

Accounts for Danish Packaging Flows

Physical supply-use tables for packaging 2018

by

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Summary

This report describes the methods and results of a project carried out at Statistics Denmark that aimed to develop a first set of material flow accounts for packaging associated with Denmark in 2018. The accounts are formed as physical supply-use tables (PSUT), including empty packaging, filled packaging and packaging waste. The accounts include separate descriptions of five types of packaging: plastics, paper and cardboard, glass, metal and wooden packaging. All accounts are broken down by industry groups and households, etc.

The supply and use tables for empty packaging are based on the existing complete supply-use tables (SUT) for all Danish product flows in 2018 and underlying micro data from the Statistics on International Trade in Goods and the Industrial Sales Statistics. The latter is used to improve the identification of which flows that are related to packaging production or use.

Some accounting items are consistent with the existing *Packaging Statistics 2018* from the Danish Environmental Protection Agency, while for others there are big discrepancies. Most of the discrepancies can be explained by differences in methodology and scope, but others will require more research to disentangle.

According to the packaging accounts, total supply of empty packaging was 1 602 073 tonnes in 2018. 928 639 tonnes were produced by Danish industries and 665 135 tonnes were imported. One third of the empty packaging was exported, while most of the remaining two thirds was acquired by Danish industries for use as transport and sales packaging.

Filled packaging flows were determined partly on the basis of the flows of empty packaging, partly on estimations of how much filled packaging that are required for transport and sale of products. Packaging for all products produced, imported and exported have been included. The packaging amount and material composition was determined on the basis of a comprehensive dataset of packaging percentages for specific products from the Danish Environmental Protection Agency.

The total supply of filled packaging was 2 004 644 tonnes of which a little more than half was supplied from Danish industries and a little less than half from imports. On the use side, 907 081 tonnes were exported, 641 923 tonnes were distributed to industries and 455 640 tonnes went to households and other domestic uses.

Sorted and unsorted packaging waste is estimated to amount to 919 387 tonnes which leaves 178 176 tonnes as an unexplained balance item. The latter should be subject for further investigation in order to achieve a full identification and quality check of all flows from empty packaging through filled packaging to packaging waste.

427 009 tonnes of packaging waste were exported, mainly for recycling in other countries, while 285 503 tonnes were aimed for recycling within Denmark and a similar amount was collected for incineration.

For plastic packaging, the supply of empty packaging consists of 151 728 tonnes plastic packaging produced in Denmark, and 148 796 tonnes imported.

The Danish supply of filled plastic packaging is 194 400 tonnes and the import is 252 966 tonnes. The export of filled packaging is 199 874 tonnes leaving 247 492 tonnes plastic packaging for total domestic use. *Manufacture of food, beverage and tobacco* as well as *Manufacture of chemicals and pharmaceuticals* are the most important industries.

From industries and private consumers 21 061 and 34 372 tonnes of plastic packaging waste, respectively, have been sorted for recycling. The remaining waste is assumed to contain 113 900 tonnes of plastic packaging waste.

Paper and cardboard packaging is the largest of the five packaging categories described in the packaging accounts in this project. Overall, we found that 646 730 tonnes of empty paper and cardboard packaging were supplied to the Danish economy of which most were produced in Denmark, mainly by the industry *Manufacture and paper and paper products*. 443 082 tonnes were used by Danish industries. Especially the industries *Wholesale and retail trade, etc.* and *Manufacture of food products, beverages and tobacco* bought large quantities of paper and cardboard packaging. 198 158 tonnes were exported.

443 083 tonnes of paper and cardboard packaging were filled in Denmark and 328 198 tons came across the Danish borders as filled packaging. A large part of the filled packaging were distributed from the *Wholesale and retail trade, etc. industry and from Manufacture of food products, beverages and tobacco*. 346 136 tonnes of filled paper and cardboard packaging were distributed to industries, especially to *Wholesale and retail trade, etc.* and *Manufacture of food products*. 113 366 tonnes ended in households. In addition, 301 555 tonnes were used as transport and sales packaging in relation to the Danish exports.

A substantial part, 302 656 tonnes, of the paper and cardboard packaging waste from industries was collected as sorted waste, and only 43 480 tonnes as unsorted waste. For households approximately half of the waste was collected as sorted waste. The sorted paper and cardboard packaging waste is to a very large extent exported for recycling abroad.

Packaging of glass is used for a relatively small number of products compared to e.g. plastics or paper. The total supply equals the total use of empty glass packaging: 194 391 tonnes. Close to half of the supply (44 per cent, 85 947 tonnes) is exported (as empty packaging). The main domestic use of empty glass packaging is as intermediate consumption in *Manufacturing of food and beverages* (72 234 tonnes). Use of filled glass packaging is mainly for households' private consumption (151 380 tonnes) – and exports (104 113 tonnes). The most significant use as intermediate consumption by industries is in *Accommodation and food service activities* (hotels and restaurants etc.). Most glass packaging waste is collected from private consumption/households (134 463 tonnes) – this corresponds quite well to the use of filled glass packaging for private consumption (151,380 tonnes).

The flows of metal packaging are smaller compared to flows of most of the other packaging materials used in Denmark, as described in this report. Metal packaging is mainly used within the food industry, including pet food. However, metal is also used for containers within the chemical and pharmaceutical industry.

The total Danish use of empty metal packaging in 2018 amounts to 133 396 tonnes. Nearly the same amount of empty metal packaging is imported (68 481 tonnes) as supplied from Danish production (64 723 tonnes). The main Danish production of empty metal packaging is supplied from *Manufacturing of basic metals and fabricated metal products* (64 648 tonnes). In total, 42 567 tonnes empty metal packaging is exported. Supply of filled metal packaging is slightly greater (141 160 tonnes) compared to the use of empty metal packaging. Filled metal packaging is mainly supplied from the industry of *Manufacture of food products, beverages and tobacco* (36 888 tons) and *Wholesale and retail trade, etc.* (28 689 tonnes).

Danish domestic use of filled metal packaging is 62 541 tonnes, from which 14 729 tonnes are separately sorted and collected as waste. Most of the metal packaging that

is collected as metal waste is exported (12 129 tons) and the rest is collected for recycling within Denmark (2600 tonnes).

Wood packaging contribute about 20 per cent of the total supply of all packaging materials. Wood pallets is a large (and heavy) flow in the overall wood packaging flows, and contribute more than 90 per cent of wood packaging flows.

A total of 325 577 tonnes of empty wooden packaging is supplied to the Danish economy. The imports account for 199 495 tonnes of empty packaging, while 126 080 tonnes are produced in Denmark.

Use of empty wooden packaging is 218 078 tonnes. The main flows of empty wooden packaging are used in *Wholesale and retail trade* (76 766 tonnes), presumably for repacking of products, *Manufacture of machinery* (33 584 tonnes) and *Manufacture of basic metals* (17 556 tonnes).

The use of filled wooden packaging in Danish industries (intermediate consumption) is 102 558 tonnes. The main flows are used in *Construction* (45 603 tonnes) and *Manufacturing of food products etc.* (17 955 tonnes). Exports of filled wooden packaging is 222 920 tonnes, while private consumption and other final use is 34 317 tonnes.

After products are unpacked, the residual wood packaging is collected as waste. The amount of wooden packaging waste is, however, smaller than the total domestic use of filled wooden packaging, resulting in a balancing post of 66 647 tonnes.

Packaging make up a significant flow of materials in the Danish economy. It is therefore relevant to look at the degree of circularity in packaging material flows and explore if indicators for measuring the degree of circularity in packaging material use can be developed based on the packaging accounts. The packaging flow accounts show that the circularity of packaging flows, measured as packaging waste collected for recycling as a share of total domestic use of packaging varies significantly by packaging type, from 12 per cent for wooden packaging to 86 per cent for glass packaging.

1. Introduction

Large amounts of packaging are supplied to the Danish market each year. After use, much – but not all - is collected as packaging waste and recycled within Denmark or abroad. Minimizing the amounts of packaging waste and improving the reuse and recycling rates are policy goals both at EU level and in Denmark.

In order to minimize the generation of and enhance the reuse of packaging waste, it is important to have solid statistics and accounts for packaging and packaging waste available. In Denmark, good and detailed packaging statistics and packaging waste statistics are produced by the Danish Environmental Protection Agency (DEPA). However, so far, Danish packaging data with a breakdown by industries and households has not been produced in a systematic way. Therefore, there is a need to establish a coherent accounting framework, which collects, merge and reconciles all available data and fills out gaps with estimates when possible. Such a framework will form an essential basis for in depth analysis of the circular economy, including tracking policy goals within the area of packaging waste.

In that context, this report describes the methods and results of a project carried out at Statistics Denmark to develop detailed Danish material flow accounts for packaging measured in tonnes. The accounts are established in accordance with the principles described in the international statistical standard *The System of Environmental-Economic accounts – Central framework (SEEA Central Framework)*¹.

The accounts have been developed as an extension of the Danish physical supply-use table (PSUT) for 2018, and the packaging accounts are correspondingly formed as specific packaging PSUT.

It must be underlined that results presented in this report should be used with caution. Many of the data are the result of first estimations and includes assumptions and shortcuts. It has not been possible within the scope and resources available for the project to make a complete quality check of all data or to take into account all available data on packaging. For this, and other reasons described in the report, some of the data may therefore conflict with other data on packaging, for instance, the Packaging Statistics from DEPA and data reported from the Agency to Eurostat.

The work has only been possible thanks to a grant from the European Commission – Eurostat and through kind assistance from DEPA from which we have received otherwise non-published data concerning packaging percentages for all types of products.²

Section 2 presents the method and underlying data we have used to implement the packaging PSUT. It starts with a short explanation of the layout of a PSUT and refers to the complete PSUT for all products for Denmark 2018, which is the basis for our work. It continues with three subsections, which present data and methods for first empty packaging, then filled packaging and subsequently packaging waste. These three subsections also include tables with main aggregates from the packaging PSUT.

Section 3 includes five subsections, one for each of the five types of packaging materials: Plastic, paper and cardboard, glass, metal and wood. In each subsection two tables, one for supply and one for use of the specific packaging material are presented. These tables include a breakdown of the flows by 23 main industry

¹ <https://seea.un.org/content/seea-central-framework>
https://seea.un.org/sites/seea.un.org/files/seea_cf_final_en.pdf

² However, the content of this report, all data presented and any errors or misinterpretations that may occur is the sole responsibility of the authors of the report.

groups, households and other final use as well as imports or exports. In addition, each subsection includes a Sankey diagram for the specific packaging type. The diagram illustrates the complete chain from the supply of empty packaging, through filled packaging, to packaging waste generation and treatment.

Finally, in section 4, the possibilities for calculating indicators on the degree of circularity of packaging are explored. In particular, the Circular Materials Use Rate (CMUR) indicator developed by Eurostat for the measurement of the degree of recycling of materials is discussed. The section includes a suggestion for a slight modification of the indicator when it comes to packaging, and presents corresponding indicators for the five packaging types.

2. Physical supply-use tables for packaging - methodology and data

2.1. Introduction to physical supply-use tables (PSUT)

The supply-use table (SUT) methodology is well developed and has shown its relevance and suitability for many years in relation to the national accounts (monetary flows) and also in relation to physical accounts, especially for energy.

When it comes to physical supply-use tables (PSUT), i.e. tables for supply and use of materials measured by tonnes, the general purpose is to shed light on the type and quantity of materials (natural resources, goods, waste and other residuals) linked to the activities of industries and the consumption of households and government, etc.

As the name indicates, there are two separate tables, one describing the supply of products/materials, etc., and one describing the use of the same products/materials.

One dimension of the table includes the activities/units in the economy by listing all industries as well as categories for private and government consumption, accumulation (inventories and capital formation) and the rest of the world (imports and exports). In the physical supply table, these categories represent the origin (production and imports, etc.) of the material flows. In the use table, the categories represent the destination of the material flows (intermediate consumption by industries, etc. exports, consumption by households, etc.).

The other dimension includes the product or materials that are of interest. Three main groups of materials are found in a generic PSUT: Natural resources, products (goods) and residuals. Residuals is the generic term used in PSUT for waste and air emissions, etc. However, when it comes to a specific PSUT focusing on a subset of flows it is not always relevant to include natural resources and all types of residuals as categories in the tables. Thus, the tables presented in this report for packaging only include products and residuals in the form of solid waste.

It is an essential feature of supply-use tables that they include bookkeeping identities. For the PSUT this means that the supply and use side should balance when all relevant materials and flows have been recorded.

For each of the activities along the heading, i.e. each of the industries and the consumption categories, the total inputs (intermediate consumption, private consumption, etc.) of materials should match exactly with the total outputs (outputs of goods and residuals).

For each group of natural resources, products or residuals specified in the tables the balancing principle means that the total supply (extraction, production, imports,

etc.) of the material group should match the total use (intermediate consumption, private and government consumption, exports, accumulation).

The advantage of organising data within PSUT and applying the bookkeeping identities is that it is often possible to identify and estimate otherwise missing data from the data that are recorded in the tables. Some times these estimates for missing data (as well as uncertainties involved) are introduced in the tables as so-called balancing items, i.e. items that ensures that there is a balance between supply and use of materials.

2.2. The complete Danish physical supply-use tables

Statistics Denmark has published complete PSUT for Denmark for 2016 and 2018 as part of a comprehensive set of environmental-economic accounts according to the principles outlined in SEEA Central Framework. These PSUT measured in tonnes include all supply and use of natural resources extracted from the Danish environment and all types of goods and residuals.

