

# Glass Collection & Re-processing Options Appraisal in Scotland

IMR001-002



A report assessing current collections of household and C&I container glass for recycling in Scotland, and making recommendations for collection methods to achieve increases in remelt quality glass recycling.

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# 1 Executive Summary

This report sets out the findings of a review of current arrangements for the collection and recycling of container glass in Scotland from both Household and Commercial & Industrial sources. The report assesses glass waste arisings and current collections; estimates the impact of the Waste (Scotland) Regulations 2012; proposes identified good practice for recycling glass; and makes recommendations for increasing future closed loop glass recycling rates in Scotland.

The immediate context is the publication of the draft Waste (Scotland) Regulations 2012 by the Scottish Parliament, which seek to promote the closed loop recycling of container glass waste both to maximise the carbon savings and to recover the economic value in waste glass.

## 1.1 Waste Arisings

Current Household and C&I container glass arisings in Scotland are estimated to be between 231,000 and 322,000 tonnes (A calculated lower estimate based on Defra data and an upper estimate based on data from Scotland's Zero Waste Plan and SEPA's C&I waste data digest – see section 8.1). This wide range of estimates reflects the uncertainty of the data currently available and the methods used. The report uses the mid-point to suggest a figure of 276,500 tonnes arising. Slightly under two thirds is estimated to be household glass, while the remainder arises from C&I sources, particularly the hospitality and leisure sectors.

Clearly primary data and a more detailed assessment are still required as suggested in Scotland's Zero Waste Strategy. However the broad themes emerging from this work do not rely on this estimate and are considered to be valid.

## 1.2 Waste Collections

Current collection practice includes substantial collection of mixed glass waste, and this appears to have been an increasingly popular approach. The Waste (Scotland) Regulations 2012 will require kerbside collections to be implemented, affecting a number of Councils who do not currently have these services, and there is a need to ensure these new services are optimised from the outset. This report reviews the available evidence and provides estimates of likely results from different collection approaches to inform development of these services.

There is wide variation in current collection levels of container glass by local authorities. Some of this is a result of geographic and demographic factors but most of the variance can be explained by the collection methods adopted. With the Waste (Scotland) Regulations 2012 affecting the way that glass must be collected in future, and Local Authorities the largest collectors of glass for recycling, there is an urgent need for collection methods to reflect good practice.

## 1.3 Impacts of new regulation

We estimate that the impact of implementing the new duties set out in the Waste (Scotland) Regulations 2012 will be to substantially increase the collection of glass, and that providing the duties are fully complied with by the stated deadline, the additional quantity of cullet available to the remelt sector would be around 72,000 tonnes, with no overall change in the proportion which is colour separated at source anticipated. Proposed changes to the Packaging Waste Regulations will have only a very limited impact, and only in the longer term.

## 1.4 Good practice

Within the context of the new Waste (Scotland) Regulations 2012 which will apply to glass collections from the end of 2013, the following key points are stated as representing current good practice:

- Mechanical crushing of glass prior to collection or processing results in a significant proportion of fine particles which are too small to then be colour sorted. The loss may exceed 30% by weight of the collected material, and this material would not meet quality standard for remelt end uses. Crushing prior to recycling should therefore be avoided where possible.

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- Education and promotion to householders and waste glass producers will have a significant impact in improving glass quality by keeping contamination to a minimum, whether the glass collected is colour sorted or not.
- Colour separated bring sites are the most cost effective method of waste glass collection relative to material quality and quantity. There are examples of high performing Local Authorities who rely wholly on Bring Banks to collect all glass waste, and it is likely that bring sites will form some part of a successful overall strategy. Where bring sites are made accessible to C&I glass waste producers, they may significantly increase the total glass waste recycled at no net cost to the collector.
- Colour separated kerbside collections of glass are likely to be cheaper than mixed glass collection after taking account of the material values and further costs of processing cullet to the standard required for closed loop recycling as required by the Waste (Scotland) Regulations 2012.
- While deprivation and high population housing density do correlate to some extent with lower levels of recycling, good quality services can outweigh these disadvantages, and some lower income authority areas and those with higher housing density do perform well above the average, showing that this trend is not inevitable.
- Full coverage of households with kerbside collections is the strongest predictor of high glass recycling performance in a local authority area. Successful colour separated kerbside collections operate in both rural and urban environments, and in areas with varying levels of affluence.
- Approximately half of the C&I glass collected by local authorities is currently collected with colour separation at source, contradicting the conventional wisdom that C&I glass can generally only be collected mixed. While not all C&I glass will easily be collected on a colour separated basis, this option can be both cost effective and practicable.

### 1.5 Opportunities for action

Recommendations for further actions to increase the supply of high quality cullet for the container glass manufacturing sector in Scotland include:

- Produce a mass balance and arisings estimate for glass waste in the Scottish economy which identifies the amount of glass waste available in the overall waste stream, how much is being recovered and to which markets, and enables recovery targets to be set and monitored. This may also encourage others to identify opportunities to invest in glass supply chains which recycle glass waste in closed loop remelt applications. This is already an objective of Scotland's Zero Waste Plan.
- A mass/material balance is needed for glass waste within all of Scotland's waste streams, which gives up to date estimates of the total arisings, and information about the fate of glass by end use and disposal methods. This is already an objective of Scotland's Zero Waste Plan.
- Assuming that the Waste (Scotland) Regulations 2012 are implemented as currently anticipated, collection arrangements which collect glass comingled with other recyclables will not meet the required standard, as the material is not acceptable to the remelt sector and will therefore need to be phased out before 2014.
- Use of bring banks for household glass collection on a colour separated basis, should replace mixed glass bring sites wherever possible. Colour separated bring sites are the most cost effective method of waste glass collection relative to material quality and quantity.
- Case studies which explain the glass collection successes of Scottish Local Authorities should be produced in a common format with the involvement of Zero Waste Scotland to enable concrete examples of methods used by the higher performing authorities to be shared and applied more widely.
- A Kerbside Good Practice Guide for Waste Collectors and producers affected by the Waste (Scotland) Regulations 2012 will be needed when the final guidance is available, and it is expected that some of the data and analysis included in this report will be a useful resource in the production of that guide. We understand that Zero Waste Scotland already plan to publish such a guide.

- Local Authorities and others, should be provided with support to review and develop their glass recycling strategies in light of the Waste (Scotland) Regulations 2012 if the objective of maximising closed loop recycling is to be achieved.
- Available methods and strategies to increase overall glass collection from C&I glass waste producers should be investigated. Good practise and the barriers to C&I collection should be reviewed with the businesses, Local Authorities and third sector organisations already providing these services. The support streams available should be reviewed and updated to reflect the views of the industry and the needs of Local Authorities and others.
- Use of bring banks to collect glass from the licensed trade should be reviewed. Where bring sites are made accessible to C&I glass waste producers, they may significantly increase the total glass waste recycled at no net additional cost to the collector, while discharging the duty to provide services on demand to non household waste producers.
- While there are clear differences in competitive strategies between stakeholders on exact methods for collecting and recycling glass, there are some areas of strong agreement, notably:
  - The promotion of increased participation by householders and businesses. There may be opportunities to take a common approach to promoting, branding, and communicating efforts to increase recycling in ways which reflect Scotland's distinctive ambitions in waste management. The option of a Scotland wide campaign to increase participation in glass recycling in an agreed way should be investigated.
  - Concern over a gradual lowering of the overall quality of glass collected. Such that any measures to improve quality and reduce contamination of material presented for collection, whatever the method, would receive strong support.
  - The ambition across all processors to increase the glass available to, and utilised by the remelt sector based on economic and environmental advantages.

A conference of stakeholders or similar may be a useful way to establish common ground on approaches to collection – notably on the debate between colour separated collection and colour sorting. Zero Waste Scotland along with other partners such as Ministers in the Scottish Parliament and SEPA should consider liaison work between the major stakeholders in the waste glass cullet supply chain, including the end users in container manufacture; the waste collection and re-processing sector; colour sorting facility operators; and local authorities in order to identify and share areas of agreement.

This may be a one-off event or ongoing/task based working group. The forthcoming publication of the Statutory Guidance on the new regulations by the Scottish Parliament presents an ideal opportunity to initiate this process.

- Review the output quality, quantities and end markets of glass when the new glass sorting facility is operational. Major stakeholders have different views as to the effectiveness and suitability of colour sorting technologies, and the degree to which they can meet quality requirements. This study found that sorted glass can meet the quality specifications for cullet grades set out in PAS101, although not all container manufacturers consider this is sufficient for all grades of container production. This suggests that the key barriers to maximizing glass recycling into remelt markets may be largely a result of perceptions and competitive strategies i.e. "Market Forces", more than of technical factors. Reviewing the real impact of this major investment on actual glass levels into remelt and other markets will allow stakeholders in Scotland to understand if the requirements of the Waste (Scotland) Regulations 2012 are being fulfilled.

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### 3 Introduction

This report has been commissioned by Zero Waste Scotland to review the current position in Scotland for the collection of container glass waste. Particular emphasis is placed on recovering waste container glass into high-value markets which are able to deliver the greatest available benefits in terms of both carbon savings and economic value recovered.

The following assumptions provide the context for the findings and recommendations of the report:

- The Scottish Parliament is in the process of introducing the requirement for certain key recyclable materials, including glass, to be collected separately from other wastes. New duties are expected to be in place by autumn 2012, with a requirement that glass be collected separately by 1<sup>st</sup> January 2014. The current indication is that glass must generally be separated by colour at the point of collection, but final confirmation of this awaits the decision of the Scottish Parliament.
- The Packaging Waste Regulations are currently in the final stages of review with the most recent targets and changes included as elements in the Chancellor's UK Budget speech on 21<sup>st</sup> March 2012. The Packaging Waste Recovery system is not a devolved matter and applies to the UK as a whole, and the effects of the proposed changes are considered within this report.
- There are longstanding concerns within the container manufacturing sector that the quality of recycled glass cullet has reduced in recent years and may often not reach the standards required for use in remelt applications.
- It is generally accepted that the most desirable end market for recycled glass cullet should be into closed loop manufacturing of further containers, since this achieves the greatest carbon savings compared to other end markets, and compared to producing containers from virgin materials. This is the stated policy objective of the Scottish Parliament, and of Scotland's Zero Waste Plan.

There are also a range of other end markets for recycled glass which have varying carbon saving benefits shown below, through displacing virgin materials and reducing energy consumption in production processes. In order of relative size (by tonnage of glass used) these markets include manufacture of fibreglass; use of glass as aggregate substitutes; use of glass sand as filtration media, in dressing fine turf, and in equine surfaces; and for glazes and manufacturing decorative items.

Life Cycle Analysis of options for container glass in the UK. CO<sub>2</sub> savings by end use (in comparison with landfill)

End use	Kg CO <sub>2</sub> per tonne glass
Reduction	843
Re-use	620
Recycle – closed loop	314
Recycle – closed loop (export)	290
Glass fibre	275
Bricks	66
Shot blast	19
Aggregate	-2
Filtration	-43

*Source: The impact of the carbon agenda on the waste management business, Grant Thornton & Oakdene Hollins, 2006*

The report includes the following sections which build on the previous sections:

- **Assessment of the total container glass waste in Scotland**, including where it arises, how it is collected and by who, including:
  - An outline and analysis of the collection of waste glass for recycling by Local Authorities, including quantities, types and collection methods.
  - Reviews the current estimates for commercial glass waste arisings and provides estimates of likely arisings.

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- Summarises the total estimated waste container glass arising from both household and non household sources in Scotland, the rate of potential growth, and the likely amounts that may be collected for recycling.
- **Review of the industries and sectors which process waste glass** collected for recycling and sets out their technical capabilities and capacities for processing collected glass wastes to a standard that meets the quality requirements of end users in the container glass manufacturing sector.
- **Assessment of the impacts of proposed changes in regulation** and legal duties on glass recycling in Scotland.
- **A review of potential options for collecting container glass** waste taking into account the needs and quality standard of markets and end users.
- **Conclusions and recommendations.**



## 4 Aims & objectives

The aim of this report is to provide an overview of the current collection and subsequent management of container glass in Scotland and the factors that will influence this supply chain in the near future. The findings and recommendations from the report will be used by Zero Waste Scotland to inform its strategy for supporting increased supply of Scottish cullet to remelt markets. In order to achieve this aim, a number of objectives have been set by Zero Waste Scotland:

- To identify the current levels and range of activities by local authorities and private sector waste management companies in undertaking collection of glass, including mixed glass colours collected together, colour segregated collections, and glass mixed with other waste or other recyclable materials.
- To draw together available data on the total amount of glass available for collection within Scotland, and comment on current capture rates of glass collected for recycling, and potential increase through current planned changes.
- To assess the current level of glass waste which is segregated into different colour fractions at the point of collection, evaluate likely trends for colour segregated collections, and identify factors which may influence this. This will also discuss the quality and other needs of end markets, particularly in the container glass remelt sector and evaluate the degree to which mixed glass can be colour sorted by currently available processes while still reaching quality requirements of cullet users.
- To identify key markets in which recycled glass is used, and comment on how this can be further optimized to achieve the most resource and carbon efficient outcomes.
- To draw together information on current and planned capacity and technical capability of Material Recovery Facilities (MRF) and glass sorting technologies in the Scottish market.
- To make suggestions as to which methods of collection may be most successful, in terms of achieving policy objectives for the recovery of the greatest proportion of glass into end uses which offer the greatest benefits in terms of carbon impacts and economic gains. This will take account of the broader context including geography and demographics, and comment on how new methods might be implemented, supported, and incentivized through policy, funding and other means.
- To indicate the most promising areas for further investigation in terms of the opportunities for achieving resource efficiency, carbon or cost savings for relevant industries which produce, recover or use container glass waste.
- To make recommendations for future activity or intervention in glass recovery in Scotland in terms of volume/tonnage, carbon impact and economic value added to current recovery and recycling activities.

These objectives form the structure of this report and the findings are augmented with insights from key stakeholders handling and using container glass within Scotland.

## 5 Statistical sources and methods

A number of datasets and total estimates of glass waste arisings in Scotland have been used for analysis in this report, and the data which appears in this section is largely drawn from that data. These datasets include:

- The WRAP Local Authority Survey 2009/10 – this is undertaken on behalf of WRAP, and includes collection of information from all local authorities about all forms of collection, recycling, service provision etc. Data included is statistical<sup>1</sup> and service oriented, providing information about collection methods and service provision.
- The WasteDataFlow online reporting system to which all UK local authorities contribute, and from which data is collected by the Scottish Environmental Protection Agency (SEPA) for analysis. Data from 2010/11 was available for analysis. Data included is primarily statistical<sup>2</sup> and regulatory, and relates to types and tonnages of waste collected, with sources and destinations for its management.
- Estimates made by the Scottish Environmental Protection Agency of the amount of Commercial & Industrial glass waste, which appear in the annual Waste Data Digest for 2010/11.
- Estimates published by the Scottish Parliament for the purposes of the national waste strategy - **Scotland's Zero Waste Plan**.

Both the two Local Authority datasets include data regarding glass collected broken down by colour type and tonnage which is attributed to each of the Scottish Local Authorities (LAs). This overlap of similar data fields included enables comparison between the two datasets, and although the data represents different collection years (2009/10 for WRAP data, 2010/11 for SEPA). We would expect to see a good correlation between the two. A strong correlation would indicate that the methods of data gathering in the two systems, and original sources of data provided were very similar, and that the two datasets could be considered to be broadly interchangeable. A weak correlation would indicate that sources of data were likely to be different, and either prevent comparison between the two datasets, or suggest that one or both datasets included significant errors.

To test how similar the two datasets are, the reported glass collection tonnages for each of the 32 Scottish LAs were compared using the correlation function in Excel for both mixed glass collected and total glass collected. This produces a comparison between the reported totals in the two surveys, expressed as a single figure between -1 and 1. A result close to 1 or -1 indicates a strong correlation, or inverse correlation, and a result close to 0 indicates that there is no statistical relationship between the two factors. The results are shown in table 1 below:

Correlation between WRAP 2009/10 data and SEPA 2010/11 data (overall glass collected)	0.9936
Correlation between WRAP 2009/10 data and SEPA 2010/11 data (mixed glass collected)	0.9015

This indicates that there is a very strong correlation (99% and 90% respectively), and roughly similar results are being reported by the local authorities to the two different surveys. Some change would be expected from one year to the next, but this strong correlation shows that the results are reliable and comparable. As a result we can assume that:

- Data included only in the WRAP survey which describes collection methods and breakdown between household and non-household sources in the 2009/10 dataset, will also generally be applicable to the SEPA 2010/11 dataset.
- Data included only in the SEPA dataset which describes destinations and facilities receiving/processing glass collected in 2010/11 will also generally be applicable to the WRAP 2009/10 dataset.

<sup>1</sup> One likely error was found in WRAP data where recycled glass figures for Fife Council appeared twice – in household collections and C&I Collections.

<sup>2</sup> Data was missing for Dumfries and Galloway, and the gap was filled using the equivalent WRAP 2009/10 data

## 6 Local authority collections of glass wastes

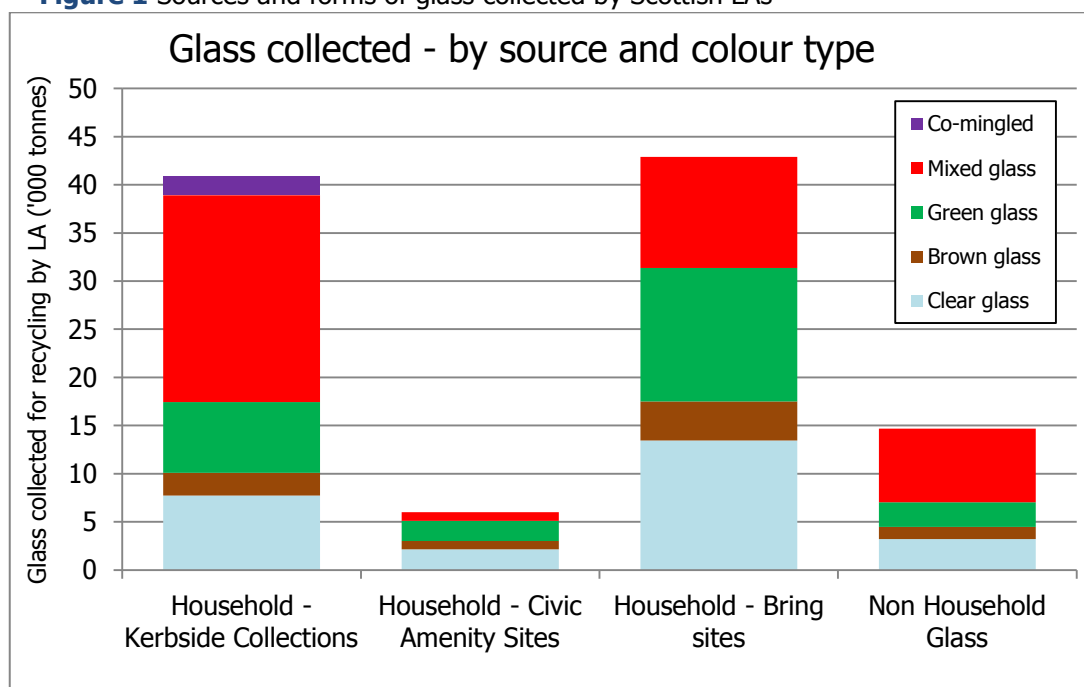
### 6.1 Overview of Local Authority Collection methods

Local authorities may collect glass through a number of routes, including kerbside collections, bring sites (bottle banks), and Civic Amenity sites (Household Waste Recycling Centres), and may also collect glass from commercial and other non-household sources<sup>3</sup>. Table 1 below summarises the route by which Councils collected glass in 2010/11 and the form it took – colour separated, colour mixed or co-mingled (glass of all colours mixed with other materials).

