Final Report

Wood Flow 2025

A review of the quantity of wood packaging being placed on the UK market (POM) and recycled in 2017 and scenario projections to 2025

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Executive summary

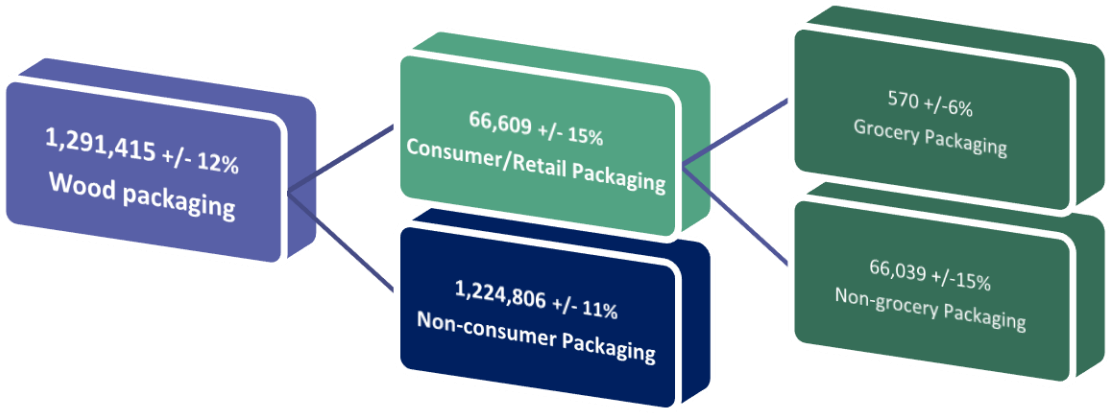
Wood Flow 2025 has been produced to support Defra in its understanding of current quantities of UK wood packaging placed on the UK market (POM)[1] and recycled, and potential future quantities placed on the market and recycled to 2025. Wood Flow 2025 also reports a compliance assessment against UK packaging targets to 2020 and the Circular Economy Package (CEP) target in 2025.

Defra is keen to ensure that the estimates being used for its work on packaging policy are as accurate as possible and this report has been prepared with this in mind. Error margins and robustness assessments have been used and provided wherever possible.

Wood Packaging POM

- This project estimates wood packaging POM in 2017 at 1,291k tonnes (+/- 12%): a slight decrease of 1.4% from the previous wood POM figure of 1,310k tonnes (2014). The error margin indicates the two wood packaging POM figures are not significantly different.
- Wood in new and refurbished pallets accounts for the largest proportion (74%) of total wood packaging POM in 2017.
- Cases, boxes, crates and drums are the next largest product format for wood packaging, representing 21% of wood packaging POM in 2017.
- Wooden casks, barrels, vats, tubs & coppers products represent around 1% of total wood packaging POM in 2017.

Figure ES1 Wood packaging POM by sector, 2017 (tonnes, %)



- The estimate for wood packaging POM in the consumer sector is ~67k tonnes (+/- 15%) in 2017, of which 66k tonnes (+/-15%) is estimated to be consumer non-grocery wood packaging. Grocery wood packaging is estimated to be 570 tonnes (+/- 6%)

[1] Wood packaging placed on the market means all household and non-household wood packaging used around products and used to transport products in the UK.

- The estimate for wood packaging POM in the non-consumer sector is 1,225k tonnes (+/- 11%) in 2017. The vast majority (95%) of wood packaging POM is in the non-consumer sector.

- Obligated wood packaging POM in 2017 is estimated to be 1,168k tonnes in 2017, 90% of total wood packaging POM.

- The proportion of wood packaging POM that is unregistered is estimated to be 10% (~123k tonnes) in 2017. This shows a slight increase on the estimated 8% of wood packaging POM unregistered in 2014.

Wood packaging recycling

- Local authorities collected 860k tonnes of wood waste (wood packaging and non-packaging wood) in 2016/17, the vast majority (99%) of wood waste collected is via HWRC/CA sites.

- It is estimated that just 8k tonnes of waste wood packaging is collected by local authorities.

- Total UK waste wood packaging recycled is estimated to be 546k tonnes in 2017, the total recycling rate for wood packaging is 42%.

- Accredited waste wood packaging recycling is estimated to be 411k tonnes in 2017, the accredited recycling rate for wood packaging is 32% (compared to wood packaging POM of 1,291k tonnes).

- Unaccredited wood packaging waste recycling is estimated to be 135k tonnes in 2017.

- Based on estimates from 2009-11 wood packaging waste arising is approximately 1-1.2 million tonnes per year (note that there is a significant degree of uncertainty around this estimate). Wood packaging waste arising estimates will not match the POM estimates. Wood packaging is designed to be durable, has a long life on the market, and is extensively re-used and repaired. Therefore, wood packaging in the waste stream can be placed on the market at very different points in time. However, if the waste arising figure is broadly accurate then the fate of substantial tonnages (~450k to 620k tonnes) of wood packaging waste is not accounted for. At the time of writing there was insufficient data to show how much wood packaging was going to each non-recycling destination.

Wood flow POM and recycling projections and compliance

- Wood packaging POM is projected to decline slightly from 1,291k tonnes in 2018 to 1,259k tonnes in 2020, and to 1,227k tonnes in 2025, a decline of 64k tonnes or 5% in 2025 compared to 2018.

- Accredited wood packaging recycling is projected to increase from 454k tonnes in 2018 to 520k tonnes in 2020, and to 607k tonnes in 2025, an increase of 153k tonnes or 34% in 2025 compared to 2018.

- Based on the POM and accredited recycling scenarios for wood packaging it is regarded as *moderately* possible that the UK meets the wood packaging recycling targets in 2018 to 2020. In 2019 the compliance scenario projects accredited wood

packaging recycling tonnage slightly below (5k tonnes) that required to meet the target. In 2020, the shortfall is 27k tonnes.

- The associated probabilities of meeting the national equivalents of the business targets for wood packaging recycling in 2018, 2019 and 2020 are 53.5%, 48.7% and 44.0%.

- There are no targets set for wood packaging recycling beyond 2020 other than the CEP target of 25% in 2025. This report estimates an accredited wood packaging recycling rate of 32% in 2017. Therefore, the compliance scenario *assumes* a wood packaging recycling target of 46% in 2025 (which equates to a business target of 50%).

- On the basis of this assessment it is regarded as *moderately* possible that wood packaging would meet a 46% national recycling target in 2025. The associated probability of meeting a 46% target for wood packaging recycling in 2025 is 58.3%

Project Recommendations

Research to provide an updated assessment of waste wood packaging arising

The 1-1.2 million tonnes per year estimate of wood packaging waste arising referenced in this report is very dated. It implies, assuming other estimates are robust, that the fate of substantial tonnages (~450k to 620k tonnes) of wood packaging waste is not accounted for by UK recovery, recycling, disposal or export. However, it may be the case that wood packaging waste arising is a lower figure and an up to date research assessment, which could also establish a repeatable methodology, would shed light on this.

Reviewing elements of the Packaging Regulation to capture more non-obligated tonnage and/or more unregistered tonnage of wood packaging

This could include assessment of lowering or removing the de minimis threshold for wood packaging and/or the potential impact of obligating wood packaging classified as internal use.

A study on the impact of accreditation of all wood packaging recycling activities

This could be mandatory accreditation and reporting by wood recycling businesses or some other form of incentivisation to accredit and report. The objective here being that as much evidence as is possible is counted towards achievement of wood packaging recycling targets. A research study could establish the benefits of mandatory accreditation in terms of higher recycling weighed against the costs.

Contents

Figures

Appendices

Glossary

bn	Billion
CA	Civic amenity site
C&I	Commercial and Industrial
C&D	Construction and demolition
EA	Environment Agency
EfW	Energy from Waste
EPIC	Environmental Product Information Centre
GDP	Gross Domestic Product
GVA	Gross Value Added
HWRC	Household waste recycling centre
k	Thousand
kt	Thousand tonnes
LA	Local authority
NPWD	National Packaging Waste Database
POM	Placed on the market
Primary Packaging	Any packaging that the customer will take home, remove and throw away e.g. aluminium can, plastic bottle
PRN	Packaging Recovery Note
PERN	Packaging Export Recovery Note
RDF	Refuse Derived Fuel
Secondary Packaging	Inner packaging used to transport or display goods to/in store, usually cardboard boxes or shelf ready packaging
Transit/Tertiary Packaging	Any transit packaging e.g. pallets, shrink wrap, staples or strapping
WDF	Waste Data Flow

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- Advisory Committee on Packaging (ACP);
- Wood Recyclers Association (WRA);
- Wood Packaging Industries Federation (WPIF);
- Norbord
- TIMCON
- Kronospan
- Environment Agency (EA).

1.0 Introduction

1.1 Background

It is important to ensure that the estimates being used by Defra for its packaging policy work are as accurate as possible. To support Defra, this work focuses on reviewing the estimates of UK wood packaging POM and the associated compliance implications.

The existing Defra wood packaging POM estimate for the UK is 1,310k tonnes, the Wood Flow 2020 project[2] and industry assessment formed the basis for this estimate. The objectives of the Wood Flow 2025 report are to provide: an updated estimate of wood packaging POM for 2017; an estimate of wood packaging recycled in 2017, and; project scenarios for wood packaging POM and recycling to 2025.

1.2 Project Objectives

Wood Flow 2025 had the following key objectives:

- Develop a methodology that utilises and builds on existing approaches to estimate 2017 wood packaging POM by format, stream and source;
- Assemble a Steering Group to provide expertise and insights, and guide the project;
- Identify any appropriate sources/approaches to improve and build on the net pack fill estimates based on National Packaging Waste Database (NPWD) obligated producer data, to cross-check and estimate unregistered flow;
- Estimate the quantities of wood packaging collected through civic amenity sites, kerbside and pick-up collections and other collection types for both consumer and non-consumer sources in 2017;
- Estimate the quantities of wood packaging, by format type and by stream;
- Project scenarios for wood packaging POM and recycling year by year to 2025, based on accepted assumptions and techniques;
- Assess the likely compliance performance, per year, up to 2025;
- Provide estimates of the quantities of obligated wood packaging that is recycled by accredited reprocessors but does not generate a PRN/PERN (unaccredited recycling), and quantities of non-obligated wood packaging that is recycled;
- Indicate the degree of uncertainty/quality of data associated with estimates (POM and recycling rates), and key factors influencing temporal variability in the data; and
- Produce a final report detailing the findings of the study, and a set of slides to present to key industry groups.

[2] http://www.wrap.org.uk/sites/files/wrap/Wood%20Flow%202020%20Final%20for%20publication.pdf

2.0 Methodology

It is common practice, and indeed is accepted by the EU, that establishing packaging recycling rates based on POM is an appropriate method. An alternative is to calculate wood packaging recycling rates as the ratio of the quantity of wood packaging recycled and the quantity of wood packaging waste arising. The use of plastic packaging POM instead of plastic packaging waste arisings to calculate plastic packaging recycling rates has recently been called into question by Eunomia (2018)[3], particularly as estimates of plastic packaging waste arisings established through composition analyses applied to waste data collated from multiple sources, tend to present higher results. The Eunomia report claims that NPWD's registered producer data (reported by producers who have registered their obligation under the packaging regulations) is likely to be subject to systematic underestimation, as companies have a vested interest in under-reporting their POM tonnages. It suggests that this might have resulted in an underreporting of plastic packaging POM and an overestimate of the plastic packaging recycling rate.

The Eunomia report proposes an alternative calculation based on plastic packaging waste arising. While the approach is valid, it (like any methodology) has a number of significant limitations, relating to the accuracy of data for:

- The composition of household waste;
- The quantity of waste arisings from local authorities; and
- The quantity and composition of waste arisings in commercial and industrial streams.

Regarding plastic packaging, the justification of the use of POM data over alternatives is provided in full in section 1.3.1 of PlasticFlow 2025[4].

For wood packaging, estimates of waste arising will likely be very different from POM estimates. Essentially, because of the durability of wood packaging, it has a long life on the market and is extensively re-used and repaired. Therefore, there is a long (and unknown) lag between wood packaging being POM and arising in the waste stream. Further, there are no comprehensive sources for waste wood statistics for the UK that include up-to-date and accurate data on waste wood and packaging wood waste arising. Waste Data Flow is of limited use for estimating wood packaging waste arising. The vast majority of wood packaging is non-consumer and there are only very small quantities of wood packaging waste collected by local authorities.

An overview of the estimation of the quantity of wood packaging POM and recycling of wood packaging are provided below.

2.1 POM (Bottom Up Approach)

Wood packaging POM is estimated using a bottom up approach that references a variety of data sources for wood packaging products placed on the market combined with data and estimates provided by industry. The results of this method are cross-checked against wood packaging POM tonnages reported in NPWD by producers with an obligation who are registered, and data provided by the project's industry Steering Group. The baseline year is 2017, where 2017 data are not available the most recent available data are used.

[3] *Eunomia: Plastic Packaging – Shedding Light on the UK Data, http://www.eunomia.co.uk/reports-tools/plastic-packaging-shedding-light-on-the-uk-data/*
[4] *http://www.wrap.org.uk/content/plasticflow-2025-plastic-packaging-flow-data-report*

Further details of the methodology to quantify the amount of wood packaging POM in 2017 and results are provided in Section 3 of this report.

2.2 POM Cross-check (Net pack fill)

The cross-check collates data on the quantity of wood packaging data reported by obligated producers registered in NPWD. The net pack fill estimate is thought to capture the vast majority of obligated tonnage but it does not include wood packaging handled by unregistered producers ('de-minimis' businesses below the threshold for obligation which is an annual turnover (in the previous year) of £2 million and handling 50 tonnes of packaging or more per year, and businesses with an obligation but are not registered with the relevant agency 'free-riders') and packaging for internal company use, which is non-obligated packaging under the regulations.

To estimate the amount of packaging placed on the UK market that is reported by obligated producers in NPWD[5], the net pack fill calculation set out below is applied. Details are reported in section 3.5.

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

2.3 Recycling

NPWD was used as the source for accredited (recorded) recycling of wood packaging. Industry representatives were consulted on the recycling of wood packaging that might not, for whatever reason, be reported on NPWD.

The output of these discussions, together with an estimate of wood packaging waste arising were used to estimate a figure for total wood packaging and non-accredited (unrecorded) wood packaging recycling.

2.4 Projections and scenario analysis

The final section of the report considers historical trends based on data for wood packaging POM and levels of accredited wood packaging waste recycling to inform scenario projections of wood packaging POM and accredited wood packaging waste recycling to 2025.

2.5 Robustness and uncertainty

There are levels of uncertainty around the data used to establish the various elements that are combined to estimate total wood packaging POM. POM estimates and consumer, non-consumer splits are presented with error margins, providing an indicative range of uncertainty. The robustness scores established for each element of data are presented in Appendix I and these have been converted into a percentage and related to appropriate margins of error[6], as shown in **Figure 2**. The respective margins of error are provided throughout the report.

Figure 2 Relating robustness scores to appropriate margins of error

[5] www.npwd.environment-agency.gov.uk
[6] These are assumed estimates of error margin and not the outputs of statistical calculation

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%

To calculate the margin of error for the total POM, the margins of error for the sub-elements that make up total POM are converted to tonnages and then expressed as an overall percentage using a Root of Sum of Squares calculation (since we are dealing with the overall error of a summation of subcategories with different error margins).

3.0 Wood packaging POM

This section of the report provides an overview of how wood packaging flows onto the UK market. It provides details of the data sources used and presents an estimate of the quantity of wood packaging POM in 2017.

Wood packaging typically enters the UK market in the following formats, which have been adopted for the purposes of this report:

- **Flat pallets** – extensively used as transit packaging by industries requiring transport of large quantities of goods and bulky items. Pallets are typically made to standard sizes and managed operationally through large leased pallet pools. Pallets are designed for multiple use, and are durable, reusable and repairable (often repaired several times during their lifetime). However, flat pallets may also be single use pallets when required in specialist circumstances. It is only the quantity of new wood used in pallet manufacture and new wood added by repair/refurb activities that is included in the estimate of POM tonnage;
- **Box pallets and load boards** – box pallets offer further protection to products on flat pallets and are often used in manufacturing industries to bulk transport components and parts. Load boards are planks of wood used to cushion heavy goods during transit;
- **Casks, barrels, vats, tubs & coopers' products** – used typically in the beverage industry to brew, store and transport drinks up to the bottling stage. Wooden coopers' products are used in the transportation of wiring;
- **Other** – all other forms of wood packaging such as wood shaving fillers, wood wool and specialist items not covered above.

An estimate of the total weight of UK wood packaging POM in 2017 is established as the weight of wood packaging produced in the UK plus the weight of wood packaging net imports into the UK (i.e. the weight of imported wood packaging less the weight of wood packaging exported).

To estimate the weight of wood packaging produced in the UK 2017 industry data are used where possible to provide a more complete coverage of the wood packaging supply chain (for example compared to net pack fill which only covers the tonnage of wood packaging reported by registered obligated producers). **Figure 3** provides an overview of the methodology used and the key data sources.

