picture in Scotland from 2016/17 to 2035/36, Eunomia's modelling approach started from an estimate of total waste generation in 2016/17 using the latest statistics published by SEPA:

- 2017 Scottish household waste data; and
- 2016 business waste data.

For this analysis, only household residual waste and the portion of commercial and industrial (C&I) waste streams likely to be affected by the ban were modelled. C&I waste streams, such as mining wastes and construction and demolition wastes, were excluded as they are unlikely to be affected. A relatively large tonnage of C&I waste is suitable for management by low-cost routes (e.g. direct land-spreading) or specialist facilities for managing industrial residues. This 'Other waste' was also excluded from the estimate of residual waste. The resulting estimate of residual waste is shown in Table 2. A full list of the C&I wastes assumed to be subject to the ban can be found in Appendix 4.

To establish the amount of residual waste likely to result, we deduct the proportion of waste that is likely to be recycled. For household waste, the starting point is the latest published recycling rates. Recycling rates were not available for business waste and therefore an assumption of 50% recycling has been applied to 2011 arisings, increasing incrementally to 55% by 2020. The resulting modelled recycling rates for 2017/18 are:

- 45.6% for household waste, and
- 53.8% for C&I waste.
- Assumptions regarding future recycling rates are discussed below.

Table 2: Total Waste Arising Assumptions 2016/17 (Millions of Tonnes)

Waste Stream	Total Waste Generation (million tonnes)	Recycling Rate	Rate of Other Waste	Total Residual Waste (million tonnes)
Household Waste[1]	2.50	45.2%	N/A	1.37
Commercial Waste[2]	1.53	53.4%	6.7%	0.61
Industrial Waste[2]	1.54	53.4%	18.6%	0.43
Total	**5.58**	**-**		**2.41**

Notes: [1] Scottish Household Waste – Summary Data 2017, Table 1: Scottish Household Waste Generated and Managed in 2017 – Summary Data.
[2]Scottish Business Waste Generated by Waste Type and Economic Sector 2016 (tonnes)

Modelling Treatment Capacity

Eunomia maintains a treatment facility database, which was used to establish the availability of treatment capacity in Scotland. The database includes facilities across the development lifecycle, but in order to focus on facilities that are likely to be available for use, the modelling was restricted to:

- operational facilities;
- capacity currently under construction; and
- facilities considered at or near financial close.

Facilities approaching financial close, but without a clear construction timetable yet in place, are assumed to come online in 2022/23. Analysis was based on data and information correct as of December 2018. Any treatment infrastructure reaching financial close since December 2018 is not reflected within this analysis.

The modelled throughput of operational thermal treatment facilities is based on their site return data. For facilities that are currently under construction or consented, the consented capacity is used as a starting point, but is modified by applying an average operational throughput based on the performance of operational facilities.

For gasification plants, an 80% efficiency rate has been assumed alongside a 95% availability of permitted capacity to account for facility downtime. For Mechanical Biological Treatment (MBT) facilities, an efficiency of 80% has been assumed, with facilities achieving a 33.7% mass reduction on their throughput. Table 3 summarises assumptions and Table 4 details the capacity for each Scottish facility.

Table 3: Treatment Capacity Assumptions

Facility Type	Assumptions
Operational EfW	Site return data determines operational capacity
Under Construction and Consented EfW	Operational throughput of 73.7% of permitted capacity
Gasifier	80% operational efficiency 95% availability of permitted capacity due to downtime
MBT	80% operational efficiency 33.7% of throughput treated

Table 4: Scottish Facility Capacity Assumptions

Facility Name	Operator	Facility Type	Facility Capacity (Taking Account of Operational Efficiency)	Modelled Capacity (Taking Account of MBT Processing)	Status	Likely Yr Operational
Dundee Energy Recycling	Dundee Energy Recycling	Incineration	84,669	84,669	Operational	-
Shetland Heat Energy & Power	Gremista, Lerwick	Incineration	22,965	22,965	Operational	-
Renewii	Dumfries & Galloway	MBT	49,400	16,648	Operational	-
Renewii	Argyll & Bute	MBT	30,780	10,373	Operational	-
Western Isles Council	Western Isles	MBT	15,960	5,379	Operational	-
Levenseat	Levenseat Waste Management Site	MBT	304,000	102,448	Operational	-

		Gasifier	45,600			
Viridor	Oxwellmains, Dunbar	Incineration	221,166	221,166	Under Construction	2019
Viridor	Polmadie	MBT/ Gasifier	152,000	152,000	Under Construction	2019
Shore Energy	Coatbridge	Gasification	60,800	60,800	Under Construction	2022
FCC Environment	Millerhill	Incineration	140,072	140,072	Under Construction	2019
Aberdeen / Aberdeenshire / Moray	East Tullos	Incineration	106,897	106,897	Consented	2022
TOTAL	-	-	-	923,416	-	-

Based on information obtained from the Environment Agency (EA), the model assumes that 17,464 tonnes of Scottish residual waste was exported to England in 2016/17. Based on SEWEB data from 2016, it is also assumed that 164,000 tonnes of residual waste is currently exported to Europe as RDF (see Appendix 3 for further information).

Finally, as a cross-check, information provided by SEPA, based on landfill site returns for 2016/17, provides the basis for assuming that 2.05 million tonnes of waste is currently sent to landfill in Scotland and would be subject to the ban in 2021[2]. In addition, based on analysis undertaken by SEPA, it has been assumed that 25% of EWC code 19 12 12 'other waste from mechanical treatment' will be removed though additional sorting of fines and can therefore continue to be sent to Scottish landfill. This accounts for ~9% of total waste currently landfilled.

Modelling Recycling Rate Scenario

Two recycling scenarios have been modelled to understand how residual waste generation may change up to 2035. At higher recycling rates, less waste will require alternative treatment solutions after the ban.

Scenario 1: Recycling Policy Compliant Scenario

This scenario assumes the following policy goals are achieved:

- EU's recycling target of 50% by 2020, which applies to household waste UK-wide;
- Scottish recycling target for all waste of 70% by 2025. As there is no specific recycling target for municipal waste, the project steering group waste experts advised that a recycling rate of 60% should be assumed for both household waste and the municipal components of C&I waste by 2025;
- EU Circular Economy Package recycling target of 65% of municipal waste by 2035; and
- Scottish policy to reduce overall waste generation by 15% compared to 2011 arisings by 2025.

Recycling rates are assumed to increase incrementally, year on year, towards the next target.

It is assumed that changes in waste composition due to greater levels of recycling will lower the overall calorific value (CV) of residual waste. This is due to high energy producing material, such as plastics, being removed disproportionately when compared to lower CV materials like food waste or glass. As the CV decreases, more tonnes of waste can be processed in each EfW facility, since their capacity is limited by their thermal treatment capacity rather than by tonnage. The

[2] SEPA's statistics are the official source of landfill tonnages and have therefore been used in undertaking this analysis.

result of this assumption is to make available an additional 169,553 tonnes of capacity by 2035.

Scenario 2: Business as Usual Scenario

This scenario assumes that the Scottish recycling rates for both household and C&I waste remain at the 2017/18 rate through to 2035 (see Table 2). No reduction in overall waste arisings has been assumed; rather, a growth rate in line with national records of Scotland annual population growth rates for household arisings (0.43% between 2017 and 2018, falling to 0.11% between 2034 and 2035) and 0.5% per annum has been assumed for commercial waste, while a reduction in industrial waste of 1.0% per annum is assumed, reflecting the trend in this sector.

In both scenarios, it has been assumed that the background rate of RDF exports to mainland Europe remains at the 2016/17 level (164,000 tonnes), reflecting the extent to which Scottish councils and businesses are currently finding it convenient to enter into contracts for this service.

Results

Figure 4 shows the results of the capacity modelling for scenario 1. Residual waste generation is anticipated to decrease to 2.1 million tonnes per annum at the point at which the ban comes into effect in January 2021. The result is a shortfall of 1.01 million tonnes of treatment capacity compared with arisings. This capacity gap shrinks as Scotland moves towards its 60% recycling target, reaching 0.39 million tonnes per annum by 2025 and falling to 0.09 million tonnes per annum by 2035, when Scotland is assumed to meet the EU Circular Economy Package recycling target.

Figure 3 shows the results of the capacity modelling for scenario 2. In this scenario, residual waste generation increases marginally up to a total of 2.40 million tonnes at the time when the ban comes into effect and 2.43 million tonnes by 2035. This leaves a capacity gap of 1.28 million tonnes at 1 January 2021, which decreases slightly as new facilities come on stream through to 2023/24 before growth in waste arisings increases it to 1.15 million tonnes by 2035.

Figure 4: Scenario 1: Recycling Target - Capacity Modelling

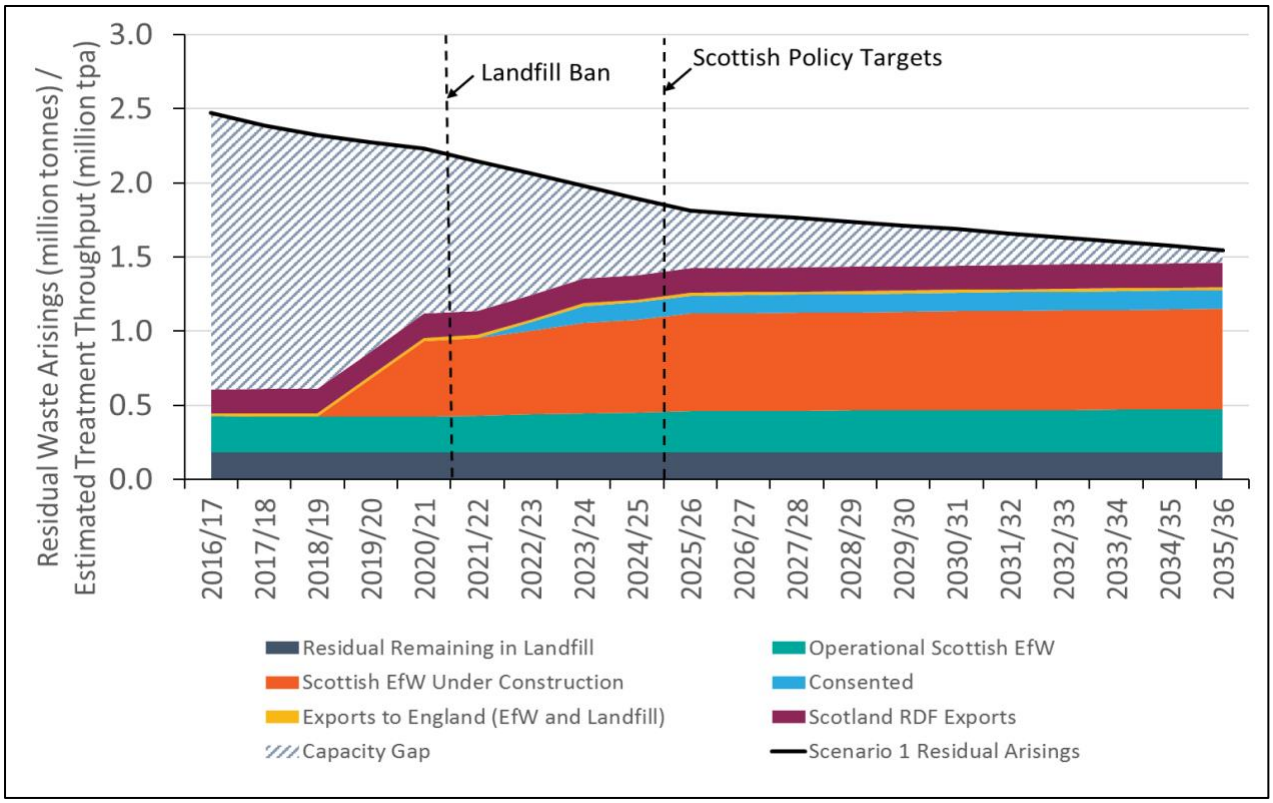
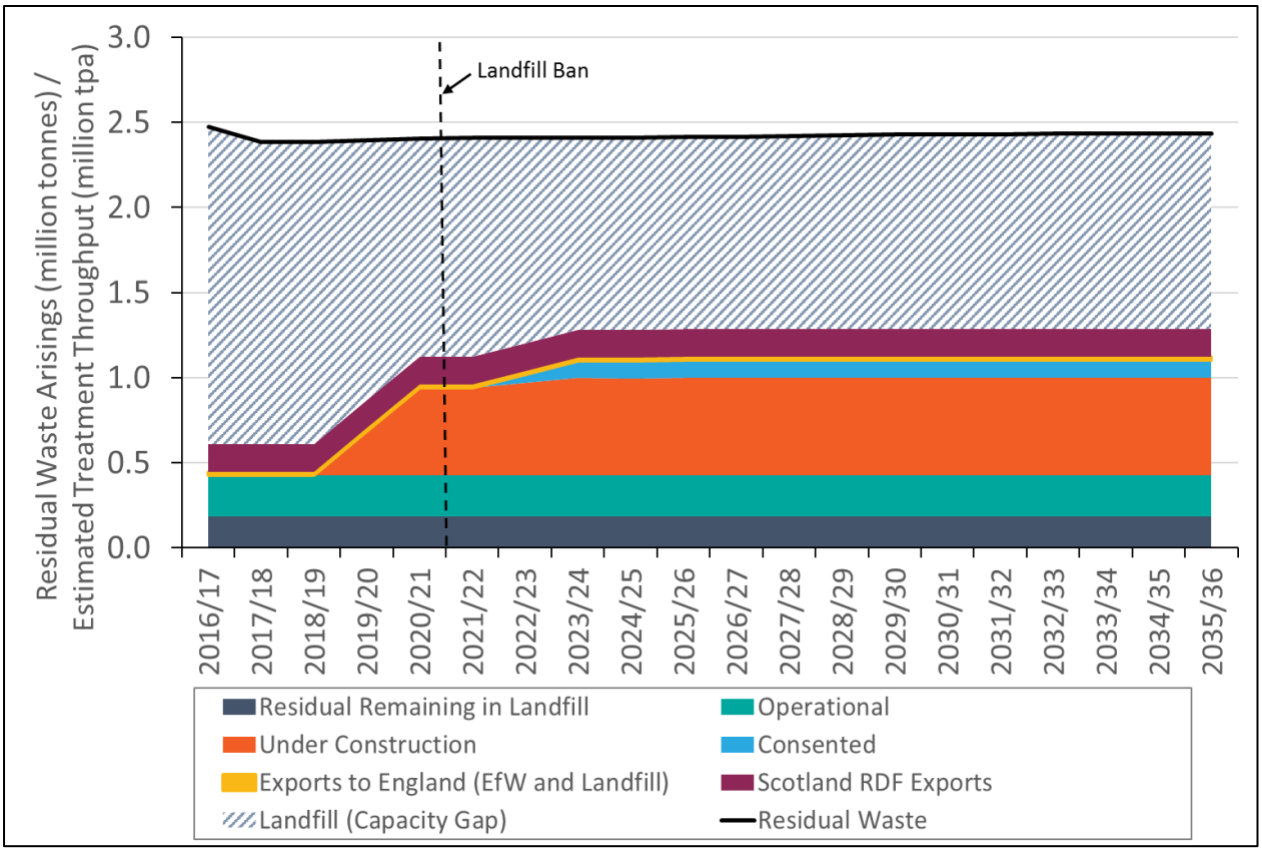


Figure 3: Scenario 2: Business as Usual - Capacity Modelling



Treatment Options

The capacity modelling shows a capacity gap under both scenarios at the point when the ban comes into effect in 2021. Under scenario 1, this gap will decrease significantly by 2035. Under scenario 2, a significant gap is projected to remain through to 2035.