**Table 1** Collection of glass for recycling by Scottish Local Authorities (source: SEPA Dataset)

Source & Collection route	Clear glass	Brown glass	Green glass	Mixed glass	Co-mingled	Total by Source/ Route
Household - Kerbside Collections	7743	2359	7331	21486	1934	40,853
Household - Civic Amenity Sites	2132	890	2079	911	0	6,012
Household - Bring sites	13433	4060	13862	11546	0	42,901
Household Glass (all routes)	23309	7309	23272	33942	1934	89,766
Non Household Glass	3208	1249	2569	7639	0	14,665
TOTAL						104,431

**Figure 1** Sources and forms of glass collected by Scottish LAs



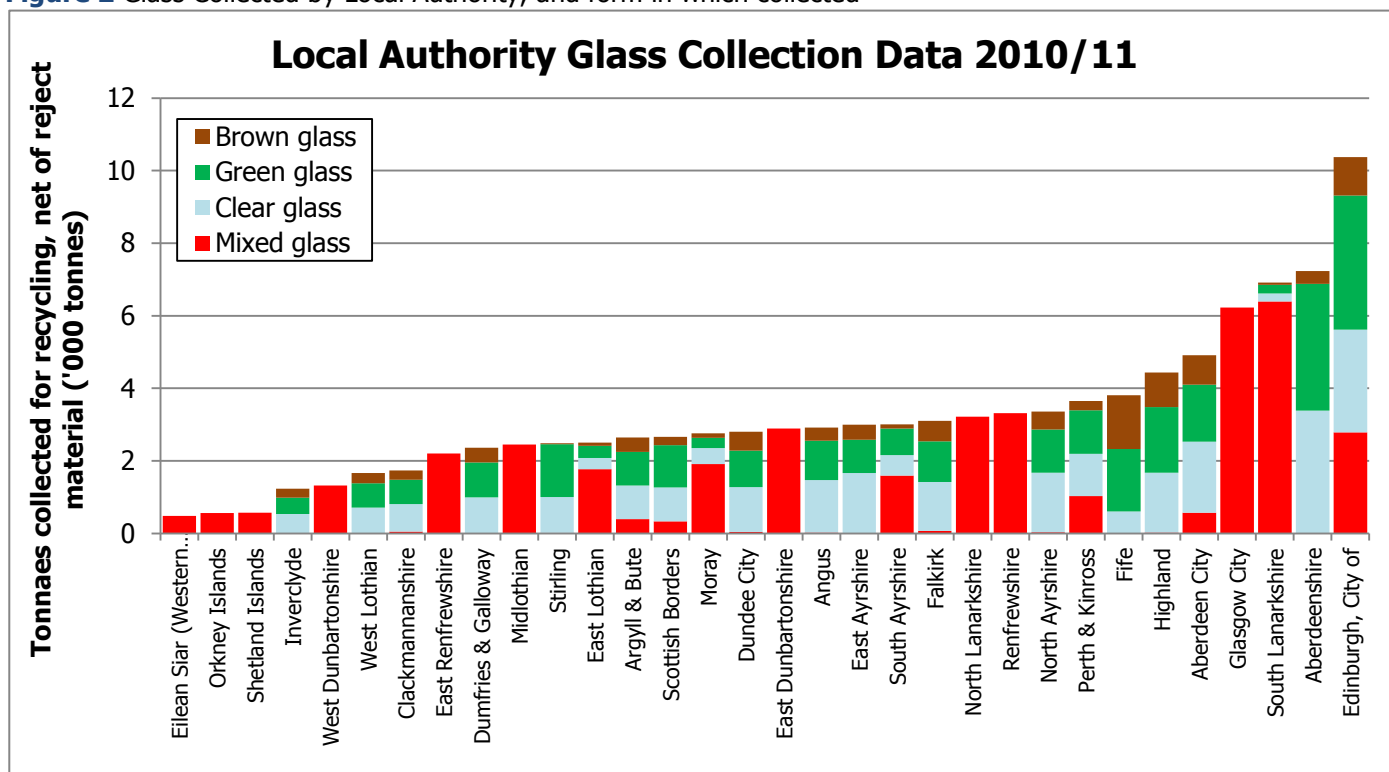
The most important source of glass for recycling from local authorities is currently the bring sites network, which provides both the largest overall share of glass collected, and the largest share of colour separated glass. The low comparative cost of undertaking glass collections using bring sites, and the limited further processing required to produce cullet of a remelt standard, make this an attractive option for collection. Some bring sites, notably those sited

<sup>3</sup> Several types of non household premises are deemed to be producers of household waste by the relevant legislation, and their waste will be reported as household waste. This includes prisons, schools, hospitals, places of worship etc. These premises are generally not likely to be significant producers of glass waste.

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in pub car parks, are known to be 'unofficially' used by pubs for disposal of glass. This may be a worthwhile option to explore in collecting commercial and industrial (C&I) glass in future. The tonnages of glass collected by Local Authorities and reported using the WasteDataFlow online recording system for 2010/11 appear in Figure 2 below. This is broken down into the colour fractions where glass is collected separately by colour and mixed glass, shown in red.

**Figure 2** Glass Collected by Local Authority, and form in which collected



Collection methods are diverse, reflecting a wide range of local circumstances and drivers. Two broad strategies are evident – collecting colours mixed (some mixed glass is then colour sorted by specialist processors, but this is limited at present, pending the start of operations at a new large scale colour sorting facility), and collecting as colour separated glass. Just over 40% of glass collected is mixed and just under 60% is collected colour separated. Both approaches are distributed amongst both small and large authorities, and for the most part authorities tend to *either* choose mixed glass or colour separation. Edinburgh is a notable exception as both approaches are utilised (this may be due to a large proportion of C&I glass where it is more difficult, to get businesses to present separate colours for collection).

Bring banks have traditionally been used to collect single colours only, but there is an increasing tendency to use mixed colour bring sites – especially in high density areas where space may be at a premium, and a single bin for mixed glass may take up significantly less space than several bins or banks for different colours.

The majority of all glass which is collected colour separated is used in closed loop remelt – these are the green, brown and pale blue coloured elements in the graph above. However competitive and contractual forces mean this is not a simple relationship that holds for all glass collection. Where glass is collected at the kerbside approximately 43% is still colour separated but only 18% of this reaches remelt markets, the majority being sold into insulation markets. It is likely that when additional colour separation capacity is available that colour separated glass will move to remelt markets. It will be important to Scotland's overall ambition to maximise glass recycling, to ensure that good quality but mixed colour residues from the colour separation processes are used to meet the ongoing needs of this sector. This is technically possible but again may be influenced adversely by pricing, competitive or contract position on the ground. The competitiveness of glass fibre insulation manufacturing would be negatively affected if this were to be the case. This was also a concern raised by the container remelt markets.

Given the complexity of real life commercial markets it will be important for Scotland's Zero Waste Plan and the Waste (Scotland) Regulations 2012 that market developments and changes in the flow of recycled glass are closely monitored to ensure the regulations are translating into the outcomes anticipated.

Most mixed glass is currently used in glass fibre insulation manufacture, glass beads, decorative uses and the aggregate market, so the red areas in the graph above are synonymous with generally lower environmental value recovery, and not closed loop remelt end markets. With the development of the colour sorting facility at Bonnyrigg, the proportion of mixed glass sold for closed loop applications in remelt after colour sorting could rise to around 76% - or up to 90% of the total collected. Assuming that the new regulations and collection duties achieve their stated intent in ensuring quality of glass which is available for remelt, the main challenge will be to increase the quantity of material captured.

While collection of colour separated glass increases the prospect of it being used in remelt, there may be important operational reasons for mixed glass collections, as well as difficulties in changing collection methods which may have been contracted commercially for a fixed period. This balance between costs and results, after taking account of issues such as sorting technologies, is one of the key issues this report aims to examine.

### 6.2 Capture rates for household glass wastes

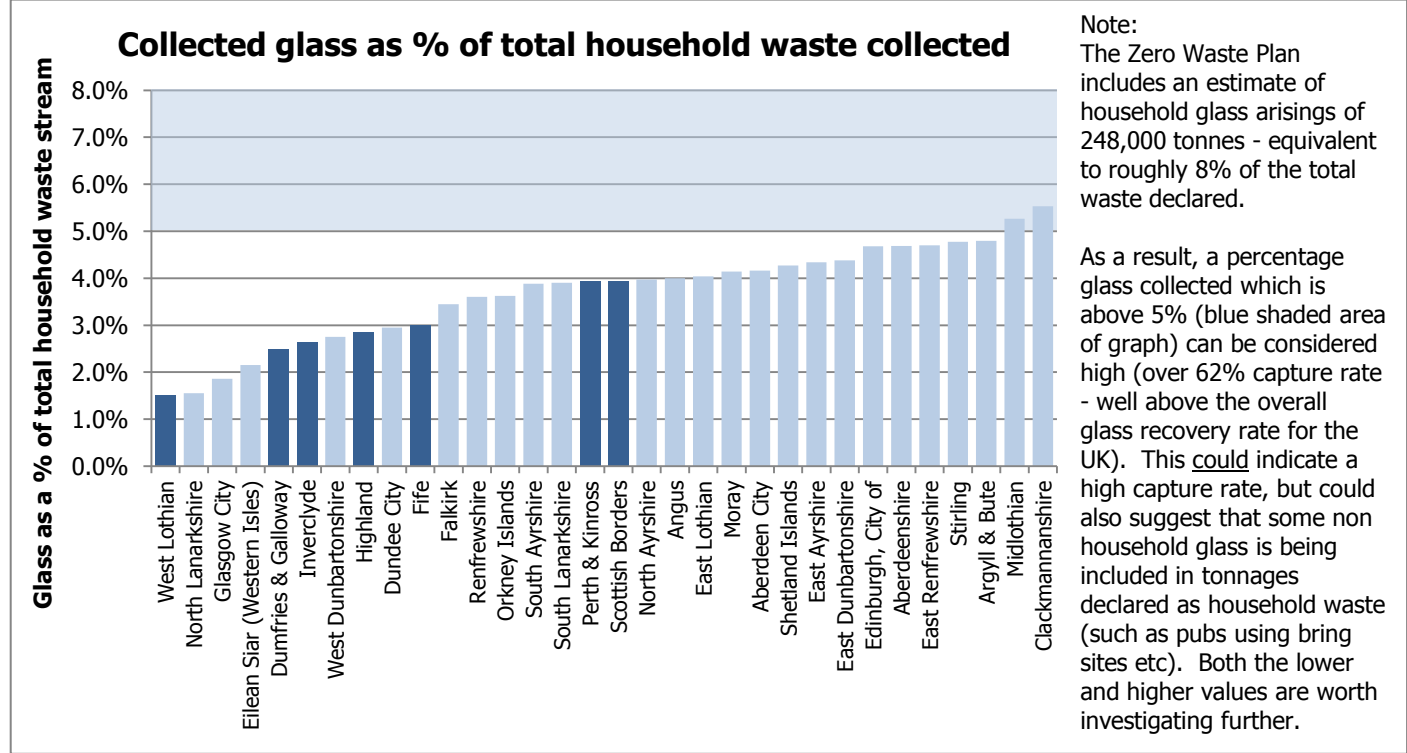
It has been difficult to produce meaningful assessments of capture rates for individual Local Authorities, as the data includes varying quantities of commercial and industrial (C&I) glass waste within the total declared for household waste. This commonly takes place for hospitality premises which may use bring banks sited within their car parks for the disposal of non-household glass waste. Because this takes place to a varying degree, its impact cannot be modelled accurately, but it is likely to be more prevalent in more remote areas, especially the island and highlands based LA areas, where the practicalities of maintaining the separation between household and C&I wastes are much more difficult.

By taking the declared totals of household waste collected by each local authority and published by SEPA, and expressing this as a percentage of the total waste it is possible to give a like-for-like comparison between glass collection rates for individual local authorities. Figure 3 below shows the variation between the 32 councils in Scotland in the amount of glass collected, as a proportion of overall waste collected. Councils which do not currently undertake kerbside collections of glass waste are shown in dark blue – these also generally show a lower overall proportion of glass is collected.

Using the SEPA estimate of 8% of total household waste being container glass, results which are below about 3% would represent the most promising areas for significant improvement. Conversely results which are above about 5% require further investigation, this may represent an excellent collection regime but may also be explained by these tonnages containing some level of glass from C&I sources.

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**Figure 3** Collected glass as percentage of total household waste collected

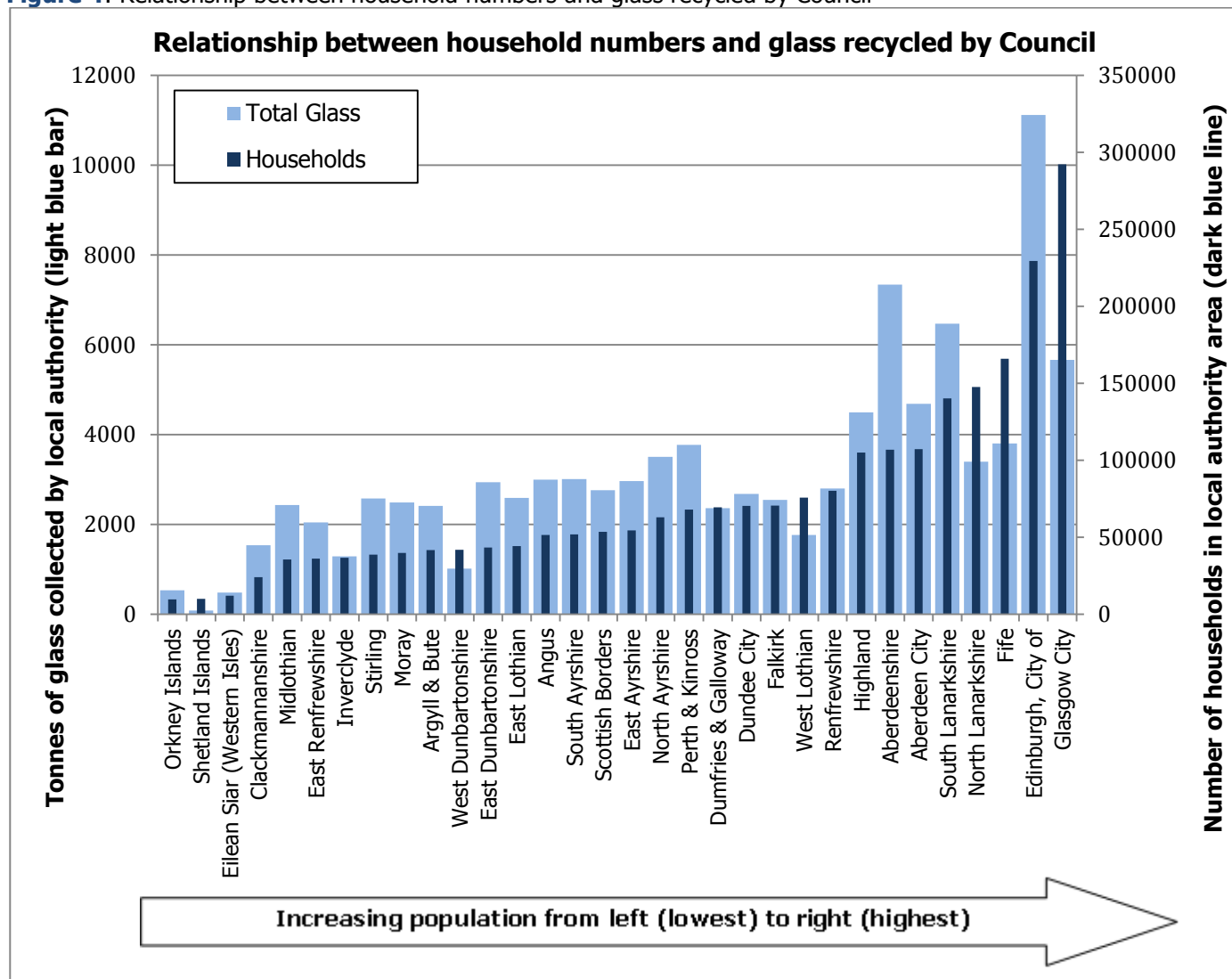


### 6.3 Links between collection methods and tonnage results

Scottish local authorities are very diverse in population size and density; degree of urbanisation; industrial profile; and economic deprivation. These and other factors have resulted in a wide range of collection solutions that have sought to achieve recycling and waste management outcomes, but influenced in the context of other local historical, political, economic and geographic opportunities and challenges.

This diversity, and the relatively small number of data points (ie Scottish local authorities) overall makes direct statistical comparison between service delivery methods and outcomes in terms of recycling difficult, and therefore any conclusions drawn can be misleading. There are too few examples in each of several categories of different models of service delivery to enable overarching conclusions to be reached.

The local authorities which have higher or lower rates of collection relative to their populations (expressed in numbers of households) are shown on Figure 4 below (dark blue lines) along with total glass recovered and reported to SEPA in 2010/11 (thicker light blue bars). Where the light blue bar is higher this indicates that the Council has collected more glass than would be expected relative to its population, and vice-versa. Using this method, it is possible to identify the lower and higher performers and seek explanations in either service delivery, demographics or other factors.

**Figure 4:** Relationship between household numbers and glass recycled by Council

From this graph we can see that Glasgow, North Lanarkshire and Fife are examples where less glass than might typically be expected is collected by comparison with their nearest peers; while Edinburgh, Aberdeenshire, South Lanarkshire are examples where higher levels of glass collections than authorities with comparable demographic factors were indicated in the data. These are examined in more detail in Table 2 overleaf.



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**Table 2A:** Analysis of examples of low performers in recovering container glass waste

Local Authority	Description of context	Service method	Comments	Kg/hh/yr glass recovered
Glasgow City	<ul style="list-style-type: none"> <li>Large population, with higher levels of deprivation.</li> <li>Higher levels of high density housing, with greater levels of high rise homes than other areas may make service delivery more difficult.</li> </ul>	<ul style="list-style-type: none"> <li>Use mainly bring sites, with some kerbside collection also undertaken.</li> <li>All glass is collected as mixed colours and sent for processing at Viridor's Bonnyrigg facility – some is colour sorted, but most is used in lower value end markets.</li> <li>Extensive network of small bring sites – one 1100 litre bin, linked to blocks of flats and sited in communal areas.</li> <li>Overall recycling performance for 2010/11 is also low.</li> </ul>	<ul style="list-style-type: none"> <li>This is an example of the difficulty of achieving high participation and engagement in the areas of higher housing density and deprivation scores.</li> <li>The key element which is likely to increase glass collection would be the extension of the kerbside collection service, although this may present significant cost and operational barriers.</li> </ul>	21.3
North Lanarkshire	<ul style="list-style-type: none"> <li>High deprivation score</li> <li>Relatively high density of housing – but much lower than Edinburgh and other urbanised areas</li> </ul>	<ul style="list-style-type: none"> <li>Glass collected is split roughly equally between kerbside collection and bring sites.</li> <li>Low % of glass collected, although North Lanarkshire is achieving above average recycling rates more generally.</li> <li>All glass is currently collected as mixed colours.</li> </ul>	<ul style="list-style-type: none"> <li>North Lanarkshire has commenced the further rollout of its glass kerbside service</li> </ul>	21.8
Fife	<ul style="list-style-type: none"> <li>Average population density, with a fairly large population.</li> <li>Above average deprivation scores.</li> </ul>	<ul style="list-style-type: none"> <li>Collections are bring and CA sites, with no kerbside collections.</li> <li>Virtually all glass is currently collected on a colour separated basis.</li> <li>Overall recycling performance for 2010/11 is above average for Scotland.</li> </ul>	<ul style="list-style-type: none"> <li>Achieves slightly above the average rate per household for Scotland without providing a kerbside service.</li> <li>The key element which is likely to increase glass collection would be the implementation of a kerbside collection service.</li> </ul>	46.1

In general, the lack of a kerbside collection service is the strongest predictor of low rates of glass recycling, along with demographic factors such as high levels of deprivation, high-density housing etc. But it should be noted that local factors such as the length of time that services have been established; the extent of participation promotion; and decisions to focus on recycling other materials such as paper, explain just as much of the variance within the dataset. Some of the lower glass recycling areas perform highly in recycling overall, and neighbouring authorities with comparable demographic profiles, may have very different performance.