Figure 3 Key data sources for wood packaging POM, 2017

UK production, import/export* and de-minimis wood packaging	=	**UK production** PRODCOM UK production of new/refurbished pallets PRODCOM UK non-pallet packaging production	+ +	**Imports** NPWD Table 3a imported for the purpose of pack/fill and selling + Table 3b packaging removed from imports De-minimis imports (estimate)	- -	**Exports** NPWD Table 2a direct exports pack/fill +Table 2b exports by 3rd party pack/fill De-minimis exports (estimate)
UK wood packaging POM	=	UK wood packaging production	+	UK imported wood packaging	-	UK exported wood packaging

3.1 Wood packaging production

This section reports estimates of wood packaging produced in the UK. Wood packaging production statistics are available by product category according to industry 1624 Manufacture of Wooden Containers Standard Industrial Classification of Economic Activities (SIC) 2007. The two key data sources used in this report are the Timber Packaging and Pallet Confederation & Forestry Commission, Wood Packaging Study (TIMCON), and the Office for National Statistics (ONS), UK Manufacturers' Sales by Product (PRODCOM).

UK wood packaging production is divided into two sectors, production of:

- new pallets (16241133) and refurbished pallets (16249999), and
- non-pallet packaging (the remainder of SIC 1624)

Figure 4 summarises the PRODCOM categories of wood packaging and the methodology to convert 'number of units' data to 'weight data' for wood packaging produced in the UK. The total weight of UK wood packaging production in 2017 is the summation of the tonnages estimated in these categories.

Figure 4 Conversion of PRODCOM wood production data to Kg

PRODCOM	Product description	Unit	Conversion to Kg
16241133	New flat pallets and pallet collars of wood	Number of items	TIMCON average volume (cubic metres) of new wood per pallet x number of items x 507
16241135	Box pallets and load boards of wood EXCLUDING: - flat pallets	Number of items	Volume (cubic metres) of new wood per box pallet x 2 x number of items x 507
16241200	Casks, barrels, vats, tubs, and coopers' products and parts thereof of wood INCLUDING: - staves	kg	
16241320	Cases, boxes, crates, drums and similar packings of wood EXCLUDING: - cable drums	Kg	

16241350	Cable-drums of wood	Kg	
16249999	Refurbished flat pallets and pallet collars of wood	Number of items	TIMCON average volume (cubic metres) of new wood per refurbished pallet x number of items x 507

A fundamental characteristic of wood is that it is hygroscopic meaning that wood will gain or lose moisture based on the conditions of its surrounding environment. When a tree is first felled, it is considered to be in the green state, and contains a very large amount of moisture. Wood packaging products are made from both green and kiln dried materials and over the lifetime of wood packaging its moisture content can reduce from 50% to 10% or less. The moisture content of wooden pallets (imported into the UK or exported) will typically decrease over its lifetime and consequently its weight will vary at different points along the supply chain.

The weight of new wood used in the production of flat pallets and box pallets[7] was calculated using TIMCON figures for the volume (cubic metres) of new wood[8] used in new pallet production multiplied by the standard density[9] of wood used in wood packaging of 507 kg per cubic metre. The weight of new wood used in pallet repair was calculated using TIMCON figures for the volume (cubic metres) of new wood used in pallet repair multiplied by the standard density of 507 kg per cubic metre.

Figure 5 New wood used in UK wood packaging production, 2017 (k tonnes)

New wood used in wood packaging production by product	Quantity
Production of new pallets	575
Refurb/repair of new pallets	82
TOTAL new wood used in pallet production & pallet refurb/repair	**657**
Box pallets and load boards of wood EXCLUDING: - flat pallets	27
Casks, barrels, vats, tubs, and coopers' products and parts thereof of wood INCLUDING: - staves	7
Cases, boxes, crates, drums and similar packings of wood EXCLUDING: - cable drums	157
Cable-drums of wood	2
Total non-pallet packaging (incl. fastenings)	193
Total new wood in non-pallet packaging (excl. fastenings[10])	**189**
Total new wood used in wood packaging production	**846**

[7] It is assumed that a new box pallet contains twice the quantity of new wood as a new flat pallet.
[8] Based on the 2017 TIMCON survey the volume of new wood used per new pallet is estimated to be 0.0262 m^3 and the volume of new wood per pallet repair is estimated to be 0.0031m3. Volumes of wood per pallet and per pallet repair are the averages of the volume data in 2015, 2016 & 2017.

[9] The density of wood depends on both species and moisture content. TIMCON agreed a standard density of 507 Kg per cubic metre with the EA in 2001 based on analysis carried out by the Timber Research and Development Association (TRADA) on a basket of timbers representing the mix commonly used in the industry at a moisture content at the end of life.

[10] Industry data used in Wood Flow 2020 indicated that fastenings represented no more than 2.3% of the weight of a finished pallet. No data was available for fastenings within non-pallet wooden packaging, therefore it is assumed that the proportional weight of fastenings in pallets and non-pallets packaging is the same.

Estimates of the total weight of new wood used in UK production of wood packaging products in 2017 are reported in **Figure 5**. The total quantity of new wood used in UK production of pallets and non-pallet wood packaging is estimated to be 846k tonnes in 2017.

The total quantity of new wood used in the production and repair of pallets in the UK is estimated to be 657k tonnes in 2017. The total quantity of new wood used in the production of non-pallet wood packaging in the UK is estimated at 189k tonnes in 2017.

3.2 Wood packaging imported into the UK

This section provides an estimate of the quantity of wood packaging imported into the UK by registered producers in 2017 and an estimate of the quantity of wood packaging imported into the UK by unregistered producers in 2017.

Producers with an obligation under the packaging regulations who are registered report their data on the tonnages of imported wood packaging into NPWD (note that imports of wood packaging are not covered by the TIMCON and PRODCOM datasets). The quantities reported by producers in compliance year 2018 are actual 2017 sales data and include empty and filled wood packing and wood packaging that is transit packaging.

The quantity of wood packaging imported into the UK by unregistered producers is estimated using the import ratio for small businesses (to total imports) established by the methodology in the Wood Flow 2020 report[11]. It estimated that 15.4% of total imported wood packaging was imported by unregistered producers. This ratio is used to scale up the estimate of wood packaging imported by registered producers to total imports of wood packaging.
Figure 6 shows that a total of 628k tonnes of wood packaging was imported into the UK by registered producers and 114k tonnes of wood packaging was imported into the UK by unregistered producers.

The total quantity of wood packaging imported into the UK by registered and unregistered producers in 2017 is 742k tonnes.

Figure 6 Wood packaging imported into the UK, 2017 (k tonnes)

Wood packaging imports by registered and unregistered producers	Quantity
Registered producers	
Table 3a Packing/filling (imported empty packaging for pack/fill that remains in the UK)	18
Table 3a Selling (packed goods imported for onward selling in the UK)	245
Table 3b Packaging removed from direct imports	366
TOTAL wood packaging imported by registered producers	**628**
Wood packaging imported by unregistered producers	114
TOTAL wood packaging imported by registered and unregistered producers	**742**

[11] *A detailed explanation of this methodology is provided in section 5.1.2.2 of the Wood Flow 2020 report*

3.3 Wood packaging exported from the UK

This section provides an estimate of the quantity of wood packaging exported from the UK by registered producers in 2017 and an estimate of the quantity of wood packaging exported from the UK by unregistered producers in 2017.

Producers with an obligation under the packaging regulations who are registered report their data on the tonnages of exported wood packaging into NPWD (note that exports of wood packaging are not covered by the TIMCON and PRODCOM datasets). The quantities reported by producers in compliance year 2018 are actual 2017 sales data which include empty and filled wood packing and wood packaging that is transit packaging.

The quantity of wood packaging exported from the UK by unregistered producers is estimated using the export ratio for small businesses (to total exports) established by the methodology in the Wood Flow 2020 report[12]. It estimated that 12.5% of total exports of wood packaging was exported by unregistered producers. This ratio is used to scale up the estimate of wood packaging exported by registered producers to total exports of wood packaging.

Figure 7 shows that a total of 260k tonnes of wood packaging was exported from the UK by registered producers and a total of 37k tonnes of wood packaging was exported from the UK by unregistered producers.

The total quantity of wood packaging exported from the UK by registered and unregistered producers in 2017 is estimated to be 297k tonnes.

Figure 7 Wood packaging exported from the UK, 2017 (k tonnes)

Wood packaging exported by registered and unregistered producers	Quantity
Registered producers	
Table 2a Packing/filling (direct exports)	246
Table 2b Packing/filling (third party exports)	14
TOTAL wood packaging exported by registered producers	**260**
Wood packaging exported by unregistered producers	37
TOTAL wood packaging exported by registered and unregistered producers	**297**

3.4 Total UK wood packaging POM 2017

This section reports this project's final estimate of wood packaging POM in 2017. Wood packaging POM is estimated at 1,291k tonnes (+/- 12%) in 2017, a decrease of 1.4% from the previous estimate of 1,310k tonnes (2014). The error margin indicates that the two wood packaging POM figures are not significantly different. Detailed figures are presented in **Figure 8**.

A total of 846k tonnes (66% of wood packaging POM) of new wood packaging is estimated to have been produced in the UK in 2017, of which 657k tonnes is estimated to be new/refurbished wooden pallets and 189k tonnes is non-pallets wood packaging.

[12] *A detailed explanation of this methodology is provided in section 5.1.3.2 of the Wood Flow 2020 report*

Total imports of wood packaging are estimated to be 742k tonnes in 2017, of which 628k tonnes is wood packaging imports declared by obligated producers who are registered, and 114k tonnes is estimated to be wood packaging imported by unregistered producers.

Total exports of wood packaging are estimated to be 297k tonnes in 2017, of which 260k tonnes is wood packaging exports declared by obligated producers who are registered, and 37k tonnes is estimated to be wood packaging exported by unregistered producers.

Figure 8 Total UK wood packaging POM, 2017 (k tonnes)

UK production, import/export* and de-minimis wood packaging	=	**UK production** New/refurbished pallets 657 + Non-pallet packaging 189	+ +	**Imports** Table 3a + Table 3b 628 De-minimis imports 114	+	**Exports** Table 2a+Table 2b pack/fill 260 De-minimis exports 37
UK wood packaging POM 1,291	=	UK wood packaging production 846	+	UK imported wood packaging 742	-	UK exported wood packaging 297

*weight of wood packaging reported by obligated producers who are registered

3.5 Obligated wood packaging: Net Pack Fill

This section of the report presents estimates of the total weight of obligated wood packaging POM in the UK in 2017. The tonnages for obligated wood packaging are those reported into NPWD by businesses with an obligation under the packaging regulations who are registered i.e. businesses with a turnover of more than £2 million (in the previous year) who handle more than 50 tonnes of packaging per year.

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 packing/filling

The net pack fill calculation (outlined above) for wood packaging takes the weight of packaging reported at the *packing/filling* stage of the supply chain as opposed to the *selling* stage of the supply chain. It is believed by stakeholders[13] that because of the likely size of businesses who are packer/fillers there are fewer unobligated packer/filler businesses in comparison to unobligated sellers. Also, other activities such as raw material manufacturing will include process losses which means that not all material manufactured will be converted or pack/filled, so it is expected that declared tonnage will reduce as it moves further down the supply chain.

[13] *A conclusion from knowledge of the industry structure, no data evidence data is available to support this.*

Based on the net pack fill calculation the total obligated wood packaging POM in 2017 is 1,163k tonnes, as shown in **Figure 9**[14].

Figure 9 Obligated wood packaging POM 2017 (Net pack fill, k tonnes) [15]

Table 1 Pack/fill (UK packing/filling)	818
Imports:	
Table 3a Selling (imported for selling)	245
Table 3b Packaging removed from imports	366
Total UK pack/fill + imported	**1,428**
Table 2a Packer/filling (direct exports)	246
Table 2b Packer/filling (third party exports)	14
Total exported	**260**
Net Pack/Fill	**1,168**

It is important to note that the net pack fill estimate is open to the possibility of a degree of error because it relies on the accuracy of the data that is submitted by registered producers to NPWD. The NPWD data is widely recognised as being the best available as there is a legal obligation for companies to submit data that is as accurate as is reasonably possible, which is then audited by the regulating body. This data is used by policy makers and their agencies.

The net pack fill calculation does not account for the tonnage of wood packaging handled by unregistered producers which are:

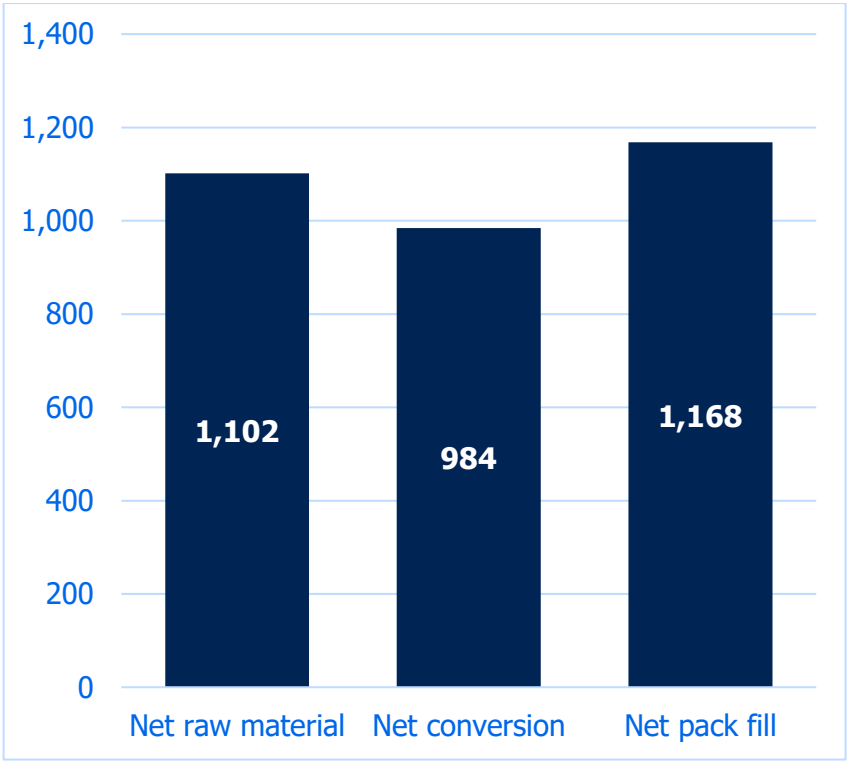
- De-minimis producers – businesses handling fewer than 50 tonnes of packaging or with a turnover (in the previous year) below £2 million;
- Free-riders – businesses that are obligated but are not registered; and
- Illegal importers.

There is no methodology available to accurately quantify the quantity of wood packaging handled by unregistered producers. It is estimated that the unregistered tonnage for wood packaging is 123k tonnes (or 10% of the wood packaging POM estimate in section 3.5). This compares to 8% unregistered tonnage for wood packaging POM in the previous report. Unregistered wood packaging POM is calculated as this project's wood packaging POM estimate of 1,291k tonnes less the net pack fill figure of 1,168k tonnes.

As a sense check of the obligated tonnage established by the net pack fill calculation, net UK tonnages declared by registered producers in other activities along the supply chain are calculated. Net UK tonnages are established for raw material manufacturing and conversion, in addition to pack/filling. The aim was to identify the obligated tonnage at other stages of the supply chain to see how they differ. The results are shown in **Figure 10**.

[14] *Based on 2017 sales data as reported by producer in compliance year 2018.*
[15] *Data correct in February 2019. Amendments to the 2017 data are still possible.*

Figure 10 Net pack/fill, net raw material and net conversion, 2003 to 2017 (k tonnes) [16]



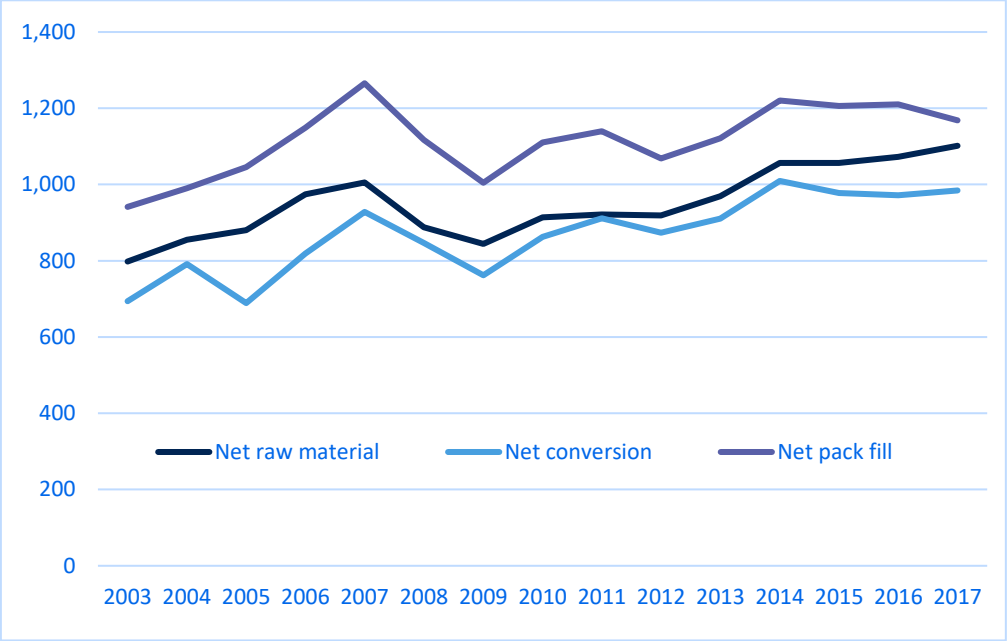
For wood packaging the tonnages of net raw material production and net conversion are below net pack fill. The comparison across supply chain activities for wood packaging shows a different pattern to that of other packaging materials (where manufacturing and conversion tonnages are comparable or higher than the net pack fill tonnage).

