Working together for a world without waste

**Final Report**

# Benefits of Reuse Case Study: Electrical Items

**Project code:** SAP134
**Research date:** 2010-2011

**Date:** November 2011

Our 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.

Find out more at www.wrap.org.uk

**Written by:** Keith James (WRAP) Peter Maddox (WRAP) and Karen Fisher (ERM Ltd)

**Front cover photography:** Domestic electrical products (ID: 16622) (Adam Coupe)

# Executive Summary

In 2009, WRAP published *Meeting the UK Climate Challenge: The Contribution of Resource Efficiency*. This showed that one of the best resource efficiency strategies for reducing greenhouse gas emissions was reuse[1].

WRAP has developed a specific methodology for quantifying the benefits of reusing products. This can be applied to a range of products using an accompanying excel-based tool to provide a consistent means of assessing the impacts of different activities. The tool allows the calculation of three environmental indicators (i) greenhouse gas emissions, (ii) energy demand and (iii) resource depletion, and two economic indicators (i) number of jobs and (ii) financial impacts, as well as where these occur in the supply chain. This methodology is outlined in www.wrap.org.uk/benefitsofreuse.

The methodology and tool has been tested for specific clothing, furniture and electrical products. This case study describes the results for electrical items.

The products chosen were a washing machine and a television.

**Washing Machines**

Approximately 100,000 washing machines (6,700 tonnes) are reused in some form in the UK every year. This represents 3% of all washing machines reaching the end of their life each year. The remaining 97% are sent to recycling or landfill.

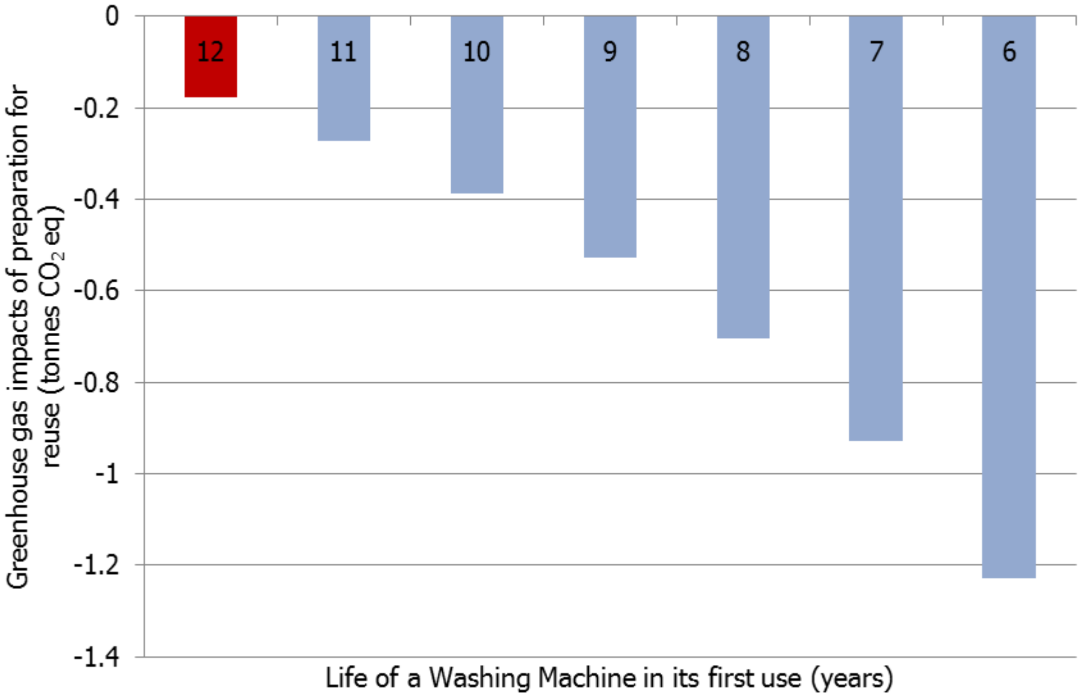
The key environmental, financial and employment benefits associated with this reuse activity are:

- Current levels of reuse of washing machines avoid 2,600 tonnes $CO_2$ eq per year.
- Providing 1 tonne of washing machines for direct reuse e.g. via a charity shop or online exchange can result in a net GHG saving of 0.5 tonnes $CO_2$-eq. This is just over 30kg $CO_2$-eq per machine.
- Providing 1 tonne of washing machines to a preparation for reuse network can result in a net GHG saving of 0.2 tonnes $CO_2$-eq net. This is about 12kg $CO_2$-eq per washing machine.
- As well as the carbon benefits, there are parallel resource and energy savings as a result of this reuse activity.
- Each washing machine reused can yield over £4 net revenue to reuse organisations (discounting wider costs or losses to householders and businesses)
- Households benefit by over £35 million per year as a result of sale of items through reuse exchange and avoiding purchase of (more expensive) new items.
- The *net* employment impact of dealing with all washing machines that reach the end of their life today (business-as-usual) is positive, despite the low levels of reuse.

A key variable is the anticipated lifetime of a washing machine being replaced. Figure i below shows the effect of changing the life expectancy of a new machine displaced by a reused machine. All other assumptions remain unchanged.

[1] *"Reuse" covers reuse, repair and refurbish*

**Figure i** Sensitivity of results to assumptions about life of washing machine




The closer the life of a new and reused washing machine, the greater the environmental benefit. If a new machine lasts for 12 years, we estimate that 2 reused machines will be required over that period to replace it. If a new machine lasts for 6 years, only 1 reused machine is required over that period to replace it.

**Televisions**

Approximately 1.3 million televisions (16,000 tonnes) are reused in some form in the UK every year. This represents 13% of all televisions reaching the end of their life each year by weight. The remaining 87% are sent to recycling or landfill. The average weight of a reused television is considered to be lower than the average weight of a disposed television due to changes in technology (e.g. CRT televisions are more likely to be disposed of than reused).

The key environmental, financial and employment benefits associated with this reuse activity are:

- Current levels of reuse of TVs avoid 156,000 tonnes $CO_2$ eq per year.
- Providing 1 tonne of TVs for direct reuse e.g. via a charity shop or online exchange can result in a net GHG saving of 8 tonnes $CO_2$-eq. This is just over 100kg $CO_2$-eq per TV.
- Providing 1 tonne of TVs to a preparation for reuse network can result in a net GHG saving of 5 tonnes $CO_2$-eq net. This is about 66kg $CO_2$-eq per TV.
- As well as the carbon benefits, there are parallel resource and energy savings as a result of this reuse activity.
- Each TV reused can yield £9 net revenue to reuse organisations (discounting wider costs or losses to householders businesses)
- Households benefit by almost £500 million per year as a result of sale of items through reuse exchange and avoiding purchase of (more expensive) new items.
- The *net* employment impact of dealing with all TVs that reach the end of their life today (business-as-usual) is positive.

**Electrical Items**

The results of the case study show that for both items, net employment gains are provided by reuse, with no losses in manufacturing jobs due to a lack of primary manufacturing in the UK.  The environmental and financial impacts of reuse are dependent on the value of the product and it's inherent properties.  It is therefore inappropriate to draw conclusions for all electrical items based on the case studies undertaken.

**Next steps**

This project to understand the benefits of reuse has clearly indicated the need to improve the quality of the primary data used in the tool to make the conclusions more robust. WRAP would like to work with stakeholders to improve the quality of this data on electrical items contained in the tool. In particular, we encourage research for or sourcing of better quality data on:

- the proportion of displacement of new items;
- the relative lifetime of new and reused items;
- the lifetime extension afforded through refurbishment;
- the manufacturing burdens associated with new televisions.
- the likelihood of an increase in future recycling rates of washing machines; and
- costs and employment associated with waste collection and reuse activities.

# Contents


**1.0 Washing machines ... 8**
- 1.1 Washing Machine Reuse in the UK ... 8
  - 1.1.1 What does Direct Reuse look like for Washing Machines in this Assessment? ... 10
  - 1.1.2 What does Preparation for Reuse look like for Washing Machines in this Assessment? ... 11
  - 1.1.3 What does Disposal look like for Washing Machines in this Assessment? ... 11
- 1.2 Quantifying the Benefits of Reusing Washing Machines ... 12
  - 1.2.1 Approach to the Assessment ... 12
  - 1.2.2 Data Quality ... 12
- 1.3 Results and Discussion ... 13
  - 1.3.1 Environmental Impacts: Washing Machines ... 13
  - 1.3.2 Financial Costs and Benefits: Washing Machines ... 17
  - 1.3.3 Employment Opportunities: Washing Machines ... 20
- 1.4 Conclusions: Washing Machines ... 21

**2.0 Televisions ... 22**
- 2.1 Television Reuse in the UK ... 22
  - 2.1.1 What does Direct Reuse look like for televisions in this Assessment? ... 24
  - 2.1.2 What does Preparation for Reuse look like for Washing Machines in this Assessment? ... 25
  - 2.1.3 What does Disposal look like for televisions in this Assessment? ... 25
- 2.2 Quantifying the Benefits of Reusing Televisions ... 25
  - 2.2.1 Approach to the Assessment ... 25
  - 2.2.2 Data Quality ... 25
- 2.3 Results and Discussion ... 27
  - 2.3.1 Environmental Impacts: Televisions ... 27
  - 2.3.2 Financial Costs and Benefits: Televisions ... 30
  - 2.3.3 Employment Opportunities: Televisions ... 33
- 2.4 Conclusions: Televisions ... 34

# Glossary

**Economic Life**
*Period over which an asset (e.g. clothing, electrical item) is expected to be usable, with normal repairs and maintenance, for the purpose it was acquired, rented, or leased. Expressed usually in number of years, process cycles, or units produced, it is usually less than the asset's technical life, and is the period over which the asset's depreciation is charged. (businessdictionary.com)*

**Preparation for reuse**
*Means checking, cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing .* (Waste Framework Directive 2008)

**Private costs**
*Costs that are incurred to an individual or firm when they are carrying out the activities of consumption or production. They include costs of labour, rent, taxes and transfers, and with the costs of capital reflecting market rates.*

**Psychological Life**
*The period until which "a product that is still sound in terms of quality or performance becomes 'worn out' in our minds because a styling or other change makes it seem less desirable*" (Packard, 1960)

**Reuse**
*Any operation by which products or components that are not waste are used again for the same purpose for which they were conceived (i.e. dealing with waste prevention); (Waste Framework Directive 2008)*

**Social costs**
*The total costs of an activity to society. As such, the social cost excludes taxes and transfers which move money from one part of the economy to another, but do not add to or remove from the overall balance.*

**Technical Life**
*The period over which the product is designed to function (i.e. to the point at which it is 'worn out' or beyond repair).*

# Acknowledgements

This case study has been developed in conjunction with a steering group comprising representatives from a range of organisations involved in the reuse of a variety of products, as well as representatives of Government, enforcement agencies and private companies. We would like to acknowledge the invaluable input of the following individuals and organisations.