There are two main options available to address the capacity gap in both scenarios, which can be deployed individually or in combination.

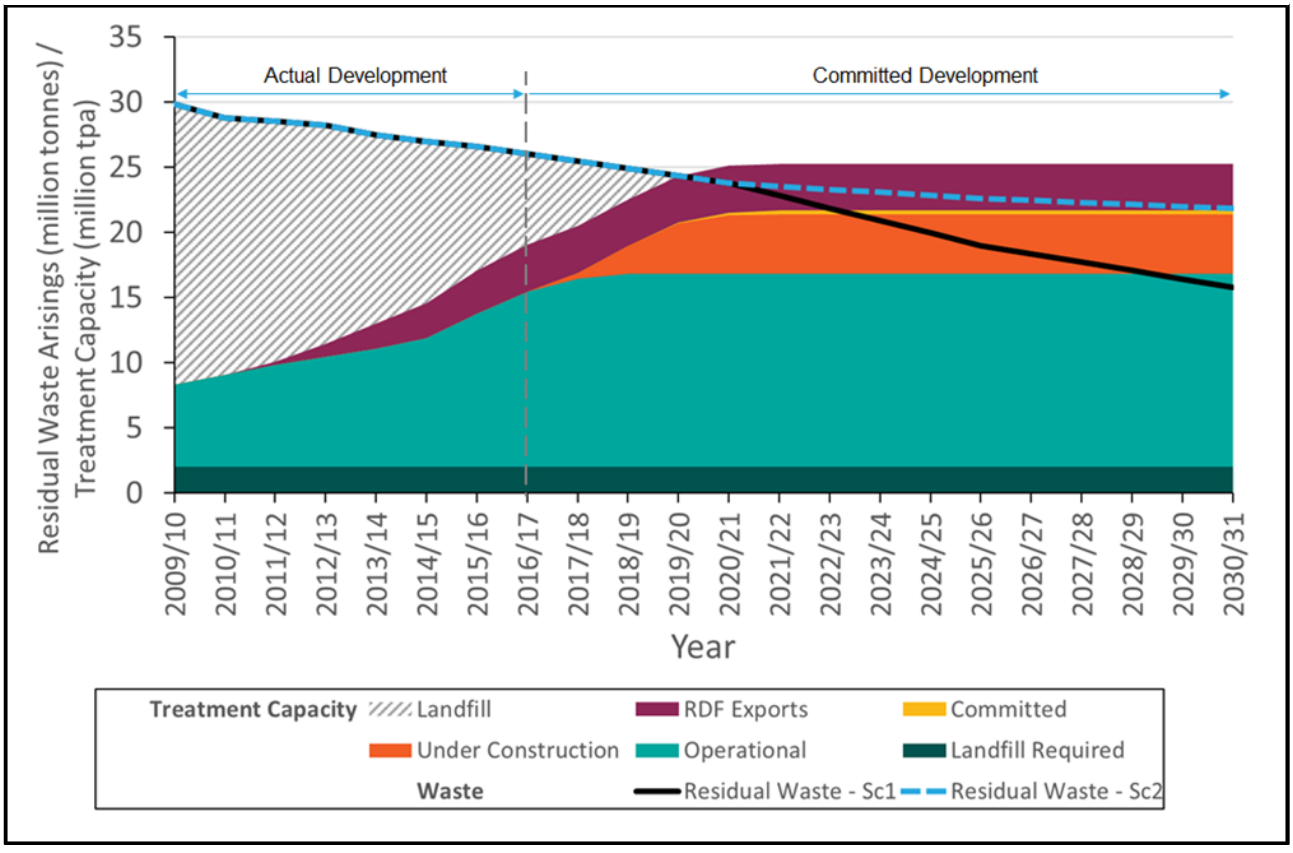
Option 1: Export to England or Europe

Scotland could meet its need for capacity by making use of both the English and European waste markets, whether as a short/medium-term interim solution or as a long-term solution in its own right. The sections below provide commentary on trends within these markets and their capacity to take Scottish waste and how they might be expected to react to the Scottish ban.

English Residual Waste Treatment

The UK's non-landfill residual waste treatment infrastructure sector has seen significant development in the last decade, but the great majority of this has taken place in England. According to a review of the sector undertaken by Eunomia in 2016, treatment capacity more than doubled from 6.3 million tonnes in 2009/10, to

Figure 5: English Treatment Capacity



13.5 million tonnes by the end of 2016[3]. Figure 5[4] shows that numerous facilities are under construction, and further developments continue to be proposed.

Alongside this expansion in capacity, the quantity of residual waste suitable for treatment has fallen from an estimated 29.9 million tonnes per annum to 26 million tonnes per annum, mainly due to increased efforts to recycle waste. This downward trend is expected to continue as the UK moves towards its 50% household recycling rate target by 2020. The Resources and Waste Strategy for England[5] contains policies to enable a 65% recycling target for municipal waste to be met by 2035.

If England is successful in achieving a much higher recycling rate, this could result in treatment capacity exceeding the available quantity of residual waste in the medium term.

In the shorter term, there are already some indications of more thermal treatment capacity being available in the English market. Most facilities in England have been built with the primary aim of meeting the requirements of one or more local authorities, although typically each provides a little spare capacity to be filled with waste from commercial sources. Table 5 shows a slight downwards trend in the capacity of UK incinerators taken up by local authority contracts, with a greater share taken by C&I waste – typically on short-term contracts.

Table 5: Thermal Treatment Inputs by Waste Stream[6]

Waste Source	Local Authority Collected Waste	C&I Waste
2014/15	85.4%	14.6%
2015/16	85.1%	14.9%
2016/17	83.2%	16.8%

Capacity of this kind would potentially be available for Scottish waste, at least where it is sufficiently close to the border. An analysis of the operational and under construction facilities in North East and North West England, shows a total of 2.15m tonnes per annum of treatment capacity, although the great majority of this is more

[3] Eunomia Research & Consulting (2016) *Residual Waste Infrastructure Review - Issue 12*, December 2016, http://www.eunomia.co.uk/reports-tools/residual-waste-infrastructure-review-12th-issue/

[4] It should be noted that this presents a UK wide situation, drawing upon 2017 data and specific assumptions. The modelling does not account for regional variation which may vary significantly.

[5] "Our Waste, Our Resources: A Strategy for England": https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/765914/resources-waste-strategy-dec-2018.pdf

[6] Tolvik Consulting (2018); UK Energy from Waste Statistics - 2017

than an hour's drive from the border. If 15% of this is potentially available, in line with the national estimate, that would offer around 325,000 tonnes of potential capacity per year that could be accessed subject to contract churn and price competitiveness.

English Landfill

England could also offer landfill capacity to receive waste from Scotland. Although this option might not be wholly consistent with the aims of the ban, which seeks to divert waste from landfill, it might be useful as an interim solution.

Landfill infrastructure in Northern England is the most accessible to the Scottish market. Appendix 2 provides an analysis of the capacity of Northern English landfill to accommodate Scottish residual waste. This suggests that:

- In scenario 1 where Scotland meets waste reduction and recycling targets, with the addition of Scottish residual waste, landfill capacity in Northern England will be exhausted in early 2025.
- In scenario 2, capacity will likely be exceeded in late 2025.

Whilst Northern England landfill is unlikely to be a logistically and economically viable solution for all Scottish residual waste, there appears to be capacity for it to provide an interim solution for waste arising relatively close to the border. However, there is unlikely to be long term capacity without further expansion of landfill sites beyond that already permitted.

European Waste Market

The UK's use of RDF exports has grown significantly since it began in 2010. Northern European countries that invested heavily in incineration in the early 1990s and 2000s, such as the Netherlands, Germany and Denmark, have found themselves with spare capacity as increased recycling has cut residual waste generation. In some cases, e.g. Sweden, where incineration is used as part of district heating networks, the increasing demand for heat has driven more capacity to be developed despite a lack of waste. More detailed analysis is presented in Appendix 3.

A combination of competitive gate fees and the impact of the UK's landfill tax escalator led RDF export to become a viable alternative to domestic landfill and treatment, even taking account of the pre-treatment and haulage costs associated with RDF.

Over the last 8 years, as the UK RDF export market has ramped up from zero to c.3.5mt/a, as shown in Figure 6, a number of changes have taken place including:

- As imports have filled continental facilities, the competition between those facilities has reduced and gate fees have risen slightly;

- The supply chain has matured with increased sophistication in logistics and fewer, bigger players involved; and
- Brexit has introduced some concerns about potential interruption of the supply chain, while a fall in the value of Sterling has effectively increased continental gate fees for UK waste producers.

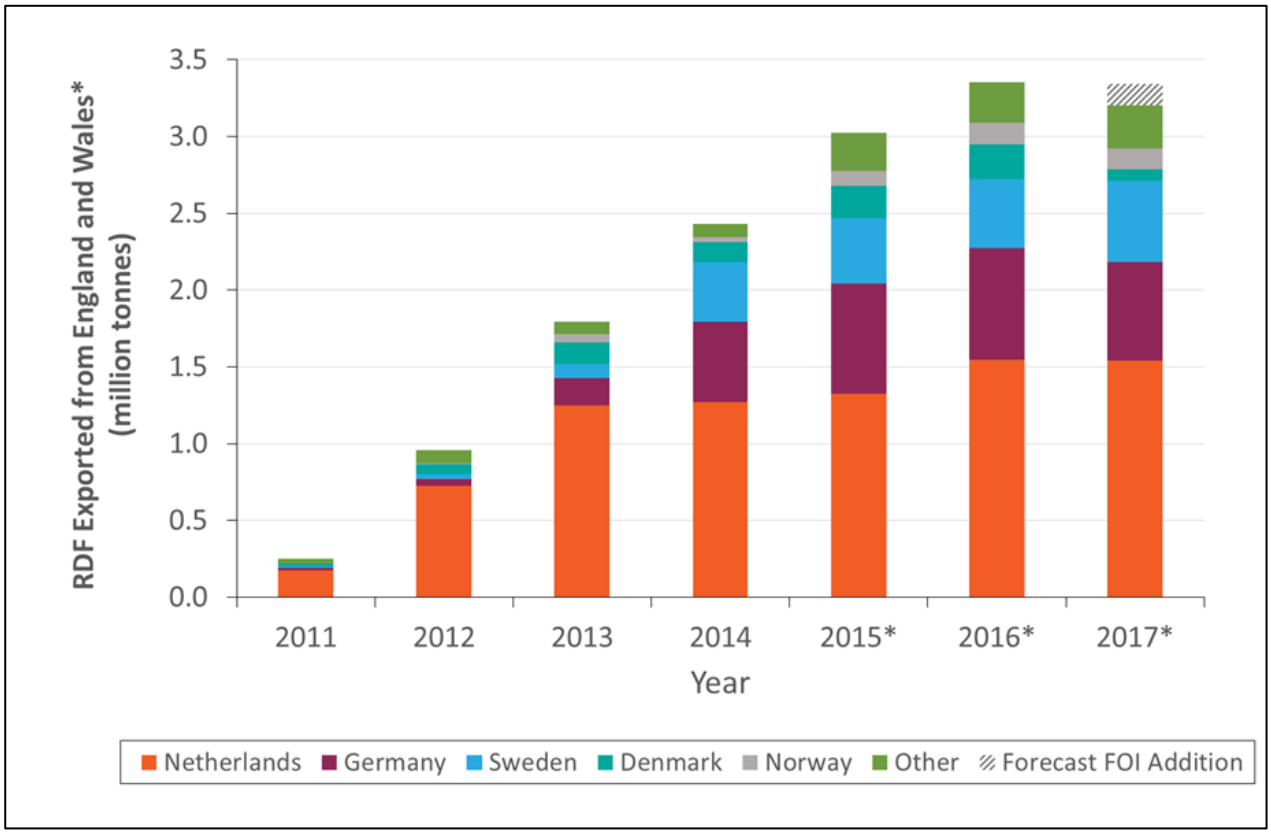
When the market first began to develop, most contracts were 'spot' contracts, with many small brokers doing deals on individual shipments for a small commission. Then, as off-takers started to develop relationships up the supply chain, contracting became the norm with typical contract lengths of 6 to 18 months. Over time there has been an increasing move towards longer contracts, depending on the requirements of the counterparties. Today, contracts of 10-15 years are not unusual; the rise in contract length has reduced churn (renewal) and provided increased security. That having been said, the full spectrum of contract terms remains available in the market, typically with a higher fee for shorter contracts.

LAs considering using the European market to meet their future needs could simply wait until they have a requirement for capacity before seeking to procure it, safe in the knowledge that there will always be some churn in RDF contracts. However, that would expose those LAs to the market conditions prevailing at that time. Over the next few years it is expected that those market conditions will be relatively challenging for service buyers, with demand for treatment at times outstripping supply. The landfill ban could be expected to worsen market conditions as demand absorbs capacity in England and leads to fresh competition for access to continental facilities.

There is still some uncertainty regarding the impact of Brexit on the European waste export market. It is unlikely that new non-tariff controls would be introduced by the EU after Brexit: the system is already closely regulated, and much the same system of notifications and documentation are required under the OECD and UN agreements already in place, and to which both the UK and receiving countries are signatories. Even if the UK leaves the single market, it appears that the framework for exports should remain much as it is today, although contracts and notifications may need to be renewed so that they refer to the correct legal framework.[7]

[7] European Commission (2018), Notice to Stakeholders: Withdrawal of the United Kingdom and EU Waste Law, http://ec.europa.eu/environment/waste/shipments/pdf/Notice_to_stakeholders_Brexit_waste.pdf

Figure 6: RDF Exports from England and Wales[8]



Option 2: Build Additional Treatment Capacity

The principal alternative to exporting waste is to build additional capacity in Scotland. Due to the lead in time associated with the development of additional treatment infrastructure, it is highly unlikely that any additional thermal treatment will be on-line and operational in advance of the ban in 2021. If Option 2 is pursued, it is likely that an interim solution will be required to treat or dispose of waste until new facilities come on stream.