A possible reason for this could be due to the nature of the wood production industry. Producers at the manufacturing stage may not be aware of the extent to which their wood products are made into packaging further along the supply chain. Also, due to the high quantity of re-use pallets in circulation there could potentially be producers entering these incorrectly into their packaging returns (they should only be declared when entering the market for the first time).

Other potential contributory factors could be that there are differing levels of de-minimis and/or free-riders at each stage of the supply chain. Note this pattern for wood packaging is not peculiar to 2017 and can be seen in data from 2003 onwards as shown in **Figure 11**.

[16] *Data correct as in February 2019. Amendments to the 2017 data are still possible.*

Figure 11 Producer data net pack/fill, net raw material and net conversion, 2003 to 2017 (k tonnes)

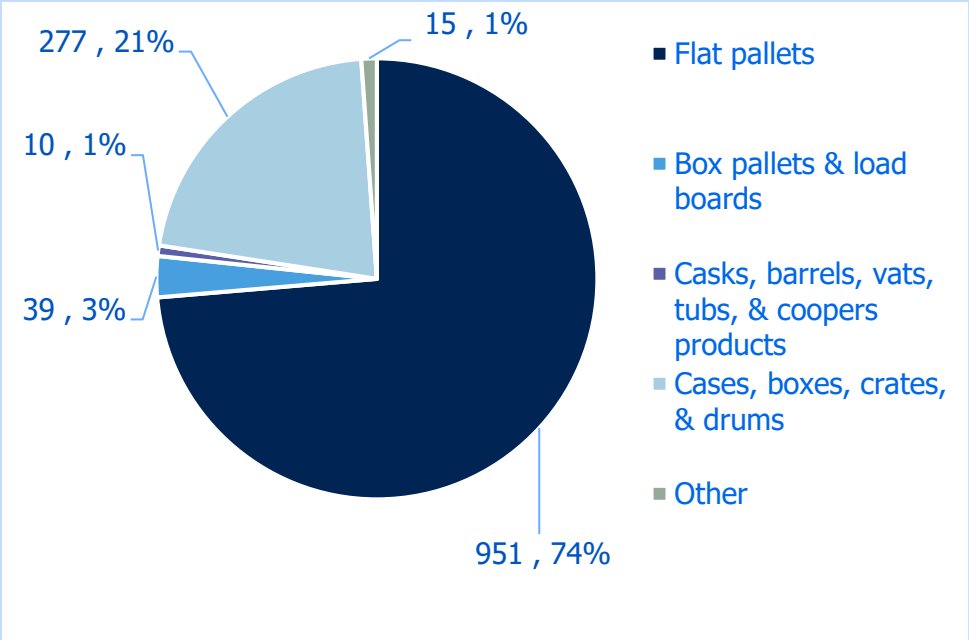


3.6 Wood packaging POM by format

Figure 12 shows final project estimates of wood packaging POM in 2017, by format. Wood packaging in new and refurbished pallets accounts for the largest proportion of total wood packaging POM at 74% in 2017. Cases, boxes, crates and drums are the next largest product format for wood packaging and represent 21% of total wood packaging POM in 2017. Wooden casks, barrels, vats, tubs & coppers products represent around 1% of total wood packaging POM in 2017.

These estimates for 2017 are derived from a combination of sources including TIMCON and PRODCOM to cover packaging supplied to business as well as Valpak's EPIC database relating to retail primary packaging supplied to consumers in the UK.

Figure 12 UK wood packaging POM by format, 2017 (k tonnes, %)



3.7 Consumer

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.

3.8 Consumer grocery

To estimate the amount of wood packaging POM by grocery retailers, this report uses aggregated NPWD data provided by the Environment Agency for 12 UK supermarkets with a combined market share of 95%[17] of the UK grocery market. The data provided is 2017 wood packaging tonnages reported by these supermarkets in the 'Table 1 selling' activity in NPWD[18].

Scaling the aggregated NPWD figure for supermarkets to 100% of the UK grocery market provides an estimate of consumer grocery wood packaging POM for 2017 of 570 tonnes (+/- 6%).

3.9 Consumer non-grocery

To scale up the grocery retail figure to represent total UK retail, including non-grocery retail, the Office of National Statistics (ONS) retail sales figures are used. ONS retail sales figures show grocery retail sales accounted for 43% of total UK retail sales in 2017.[19]

However, simply scaling up using market share was not considered robust, since it is likely that wood packaging usage in the grocery and non-grocery sectors is very different. The difference in wood packaging used by the grocery sector and non-grocery retail sectors is

[17] *Based on grocery retail market share data as published by Kantar*
[18] *The figure does not include wood packaging handled by unregistered producers (free-riders or de minimis).*
[19] *https://www.ons.gov.uk/businessindustryandtrade/retailindustry/datasets/poundsdatatotalretailsales*

analysed using Valpak memberships' reported wood packaging data[20]. The analysis involved the following key stages:

- Identification of grocery and non-grocery retail members;
- Gathering of company reported data and information; and
- Calculation of wood packaging tonnage per billion-pound turnover for grocery and non-grocery retailers, for which available data covers around 2% of wood packaging.

The method assumes the wood 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.

The estimate of consumer non-grocery wood packaging POM is 66,039 tonnes (+/-15%)[21].

3.10 Consumer POM (Grocery + Non-grocery POM)

In summary the following key steps were taken to estimate total retail wood packaging consumption in the consumer (retail) sector in 2017[22]:

- Total consumer grocery wood packaging flow in 2017 is 570 tonnes (see section 3.7);
- The proportion of grocery sales to total retail in the UK is 43% in 2017[23];
- Total retail wood packaging flow, assuming a like for like packaging composition is 1,327 tonnes in 2017;
- Wood packaging usage estimated to be: in grocery 3 tonnes /£bn turnover and in non-grocery 256 tonnes /£bn turnover (this is because non-grocery retail covers sectors such as DIY stores and garden centres);
- Non-grocery wood packaging tonnes/£bn turnover is 87 times that of grocery wood packaging tonnes/£bn turnover; and
- Multiply the difference between the like for like total retail (1,327 tonnes) and grocery retail (570 tonnes) by 87 which equates to 66,039 tonnes of consumer non-grocery wood packaging

Therefore, total retail or consumer wood packaging POM in 2017 is estimated at 66,609 tonnes (+/-15%)[24].

3.11 Consumer POM by format

A breakdown of wood packaging consumer POM by format is estimated from the wood packaging composition of the supermarkets within Valpak's EPIC database as a proxy for grocery packaging, and a sample of non-grocery retailers used as a proxy for non-grocery packaging within Valpak's EPIC database. The results of this analysis are shown in **Figure 13**.

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[20] 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.

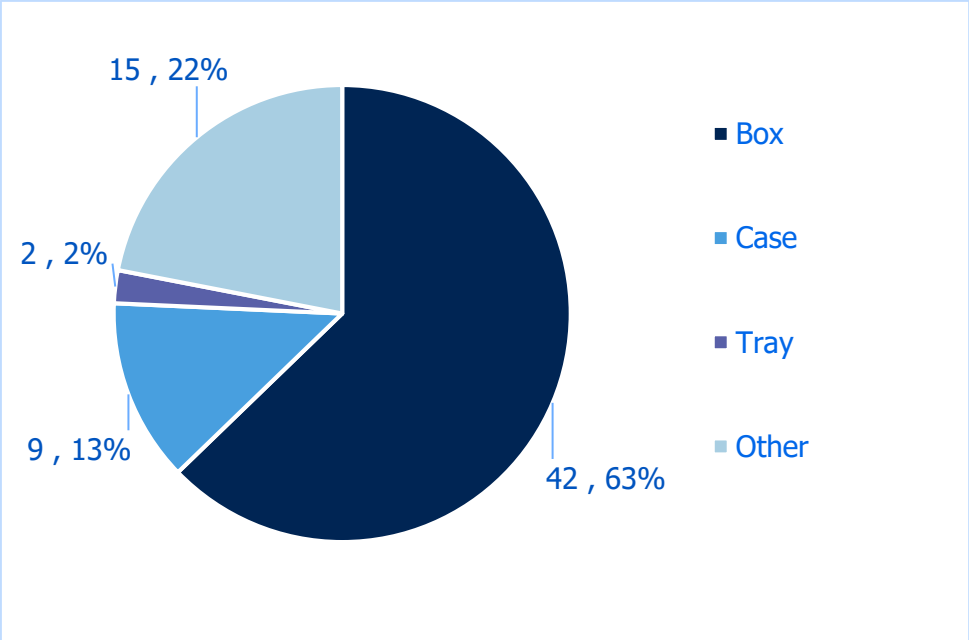
[21] As described in Figure 2

[22] All figures subject to rounding

[23] https://www.ons.gov.uk/businessindustryandtrade/retailindustry/datasets/poundsdatatotalretailsales In 2013 this was 47%, as whilst both the grocery and non-grocery retail sectors have seen increased sales since 2013, the non-grocery sales have increased to a greater extent. Much of this growth is as a result of an increase in online sales.

[24] As described in Figure ES1

Figure 13 UK Consumer wood packaging POM by format, 2017 (k tonnes, %)



3.12 Non-consumer POM

The quantity of non-consumer wood packaging POM is estimated as the total POM estimate (1,291k tonnes) less the estimate of consumer wood packaging POM (~67k tonnes).

This provides an estimate of 1,225k tonnes (+/- 11%) of non-consumer wood packaging POM in the UK in 2017. Based on this estimate non-consumer wood packaging accounts for 95% of total wood packaging POM in the UK.

3.13 Non-consumer POM by format

To break down the non-consumer packaging by format, the data was initially separated into pallets and non-pallets wood packaging. The PRODCOM data then allowed for a further breakdown of non-pallet packaging products. **Figure 14** shows the breakdown of non-consumer wood packaging POM in 2017.

Figure 14 UK Non-consumer wood packaging POM by format, 2017 (k tonnes, %)

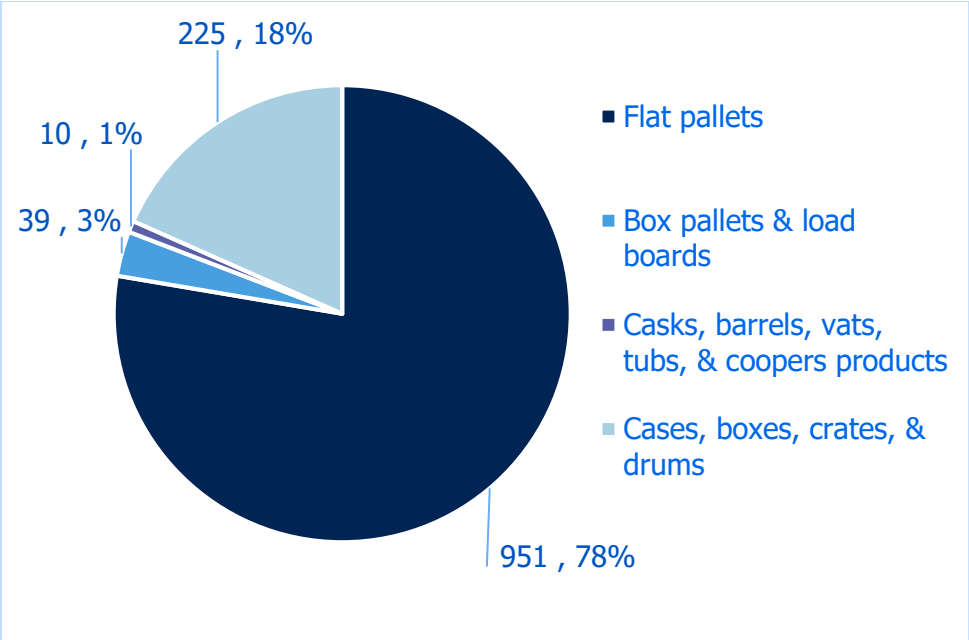


Figure 14 shows that wood packaging in new and refurbished pallets accounts for 78% of non-consumer wood packaging POM in 2017. The next largest product format for wood packaging in the non-consumer sector is cases, boxes, crates and drums with an estimated 18% share of non-consumer wood packaging.

4.0 Recycling of wood and wood packaging waste

This section of the report examines the quantities of wood packaging waste collected and recycled/reprocessed within the UK or exported in 2017. Estimates of the collection of wood packaging waste sourced from local authorities (LAs) and from commercial and industrial (C&I) businesses are provided. These estimates are based on assumptions made in previous flow projects, namely; the quantity of wood waste collected is assumed to be equivalent to the quantity of waste wood recycled; household data on LA recycling collections taken from Waste Data Flow (WDF)[25] is used as a proxy for household recycling; and, the quantity of wood packaging waste accepted by accredited reprocessors / exporters for generation of PRN/PERNs (as reported on the National Packaging Waste Database, NPWD) equates to accredited UK recycling of wood packaging waste. Since these figures do not account for unaccredited recycling[26] of wood packaging waste, a separate analysis of this is presented.

4.1 Collection of wood packaging waste

Where wood waste is collected by LAs and/or by private collectors on behalf of LAs, it is generally collected from:

- Kerbside;
- Bring sites; and
- Household waste recycling centres (HWRCs) or civic amenity (CA) sites.

The majority (99%) of wood waste collected by LAs is collected at HWRC/CA sites. However, some may be collected at kerbside, although this is likely to be part of bulky item collections. Collection tonnage data is reported into WDF by LAs as; wood for composting; wood, chipboard and MDF; and composite wood materials. The C&I collections of wood are usually carried out by private waste management companies or wood recyclers.

4.2 Local authority collection of wood packaging waste

LA household collections of wood packaging waste in the UK can be represented as follows:

Total UK Wood Packaging Collected by Local Authorities	=	Kerbside Collection[27]	+	Bring Site Collection	+	HWRC/CA Site Collection

Data on kerbside, bring and HWRC/CA sites was extracted from WDF and figures are reported based on the financial year 2016/17[28]. Collection tonnage data for wood waste reported into WDF refers to all wood waste and does not separately report waste wood that is packaging. It is estimated that around 1% of wood waste collected by local authorities is packaging[29].

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[25] It should be noted that WDF is based on the collection of data from all LAs in the UK and as such due to the number of those reporting data that there is the risk of inconsistencies in the way LAs interpret the questionnaire and / or report data. WDF is used as it is considered the best available dataset for LA collected wood.

[26] That which is recycled or exported for recycling by a company that is not accredited / registered with the Environment Agencies to raise PRNs / PERNs on packaging reprocessed / exported.

[27] Kerbside collection refers to LA (or a waste management company on behalf of a LA) collection from households

[28] At the time of writing 2016/17 was the most recent full set of WDF data available.

[29] Adopting the same assumption for the share of wood packaging in total wood collected as that in the Wood Flow 2020 report. This is supported by waste compositional analysis of mixed waste collected by LAs published by Defra in 2009[29], which concluded that 4% of all LA collected waste (at kerbside, HWRCs and bring sites) is estimated to be wood, of which only 1.48% is untreated wood and is therefore likely to include an element of packaging wood waste.

A summary of the UK local authority wood waste and wood packaging waste collection is shown in **Figure 15**.

Figure 15 Local authority wood waste collection, 2016/17 (k tonnes)

LA collected waste wood	Kerbside	Bring	HWRC/CA	TOTAL
Waste wood (non-packaging)	4	6	842	851
Waste wood (packaging)	0	0	9	9
Total waste wood	4	6	850[30]	860

Figure 15 shows a total of 860k tonnes of wood waste (wood packaging and non-packaging wood) is reported in WDF as collected by local authorities in 2016/17, of which it is estimated that just 8k tonnes is waste wood packaging. The vast majority (99%) of waste wood collected is via HWRC/CA sites.

4.3 Commercial & Industrial (C&I) collection of wood packaging waste

C&I collection of wood packaging waste is estimated as follows:

Total UK wood packaging recycled	-	Local authority collected wood packaging waste	=	Commercial & Industrial collected wood packaging waste

The total quantity of wood packaging recycled is the tonnage of accredited wood packaging recycling from NPWD[31]. Local authority collected tonnages of wood packaging are based on WDF. C&I collected tonnages of wood packaging waste are then estimated as the difference between the total quantity recycled and local authority collected wood packaging waste. The estimate of C&I wood packaging waste collected is shown in **Figure 16**[32].

It is important to highlight that what is collected for recycling is not equal to that which is ultimately recycled. The WDF collection figures will not equal the amount recycled, as many local authorities do not robustly account for material rejected by the materials recycling facilities (MRFs) during the sorting process. Therefore, for simplicity, by assuming that the total collected for recycling equals the total actually recycled, this calculation distorts the representation of contamination and non-target material, accounting for them all upfront (in this case, by default, within the C&I collections estimate). This means that C&I collections as reported here are implicitly underestimated by the combined, unknown level of contamination and non-target material.

It is also important to note that the NPWD figure only covers obligated waste recycled by accredited reprocessors/exporters and does not include tonnages recycled without a packaging recovery note/ packaging exported recovery note (PRN/PERN) being generated. Section 4.5 provides information regarding unaccredited reprocessing.

[30] *Figures do not sum due to rounding.*

[31] http://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx

[32] *There is a time difference between the NPWD figures (calendar year 2017) and the LA figures (2016/17 financial year); however, this was the best available data.*

Figure 16 C&I wood packaging waste collected, 2016/17 (k tonnes)

Collected wood waste packaging	Quantity
Total collected	411
LA collected	9
C&I collected	402

4.4 Recycling of wood packaging

This section of the report examines the quantity of wood packaging recycling in the UK and that which is exported. In contrast to collection it specifically focusses on wood packaging that is successfully recycled (i.e. where wood packaging waste is used to manufacture products derived from waste packaging wood).

