Working together for a world without waste

Overview

Electrical product material composition

Overview of updated data within the Market Flows Model of Electronic Products.

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WRAP's vision is a world without waste, where resources are used sustainably.

We work with businesses, individuals and communities to help them reap the benefits of reducing waste, developing sustainable products and using resources in an efficient way.

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Front cover photography: Image of laptop and circuit boards

Executive summary

WRAP wished to build upon the Market Flow Model of Electronic Products to investigate the composition of Waste Electrical and Electronic Equipment (WEEE), with particular emphasis on identifying high priority materials that could be recovered from WEEE.

By analysing product composition the model has been updated to include more detail on material compositions. It has shown that the material value of WEEE disposed of in the UK is more than £1.3 billion, equivalent to approximately £22/head of population. Of this, nearly £400 million of material replacement[1] value is either hoarded or landfilled, while the majority of the remainder is treated either through the UK WEEE compliance scheme or informally as part of the wider metals recycling system. The treatment process used does not however recover the maximum material value from products.

The amount of precious metals in the WEEE stream is estimated at about 50 tonnes, at an average concentration of 30g/tonne. This figure consists of 21.41g/tonne silver, 6.45g/tonne gold and 2.14g/tonne Platinum Group Metals (PGMs). In comparison, these materials are commercially mined at concentrations down to 850g/tonne (silver), 5g/tonne (gold) and <2g/tonne (PGMs).

Of the 13 WEEE categories, categories 3 and 4 (IT and telecommunications equipment and consumer appliances) were calculated to have the highest replacement value of around £1,500/tonne. This value could be more easily liberated by separate collection of these categories, which would concentrate the value to make a richer and more attractive composition.

[1] *Material replacement value refers to the value of the material in the equipment and not the products market value.*

Contents

1.0 Introduction

1.1 Project background

It is estimated that 1.5 million tonnes of Waste Electrical and Electronic Equipment (WEEE) is produced yearly in the UK; of this, approximately 30% (475,000 tonnes) is officially collected and recorded through the WEEE system. Due to the high-value materials present in many WEEE items, this stream represents a potential source of resources that will be essential in a closed loop society.

In order to estimate material availability, product composition analysis was carried out on a selection of prioritised product categories and items. Prioritisation was based on volume, prevalence in the waste stream, economic value and ease of recycling.

Table 1 Items selected for compositional analysis

Category	Sub-category	Item	No. required
Small household	Kitchen blenders, food processors, toasters etc.	Blender/food processor	2
		Toaster	3
	Vacuum cleaners	Upright-type vacuum cleaner	5
		Cylinder-type vacuum cleaner	5
	Coffee and tea boilers, percolators	Coffee machine	3
	Small household appliances - other	Clock	5
		Microwave	5
		Kettle	5
IT and Telecommunications	Desktop PC	Computer tower	7
		Mouse	2
		Keyboard	2
	Laptop PC	Laptop	5
		Notebook	5
		Tablet PC	1*
	Mobile phones and equipment	Traditional (keypad) phone	3
		Smart phone	7
	Calculators	Calculator	3
	IT and telecommunications equipment - other	Home landline phone	3
		Office landline phones	3
		Wireless landline phones	3
		Hard drive	2
		E-reader	1*
		Remote control	2
	Fax, scanner, printer or multifunction printer	Fax machine	3
		Scanner	5
		Printer	3

Table 1 continued

Consumer	Radios, hifi systems, speakers	Digital radio	3
		Hi-fi system	3
		Loudspeaker	5
	Video players and recorders	VHS player	5
		DVD player	10
		Set-top box (variety of ages and makes)	7
	Consumer equipment – other	Digital camera	5
		Videocamera	3
Tools	Miscellaneous tools	Battery-powered tool (assorted)	5
		Mains-powered tool (assorted)	5
		Sewing machine	3
		Lawnmower	2
Leisure/sports	Toys and models with motors, plastic	Toy with motor and/or moving parts	7
		Toy with screen, buttons, etc.	8
	Video games consoles for use with television	Sony Playstation 2	1
		Sony Playstation 3	1
		Nintendo Gamecube	1
		Nintendo Wii	1
		Microsoft Xbox	1
		Microsoft Xbox 360	1
Display equipment	Television, flatscreen (LCD/Plasma)	LCD/Plasma flatscreen TV	2
		LCD/Plasma flatscreen computer monitor	2
		Total	174