The scale at which additional treatment infrastructure will be required will largely be determined by the scenario, with considerably less capacity needed in scenario 1 than in scenario 2. It would be wise to limit development of new thermal treatment capacity to that required once any targets have been met to avoid creating overcapacity as recycling increases.

Counterparty Risk Associated with Options

Local authorities have a range of different types of residual waste contract in place. The landfill ban will create significant disruption in the market, and could create problems for some contracts. The reliability of the residual waste contracts that

[8] Data relates to England only from 2015 onwards. Source: Environment Agency. 2017 figures are provisional. In previous years, the provisional figure has increased once final data has been obtained through a Freedom of Information request. We have included additional tonnage to reflect the expected increase in the figure once this data is available

local authorities have with counter-parties depends on many factors. It is difficult to foresee at this point which contracts may prove to be unsustainable. However, some useful observations can be made based on knowledge of the market. Assuming contracts are drafted and executed so as to be fit for purpose, the types of risk that LAs may be exposed to in different contract types are set out below.

- **Long-Term Public Private Investment (PPI) Contracts**: Some local authorities have entered into 20 year+ PPP contracts, under which dedicated new facilities have been built. The counterparties in such arrangements will typically be established UK waste management companies that have a track record of delivering and maintaining residual treatment facilities. The risks to authorities in such contracts are generally small but may include:
  - **Technology / market failure** – there are examples of long-term PPI contracts failing where a combination of technology performance and changing market conditions impact the financial viability of the project. For example, MBT-based contracts premised on high values being obtained for fuel and recyclate outputs have struggled in recent years as the markets for such outputs has faltered. Examples include Lancashire and Dumfries and Galloway. Where the outputs from MBT are currently landfilled, the risks of contract failure will be increased by the landfill ban, as the contractor may face difficulties in securing an outlet for the waste. There are also examples of failed contracts based on thermal treatment facilities, such as Greater Manchester, although that contract included a variety of facility types including MBT. Contracts based on Advanced Conversion Technologies are fewer and further between, but such contracts are considered to carry a higher risk of failure due to reliance on less proven technology. Such failures have, to date, all involved a negotiated exit, but leave the council re-exposed to the market sooner than intended. Generally, where the technology is moving grate mass-burn incineration, the technology / market risk of contract failure can be considered negligible.

- **Medium Term RDF Contracts**: Some authorities have medium-term (c. 10 years) contracts with counterparties that have an equivalent term agreement for RDF export. The counterparties in such arrangements may be established UK waste companies or perhaps smaller regional operators. There are few, if any, UK examples of councils contracting directly with RDF off-takers (i.e. the operators of continental EfW facilities). The risks to authorities may include:
  - The immediate counterparty, especially if not an established UK operator, may have limited ability to ride market changes even where they are not directly related to the contractual arrangement with the council. For example, if a regional operator

with a long-term RDF contract also has landfill interests, the impact of the landfill ban on those landfill interests may affect the overall viability of the operator.

- The robustness of medium-term RDF contracts (bearing in mind local authorities will typically be once removed from the off-taker via an intermediary operator and/or trader) has not to date been tested. Currently, the RDF off-take market is effectively full with increasing pressure on the capacity available to the UK as overseas domestic inputs increase. Local authorities relying on such agreements may have quite limited penalty, contingency, bond and / or guarantee benefits in the event of contract default with perhaps 6 to 12 months of 'cover' being in place. It is very unlikely indeed that authorities will be able to rely upon any form of 'step-in' rights to give them continued access to off-taker facilities in the event of contractual default. Even if counterparties do not tactically avoid contractual commitments due to improved commercial opportunities elsewhere, any stress on these medium-term contractual supply chains could rapidly place operational risk with authorities.

- **Short Term Contracts**: Some councils have contracts with operators for 2-3 years for either landfill or RDF export. The risks to authorities are:

  - Short-term RDF export contracts will, by definition, be subject to renewal against market conditions. Currently, and for the immediately foreseeable future, export capacity is constrained with contract renewal most likely to result in upwards pressure on price – assuming a contract can be secured.
  - Short-term landfill contracts will be vulnerable to the direct effects of the landfill ban. Even if there are 'change of law' provisions in such contracts, the likelihood is that such provisions will place the risk on the authority. In any event, it is hard to envisage how a council would be able to require an operator to honour its obligations under a short-term landfill contract once the landfill ban is in place.

Financial Modelling

In order to understand the financial costs associated with each option to both Scottish local authorities and the Scottish C&I sector, financial modelling was undertaken to determine the likely marginal costs for each option under each scenario.

Methodology

Modelling Approach

To assess the financial impact of the landfill ban in respect of residual waste, the costs for household and private collected waste at an authority level have been

modelled against the baseline (i.e. where all material goes to the current, or currently planned, treatment/disposal solution).

All of the costs in the financial modelling have been presented in nominal terms and include taxation. The costs considered are the gate fee for the treatment or disposal of material and the transfer and haulage costs to the point of disposal or treatment. The following section details the assumptions used when modelling the financial costs of the landfill ban.

Option Assumptions

In both options, it has been assumed that Scottish thermal and other residual treatment plants fully utilise local authority feedstocks. C&I waste is only assumed to be a feedstock where there is additional capacity, beyond that required for local authority household waste, in remote locations where other councils are unlikely to send waste.

Option 1 Assumptions

In this option, no further thermal treatment capacity is developed beyond what is currently operational, under construction, or reaching financial close. All residual waste not served by treatment capacity expected to be developed by 2025/26 will be exported to English thermal treatment/landfill or as RDF to Europe.

The total amount of waste requiring treatment outside of Scotland for the 14 years of the modelled period (from 2021 to 2035) is:

- Scenario 1 – 5.6 million tonnes; and
- Scenario 2 – 16.2 million tonnes.

The modelling relies on the ranking given to local authorities, explained above. In both scenarios, we have made assumptions about the solution most likely to be adopted by each rank 2, 3 and 4 authority – those that will not have thermal treatment in place by 2021 and so have an uncertain position in the short term, the long term, or both. Initially, these authorities produce some 538k tonnes of residual waste per year.

Authorities closest to port facilities in Edinburgh or Aberdeen are assumed to make use of European export markets whereas authorities close to the border were assumed to export to English capacity.[9] In both scenarios, C&I waste generation from Northern Scotland and around Edinburgh are assumed to be exported as RDF, while waste generated near the border is exported to England.

[9] It is outside the scope of this work to determine the likelihood of export to English landfill or English thermal treatment facilities. English landfill has therefor been assumed as a ‘worst case’ scenario for the purposes of modelling.

Option 2 Assumptions

For scenario 1, it is assumed that sufficient treatment capacity is developed to treat the 87,000 tonnes of residual waste per annum anticipated to arise when all targets have been met in 2035. In scenario 2 it is assumed that 1.146 million tonnes per annum of treatment capacity will be required. It is assumed that this additional capacity will come online in 2025/26.

In order to model the logistics and potential transport costs associated with this option, a high-level assessment was undertaken to determine potential locations for the development of additional thermal treatment infrastructure within Scotland. This was informed by the location of:

- existing/under development/committed thermal treatment;
- local authorities that do not currently have solutions in place to address the ban (rank 2 3, and 4 authorities); and
- major population centres.

For scenario 1, it is assumed that one additional treatment facility would be located in central Scotland.

For scenario 2, it is assumed that two additional treatment facilities would be located in Central Scotland with a third located in Northern Scotland.

In both scenarios, where no specific information is available, assumptions have been made regarding the interim solutions adopted by rank 2, 3 and 4 authorities until sufficient additional capacity is available. Authorities closest to Edinburgh or Aberdeen were assumed to make use of European export markets whereas authorities closest to the border were assumed to export to England[10].

It is assumed that waste is hauled to the nearest facility, with haulage costs and associated impacts modelled accordingly.

For both scenarios, it is assumed that Scotland continues to have access to at least the amount of overseas treatment capacity that it currently makes use of. This is consistent with other scenarios, and reflects the overseas treatment capacity already secured by Scottish waste collectors. However, RDF exports may increase above that level as a result of the policy, resulting in additional capacity needing to be secured to treat Scottish waste.

Gate Fee Assumptions

Wherever possible, gate fees have been based on information provided through local authority and commercial waste sector interviews. However, concerns

[10] It is outside the scope of this work to determine the likelihood of export to English landfill or English thermal treatment facilities. English landfill has therefor been assumed as a ‘worst case’ scenario for the purposes of modelling.

regarding commercial confidentiality limited the extent to which interviewees were willing to supply this information.

It is expected that the ban will result in initial disruption to the market. In the current market, the need to compete with landfill helps limit the gate fees of waste treatment and export. The ban will effectively remove this restriction; instead, English landfill costs (inclusive of haulage) are likely to act as the market restriction post-2021. This is likely to allow an increase in gate fees for other treatment routes, whether RDF exports to Europe or treatment capacity in England. After an initial peak, prices are expected to level out over the medium-long term due to a rebalancing in the market and increased competition. Gate fee assumptions are provided in more detail in Appendix 5.

For options involving thermal treatment development, it is assumed that the capital development costs are covered though PPP arrangements and reflected within the gate fee.

Transport Costs Assumptions

Based on 2018 figures, Table 6 sets out the haulage costs that have been assumed. Only road and ship haulage has been considered within the scope of this work as the availability of rail networks accessible to waste infrastructure is unknown. Rail haulage may be feasible and cost effective where an authority's transfer infrastructure and subsequent facility offloading infrastructure is located sufficiently near to rail heads/sidings. Unless this requisite infrastructure is already in place, establishing it would only be viable in the context of a medium-long term contract. Even in favourable circumstances, rail is only likely to be competitive with road haulage over relatively long distances.

Table 6: Transport Cost Assumptions (2018)

Transport Type	Assumptions (/t/mi)	Source
Road	£0.15	Eunomia R&C industry knowledge
Ship	£0.55	Eunomia R&C industry knowledge
Road & Ship	£0.28	Assumed 1/3 ship transport and 2/3 road transport for 'Island'

Results

The following sections present the marginal cost modelling for each option under each scenario. The analysis looks only at the costs of residual waste treatment and does not account for any costs/savings associated with any increase in recycling performance.

Household Waste

Figure 7 shows the marginal costs for household waste in cash terms under a recycling rate-compliant scenario. Figure 8 shows marginal costs in cash terms for household waste under a business as usual scenario.

The bar graphs show the marginal per tonne costs based on an authority's 'state of readiness' rank as categorised above. The line graphs show the overall marginal costs to Scotland for household waste.

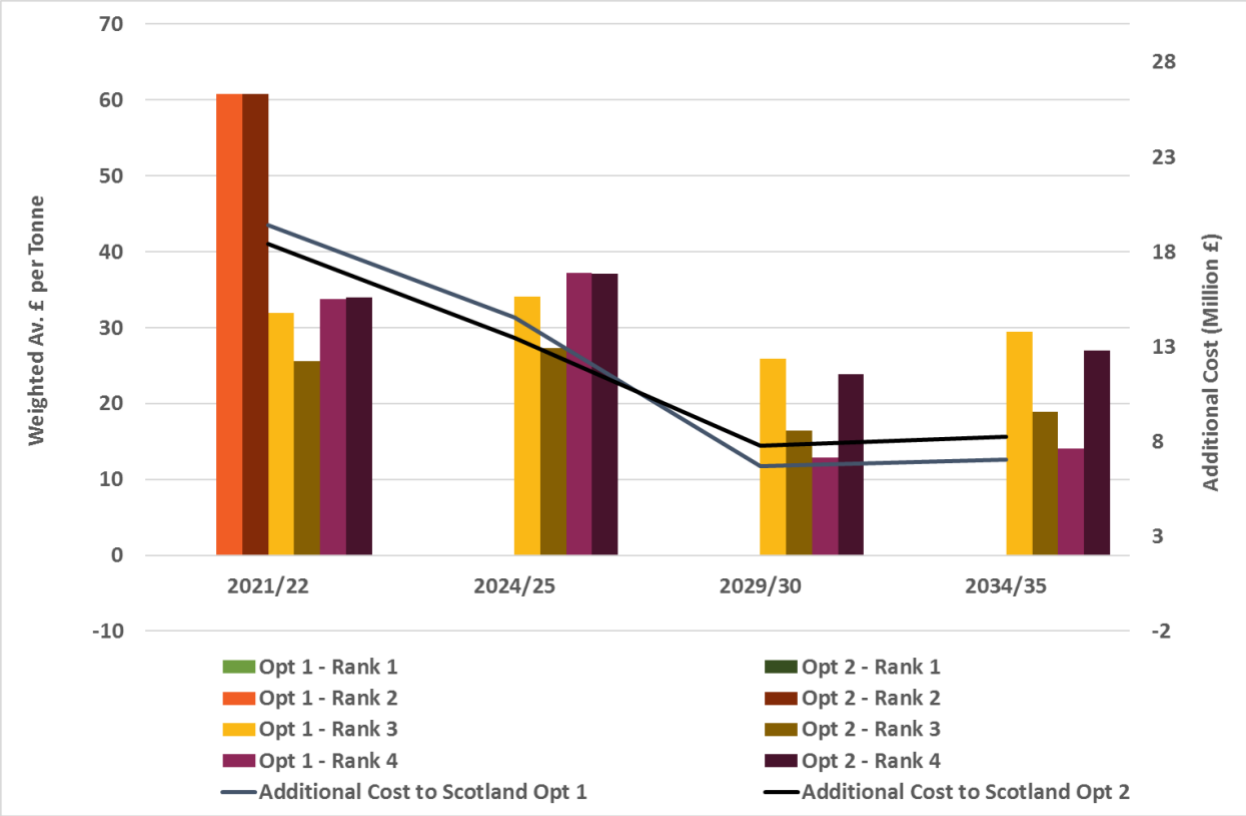
In both scenarios, both options result in a significant increase in overall cash costs of managing household residual waste compared with the price of landfill. The overall marginal costs are likely to be lower where additional thermal treatment capacity is developed in the short-medium term; however, as the market levels following an initial shock, the option to export becomes more favourable as a result of RDF export gate fees becoming more competitive.

In both scenarios, for rank 1 authorities, there will be no impact on marginal costs per tonne as a result of the landfill ban policy as they have already secured contracts. However, for authorities that have not yet secured contracts, the landfill ban policy is likely to have a significant impact upon marginal costs per tonne.