Craig Anderson, FRN
Emma Hallet, REalliance
Pauline Hinchion, CRNS (to March 2011)
Rhiannon Jones, Welsh Government
Nicola Leeds, DEFRA
Neil Lovelock, CRNS (March 2011)
Cristina Osoro Cangas, Charity Retail Association
Fay Skevington, DEFRA
Richard Thomas, Cylch
Matthew Thomson, London Community Reuse Network
Sarah Clayton, WRAP
Liz DixonSmith, WRAP
Gerrard Fisher, WRAP
Rachel Gray, WRAP
Sarah Gray, WRAP
Nick Kightley, WRAP
Peter Maddox, WRAP
Kimberley Pratt, Zero Waste Scotland
Mike Robey, WRAP
Laura Underwood, WRAP
Julie Taylor, WRAP Cymru

Thanks also to Lucy Keal (WRAP) and to Caroline Lee-Smith (FRN) for the provision of a range of information. Finally, we would like to acknowledge the preliminary work carried out by Giraffe Innovation, Eunomia and SKM Enviros in shaping this project.

# 1.0 Washing machines

This chapter discusses washing machine reuse in the UK and provides an estimate of the net environmental and economic, both financial and social, benefits of the current levels of washing machine reuse and the potential impact of increases in reuse.

An 'average' washing machine is assumed to be the item replaced by reusing a washing machine. This is modelled as being made of low alloyed steel (29%) concrete (28%) cast iron (17%), aluminium (3%) and other materials (23%)

This chapter outlines:

- An overview of washing machine reuse in the UK, including material flows from the end of their first life through the various reuse and disposals routes.
- The methodology and data quality issues relating to this analysis of the benefits
- The current business-as-usual situation today for washing machines with some scenario analysis for:
    - environmental benefits
    - financial costs
    - employment opportunities
- The key conclusions

## 1.1 Washing Machine Reuse in the UK

Washing machines are thought to pass through a wide range of pathways once they have reached the end of their first life. This may be via direct reuse (e.g. passed on to friends and family, sold, or given to a charity), retailer 'take-back' schemes, bulky waste collections and drop off at Household Waste Recycling Centres. Owing to their bulk, washing machines are not thought to be disposed of through regular household waste collections.

Information on the current understanding of the flow of washing machines is provided in Figure1. Despite the range of routes to reuse and recycling, current data suggest that over 54% of washing machines discarded in the UK end up in landfill (Environment Agency, 2011). Of the machines not sent to landfill, the majority are shredded for recycling rather than refurbished for reuse. Such refurbishment only takes place in cases where it is economically viable.

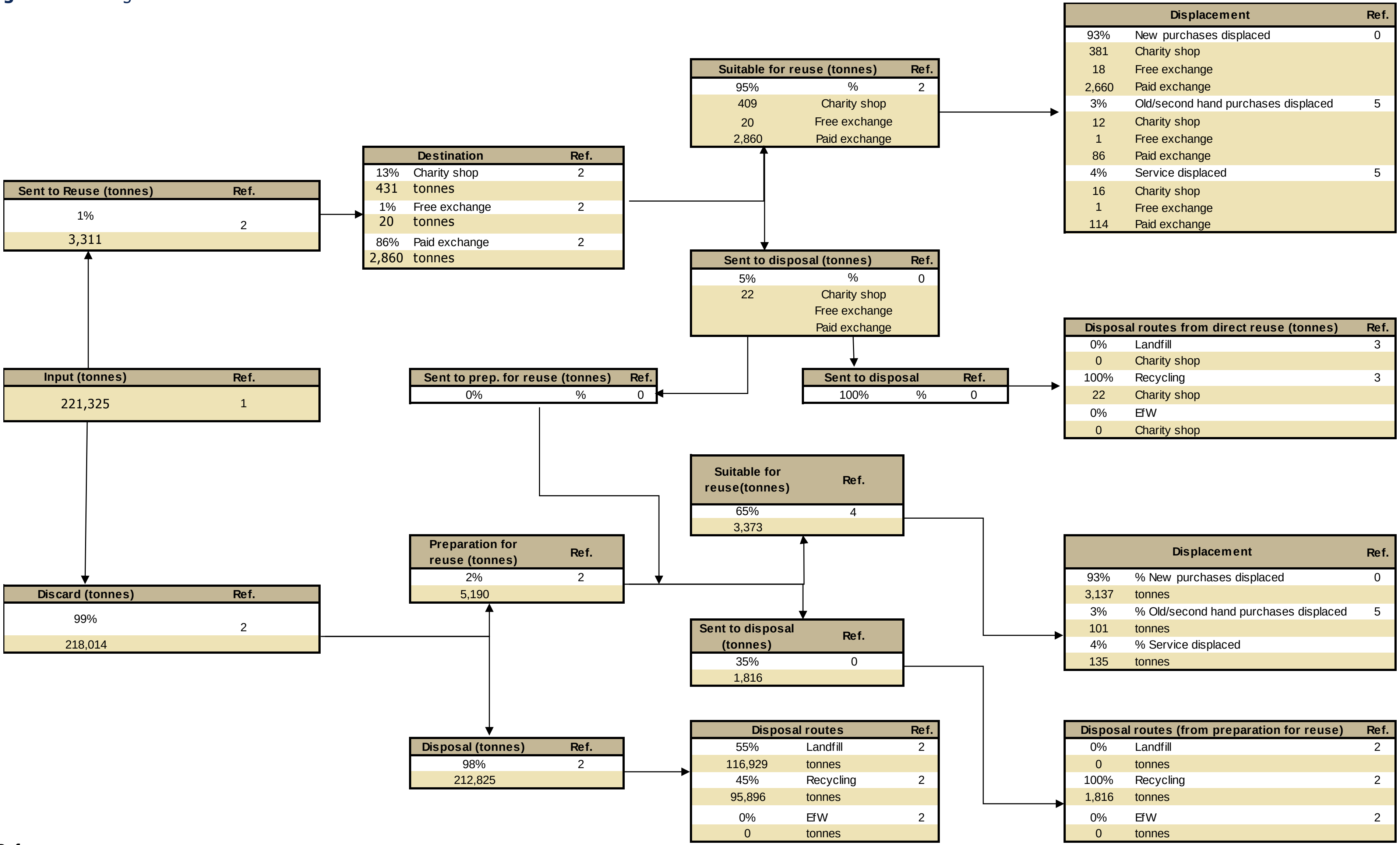
WRAP has developed estimates of annual washing machine waste arisings and subsequent fates, as outlined in Figure 1. This sets out the 'business-as-usual' profile modelled in this assessment, with 'direct reuse' characterised by local donation to charity shops or free/paid exchanges and 'preparation for reuse' characterised by a furniture reuse network. Key estimates are made of the percentage of new washing machine purchases that are avoided as a result of the reuse action. This is called the displacement effect.

Figure 2 shows the final destination of washing machines which pass through the different pathways identified in Figure 1. Only 3% of washing machines that reach the end of their life are reused.

On average, of the machines received by reuse organisations, 25% are sent to recycling immediately, with another 10% sent to recycling after initial testing. The result is a low level of reuse of washing machines. Preparation for reuse by charitable and private organisations currently accounts for just 1.5% of discarded washing machines in the UK, while 1.3% are reused directly via online exchanges or otherwise (Environment Agency, 2011).

The following sections briefly describe each pathway, as modelled in the assessment.

**Figure 1** Washing machine mass flow – 'business-as-usual'





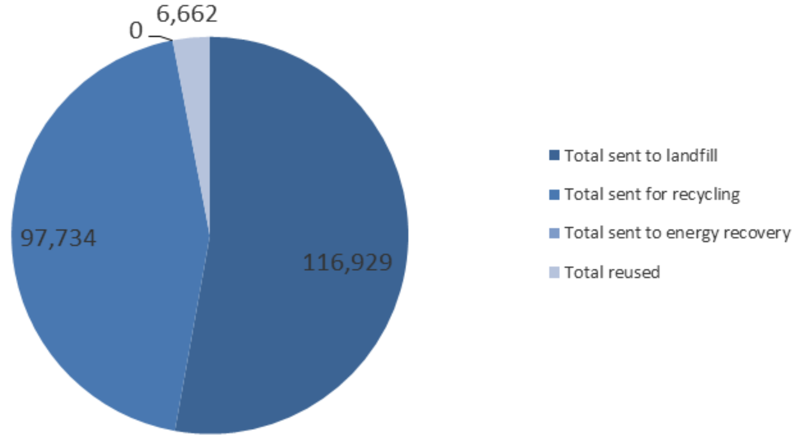
**Reference**

1 Euromonitor International (2010)

2 Calculated from Office for National Statistics (2010) and Environment Agency (2011)

3 Environment Agency (2011)

**Figure 2** Final Destination of Washing Machines– 'business-as-usual' (tonnes)




### *1.1.1 What does 'direct reuse' look like for washing machines in this assessment?*

The general definition of 'direct reuse' in this assessment is set out in the glossary and in WRAP (2011). Based on the best available data, direct reuse of washing machines is believed to mainly take place through exchange between family and friends, online networks and charity shops. No data on sales through second hand shops was identified.

For some electrical items, it is possible that second hand purchases are additional to existing items (e.g. an additional television). For washing machines, this is not considered a realistic scenario. However, the purchase of a washing machine may replace the service provided by a laundrette. Such a 'replacement of service' is accounted for in this assessment.

