Final Report

GlassFlow 2025

A review of the quantity of glass packaging being placed on the market (POM) and recycled in 2017

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Front cover photography: Glass Packaging

Executive summary

Introduction

GlassFlow 2025 has been produced to support Defra in its understanding of current levels of UK glass packaging placed on the market (POM)[1] and recycled, and potential future levels to 2025. GlassFlow also reports the associated UK and European compliance implications of projected glass packaging POM and recycling. Defra is keen to ensure that the estimates being used for its packaging policy work are as accurate as possible; this report has been prepared to support this aim. Error margins and robustness assessments have been used and provided wherever possible.

Project Conclusions - Material Flow

There were 2,487k tonnes (+/- 7%) of glass packaging POM in 2017: an increase of 4% from the estimated current flow figure (2012)

This has been derived using a methodology consisting of identifying UK production of glass packaging and adding imports and removing exports. Data was used from a variety of sources for each sector with the results combined. It has been cross-checked with reported obligated data on National Packaging Waste Database (NPWD) and with the project's Steering Group. Analysis by the Environment Agency showed that a significant part of this increase was from existing obligated producers rather than new producers coming into the system.

The final project estimate for glass packaging POM in the consumer sector is 1,835k tonnes (+/- 11%)

This method is based on primary data alongside reliable market share data - no other was used for deriving consumer data as this is considered the most robust available and is accepted by industry.

The final project estimate for glass packaging POM in the non-consumer sector is 653k tonnes (+/- 11%)

This data was derived by taking the consumer sector tonnage away from the total POM estimate. Sense checks were made by the British Beer and Pub Association (BBPA) and the Wine and Spirit Trade Association (WSTA).

Non-obligated or unregistered flow for glass packaging accounted for 8% of POM in 2017 – this represents a decline from that reported in 2012 of 12%

Using data from the National Packaging Waste Database (NPWD), an estimate of the unobligated/unreported tonnage (205k tonnes, 8%) has been made by subtracting the net pack fill figure of 2,282k tonnes from the project's final flow estimate of 2,487k tonnes. The unobligated proportion of 8% is a reduction from the 12%[2] identified in the GlassFlow 2012

[1] *Glass packaging placed on the market means all household and non-household glass packaging used around products within the UK.*

[2] *This was revised from 14% in the published version of the report to 12% once final NPWD data was published and the calculations updated accordingly.*

report. British Glass believes the 2017 estimate is more realistic than the previous one based on their understanding of the market.

The final project estimate of glass packaging POM by type is 2,118k tonnes (85%) bottles, 356k tonnes (14%) jars, 13k tonnes (1%) other packaging

Primarily using information derived from Valpak's EPIC database and sense-checked by British Glass, the final project estimate by format has been made. This indicates that bottles make up most of the glass packaging.

Project Conclusions - Recycling

The total quantity of UK glass packaging recycled in 2017 is estimated to be 1,715k tonnes

This includes reported (NPWD) and an estimate for unreported recycling (92k tonnes). Based on the POM calculated as part of this project, this gives an overall recycling rate of 69%. Of this, 1,623k tonnes was reported on NPWD, representing a recycling rate of 65%.

The total quantity of consumer[3] UK glass packaging recycled is estimated to be 1,354k tonnes

Based on Waste Data Flow (WDF) and the consumer POM calculated as part of this project, this gives a consumer recycling rate of 74%.

The total quantity of non-consumer[4] UK glass packaging recycled is estimated to be 361k tonnes

This is calculated by removing the consumer recycling tonnage from the total tonnage recycled figure. Based on the non-consumer POM estimate calculated as part of this project, this gives a non-consumer recycling rate of 55%.

Of the total 772k tonnes unrecycled glass packaging, 394k tonnes (51%) was sent for energy recovery and 378k tonnes to landfill (49%)

This was based on an estimated total of 480k tonnes of consumer glass packaging not being recycled and 292k tonnes of non-consumer, which was derived using WDF and published statistics on UK disposal routes.

Project Conclusions - Projections and Compliance

The scenario projection for glass POM projects an increase from 2,487k tonnes in 2018[5] to 2,550k tonnes in 2020, and to 2,544k tonnes in 2025

This represents an increase of 57k tonnes or 2.3% in 2025 compared to 2018.

The scenario projection for glass packaging recycling projects an increase from 1,687k tonnes in 2018 to 1,732k tonnes in 2020, and to 1,813k tonnes in 2025

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[3] Consumer packaging is packaging consumed in the household

[4] Non-consumer packaging is packaging consumed in the commercial/industrial sector

[5] Compliance year 2018 is data reported in 2018 by obligated companies, this relates to packaging POM in 2017.

This represents an increase of 125k tonnes or 7.4% in 2025 compared to 2018.

Based on the POM and recycling scenarios, accredited glass packaging recycling is expected to fall short of the national equivalents of the business targets in 2018, 2019 and 2020

The associated probabilities of meeting the national equivalents of the business targets for glass accredited packaging recycling in 2018, 2019 and 2020 are 12.4%, 14.6% and 15.6% respectively.

Based on the POM and recycling scenarios, the proposed CEP target of 70% in 2025 is likely to be met

There are no targets for glass packaging recycling beyond 2020 other than the CEP target in 2025.

Project Recommendations

Reviewing elements of the Packaging Regulations to capture more non-obligated or unregistered tonnage

This could form part of Defra's reform of the Packaging Regulations in 2018 and could include:

- Removal of de minimis; and
- Investigative opportunities for capturing more tonnage within the system if the de minimis is not removed.

Recommended accreditation for all recycling activities

All companies in the UK performing recycling activities on packaging should become accredited and report all their recycling. This would ensure that Packaging Recovery Notes (PRNs) are issued on more of the packaging material recycled, resulting in no unaccredited recycling and easier compliance with UK regulatory targets.

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Glossary

BBPA	British Beer and Pub Association
bn	Billion
C&I	Commercial and Industrial
Consumer Packaging	Packaging consumed in the household
CSP	Ceramics, Stones and Porcelain
Cullet	Crushed glass prepared for use in the glass manufacturing process
DAERA	Department of Agriculture, Environment and Rural Affairs
DRS	Deposit Return System
EA	Environment Agency
EfW	Energy from Waste
EPIC	Environmental Product Information Centre
GDP	Gross Domestic Product
Glass Recycler / Reprocessor	Organisation which processes glass to prepare it for end markets such as remelt (container and fibreglass manufacturing), filtration, shotblasting, aggregates and export
HMRC	Her Majesty's Revenue and Customs
k	Thousand
kt	Thousand tonnes
LA	Local Authority
Non-consumer Packaging	Packaging consumed in the commercial/industrial sector (away from home or on the go in hotels, bars, restaurants and businesses
NPWD	National Packaging Waste Database
ONS	Office of National Statistics
PERN	Packaging Export Recovery Note
POM	Placed on Market
PRN	Packaging Recovery Note
RDF	Refuse Derived Fuel
SEPA	Scottish Environment Protection Agency
VDS	Valpak Data Solutions
WDF	WasteDataFlow
WRAP	Waste and Resources Action Programme
WSTA	Wine and Spirit Trade Association

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- Advisory Committee on Packaging (ACP);
- British Glass;
- Defra;
- Environment Agency;
- UKHospitality;
- Viridor; and
- Wastepack Ltd.

1.0 Introduction

1.1 Background and Existing Data

Defra is keen to ensure that the estimates being used for its packaging policy work are as accurate as possible. To support Defra and other industry stakeholders, this work focuses on generating the most robust estimates of UK glass packaging placed on the market (POM)[6] as possible. The report also considers the levels of UK glass packaging recycling, both in the UK and abroad, and provides some insight into the end markets and products that UK recycled glass packaging is used in.

Using as much historical data as possible, future glass packaging flows and recycling rates have also been projected. These recycling rates have been set against UK and European packaging recycling targets, where they exist, and the statistical probability of the UK achieving national and European compliance has been calculated.

1.2 Objectives

The set objectives for GlassFlow 2025 are to:

- Provide updated (and cross-checked) baseline estimates of glass packaging placed on the UK market, by packaging:
    - Format e.g. bottles, jars, other
    - Stream e.g. consumer, non-consumer
    - Source e.g. obligated, non-obligated
- Estimate the quantities of glass packaging collected through CA sites, kerbside and pick-up collections and other collection types, by stream;
- Estimate the quantities of glass packaging recovered and recycled, sent for incineration with energy recovery, and sent to landfill for both UK and overseas end destinations;
- Project glass packaging POM and recycling rates year by year to 2025;
- Assess likely compliance performance up to 2025; and
- Provide estimates of the quantities of obligated glass packaging that is recycled but does not generate a PRN/PERN and quantities of non-obligated glass packaging that is recycled.

1.3 Methodology

1.3.1 *POM*

Glass packaging POM was estimated using the following methodology:

Total UK Glass Packaging Consumption	=	Total Production	-	Exports (Empty)	-	Exports (Filled)	+	Imports (Empty)	+	Imports (Filled)

[6] *Glass packaging placed on the market means all household and non-household plastic packaging used around products sold within the UK.*

This methodology references a variety of data sources of glass packaging products placed on the market combined with cross-checks where possible. The details of how the amount of glass packaging POM was estimated and cross-checks performed is provided in section '2.0 Glass Packaging POM' of this report.

The results of this method have been verified against an assessment of the glass packaging POM reported on the National Packaging Waste Database (NPWD) by obligated producers and data provided by the project's industry Steering Group. The baseline year was 2017.

Other methodologies were considered, such as using waste collection and composition data; however, this was not taken forward as this methodology has several significant limitations and is reliant on the composition of household waste, waste arisings from local authorities and similar data from the non-consumer sector, all of which will vary in terms of robustness. The justification of the use of POM data over alternatives is provided in full in section 1.3.1 of PlasticFlow 2025[7].

POM Cross-check (Net Pack Fill)

The cross-check used glass packaging data reported by obligated companies and published in the NPWD. The estimate is thought to capture the vast majority of the relevant quantity, but it does omit the glass packaging handled by non-obligated companies, free-riders[8] and packaging for internal company use (considered to be non-obligated packaging under the regulations).

To estimate the amount of packaging placed on the UK market by obligated companies, the calculation set out below was applied. This calculation uses the total data reported by obligated packaging producers and is available on the NPWD website[9]:

Net Pack Fill	=	**Packing/Filling** Table 1 - pack/filling	+	**Imports** Table 3A - imported for selling	+	**Imports** Table 3B - packaging removed from around imports	-	**Exports** Table 2A + Table 2B – pack/filling

1.3.2 *Recycling*

NPWD was used as the source for accredited (recorded) recycling of glass packaging. The industry, including those involved in producing cullet and exporting glass, were consulted on the recycling of glass packaging that might not, for whatever reason, be reported on NPWD. The output of these discussions was used to estimate a figure for non-accredited (unrecorded) recycling.

The total recycling figure, consisting of recorded and unrecorded recycling, was then split into consumer and non-consumer recycling. Waste Data Flow (WDF) was used as the source for the consumer recycling data. The difference between this and the overall recycling total was assumed to be non-consumer recycling.

1.3.3 *Projections and Scenario Analysis*

[7] https://www.valpak.co.uk/information-zone/reports/plastic-flow-2025
[8] *Those companies who are above the packaging obligation threshold by having a turnover of £2 million and handling 50 tonnes of packaging or more, but are not registered with the relevant agency.*
[9] www.npwd.environment-agency.gov.uk

The final section of the report documents a historical analysis of glass packaging POM and recycling, which provides the basis for glass POM and recycling projections from 2018 to 2025. This is then used to provide analysis around compliance with future recycling targets.

2.0 Glass Packaging POM

2.1 Introduction

This section of the report estimates the total glass packaging POM in the UK in 2017. The POM figure is split between consumer and non-consumer; for the purposes of this report consumer is defined as what is consumed at home and non-consumer is what is consumed at pubs, clubs, restaurants, etc.

It is important to note that the report later calculates consumer consumption through grocery sales, such that all glass packaging around groceries counts towards the 'consumer' flow. This method will, in effect, include goods purchased in supermarkets by some of the smaller pubs, clubs, restaurants, etc. for consumption on their premises.

This section includes a series of sense checks against the data being used; the majority of these are included as appendices.

The packaging recycling targets are currently based on a percentage requirement of what is flowing onto the market: the EU directive target (in place since 2008) is 60% of the total glass packaging waste arising in 2017. To achieve this, companies in the UK that handle over 50 tonnes of packaging annually and have a turnover more than £2M are obligated to contribute to this, with a recycling target of 77% of the amount of glass placed on the market in 2017 rising to 80% in 2020[10]. Of the total amount recycled, 67% must be from re-melt.

2.2 Data Robustness

As there are levels of uncertainty around the data used to establish the various elements that are combined to estimate glass packaging POM, they are each presented with error margins, providing a range around the estimate. The robustness scores established for each data piece used are presented in Appendix I and these have been converted into a percentage and related to appropriate margins of error[11], as shown below. The respective margins of error are provided throughout the report.

Figure 1 Relating Robustness Scores to Appropriate Margins of Error

Robustness			Error Margin	
96%	to	100%	+/-	3%
91%	to	95%	+/-	6%
86%	to	90%	+/-	9%
81%	to	85%	+/-	12%
76%	to	80%	+/-	15%
71%	to	75%	+/-	18%
66%	to	70%	+/-	21%
61%	to	65%	+/-	24%
56%	to	60%	+/-	27%

[10] The business recycling target of 77% was set up with a buffer against the 60% total recovery target. Therefore, 77% of the business flow will be higher than the 60% of total flow.

[11] These are assumed estimates of error margin and not the outputs of statistical calculation.

The method used to calculate the margin of error for the total POM used the margins of error for the elements that made up the total POM to convert this to a tonnage, and then, using the Root of Sum of Squares (since we are dealing with the error of a sum), it was expressed as a percentage.

2.3 UK Production

To identify how much glass packaging is produced in the UK, production data provided by British Glass was used, as shown in Figure 2. This data was provided to British Glass by five out of six glass UK glass packaging manufacturers and was scaled up to estimate the total UK production, based on their previous market share and average performance.

Figure 2 UK Glass Container Production 2013 – 2017 (k tonnes)

	2013	2014	2015	2016	2017
Glass Container Production	2,241	2,246	2,194	2,204	2,296
Change from previous year	N/A	0%	-2%	0%	4%

This shows that between 2013 to 2017, glass container production increased by approximately 2.5% (or 56k tonnes). Compared to the previous GlassFlow estimate for 2012 (2,174k tonnes), it has increased by 6%.

To identify whether this increase was from existing producers or from new producers entering the system, the Environment Agency reviewed their internal database of producer data returns. This exercise identified that the increase in production was predominantly from existing producers rather than new ones.

Appendix II provides information regarding a sense check of this data against the National Packaging Waste Database (NPWD)[12] and Prodcom[13] (Eurostat statistics on the production of manufactured goods). It is important to note that the NPWD figures for the 2017 consumption are 'live'; they may change until re-submissions are finalised. Therefore, when NPWD data is used it is the latest available at the time of writing and it is not believed the final NPWD data will vary significantly from the figures used in this report[14].

However, for the purposes of this report, the British Glass figure 2,296k (+/- 6% error margin) was used. The British Glass and NPWD production figures were similar, with the British Glass figure only 0.4% higher, which may be a result of small specialist producers not being included in the NPWD data.

2.4 Exports (Empty)

Exports of empty glass packaging from NPWD Table 2a Conversion data are shown in Figure 3. British Glass also provided empty exports (empty) data; however, due to their

[12] http://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx, *Accessed (08/02/2019)*
[13] https://www.ons.gov.uk/businessindustryandtrade/manufacturingandproductionindustry/adhocs/008127prodcomproductlist2017, *Accessed (16/01/2019)*
[14] *Data correct in February 2019. Amendments to the 2017 data are still possible.*

membership not covering the full import/export supply chain (and their figure being 10% less than NPWD), the NPWD data was used.