The accounts are based on several statistics published by Statistics Denmark: the International Trade in Goods Statistics, the Industrial Sales Statistics (the Danish PRODCOM statistics) and the Environmental-Economic Accounts, supplemented by data and information from various research reports and company websites. The primary data are processed and supplemented by estimations and allocations, after which they are organised in the PSUT. Finally, the data are adjusted in such a way that supply equals use.

The Danish PSUT are produced and balanced at a detailed level, which include approximately 1 900 goods, 26 types of natural resources and 130 types of residuals, 117 industries and various groups of final consumption. However, due to the large uncertainties involved, they are published only by 182 material groups and 48 supply/use categories. The complete PSUT for 2018 and corresponding statistical documentation can be accessed through *Detailed material flow accounts (physical supply-use tables)* at www.statbank.dk/20294.

2.3. Supply and use of empty packaging

The complete Danish PSUT for 2018 include information about empty packaging, i.e. amongst the 1 900 product groups 36 have been characterised as groups, which include material, which potentially can be used as packaging material. It includes six plastic products, 12 paper and cardboard products, two glass products, 12 metal products and four wooden products.³ The product groups are presented in Table 1. However, since some of these product groups include products, which are also used for other purposes than packaging, we have, for this project, made an assessment of the underlying detailed reported data from individual companies on industrial sales, imports and exports by detailed Combined Nomenclature (CN) 8-digit product classification⁴. Through the assessment, we have separated those flows that may be assumed to be related to packaging from those that are related to non-packaging uses.

³ In addition, textiles packaging is used in Denmark. However, since the amounts are quite small and there are large uncertainties involved we have not included any information on textile packaging in this report.

⁴ <https://www.dst.dk/en/Statistik/dokumentation/nomenklaturer/kn?id=bdccfab4-a71c-4f32-8b96-d3d9ed56013c>

Table 1. Products used as packaging materials, (Danish supply-use table product classification¹⁾)

Plastic packaging		Glass packaging	
V392100	Plates of cellular plastics/plastics nec.	V701001	Glass ampoules
V392302	Boxes, cases, etc., of plastics	V701003	Carboys, bottles, flasks, jars, etc., of glass
V392304	Sacks and bags, of plastics		
V392307	Carboys, bottles, flasks, etc., of plastics	Metal packaging	
V392309	Spools, cops, bobbins and similar supports, of plastics	V731002	Tanks, casks, drums, etc., of iron or steel
V392311	Caps and capsules, of plastics	V731003	Cans, etc. of iron and steel
		V731004	Cans, etc. of iron and steel, for soldering
Paper and cardboard		V731100	Containers of iron or steel for liquefied gas
V480800	Paper, cardboard, corrugated, crepped, embossed	V760701	Aluminium foil, not backed
V481101	Paper, cardboard, with tar, etc.	V760703	Aluminium foil, backed
V481103	Cardboard with adhesive	V761201	Tubes, of aluminium
V481105	Paper, cardboard, coated with plastics	V761203	Casks, drums, cans, boxes, etc., of aluminium
V481109	Paper, cardboard, with cellulose wadding	V761300	Containers, nec, of aluminium
V481901	Boxes, etc. of corrugated paper and cardboard	V830901	Crown corks, of base metals
V481903	Boxes, etc. of paper and cardboard carton	V830903	Stoppers, caps and lids, etc., of metal
V481905	Sacks and bags, min 40 cm		
V481907	Sacks and bags, max 40 cm	Wooden packaging	
V481909	Packaging, paper and cardboard, nec.	V440500	Wood wool and wood powder
V482100	Labels and tags	V441500	Cases, boxes, pallets, etc., wooden
V482200	Bobbins, spools, etc.	V441600	Casks, barrels, vats, etc., wooden
		V450301	Corks and stoppers, of natural cork

¹⁾ The paper and cardboard groups are classified according to the classification used in the Danish supply-use tables (PSUT). In general, the first four digits corresponds to the first four digits in the CN-classification.

We examined approximately 13 000 reporting items from companies and in each case, based on the type of company, decided whether the output, import and export flow were related to packaging or not. Often, the distinction could be made immediately by looking at the company name, since many of the reports came from specialized packaging companies with names including “Packaging” in some form. In other cases, we visited the homepages of the companies to get an idea of the character of the products produced or imported by the company.

As examples, we have assumed that output of cartons of paper or cardboard by the company *Ds Smith Packaging*, Denmark are output of packaging, while paper bags produced by the Danish *Nilfisk* vacuum cleaner manufacturing company are not.

The detailed CN 8-digit level assessment were subsequently aggregated in order to obtain adjustment factors for output, imports and exports according to each of the supply-use product groups presented in Table 1. As an example, Table 2 shows the percentages of each paper and cardboard flow that can be assumed to be related to packaging material.

Table 2. Packaging share of aggregated paper and cardboard products groups

		Output	Imports	Exports
		Per cent ¹⁾		
V480800	Paper, cardboard, corrugated, crepped, embossed	100	99	99
V481101	Paper, cardboard, with tar, etc.		-	-
V481103	Cardboard with adhesive	2	96	98
V481105	Paper, cardboard, coated with plastics	99	93	100
V481109	Paper, cardboard, with cellulose wadding	96	21	33
V481901	Boxes, etc. of corrugated paper and cardboard	100	100	100
V481903	Boxes, etc. of paper and cardboard carton	100	100	100
V481905	Sacks and bags, min 40 cm	100	100	100
V481907	Sacks and bags, max 40 cm	100	98	99
V481909	Packaging, paper and cardboard, nec.	100	100	100
V482100	Labels and tags	100	100	100
V482200	Bobbins, spools, etc.		100	100

¹⁾ The percentages show how much of a given amount (tonnes) of the product that can be assumed to be packaging material.

The calculated packaging percentages were used to adjust the supply and use of the 36 product groups in order to arrive at supply and use of packaging. For outputs, they were used uniformly across all producing industries, etc.⁵ Subsequently some additional adjustments were made, which aimed of removing potential packaging products that are used for further processing. For instance, inputs of paper and cardboard into the paper manufacturing industry were removed from the assessment, since these inputs are most likely used for further processing. By removing the intermediate consumption by the paper industry double counting of empty packaging products are avoided.

Table 3 summarises the resulting main aggregates from the PSUT for each packaging type. We found an overall total supply of packaging materials of 1 602 073 tonnes of which 928 639 tonnes are supplied by Danish industries and 665 135 tonnes are imported. In addition, 8 299 tonnes are other domestic supply. This item covers packaging materials withdrawn from inventories.

646 730 tonnes or 40 per cent of the total packaging supply is paper and cardboard packaging. A dominant part, 438 410 tonnes, is domestically supplied.

The total supply of empty wooden packaging and plastics packaging are of similar size, 325 577 tonnes and 301 977 tonnes, respectively. For plastics, the shares for Danish output and for imports are almost equal. More wooden packaging is supplied via imports than via Danish production.

12 per cent of the total supply of empty packaging materials are glass. Most of it is produced in Denmark. It should be observed that these numbers reflect the supply of new glass packaging, i.e. reused bottles are not included.

The last and smallest packaging category, metal, accounts for 8 per cent of total supply. As for plastics, the domestic output and imports of metal are of almost equal size.

Table 3. Supply and use of empty packaging, 2018

	Packaging, total		Paper and cardboard	Glass	Metal	Wooden
	Tonnes					
Danish output	928 639	151 728	438 410	147 698	64 723	126 080
Other domestic supply	8 299	1 453	6 632	18	194	2
Domestic supply total	936 938	153 181	445 042	147 716	64 917	126 082
Imports	665 135	148 796	201 688	46 675	68 481	199 495
Total supply	1 602 073	301 977	646 730	194 391	133 398	325 577
Intermediate consumption	1 046 744	194 400	443 082	102 114	89 070	218 078
Households, etc.	22 002	5 867	5 489	6 330	1 762	2 554
Domestic use, total	1 068 746	200 267	448 571	108 444	90 832	220 632
Exports	533 330	101 712	198 158	85 947	42 567	104 946
Total use	1 602 076	301 979	646 729	194 391	133 399	325 578
Net imports	131 805	47 084	3 530	- 39 272	25 914	94 549

One third, 533 330 tonnes, of empty packaging is exported, while most of the remaining two thirds of Danish use is acquired by industries with the purpose of being used as transport and sales packaging, when they deliver products to their customers. In the supply and use table, this is recorded as intermediate consumption. A small amount of packaging materials is recorded as households, etc.

⁵ The uniform adjustments were done as a short cut. With some extra effort it would be possible to make more precise adjustment of individual industries' output.

(other final use)⁶. It covers, for instance, plastic boxes and bags, and glass jars purchased as household goods.

Our estimates of the domestic supply of empty packaging (output + imports - exports) can to some extent be compared with corresponding estimates published in *Packaging Statistics 2018*⁷ from DEPA, see Table 4.

Table 4. Comparison of alternative statements of domestic supply of empty packaging, 2018

	Packaging, total	Plastics	Paper and cardboard	Glass	Metal	Wooden
	Tonnes					
PSUT-estimates	1 068 746	200 267	448 571	108 444	90 832	220 632
Packaging Statistics 2018 ¹⁾	950 841	212 000	340 000	104 744	58 000	236 097
Difference	117 905	- 11 733	108 571	3 700	32 832	- 15 465

¹⁾ Source: *Emballagestatistik 2018* (see reference in footnote 7) Section 6.1. Glass packaging is here exclusive of 5 256 tonnes of re-used bottles. Wooden packaging is exclusive of 41 903 tonnes of repaired wooden pallets. Under the table heading *Paper and Cardboard* we have recorded what is called *Fibers* in the *Packaging Statistics 2018*. It does probably not correspond exactly to paper and cardboard as recorded in the PSUT.

For empty plastic, glass packaging and wooden packaging *Packaging Statistics 2018* and the packaging PSUT present estimates, which are reasonable close to each other. For paper and cardboard and metal the PSUT estimates are considerable higher than the ones given by *Packaging Statistics 2018*. For wooden packaging the difference is moderate.

The *Packaging Statistics 2018* use also the International Trade in Goods Statistics and the Industrial Sales Statistics from Statistics Denmark to estimate the imports, exports and Danish output. The methodology used to identify, which items that should be included as packaging is however somewhat different if we have understood the reports on the packaging statistics properly. Some differences are the following.

The *Packaging Statistics 2018* rely on expert judgements of which CN-8 digit products that should be included as packaging and whether all of it or only part of it should be counted as packaging. In contrast, the PSUT-estimates rely on a filtering of the underlying company reports to Statistics in order to exclude reports from companies, which most likely produce or use the products for other purposes than packaging.

There may also be some differences (data revisions) in the versions of the International Trade in Goods Statistics and the Industrial Sales Statistics used for the two alternative statements.

Packaging Statistics 2018 is based on additional information collected from packaging companies and expert assessments, whereas the PSUT do not.

Packaging Statistics 2018 aim to include all packaging used domestically, including reused packaging (deposit glass bottles and wooden reuse pallets), while the PSUT focus on new empty packaging, only.

In the Industrial Sales Statistics, the physical data for packaging products are often stated in other measuring units than tonnes, e.g. pieces or cubic metres. In such cases

⁶ Here households, etc. (other final use) refers to refer to private consumption, government consumption, capital formation and changes in inventories, i.e. domestic use/consumption different from intermediate consumption. See tables in Section 3 for a breakdown by subcategories.

⁷ In the following we use *Packaging Statistics 2018* to refer to the Danish report from DEPA: Miljøstyrelsen, Redaktion: Simon Graasbøll, COWI Erik Nørby, POLYTEC: Statistik for emballageforsyning og indsamling af emballageaffald 2018; *Emballagestatistik 2018*. <https://www2.mst.dk/Udgiv/publikationer/2020/12/978-87-7038-246-5.pdf>
The publication is in Danish but includes an English summary.

the *Packaging Statistics 2018* estimate the output in tonnes by dividing the corresponding monetary value with a corresponding unit price for exports. For the PSUT the conversion is instead based on weight per alternative unit, e.g. kilograms per piece or kilograms per cubic metre.

The *Packaging Statistics 2018* include a separation of materials in composite packaging in order to ensure that the five packaging groups are clean cut, whereas the PSUT includes an overall allocation according to the CN-classification.

Given these differences in methodology and scope it is not surprising that there are differences. When it comes to the large difference for paper and cardboard, the main reason for the difference seems to be the different conversion method from alternative measuring units to tonnes. We are, however, not able to point at any particular reason for the large difference for metal packaging. Further investigation of the data and conversion would be needed to clarify this.

2.4. Supply and use of filled packaging

The next step in assessing packaging flows is to establish data on filled packaging i.e. the packaging materials after it has been used to pack various products for transport and final sale in stores. The assessment of the weight of filled packaging relates to the packaging materials only, i.e. the weight of the products being packed is excluded.

DEPA maintains a dataset that shows for each of the detailed goods in external trade statistics (CN 8-digit level, more than 9 000 products) their typical packaging characteristics in the form of packaging type and packaging weight. Based on a given product weight (e.g. the weight of potatoes) it is possible to estimate how much packaging that are needed for transportation and sale. Further, it is possible to estimate the packaging material type, i.e. how much of the packaging that are plastics, paper and cardboard, glass, metal and wooden packaging (including wood pallets). In the following, we refer to this DEPA dataset as the *product/packaging dataset*⁸.

DEPA uses the product/packaging dataset to calculate net import flows of filled packaging for their *Packaging Statistics 2018*. We have, however, extended the use of the dataset beyond the net import flows by combining the product/packaging dataset in combination with the complete PSUT for all products in order to establish a PSUT for filled packaging, including all types of flows: imports, exports, output from Danish industries, intermediate consumption by industries, households consumption, etc⁹.