- Rank 2 authorities see the highest short-term marginal cost. This is because the authorities in this rank currently rely on landfill and will need to go to the market to secure very short-term export contracts just as the ban takes effect. Because of their northerly location, they are unlikely to be able to leverage alternative options to secure low gate fees, and so are likely to face relatively high-cost interim contracts. However, as they are already committed to long term thermal treatment contracts, the landfill ban policy will not impact their marginal cost per tonne once their treatment infrastructure comes online.
- In the short term, the cost increases for rank 3 and 4 authorities that don't have a long-term solution in place are likely to be lower than those for rank 2 authorities, due to their geographical location and their ability to go to the market at a more favourable time. In the medium- and long-term, these authorities will experience additional costs as a result of the policy, although these will be lower than those initially visited on rank 2 authorities, as the export market is expected to gradually re-balance.

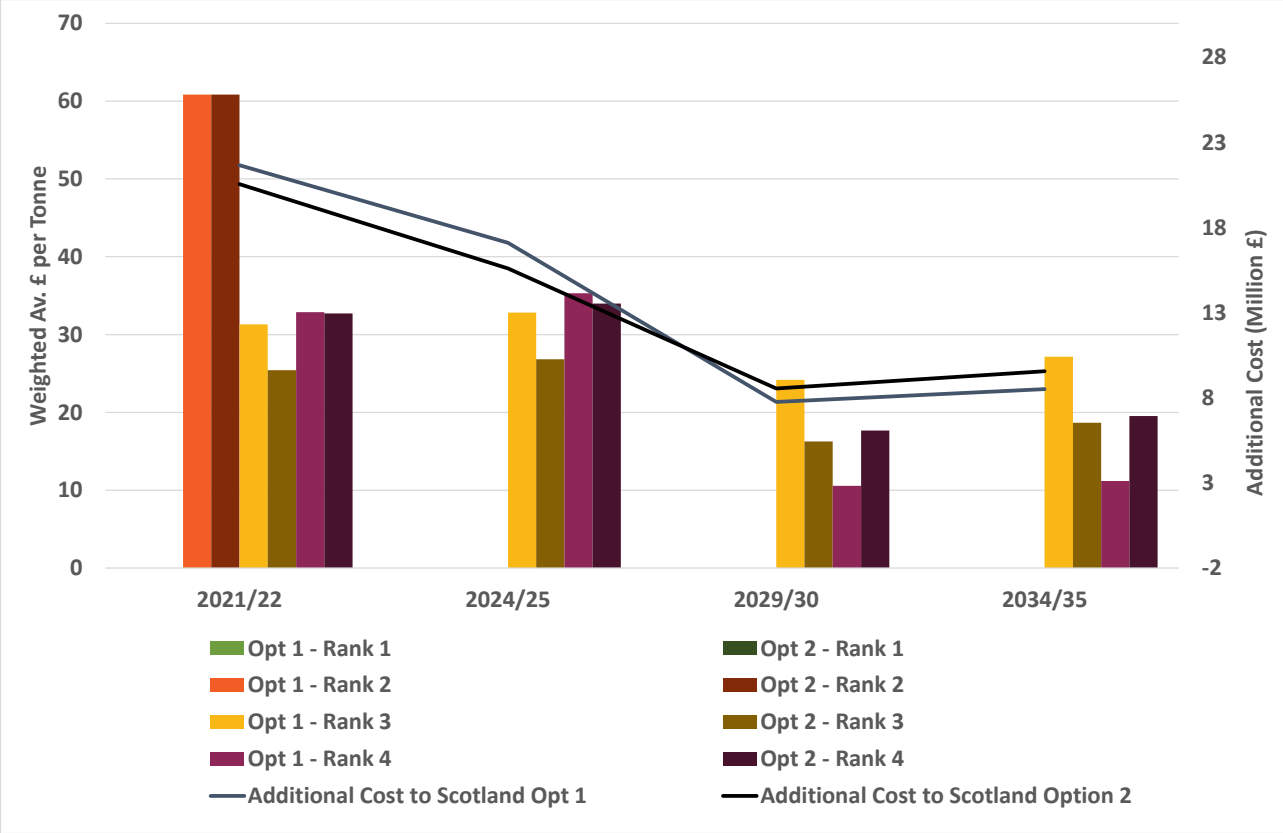
In both scenarios, for most authorities, if Scotland builds additional thermal treatment capacity it will result in a slightly smaller increase in marginal cost per tonne than export options in the short and medium-term. The short-term savings result from councils being less likely to need to invest in additional waste transfer and processing facilities if they plan to make use of domestic facilities, an investment that would be required if they propose to make long-term use of export options. However, as the market stabilises, the option to export will become more favourable.

Figure 7: Scenario 1: Recycling Policy Compliant - Marginal Costs for Household Waste



In both scenarios, the marginal cost per tonne is likely to be slightly higher for rural authorities, and significantly higher for island authorities. This is primarily due to the effect of transport costs.

Figure 8: Scenario 2: Business as Usual - Marginal Costs for Household Waste



Commercial & Industrial Waste

Figure 9 shows the marginal cost for the C&I waste sector under a recycling rate-compliant scenario. Figure 10 shows the marginal costs for the C&I waste sector under a business as usual scenario.

In both scenarios, the overall marginal costs to the Scottish C&I market are likely to significantly increase at the point at which the ban comes in. There is a decreasing overall marginal cost trend up to 2030 in both scenarios as the market starts to level and, in scenario 1, recycling rates increase. However, in option 2 where additional Scottish thermal treatment capacity is developed, lower overall marginal costs will likely be experienced by the sector as treatment infrastructure capacity becomes available at more competitive gate fees than export markets. This presumes that additional capacity has a downward influence on gate fees in the areas of Scotland that it would be likely to serve, but also relates to the fact that new Scottish thermal treatment facilities would presumably be procured by Scottish local authorities. Through such procurement processes it should be possible to secure lower gate fees in return for long term waste supply. This effect is more pronounced in scenario 2 as a result of the greater quantity of waste requiring treatment.

Unsurprisingly, in both scenarios, the marginal cost per tonne is likely to be slightly higher for rural C&I waste, and significantly higher for waste arising on islands, than for urban providers. This is primarily due to the effect of transport costs.

In both scenarios, for rural and urban C&I markets, the marginal costs per tonne are expected to decrease in comparison to the baseline for option 2 as Scottish thermal treatment capacity comes online and the market is able to secure favourable gate fees in comparison to export options. This effect is not seen in the islands markets, as no new capacity is assumed to be brought on stream in these areas.

Figure 9: Scenario 1: Recycling Policy Compliant – Marginal Costs for C&I Waste

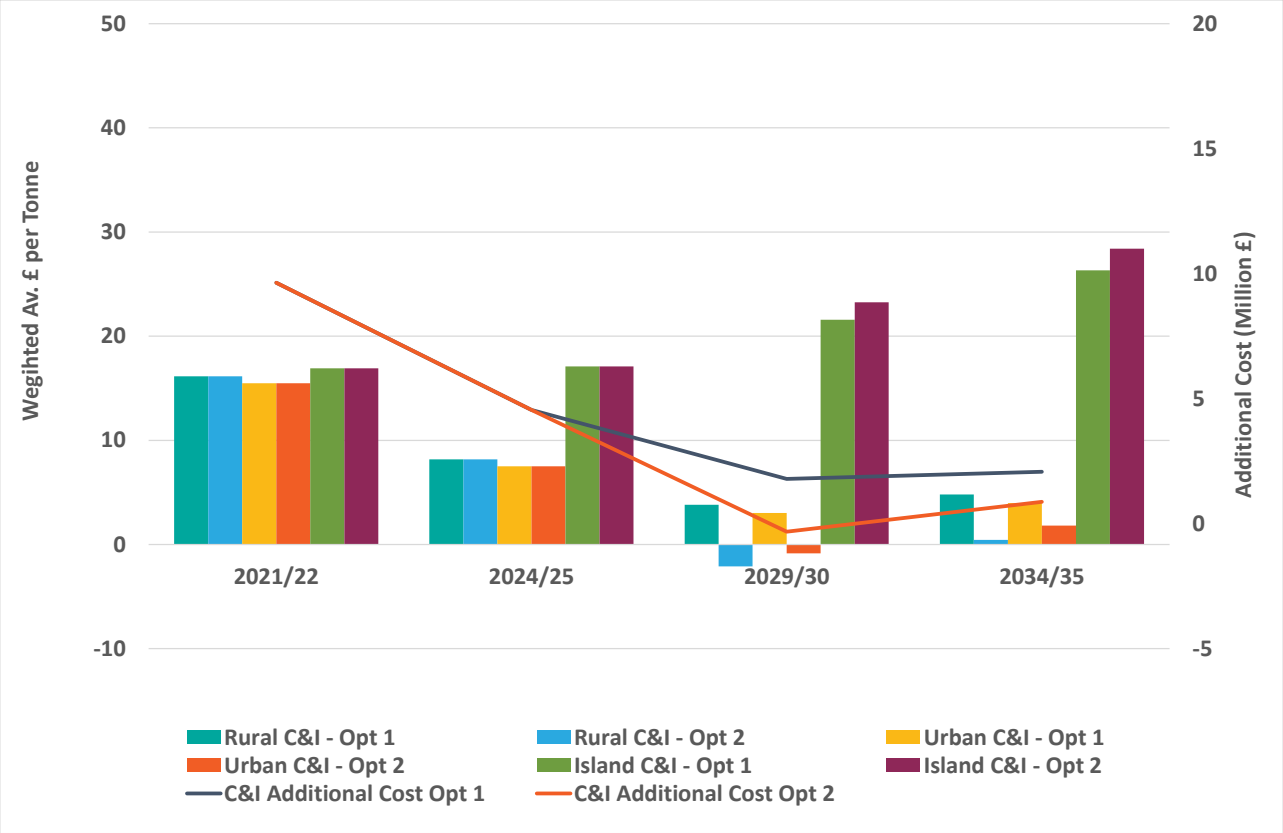
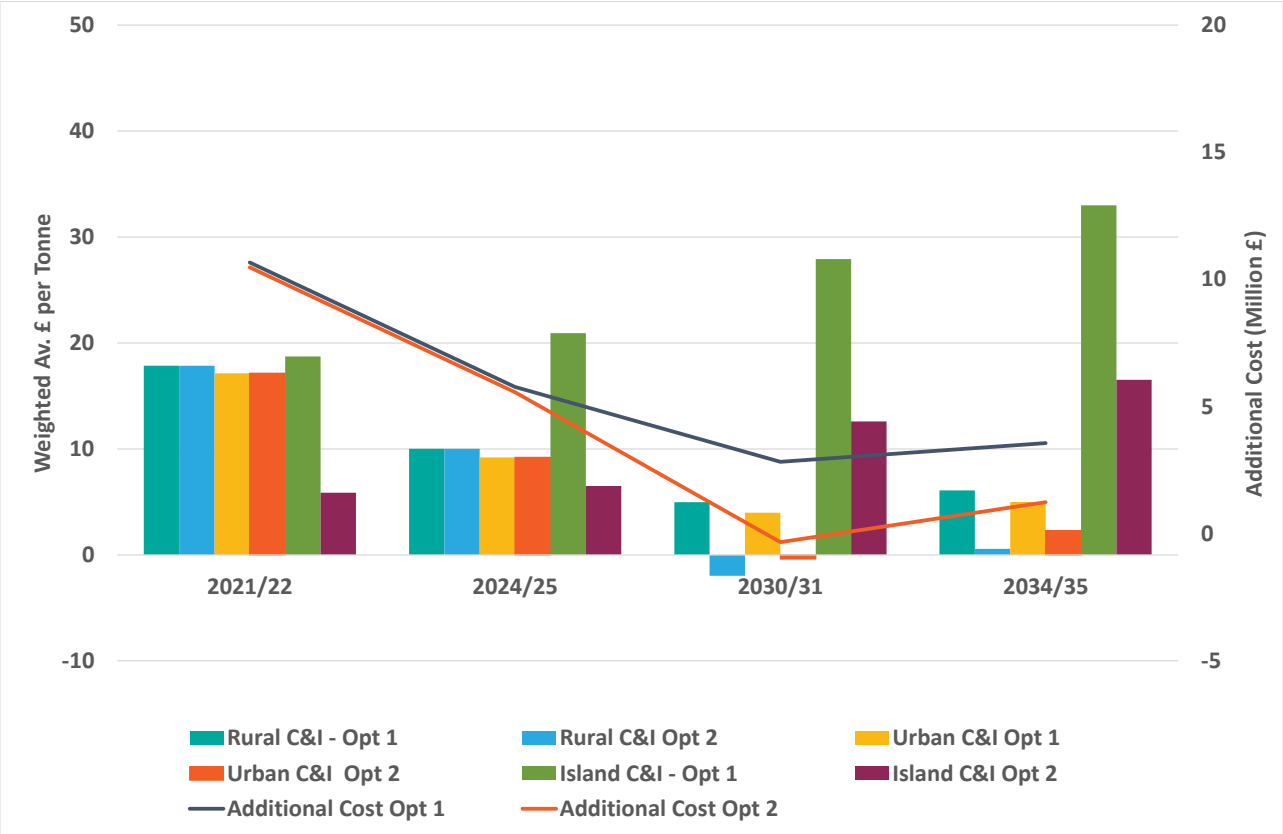


Figure 10: Scenario 2: Business as Usual - Marginal Costs for C&I Waste



The additional costs may create issues for some private operators that have a relatively marginal business, especially if they are subject to competition from larger, vertically integrated collectors that are better protected from landfill closure. In the event that the landfill ban makes it unviable for some private sector collectors to collect commercial waste, the market may be affected.

- In some areas, the number of different collectors may decrease. Additional costs and reduced competition may mean that prices for customers increase.
- Some customers may need to change contractor.
- Local authorities that collect C&I waste may see an increase in customers; but those that do not currently collect it may find themselves called upon to take a more active role in fulfilling their duty to arrange for commercial waste collections in their area if requested to do so.

Economic Modelling

An economic impact assessment has been developed to assess the impacts of the landfill ban on residual waste over 10 years from its implementation in 2021, in accordance with the Treasury's Green Book guidance. The impact assessment takes into account the economic costs (presented as negative numbers) and benefits (presented as positive numbers) of the market and non-market impacts associated with the proposed alternative treatment options (as described in the

Financial modelling section). These options are both compared to a common baseline where no landfill ban is introduced.

Methodology

Modelling Approach

All figures presented in the economic modelling are presented in real terms (2017 prices). The geographical remit is limited, so far as practicable, to Scotland. Accordingly, in scenarios where waste is treated beyond this geographical boundary only the impact of waste treatment in Scotland is considered. Transport emissions that occur within the UK are attributed to Scotland. The costs and benefits are delineated according to Standard Industrial Codes in alignment with the Input Output framework used by Scottish Government. The categories of economic actors used are:

- Public authorities (local authority collected waste);
- Waste collectors (private collected waste);
- Waste brokers;
- Hauliers;
- Exporters;
- Treatment/landfill providers in Scotland.