2.0 Product material composition

In order to analyse product composition, items were manually dismantled and separated into several categories; plastic, metal, wiring, LCD (Liquid Crystal Display) screens, circuit boards, batteries, and others. NB: complex components such as speakers, motors and magnetrons were placed in the 'others' category.

The following data that resulted from the analysis was fed in to the Market Flows Model to provide estimates of quantities and value within the waste stream.

From the items dismantled, a selection of whole components was chosen for further detailed analysis. These were:

- Circuit boards;
- Hard drives;
- Magnetron from a microwave;
- Motors; and
- Speakers.

Items were taken and analysed further for plastic and major metal content, using a combination of FT-IR and XRF spectroscopy. **Figure 1** shows the breakdown of the metallic content of each category. It can immediately be seen that ferrous metal (i.e. steel) makes up a very large proportion of the metals present. This is not surprising, as steel is relatively inexpensive and suitably robust for regular day to day use. Category 3 (IT and Telecommunications) contains a significant quantity of aluminium, most likely due to the fact that it is lightweight and therefore suitable for portable items such as laptops.

Figure 1 Composition of metallic part of categories studied

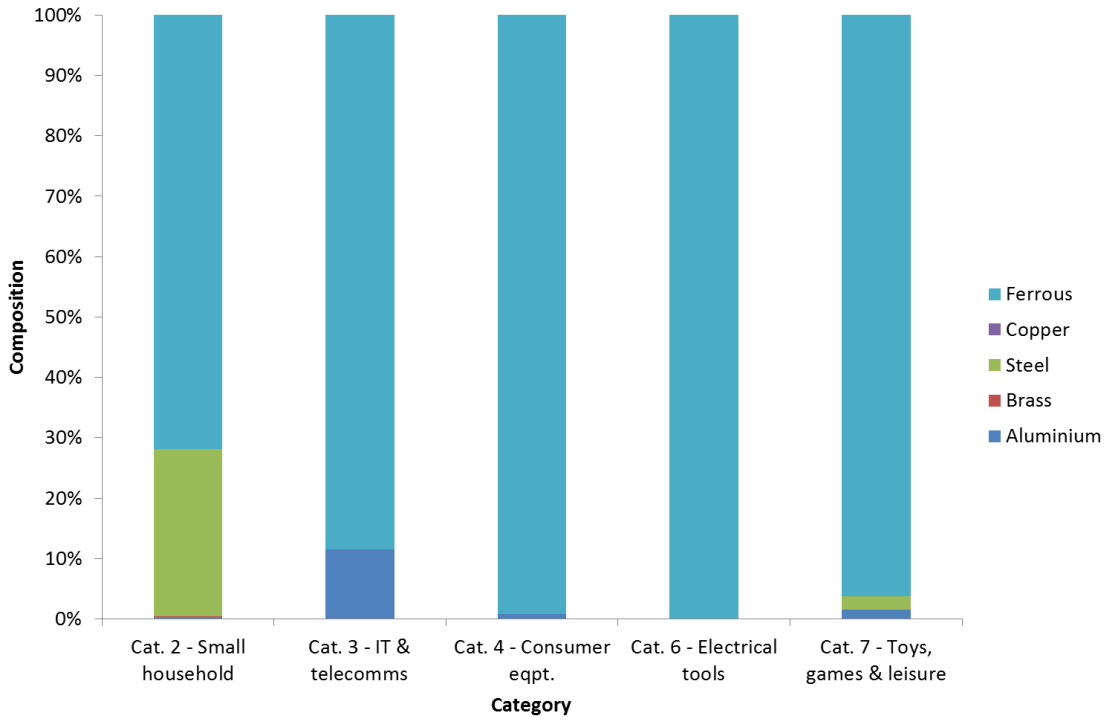
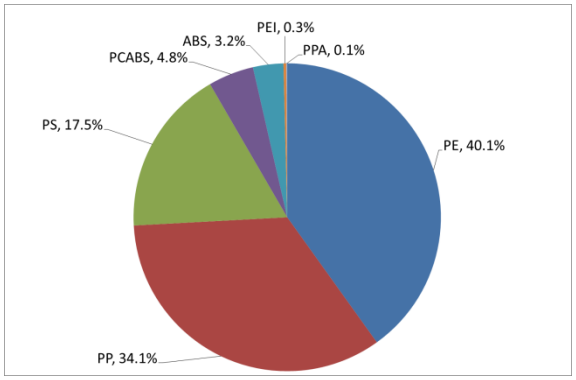
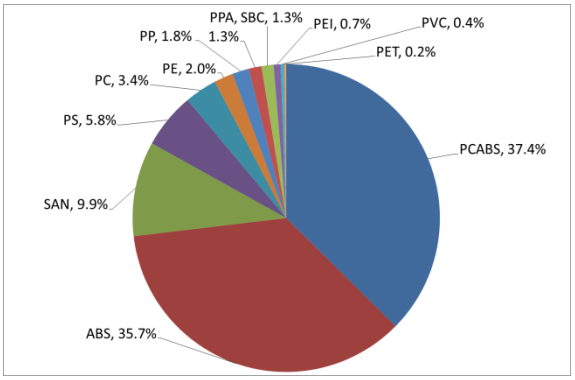