Figure 3 UK Exports (Empty) 2013 – 2017 (k tonnes)

	2013	2014	2015	2016	2017
Exports (empty) - Table 2a Conversion	198	181	222	186	203
Change from previous year	N/A	-9%	23%	-17%	10%

There has been an oscillation between positive and negative annual growth between 2013 and 2017. However, over the whole period, empty glass packaging exports are up ~15k tonnes (4%) in 2017 from 2012 (195k tonnes[15]). Following cross referencing against HMRC beverage exports and British Glass figures (detailed in Appendix III); which showed that the British Glass data, although slightly lower, followed the same trend as NPWD; the NPWD data was used giving a UK exports (empty) figure of 203k (+/- 9%).

British Glass also stated that there will only be minimal unregistered tonnage as exports (empty) tend to be done by the large producers. This is because it is typically done to meet a particular demand, due to its being costly, as it is essentially the export of packaging coupled with a lot of void space.

2.5 Exports (Filled)

Estimates for the export of filled glass packaging were taken from NPWD data Table 2b Conversion and are shown in Figure 4 below.

Figure 4 UK Exports (Filled) 2013 – 2017 (k tonnes) [16]

	2013	2014	2015	2016	2017
Exports (Filled) – NPWD Table 2b Conversion	697	700	731	729	789
Change from previous year	N/A	0%	4%	0%	8%

It was recognised by the Steering Group that this figure could exclude glass sourced in the UK that is subsequently exported to countries, such as Eire or Gibraltar. Using Valpak member data submissions, it was possible to calculate a figure for this; however, as this only applies to Valpak members, it is considered a minimum figure. As this was only calculated for 2017, for 2013 – 2016 an estimate was made applying the proportion of the 2017 figures; this is summarised in Figure 5.

[15] https://www.valpak.co.uk/information-zone/reports/glassflow-2012

[16] http://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx, *Accessed (08/02/2019). Only conversion data was used as the way the data form is submitted, based on Valpak experience, the numbers for raw material manufacture are the same as conversion and so are not included.*

Figure 5 UK Exports (Filled) 2013 – 2017 with Uplift (k tonnes)

	2013	2014	2015	2016	2017
Exports (Filled) NPWD - Table 2b Conversion	697	700	731	729	789
Excluded EIRE/Gibraltar Exports	4	4	4	4	4
Exports (Filled)	701	703	735	733	793

The project Steering Group believed that there will be only minimal unregistered tonnage as exports (filled) will tend to be done by large producers. There is a cross referencing exercise against HMRC exports data (detailed in Appendix IV). This shows that the exports (filled) NPWD trend is generally supported by the HMRC trade data trend for beverage exports[17]. However, it is worth noting that this is only partly indicative as this includes beverages exported, regardless of packaging types.

This method shows that there were 793k tonnes (+/- 9%) of exports (filled) in 2017.

2.6 Imports (Empty)

NPWD data was used to estimate imports of empty glass packaging. British Glass also provided empty exports data; however, due to their membership not covering the full import/export supply chain, NPWD data was used. The NPWD imports (empty) data is shown in Figure 6.

Figure 6 UK Imports (Empty) 2013 – 2017 (k tonnes)[18]

	2013	2014	2015	2016	2017
Imports (Empty) – NPWD Table 3a Pack / Fill	79	94	125	92	95
% Change from prev. year	N/A	18%	33%	-26%	3%

This shows that in 2017 there were 95k tonnes (+/- 9%) of imports (empty) of glass packaging. Compared to 2012, this is an overall decrease of 36k tonnes (28%) and highlights that that the import/export of empty glass packaging is often done to meet particular demands and can fluctuate significantly.

The project Steering Group believed that there will be only minimal unregistered tonnage as imports (empty) also tend to be done by the large producers. This is because they will typically be done in large quantities to meet a specific demand; it can be expensive as it is essentially transporting glass packaging with a lot of air/void space. The exception to this is that empty glass packaging will be imported by small-scale specialist packaging suppliers, but the tonnage is likely to be minimal.

[17] https://www.uktradeinfo.com/Pages/Home.aspx, *Accessed (06/12/2018)*

[18] http://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx, *Accessed (08/02/2019)*

These figures were also cross referenced against British Glass figures, which are included in Appendix V.

2.7 Imports (Filled)

2.7.1 *Introduction*

The filled imports are more complicated to calculate. To estimate this, the following calculation is used:

Imports (Filled)	=	Obligated Imports	+	Unobligated / Unregistered Imports	+	Cross Border Shopping

2.7.2 *Obligated Imports*

As shown in the formula above, total filled imports comprise the obligated imports (those covered by the packaging regulations), unobligated/unregistered imports and cross border shopping.

It is possible to calculate obligated (filled) imports using information provided by the NPWD: Table 3a: packaging imported into the UK for selling. The NPWD Table 3a data is shown in **Error! Reference source not found.**.

Figure 7 UK Obligated Imports (Filled) 2013 – 2017 (k tonnes)[19]

	2013	2014	2015	2016	2017
Imports (Filled) - NPWD Table 3a: Imported for Selling	964	950	990	979	1,039
Change from previous year	N/A	-1%	4%	-1%	6%

This shows the obligated filled imports based on the NPWD data is 1039k tonnes (+/- 9%). This has increased 8% since 2013 and analysis by the Environment Agency indicates this increase is from existing obligated players in the UK grocery supermarket sector, closely followed by the drinks sector rather than from newly obligated businesses.

A cross reference against HMRC and NPWD (plastic, steel and aluminium) is included in Appendix VI. This showed that whilst the HMRC data had an increase from 2013 to 2017 and follows an overall upward trend it does not follow the same upward trend as NPWD data. The NPWD data shows an overall increase for glass, plastic and steel and aluminium from 2013 to 2017, with aluminium having the largest increase at 26% followed by plastic at 18%. In comparison, glass only increased by 8% which could be due to bulk importation of wine to be bottled in the UK.

2.7.3 *Unobligated / Unregistered Imports*

The unobligated importers are those that import filled glass packaging, but fall below the packaging regulations threshold for turnover and packaging tonnage handled, and are

[19] http://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx, *Accessed (08/02/2019)*

known as *de-minimis*. It is assumed that the majority of those that fall below the packaging regulations threshold are less likely to import filled glass packaging as they are not large enough to benefit from the economies of scale offered. However, the import of some specialist products supplied to local ethnic shops for example will still occur. This could also include local wine clubs that import from specific vineyards, for example. There are also those that are obligated under the regulations but that are not registered: free riders. This will include those that do not register, either through lack of knowledge of the regulations (where there is confusion around who the importer is, for example) or those that deliberately avoid the regulations.

Valpak made an estimate based on the estimated number of free riders and their typical tonnages, plus the number of *de-minimis* and their typical tonnage. This figure was estimated at 50k tonnes in 2012 and is thought to have remained at this level since then (based on internal Valpak knowledge regarding new registrations and the market not changing significantly over this period); therefore, 50k tonnes (+/- 27%) has been used from 2013 to 2017[20]. This estimate for unobligated/unregistered imports (filled) was sense checked by British Glass, which agreed this figure was in line with their estimate.

2.7.4 *Cross Border Shopping*

The passenger numbers were taken from a variety of sources: air [21], sea[22], Eurostar[23] and Le Shuttle[24]. As this is by full journeys (return trips), the passenger numbers were halved to determine all inbound journeys. The number of passengers buying alcohol was based on figures from Keynote[25] and it is assumed one glass bottle of alcohol purchased per buying passenger, with an average weight of 0.37kg. This is applied to the proportion of these alcoholic purchases that are packaged in glass, using the retail sales figures from the Valpak Data Solutions (VDS) database. The estimates depend on the assumptions set out above; therefore, there is some uncertainty around the quantities. However, they represent a relatively small proportion of the overall total compared with the more robust estimates of, for example, production, exports, etc. Figure 8 summarises the estimates for cross border shopping.

Figure 8 Cross Border Shopping 2017

	Air	Sea	Rail - Eurostar	Rail - Le Shuttle	Total
Total Passengers	287,649k	21,469k	10,300k	9,700k	329,118k
Inbound Passengers	143,825k	10,734k	5,150k	4,850k	164,559k
Passenger Purchase Ratio	2%	40%	1%	54%	6%
Passengers Purchasing Duty Free	2,876k	4,294k	52k	2,619k	9,841k
Proportion Glass Purchases	82%	82%	82%	82%	82%
Av Bottle Weight (kg)	0.37	0.37	0.37	0.37	N/A
Total Imported (k tonnes)	1	1	0	1	3

[20] *This is based on internal Valpak research. Due to the nature of this estimate i.e. it is unobligated/unregistered tonnage and is not recorded it is difficult to provide a greater level of confidence, and as such, has been given a large error margin.*
[21] http://www.caa.co.uk/default.aspx?catid=80&pagetype=88&pageid=3&sglid=3, *Accessed (16/01/2019)*
[22] https://www.gov.uk/government/collections/maritime-and-shipping-statistics, *Accessed (16/01/2019)*
[23] http://www.eurostar.com/uk-en/about-eurostar, *Accessed (17/01/2019)*
[24] http://www.eurotunnelgroup.com/uk/home/, *Accessed (17/01/2019)*
[25] *KeyNote: Cross Border Shopping (2000)*

This shows that there were 3k tonnes (+/- 24%) of glass packaging POM from cross border shopping in 2017.

2.7.5 *Total Imports (Filled)*

Figure 9 shows the total imports filled for glass packaging entering the UK.

Figure 9 Total Imports (filled) for Glass Packaging Entering the UK (k tonnes)

	Obligated Imports	Unobligated / Unregistered Imports	Cross Border Shopping	Total
Imports (Filled)	1,039	50	3	1,092

This shows that there were 1,092k tonnes (+/- 9%) of imports (filled) of glass packaging in 2017.

2.8 Total Glass Packaging POM 2017

2.8.1 *Total Glass Packaging POM*

Figure 10 shows the total glass packaging POM in 2017.

Figure 10 Total Glass Packaging POM 2017 (k tonnes)

Category	Sub-Category	2017
UK Glass Packaging POM	***Glass Packaging***	**2,487**
Production	*UK Production*	2,296
	Total	**2,296**
Exports	*Empty*	203
Exports	*Filled*	793
	Total	**996**
Imports	*Empty*	95
Imports	*Filled - Obligated*	1,039
Imports	*Filled - Unregistered*	50
Imports	*Filled - Cross border selling*	3
	Total	**1,187**

There was a total of 2,487 tonnes (+/- 7%) of glass packaging POM in 2017. This represents an increase in POM of 88k tonnes (4%) since 2012.

2.8.2 *Consumer/Non-consumer POM*

It is important for policy makers to understand where the glass is placed on the market; therefore, this section breaks down the total glass packing POM in the UK into consumer (packaging consumed in the household) and non-consumer (packaging consumed in the commercial/industrial sector; away from home or on the go in hotels, bars, restaurants and businesses) sectors.

Consumer Glass Packaging POM

For the purposes of this report, the consumer sector has been broken down into grocery and non-grocery. The addition of these two sub-sectors equates to the total consumer sector.

Grocery

To estimate the amount of packaging POM by the grocery retail market, aggregated Environment Agency (EA) data was used. The data provided by the EA was 2017 glass packaging quantities reported in 'Table 1 Selling' from NPWD for 95% of UK grocery retailers[26]. This data was scaled up to 100% of the UK grocery market and resulted in an estimated glass POM for 2017 of 1,519k tonnes (+/- 6%).

This estimate was cross referenced with Valpak's Environmental Product Information Centre (EPIC)[27], which was assessed to provide data on annual sales and packaging weights for all relevant products packaged in glass. This was taken from a selection of Valpak's supermarket clients, representing a cross-section of grocery retailers in the UK.

Using volume market share information from Kantar World Panel (not publicly available) for these supermarkets (representing 55% of the grocery retail market by sales volume for 2017), the resulting quantity of glass packaging was scaled up to represent an estimate for the UK grocery retail market. This method assumes that the glass packaging profile of the supermarkets in EPIC is representative of those not represented in EPIC. Based on this analysis, glass packaging in the grocery retail sector was estimated to be 1,486k tonnes in 2017 which is 34k tonnes lower than the estimate produced using the EA data.

In previous years, EPIC and EA data were closely aligned, with EPIC ultimately being used to estimate consumer POM due to it allowing for a greater level of interrogation of the data. However, based on the EA having higher market coverage and coupled with the increasing market share of discount retailers such as Aldi and Lidl in the grocery sector (which are not included in the Valpak database), this time the EA data was used to estimate consumer POM.

The final grocery retail glass packaging POM for 2017 of 1,519k tonnes (+/- 6%) was used. This is 2% higher than that identified for 2012[28]. Appendix I provides a detailed assessment of relative levels of confidence in the data.

Non-grocery

[26] The figure does not include non-obligated or unregistered producers.
[27] The database is based on information collected direct from suppliers as well as information sourced internally, meaning that it holds a wide coverage of information across multiple product ranges. Product specific data collection is completed through site visits, supplier mailings and weighing in-house (purchasing product and collecting used product from staff). All data goes through a comprehensive checking process on receipt and is stored in Valpak's bespoke software Environmental Product Information Centre (EPIC).
[28] https://www.valpak.co.uk/information-zone/reports/glassflow-2012

To scale up the grocery retail result to represent total UK retail, including non-grocery retail, the Office of National Statistics (ONS) retail sales data was used. This shows that the proportion of grocery spend of total UK retail spend was 43% in 2017[29].

However, simply scaling up using market share was not considered robust, since it was likely that packaging usage within both sub-sectors differed. Therefore, the difference in glass packaging used by the grocery sector and other retail sectors was analysed using Valpak membership's reported data[30]. Analysis involved the following key stages:

- Identification of grocery and non-grocery retail members;
- Gathering of company reported data and information; and
- Calculation of glass packaging tonnage per billion-pound turnover for grocery and non-grocery retailers (using Valpak data) representing 56% of reported tonnage of glass packaging on NPWD in 2017.

The method used assumes the packaging profile of those retailers within the sample is representative of those not in the sample and that turnover is a suitable scaling factor for packaging usage. Based on this method, total non-grocery POM is estimated at 110k tonnes (+/- 18%).

Adding the grocery and non-grocery estimates provides a consumer POM estimate of 1,630k[31] tonnes (+/- 6%). However, this is based on obligated producer packaging data and does not include the unobligated/unregistered tonnage. Discussions with the project Steering Group highlighted that they believe the unobligated/unregistered tonnage will most likely relate to small organisations in the consumer sector that are below or unaware of the producer responsibility threshold. Therefore, if the unobligated/unregistered tonnage of 205k (calculated by taking the obligated POM estimate away from the total POM) is added to the consumer grocery and non-grocery estimates, it provides a total for consumer packaging of 1,835k tonnes (+/- 11%). This estimate represents an increase of 2% in consumer POM since 2012.

Non-consumer Glass Packaging POM

The non-consumer glass packaging estimate can be derived from taking the consumer estimate from the total glass POM as shown in Figure 11.

Figure 11 Non-consumer Glass Packaging (k tonnes)

Non-consumer Packaging	=	Total POM	-	Consumer packaging
653	=	2,487	-	1,835

This shows that non-consumer packaging accounts for 653k tonnes (+/- 11%), which is an increase of 9% since 2012. It also shows that consumer POM accounts for 74% and non-

[29] https://www.ons.gov.uk/businessindustryandtrade/retailindustry/datasets/poundsdatatotalretailsales
[30] Valpak membership represents approximately 50% of all obligated companies, by obligation. The entire NPWD database was considered for analysis; however, for confidentiality reasons it was not possible to gain access to NPWD to conduct the same analysis on the complete dataset.
[31] *Due to rounding.*

consumer accounts for 26% of the glass packaging POM. This is therefore broadly unchanged when compared with the 75%/25% split estimated in 2012.

Consumer Type Glass Packaging

It was considered of interest to provide a POM estimate for glass packaging that could be defined as 'consumer-type'. A review of all categories of glass packaging used within the EPIC database for non-consumer glass packaging was conducted by Valpak and British Glass to determine the split between 'household-like' and 'non-household like'.

This concluded that all categories of glass packaging used could potentially be considered 'consumer-type' and, although there may be the odd item that would be considered a novelty/specialist item of packaging, in terms of overall weight, this would be negligible.

Therefore, the total POM estimate of 2,487 tonnes (+/- 7%) is considered 'consumer-type'.

2.8.3 *POM Composition by Colour and Format*

Colour Composition

The following consumer colour splits provided by British Glass were used in the GlassFlow 2012 report:

- Clear (45%);
- Amber (10%); and
- Green (45%).