The product/packaging dataset cover net import of products, however, in this project we assumed that, at the detailed CN 8-digit level, the dataset would also be representative for both imports and export flows as well as for Danish production.¹⁰ It is possible that the different product flows are characterised by different packaging methods, for instance, that imported goods are embedded in more or different packing than exports because they are transported over larger distances. If this is the case, our assumption may not fully reflect reality.

The next step involved an aggregation from CN 8-digit data (approx. 9 000 products) to the Danish supply-use table product classification (approx. 1 900 products). Separate aggregation schemes were applied for imports, exports and Danish output by:

⁸ In Danish it is referred to as *Forudsætningsdatabasen*.

⁹ The Danish Environmental Protection Agency have kindly made the dataset available to us and have assisted us in explaining its use. However, the sole responsibility for any misuse and errors is, of course, ours.

¹⁰ The exemption from this is wood pallets, where the product/packaging dataset provides detailed characteristics for import and export flows, respectively. Here, the separate data for packaging related to export flows are used as an estimate for the packaging in the Danish production.

1. Calculating a weighted average for the overall packaging percentage for each product. Each detailed CN 8-digit product was assigned a weight based on its contribution to the sum of the specific material flow (import, export or Danish production) at the more aggregated supply-use table level.
2. Calculating the associated packaging material shares for the five materials for each aggregated product. This was done by calculating the amount (in kilos) for the aggregated product categories and thereafter calculating shares.

In some cases further discretionary adjustments of the resulting data were needed, for instance, by filling in missing data for Danish output, where this could not be established based on the original data on imports/exports.

Table 5 present an example of the resulting aggregated datasets for imports, exports and Danish production. The example relates to imports of filled packaging. Each of the datasets includes for each of the PSUT product groups a) the packaging percentages, and b) the packaging material shares. The packaging percentages and material shares differ for import, export and domestic production. This is due to the weighted aggregation, as described above, which takes into account that the flows at the aggregated (PSUT classification level) differ with regard to which CN 8-digit products it is composed of. For instance, packaging of imported vegetables differ from vegetables produced in Denmark, and therefore have different packaging characteristics, including packaging amount and type of material.

Table 5. Example: Estimated packaging percentages and material shares for imports of some vegetable products.

PSUT product category	Import (kilo)	Packaging percentage (share of total import)	Plastic Fiber share share of packaging	Fiber share of packaging	Glass share of packaging	Wood (non-pallets) share of packaging	Metal share of packaging
V070200 Tomatoes, fresh	37 941 341	0.04	0.28	0.70	0.00	0.03	0.00
V070300 Onion and leek, fresh	12 887 019	0.05	0.24	0.61	0.00	0.15	0.00
V070400 Cabbage cauliflower green cabbage	29 735 297	0.01	0.28	0.71	0.00	0.01	0.00
V070500 Salad and cikorie	20 482 654	0.03	0.74	0.26	0.00	0.00	0.00
V070600 Carrots beets beetroots	19 965 729	0.02	0.53	0.47	0.00	0.00	0.00
V070700 Cucumber, pumpkins	24 543 807	0.03	0.39	0.61	0.00	0.00	0.00
V070800 Legumes	2 414 106	0.06	0.15	0.85	0.00	0.00	0.00
V070900 Other vegetables	63 219 098	0.11	0.34	0.59	0.00	0.07	0.00
V071001 Potatoes, frozen	5 418 461	0.06	0.33	0.67	0.00	0.00	0.00
V071008 Vegetables, frozen	37 796 067	0.07	0.34	0.66	0.00	0.00	0.00

For the purpose of this project, we did not include all details from the full product/packaging dataset such as the distinction between transport and sales packaging and specific data on packaging use, for instance, the data on use of return wood pallets. In future work these additional data could be useful for further development of the packaging PSUT.

In order to estimate the Danish output by industries, imports and exports of each of the five filled packing materials packaging percentages and material type shares were subsequently multiplied by the output, imports and exports data from the complete PSUT with a breakdown by the product groups for which the packaging was used

Overall, the estimations showed an output of 1 089 527 tonnes of filled packaging from Danish industries. This can be compared to the intermediate consumption of empty packaging of 1 046 744 tonnes, cf. Table 3 above.

Since we, as explained in Section 2.2, have taken care to exclude flows of materials that are used for other purposes than packaging and also inputs of materials, that are assumed to be further processed and sold as packaging material, it may be assumed that the inputs of empty packaging in industries result in similar outputs of filled packaging.

Our data seems to confirm this: The difference is only four per cent. However, this result applies to the total output of packaging materials, whereas we find substantial larger differences when it comes to the packaging material shares. For plastics, paper and cardboard, glass, metal and wooden packaging the differences between estimated output of filled packaging and the input of empty packaging are 24, -14, 1, 27 and 14 per cent, respectively.

One reason for some of the difference may be that the product/packaging dataset material shares may be “cleaner”, in the sense that it seems to have allocated materials from composite packaging material to the relevant groups, whereas we didn’t make any effort to do that. Thus, we have allocated the total product weight of all paper and cardboard products to the paper and cardboard group, even if some of these products may contain plastics.

Given the rather rough method and the assumptions involved in estimating the output of filled packaging, it seems appropriate to assume that the intermediate consumption of empty packaging gives a quite precise picture of how much filled packaging the Danish industries distributed to their customers. Thus, we have for each of the five packaging types adjusted the estimates of Danish output of filled packaging so that it matches the intermediate consumption of empty packaging¹¹.

It has not been possible to verify the estimates of imports and exports of filled packaging in a similar way. However, we have been able to compare our estimates of net imports with the data on net imports presented in the *Packaging Statistics 2018* from DEPA. The results for net imports are (our estimate vs. *Packaging Statistics 2018*): Plastics: 53 vs. 33 tonnes, Paper and card board: 27 vs. 46 tonnes; Glass: 79 vs. 62 tonnes; Metals: -27 vs. -26 tonnes For wooden packaging the numbers cannot be compared meaningfully, since the treatment of reuse pallets are different.

In principle, the two statements are based on the same method (product/packaging dataset and foreign trade data). The differences do not appear overly large given that different versions of the international trade statistics have been used, different aggregation levels are involved and that net imports are the result of two large numbers being subtracted. In that light, we rely on our estimates of imports and exports of filled packaging.

Based on the adjusted numbers for Danish output of filled packaging and the numbers for imports and exports, we estimated the total domestic use of filled packaging for each product group by subtracting the exports from the sum of output and imports. Subsequently, the full PSUT for filled packaging was established by allocating – for each of the product groups in the PSUT - the domestic use of filled packaging by industries and households in proportion to the domestic use of the product group.

Main aggregates from the PSUT for filled packaging are presented in Table 6.

The total supply of filled packaging was approximately 2 004 644 tonnes, of which a little more than half was supplied from Danish industries and a little less than half from imports. Paper and cardboard packaging and plastics were the largest groups of packaging material with 38 and 22 per cent of the total supply. It was followed by wooden packaging, glass and metal with 18, 14 and 7 per cent, respectively.

For filled plastics and glass packaging the largest amounts came from imports. For paper and cardboard, metal and wooden packaging, the amounts supplied domestically are larger than the imports.

¹¹ In doing this we assume that the losses of empty packaging are negligible.

On the use side, 907 081 tonnes of filled packaging is exported. Of the remaining filled packaging, 641 923 tonnes (58 per cent) is distributed to industries (intermediate consumption) and 455 640 tonnes (42 per cent) to households, etc.

Table 6. Supply and use of filled packaging, 2018

	Packaging,	Plastics	Paper and	Glass	Metal	Wooden
	total		cardboard			
Tonnes						
Danish output	1 046 744	194 400	443 083	102 114	89 069	218 078
Imports	957 900	252 966	328 198	182 928	52 091	141 717
Total supply	2 004 644	447 366	771 281	285 042	141 160	359 795
Intermediate consumption	641 923	143 145	346 136	29 091	20 993	102 558
Households, etc.	455 640	104 347	123 590	151 838	41 548	34 317
Domestic use, total	1 097 563	247 492	469 726	180 929	62 541	136 875
Exports	907 081	199 874	301 555	104 113	78 619	222 920
Total use	2 004 644	447 366	771 281	285 042	141 160	359 795
Net imports	50 819	53 092	26 643	78 815	- 26 528	- 81 203

For the five different types of filled packaging there are large differences when it comes to the relation between industries on one side and households' use on the other: Glass and metal packaging end up mainly in households, while paper and cardboard packaging and wooden packaging to a relatively larger extent find its way to industries. For plastic packaging, industries are also the main user group, although the relation between industries and households is more even.

In addition to the filled packaging imports described above and elsewhere in this report additional filled packaging enters Denmark through border trade. Due to the lower taxes/prices in Germany it is quite common for Danes to cross the border with the purpose of buying beer and soft drinks. In the *Packaging Statistics 2018* these amounts of filled packaging are stated as presented in Table 7.

Filled packaging is also exported, for instance to Sweden and Norway, via border trade. Probably, this export is smaller than the border trade imports (typically from Germany).

So far, we have not included any data for border trade of filled packaging in the PSUT for packaging. As the border trade imports of especially filled glass and metal packaging is relatively large when compared to the conventional supply presented in Table 6 it will be appropriate to also record the border trade flows in any future versions of the PSUT for packaging.

Table 7. Total imports of filled packaging through border trade, 2018

	— Tonnes —
Plastics	629
Cardboard	18 396
Glass	13 751
Metal	12 159
Total	26 935

Source: Table 8 in *Packaging Statistics 2018*: Miljøstyrelsen, Redaktion: Simon Graasbøll, COWI Erik Nørby, POLYTEC: Statistik for emballageforsyning og indsamling af emballageaffald 2018; Emballagestatistik 2018. <https://www2.mst.dk/Udgiv/publikationer/2020/12/978-87-7038-246-5.pdf>

2.5. Supply and use of packaging waste

After unpacking, industries and households discard the packaging materials as waste. The waste accounts from Statistics Denmark¹² include information on separately sorted packaging waste collected for recycling. In total 603 606 tonnes of packaging waste was sorted in 2018 (see Table 8). In terms of weight, 60 per cent of collected packaging waste was paper and cardboard packaging and 26 per cent was glass. Less than 10 per cent was plastic packaging. Metal and wooden packaging accounted each for approximately 2.5 per cent of the total sorted packaging waste.

When calculating the amount of filled packaging, we have not included glass bottles and wooden pallets that are reused as packaging as they are, without being disintegrated. Therefore, it seems reasonable to assume that all of the filled packaging end up as waste. If we further assume that the filled packaging is discarded in the same year as it is received by the industries or households, the total domestic use of 1 097 563 tonnes of filled packaging (Table 6) seems to be a reasonable estimate of the total amount of sorted and unsorted packaging waste.

Table 8. Domestic supply of packaging waste, 2018

	Packaging waste, Tonnes					
	Packaging waste, total	Plastics	Paper and cardboard	Glass	Metal	Wooden
Sorted packaging waste	603 606	55 433	362 364	155 021	14 729	16 059
Estimated unsorted packaging waste ¹⁾	315 781	113 952	107 362	25 908	14 390	54 169
Total of sorted and estimated unsorted p.w.	919 387	169 385	469 726	180 929	29 119	70 228
Balance ²⁾	178 176	78 107	0	0	33 422	66 647
Total filled packaging	1 097 563	247 492	469 726	180 929	62 541	136 875

¹⁾ Initially 138 240 tonnes of paper and cardboard packaging and 29 079 tonnes of glass packaging in other waste fractions were estimated. With these estimates the total amounts of waste surpasses the total domestic use those packaging types. Therefore, the amounts were reduced by 30 878 tonnes and 3 171 tonnes, respectively.

²⁾ Estimated as use of filled packaging minus sorted and estimated unsorted packaging waste

With 603 606 tonnes of sorted waste we may thus expect that the unsorted waste from industries and households include 493 957 tonnes of packaging (= Total filled packaging – Sorted packaging waste). To qualify this estimate we have multiplied percentages for the content of packaging in some unsorted waste fractions with data for total amounts of corresponding mixed waste from Statistics Denmark's waste accounts. It shows an estimate of unsorted packaging waste of 315 781 tonnes, i.e. 178 176 tonnes less unsorted waste than expected based on the amount of filled packaging used domestically, see Table 8. We introduce the discrepancy as a specific balance item in the packaging PSUT.

The source of the percentages for the content of packaging in unsorted waste fractions is a methodological report from DEPA¹³. In that report, percentages are presented for some waste fractions based on physical analysis of the waste at waste treatment plants. We have applied percentages for mixed municipal waste, waste suited for incineration, mixed packaging, wood waste and other wastes. However, for some waste fractions, for instance, sorted plastic waste¹⁴, we did not find and

¹² Waste accounts are published on a yearly basis from Statistics Denmark as part of the environmental-economic accounts, see www.statbank.dk/20294. They include information on the generation of a large number of waste categories/fractions from 117 industries and households. Also imports and exports of waste are included. The waste accounts are based on and corresponds to the Waste Statistics form DEPA, but with some reallocation of the data in order to ensure coherence with the economic activities as described in the national accounts and the environmental-economic accounts.

¹³ Miljøstyrelsen: Opdateret metode til udarbejdelse af emballagestatistik. Miljøprojekt nr. 2155, December 2020. <https://www2.mst.dk/Udgiv/publikationer/2020/12/978-87-7038-257-1.pdf>

¹⁴ Sorted plastic waste and sorted plastic packaging waste are separate categories in the Danish waste accounts. The same applies to the other material types.

apply any percentages. Most likely, this explains the rather large difference/balance between the expected total amount of and the sum of the sorted waste and the estimated amount of packaging in unsorted waste.

