Material Flow Analysis

and

Value Chain Analysis

for the

UK Plastics Sector

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Contents

Glossary

EP	Epoxy resins
EPS	Expanded polystyrene
HDPE	High density polyethylene
LDPE	Low density polyethylene
LLDPE	Linear low density polyethylene
PERN	Packaging Waste Export Recovery Note
PET	Polyethylene terephthalate
PH	Phenolic resins
PP	Polypropylene
PRN	Packaging Waste Recovery Note
PS	Polystyrene
PVC	Polyvinyl chloride
SIC	Standard Industrial Classification
UPE	Unstaurated polyester resins
WRAP	Waste Resources Action Programme

1. Introduction

1.1 Objectives, data sources and report structure

This report has been produced as part of the EPSRC-funded research project, *Carbon Calculations over the Life Cycle of Industrial Activities* (CCaLC).[1] The objectives of the report are:

- to map the physical flows of plastics in the United Kingdom, from their initial production, through their conversion and use, to their final disposal;

- to provide estimates of the economic (monetary) values of those flows;

- to estimate the value added per tonne of output for the main processes in the lifecycle system for plastic materials.

The report is divided into two sections. Following a brief overview of the UK plastics sector in this introductory section, a <u>material flow analysis</u> of the plastics lifecycle system is undertaken in section 2 of the report. In section 3, prices for the various flows are derived in order to provide a <u>value chain analysis</u> of the system.

The analysis draws on data from a number of different sources; the main ones being:

- PRODCOM Sales and Trade data

  PRODCOM (PRODucts of the European COMmunity) is an EU-wide survey of production for the manufacturing industries. Sales volume and value data is collected from a representative sample of UK companies in around 250 different industries for around 4,400 product categories. This is grossed-up and collated with trade data provided by Customs and Excise. In addition, information is provided at the industry level for the sales value of waste products, non-manufacturing income, and total sales.

  Data for the relevant industries was downloaded from the EUROSTAT PRODCOM database (http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/data/database). For primary plastics, this only contained sales data for 2006 and 2007, so data for earlier years was taken for the PRODCOM reports for that industry published by the Office of National Statistics (http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=9660).

- EUROSTAT External Trade database

  The EUROSTAT External Trade database (http://epp.eurostat.ec.europa.eu/portal/page/portal/external_trade/data/database) provides data on imports and exports of products at the CN8 (Combined Nomenclature 8 digit) level – which is equivalent to the PRODCOM product classification. It was used to provide data for the imports and exports of waste plastics and to derive the average weight conversion factors for products where sales volume data was reported in units other than kilograms / tonnes.

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[1] EPSRC Research Project: EP/F003501/1

- Waste Watch Report: *Plastics in the UK Economy*

  This report – published by Waste Watch in 2003 – reviews the production and consumption of plastics in the United Kingdom for the year 2000 and assesses the opportunities for recycling. It covers seven consumption sectors: packaging; automotive; electrical and electronic; building and construction; agriculture and horticulture; medical; furniture and house-wares. The report contains (as an annex) a plastics mass balance analysis for the UK, undertaken by Bowman Process Technology as part of the Biffaward Programme on Sustainable Resource Use.

- WRAP Report: *UK Plastics Waste – A review of supplies for recycling, global market demand, future trends and associated risks*

  This report – published by WRAP[2] in November 2006 – assesses the quantities of plastic waste arisings from four sectors (packaging; agriculture; end-of-life vehicles; electronic and electrical equipment) and reviews the domestic and international demand for recovered plastics. For packaging, it provides detailed breakdowns of the composition of consumption, waste arisings and recovery by application and polymer for 2005.

- WRAP Market Situation Report: *Realising the value of recovered plastics*

  This report – published by WRAP in the autumn of 2007 – assesses the key factors influencing the market for recovered plastics; movements in prices; the environmental benefits from recycling plastics; and the relationship between virgin and recovered plastics markets. It provides information on the composition of plastics demand by end-market and by polymer for 2005, plus information on the prices of processed recovered polymers.

- letsrecycle.com: Plastic Prices Archive

  On its website (http://www.letsrecycle.com/prices/plastics/), letsrecycle.com provides an archive database of the prices paid for used plastic film and bottles delivered to a UK merchant, or reprocessing business and for use overseas. Monthly prices are provided since 2000, with a distinction being between different polymers (i.e. LDPE, HDPE, PET, etc.) and colour (i.e. clear, single colour, mixed colours, etc.).

Other sources are used for specific pieces of information required for the analysis. These are identified where they are used.

1.2 Overview of the UK plastics sector

There are many different types of plastics; with these being used in wide variety of applications. *Plastics Europe (2008)* provides a useful taxonomy of the different types, which is reproduced in Figure 1.1. Plastics is one of three sub-groups of synthetic polymers; the others being synthetic elastomers and synthetic fibres. Essentially, these three sub-groups correspond to the following Standard Industrial Classification (SIC)[3] classes:

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[2] Waste Resource Action Programme.

[3] UK Standard Industrial Classification of Economic Activities 2003 – UK SIC (2003)

- 24.16 Manufacture of plastics in primary forms
- 24.17 Manufacture of synthetic rubber in primary forms
- 24.70 Manufacture of man-made fibres

Within plastics, a distinction is made between thermoplastics, polyurethanes (which together constitute plastic materials) and other plastics; with the last comprising thermosets, adhesives, coatings and sealants. Thermoplastic polymers soften when heated and harden when cooled. They can be-reheated and re-heated repeatedly, and hence are capable of being recycled. In contrast, thermosets undergo a chemical change when they are first heated and do not soften during subsequent re-heating. Hence they are not capable of being recycled, other than for use as an inert filler.

Figure 1.1   Plastics Taxonomy

Synthetic Polymers	Plastics (SIC 24.16)	Plastic Materials	Thermoplastics	Standard Thermoplastics
				Engineering Thermoplastics
			Polyurethanes	
		Other Plastics	Thermosets	
			Adhesives	
			Coatings	
			Sealants	
	Synthetic Elastomers (SIC 24.17)			
	Synthetic Fibres (SIC 24.7)			

Source: Plastics Europe (2008)

A distinction is made between standard thermoplastics and engineering thermoplastics. The former have limited stress and low temperature resistance, and are used mainly for inexpensive or disposable products and packaging; while the latter have higher strength and thermal resistance, and are used in applications requiring wear resistance, long life expectancy, flame resistance and / or the ability to endure cyclic stress loading. The main standard thermoplastics are:

- low density polyethylene (LDPE)
- high density polyethylene (HDPE)
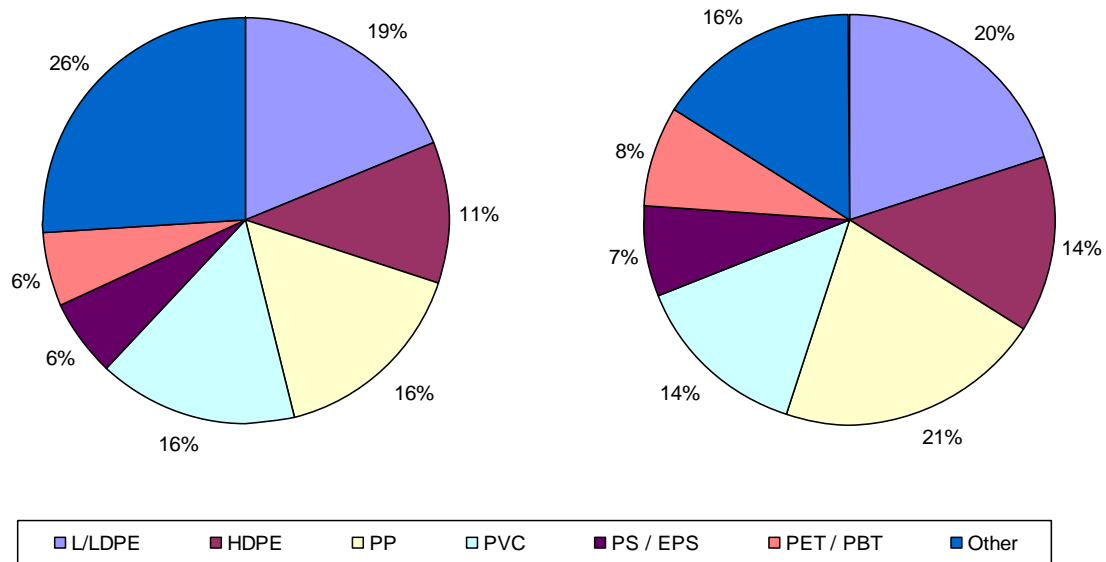- polypropylene (PP)
- polystyrene (PS)

- expanded polystyrene (EPS)
- polyvinyl chloride (PVC)
- polyethylene terephthalate (PET)

Figure 1.2 shows the composition of UK demand for plastic materials in 2005, together with the composition for Western Europe (for 2007); from which it can be seen that these standard thermoplastics account for the large majority of total demand (i.e. 74-84%). Four polymers alone – high and low density polyethylene (HDPE and LDPE), polypropylene (PP) and polyvinyl chloride (PVC) – account for around two-thirds of total demand.

Figure 1.2   Demand for plastic materials by polymer type

a)   United Kingdom (2005)   **b)   Western Europe (2007)**

| ■ L/LDPE | ■ HDPE | □ PP | □ PVC | ■ PS / EPS | ■ PET / PBT | ■ Other |

Sources: a)   WRAP (2007)

b)   Plastics Europe (2008)

Table 1.2 shows the main applications of the various standard thermoplastics. All six polymers are used in the production of packaging products to varying degrees; with HDPE / LDPE and PET being used for bottles, while the other three are used for food containers and trays. However, packaging is by no means the only application, with the polymers also being used (*inter alia*) in building sector applications (PET and PVC); for thermal insulation (PS and PVC); and in the production of electrical components (PP), automotive parts (PVC) and house-ware goods.

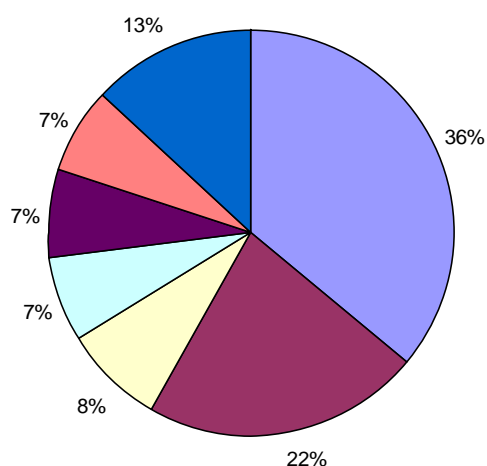**Table 1.2   Main applications of standard thermoplastics**

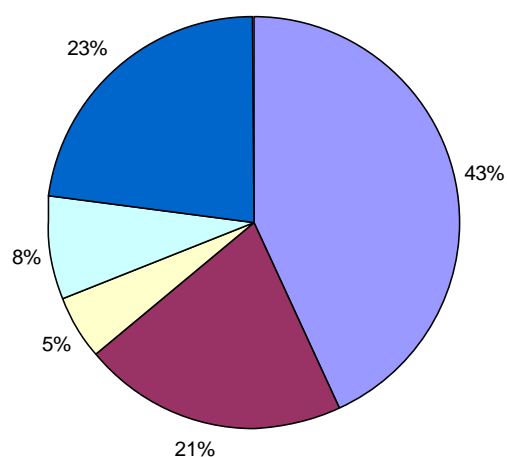| Polymer	Main applications
HDPE / LDPE	Milk bottles, cleaner and shampoo bottles, toys, packaging film and carrier bags
PET	Fizzy drink and water bottles, trays, building sector applications
PP	Microwaveable meal trays, electrical components, wall coverings, vehicle upholstery
PS	Food containers, plastic cutlery, protective packaging for electronic goods and toys, house-ware elements, insulating material
PVC	Pipes, window and door frames, thermal insulation, automotive parts, food trays, bottles, films

Source: WRAP website

Figure 1.3 provides a breakdown of the demand for plastic materials by end-market application, again with a comparative breakdown for Western Europe. As with the composition by polymer type, the United Kingdom is fairly typical of Western Europe as a whole.[4]

Figure 1.3   Demand for plastic materials by end-market

a)   United Kingdom (2005)   **b)   Western Europe (2007)**

Sources: a)   WRAP (2007)

b)   Plastics Europe (2008)

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[4] The figures for Western Europe do not break out furniture and homeware, or agriculture; these being included in other end markets.

Not surprisingly – given their preponderance in the list of applications for standard thermoplastics – packaging and building / construction are the two largest end-markets for plastic materials; with the former accounting for around one third of total demand, and the latter, over twenty percent. The other four identified end-markets are of similar sizes, each accounting for around 7-8% of total demand.

Plastics are used to make a wide variety of products (both end-products and intermediate components) and as inputs to the production of multi-material products. Broadly, these are covered in official statistics by the Standard Industrial Classification group SIC 25.2, Manufacture of Plastic Products, and the associated PRODCOM product codes. However, unlike primary plastics, the fit is less precise. For the purposes of official statistics, companies are assigned to a particular industry according to their main production activity; with the list of "published", or "identified", products for that industry reflecting the products that they manufacture. Unfortunately, the manufacturers of some plastic products are assigned to other industries, with the products being subsumed within the product classes identified for those industries. Consequently, these products cannot be identified in PRODCOM, or other official statistics.

Table 1.3 provides a list of the plastic products that are identified within the official statistics and those that are not. As can be seen, the list of unidentified products contains some reasonably significant product classes (e.g. plastic furniture). While it is not possible to obtain official data on these product classes, some information is provided in market research reports. In addition, the aggregate quantity of plastics used in their production can be inferred by comparing the total supply of plastics with the aggregate demand for the identified products.
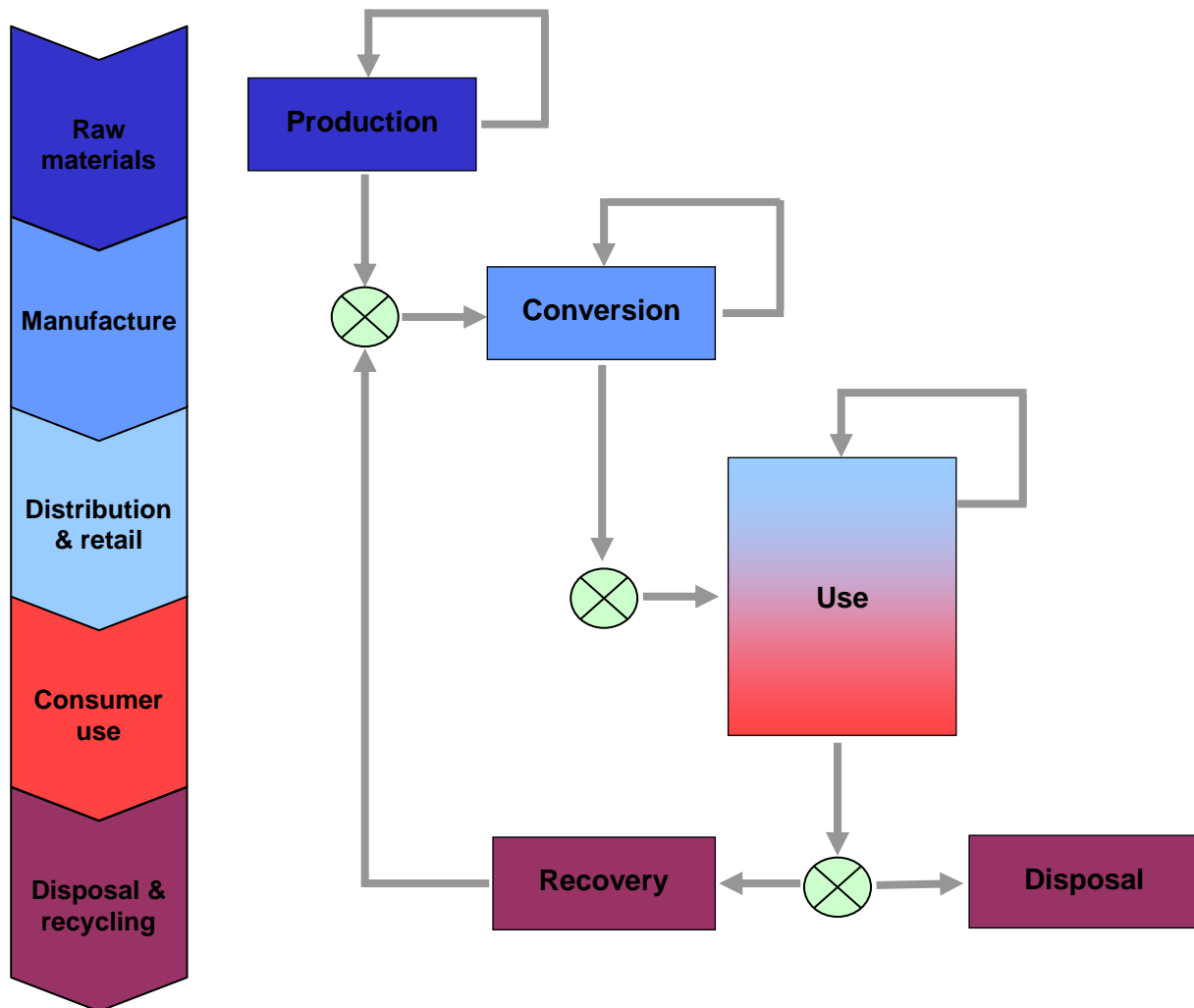
Table 1.3   Coverage of plastic products in official statistics