## Glass Collection & Re-processing Options Appraisal in Scotland 17

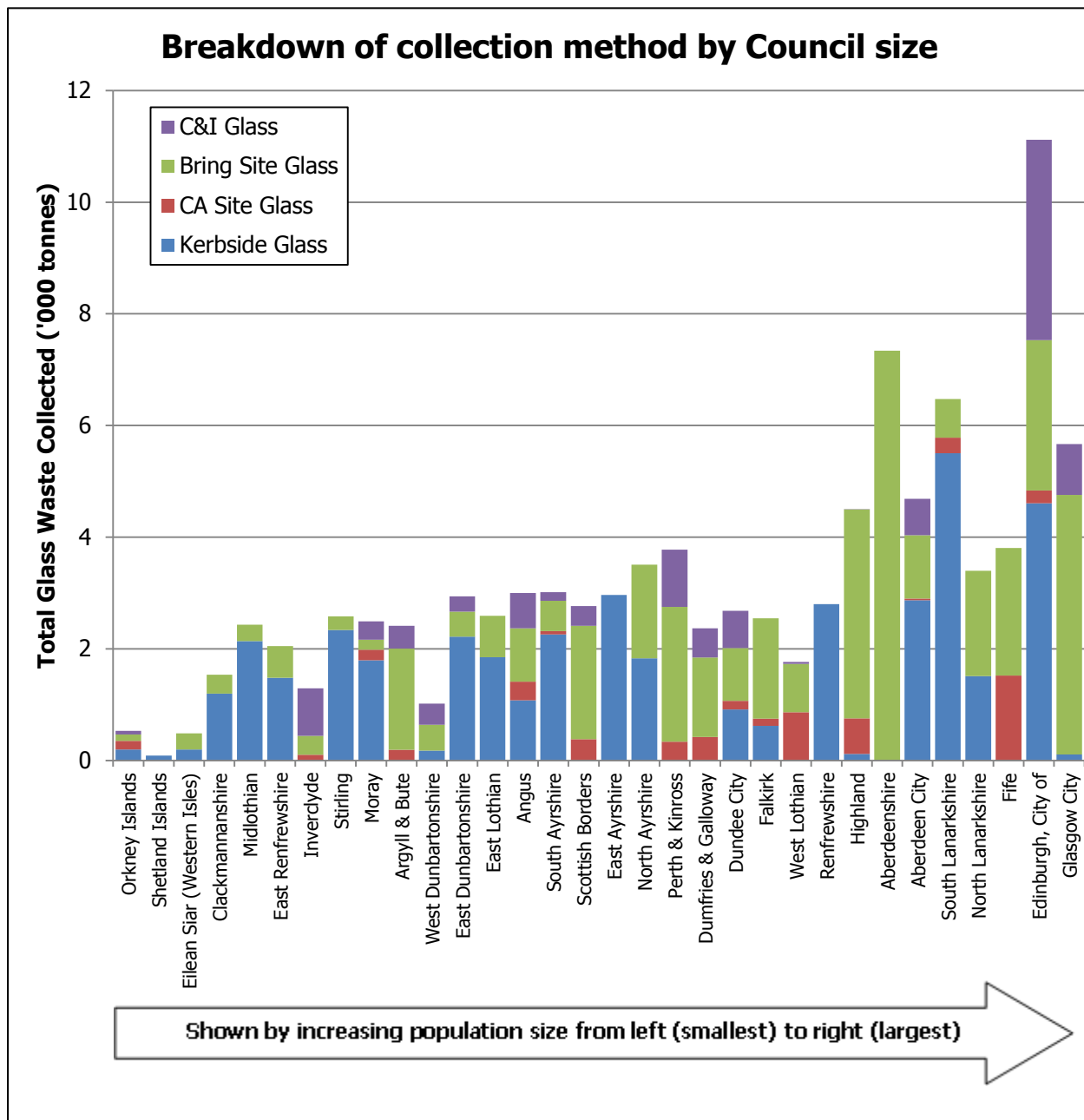
**Table 2B:** Analysis of higher performers in recovering container glass waste

Local Authority	Description of context	Service method	Comments	Kg/hh/yr glass recovered
Edinburgh	<ul style="list-style-type: none"> <li>Large population</li> <li>Large tourism sector</li> <li>Areas of significant deprivation and high density housing.</li> </ul>	<ul style="list-style-type: none"> <li>Highest overall glass recovered by a Scottish authority in tonnage terms.</li> <li>Substantial reliance on C&amp;I tonnage indicates Edinburgh's tourist economy may be an important factor</li> <li>Below average recycling performance overall in 2010/11.</li> </ul>	<ul style="list-style-type: none"> <li>An example of a mixed strategy of bring sites and kerbside collections achieving just above average recovery rates</li> <li>Included here as a 'higher performer' as this is an example of a large city area with areas of high deprivation and high density housing which is performing at a higher level in glass collection.</li> </ul>	45.2
Aberdeenshire	<ul style="list-style-type: none"> <li>Large geographic area – with below average population density.</li> <li>Relatively large population – 6<sup>th</sup> largest in Scotland.</li> <li>Comparatively low levels of economic deprivation.</li> </ul>	<ul style="list-style-type: none"> <li>Relies mainly on bring sites for glass collection, with all glass collected on a colour separated basis.</li> <li>Higher levels of glass are recovered achieving both quality and quantity outcomes.</li> <li>No C&amp;I Glass is disclosed within this total.</li> </ul>	<ul style="list-style-type: none"> <li>New duties will require rollout of kerbside collections – this would be expected to provide a significant increase in overall collections, but may divert some of current bring site tonnages. Aberdeenshire have recently introduced a kerbside collection, but the impact does not yet appear in the data.</li> <li>There are likely to be future opportunities to include C&amp;I collections alongside household collections.</li> <li>This is a bring site strategy which successfully overcomes low density populations and rural cost to recover higher levels of glass.</li> </ul>	67.6
South Lanarkshire	<ul style="list-style-type: none"> <li>Moderate to higher levels of deprivation in parts of area.</li> <li>Lower than average population density</li> </ul>	<ul style="list-style-type: none"> <li>Almost all glass is collected as mixed colours.</li> <li>Just less than half collected at kerbside, the rest from bring sites</li> </ul>	<ul style="list-style-type: none"> <li>Achieves above average recovery rates for glass.</li> <li>Current end use for glass is mostly in fibreglass and other lower value end markets, but after the upgrading of the Viridor facility, this may be recycled in closed loop remelt.</li> </ul>	49.3

It is striking that some of the councils achieving greatest success, such as Aberdeenshire, have done so using bring site collections, and have succeeded in achieving both quantity and quality objectives in recovered colour separated glass in large volumes. Many councils successfully recovering glass at higher rates have more favourable demographic profiles such as lower deprivation and lower density housing.

The whole Local Authority collection dataset is included in Figure 4 below which shows both the total container glass tonnage collected by each Council, and the breakdown between the four sources: Bring Sites; CA Sites; Kerbside Collections; and Commercial and Industrial glass wastes.

**Figure 5:** Breakdown of collection methods by Council size



There are no clear patterns which emerge from the dataset regarding the methods adopted by Scottish Councils for the collection of glass. The following broad comments can be made:

- While larger councils do generally recover more glass, the rate of collection per household varies widely from 21.3 to 72.0 kg per household per year recovered.
- The lowest recovery rates are generally seen in those Councils which do not currently offer kerbside collection. However, this is not a simple cause and effect relationship – indeed it may be that some councils have previously taken the decision not to offer kerbside collections to residents because either, other collection methods appear successful at lower cost; or because of practical difficulties in delivering kerbside services.

## 6.4 Use of Bring Sites for Glass Collection

Bring sites are known to be the lowest cost overall form of collection, enable colour separation without substantial additional cost by requiring site users to separate glass into different collection banks. British Glass, the glass manufacturing sector trade body, expressed the view that colour separated bring sites were the lowest cost route to achieving the quality requirements of the remelt sector.

To some extent the requirement for the provision of kerbside collections by the Waste (Scotland) Regulations 2012 overtake this option as a main strategy for glass collection, but bring sites (and CA sites, which play a smaller but similar role) are likely to remain an important element of any strategy. Where kerbside services are provided, residents will tend to increasingly use these as the default option, due to the added convenience. But bring sites currently collect around 40% of Scotland's recovered glass, and the majority of its colour separated glass, so the importance of this option cannot be ignored.

In particular, bring sites provide a cheaper alternative route for glass collection, and where separate glass collections will be required, any material that *can* be collected at bring sites may represent a cost saving in kerbside services, in that material will not need to be sorted at kerbside, and could help control the need for additional labour in the service that full kerbside sorting would require. It has already been noted that some authorities successfully use bring sites, notably:

- **Aberdeenshire** – have previously relied on bring sites for all glass collections – although have now introduced kerbside collection, and this proportion will clearly fall as a result.
- **Edinburgh** – one of the few large city areas with a relatively high performance, and which uses a mixed strategy of bring sites and kerbside collection.

Depending on location, tonnage recovered, and the material quality collected, glass merchants and re-processors may be willing to provide serviced glass collection banks at lower cost than kerbside collection options, although costs will rise sharply for more remote areas. Strategies which rely significantly on bring sites are most likely to be successful in areas of medium to high population density – including main population settlements within otherwise sparsely populated local authority areas.

Figure 6 overleaf, shows bring site collected glass for the 32 local authorities. This is based on the percentage breakdown appearing in the dataset for 2009/10, but this breakdown has been mapped onto actual glass collected in the 2010/11 dataset which was compiled from returns to SEPA. C&I glass and CA sites glass (which is a small amount of the overall total) has not been included in this graph, so the bars in the graph for some authorities without kerbside services do show less than 100% collected through bring sites.

The data for two authorities within the dataset may include reporting errors: data for Fife and Inverclyde includes an unusually high level of C&I glass waste collected, and it is likely that this has been included incorrectly when the 2009/10 survey was undertaken. This has the effect of showing two of the authorities without kerbside services collecting a low proportion of glass waste through bring sites.

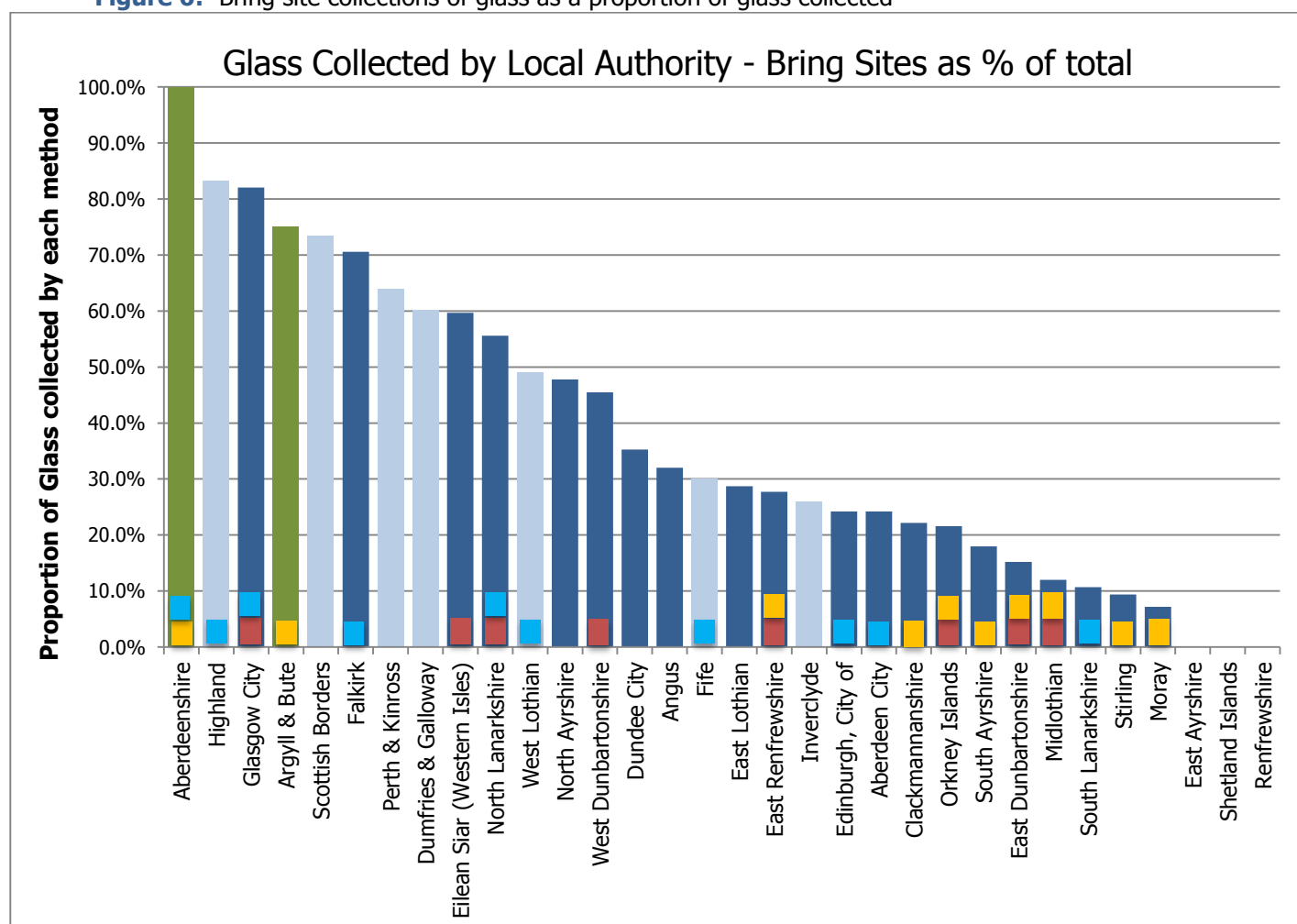
The key to colours used below also highlights additional data that has been added to the graph to enable possible relationships between other factors and bring sites usage to be more clearly seen.

### Key to colours and markers used to illustrate features of the collection service in Figure 6 overleaf

	Indicates LAs which have not yet introduced a kerbside collection - 8 authorities in total (other glass for these authorities is C&I)
	LAs which have recently introduced kerbside collections, but where they do not yet appear in the dataset
	Indicates LAs collecting mixed glass in bring sites – those <u>mainly</u> relying on mixed glass through bring sites
	Indicates LAs in the top 10 performers in Scotland – in terms of kg/hh glass recovered
	The largest 10 Scottish LAs according to the total number of households.

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**Figure 6:** Bring site collections of glass as a proportion of glass collected



- Most LAs recovering higher levels of glass (yellow marker in the graph above) show bring site tonnages of mostly less than 10% of their total. This may indicate residents simply opting to use the kerbside service instead.
- Larger authorities (blue marker) are distributed throughout the spectrum – so there is no significant relationship between authority size and the importance of bring sites as a proportion of glass collected.
- LAs undertaking mixed glass collections (red marker) are distributed throughout the spectrum – so there is no evidence that mixed glass bring sites collection are generally relied on as a collection strategy.
- The provision of bring sites in pub car parks may be a cost effective way of delivering services to licensed premises outside the main settlement areas where they may require services from their local authority.

Again, overall the data shows a diverse range of LA's deploying a range of collection strategies, as outlined in Sections 6.2 to 6.4 and Figures 2 to 6.

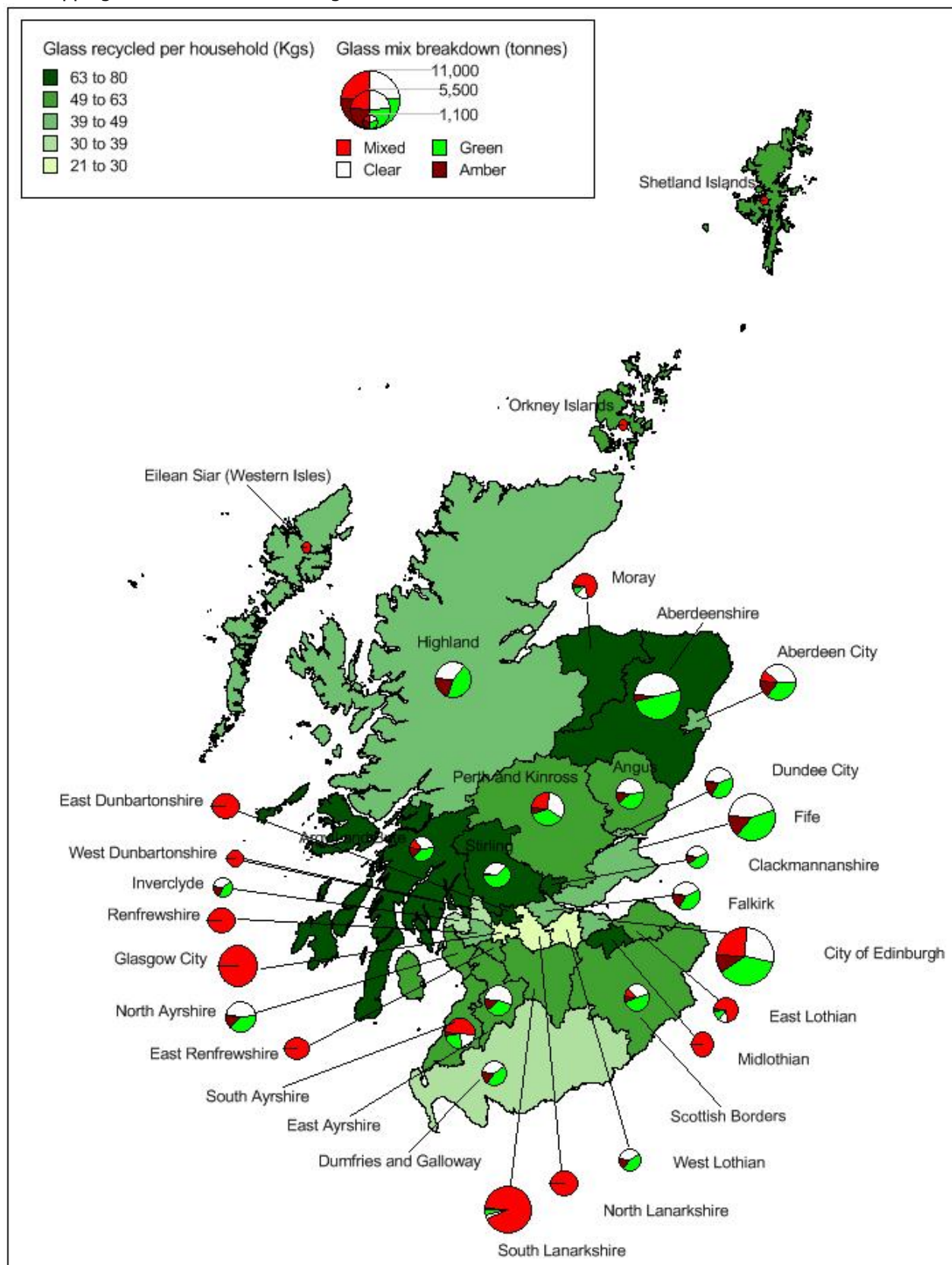
### 6.5 Summary of Local Authority collected container glass waste

**Figure 7** overleaf summarises the dataset for Local Authority collected container glass waste. The background colour is shaded according to the recycling rate per household (the darker colours indicate higher glass recovery rates). The pie charts for each local authority area show the glass outputs, by colour separated glass and mixed glass fraction.

When these two factors are seen together, it becomes clear that there is no strong correlation in Scotland between higher overall recovery rates (i.e. darker shaded areas), and mixed glass collections. This is an interesting finding

given that a frequently used argument for mixed glass collection is that while quality of cullet may suffer, quantity overall is substantially increased. Note that, in statistical terms, this does not *prove* these factors are unrelated, just that other factors are *better* explanations for higher and lower performance.

**Figure 7:** Mapping of collections rates and glass colour breakdown





### 7 Commercial & industrial collections of glass wastes

There is limited data available on total of Commercial & Industrial (C&I) glass arisings, and less still on collections of C&I glass by the private sector (i.e. C&I collections not undertaken by LAs). Scotland's Zero Waste Plan<sup>4</sup>, states that '....In the medium to long-term SEPA will move towards collecting and publishing information on the individual material streams (e.g. paper, glass) in Scottish waste.....' (Section 9.4). Until this material specific assessment is produced in line with the plans set out in Scotland's Zero Waste Plan, SEPA continues to produce estimates of total C&I waste arisings by extrapolating from a 2006 SEPA survey, and therefore the confidence in this data is low. Figures, including for glass arisings, are published annually as part of the SEPA Waste Data Digest.

The extract showing the breakdown of C&I glass waste by industry sector for 2009/10 is shown in **Table 2** below. As this does not include construction and demolition waste, little or no flat glass from this sector is included. One particular sector which is excluded from consideration for the purpose of this report is the 'Non Metallic Minerals' sector, as this relates to manufacturing of non-container glass including pyro-ceramics, glass tableware, sanitary ware etc, all of which are not relevant to container glass recycling. This gives a best available estimate of 108,936 tonnes of C&I container glass waste arisings in Scotland annually.

**Table 2** Waste glass arisings by commercial/industrial sector type

Commercial/Industrial Sector	Estimated Glass waste (tonnes)
Agriculture, Forestry and Fishing	441
Mining and Quarrying	39
Food and Drink	17,728
Wood and Wood Products	5
Paper and Printing	32
Chemicals	732
Non Metallic Minerals	12,027
Machinery & Equipment	7
Misc Manufacture	15
Water and Sewerage	1
Waste Disposal and Recovery	12
Wholesale & Retail	20,258
Transport	4728
Hotels & Restaurants	48,308
Communication	17
Finance	540
Real Estate	687
Professional & Scientific	461
Admin & Support	176
Public Admin	792
Education	1,480
Health & Social Work	1,612
Arts & Recreation	5,959
Other Service Activities	4,905
<b>Total</b>	<b>120,963</b>
<b>Net of excluded sector</b>	<b>108,936 tonnes</b>

Some of this glass is collected within the municipal waste streams and appears within Local Authority Collected Waste (LACW), where roughly 14% of total glass waste collected is attributed to non-household sources. There is no separate data source which draws together the additional container glass collection activity undertaken in the private sector, and estimates of this must be constructed from other sources. This has been calculated by taking the known quantity of recovered container glass waste in the UK from published packaging waste recycling estimates, and including a pro rata amount representing Scotland's population as a percentage of the UK population (8.4%).

<sup>4</sup> Copy available at: <http://www.scotland.gov.uk/Resource/Doc/314168/0099749.pdf>



After deducting the known tonnage of C&I glass waste collected within LACW, this gives an indication of private sector glass collection activity. The amount estimated is roughly 38,000 tonnes per annum. – a relatively low recovery rate overall for C&I glass at just under 48%, which is well below the UK-wide glass recycling rate of 60.1% in 2010.

## 8 Total Glass Arisings in Scotland

### 8.1 Current glass collected for recycling

Taking the two main sources of arisings, Local Authority Collected Wastes, and Commercial and Industrial Wastes, discussed in the preceding sections gives a total estimated quantity of glass arisings in Scotland. It should be recognised that Scotland cannot be wholly considered in isolation from the totals for the UK as a whole as glass waste, and processed glass cullet can move freely between the home nations to access treatment infrastructure, centralised processing locations, or end markets. Many of these movements of material are large relative to the overall glass flows and not recorded in publicly accessible datasets. Some are considered commercially confidential by those who hold the data. Some degree of uncertainty therefore remains.

The following table sets out the estimates of current upper and lower estimates for both household and C&I wastes and the overall total for container glass in Scotland. The table uses the following assumptions:

- A rate of growth of 1% annually for container glass has been applied, as per the DEFRA projections provided within the recent Packaging Waste Regulations amendment consultation. This has been used to project changes in tonnage over the next five years.
- Lower estimates for household glass are based on total glass arisings, as per the DEFRA projections for the UK, with a pro rata quantity of 8.3% allocated, representing the proportion of the UK population resident in Scotland. This assumes no variation in consumption patterns between Scotland and the UK as a whole.
- Upper estimates for total household arisings are based on figures cited in Scotland's Zero Waste Plan, 248,000 tonnes in 2010, plus the SEPA estimates of total C&I waste 108,936 tonnes for 2011 (14% of which is included in the data for council collected waste and so an assumed 14% or 35,000 tonnes of C&I has been removed from the 248,000).