The non-consumer splits provided by WRAP[32] for the GlassFlow 2012 report and were sense checked by British Glass to determine if they were still valid. They were:

- Clear (57%);
- Amber (15%); and
- Green (28%).

Both consumer and non-consumer splits have been sense-checked by British Glass, who believe they still look sensible. Using these splits, Figure 12 shows the quantity of glass packaging POM by colour.

Figure 12 Glass Packaging POM by Colour (k tonnes)

	2017
Total Consumption	2487
Total Consumer Consumption	1835
Clear	826
Amber	183

[32] *WRAP, Glass Crushers in hospitality – optimising for re-melt uses (2008):* http://www.wrap.org.uk/sites/files/wrap/Glass%20crushers%20in%20hospitality%20optimising%20for%20remelt%20uses.pdf

Green	826
Total Non-consumer Consumption	653
Clear	372
Amber	98
Green	183

Format Composition

By using the EPIC database, the breakdown in format of glass POM can be identified for consumer and non-consumer glass, then using these splits and applying them to the POM estimates for consumer and non-consumer POM, the quantity of glass by format can be derived, as shown in Figure 13. This was sense-checked by British Glass, which agreed the splits were in line with their estimates.

Figure 13 Glass Packaging POM by Format (k tonnes)

	2017
Total Consumption	2,487
Total Consumer Consumption	1,835
Bottles	*1,505*
Jars	*330*
Other	*0*
Total Non-consumer Consumption	653
Bottles	*613*
Jars	*26*
Other	*13*

This shows that bottles are the most used format of glass packaging POM in both the consumer and non-consumer sectors, accounting for 82% and 94% respectively. By further interrogating the EPIC database, the percentage of bottles that are beverage bottles can be identified and by applying this to the estimate for bottles POM, it is estimated that 1,400k tonnes of consumer bottles and 595k[33] tonnes of non-consumer bottles are beverage containers.

2.9 POM Cross-check - Net Pack Fill

This section of the report is used as a cross-check of the total glass POM in the UK in 2017, based on the data stored on NPWD as reported to the EA by obligated organisations.

The 2017, UK flow of glass packaging was calculated using the packaging weights reported to the EA by registered producers, which is publicly available on the NPWD website. The calculation used is shown below:

[33] *This figure varies from the WRAP Drinks Recycling On-the-Go report due to new data becoming available to the GlassFlow 2025 project and the project revising total POM and non-consumer POM estimates.*

Net Pack Fill	=	Packing/Filling Table 1 - pack/filling	+	Imports Table 3A - imported for the purpose of selling	+	Imports Table 3B - packaging removed from around imports	-	Exports Table 2A + Table 2B – pack/filling

This methodology took the weight reported at the *packing* stage of the supply chain as opposed to the *selling* stage of the supply chain. This was used as the Steering Group believed[34] that there would be fewer unobligated packers in comparison to unobligated sellers, due to the likely size of packers being larger than sellers. In addition, raw material manufacturing will include process losses; not everything manufactured will be converted or pack/filled, so it is expected that obligated tonnage is likely to decline as we move further down the supply chain.

Using this method, the total obligated glass POM in 2017 is **2,282k tonnes** (as shown in Figure 14)[35].

Figure 14 Obligated Glass Packaging (Net Pack Fill total) 2017[36] (k tonnes)

	Glass Packaging
Table 1 Pack/Fill (UK pack/filling)	2,040
3A Selling (filled imports)	1,039
3B (packaging removed from imports)	1
Total	**3,080**
2A P/F (direct exports)	722
2B P/F (third party exports)	76
Total Exported	**798**
Net Pack Fill	**2,282**

This method does not account for glass packaging handled by unregistered producers, which was likely to include the following:

- Non-obligated producers – those below the registration thresholds of 50 tonnes of packaging or £2 million turnover;
- Free-riders – those obligated to register but not doing so; and
- Illegal importers.

There is no way of robustly quantifying the unreported quantity of packaging, except through iteration.

An estimate of the unobligated/unregistered quantity has been made by subtracting the net pack fill figure of 2,282k tonnes from the project's final flow estimate of 2,487k tonnes. This leaves 205k tonnes, or an unobligated proportion of 8%.

The unobligated proportion of 8% is a reduction from the 12% identified in the GlassFlow 2012 report[37]. This change could be due to an increase in tonnage reported by obligated

[34] *No evidence data is available to support this.*
[35] *As reported by businesses in 2018.*
[36] *http://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx, Accessed (08/02/2019). Amendments to the 2017 data were still possible at the time of writing.*

companies (due to higher sales) and companies reporting that previously had been free-riding.

British Glass sense checked the unobligated/unregistered estimate of 8% and stated it was more in line with their estimate than the previous estimate of 12%.

[37] Within the GlassFlow 2012 report, the unobligated/unregistered estimate was 14% at the time of writing; however, following updates to NPWD data this was revised to 12% when using the revised data.

3.0 Collection and Reprocessing

3.1 Accredited Recycling of Glass Packaging (Recorded)

The NPWD was used to identify the total accredited (recorded) recycling of glass packaging, both in the UK and of exports for recycling overseas. For 2017, this shows 1,623k tonnes of glass packaging recycling, of which 1,273k tonnes (78%) took place in the UK. Of the total (UK and exports), 1,213 tonnes (75%) relates to recycling for remelt applications (usually recycled into glass containers) and 410k tonnes (25%) to recycling for other (typically aggregate) applications. Most exports were for recycling in remelt applications, with fewer than 2k tonnes (0.5%) of exports for other applications.

Based on the overall POM calculated in this report, the total recorded recycling figure of 1,623k tonnes gives a recorded recycling level of 65% in 2017.

PRNs and PERNs can be issued at various points of the supply chain depending on whether the glass is recycled in remelt or non-remelt applications, which was revised following the adoption of the EU End of Waste Regulation for Glass Cullet[38]. Appendix VII provides a diagram showing where in the supply chain PRNs and PERNs can be issued.

3.2 Recycling of Glass Packaging (Unrecorded)

It is important to recognise that not all the recycling of glass packaging might be accredited and recorded on NPWD. To try and identify the scale of unrecorded recycling, discussions were held with the project Steering Group as well as UK recyclers and exporters handling recovered glass packaging.

For glass recycled into remelt applications, whether this occurs in the UK or overseas, the view of those consulted was that all of it is being captured on NPWD. The rationale for this conclusion is that glass recycling operations that prepare cullet for the remelt sector are large scale operations that are known to be accredited. For exports, the economic feasibility relies on the revenue generated from the PERNs and so shipments outside of the UK are unlikely to occur through unaccredited exporters. Therefore, the capture on NPWD of recycling for remelt was assumed to be 100%.

For recycling of glass packaging for use in non-remelt applications, it was believed that there was some loss in 2017, related to MRF glass fines used in aggregate applications. The payment of gate fees for glass fines and the potential to use relatively simple processing equipment to produce an aggregate (compared to that required to produce a furnace ready cullet) meant that some non-accredited recycling would likely happen. Following discussions with the Steering Group and other representatives from industry, it was assumed that 85% of the 'other' recycling (non-remelt) was captured on NPWD in 2017.

During the production of glass cullet for remelt applications, ceramics, stones and porcelain (CSP) must be removed. This is done using optical sorting equipment that removes this contamination with jets of air. This ejected fraction typically contains high percentages of glass packaging that are removed along with the CSP. As this material is often used in aggregate applications, it is typically captured on NPWD. However, whilst those contacted believed that most companies recycling this fraction were accredited, discussions identified that this is not always the case. An unrecorded recycling figure of 20k tonnes has been used to account for the recycling of this fraction where PRNs were not issued.

[38] https://npwd.environment-agency.gov.uk/filedownload.ashx?fileid=edee7dc6-4249-4187-834e-88fb6a8b5bdd

In total, it is estimated that there were 92k tonnes of unrecorded glass packaging recycled in 2017.

3.3 Total Recycling (Recorded and Unrecorded)

The total glass packaging recycling can be calculated by combining the recorded recycling on NPWD with the estimate for unrecorded recycling:

Total UK Glass Packaging Recycled	=	Total Recorded Recycling	+	Total Unrecorded Recycling

This gives a total recycling rate for glass packaging of 1,715k tonnes. Based on the POM calculated in this report, this would be a recycling rate of 69%.

3.4 Consumer and Non-consumer Recycling

3.4.1 *Consumer Recycling*

Consumer recycling data was extracted from Waste Data Flow (WDF) and figures are reported based on the financial year 2016/17. This means there is some degree of inconsistency between the collection figures for April 2016 - March 2017 and the consumption figures for January 2017 - December 2017[39]. A summary of the glass packaging collections is shown in Figure 15.

Figure 15 Glass Packaging WDF Data 2016/17 (k tonnes)

	Kerbside	Bring	HWRC	Total
Glass Packaging Collected	1,249	163	48	1,460

Adjustments were made to more accurately reflect the actual consumer glass recycling from the collection data reported in WDF by taking into consideration contamination.

Glass PRNs are issued at the point the cullet is produced and so will exclude any contamination, including caps, closures and corks. Exports also need to account for contamination prior to reporting on NPWD. Estimates were made related to contamination in the WDF figures, so they better align with NPWD figures. It was assumed that local authorities (LAs) would report any glass that was separately collected from other materials based on vehicle delivery weights. WDF shows this to be 39% of the glass in 2017, either separately collected at the kerbside or in bring banks, including those at Household Waste Recycling Centres (HWRCs). Where the glass is collected separately, a 3% loss is assumed for contamination (primarily caps and closures). Around 7-8% of the glass is ejected during the cullet-making process whilst removing CSP (see above); however, this has not been deducted as it is assumed to be recycled (recorded or unrecorded).

[39] The figure is approximate, as data is reported in different ways. Most is for the period April 2016 to March 2017; however, the SEPA data reviewed was for 2017. Also, some data was for household waste (used where available) and other data for municipal solid waste.

The remaining 61% of the glass is collected comingled with other materials. Here, the material will also contain caps and closures, but it is assumed that higher levels of other contamination will be present than for glass collected source separated. Glass is harder to sample at single stream MRFs than other materials due to the presence of small broken fragments that will fall through the sieve used to separate large items and fines during the sampling process. It is contamination in this fines fraction that may impact on contamination levels reported on WDF. If MRFs choose to allocate glass to suppliers based on outputs, then again, contamination will be contained within it at higher levels than source separated glass. For the calculation, it is assumed that glass collected with other materials will be reported with 10% contamination levels.

Based on the above assumptions, it is estimated that the total glass collected as reported on WDF should be reduced by 106k tonnes to account for the presence of contamination (that would not be included in the NPWD figures). By making this reduction it means that 1,354k tonnes of consumer glass packaging was recycled in 2017. Based on the POM calculated in this report, this would give a consumer glass packaging recycling rate of 74%.

Whilst no adjustment was made for non-consumer glass in WDF figures, it should be noted that it may be present. Non-consumer glass might arrive in the flow from several sources:

- Local authority collections of glass from licensed premises and offices;
- Licensed premises placing glass in bottle banks or domestic kerbside bins;
- Businesses and offices collecting glass and placing it in bottle banks or domestic kerbside bins; and
- Individuals purchasing drinks in glass bottles from small commercial outlets such as takeaways and sandwich shops that they then recycle at home.

3.4.2 *Non-consumer Recycling*

Non-consumer recycling was estimated as follows:

Non-consumer Recycling	=	Total Recycling	-	Consumer Recycling
361k	=	1,715k	-	1,354k

This gives a non-consumer recycling estimate for glass packaging of 361k tonnes in 2017. Based on the calculated non-consumer POM, this gives a recycling rate of 55%.

3.5 Glass Packaging Not Recycled

By taking the consumer and non-consumer recycling totals from the respective POMs (see Figure 13) we are left with the non-recycled tonnages.

For consumer glass packaging, the non-recycled total is 480k tonnes. An analysis of data on WDF combined with data from the Scottish Environment Protection Agency (SEPA), StatsWales and the Department of Agriculture, Environment and Rural Affairs (DAERA) was used to estimate the percentage of residual household waste that was sent to Energy from

Waste (EfW) and landfill. This showed that in 2017 approximately 65% of consumer waste was disposed using EfW and 35% to landfill. The 65% to EfW includes refuse derived fuel (RDF) that is exported to EfW plants in mainland Europe. Using these percentages, it is estimated that of the total consumer glass packaging not recycled, 312k tonnes was sent for energy recovery and 168k tonnes to landfill.

For non-consumer glass packaging, the non-recycled total is 292k tonnes. Here, a figure for glass sent for EfW was derived by estimating the average glass packaging content in both commercial and industrial (C&I) waste sent for energy recovery in the UK and in the RDF exported to overseas energy recovery plants. There is limited data available on C&I waste composition and it will also vary depending on the source of the C&I waste. An assumption was therefore made that the glass content of C&I waste entering EfW and RDF plants would be similar to that in MSW waste. A figure of 3% was used, based on Defra data from 2011[40]. All glass was assumed to be packaging. For RDF, it was assumed that 50% of the glass content would be removed during processing into the fines fraction and either be landfilled or used in landfill construction applications. A figure of 1.5% was therefore used for glass in RDF delivered to overseas EfW plants.

A figure of 1.83M tonnes of C&I waste being sent to UK EfW plants was used. This was based on research by Tolvic[41] on the total quantity of waste delivered to UK EfW plants in 2017 (10.89M tonnes) and the percentage of this that was C&I waste (16.8%). For RDF exported, a figure of 3.56M tonnes[42] of UK RDF exports in 2017 was used with the assumption made that 50% of this was produced from C&I waste. Finally, it was assumed that any non-recycled, non-consumer glass packaging remaining was sent for landfill. Using these assumptions, it was estimated that of the total non-recycled, non-consumer glass packaging, 82k tonnes (28%) was sent for energy recovery and 210k tonnes to landfill (72%).

[40] Defra: Digest of Waste and Resources Statistics, 2018 edition. Composition of MSW sent to landfill in 2011 for England and Wales. For MSW falling under 20.03.01 (3% glass).
[41] Tolvic Consulting UK Energy from Waste Statistics 2017
[42] This is based on data from the Environment Agency, National Resources Wales (Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved), the Department of Agriculture, Environment and Rural Affaires in Northern Ireland, and the Scottish Environment Protection Agency. The data from England and Wales is subject to the Open Government License (http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/).

4.0 Glass Packaging End Markets

Based on NPWD figures for 2017, 78% of the recorded glass packaging recycling took place in the UK and 22% overseas. Of the glass packaging recycled in the UK, 865k tonnes (68%) went into remelt applications and 408k tonnes (32%) into 'other' applications. Of the remelt fraction, input from industry suggests 10-15% is used to produce glass mineral wool and the remainder is used by the container industry. The 'other' category on NPWD is used for non-remelt applications, typically the use of glass in some form of aggregate substitute application. This includes glass used in road construction, concrete products, as a shot blasting abrasive or filtration media.

A freedom of information request was made to the EA to determine where glass packaging was exported to for recycling. It can be seen from the breakdown given below that it is all exported to other EU countries. Exports tend to be focused on either wine making regions, such as Portugal and Spain, or countries in North West Europe where logistics costs are relatively low. As mentioned earlier, nearly all the exports in 2017 were destined for remelt applications with the container sector believed to take the majority.

Figure 16 Glass Packaging Export Destinations (2017)[43] (k tonnes)

Country	Export	% of exports
Portugal	206	59
Netherlands	69	20
Belgium	56	16
Spain	16	5
Ireland	2	1

[43] *Data source: UK Environment Agency. Freedom of Information request*
Data Manipulation: Verde Research and Consulting Ltd
Contains public sector information licensed under the Open Government License v3.0.
http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/

5.0 Glass Packaging Projections & Compliance

This section of the report reviews the historical data and trends for glass packaging placed on the market (POM) in the UK, and glass accredited recycling as reported by on NPWD.

Based on this data, univariate time-series models (linear trend and autoregressive models) are estimated and, using these statistical models, a range of scenarios for glass packaging POM and accredited recycling are projected forward to 2025. The intention is to provide a range of plausible possible futures for glass packaging POM and accredited recycling to inform a compliance assessment for policymakers and other stakeholders.