Identified products (SIC 25.2)	Unidentified products
▪ Plastic plates, sheets, tubes and profiles (SIC 25.21) ▪ Plastic packing goods (SIC 25.22) ▪ Builders' ware of plastics (SIC 25.23) ▪ Other plastic products (SIC 25.24)	▪ Plastic travel goods (incl. in SIC 19.20) ▪ Plastic footwear (incl. in SIC 19.30) ▪ Plastic medical and dental appliances (incl. in SIC 33.10) ▪ Plastic optical elements (incl. in SIC 33.40) ▪ Plastic furniture (incl. in SIC 36.1) ▪ Mattresses of uncovered cellular plastic (incl. in 36.15) ▪ Plastic sports requisites (incl. in 36.40) ▪ Plastic games and toys (incl. in 36.50)

2.   Material Flow Analysis

Figure 2.1 provides a high-level schematic representation of the process map that is used for mapping the physical (and monetary) flows through the "UK plastics system". It is based on the approach set out in the PAS 2050 guidelines for carbon footprinting (*Carbon Trust, 2008*).

Figure 2.1   High-level process map for the UK plastics system

For "business-to-consumer goods", the guidelines identify five process map steps; starting with raw materials, and moving through manufacture, distribution and retail, to consumer use and finally disposal and / or recycling. These steps are shown down the left-hand side of the figure.

This high-level process map comprises five broad processes – represented by the boxes. In the first step, various petrochemical inputs (not shown) are used to produce primary plastics (e.g. polymers, resins, etc.). These are converted into a wide range of plastic products in the second step. Because of the nature of plastic products – particularly packaging, the third and fourth stages are combined in a single process, termed use. This encompasses the use of plastic products in the manufacture of other goods, the distribution and retail of those goods,

and their final consumption. In the final step, the post-use waste plastics are either sent for disposal (which is assumed to be in landfill), or they are recovered. Each of these broad processes can potentially be broken down, either into more detailed sub-steps (e.g. separating out distribution and retail, etc.), or by different types of primary plastic (e.g. individual polymers, etc.), or by different types of plastic product. This is done to a certain extent in the following analysis; with the conversion and use processes both being broken down by product type.

Plastic materials flow down through the system (shown by the arrows), from production to eventual disposal. In order to simplify the diagram, it is assumed that waste is only generated by the use process. In reality, small amounts of waste plastic are generated during production and conversion, although much of this is recovered and re-used within the process – as depicted by the <u>feedback</u> arrows. For some plastic products the use process can last for many years, with the product being stored from one year to the next. In effect, this can be thought of as repeated internal recovery and hence is also depicted by a feedback arrow. In steady state, this feedback process has no impact. However, when use is growing, the resultant "stock-building" means that the outflows from the use process will be less than the inflows. In addition to the internal recovery within processes, a proportion of the waste plastic that is generated may be recovered and fed back into the conversion process.

The geographical boundary for the system is the United Kingdom. Flows across this boundary – in the form of imports and exports – are depicted by the light-green ⊗ symbols. Such flows may occur for primary plastics, for plastic products, or for waste plastic.

Each of the five processes is considered in turn; with estimates being made of the material inflows and outflows (measured in tonnes), together with the trade flows across the system boundary. Flows are calculated as the annual average for the years 2004-2007, although data is also provided for the individual years. Where it is available, data is also shown for the years 2000-2003, to provide some insights regarding the medium term trends.

2.1 Production

Table 2.1 provides a summary of UK production and trade volumes (in thousands of tonnes) for plastics in primary forms (i.e. SIC 24.16), derived from the reported PRODCOM data. The figures are broken down by the main thermoplastic polymers, total thermosets, polyurethane and miscellaneous other plastics.

Table 2.1   Supply of plastics in primary forms (average 2004 - 2007)

	(tonnes 000)			
	Production	**Exports**	**Imports**	**Supply**
LDPE	744.9	128.8	612.4	1,228.5
HDPE	19.5	0.9	479.8	498.4
PP	576.4	216.7	293.0	652.7
PVC	807.0	181.1	338.7	964.6
PS	114.2	118.7	56.1	51.6
EPS	13.0	1.6	47.9	59.3
PET [(1)]	400.0	132.0	112.0	380.0
Other TP	886.3	693.2	1,284.6	1,477.6
Thermoplastics	**3,561.3**	**1,473.1**	**3,224.5**	**5,312.7**
Thermosets	830.7	309.4	237.7	759.0
Polyurethane	78.9	40.7	46.4	84.6
Other	10.1	13.5	11.0	7.6
Total Plastics	**4,481.0**	**1,836.8**	**3,519.6**	**6,163.9**

Source: PRODCOM (except PET production)

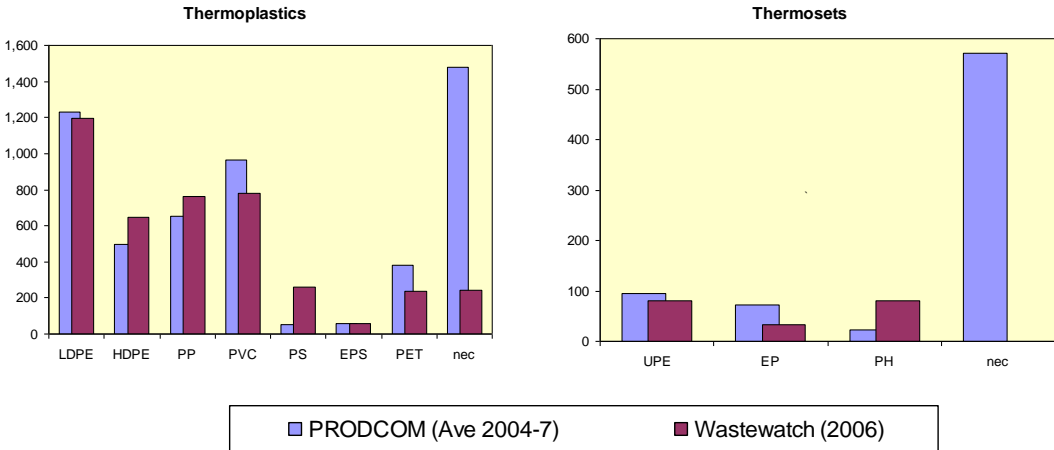(1) Estimated production volume for PET – see footnote [x]

Over the four years 2004–2007, reported annual production ranged from 2.7 million tonnes (in 2006) to 4.2 million tonnes (in 2004). However, in each year, production figures for around 40% of products were suppressed to preserve confidentiality, and hence the reported figures understate the actual production levels. Fortunately, the products that were suppressed vary from year-to-year and the majority of products have reported production data for at least one of the four years.[5] Consequently, production figures were estimated by calculating the average over the years for which data was reported. This still left nine products (i.e. 18% of the total) for which production volumes could not be estimated – including polyethylene terephthalate (PET). Given the importance of this polymer, production volumes were estimated (at around 400,000 tonnes per annum) based on the estimate of UK demand for PET.[6] The trade data was not subject to any suppression and hence the reported data provides a comprehensive picture of imports and exports.

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[5] 14 products (27.5% of the total) had reported production data for all four years; 14 products (27.5%) had reported data for three years; 8 products (15.7%) had reported data for two years; 6 products (11.8%) had reported data for one year. Only 9 products (17.6% of the total) had production data suppressed in all four years.

[6] Annual demand for PET by UK packaging producers averaged around 360,000 tonnes over the period 2004-7 (see section 2.3a). Since packaging accounts for around 92% of PET consumption (*Wastewatch, 2003*), this implies a total demand of around 380,000 tonnes.

After correcting the missing products, the estimated total supply of plastics in primary forms averaged around 6.2 million tonnes over the period 2004-7. This is considerably higher than the figure reported by Wastewatch, who estimated that the total supply was around 4.1 million tonnes in the year 2000. Even allowing for an average growth of 3%, total supply would only have grown to around 4.4 million tonnes by 2006 – some 30% less than the PRODCOM estimate. However, as can be seen in Figure 2.2, when the respective supply figures are compared for individual polymers, there is much more consistency between the two sources.

Figure 2.2   Supply of plastics (tonnes 000)

While there are some differences for the individual polymers, these are relatively small in magnitude and may well reflect definitional differences and the fact that the "grossed-up" Wastewatch figures do not allow for differences in growth artes between polymers. It is clear from Figure [x] that the main reason for the difference in the aggregate supply figures is that the Wastewatch figures omit a number of polymers and resins that are included in the PRODCOM figures. In particular, the Wastewatch figures do not include silicones, urea and melamine resins, acrylic polymers (excluding PMMA) and polymers of vinyl acetate (PVA) – which together accounted for almost 1 million tonnes of production according to PRODCOM. Consequently, it is believed that that the amended PRODCOM figures provide a more comprehensive and accurate view of the production and supply of plastics, and hence it us these that have been used in the analysis.

In addition to the supply of virgin plastics, it is estimated that, on average, around 200,000 tonnes of waste plastic packaging were recycled in the UK each year (see section x.x below), giving a total supply of plastics of around 6.4 million tonnes per annum.

2.2 Conversion

As was noted above, plastics are used in the production of a wide variety of products. Some of these are "identified" specifically as plastic products and are covered by SIC 25.2 and the associated PRODCOM codes (i.e. PRC 252xxxx). Others are not identified specifically in official statistics, being subsumed in other broader product classes. Because of this, the analysis of conversion – and the following analyses of use (section 2.3) and recovery / disposal (section 2.4) – only considers identified plastic products. Furthermore, because the focus is on plastic packaging (SIC 25.22), the other three classes – plastic plates, sheets, tubes and profiles (SIC 25.21); builders' ware of plastics (SIC 25.23); other plastic products (SIC 25.24) – are combined into a single class, other plastic products.

Figure 2.3   Use of plastics

For each of the two classes of identified plastic products, estimates are provided for production, exports, imports, and hence supply – based largely on PRODCOM data. In addition, the demand for plastics as an input to production is estimated for each class.

While unidentified products are not analysed, the demand for plastics in the production of these products is calculated as a residual – i.e. as the difference between total supply and total demand arising from the production of identified products. This provides a useful check on the validity of the estimates for the identified products.
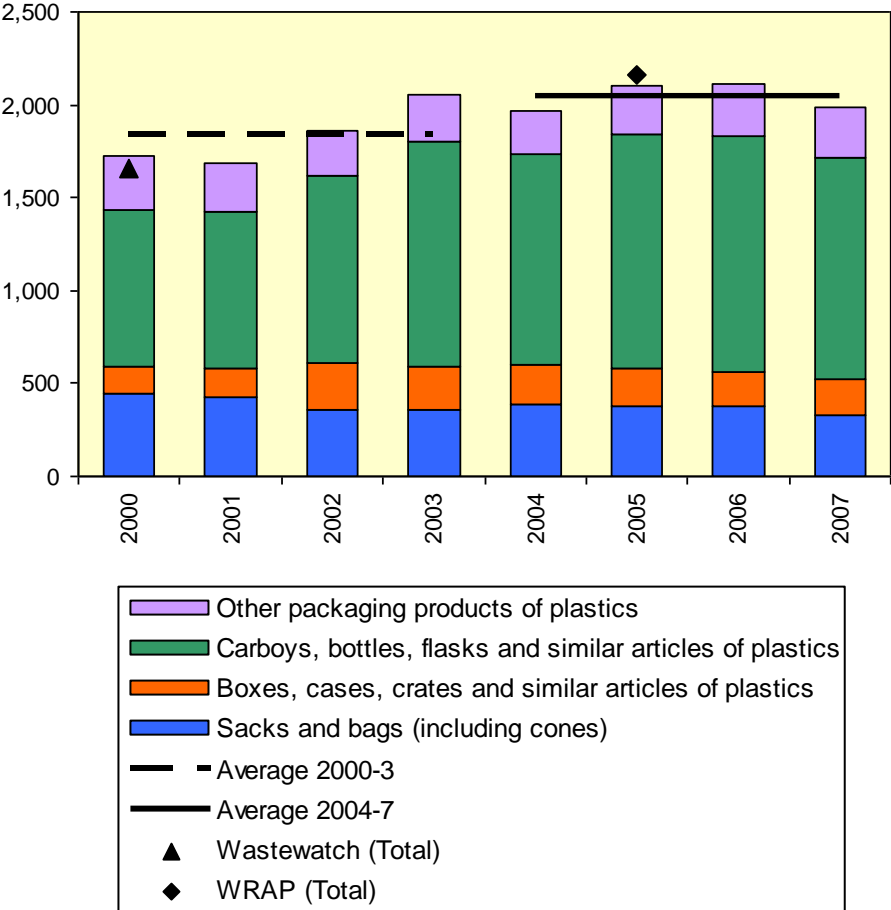
a)   *Plastic packaging*

Figure 2.4 shows total UK production of plastics packaging (i.e. SIC 25.22) for the years 2000 – 2007 as reported by PRODCOM, broken down into the four main sub-categories: sacks and bags; boxes, cases and crates; carbuoys, bottles and flasks; other packaging products.

Over the eight year period, there was an increase in the total production of packaging – with most of the growth occurring between 2001 and 2003. Average production for the period 2004-7 (at around 2 million tonnes) was around 12% greater than for the preceding four-year period – equivalent to an average growth rate of almost 3% per annum. Carbouys, bottles and flasks accounted for the majority of production (almost 60%), followed by sacks and bags (at 18%).