**Table 3** Upper and lower estimates for household and C&I was glass arisings in Scotland

	Year					
	2012	2013	2014	2015	2016	2017
Lower estimate of total container glass waste arisings, including both household & C&I sources.	231,000	235,000	237,000	239,000	242,000	244,000
Midpoint estimate	276,500	280,000	282,500	285,000	287,500	290,000
Upper estimate of total container glass waste arisings, including both household & C&I sources	322,000	325,000	328,000	331,000	334,000	337,000
Kilogrammes per household of container glass waste produced, based on upper estimate in range.	128	129	131	132	133	135
Container glass as a percentage within total tonnage of household and C&I waste.	3.19%	3.23%	3.26%	3.29%	3.32%	3.36%

The table also includes a calculation of the total number of kilogrammes of container glass produced per household based on the upper estimate in the range in the table, and a calculation of the total container glass and a percentage of the total of household and C&I waste. These two sets of figures are included to give an additional reality check on the estimates themselves.

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The kilogrammes per household calculation gives an unexpectedly high figure, and with the inclusion of C&I waste, the upper estimate would indicate a composition of 3.35 to 3.52%. While the tourism and hospitality sector, which produce a higher level of container glass waste than other sectors, is particularly important in Scotland's economy, these estimates seem high, and more robust estimates and supporting evidence are needed. Scotland's Zero Waste Strategy states an intention to develop better evidence and estimates for specific material streams, and these estimates will need to be updated to reflect the findings from that process.

## 8.2 Potential increases in glass collected for recycling

Not all Scottish councils currently undertake kerbside collections of glass from householders, as would be required by the proposed Waste (Scotland) Regulations 2012, and some have not yet extended the service to all households. If the regulations are implemented as currently set out in the consultation document, it is possible to approximately model the potential for increased future supply of collected glass.

Table 4 sets out estimates of potential additional tonnages of glass which might be expected to result from the end of 2013 from councils implementing the new regulatory requirements. The table also sets out the assumptions made to estimate the figures provided. This additional glass could be collected within mixed recyclables, as mixed glass, or as colour separated glass, and the exact detail of the duties required under the regulations are not yet fully clear. The figures are based on the assumptions that increased rollout of services and higher priority being placed on recycling will increase overall recycling levels to at least the average current glass collection rate per household.

**Table 4** Estimates of additional tonnages of glass following the new Scottish regulatory requirements

Assumptions made	Potential tonnage
1. That all councils who currently do not provide kerbside container glass collections to households (a total of 8) will implement these services in accordance with the currently stated requirements of the Waste (Scotland) Regulations 2012, and achieve at least the average collection rate achieved by councils which currently operate kerbside collections (currently 56.7 kg/hh/yr actually being achieved now by the other Scottish councils)	Roughly 20,000 tonnes
2. Likely increases in collection rates in Scottish councils more generally, arising from increased policy and legislative focus on collection of recyclable materials, and continued rollout of kerbside services to more households in line with new legislative requirements. Assumes that all councils increase glass collection rates to the current average of 56.7kg/hh/yr (12 are currently below this level now) now being achieved by Scottish councils who provide kerbside collections.	Roughly 16,000 tonnes
3. Estimate of increased C&I collections – not including C&I glass collected by councils. This figure assumes 80% compliance with the new statutory requirement for all non-household waste producers to segregate the specified recyclable materials. This figure is based on SEPA estimates of total C&I glass, and assumes that current overall glass recovery rates for the UK as a whole, hold true for Scotland.	Roughly 36,000 tonnes
4. <b>Total potential increased supply of container glass arising from the new legal duties within the Waste (Scotland) Regulations 2012 as currently proposed.</b> Some of this additional glass is likely to be mixed rather than colour separated, although by 2014, only a very small amount of container glass is likely to still be collected co-mingled with other wastes.	<b>Roughly 72,000 tonnes</b>

Pending Statutory Guidance on the interpretation of the Waste (Scotland) Regulations 2012, there is uncertainty as to the circumstances in which mixed colour collection will still be permitted. It is assumed for the purposes of this report that this practice will broadly maintain its current proportions (just over 40% collected mixed for HH glass and just under 60% when C&I is also considered) as collectors and local authorities become required to justify mixed glass collections this percentage will not continue to grow, but the availability of high quality sorting capacity in Scotland will continue to make mixed colour collection a viable option.

Pending the development of the guidance, and more data on the quality of outputs from colour sorting processes now in development, we have modelled glass collected based on the following assumptions:

1. Bring sites will move to colour separated provision – although small amounts of mixed glass may be collected in remote or difficult to serve locations.
2. Collections of container glass co-mingled with other wastes will cease – other than a very small amount of waste collected from difficult to serve locations.

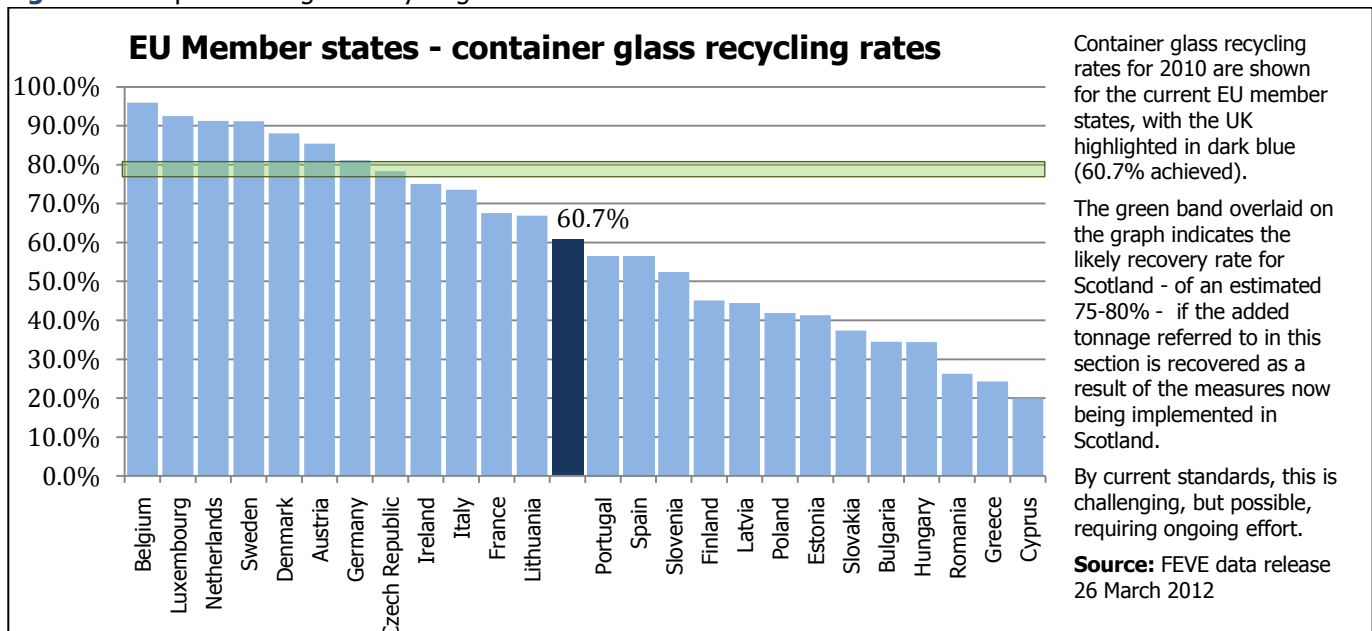
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3. New kerbside collections will continue to be generally colour separated in around half of existing, expanded and new schemes.
4. C&I glass waste will move to to include higher levels of mixed glass, but this will not grow to dominate collection methods (currently around half).
5. Hence overall the proportion of mixed collection is estimated to remain roughly the same.

It is felt that without the Waste (Scotland) Regulations 2012 that points 3,4 and 5 above would be replaced with a continuing and perhaps acceleration of moves to mixed glass collection.

Given the difficulties of producing separate figures for Scotland from datasets which largely apply to the UK as a whole, this should be regarded only as an approximate estimate, which can be further refined when the assessment for total glass arisings set out in Scotland's Zero Waste Plan has been produced. If this increase in glass recovery is achieved, the recycling rate for glass in Scotland would increase to 75-80% (caution - based on mid-point estimate of total glass arisings). This recycling level compares to levels reported in Italy, Germany, and Ireland (see **Figure 8** below).

**Figure 8** Comparison of glass recycling rates within EU member states



Summarising this data gives tonnage estimates for collected container glass in Scotland, covering both household and Commercial and Industrial glass waste. This is broken down into colour separated and mixed glass. Data is shown in **Table 5** below for current collections, and an alternative scenario with revised tonnages due to impacts of proposed new duties to segregate and collect container glass waste, based on the assumptions set out in this section.

**Table 5** Comparison of glass collection rates before and after Scottish regulatory requirements

	<b>Total Glass Collected</b>	<b>Clear glass collected</b>	<b>Green Glass Collected</b>	<b>Amber glass collected</b>	<b>Mixed glass collected</b>
Estimated total glass collected under current services and legal duties (2010/11 data)	144,249	26,517	25,842	8,558	83,332
Estimated total glass collected after full implementation of proposed new duties (after 2013)	216,249	39,753	38,741	12,830	124,926
Change	+ 72,000	+ 13,236	+ 12,899	+ 4,272	+ 41,594

This shows the increased total tonnage of roughly 72,000, but with the likelihood of an absolute increase in mixed glass collected of around 42,000 tonnes. On this basis, the amount of material collected to a quality suitable for remelt after 2013 is already likely to be dependent on the quality and capacity of planned glass colour sorting facilities.

Without the well publicised investments in this colour sorting capacity the assumptions above would need to be adjusted and would need a significant shift to greater colour separated glass collection to meet the requirements of the Waste (Scotland) Regulations 2012.

This basic forecast of mixed and colour separated glass tonnages shows that close to the full planned colour separation capacity in Scotland will be required if the overall tonnage of glass collected increases as anticipated. The ability of the planned new facility to deliver to remelt quality standards at full capacity will be a critical factor in Scotland achieving its ambitions to maximise closed loop recycling of glass.

Ongoing monitoring of the impact of the regulations will be required. If the impact of the regulations is less than anticipated in halting the growth of mixed collection Scotland's ambition to maximise closed loop recycling is unlikely to be met. If the impact of the regulations is greater it may mean that overall growth is lower but a higher proportion is collected colour separated.

## 9 Methods for Glass Collection

The three basic methods of collection – Bring sites (including Civic Amenity sites), source segregated glass collections, and co-mingled collections are reviewed in the following Tables. This sets out key advantages and disadvantages of each method – broken down into mixed glass and colour separated glass where appropriate. The table also includes comments on the potential impact expected as a result of the **Waste (Scotland) Regulations 2012**, including the new duty to collect glass separately, which are now before the Scottish Parliament.

**Table 6a:** Bring site & Civic Amenity Sites

Collection Method	Cost of recovering glass	Quality of material collected	Further Processing Needs	Views of Container Glass sector (cullet end users)	Views of Collection/Waste management sector	Overall suitability of collection method
<b>Mixed Glass Bring or CA Sites</b>	Low to Medium – low actual cost of collection is offset by sorting costs, and probably loss of material value	Lower	Colour sorting and removal of non-glass contaminants	<ul style="list-style-type: none"> <li>Lower quality material produced – often not be suitable for remelt.</li> <li>Higher losses may occur in sorting process depending on whether crushing has taken place.</li> <li>Fails 'quality' and 'quantity' standards in new regulations.</li> </ul>	<ul style="list-style-type: none"> <li>Ease of use encourages higher levels of participation and material collected.</li> <li>Lower cost of collection – although this is offset by processing costs.</li> <li>Colour sorted material reaches sufficient quality for some remelt customers.</li> </ul>	<ul style="list-style-type: none"> <li>The regulations will generally expect bring sites to be colour segregated to achieve the highest cullet quality for remelt uses. But colour sorting may still be economically viable, and achieve quality standards in some cases.</li> <li>Some bring sites where mixed glass is collected may be justified where there are demonstrable constraints of space or other operational factors, and the council or collector has access to high quality sorting facilities, which can ensure that the output cullet reaches remelt market quality.</li> <li>Very rural areas where transport costs are high, and arisings low may be able to justify mixed glass bring sites, but otherwise this option seems likely to reduce substantially.</li> </ul>
<b>Colour separated Bring or CA Sites</b>	Very Low – only limited processing and contaminant removal required	Higher	Removal of non-glass contaminants	<ul style="list-style-type: none"> <li>Higher quality material produced.</li> <li>Lower losses in sorting process – removal of contaminant can be achieved in a single pass with high accuracy.</li> <li>Should be promoted as the default option for glass waste producers.</li> <li>Ensures competitively priced supply of high quality cullet.</li> </ul>	<ul style="list-style-type: none"> <li>High quality material produced.</li> <li>Lower collection cost.</li> <li>Cannot achieve high enough capture rates without other collection methods being used.</li> <li>Some colour sorting facilities question the need for sorting at source given the current technology available</li> </ul>	<ul style="list-style-type: none"> <li>Likely to increase substantially when the new regulations pass into law. Increasing and promoting colour separated bring sites would reduce the added burden on colour sorting in kerbside collections.</li> <li>For glass which is already colour separated with low contamination, fines are less of a problem as they do not affect the cullet quality. Where quality is high at the point of collection, crushing would not be a problem, and may reduce transport costs</li> <li>As well as avoided sorting costs, colour separated glass is likely to generate an income stream for the collector. This has been <i>roughly</i> estimated at £30-40 per tonne differential.</li> <li>PRN income may be higher where higher quality cullet can be used in remelt – after implementation of the proposed closed loop requirements of the new Packaging Waste Regulations.</li> <li>Requires ongoing promotion/publicity to persuade householders to make the effort to keep using the service, and to keep contamination levels down.</li> </ul>

**Table 6b:** Kerbside Collections

Collection Method	Cost of recovering glass	Quality of material collected	Further Processing Needs	Views of Container Glass sector (cullet end users)	Views of Collection/Waste management sector	Overall suitability of collection method
<b>Mixed Glass kerbside collection</b>	Medium to high – relatively low direct collection costs is offset by high sorting costs and loss material value	Lower	Colour sorting, removal of non-glass contaminants	<ul style="list-style-type: none"> <li>■ Lower quality material produced.</li> <li>■ Potential for losses in sorting process</li> </ul>	<ul style="list-style-type: none"> <li>■ Ease of use encourages higher levels of material collected.</li> </ul>	<ul style="list-style-type: none"> <li>■ Likely to be the most contested area of the new regulations. Colour sorting facilities, and some container manufacturers believe that post collection sorting can deliver colour sorted cullet to remelt quality standards, without substantial quantity loss. Other container manufacturers disagree. This remains a residual risk for councils considering mixed glass collections, as if the sorting technology fails to reach a standard required by end markets, further collection service changes may need to be considered (see also section 13).</li> <li>■ The expected position after the ratification of the regulations and publication of the guidance is that, in most situations, colour separated collections should be undertaken, but there may be a case for mixed glass collections where available colour sorting capacity can achieve output quality standards.</li> </ul>
<b>Colour separated kerbside collection</b>	High – but net cost greatly reduced after taking account of avoided sorting cost and material value received	Higher	Removal of non glass contaminants (caps and fasteners etc).	<ul style="list-style-type: none"> <li>■ Highest possible quality material produced.</li> <li>■ Contaminants can be excluded from collections by operatives –no further sorting required.</li> <li>■ Very low losses in sorting process – removal of contaminant can be achieved in a single pass with high accuracy</li> </ul>	<ul style="list-style-type: none"> <li>■ More difficult to achieve in areas of high density housing or high traffic flow, where the slower collection process adds costs and operational difficulty.</li> <li>■ Expensive to deliver services – although this expense is offset by increased income from materials.</li> <li>■ Additional Health &amp; Safety risks at the point of collection – manual handling risks</li> </ul>	<ul style="list-style-type: none"> <li>■ This is the assumed default position for provision of services to waste glass producers – both household and C&amp;I, and would achieve both quality and quantity standards.</li> <li>■ While it is more expensive to provide services, the added cullet value received by the collector, and the avoided sorting cost of glass which is already colour separated makes a substantial contribution towards those extra costs. These will vary according to contracts, but have been roughly estimated £30-40 per tonne.</li> <li>■ Costs of further processing are low, as most contamination is excluded at the point of collection, eg pyro-ceramics and non glass contras.</li> <li>■ Requires ongoing promotion/publicity to persuade householders to make the effort to keep using the service, and to keep contamination levels down.</li> <li>■ For the 8 Councils not currently collecting glass through kerbside collections (and several others who have incomplete coverage of households), this would be the expected method for new service delivery before the start of 2014.</li> </ul>



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**Table 6c:** Co-mingled collections

Collection Method	Cost of recovering glass	Quality of material collected	Further Processing Needs	Views of Container Glass sector (cullet end users)	Views of Collection/Waste management sector	Overall suitability of collection method
<b>Co-mingled recyclates collected at kerbside</b>	Low – but faces additional costs of separating glass, additional costs of sorting glass, then additional costs of processing to remove contaminants	Very low	Initial material sorting for mixed recyclates, followed by colour sorting, further removal of non glass contaminants.	<ul style="list-style-type: none"> <li>Low quality material produced – will often not reach remelt quality requirements.</li> <li>High losses in sorting process.</li> <li>Specialist glass reproducers have indicated that co-mingling only glass and cans would not be an issue as they can be easily separated at their sites.</li> </ul>	<ul style="list-style-type: none"> <li>Ease of use encourages high levels of material collected.</li> </ul>	<ul style="list-style-type: none"> <li>The Regulations indicate that quality standards will be the key factor in determining the terms under which co-mingled collections of glass will be permitted. The Scottish Government seeks to address this by providing guidance that co-mingled collections must achieve similar levels of quality to that obtained via source segregated collections and hence be suitable for closed loop remelt application.</li> <li>It remains to be seen whether the Guidance will make any concessions for remote areas where collection costs may be high and services difficult to deliver, although this would only amount to a very small part of the overall population and glass stream.</li> </ul>
<b>Co-mingled wastes</b>	Low – but very little effective recovery takes place. This can function as a landfill diversion technology, but not as an effective recycling technology	Extremely low	<p>MRF Processing would produce an inert fraction, which may be suitable for low grade aggregate use.</p> <p>Further processing would be unlikely to enable material to reach remelt quality at a viable cost.</p>	<ul style="list-style-type: none"> <li>Will not achieve standards required for remelt sector without extensive processing without significant losses in sorting.</li> <li>Not a relevant method for glass recycling.</li> </ul>	<ul style="list-style-type: none"> <li>Enables further processing of residual wastes to maximise landfill diversion and value recovery.</li> <li>Not intended as a primary route for glass collection – mainly a means of landfill diversion</li> </ul>	<ul style="list-style-type: none"> <li><b>Co-mingling will not be permitted under the new regulations..</b> It is unlikely that this will be allowed in any context after 2014 (other than possibly for a <u>very</u> small number of very geographically remote households).</li> <li>One Council currently providing this service will presumably be required to implement separate arrangements for glass collections before 2014.</li> <li>This may remain relevant to the sorting of residual wastes in the medium term – ie removing any remaining recyclables from waste collected for disposal, where separate collection arrangements for recyclables are in place. But, assuming the new regulations are effective, the sorting of residual wastes will become less viable over time as more recyclables will have already been captured in separate collections.</li> </ul>

## 10 Recovery of glass cullet by MRFs

### 10.1 The impact of MRFs on co-mingled glass

New statutory responsibilities on local authorities to collect recyclable materials from householders will make glass collection at kerbside an increasing area of focus. There was a strong possibility that collection cost pressures would encourage more local authorities to consider including glass in comingled collections, rather than keeping this as a separate stream in its own right. The materials that glass is co-mingled with at kerbside can have a significant impact upon the quality of those materials further down the supply chain and the Scottish Parliament will respond to this through the Waste Regulations (Scotland) 2012. The co-mingling of glass with other materials will not be permitted under the regulations as the container manufacturers will not accept this material.

Only a limited number of UK MRFs that process co-mingled dry recyclables accept container glass as part of the incoming stream and none in Scotland operate in this way. MRFs must be able to operate with minimal residual waste outputs to be cost effective, and provide material outputs that meet the specifications of their customers. Previous WRAP research on MRFs shows that glass is a particularly problematic material in MRFs. Particular issues include

- UK paper mills have concerns regarding glass contamination of the paper, with risks of fine particles becoming embedded during the sorting process. Contaminated paper is generally exported to markets where this level of contamination can be managed, depriving UK mills of valuable feedstock, and the MRF of a premium return per tonne.
- The sharp crushed glass also abrades the MRF processing equipment it comes into contact with, increasing wear rates.
- Crushing equipment in MRFs reduces some of the glass to a particle size below that which can later be mechanically sorted. The smaller size cullet (fines) tends to be sold to the sand blasting or aggregates markets, with a resulting loss to remelt markets which may be 30% or more.
- The glass quality outputs from MRFs are also much lower, compared to colour separated glass. Glass collected through source segregated systems suffers less from cross-contamination as it does not come into contact with other materials. Dedicated glass collection systems are also less contaminated with non-glass materials, particularly where loads can be visually inspected. A major challenge for the glass recycling supply chain is to maintain the quality of the glass collected through co-mingled systems, where the glass must subsequently be separated from other materials.