5.1 Glass Packaging POM and Projections

Historically, glass packaging POM has been estimated by a process of consultation and periodic review with industry and stakeholders[44]. In the PackFlow methodologies, glass packaging POM was established using assumed growth rates from a historical baseline, with the growth rates and resultant POM tonnages discussed and agreed with industry, government and stakeholders before being adopted for target setting.

A long historical time series (suitable for modelling) is not available for glass POM tonnages because past estimates of POM tonnages were established by a process reflecting a mixture of data and expert judgement and therefore may not necessarily accurately reflect actual trends in materials being placed on the market.

However, the EA's NPWD does provide a data source from which to assess trends over time in glass packaging placed onto the UK market by businesses that are obligated to comply with the packaging regulations. Obligated businesses are required to report their packaging tonnages data into NPWD each year. Therefore, historical data on the quantities of glass packaging handled by obligated producers is available for trend analysis.

An unknown variable is the quantity of non-obligated and unregistered packaging; packaging handled by businesses who are 'de minimis' or who are, for whatever reason, 'free-riders'. However, once a total POM is established, this can be straightforwardly estimated. If, in the past, the proportion of non-obligated and unregistered packaging POM was small and/or fairly constant over time, then it seems reasonable that trends observed in obligated packaging POM can be expected to closely mirror trends in overall POM.

That said, the tonnages reported by obligated producers in NPWD are impacted, for example, by businesses coming into the regime that were previously 'free-riding'. Also, since the packaging regulations were introduced there have been instances of changes to legislation which may also affect POM tonnages; for example, the status of packaging for 'internal use only' not being obligated. However, it is likely that over time businesses would have gained a better understanding of the requirements of the legislation, which in itself has likely improved the accuracy of data reported into NPWD.

Here, it is assumed that the glass packaging net pack fill tonnages 1997 to 2017 (calculated using NPWD data as described in section 2.9 of this report) are the best available data to:

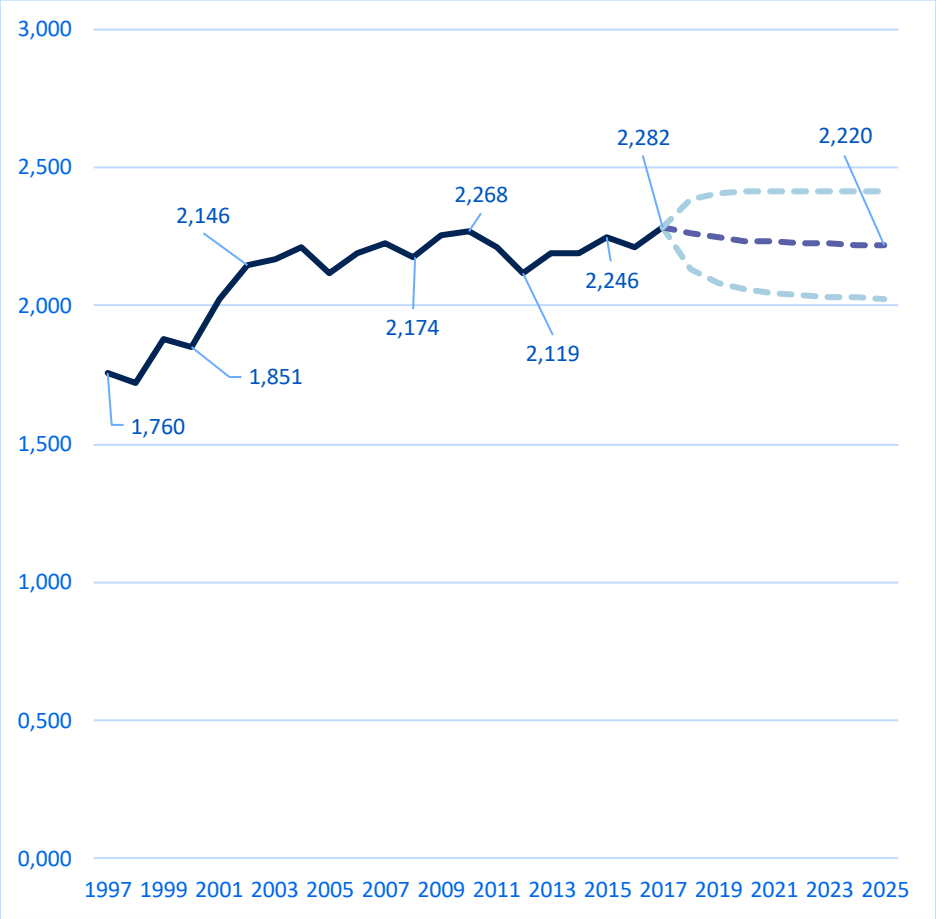
- Assess trends in the overall quantity of glass packaging POM;
- Estimate empirical models of glass packaging POM; and

[44] *For example in the GlassFlow 2012, the PackFlow 2017, and PackFlow 2012 reports.*

■ Project plausible possible future scenarios for glass packaging POM.

Figure 17 shows the historical data for glass packaging UK net pack fill (with a 95% confidence interval). The past outturns for net pack fill show a steady increase from 1997 to 2004, followed by a period of slower growth to 2010, which was likely affected by the 2008/9 recession. There is then a decline in 2011 and 2012. Since 2012, glass packaging net pack fill has increased at a slightly faster pace in comparison to growth over the period 1997 to 2017.

Figure 17 Glass Packaging Historical Net Pack Fill and Projections (k tonnes)



While the recession may have had an impact on glass packaging POM, it is also likely that light weighting activity has also suppressed glass packaging relative to consumption; however, the extent to which this has happened is not precisely known. Other factors potentially impacting on glass POM trends (past and future) are discussed in Figure 18.

Figure 18 Glass Packaging NPF Versus Economic Activity Indicators

	1997-2017		2012-2017		2018 - 2020		2018 - 2025	
	Level	Average Growth	Level	Average Growth	Level	Average Growth	Level	Average Growth
Net Pack Fill	30.0%	1.3%	8.0%	1.5%	-1.0%	-0.5%	-2.0%	-0.3%
GDP	49.0%	2.0%	6.0%	2.0%	3.1%	1.5%	11.2%	1.5%
POP	13.2%	0.6%	2.2%	0.7%	1.2%	0.6%	3.7%	0.5%
Retail Sales	69.0%	2.7%	10.5%	3.4%	2.0%	1.0%	11.1%	1.5%

Figure 18 compares the level and growth of net pack fill to other indicators of economic activity, such as Gross Domestic Product (GDP), population[45] and retail sales. Over the two decades previous to 2017, glass packaging net pack fill average growth was below that of GDP and retail sales, but above population growth. Since 2012, growth in glass packaging net pack fill has averaged 1.5% a year.

Using the historical net pack fill data for glass packaging, three statistical univariate time-series models (a linear trend model and two autoregressive models) were developed. Based on the preferred AR(1) model, which was selected based on statistical criteria, a scenario for glass packaging POM is projected to 2025. Full details of the methodology used to estimate the models can be found in Appendix VIII.

By assumption, factors driving past trend growth in glass packaging net pack fill (and hence by assumption POM) are projected into the future. Whilst this projection is 'data based', it is not intended to be sophisticated. For example, it doesn't account for potential substitution effects within glass packaging or between glass packaging and other packaging materials (likely given the recent backlash against plastic packaging but to an unknown extent), reform of extended producer responsibility, uncertainty due to EU exit, or changes in future trends in light-weighting of glass packaging.

All projections are subject to uncertainty; however, the uncertainty around projections based on statistical models such as these can be estimated using the modelled standard error from the statistical analysis. Assuming a normal distribution, 95% confidence intervals are calculated as the upper and lower bounds to the projection shown in **Figure** 17.

A scenario for glass packaging POM to 2025 based on the projected growth rates of the model estimated for net pack fill was discussed with the project Steering Group. It was noted that past growth had been observed during periods of GDP and retail sales growth. Therefore, the statistical model projection of a decline in glass packaging POM seemed out of kilter with the expectation of continued GDP[46] growth and retail sales growth[47] over the

[45] Office for National Statistics, UK population projections published 26 October 2017
[46] Office for Budget Responsibility (OBR), October 2018 forecast of UK GDP growth 2018 to 2023, GDP growth rates in 2024 and 2025 are assumed equal to the OBR forecast of UK GDP growth in 2023.
[47] Retail sales growth projected 2018 to 2025 based on an estimated linear statistical model.

projection horizon, especially given average growth of 1.5% in glass packaging net pack fill since 2012. It was suggested that some growth in glass packaging POM was plausible and could reasonably be expected in the near term before some levelling off.

The scenario for glass POM, reported in Figure 19 is based on assumed growth rates of 1.5%, 1% and 0.3% in 2019, 2020 and 2021. Beyond 2021, the growth rates of glass packaging POM are the projected growth rates from net pack fill AR(1) model. The projection for POM growth for 2018 to 2020 is therefore more in line with expected GDP growth and retail sales growth. The projection also assumes that the 2018 glass packaging POM figure (the first year of the projection scenario) is the same as the 2017 POM figure of 2,487k tonnes developed in this project.

In this scenario, glass packaging POM is projected to increase from 2,487k tonnes in 2018 to 2,550k tonnes in 2020, and to 2,544k tonnes in 2025. This is an increase of 57k tonnes or 2.3% in 2025 compared to 2018.

Figure 19 Glass Packaging POM Projected Scenario 2018 to 2025 (k tonnes)

Year	2018	2019	2020	2021	2022	2023	2024	2025
POM	2,487	2,525	2,550	2,556	2,551	2,548	2,546	2,544
% change	-	1.5	1.0	0.3	-0.2	-0.1	-0.1	-0.1

5.2 Glass Packaging Recycling Projections

This section reviews the historical data and trends for the quantity of accredited glass packaging recycling reported by UK accredited reprocessors/exporters into NPWD. It therefore omits glass packaging that is recycled by non-accredited reprocessors/exporters and glass packaging that is recycled but not recorded as accredited recycling by accredited reprocessors/exporters.

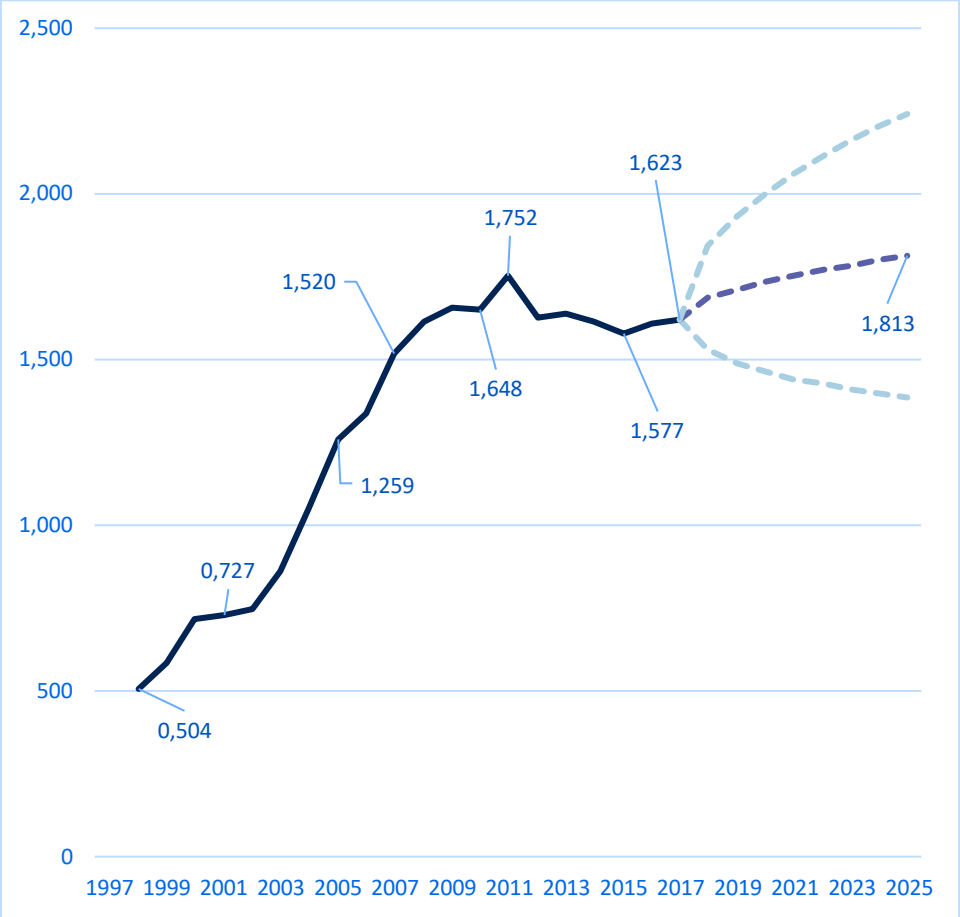
To establish a scenario for accredited glass packaging recycling to 2025, statistical models - univariate time series models (linear trend and auto-regressive models) – were produced. The preferred model selected on statistical criteria was the AR(1) model. Based on this model a scenario for accredited glass packaging recycling is projected to 2025 and is shown in Figure 20**Error! Reference source not found.**. Full details of the methodology used to estimate the models can be found in Appendix VIII.

This projection extends the trend observed in historical accredited recycling into the future. By assumption, factors driving past performance are also projected into the future. The Steering Group noted the anomaly in the 2012 reported accredited glass recycling, which, at the time, was caused by fraudulent generation of evidence for glass packaging. It is estimated that the scale of this fraud was in the order of 100k tonnes to 150k tonnes and so distorted the true picture in 2012 (the extent to which earlier recorded accredited glass recycling could have been affected is not known and neither is the possible impact of its detection beyond 2012). However, estimating the statistical models after adjusting for this distortion did not significantly change the model parameters or the projection.

As discussed above, while it is 'data based' and intended to be plausible, the projection is not intended to be sophisticated. In addition to factors potentially impacting the weight of glass packaging POM discussed above, it ignores factors such as the timing and extent of potential future policy initiatives (for example Deposit Return Schemes, a reform of extended

packaging producer responsibility), possible changes in legislation and the impact of possible targets for packaging recycling beyond 2020. It also excludes other potential external influences that might impact on recycling markets such as the potential for investment in UK reprocessing and collections, the continued availability of export markets for glass packaging and the potential demand for recycled content in glass packaging.

Figure 20 Glass Packaging Historical Accredited Recycling and Projections (k tonnes)



Provisional 2018 figures for accredited glass packaging recycling are available for 2018 Q1 to Q3 from NPWD. Glass packaging recycling is reported as 395k tonnes for 2018 Q1, 427k tonnes for 2018Q2 and 408k tonnes in 2018Q3, so for January to September 2018 a total of 1,230k tonnes of glass packaging was recorded as accredited recycling, which is an increase of 0.2% compared to the same period in 2017.

The 2018 full year estimate of 1,687k tonnes assumes quarter on quarter growth in accredited glass packaging recycling of 12% in 2018 Q4, with the estimated 2018 full year figure increasing by 4% compared to the 2017 full year figure for accredited glass recycling.

In the scenario projection for accredited glass packaging, recycling the 2018 full year figure over-rides the model-based projection. The annual projections from 2019 to 2025 are based on the estimated AR(1) model projections for accredited glass packaging recycling, which are shown in**Error! Reference source not found.** Figure 20 together with 95% confidence intervals as indicative upper and lower bounds to the projection.

Figure 21 Glass Packaging Accredited Recycling and Projection 2018-25 (k tonnes)

Year	2018	2019	2020	2021	2022	2023	2024	2025
Accredited Recycling	1,687	1,711	1,732	1,752	1,769	1,785	1,800	1,813
% change	4.0	1.4	1.2	1.1	1.0	0.9	0.8	0.7

Figure 21 reports the projected tonnages for accredited glass packaging recycling to 2025. In this scenario, glass packaging increases from 1,687k tonnes in 2018 to 1,732k tonnes in 2020, and to 1,813k tonnes in 2025, which is an increase of 125kk tonnes or 7.4% in 2025 compared to 2018. This scenario for accredited glass packaging recycling is used in the compliance assessment in section 5.3.

5.3 Glass Packaging Recycling Scenarios and Compliance Assessment

This section provides a compliance assessment based on the scenarios to 2025 for glass packaging POM and accredited glass packaging recycling reported in sections 5.1 and 5.2.