To estimate the total quantity of wood packaging recycling that is taking place, recycling activities are split into two categories:

- Accredited recycling, meaning wood waste packaging recycling reported by accredited wood recyclers and accepted as eligible for issuing PRN/PERNs
- Unaccredited recycling, meaning wood waste packaging that is recycled but not recorded by accredited and unaccredited wood recyclers

4.5 Accredited wood packaging recycling

Accredited recycling and recovery is that undertaken by a reprocessor/exporter whose activities are eligible for registration as an accredited reprocessor/exporter and to issue PRN/PERNs. Only the activities of wood recyclers registered as accredited are considered here.

Eligible markets for the recycling/recovery of waste wood packaging include:

- Manufacture of wood board, for example, chipboard or orientated strand board (OSB);
- Decorative woodchip;
- Utility chip (including that used in riding arenas etc., and as a biomass fuel); and
- Animal bedding.

There may be an element of wood packaging waste in mixed waste which is combusted in energy recovery facilities. This material is eligible for recovery PRNs under the following circumstances:

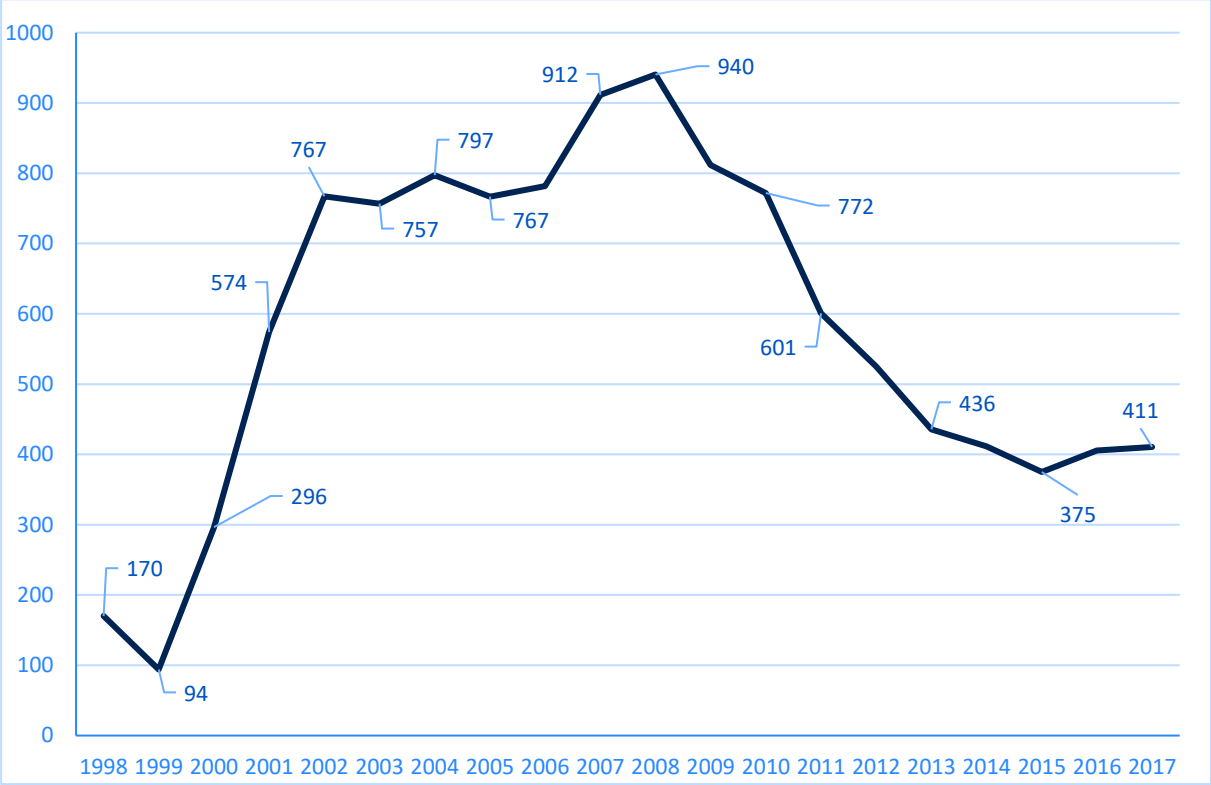
- Energy recovery from packaging waste burnt in a municipal waste incinerator where the energy efficiency meets the requirement of the R1 specification (i.e. with an energy efficiency of 0.6 or above applies to installations permitted before 1 January 2009; for installations permitted after 31 December 2008 the energy efficiency is 0.65 or above[33]).

[33] *Potentially 36 EfW facilities in England meet this status: 14 of these are operational, 22 are in design stage only. https://ea.sharefile.com/share/view/sc1633ad5ae44693b dated 18/05/18, accessed 19/12/18.*

Recovery PRNs can be issued for 19% of the waste unless the operator of the incinerator proposes an alternative sampling method in the accreditation application to demonstrate the packaging content of these waste streams.

The total quantity of accredited wood packaging waste recycled (reprocessed in the UK or exported by accredited exporters) from 1998 to 2018 is shown in **Figure 17**[34].

Figure 17 Accredited wood packaging recycling, 1998 to 2017 (k tonnes)



The quantity of accredited wood packaging recycling has followed two trends. It increased from 2000 up to 2008 when it reached 940k tonnes. However, it then started to decrease, and this trend continued to a low point in 2015, since when it has stabilised around 400k tonnes to 411k tonnes.

It is believed the decrease from 2009 is due to an increase in wood packaging being used in end markets such as biomass energy[35] (which is classified as recovery rather than recycling) and the fall in the number of accredited wood reprocessors. At the time of reporting there were no biomass energy facilities listed as registered reprocessors with any UK regulatory body[36].

It is important to note that while the *proportion* of wood packaging used in biomass energy is low, the actual amount is likely increasing because of the increasing quantities of waste

[34] http://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx

[35] *Discussions with Wood Recyclers Association (WRA) on 12/12/2018 and Wood Panel Industries Federation (WPIF) on 13/12/2018.*

[36] *Biomass could become accredited; however, the regulatory body would consider each application on a case by case basis. Accreditation would depend on the information provided within the Sampling and Inspection Plan and there would need to be a site-specific protocol formulated to identify the wood packaging content, as the content of biomass can contain a wide array of materials: virgin wood, energy crops, agricultural residues, food waste, industrial waste and co-products from manufacturing and industrial processes.*

wood used in bioenergy plants (note that this is an area of uncertainty with a lack of data as of the time of writing). As bioenergy plants are not operated by accredited reprocessors and bioenergy is classed as recovery not recycling, any packaging wood waste going to bioenergy plants is not captured in accredited wood packaging recycling.

4.6 Unaccredited recycling

The project team and the Steering Group believe that there are substantial quantities of waste wood packaging that are being recycled/recovered but it is taking place without any recycling or recovery evidence being issued and as such is considered unaccredited (or unrecorded) recycling.

This section presents analysis to determine the quantity of packaging wood waste recovered and used in different end markets, in order to identify how much unaccredited recycling occurred in 2014. This involved a two-step process:

1. Determining current markets for wood waste; and
2. Determining the quantity of packaging waste wood utilised by each market.

There is no fully inclusive and comprehensive source of waste wood statistics for the UK that includes up-to-date and accurate data on waste wood arisings and markets. This is complicated by the fact that a significant quantity of wood waste does not go to final disposal, but instead goes directly to re-use, recycling or recovery. The most recent published reports on waste wood markets include:

- An assessment of the environmental impact of the management options for wood waste, AEA, published by Defra, 2012;
- The business case for wood waste collection hubs, WRAP, 2012;
- 2011 Briefing Report – The UK Waste Wood Market, Tolvik Consulting, 2011;
- Realising the value of recovered wood – Market Situation Report, Pöyry Forest Industry Consulting Ltd, published by WRAP, 2011;
- Annual Data on Wood Recycling – 2011 Market Statistics, Wood Recyclers Association (WRA), 2011;
- Impact Assessment of a Quality Protocol for Waste Wood, Environment Agency, 2011; and
- Wood Waste Market in the UK, Pöyry Forest Industry Consulting Ltd & Oxford Economics Ltd, published by WRAP, 2009;
- Anthesis (2017) The UK Wood waste to energy market.

These data sources were reviewed, and the information drawn from them updated using information on current markets for wood waste from the Wood Recyclers Association and the Wood Panel Industries Federation.

It is estimated that the construction and demolition sectors each account for around 25% of wood waste arising compared to 9% in joinery and furniture[37]. In 2017, the construction industry was the initial destination for 30% of all new pallets[38], compared to 21% in FMCG markets, 10% in engineering/automotive, 10% in paper industries and 8% in chemicals industries. When the above reports were written the construction sector was in recession in the UK[39]. No update of the estimates of waste wood arisings have been produced since

[37] *Realising the value of recovered wood (WRAP & Pöyry, 2011)*

[38] *The UK Wood Pallet & Packaging Market in 2017 (TIMCON & The Forestry Commission,2019)*

[39] *Anthesis The UK wood waste to energy market (2017)*

2011-12. However, since then the construction sector has recovered from the recession. Housing construction increased by 84% in 2017 versus 2012 and repair and maintenance increased by 28%[40]. So, in 2019 the construction sector is likely to be using more materials (than in 2011/12), possibly resulting in a greater net use of wood packaging. The net effect of this could be that the amount of packaging waste (arising from the construction and demolition sector) could be higher than that estimated in 2011/12.

However, there is no clear data on this, so we have used the data provided in 2009 – 11 to estimate total wood packaging waste in **Figure 18**. Wood packaging waste arising estimates will not match the POM estimates provided elsewhere in this report, essentially because wood packaging is durable, has a long life on the market, and is extensively re-used and repaired.

Figure 18 Wood packaging waste arising (k tonnes)

	WRAP, Wood waste market in the UK, 2009	Tolvik, 2010	WRAP Realising the value of recovered wood 2011
Wood packaging waste	1,170	998	1,100

Major end markets for waste wood (including packaging) include:

- Panel board manufacture;
- Biomass energy generation;
- Other recycling (animal bedding, equine surfaces and mulches etc.)

To understand how wood waste packaging may be used in different markets, it is first necessary to understand the quality requirements of each market. Wood waste comes from a variety of sources that dictate the level of contamination in the waste wood. The source and level of contamination is used by wood recyclers to grade the quality of the wood waste, providing an indication of the need for processing and potential end markets. This classification has been standardised by the WRA and is used in the Publicly Available Standard 111. Essentially there are four grades of waste wood, as summarised in **Figure 19**.

[40] *Output in the construction industry, ONS, January 2019*

Figure 19 Grades of Waste Wood (k tonnes)

Grade	Definition	Typical markets
Grade A – Clean un treated wood	Relatively homogenous (hardwood/softwood), primary processed woods. Source: distribution, retailing, packaging and secondary manufacture e.g. joinery and pallet reclamation. Materials: solid softwood and hardwood. Packaging waste, scrap pallets, packaging cases and cable drums. Process offcuts from the manufacture of untreated products.	Manufacture of professional and consumer products, such as animal bedding, equine and landscaping surfaces. May also be used as a fuel in domestic and non-IED Chapter IV biomass installations and for the manufacture of pellets and briquettes.
Grade B- Industrial waste wood	Source: Grade A plus construction and demolition operations, skip operators, transfer stations Materials: may contain up to 60% Grade A material as above plus building and demolition materials and domestic furniture made from solid wood.	Industrial wood processing operations e.g. panel board manufacture
Grade C – Municipal waste wood	Source: As above plus municipal collections, transfer stations and HWRCs. Materials: all of the above plus fencing products, flat pack furniture made from board products and DIY materials	IED Chapter IV biomass installations and for panel board in controlled volumes
Grade D - Hazardous waste wood	Source: All of the above plus agricultural fencing, trackwork and transmission pole contractors Materials: Agricultural fencing, transmission poles, railway sleepers, cooling towers.	Must be disposed at facilities licensed to accept hazardous waste.

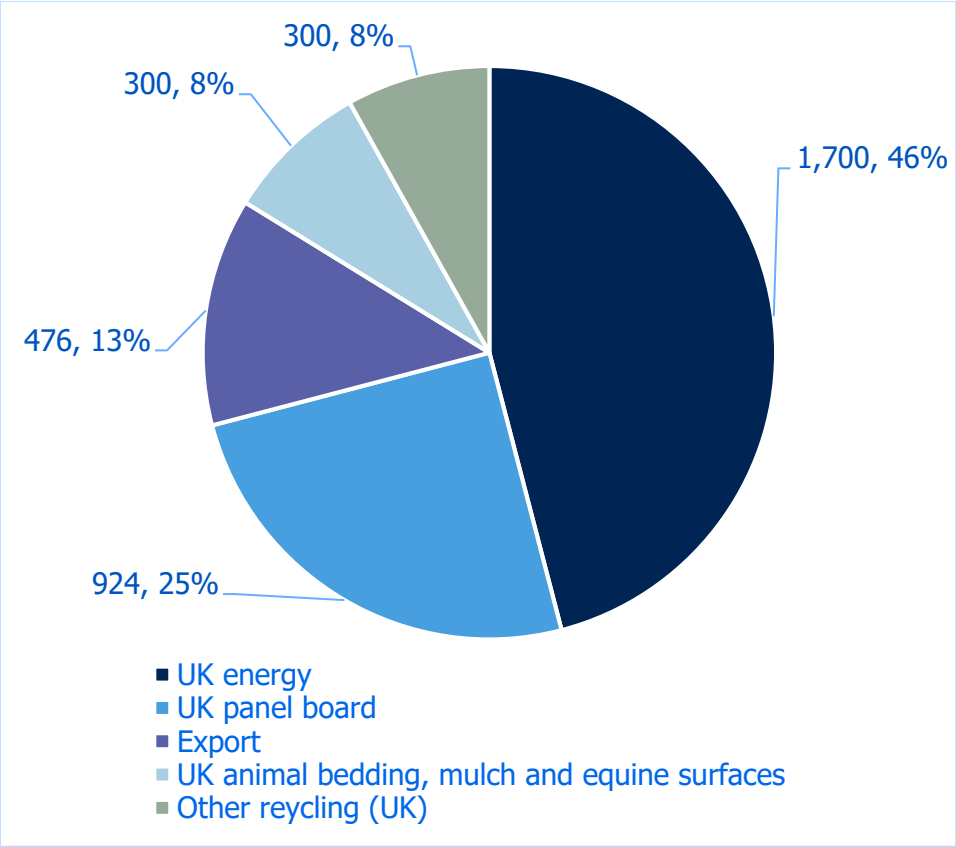
This suggests that the main markets for packaging wood waste are predominantly in Grade A applications, i.e., animal bedding, equine surfaces, but also in Grade B applications, i.e., panel board. There will also be packaging wood waste present in mixed wood waste streams, i.e., Grade C and possibly Grade D.

In reality the quality of wood waste will vary considerably on a load by load basis. Therefore, in some cases loads delivered may not align perfectly to the grades in **Figure 19**.

Figure 20 reports the quantities of waste wood going to various wood waste markets in 2017 according to the WRA. It should be emphasised that these figures are for all types of waste wood, not just wood packaging waste.

Having identified the total quantity of wood waste utilised by each market, the next stage in the analysis is to estimate tonnages of packaging wood waste used by each end market. Actual data on packaging wood waste used by UK panel board manufacturers is available, for other sectors assumptions are made based on discussions with the WRA.

Figure 20 UK waste wood markets, 2017 (k tonnes, %)



4.7 Panel board production

The Wood Panel Industry Federation (WPIF) was established in 1995 and represents the interests of industrial manufacturers in the UK and Ireland of Wood Chipboard, Oriented Strand Board (OSB) and Medium Density Fibreboard (MDF). There are currently three manufacturing companies in the UK, with a total of six plants:

- Norbord Europe Ltd (3 sites);
- Kronospan Ltd (1 site);
- Egger Ltd (2 sites).

Five of the six sites accept waste wood for recycling into chipboard.

The WPIF collects detailed annual data from its members on the quantities of recovered wood used in panel board production. Annual data for 2010 to 2017 provided by the WPIF is reported in **Figure 21**. All six of the UK's panel board manufacturers are WPIF members and the figures reported are based on a 100% return rate.

Figure 21 Waste wood recycling in UK panel board production, 2010 to 2017 (k tonnes)

Year	Raw board production[41]	Recycled waste wood[42]	Recycled waste wood packaging	Quantity declared for PRNs
2010	3,367	1,120	550	504

[41] *K green tonnes refers to the weight measurement of timber freshly felled before any natural or artificial drying has occurred.*
[42] *K green tonnes refers to the weight measurement of timber freshly felled before any natural or artificial drying has occurred.*

2011	3,271	952	423	396
2012	3,298	909	345	304
2013	3,117	853	296	274
2014	3,223	812	266	247
2015	3,198	852	274	273
2016	3,146	839	272	271
2017	3,223	924	258	254

In 2017, the panel board manufacturers reported recycling of 258k tonnes of waste wood packaging, of which 254k tonnes was accredited recycling. There was a view among WPIF members in the Steering Group that wood packaging waste recycling could increase by around 90-100k tonnes in 2019, providing the price of a wood PRN remains at a level that is sufficient to drive recycling. WPIF members have the capacity to take this additional wood packaging. However, market access to the available waste wood packaging will depend on competition for wood waste packaging from other sectors.