A number of sorting techniques are available to MRFs for managing glass within mixed recycle streams:

- Manual sorting of glass may occur after containers are separated from the fibre. Typically it occurs early in the sorting process with metals separation at the subsequent stage.
- Disc screens or trommel screens may be used early in the process. This 'negatively sorts' smaller particles, including glass, from the container fractions and paper/card which are then further sorted mechanically and manually.
- The container line passes through a crushing system which flattens plastics and breaks the glass containers. A trommel screen can then be used to sort the glass cullet from larger containers (plastic, aluminium and ferrous metals).
- Air classification systems or glass cleaning units can be used to further classify the heavies from lighter material such as labels, caps, foil, tops and dust. This will present the glass in a cleaner format for onward optical separation if required.

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### 10.2 How MRFs handle glass in Scotland

In the 2010/11 reporting year, it was identified that a total of 40,312 tonnes of mixed glass waste was collected from households by Local Authorities and their contractors, and reported into the WasteDataFlow online reporting system. Collected mixed glass is sent for recycling to a total of 18 facilities, most of which are located in Scotland.

In order to understand how Scottish MRFs handle and process glass at their sites, a basic survey was undertaken. A summary of the key features of the MRFs in Scotland is provided in Table 6. The table only includes MRFs that handle glass at their sites. The following MRFs were contacted but do not handle any container glass at their facilities:

- Binn Farm - SITA, Perth
- Oran, Grangemouth
- SecureRecycle Scotland, Kirkaldy
- Shanks Avondale (not yet operational)
- Shred IT, Edinburgh
- SITA, Aberdeenshire (not yet operational)
- Smurfit Recycling, Glasgow
- William Munro Construction, Evanton

The figures provided in Table 6 are for the estimated quantities of glass handled on site per annum. The figure for the Bonnyrigg site is for total capacity to process glass through its facility as of January 2012. Capacity will increase to 130,000 tonnes with the further investment in sorting capacity taking place during 2012. A proportion of the glass handled at the Bonnyrigg site is flat glass.

**Table 7** A summary of Scottish MRF's handling glass at their sites

Name of Facility	Location	Glass inputs and outputs	Approx annual tonnage	Market
Alloa Community Enterprises	Alloa	Colour sorted	1,500	OI - Alloa
Barr Environmental	Ayr	Colour sorted	100	OI - Alloa
ChangeWorks Recycling	Edinburgh	Mixed colour	150	Viridor - Bonnyrigg
East Ayrshire Council	Kilmarnock	Colour sorted	3,000	Viridor - Bonnyrigg
Eilean Siar (Western Isles Council)	Western Isles	Mixed colour	500	Siar Glass (decorative)
Glasgow City Council	Glasgow	Mixed colour	6,500	Viridor - Bonnyrigg
Inverclyde Council	Inverclyde	Mixed colour	1,000	OI - Alloa
Lowmac Alloys - North Ayrshire	Irvine	Both	1,500	Viridor - Bonnyrigg
Shanks, Blochairn MRF	Glasgow	Mixed colour	550	Viridor - Bonnyrigg
Shanks	West Lothian	Mixed colour	1,700	Viridor - Bonnyrigg
Shetlands Gremista	Shetlands	Mixed colour	600	Enviroglass aggregate and filtration media
Viridor at Bargeddie	Glasgow	Both	9,200	Viridor - Bonnyrigg
Viridor Gilmerton	Edinburgh	Both	1,800	Viridor - Bonnyrigg
Viridor Glass - Bonnyrigg	Bonnyrigg	Both	100,000	Fibre glass, concrete blocks, remelt, and aggregates
William Tracey - Linwood	Paisley	Both	4,500	OI - Alloa

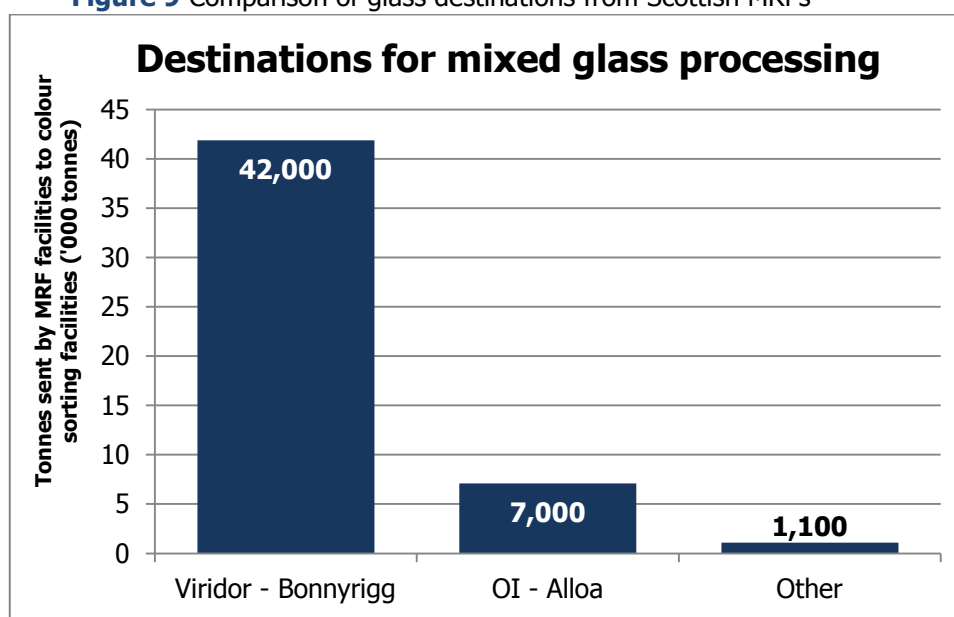
*NB: It should be noted that these totals relate specifically to MRFs handling glass in Scotland and do not include additional transfer stations also handling and bulking up glass. This is therefore a proportion of the overall container glass being handled in Scotland, not the total.*

In parts of the UK, some of the older MRFs have sought to add additional technologies to enable them to accept glass. In Scotland however, the existing network of MRF facilities have chosen to avoid passing glass through their sorting processes. Those handling glass perform no sorting process on it and merely act as a bulking point for glass where it can be consolidated and sold on in its existing form. The only exception to this is the specialist glass reprocessing facility operated by Viridor at Bonnyrigg. This facility is discussed in more detail in Section 11. Half of the MRFs provide colour sorted glass output, but this is only transfer of existing collections of colour separated glass.

The reasons given by the MRFs for not processing glass through their facilities are consistent with the findings from MRF related literature detailed above. Operators are concerned about the costs of investing in glass separation technology if there is a risk of this impacting negatively upon the quality of output material, including paper. Another major concern is the impact glass can have on the maintenance of a MRF. Glasgow City Council did consider including glass in their MRF process, but on visiting a number of English MRFs they were put off by issues relating to the wear and tear of sorting discs and conveyors. The recently refurbished MRF run by Shanks at Blochairn in Glasgow had plans to separate glass through its process. In anticipation of Glasgow City Council and others seeking to co-mingle glass in kerbside collections in the future, Shanks invested in a glass separator and destoner. However, the equipment was not incorporated into the process after the Council decided not to pursue this strategy.

The main outlet for the glass being bulked up at MRF sites in Scotland is Viridor. **Figure 9** shows the main processors for mixed container glass initially handled by MRFs. This includes the material delivered directly to the Bonnyrigg facility.

**Figure 9** Comparison of glass destinations from Scottish MRFs



Over 80% of material handled at these MRFs is sent there. Part of this stems from Viridor's strong collection service, with many councils contracting Viridor to deliver all or a proportion of the glass collection service for them. Their ability to access material at source enables them to fulfil a significant proportion of their container glass capacity at the Bonnyrigg facility. None of the MRF facilities have plans to further invest in glass sorting capabilities in the short term. The main concern for them is local authorities incorporating glass with other materials at kerbside and their ability to manage this material.

Currently, the only multi-material co-mingled glass collected at kerbside in Scotland is from East Lothian Council. The glass requires separation from the other materials and is sent to a facility in Blackburn, England where the sorted glass is used in the aggregates market.

### 11 Impact of the Waste (Scotland) Regulations 2012

The draft Waste (Scotland) Regulations 2012<sup>5</sup> set out a number of important new duties which apply from 1 January 2014, including:

- Non household waste producers must present recyclables waste separately for collection.
- Recyclable materials must be separate from each other to enable their recycling into the preferred (i.e. lower carbon impact) method of recovery – which will usually be closed loop end uses.
- Any mixing of different waste types must not reduce either the quantity of any of them that can be recovered, nor the quality of the material recovered.
- Those collecting waste have a duty to collect wastes in accordance with these material separation requirements.
- Local authorities must provide collections of recyclable materials to households which are similar to those for non household producers as above.
- Opt outs for household service provision may apply to rural areas, and where the authority can show that material collected at kerbside would be already being collected through bring banks.
- Local authorities have a duty to provide collections of recyclable waste to business on request.

This will prevent local authorities including glass in co-mingled kerbside collections after 2013, and it is assumed that current co-mingled schemes will be phased out. The guidance to the regulations is expected to be published in summer 2012, and is expected to reinforce the requirement for colour separation of container glass waste at source to the extent that growth in the proportion of glass collected mixed will stop. It is anticipated that mixed glass collection may still be possible, but where mixed glass is collected, it must produce an equivalent yield of glass suitable for remelt, as glass which has been separated by colour at source. In this context, yield should be taken to indicate the net amount of glass produced, after all processing and sorting operations, which meets closed loop remelt quality standards. For example, a collection scheme which collects mixed glass, but succeeds in collecting 20% more glass than an equivalent colour separated collection service, could be justified under the new rules if the losses during sorting and processing did not exceed this additional 20%.

Given the high volumes of mixed glass anticipated and the dependency on colour separation, the operational efficiency, oversight of quality and end markets receiving the colour separated glass will be critical to ensuring the provisions of the Waste (Scotland) Regulations 2012 are actually being met, in the short and longer term.

This guidance will therefore prompt local authorities to consider carefully what happens next in the supply chain. If mixed glass material is collected, the next stage of sorting must deliver sufficient quantities of quality cullet suitable for remelt to meet the regulatory requirements. Pending final confirmation of the legal duties from the Scottish Parliament, there is not likely to be a demand for MRF sorting which includes glass within the recyclables stream. For the mixed glass which is collected, it is expected that MRFs will continue to provide a transfer facility, where material is transported to specialist glass re-processors, which are considered in more detail in Section 11.

A landfill ban is also proposed on any glass waste collected. This would ensure that even low quality glass collected must be recycled. However, SEPA data suggests only 191 tonnes of glass waste was disposed of to landfill in 2009/10. A landfill ban will encourage better sorting at source by waste producers and reduce glass within mixed waste. This obligation is also likely to encourage more rigorous control of collection and handling processes, and the tightening of segregation and quality standards on glass waste producers by collectors.

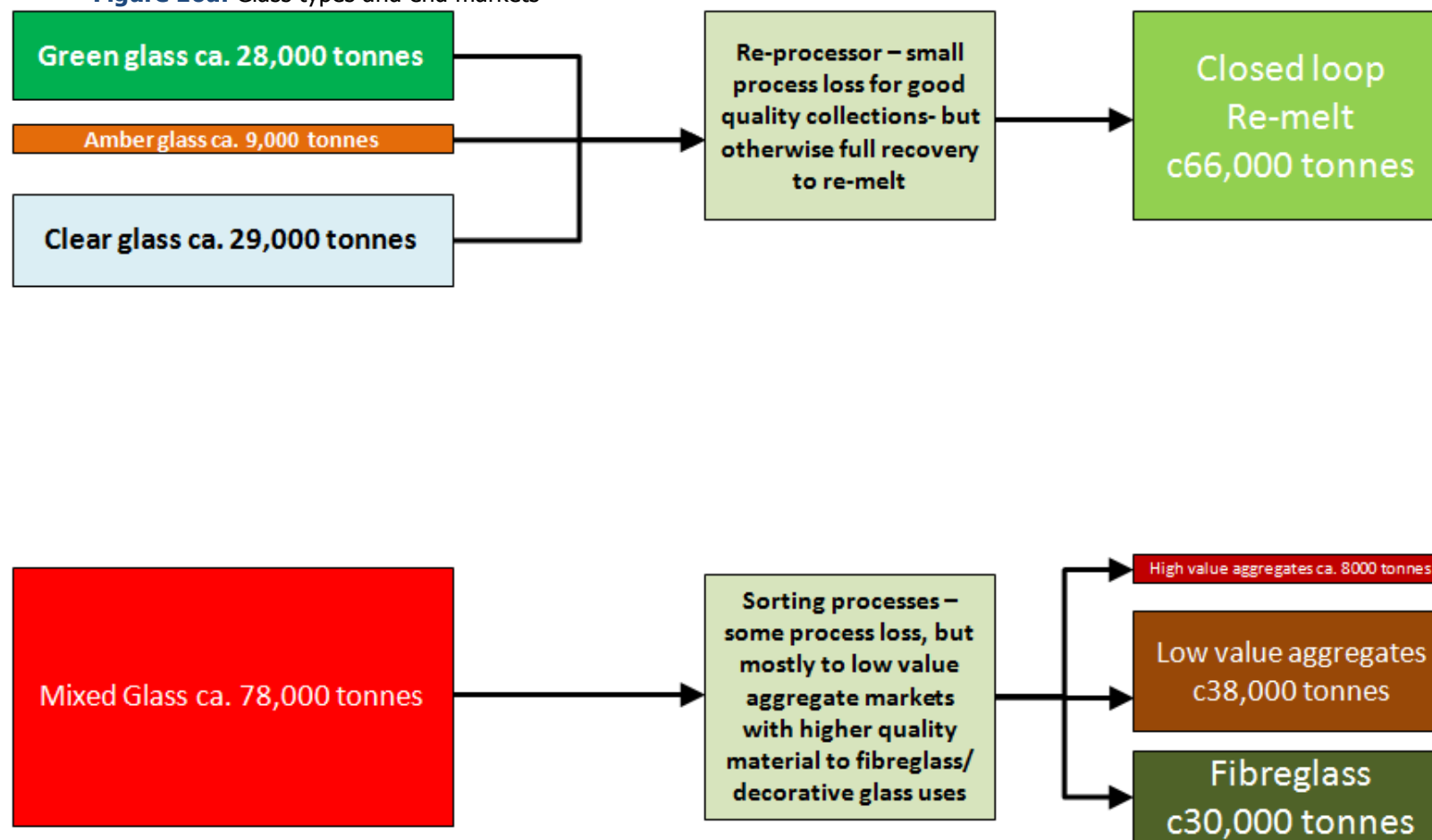
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<sup>5</sup> Original text of draft regulations can be found at [http://www.legislation.gov.uk/sdsi/2012/9780111016657/pdfs/sdsi\\_9780111016657\\_en.pdf](http://www.legislation.gov.uk/sdsi/2012/9780111016657/pdfs/sdsi_9780111016657_en.pdf)

## 12 Fates of colour separated and mixed glass in end markets

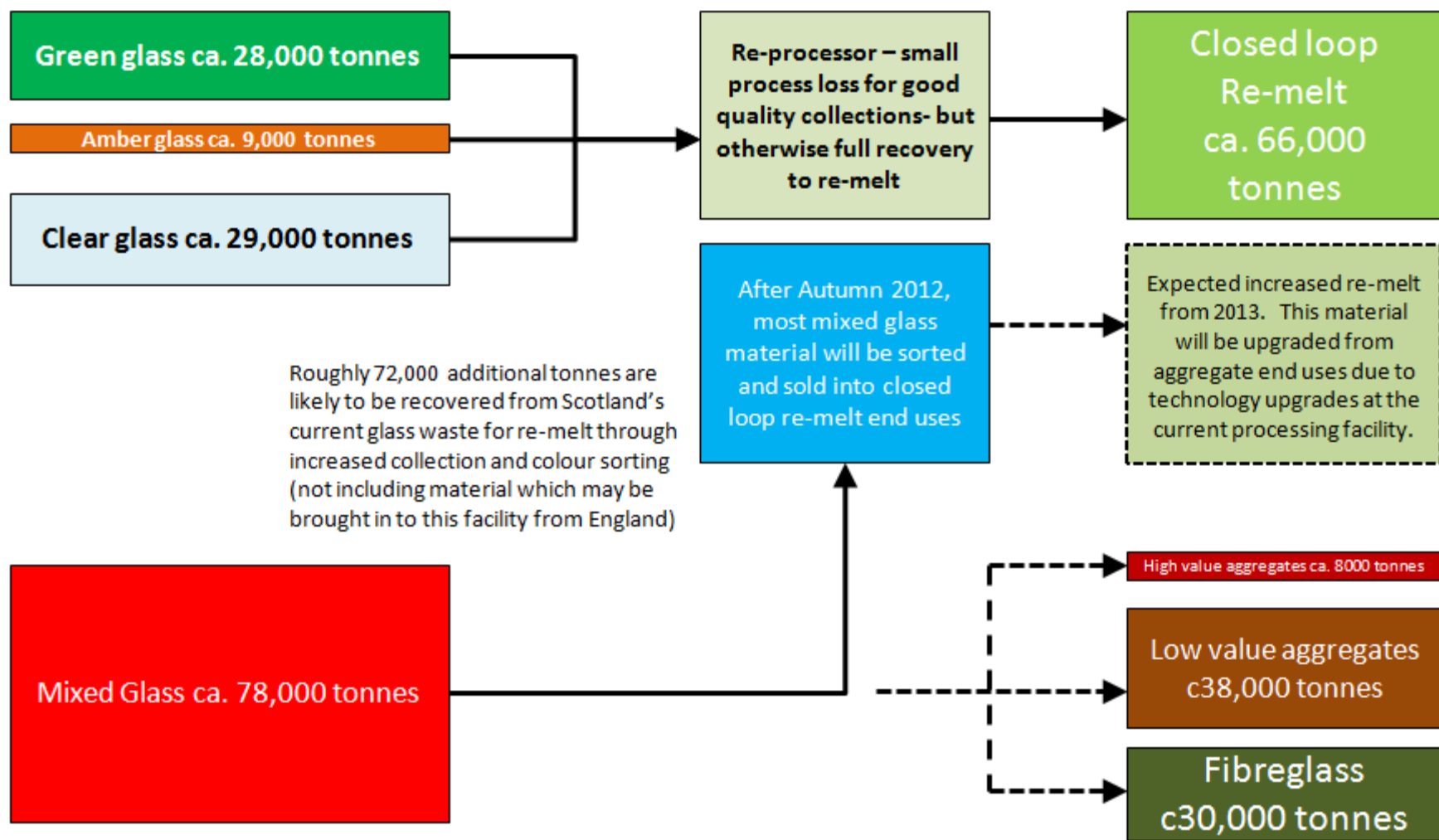
Figure 10a and 10b below illustrate the current fates of collected container glass material in Scotland, based on 2010/11 data. On the left hand side, the glass inputs are shown (blocks are shown to scale according to total amounts) representing the actual amount collected in Scotland by LAs and private sector companies, based on the modeling undertaken for this report. In the centre the activities of processors and sorting facilities are shown - from autumn 2012, newly available colour sorting capacity will process much of the mixed glass collected into closed loop remelt markets – this is shown with the blue box and dotted lines in Figure 10b. On the right of the diagram, the end fates are shown – including expected changes in end uses.

**Figure 10a:** Glass types and end markets



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**Figure 10b:** Glass types and end markets





## 13 Outline cost benefit analysis for glass collection options

This study also sought to draw together available information on the costs and benefits of the different approaches to glass collection which would be applicable in the specific context of Scotland and produce outline recommendations. These recommendations are intended to provide guidelines for Local Authorities on methods which are likely to be suitable, but each Local Authority would need to develop their own business case to inform their choice of service delivery, based on locally specific information from their own research. This section should be read as an indication of method to be followed in assessing the business case for different collections options, illustrated by cost examples, rather than an attempt to directly calculate the costs which would apply to individual Scottish Local Authorities.

A central problem of seeking to produce estimates of cost for different collection options is that many of the existing studies generalise from a relatively small number of collection datasets, when the actual variation between the whole set of authorities may be quite large, and results may be linked to factors not directly connected to collection method, such as demographics, local markets, labour costs, and procurement approaches.

### 13.1 WRAP Kerbside collection options: Wales study, 2011

The study which is most comparable to the operating context in Scotland is **Kerbside Collections Options: Wales**, which was published in January 2011 by WRAP for the Welsh Assembly Government (WAG). This extensive study collected data from six case study authorities throughout Wales, including examples of rural and urban collections. The study reviews costs and related them to collection methods to arrive at a whole cycle costing for each collection method, including making allowances for differences in material capture rates and material values after processing.

However, this comparison should be approached with caution as a number of important differences exist between that study and this, notably:

- The Wales study was based on actual costs incurred and analysed, whereas this study was undertaken on a much smaller scale and did not derive direct cost data from any of the Scottish authorities. The sample size was small, and results may not easily be generalisable to all Scottish authorities.
- The Wales study did not make reference to colour sorting of glass to achieve remelt applications, which is not a requirement of the Welsh Assembly. This can be addressed by adding these additional costs to the calculations provided in the report.
- The geography of the authorities within the study is mostly less challenging than in Scotland, resulting in transport costs much lower than typical for the most remote areas. However, for most Local Authorities, the Welsh study is likely to produce useful lessons.
- There are clear market differences in that Scotland has large scale glass colour sorting facilities, and container manufacturers which are likely to make colour separation cost effective in more cases than in Wales, where the longer transport distances may result in mixed glass being used in low value non closed loop markets.

Despite these differences, a simple methodology was used to extract relevant data from the WAG 2011 report to produce comparison scenarios for Scotland. Cost estimates (page 32 of report); material capture rates and reject fractions (page 36) were taken for the three scenarios of full kerbside sorting, twin stream (glass separate) and co-mingled recyclables.