For this compliance assessment, the material specific targets on obligated businesses for glass packaging (78% in 2018, 79% in 2019 and 80% in 2020) are expressed as equivalents to national (or all material) recycling targets based on total glass packaging POM, which are: 71.6% in 2018, 72.5% in 2019 and 73.4% in 2020.

Glass packaging recycling is currently meeting the minimum EU recycling rate of 60%. However, using the CEP target of 70% in 2025 in this scenario would mean the 2025 target is below the current national target equivalents of the business targets in 2018, 2019 and 2020 (the CEP target is assumed to apply to all glass packaging POM).

There are no targets for glass packaging recycling set beyond 2020. Here, the compliance assessment targets for 2021 to 2025 are assumed to be equal to the national equivalent of the 2020 business target.

Based on these targets and the projection scenarios for glass packaging POM, the tonnages of recycling required by obligated businesses each year to meet the targets are calculated and compared to the projection scenario tonnages for accredited glass packaging recycling.

To assess the likelihood of meeting the targets, the probability of meeting the target in each year is also calculated. Assuming that in each year the probability distribution around the scenario projection for recycling is normally distributed and centred on the projected figure, with a standard deviation estimated by the standard error of the estimated model in each year.

As noted above, there are no targets beyond 2020 other than the CEP target of 70% for 2025. This compliance assessment is therefore only meaningful versus the published 2018 to 2020 targets and the target for 2025.

Figure 22 reports a compliance assessment for the projected scenarios to 2025 for glass packaging POM and accredited glass packaging recycling.

Assuming the 2018 POM figure of 2,487k tonnes developed in this project is applicable in this scenario, and that the projections for glass packaging POM and accredited glass packaging recycling are plausible, based on this assessment, the UK is unlikely to meet the glass packaging recycling targets in 2018, 2019 and 2020.

Figure 22 Glass Packaging Accredited Recycling Compliance Assessment 2018-25 (k tonnes)

Year	POM*	National Target (%)	Required Recycling	Projected Accredited Recycling**	Probability of Meeting the Target (%)	National Recycling Rate (%)
2018	2,487	72	1,780	1,687	12.4	67.8
2019	2,525	72	1,830	1,711	14.6	67.8
2020	2,550	73	1,872	1,732	15.6	67.9
2021	2,556	73	1,877	1,752	21.5	68.5
2022	2,551	73	1,873	1,769	27.8	69.3
2023	2,548	73	1,871	1,785	32.8	70.1
2024	2,546	73	1,869	1,800	36.8	70.7
2025	2,544	73	1,868	1,813	40.0	71.2

*model-based projection for POM as reported in section 5.1, ** model-based projection as reported in section 5.2

In each year of this compliance scenario, the projection for accredited recycling tonnage is below the expected amount of accredited recycling required to meet the target; hence, the implied recycling rates for glass packaging are below the targets.

The associated probabilities of meeting the national equivalents of the business targets in 2018, 2019 and 2020 are 12.4%, 14.6% and 15.6%.

As discussed above, there are no targets for glass packaging recycling beyond 2020 other that the CEP target in 2025. Based on this assessment, the proposed CEP target of 70% in 2025 is likely to be met, but there's a lower probability that the assumed glass packaging target of 73.4% in 2025 is also met.

6.0 Conclusions

6.1 POM

There were 2,487k tonnes (+/- 7%) of glass packaging POM in 2017: an increase of 4% from the estimated current flow figure (2012)

This has been derived using a methodology consisting of identifying UK production and adding imports and removing exports. Data was used from a variety of sources for each sector with the results combined. It has been cross-checked with reported obligated data on NPWD and with the project's Steering Group. Analysis by the Environment Agency showed that a significant part of this increase was from existing producers rather than new producers coming into the system.

The final project estimate for glass packaging POM in the consumer sector is 1,835k tonnes (+/- 11%)

This method is based on primary data alongside reliable market share data. No other method was used for deriving consumer data as this method is considered the most robust available and is accepted by industry.

The final project estimate for glass packaging POM in the non-consumer sector is 653k tonnes (+/- 11%)

This data was derived by taking the consumer sector tonnage away from the total POM estimate. Sense checks were made by the British Beer and Pub Association (BBPA) and the Wine and Spirit Trade Association (WSTA).

Non-obligated or unregistered flow for glass packaging accounted for 8% of POM in 2017 – this represents a decline from that reported in 2012 of 12%

Using data from NPWD, an estimate of the unobligated/unreported tonnage (205k tonnes, 8%) has been made by subtracting the net pack fill figure of 2,282k tonnes from the project's final flow estimate of 2,487k tonnes. The unobligated proportion of 8% is a reduction from the 12%[48] identified in the GlassFlow 2012 report. British Glass believes the 2017 estimate is more realistic than the previous one.

The final project estimate of glass packaging POM by type is 2,118k tonnes (85%) bottles, 356k tonnes (14%) jars, 13k tonnes (1%) other packaging

Primarily using information derived from Valpak's EPIC database and sense-checked by British Glass, the final project estimate by format has been made. This indicates that bottles make up most of the glass packaging.

[48] This was revised from 14% in the published version of the report to 12% once final NPWD data was published and the calculations updated accordingly.

6.2 Recycling

The total quantity of UK glass packaging recycled is estimated to be 1,715k tonnes

This includes reported (NPWD) and an estimate for unreported recycling (92k tonnes). Based on the POM calculated as part of this project, this gives an overall recycling rate of 69%. Of this, 1,623k tonnes was reported on NPWD, representing a recycling rate of 65%.

The total quantity of consumer UK glass packaging recycled is estimated to be 1,354k tonnes

Based on WDF and the consumer POM calculated as part of this project, this gives a consumer recycling rate of 74%.

The total quantity of non-consumer UK glass packaging recycled is estimated to be 361k tonnes

This is calculated by removing the consumer recycling tonnage from the total tonnage recycled figure. Based on the non-consumer POM calculated as part of this project, this gives a non-consumer recycling rate of 55%.

Of the total 772k tonnes unrecycled glass packaging, 394k tonnes (51%) was sent for energy recovery and 378k tonnes to landfill (49%)

This was based on an estimated total of 480k tonnes of consumer glass packaging and 292k tonnes of non-consumer not being recycled, which was derived using WDF and published statistics on UK disposal routes.

6.3 Projections and Compliance

The scenario projection for glass POM projects an increase from 2,487k tonnes in 2018[49] to 2,550k tonnes in 2020, and to 2,544k tonnes in 2025

This represents an increase of 57k tonnes or 2.3% in 2025 compared to 2018.

The scenario projection for glass packaging recycling projects an increase from 1,687k tonnes in 2018 to 1,732k tonnes in 2020 and to 1,813k tonnes in 2025

This represents an increase of 126k tonnes or 7.4% in 2025 compared to 2018.

Based on the POM and recycling scenarios, accredited glass packaging recycling is expected to fall short of the national equivalents of the business targets in 2018, 2019 and 2020

The associated probabilities of meeting the national equivalents of the business targets for glass accredited packaging recycling in 2018, 2019 and 2020 are 12.4%, 14.6% and 15.6% respectively.

[49] Compliance year 2018 is data reported in 2018 by obligated companies, this relates to packaging POM in 2017.

Based on the POM and recycling scenarios, the proposed CEP target of 70% in 2025 is likely to be met

There are no targets for glass packaging recycling beyond 2020 other than the CEP target in 2025.

7.0 Recommendations for Further Work

Reviewing elements of the Packaging Regulations to capture more non-obligated or unregistered tonnage

Removal of de minimis - those companies who are below the packaging obligation threshold by having a turnover of under £2 million and handling less than 50 tonnes of packaging. If the de minimis is not removed, the following could be considered:

- Re-introducing the service provider clause. This was originally introduced to capture tonnage sold to small businesses by wholesalers and therefore not captured because the 'selling' organisation was too small to be obligated. A revised version of this clause could be re-introduced to capture this non-obligated tonnage by placing an obligation on the wholesaler;
- Extend the clauses in the Regulations that exist to capture tonnage handled by lessors and franchisors, who do not necessarily perform pack filling and selling, but are responsible for these activities and, as such, take on their packaging obligation. This could be extended to cover other organisations, for example, businesses performing a "fulfilment service", who either do not perform the packaging activities or do not own the packaging but are responsible for the sales outlet and/or marketing function of the products sold. This business model has become increasingly popular for "online" sales;
- Investigate the potential for unobligated or unregistered tonnage to be supplied through increasing use of internet "marketplace" arrangements, particularly where products are supplied from other countries;
- Including, packaging used internally by an organisation (for example for transporting between or within sites) which is currently exempt from the Regulations. This is not expected to be a significant volume for glass; and
- In cases where the brand owner supplies packaging to contract packers free of charge (contract packing), the brand owner is responsible for the obligation. However, it is suspected that this may be overlooked by producers in many cases and as such could be a focus of compliance scheme or enforcement agency auditors to carry out checks and issue reminders.

Recommended accreditation for all recycling activities

All companies in the UK performing recycling activities on packaging should become accredited and report all their recycling. This would ensure that PRNs are issued on more of the packaging material recycled, resulting in no unaccredited recycling and easier compliance with UK regulatory targets.

Appendix I

Data Robustness

A robustness analysis was completed on the key data sources used. This was developed to highlight the level of uncertainty for each data source by scoring them on the evidence and agreement level from stakeholders. Questions were asked relating to the evidence and agreement levels of the data used (see the tables later in this section for details) and then the data were scored on each axis. The results are shown in Figure 23 (POM), Figure 24 (Recycling) and a summary in Figure 25, which has been constructed based on analysis completed for each project estimate.

The tables thereafter provide a full breakdown for each project estimate. If the question is answered 'Yes' then a score of 3 is given, if it is answered 'No' then a score of 0 is given. A score of 1 or 2 is given depending on the degree of reservation over the robustness.

Figure 23 Data Robustness Assessment Results – POM

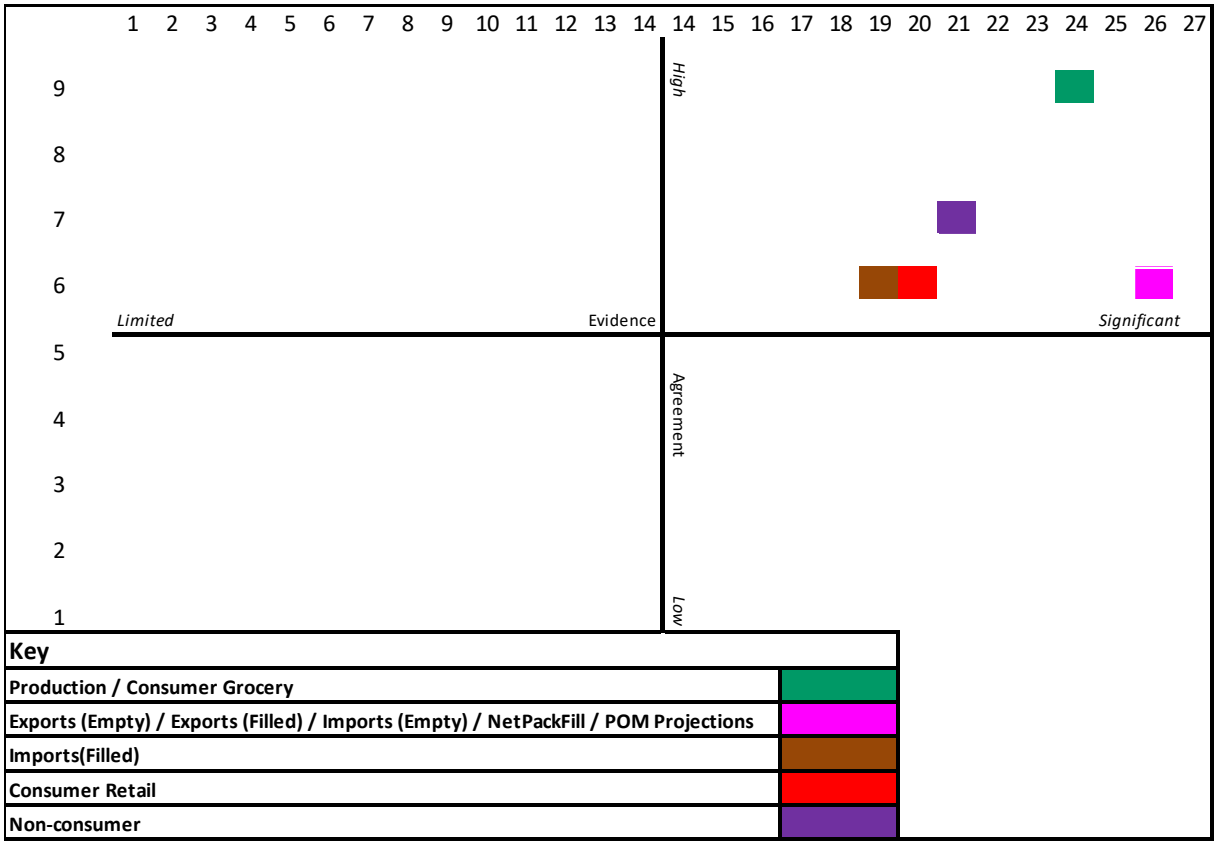


Figure 24 Data Robustness Assessment Results – Recycling

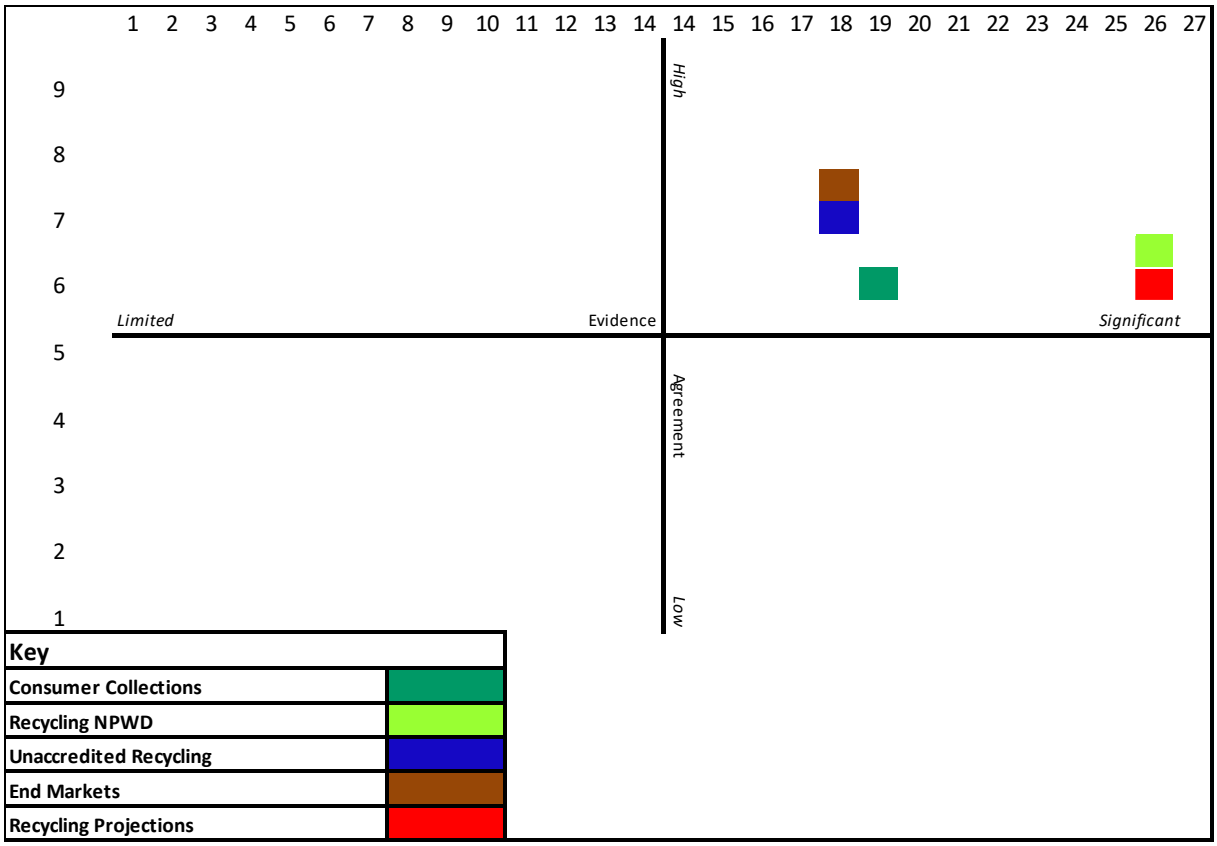


Figure 25 Data Robustness Assessment Results – Summary

		Robustness Scores		Error Margin
	Data & Source	Evidence (Robustness and completeness, max 27):	Degree of agreement around the findings (max 9):	Error Margin (+/-)
1	British Glass Production Data	24	9	6%
2	NPWD Producer Data 2017	26	6	9%
3	Valpak & British Glass - Imports (Filled) Unregistered	14	6	27%
4	Various Transport Data - Imports (Filled) Cross Border Selling	16	6	24%
5	Environment Agency Grocery Retailer Packaging Handled	24	9	6%
6	Valpak Turnover & Packaging Handled Data	20	6	18%
7	Valpak Hospitality EPIC Data	22	6	15%
8	NPWD Recycling Data 2017	26	6	9%
9	Verde Research and Consulting Ltd Survey of Recyclers and Exporters 201	18	7	21%
10	WDF 2016/17	19	6	21%