Accredited wood packaging recycling reported in 2017 was 411k tonnes, with WPIF members accounting for 62% of all wood PRNs issued in 2017. The amount of wood packaging recycled by WPIF members was 47% of the total wood packaging estimated to be recycled in 2017, see **Figure 22**.[43]

4.8 Other markets

For other waste wood markets figures are available for total wood waste usage, but this is not split into the fractions of wood waste used, meaning that no data are available on the quantities of packaging wood waste used. Therefore, assumptions are made on the proportion of wood waste that is wood packaging waste in each end market. These assumptions are informed by industry understanding of the quality requirements and grade specifications in each market. For example, wood recycling markets such as production of animal bedding, equine surfaces and mulches require high quality 'Grade A' waste wood. Grade A wood waste consists predominantly of packaging waste but may also contain waste wood from other sources, for example manufacturing and joinery wood waste.

Based on the latest figures available at the time of writing (2017 data) the WRA estimate that 80% of the wood waste used in the manufacture of animal bedding, equine surfaces and mulches is likely to be waste wood packaging.

It is estimated that no packaging wood waste is exported for use by European panel board manufacturers in 2017[44].

Estimates of waste wood usage and usage of waste wood packaging are summarised in **Figure 22**. This includes information on the quantities of wood recycling reported by

[43] *The latest estimates available at the time of writing.*

[44] *It is estimated that 26k tonnes of waste wood was exported to the European panel board market. Discussions with the WPIF and the WRA indicated that none of this is likely to be waste wood packaging due to its high value in the UK.*

members of the WRA and estimates made by the WRA of the quantities of wood waste managed by non-members[45].

The proportion of wood packaging waste included in the UK and export bio-energy markets is thought to be low, with these markets mainly utilising lower grade mixed wood waste streams. However, even at 5% of this market waste wood packaging would represent 85k tonnes. Note that any waste wood packaging going to these markets is classed as recovery and not counted as recycling.

It is likely that "Other recycling" includes some wood packaging. The WRA estimates that around 10% of this is wood packaging but is not certain whether this fraction is recycled or recovered (i.e. used for energy). In the estimates presented in **Figure 22** it is included as recycling.

In addition to the data in **Figure 22**, the Biomass Suppliers List (BSL) estimate that 350kt of waste wood went into small scale RHI. Some of this may be wood packaging waste, but no data on this faction is available, so it is not possible to estimate the quantity of wood packaging waste recovered in this way.

Other potential markets/disposal routes for packaging wood waste are summarised in Section 4.10.

Figure 22 UK waste wood recycling by end market, 2017 (k tonnes, %)[46]

Market	WRA Members	WRA Member share of UK market (%)	UK market	Wood packaging content (%)	Wood packaging recycled
UK panel board	852	92	924	n/a	258[47]
UK energy	1,663	98	1,700	5	85
UK animal bedding, mulches and equine surfaces	300	100	300	80	240
Other recycling (UK)	262	55	476	10	48
Export	262	87	300	0	0
Total recovered					85
Total recycled					546
Total			**3,700**		**631**

A total of 3.7 million tonnes of waste wood was recovered/recycled in 2017. Waste wood recovery by UK energy was 1.7 million tonnes, the panel board industry recycled 924k tonnes of waste wood, 300k tonnes of waste wood was recycled by UK manufacturers of animal bedding, mulches and equines surfaces, other UK recyclers used 476k tonnes of waste wood, and 300k tonnes of waste wood was exported.

[45] It is possible for WRA to estimate waste wood use across the UK as they now represent a significant number of both reprocessors and users. However, in 2014 this was not possible so that figures presented in Wood flow 2020 are only for WRA and cannot be compared to figures for the whole of the UK, as shown here.
[46] 2017 WRA data latest available at time of writing.

[47] Wood packaging waste recycling in production of panel board reported by WPIF, see Figure 21

The total quantity of wood packaging waste recycled in 2017 is estimated to be 546k tonnes. Subtracting the accredited recycling figure of 411k tonnes gives a total figure for unaccredited wood packaging recycling of 135k tonnes.

4.9 Data verification

The data reported by the panel board sector is based on actual tonnes of packaging wood recycled, as outlined above, the data for other sectors is based on estimates and will be subject to an element of uncertainty. There is no routine collection of waste wood statistics for the UK in general; therefore, there is no routine collection of waste wood packaging data (apart from data provided by accredited recyclers). The estimates of packaging waste content used by each market in **Figure 22** have been informed by both the WPIF and the WRA (both members of the Steering Group). For example, the WRA works across the supply chain to make its annual estimates of markets supplied by non-members. Despite this, the complexities of the waste wood market and the mixed types of wood used by some markets means that there will be a degree of error in the data.

In a Briefing on Regulation of Wood[48] published by the Environment Agency, it stated that wood must be effectively segregated into the four grades – A, B, C, and D – before subsequent processing for use. The markets dictate the quality specification, and therefore the grade and type of wood that is supplied to them. For example, the use of waste wood permitted for use in UK animal bedding, mulch and equestrian surfaces includes untreated wood only, i.e., packaging wood and process off-cuts from the manufacture of products from untreated timber. This gives confidence to the WRA that the estimates of packaging content in the table above are as accurate as possible.

Further robustness of the estimates could be achieved by more accurate or mandatory reporting of waste wood type received by recyclers/reprocessors, and by the wider adoption of the PAS 111 specification that provides the definitions, minimum requirements and test methods for processing waste wood into materials intended for use in suitable new applications or end products.

4.10 Other non-recycling destinations for wood waste

The data presented in **Figure 18** indicates (based on estimates from 2009-11) that there could be in the region of 1-1.2 million tonnes of wood packaging waste arising in the UK. Subtracting the total of accredited and non-accredited wood packaging recycling suggests that there remains a substantial element of packaging wood waste unaccounted for (estimated to be around ~450k tonnes to ~620k tonnes in 2017). Note that given the growth in the construction sector since these estimates were made, the non-recycled tonnage is likely to be higher. There are a number of other markets and outputs that can be considered as accounting for this difference, but the reader should note that at the time of report writing there is a lack of market data on the amount of wood packaging destined for other non-recycling destinations.

Disposal to landfill

There will be an element of wood packaging waste disposed of in landfill, but it is thought by the Steering Group to be very small quantities. This is because the waste wood market works well, and Grade A wood packaging waste is valued by the market, see section 4.13. It is probable that waste wood packaging going to landfill will be low grade material and present in mixed waste only.

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[48] Briefing on Regulation of Wood – Our approach to working with the wood recycling sector on the management of waste wood, September 2014. The grades of waste wood were described in detail in PAS 111 (2012). The Agency is currently examining how hazardous waste wood is classified, https://www.letsrecycle.com/news/latest-news/agency-extend-rps-waste-wood-classification/ .

Present in lower grades of wood waste used in bioenergy

Clean wood and wood waste can also be used as a biomass fuel under the Renewables Heat Incentive and in dedicated bioenergy plants operating under the Renewables Obligation.

Renewable heat incentive (RHI)

The Biomass Suppliers List (BSL) has been developed to help small scale plants comply with sustainability requirements set out in the RHI. The BSL has estimated that 350kt of waste wood went into small scale RHI. Some of this may be wood packaging waste, but no data has been collected on this, so it is not possible to estimate the quantity of wood packaging recovered in this way.

Renewable obligation (RO)

The RO is now closed, but a number of plants continue to operate and are supported under the RO. Waste wood packaging may be classed as clean wood waste, or it may be mixed with post-consumer wood waste and classed as low-grade waste wood. In either case there is a possibility that wood packaging waste is going to dedicated wood energy plants, so we have included this in our estimates. In **Figure 22** it is estimated to be 5% of the incoming feedstock or 85kt in 2017. However, it is possible that more wood packaging waste may be going to dedicated bioenergy as part of the mixed waste stream. It is difficult to understand if this is the case. This situation should be clarified in 2018, as wood PRN prices rose to a high level, making sorting packaging wood from mixed wood waste more viable.

In 2016-17 bioenergy plants reported use of 1.7 million tonnes of wood, including waste wood. This demand could rise to 3 million tonnes (within a range of 2.5 – 3.6 million tonnes, depending on the final number of legacy plants that become operational under the RO in the next year and the waste wood taken in plants that can take more than one source of waste). A large proportion of the recent and currently constructed plants are compliant with the Industrial Emissions Directive (IED) for the purposes of combustion, and target low grade wood waste, which will contain relatively low quantities of packaging wood waste. A database of plants that are compliant with the IED can be found on the GOV.UK website[49], although IED compliance does not in itself mean that a plant is operational, so this list represents maximum demand.

Present in household and C&I waste treated in EfW facilities

Tolvik report operational incineration capacity in 2017 at 11.85 million tonnes, expected to reach 14.8 million tonnes in 2020 and 15.7 million tonnes in 2022, an increase of 3.9 million tonnes by 2022 assuming all of what is planned or in construction is built[50]. However, it is very unlikely that much wood packaging is in the residual waste going to EfW as its value in other markets is high.

It should also be noted that if wood packaging waste is going to EfW, this waste would only be counted as recovery where it is used in facilities that have been deemed to be compliant with the R1 classification for waste recovery.

Unrecorded but legitimate use in biomass plants which are accredited under RHI

Some packaging wood waste (e.g. broken pallets) is used as a fuel in small-scale biomass plants including those accredited under the RHI. Whilst participants of the RHI are obligated to keep records of quantities and type of fuel used, this data is not centrally collated.

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[49] https://www.gov.uk/government/collections/industrial-emissions-directive-ied-environmental-permits-issued

[50] *Tolvik (2017) UK Energy from waste statistics - 2017 http://www.tolvik.com/wp-content/uploads/Tolvik-UK-EfW-Statistics-2017.pdf*

As most small scale RHI boilers are designed to take processed fuel (pellets or chips) it is likely that any use of waste wood packaging on site is likely to be relatively low.

Used in the manufacture of pellets for biomass plants

Whilst most wood pellets are manufactured from virgin wood, there are pellets being manufactured from clean waste wood, some of which may include waste wood packaging.

Used in non-legitimate (i.e. not adhering to standards) markets for animal bedding

According to the WRA wood packaging waste may be being used in markets that do not adhere to standards, for example, in animal bedding that is also using lower grade wood waste.

Re-use by the third sector

The third sector plays an important role in facilitating the re-use and recycling of wood waste through the delivery of a wide range of collection, repair and re-use schemes. Community Wood Recycling (CWR) represents a UK wide network of community wood recyclers. This organisation predominantly collects wood from construction sites, offering an alternative to open skips. It grades wood collected by re-use outcomes, as opposed to the type of wood it is. For example, wood waste collected by its members will be classed as high or low grade. High grade is wood that can be re-used in DIY projects or made into furniture or other items. High grade wood includes pallets that can be repaired and sold back to pallet distributors. Low grade wood is wood that is not suitable for re-use and is subsequently used for fire wood and kindling. Some low-grade wood will also be sent to other recyclers for chipping. CWR has seen a rise in the popularity of using packaging wood from pallets as cladding and decoration in shops and restaurants.

In 2017, CWR recorded 20.7k tonnes of wood collected across its network, of which more than 50% was re-used as timber for sale, made into products or sold to the public as firewood. The remainder was sent for chipping. Whilst CWR collect detailed data on wood collected, it does not break the data down any further into the type of waste wood. Instead its focus is on recording the end use/ re-use of the waste wood collected, providing information to its customers on what is happening to their waste wood. However, CWR has estimated that 20% of waste wood collected by weight is packaging wood[51]. Note that this is just an estimate and is uncertain.

Burned on bonfires and other 'back-yard' burning

Packaging waste is commonly disposed of in bonfires and other examples of back-yard burning, both by householders and businesses.

4.11 Wood recyclers accreditation

To gain an understanding of the role of the PRN price as a driver of wood recycling, businesses becoming accredited to issue PRNs, the number of large and small accredited reprocessors or exporters for wood packaging is plotted against the average wood PRN price, see **Figure 23**. This shows that although accredited reprocessors decreased from 2009 to 2015, following PRN price decreases (19 companies dropped their EA accreditation; these were predominantly large companies; of these 19 companies, 10 continued to operate after deciding not to renew their accreditation[52]). Since 2015 a number of sites became active again and several new companies registered for accreditation.

[51] *E-mail from CWR, 18/12/18. CWR has also provided 2018 statistics that show 21.5k tonnes wood in 2018 (e-mail 14/01/18)*

[52] *The remainder are not necessarily out of business but may no longer see waste wood reprocessing as a core part of their business. In addition, there has been some rationalisation of the reprocessing sector, which also accounts for some of the decrease.*

In 2018 there were eight more wood reprocessors accredited in 2018 compared to 2017. One reason for this is that during 2018 the price of wood PRNs increased (to over £73 per tonne by October 2018). **Figure 23** shows average annual PRN prices, which is why the full year figure for 2018 is £35 per tonne (the price increased from £7.50 per tonne at the start of the year to £73 per tonne). Commenting on these figures the WPIF noted that there had been a couple of issues in 2018 that had influenced wood PRN prices:

- Kronospan had an unscheduled five-week outage during 2018 Q3, which restricted their ability to recycle wood.
- Two WRA members dropped out of accreditation and took longer than normal to come back in again. In addition, there were signs that the higher wood PRN prices were encouraging more re-processors to consider becoming accredited.

According to feedback from the WPIF, these issues also disguised the fact that the increased wood PRN prices resulted in increased segregation of waste wood packaging and increased availability of PRNs (as indicated above through the increase in accredited reprocessors).

Figure 23 Accreditation by wood recyclers versus wood packaging PRN price, 2008 to 2018[53]

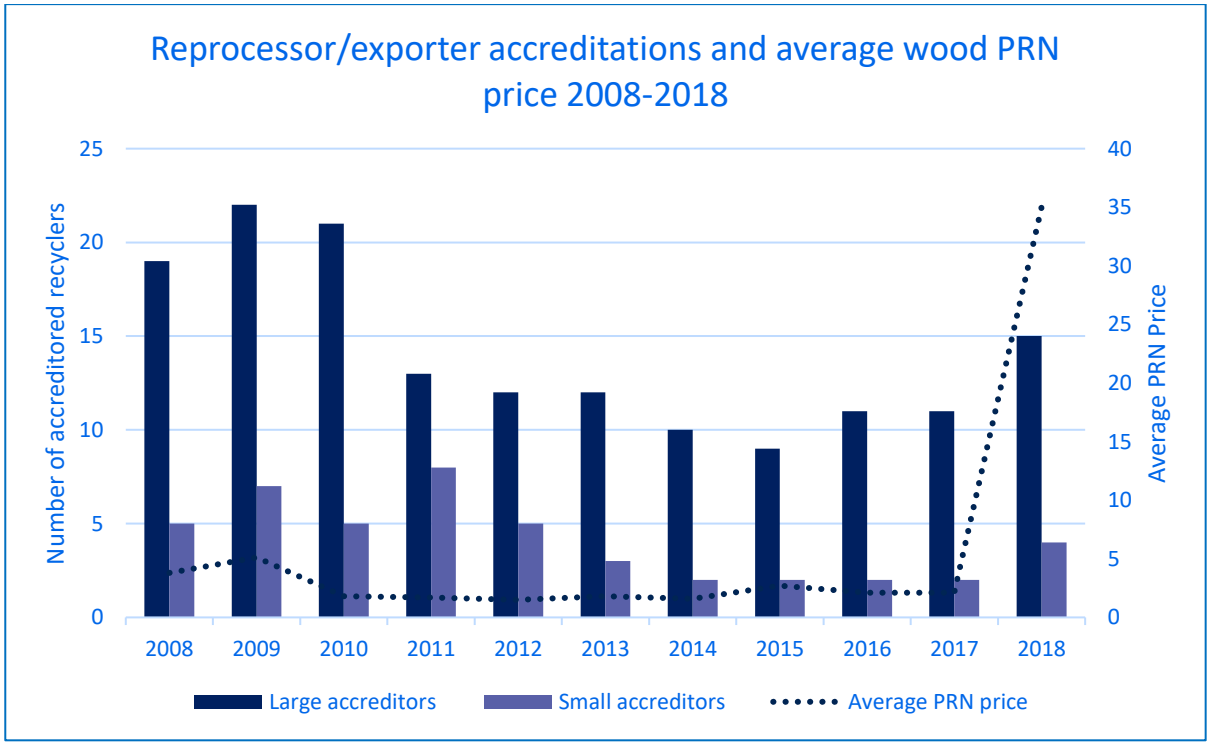


Figure 24 shows the number of accredited reprocessors alongside the quantity of accredited wood packaging recycling. While the quantity of accredited recycling decreased to 2015, this was probably due a fall in the number of reprocessors registering for accreditation (and the low PRN price) rather than a fall in the throughput of wood packaging waste recycled by the industry. This is supported by the fact that there are a number of major players in the wood waste market who were previously accredited but who were not

[53] *Based on the number of active reprocessors / exporters reported on NPWD on 12/12/2018. Price data based on WRAP data (http://www.wrap.org.uk/content/wood-1) and published data in Let's Recycle (https://www.letsrecycle.com/prices/prns/prn-prices-2017/). Note these are average prices, not peak prices. For 2018 the average was until October only. Prices continued to increase after October to a peak of £73 in December.*

accredited in 2015, but continued operation. Since 2015 the number of accredited large-scale wood reprocessors and the quantity of accredited recycling has increased.