Figure 2 shows the composition breakdown for the plastic content of each category. It can be seen that there is a very large range of different plastics, and little similarity between categories; this is representative of the different applications in which these items are used.

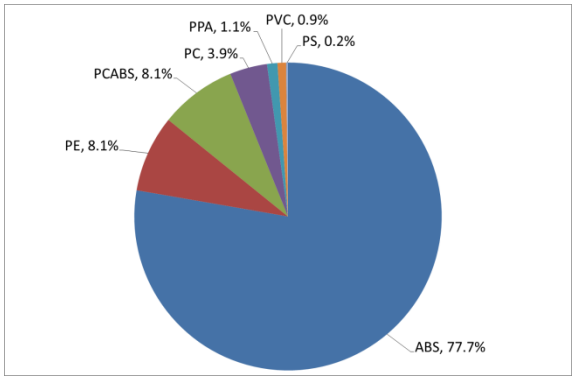
Figure 2 Composition breakdown for plastics in categories studied[2]



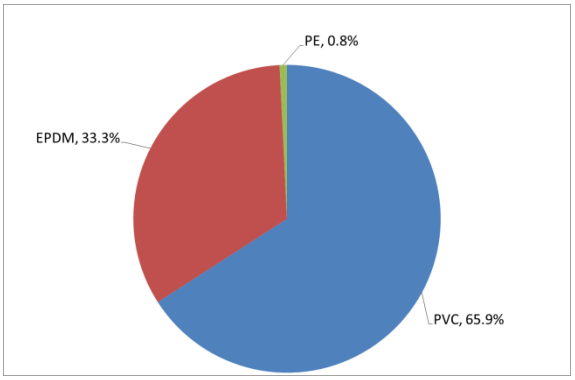
Category 2: Small household appliances



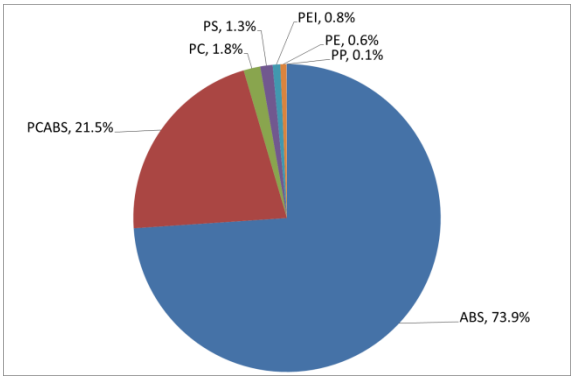
Category 3: IT & telecommunications equipment