The notional cost of collecting glass was calculated based on glass making up 21% of total recyclables collected (i.e. that 21% of total collection cost could be attributed to glass). Allowance was made for the further cost of sorting glass and associated process losses during colour sorting, drawing on data obtained and outlined in section 14.3 of this report. The objective of this was to:

- Establish the likely amount of glass which might actually be recovered in the three potential collection scenarios for comparison – the '**Quantity**' requirement of the new regulations.
- Calculate the likely losses in processing for typical glass waste streams in order to reach an acceptable standard for use closed loop container remelt end uses – the '**Quality**' requirements of the new regulations.
- Indicate the relative costs incurred in reaching these standards in terms of cost per kilogramme of glass waste recovered in closed loop end uses.

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### 13.2 Cost benefit calculations for different collection methods

The result of this calculation is set out in **Table 8** below. The calculation is set out fully in **Appendix 1**, which also sets out the basis for each of the assumptions made.

Collection Method	Glass recovered to remelt per household (kg)	Net cost of recovering this quantity of glass, inc colour sorting	Cost per kg recovered to closed loop remelt end uses
Comingled collections (i.e. mixed recyclables)	24	£5.72	£0.24
Two stream collections (i.e. glass separate)	28	£5.34	£0.19
Kerbside collections (colour sorted collection)	29	£3.57	£0.12

**Table 8:** Potential cost and yield comparisons for the three collection methods

This calculation shows that the net cost of kerbside colour sorting, per kilogramme of mixed glass recovered to remelt standard, is around half that incurred in comingled collections, and the amount recovered is over 20% higher. The original study also found that the net service cost was lower in absolute terms for Kerbside recycling. This calculation indicates that, *in principle*, kerbside sorting is the most likely option to achieve the 'Quality' and 'Quantity' requirements of the Waste (Scotland) Regulations 2012, and at lowest overall cost, based on the findings of the 2011 study.

An often cited advantage of comingled collections is that they collect higher volumes of materials as a result of higher participation, and that the loss of quality is compensated by the increase in quantity. This calculation indicates that process losses in sorting are likely to exceed the additional material collected where glass is concerned, and the net material recovered is lower overall – at least where closed loop recycling is the objective. But it is also clear that a two stream collection (i.e. with glass separated from other recyclates but mixed by colour) can achieve almost as much remelt quality glass, albeit at higher overall cost.

While these calculations are rooted in real recycling collection data from local authorities, the sample sizes are quite small and the differences between different types of Local Authority areas are lost in the averaging of data. As a result, these calculations may not apply directly to all Local Authorities in Scotland. Each local authority will need to review its own operations, both against the Statutory Guidance from the Scottish Parliament (when it is published), and in relation to current service contract terms to develop a locally specific business case for collecting glass and other materials. While the evidence above suggests that colour separation will be the most cost effective way of achieving quality standards for closed loop recycling, there may be exceptions:

- LAs which are close to the colour sorting facility at Bonnyrigg, when it is fully operational, could find that mixed glass collection remains cost effective, due to much lower transport costs.
- Some LAs with high density housing may find increased colour separation difficult practically due to lack of space to store bins for separate colours. This may necessitate some continued collection of mixed colour glass.
- Where a change from a current service to kerbside sorting requires significant capital investment in new vehicle types etc., the cost of changing to new service methods may outweigh the potential for savings.
- Where current contractual arrangements may commit LAs to a particular collection method for a contract period, the costs of seeking to negotiate changes may be disproportionate to the savings, and it may be more effective to postpone change until contracts fall due for renewal.

There are potentially long lead-in times for undertaking changes in collection approaches, and there will be a need to consider communication strategies with householders and other users where any change is implemented. Local Authorities will therefore need to undertake a service review of costs and delivery methods, when the guidance is available, based on their own local circumstances, to understand which collection option will deliver the best results. Clearly this will apply to all recyclables, and not only glass collections.

## 14 Colour sorting equipment for mixed glass waste

### 14.1 Issues with contamination

As we have found in Section 6, over 50% of the container glass collected from both domestic and commercial/industrial sources is mixed colour glass, meaning that further colour separation is likely to be required to enable processing back into container form. While, some container manufacturers are able to use a small proportion of mixed glass and even uncontaminated mixed glass fines in green and amber glass furnaces, this seems to be generally glass residues from their existing feedstock which they are utilising, rather than material they have sourced on the open market..

In Scotland and the rest of the UK, the only facilities capable of sorting glass to this level, are specialist material recovery facilities (MRFs), linked to glass reprocessors. These MRFs target only glass and handle glass that is separately collected or has been separated from other material streams. In Scotland, mixed glass is collected separately from other materials, consolidated and sold to these specialist reprocessors. Single stream glass collections still have the potential to suffer from contamination, something cited by the MRFs spoken to in Section 10. The importance of clear communication to consumers on how to prepare glass for recycling is therefore of vital importance to the closed-loop container supply chain.

Material that is co-mingled, requiring segregation at a MRF, is even more liable to become contaminated with other materials. Container glass, whilst requiring colour separation, is very sensitive to additional contaminants, which must be removed in order to be suitable for remelting back into containers. The container industry uses soda-lime glass due to the specific properties that make the material suitable for container manufacture. Glass which does not have a soda-lime physico-chemical composition is therefore an additional contaminant.

Contaminants can be summarised into 2 categories:

#### 1. Non-glass material contaminants

- Metals
- Non-metal, non-glass inorganics
- Ceramics, stones and porcelain (CSP)
- Glass ceramics or pyro-ceramics (ie heat resistant, non-glass ceramic material)
- Organics (food, textiles, wood)
- Hazardous materials still in the containers

#### 2. Glass material contaminants

- Lead-crystal glass
- Borosilicate glass from lightbulbs and fluorescent tubes

The key contaminants, which prove most problematic to glass manufacturers and their supply chain, are non-metal, non-glass inorganics, CSP and pyro-ceramics. These materials have a higher melting point than glass and have the potential to cause product defects if they do not melt in the process. Optical sorting is now very sophisticated and can help to reduce CSP levels to around 25-50g/tonne (Van Santen and Beerkens, 2005).

Pyro-ceramic contamination is a more recent issue for the glass industry, and is particularly problematic. The material is difficult to detect in the raw cullet, causes defects in finished products and can block the liquid glass flow in the glass moulding machinery. The technology for removing pyro-ceramic contamination is now available, and is still in its early stages of commercialisation. Avoiding this kind of contamination at source is therefore a key message for those involved in the collection of glass.

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Metals are the other most serious form of contamination. They fall to the bottom of the glass furnace and can react, giving rise to gas bubbles in the glass melt, again ending up in the finished product and causing rejects.

Parameters for the minimum levels of acceptable contamination are outlined in the PAS 101 guidance, which is a specification for quality and guidance for good practice in container glass collection. PAS 101 seeks to harmonize various independent specifications to provide a comprehensive specification for all raw container glass collected in the UK for recycling. It introduces a four tier grading system for raw cullet quality, grades A to D, according to the degree of colour separation, contamination and particle size.

**Table 7** Quality grading system and acceptable contamination levels under PAS 101

Contaminant	Grade A	Grade B	Grade C	Grade D
Other colours	4-5%*	6-30%*	Any	Any
Organic	0.5%	0.5%	1%	N/A
Inorganic	Unspecified	Unspecified	Unspecified	Unspecified
Ferrous	0.1%	0.1%	0.2%	N/A
Non-ferrous	0.2%	0.2%	0.4%	N/A
All contaminants	N/A	N/A	N/A	N/A

*\*Depending on the colour of the cullet supplied. Clear is the least tolerant, whilst green is the most.*

It is possible to operate furnaces on 100% cullet, however 90% is a more realistic maximum level. If exacting quality standards, taking account of the contaminants just discussed, can be maintained constantly. Green glass furnaces have traditionally operated on the highest percentage of cullet, with clear and amber glass bottle manufacturer more limited due to less availability, technical issues and tighter colour specifications.. The maximum cullet levels for clear furnaces is 50-60%, possibly lower for the premium quality and clarity flint glass produced for the spirits industry. Amber cullet restrictions are 60-70%. It is also, in some cases, possible to incorporate mixed cullet into green glass furnaces - in small managed concentrations. Typical limits for green glass are between 10 and 15%.

“Fines” are produced by all glass processing operations, transfers and transport. They are viewed as the most problematic issue for glass reprocessors. Fine material is classed as material that is too small to enable optical separation by colour or the detection of pyro-ceramics (typically less than 5mm). This is something the specialist glass reprocessor has no control over once the material has been delivered to the facility. The threshold for what is classed as ‘fines’ is not fixed. As technology advances, the definition of the minimum inspection threshold for size drops. A facility is only able to sort particle sizes to the specification of the technology it uses.

Fines are generated as the glass is crushed earlier in the supply chain, during collection, sorting and transportation. The crushing technologies employed at multi-material MRFs to separate materials by density are particularly destructive to container glass and can result in the generation of fines below the optical sorting thresholds. This means the material is unacceptable to the closed-loop supply chain.

The ability to remove contaminants, and separate fine particles of glass material by colour are the key selling points for technologies designed for high-value glass reprocessing. In a fast moving, highly competitive and energy intensive sector, it is important to understand the latest capabilities of the equipment on the market.

Data on the varying quality of glass obtained through different methods of kerbside collection is not currently available in Scotland, but some insight has been gathered in the form of industry views on the quality of glass arriving at reprocessing and manufacturing facilities in Scotland.

Based on reprocessors experience, local authority mixed colour kerbside glass collections tend to contain around 2% to 10% contamination from other non-glass materials. This is generally a mixture of metals, wood, paper, plastic, textiles, ceramic, stone, porcelain and organics.

Where glass is further co-mingled with other containers (i.e. plastic, metal and glass), contamination increases further, typically in the form paper and organics. Organic material attached to glass is one of the key contamination issues for reprocessors seeking to achieve remelt quality.

Glass collected at kerbside in single colour streams has the lowest levels of contamination. However, some glass processors can remove the sort of contamination described above and are neutral towards colour separate or mixed collections.

Inevitably higher levels of contamination have an impact on the prices paid, so it is in the interests of the local authorities to minimise contamination wherever possible.

There is consensus amongst stakeholders that the implementation of the Waste (Scotland) Regulations 2012 will work to improve quality if it can be enforced. A move away from co-mingled collection will help to avoid issues of organic and fibre contamination, and the generation of fines during the collection and sorting stages

Contamination levels have the potential to be further reduced if glass is collected in single colour streams. However, this can be at the cost of additional investment in the collection system. Each Authority will be required to make a judgment call as to whether this additional increase in quality is necessary based on its specific context and the type of remelt markets it (through its recycling contracts) has access to.

## 14.2 Separation technologies

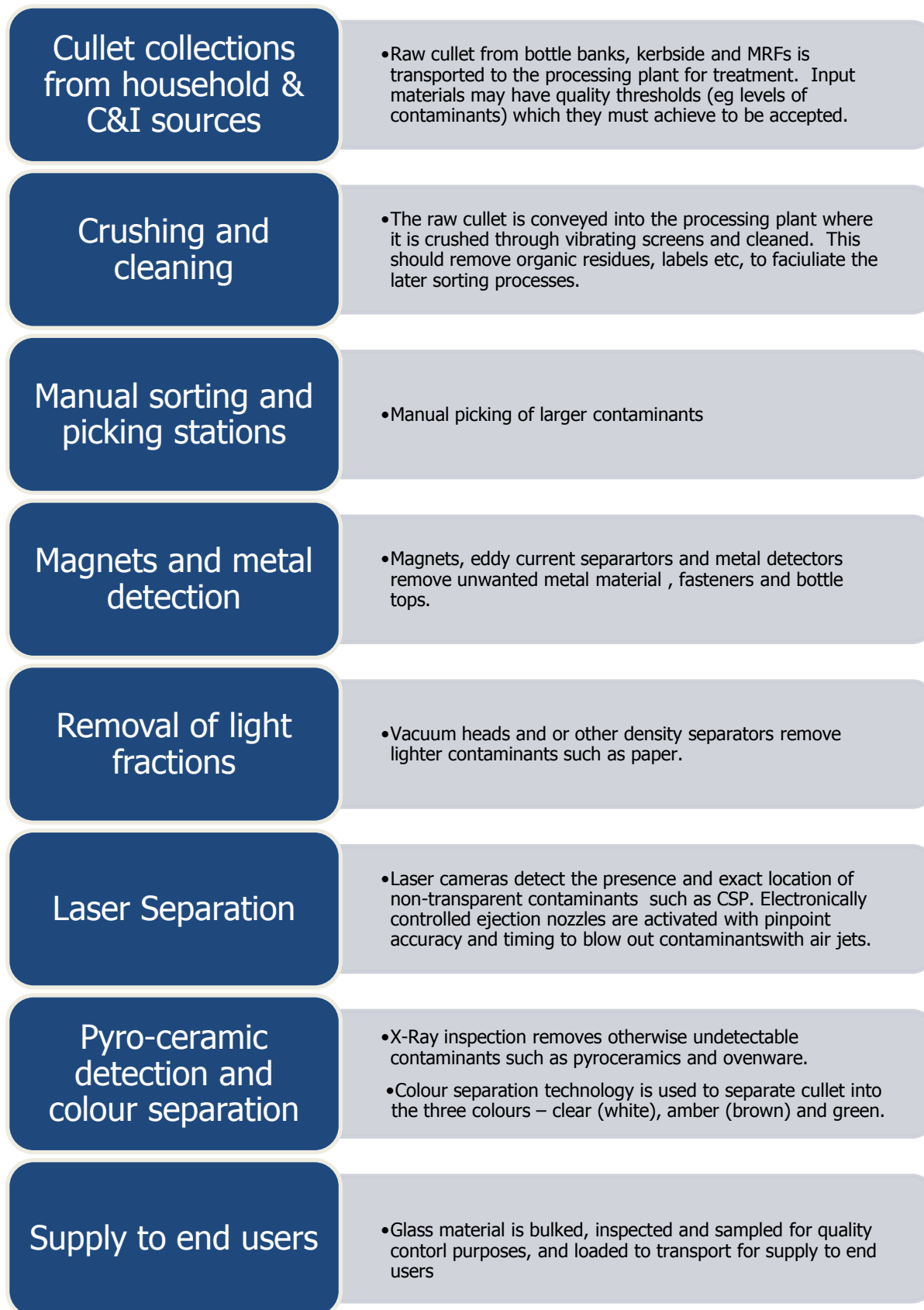
The separation of cullet from contaminants and by colour is extremely important and often contentious for the container manufacturing sector. Most processors are equipped with magnetic and eddy current separation for the removal of ferrous and non-ferrous metals. Some stakeholders have now invested in equipment for colour enhancement (to further improve the quality of a colour sorted stream) and colour separation (to sort a mixed coloured glass stream). Further investment is now taking place in the glass reprocessing industry to roll out and improve pyro-ceramic detection systems to further improve cullet quality and access to feedstock.

These systems have a high capital cost and to combine them is only financially viable on high throughput plants. This is why specialist glass plants have been the focus for investment in this kind of glass-specific sorting technology, as opposed to multi-material MRFs. At the time of writing, there are three stakeholders in the UK that have invested in facilities under their management to develop state-of-the-art glass-specific colour sorting facilities with the capacity to colour sort and remove contamination to a level suitable for remelt. These stakeholders are Viridor, Recresco and Berryman. Viridor is in the process of investing in brand-new colour sorting technology at its glass reprocessing facility in Bonnyrigg in Scotland. Previously, the main proportion of glass reprocessed here was sold into the fibre glass industry. This will be the only facility with colour sorting capabilities in Scotland and will be one of the most advanced glass sorting facilities in the world when it becomes operational from Autumn 2012.

The technology employed in such facilities is continually advancing, allowing them to process glass that would previously not have been acceptable for remelt quality reasons. The specific technologies and their configuration vary across the different operators and is of a commercially confidential nature. As a consequence, specific operating models are not provided in this report for the three stakeholders mentioned. As a general rule, each specialist glass facility will incorporate the “typical” processes explained in **Figure 11** with varying degrees of specification.

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**Figure 11:** State-of-the-art glass separation process



There are a number of specialist manufacturers of sorting technology for the glass sector. The specific impact on the quality of the cullet will vary significantly according to the type/size of the input product, what defects need to be removed and the level of technology employed to remove contamination and colour sort. There is therefore no 'one size fits all' solution when it comes to sorting glass. The manufacturers of this type of equipment are able to offer bespoke solutions that can be integrated into most existing systems employed at the customer's facility.

Throughput levels will vary considerably depending on the defect level of the cullet being sorted, and the amount of processes required to remove these defects. However, accepted product out-quality can get as high as 99% clean after sorting depending on the configuration used. Configurations should be judged according to the product requirements. The manufacturers will seek an initial sample and background information from the reprocessor prior to recommending any specific types of equipment and their configuration. They will use the sample to conduct tests to determine potential throughputs and efficiencies.

Table 8 below provides an overview of a selection of key technology providers, based on the information they provided for inclusion in this report. The technologies highlighted focus on the separation of the following:

- Glass by colour;
- Metals;
- Ceramics, stones and porcelain (CSP);
- Glass ceramics or pyro-ceramics.

The technology available on the market for removing these types of contamination is very flexible. All systems are modular and can be bolted on to an existing process or integrated into a new process in stages. Some of the systems have the different sorting capabilities integrated into a single line. There exist a range of segregation systems to reflect differing customer requirements.

Power requirements range between 2.5 and 5kW, depending on the type of kit being used. Fully integrated systems using multiple sorting systems may require up to 15kW of electricity. Systems set up for sorting glass by colour can offer a sorting width anywhere between 640mm and 2000mm, depending on customer need. All systems can handle particle sizes between 6 and 50mm, with some going as low as 2mm and as high as 60mm.

The sorting rate for equipment can vary considerably, from a basic 5 tonnes per hour for heavily contaminated material using a small band width, to up to 30 tonnes per hour, for low defect material passing through a high bandwidth. Output quality for those responding ranged between 95 and 99% clean cullet – suitable for all remelt applications. Yield will vary considerably depending on contamination levels of input material, and whether it has been compacted, but for input material which is mostly at or above the minimum specified particle size, yields of above 90% would be expected.

More detailed information for each manufacturer is contained in **Table 8** overleaf.



**Table 8** Technical data summary for key manufacturers of container-glass optical sorting technology

Manufacturer	MSS		Mogensen		Redwave			BEST	SEA (SRL)		S+S (UK)		Binder & Co.	
Location	USA		Germany		Austria			Belgium	Italy		UK		Austria	
Equipment name	Glass ColorSort (CSP)	Glass ColorSort	Mikro sort AX	Mikro Sort AQ 1101	Red wave IR	Red wave C	Red wave XRF-G	Genius	Crystal 2 & 4	Vetro	Varisort XE-G	Spek-trum CS-G	Clarity compact	Clarity lead
Colour sort	No	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No
CSP sort	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	No	No	Yes	No
Pyro-ceramic sort	No	No	No	Yes	No	No	Yes	No	No	Yes	Yes	No	No	Yes
Metal sort	Optional extra	Optional extra	Yes	No	Yes	No	Lead, Zinc etc	Yes	Yes	Yes	No	No	Yes	No
Sorting rate	15-23t/hr	5 - 7.5t/hr	8-20t/hr	-	6-8t/hr	12t/hr	28t/hr	5-30t/hr	7 or 12.5t/hr	10-15t/hr	-	-	6, 10, 12t/hr	7, 10, 14t/hr
Cost	Costs range from £150,000 to £300,000 depending on the type of technology employed, the throughput required and the precise nature of the installation, including the need for supporting equipment such as conveyors and loading equipment. Typical average costs £200,000 to add limited throughput colour sorting to an existing facility.													
Particle size limits	6-50mm	6-50mm	5-60mm	Handles <10mm	8-50mm	3-60mm	8-50mm	5-60mm	10-40mm	2-50mm	-	-	3-50mm	3-50mm
Output quality	Quality of 99%+ is achievable, but a range between 95 and 99% is determined by the level of input contamination													

As Table 8 demonstrates, the technology is on the market for producing clean, colour-separated glass suitable for remelt, from collected cullet that exhibits partial contamination. It is appropriate technology for those operators handling large quantities of glass with customers seeking very high quality material for remelt. For operators selling glass into lower-specification markets, it may be appropriate to employ some of these technologies but not others.

### 14.3 Operational indicators for specialist glass reprocessors and sorters

For those operators seeking to employ colour separation technology for cullet to go into remelt, an overview of typical capabilities is provided in Table 9.