A washing machine has a 'technical lifetime' defined by the maximum number of cycles it can complete. For the purposes of this study, the technical lifetime of a washing machine is assumed to be 12 years (approximately 3000 cycles), consistent with Market Transformation Programme (2009) and DEFRA (2011).

The project steering group contacted members of their organisations and identified that typically, a washing machine donated to a preparation for reuse organisation is 4-5 years old. This is likely to be the point at which the item has reached the end of its economic life for the first owner (e.g. it requires a repair the owner has decided not to undertake). With a technical life of 12 years, this suggests that a reused item may last up to 8 years in its second life.

The technical lifetime can typically be extended by refurbishment. Data describing refurbishment periods are limited, but this study assumes that refurbishment occurs once and extends the lifetime of a washing machine by 6 years (1500 cycles), again consistent with DEFRA (2011). The benefit accruing from displacement by the reused item is a function of this lifetime – i.e. a reused washing machine that lasts for 12 years entirely displaces the impact of the production of a new machine. However, a reused washing machine that lasts six years only displaces half of the impact arising from the production of a new machine.

These assumptions represent only one of many potential reuse scenarios, and so alternative reuse scenarios have also been investigated to test the sensitivity of the results to the assumptions. Section 1.3.1 describes these scenarios in greater detail.

The following displacement options have also been assumed as a default:

- **4% displacement of service**. This route assumes that the purchase of a reused washing machine displaces the use of a laundrette. 96% of UK households own a washing machine (ONS, 2010), and therefore the proportion of households that regularly use a laundrette service is likely to be around 4%. Behrendt et al

(2004) found that in Germany the main reason people use laundrettes is because they do not own a washing machine, and suggested 4.6% of the population regularly use laundrettes. While it is noted that laundrette machines are likely to be different from domestic machines in both their material composition and lifespan, sufficient data to model these differences were not available and, for simplicity, it has been assumed that the technical life (i.e. number of cycles) is similar for both domestic and commercial machines and that the environmental impacts of both are similar.

- **93% displacement of a new item**. In the case of washing machines, 'displacement of new' assumes that the reused item will directly avoid the production of a new washing machine, leading to an environmental benefit. However, the forgone new washing machine is likely to have been more energy efficient than the reused machine. Therefore, there is an environmental impact associated with the forgone benefit of this increased efficiency. Research suggests that the majority of washing machines currently in use are 'A-rated' for efficiency. By 2014, 'A+-rated' machines are likely to take over in the majority of households (DEFRA 2011). Therefore, this assessment assumes that the reuse of an A-rated washing machine displaces a new A+-rated machine. Earlier we noted that currently 3% of washing machines disposed of in the UK are reused. Assuming all discarded washing machines are replaced, the market for washing machine replacement consists of 97% new products and 3% refurbished products. Therefore, of the purchases that do not replace a service, 97% of these will be likely to displace the purchase of a new machine. This means that 97% of 96% = 93% of reused washing machines displace the purchase of a new item. It should be noted that this assumption does not take into account market growth. However, this is unlikely to affect the result significantly.

- **3% displacement of an old item**. This route assumes that the reuse of a washing machine will displace the purchase of a second-hand machine, rather than a new item. In this case, no avoided production is allocated, to avoid the double-counting of such benefits, and no impact during the use phase is allocated as the efficiency of both machines is assumed to be the same.

A full list of data and assumptions used to characterise direct reuse for washing machines is set out in Tables A1 to A3 in Appendix A.

### *1.1.2 What does 'preparation for reuse' look like for washing machines in this assessment?*

In the case of washing machines, the preparation for reuse pathway includes the collection, refurbishment and sale of discarded washing machines by charitable and private organisations. Not all discarded washing machines are suitable for refurbishment and hence this pathway has a direct link to the recycling pathway. According to the Environment Agency (2011), 25% of washing machines collected for preparation for reuse are sent to recycling directly, while a further 10% are sent to recycling following testing.

As is the case with directly reused washing machines, washing machines in the preparation for reuse stream are assumed to be kept for six years and to be refurbished once in this time.

In this study, preparation for reuse is assumed to include the financial, employment and environmental burdens of:

- **collection** – e.g. via kerbside collection, bring sites or direct delivery from businesses;
- **sorting and refurbishment** operations at handling facilities;
- **delivery of items suitable for reuse** for sale or gifted in the UK;
- **onwards recycling** of items unsuitable for reuse; and
- **avoided impacts** of displacing new items – using the same profile as for direct reuse.

A full list of data and assumptions used to characterise the preparation for reuse pathway for washing machines, including the materials associated with refurbishment, is set out in Tables A1A1 to A3 in Appendix AA3.

### *1.1.3 What does 'disposal' look like for washing machines in this assessment?*

As discarded washing machines do not typically end up in the residual waste stream, no washing machines are sent to incineration. As a result, disposal in this study is characterised into just two principal routes:

- **Recycling** (45%) – typically, waste electrical and electronic equipment (WEEE) sent for recycling is shredded and its materials separated into three fractions: ferrous metals, non-ferrous metals, and 'fluff'. The metals are reprocessed as secondary metal, while the fluff fraction – consisting mainly of low quality plastics and fines – is sent to landfill. NB WRAP has recently completed successful trials on recycling the plastic fraction WRAP 2008).

- **Landfill** (55%) – including collection and subsequent disposal in landfill. As all of the materials in a washing machine are inert, no direct emissions associated with materials degrading in landfill are considered.

## 1.2 Quantifying the Benefits of Reusing Washing Machines

### *1.2.1 Approach to the assessment*

For an overview of the approach adopted for this case study please refer to WRAP (2011) *A methodology for quantifying the environmental and economic impacts of reuse.*

### *1.2.2 Data Quality*

Tables A1 to A3 in Appendix A set out all of the data sources and assumptions used in the assessment of environmental and financial costs and employment criteria, along with a consideration of their quality and applicability for the study.

The most up-to-date information available has been sourced. However, we note that some considerable uncertainties remain. In particular, there are the following sources of error or variability:

- Current arisings data are very uncertain on an individual-item basis. The mass flow data for washing machines gathered by WRAP suggest that around 10% of machines currently in circulation enter the waste or reuse stream annually (based on approximately 26 million households in the UK) (ONS 2011a).

- The material requirements for refurbishment are based on a 'standard' refurbishment. It is uncertain to what extent this is representative of all refurbishments.

- The lifetime extension afforded by refurbishment is uncertain. The sensitivity of the results to this uncertainty is explored in more detail below.

- There is a high level of benefit associated with the recycling of metals. For reuse pathways, it is assumed that the recycling rate at the end of second life is equal to the targets set under the WEEE Directive, as opposed to current rates. The sensitivity of the results to this assumption, given the high benefit of recycling, is discussed below.

- Cost and employment data were provided by WRAP and steering group partners for the assessment. The best currently available sources have been gathered, but the uncertainty and high potential variability of the values used is noted.

- With regard both to costs and to employment impacts, assumptions relating to the amount of time spent checking, sorting and preparing items, as well as resale value, are subject to considerable uncertainty. It is recommended that further information is sought for these issues.

## 1.3 Results and Discussion

### *1.3.1 Environmental impacts: Washing machines*

#### Environmental impacts: Business-as-usual

Table 1 presents the **environmental impacts and benefits associated with the current management of all end-of-life washing machines estimated to arise in the UK each year**. This includes the impacts associated with waste management activities in the UK (and abroad where exported), and the benefits of avoided production of materials through reuse and recycling – whether- occurring in the UK or abroad. Net impacts/benefits are also presented for a single washing machine and a tonne of washing machines in Table 2.

Note that these are the *absolute* impacts/benefits associated with current levels of disposal and reuse. Different management pathways are compared in Table 33.

Table 1 and Table 2 show that **current UK management of washing machines results in net GHG savings** of around 70,000 tonnes $CO_2$-eq, or 20kg $CO_2$-eq per washing machine handled. This reflects the high current levels of recycling. Current levels of reuse save 2,557 tonnes $CO_2$ eq per annum, including recycling of machines not suitable for reuse or preparation for reuse.

**Table 1** Business-as-usual management: **Total UK** environmental impacts

| Activity | Total UK Washing Machines – GHG Emissions (tonnes $CO_2$-eq) | Total UK Washing Machines – Resource Depletion (tonnes Sb-eq) | Total UK Washing Machines – Global Energy Demand (MJ-eq) |
|---|---|---|---|
| Reuse pathway | -862 | -5 | -5,400,000 |
| *- of which collection* | | | |
| *- of which site operation (inc. refurbishment)* | *1,340* | *9* | *15,800,000* |
| *- of which disposal of residuals** | *-2,200* | *-14* | *-21,200,000* |
| | | | |
| Preparation for reuse pathway | -135 | -2 | 3,210,000 |
| *- of which collection* | *764* | *5* | *11,000,000* |
| *- of which site operation (inc. refurbishment)* | *2,760* | *16* | *27,500,000* |
| *- of which disposal of residuals** | *-3,660* | *-23* | *-35,300,000* |
| | | | |
| Disposal pathway | -68,900 | -424 | -644,000,000 |
| *- of which landfill* | *5,750* | *37* | *82,800,000* |
| *- of which incineration* | | | |
| *- of which recycling* | *-74,700* | *-461* | *-727,000,000* |
| | | | |
| Reuse displacement effects | -1,560 | -28 | -137,000,000 |
| | | | |
| **TOTAL** | -71,500 | -459 | -783,000,000 |

Note: negative figures denote a net saving, through displacement of other products/materials and their avoided production
* this includes the recycling of items unsuitable for reuse and the ultimate disposal of reused items at the end of their second life (75% recycling, 25% landfill, consistent with WEEE directive targets)

**Table 2** Business-as-usual management: Environmental impacts

| Scale | GHG Emissions (tonnes $CO_2$-eq) | Resource Depletion (tonnes Sb-eq) | Energy Demand (MJ-eq) |
|---|---|---|---|
| Per total UK washing machine arisings | -71,500 | -459 | -783,000,000 |
| Per tonne of washing machines | -0.32 | -0.00207 | -3540 |
| Per washing machine | -0.021 | -0.00014 | -230.0 |

Note: negative figures denote a net saving, through displacement of other products/materials or their avoided production

The key finding from these results is that all impact indicators for the 'business-as-usual' case are negative. As reuse is assumed to occur at a very low level, this is primarily due to the **high displacement benefits associated with the recycling of metals.**

There are considerable uncertainties around these 'business-as-usual' flows and so the values should be treated with caution in their absolute sense. In particular, overall findings are sensitive to the following factors:

- Current arisings (tonnage) of end-of-life washing machines in the UK. Impact estimates will increase or decrease in a linear correlation with this figure. While we believe that a sound source has been used, this figure is likely to fluctuate on a yearly basis. Impact results on a 'per tonne' or 'per item' basis are not susceptible to such fluctuations, but are sensitive to assumptions around the weight of an individual item, which can vary.