Category 4: Consumer equipment



Category 6: Electrical and electronic tools

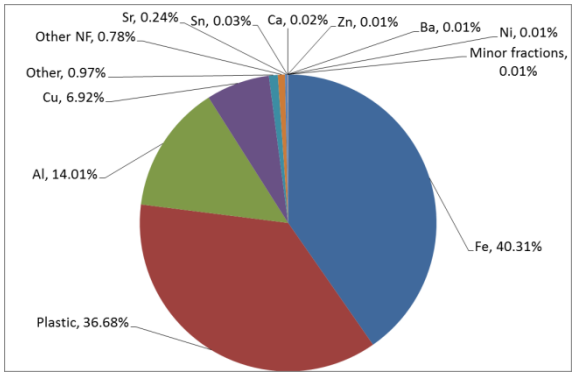


Category 7: Toys, leisure and sports equipment

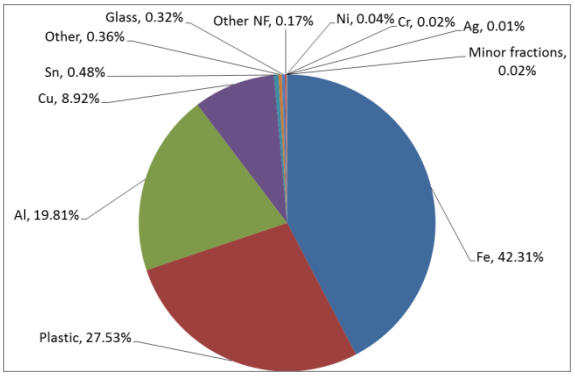
2.1 Average material composition by mass

Figure 3 shows the average composition by mass of each of the categories studied; note that for simplicity, all fractions less than 0.01% are combined as a 'minor fractions' category. As is to be expected, the vast majority of the mass is made up by plastic and the major metals (iron, aluminium, copper), with well over half of each category being made up of Iron and plastic.

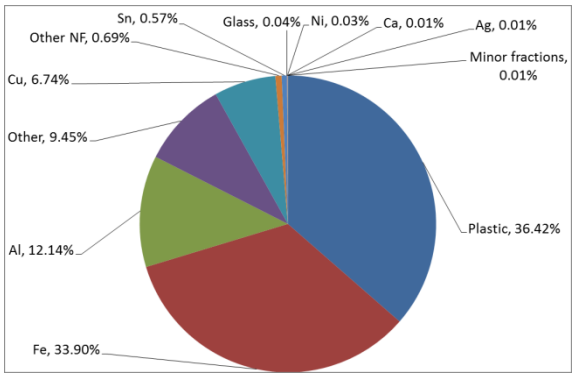
Figure 3 Average composition by mass of major fractions (>0.01%) in categories studied



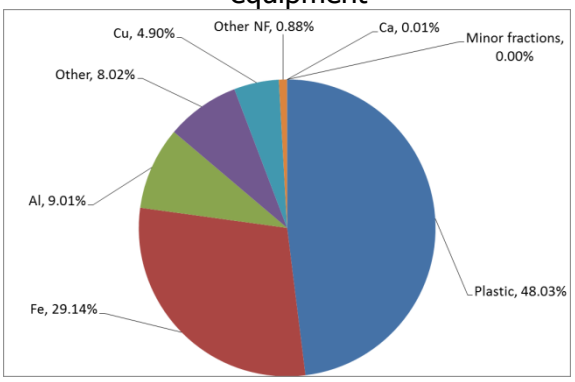
Category 2: Small household appliances



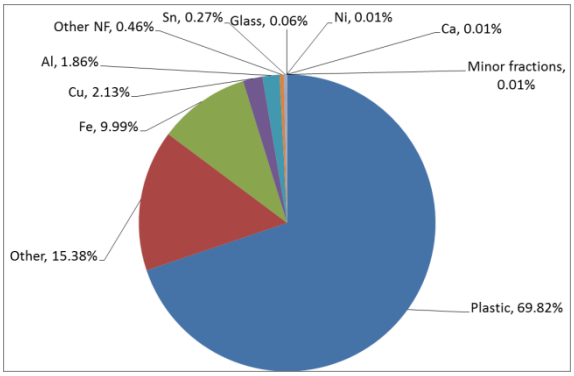
Category 3: IT and telecommunications equipment