Figure 26 British Glass Production Data

Data
British Glass production data from UK glass manufacturers (members of British Glass)
Source
British Glass
Data Used In:
POM

Evidence (Robustness and completeness, max 27):	Scoring (Max 27)	
Does the data cover the correct time-frame?	Yes	3
Does the data provide complete coverage?	More yes than no, but equivocal	1
Has the data been sourced from credible, up-to-date sources?	Yes	3
Is the underlying data reasonably free from concerns (e.g. official data from the ONS)?	Yes with some reservations	2
Have the findings been independently peer-reviewed?	Yes	3
Is the methodology/calculation reasonably free from concerns?	Yes	3
Have the methodology/calculations been independently checked (internally or externally)?	Yes	3
Is the quantitative evidence well rooted in a wider qualitative understanding of the issue?	Yes	3
Have the findings been sense-checked against credible alternative sources (incl. inconclusively)?	Yes	3
Total		**24**

Degree of agreement around the findings (max 9):	Scoring (Max 09)	
Does more than one data source confirm the findings (within +/- 5%)?	Yes	3
Do the key stakeholders/experts actively agree with the findings?	Yes	3
Has feedback from the key stakeholders been incorporated in the reporting of findings?	Yes	3
Total		**9**

Scoring	Score
Yes	3
Yes with some reservations	2
More yes than no, but equivocal	1
No	0

Figure 27 NPWD Producer Data 2017

Data
NPWD Producer Data 2017
Source
NPWD
Data Used In:
Import, Export and POM Sense-check

Evidence (Robustness and completeness, max 27):	Scoring (Max 27)	
Does the data cover the correct time-frame?	Yes	3
Does the data provide complete coverage?	Yes with some reservations	2
Has the data been sourced from credible, up-to-date sources?	Yes	3
Is the underlying data reasonably free from concerns (e.g. official data from the ONS)?	Yes	3
Have the findings been independently peer-reviewed?	Yes	3
Is the methodology/calculation reasonably free from concerns?	Yes	3
Have the methodology/calculations been independently checked (internally or externally)?	Yes	3
Is the quantitative evidence well rooted in a wider qualitative understanding of the issue?	Yes	3
Have the findings been sense-checked against credible alternative sources (incl. inconclusively)?	Yes	3
Total		**26**

Degree of agreement around the findings (max 9):	Scoring (Max 09)	
Does more than one data source confirm the findings (within +/- 5%)?	No	0
Do the key stakeholders/experts actively agree with the findings?	Yes	3
Has feedback from the key stakeholders been incorporated in the reporting of findings?	Yes	3
Total		**6**

Scoring	Score
Yes	3
Yes with some reservations	2
More yes than no, but equivocal	1
No	0

Figure 28 Valpak and British Glass – Imports (Filled) Unregistered

Data
Valpak & British Glass estimates based in internal analysis
Source
Valpak & British Glass
Data Used In:
Imports (Filled) Unregistered

Evidence (Robustness and completeness, max 27):	Scoring (Max 27)	
Does the data cover the correct time-frame?	Yes	3
Does the data provide complete coverage?	Yes with some reservations	2
Has the data been sourced from credible, up-to-date sources?	Yes with some reservations	2
Is the underlying data reasonably free from concerns (e.g. official data from the ONS)?	No	0
Have the findings been independently peer-reviewed?	More yes than no, but equivocal	1
Is the methodology/calculation reasonably free from concerns?	More yes than no, but equivocal	1
Have the methodology/calculations been independently checked (internally or externally)?	Yes with some reservations	2
Is the quantitative evidence well rooted in a wider qualitative understanding of the issue?	Yes with some reservations	2
Have the findings been sense-checked against credible alternative sources (incl. inconclusively)?	More yes than no, but equivocal	1
Total		**14**

Degree of agreement around the findings (max 9):	Scoring (Max 09)	
Does more than one data source confirm the findings (within +/- 5%)?	Yes with some reservations	2
Do the key stakeholders/experts actively agree with the findings?	Yes with some reservations	2
Has feedback from the key stakeholders been incorporated in the reporting of findings?	Yes with some reservations	2
Total		**6**

Scoring	Score
Yes	3
Yes with some reservations	2
More yes than no, but equivocal	1
No	0

Figure 29 Various Transport Data – Imports (Filled) Cross Border Selling

Data
Transport Data
Source
Various incl. Civil Aviation Authority, GOV Maritime Shipping Statistics and Eurostar
Data Used In:
Imports (Filled) Cross Border Shopping

Evidence (Robustness and completeness, max 27):	Scoring (Max 27)	
Does the data cover the correct time-frame?	Yes	3
Does the data provide complete coverage?	Yes with some reservations	2
Has the data been sourced from credible, up-to-date sources?	Yes with some reservations	2
Is the underlying data reasonably free from concerns (e.g. official data from the ONS)?	Yes with some reservations	2
Have the findings been independently peer-reviewed?	More yes than no, but equivocal	1
Is the methodology/calculation reasonably free from concerns?	More yes than no, but equivocal	1
Have the methodology/calculations been independently checked (internally or externally)?	Yes with some reservations	2
Is the quantitative evidence well rooted in a wider qualitative understanding of the issue?	Yes with some reservations	2
Have the findings been sense-checked against credible alternative sources (incl. inconclusively)?	More yes than no, but equivocal	1
Total		**16**

Degree of agreement around the findings (max 9):	Scoring (Max 09)	
Does more than one data source confirm the findings (within +/- 5%)?	Yes with some reservations	2
Do the key stakeholders/experts actively agree with the findings?	Yes with some reservations	2
Has feedback from the key stakeholders been incorporated in the reporting of findings?	Yes with some reservations	2
Total		**6**

Scoring	Score
Yes	3
Yes with some reservations	2
More yes than no, but equivocal	1
No	0

Figure 30 Environment Agency – Grocery Retailer Packaging Handled

Data
Environment Agency Grocery Retailer Packaging Handled
Source
Environment Agency Data
Data Used In:
Consumer POM

Evidence (Robustness and completeness, max 27):	Scoring (Max 27)	
Does the data cover the correct time-frame?	Yes	3
Does the data provide complete coverage?	Yes with some reservations	2
Has the data been sourced from credible, up-to-date sources?	Yes	3
Is the underlying data reasonably free from concerns (e.g. official data from the ONS)?	Yes	3
Have the findings been independently peer-reviewed?	Yes with some reservations	2
Is the methodology/calculation reasonably free from concerns?	Yes with some reservations	2
Have the methodology/calculations been independently checked (internally or externally)?	Yes	3
Is the quantitative evidence well rooted in a wider qualitative understanding of the issue?	Yes	3
Have the findings been sense-checked against credible alternative sources (incl. inconclusively)?	Yes	3
Total		**24**

Degree of agreement around the findings (max 9):	Scoring (Max 09)	
Does more than one data source confirm the findings (within +/- 5%)?	Yes	3
Do the key stakeholders/experts actively agree with the findings?	Yes	3
Has feedback from the key stakeholders been incorporated in the reporting of findings?	Yes	3
Total		**9**

Scoring	Score
Yes	3
Yes with some reservations	2
More yes than no, but equivocal	1
No	0

Figure 31 Valpak – Turnover and Packaging Handled Data

Data
Valpak Turnover & Packaging Handled Data
Source
Valpak
Data Used In:
Consumer POM

Evidence (Robustness and completeness, max 27):	Scoring (Max 27)	
Does the data cover the correct time-frame?	Yes	3
Does the data provide complete coverage?	Yes with some reservations	2
Has the data been sourced from credible, up-to-date sources?	Yes	3
Is the underlying data reasonably free from concerns (e.g. official data from the ONS)?	Yes	3
Have the findings been independently peer-reviewed?	No	0
Is the methodology/calculation reasonably free from concerns?	Yes	3
Have the methodology/calculations been independently checked (internally or externally)?	Yes	3
Is the quantitative evidence well rooted in a wider qualitative understanding of the issue?	Yes	3
Have the findings been sense-checked against credible alternative sources (incl. inconclusively)?	No	0
Total		**20**

Degree of agreement around the findings (max 9):	Scoring (Max 09)	
Does more than one data source confirm the findings (within +/- 5%)?	No	0
Do the key stakeholders/experts actively agree with the findings?	Yes	3
Has feedback from the key stakeholders been incorporated in the reporting of findings?	Yes	3
Total		**6**

Scoring	Score
Yes	3
Yes with some reservations	2
More yes than no, but equivocal	1
No	0

Figure 32 Valpak – Hospitality EPIC Data

Data
Valpak Hospitality EPIC Data
Source
Valpak
Data Used In:
Non-consumer POM

Evidence (Robustness and completeness, max 27):	Scoring (Max 27)	
Does the data cover the correct time-frame?	Yes	3
Does the data provide complete coverage?	Yes with some reservations	2
Has the data been sourced from credible, up-to-date sources?	Yes	3
Is the underlying data reasonably free from concerns (e.g. official data from the ONS)?	Yes	3
Have the findings been independently peer-reviewed?	No	0
Is the methodology/calculation reasonably free from concerns?	Yes	3
Have the methodology/calculations been independently checked (internally or externally)?	Yes	3
Is the quantitative evidence well rooted in a wider qualitative understanding of the issue?	Yes	3
Have the findings been sense-checked against credible alternative sources (incl. inconclusively)?	Yes with some reservations	2
Total		**22**

Degree of agreement around the findings (max 9):	Scoring (Max 09)	
Does more than one data source confirm the findings (within +/- 5%)?	No	0
Do the key stakeholders/experts actively agree with the findings?	Yes	3
Has feedback from the key stakeholders been incorporated in the reporting of findings?	Yes	3
Total		**6**

Scoring	Score
Yes	3
Yes with some reservations	2
More yes than no, but equivocal	1
No	0

Figure 33 NPWD – Recycling Data 2017

Data
NPWD Recycling Data 2017
Source
NPWD
Data Used In:
Recycling and Recycling Projections

Evidence (Robustness and completeness, max 27):	Scoring (Max 27)	
Does the data cover the correct time-frame?	Yes	3
Does the data provide complete coverage?	Yes with some reservations	2
Has the data been sourced from credible, up-to-date sources?	Yes	3
Is the underlying data reasonably free from concerns (e.g. official data from the ONS)?	Yes	3
Have the findings been independently peer-reviewed?	Yes	3
Is the methodology/calculation reasonably free from concerns?	Yes	3
Have the methodology/calculations been independently checked (internally or externally)?	Yes	3
Is the quantitative evidence well rooted in a wider qualitative understanding of the issue?	Yes	3
Have the findings been sense-checked against credible alternative sources (incl. inconclusively)?	Yes	3
Total		**26**

Degree of agreement around the findings (max 9):	Scoring (Max 09)	
Does more than one data source confirm the findings (within +/- 5%)?	No	0
Do the key stakeholders/experts actively agree with the findings?	Yes	3
Has feedback from the key stakeholders been incorporated in the reporting of findings?	Yes	3
Total		**6**

Scoring	Score
Yes	3
Yes with some reservations	2
More yes than no, but equivocal	1
No	0

Figure 34 Verde Research and Consulting Ltd – Survey of Recyclers and Exporters 2019

Data
Survey of Recyclers and Exporters 2018
Source
Verde Research and Consulting Ltd
Data Used In:
Recycling and End Markets

Evidence (Robustness and completeness, max 27):	Scoring (Max 27)	
Does the data cover the correct time-frame?	Yes	3
Does the data provide complete coverage?	Yes with some reservations	2
Has the data been sourced from credible, up-to-date sources?	Yes	3
Is the underlying data reasonably free from concerns (e.g. official data from the ONS)?	More yes than no, but equivocal	1
Have the findings been independently peer-reviewed?	No	0
Is the methodology/calculation reasonably free from concerns?	Yes with some reservations	2
Have the methodology/calculations been independently checked (internally or externally)?	Yes	3
Is the quantitative evidence well rooted in a wider qualitative understanding of the issue?	Yes	3
Have the findings been sense-checked against credible alternative sources (incl. inconclusively)?	More yes than no, but equivocal	1
Total		**18**

Degree of agreement around the findings (max 9):	Scoring (Max 09)	
Does more than one data source confirm the findings (within +/- 5%)?	Yes with some reservations	2
Do the key stakeholders/experts actively agree with the findings?	Yes with some reservations	2
Has feedback from the key stakeholders been incorporated in the reporting of findings?	Yes	3
Total		**7**

Scoring	Score
Yes	3
Yes with some reservations	2
More yes than no, but equivocal	1
No	0

Figure 35 WDF 2016/17

Data
WDF Local Authority Collection Data
Source
WDF 2016/17
Data Used In:
Consumer Recycling

Evidence (Robustness and completeness, max 27):	Scoring (Max 27)	
Does the data cover the correct time-frame?	Yes with some reservations	2
Does the data provide complete coverage?	Yes with some reservations	2
Has the data been sourced from credible, up-to-date sources?	Yes	3
Is the underlying data reasonably free from concerns (e.g. official data from the ONS)?	Yes with some reservations	2
Have the findings been independently peer-reviewed?	no	0
Is the methodology/calculation reasonably free from concerns?	Yes with some reservations	2
Have the methodology/calculations been independently checked (internally or externally)?	Yes with some reservations	2
Is the quantitative evidence well rooted in a wider qualitative understanding of the issue?	Yes	3
Have the findings been sense-checked against credible alternative sources (incl. inconclusively)?	Yes	3
Total		**19**

Degree of agreement around the findings (max 9):		
Does more than one data source confirm the findings (within +/- 5%)?	No	0
Do the key stakeholders/experts actively agree with the findings?	Yes	3
Has feedback from the key stakeholders been incorporated in the reporting of findings?	Yes	3
Total		**6**

Scoring	Score
Yes	3
Yes with some reservations	2
More yes than no, but equivocal	1
No	0

Appendix II

Production Data Cross Reference

The production data was cross referenced with data from NPWD[50] and Prodcom[51] (Eurostat statistics on the production of manufactured goods).

The latest available Prodcom data is from 2017 (released 03/07/2018) and only gives the number of container units produced. Therefore, an average weight was applied to the number of units and this was calculated using the average weight of glass packaging (taken from the Valpak Data Solutions database[52]), which was 0.37kg. The Prodcom data is summarised in Figure 36 and the quantities match that of British Glass, within ~7% in 2017. However, due to data exclusion for confidentiality issues within the Prodcom data and how sensitive the estimate is depending on the conversion units used (units to tonnes), the British Glass data was preferred.

Figure 36 Prodcom – UK Glass Container Production 2013 – 2017 (k tonnes)

	2013	2014	2015	2016	2017
Prodcom – No. of Items	6,168	6,173	6,435	6,551	6,645
Estimated Tonnage	2,283	2,285	2,382	2,424	2,459

Another cross reference for the British Glass production data was the NPWD figures taken from Table 1 Conversion. This will include all obligated companies and the glass packaging they handle and convert. This is summarised in the table below for the years 2013 – 2017[53]. This data is summarised in Figure 37.