The DEPA *Packaging Statistics 2018* report numbers for sorted packaging waste are based on a more detailed assessment of the waste statistics than we have used for the PSUT. In total, these numbers are approximately 70-80 000 tonnes larger than the items for sorted packaging waste, which we have included in the PSUT. Thus, by using the same delimitations for sorted packaging waste as the *Packaging Statistics 2018* the balance item could be substantially reduced.

Another reason is that there are large uncertainties involved when it comes to the percentages applied. Future work, involving the introduction of more precise data on packaging waste from the *Packaging Statistics 2018* from DEPA, may lead to a more precise estimation of the packaging waste in other waste fractions. For now, we introduce our first rough estimate of unsorted waste in the accounts and note that it leaves a balance item when filled packaging and packaging waste are compared, and that there is room and possibilities for improvement of these estimates.

55 880 tonnes of sorted packaging waste were imported from abroad and we have estimated that the imports of unsorted waste included 7 022 tonnes of packaging. The latter estimate is based on the same method as used for the domestically generated waste. On the other hand 418 913 of sorted packaging waste were exported for treatment in other countries and 8 096 tonnes were included in exports of unsorted waste fractions according to the estimates.

Table 9. Imports and exports of packaging waste, 2018

	Packaging waste, total					
	Plastics	Paper and cardboard	Glass	Metal	Wooden	
Tonnes						
Imports, total	62 902	8 389	27 341	26 585	78	509
Sorted packaging	55 880	5 250	24 202	26 428	0	0
Estimated unsorted packaging waste	7 022	3 139	3 139	157	78	509
Exports, total	427 009	49 302	319 354	38 249	12 130	7 974
Sorted packaging	418 913	49 243	319 295	38 246	12 129	0
Estimated unsorted packaging waste	8 096	59	59	3	1	7 974

The numbers for domestic supply and external trade of packaging in waste show that the total amount of packaging in waste, which needs to be processed in Denmark is 555 284 tonnes (=919 387 + 62 902 – 427 009 + some rounding errors).

Table 10 shows the domestic treatment of packaging waste according to its intended method of treatment. Of the 555 284 tonnes of packaging waste treated in Denmark approximately half is collected for recycling and half for incineration. However, there are large differences depending on the material type. For glass and wooden packaging 88 and 80 per cent, respectively, are collected for recycling, while the number is only 11 per cent for plastics. 38 per cent of paper and cardboard packaging waste and 27 per cent of metal packaging are collected for recycling. In addition to the recycling and incineration, small amounts of packaging waste end up at deposits.

Table 10. Domestic treatment of packaging waste, 2018

	Packaging waste, total	Plastics	Paper and cardboard	Glass	Metal	Wooden
	Tonnes					
Total domestic treatment	555 284	128 471	177 713	169 265	17 070	62 765
Collected for recycling	285 503	13 687	67 344	149 566	4 606	50 300
Collected for incineration	269 293	114 753	110 232	19 686	12 462	12 160
Collected for depositing, etc.	488	31	137	13	2	305

Note: Each of the treatment categories include both sorted packaging waste and packaging waste in other waste fractions. For the packaging amount in other waste fractions it has been assumed that the packaging waste is treated in the same way as the total amount of waste.

When assessing our estimates for packaging waste in Denmark a number of issues for future improvement of the accounts should be noted:

- The estimates for waste recycling refer to the intended treatment at the time the waste was collected. In most cases, the actual recycling is somewhat lower since some of the waste may be of poor quality, which makes recycling difficult.
- We have not included the balance item mentioned above, since we have no possibility to assess how the corresponding amount of packaging waste is treated.
- We have only focused on domestic waste treatment in this project. In addition to the recycling within Denmark, most of the exported waste is sent abroad for recycling.
- The exclusion of border trade of filled packaging may distort the comparison of domestic use of filled packaging on one side and the supply of packaging waste on the other. Probably, the same applies to packaging related to international internet trade.

2.6. Summary of data sources and method for reconciliation of data at detailed level

In the previous sections, we have presented the main data sources, the main methodology and the resulting main aggregates for empty packaging, filled packaging and packaging waste. In this section, we add a few more details and summarize how the data for individual industries and households, etc. have been estimated. The balancing procedures described have been applied to each of the five packing types.

Table 11 summarize the main data sources for each type of packaging flow.

For the supply and use of **empty packaging** the complete PSUT includes a breakdown of supply and use by 117 industries and various groups of final use (households, etc.) for the 36 types of potential packaging product groups.

As described, we adjusted the numbers for output, imports and exports by applying adjustment factors, which account for the fact that some of the products are not used for packaging. For outputs, the adjustment factors for each product group were applied uniformly across all industries that produce the product. For instance, if the paper industry and the printing industry both produce the same type of paper packaging, both were adjusted downward by the same factor¹⁵.

¹⁵ Based on the underlying detailed data from the Industrial Sale Statistics it would probably be possible to enhance the quality of the accounts by estimating specific adjustment factors for each industry.

Table 11. Main data sources used for the packaging accounts ¹⁾

	Supply	Use
Empty packaging	Complete physical supply-use table, PSUT	Complete physical supply-use table, PSUT
Filled packaging	Output equal to input of empty packaging Imports estimated based on the flows of products and percentages for packaging (DEPA dataset)	Estimates are based on the flows of products and percentages for packaging (DEPA dataset)
Sorted packaging waste	Waste accounts	Waste accounts
Unsorted packaging waste	Estimated as per cent of supply of mixed waste	Estimated as per cent of use of mixed waste

¹⁾ The table refer to the main sources and initial estimations. In addition, other data sources, adjustments and balancing is involved.

After the adjustment of outputs by industries, imports and exports, the total domestic use for each empty packaging group was estimated. This was done by summarizing the outputs and the imports and subtracting the exports. After this, the totals for each product group were allocated by industries and households etc. in proportion to the original use data from the complete PSUT. Subsequently, some adjustments for specific uses were made. For instance, inputs of paper and cardboard into the paper manufacturing industry were removed from the assessment, since these inputs, most likely, are intermediate consumption of paper and cardboard used for processing of packaging by the paper industry. By removing the intermediate consumption by the paper industry double counting of empty packaging products are avoided. However, this removal of certain intermediate consumption of paper and cardboard packaging led to unbalanced supply and use. To ensure the balance, the supply side entries (industries' output and imports) were downscaled, in general, by a uniform adjustment across the different entries on the supply side.

As described above, the domestic supply of **filled packaging** from each of the 117 industries was determined by each industry's intermediate consumption of empty packaging. Imports and exports of filled packaging were estimated based on the imports and exports of all products and the corresponding packing percentages and packing material share as given by the product/packaging dataset from DEPA.

Similarly, an initial estimate of the allocation of the filled packaging use across 117 industries and households, etc. was obtained by using the information on intermediate consumption and private consumption, etc. from the complete PSUT and the packaging percentages and share. Subsequently, the allocation of the use of filled packaging was adjusted proportionally for all industries and households, etc. (excluding exports) in order to ensure that the total use of filled packaging is equal to the total supply.

Since use of filled packaging should not be larger than the amounts of packaging waste, we compared for each industry and households the use of filled packaging with the amount of sorted packaging waste. If, for a particular industry, we found that the amount of sorted waste was larger than the use of filled packaging, we made an upward adjustment of the use of filled packaging and a corresponding discretionary downward adjustment for another industry. Preferably, it was ensured that the corresponding upward and downward adjustment were made for industries with similar characteristics, for instance, two industries within the food and beverage

sector or two industries within the service sector. The background for removing the inconsistencies by adjusting the supply of filled packaging only, and not the sorted waste, is that the data on sorted waste is based on the waste statistics and actual reporting from companies, whereas the data on the use of filled packaging relies on estimations with all its uncertainties.

After having adjusted the inputs of filled packaging as described above the total amounts of **packaging waste**, i.e. the total of sorted waste and estimated unsorted waste was, for each of the 117 industries and the households, compared with the corresponding use of filled packaging. In cases where the total packaging waste generation was larger than the use of filled packaging, we made a downward adjustment of the estimate of unsorted packaging waste in order to obtain a balance. To ensure that the estimated total of unsorted waste was maintained, a corresponding upward adjustment was made for another industry for which the use of filled packaging was much smaller than the packaging waste generation. Again, preferably, the corresponding upward and downward adjustments were aimed at industries with the same characteristics.

3. Detailed supply-use tables for packaging

In each of the following five subsections for plastic, paper and cardboard, glass, metal and wooden packaging, respectively, a supply table and a use table for the specific material type are presented. The tables include a breakdown of the flows by 23 main industry groups, households and other final use as well as imports or exports.¹⁶

In addition, each subsection includes a Sankey diagram. The diagram illustrates the complete flow from the supply of empty packaging, through filled packaging, to packaging waste generation and treatment.

3.1. Plastic packaging

The supply of empty plastic packaging aggregated in main groups is presented in Table 12. Plastic boxes etc. are the most common type followed by plastic sacks and bags and plastic film etc. 151 728 tonnes plastic packaging are produced in Denmark, and 148 796 tonnes are imported.

Table 12. Supply of empty plastic packaging (tonnes)

	Supply from industries	Residuals from domestic final use	Import	Total supply
Boxes, cases, crates and similar articles of plastics	84 538	211	39 908	124 657
Sacks and bags, incl. cones, of plastics	20 697	970	50 126	71 793
Plates, sheets, film, foil and strip, of non-cellular and cellular plastics, n.e.s.	12 750	2	41 156	53 908
Stoppers, lids, caps and other closures, of plastics	12 147	172	13 341	25 660
Carboys, bottles, flasks and similar articles for the conveyance or packaging of goods, of plastics	21 593	98	3 767	25 458

The majority of the empty plastics packaging produced in Denmark is produced by the *Manufacture of rubber and plastics* industry covering more than 95 pct. of the

¹⁶ All tables are constructed at a detailed level including 117 industries and several packaging products and packaging waste types. However, the uncertainties are very large at this level.

national supply. The raw material for the Danish production of plastic packaging is imported as polymer granulate or as semi manufactured products.

Empty plastic packaging is used in a wide range of industries and the five major industries are shown in Table 13. The use of plastic packaging in *Wholesale and retail trade, etc.* may be both primary packaging i.e. packaging for a single product as well as secondary packaging for transport of numerous single products.

Table 13. Use of empty plastic packaging – top 5 industries (tonnes)

	Use of empty packaging
Wholesale and retail trade, etc.	90 891
Manufacture of food products, beverages and tobacco	42 956
Manufacture of chemicals	14 543
Manufacture of machinery	6 766
Pharmaceuticals	6 461

The most frequent products in plastic packaging are shown in Table 14.

Table 14. Top 5 products in plastic packaging

Product	Product code	Calculated packaging weight (tonnes)
Water, sweet, aromatic non-alcoholic beverages	V220200	15 302
Cheese	V040601	12 438
Pork meat, fresh/refrigerated	V020301	9 822
Washing and cleansing agents	V340203	9 749
Pharmaceuticals	V300400	9 254

The Danish supply of filled plastic packaging is 194 400 tonnes and the import is 252 966 tonnes. The export of filled packaging is 199 874 tonnes leaving 247 492 tonnes plastic packaging for total domestic use. *Manufacture of food, beverage and tobacco* as well as *Manufacture of chemicals and pharmaceuticals* are the most important industries.

From industries and private consumers 21 061 and 34 372 tonnes of plastic waste, respectively, have been sorted for recycling. The remaining waste is assumed to contain 113 900 tonnes of plastic packaging waste. **The plastic packaging waste** sum up to 169 385 tonnes, resulting in a difference at 78 107 tonnes plastic packaging (balance) compared to the total domestic use.

During the work with this report, a number of issues related to plastics packaging for future research have been identified:

- Specification of plastic types (PE, PP, PS, PET or other) is important to improve recycling
- Manual or automatic sorting of waste
- Efficiency of plastics recycling (how much sorted plastic waste goes to incineration?)