- The **second lifetime of displaced products.** The length of the extended lifetime of reused products has a significant impact on the benefits accrued through displacement. This is discussed in more detail below.

Despite these uncertainties, there are clear environmental benefits associated with the current management of end-of-life washing machines. The majority of this environmental benefit is associated with the recycling of the metals that form a large part of the washing machine.

## Environmental impacts: Scenario analysis

Table 3 shows the net environmental impacts associated with a range of hypothetical scenarios. As in the case of textiles, these results are reported on a per item basis.

**Table 3** Scenario analysis: Environmental impacts per tonne of washing machines

| Scenario | GHG Emissions (tonnes $CO_2$-eq) | Resource Depletion (tonnes Sb-eq) | Energy Demand (MJ-eq) |
|---|---|---|---|
| Business as usual | -0.32 | -0.00207 | -3540 |
| 100% direct reuse | -0.49 | -0.0057 | -22100 |
| 100% preparation for reuse | -0.18 | -0.0031 | -12800 |
| 100% recycling | -0.78 | -0.00481 | -7580 |
| 100% landfill | 0.05 | 0.000314 | 708 |
| Current rates of disposal* | -0.32 | -0.00199 | -3030 |

Note: negative figures denote a net saving, through displacement of other products/materials and their avoided production
* 100% disposal at current recycling rates (45% recycling, 55% landfill)

These results suggest that in terms of GHG emissions, the most environmentally beneficial route for a discarded washing machine is likely to be recycling. In terms of resource depletion, direct reuse presents the most environmental benefit while, for energy demand, both direct reuse and preparation for reuse of washing machines provide a greater environmental benefit than recycling.

Preparation for reuse yields lower benefits than direct reuse due to a higher reject rate. Whilst all machines exchanged for cash or free are assumed to function, only 65% of items provided for preparation for reuse and reuse via charity shops are suitable for reuse.

This highlight the fact that different environmental impacts are sometimes decoupled. In these circumstances, trade-offs may be required to determine the most 'environmentally friendly' solution. These trade-offs will usually have to be made on the basis of value judgements over which impact is seen as the most important by stakeholders.

For GHG, recycling performs better than reuse, partly because of the impact incurred in reuse pathways from refurbishment and the comparative loss of efficiency, and partly because some of the materials in reused machines are assumed to be 'lost' to landfill at eventual end of life. This impact is partly, but not completely, offset by the displacement of 50% of the manufacturing impact. (see Section 1.1.1 above).

Under the allocation rule for recycling benefits used in this study, the benefit of recycling is applied at the end of life (i.e. when a material is recycled) rather than the beginning of life (i.e. when recycled material is used in manufacture). Aluminium, which in its primary form incurs a very high GHG burden, forms a large part of washing machines. As a result there are large GHG benefits to be accrued from the displacement of primary aluminium through recycling of washing machines.

Of the two reuse pathways, direct reuse offers the greatest environmental benefit across all categories. It is assumed that 100% of washing machines entering this pathway are suitable for reuse (following refurbishment), thereby conferring the substantial displacement benefits of avoided washing machine production. Preparation for reuse shows lower environmental saving than direct reuse, partly because only 65% of machines are deemed suitable for reuse, so a proportion of the displacement benefits associated with direct reuse are lost.

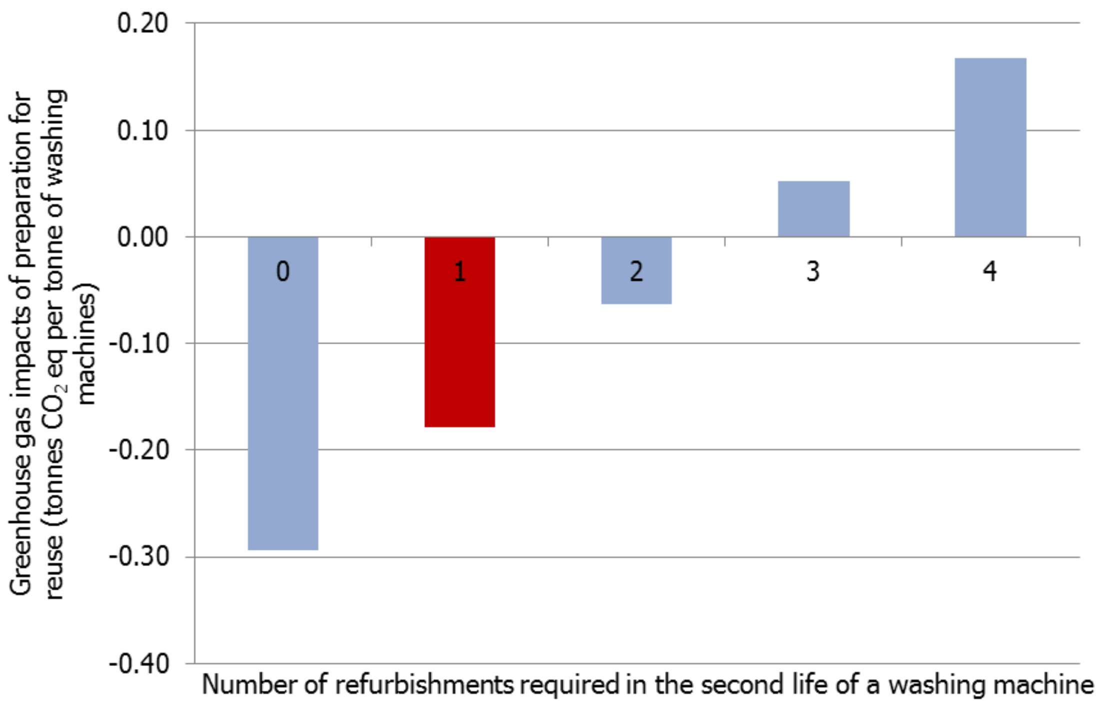
These findings are highly sensitive to a number of assumptions made as part of this study, as explored further below.

## Environmental impacts: Sensitivity analysis

### Lifetime extension due to refurbishment

The act of refurbishing a washing machine requires the use of raw materials and energy, each giving rise to an environmental impact. Based on DEFRA (2011), it is assumed in this study that to achieve a second lifetime of six years (i.e. to displace half of the lifetime of one new washing machine), a second-hand washing machine must be refurbished once. However, the results of the model are highly sensitive to this assumption. Figure 3 below shows the effect of increasing the number of refurbishments required during reuse of a washing machine, with the default assumption highlighted in red. This shows that if more than 2 refurbishments are required, the avoided greenhouse gas emissions from preparation for reuse switch to become a net emissions.

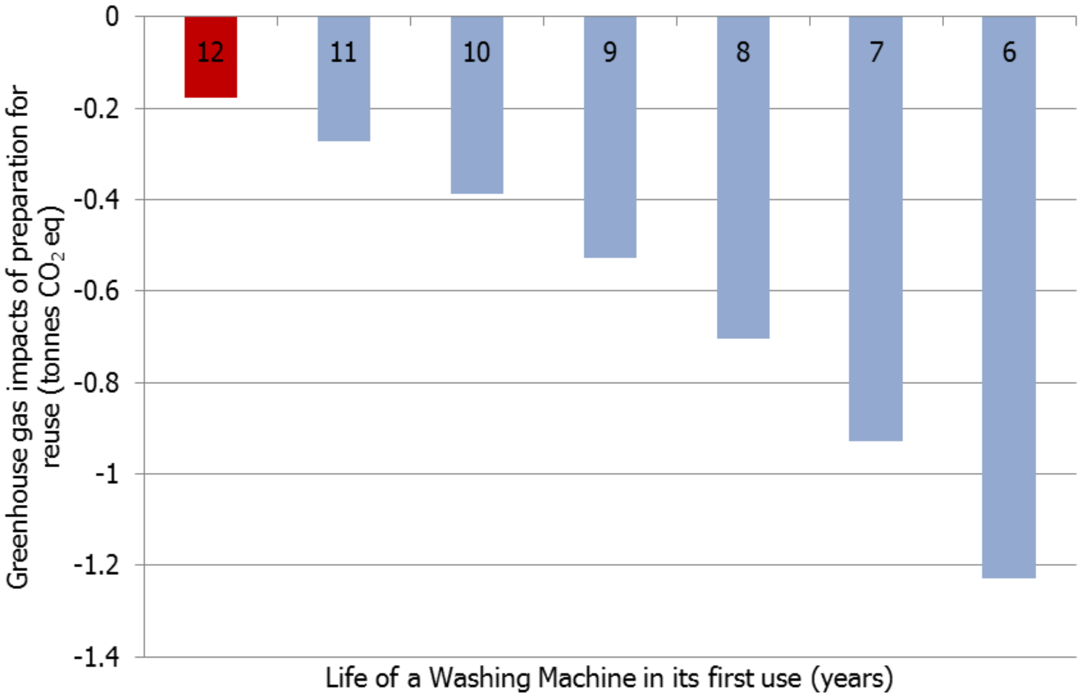
**Figure 3** Change in greenhouse gas impact of preparation for reuse with number of refurbishments (tonnes $CO_2$eq per tonne washing machines)




Another potential scenario is that, if one refurbishment allows a six-year lifetime extension for a washing machine, two refurbishments of the same machine could allow it to last for 12 years and therefore displace the entire impact of producing a new washing machine. Under this scenario, the environmental benefits for the preparation for reuse pathway increase by 45% for GHG emissions; 60% for resource depletion and 80% for fossil energy demand.