Category 4: Consumer equipment



Category 6: Electrical and electronic tools



Category 7: Toys, leisure and sports equipment

For each category the average value per tonne of material was calculated, based on the compositions shown above, estimated compositions for other categories from reference and material values from a variety of sources, including the London Metal Exchange and industrial knowledge. The results are outlined in Figure 4. It can immediately be seen that Categories 3 and 4 (IT equipment and consumer equipment) have significantly larger values per tonne than other categories; this is mainly due to the relatively high concentration of precious metals (silver, gold and platinum) in these categories. Note however, that these figures are purely the material values and do not take into account extraction and refining costs – nor does this include the value attributed to the item itself, independent of the materials of construction (for example the value of a computer derived from its function, etc).

The concentration of the precious metals discovered in the WEEE items studied can be seen in **Figure 5**. This can be translated into yearly values, which are shown in **Table 2**. Approximate global production figures are also shown for comparison. Averaged over the whole UK WEEE stream, this translates to a total precious metals concentration of 21.41g/tonne silver, 6.45g/tonne gold and 2.14g/tonne PGMs (also shown in **Table 2**). In comparison, these materials are commercially mined at concentrations down to 850g/tonne (silver), 5g/tonne (gold) and <2g/tonne (PGMs).

Table 2 Estimated amount of precious metals disposed of in UK WEEE compared to world production

Material	Disposed of in UK WEEE (t/yr)	Approximate global production (t/yr)	Concentration in UK WEEE stream (g/t)	Concentration in mine ore (g/t)
Silver	35.01	>25,000	21.41	850
Gold	10.54	>2,500	6.45	5
PGMs	3.50	~500	2.14	<2