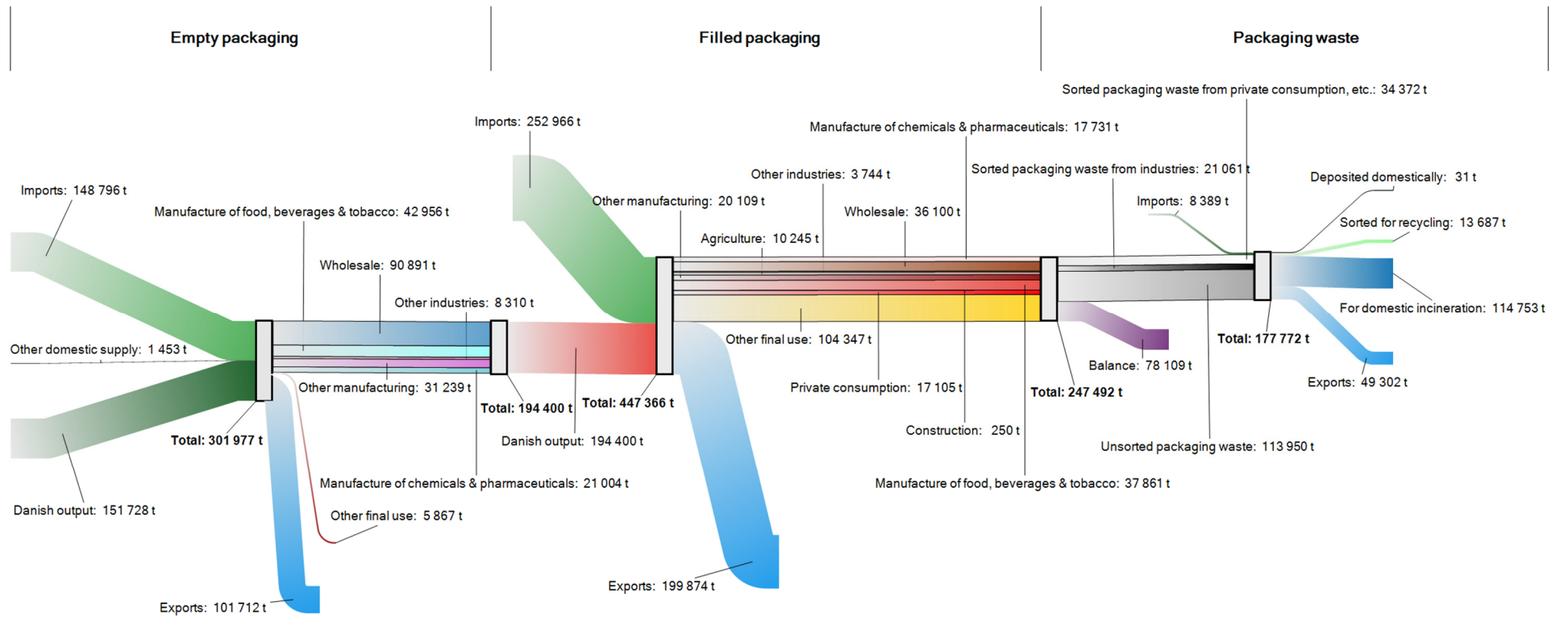
Table 15. Supply of plastic packaging

	Empty packaging	Filled packaging	Sorted packaging waste	Estimated unsorted packaging waste
Tonnes				
Total supply	301 977	447 366	60 683	117 089
Output from industries, total	151 728	194 400	21 061	43 975
10600 Agriculture, etc; Mining and quarrying		2 738	542	6 586
10120 Manufacture of food products, beverages and tobacco	19	42 956	2 937	23 385
13150 Manufacture of textiles and leather products	51	2 069	56	4
16310 Manufacture of wood, wood products, furniture and other manufacturing	502	4 547	676	35
17000 Manufacture of paper and paper products	274	3 509	224	15
18000 Printing etc.	134	993	167	2
20000 Manufacture of chemicals	322	14 543	1 406	7
21000 Pharmaceuticals		6 461	295	162
22000 Manufacture of rubber and plastic products	145 225	2 500	2 657	
23000 Manufacture of other non-metallic mineral products	1	1 179	138	1 671
24250 Manuf. of basic metals and fabricated metal products	4 729	5 522	311	46
26270 Manufacture of electronic components and electric equipment	286	1 416	122	11
28000 Manufacture of machinery	12	6 766	667	43
35000 Electricity, gas, steam and air conditioning supply		15	13	993
38391 Collection of waste for incineration		71		
38393 Other waste management services and materials recovery, etc.		227	11	172
41430 Construction		1 082	275	150
45470 Wholesale and retail trade, etc.		90 891	7 640	369
49000 Land transport and transport via pipelines		324	564	79
52000 Support activities for transportation		431	702	
55560 Accommodation and food service activities		490	108	2 687
80820 Security; services to buildings and landscape; other business service activities		239	288	2 653
99999 Other industries	173	5 431	1 262	4 905
Other supply, total	150 249	252 966	39 622	73 114
Waste from private consumption			34 371	61 911
Disposals and scrap from capital, etc.	7			3 676
Reductions in inventories, etc.	1 446			3 364
Other supply			1	1 024
Imports	148 796	252 966	5 250	3 139

Table 16. Use of plastic packaging

	Empty packaging	Filled packaging	Sorted packaging waste	Estimated unsorted packaging waste
	Tonnes			
Total use	301 979	447 366	60 683	117 091
Intermediary consumption, total	194 400	143 145	11 426	117 014
10600 Agriculture, etc; Mining and quarrying	2 738	10 245		
10120 Manufacture of food products, beverages and tobacco	42 956	37 861		
13150 Manufacture of textiles and leather products	2 069	920		
16310 Manufacture of wood, wood products, furniture and other manufacturing	4 547	6 424		
17000 Manufacture of paper and paper products	3 509	974		
18000 Printing etc.	993	169		
20000 Manufacture of chemicals	14 543	14 569		
21000 Pharmaceuticals	6 461	3 162		
22000 Manufacture of rubber and plastic products	2 500	2 657		
23000 Manufacture of other non-metallic mineral products	1 179	3 294		
24250 Manuf. of basic metals and fabricated metal products	5 522	1 943		
26270 Manufacture of electronic components and electric equipment	1 416	750		
28000 Manufacture of machinery	6 766	2 978		
35000 Electricity, gas, steam and air conditioning supply	15	3 683		
38391 Collection of waste for incineration	71	61	389	114 364
38393 Other waste management services and materials recovery, etc.	227	250	11 037	2 650
41430 Construction	1 082	11 004		
45470 Wholesale and retail trade, etc.	90 891	8 018		
49000 Land transport and transport via pipelines	324	666		
52000 Support activities for transportation	431	702		
55560 Accommodation and food service activities	490	11 337		
80820 Security; services to buildings and landscape; other business service activities	239	4 373		
99999 Other industries	5 431	17 105		
Other use, total	107 579	304 221	49 257	77
Private consumption	3 555	96 282		
Capital formation	1 479	3 676	1	
Increases in inventories, etc.	833	3 364	13	18
Other use		1 025		
Exports	101 712	199 874	49 243	59

Figure 1 . Sankey diagram for plastic packaging



3.2. Paper and cardboard packaging

Paper and cardboard packaging is the largest of the five packaging categories. It includes a number of different products, e.g. corrugated paper and cardboard, kraft paper, creped or crinkled, paper and cardboard with or without coatings of plastics and other materials, cartons, boxes and cases of corrugated paper or paperboard paper, sacks and bags of different sizes, labels, bobbins, spools, cops, etc. The dominant product within paper and cardboard packaging is boxes and cases.

The PSUT for empty packaging are at an aggregated level presented in the first columns of Table 17 and 18. The supply and use of the 12 groups of empty paper and cardboard packaging are shown as a total for empty packaging. Likewise, the 117 industries in the detailed table are here aggregated to 23 industry groups. The main information in Table 17 and 18 is presented as a Sankey diagram in Figure 2.

Overall, we find that 646 730 tonnes of **empty paper and cardboard packaging is supplied to the Danish economy**. 438 410 tonnes are produced in Denmark, mainly by the *Manufacture and paper and paper products*. The printing industry and some other manufacturing industries supply also empty paper and cardboard packaging, although only small amounts. 201 688 tonnes of empty paper and cardboard packaging are imported and 6 632 tonnes were withdrawn from inventories.

443 082 tonnes, corresponding to a little more than two thirds, of the total supply of **empty paper and cardboard packaging were used** by Danish industries. Especially *Wholesale and retail trade, etc.* and *Manufacture of food products, beverages and tobacco* buy large quantities of paper and cardboard packaging, 178 174 tonnes and 148 015 tonnes, respectively. Other industry groups have more modest purchases of empty paper and cardboard packaging. Amongst these, *Manufacture of chemicals* and *Pharmaceuticals* are the largest consumers of empty packaging.

198 158 tonnes of empty paper and cardboard packaging were exported. The amount of exports is very close to the imports of empty paper and cardboard packaging. Thus, the net import of empty paper and cardboard packaging is close to zero.

Other final uses of empty paper and cardboard packaging include a small amount put in inventories, etc. and an even smaller amount of paper and cardboard boxes and paper bags, etc. purchased as household goods by households.

The total **supply of filled paper and cardboard packaging** is estimated to 771 281 tonnes. This covers a Danish production of 443 083 tonnes and an import of 328 198 tonnes.

Due to our estimation method (see Section 2) the Danish output of filled packaging (column 2 in Table 17) corresponds exactly to the intermediate consumption of empty packaging by industries (column 1 in Table 18). It follows that filled paper and cardboard packaging is to a very large extent supplied by *Wholesale and retail trade, etc.* and *Manufacture of food products, beverages and tobacco*, although all industry groups are suppliers of filled packaging.

As explained in Section 2.4, the **use of filled paper and cardboard packaging** is estimated based on the *product/packaging* dataset and thereby, with some exceptions, it is allocated according to use of the products for which the packaging is used. We have estimated that 349 995 tonnes of filled paper and cardboard packaging is used/received by the industries, 301 555 tonnes follows products that are exported, while 113 366 tonnes end up in households. Capital formation,

increases in inventories and other final uses (including individual government consumption) accounts for 10 224 tonnes of filled paper and cardboard packaging materials.

Wholesale and retail trade, etc. and *Manufacture of food products, beverages and tobacco* are dominant also when it comes to use of filled paper and cardboard packaging. The two industries accounts for uses of 210 585 and 24 448 tonnes of this type of packaging.

The large number for *Wholesale and retail trade, etc.* seems at first a little surprising since this industry does not use products as such. Instead, it receives products and sells the same products. The large amounts of filled paper and cardboard packaging ending up in this industry is however linked to wholesale and retail trade companies unpacking from boxes etc. of products received for further sale.

A dominant part of the filled paper and cardboard packaging is related to food products, especially dairy and meat products, but also to beer and other kind of beverages. For imports, wine and wearing apparel are groups, which are relatively large when it comes to paper and cardboard packaging.

After unpacking by industries and households the packaging materials are discarded and become waste. In total, industries discard 302 656 tonnes of **paper and cardboard packaging as separately sorted packaging waste**, while households discard 56 067 tonnes and others (including individual government consumption) 3 641 tonnes. In other words, industries account for 87 per cent of the total 362 364 tonnes of paper and cardboard waste, which were separately sorted and collected in Denmark.

In addition to the paper and cardboard packaging, which are separately sorted and collected, parts of the packaging end up in unsorted waste fractions such as mixed municipal waste and waste suited for incineration. For paper and cardboard packaging the amount discarded from industries in this way is estimated to 43 480 tonnes, while the amounts discarded from households and other domestic activities are estimated to 57 299 and 6 583 tonnes, respectively.

Adding up all the paper and cardboard packaging waste mentioned above gives a total of 469 726 tonnes. This amount corresponds to the total use of filled packaging by industries, households and other domestic uses.

In addition to the domestically generated paper and cardboard packaging waste, 24 202 and 3 139 tonnes of packaging is imported as sorted and mixed waste. Thus, the total supply of paper and cardboard packaging waste is 497 067 tonnes, of which 386 566 tonnes are separately sorted and collected for recycling while 110 501 tonnes is embedded in mixed waste.

The main part, 319 295 tonnes or 83 per cent, of the sorted waste is exported for recycling abroad while 66 713 tonnes are treated by Danish waste materials recovery facilities. The remaining parts are either put in inventories/deposits (116 tonnes) or are being incinerated (442 tonnes).

Almost all, more than 99 per cent, of paper and cardboard packaging waste in mixed waste fractions are used by incineration plants with energy production.

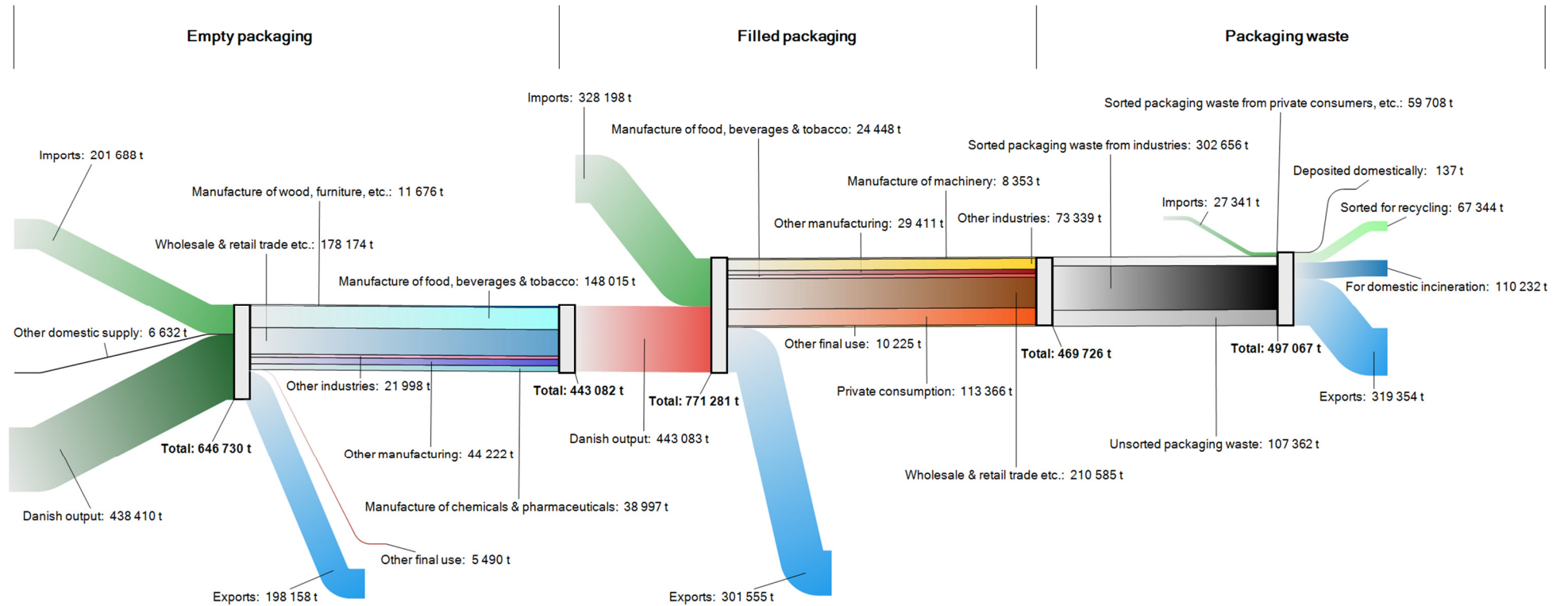
Table 17. Supply of paper and cardboard packaging