Also shown in Figure 2.4 is the estimate of total production reported in *Wastewatch (2003)* for the year 2000 (denoted by ▲) and the estimate of total production provided by *WRAP (2006)* for the year 2005 (denoted by ♦). Both of these are very close to the reported PRODCOM figures for the respective years (both being within 4% of the reported figures); providing confidence for the PRODCOM figures across the whole period.
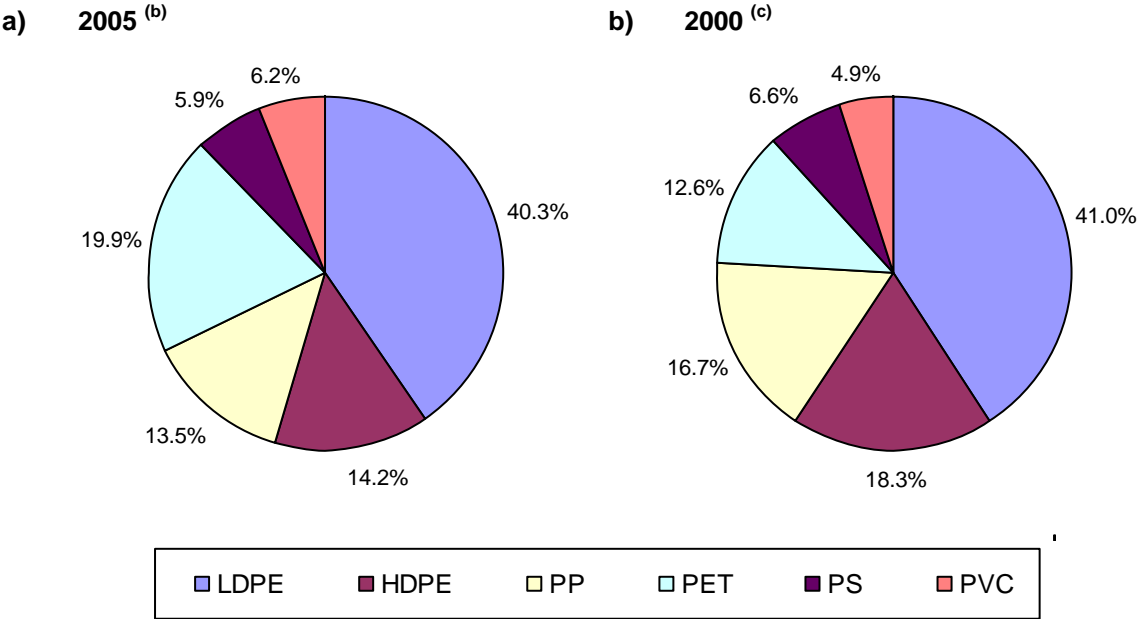
Figure 2.4   UK production of plastic packaging (tonnes 000)

According to *Wastewatch (2003)*, production scrap (net of internal recycling) amounted to around 5% of plastic material inputs in the year 2000 – i.e. the conversion rate was around 95%. Assuming that there was no significant change in the conversion rate over the following years, this implies that the demand for plastic materials by the UK packaging producers averaged around 2.1 million tonnes over the period 2004-7. This is consistent with the estimated demand of 2.16 million total tonnes in 2005 provided in *WRAP (2006)*.

Figure 2.5 provides breakdowns of demand for plastics by UK packaging producers by the six major polymer types for the years 2000 and 2005. Together, these six polymer types account for over 90% of total demand. There is a great deal of consistency between the two years, despite the different sources, although the use of PET appears to have grown between the two years at the expense of polypropylene (PP). LDPE is the most commonly used polymer

(accounting for around 40% of demand); followed by PET, HDPE and polypropylene, with each accounting for around 15-20% of demand.

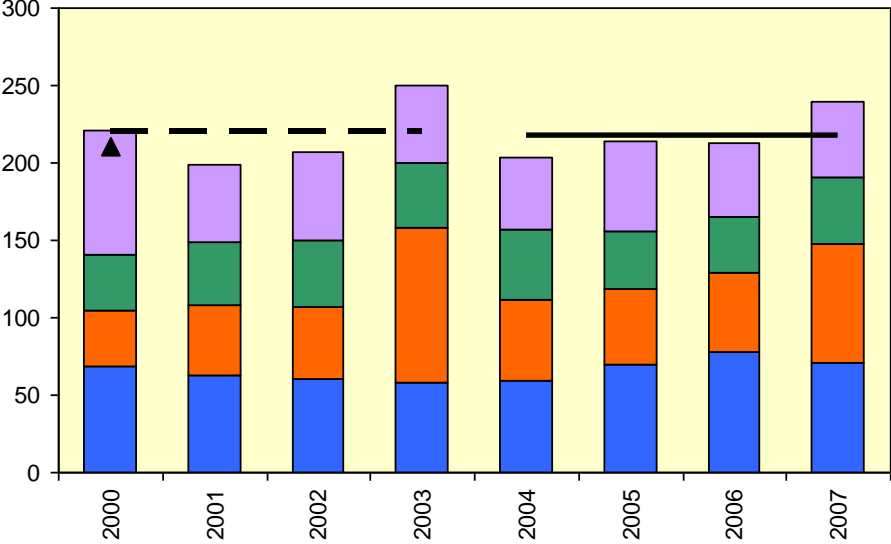**Figure 2.5   Composition of plastics demand by UK Packaging producers [a]**

a)   2005 [b]   **b)   2000 [c]**

(a)   Major polymers only

(b)   Source: *WRAP (2006)*, Table 2.1

(c)   Source: *Wastewatch (2003)*, Appendix A

Figure 2.6 provides information on the exports and imports of plastic packaging for the years 2000 – 2007, as reported by PRODCOM.   While there are a few annual discrepancies (notably for boxes and crates in 2003), exports of packaging have remained relatively stable at around 225,000 tonnes per annum.   In contrast, imports of packing grew steadily over the period – averaging around 740,000 tonnes over the period 2004-7 (x% greater than for the previous four years). Also shown are the figures reported by *Wastewatch (2003)* for the year 2000 (denoted by the ▲). While there is relatively close agreement for exports, the import figure is less than half that reported by PRODCOM for that year. The Wastewatch estimates imply a small net outflow of packaging (i.e. around 30,000 tonnes). This is at odds both with the PRODCOM figures and the net import figure of 314,000 tonnes for 2005 reported by *WRAP (2006)*.   While the WRAP net import estimate is less than the PRODCOM figure for that year (i.e. around 490,000 tonnes), it suggests that the PRODCOM figures provide a reliable picture of the trade flows for plastic packaging.[7]
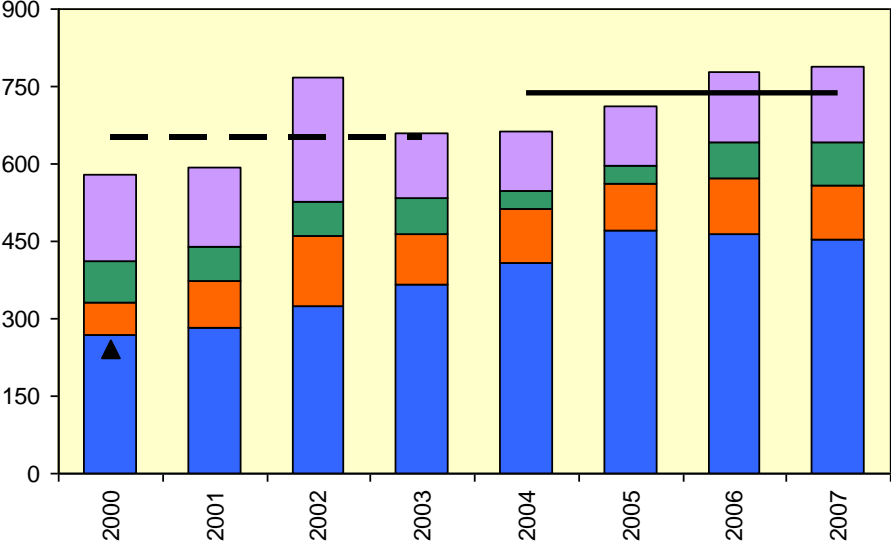
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[7] The WRAP estimates are based on comments from businesses and PIFA data for films (see footnote 21, WRAP, 2005), rather than official trade statistics.

Figure 2.6   UK trade of plastic packaging (tonnes 000) [a]
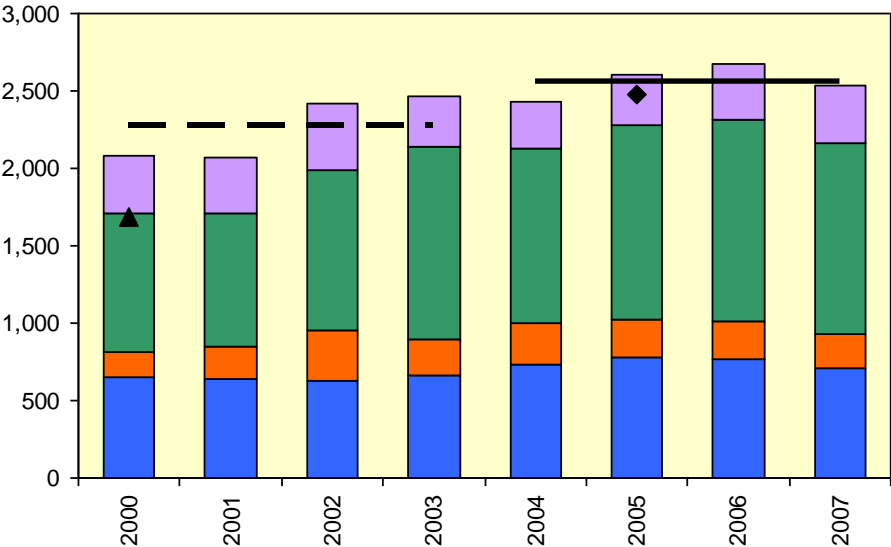
a) Exports

b) Imports

[a]   See Figure x for key

Source: PRODCOM (except ▲)

It should be noted that the trade figures shown in Figure 2.6 do not include the imports and exports of packaging materials imbedded in packaged goods (e.g. imports of bottled mineral water, etc.). The direction and magnitude of this "hidden" trade is discussed in section 2.3, the use of plastic packaging.

Combining the PRODCOM production and trade figures yields the figures for the total supply of plastic packaging shown in Figure 2.7. There was a significant growth in supply over the period, reflecting the growth in both production and imports. Average annual supply for the period 2004-7 – at slightly under 2.6 million tonnes – was around [x]% greater than for the

preceding four-year period. A detailed breakdown of the total supply figure is provided in Table 2.2, from which it can be seen that carboys, bottles and flasks accounted for almost half of the total.

Figure 2.7   UK supply of plastic packaging (tonnes 000) [a]

[a]   See Figure x for key

Source: PRODCOM (except ▲ and ♦)

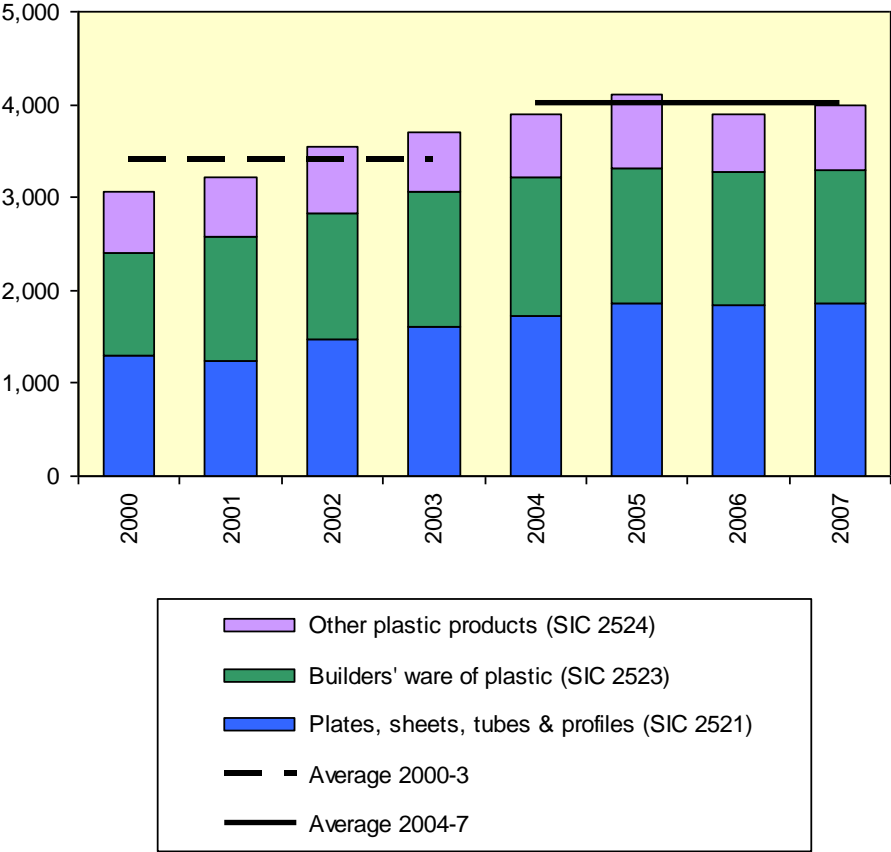**Table 2.2   Supply of plastics packaging (average 2004 – 2007)**

	(tonnes 000)			
	Production	**Exports**	**Imports**	**Supply**
Sacks & bags	368.1	69.8	448.4	746.8
Boxes, case & crates	197.8	56.7	102.3	243.4
Carbuoys, bottles & flasks	1,213.4	40.6	56.3	1,229.1
Other	263.3	50.1	128.5	341.6
Total packaging	**2,042.6**	**217.2**	**735.5**	**2,560.9**

Source: PRODCOM

b)   *Other plastic products*

Figure 2.8 shows UK production of other identified plastic products over the eight years 2000 – 2007, derived from the reported PRODCOM data. As was the case with packaging, production grew over the period, with production for 2004-7 (at around 4 million tonnes) being around 19% greater than for the preceding four-year period – equivalent to an average annual growth rate of around 4%.

Figure 2.8   UK production of other identified plastic products (tonnes 000)
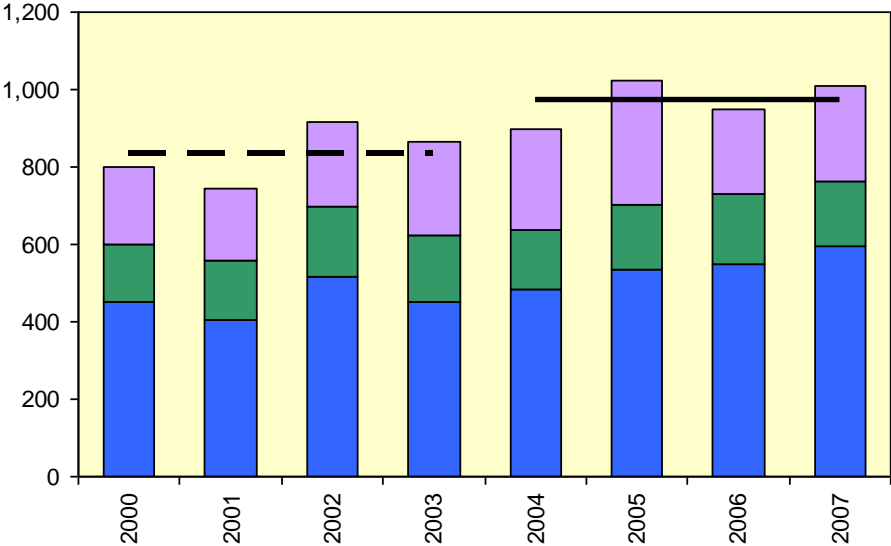

Source: PRODCOM

While most of the constituent products have production figures reported in tonnes, some have figures reported in square metres, or numbers of pieces; while others only report production value figures (in £000). Where volume figures are provided in other units, these were converted into tonnes using average weight factors, either derived directly from trade statistics, or calculated by comparing the average price of production with the average trade price.[8] Where only production value figures are provided, these were converted to tonnes using the average trade price. In each case, the underlying assumption is that the average weight and / or price of trade flows provide good approximations of the corresponding values for production. While this is the case for many products, it is not universally true. Consequently, the production estimates derived for individual products may be subject to a significant margin of error. However, in aggregate any errors may tend to cancel out and hence the overall estimate is likely to be reasonable.