Figure 37 NPWD – UK Glass Container Production 2013 – 2017 (k tonnes)

	2013	2014	2015	2016	2017
NPWD - Table 1 Conversion	2,217	2,171	2,228	2,243	2,287

Both the British Glass and EA data are summarised in Figure 38 with a graphical representation of the trends.

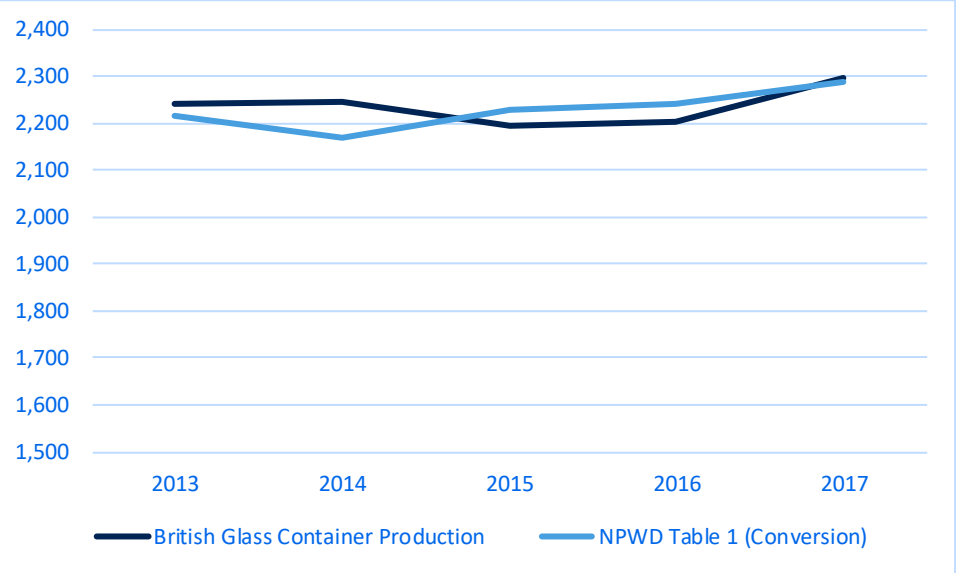
[50] http://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx, *Accessed (08/02/2019)*

[51] https://www.ons.gov.uk/businessindustryandtrade/manufacturingandproductionindustry/adhocs/008127prodcomproductlist2017, *Accessed (16/01/2019)*

[52] *Valpak's Data Solutions database is one of the largest packaging databases in the country. Valpak work with over 70 companies including Tesco, Sainsbury's, Marks & Spencer and Mothercare and hold significant market coverage across many top retail sectors as well as distributors, brand owners and the retail supply chain. Data Solutions collect information direct from customers, suppliers as well as source information in house meaning that they hold a wide coverage of information across multiple product ranges. Product specific data collection is completed through site visits, supplier mailings and weighing in house (purchasing product and collecting used product from staff). All data goes through a comprehensive checking process on receipt and is stored in their bespoke innovative software Environmental Product Information Centre (EPIC).*

[53] http://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx, *Accessed (08/02/2019)*

Figure 38 UK Glass Container Production 2013 – 2017 (k tonnes)



	2013	2014	2015	2016	2017
British Glass - Container Production	2,241	2,246	2,194	2,204	2,296
NPWD - Table 1 Conversion	2,217	2,171	2,228	2,243	2,287

This shows that the British Glass and EA figures overall follow a similar trend over the period. However, since the British Glass figures are member submissions and are considered less likely to change, coupled with the way NPWD producer data is recorded, which can see producer data drop out of the system if they are taken over by another organisation, the British Glass data was used.

Appendix III

Exports (Empty) Cross Reference

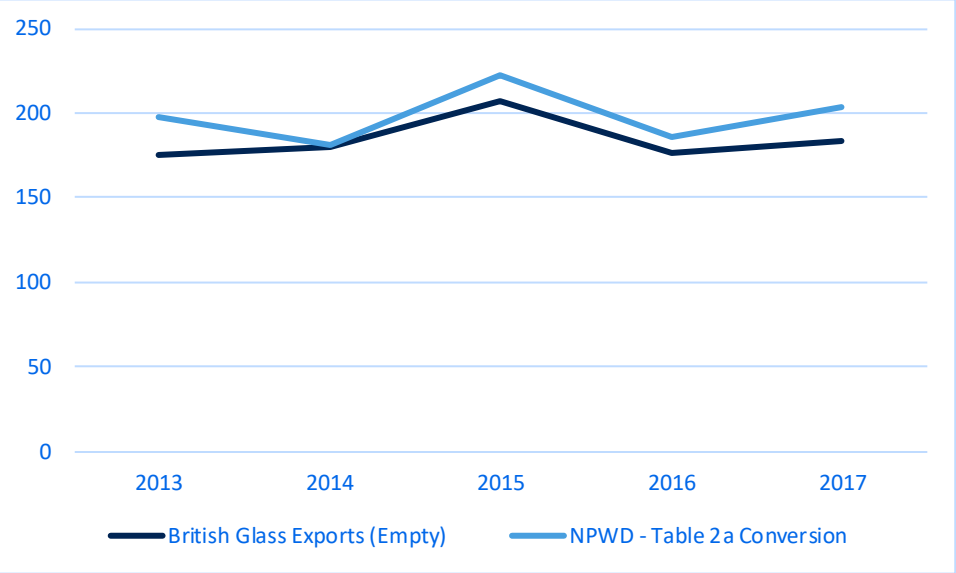
The empty export figures were cross referenced against British Glass Exports (Empty) data, shown in Figure 39.

Figure 39 British Glass – UK Exports (Empty) 2013 – 2017 (k tonnes)

	2013	2014	2015	2016	2017
Exports (Empty)	175	180	207	177	184
% Change from previous year	N/A	3	15	-15	4

As with the NPWD figures, these oscillate between positive and negative growth; however, the 2008 figure is higher than the 2012 figure. A graphical representation of the trends is provided in Figure 40.

Figure 40 UK Exports (Empty) 2013 – 2017 (k tonnes)



As shown, the British Glass figures follow a similar trend to NPWD. Following discussions with British Glass it was agreed to use the NPWD data as it was considered more complete in terms of the import/export supply chain. British Glass also stated that there will be only minimal unregistered tonnage, as Exports (Empty) tend to be done by the large producers.

The export trends were checked against the HMRC trade data[54] for beverage exports, as shown in Figure 41. It is worth noting that this is only partly indicative as it includes beverages exported regardless of packaging types; including beverages exported in glass bottles, but also cans for example. This shows exports rising between 2013 and 2017, whereas both the NPWD and British Glass figures oscillate between positive and negative growth.

[54] www.uktradeinfo.com, *Accessed (06/12/2018)*

Figure 41 HMRC – Beverage Exports 2013 – 2017 (k tonnes)

	2013	2014	2015	2016	2017
Net Mass (Export + Dispatch)	2,615	2,719	2,731	2,879	3,078
% Change from previous year	N/A	4	0	5	7

Appendix IV

Exports (Filled) Cross Reference

For exports (filled) the NPWD Table 2b Conversion (with an uplift for glass sourced in the UK that is subsequently exported to countries) was used as shown in **Error! Reference source not found.**.

Figure 42 UK Exports (Filled) 2013 – 2017 with Uplift (k tonnes)

	2013	2014	2015	2016	2017
Exports (Filled) NPWD - Table 2b Conversion	697	700	731	729	789
Excluded EIRE/Gibraltar Exports	4	4	4	4	4
Exports (Filled)	701	703	735	733	793

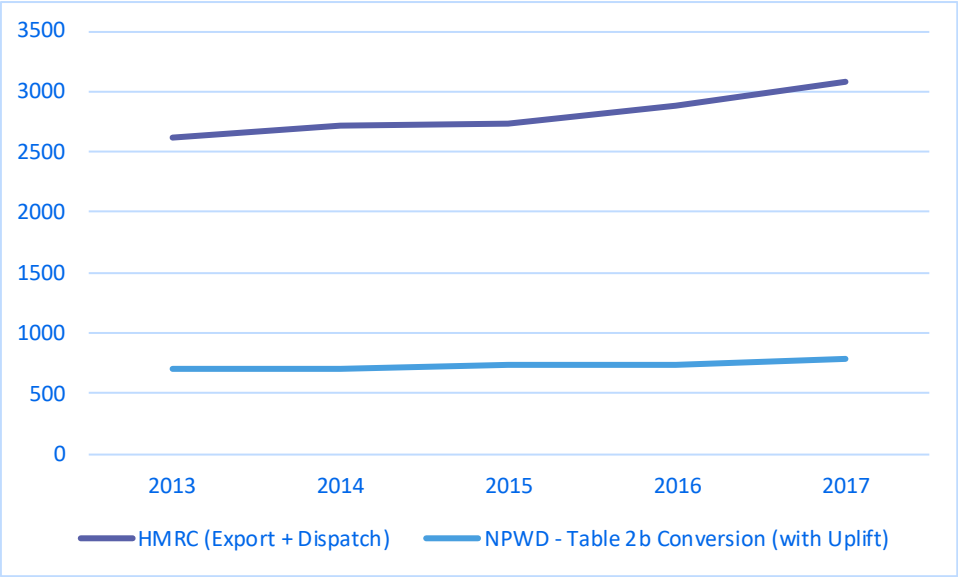
British Glass no longer collects exports (filled) data from its members. Therefore, the NPWD (with uplift) data was sense checked against HMRC trade data[55] for beverage exports shown in Figure 43.

Figure 43 HMRC – Beverage Exports 2013 – 2017 (k tonnes)

	2013	2014	2015	2016	2017
Net Mass (Export + Dispatch)	2,615	2,719	2,731	2,879	3,078
% Change from prev. year	N/A	4%	0%	5%	7%

Figure 44 shows a graphical representation of the data and trends.

Figure 44 UK Exports (Filled) 2013 – 2017 (k tonnes)



[55] www.uktradeinfo.com, *Accessed (06/12/2018)*

The exports (filled) NPWD trend (a gradual increase of 13% from 2013 to 2017) is generally supported by the HMRC trade data trend (a gradual increase of 18% from 2013 to 2017) for beverage exports[56], as shown in Figure 44. It is worth noting that this is only partly indicative as this includes beverages exported regardless of packaging types; including beverages exported in glass bottles, but also cans for example.

[56] *www.uktradeinfo.com, Accessed (06/12/2018)*

Appendix V

Imports (Empty) Cross Reference

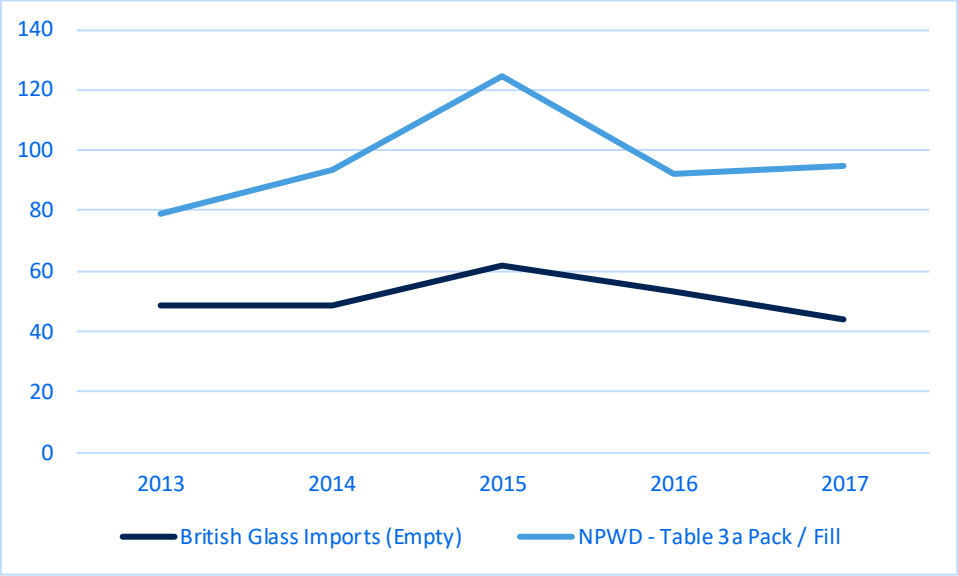
The NPWD Table 3a pack/fill[57] was cross referenced against British Glass figures for imports (empty). These are summarised in Figure 45.

Figure 45 British Glass – Imports (Empty) 2013 – 2017 (k tonnes)

	2013	2014	2015	2016	2017
British Glass Imports (empty)	49	49	62	53	44
% Change from prev. year	N/A	0	27	-14	-18

Both sources (NPWD and British Glass) are summarised in Figure 46 by a graphical representation of the trends.

Figure 46 Imports (Empty) 2013 – 2017 (k tonnes)



	2013	2014	2015	2016	2017
British Glass Imports (Empty)	49	49	62	53	44
NPWD - Table 3a Pack / Fill	79	94	125	92	95

As discussed, the British Glass figure is lower than the NPWD figure due to the British Glass data not including all potential importers; however, the trend follows a similar pattern.

[57] http://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx, *Accessed (08/02/2019)*

Appendix VI

UK Obligated Imports (Filled) Cross Reference

The obligated filled imports estimate was cross referenced against HMRC trade data[58]; however, these figures are only used for a sense check as it is believed they are too broad and had potential consistency issues in terms of categorisation. The HMRC beverage imports are shown below for the years 2013 to 2017.

Figure 47 HMRC – Beverage Imports 2013 – 2017 (k tonnes)

	2013	2014	2015	2016	2017
Net Mass (Import + Arrival)	4,788	4,841	5,207	5,454	5,307
% Change from prev. year	N/A	1	8	5	-3

This shows an increase from 2013 to 2016 and although it follows an overall upward trend it does not follow the same upward trend as NPWD data. The NPWD data shows an overall increase for glass, plastic and steel and aluminium from 2013 to 2017 (Figure 48) with aluminium having the largest increase at 26% followed by plastic at 18%. In comparison, glass only increases by 8%, which could be due to bulk importation of wine to be bottled in the UK.