The age of the washing machine being substituted for is another critical issue. Although the Market Transformation Programme (2009) suggests the average machine lasts 12 years, sales data from Euromonitor (2010) divided by the number of UK households suggests that machines are retained for only 8 years. Figure 4 below shows the change in GHG emissions if a reused item is used in place of a washing machine which would otherwise last for different periods of time, with the default assumption highlighted in red. This shows that if the life of a new washing machine is less than 12 years, the benefit of reuse increases.

**Figure 4** Sensitivity of results to assumptions about life of washing machine




There are many potential scenarios for reuse pathways, machine lifetimes and refurbishment (including many not considered within this sensitivity analysis), and it is important to note that the core results of this assessment consider just one scenario. However, it is equally useful to note that, regardless of the scale of environmental benefits calculated, under the majority of reasonable scenarios these are net benefits as opposed to impacts.

**Future recycling rates**

In the default scenarios, it is assumed that the recycling targets set by the EU WEEE Directive (2002/96/EC) are reached by the end of the second life of the washing machine. This presents itself as an added benefit of reuse, as entry into the waste stream is delayed until a time when disposal is more environmentally favourable. However, predicting whether targets such as these will be met is difficult. Indeed, these targets were originally to have been met by 31 December 2006. Assuming a worst case scenario in which recycling rates remain the same as today, the overall benefit of the reuse scenarios assessed falls by 20–30% for GHG emissions, 10% for resource depletion and 5% for energy demand.

The sensitivity of results to these recycling rates, particularly for GHG emissions, suggests that an increase in the rate at which WEEE is recycled is a valuable target in terms of environmental impact reductions.

**Scaling from an individual case to all UK arisings**

Based on this study, there is a large environmental benefit associated with direct reuse. This is because it is assumed that all washing machines entering this pathway are suitable for reuse and that none are sent directly to disposal. Whilst this may be true of current operations, it is extremely unlikely to be the case that all end-of-life washing machines are suitable for direct reuse. In view of this, caution is advised in extrapolating these results.

### *1.3.2 Financial costs and benefits: Washing machines*

## Financial cost: Business-as-usual

Analysing the business-as-usual case, as set out in Figure 2, yields the following results for the private metric accounting approach (landfill tax included).

Table 4 presents costs for each pathway and core activity, split according to the party to which costs and benefits accrue. These present estimates for the current overall UK situation. Due to the uncertainty surrounding total UK arisings, net costs and benefits on a unit item or unit mass basis are also presented (Table 5).

**Table 4** Business-as-usual: **Total UK** net cost/benefit (private metric)

| Activity | Total UK Net Cost/Benefit (£) | …of which to Local Authorities** | …of which to Reuse organisations | …of which onward employment from ROs | …of which to households*** | …of which to business**** |
|---|---|---|---|---|---|---|
| Reuse pathway | £1,020,000 | £412,000 | £611,000 | | | |
| *- of which collection* | | £0 | £0 | | | |
| *- of which site operation* | £611,000 | £0 | £611,000 | | | |
| *- of which disposal of residuals** | £412,000 | £412,000 | £0 | | | |
| Preparation for reuse pathway | £3,140,000 | £493,000 | £2,640,000 | | | |
| *- of which collection* | £910,000 | £0 | £910,000 | | | |
| *- of which site operation* | £1,730,000 | £0 | £1,730,000 | | | |
| *- of which disposal of residuals** | £493,000 | £493,000 | £0 | | | |
| Disposal pathway | £33,800,000 | £33,800,000 | £0 | | | |
| *- of which landfill* | £30,100,000 | £30,100,000 | £0 | | | |
| *- of which incineration* | £0 | £0 | £0 | | | |
| *- of which recycling* | £3,750,000 | £3,750,000 | £0 | | | |
| Displacement effects and sales | -£580,000 | -£580,000 | -£3,420,000 | | -£36,600,000 | £40,000,000 |
| Onward employment from reuse | -£838,000 | £0 | | -£838,000 | | |
| **TOTAL** | £36,542,000 | £34,125,000 | -£169,000 | -£838,000 | -£36,600,000 | £40,000,000 |

Notes:
negative figures denote income or avoided purchase
* this includes the recycling of items unsuitable for reuse and the ultimate disposal of reused items at the end of their second life (75% recycling, 25% landfill). It includes treatment costs, collection costs and revenue from recyclate.
** for the private metric this includes landfill tax.
*** benefits accruing to householders as a result of the sale of items through paid exchange and through avoiding the purchase of new items. This is net of the income to charity shops/PFR organisation (assumed from householders).
**** cost to retailers of new washing machines in terms of lost revenue from sales

**Table 5** Business-as-usual management: Financial cost

| Scale | Private Metric (inc. landfill tax) (£) | Social Metric (no landfill tax) (£) |
|---|---|---|
| Total UK washing machine arisings | £36,542,000 | £30,844,000 |
| Per tonne of washing machines | £165 | £139 |
| Per washing machine | £10.70 | £9.06 |

Key points from the results are as follows:

- Overall results are positive (net expenditure). This is due to low levels of reuse, resulting in low levels of income from sales. There are significant uncertainties around 'business-as-usual' flows, and so these values should be treated with caution in their absolute sense.
- Although recycling of washing machine materials is a source of revenue (£100 per tonne), the cost of collection (£99–£300 per tonne) largely outweighs this. As a result, the collection and recycling of washing machines represents a net expenditure.
- The bulk of the cost falls to local authorities, as the majority of washing machines currently enter the domestic waste stream (NB: some of these costs will then be passed on under Producer Responsibility schemes).

The following sensitivities are noted:

- **Net profit from sales of second-hand washing machines.** The results show that, although £3,500,000 of income is generated by sales of washing machines by reuse organisations, this represents only a modest profit of around £169,000 (when collection and operational costs are taken into account). A reduction of 15% in the resale value of washing machines would turn this profit into a net loss.

- **Waste collection costs.** Waste management costs account for almost all of the cost incurred through the treatment of end-of-life washing machines. These costs have a significant effect on the results presented. A 10% increase in the cost of collection leads to a 9.5% increase in overall costs, suggesting that uncertainty surrounding these values has a disproportionately large impact on the overall figure.

- **Savings on social welfare payments associated with the provision of training and onward employment**. Although there is uncertainty over the magnitude of these savings, as the benefit is relatively small, the uncertainty surrounding it is unlikely to affect the overall results.

Up to 50% of sales of electrical items (including washing machines) through preparation for reuse networks can come through Social Fund Community Care Grant Schemes. The welfare money spent on reused items through this action could otherwise have been spent on more expensive new items, therefore the act of reuse theoretically presents an additional saving to the welfare budget. This has not been quantified in this study. However, it is anticipated that they will be included in future as data quality improves.

## Financial cost: Scenario analysis

As for the environmental criteria, it is useful to compare the status quo with a range of possible scenarios. Again, costs are considered on a per-item basis, as opposed to considering the unlikely event of a wholesale shift in the treatment of end-of-life washing machines. Table 6 presents net costs and benefits per tonne of washing machines for a range of scenarios. This includes collection, operation (rent, utilities, labour), sales, disposal of residuals, eventual disposal of reused items at end of life and the avoided disposal of new items displaced.

**Table 6** Scenario analysis: **Financial** costs per tonne of washing machines

| Scenario | Private Metric (£) | Social Metric (£) |
|---|---|---|
| Business as usual | £165 | £139 |
| 100% direct reuse | £222 | £208 |
| 100% preparation for reuse | £386 | £377 |
| 100% recycling | £39 | £39 |
| 100% landfill | £257 | £209 |
| Current rates of disposal | £159 | £133 |

Table 6 shows that all pathways for the management of end-of-life washing machines result in a net cost to the UK economy as a whole. The highest cost is through the preparation for reuse pathway. Although this pathway provides benefit to households through avoided cost of purchase and delivers a modest profit to the reuse organisations through sales, this is at the expense of retailers of new machines. Therefore, the net benefit of these sales at an economy level is zero.

Direct reuse represents an average of all reuse routes – paid exchange, free exchange and provision of machines through charity shops. The costs vary significantly by route and the average cost does not reflect the cost of the routes individually.

Although much of the displaced retail cost will actually be borne by manufacturers overseas, it was not possible in the scope of this assessment to apportion costs in this respect, and so they are included for completeness, and to maintain a conservative perspective. Further research is required to understand the international division of the financial impact of displacement.

### *1.3.3 Employment opportunities: Washing machines*

## Employment opportunities: Business-as-usual

Analysing the business-as-usual case, as set out in Figure 1, yields the following results with regard to employment opportunities.

**Table 7** Business-as-usual: **Total UK** employment (full time equivalents, excluding volunteers**)**

| Activity | Total UK Net Cost/Benefit (FTE) | …of which to Local Authorities | …of which to Reuse organisations |
|---|---|---|---|
| Reuse pathway | | | 17 |
| *- of which collection* | | | |
| *- of which site operation* | | | *17* |
| *- of which disposal of residuals** | | | |
| Preparation for reuse pathway | 72 | 11 | 61 |
| *- of which collection* | *13* | | *13* |
| *- of which site operation* | *48* | | *48* |
| *- of which disposal of residuals** | *11* | *11* | |
| Disposal pathway | 1200 | 1200 | |
| *- of which landfill* | *1170* | *1160* | |
| *- of which incineration* | | | |
| *- of which recycling* | 38 | 38 | |
| Displacement effects | | | |
| **TOTAL full time equivalents** | **1280** | **1210** | **66** |

Notes:
negative figures denote loss of employment
for preparation for reuse, it is assumed that volunteer labour is used in both collection and on site operations* this includes the recycling of items unsuitable for reuse and the ultimate disposal of reused items at the end of their second life (75% recycling, 25% landfill)

Key points from the results are as follows:

- There are no displaced jobs associated with reusing washing machines, as no large scale UK manufacturing is believed to exist.
- The principal employment benefits associated with the end-of-life management of washing machines are associated with waste management (including local government and waste management companies). This is due to the estimate that 2.7 million (80%) washing machines are collected as bulky waste, with 96% of waste management jobs being associated with collection rather than treatment. Data used for this study suggest that a team of two people can make a maximum of 20 collections per day.
- Preparation for reuse requires more labour per tonne than disposal. An increase in reuse activity via preparation for reuse could therefore lead to a benefit in terms of employment. The scale of employment in preparation for reuse is dependent on the assumptions around labour for preparation and checking.
- If volunteer employment were to be included in Table 7, net employment opportunities for the reuse organisations increase to 111 (See table A3 for assumptions made).
- As for other criteria, there are uncertainties around 'business-as-usual' flows, and so these values should be treated with some caution in their absolute sense.