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[8] For most products, import and exports are reported in both tonnes and units in the Eursotat COMEXT database. These data were used to provide an estimate of the average weight per unit. In some cases, data is only reported in tonnes and it is not possible to use this approach. In these cases the average weight was calculated by dividing the average price of production (£ per unit) by the average price of imports and exports (£ per tonne) – i.e. tonnes / unit = (£ / unit) / (£ / tonne).
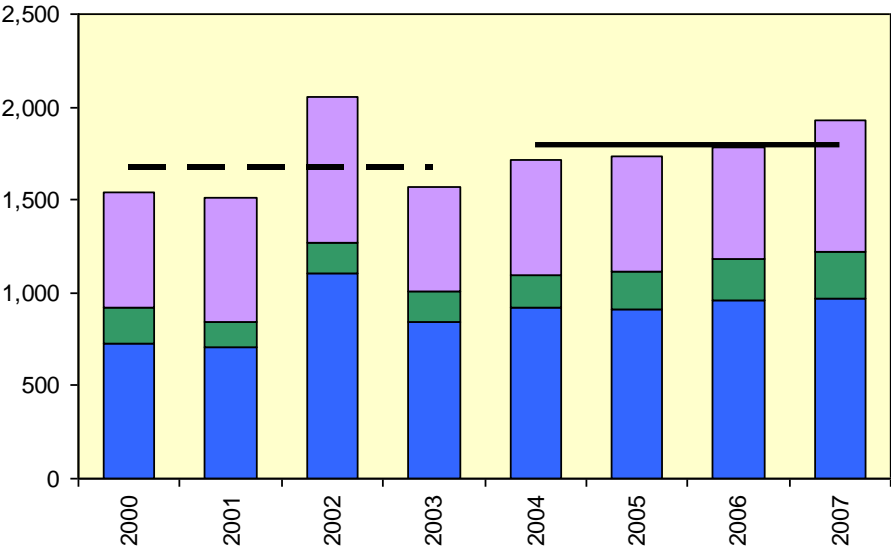
The figures for other plastic products (SIC 2524) do not include plastic components (PRC 25249010-97), for which no volume or price data was available during the period. However, the sales value of these products averaged around £1,200 million over 2004-7. Based on the average price in the latest years for which volume data is available (i.e. 1995-6), this would amount to a production volume of around 250,000 tonnes. Thus, it would seem reasonable that total production of other identified plastic products averaged around 4.25 million tones during 2004-7. Assuming that the conversion rate was similar to that for plastic packaging (i.e. c. 95%), this would imply a demand for plastic materials of around 4.45 million tonnes per annum.

Figure 2.9   UK trade of other identified plastic products (tonnes 000) [a]

a) Exports

b) Imports

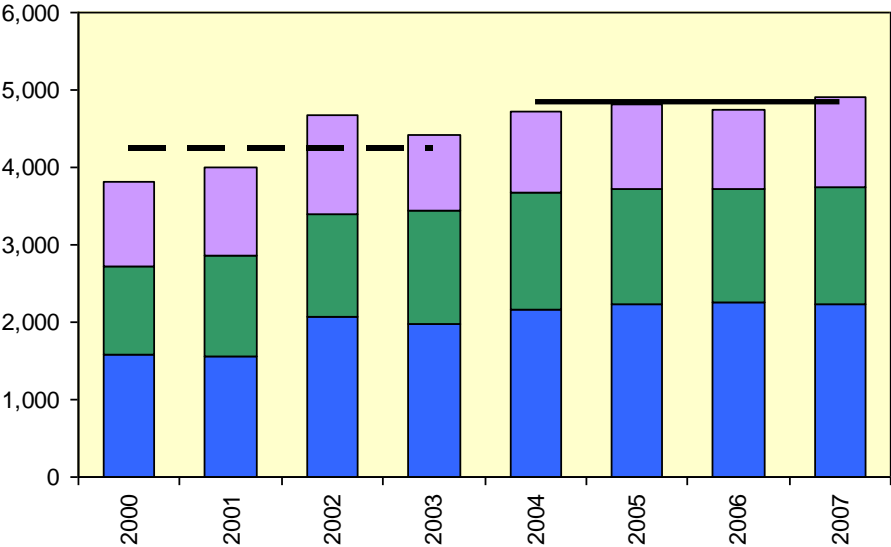[a]   See Figure x for key

Source: PRODCOM

Figure 2.9 provides information on the exports and imports of unidentified plastic products for the years 2000 – 2007, as reported by PRODCOM. While there are a few annual discrepancies (notably for imports of plates, sheets, tubes and profiles in 2002), both exports and imports show an increasing trend over the period. For the period 2004-7, exports averaged around [900,000] tonnes per annum, while imports averaged around 1.7 million tonnes per annum; giving a net inflow of around [800,000] tonnes per annum.

As with the production figures, the trade figures shown in Figure 2.9 do not include plastic components (PRC 25249010-97), for which trade data was only reported in two years – 2004 and 2005. In these years, reported exports averaged 875,000 tonnes, while imports averaged 1.675 million tonnes. If these years were typical, it suggests that total net imports are likely to have been closer to 1.6 million tonnes per annum over the period 2004-7, rather than the [800,000] tonnes reported in PRODCOM.

Figure 2.10   UK supply of other identified plastic products (tonnes 000) [a]

[a]   See Figure x for key

Source: PRODCOM

Figure 2.10 shows the resultant supply figures for other indentified plastic products for the years 2004 – 2007, based on the reported figures. There was a steady increase over the period, reflecting the underlying growth in production volumes – the net trade balance remained roughly constant. Average annual supply for the period 2004-7 was around 4.8 million tonnes, some 14% greater than for the previous four years. If allowance is made for the unreported plastic components, then average supply was probably closer to 5.8 million tonnes.

c)   Unidentified products

Together, the estimated demand for plastics for the production of packaging and for the production of other identified plastic products amount to around 6.5-6.6 million tonnes. This is slightly greater than the estimate of the total supply, at around 6.4 million tonnes. As was noted above, the supply figure is an underestimate, as it excludes the production of some

products (to preserve confidentiality). However, the magnitude of these suppressed production figures is not believed to be great. Consequently, the demand for plastics in the production of unidentified products is unlikely to be significant.
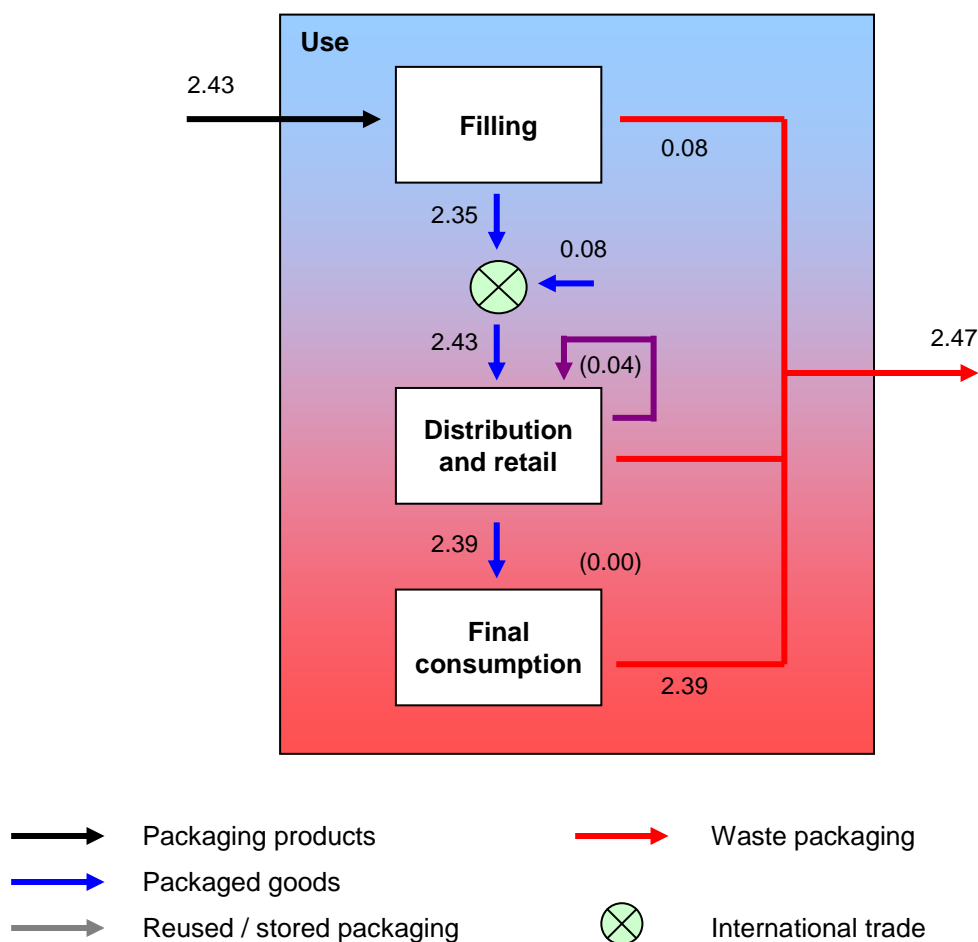
Wastewatch (2003) estimates the demand for plastics in the production of furniture and homewares (one of the main unidentified product categories) at 395,000 tonnes in 2000. On the basis of this figure, an estimate for the demand from the production of all unidentified products of around 500,000 tonnes seems plausible, giving a total demand figure of around 7 million tonnes per annum. If the production of the suppressed products amounted to around 200,000 tonnes (i.e. c.4% of total production), then this suggests that the estimates for the production of identified plastic products may be overstated by around 5%.

2.3 Use

a) Packaging

The use stage for packaging comprises three component steps (see Figure 2.11). In the first step, "packer-fillers" combine the packaging products with various manufactured contents to produce packaged goods.[9] These goods then pass through the distribution / retailing pipeline, before they are finally consumed. At this point, the packaging is separated from the content and enters the waste stream – either for disposal, or for recycling (see section 2.4 below). Smaller amounts of packaging may also enter the waste stream from the first two steps – i.e. in the form of packer-filler waste and / or redundant stock

Fig. 2.11   Packaging flows in the use stage (tonnes millions)

The total supply of packaging products to packer-fillers averaged around 2.43 million tonnes per annum over the period 2004-7 (see Table 2.2 above[10]). *Wastewatch (2003)* estimate that

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[9] These need not necessarily be consumed by individuals and households. They may also be consumed by businesses and other organisations.

[10] The estimated in Table [x] (i.e. 2.56 million tonnes) has been reduced by 5% to reflect the comments at the end of section 2.2.

packer-filler losses in the year 2000 were 3% of total packaging input, while losses from distribution and retail were minimal. This is consistent with the estimated 2.5% for the combined packaging losses from the two steps in 2005 provided by *WRAP (2006)*. Using the higher figure and assuming that all of the losses occurred at the packer-filler step would imply that the output of packaged goods by UK manufacturers contained around 2.35 million tonnes of packaging.

In addition to the packaging contained in UK manufactured packaged goods, account must also be taken of the packing contained in the imports and exports of packaged goods. *Wastewatch (2006)* estimate that the two flows cancelled out in 2000 (each being around 210,000 tonnes) and hence that there was minimal impact on the total volume of packaging entering the distribution / retail chain. However, since the UK is a net importer of consumer goods, this does not seem very plausible. Over the period 2004-7, net imports of consumer goods (excluding cars) averaged around £21.5 billion per annum (see Table 2.3). Over the same period, household consumption of goods averaged around £375 billion per annum. Assuming that households accounted for around 60% of the total consumption of packaged goods[11], this would suggest that net imports of packaging imbedded in packaged goods may have been as much as 80,000 tonnes.[12] Taking this into account would suggest that the total amount of packaging entering the distribution / retail chain averaged around 2.43 million tonnes per annum.

Table 2.3   Net imports of consumption goods and household consumption expenditure (£ billion)

	Exports	Imports	Balance	Household consumption
2004	15.8	35.1	(19.3)	353.8
2005	17.7	37.7	(20.0)	364.4
2006	18.7	40.7	(22.0)	380.4
2007	19.1	43.8	(24.7)	400.1
Average	**17.8**	**39.3**	**(21.5)**	**374.7**

Sources: Monthly Review of External Trade Statistics, September 2009 (Table E2)

Annual Abstract of Statistics, 2009 Edition (Table 16.14)

Most packaging has a relatively short life – entering the waste stream within the same year that it is produced. However, returnable transit packaging (RTP), intermediate bulk storage (IBS) and other reusable packaging may have several years of service life before they become waste. In steady state, this would not need to be taken into account, as the amount of packaging leaving carried forward to the next year would be exactly equal to the amount brought forward from the previous year. However, with growing use of plastic packaging, the amount carried forward will exceed the amount brought forward, resulting in a small "loss" in

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[11] This is based on the estimated household share of plastic packaging waste. In 2005, domestic plastic packaging waste was estimated to be 1332 kt, while total post-use waste was estimated at 2270 kt (WRAP, 2006 – table 2.2).

[12] The estimated value of total output of consumer goods by UK manufacturers is £603.5 billion (i.e. £375bn / 0.6 - £21.5bn). Thus, net imports of packaged goods is estimated to be 3.5% of domestic output (i.e. £21.5bn / £603.5bn) and hence volume of packaging is estimated to be c.80,000 tonnes (i.e. 3.5% of 2.35 mt).

each year.[13] *WRAP (2006)* estimate that this loss was around 40,000 tonnes in 2005 and this figure has been assumed for the analysis. A similar loss may also occur in the final consumption step due to storage of product packaging for re-use in the future.[14] Unfortunately, there are no estimates available for any such leakage, but it is unlikely to be significant. Consequently, the amount of packaging entering the waste stream from final consumption during the period 2004-7 is estimated to have averaged around 2.39 million per annum.

This estimate is only around 100,000 tonnes higher than the estimate derived in WRAP (2006), but it is significantly greater than the estimated quantity of waste plastic packaging used by Defra to monitor the recycling rates achieved under producer responsibility regulations[15], which averaged 2.0 million tonnes over this period. However, the Defra figures are based on forecasts provided to the Task Force of the Advisory Committee on Packaging (ACP) in November 2001, rather than on any measured data for the actual years. Consequently, the estimate derived above is believed to provide a more realistic view of the amount of waste plastic packaging entering the waste stream.

b) Other

The use stage for other identified plastic products will also comprise a number of steps. However, unlike the case of packaging, there is no information available on the internal flows and so it is not possible to analyse the stage in the same level of detail.

One of the main differences between packaging and other plastic products is that the latter have considerably longer service lives – i.e. there may be a considerable delay between the product being acquired and it finally entering the waste stream. If consumption is growing over time, then this will result in a discrepancy between the quantity consumed in a particular year and the quantity entering the waste stream. The magnitude of this discrepancy will depend on the length of the service life (L) and the underlying growth rate (r); with the waste-consumption ratio (WCR) being given by:

$$\text{WCR} \quad = \quad \frac{1}{(1+r)^L}$$

Figure 2,12 shows the relationship between the ratio and average service life for two different growth rates (3.5%pa and 5%pa). When the service life is short, the value of the ratio is equal to (or close to) one, as is assumed to be the case with packaging. However, when the service life is long, the value of the ratio can be significantly less than one. For example, if the average service life of the product is 15 years then the value of the ratio is around 0.5-0.6 depending on the growth rate.

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[13] The scale of the loss depends on the llength of the service life and the growth rate.

[14] The re-use of plastic bags will not have a significant impact as the service-life will still be less than a year. However, some consumers will keep packaging for durable products (e.g. in the loft) in case it is needed for future transit.

[15] Producer Responsibility Obligations (Packaging Waste) Regulations 1997.