**Table 9** Overview of typical glass colour sorting technology

Criteria	Typical colour sort capability
Machine sorting width	1200mm
Sorting rate	12 tonnes/hour
Power requirements	3kW
Particle size limits	5-50mm
Output quality	99%
Cost	~£200,000
Payback period	4 years
Configuration	Modular

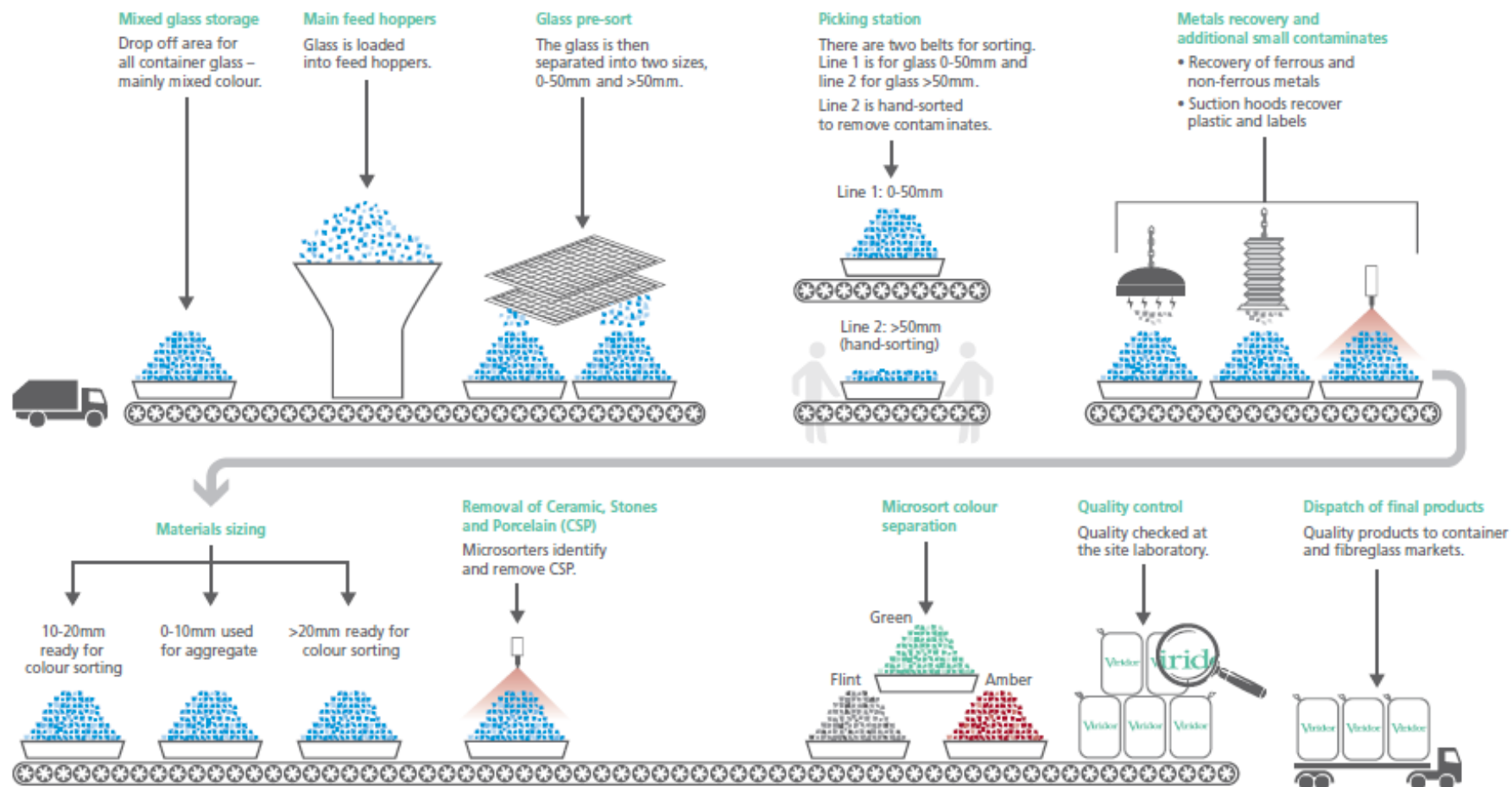
The costs for a typical sorting line must be multiplied for larger facilities and added to the costs of decontamination lines and ancillary equipment.

It has been possible to establish some basic typical operating parameters for high-quality processing of glass waste using information from a range of glass stakeholders.

- From a feedstock perspective, the additional cost of sourcing material can vary, with mixed cullet, at the time of writing, costing up to £5/tonne. Source separated clear glass varies by colour and can reach up to £32/tonne for clear, £25/tonnes for amber and £10/tonne for green (LetsRecycle.com).
- Operational costs for the processing of cullet typically range between £15 and £25/tonne depending upon the type of plant, the type of glass being processed and the volume being handled. This cost accounts for the staffing and operation of the facility, plus its management and maintenance.
- Losses of material to fines can range anywhere between 10 and 20% at a typical facility, but in high performing facilities, up to around 93% of mixed glass can typically be processed to remelt quality – depending on levels of contamination in the glass feedstock. This is subject to the processes earlier in the supply chain and the resulting issues of contamination and fines that can occur.

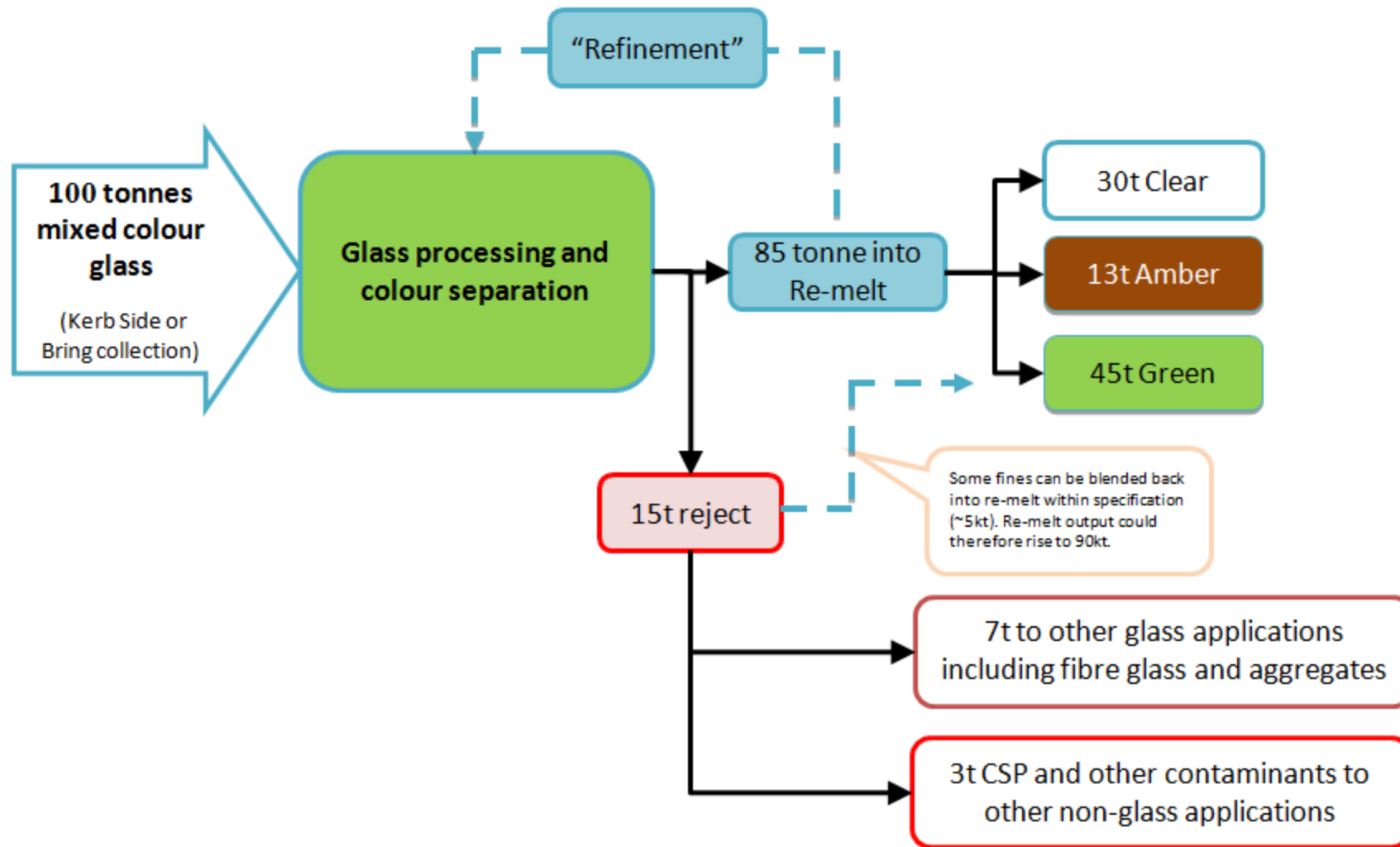
The development stage and the application of glass processing and colour sort technology are individual to each company operating in the sector. In **Figure 12**, below, a “typical” Viridor application of the technology is shown.

**Figure 12 A typical Viridor glass reprocessing plant**



To understand if it is practical to achieve the provisions of the Waste (Scotland) Regulations 2012 with the anticipated overall growth in collection and the growth in mixed colour collection specifically, it is necessary to understand the colour sort process in mass balance terms. Below in **Figure 13** is set out an overview of the technology based on an initial reports of how it is to be applied in Scotland.

**Figure 13** Mass Balance Assessment of modern colour separation technology.



Key considerations of this mass balance overview are:

A typical 100 tonnes of mixed glass input can achieve 85k tones of remelt quality colour separated glass. By this reasoning, the Bonnyrigg facility with a capacity of 130ktpa should achieve 110ktpa. If they can achieve rejection rates that average 7%, as claimed, then this would be closer to 120ktpa. However, this does not account for downtime for routine maintenance or if unplanned down time, as has been common with other similar plants.

A typical plant averages between 10% and 20% reject rates so a mid-range figure has been used here (Bonnyrigg suggest their reject rate will be closer to 7%), this suggests that overall collection levels for glass would need to increase by around 20% to achieve the original 100 tonnes of glass into remelt markets if mixed collection and later colour sort were used. Given the forecast increases (Table 5.) this seems likely to be achieved and so justify these collection methods in the context of the Waste (Scotland) Regulations 2012.

In traditional glass processing facilities, around half of the mixed glass (green and amber) has to be passed through the process twice to achieve full colour separation. In addition the clear glass stream may be passed through a second time to "refine" the colour quality which can be a customer issue where high proportions of clear recycled glass are used in manufacture. This can limit effective capacity significantly. However, the Viridor Bonnyrigg facility has confirmed that its planned equipment achieves three colour separation in a single pass.

Some fines can be blended back into remelt within specification (~5 tonnes). Remelt output could therefore rise to 90 tonnes. However this aspect, and the colour quality of clear in particular are subject to individual processor – manufacturer specifications and contracts.

## 15 Views from UK remelt stakeholders

In order to understand how investment in this technology has impacted upon container glass being redirected into remelt markets, we made contact with those handling glass towards the end of the remelt supply chain. This includes specialist glass reprocessor Viridor, plus the container manufacturers Owens of Illinois, as well as British Glass – the trade body for the glass manufacturing sector. While others were also contacted but did not respond in time for their comments to be included in this report, comments already in the public domain were also reviewed.

### 15.1 View from Viridor

Viridor has developed what it claims is one of the most hi-tech glass recycling facilities in the world with a £6m investment at its Midlothian site at Bonnyrigg. According to the company, the plant will be one of only three of the latest specification technology solutions to be developed across the globe, with similar facilities being developed in France and Australia.

The site already hosts a 100,000 tonnes facility at Bonnyrigg for reprocessing both container and flat glass with the output supplying container markets, fibreglass and insulation markets, the block construction sector and the aggregates sector. The facility was previously run by Scottish firm MacGlass before being acquired by Viridor in 2003. The recent investment by Viridor to upgrade the facility will result in the ability to reprocess a much higher proportion of the glass so that it is suitable for closed-loop container markets. While the specific technology to be employed was considered to be commercially sensitive, Viridor have invested in optical sorting lines to colour-sort and to remove key contaminants including CSP, metals and pyro-ceramics.

On speaking to Viridor, they estimate that the site will have its full sorting capacity operational in Autumn 2012 and the capacity at this point will reach ~130,000 tonnes per annum. They are seeking to fulfil their capacity using glass sourced entirely from Scotland. There is the flexibility to transport material from the North West of England, should throughput drop below requirements. At the moment, they are close to hitting the capacity figure in terms of secured supply agreements.

Viridor had a number of observations about the container glass sector that they were open to sharing in this report:

- Further education, communication and support is required earlier in the supply chain to ensure that the glass arriving at plants such as Viridor's is of the required quality and particle size.
- This does not necessarily mean collecting glass that is sorted by colour at source.
- The effort to collect by colour will push up the cost of collection beyond the additional value of the separated material, and is unnecessary.
- Mixing glass colours helps to reduce the cost of collection, but barely impinges on the recycling rates or quality of processed cullet.
- Mixed colours can be satisfactorily separated and decontaminated to remelt quality with very low losses to aggregate, and both mixed and colour segregated glass can be processed into finished product in a single pass through modern plant
- It is not necessary to separate glass from metal cans collected at source if sent to Viridor as they can separate and process these.
- The key issues to avoid in getting glass to the Viridor facility in Bonnyrigg are mingling glass with additional materials, particularly organic matter, and compacting glass.
- In relation to the definition of recycling under the forthcoming Waste (Scotland) Regulations 2012, Viridor state that waste glass from the cullet process (cullet with concentrated levels of ceramic, stone and porcelain rejections) will always be generated and aggregate substitution represents a suitable outlet for this material. Viridor therefore argue that it does constitute recycling. However they agree that aggregate substitution should not be a target market for waste glass. One possibility would be to prohibit the direct sale (or disposal) of glass waste to an aggregate producer.

## 15.2 View from Owens of Illinois (OI)

OI operates a 110,000tpa capacity glass container manufacturing plant in Alloa, which employs more than 450 people, representing the largest private employer in the area. It is also said to be the leading supplier of glass packaging to the Scottish whisky industry, as well as supplying lightweight bottles to the wine and non-alcoholic drinks industries. OI is a major outlet for container quality cullet in Scotland. It is able to accept cullet for the manufacture of clear, green and amber containers at its facility. It operates a manual picking MRF at its site to remove contamination and correct any mis-sorted colours in order to maintain high quality standards. Unlike Viridor, it has not invested in the latest optical sorting technology to separate glass by colour and remove contamination from feedstock.

Its suppliers of material are mainly collectors of local authority household glass and commercial glass from the hospitality sector. Glass must be segregated by colour to be suitable for purchase by OI and with there being limited separation facilities in Scotland with this capability the company relies heavily on glass being segregated by colour at the point of collection.

The highly competitive market of cullet means OI has seen its market share of collected feedstock drop significantly, which has had a significant impact on its capacity to incorporate cullet generated in Scotland. OI relies on supplementing this feedstock with material purchased from the North of England, as well as Finland and Norway. The high quality of the imported material is offset by increased import costs of this feedstock.

A major issue for OI is the cost of the Scottish feedstock in relation to its quality. They pay high-premiums for colour separated cullet. However, they experience on average around 10% contamination, which they have to landfill at cost, adding to the overall cost of the material per tonne. From a purely economic perspective, OI are getting closer to the

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tipping point at which they question the value of using cullet. This is particularly the case when sand raw material costs remain low at £20/t. However, OI is keen to continue using cullet from a low-carbon perspective and material feedstock quality therefore takes on increasing importance.

OI are reluctant to invest in state-of-the-art sorting equipment with the risk of losing further share of available feedstock still a realistic proposition. For OI, improving the quality of material collected at source is most important. The potential for the Waste (Scotland) Regulations 2012 to encourage colour sorting at source is seen as a positive opportunity by OI, although they are sceptical about increases in quality due to councils having less money to invest in this area.

### 15.3 Recresco and Quinn Glass

Recresco did not provide a view on the future of glass supply for remelt markets in time to be included in this report. However, Recresco has previously gone on record to provide its views on the growth of cullet supply to the remelt sector. Recresco has recently invested in state-of-the-art, specialist glass reprocessing facilities at sites in Ellesmere Port and South Wales, and has a large cullet processing operation in the Midlands which sources material throughout England. Through these developments it has secured a ten-year contract to supply recycled glass worth more than £100m to Quinn Glass, a large manufacturer of container glass.

Recresco has made these investments in response to increasing demand for a service to separate mixed glass containers collected from both domestic and commercial sources. The position Recresco and Quinn Glass have taken through this contract is to accept mixed-colour glass collections as the primary future route for obtaining glass for remelt. Quinn Glass has explained that the supply contract with Recresco Ltd was only signed after careful evaluation of their ability to meet extremely high quality standards. According to Recresco, more than 90% of the mixed glass processed at its facilities is destined for the production of new glass bottles and glass containers. The residue that cannot be colour-separated is processed into alternative markets. Recresco believes that the relationship it has established with Quinn Glass demonstrates there is a sustainable market for mixed glass at competitive prices.

### 15.4 Reconciling these views

The views of Viridor contrast with those of OI on certain aspects of glass collection on the basis that Viridor has already invested in technology at its Bonnyrigg facility that has the capacity to sort glass by colour and remove contamination. The two businesses are effectively competing for the same material in Scotland. The structure of Viridor is more suited to accessing material at source, via its network of collection, sorting and bulking facilities across Scotland and other parts of the UK. Investment in this type of technology was therefore perceived as a risk worth taking to achieve a competitive edge. OI is heavily reliant on either purchasing sorted material from specialist glass sorting MRFs like Viridor's, or purchasing directly from organisations collecting colour source-separated glass. Its limited collection capability makes investment in separation technologies high risk.

The Waste Regulations (Scotland) 2012 could impact on both businesses in different ways. The potential requirement for glass colour separation at source to be the default approach is viewed as a very positive development by OI, but unnecessary by Viridor, given their investment. In the context of glass collection, there is therefore a case for a balanced approach in developing guidance for the implementation of the Regulations. Both OI and Viridor are in clear agreement that maintaining the quality and particle size of the material across the supply chain, before it reaches their facilities, is of paramount importance for remelt. This should be a key consideration for the guidance on collection. Ensuring that material is kept separate from other materials when collected at source and is not put through multi-material MRFs will benefit both parties and help to minimise lost revenue.

British Glass expressed the view that with sufficient promotion and service provision, bring sites provide a cost effective way of both reaching quantity and quality standards, while recovering glass at low cost overall. They believe that where public participation in using bring site based services is increased through education and publicity, there would be no need to consider lower quality collection services such as mixed glass. There is evidence from some authorities,



notably Aberdeenshire, that this *can* be true, but it is not clear that it can be applied throughout Scotland with the same effectiveness. In any event, the new duty on local authorities to provide household collection services by 2013 may undermine strategies based mainly on bring bank collection.

The types of authority in Scotland are varied and both parties agree that one size doesn't necessarily fit all when it comes to sourcing this material. The economic and practical issues of collecting colour separated glass are highly challenging in some circumstances. In these instances, mixed glass collections can offer a more viable approach for recycling the material back into containers. Collectors will need to make the case for mixed collection as an acceptable alternative for achieving the new duties and this will only be possible by working in partnership with specialist reproprocessors. Colour sorting after collection is possible and can achieve high levels of the original feedstock - around 90%. In principle some mixed sorting can be justified.

All respondents indicated concerns over a generally falling cullet quality through non container glass contamination, and there was general agreement that the promotion of participation by waste producers (including householders), and education on materials required would help address quality issues in the sector.

## 16 Current markets for cullet in Scotland

Total glass manufacture in Scotland, including container manufacture, glass fibre manufacture, widows manufacture and smaller sectors producing decorative wares etc are estimated by British Glass, the relevant trade body, to produce around 700,000 tonnes of glass per annum.

Within this glass manufacturing presence in Scotland, there exists significant demand for cullet as a raw material and is the highest-value market. The manufacturing facilities using cullet have a combined capacity of nearly 420,000 tonnes, with 70% of this (298,000 tonnes) dedicated to the manufacture of container glass. **Table 10** overleaf highlights the capacity of these sites and the estimated throughput of cullet they currently use.

**Table 10** Capacity of established cullet users in Scotland

Business	Feedstock	Maximum cullet intake	Known throughput of cullet	Location	Product(s)
<b>AllGlass</b>	Mixed	15,000t/yr	~4,500t/yr	Linwood	Filtration, abrasion and aggregates
<b>Ardagh Glass</b>	Clear, green, amber	187,500t/yr	~80,000t/yr	Irvine	Containers
<b>Brand and Rae</b>	Mixed	17,000t/yr	~10,000t/yr	Fife	Construction blocks
<b>Dryden Aqua</b>	Mixed	20,000t/yr	~1,500t/yr	Bonnyrigg	Filtration media
<b>Owens of Illinois</b>	Clear, green, amber	110,000t/yr	~40,000t/yr	Alloa	Containers
<b>Superglass</b>	Clear, mixed	70,000t/yr	~30,000t/yr	Stirling	Fibreglass insulation

Owens of Illinois (OI) manufactures all three colours of container glass bottles. Around 45% of the output material is clear containers, with green 41% and amber 14%. The cullet limits for their products are quoted as:

- Clear glass – 35%
- Green glass – 95%
- Amber glass – 40%

Wherever possible they seek to use colour separated container glass sourced from Scotland, and the low throughput

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reported in Table 10 is the result of increased competition for material from local authority collections and the hospitality sector. OI is reliant on the supply of glass that is colour separated and of high quality. The facility can incorporate 10% to 20% of mixed into its green glass container production, depending on the quality and colour mix. Ardagh glass currently sources its cullet from outside of Scotland, mainly from England, but the capacity is available to receive colour sorted glass feedstock from Scotland. Approximately 67% of its output is green containers, with 25% clear and 8% amber.

The mid-point estimate for total domestic and commercial glass currently collected in Scotland is 276,500 tonnes. Accounting for the cullet limits placed on each colour container type, there is likely to be sufficient capacity to utilise this material in the two container glass manufacturers in Scotland alone. However, it is possible not all of this material will be of sufficient quality for remelt. Until the recent investment by Viridor into colour separation, alternative markets had to be found for mixed glass. One of the key markets has been the manufacture of fibre glass insulation, with Superglass in Stirling a major outlet for both plate cullet and container cullet, particularly clear and high quality mixed colour glass. The majority of this feedstock is sourced from the Viridor plant at Bonnyrigg, who prior to the operation of their optical sorting, supplied two thirds of their output to the fibreglass sector.