The modelling does not seek to account separately for the capital costs and capital value of the key assets that might be developed under each scenario – principally EfW facilities and (to a far lesser degree) transfer and pre-treatment facilities. In each case, we have sought to address these capital costs through the gate fees that are charged, rather than accounting for them separately. This is because capital costs vary significantly depending on the source, and may be incurred either by public or private bodies making them difficult to attribute for modelling purposes. Amortisation of capital can also be made difficult by variations in the projected lifespan of facilities and the potential for them to be refurbished to extend their working lives.

To provide an indication of the capital costs, prior work by Eunomia has found an approximate average cost for an incinerator of less than 200,000tpa to be in the range of £750-850 per tonne of capacity, with prices falling below £650 per tonne of capacity for much larger facilities. Two recent Scottish data points suggest prices may be somewhat higher at present in Scotland:

- The Edinburgh incinerator is expected to cost £142m and have a capacity of 155,000tpa, a cost of £916 per tonne of annual capacity.[11]

[11] https://waste-management-world.com/a/halfway-mark-for-construction-of-142m-waste-to-energy-plant-in-edinburgh

- The planned Grangemouth incinerator, projected to cost £210m to build, would have a capacity of around 216,000tpa, a cost of £972 per tonne of annual capacity.[12]

Even assuming these higher costs, and that the full cost would be capitalised, projected gate fees in the late 2020s exceed £120 per tonne, meaning that the great majority of the cost of capital for any new facilities would be recouped within the timeframe examined in the study. Capital considerations have therefore been excluded from the modelling.

Beyond impacts falling on specific economic actors, there are also impacts that are not valued in markets ('non-market impacts'), but have an impact on society as a whole. For waste management, these tend to relate to environmental impacts such as greenhouse gas emissions and air pollution. These include methane emissions from biogenic carbon resulting from the disposal of residual waste to landfill or emissions of CO_2 and nitrogen oxides (NOx) as a result of incinerating waste within Scotland or of transporting material by road within the UK (see Table 7).Transport emissions within England are likely to be small, and sensitive to assumptions regarding where in Northern England waste is treated; we have not therefore sought to separate these impacts from those in Scotland. Where possible, we have sought to monetise environmental impacts so that they can be taken into account.

This modelling takes account of treatment emissions that occur within Scotland, in line with the economic actors analysis; thus, options in which material is exported for treatment may look environmentally favourable. To understand the impacts of material disposal and transport outside Scotland's boundary, an estimate has been calculated for illustrative purposes. For the analysis it has been assumed that the material is shipped to either the Netherlands, Denmark or Sweden. This analysis also excludes the impacts of particulate matter emissions from road transport.

Table 7: Environmental Assessment Assumptions (Tonnes of Emissions per Tonne of Waste)

Treatment Type	Carbon (CO_2 eq	NOx
Landfill	0.31	N/A
Thermal Treatment (UK)	0.28	0.001
Thermal Treatment (Europe)	0.13*	0.001
Road Transport (kg per litre)	N/A	0.019
Boat Transport (per km)	0.03	N/A

Notes: Assumptions based on prior Eunomia modelling in which assumptions regarding waste compositions and the performance of facilities have been combined to produce emissions estimates.
*Assumed median value across incineration in Denmark, Netherlands and Sweden.

[12] https://www.heraldscotland.com/business_hq/17306576.new-grangemouth-incinerator-will-prevent-landfilling-a-fifth-of-scotlands-annual-waste/

The model uses assumptions regarding equivalent CO_2 and NOx emissions per tonne of material disposed/treated that are derived from previous Eunomia environmental modelling that is relevant to the position in Scotland. Estimating the net carbon emissions from landfill and thermal treatment can be complex, and depends on assumptions regarding factors such as:

- Residual waste composition, including carbon content and the proportion of the waste that is biogenic;
- Landfill gas capture rates and how captured gas is used;
- The rate at which material degrades in landfill;
- The efficiency of the incinerator engine;
- The carbon intensity of any electricity and/or heat generation requirement that is displaced by energy from waste.

Account has been taken of these factors in preparing the emissions estimates. A range of defensible estimates is possible depending on the assumptions made, but the ongoing decarbonisation of the electricity grid is gradually eroding the environmental benefit provided by EfW.

The equivalent tonnes of CO_2 emissions and NOx emissions are monetised using BEIS updated short-term traded carbon values[13] and a NOx damage cost of £9,094/tonne (Defra Air Quality Economic Analysis, 2015 prices inflated to 2017 prices).[14]

The economic assessment excludes taxation, which is regarded as a transfer between economic actors rather than a cost. For this policy this is a particularly important consideration as it excludes the impact associated with landfill tax, which currently stands at £88.95 per tonne (standard rate). Other taxes, such as VAT and corporation tax, are also excluded. For private actors, it is assumed that 10 per cent of turnover is profitable and that the main rate of corporation tax is 19%, falling to 17% by April 2020. The corporation tax impact of the policy options is again excluded from consideration in the financial modelling.

No account has been taken of the impacts of the change to the amount of waste recycled which is outside the scope of this assessment. Since the recycling rate is modelled as a scenario rather than as a consequence of the landfill ban, it is a consistent factor between the options.

Baseline Development

The costs and benefits for the options considered in this economic assessment are measured against a common baseline. The baseline is, in effect, a prediction of

13 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/671191/Updated_short-term_traded_carbon_values_for_modelling_purposes.pdf

14 Reported results exclude biogenic carbon emissions.

how the waste sector will develop over a 10-year period in the absence of the landfill ban and in accordance with the recycling rates assumed within each scenario. This is used to compare the two options against one another.

For each authority area for household waste (collected by local authorities) and C&I waste (collected by waste collectors), a baseline was developed that estimates the costs that would be incurred throughout the supply chain under current and firmly planned treatment solutions. For example, authorities that currently landfill as a treatment solution are forecast to continue to use this solution.

As no data is available to identify the volume of C&I waste collected by public authorities, it has been assumed for the purposes of this modelling that all C&I waste is collected by private waste collectors.

Options Development

To assess the impacts in relation to the baseline, the next step was to define two options that apply in each scenario:

- Option 1 – no new treatment capacity is developed in Scotland; and
- Option 2 – additional thermal treatment capacity is developed to meet Scotland's longer-term needs.

For these options, changes in costs were calculated for each aspect of the value chain; from waste collection, treatment and disposal. The cost and benefits attributable to the following sectors have been attributed to the following actors:

- Public authorities (local authority collected waste);
- Waste collectors (private collected waste);
- Hauliers;
- Exporters;
- Treatment/landfill providers in Scotland.

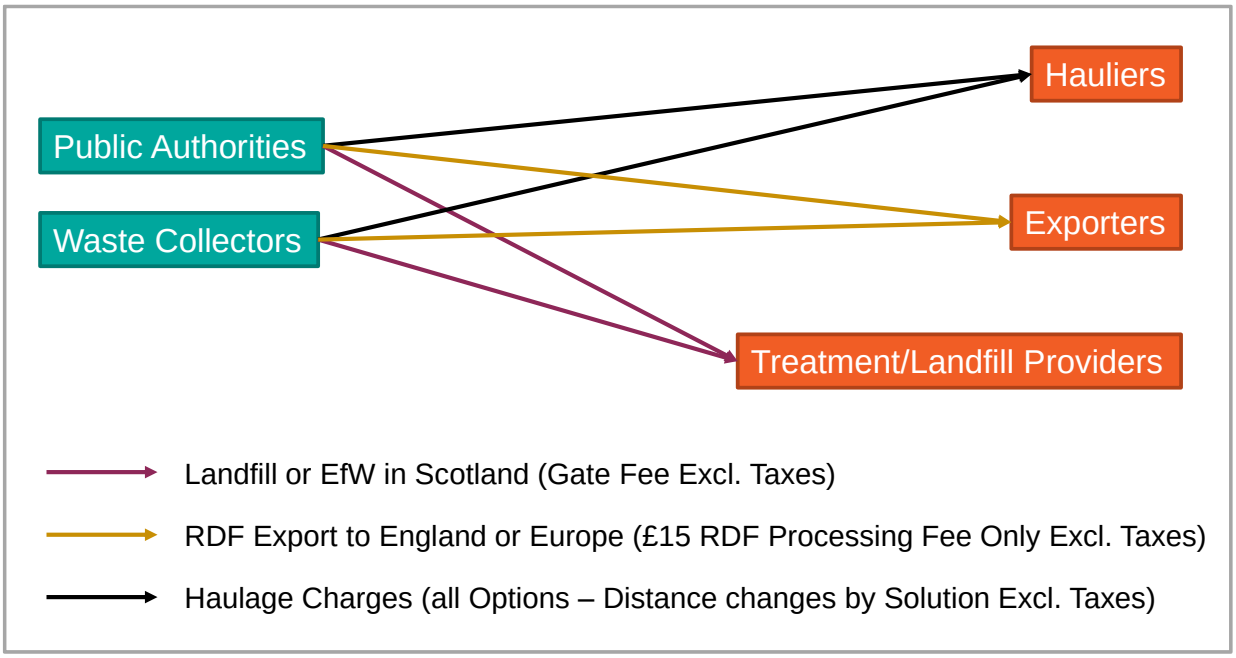
The economic impacts falling on these actors associated with the treatment of residual waste (irrespective of option) include:

- Public authorities (for household material) and waste collectors (for C&I material) incur costs for the haulage and treatment/disposal of residual waste;
- Hauliers receive the value of transport from the waste collectors and public authorities;
- If the material is being treated or disposed of in Scotland, the value paid by public authorities and waste collectors (excluding taxes) is transferred to the treatment/landfill providers; or

- If the material is being treated or disposed of outside of Scotland, an allowance of £15 (excluding taxes) is transferred to exporters with the remaining value paid by the authorities 'lost' to the Scottish economy.

Figure 11 illustrates how the distribution of economic impacts moves through the Scottish economy.

Figure 11: Waste Supply Chain Transfers



Calculation of the Impacts

The modelling analyses the impacts year-by-year at an authority level, looking separately at the changes in economic costs for the treatment of household and C&I waste. In general terms the key changes are:

- Changes in haulage and the associated economic impact;
- Changes in treatment gate fees and associated economic impacts; and
- Impacts on the environment associated with the changes above.

The outputs from this assessment have then been summed to provide a net figure for each year. The first ten annual net values are then discounted, using a social discount factor of 3.5%, and summed to give a Net Present Value (NPV). This method is in alignment with established economic impact assessment methodology.

Results

Table 8 and Table 9 show the results of the economic modelling for each scenario within Scotland. In both scenarios, both options result in an overall loss to the Scottish economy. This result derives principally from the increase in waste exports resulting from the landfill ban. Table 10 details the additional environmental impact

for waste exported for outside of Scotland for treatment compared to the baseline. Note that the figures in Table 10 are provided for information and are not included in the main economic costs in Tables 8 or 9 or in the Executive Summary.

In both scenarios, the total combined economic and environmental cost to Scotland is greater for option 1, where no further thermal treatment capacity is developed. In this option, a far greater quantity of waste is exported, with most of the value received by treatment providers outside of Scotland. Only the economic value of waste haulage and RDF processing remains of benefit to the Scottish economy. The costs in scenario 1 are lower throughout, but in both cases costs gradually decrease over time.

In option 2, there is an initial loss to the Scottish economy; however, as thermal treatment capacity comes online, principally in 2025, this loss subsides. After 2025, there is no longer an annual economic cost to Scotland each year, but the economic benefits achieved are not sufficient to outweigh the costs – in excess of £100m each year – incurred between 2021 and 2024. This change over time is shown in further detail in Appendix 6.

The combined total costs are greater in the 'business as usual' scenario (scenario 2) as a result of the higher tonnage of waste requiring treatment. This results in more waste being exported, and therefore a greater loss the Scottish economy. Somewhat counter-intuitively, the environmental results are greater in scenario 2 due to the higher volumes of waste diverted from the baseline landfill scenario. Similarly, the option to export waste seems to result in a more favourable environmental impact, primarily due to the fact that environmental impacts from treatment outside Scotland are not accounted for within the modelling. (The impact of these non-Scottish emissions (together with non-UK transport emissions), which are generally excluded from economic models of this type, are shown for information in Table 10). In reality, the environmental impacts of emissions associated with overseas treatment and (to a lesser extent) transport of waste outside the UK, would add to the impact of the policy. In all scenarios and options, environmental performance improves as 2030 approaches.

Table 8: Scenario 1 - Economic Costs Modelling (2021-2030)

Option		NPV (£m)
Option 1	Total Economic Costs	-984
	Total Environmental Costs	40
	Combined Total Cost	**-943**
Option 2	Total Economic Costs	-430
	Total Environmental Costs	16
	Combined Total Costs	**-414**

Note: figures may not sum to the totals due to rounding.

Table 9: Scenario 2 - Economic Costs Modelling (2021-2030)

Option		NPV (£m)
Option 1	Total Economic Costs	-1,213
	Total Environmental Costs	57
	Combined Total Cost	**-1,156**
Option 2	Total Economic Costs	-486
	Total Environmental Costs	37
	Combined Total Costs	**-449**

Note: figures may not sum to the totals due to rounding.

Table 10: Additional Environmental Impact Outside of Scotland

Scenario		Option 1 NPV (£m)	Option 2 NPV (£m)
Scenario 1	Landfill Emissions in England	-7	-5
	Incineration Emissions in Europe	-104	-86
	Transport to Europe	-6	-4
	Combined Additional Cost	**-116**	**-95**
Scenario 2	Landfill Emissions in England	-9	-7
	Incineration Emissions in Europe	-130	-106
	Transport to Europe	-7	-6
	Combined Additional Costs	**-146**	**-118**

Note: figures may not sum to the totals due to rounding.

Industry Impact

As shown in Table 11, for all options, local authorities and private waste collectors are likely to suffer a negative economic impact as a result of the ban, due to the additional waste management costs they incur. The policy is likely to result in waste being transported further than in the baseline, whether to Scottish facilities or those in England or on the continent. Hauliers and exporters are therefore likely to see most economic benefit from the ban. Treatment providers in Scotland also lose out initially as landfill receipts will decline before all thermal treatment infrastructure becomes operational. However, as capacity comes online, economic value is diverted back into the Scottish economy (and at a higher rate than the landfill gate fee minus landfill tax) rather than being lost via exports to Europe or England.