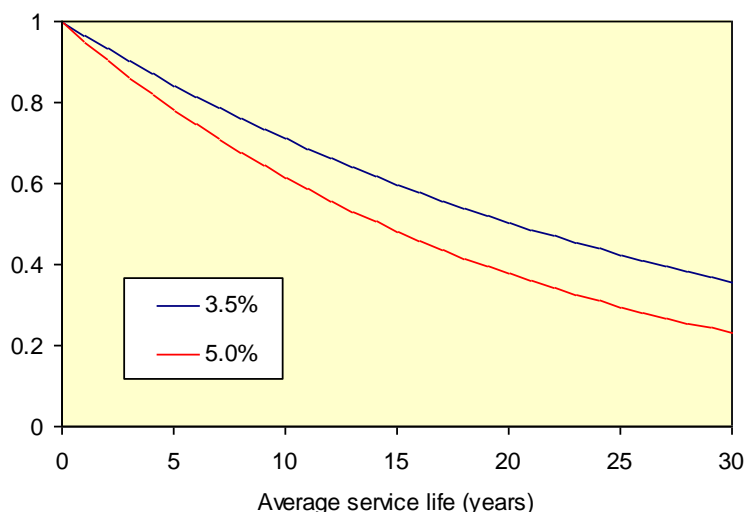**Figure 2.12   Waste-consumption ratio by average service life**

Table 2.4 shows the waste-consumption ratios estimated by *Wastewatch (2003)* for various product categories for the year 2000; together with the implied service lives under two different growth rate assumptions used in Figure [x]. The ratios range from 0.27 (for building and construction products) to 0.56 (for electrical and electronic products), with a weighted average value of 0.35. The implied service lives look implausibly high (particularly for agricultural products), but are probably overstated as growth prior to the year 2000 is likely to have been higher than for the subsequent years. Consequently, in the absence of any other information, the weighted average value is adopted for the analysis. Applying this value to the estimated UK consumption of other plastic products (equal to the total supply), yields an estimate for the quantity of plastic entering the waste stream of around 1.6 million tonnes per annum. This is considerably higher than the 1.0 million tonnes implied by the *Wastewatch (2003)* estimate for 2000, reflecting the higher estimate for total consumption.[16]

Table 2.4   Waste-consumption ratios for other plastic products (2000)

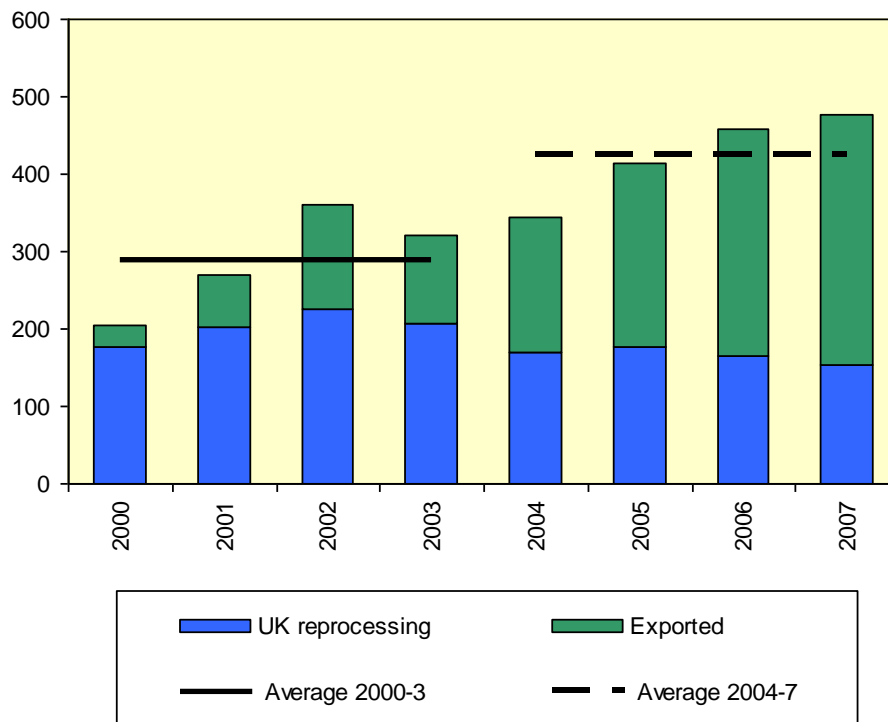| Product category	Waste Consumption Ratio	Implied service life (years)	
		Growth 3.5% pa	Growth 5.0% pa
Building & construction	0.27	39	27
Electrical & electronics	0.56	17	12
Automotive	0.45	24	17
Agricultural	0.30	36	25
Weighted average	**0.35**	**31**	**22**

Source: Wastewatch (2003)

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[16] *Wastewatch (2003)* estimate that the aggregate amount of plastic entering the waste stream for the identified product categories was around 730,000 tonnes in 2000. Assuming that the growth rate (in the past) was 5% per annum, this would imply that the figure would have grown to around 970,000 tonnes by 2006.

2.4 Recycling and disposal

a) Packaging

Since the introduction of the Packaging Waste Regulations in 1997, there has been reliable data on the quantity of waste packaging that has been recovered from the waste stream; with material-specific Packaging Waste Recovery Notes (PRNs) being issued by accredited reprocessors (on a one-for-one basis) for each tonne of packaging waste that is recycled in the UK, and Packaging Waste Export Recovery Notes (PERNs) being issued for each tonne of waste that is exported for recovery. PRNs and PERNs are purchased by businesses in the packaging chain to discharge their obligations under the Regulations and hence have a monetary value.[17] Because of this, very little waste packaging is recovered without a PRN / PERN being issued. Consequently, the returns from the accredited reprocessors provide a very good picture of the quantity of waste packaging that is diverted from the waste stream.

Figure 2.13   Recovery of waste plastic packaging (tonnes 000) [(a)]

Source: Defra and Environment Agency (National Waste Packaging Database)

(a) The PRN / PERN split for 2000 is based on the revenue split for that year

Figure 2.13 shows the quantities of plastic recovered for the years 2000 – 2007, based on the returns of accredited reprocessors. This shows that the amount of waste plastic packaging that was recovered from the waste stream grew significantly over the period; with recovery averaging around 425,000 tonnes per annum for 2004-7, almost 50% up on the preceding four-year period. This represented an average recovery rate over the period of approximately

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[17] The prices of PRNs / PERNs vary between materials, reflecting differences in the relative stringency of the respective recycling targets.

18%.[18] All of the growth was due to the increase in exports; with the amount of waste plastic packaging recycled in the UK declining slightly to an average of around 170,000 tonnes per annum.

A small amount of waste plastic is imported into the UK for reprocessing. Over the period 2004-7, it averaged around 60,000 tonnes per annum. It is reasonable to assume that that the large majority of this "packaging-like" waste, and it is therefore treated as waste packaging. This has the effect of increasing the quantity of waste plastic packaging that is recycled in the UK to around 230,000 tonnes per annum and to reduced the (net) quantity that is exported to around 200,000 tonnes per annum.

The reprocessing figures imply that – on average – slightly under 2.0 million tonnes of waste plastic packaging were sent for disposal each year over the period 2004-7. A small proportion of this would have been diverted through the incineration of municipal solid waste (MSW), but the large majority (i.e. around 95%) was sent to landfill.[19]

b) Other

End-of-life packaging accounts for the large majority of waste plastics that are recovered from the waste stream. However, the recovery of other plastic products and post-production scrap is growing. While the total quantity of plastics recovered from these products was negligible in 2005, *WRAP (2006)* forecasts that it would have grown to around 150,000 tonnes by 2008; a trend that is mirrored in the exports of non-packaging waste plastics.
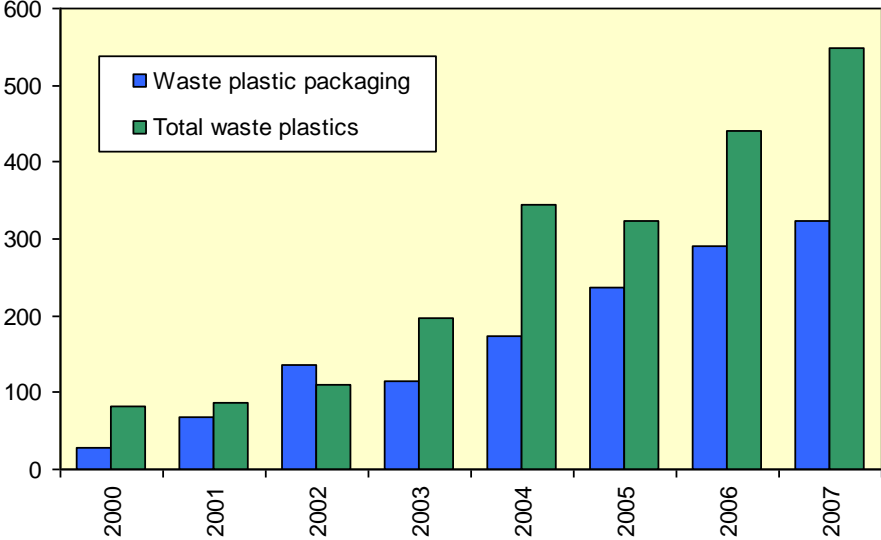
Figure 2.14 compares the total exports of waste plastics with the exports of waste plastic packaging (based on PERN data) over the period 2000 – 2007; with the difference between the two representing exports of other waste plastics. There is a clear divergence of the two series over the period. Exports of other waste plastics averaged around 150,000 tonnes per annum over the period 2004-7, compared with only around 30,000 tonnes per annum in the preceding four-year period.

Based on its consultations with exporters, *WRAP (2006)* concludes that a large proportion of these exports were post-production scrap from injection moulding of plastic bottles, with the balance comprising car components and other products. This would be consistent with the 5% production scrap rate for packaging converters estimated by *Wastewatch (2003)* (see section 2.2 above), and would suggest that exports of other waste plastic products averaged around 30,000 tonnes over the period. This would account for virtually all of the other plastic products recovered; which again, is plausible.

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[18] This is lower than the recovery rate reported by Defra over the period (i.e. around 21%), which is based on its lower estimate of the quantity of plastic packaging entering the waste stream.

[19] *Wastewatch (2003)* estimate that around 142,000 tonnes of waste plastic packaging were incinerated for EfW in 2000, representing around 30% of the total packaging recovered through the incineration of MSW. However, by 2006, the total recovery of packaging via the incineration of MSW had declined by around 30%, suggesting that the amount of waste plastic packaging diverted to EfW was probably closer to 100,000 tonnes.

Figure 2.14   Exports of waste plastics and waste plastic packaging (tonnes 000s)

Source: Defra and Environment Agency (NWPD) for waste plastic packaging

EUROSTAT for total waste plastics

2.5 Summary

The results of the preceding analyses are brought together in Figure 2.15. This shows the plastic material flows through the various stages; distinguishing between flows of plastics in primary forms, plastic products, waste plastic and recovered plastic. The trade flows represent net imports for plastics in primary forms and plastic products; and represent net exports for recovered waste plastics.

The figures have been adjusted to take account of the issues highlighted in the analyses and to impose consistency between the stages – i.e. to force equality between supply and demand. In particular:

- the production of plastics in primary forms has been increased by 200,000 tonnes to account for the suppressed products excluded from the PRODCOM reported figures;

- the production estimates for packaging and for other plastic products have been reduced by 5% to ensure equality between the total demand for plastics in primary forms and the total supply;

- the net imports of plastic packaging products have been increased by 80,000 tonnes to reflect the packaging imbedded in the net imports of packaged goods;[20]

- the production of other plastic products has been increased by 200,000 tonnes, and the net imports by 750,000 tonnes, to account for the plastic components excluded from the PRODCOM figures

Total UK production of virgin primary plastics is estimated at around 4.7 million tonnes per annum for the period 2004-7, while consumption is estimated to have been around 6.6-6.7 million tonnes per annum – the balance being made up of net imports and recycled plastics. Both of these are considerably higher than previous estimates.[21] However, they are supported by the reported product-level data for production and trade data, and we believe that they provide a more realistic picture of actual production and consumption flows.
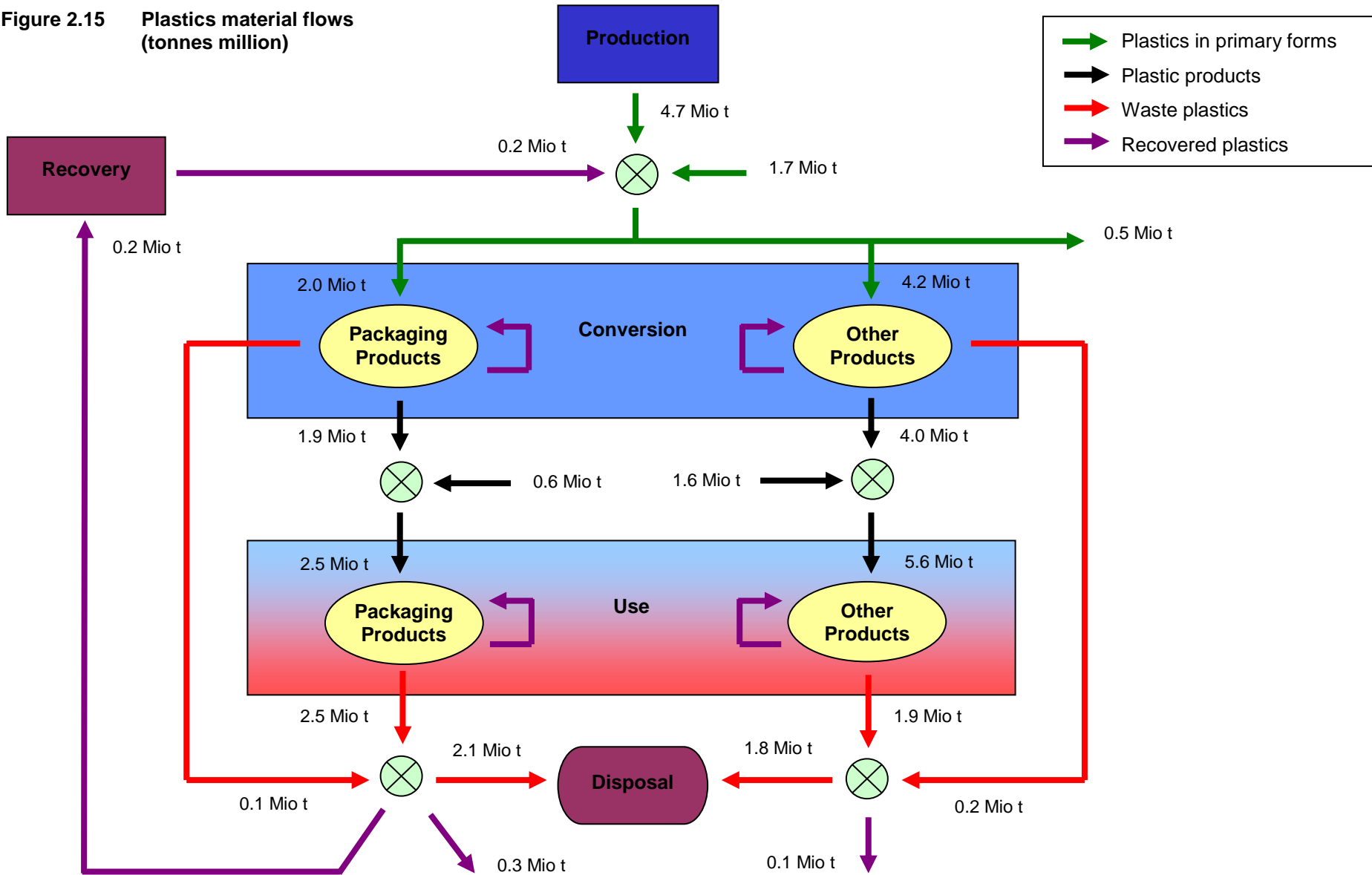
Around 2.0 million tonnes of primary plastics were used in the production of packaging products. Taking account of net imports (including those imbedded in packaged goods), the total supply of packaging to UK "users" was around 2.5 million tonnes. Virtually all of this would have entered the waste stream within the same year, with the vast majority (i.e. around 80%) being sent to landfill.