## 1.4 Conclusions: Washing Machines

Approximately 102,500 washing machines (6,662 tonnes) are reused in some form in the UK every year. This represents 3% of all washing machines reaching the end of their life each year. The remaining 97% are sent to recycling or landfill.

The key environmental, financial and employment benefits associated with this reuse activity are:

- Current levels of reuse of washing machines avoid 2,557 tonnes $CO_2$ eq per year.
- Providing 1 tonne of washing machines for direct reuse e.g. via a charity shop or online exchange can result in a net GHG saving of 0.49 tonnes $CO_2$-eq. This is just over 32kg $CO_2$-eq per machine.
- Providing 1 tonne of washing machines to a preparation for reuse network can result in a net GHG saving of 0.18 tonnes $CO_2$-eq net. This is about 12kg $CO_2$-eq per washing machine.
- As well as the carbon benefits, there are parallel resource and energy savings as a result of this reuse activity.
- Each washing machine reused can yield over £4 net revenue to reuse organisations (discounting wider costs or losses to householders businesses)
- Households benefit by over £36 million per year as a result of sale of items through reuse exchange and avoiding purchase of (more expensive) new items.
- The *net* employment impact of dealing with all washing machines that reach the end of their life today (business-as-usual) is positive, despite the low levels of reuse.

Whilst there are concerns over data quality, the results of this study show that there are environmental benefits both from the current end-of-life scenario for washing machines and from scenarios that include an increased level of reuse. These benefits are accrued from the displacement of materials or products, either through recycling (displacing metals) or through reuse (displacing whole washing machines). These benefits are greater than the impacts associated with transport and handling of the end-of-life machines.

These environmental benefits come at a financial cost, primarily due to the high costs of bulky waste collection from households, which outweigh the income from recycling. However, the net cost is significantly lower than disposing of machines to landfill. Within these overall net costs there are reuse organisations employment benefits, financial benefits associated with second-hand washing machine sales and potential savings on social welfare payments associated with the creation of training opportunities in reuse organisations.

These findings are not without their sensitivities, and the absolute values presented should be treated only as estimates. The following unknowns, or known variations in the different systems assessed, were found in particular to have the potential to affect the overall conclusions:

- the lifetime extension afforded through refurbishment;
- the likelihood of an increase in future recycling rates of washing machines; and
- costs and employment associated with waste collection.

It is recommended that any further work is focused on enabling better quantification of these issues.

# 2.0 Televisions

This chapter discusses reuse of televisions in the UK and provides an estimate of the net environmental and economic, both financial and social, benefits of the current levels of television reuse and the potential impact of increases in reuse.

An 'average' television table is assumed to be the item replaced by reusing a television. This is modelled as being a 32" LCD TV made of ferrous metal (53%) injection moulded plastic (24%), LCD and CCFL (12%) electrical components (7%), non-ferrous metal (3%) and other materials (2%) (NB figures are rounded so do not add up to 100%).

This chapter outlines:

- An overview of TV reuse in the UK, including material flows from the end of their first life through the various reuse and disposals routes.
- The methodology and data quality issues relating to this analysis of the benefits
- The current business-as-usual situation today for TVs with some scenario analysis for:
    - environmental benefits
    - financial costs
    - employment opportunities
- The key conclusions

## 2.1 Television Reuse in the UK

Televisions may pass through a similar range of pathways to washing machines at the end of their first life. This may be via direct reuse (e.g. passed on to friends and family, sold, or given to a charity), retailer 'take-back' schemes, bulky waste collections and drop off at Household Waste Recycling Centres. Owing to their bulk, televisions are not thought to be disposed of through regular household waste collections.

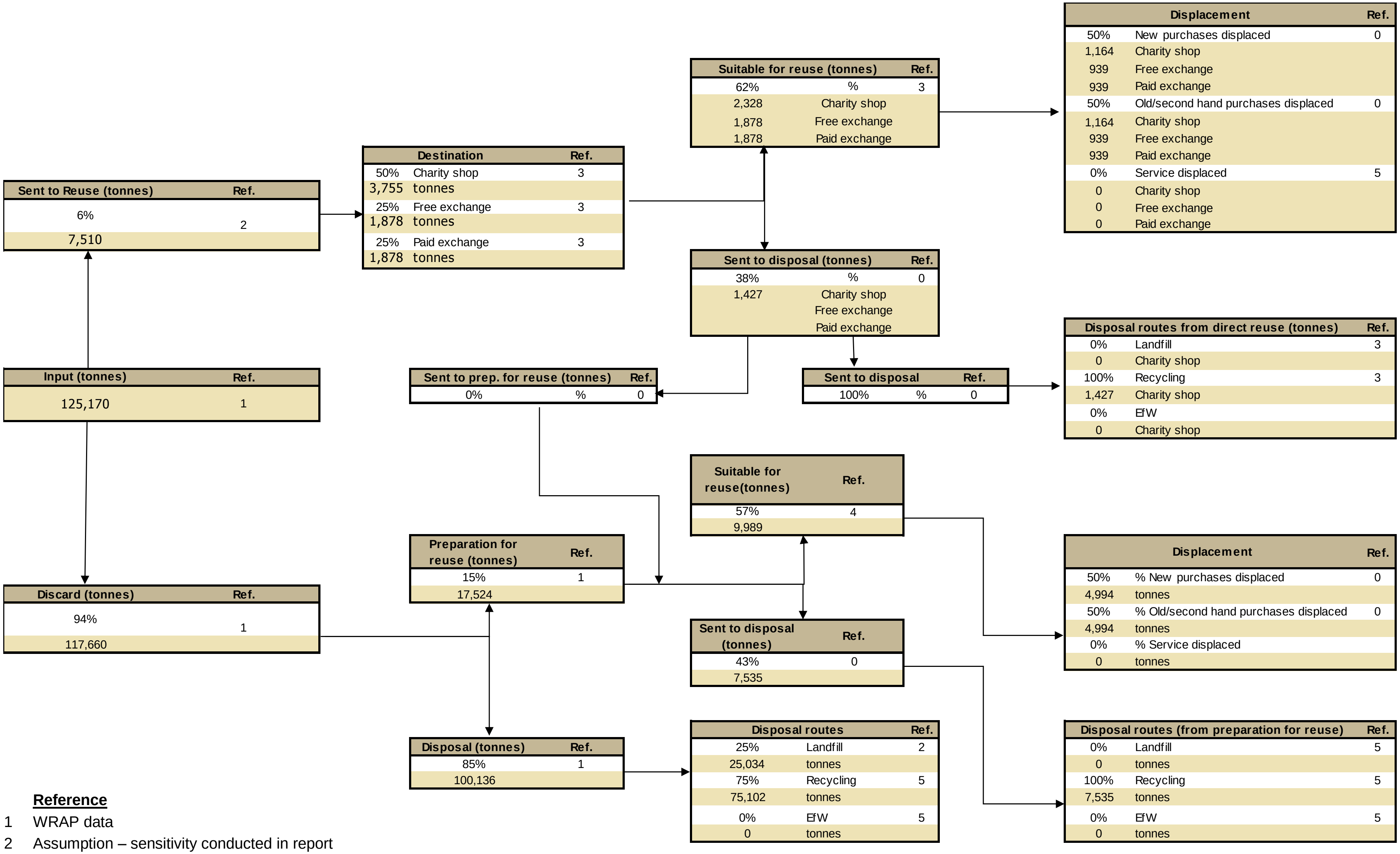
Current data suggest that 6% of televisions enter reuse, while 14% enter preparation for reuse either via charitable organisations or retailer 'take-back' schemes (Environment Agency, 2011). Of the TVs entering preparation for reuse, only 33% are in good working order. 24% of sets are in need of some repair while 43% are beyond repair and must instead be sent to recycling (Cooper, 2004).

Currently in the UK, 60% of discarded televisions are recycled, while 20% go directly to landfill (Environment Agency, 2011). Although a 2004 report for the Environment Agency noted that a large number of televisions were exported for recycling in 2003 (ICER, 2004), the latest figures from 2010 suggest that this is no longer the case, with no end-of-life TVs exported in that year (Environment Agency, 2011). For the purposes of this study, it is assumed that all end-of-life TVs remain in the UK.

WRAP has developed a 'business as usual' case for the fate of discarded televisions, extracted from various data sources.. This is shown in Figure 5. The Figure can be used to trace the fate of televisions - approximately 125,000 tonne/year – passing through the various pathways. Key estimates are made of the percentage of new TV purchases that are avoided as a result of the reuse action. This is called the displacement effect.

Figure 6 shows the final destination of TVs which pass through the different pathways identified in Figure 5. Only 13% of TVs that reach the end of their life are reused.

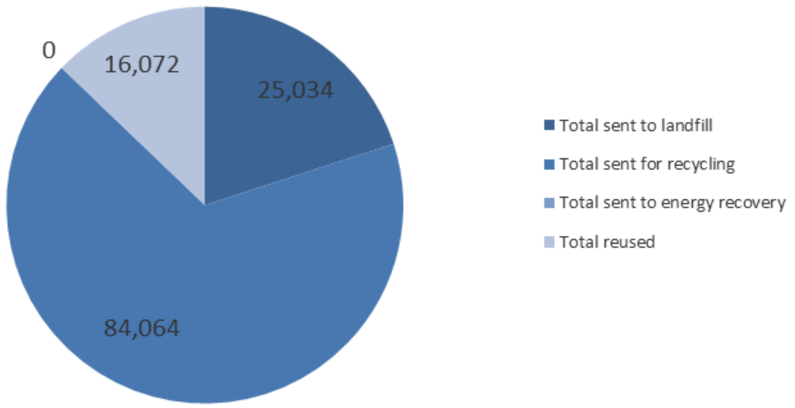
**Figure 5** Television mass flow – 'business-as-usual'




**Reference**

1 WRAP data
2 Assumption – sensitivity conducted in report
3 Environment Agency (2011)
4 Charity Retail Charity Retail Association, completed survey for this study, August 2010
5 Cooper (2004)

**Figure 6** Final Destination of TVs– 'business-as-usual' (tonnes)




### *2.1.1 What does 'direct reuse' look like for televisions in this assessment?*

The general definition of 'direct reuse' in this assessment is set out in the WRAP (2011). Unlike the case for washing machines, certain second-hand shops will accept televisions, so a small percentage of end-of-life TVs are reused via charity shops. The number of TVs that go to charity shops is small, as sets must undergo Portable Appliance Testing before they can be sold and only a minority of charity shops carry out this service. In addition to second-hand shops, direct reuse for televisions can be facilitated through friendship networks and free or paid-for online exchanges.