Figure 4 Average replacement value per tonne for each category

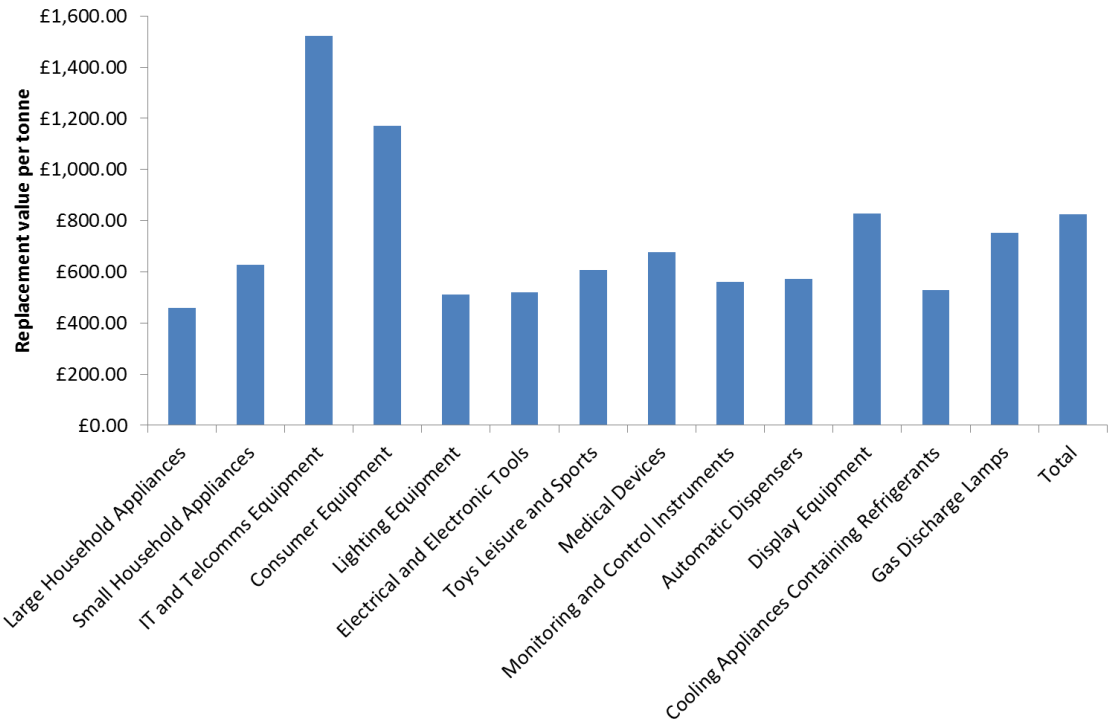
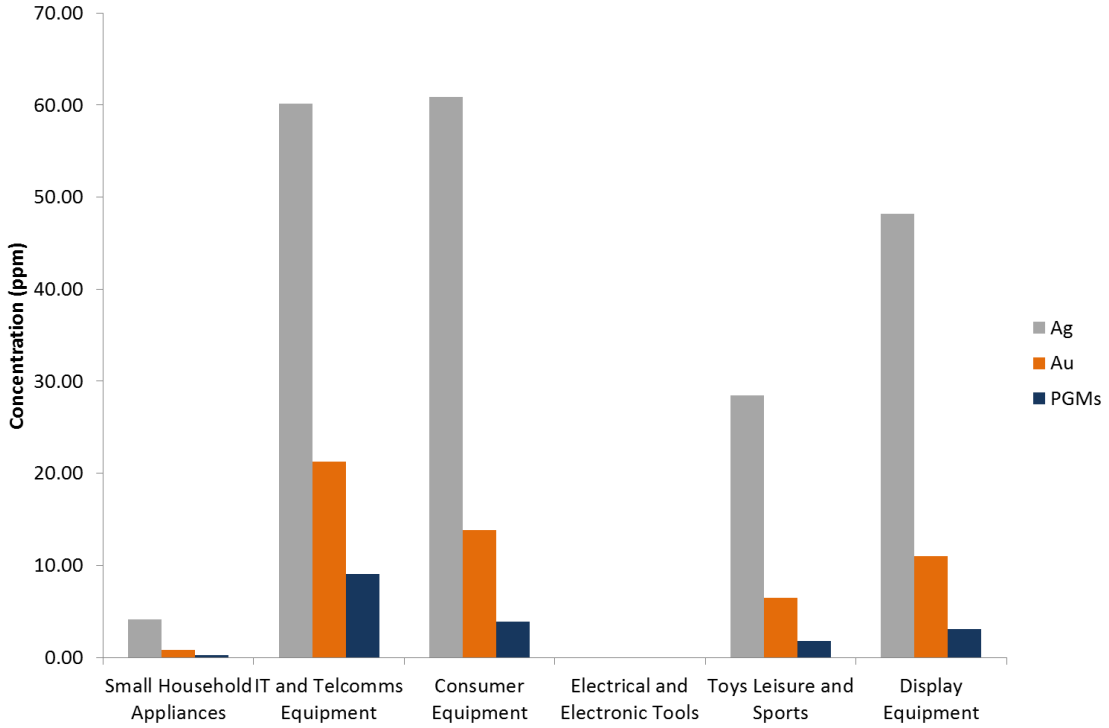