Consumption of other identified plastic products is estimated to have averaged around 5.6 million tonnes over the period, although this figure is subject to a degree of uncertainty. However, unlike packaging, these products typically have lengthy service lives and hence only a relative small proportion fed through to the waste stream, with virtually all being sent for disposal in landfill.

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[20] That is, imports / exports of packaged goods are treated as if the packaging and contents are traded separately and combined in the destination country.

[21] For example, *WRAP (2007)* estimates that UK consumption of plastics in 2005 was "over 5 million tonnes per annum".

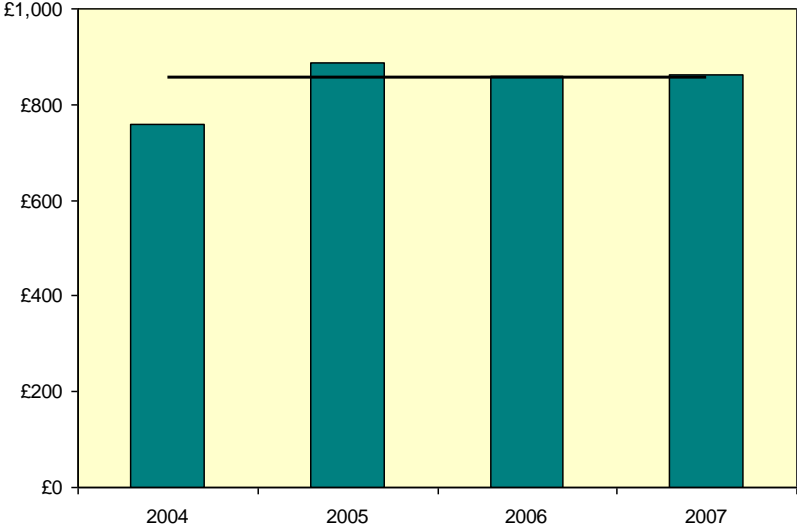**Figure 2.15   Plastics material flows (tonnes million)**

Legend:
- Plastics in primary forms
- Plastic products
- Waste plastics
- Recovered plastics

Production → 4.7 Mio t

0.2 Mio t ← Recovery

1.7 Mio t

0.5 Mio t

Conversion
- Packaging Products: 2.0 Mio t
- Other Products: 4.2 Mio t

0.2 Mio t

1.9 Mio t   0.6 Mio t   1.6 Mio t   4.0 Mio t

Use
- Packaging Products: 2.5 Mio t
- Other Products: 5.6 Mio t

2.5 Mio t   2.1 Mio t   1.8 Mio t   1.9 Mio t

Disposal

0.1 Mio t   0.3 Mio t   0.1 Mio t   0.2 Mio t

3. Value chain analysis

In this section, the monetary values of the various system flows are estimated. This is done by deriving an average price estimate for each flow and then applying these to the estimates of the physical flows derived in the previous section. All of the prices are expressed in current-value (or "money of the day") terms, with no adjustment being made for inflation.

3.1 Production

Figure 3.1 shows the volume-weighted average production prices of plastics in primary forms, calculated from the value and volume data reported in PRODCOM for the years 2004 to 2007. Prices remained relatively stable over the period, averaging around £856 per tonne. This value excludes PET and the other suppressed products.[22] According to *WRAP (2007)*, the average price of virgin PET over this period was around £850 per tonne. This is slightly higher than the import and export prices reported in PRODCOM (i.e. around £770 and £700 per tonne respectively) and so a value of £800 per tonne has been assumed for the analysis. Taking this into account brings the overall average production price down slightly, to £850 per tonne for the period.

Figure 3.1 Average production price of primary plastics (£ per tonne) [a]

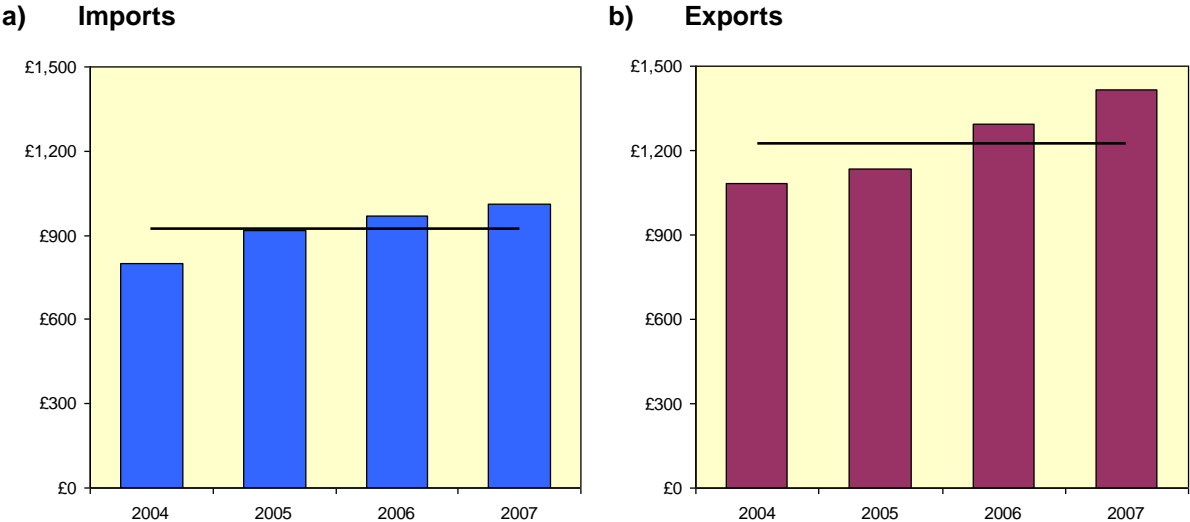(a)   Excluding PET and other suppressed products

Source: PRODCOM

Over the period, the average prices of imports and exports reported in PRODCOM both rose continuously, averaging around £920 per tonne and £1225 per tonne respectively (see Figure 3.2). Unlike the prices for production, these figures include all products and hence there is no need for any adjustment. The figures yield an average price for net imports over the period of [£590] per tonne.[23]

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[22] See section 2.1 for explanation.

[23] The average price of net imports is given by $(p_M M - p_X X) / (M - X)$, where M and X denote imports and exports respectively. As such, the price is much more volatile than the component prices and does not necessarily lie between the two values.
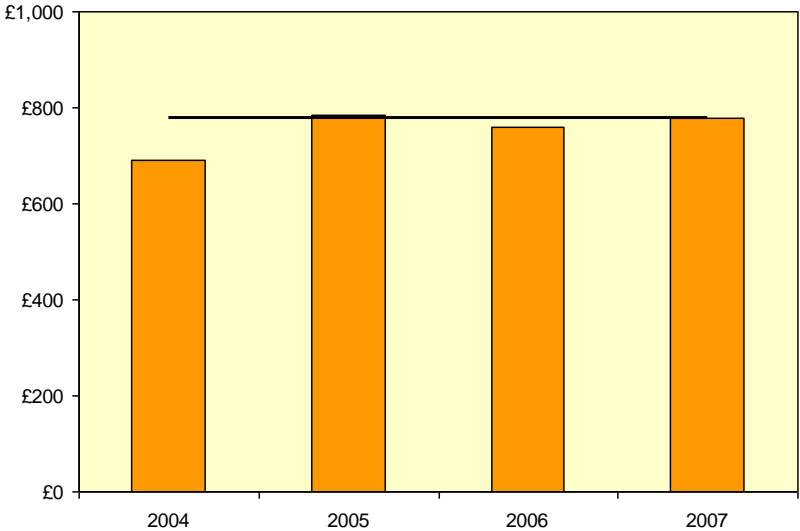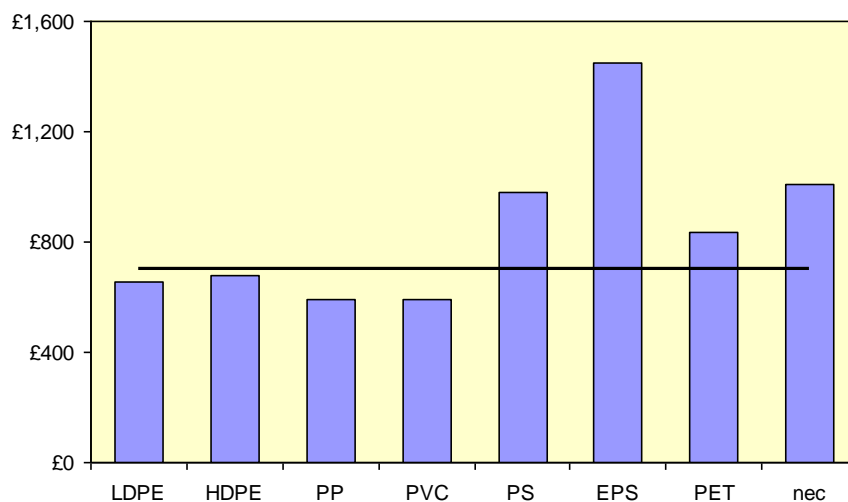
Figure 3.2   Average trade prices of primary plastics (£ per tonne)

a)   Imports

b)   Exports

Source: Prodcom.

The resultant average prices for the supply of primary plastics over the period are shown in Figure 3.3. These exhibit a similar pattern to that of production prices, averaging just under £780 per tonne.[24] Again, these prices exclude PET (and the other suppressed products), although taking this into account only has a minimal impact on the price

Figure 3.3   Average supply price of primary plastics (£ per tonne) [a]

(a)   Excluding PET and other suppressed products

Source: PRODCOM

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[24] The average supply price is given by $(p_Y Y + p_N N) / (Y + N)$, where Y and N denote production and net imports respectively – i.e. the volume weighted average of the production and net import prices.

3.2 Conversion

a) *Plastic packaging*

Figure [x] shows the average supply prices over the period 2004-7 for the different polymers, together with weighted average input price for packaging production.[25] The prices of LDPE / HDPE, polypropylene and PVC all averaged around £600 per tonne, while the prices of PET and polystyrene averaged around £800-900 per tonne. The price of EPS was considerably higher at over £1400 per tonne. The average input price was around £700 per tonne, about 10% lower than the overall average supply price, reflecting the lower prices of standard plastics compared to the higher specification engineering plastics.

Figure 3.4 Average prices of plastics used in packaging production 2004-7 (£ per tonne)

Source: PRODCOM (except PET production price)

Figure 3.5 shows unit production prices of the different plastic packaging products for the years 2000 – 2007, calculated from the value and volume figures reported in PRODCOM. As can be seen, there is considerable price variation between product categories, with the price of carboys and bottles averaging around one third of the price of the other packaging product categories. Prices remained relatively stable over the period, although there was a slight decline in the average price of other packaging products and a slight rise in the average price of sacks and bags. The net effect of these changes was a slight decline in the overall average price of packaging products; with the average price for 2004-7 (at £1345 per tonne) being around 7.5% down on the previous four-year period.

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[25] The weights reflect the composition of plastics demand by UK packaging producers in 2005 (see Figure [x])

Figure 3.5   Average production price of plastic packaging (£ per tonne).
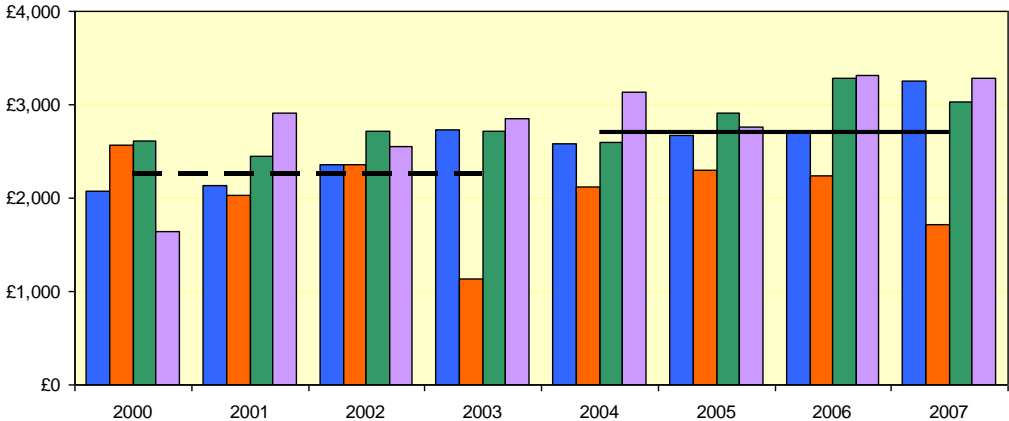

Source: PRODCOM

The unit price of exported packaging goods was significantly higher than the production price, averaging around £2500 per tonne over the period 2004-7 (i.e. almost double) – see Figure 3.6. The difference was particularly marked for carboys and bottles where the export price was more than four times greater than the production price. Although this seems implausibly high, it is consistent across the entire period. Consequently, it may just indicate that exports were skewed towards larger or higher specification (and hence higher price) products.

Import prices were slightly higher than production prices, averaging around £1500 per tonne over the period 2004-7; up almost 20% on the preceding four-year period. As with exports, the average price for carboys and bottles is significantly higher than the production price. The import prices are particularly high in 2004 and 2005, suggesting that there may be a problem with the data reported in PRODCOM for these years.[26]   Based on the reported data, the unit price of net exports averaged around £1000 per tonne over the period 2004-7. However, based on the preceding comments, this figure should be treated with a degree of caution.
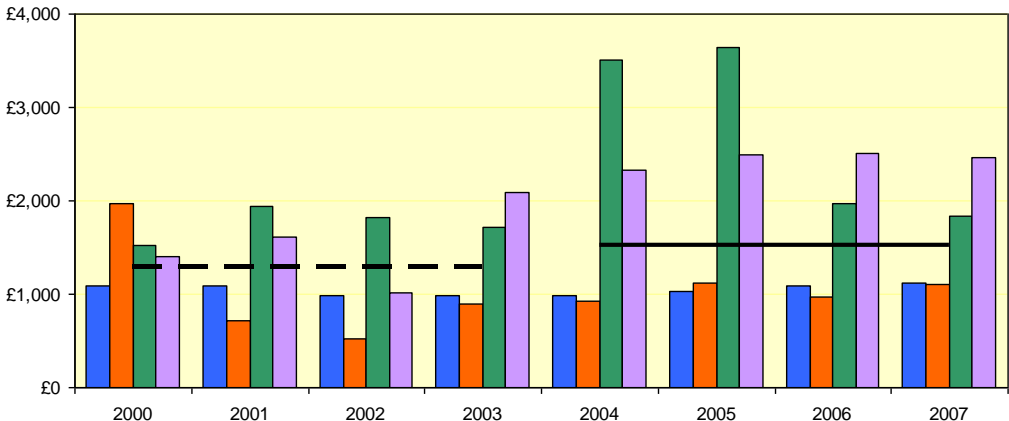
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[26] There was a change in the reporting units for imports and exports between 2003 and 2004 – from kilograms to thousand items. It is possible that data import volumes may have been recorded in the wrong units for 2004 and 2005. However, this is not obvious from the time series – i.e. imports were reported as 70,319 tonnes in 2003 and as 654 million items in 2004.