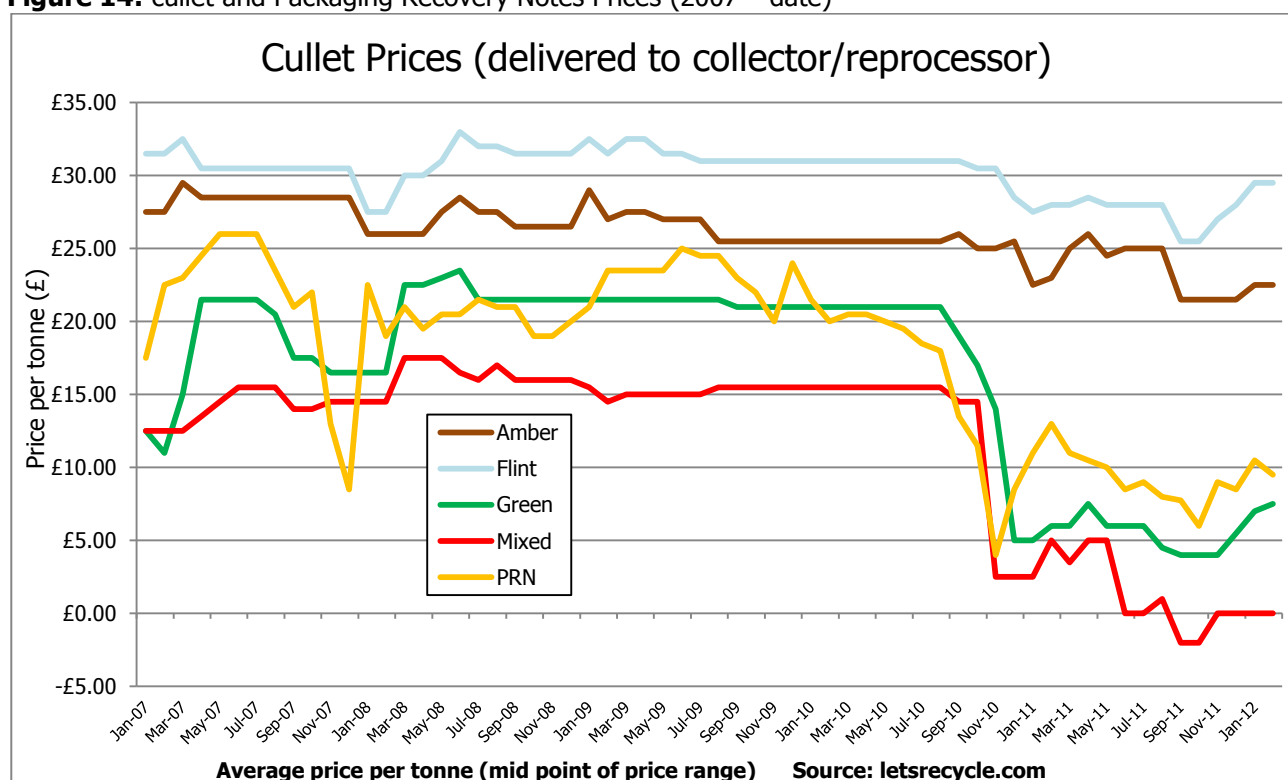
Other emerging markets include AllGlass in Linwood, which produces glass beads from mixed glass for use in a range of applications, including filtration media, abrasion and aggregates. The business is linked to the William Tracey Group who also handle glass collected from domestic and commercial sources. Brand and Rae incorporate mixed glass into concrete construction blocks, and Dryden Aqua have developed Active Filtration Media (AFM) using mixed cullet, although these are still both emerging applications.

Smaller market sectors such as decorative wares, jewellery, glazes in the ceramics sector etc, do not account for a substantial tonnage of glass production or use, and while their added economic value may be important, particularly to more isolated local communities, such as in the Western Isles with Siar Glass, the tonnages are not considered relevant to the scope of this report.

## 17 Impacts of the Packaging Waste Regulations on cullet recovery

Prices for quality cullet delivered to reprocessors and Packaging Recovery notes for container glass were collated for the period January 2007 to date in order to understand the commodity price pressures influencing recovery rates. While prices are quoted in a range, the mid point of each range has been taken. These prices can be seen as a UK average – areas which have significant demand from local end users, such as container manufacturing furnaces may see higher prices, while more distant locations where longer transport distances would add to overall material cost, the cullet price will be lower.

It should be noted that these represent prices for uncontaminated cullet meeting a quality standard delivered in bulk to a re-processor and requiring little further processing or grading. Primary collectors such as local authorities or waste management companies are unlikely to achieve these prices unless they undertake further processing to remove contaminants and provide assurance on quality standards.

**Figure 14:** cullet and Packaging Recovery Notes Prices (2007 – date)

- Prices for clear and amber cullet have remained fairly stable over the 5 year period, while prices fell markedly in late 2010 for green and mixed cullet. There are no significant changes in actual cullet demand which might explain these changes. A possible explanation is the increase in mixed glass collection, and falling quality of cullet supplies generally reported by end users creating a rising excess of poor quality green and mixed cullet for which UK demand is fairly limited.
- Even poor quality cullet may be the subject of PRN issue when recovered, which provides price support for relatively low value markets. For example, mixed glass used as aggregate may still carry a PRN with a value of around £10 per tonne, and it is possible for the cullet supplier to use this to subsidise the price of supply to the end users.
- The PRN price, as would be expected, has correlated most closely with the cheapest cullet type, as PRN buyers seek compliance at lowest cost. With substantial current markets for mixed glass as aggregates, the PRN price overall remains low. With an obligation to recycle to remelt to achieve PRN accreditation, the PRN price should rise in principle, but the constraints imposed on use in aggregates only amounts to a freeze in tonnage terms, and this price pressure will not be significant in the short to medium term.
- Since the UK as a whole is already achieving the recovery targets under the Packaging Waste Regulations (albeit with a substantial diversion of material into non closed loop markets such as aggregates), there is little pressure on the glass packaging supply chain from these regulations.
- The margin between colour separated clear and mixed glass has roughly doubled in the last 12-18 months. A longer time series would be needed to confirm whether this is likely to remain a lasting trend, but a differential of around £30 per tonne between mixed glass and processed clear is evident. This suggests that, all other factors being equal, a re-processor would need to be able to undertake colour separation operations to produce cullet of a marketable quality for less than around £30 per tonne, including any cost for buying in the actual material for the operation to be viable. With typical sorting costs ranging between £15 and £25 per tonne (see 11.3 above), and levels of contamination of incoming feedstock being uncertain, this creates significant risk for potential investors in the processing sector who would need to invest a minimum additional £200,000 in an existing facility to add colour sorting technology. But for stakeholders who are confident of their access to sufficient feedstock, this risk may be balanced by the opportunity. The business model based on collection and subsequent sorting of mixed glass waste is well established and is likely to retain a significant market share.

### 17.1 Proposed changes to the Packaging Waste Regulations (PWR)

The EU Packaging Waste directive applies to the UK as a whole, and the devolved administrations are subject to the same UK wide implementation process, the Packaging Waste Regulations. DEFRA has recently consulted on revision to the regulations for the whole of the UK, and the approach which is planned was confirmed by the UK Chancellor of the Exchequer in the Budget Speech in March 2012. Legislation is expected to be tabled in the UK Parliament shortly.

The proposals will cap the amount of glass recycled to aggregate end markets at the 2009 level – equivalent to 650,000 tonnes for the UK - and require a minimum proportion of recycled glass to be recycled into closed loop remelt markets (back into container glass). With the expected annual growth in overall obligated tonnage, this may have a small but cumulative effect, which is intended to act as a brake on the growth of aggregate end markets, but even DEFRA's own estimates suggest that this will not affect the percentage required for remelt until 2016. Because PRN supply exceeds demand by a stable and sufficient margin, PRN prices remain low, and there is little added incentive from the PRN system to change markets or increase recycling.

This is not likely to change unless either the recycling/recovery target increases significantly beyond the current levels, or the issue of PRNs for recovery into non remelt markets such as aggregates is substantially curtailed. These possibilities will not arise in the short to medium term based on the currently proposed PWR changes. The proposal to cap the amount of glass used in aggregates for which PRNs are issued will have only a limited impact. The restriction would only equate to requiring an increased proportion of about 1.1% of Scotland's total glass waste stream to be diverted from aggregates, into closed loop remelt markets.

The required increase in glass to remelt required for the whole of the UK by the PWR – 1% in 2016 – amounts to an increased UK wide obligation of 17,870 tonnes to remelt markets – ie diverted into closed loop end uses. If the increased glass collections estimated in Section 8.2 (see Table 5) are achieved in Scotland, around 72,000 tonnes of net additional glass would be collected annually after 2013.

This suggests that, if the required changes in service provision by local authorities and others are achieved, and if the new separation requirements are broadly complied with by glass waste producers and processors, the additional obligation will easily be met for the UK, without any change in practices being required outside of Scotland. This increased supply of quality cullet may also confer a competitive advantage for container glass manufacture in Scotland.

## 18 Conclusions

- Scotland currently has no multi-material MRFs capable of sorting glass from a combination of other dry-recyclable material streams. MRFs act instead as transfer stations for collected glass, simply consolidating material, removing visible contaminants and selling this on to third parties. As the collection of glass mixed with other wastes will not meet the duties set out in the Waste (Scotland) Regulations 2012, no major changes in MRF practice are likely to address the increased collections of glass. This is the ideal scenario for the bottle reproducers and manufacturers using cullet, as it minimises the risks of cross contamination and cullet being crushed to particle sizes that cannot be sorted by colour.
- Changes to packaging waste regulations are not likely to produce significant changes in behaviour in collection or processing of container glass. The cap on the use of glass in aggregate markets may constrain the growth in mixed glass collections, but is not likely to influence existing practices, as the effect is slight and the rate of change slow. Other measures, such as forthcoming voluntary agreements for the Hospitality and Foodservice Sector, and the Waste (Scotland) Regulations 2012 are much more likely to influence behaviour strongly and accelerate recycling rates in Scotland
- New duties to separate key recyclable materials are likely to produce significant increases in recovered glass which can be expected to ensure that Scotland reaches recycling rates for glass which are significantly above the current EU wide average of 67%. However, this will require significant investment in provision of services by Local

Authorities and the private sector, and will need to be supported by changes in behaviour by waste producers, and medium to long term stability in the current policy.

- Across the UK adding kerbside collections is seen as an essential investment for Local Authorities to achieve high glass recycling rates. While this is supported by individual Local Authority case studies in this report, there is insufficient evidence available to date from all Local Authorities in Scotland for this to be conclusive, as there are also Local Authorities which have achieved high recycling rates without kerbside.
- Despite the focus on kerbside collections as a means of increasing the overall tonnage of glass collected, colour separated bring sites are the most cost effective methods of waste glass collection relative to material quality and quantity. There are examples of high performing Local Authorities who rely wholly on Bring Banks to collect all glass wastes, and it is likely that bring sites will form some part of a successful overall strategy for all LAs. Where bring sites are made accessible to C&I glass waste producers, they may significantly increase the total glass waste recycled at no net cost to the collector.
- The current trends in glass collection methods are likely to remain broadly the same. Given the limits being imposed on low value alternative markets such as aggregates and the availability of glass colour sorting capacity which can produce colour separated cullet that reaches the quality standards required by end users in the container glass sector, it is anticipated that the overall increase in glass collected will mainly be used in remelt markets. This pragmatic point was strongly and consistently reflected by all members of the glass recycling supply chain and the remelt sector.
- For glass that is collected mixed by colour, there will be a reprocessing facility capable of sorting to remelt quality by Autumn 2012. This will be run by Viridor at its Bonnyrigg site and will have a capacity of up to 130,000 tonnes per annum. The facility, will mainly process glass from the high-density population concentrations in the Central Lowlands of Scotland. Where mixed glass can be justified by local authorities and commercial collectors beyond 2013, then it is in the Central Lowlands that the case is strongest, given the proximity to the Viridor facility. A high proportion of the output (typically 85% by weight) from this facility is expected to go to remelt applications. However, this remains sensitive to the input quality from suppliers. The quality and efficiency of this plant will be a critical factor in individual Local Authorities and Scotland overall meeting the ambition to maximise closed loop glass recycling set out in the Waste (Scotland) Regulations 2012. However this remains a complex judgement call which will need to be carefully considered in the context of each individual area.
- The type of Local Authorities in Scotland, rural urban mix etc, are varied and one size doesn't necessarily fit all when it comes to collecting glass. The economic and practical issues of collecting colour separated glass are highly challenging in some circumstances. For example highly remote areas, or urban concentrations with higher deprivation levels and higher multi-occupancy housing. (The inter-related cause and effect influences of these complex social, demographic and geographic influences on recycling behaviours are not well understood.) In these instances, mixed glass collections can offer a more viable approach for recycling, including back into the remelt sector. Collectors will need to make the case for mixed collection as an acceptable alternative for meeting the Waste (Scotland) Regulations 2012 and this will only be possible by working in partnership with specialist reproducers. There is evidence that colour separation of mixed glass after collection is capable of reaching remelt qualities for some customers. This will have to be demonstrated consistently and at high volumes to meet the requirements of the Waste (Scotland) Regulations 2012.
- The work done to date in Scotland and the specific requirements of the Waste (Scotland) Regulations 2012 (as anticipated) appear to be very timely and supportive of a significant increase in the total amount of glass collected and in increasing the amount recycled into the remelt sector, therefore increasing the overall environmental gains in terms of reduced carbon emissions.

The competitive strategies across the major businesses in Scotland's glass recycling sector are varied. The current limited data of glass waste and the social, demographic and geographic understanding of the exact drivers of recycling behavior in Scotland make it difficult to identify a clear single best practise approach to collection. There are initial indications that colour separated glass may present cost advantages in certain situations but the data available at this time does not support the development of further conclusions.

## 56 Glass Collection & Re-processing Options Appraisal in Scotland

The medium term holds out a positive outlook for glass recycling in Scotland. Balancing the inexorable decline in quality and the steady increase in mixed collection through support for colour separated collection, the investments in technology and the investment and support available to local Authorities could feasibly increase glass recycling via remelt markets towards its technical limit.

- The contamination levels of input feedstock across the supply chain, whether collected mixed or colour separated, is a critical issue for the remelt sector. Reducing contamination will have a significant impact on the net amount of glass recovered into remelt, as poor quality glass may not be viable for processing to the standards required for remelt markets even if collected as separate colours. Requirements in the regulations to keep glass separated from other non-glass materials will be an important step in encouraging quality feedstock.

## 19 Recommendations

- A mass/material balance is needed for glass waste within all of Scotland's waste streams, which gives up to date estimates of the total arisings, and information about the fate of glass by end uses and disposal methods. This is already an objective of Scotland's Zero Waste Plan.
- Assuming that the Waste (Scotland) Regulations 2012 are implemented as currently anticipated, collection arrangements which collect glass comingled with other recyclables will not meet the required standard, as the material is not acceptable to the remelt sector and will therefore need to be phased out before 2014. Comingled collections are only likely to be permissible for a very small minority of collections where unusual circumstances apply (such as geographical remoteness).

Local Authorities and commercial businesses affected should move quickly to review and put in place plans to change their arrangements. The changes in the glass recycling markets in Scotland may present those organisations that need to make changes with opportunities to increase tonnages, improve quality and improve financial outcomes.

- Use of bring banks for household glass collection on a colour separated basis, should replace mixed glass bring sites wherever possible. In all but the most remote areas the collection and transport costs are likely to enable this service to be provided at lower or equivalent net cost than alternative options. Colour separated bring sites are the most cost effective method of waste glass collection relative to material quality and quantity.
- Case studies which explain the glass collection successes of Scottish Local Authorities should be produced in a common format with the involvement of Zero Waste Scotland to enable concrete examples of methods used by the high performing authorities to be shared and applied more widely. Case studies could illustrate costs, quantities and qualities of materials recovered, and how practical issues such as rural collections; high density urban collections; distances from end markets or re-processors have been managed within the distinct strategy and regulatory requirements of Scotland.
- A Kerbside Good Practice Guide for Waste Collectors and producers affected by the Waste (Scotland) Regulations 2012 will be needed when the final guidance is available, and it is expected that some of the data and analysis included in this report will be a useful resource in the production of that guide. We understand that Zero Waste Scotland already plan to publish such a guide.
- Local Authorities and others, should be provided with support to review and develop their glass recycling strategies in light of the Waste (Scotland) Regulations 2012 if the objective of maximising closed loop recycling is to be achieved. The support streams available to LA's, third sector groups (and businesses in sectors which have high glass arisings) should be reviewed and updated to reflect the views of the industry and the needs of Local Authorities to make and be accountable for this complex judgement call.
  - Available methods and strategies to increase overall glass collection from C&I glass waste producers should be investigated. A review of good practice and the barriers to C&I collection should be reviewed with the businesses, Local Authorities and third sector organisations already providing these services. The support



streams available should be reviewed and updated to reflect the views of the industry and the needs of Local Authorities and others.

- Use of bring banks to collect glass from the licensed trade should be reviewed. Where bring sites are made accessible to C&I glass waste producers, they may significantly increase the total glass waste recycled at no net additional cost to the collector, while discharging the duty to provide services on demand to non household waste producers. In smaller settlements, the ability to site bring banks in pub car parks and similar, provides a particularly cost effective solution for colour separated collections. Administrative and reporting complexities, legal implications and charging processes are likely to be increased in this scenario and will need to be resourced by Local Authorities and, or their partners.
- While there are clear differences in competitive strategies between stakeholders on exact methods for collecting and recycling glass, there are some areas of strong agreement, notably:
  - The promotion of increased participation by householders and businesses. There may be opportunities to take a common approach to promoting, branding, and communicating efforts to increase recycling in ways which reflect Scotland's distinctive ambitions in waste management. The option of a Scotland wide campaign to increase participation in glass recycling in an agreed way should be investigated.
  - Concern over a gradual lowering of the overall quality of glass collected. Such that any measures to improve quality and reduce contamination of material presented for collection, whatever the method, would receive strong support.
  - The ambition across all processors to increase the glass available to, and utilised by the remelt sector based on economic and environmental advantages.

A conference of stakeholders or similar may be a useful way to establish common ground on approaches to collection – notably on the debate between colour separated collection and colour sorting. Zero Waste Scotland along with other partners such as Ministers in the Scottish Parliament and SEPA should consider liaison work between the major stakeholders in the waste glass cullet supply chain, including the end users in container manufacture; the waste collection and re-processing sector; colour sorting facility operators; and local authorities in order to identify and share areas of agreement.

This may be a one-off event or ongoing/task based working group. The forthcoming publication of the Statutory Guidance on the new regulations by the Scottish Parliament presents an ideal opportunity to initiate this process.

- Review the output quality, quantities and end markets of glass when the new glass sorting facility is operational. Major stakeholders have different views as to the effectiveness and suitability of colour sorting technologies, and the degree to which they can meet quality requirements. This study found that sorted glass can meet the quality specifications for cullet grades set out in PAS101, although not all container manufacturers consider this is sufficient for all grades of container production. This suggests that the key barriers to maximizing glass recycling into remelt markets may be largely a result of perceptions and competitive strategies i.e. "Market Forces", more than of technical factors. Reviewing the real impact of this major investment on actual glass levels into remelt and other markets will allow stakeholders in Scotland to understand if the requirements of the Waste (Scotland) Regulations 2012 are being fulfilled.



## Appendix 1: Cost benefit analysis for collection options

The table included below sets out the basic model and assumptions used for data derived from the WRAP Report, **Kerbside Collections Options: Wales** (Jan 2011) which has been used to assess costs and benefits in Section 13.2. For the purposes of this simple model, no impacts of promoting increased participation are included, although this is likely to increase material capture rates. This assessment is based on limited direct evidence. An updated version of this basic model which is directly applicable to Scotland is in preparation.

	Net service cost per household of material collected	Assumed participation level - material capture rate (kg/hh)	Process losses and rejects (% loss dependent on process)	Net glass content per tonne of initial material collected (kg/hh)	Notional allocation of collection to glass on a pro rata basis (£)	Net cost of colour sorting (£)	Loss of material during colour sorting (kg/hh)	Net Glass recovered to remelt (kg/hh)
Assumptions made	Based on collection and disposal recovery costs set out in the WRAP Wales study. This includes material values recovered.	Based on collection scenarios set out in the WRAP Wales Study 2011.	Data taken from WRAP Wales Study 2011	21% of material collected in glass. The average glass collection per household (trimmed mean which removed the 5% outliers from the calculation is 50kg/hh)	21% of total net service cost is allotted to glass to give a separate cost for this material only	Based on gate fees advised for sorting and processing mixed glass wastes. The range advised is £15-25 per tonne - the midpoint of this range was taken	Losses of 20% from comingled collections due to contamination & fines, and 10% from mixed glass collections due to fines, and 2% from kerbside sort for cleaning and processing	Total of glass collected – loss occurring during colour sorting to remelt standards.
Comingled collections (i.e. mixed recyclables)	£24.41	164.0	13.4%	29.8	£5.13	£0.60	6.0	23.9
Two stream collections (i.e. glass separate)	£22.49	162.0	9.9%	30.7	£4.72	£0.61	3.1	27.6
Kerbside collections (colour sorted collection)	£16.98	143.0	2.1%	29.4	£3.57	£ -	0.6	28.8



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