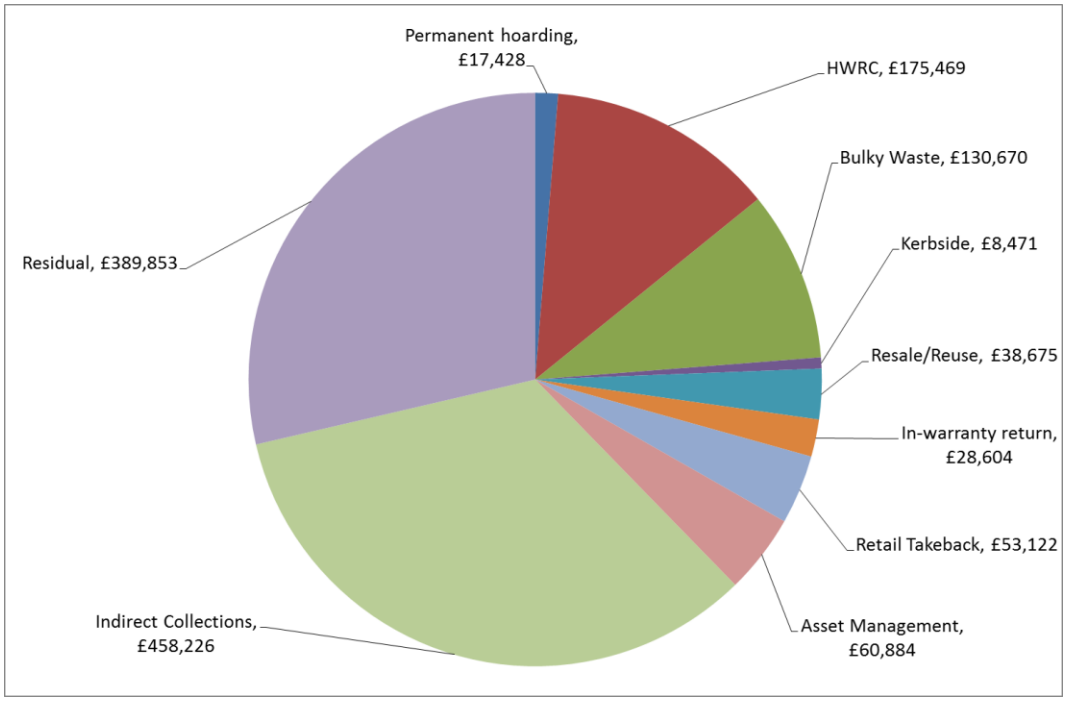
Figure 5 Concentration of precious metals in categories studied



The information in Figure 4 shows that the replacement value of the materials in an average tonne of WEEE items is approximately £825; previous work has estimated that around 1.6m tonnes of WEEE is arising per year, which means that the total replacement value of the materials in WEEE disposed in the UK is more than £1.3bn, or £22/head population. Note that, as in the preceding paragraphs, the term 'replacement value' refers only to the value of the material in the equipment and not to the market value of the items, which will be significantly higher.

The breakdown of how this WEEE is disposed of is shown in **Figure 6**; by far the largest single disposal route is through indirect collections, which end up being processed in authorised metal recycling plants but categorised as light iron rather than WEEE. This is roughly balanced by the sum of all the official WEEE processing routes (Household Waste Recycling Centre (HWRC), bulky waste, kerbside, in-warranty return, retail take-back and asset management). The chart also shows nearly £400m (£6.50/head) of WEEE replacement material value being disposed of through residual waste, and £17m (£0.25/head) of material value being hoarded per year.

Figure 6 Breakdown of replacement material value of WEEE arising in the UK by disposal route (values in '000s)



3.0 Summary

The analysis estimates that the replacement value of the materials in the WEEE that is disposed in the UK each year is more than £1.3bn, equivalent to approximately £22/head of population. Of this, nearly £400m of material replacement value is either hoarded or landfilled, while the majority of the remainder is treated either through the UK WEEE compliance scheme or informally as part of the wider metals recycling system. The amount of precious metals in the WEEE stream was estimated at about 50 tonnes, at an average concentration of 30g/tonne, or ppm. This figure consists of 21.41g/tonne silver, 6.45g/tonne gold and 2.14g/tonne Platinum Group Metals. In comparison, these materials are commercially mined at concentrations down to 850g/tonne (silver), 5g/tonne (gold) and <2g/tonne (PGMs). Of the materials studied, no significant Rare Earth Metals were discovered.

Of the 13 WEEE categories, 3 and 4 (IT & telecommunications equipment and consumer appliances) were calculated to have the highest replacement value of around £1,500/tonne. This value could potentially be more easily liberated by separate collection of these categories, which would concentrate the value to make a richer and more attractive 'urban mine'.

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