Figure 24 Accredited wood packaging recycling and number of accredited businesses, 2008 to 2018 (k tonnes, number)

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Accredited recycling	940	762	772	601	525	436	412	375	405	411	454*
No. of Accredited Reprocessors	31	33	32	24	21	18	15	11	13	13	21

*provisional

4.12 Wood packaging waste market dynamics

In 1996, the WRA estimated that less than 4% of wood waste arisings were recycled/recovered by its members. By 2011, that figure had risen to 60% of wood waste arisings (around 2.8 million tonnes) and in 2014 this was estimated to be just over 3 million tonnes. These figures are WRA estimates and do not reflect the quantity of wood recycling by non-WRA members.

For the past two years the WRA has provided figures that reflect UK waste wood recycling. These figures represent all wood waste not just wood packaging waste. The largest increase in use of reprocessed waste wood has been for energy, which was estimated to be 1.7 million tonnes in 2017. This increase has been rapid since 2014. It is likely that this market will increase substantially to between 2.4 million tonnes and 3.6 million tonnes in 2019 depending on the number of new plants entering into operation following the closure of the Renewables Obligation to new entrants. These plants are unlikely to use high quantities of wood packaging waste (beyond the 5% estimate included in this report), although it is possible that competition for waste wood could mean higher wood packaging content. However, if wood PRN prices remain high, it is likely that lower proportions of wood packaging will go to energy recovery.

Animal bedding, equine surfaces and mulches are steady at around 300k tonnes per year. Use of wood packaging in these markets has grown over the last decade as wood recyclers sought to diversify from the panel board sector and access higher value markets. The WRA think that this market is now reaching a point of maturity with limited potential for substantial growth, although the price of substitutes for animal bedding products (such as straw) may influence this.

In 2017 UK production of panel board was 3.2 million green tonnes (the same level of production as in 2014) but the amount of wood waste used by the panel board industry has increased since 2014. The amount of wood packaging waste used in panel board production increased in 2015 and 2016 but in 2017 was below its 2014 level due to competition from other markets for waste wood packaging, see **Figure 21**.

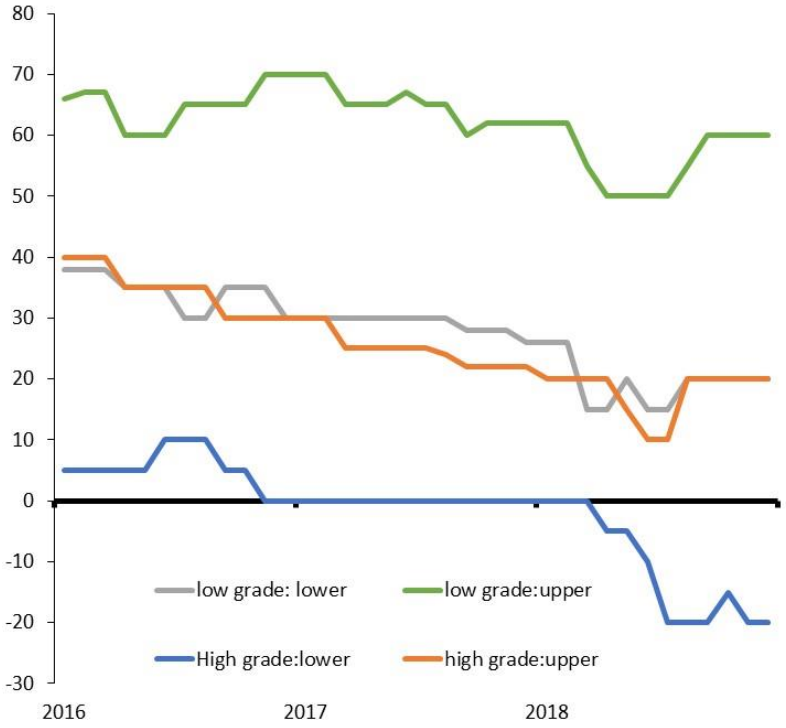
4.13 Market pricing

Reprocessors are willing to pay for good quality, clean Grade A wood, whereas they charge a gate fee for lower grades of waste wood. **Figure 25** shows gate fees being charged by waste wood reprocessors to take waste wood between 2016 and 2018. In 2018 reprocessors

paid up to £20 per tonne for some high grades of waste wood and low-grade waste wood gate fees were on a downward trend.

It is estimated that Grade A wood for animal bedding markets has a value of £80 per tonne to £400 per tonne (or more), with indicative pricing suggesting the pet bedding market pays the highest prices[54]. Similar quality wood sent to biomass markets will see indicative values of around £50 per tonne to £80 per tonne (chipped[55]). The panel board industry is thought to pay lower prices for wood waste meeting its specifications, which means it cannot easily compete for this high-grade reprocessed wood. Therefore, it reasonable to suppose that Grade A wood waste, i.e., wood waste that includes packaging wood waste, has a clear price advantage over other grades of wood.

Figure 25 Wood waste gate fees, 2016 to 2018 (£ per tonne)



Waste wood prices are a combination of:

- Gate fees for the waste wood coming on site;
- Market prices for the products leaving the site; and
- Reprocessing investment and operating costs.

The price of wood waste is very demand orientated. In a low demand market, the wood reprocessors will increase the gate fee to decrease waste wood coming into their site. In a market where there is high demand, the reprocessors may choose to decrease their gate fees to attract waste wood to their sites. Prices vary depending on demand, location, specification, and by time of year.

Reprocessors can react quickly to market conditions by altering gate fees, although in the short term they can also change the amount of wood waste stored on site as a temporary smoothing of supply and demand. This means that they can act to ensure that the price of the final product does not vary significantly on short term cycles. However, current permit

[54] *Source: prices currently quoted on the internet for these products. The higher prices are packaged and delivered prices.*

[55] *Source: prices currently quoted for wood chips on the internet at processor gate.*

conditions typically mean that reprocessors are not allowed to stockpile waste wood on site indefinitely, nor do they allow for large stock piling. As a result, they will not take in waste wood for which there is no foreseeable market. Conversely, as demand for waste wood increases, they can lower gate fees to attract waste wood into the site. This has proved to be a successful strategy to date for the reprocessors.

4.14 Wood packaging recycling rates

Section 3 reports this project's final estimate of wood packaging POM, section 4 has considered various estimates for wood packaging recycling and recovery recovered in 2017. **Figure 26** shows the recycling and recovery rates calculated based on these estimates.

Figure 26 Wood packaging recycling and recycling rates, 2017 (k tonnes, %)

	POM	Accredited Recycling	Total Recycling
Wood packaging	1,291	411	546
Recycling rate (%)		32	42

Based on this project's estimate of total UK wood packaging POM in 2017 and the reported accredited of wood packaging waste it is estimated that the accredited recycling rate was 32% in 2017 (or 42% if unaccredited wood packaging recycling is included).

5.0 Wood packaging projections and compliance assessment

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

Based on these data, univariate time-series models (linear trend and autoregressive models) are estimated. A preferred model is selected based on statistical criteria and this model is used to project scenarios for wood packaging POM and accredited wood packaging recycling to 2025. The intention here is to provide a range of plausible possible futures for wood packaging POM and accredited wood packaging recycling to inform policymakers and other stakeholders.

Finally, assuming these scenarios represent plausible possible futures for wood packaging POM and accredited wood recycling, a compliance assessment of packaging recycling versus the recycling targets to 2020, and the CEP target in 2025 is made.

5.1 Wood packaging POM projections

Historically, wood packaging POM has been estimated by a process of consultation and periodic review with industry and stakeholders (for example in the Wood Flow 2020 report, and the PackFlow 2017, and PackFlow 2012 reports). In the PackFlow report methodologies wood packaging POM was established using assumed growth rates from an historic baseline, with the growth rates and resultant POM tonnages discussed and agreed with industry, government and stakeholders before being adopted for target setting.

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, there isn't a long historic time series (suitable for modelling) available for wood packaging POM tonnages.

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

What is not known is the quantity of non-obligated and unregistered packaging placed on the market i.e. packaging handled by businesses who are 'de minimis' or who are for whatever reason 'free-riders'. 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. In the previous report the proportion of unregistered POM was 8% compared to 10% in this report.

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'. And, 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' being not obligated. However, it is likely that over time businesses have gained a better understanding of the requirements of the legislation which itself has likely improved the accuracy of data reported into NPWD.

Here it is assumed that the wood packaging net pack fill tonnages 1997 to 2017 (calculated using NPWD data as described in Section 3.1 of this report) are the best available data to:

- Assess trends in the overall quantity of wood packaging POM;
- Estimate empirical models of wood packaging POM; and,
- Project plausible possible future scenarios for wood packaging POM.

Figure 27 shows the historic tonnage data for wood packaging UK net pack fill. The past outturns for net pack fill show a decline from 1997 to 2002 followed by a sharp increase to 2007. Wood packaging net pack fill appears to have been clearly impacted by the 2008/9 recession, declining sharply in 2008 and 2009. Wood packaging net pack fill grew steadily between 2009 and 2014 (apart from a dip in 2011) but didn't regain its pre-recession peak, and since 2014, wood packaging net pack fill has declined.

Figure 27 Wood packaging net pack fill, projection and 95% confidence interval, k tonnes

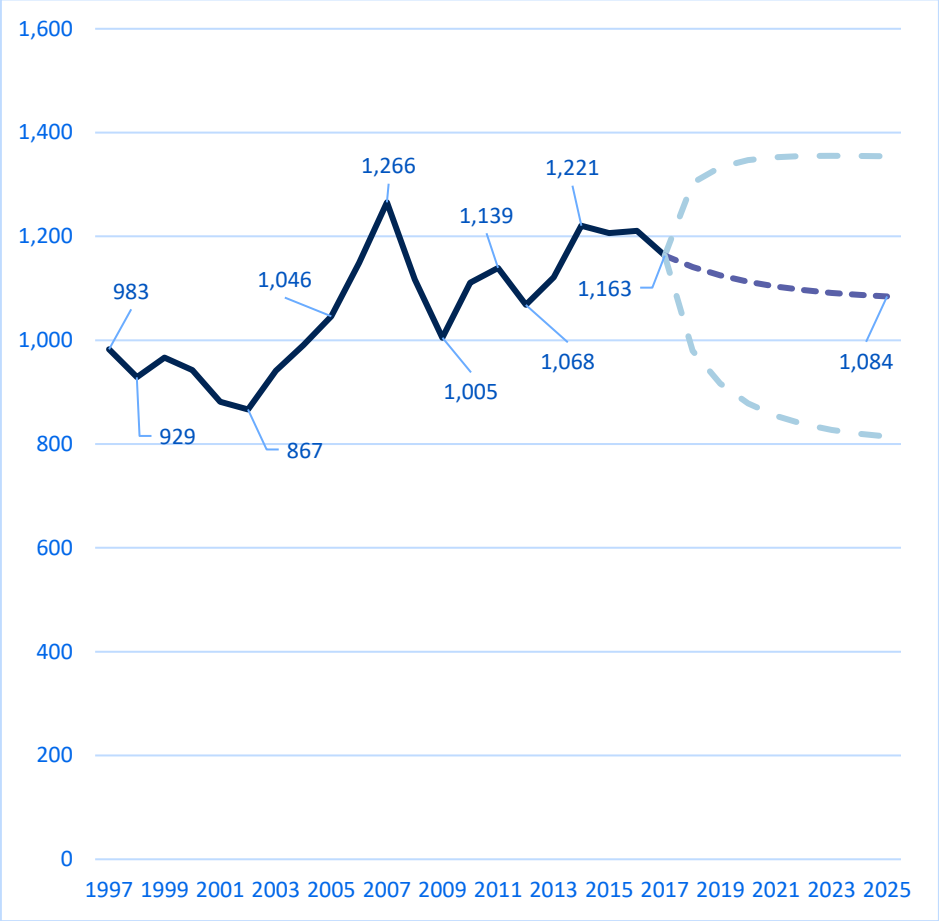


Figure 28 compares the level and growth of net pack fill to other indicators of economic activity such as GDP[56], construction activity[57], population[58] and retail sales[59] between 1997 and 2017 (the full sample available for wood packaging net pack fill), between 2014 and 2017 (the period since the Wood Flow 2020 report) . Over the two decades to 2017 average growth in wood packaging net pack fill has been below that of GDP, construction and retail sales, and in fact on average closer to average population growth. However, since 2014 growth in wood packaging net pack fill has *declined* on average by 1.6% a year. By contrast, over the same period construction activity has averaged growth of 5% a year, and GDP has averaged growth of 2% a year.

[56] *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.*
[57] *Construction activity here is measured by real GVA, the projections are based on the Construction Product Association's Spring 2018 forecasts*
[58] *Office for National Statistics, UK population projections published 26 October 2017*
[59] *Retail sales growth projected 2018 to 2025 based on estimated linear statistical model.*

Figure 28 Wood packaging net pack fill versus economic activity indicators (%)

	1997-2017		2014-2017		2018 - 2020		2018 – 2025	
	Level	Average growth	Level	Average growth	Level	Average growth	Level	Average growth
Net pack fill	18.4%	0.8%	-5.0%	-1.6%	-2.5%	-1.3%	-5.0%[60]	-0.7%
Construction	151%	4.7%	16.0%	5.0%	4.7%	2.3%	12.9%	1.7%
GDP	49.0%	2.0%	6.0%	2.0%	3.1%	1.5%	11.2%	1.5%
Population	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%

Therefore **Figure 28** clearly suggests that the trend in wood packaging net pack fill (and hence POM) has become decoupled from the other economic indicators considered here since 2014.

Using the historical net pack fill data for wood packaging, three statistical univariate time-series models (a linear trend model and two autoregressive models) and a model based on construction activity[61] are estimated. The preferred model selected on statistical criteria was the model based on construction activity and it was used to project a scenario for wood packaging POM to 2025.

This scenario was discussed with the Steering Group. The feedback from the Steering Group noted the apparent de-coupling of the trend in wood packaging POM (as represented by net pack fill), indicated in **Figure 29**, and suggested that linking future wood packing POM growth to growth in construction activity now seemed a less plausible approach. Instead, a scenario for wood packaging POM is projected to 2025 based on the AR(1) for wood packaging net pack fill. Full details of the methodology used to estimate these models can be found in Appendix III.

By assumption, factors driving past trend growth in wood packaging net pack fill (and hence by assumption POM) are projected into the future. While this projection is 'data based' it is not intended to be sophisticated. For example, it doesn't account for potential substitution effects, for example where wooden pallets are replaced by plastic pallets or trends in pallet weights. The Steering Group noted that because pallets are extensively re-used they need to be durable hence it was likely that pallets weights could increase if more wood was used in pallet manufacture/repair.

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

[60] *The projection for wood packaging net pack fill is based on the AR(1) model discussed below.*

[61] *Wood Flow 2020 developed a scenario model for wood packaging POM to 2020 based on a projection for activity in the construction sector. The assumption being that construction industry growth would continue to be associated with growth in wood packaging POM. This report updated that approach in addition to estimation of the other statistical models.*

calculated for the AR(1) model projection of wood packaging net pack fill and shown as the upper and lower bounds to the projection in

Figure 27.

The scenario for wood packaging POM to 2025 is based on the projected growth rates of the AR(1) model for net pack fill and is shown in **Figure 29**. The scenario assumes this project's wood packaging POM figure is applicable for 2018. Wood packaging POM is projected to decline slightly from 1,291k tonnes in 2018 to 1,259k tonnes in 2020, and to 1,227k tonnes in 2025, a decline of 64k tonnes or 5% in 2025 compared to 2018.

This scenario for wood packaging POM is used in the compliance assessment in section 5.3.

Figure 29 Wood packaging POM projected scenario, 2018 to 2024 (k tonnes, %)

Year	2018	2019	2020	2021	2022	2023	2024	2025
POM	1,291	1,273	1,259	1,249	1,241	1,235	1,230	1,227
% change	-	-1.4%	-1.1%	-0.8%	-0.6%	-0.5%	-0.4%	-0.3%

5.2 Accredited wood packaging recycling projections

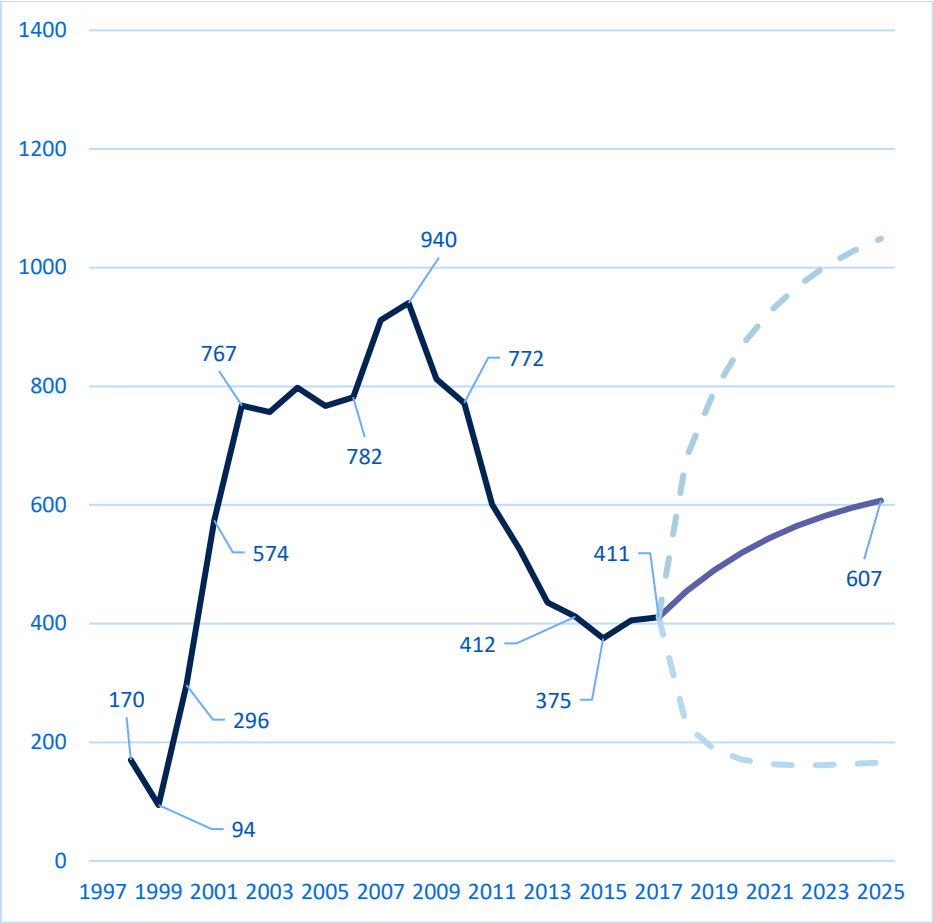
This section reviews the historical data and trends for the quantity of accredited wood packaging recycled reported by UK accredited reprocessors/exporters into NPWD. It therefore excludes wood packaging that is recycled but not recorded by non-accredited reprocessors/exporters and wood packaging that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

To establish a scenario for accredited wood packaging recycling to 2025 statistical models are estimated. These are univariate time series models, a linear trend model and two auto-regressive models. The preferred model is selected on statistical criteria. For accredited wood packaging recycling the auto-regressive model with one lag or AR(1) model is the preferred model. This model is used to project a scenario for accredited wood packaging recycling to 2025 and is shown in **Figure 30Error! Reference source not found.**.