Current figures suggest that the average household contains 2.4 televisions (TV Licensing, 2011). It is therefore possible that a second-hand television will serve as an 'extra' TV rather than a replacement TV, i.e. it does not displace the production of a new TV, although no data has been identified on this issue.

Estimating the benefit of displacement is further complicated by the dynamic nature of the television market and technology. In addition to the move from Cathode Ray Tube (CRT) sets to 'flat screen' LCD or plasma sets, the average screen size of televisions purchased in the UK is increasing as the price of larger screens continues to fall. DEFRA (2009) suggests that TV energy efficiency will increase and, as new 'auto-off' features are implemented, 'on time' will decrease by 2020. However, the same report suggests that average screen size will increase over this period, resulting in a net efficiency increase of just 5% by 2020. Due to the small value and high level of uncertainty around this figure, no efficiency losses in the reuse phase for TVs are modelled in this study.

The technical lifetime of a TV in this study is defined as the half-life of the lamps within the TV, i.e. the length of time before the brightness of lamps within a set are half of that when they were originally supplied (InfOrganisation, 2006). This technical lifetime can be up to 28 years and is likely to be longer than the economic (average) lifespan of a TV considered in this study. The economic lifetime of a TV used in this study is therefore determined by consumer preference and is taken to be eight years (Fraunhofer IZM, 2007).

In this study it is assumed that a directly reused TV is kept for four years (Fraunhofer IZM, 2007). If this TV displaces a new product, this leads to a displacement of half of the impact associated with the production of a new TV.

The following displacement options have also been assumed as a default:

- **50% displacement of a new item**. In the case of televisions, 'displacement of new' assumes that the reused item will directly avoid the production of a new television, leading to an environmental benefit. This is assumed to be a new 32" LCD TV (representing an 'average' TV) in this study.

- **50% displacement of an old item**. This route assumes that a reused item will either replace another reused item rather than a new item, or be purchased as an additional TV, displacing neither. In this case, no benefits from avoided production are allocated.

A full list of data and assumptions used to characterise the direct reuse pathway is set out in Tables A1, A2 and A3 in Appendix A

### *2.1.2 What does 'preparation for reuse' look like for TVs in this assessment?*

For televisions, the preparation for reuse pathway includes the collection, sorting, refurbishment, delivery and sale of TVs by charitable and private organisations. It also includes onward recycling of items unsuitable for reuse. It is assumed that 33% of TVs are in full working order, 24% require some form of repair and 43% are beyond repair and sent to recycling, based on Cooper (2004). In cases where parts are required, beyond-repair TVs are often 'cannibalised' for parts (ICER, 2004). Therefore it is assumed that this repair is carried out using reused components to which no environmental burdens are attributed. However, there will be a financial cost to their use.

As for directly reused TVs, TVs in the preparation for reuse stream are assumed to be kept for four years. A full list of data and assumptions used to characterise the preparation for reuse pathway for televisions, including the materials associated with refurbishment, is set out in Tables A1 to A3 in Appendix A.

### *2.1.3 What does 'disposal' look like for televisions in this assessment?*

Current mass flow data for TVs suggest that 60% of the total arisings are sent to recycling, 20% are sent to landfill and 20% are reused in some fashion. It is assumed that a 'disposal only' scenario would have the same percentage split as the current, 'business-as-usual' disposal route, i.e. 75% recycled, 25% landfilled.

- **Recycling** (**75%)** – typically, televisions sent for recycling are dismantled and sorted into major components, including glass, wires and metals and plastics. Once separated, all of these materials are sent for recycling. It is unclear what levels of losses occur within the recycling process. Whilst most glass and metal may be recovered, higher loss rates (circa 20%) are reported for plastic (WRAP 2006). A typical loss rate of 10% is used in this study.

- **Landfill (25%)** – this includes collection and subsequent disposal in landfill. As all of the materials in a television are inert, no direct emissions associated with materials degrading in landfill are considered.

## 2.2 Quantifying the Benefits of Reusing Televisions

### *2.2.1 Approach to the assessment*

For an overview of the approach adopted for this case study please refer to WRAP (2011) *A methodology for quantifying the environmental and economic impacts of reuse.*

### *2.2.2 Data quality*

Tables A1 to A3 in Appendix A set out all of the data sources and assumptions used in the assessment of environmental, financial cost and employment criteria, along with a consideration of their quality and applicability for the study.

The most up-to-date information available has been sourced, but we note that some considerable uncertainties remain. In particular, the following sources of error or variability are evident.

- Current arisings data are very uncertain on an individual-item basis. The mass flow data for TVs gathered by WRAP suggest that around 20–-40% of sets currently in circulation enter the waste or reuse stream annually (based on approximately 26 million households in the UK and 2.4 TVs per household (ONS 2011a, TV Licencing 2011).

- There is considerable uncertainty surrounding the number of TVs that are reused via charity shops. An assumption that 50% of TVs in the direct reuse pathway (3% of total arisings) go to charity shops was used as a base case for this study. An analysis of the sensitivity of the results to this assumption is presented below.

- Cost and employment data were provided to WRAP by steering group partners for the assessment. The best currently available sources have been gathered, but the uncertainty and high potential variability of the values used is noted. It is recommended that further information is sought for these issues.

## 2.3 Results and Discussion

### *2.3.1 Environmental impacts: Televisions*

**Environmental impacts: Business-as-usual**

Table 8 presents the **environmental impacts and benefits associated with the current management of all end-of-life televisions estimated to arise in the UK each year**. This includes the impacts associated with waste management activities in the UK, and the benefits of avoided production of materials through reuse and recycling, whether in the UK or abroad. Net impacts/benefits are also presented for a single TV and a tonne of TVs in Table 9.

Note that these are the *absolute* impacts/benefits associated with current levels of disposal and reuse. Different management pathways are compared in Table 10.

Table 8 and Table 9 show that **current UK management of televisions results in net GHG savings** of around 160,000 tonnes $CO_2$-eq, or 15kg $CO_2$-eq per television handled. Current levels of reuse avoid emissions of 156,000 tonnes $CO_2$ eq., including emissions from reuse activities.

**Table 8** Business-as-usual management: **Total UK** environmental impacts

| Activity | Total UK Televisions – GHG Emissions (tonnes $CO_2$-eq) | Total UK Televisions – Resource Depletion (tonnes Sb-eq) | Total UK Televisions – Global Energy Demand (MJ-eq) |
|---|---|---|---|
| Reuse pathway | 296 | 12 | 33,700,000 |
| *- of which collection* | | | |
| *- of which site operation (inc. refurbishment)* | *650* | *13* | *21,900,000* |
| *- of which disposal of residuals** | *-354* | *-1* | *11,700,000* |
| | | | |
| Preparation for reuse pathway | 6,550 | 42 | 113,000,000 |
| *- of which collection* | *2,580* | *17* | *37,200,000* |
| *- of which site operation (inc. refurbishment)* | *4,920* | *29* | *47,000,000* |
| *- of which disposal of residuals** | *-953* | *-3* | *28,500,000* |
| | | | |
| Disposal pathway | -4,140 | -12 | 151,000,000 |
| *- of which landfill* | *1,230* | *8* | *17,700,000* |
| *- of which incineration* | | | |
| *- of which recycling* | *-5,380* | *-20* | *133,000,000* |
| | | | |
| Reuse displacement effects | -163,000 | -1,150 | -1,950,000,000 |
| | 0 | 0 | 0 |
| **TOTAL** | -161,000 | -1,110 | -1,650,000,000 |

Note: negative figures denote a net saving, through displacement of other products/materials and their avoided production
* this includes the recycling of items unsuitable for reuse and the ultimate disposal of reused items at the end of their second life (75% recycling, 25% landfill)

**Table 9** Business-as-usual management: Environmental impacts

| Scale | GHG Emissions (tonnes $CO_2$-eq) | Resource Depletion (tonnes Sb-eq) | Energy Demand (MJ-eq) |
|---|---|---|---|
| Per total UK television arisings | -161,000 | -1,110 | -1,650,000,000 |
| Per tonne of televisions | -1.28 | -0.00887 | -13200 |
| Per television | -0.0157 | -0.00011 | -161.0 |

Note: negative figures denote a net saving, through displacement of other products/materials their avoided production

The key finding from these results is that all impact indicators for the 'business-as-usual' case are negative, i.e. there are net reductions in environmental impacts. Some of the reasons for this are listed below.

- The levels of displacement associated with current levels of reuse. 50% of the televisions reused via either reuse pathway are assumed to displace the purchase of a new LCD television. Whilst this assumed to be reasonable, due to the significance of displacement to the overall result, the sensitivity of the results of this study to this data is explored below.
- The high displacement benefit associated with the avoided production of new televisions. The environmental impact associated with the production of LCD TVs, particularly of the LCD screen and Printed Circuit Board (PCB) components, is very high. As a result, the displacement of these impacts yields a very high environmental benefit.

There are considerable uncertainties around these 'business-as-usual' flows and so the values should be treated with caution in their absolute sense. In particular, overall findings are sensitive to the factors listed below.

- Current arisings (tonnage) of end-of-life televisions in the UK. As with washing machines, impact estimates will increase or decrease in a linear correlation with this figure, which is likely to fluctuate on a yearly basis. Impact results on a 'per tonne' or 'per item' basis are not susceptible to such fluctuations, but are sensitive to assumptions around the weight of an individual item, which can vary.
- The **amount of new televisions displaced through reuse.** Although primary data were collected for this study, this should be regarded as an estimate and viewed with appropriate caution. This point is discussed further below.