	Empty	Filled	Sorted	Estimated
	packaging	packaging	packaging	unsorted
	Tonnes			
	packaging	packaging	waste	packaging
				waste
Total supply	646 730	771 281	386 566	110 501
Output from industries, total	438 410	443 083	302 656	43 480
10600 Agriculture, etc; Mining and quarrying		2 921	1 083	5 252
10120 Manufacture of food products, beverages and tobacco	18	148 015	11 801	12 647
13150 Manufacture of textiles and leather products	41	2 094	1 081	1
16310 Manufacture of wood, wood products, furniture and other manufacturing	194	11 676	3 259	153
17000 Manufacture of paper and paper products	436 137	49	5 276	552
18000 Printing etc.	1 021	1 872	3 509	
20000 Manufacture of chemicals	114	26 234	2 094	1 368
21000 Pharmaceuticals		12 763	1 118	295
22000 Manufacture of rubber and plastic products		11 916	2 431	
23000 Manufacture of other non-metallic mineral products		3 735	365	2 372
24250 Manuf. of basic metals and fabricated metal products	120	10 602	1 953	755
26270 Manufacture of electronic components and electric equipment	765	4 959	2 375	454
28000 Manufacture of machinery		8 995	4 975	3 378
35000 Electricity, gas, steam and air conditioning supply		57	139	524
38391 Collection of waste for incineration		1 972		24
38393 Other waste management services and materials recovery, etc.		3 871	1 248	39
41430 Construction		36	2 179	3 145
45470 Wholesale and retail trade, etc.		178 174	210 168	417
49000 Land transport and transport via pipelines		932	8 580	61
52000 Support activities for transportation		107	6 107	
55560 Accommodation and food service activities		1 891	6 824	8 241
80820 Security; services to buildings and landscape; other business service activities		1 600	2 726	206
99999 Other industries		8 612	23 365	3 596
Other supply, total	208 320	328 198	83 910	67 021
Waste from private consumption			56 067	57 299
Disposals and scrap from capital, etc.	13		5	3 901
Reductions in inventories, etc.	6 619			2 459
Other supply			3 636	223
Imports	201 688	328 198	24 202	3 139

Table 18. Use of paper and cardboard packaging

	Empty packaging	Filled packaging	Sorted packaging waste	Estimated unsorted packaging waste
	Tonnes			
Total use	646 729	771 281	386 566	110 501
Intermediate consumption, total	443 082	346 136	67 155	110 421
10600 Agriculture, etc; Mining and quarrying	2 921	6 335		
10120 Manufacture of food products, beverages and tobacco	148 015	24 448		
13150 Manufacture of textiles and leather products	2 094	1 082		
16310 Manufacture of wood, wood products, furniture and other manufacturing	11 676	3 412		
17000 Manufacture of paper and paper products	49	5 828		
18000 Printing etc.	1 872	3 509		
20000 Manufacture of chemicals	26 234	3 462		
21000 Pharmaceuticals	12 763	1 413		
22000 Manufacture of rubber and plastic products	11 916	2 431		
23000 Manufacture of other non-metallic mineral products	3 735	2 737		
24250 Manuf. of basic metals and fabricated metal products	10 602	2 708		
26270 Manufacture of electronic components and electric equipment	4 959	2 829		
28000 Manufacture of machinery	8 995	8 353		
35000 Electricity, gas, steam and air conditioning supply	57	663		
38391 Collection of waste for incineration	1 972	24	442	109 790
38393 Other waste management services and materials recovery, etc.	3 871	1 287	66 713	631
41430 Construction	36	5 324		
45470 Wholesale and retail trade, etc.	178 174	210 585		
49000 Land transport and transport via pipelines	932	8 641		
52000 Support activities for transportation	107	6 107		
55560 Accommodation and food service activities	1 891	15 065		
80820 Security; services to buildings and landscape; other business service activities	1 599	2 932		
99999 Other industries	8 612	26 961		
Other use, total	203 647	425 145	319 411	80
Private consumption	828	113 366		
Capital formation	7	3 906		
Increases in inventories, etc.	4 654	2 459	116	21
Other use		3 859		
Exports	198 158	301 555	319 295	59

Figure 2 . Sankey diagram for paper and cardboard packaging



3.3. Glass packaging

Empty glass packaging is supplied from imports (46 675 tonnes) and from domestic production (147 698 tonnes). All domestic production is by *Manufacturing of other non-metallic mineral products*, which includes manufacture of glass products.

The total supply equals the **total use of empty glass packaging**: 194 391 tonnes. Close to half of the supply (44 per cent, 85 947 tonnes) is exported (as empty packaging). The main domestic use of empty glass packaging is as intermediate consumption in *Manufacturing of food and beverages* (72 234 tonnes), but there is also use in *Manufacturing of pharmaceuticals* (2 297 tonnes), and in *Wholesale and retail trade* (26 334 tonnes). The latter is presumably for repackaging. Other uses are negligible.

Total imports of filled glass packaging is 182 928 tonnes, while there is a Danish production of 102 114 tonnes. Exports of filled glass packaging are 104 113 tonnes.

Packaging of glass is used for a relatively small number of products compared to e.g. plastics or paper. Based on the packaging PSUT, 67 products (at the level of NrNr codes) are packaged in glass – and a small number of these make up the majority of the weight. The products that make up the majority of filled glass packaging weight in Danish production are beer, jams, and pickled vegetables. In imports, the ‘top 3’ are wine, spirits and beer. In exports, beer, spirits and wine are the top 3 products by glass packaging weight.

Packaging of glass is primarily used for food and (especially) beverages, but also in some cases for pharmaceutical and chemical products. Glass as a packaging material is heavy, very recyclable, gives off no taste to contents, and is seen as the ‘appropriate’/traditional packaging for certain foods and beverages (for example: wine above a certain price will always be in glass bottles, only the cheapest jam is sold in plastic containers in Danish supermarkets).

The product level use is reflected in the distribution by industries, as the main use of empty glass packaging and corresponding supply of filled glass packaging is by/from *Manufacturing of food and beverages* (72,234 tonnes). There is also a small supply from *Manufacturing of pharmaceuticals* as well as some supply from *Wholesale and retail trade*.

Use of filled glass packaging is mainly for households’ private consumption (151 380 tonnes) – and exports (104 113 tonnes). The most significant use as intermediate consumption by industries is in *Accommodation and food service activities* (hotels and restaurants etc.). This reflects that the main products in filled glass packaging is beverages (beer, wine and spirits) – which is mainly used by households for private consumption, either directly as goods or indirectly (as part of services in restaurants, etc.).

Total supply (output) of filled glass packaging is 285 042 tonnes, of which 104 113 is exported – leaving a domestic use of 180 929 tonnes. This is also the amount of glass packaging waste – due to the balancing of the PSUT. The amount of glass packaging waste collected and registered separately is 155 021 tonnes, with a further 25 908 tonnes of glass packaging waste estimated in other waste fractions.

Most glass packaging waste is collected from private consumption/households (134 463 tonnes) – this corresponds quite well to the use of filled glass packaging for private consumption (151,380 tonnes). Sorting and separate collecting of glass waste is very well established in Denmark with a long history.

In Denmark, glass bottles of certain types are collected, cleaned and reused - through a deposit scheme. These bottles are therefore used many times, but in the packaging PSUT they will only be counted when they enter the system as new, empty packaging and are filled for the first time - and when they eventually exit as glass packaging waste. So the PSUT is not suitable for describing how reuse affects packaging flows, including how reuse will limit the need for new packaging materials. There is also a deposit scheme for glass bottles that are recycled (broken down, melted and made into new bottles). These bottles are included in the PSUT as new empty packaging every time they are produced.

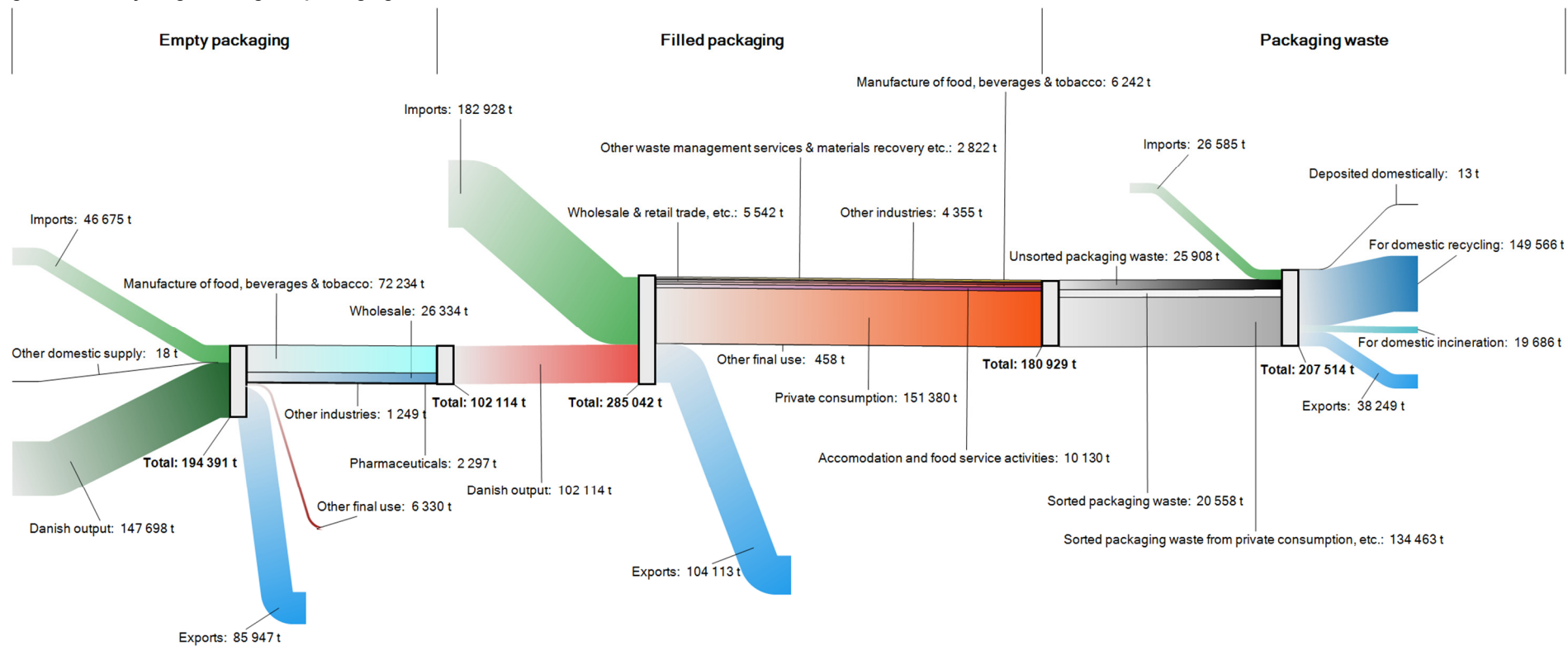
Table 19. Supply of glass packaging

	Empty packaging	Filled packaging	Sorted packaging waste	Estimated unsorted packaging waste
	Tonnes			
Total supply	194 391	285 042	181 449	26 065
Output from industries, total	147 698	102 114	20 558	8 533
10600 Agriculture, etc; Mining and quarrying		1	88	15
10120 Manufacture of food products, beverages and tobacco		72 234	2 754	3 488
13150 Manufacture of textiles and leather products		1		25
16310 Manufacture of wood, wood products, furniture and other manufacturing		20	20	
17000 Manufacture of paper and paper products				1
18000 Printing etc.			1	3
20000 Manufacture of chemicals		435	12	246
21000 Pharmaceuticals		2 297	32	162
22000 Manufacture of rubber and plastic products			1	5
23000 Manufacture of other non-metallic mineral products	147 698		34	
24250 Manuf. of basic metals and fabricated metal products		542	12	4
26270 Manufacture of electronic components and electric equipment		50	14	
28000 Manufacture of machinery			16	
35000 Electricity, gas, steam and air conditioning supply			11	
38391 Collection of waste for incineration				
38393 Other waste management services and materials recovery, etc.			2 822	
41430 Construction			69	4
45470 Wholesale and retail trade, etc.		26 334	5 436	106
49000 Land transport and transport via pipelines			46	
52000 Support activities for transportation			214	
55560 Accommodation and food service activities			6 238	3 892
80820 Security; services to buildings and landscape; other business service activities			184	
99999 Other industries		200	2 554	582
Other supply, total	46 693	182 928	160 891	17 532
Waste from private consumption			134 306	17 074
Disposals and scrap from capital, etc.	1			1
Reductions in inventories, etc.	17			204
Other supply			157	96
Imports	46 675	182 928	26 428	157

Table 20. Use of glass packaging

	Empty packaging	Filled packaging	Sorted packaging waste	Estimated unsorted packaging waste
	Tonnes			
Total use	194 391	285 042	181 449	26 065
Intermediary consumption, total	102 114	29 091	143 196	26 056
10600 Agriculture, etc; Mining and quarrying	1	103		
10120 Manufacture of food products, beverages and tobacco	72 234	6 242		
13150 Manufacture of textiles and leather products	1	25		
16310 Manufacture of wood, wood products, furniture and other manufacturing	20	20		
17000 Manufacture of paper and paper products		1		
18000 Printing etc.		4		
20000 Manufacture of chemicals	435	258		
21000 Pharmaceuticals	2 297	194		
22000 Manufacture of rubber and plastic products		6		
23000 Manufacture of other non-metallic mineral products		34		
24250 Manuf. of basic metals and fabricated metal products	542	16		
26270 Manufacture of electronic components and electric equipment	50	14		
28000 Manufacture of machinery		16		
35000 Electricity, gas, steam and air conditioning supply		11		
38391 Collection of waste for incineration				19 686
38393 Other waste management services and materials recovery, etc.		2 822	143 196	6 370
41430 Construction		73		
45470 Wholesale and retail trade, etc.	26 334	5 542		
49000 Land transport and transport via pipelines		46		
52000 Support activities for transportation		214		
55560 Accommodation and food service activities		10 130		
80820 Security; services to buildings and landscape; other business service activities		184		
99999 Other industries	200	3 136		
Other use, total	92 277	255 951	38 253	9
Private consumption		151 380		
Capital formation	1 219	1	1	1
Increases in inventories, etc.	5 111	204	6	5
Other use		253		
Exports	85 947	104 113	38 246	3

Figure 3 . Sankey diagram for glass packaging



3.4. Metal packaging

Throughout, all flows of empty and filled metal packaging, including import, export and Danish production are smaller compared to flows of most of the other packaging materials used in Denmark, as described in this report.