This projection extends the trend observed in historical accredited recycling into the future. By assumption, factors driving past performance are projected into the future.

As discussed above while 'data based' and intended to be plausible the projection is not intended to be sophisticated. In addition to factors potentially impacting on the weight of wood packaging POM discussed above, it ignores factors such as the timing and extent of potential future policy initiatives such as reform of extended packaging producer responsibility, possible changes in legislation, the impact of possible targets for wood packaging recycling beyond 2020 and other potential external influences that might impact on wood recycling markets. For example, the potential for investment in UK reprocessing and collections or the relative prices of substitutes for wood waste packaging as a feedstock and the relative prices of substitutes for products manufactured from waste wood packaging.

Figure 30 Accredited wood packaging recycling projection and 95% confidence interval (k tonnes, %)



Provisional 2018 figures from NPWD report accredited wood packaging recycling at 454k tonnes, an increase of 44k tonnes or 10.6% compared 2017.

In the scenario projection for accredited wood packaging recycling the 2018 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 wood packaging recycling which are shown in**Error! Reference source not found. Figure 30** together with 95% confidence intervals as indicative upper and lower bounds to the projection. As discussed in section 4.2 the historic trend in accredited wood packaging recycling is dominated by the break in trend pre and post 2008 which means that there is substantial uncertainty surrounding projections from models estimated on this sample. This is reflected by the width of the 95% confidence interval in **Figure 30**.

Full details of the methodology used to estimate the models can be found in Appendix III.

Figure 31 Accredited wood packaging recycling projection, 2018 to 2025 (k tonnes, %)

Year	2018	2019	2020	2021	2022	2023	2024	2025
Accredited recycling	454	490	520	545	565	582	596	607
% change	10.6	7.9	6.1	4.7	3.7	3.0	2.4	1.9

Figure 31 reports the projected tonnages for accredited wood packaging recycling to 2025. In this scenario, accredited wood packaging recycling increases from 442k tonnes in 2018 to

544k tonnes in 2020, and to 620k tonnes in 2025, an increase of 178k tonnes or 4.9% in 2025 compared to 2018.

This scenario for accredited wood packaging recycling is used in the compliance assessment in section 5.3.

5.3 Wood packaging compliance assessment

This section reports a compliance assessment based on the scenarios to 2025 for wood packaging POM and accredited wood packaging recycling reported in sections 5.2 and in this section.

For this compliance assessment, the material specific targets on obligated businesses for wood packaging (38% in 2018, 43% in 2019 and 48% in 2020) are expressed as equivalent to national (or all material) recycling targets based on total wood packaging POM, these are 34% in 2018, 38% in 2019 and 43% in 2020.

The CEP wood packaging target is 25% in 2025 (the CEP target is assumed to be a national target and apply to all wood packaging POM). However, accredited wood packaging recycling is already meeting this. **Figure 26** estimates a 31% recycling rate for accredited wood packaging in 2017. Therefore, this compliance scenario assumes a 45% national recycling target for wood packaging in 2025 (which equates to a business target of 50% for wood packaging recycling in this analysis).

There are no targets set for wood packaging recycling set beyond 2020, here the compliance assessment targets for 2021 to 2025 are a linear extrapolation between the 2020 43% national target in 2020 and the assumed 45% wood packaging target in 2020.

Based on these targets and the projection scenarios for wood 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 wood packaging recycling.

To assess the likelihood of meeting the targets the probability of meeting the targets in each year is also calculated. The probability of meeting the target in each year is calculated assuming that in each year the probability distribution around the scenario projection for accredited wood packaging 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 set beyond 2020 other than the CEP target of 25% for 2025. This compliance assessment is therefore only meaningful versus the published 2018 to 2020 targets for wood, the assumed 45% target in 2025 for wood packaging in this scenario is purely hypothetical.

Figure 32 reports a compliance assessment for the projected scenarios to 2025 for wood packaging POM and accredited wood packaging recycling.

Figure 32 Wood packaging compliance assessment, 2018 to 2025 (k tonnes, %)

Year	POM*	National target	Required recycling	Projected accredited recycling**	Probability of meeting the target
2018	1,291	34	444	454	53.5%

2019	1,273	39	495	490	48.7%
2020	1,259	43	547	520	44.0%
2021	1,249	43	542	545	50.5%
2022	1,241	44	544	565	54.0%
2023	1,235	44	547	582	56.4%
2024	1,230	45	551	596	58.1%
2025	1,227	46	560	607	58.3%

*projection based on AR(1) model, ** projection based on AR(1) model

Assuming the 2018 POM figure of 1,291k tonnes developed in this project is applicable in this scenario, and that the projections for wood packaging POM and accredited wood packaging recycling are plausible, based on this assessment it is regarded as *moderately possible* that the UK meets the wood packaging recycling targets in 2018 to 2020.

In 2019 this compliance scenario projects accredited wood packaging recycling tonnage slightly below (5k tonnes) the expected amount of recycling required to meet the target. In 2020, the shortfall is (27k tonnes). The associated probabilities of meeting the national equivalents of the business targets for wood packaging recycling in 2018, 2019 and 2020 are 53.5%, 48.7% and 44.0%.

As discussed above there are no targets set for wood packaging recycling beyond 2020 other that the CEP target of 25% in 2025. This scenario *assumes* a wood packaging recycling target of 46% in 2025 (which equates to a business target of 50% for wood packaging recycling in this analysis). On the basis of this assessment it is *moderately possible* that wood packaging would meet a 46% national recycling target in 2025. The associated probability of meeting a 46% target for wood packaging recycling in 2025 is 58.3%.

5.4 Summary

The key conclusions from the wood packaging flow and recycling projections, and the compliance assessment are:

- Wood packaging POM is projected to decline slightly from 1,291k tonnes in 2018 to 1,259k tonnes in 2020, and to 1,227k tonnes in 2025, a decline of 64k tonnes or 5% in 2025 compared to 2018.

- Accredited wood packaging recycling is projected to increase from 454k tonnes in 2018 to 520k tonnes in 2020, and to 607k tonnes in 2025, an increase of 153k tonnes or 34% in 2025 compared to 2018.

- Based on the POM and accredited recycling scenarios for wood packaging it is regarded as *moderately possible* that the UK meets the wood packaging recycling targets in 2018 to 2020. In 2019 the compliance scenario projects accredited wood packaging recycling tonnage slightly below (5k tonnes) that required to meet the target. In 2020, the shortfall is 27k tonnes. The associated probabilities of meeting the national equivalents of the business targets for wood packaging recycling in 2018, 2019 and 2020 are 53.5%, 48.7% and 44.0%.

- There are no targets set for wood packaging recycling beyond 2020 other than the CEP target of 25% in 2025. This report estimates an accredited wood packaging recycling rate of 32% in 2017. Therefore, the compliance scenario *assumes* a wood packaging recycling target of 46% in 2025 (which equates to a business target of 50%). On the basis of this assessment it is *likely* that wood packaging would meet a 46% national recycling target in 2025. The associated probability of meeting a 46% target for accredited wood packaging recycling in 2025 is 58.3%

6.0 Conclusions

6.1 Wood packaging POM

- This project estimates wood packaging POM in 2017 at 1,291k tonnes (+/- 12%): a slight decrease of 1.4% from the previous wood POM figure of 1,310k tonnes (2014).

- Wood in new and refurbished pallets accounts for the largest proportion (74%) of total wood packaging POM in 2017.

- Cases, boxes, crates and drums are the next largest product format for wood packaging, representing 21% of wood packaging POM in 2017.

- Wooden casks, barrels, vats, tubs & coppers products represent around 1% of total wood packaging POM in 2017.

- The estimate for wood packaging POM in the consumer sector is 67k tonnes (+/- 15%) in 2017, of which 66k tonnes (+/-15%) is estimated to be consumer non-grocery wood packaging.

- The estimate for wood packaging POM in the non-consumer sector is 1,225k tonnes (+/- 11%) in 2017. The vast majority (95%) of wood packaging POM is in the non-consumer sector.

- Obligated wood packaging POM in 2017 is estimated to be 1,168k tonnes in 2017, 90% of total wood packaging POM.

- The proportion of wood packaging POM that is unregistered is estimated to be 10% (~123k tonnes) in 2017. This is an increase on the estimated 8% of wood packaging POM unregistered in 2014.

6.2 Wood packaging recycling

- Local authorities collected 860k tonnes of wood waste (wood packaging and non-packaging wood) in 2016/17, the vast majority (99%) of wood waste collected is via HWRC/CA sites.

- It is estimated that just 8k tonnes of waste wood packaging was collected by local authorities in 2017.

- Total UK waste wood packaging recycled is estimated to be 546k tonnes in 2017, the total recycling rate for wood packaging is 42%.

- Accredited waste wood packaging recycling is estimated to be 411k tonnes in 2017, the accredited recycling rate for wood packaging is 32%.

- Unaccredited wood packaging waste recycling is estimated to be 135k tonnes in 2017.

- It is estimated that UK wood packaging waste arising is approximately 1-1.2 million tonnes per year, but maybe more based on the growth in the construction sector (note that there is a significant degree of uncertainty around this estimate). Note in a given year wood packaging POM will be different to wood packaging waste arising due to the durability and reuse/repair of wood packaging) If this figure for waste arisings is broadly accurate then the fate of substantial tonnages (~450k to 620k tonnes) of wood packaging waste is not accounted for. At the time of publication there is significant uncertainty as to how much wood packaging is being sent to each non-recycling destination.

6.3 Wood packaging projections and compliance

- Wood packaging POM is projected to decline slightly from 1,291k tonnes in 2018 to 1,259k tonnes in 2020, and to 1,227k tonnes in 2025, a decline of 64k tonnes or 5% in 2025 compared to 2018.

- Accredited wood packaging recycling is projected to increase from 454k tonnes in 2018 to 520k tonnes in 2020, and to 607k tonnes in 2025, an increase of 153k tonnes or 34% in 2025 compared to 2018.

- Based on the POM and accredited recycling scenarios for wood packaging it is regarded as *moderately* possible that the UK meets the wood packaging recycling targets in 2018 to 2020. In 2019, the compliance scenario projects accredited wood packaging recycling tonnage slightly below (5k tonnes) that required to meet the target. In 2020, the shortfall is 27k tonnes.

- The associated probabilities of meeting the national equivalents of the business targets for wood packaging recycling in 2018, 2019 and 2020 are 53.5%, 48.7% and 44.0%.

- There are no targets set for wood packaging recycling beyond 2020 other than the CEP target of 25% in 2025. This report estimates an accredited wood packaging recycling rate of 32% in 2017. Therefore, the compliance scenario *assumes* a wood packaging recycling target of 46% in 2025 (which equates to a business target of 50%).

- On the basis of this assessment it is regarded as *moderately* possible that wood packaging would meet a 46% national recycling target in 2025. The associated probability of meeting a 46% target for wood packaging recycling in 2025 is 58.3%

7.0 Recommendations for further work

Research to provide an updated assessment of waste wood packaging arising

The 1-1.2 million tonnes per year estimate of wood packaging waste arising referenced in this report is very dated. It implies, assuming other estimates are robust, that the fate of substantial tonnages (~450k-620k tonnes) of wood packaging waste is not accounted for by UK recovery, recycling, disposal or export. However, it may be the case that wood packaging waste arising is a lower figure and an up to date research assessment, which could also establish a repeatable methodology, would shed light on this.

A review of elements packaging regulation reform to capture more non-obligated tonnage and/or more unregistered tonnage of wood packaging

This could include assessment of lowering or removing the de minimis threshold for wood packaging and/or the potential impact of obligating wood packaging classified as internal use.

A study on the impact of accreditation of all wood packaging recycling activities

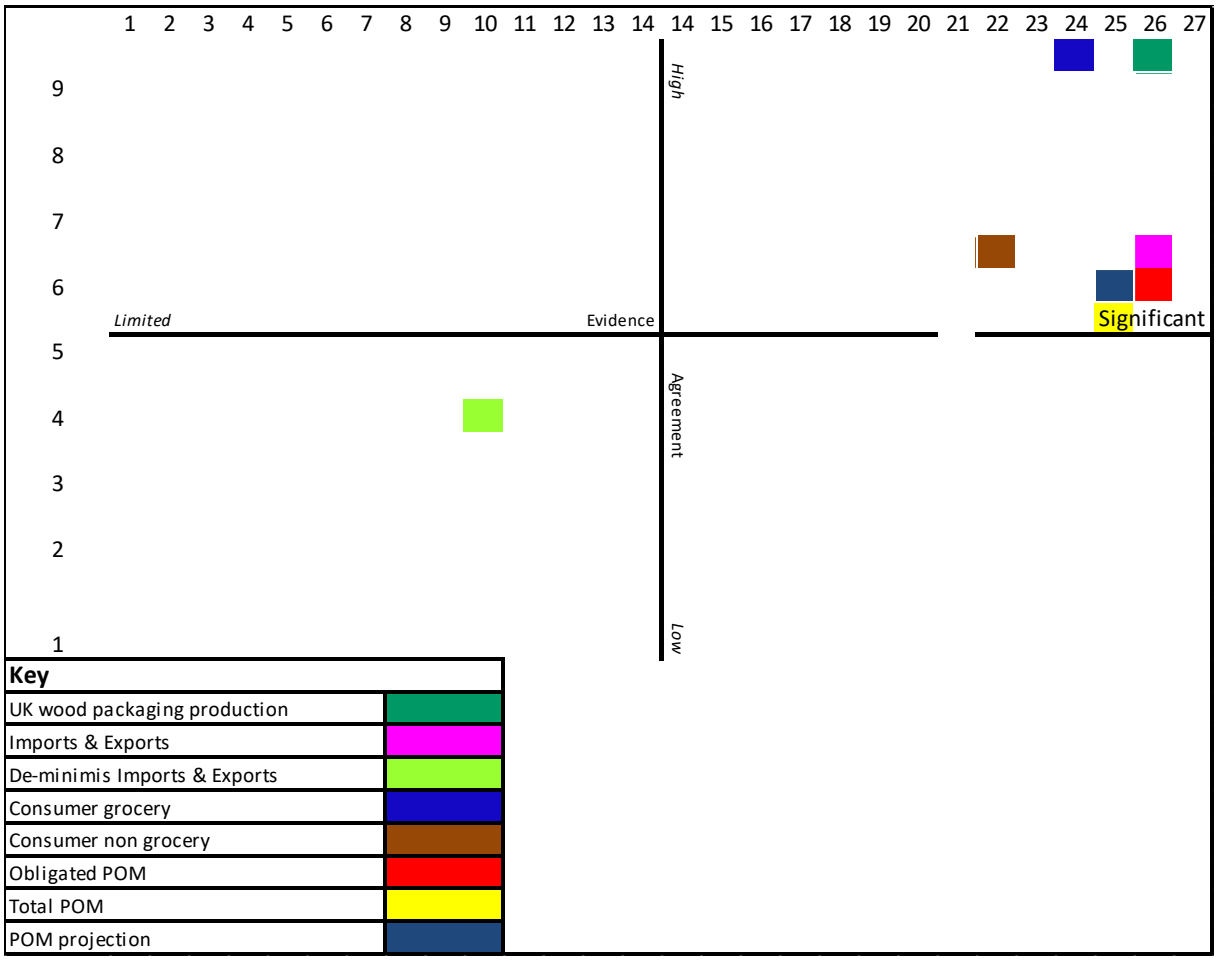
This could be mandatory accreditation and reporting by wood recycling businesses or some other form of incentivisation to accredit and report. The objective being that as much evidence as is possible is counted towards achievement of wood packaging recycling targets. A research study could establish the benefits in terms of higher recycling, weighed against the costs.

Appendix I Data Robustness Assessment

A robustness analysis was completed on the data sources used. This was developed to highlight the level of uncertainty for each data source by scoring the data sources 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 A1 (POM), Figure A2 (Recycling) and a summary in Figure A3, which has been constructed based on analysis completed for each project estimate.