Table 11: Economic Impact on Industry Actors

Industry		NPV (£m)			
		Scenario 1: Option 1	**Scenario 1: Option 2**	**Scenario 2: Option 1**	**Scenario 2: Option 2**
Public Authorities		-853	-842	-1,132	-1,114
Waste Collectors		-770	-713	-953	-879
Haulage	Household	54	44	70	52
	C&I	34	21	41	24
Exporters	Household	46	43	58	51
	C&I	102	56	126	63
Scottish Treatment/Landfill Providers	Household	464	649	648	897
	C&I	-61	312	-71	420
TOTAL		**-984**	**-430**	**-1,213**	**-486**

Note: figures may not sum to the totals due to rounding.

Multiplier Effect

Changes in activity in particular areas of the economy can have wider effects, benefiting or damaging other sectors. Multipliers have been developed by the Scottish Government to estimate these wider effects. In this section we provide extracts of the Scottish Government's Input-Output tables that relate to the waste industry to illustrate the extent to which changes in this sector may impact upon the wider economy. The latest tables available were published in July 2018 and relate to the period 1998-2015[15].

The Scottish Government's website explains multiplier effects as follows:

"If there is an increase in final use for a particular industry output, we can assume that there will be an increase in the output of that industry, as producers react to meet the increased use; this is the direct effect. As these producers increase their output, there will also be an increase in use on their suppliers and so on down the supply chain; this is the indirect effect. As a result of the direct and indirect effects the level of household income throughout the economy will increase as a result of increased employment. A proportion of this increased income will be re-spent on

[15] Scottish Government (2018) Input Output Tables for Download, available here https://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output/Downloads

final goods and services: this is the induced effect. The ability to quantify these multiplier effects is important as it allows economic impact analyses to be carried out on the Scottish economy."

It was determined that the industries which would be affected by the ban were:

- Public Authorities;
- Waste Collectors;
- Brokers;
- Haulage;
- Exporters;
- Treatment/ Landfill Providers (based in Scotland only).

Analysis of Standard Industrial Classification (SIC) guidance[16] found that the code which covered the waste activities for these industries was SIC E38 'Waste collection, treatment and disposal activities; materials recovery'. Unfortunately, the Input-Output tables do not separate E38 from E39 (Remediation activities and other waste management services'). Whilst analysing these figures is still useful, it is important to bear in mind that they include a wider industry group than will likely be affected by the ban.

Table 12 provides extracts from the Scottish Input-Output tables for Type 1 and Type 2 Multipliers. The most useful figures shown in these tables are the 'output multipliers'. Type 1 multipliers relate to direct impacts, while Type 2 relates to indirect impacts.

[16] More information on Standard Industrial Classification can be found here: https://www.ons.gov.uk/methodology/classificationsandstandards/ukstandardindustrialclassificationofeconomicactivities/uksic2007

Table 12: Multiplier Effects

Multiplier Type	SIC	Industry Group	Output Multiplier	Rank	Income Effect	Rank	Employment Effect	Rank	GVA Effect	Rank	Income Multiplier	Rank	Employment Multiplier Rank		GVA Multiplier	Rank
Type 1 Multipliers	38 39	Waste, remediation & management	1.4	24	0.4	50	7.8	74	0.6	65	1.4	26	1.8	16	1.5	24
Type 2 Multipliers	38 39	Waste, remediation & management	1.6	25	0.5	50	9.8	71	0.7	61	1.6	26	2.2	13	1.9	22

The tables illustrate that the 'waste, remediation and management' industry group has an output multiplier of 1.4 for type one and an output multiplier of 1.6 for type two impacts. These are ranked highly at 24 and 25 out of 98 respectively suggesting impact upon other sectors is high. This demonstrates that events that affect this industry influence a wide range of other sectors and have a significant wider impact on the Scottish economy.

Within the economic modelling, costs are incurred by public bodies and waste collectors, but there is no increase in the use of their services. If option 2 is adopted, these additional expenditures result in an increase in demand for waste treatment in Scotland, which is met through the development of additional waste treatment facilities. The development of these facilities may give rise to multiplier effects. However, where waste is exported, the opportunity for these multiplier effects within the Scottish economy are lost.

Conclusions

When the ban takes effect in 2021, there will be insufficient treatment capacity available in Scotland to receive the material diverted from landfill. The scale of the capacity gap will be significantly influenced by the rate at which Scotland is able to meet recycling rate targets. It is therefore essential for alternative treatment and disposal routes to be found outside of Scotland, at least as a short-medium term solution. In the longer term, Scotland could reduce its reliance on exports by building additional residual waste treatment capacity.

The results of this work indicate that, under the two selected recycling scenarios, there is likely to be an initial shock to the market resulting in a short term gate fee increase for exports. This is likely to level out in the medium to long term.

The level of preparation for the effects of the ban vary considerably, both amongst local authorities and private waste collectors. However, a significant proportion of both do not yet have suitable alternative arrangements in place.

For those authorities and private contractors that have already secured solutions that will be operational at the point at which the ban comes into effect, financial investment has already been made and therefore there will be no impact upon marginal gate fees. For all other waste collection operators, the extent to which their costs per tonne increase (in cash terms) will largely be influenced by the timescales within which they need to seek a solution, with organisations that ride out the market until others have committed to new treatment facilities perhaps being exposed to lower costs than those whose existing commitments may result in them needing new interim contracts at an unfavourable time.

The ban will have a negative overall economic impact on the Scottish economy, as it will result in more waste being exported, which reduces economic activity in Scotland and would lead to a significant reduction in the revenue from Landfill Tax to the Scottish Government. It will also have some environmental impacts due to the additional haulage required for export solutions.

These impacts can be mitigated by building additional thermal treatment capacity necessary to provide a long-term solution, rather than relying upon export to either Europe or England, as this will retain more revenue in Scotland. However, the capacity of new thermal treatment facilities to be developed should be limited to that required once targets have been met to avoid creating excess capacity that will not be needed in the future.

It should be noted that this study focuses on the impact of the ban on the cost and benefits of the disposal of residual waste. The impact upon waste reduction, reuse and recycling is not considered. The likely substantial economic and environmental benefit that might be expected from the increase in reuse and recycling is therefore not reflected in these results.

APPENDICES

Appendix 1 – EWC Codes Included in the Ban

Table 13: EWC Codes Included in the Ban

EWC Code	Description
Separately Collected Fractions	
20 01 01	Paper and cardboard
20 01 08	Biodegradable kitchen and canteen waste
20 01 10	Clothes
20 01 11	Textiles
20 01 25	Edible oil and fat
20 01 26	Oil and fat other than those mentioned in 20 01 25
20 01 37	Wood containing dangerous substances
20 01 38	Wood other than that mentioned in 20 01 37
20 01 99	Wastes not specified otherwise
Garden and park Waste	
20 02 01	Biodegradable wastes
Other Municipal Waste	
20 03 01	Mixed municipal waste
20 03 02	Waste from markets
20 03 07	Bulky waste
20 03 99	Waste not specified otherwise
Wastes from Aerobic Treatment of Solid Wastes	
19 05 01	Non-composted fraction of municipal and similar wastes
19 05 03	Off-specification compost
Wastes from Anaerobic Treatment of Waste	
19 06 04	Digestate from anaerobic treatment of municipal waste
19 06 06	Digestate from anaerobic treatment of animal and vegetable waste
Wastes from the Mechanical Treatment of Waste (for example sorting, crushing, compactir	
19 12 01	Paper and cardboard

	19 12 06	Wood containing dangerous substances
	19 12 07	Wood other than that mentioned in 19 12 06
	19 12 08	textiles
	19 12 10	Combustible waste (RDF)
	19 12 11	Other wastes (including mixtures of materials) from mechanical treatment of waste containing dangerous substances
	19 12 12	Other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11
Packaging		
	15 01 01	Paper and cardboard packaging
	15 01 05	Composite packaging
	15 01 06	Mixed packaging
	15 01 09	Textile packaging

Appendix 2 – England Landfill Analysis

Eunomia carried out an analysis of the availability of landfill in England to meet potential additional demand from Scotland following the landfill ban.

Landfill site return data was obtained through a Freedom of Information request to the Environment Agency in October 2018. Data on the remaining volume of landfill capacity at the end of 2017 was also obtained.

Only landfill sites in the North West and North East regions of England were considered logistically feasible disposal routes for Scottish waste – although sites closer to the border are likely to be more attractive from the point of view of haulage costs. Landfill sites for which no data had been received within the last three years and/or with no remaining void space were assumed to be non-operational. Inert and hazardous landfill sites were removed as these sites are unlikely to be suitable disposal routes for residual waste.

Figure 12 shows a total of 30 landfill sites identified as meeting the criteria listed above. Using the Environment Agency's assumed bulk density for non-hazardous waste of 0.83t/m3[17], the volume of remaining landfill capacity volume was converted into a tonnage capacity estimate. This suggests a total remaining landfill capacity of 22.5 million tonnes in Northern England at the start of 2019.

The 'tonnes removed' figure was deducted from 'tonnes received' to derive assumptions regarding the quantity of waste currently being landfilled at each site. Table 14 shows the total amount landfilled across the sites was 2.9 million tonnes in 2015, decreasing to 2.2 million tonnes in 2016. This then increased to 3.9 million tonnes in 2017.

A detailed analysis of likely future demand for landfill for English waste would be very challenging. However, with limited thermal treatment capacity development under construction in this region, it is prudent to assume that for the time being this will remain relatively constant at an average of ~3 million tonnes based on 2015-17 site return figures.

Table 15 and Table 16 show the timescales within which the remaining capacity of Northern England landfill will be exceeded should Scotland utilise this disposal route within each modelled scenario. This suggests that:

- In scenario 1, where Scotland meets its waste reduction and recycling targets, landfill capacity in Northern England will be exceeded in late 2025.
- In scenario 2, capacity will likely be exceeded in late 2024.

[17] http://webarchive.nationalarchives.gov.uk/20140328141656/http://www.environment-agency.gov.uk/research/library/data/150328.aspx

Whist it is unlikely that English landfill will be a logistically and economically viable solution for all Scottish residual waste, there is clearly some capacity to provide an interim solution for waste arising close to the border. However, unless further landfill capacity is developed, this is unlikely to be a viable medium- to long-term solution for Scotland.

Table 14: N. England Landfill Sites

Operator	Site Name	Region	Assumed Landfilled 2015 (tonnes)	Assumed Landfilled 2016 (tonnes)	Assumed Landfilled 2017 (tonnes)	Remaining Capacity (m3)	Remaining Capacity (tonnes)
SITA (Lancashire) Limited	Clifton Marsh Landfill Site	Cumbria and Lancashire	78,224	140,494	2,148	1,869,346	1,551,557
SITA (Lancashire) Limited	Whinney Hill (Phase 2) Landfill Site	Cumbria and Lancashire	280,819	348,385	455,762	3,561,998	2,956,458
SITA (Lancashire) Limited	Jameson Road (Phase 2) Landfill Site	Cumbria and Lancashire	131,122	139,113	133,492	1,043,664	866,241
Lakeland Waste Management	Flusco Pike Landfill Site	Cumbria and Lancashire	57,604	45,649	49,640	884,621	734,235
Cumbria Waste Management Ltd	Hespin Wood Landfill Site	Cumbria and Lancashire	62,528	41,995	61,321	1,314,978	1,091,432
FCC Waste Services (UK) Limited	Bennett Bank Landfill	Cumbria and Lancashire	50,435	32,135	28,849	132,479	109,958
Keadby Generations Ltd	Fiddlers Ferry Ash Lagoons	Gtr Mancs Mersey and Ches	-18,263	-202,500	-229,322	1,911,645	1,586,665
3C Waste Limited	Maw Green Landfill Site	Gtr Mancs Mersey and Ches	99,711	105,813	133,005	224,902	186,669
Viridor Waste Management Ltd	Pilsworth South Landfill	Gtr Mancs Mersey and Ches	528,014	355,452	265,665	4,991,549	4,142,986
Biffa Waste Services Ltd	Houghton-Le-Spring Landfill	Northumberland Durham and Tees	254,310	312,254	345,392	341,431	283,388

Operator	Site Name	Region	Assumed Landfilled 2015 (tonnes)	Assumed Landfilled 2016 (tonnes)	Assumed Landfilled 2017 (tonnes)	Remaining Capacity (m3)	Remaining Capacity (tonnes)
Quercia Ltd	CLAYTON HALL LANDFILL SITE	Cumbria and Lancashire	26,922	19,204	57,574	659,956	547,763
Augean North Limited	Port Clarence Non-Hazardous Landfill Site	Northumberland Durham and Tees	85,975	176,995	203,432	632,950	525,349
3C Waste Limited	GOWY LANDFILL SITE	Gtr Mancs Mersey and Ches	180,360	208,949	365,902	1,017,108	844,200
Biffa Waste Services Ltd	RISLEY LANDFILL SITE	Gtr Mancs Mersey and Ches	110,855	39,340	40,865	0	0
Booth Ventures Limited	HARWOOD QUARRY LANDFILL SITE	Gtr Mancs Mersey and Ches	222,603	167,362	355,111	1,701,292	1,412,072
Augean North Limited	MARKS QUARRY LANDFILL SITE	Northumberland Durham and Tees	0	0	9,796	0	0
Cory Environmental (Central) Ltd	Lyme and Wood Pits Landfill	Gtr Mancs Mersey and Ches	261,426	-17	325,385	0	0
SITA UK Limited	Ellington Road Landfill Site	Northumberland Durham and Tees	1,497	-11,648	304,715	1,023,357	849,386
Alab Environmental Services Ltd	SEATON MEADOWS	Northumberland Durham and Tees	74,360	6,419	7,634	1,000,000	830,000
FCC Recycling (UK) Limited	Lillyhall Stage 3 Landfill Site	Cumbria and Lancashire	15,788	13,073	5,090	891,053	739,574
British Salt Ltd	Hilltop Farm Brinefields	Gtr Mancs Mersey and Ches	6,152	6,972	7,245	627,446	520,780

Operator	Site Name	Region	Assumed Landfilled 2015 (tonnes)	Assumed Landfilled 2016 (tonnes)	Assumed Landfilled 2017 (tonnes)	Remaining Capacity (m3)	Remaining Capacity (tonnes)
Churchill Enviro Ltd	Fletcher Bank Landfill Site	Gtr Mancs Mersey and Ches	0	0	148,997	3,000,000	2,490,000
Thompsons Of Prudhoe Limited	Springwell Quarry	Northumberland Durham and Tees	1,424	3,044	1,125	18,000	14,940
Woods Waste Limited	Westby Landfill Site	Cumbria and Lancashire	1,132	904	135	354,700	294,401
WRG Waste Services Ltd	Deerplay Landfill	Cumbria and Lancashire	0	0	48,658	1,490,898	1,237,445
Durham County Council	Joint Stocks Landfill Phase 2	Northumberland Durham and Tees	9,031	-3,279	288,596	1,700,000	1,411,000
Elementis Uk Ltd	Coatham Stob Quarry (Area 6)	Northumberland Durham and Tees	34	0	41	164,115	136,215
Highfield Environmental Limited	Cowpen Bewley Landfill Site	Northumberland Durham and Tees	0	0	145,299	1,374,099	1,140,502
Highfield Environmental Ltd	ICI No 2 Teesport	Northumberland Durham and Tees	0	-866	125,763	818,089	679,014
Octagon Green Solutions Limited	Blaydon Quarry Landfill Site	Northumberland Durham and Tees	446,685	329,459	241,094	1,788,700	1,484,621
TOTAL			**2,968,746**	**2,274,700**	**3,928,409**	**34,538,376**	**28,666,852**