Metal packaging is mainly used within the food industry, including for pet food. However, metal is likewise used for containers within the chemical and pharmaceutical industry.

The total Danish use of empty metal packaging in 2018 amount to 133 396 tonnes. Nearly the same amount of empty metal packaging is imported (68 481 tonnes) as supplied from Danish production (64 723 tonnes). The main Danish production of empty metal packaging is supplied from *Manufacturing of basic metals and fabricated metal products* (64 648 tonnes). In total, 42 567 tonnes empty metal packaging is exported. **Empty metal packaging is mainly used** within the industry of *Manufacture of food products, beverages and tobacco* (36 886) and *Wholesale and retail trade, etc.* (28 689 tonnes).

Supply of filled metal packaging is slightly greater (141 160 tonnes) compared to the use of empty metal packaging.

Unlike empty metal packaging, most of the **filled metal packaging is supplied** from Danish industries (890 669 tonnes), whereas a smaller amount is imported (52 091 tonnes). The amount of filled metal packaging exported (78 619 tonnes) exceeds the imported amount.

Filled metal packaging is mainly supplied from the industry of *Manufacture of food products, beverages and tobacco* (36 888 tons) and *Wholesale and retail trade, etc.* (28 689 tonnes). However, some filled metal packaging is also supplied from the *Pharmaceuticals* (6 301 tonnes) and *Manufacture of chemicals* (4 202 tonnes) industries, just as some is supplied from *Manufacturing of basic metals and fabricated metal products* (4 880 tonnes) and *Manufacture of machinery* (2 511 tonnes). Lastly, is some of the filled metal packaging supplied from *Manufacture of paper and paper products* (2 652 tonnes), whereas the last industries are insignificant.

Most of the **filled metal packaging is used** as private consumption (44 329 tonnes) and a smaller amount is used within the industries of *Manufacture of food products, beverages and tobacco* (6 747 tons) and *Accommodation and food service activities* (6 639 tons). In addition, some is used within *Wholesale and retail trade, etc.* (1 125 tonnes) and within the industry of *Manufacture of chemicals* (1 102 tonnes).

The far largest product supplied in metal packaging is biscuits (53 017 tonnes) but metal packaging is also used for other food products like fish, nuts, berries, dairy products and canned tomatoes. However, the second largest product metal packaging is used for is dog and cat food (10 194 tonnes).

Danish domestic use of filled metal packaging is 62 541 tonnes, from which 14 729 tonnes are separately sorted and collected as waste. Most of the metal packaging that is collected as metal waste is exported (12 129 tons) and the rest is collected for recycling within Denmark (2600 tonnes).

Similar amounts (14 471 tons) is estimated to be collected unsorted, embedded in other waste fractions. Most of the unsorted metal packaging waste is estimated to be collected for incineration (12 462 tonnes).

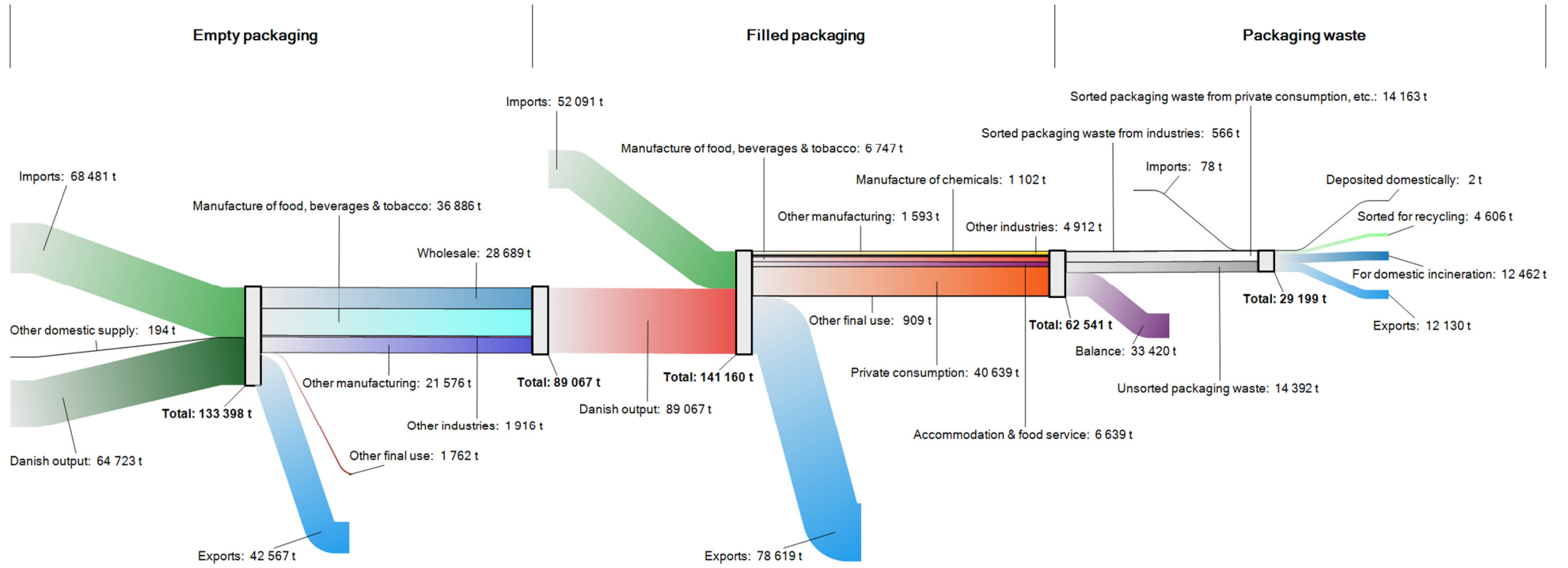
Table 21. Supply of metal packaging

	Empty packaging	Filled packaging	Sorted packaging waste	Estimated unsorted packaging waste
	Tonnes			
Total supply	133 397	141 160	14 729	14 470
Output from industries, total	64 723	89 069	566	1 315
10600 Agriculture, etc; Mining and quarrying		6		27
10120 Manufacture of food products, beverages and tobacco		36 888	327	471
13150 Manufacture of textiles and leather products		9		1
16310 Manufacture of wood, wood products, furniture and other manufacturing	9	102	12	7
17000 Manufacture of paper and paper products	12	2 652		5
18000 Printing etc.		24		1
20000 Manufacture of chemicals	5	4 202	25	1
21000 Pharmaceuticals		6 301		2
22000 Manufacture of rubber and plastic products	1	681		5
23000 Manufacture of other non-metallic mineral products		226		2
24250 Manuf. of basic metals and fabricated metal products	64 648	4 880		11
26270 Manufacture of electronic components and electric equipment	5	75		3
28000 Manufacture of machinery	43	2 511	15	7
35000 Electricity, gas, steam and air conditioning supply		7		
38391 Collection of waste for incineration		1		
38393 Other waste management services and materials recovery, etc.		7	66	
41430 Construction		70	25	24
45470 Wholesale and retail trade, etc.		28 689	10	325
49000 Land transport and transport via pipelines		8		2
52000 Support activities for transportation		14	3	
55560 Accommodation and food service activities		5		107
80820 Security; services to buildings and landscape; other business service activities		18		39
99999 Other industries		1 693	83	275
Other supply, total	68 674	52 091	14 163	13 155
Waste from private consumption			14 076	13 028
Disposals and scrap from capital, etc.	1		5	
Reductions in inventories, etc.	192			
Other supply			82	49
Imports	68 481	52 091		78

Table 22. Use of metal packaging

	Empty	Filled	Sorted	Estimated
	packaging	packaging	packaging	unsorted
	Tonnes			
	packaging	packaging	waste	packaging
			waste	waste
Total use	133 396	141 160	14 729	14 471
Intermediary consumption, total	89 067	20 993	2 600	14 468
10600 Agriculture, etc; Mining and quarrying	6	582		
10120 Manufacture of food products, beverages and tobacco	36 886	6 747		
13150 Manufacture of textiles and leather products	9	27		
16310 Manufacture of wood, wood products, furniture and other manufacturing	102	46		
17000 Manufacture of paper and paper products	2 652	65		
18000 Printing etc.	24	33		
20000 Manufacture of chemicals	4 202	1 102		
21000 Pharmaceuticals	6 301	60		
22000 Manufacture of rubber and plastic products	681	115		
23000 Manufacture of other non-metallic mineral products	226	184		
24250 Manuf. of basic metals and fabricated metal products	4 880	119		
26270 Manufacture of electronic components and electric equipment	75	33		
28000 Manufacture of machinery	2 511	157		
35000 Electricity, gas, steam and air conditioning supply	7	479		
38391 Collection of waste for incineration	1	5		12 462
38393 Other waste management services and materials recovery, etc.	7	74	2 600	2 006
41430 Construction	70	387		
45470 Wholesale and retail trade, etc.	28 689	1 125		
49000 Land transport and transport via pipelines	8	33		
52000 Support activities for transportation	14	35		
55560 Accommodation and food service activities	5	6 639		
80820 Security; services to buildings and landscape; other business service activities	18	231		
99999 Other industries	1 693	2 715		
Other use, total	44 329	120 167	12 129	3
Private consumption	671	40 639		
Capital formation	301	22		
Increases in inventories, etc.	790	680		2
Other use		207		
Exports	42 567	78 619	12 129	1

Figure 4. Sankey diagram for metal packaging



3.5. Wooden packaging

Wood packaging contribute about 20 per cent of the total supply of all packaging materials. Wood pallets is a large (and heavy) flow in the overall wood packaging flows, and contribute more than 90 per cent of wood packaging flows. This holds for exports, imports as well as Danish output. Wood pallets can be single-use or return pallets. Return pallets are used many times, and can be repaired if they break. In this version of the PSUT, only single-use pallets are included in the packaging flows. This means that the pallets are registered only when they enter the economy as empty (or imported filled) packaging – and when they exit the system as wooden packaging waste. While wood pallets are usually used for transportation, other wood packaging is mostly used as sales packaging, i.e. is delivered together with the product to the costumer.

Wood boxes and frames can be tailor-built for large machines, heavy construction materials and furniture. Wood is used for protection of fragile materials such as ceramic and porcelain laboratory equipment, refrigerators and wooden furniture. In addition, wood is used for transportation and storage of fruit and vegetables, particularly citrus, berries and mushrooms. In addition, wood packaging is used for exclusive products such as wine gifts, jewelry and cigars.

Similarly as for the other material types, empty wooden packaging products were identified in the PSUT. 4 products are relevant, the largest flow, as mentioned, being wooden pallets and boxes and wooden cable spools. The remaining categories are much smaller and consist of wooden barrels, plates and buckets as well as natural cork.

A total of 325 577 tonnes of **empty wooden packaging is supplied to the Danish economy**. The imports account for 199 495 tonnes of empty packaging, while 126 080 tonnes are produced in Denmark. Other supply is negligible. The main producer of wooden packaging in Denmark is the industry *Manufacturing of wood products*.

Danish use of empty wooden packaging is 218 078 tonnes. The main flows **of empty wooden packaging are used** in *Wholesale and retail trade* (76 766 tonnes), presumably for repacking of products, *Manufacture of machinery* (33 584 tonnes) and *Manufacture of basic metals* (17 556 tonnes).

104 946 tonnes of empty wooden packaging were exported. This is roughly half of the imports of empty wooden packaging. Thus, net imports of empty wooden packaging is 94 549 tonnes in 2018.

The **supply of filled wooden packaging** from Danish production is 218 078 tonnes and the industry allocation corresponds to the industries mentioned above for the empty packaging. In addition, 141 717 tonnes of filled packaging are imported to Denmark.

All products in the trade statistics can potentially be transported on wooden pallets (Danish Environmental Protection Agency, 2020c). For other wooden packaging (non-pallets), a few product categories can be highlighted for each flow:

Imported (non-pallet) wood packaging comes primarily with ceramic or porcelain laboratory equipment, citrus fruit and iron ore products. Washing and drying machines for clothes as well as refrigerators are also contributing to flows of wood packaging. Fresh vegetables, especially mushrooms and berries as well as wine also take place in the main flows. Import of safety glass for cars, boats etc. are also contributing.