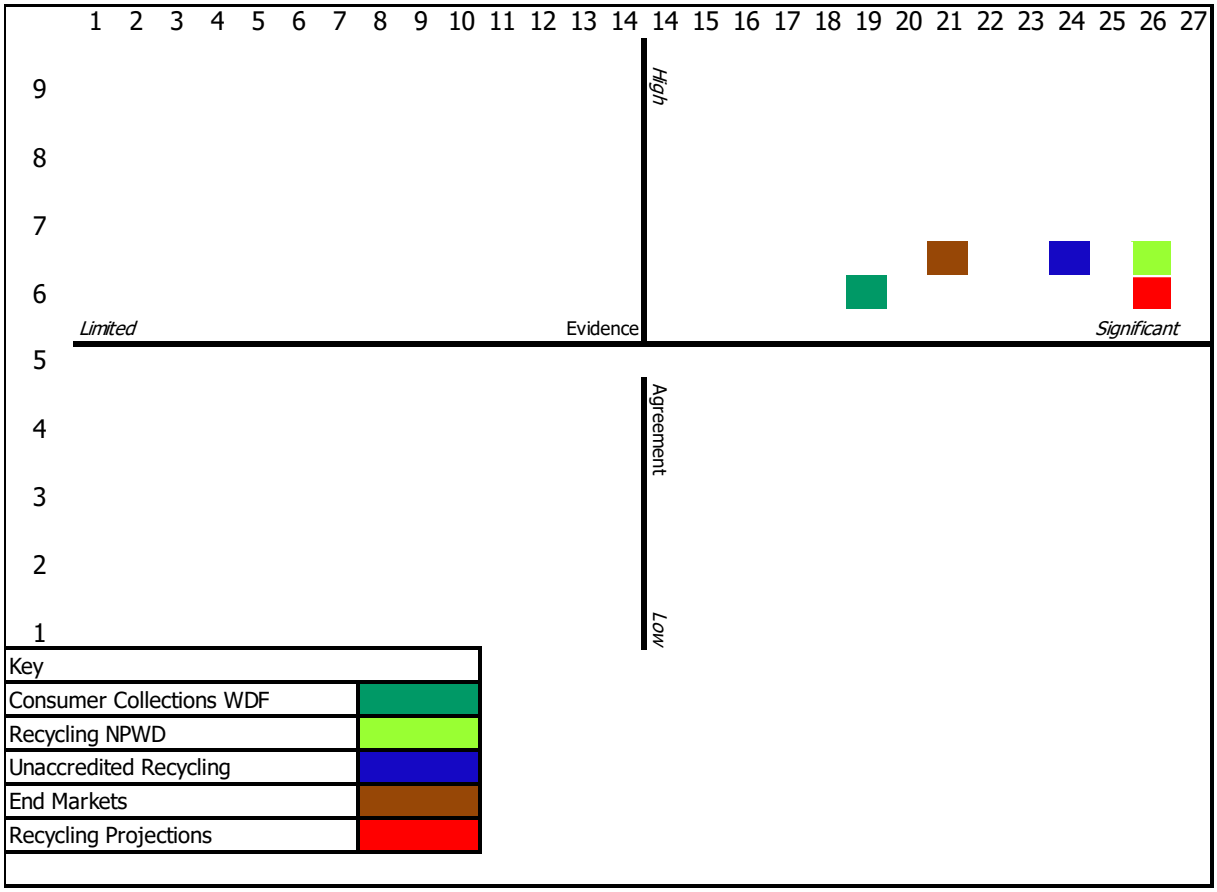
The tables thereafter provide a full breakdown for each project estimate. If the question is answered 'Yes' then a score of 3 is given, if 'No' then a score of 0. A score of 1 or 2 is given depending on the degree of reservation over the robustness.

Figure 33 Data Robustness Assessment Results – POM



To convert scores to a percentage that could be used to relate to an appropriate error margin[62], the evidence and agreement levels scores were added and the percentage of the total possible score taken.

Figure 34 Data Robustness Assessment Results – Recycling



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

Figure 35 Data Robustness Assessment Results – Summary

Source & data	Robustness scores		Error margin
	Evidence robustness and completeness (max 27)	Degree of agreement around the findings (max 9)	
ONS PRODCOM	26	9	3%
HMRC trade data	9	4	36%
EA grocery retail packaging handled	24	9	6%
Valpak EPIC data	22	6	15%
NPWD producer data 2017	26	6	9%
NPWD recycling data 2017	26	6	9%
WDF 2016/17	19	6	21%
WRA, WPIF data	24	6	12%

PRODCOM

Data		
PRODCOM		
Source		
ONS		
Data Used In:		
Wood packaging production		
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	3
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	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%)?	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

HMRC Trade data

Data		
HMRC trade data		
Source		
HMRC		
Data Used In:		
Estimate of de-minimis imports and exports		

Evidence (Robustness and completeness, max 27):	Scoring (Max 27)	
Does the data cover the correct time-frame?	No	0
Does the data provide complete coverage?	Yes with some reservations	1
Has the data been sourced from credible, up-to-date sources?	Yes with some reservations	1
Is the underlying data reasonably free from concerns (e.g. official data from the ONS)?	No	0
Have the findings been independently peer-reviewed?	Yes with some reservations	2
Is the methodology/calculation reasonably free from concerns?	Yes with some reservations	1
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 with some reservations	1
Have the findings been sense-checked against credible alternative sources (incl. inconclusively)?	No	0
Total		**9**

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 with some reservations	2
Has feedback from the key stakeholders been incorporated in the reporting of findings?	Yes with some reservations	2
Total		**4**

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

Environment Agency Grocery Retailer Packaging Handled

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

Valpak EPIC Data

Data
Valpak EPIC Data
Source
Valpak
Data Used In:
Non consumer

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

NPWD Producer Data 2017

Data
NPWD Producer Data 2017
Source
EA NPWD
Data Used In:
Net pack fill, net raw material manufacture, net conversion

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

NPWD Recycling Data 2017

Data		
NPWD Recycling Data 2017		
Source		
NPWD		
Data Used In:		
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**

Waste Data Flow 2016/17

Data		
Waste Data Flow Local Authority Collection Data		
Source		
WDF 2016/17		
Data Used In:		
LA collection and consumer collection		

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

Wood Recycling Data 2017

Data		
Total Wood Recycling Data 2017		
Source		
WRA, WPIF		
Data Used In:		
Total Wood Recycling		

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%)?	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

End Markets For Wood Recovery/Recycling Data 2017

Data		
End markets for wood waste		
Source		
WRA, WPIF, Ricardo AEA		
Data Used In:		
Wood waste recovery/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?	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)?	More yes than no, but equivocal	1
Have the findings been independently peer-reviewed?	Yes	3
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		**21**

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

Appendix II Revised 2014 estimates of wood recovery and recycling

For the purposes of this project the 2014 estimated quantities of wood waste recovery/recycling (published in the Wood flow 2020 report) were reviewed by the WRA. The WRA provided fresh insight into the 2014 figures, as a result some of the 2014 estimates have been revised.

The main revision is for use of wood packaging in the animal bedding, equine surfaces and mulches market. It is now considered that the 2014 estimate of the wood packaging content of waste wood in this market was overly optimistic. In Wood flow 2020 the wood packaging content in this market was estimated at 80%.

The market for animal bedding and equine surfaces requires the highest grade of waste wood, whereas mulches do not need to meet these very high standards. In the Wood Flow 2020 report it was estimated that the wood packaging content of waste wood used to produce animal bedding and equine surfaces was 80%, and 30% for mulches.

Based on further research for this review, it is now considered that the average wood packaging content in this market was (in 2014) more plausibly 60%. The revised figures were agreed in discussions with the WRA and are reported in Box 1.

It is now clearer that the animal bedding and equine surfaces is dominated by the quantities of animal bedding produced using only very high-grade waste wood. Note that since 2014 the Environment Agency has clarified the specification for waste wood that can be used in the production of animal bedding and equine surfaces, meaning that it is now likely to contain a high proportion of packaging material. Consequently, the 2017 estimate of the wood packaging content at 80% is considered to be plausible. The revised 2014 figures are in line with the 2017 figures in this report, see **Figure 22**.

Box 1 Revised 2014 estimates of wood recovery and recycling (k tonnes, %)

	2014 revised by WRA in 2017	Revised wood packaging content for 2014 (%)	Revised 2014 estimate for wood packaging
UK panel board	606	n/a	266
UK energy	596	0	0
Animal bedding, equine surfaces and mulches	339	60	203
Export panel board	273	35	96
Export Energy	1,128	0	
Revised 2014 total	**2,942**		**565**

Appendix III Technical Details of the Modelling and Projection Scenarios

1. Introduction

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

A scenario linking POM to construction industry activity (GVA) was also considered based on the historic correlation of construction industry activity with wood packaging POM, the assumption being that construction industry growth would be associated with growth in wood packaging POM[63].

The EA's NPWD (National Packaging Waste Database) provides a data source from which to assess trends over time in wood 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, historic data on the quantities of wood handled by obligated producers ('obligated' POM) is available for trend analysis. NPWD also reports accredited wood packaging recycling tonnages.

The modelling and scenarios assume that wood packaging net pack fill tonnages 1997 to 2017 (calculated using NPWD data as described in Section 3.5 of this report) and NPWD reported accredited wood packaging recycling (1998 to 2017) are the best available data to use to:

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

2. 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 wood packaging POM and accredited wood packaging recycling.

[63] *This approach was followed in the Wood Flow 2020 report and is updated for this report.*

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, 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 criterion, 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.

3. Wood packaging net pack fill, accredited recycling modelling and projections

This section reviews the historical NPWD data and trends for wood 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 wood packaging net pack fill are reported in detail in **Figure 36**[64]. 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 36 Wood packaging net pack fill (construction, linear and auto-regressive models)

	Construction			Linear			AR(1)			AR(2)		
Var*	**Coeff**	**t-Stat.**	**Prob.**	**Coeff**	**t-Stat.**	**Prob.**	**Coeff**	**t-Stat.**	**Prob.**	**Coeff**	**t-Stat.**	**Prob.**
C	647	10.4	0.00	821	15.7	0.00	265	1.6	0.12	298	1.8	0.09
Constr.	5.2	6.9	0.00									
Trend				14	4.8	0.00						
NPF(-1)							0.75	5.0	0.00	0.96	4.08	0.00
NPF(-2)										-0.23	-0.96	0.35
R^2	71.3%			54.8%			58.0%			65.8%		
Adj-R^2	69.8%			52.4%			55.7%			61.6%		

[64] *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.*

S.E	65470.95	80651.5	78971	74064
F-stat.	47	23	25	15
Prob(F)	0.000001	0.000125	0.000096	0.000186

*Variables: NPF is wood packaging net pack fill, (-1) denotes 1 lag, (-2) denotes 2 lags, Constr. is a measure of activity in the construction sector, Trend is a time trend, C is a constant

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 wood packaging net pack fill (and hence POM). Information criteria are reported in **Figure 37** (adj-R^2 is included for comparison), based on these statistical criteria the construction model is the preferred model of the trend in net pack fill (and wood packaging POM).

A scenario for wood packaging POM based on the construction model projection was discussed by the Steering Group. The feedback from the Steering Group noted the apparent de-coupling (since 2014) of the trend in wood packaging POM (as represented by net pack fill) and other indicators reported in **Figure 29** (section 5.1). The Steering Group suggested that linking future wood packing POM to growth in construction industry activity now seemed a less plausible approach. Instead, an alternative scenario for wood packaging POM was projected to 2025 based on the AR(1) model for wood packaging net pack fill.

Figure 37 Wood packaging net pack fill statistical model selection criteria

	Construction	Linear	AR(1)	AR(2)	AR(3)
Adj R^2	69.8%	52.4%	55.7%	61.6%	63.8%
Akaike	25.11	25.52	25.49	25.41	25.41
Schwarz-Bayes	25.21	25.62	25.59	25.56	25.60
Hannan-Quinn	25.13	25.55	25.51	25.43	25.43
Log likelihood	-261.62	-266.00	-252.86	-238.37	-224.65

The projection scenario for wood packaging net pack fill based on the AR(1) model is reported in

Figure 38. All projections are subject to uncertainty, however the uncertainty around projections based on statistical models such as this for 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 wood packaging net pack fill projection and are shown in

Figure 38 as indicative upper and lower bounds to the projection.

Figure 38 Wood 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	980	1,141	1,303
2019	916	1,125	1,334
2020	878	1,113	1,347
2021	854	1,103	1,353
2022	838	1,097	1,355
2023	827	1,091	1,355
2024	820	1,087	1,355
2025	814	1,084	1,354

4. Wood packaging POM scenario

The scenario projected for wood packaging POM tonnage is based on the projected growth rates from the estimated AR(1) model based on the historic data for wood packaging net pack fill. The scenario assumes wood packaging POM increases in line with the projected growth rates of wood packaging net pack fill based on the AR(1) model. This scenario for wood packaging POM to 2025 was discussed with the project Steering Group.

The scenario for wood packaging POM is reported in **Figure 39**. The projection assumes that the 2018 wood packaging POM figure (the first year of the projection scenario) is the same as the 2017 POM figure of 1,291k tonnes developed in this project.

Wood packaging POM is assumed to decrease to 1,259k tonnes in 2020, and to 1,227k tonnes in 2025, a decrease of 64k tonnes or 5% in 2025 compared to 2018. The average annual decline in wood packaging POM over the projection horizon is 0.7%.

Figure 39 Scenario projection for wood packaging POM, 2018 to 2025 (k tonnes, %)

Year	2018	2019	2020	2021	2022	2023	2024	2025
POM	1,291	1,273	1,259	1,249	1,241	1,235	1,230	1,227
% change	-	-1.4%	-1.1%	-0.8%	-0.6%	-0.5%	-0.4%	-0.3%

5. Accredited wood 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 wood packaging recycling. The detailed estimation results are reported in **Figure 40**. 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 40 Accredited wood packaging recycling model estimates

	Linear	AR(1)	AR(2)

Variable*	Coeff	t-Stat.	Prob.	Coeff	t-Stat.	Prob.	Coeff	t-Stat.	Prob.
C	554.3	3.1	0.01	114.4	1.7	0.10	179	3.2	0.01
Trend	1.48	0.2	0.88						
R(-1)				0.83	7.9	0.00	1.28	7.06	0.00
R(-2)							-0.56	-3.30	0.00
R^2	0.1%			78.7%			85.6%		
Adj-R^2	-5.4%			77.4%			83.7%		
S.E	253503			110903			82553		
F-stat.	0			63			45		
Prob(F)	0.882			0			0		

*R is accredited wood packaging recycling, (-1) denotes 1 lag, (-2) denotes 2 lags, C is a constant and Trend is a time trend

Details of the statistical information criterion which inform the selection of the preferred model are reported in **Figure 41**. The range of information statistics indicate that the AR(2) model for wood packaging accredited recycling is the preferred model based on the data sample available. However, the projections based on the AR(2) model appeared implausible, and instead a scenario for accredited wood recycling was developed based on the estimated AR(1) model.

Figure 41 Wood packaging accredited recycling, model selection criteria

	Linear	AR(1)	AR(2)	AR(3)
Adj R^2	-5.4%	77.4%	83.7%	81.5%
Akaike	27.82	26.17	25.63	25.68
Schwarz-Bayes	27.92	26.27	25.78	25.88
Hannan-Quinn	27.84	26.19	25.65	25.70
Log likelihood	-276.19	-246.62	-227.68	-214.32

Provisional 2018 figures from NPWD report accredited wood packaging recycling at 454k tonnes, an increase of 44k tonnes or 10.6% compared to 2017.

In the scenario projection for accredited wood packaging recycling the 2018 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 wood packaging recycling which are shown in**Error! Reference source not found. Figure 42** together with 95% confidence intervals as indicative upper and lower bounds to the projection. As discussed in section 5.2 the historic trend in accredited wood packaging recycling is dominated by the break in trend pre and post 2008 which means that there is substantial uncertainty surrounding projections from models estimated on this sample. This is reflected by the width of the 95% confidence interval in **Figure 42**.

Figure 42 Accredited wood packaging recycling projection 2018 to 2025 and 95% confidence interval (k tonnes)

Year	Lower CI	Accredited recycling	Upper CI
2018	228	454	680
2019	188	490	792
2020	171	520	869
2021	163	545	926
2022	161	565	969
2023	162	582	1,002
2024	163	596	1,028
2025	166	607	1,049

In this scenario, accredited wood packaging increases from 454k tonnes in 2018 to 520k tonnes in 2020, and to 607k tonnes in 2025, an increase of 153k tonnes or 34% in 2025 compared to 2018. Annual average growth in accredited wood packaging recycling is 4.2% over the projection horizon. This scenario for accredited wood packaging recycling is used in the compliance assessment in section 5.3 of this report.

6. Wood packaging POM and recycling projections conclusion

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

- Wood packaging POM is assumed to decrease from 1,291k tonnes in 2018, to 1,259k tonnes in 2020, and to 1,227k tonnes in 2025. A decrease of 64k tonnes or 5% in 2025 compared to 2018. The average annual decline in wood packaging POM over the projection horizon to 2025 is 0.7% a year.
- Accredited wood packaging recycling increases from 454k tonnes in 2018 to 520k tonnes in 2020, and to 607k tonnes in 2025, an increase of 153k tonnes or 34% in 2025 compared to 2018. Annual average growth in accredited wood packaging recycling is 4.2% a year over the projection horizon to 2025.

www.wrap.org.uk/relevant link

recycle