Table 15: Northern England Landfill Capacity - Scenario 1

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Available Capacity (t)	28,666,852	25,609,567	22,552,282	19,494,997	16,437,712	12,408,222	8,537,538	4,826,533	1,217,337	-2,253,283	-5,695,642
Assumed English Landfill(t)	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285
Assumed Scottish Landfill(t)					972,204	813,399	653,720	551,911	413,335	385,073	356,650
Remaining (t)	25,609,567	22,552,282	19,494,997	16,437,712	12,408,222	8,537,538	4,826,533	1,217,337	-2,253,283	-5,695,642	-9,109,577

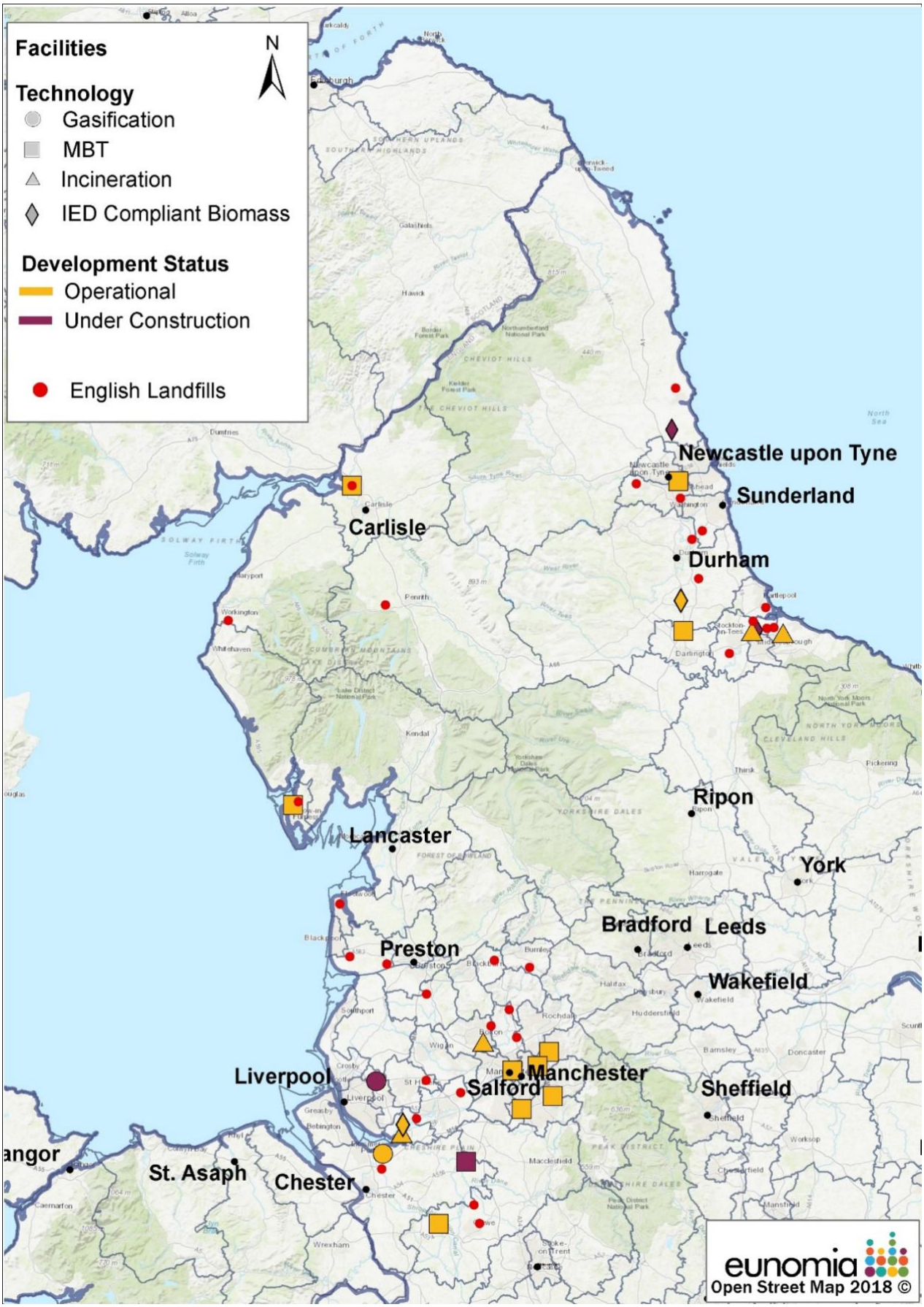
	2028	2029	2030	2031	2032	2033	2034	2035
Available Capacity (t)	-9,109,577	-12,494,951	-15,851,575	-19,179,246	-22,475,203	-25,739,294	-28,971,402	-32,171,410
Assumed English Landfill(t)	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285
Assumed Scottish Landfill(t)	328,090	299,339	270,386	238,672	206,806	174,823	142,723	110,543
Remaining (t)	-12,494,951	-15,851,575	-19,179,246	-22,475,203	-25,739,294	-28,971,402	-32,171,410	-35,339,238

Table 16: Northern England Landfill Capacity - Scenario 2

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Available Capacity (t)	28,666,852	25,609,567	22,552,282	19,494,997	16,437,712	12,125,433	7,857,572	3,633,649	-597,384	-4,827,018	-9,064,708
Assumed English Landfill(t)	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285
Assumed Scottish Landfill(t)					1,254,994	1,210,575	1,166,639	1,173,747	1,172,349	1,180,404	1,188,499
Remaining (t)	25,609,567	22,552,282	19,494,997	16,437,712	12,125,433	7,857,572	3,633,649	-597,384	-4,827,018	-9,064,708	-13,310,492

	2028	2029	2030	2031	2032	2033	2034	2035
Available Capacity (t)	-13,310,492	-17,564,411	-21,826,505	-26,096,817	-30,372,738	-34,654,362	-38,941,785	-43,235,103
Assumed English Landfill(t)	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285	3,057,285
Assumed Scottish Landfill(t)	1,196,634	1,204,810	1,213,027	1,218,635	1,224,339	1,230,138	1,236,033	1,242,023
Remaining (t)	-17,564,411	-21,826,505	-26,096,817	-30,372,738	-34,654,362	-38,941,785	-43,235,103	-47,534,411

Figure 12: N. England Treatment Facilities



Appendix 3 – European Market

This appendix presents an analysis of the supply and demand of thermal treatment capacity across 11 European states shown in Figure 13. Each of these countries is actively involved in trading RDF or Solid Recovered Fuel (SRF) with others within the group, and together they form a natural trading 'cluster'. Due to their geographical proximity in Northern Europe they are referred to here as the 'Northern Cluster'.

Figure 13: The Northern Cluster

The analysis below presents an estimate of the current and future residual waste treatment 'capacity gap' for the Northern Cluster. This relates to the tonnage of residual waste which is 'potentially available' to operators or developers of new treatment facilities relative to capacity estimates.

It should be noted that reporting methods vary across the Northern Cluster. Figures ought to be treated with caution, especially as regards comparison between Member States, because of varying data collection methods, the lack of recent data, and the complexity of waste-treatment streams. Applying different methodologies and assumptions to estimate waste quantities can have a significant impact on the results.

Figure 14 shows that, in all but three of the countries analysed, there is a current state of under capacity with demand outstripping supply. Sweden, Denmark, and the Netherlands already have more treatment capacity than residual waste, and receive imports of RDF from the UK. Some of the countries that have less capacity than waste are also recipients of UK waste exports (e.g. Germany, Norway). However, capacity within the Northern Cluster is for the most part already fully utilised at current levels of export.

Figure 14: Residual Waste Arisings and 'Effective' Treatment Capacity in Northern Cluster Countries

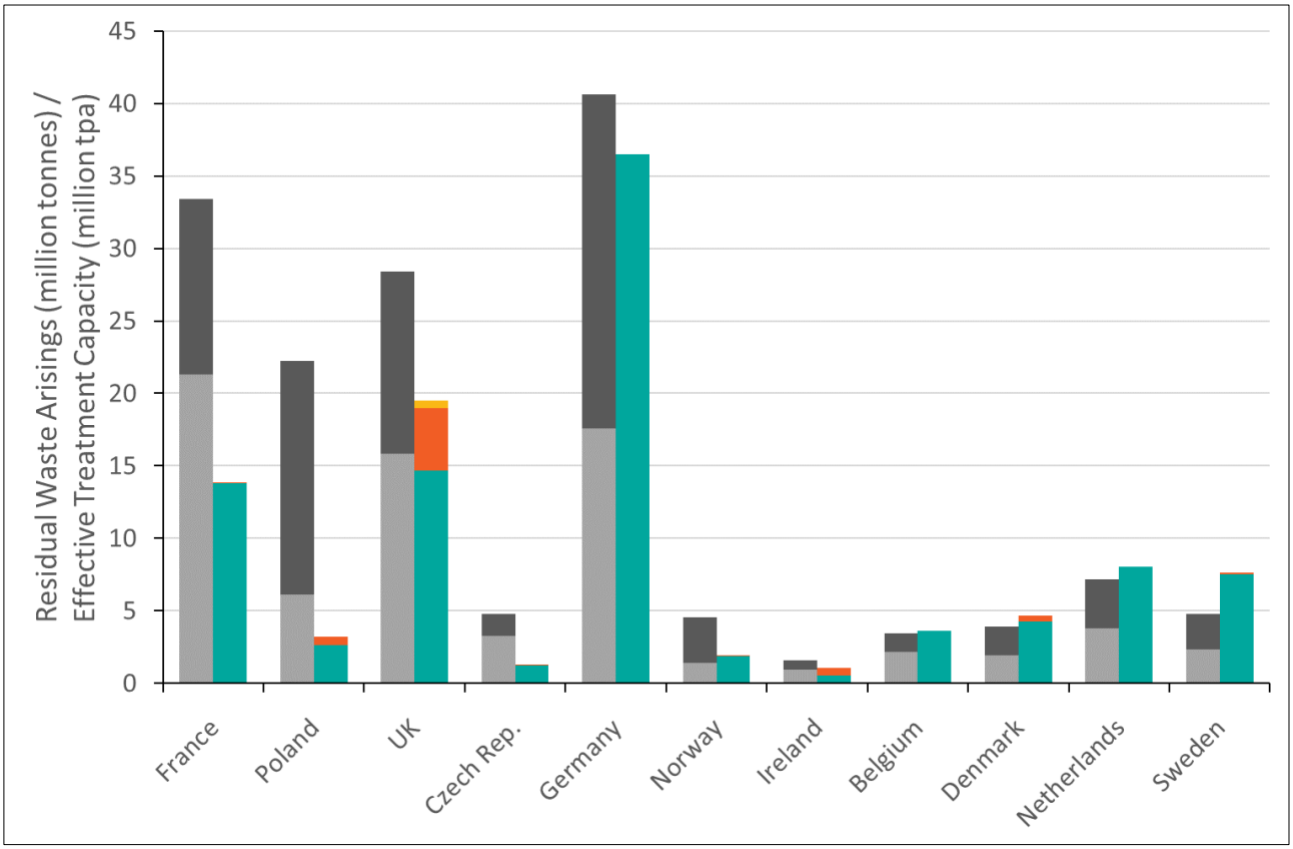
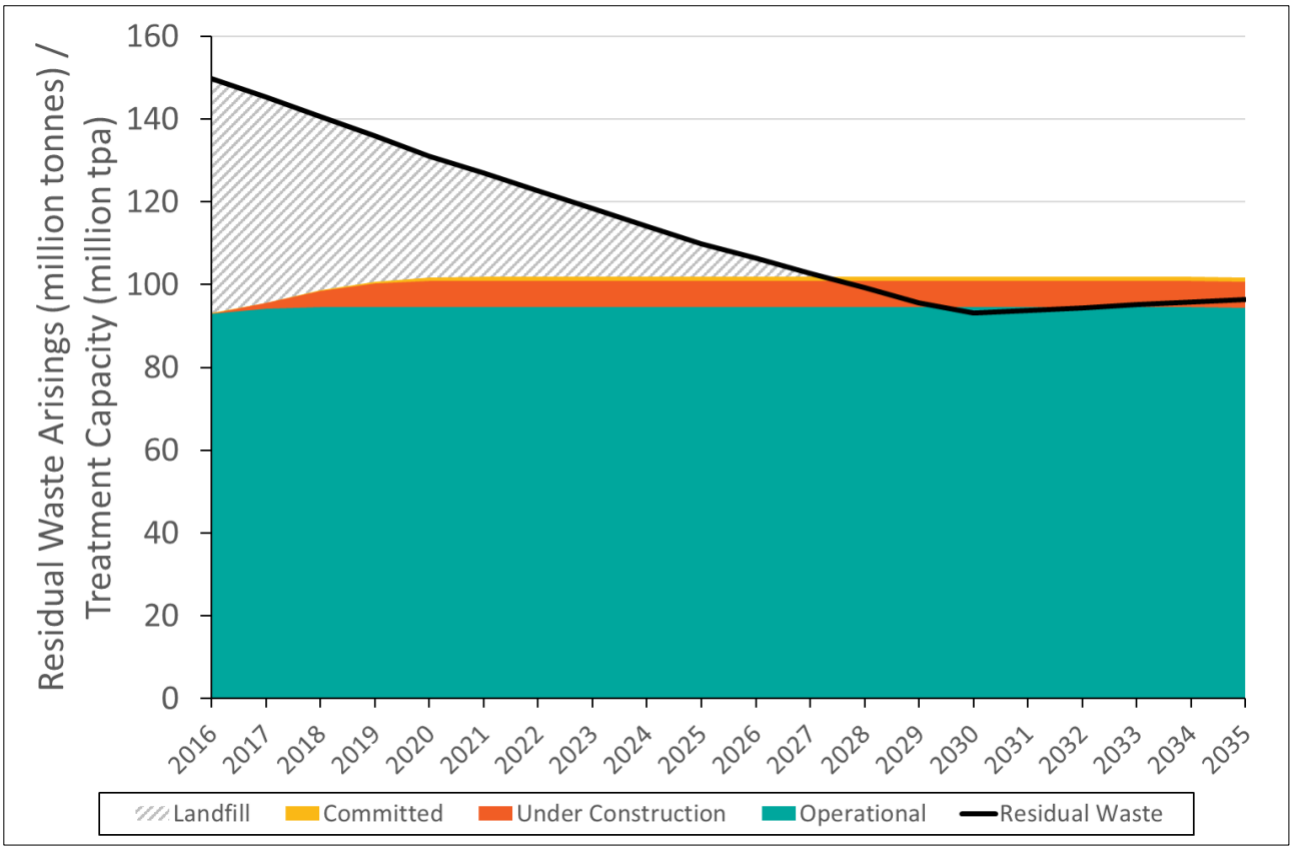


Figure 15 shows how the capacity gap is anticipated to change over time with changes in waste arisings and additional treatment infrastructure being developed. This indicates that the capacity gap will fall from the current level of 56.7 million tonnes to a situation of potential over-supply of capacity from 2028 onwards.