Figure 3.6   Average trade prices of plastic packaging (£ per tonne) [a]
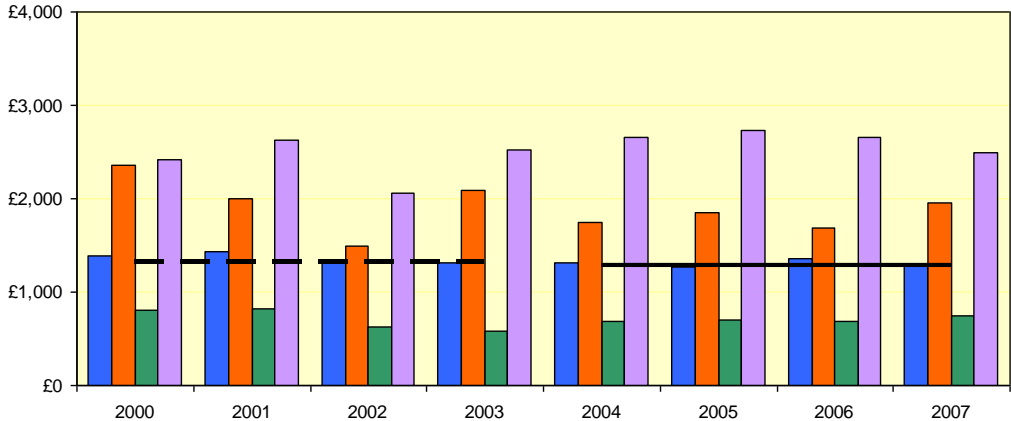
a) Exports

b) Imports

(a) See Figure x for key

Source: PRODCOM

The resultant prices for the supply of plastic packaging products are shown in Figure 3.7. These follow a very similar pattern to that of the production prices. Over the period 2004-7, the overall supply price averaged £1275 per tonne, down 4% on the preceding four-year period.

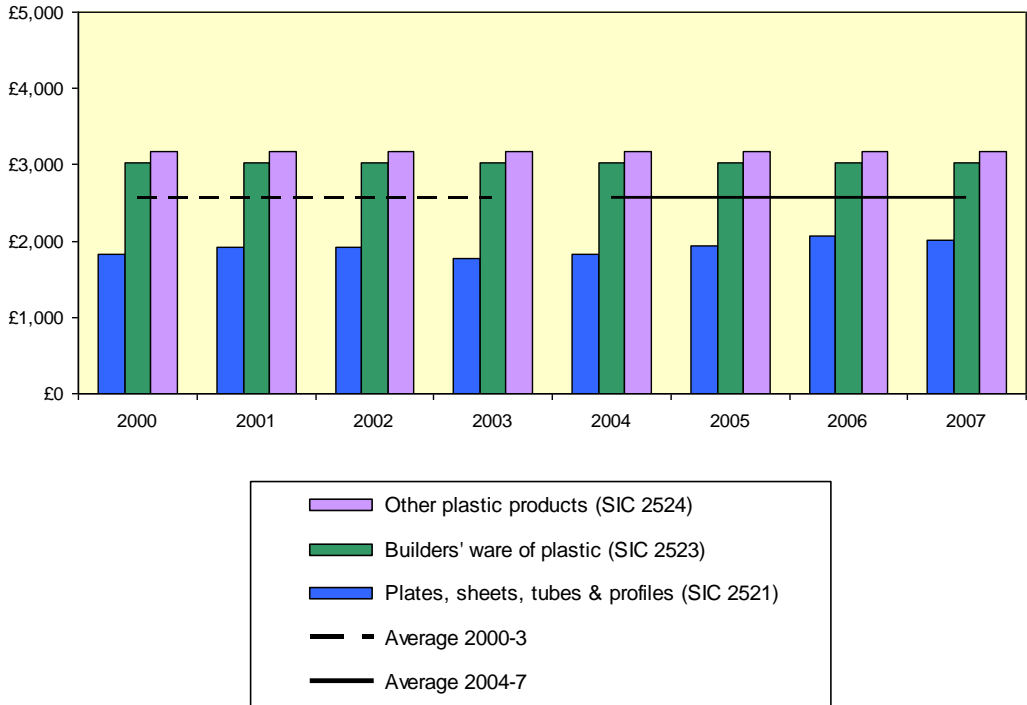**Figure 3.7 Average supply price of plastic packaging (£ per tonne) (a)**

(a) See Figure x for key

Source: PRODCOM

b)   Other plastic products

Based on the average supply price for primary plastics (i.e. £780 per tonne) and the input price for plastics used in the production of packaging (i.e. £700), the implied average input price for primary plastics used in the production of all other plastic products over the period 2004-7 was around £815 per tonne. In the absence of any information, it is assumed that there was no difference in the input prices for identified and unidentified products.

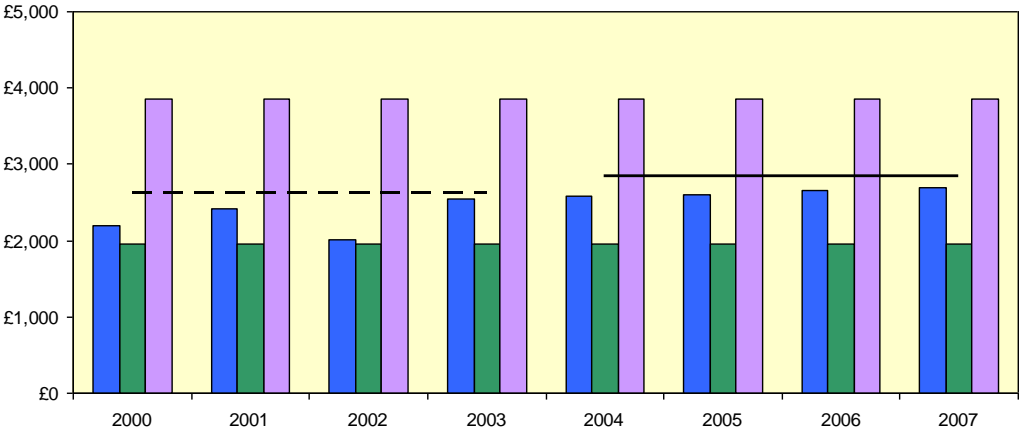**Figure 3.8 Average production price for other plastic products (£ per tonne)**
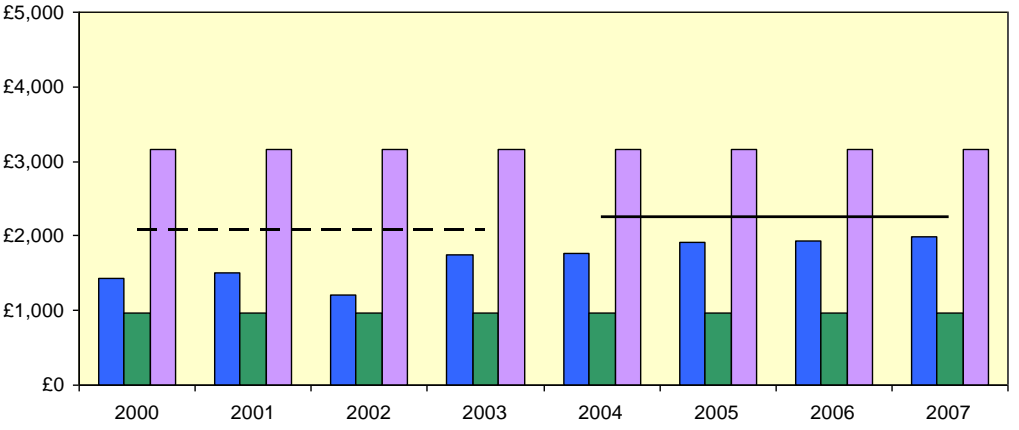

Source: PRODCOM

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Figure 3.8 shows the average production prices for other plastic products over the eight years 2000 – 2007, calculated from the volume and value figures reported in PRODCOM. These exhibit a very stable pattern, with the average price for 2004-7 (at £2560 per tonne) being virtually the same as for the preceding four-year period. As with the material flow figures discussed in the previous section, these prices exclude plastic components. The average production price of these components in 1995-6 (the latest years for which comprehensive data is available) was around £4,800 per tonne. Assuming that this price was maintained, the overall average production price for the period 2004-7 is estimated to have been around £2700 per tonne.

Figure 3.9   Average trade prices of other plastic products (£ price per tonne)

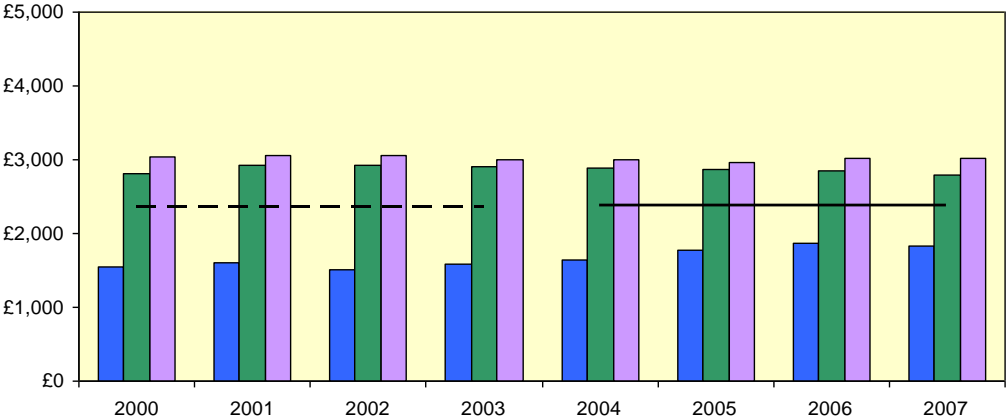**a) Exports**

b) Imports

Source: PRODCOM

Import and export prices of other plastic products were also very stable, although unlike production prices, both experienced a slight increase over the eight-year period (see Figure 3.9). The average import price for 2004-7 was around £2245 per tonne, while the export price averaged around £2845 per tonne; giving an average price for net imports of around £1530 per tonne. Again these figures exclude plastic components, for which data is only reported for 2003-4 (when the net import price averaged around £1300 per tonne). Assuming that this

prices was maintained over the next two years, the overall average price of net imports for the period 2004-7 would have been closer to £1420 per tonne.

Figure [x] shows the resultant supply prices for other plastic products over the period 200 – 2007. Again, this is very stable, reflecting the stability of its component parts. Without plastic components, the supply price averaged around £2385 per tonne over the period 2004-7; up marginally on the price in the preceding four years. Taking the components into account reduces the price to around £2340 per tonne.

Figure 3.10   Average supply price for other plastic products (£ per tonne) (a)

(a) See Figure x for key

Source: PRODCOM

c) Unidentified plastic products

As was noted above, in the absence of any other information, it is assumed that the average input price for primary plastics used in the production of unidentified plastic products was the same as that for other identified products. Consequently, the average input price for the period 2004-7 is estimated to have been around £815 per tonne.

3.3 Use

Unlike the outputs from the previous two stages, there are no direct "prices" reported for the waste streams generated by the use phase. Consequently, these are imputed from the market prices for recycled plastics (p_R), exported waste plastics (p_X), conversion scrap (p_C), and the price of landfill disposal services (p_L), according to the following formula:

$$p_W = [\sigma_R\, p_R + \sigma_X\, p_X + \sigma_L\, (-p_L) - \omega_C\, p_C] / (1 - \omega_C)$$

ω_C is the share of the conversion scrap in the waste stream and σ_R, σ_X and σ_L are the shares of the respective waste treatment options. The price of landfill disposal services is negative to reflect the fact that it is a cost. The component prices of the three waste treatment options – which are provided in section 3.4 – are assumed not to vary with the source of the waste. For example, the landfill price charged for a tonne of plastic packaging is assumed to be the same as that charged for a tonne of other plastic products. Hence, differences between the imputed "waste prices" for packaging products and other plastic products reflect only differences in the sources and treatments of their respective waste streams.

a) Packaging

According to PRODCOM, sales of waste products by plastic packaging producers averaged around £15 million per annum over the period 2004-7. Based on the estimate tonnage of production scrap (i.e. around 100,000 tonnes), this implies an average scrap price of £150 per tonne. According to the material flow analysis (see section 2, Figure [x]), around 7.5% of the plastic packaging waste stream was recycled within the United Kingdom during this period, while around 11.5% was exported. The balance (around 80%) was sent for disposal in landfill. With production scrap accounting for around 5% of the waste stream, these treatment shares yield an average price for waste plastic packaging for the period 2004-7 of £0 per tonne.
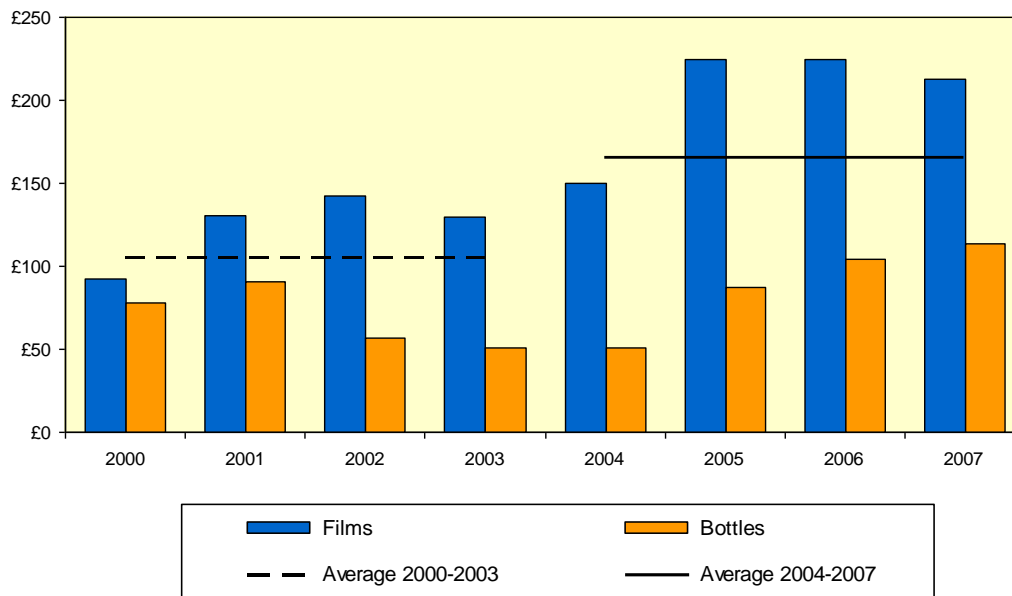
b) Other plastic products

Sales of production scrap by the producers of other plastic products averaged around £20 million per annum over the period 2004-7; implying an average price of around £100 per tonne. Unlike waste packaging, the vast majority (i.e. around 95%) of the waste stream for other plastic products was sent for disposal in landfill; with the remaining 5% being exported. With production scrap accounting for almost 10% of the waste stream, these shares yield an average price for other plastic products of –£40 per tonne (i.e. a cost of £40 per tonne) for the period 2004-7.