Figure 48 NPWD – Glass, Plastic, Steel and Aluminium Obligated Imports (Filled) 2013 – 2017 (k tonnes)[59]

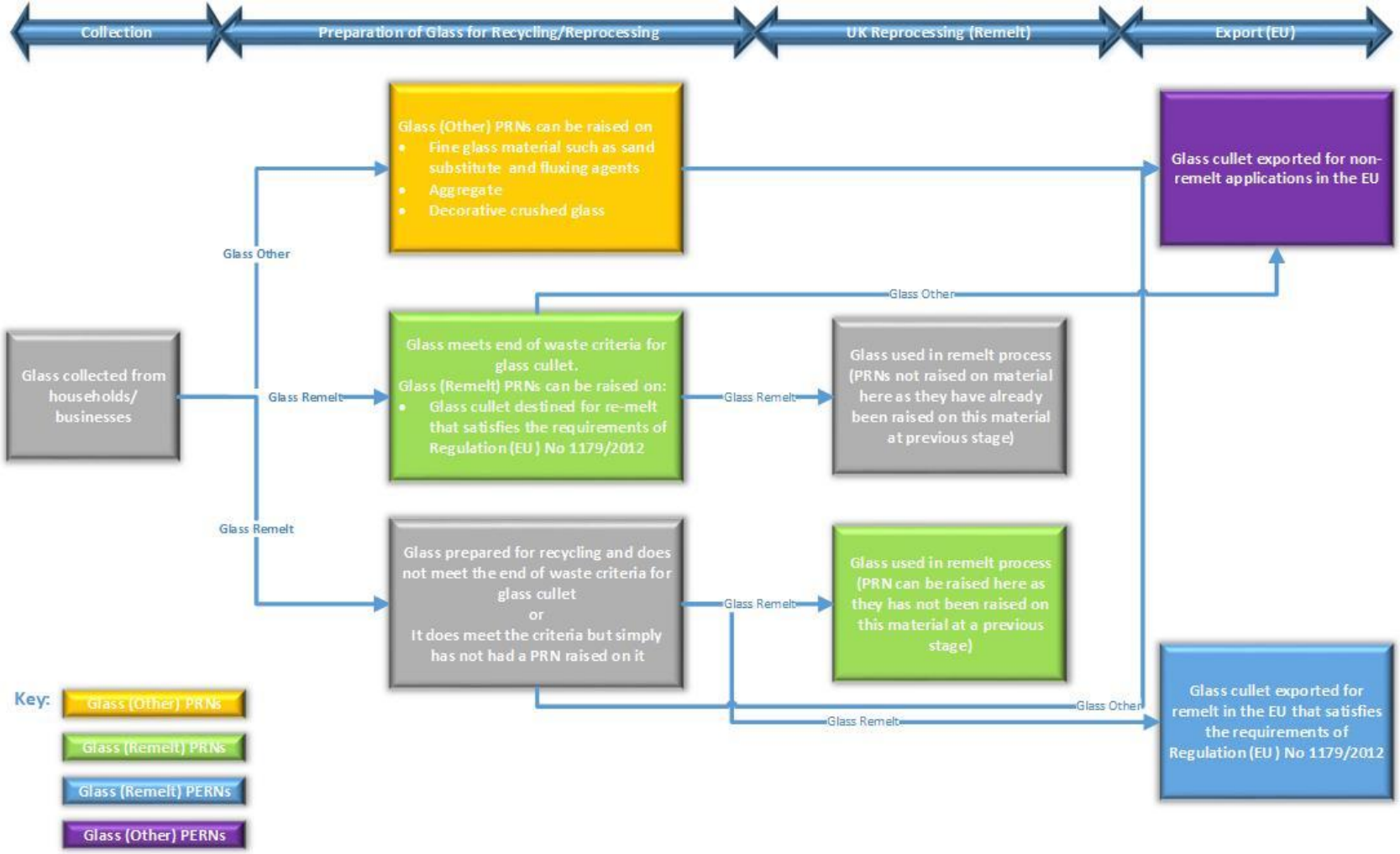
	2013	2014	2015	2016	2017
NPWD - Table 3a Glass	964	950	990	979	1,039
NPWD - Table 3a Plastic	437	462	494	509	514
NPWD - Table 3a Steel	164	167	164	163	168
NPWD - Table 3a Aluminium	40	44	48	51	50

[58] *www.uktradeinfo.com, Accessed (06/12/2018)*
[59] *http://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx, Accessed (08/02/2019)*

Appendix VII

Supply Chain Where PRNs/PERNs Can Be Issued

Figure 49 Supply Chain Where PRNs/PERNs Can Be Issued



Note:

Guidance and criteria required for when glass meets end of waste can be found here:
https://npwd.environment-agency.gov.uk/filedownload.ashx?fileid=edee7dc6-4249-4187-834e-88fb6a8b5bdd

Appendix VIII

Technical Details of the Modelling and Scenarios Projections

Introduction

This appendix reports the detailed estimates of univariate time-series models (linear trend and autoregressive models) based on historical data for glass packaging POM and accredited glass recycling. Based on these models, a range of scenarios for glass packaging POM and accredited glass packaging recycling are projected forward to 2025. The intention is to provide a range of plausible possible futures for glass packaging POM and accredited recycling to inform a compliance assessment for policymakers and other stakeholders.

The EA's NPWD (National Packaging Waste Database) provides a data source from which to assess trends over time in glass packaging placed onto the UK market by businesses that are obligated to comply with the packaging regulations. Obligated businesses are required to report their packaging tonnages data into NPWD each year. Therefore, historical data on the quantities of glass handled by obligated producers ('obligated' POM) is available for trend analysis. NPWD also reports accredited glass packaging recycling tonnages.

The modelling and scenarios assume that glass packaging net pack fill tonnages 1997 to 2017 (calculated using NPWD data as described in Section 1.3.2 of this report) and NPWD reported accredited glass packaging recycling (1998 to 2017) are the best available data to:

- Assess trends in the overall quantities of glass packaging POM and accredited glass packaging recycling;
- Estimate empirical statistical models of glass packaging POM and accredited glass packaging recycling; and
- Project plausible possible future scenarios for glass packaging POM and accredited glass packaging recycling.

Linear Trend and Auto Regressive Models

The scenario for POM and accredited recycling are the projections of univariate time-series models (linear trend and autoregressive models) estimated on historical data for glass packaging POM and accredited glass packaging recycling.

The linear trend model for a time series Y_t is

$$\mathbf{Y_t = \beta_0 + \beta_1 * T + e_t}$$

where T denotes a time trend.

A p^{th} order autoregressive model represents Y_t as a function of p of its lagged values. The number of lags, p, included in an AR(p) model, is called the order, or lag length, of the regression. The p^{th} order autoregressive model AR(p) for a time series Y_t is represented as:

$$\mathbf{Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \ldots + \beta_P Y_{t-p} + e_p}$$

Regarding the order p of the auto regression within a given sample of data, there are trade-offs to consider: too few lags potentially omits information from the more distant lagged values; whilst too many entails more coefficient estimates than necessary, which introduces greater model error into projections.

Parameters of both models can be straightforwardly estimated using OLS.

The order *p* of the auto-regression can be selected using a range of statistical information; the statistics here are Akaike, Schwarz/BIC, Hannan-Quinn and log-likelihood. To assess the adequacy of alternative models, we choose the model which overall minimises the information statistics and maximises the log-likelihood.

Glass Packaging Net Pack Fill, Accredited Recycling Modelling and Projections

This section reviews the historical NPWD data and trends for glass packaging POM in the UK and reports detailed estimates of univariate time-series models (linear trend and autoregressive AR models) and scenario projections to 2025.

Detailed estimates of the statistical models for glass packaging net pack fill are reported in detail in Figure 50[60]. The models estimated are univariate time-series models: a linear trend model, an auto-regressive model with 1 lag and an auto-regressive model with 2 lags.

Figure 50 Glass Packaging Net Pack Fill (Linear and Auto-regressive Models)

	Linear			AR(1)			AR(2)		
Variable	**Coeff**	**t-Stat.**	**Prob.**	**Coeff**	**t-Stat.**	**Prob.**	**Coeff**	**t-Stat.**	**Probability**
C	1886436	27.9	0.00	718130	3.5	0.00	725972	3.6	0.00
Trend	14975	4.2	0.00						
Glass NPF(-1)				0.6761	7.0	0.00	0.4458	2.15	0.05
Glass NPF(-2)							0.2292	1.25	0.23
R^2	50.5%			74.1%			76.4%		
Adj R^2	47.5%			72.6%			73.5%		
S.E	85914.95			62107			61091		
F-stat.	17			49			26		
Prob(F-stat.)	0.000654			0.000002			0.00001		

*NPF is glass packaging net pack fill, (-1) denotes 1 lag, (-2) denotes 2 lags

To assess the statistical adequacy of these alternative models, a range of statistical 'information criteria' are calculated to inform the choice of a preferred model from which to develop a projection scenario for glass packaging net pack fill (and hence POM). Information criteria are reported in Figure 51 (adj-R^2 is included for comparison), based on these criteria the AR(1) model is selected as the preferred model to develop projections.

[60] *Auto-regressive models up to order 3 (3 lags) were estimated for the model selection exercise below; however, since the AR(3) model performed poorly in comparison, detailed estimates are not shown.*

Figure 51 Glass Packaging Net Pack Fill Statistical Model Selection Criteria

	Linear Trend	AR(1)	AR(2)	AR(3)
Adj R^2	47.5%	72.6%	73.5%	58.7%
Akaike	25.66	25.01	25.02	25.19
Schwarz-Bayes	25.76	25.11	25.17	25.39
Hannan-Quinn	25.68	25.03	25.05	25.22
Log likelihood	-241.76	-235.60	-234.71	-222.74

The projection scenario for glass packaging net pack fill is reported in Figure 52. All projections are subject to uncertainty; however, the uncertainty around projections based on statistical models such as this can be estimated using the modelled standard error from the regression analysis.

Assuming a normal distribution, 95% confidence intervals are calculated as the upper and lower bounds to the glass packaging net pack fill projection and are shown in Figure 52 as indicative upper and lower bounds to the projection.

Figure 52 Glass Packaging Net Pack Fill, Linear Model Projections and 95% Confidence Intervals, 2018 to 2025 (k tonnes)

Year	Lower CI	Net Pack Fill	Upper CI
2018	2,132	2,260	2,388
2019	2,085	2,246	2,407
2020	2,061	2,237	2,413
2021	2,046	2,231	2,415
2022	2,038	2,226	2,415
2023	2,032	2,223	2,415
2024	2,029	2,221	2,414
2025	2,027	2,220	2,413

Glass Packaging POM Scenario

The scenario projected for glass packaging POM tonnage is based on the projected growth rates from the estimated linear model, based on the historical data for glass packaging net pack fill. The scenario provisionally assumed a glass packaging POM projection that increased in line with the projected growth rates of glass packaging net pack fill. This scenario for glass packaging POM to 2025 was discussed with the project Steering Group.

It was noted that past growth had been observed during periods of GDP and retail sales growth. Therefore, the statistical model projection of a decline in glass packaging POM seemed out of kilter with the expectation of continued GDP growth and retail sales growth over the projection horizon, especially given average growth of 1.5% in glass packaging net pack fill since 2012. It was suggested by the Steering Group that some growth in glass packaging POM was plausible and could be reasonably expected in the near term before some levelling off.

Therefore, the scenario for glass packaging POM, reported in Figure 53 is based on assumed growth rates of 1.5%, 1% and 0.3% in 2019, 2020 and 2021 respectively. Beyond 2021, the growth rates of glass packaging POM are the projected growth rates from estimated net pack fill AR(1) model. This scenario for POM growth for 2018 to 2020 is therefore more in line with expected GDP growth and retail sales growth. The projection also assumes that the 2018 glass packaging POM figure (the first year of the projection scenario) is the same as the 2017 POM figure of 2,487k tonnes developed in this project.

In this scenario, glass packaging POM is assumed to increase from 2,487k tonnes in 2018 to 2,550k tonnes in 2020, and to 2,544k tonnes in 2025, which is an increase of 57k tonnes or 2.3% in 2025 compared to 2018. Average annual growth in glass packaging POM over the projection horizon is 2.3%.

Figure 53 Scenario Projection for Glass Packaging POM, 2018 to 2025 (k tonnes)

Year	2018	2019	2020	2021	2022	2023	2024	2025
POM	2,487	2,525	2,550	2,556	2,551	2,548	2,546	2,544
% change	-	1.5	1.0	0.3	-0.2	-0.1	-0.1	-0.1

Accredited Glass Packaging Recycling Scenario

This section reports the estimation details of univariate time-series models (linear trend and autoregressive models) based on historical NPWD data for accredited glass packaging recycling. The detailed estimation results are reported in Figure 54. The models estimated are univariate time-series models: a linear trend model, an auto-regressive model with 1 lag AR(1) and an auto-regressive model with 2 lags AR(2).

Figure 54 Accredited Glass Packaging Recycling Model Estimates

	Linear			AR(1)			AR(2)		
Variable	**Coeff**	**t-Stat.**	**Prob.**	**Coeff**	**t-Stat.**	**Prob.**	**Coeff**	**t-Stat.**	**Prob.**
C	257172	1.5	0.15	199893	3.2	0.01	166079	2.3	0.03
Trend	59890	6.7	0.00						
Glass R(-1)				0.8913	19.3	0.00	1.1408	4.65	0.00
Glass R(-2)							-0.2346	-1.04	0.32
R^2	73.9%			95.9%			96.1%		
Adj R^2	72.3%			95.6%			95.6%		
S.E	195737			77954			77778		
F-stat.	45			371			187		
Prob(F-stat.)	0.000005			0			0		

*R is accredited glass packaging recycling, (-1) denotes 1 lag, (-2) denotes 2 lags

Details of the statistical information which inform the selection of the preferred model are reported in Figure 55. The range of information statistics indicate that the AR(1) model for glass packaging accredited recycling is the preferred model for the data sample available. A scenario based on the preferred model (the linear model) is projected to 2025 for accredited glass recycling.

Figure 55 Glass Packaging Accredited Recycling, Model Selection Criteria

	Linear Trend	AR(1)	AR(2)	AR(-3)
Adj R^2	72.3%	95.6%	95.6%	94.6%
Akaike	27.31	25.47	25.51	25.62
Schwarz-Bayes	27.41	25.57	25.66	25.81
Hannan-Quinn	27.33	25.48	25.53	25.63
Log likelihood	-243.80	-227.23	-226.61	-213.73

The Steering Group noted the anomaly in 2012 in the data reported for accredited glass packaging recycling which, at the time, was caused by fraudulent generation of evidence for glass packaging. It is estimated that the scale of this fraud was in the order of 100k tonnes to 150k tonnes and so distorted the true picture in 2012 (the extent to which earlier recorded accredited glass recycling could have been affected is not known and neither is the possible impact of its detection beyond 2012). To adjust for the fraud, 125k tonnes of

accredited glass packaging recycling is removed from the 2012 reported figure and the models are re-estimated. However, estimating the statistical models after adjusting for this distortion did not significantly change key model parameters or the scenario projection of the AR(1) model. The results of estimating the models on the fraud adjusted data for accredited glass packaging recycling are shown in Figure 56.

Figure 56 Accredited Glass Packaging Recycling Models Estimated on Fraud Adjusted Data

	Linear			AR(1)			AR(2)		
Variable	**Coeff**	**t-Stat.**	**Prob.**	**Coeff**	**t-Stat.**	**Prob.**	**Coeff**	**t-Stat.**	**Prob.**
C	-177095	-0.9	0.38	298362	3.7	0.2%	503246	6.1	0.00
Trend	80044	7.5	0.00						
R(-1)				0.8229	13.4	0.0%	0.4038	2.19	0.05
R(-2)							0.2912	1.83	0.09
R^2	76.0%			91.4%			92.2%		
Adj R^2	74.6%			90.8%			91.1%		
S.E	273534			143241			109108		
F-stat.	57			180			88		
Prob(F-stat.)	0.000001			0			0		

Provisional 2018 figures for accredited glass packaging recycling are available for 2018 Q1 to Q3 from NPWD. Glass packaging recycling is reported as 395k tonnes for 2018 Q1, 427k tonnes for 2018Q2 and 408k tonnes in 2018Q3, so for January to September 2018 a total of 1,230k tonnes of glass packaging was recorded as accredited recycling, which is an increase of 0.2% compared to the same period in 2017.

The estimated 2018 full year figure for accredited glass recycling over-rides the AR(1) model projection in 2018. The annual projections for 2019 to 2025 in this scenario are based on the AR(1) model projections for accredited glass packaging recycling; the projection is shown in Figure 57 together with 95% confidence intervals as indicative upper and lower bounds to the projection.

Figure 57 Accredited Glass Packaging Recycling Projection 2018 to 2025, with a 95% Confidence Interval (k tonnes)

Year	Lower CI	Accredited recycling	Upper CI
2018	1,530	1,687	1,845
2019	1,490	1,711	1,933
2020	1,462	1,732	2,002
2021	1,442	1,752	2,062
2022	1,424	1,769	2,114
2023	1,409	1,785	2,161
2024	1,396	1,800	2,204
2025	1,383	1,813	2,242

Figure 57 reports the projected tonnages for accredited glass packaging recycling to 2025. In this scenario, glass packaging increases from 1,687k tonnes in 2018 to 1,732k tonnes in 2020, and to 1,813k tonnes in 2025, which is an increase of 125kk tonnes or 7.4% in 2025 compared to 2018. This scenario for accredited glass packaging recycling is used in the compliance assessment in section 5.3 of this report.

Glass Packaging POM and Recycling Projections Conclusion

The key conclusions from the glass packaging flow and recycling projections are:

- Glass packaging POM is assumed to increase from 2,487k tonnes in 2018 to 2,550k tonnes in 2020 and to 2,544k tonnes in 2025, which is an increase of 57k tonnes or 2.3% in 2025 compared to 2018. Average annual growth in glass packaging POM over the projection horizon is 2.3%; and
- Accredited glass packaging increases from 1,687k tonnes in 2018 to 1,732k tonnes in 2020 and to 1,813k tonnes in 2025, which is an increase of 125kk tonnes or 7.4% in 2025 compared to 2018. Average annual growth in glass packaging recycling over the projection horizon to 2025 is 7.4%.

www.wrap.org.uk/relevant link

recycle