While there is relatively little capacity available in the market at present, as recycling rates rise during the 2020s it is anticipated that more may become spare. However, the timing in relation to the landfill ban may not be ideal, with capacity being available only at a relatively high price.

Figure 15: Potential Future Residual Waste Capacity Gap in Northern Cluster Countries (2016 to 2035)



Appendix 4 – Capacity Modelling Assumptions

This appendix provides the following:

- Table 17: Waste Flow Assumptions
- Details of how "Other" Arisings has been calculated
- Table 18: C&I Waste Affected by the Ban
- Details of how facility capacity has been adjust to account for recycling performance (CV Adjustment)

Table 17: Waste Flow Assumptions

	Scenario 1			Scenario 2		
	Hhld	**Commercial**	**Industrial**	**Hhld**	**Commercial**	**Industrial**
Total Arisings Growth Rate	Reduction of 15% by 2025 from 2011 levels			0.43%*	0.5%	-1.0%
Recycling Rate 2017/18	45.6%	54%	54%	45.6%	54%	54%
Recycling Rate 2025/26	60%	60%	60%	45.6%	54%	54%
Recycling Rate 2035/36	65%	65%	65%	45.6%	54%	54%
'Other' Rate 2017/18	-	7.3%	17.5%	-	7.3%	17.5%
'Other' Rate 2025/26	-	10%	13.5%	-	10%	13.5%
'Other' Rate 2035/36	-	10%	12.5%	-	10%	12.5%

Note: *based on annual projected population growth rates from National Records of Scotland.

Table 18: Coding for C&I Arising Calculations

Sector	Coding
Agriculture, forestry and fishing	Industrial
Mining and quarrying	Excluded
Manufacture of food and beverage products	Industrial
Manufacture of wood products	Industrial
Manufacture of chemicals, plastics and pharmaceuticals	Industrial
Other manufacturing †	Industrial
Power industry	Industrial
Water industry	Industrial
Waste management	Industrial
Commerce	Commercial

C&I Modelling Assumptions: Other Arisings and Affected by Ban

To calculate the percentage of material which is likely to be disposed of by alternative means to residual treatment ("Other"), the identified arisings for the material streams in Table 19 were compared to the total arisings in the commercial and industrial sectors.

Table 19 also details the material streams which have been assumed to be affected by the ban. It is assumed that in some cases these materials may be mixed in with the residual waste stream and therefore it is necessary to model the generation of all these wastes.

Table 19: Coding Assumptions for Business Waste

Material Stream	Waste Coded as "Other" or Assumed Affected by the Ban
Spent solvents	Assumed affected by ban
Acid, alkaline or saline wastes	Assumed affected by ban
Used oils	Assumed affected by ban
Chemical wastes	Assumed as "Other"
Industrial effluent sludges	Assumed as "Other"
Sludges and liquid wastes from waste treatment	Assumed as "Other"

Material Stream	Waste Coded as “Other” or Assumed Affected by the Ban
Health care and biological wastes	Assumed affected by ban
Metallic wastes, ferrous	Assumed affected by ban
Metallic wastes, non-ferrous	Assumed affected by ban
Metallic wastes, mixed ferrous and non-ferrous	Assumed affected by ban
Glass wastes	Assumed affected by ban
Paper and cardboard wastes	Assumed affected by ban
Rubber wastes	Assumed affected by ban
Plastic wastes	Assumed affected by ban
Wood wastes	Assumed affected by ban
Textile wastes	Assumed affected by ban
Waste containing PCB	Assumed affected by ban
Discarded equipment (excluding discarded vehicles, batteries and accumulators wastes)	Assumed affected by ban
Discarded vehicles	Assumed affected by ban
Batteries and accumulators wastes	Assumed affected by ban
Animal and mixed food waste	Assumed affected by ban
Vegetal wastes	Assumed affected by ban
Animal faeces, urine and manure	Assumed affected by ban
Household and similar wastes	Assumed affected by ban
Mixed and undifferentiated materials	Assumed affected by ban
Sorting residues	Assumed affected by ban
Common sludges	Assumed affected by ban
Mineral waste from construction and demolition	Assumed as “Other”
Other mineral wastes	Assumed as “Other”
Combustion wastes	Assumed affected by ban
Soils	Assumed as “Other”
Dredging spoils	Assumed as “Other”
Mineral wastes from waste treatment and stabilised wastes	Assumed as “Other”

Waste Export to England for Treatment

Table 20 sets out the volumes of Scottish waste assumed to be treated in English facilities in 2016/17 and 2017/18. This is based on information on site return data obtained from the Environment Agency for waste facilities and landfills within approximately one hour's drive time from the Scottish border. The key facilities receiving waste in these years were:

- Suez West Sleekburn Materials Recycling Facility;
- Suez Byker Reclamation Plant; and
- Suez Ellington Road.

Table 20: Scottish Residual Waste Exports to England Assumptions

Export to England	Tonnes
2016/17	17,464.44
2017/18	19,793.80

RDF Export Capacity

The capacity gap modelling includes figures for the current volume of residual waste exported from Scotland as RDF for treatment abroad. In the baseline it is assumed that this figure remains constant at the 2016/17 SEPA figure of 164,000 tonnes.

CV Adjustment for Scenario 1 (High Recycling)

As recycling performance improves under Scenario 1, it is anticipated that the CV of residual waste will reduce as the material composition changes. A recent residual waste composition for Scotland was not available, therefore to model the impact on CV change on the capacity of thermal treatment capacity, a baseline composition was developed based on current recycling rates for household and C&I waste. A future composition was then developed to reflect what the residual stream may look like as recycling targets are achieved (this is envisaged to contain less plastics, textiles etc.). It was assumed that the rate of change would be linear.

The baseline year for the modelling (2016/17) it is estimated residual waste would have a 9.82 CV, reducing to 8.30 CV by 2035/36. In 2016 it is assumed that the operational capacity (as detailed in the capacity modelling methodology) of the existing is utilised at 100%. As the CV reduces the capacity of the facilities increases, rising to 118% in 2035.

For this increase in capacity to occur in reality, treatment operators would need to increase the throughput of their facilities to maintain the level of power output which

is currently achieved. It is assumed this change would be driven by the operators to prevent any losses to income from the facility.

Appendix 5 – Financial Modelling Assumptions

This appendix sets out the following financial modelling assumptions:

- Table 21: Household Baseline Gate Fee Assumptions
- Table 22: Household Post 2021 Gate Fee Assumptions

Table 23: C&I Baseline Gate Fee Assumptions

Table 24: C&I Post 2021 Gate Fee Assumptions

- Table 25: Transfer Station Cost Assumptions

Table 21: Household Baseline Gate Fee Assumptions

	2018/19	2019/2020	2020/21	2021/22	2022/23 -
Inflation	3.7%	3.0%	2.9%	2.9%	3.0%
Landfill Gate Fee - Rural	£106.00	£109.18	£112.35	£115.60	£119.07
Landfill Gate Fee - Urban	£101.00	£104.03	£107.05	£110.15	£113.46
Landfill Gate Fee – Island	£94.00	£96.82	£99.63	£102.52	£105.59
RDF Export (incl. processing costs of £15 per tonne 2018/19)	£100.00	£103.00	£105.99	£109.06	£112.33
EfW	£103.00	£106.09	£109.17	£112.33	£115.70
Haulage per Tonne mile	£000.15	£0.15	£0.16	£0.16	£0.17

Table 22: Household Post 2021 Gate Fee Assumptions

	Readiness Ranking	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27
RDF Export*	1	£109.06	£112.33	£115.70	£119.17	£122.75	£126.43
RDF Export*	2	£109.06	£112.33	£115.70	£119.17	£122.75	£126.43
RDF Export*	3	£119.97	£121.26	£122.55	£123.85	£125.14	£126.43
RDF Export*	4	£119.97	£121.26	£122.55	£123.85	£125.14	£126.43
EfW in Scotland	1	£112.33	£115.70	£119.17	£122.75	£126.43	£130.22
EfW in Scotland	2	£119.97	£123.57	£127.27	£131.09	£135.02	£139.07
EfW in Scotland	3	£119.97	£123.57	£127.27	£131.09	£135.02	£139.07
EfW in Scotland	4	£119.97	£123.57	£127.27	£131.09	£135.02	£139.07
Export to England	1	£114.51	£117.95	£121.49	£125.13	£128.89	£132.75
Export to England	2	£114.51	£117.95	£121.49	£125.13	£128.89	£132.75
Export to England	3	£125.42	£126.89	£128.35	£129.82	£131.29	£132.75
Export to England	4	£125.42	£126.89	£128.35	£129.82	£131.29	£132.75
Haulage per tonne mile	Urban/ Rural	£0.16	£0.17	£0.17	£0.18	£0.18	£0.19
Haulage per tonne mile	Island	£0.31	£0.32	£0.33	£0.34	£0.35	£0.36

Notes: *RDF Gate fee includes processing costs of £15 per tonne 2018/19 (increased annually with inflation).

Table 23: C&I Baseline Gate Fee Assumptions

	2018/19	2019/2020	2020/21	2021/22	2022/23 -
Inflation	3.7%	3.0%	2.9%	2.9%	3.0%
Landfill Gate Fee	101	£104.03	£107.05	£110.15	£113.46
Haulage per Tonne	£0.15	£0.15	£0.16	£0.16	£0.17

Table 24: C&I Post 2021 Gate Fee Assumptions

	2021/22	2022/23	2023/24	2024/25	2025/26
RDF Export	£115	£116	£118	£119	£120
EfW in Scotland	£105	£109	£112	£116	£120
Export to England	£130	£132	£133	£135	£136
Haulage per Tonne (Mainland)	£0.16	£0.17	£0.17	£0.18	£0.18
Haulage per Tonne (Islands)	£0.31	£0.32	£0.33	£0.34	£0.35

Notes: *RDF Gate fee includes processing costs of £15 per tonne 2018/19 (increased annually with inflation).

Table 25: Transfer Station Cost Assumptions

	Capital Cost	Interest Rate	Paydown Period (Yrs)	Annualised Cost
Cost for Developing Facility	£3,000,000	2.3%	14	£253,774

Appendix 6 – Economic Modelling Time Series

Table 26: Scenario 1, Option 1 (Million £)

Economic Sector	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	Total	NPV
Public Authorities	-115	-113	-108	-104	-99	-98	-97	-96	-95	-94	**-1,018**	-853
Waste Collectors	-105	-102	-98	-94	-90	-89	-87	-86	-84	-83	**-918**	-770
Haulage	13	11	11	10	10	10	10	10	9	9	**104**	87
Exporters	22	19	19	18	17	17	17	16	16	16	**176**	148
Treatment/ Landfill Providers (Scotland)	42	56	53	51	48	47	47	47	46	46	**483**	403
Environmental Cost	1	1	1	3	4	5	7	9	10	12	52	40
Total	-143	-127	-122	-116	-111	-107	-103	-100	-97	-93	-1,120	-943

Table 27: Scenario 1, Option 2 (Million £)

Economic Sector	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	Total	NPV
Public Authorities	-114	-112	-107	-103	-97	-96	-95	-94	-93	-92	**-1,005**	-842
Waste Collectors	-105	-102	-98	-94	-78	-76	-75	-74	-72	-71	**-845**	-713
Haulage	12	11	10	10	6	6	6	5	5	5	**76**	65
Exporters	30	27	26	25	0	0	0	0	0	0	**107**	99
Treatment/ Landfill Providers (Scotland)	42	56	53	51	173	170	168	166	164	161	**1,204**	962
Environmental Cost	1	1	2	3	-1	0	2	3	4	5	21	16
Total	-135	-119	-114	-109	3	4	5	6	7	9	-443	-414

Table 28: Scenario 2, Option 1 (Million £)

Economic Sector	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	Total	NPV
Public Authorities	-132	-135	-136	-136	-136	-137	-137	-137	-138	-138	**-1,362**	-1,132
Waste Collectors	-115	-115	-115	-114	-114	-114	-114	-115	-115	-115	**-1,146**	-953
Haulage	15	13	13	13	13	13	13	13	13	13	**133**	111
Exporters	24	22	22	22	22	22	22	22	22	22	**220**	184
Treatment/ Landfill Providers (Scotland)	51	71	71	71	72	72	72	72	73	73	**698**	577
Environmental Cost	1	1	2	4	5	7	10	12	14	17	73	57
Total	-157	-143	-142	-140	-139	-137	-134	-132	-130	-128	-1,382	-1,156

Table 29: Scenario 2, Option 2 (Million £)

Economic Sector	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	Total	NPV
Public Authorities	-131	-134	-135	-135	-133	-134	-134	-134	-135	-135	**-1,340**	-1,114
Waste Collectors	-115	-115	-115	-114	-98	-98	-98	-99	-99	-99	**-1,050**	-879
Haulage	14	12	12	12	6	6	6	6	6	6	**89**	76
Exporters	33	30	30	30	0	0	0	0	0	0	**124**	114
Treatment/ Landfill Providers (Scotland)	51	71	71	71	231	231	231	232	232	233	**1,654**	1,317
Environmental Cost	2	2	3	4	4	5	8	5	6	8	46	37
Total	-147	-134	-133	-131	9	11	13	10	11	14	-477	-449

Appendix 7 – Additional Environmental Impact Modelling Assumptions

Table 30 details the additional environmental modelling assumptions used to calculate the impacts of residual waste treatment and transport outside of Scotland.

Table 30: Further Environmental Modelling Assumptions

	Assumption	Units
Average Shipping Distance*	751	km
Average Road Haulage in Europe	20	miles
Transport by Ship	0.030	kg CO_2 eq. /tonnes.km
European Incinerators	0.13	Tonnes of CO_2 eq. per Tonne of Waste
	0.001	Tonnes of NOx per Tonne of Waste

Notes: *Assumed material is shipped to Denmark, Netherlands or Sweden

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