3.4 Disposal

Figure 3.11 shows the average price of recycled plastics for the period 2000 – 2007, calculated from the prices reported by *letsrecycle.com*. They represent the simple averages of the monthly prices for different polymers and colours. Over the eight year period, there was a significant increase in prices, driven largely by an increase in the price for plastic films. The overall average price for the last four years – at £165 per tonne – was more than 50% greater than for the first four.
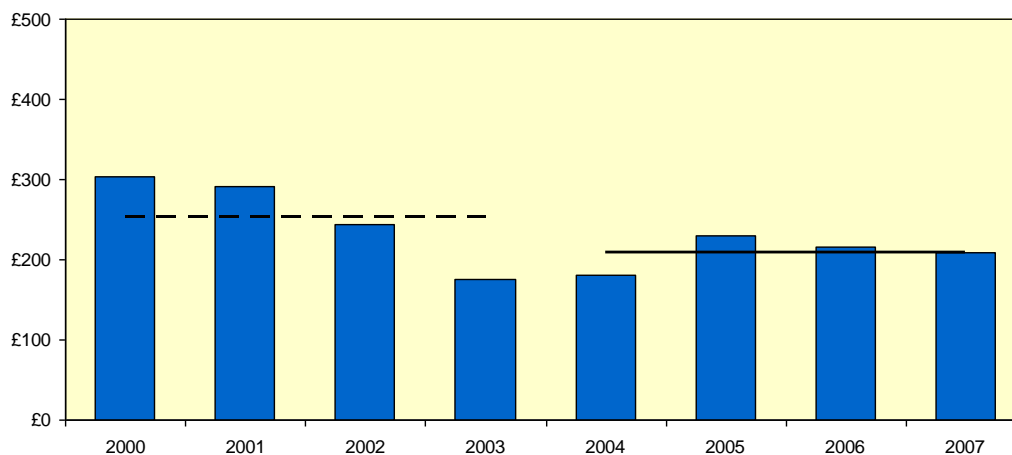
Fig. 3.11   Average price of recycled plastic (£ per tonne)

Source: http://www.letsrecycle.com/prices/plastics/

The price of waste plastic exports averaged around £210 per tonne over the period 2004-7, down almost 20% on the preceding four years.
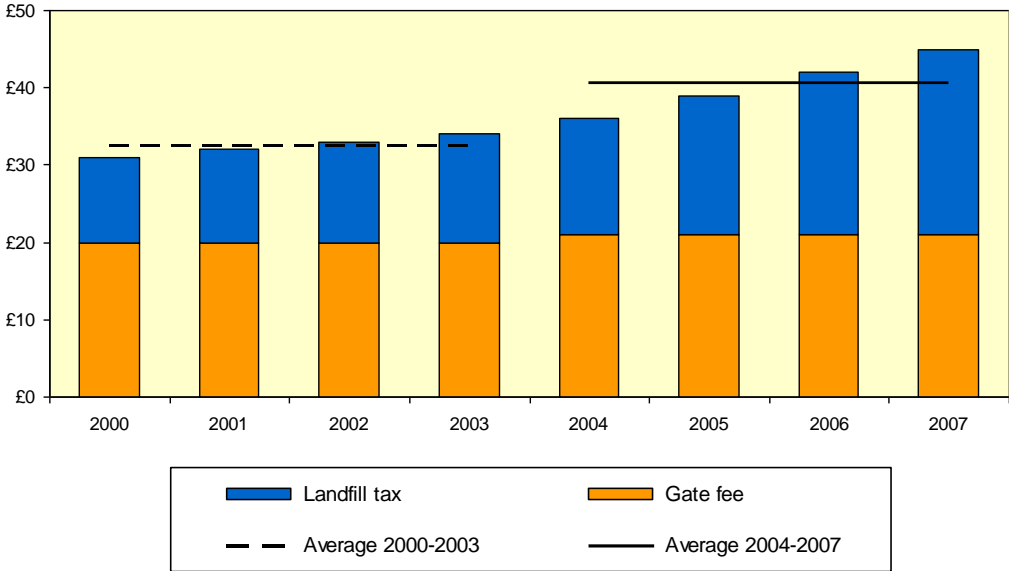
Figure 3.12   Average export price of waste plastic (£ per tonne)

Source: EUROSTAT External trade database

As can be seen in Figure [x], the price of landfill disposal rose continuously between 2000 and 2007, reflecting the increases in the landfill tax. The total price averaged around £40 per tonne over the period 2004-7; split equally between the gate fee and the landfill tax. This represented a 25% increase on the average price for the previous four years.

Fig. 3.13   Average price of landfill (£ per tonne)

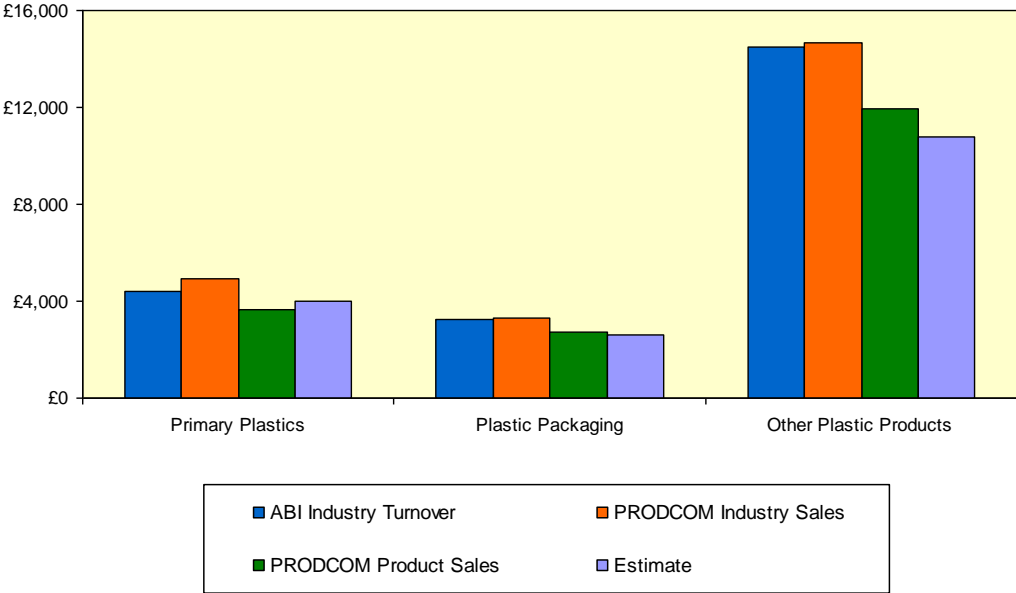Source: HMRC and WRAP Gate Fees Report, 2008

3.5 Summary

Figure 3.15 (on page x) summarises the average prices derived above for the various system flows. The price of recovered waste plastic (i.e. after it has been reprocessed) is assumed to be the same as the average supply price for virgin plastics (i.e. the weighted average of the production and net import prices).

These are applied to the physical flows derived in section 2 (see Figure 2.x), to yield the value flows shown in Figure 3.16 (on page x), which have been rounded to the nearest £5m. Because of the way in which they have been derived, there can sometimes be discrepancies between the supply and demand (i.e. input) values.[27] However, where these occur, they are not significant.

The estimated value of primary plastics production over the period 2004-7 is £4,000 million per annum; while the production values of packaging and other plastic products are £2,600 million per annum and £10,800 million respectively. Figure 3.14 provides a comparison of these derived estimates with the sales of the corresponding industry sectors, as reported in the Annual Business Inquiry (ABI) and PRODCOM, and the aggregate product sales value reported in PRODCOM.[28] Industry sales / turnover figures are generally higher than the aggregate product sales values because they include sales of merchandised goods and waste products, net carry-out sales and other income.

Figure 3.14   Comparison of estimated production values with published sales values

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[27] In theory, the monetary values of demand (i.e. input) and supply should be identical since the input price is calculated as the weighted average of the component supply prices (i.e. $p_X = (p_Y Y + p_M M) / X$, where $X=Y+M$). However, the values of both the physical flows and the prices have all been rounded, potentially breaking the identity and introducing a small rounding error.

[28] The aggregate sales value reported by PRODCOM includes most of those products for which individual sales value information is suppressed.

Comparison with the PRODCOM values for aggregate product sales provides a great deal of confidence in the estimates. The estimate for packaging production is very close to the reported figure and while the estimate for primary plastics production is around £350,000 greater than the reported figure, the latter excludes PET production (which has an estimated sales value of £320,000 per annum). The estimate for the production value of other plastic products is around £1,200 million less than the reported value (i.e. 10% less), which suggests that the average price estimate may be too low.

For both packaging products and other plastic products, there is an increase in average unit value in the conversion phase (i.e. £670 per tonne and £1900 per tonne respectively); followed by a dramatic reduction in the use phase (i.e. − £1275 per tonne and − £2400 per tonne respectively).

Figure 3.15   Plastics average prices (£ per tonne)

Production

£850

£780

Recovery

£590

£165

Plastics in primary forms
Plastic products
Waste plastics
Recovered plastics

£815

£700

£815

Packaging Products

Conversion

Other Products

£1350

£1000

£1420

£2700

£1275

£2340

Packaging Products

Use

Other Products

£0

− £40

− £40

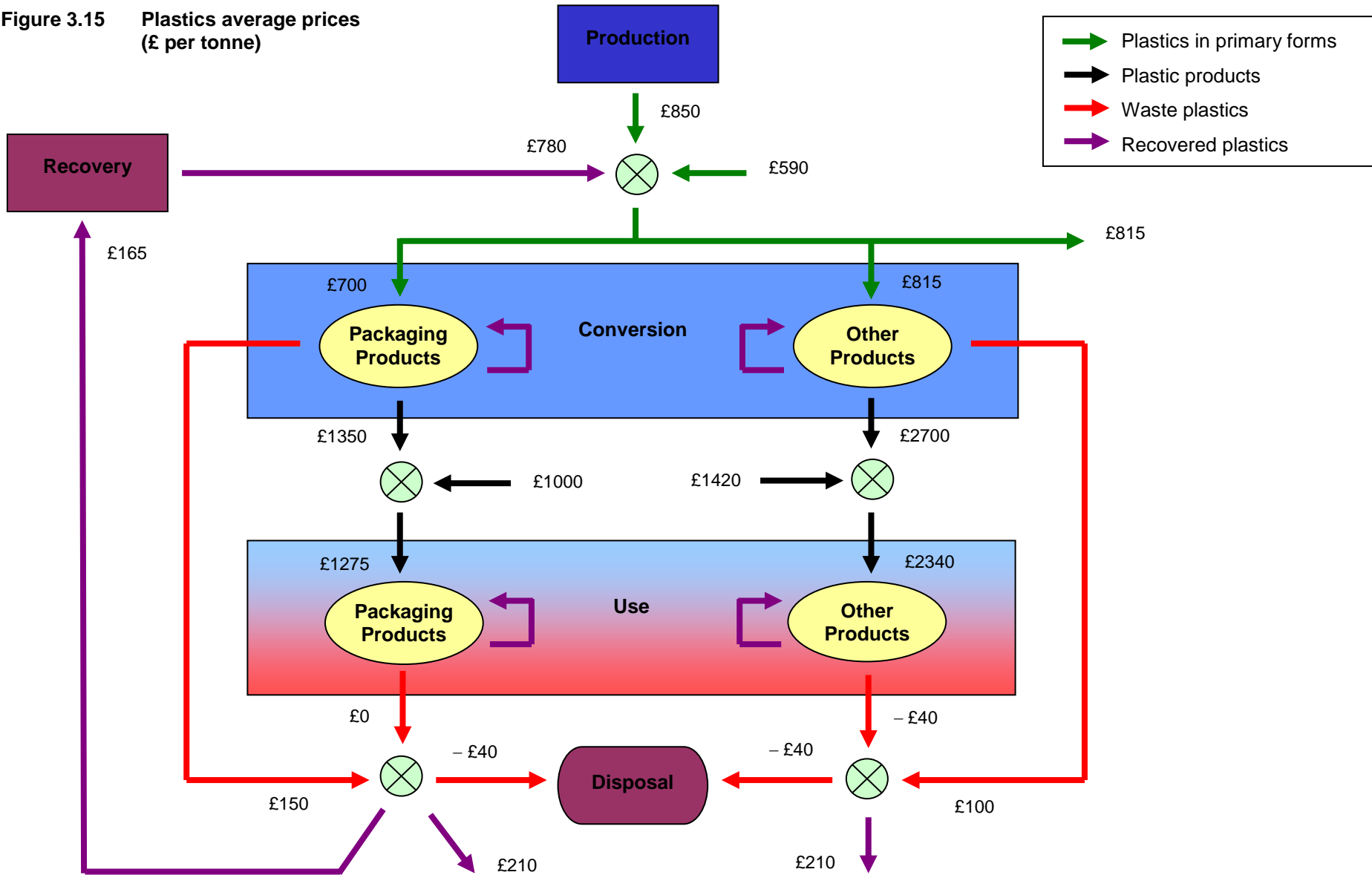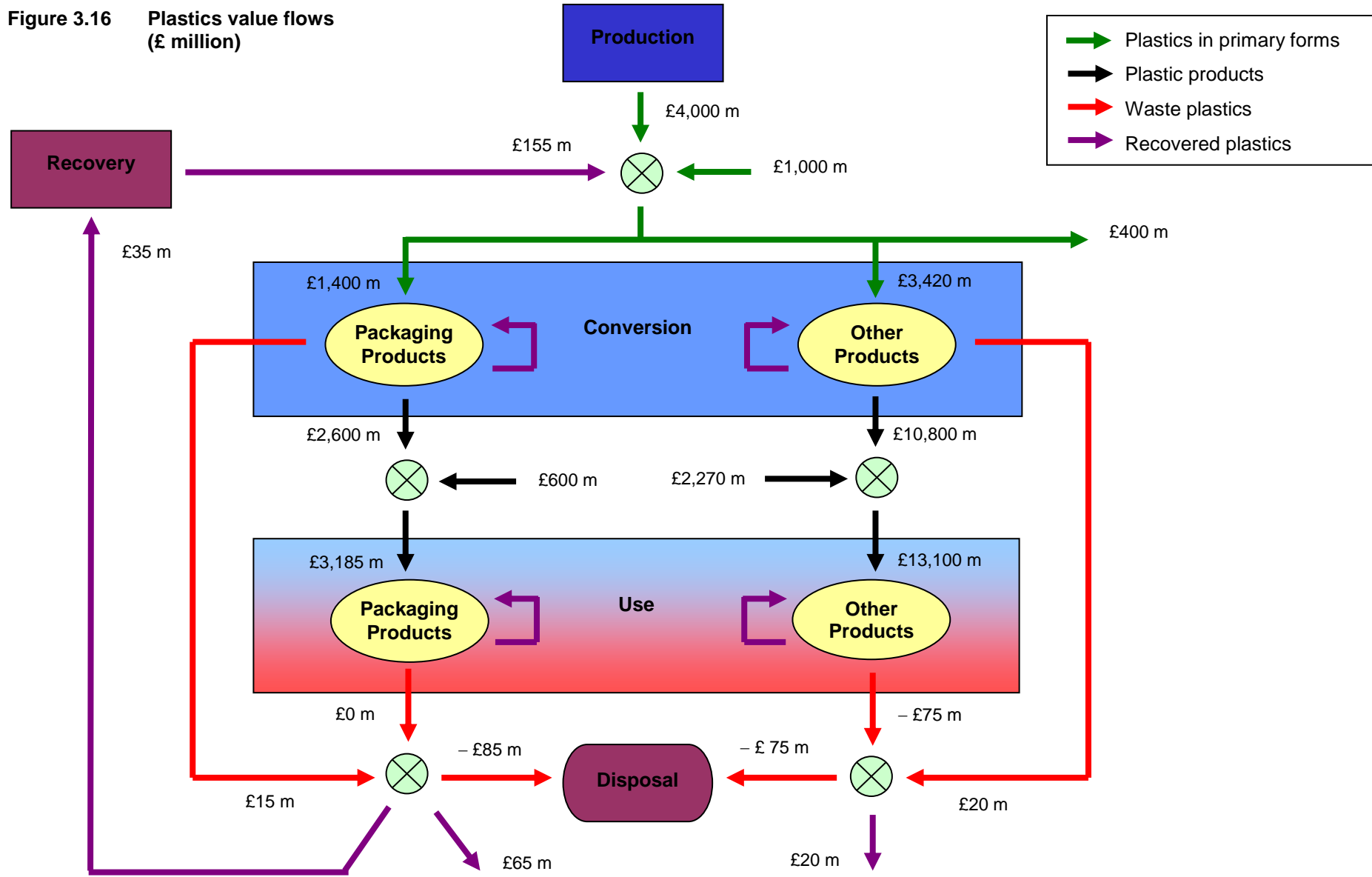− £40

£150

Disposal

£100

£210

£210

Figure 3.16   Plastics value flows (£ million)

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