Danish production of (non-pallet) filled packaging includes construction materials, bricks and concrete elements, different types of machines and pumps, wooden furniture and fruit and vegetables. Wood packaging is also used for cigars, jewelry and wine, but the amounts are smaller.

For **exports** of (non-pallet) filled wooden packaging, the largest contributor is, just like it is for imports, laboratory equipment made of ceramics or porcelain. In addition, blending and drilling machines, pumps and generators also bring a lot of wooden packaging out of the country. Refrigerators and freezers contribute, as well as citrus and other fruit exports.

The **use of filled wooden packaging** in Danish industries (intermediate consumption) is 102 558 tonnes. The main flows are used in *Construction* (45 603 tonnes) and *Manufacturing of food products etc.* (17 955 tonnes). Exports of filled wooden packaging is 222 920 tonnes, while private consumption and other final use is 34 317 tonnes.

After products are unpacked, the residual wood packaging is collected as waste. The amount of wooden packaging waste is, however, smaller than the total domestic use of filled wooden packaging, resulting in a balancing post of 66 647 tonnes.

The main flows are collected from *Households* (5 548 tonnes), *Wholesale and retail trade* (3 435 tonnes) and *Manufacturing of machinery* (2 534 tonnes).

In addition to the sorted wooden packaging waste, it is estimated that there is 54 878 tonnes of wooden packaging waste in other waste fractions (such as mixed construction waste and bulky waste from households).

A topic for further research on material flows of wooden packaging is to investigate the flows and characteristics of return vs. single-use wooden pallets, including the flows of repaired wooden pallets to and from the economy.

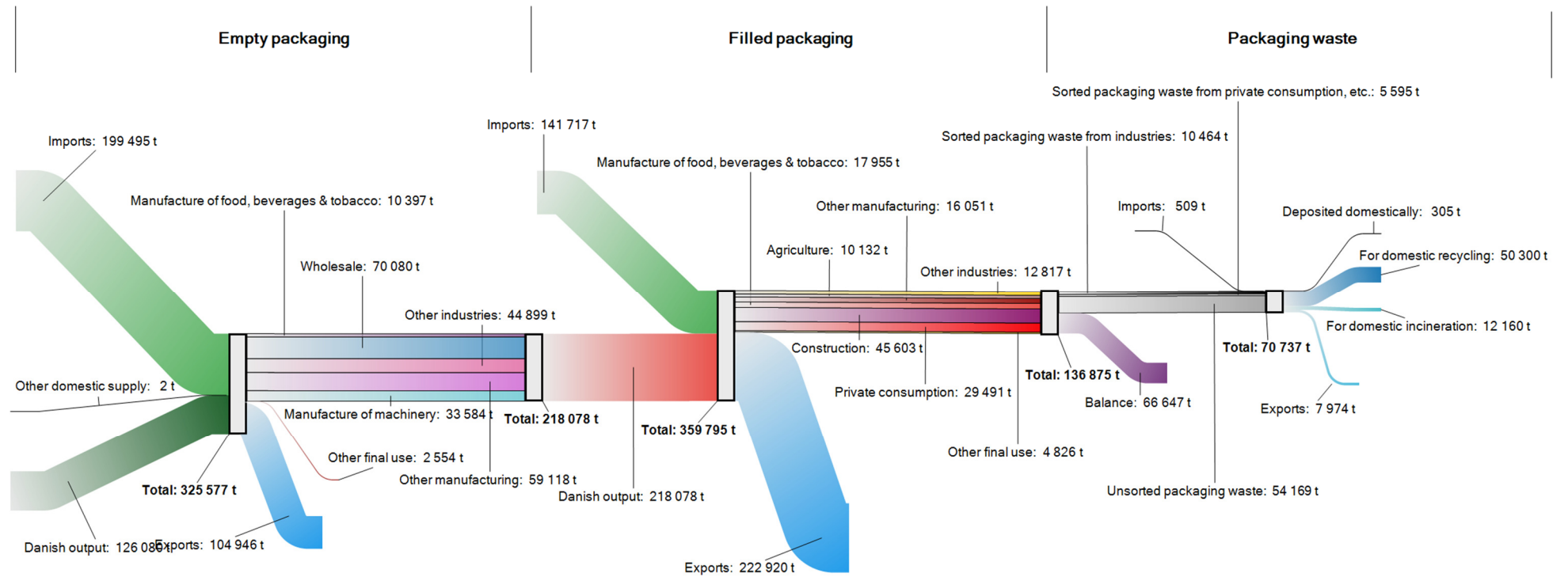
Table 23. Supply of wooden packaging

	Empty packaging	Filled packaging	Sorted packaging waste	Estimated unsorted packaging waste
	Tonnes			
Total supply	325 577	359 795	16 059	54 678
Output from industries, total	126 080	218 078	10 464	30 015
10600 Agriculture, etc; Mining and quarrying	8	2 343	7	276
10120 Manufacture of food products, beverages and tobacco	370	10 397	303	9 081
13150 Manufacture of textiles and leather products	21	463		6
16310 Manufacture of wood, wood products, furniture and other manufacturing	124 470	7 005	368	244
17000 Manufacture of paper and paper products		6 830	36	161
18000 Printing etc.		698	5	50
20000 Manufacture of chemicals	34	5 395	26	17
21000 Pharmaceuticals			5	8
22000 Manufacture of rubber and plastic products	145	4 593	265	38
23000 Manufacture of other non-metallic mineral products		8 963	173	498
24250 Manuf. of basic metals and fabricated metal products	986	17 556	653	113
26270 Manufacture of electronic components and electric equipment	5	5 185	51	28
28000 Manufacture of machinery	13	33 584	2 534	323
35000 Electricity, gas, steam and air conditioning supply			20	46
38391 Collection of waste for incineration		1		
38393 Other waste management services and materials recovery, etc.		7 608	63	
41430 Construction			1 003	17 170
45470 Wholesale and retail trade, etc.		76 766	3 435	38
49000 Land transport and transport via pipelines		6 490	262	15
52000 Support activities for transportation		10 339	474	
55560 Accommodation and food service activities			1	737
80820 Security; services to buildings and landscape; other business service activities		7 672	38	66
99999 Other industries	28	6 190	742	1 100
Other supply, total	199 497	141 717	5 595	24 663
Waste from private consumption			5 548	24 015
Disposals and scrap from capital, etc.	2			
Reductions in inventories, etc.				
Other supply			47	139
Imports	199 495	141 717		509

Table 24. Use of wooden packaging

	Empty packaging	Filled packaging	Sorted packaging waste	Estimated unsorted packaging waste
	Tonnes			
Total use	325 578	359 795	16 059	54 680
Intermediate consumption, total	218 078	102 558	16 057	46 403
10600 Agriculture, etc; Mining and quarrying	2 343	10 280		
10120 Manufacture of food products, beverages and tobacco	10 397	17 955		
13150 Manufacture of textiles and leather products	463	366		
16310 Manufacture of wood, wood products, furniture and other manufacturing	7 005	758		
17000 Manufacture of paper and paper products	6 830	832		
18000 Printing etc.	698	475		
20000 Manufacture of chemicals	5 395	1 572		
21000 Pharmaceuticals		424		
22000 Manufacture of rubber and plastic products	4 593	1 043		
23000 Manufacture of other non-metallic mineral products	8 963	3 014		
24250 Manuf. of basic metals and fabricated metal products	17 556	1 180		
26270 Manufacture of electronic components and electric equipment	5 185	685		
28000 Manufacture of machinery	33 584	3 688		
35000 Electricity, gas, steam and air conditioning supply		3 094		
38391 Collection of waste for incineration	1	18	976	11 184
38393 Other waste management services and materials recovery, etc.	7 608	104	15 081	35 219
41430 Construction		45 603		
45470 Wholesale and retail trade, etc.	76 766	3 789		
49000 Land transport and transport via pipelines	6 490	295		
52000 Support activities for transportation	10 339	474		
55560 Accommodation and food service activities		2 618		
80820 Security; services to buildings and landscape; other business service activities	7 672	124		
99999 Other industries	6 190	4 167		
Other use, total	107 500	257 237	2	8 277
Private consumption		29 491		
Capital formation	798	3 369		
Increases in inventories, etc.	1 756	1 267	2	303
Other use		190		
Exports	104 946	222 920		7 974

Figure 5 . Sankey diagram for wooden packaging



4. Indicators for the circular economy of packaging

Packaging make up a significant flow of materials in the Danish economy. It is therefore relevant to look at the degree of circularity in packaging material flows and explore if indicators for measuring the degree of circularity in packaging material use can be developed based on the packaging accounts.

In order to quantify the degree of circularity in an economy, Eurostat has proposed the application of the Circular Material use Rate (CMUR). Expressed in simple terms, CMUR measures the share of material recovered and fed back into the economy – thus saving extraction of primary raw materials – in overall material use.¹⁷ Even though CMUR generally concerns all materials used in a given economy, Eurostat also proposes CMUR for the measurement of the use rate of specific materials.

$$\text{CMUR} = \frac{U}{M} = \frac{U}{(\text{DMC} + U)}$$

U is the amount of sorted waste collected for recycling inside the Danish borders or exported for recycling abroad. U does not include imported waste. U is assumed to replace new raw materials. M is the sum of the domestic material consumption (DMC) and U. Normally the input for domestic material consumption will represent extraction of materials as well as import.

CMUR is however not directly applicable to packaging, as there is no domestic extraction of packaging – by definition, as packaging is not extracted (from nature), but produced (in the economy). Also, the flows of e.g. paper packaging are subsets of the overall flows of other paper inputs, products and residuals – recycled packaging material may become non-packaging products, and packaging may be produced from recycled non-packaging waste. So DMC, and in turn CMUR, cannot meaningfully be calculated for packaging.

Extraction of raw material for and manufacturing of packaging as well as recycling of the materials does not happen inside Denmark for all the considered materials. Raw materials for production of glass packaging are mainly extracted in Denmark. Glass is also recycled in Denmark. Virgin raw materials for production of paper packaging is imported. Paper collected for recycling may be processed in Denmark and often to other products than packaging. Raw materials for production of plastic packaging is imported. Plastic waste collected for recycling is only partly recycled as the quality of mixed plastic types is varying.

In order to develop an indicator valid for different packaging materials CMUR is proposed to be replaced by CMUR*.

$$\text{CMUR}^* = \frac{U}{M} = \frac{\text{Packaging waste sorted for recycling}}{\text{Total domestic use of filled packaging}}$$

U is unchanged. For M, we use ‘Total domestic use of filled packaging’ which is equal to Production + Import – Export of filled packaging. CMUR* then express the willingness and ability to sort packaging waste for recycling. CMUR*, as well as U and M, for the five packaging materials are presented in table 25.

¹⁷ Eurostat (2018), *Circular material use rate. Calculation method.* 2018 edition. <https://ec.europa.eu/eurostat/documents/3859598/9407565/KS-FT-18-009-EN-N.pdf/b8efd42b-b1b8-41ea-aaa0-45e127ad2e3f>

Table 25. Indicators for circular material use of packaging

	Domestic use of	Sorted	CMUR*	Recycling rates,
	filled packaging	packaging	(U / M)	DEPA ¹
	(M)	waste (U)		
	Tonnes		Per cent	
Plastics	247 492	55 433	22.4	31.3
Paper and cardboard	469 726	362 364	77.1	99.7
Glass	180 929	155 021	85.7	82.4
Metal	62 541	14 729	23.6	80.0
Wooden	136 875	16 059	11.7	45.7

Plastic bottles, glass bottles, aluminium cans and wood pallets included in the Danish deposit scheme for beverage packaging and European system for EU-pallets are not included in 'sorted packaging waste'.

¹ DEPA, *Packaging Statistics 2018*

For comparison, recycling rates from the Danish Environmental Agency (DEPA) have been included in Table 25 as the CMUR* is quite similar to what is understood by 'recycling rate'. For some packaging types, there are significant differences between the two indicators. The differences can in some cases be explained by different methodologies, for instance, the different treatment of reused packaging (wooden pallets, glass bottles) and the different conversion from alternative units to tonnes (especially paper and cardboard packaging). In other cases, an explanation of the differences will need further investigation (metal packaging), cf. Section 2.3.

The CMUR* indicators in Table 25 show that glass and paper packaging are close to the limit for potential recycling, as very high shares of these types of packaging waste are sorted and collected for recycling. Plastics, in the other hand, is far from the limit for potential recycling as just 22.4 per cent of domestic use is sorted for recycling.

The significant flow of beverage packaging through Dansk ReturSystem A/S covering recycling of glass, plastics and aluminium as a part of the Danish deposit scheme is not included in the amounts of material for recycling (total sorted packaging waste). Therefore, the actual recycling rate is higher.

Table 26 shows the share of packaging waste in total waste, in total and by packaging material types. This can be interpreted as an indicator for the waste reduction potential of packaging – if we limit (single use) packaging, how much of an effect will it have on total waste flows? All packaging waste, including the balance, make up 9.1 per cent of total waste. The largest shares are paper and cardboard, plastic and glass packaging. Note that total waste includes also construction waste.

Table 26. Packaging waste as share of total waste

	Packaging waste, total	Plastics	Paper and cardboard	Glass	Metal	Wooden
		per cent				
Total packaging waste	7.6	1.4	3.9	1.5	0.2	0.6
Total packaging waste, incl. balance ¹	9.1	2.1	3.9	1.5	0.5	1.1

¹ The balance item is explained in Section 2.5