Despite these uncertainties, there are clear environmental benefits associated with the current management of end-of-life televisions. The majority of this environmental benefit is derived from the reuse practices currently undertaken in the UK.

## Environmental impacts: Scenario analysis

Table 10 shows the net environmental impacts associated with a range of hypothetical scenarios. These results are reported on a per-item basis.

**Table 10** Scenario analysis: Environmental impacts per tonne of televisions

| Scenario | GHG Emissions (tonne $CO_2$-eq) | Resource Depletion (tonne Sb-eq) | Energy Demand (MJ-eq) |
|---|---|---|---|
| Business as usual | -1.28 | -0.00887 | -13200 |
| 100% direct reuse | -8.19 | -0.0565 | -93600 |
| 100% preparation for reuse | -5.42 | -0.0384 | -62600 |
| 100% recycling | -0.07 | -0.000266 | 1780 |
| 100% landfill | 0.05 | 0.000311 | 708 |
| Current rates of disposal* | -0.04 | -0.000121 | 1510 |

Note: negative figures denote a net saving, through displacement of other products/materials and their avoided production
* 100% disposal at current recycling rates (75% recycling, 25% landfill)

These results suggest that the net environmental impacts, across all categories, associated with both reuse pathways and current levels of reuse in the UK, are likely to be lower than those associated with recycling, and considerably lower than those for landfill or residual management.

There is a relatively minor environmental benefit of recycling of televisions, especially when compared to washing machines. This is partly due to the additional processing required to properly disassemble televisions (as opposed to simple shredding) as well as the fact that materials with a relatively low embodied environmental impact (primarily plastics and glass) are displaced, as opposed to the aluminium found in washing machines which is associated with a very high embodied impact.

These findings are highly sensitive to a number of assumptions made as part of this study, as explored further below.

## Environmental impacts: Sensitivity analysis

**Levels of displacement of new purchases associated with current levels of reuse**

Due to the relatively low environmental benefit of recycling (as described above), the environmental benefit of the business-as-usual scenario is driven almost entirely by the displacement of new televisions through reuse. However, whilst halving the displacement of new TVs reduces the environmental benefits of reuse by 54%, the magnitude of the benefit of reuse continues to exceed alternative routes (e.g. recycling). The displacement rate has to drop to 4% before recycling becomes preferable. Subsequently, while the scale of the predicted environmental benefit is sensitive to this assumption, the assertion that current levels of reuse are more environmentally beneficial than recycling of televisions is not.

**Magnitude of the displacement benefit associated with the avoided production of new televisions**

In this study, an average 'new' television is represented by a 32" LCD TV, of which the LCD component and printed wiring boards account for most of the embodied environmental impact associated with its production. Given the wide range of televisions available, there is considerable variation surrounding these environmental impacts. The sensitivity of the overall results to this variable is very similar to that for the assumption regarding levels of displacement of new televisions discussed above. While the scale of the environmental benefit varies greatly with this assumption (halving the environmental impact of production reduces the net environmental benefit by 54%), the assertion that current levels of reuse are more environmentally beneficial than recycling of televisions is again not significantly affected by this assumption.

**Level of reused TVs going through charity shops**

As noted in section 2.2.2., it is unclear what proportion is sold via charity shops. However, the results are not particularly sensitive to this assumption. Taking the most extreme case, that no televisions are sold via charity shops, only leads to an 11% change in the net environmental benefits of the business-as-usual scenario.

### *2.3.2 Financial costs and benefits: Televisions*

## Financial cost: Business-as-usual

Analysing the business-as-usual case, as set out in Figure 5, yields the following results for the private metric accounting approach (landfill tax included).

Table 11 presents costs for each pathway and core activity, split according to the party to which costs and benefits accrue. These present estimates for the current overall UK situation. Due to the uncertainty surrounding total UK arisings, net costs and benefits on a unit item or unit mass basis are also presented (Table 12).

**Table 11** Business-as-usual: **Total UK** net cost/benefit (private metric)

| Activity | Total UK Net Cost/Benefit (£) | ...of which to Local Authorities** | ...of which to Reuse organisations | ...of which onward employment from ROs | ...of which to households*** | ...of which to business**** |
|---|---|---|---|---|---|---|
| Reuse pathway | £7,310,000 | £2,010,000 | £5,300,000 | | | |
| *- of which collection* | | | | | | |
| *- of which site operation* | £5,300,000 | | £5,300,000 | | | |
| *- of which disposal of residuals** | £2,010,000 | £2,010,000 | | | | |
| Preparation for reuse pathway | £17,000,000 | £4,590,000 | £12,400,000 | | | |
| *- of which collection* | £7,130,000 | | £7,130,000 | | | |
| *- of which site operation* | £5,270,000 | | £5,270,000 | | | |
| *- of which disposal of residuals** | £4,590,000 | £4,590,000 | | | | |
| Disposal pathway | £26,400,000 | £26,400,000 | | | | |
| *- of which landfill* | £7,700,000 | £7,700,000 | | | | |
| *- of which incineration* | | | | | | |
| *- of which recycling* | £18,700,000 | £18,700,000 | | | | |
| Displacement effects and sales | -£2,120,000 | -£2,120,000 | -£32,000,000 | | -£494,000,000 | £526,000,000 |
| Onward employment from reuse | -£2,830,000 | | | -£2,830,000 | | |
| **TOTAL** | £45,760,000 | £30,880,000 | -£14,300,000 | -£2,830,000 | -£494,000,000 | £526,000,000 |

Notes:
negative figures denote income or avoided purchase
* this includes the recycling of items unsuitable for reuse and the ultimate disposal of reused items at the end of their second life (75% recycling, 25% landfill). It includes treatment costs, collection costs and revenue from recyclate.
** for the private metric this includes landfill tax.
*** benefits accruing to householders as a result of avoiding the purchase of new items. This is net of the income to charity shops/PFR organisation (assumed from householders).
**** cost to retailers in terms of lost revenue from sales of new televisions .

**Table 12** Business-as-usual management: Financial cost

| Scale | Private Metric (inc. landfill tax) (£) | Social Metric (no landfill tax) (£) |
|---|---|---|
| Per total UK television arisings | £45,760,000 | £44,180,000 |
| Per tonne of televisions | £366 | £354 |
| Per television | £4.46 | £4.31 |

Key points from the results are as follows:

- Overall results are positive (net expenditure), suggesting that under the business-as-usual scenario there is a net cost to the UK economy from dealing with end-of-life televisions. However, this should be viewed as a worst case scenario, as it is driven by the losses made by business due to avoided purchases.
- Excluding speculative data on the avoided costs of purchase to households and losses to business due to these avoided purchases, the results suggest that there is still an overall cost to the economy of around £17.5 million
- Households are estimated to save almost £500 million per year through current levels of reuse.
- Through both direct and preparation for reuse pathways, income is generate to reuse organisations and savings to households are created. Direct reuse creates an average income of £2.50 per television, whilst each television generates almost £9 income for preparation for reuse organisations.

The following uncertainties are noted:

- **Product displacement benefits associated with the avoided purchase of new televisions.** An 'avoided purchase cost' of £799 per item was allocated to the 50% of televisions that were assumed to displace new purchases. This value was based on data for the average price of televisions from the price comparison website Kelkoo.
- **Net profit from sales of second-hand televisions.** Due to the variety of discarded televisions, there is a degree of uncertainty regarding the revenue generated from their sale from preparation for reuse. However, the reuse of televisions via preparation for reuse is a relatively profitable option; far more so than the reuse of washing machines. An income of around £30 million is generated in the business-as-usual scenario, equating to a profit of around £14 million. Even when halved, the revenue generated from the sales of televisions is enough to return a profit. Therefore, it is unlikely that the uncertainty present will significantly alter the profitability of preparation for reuse.
- **Level of reused TVs going through charity shops.** As noted in section 2.2.2, there is uncertainty surrounding the number of televisions reused via charity shops.
- **Savings on social welfare payments** associated with the provision of training and onward employment. The considerable uncertainty associated with the quantification of this 'benefit' was discussed for the textiles products. However, compared to the considerable cost of waste treatment this benefit is minor. Therefore, the uncertainty surrounding it is unlikely to affect the overall results.

There are uncertainties around 'business-as-usual' flows, and so these values should be treated with some caution in their absolute sense. As discussed for the environmental criteria, the overall findings are sensitive to the assumptions regarding current arisings and flows to different pathways, as well as to the amount of displacement that occurs.

## Financial cost: Scenario analysis

As with the environmental criteria, it is useful to compare the status quo with a range of possible scenarios. Again, costs are considered on a per item basis, as opposed to considering the unlikely event of a wholesale shift in the treatment of end-of-life televisions. Table 13 presents net costs and benefits 'per television' for a range of scenarios. These include collection, operation (rent, utilities, labour), sales, disposal of residuals, eventual disposal of reused items at end of life and the avoided disposal of new items displaced.

**Table 13** Scenario analysis: Financial costs per tonne of televisions

| Scenario | Private Metric (£) | Social Metric (£) |
|---|---|---|
| Business as usual | £366 | £354 |
| 100% direct reuse | £866 | £849 |
| 100% preparation for reuse | £734 | £722 |
| 100% recycling | £260 | £250 |
| 100% landfill | £308 | £260 |
| Current rates of disposal | £264 | £252 |

Table 13 shows that all pathways for the management of end-of-life televisions result in a net cost to the UK economy as a whole – the highest via the direct reuse pathway. This pathway provides benefit to households through avoided cost of purchase and delivers a profit to charity shops and reuse networks through sales. However, it is at the expense of retailers of new TVs and so the net benefit of these sales is zero – and the costs in Table 13 are positive rather than negative. The direct reuse pathway also has the highest operating costs associated with it.

Although much of the displaced retail cost will actually be borne by manufacturers overseas, it was not possible in the scope of this assessment to apportion costs in this respect, and so they are included for completeness, and to maintain a conservative perspective.

## *2.3.3 Employment opportunities: Televisions*

### Employment opportunities: Business-as-usual

Analysing the business-as-usual case, as set out in Figure 5, yields the following results with regard to employment opportunities.

**Table 14** Business-as-usual: **Total UK** employment (full time equivalents, excluding volunteers**)**

| Activity | Total UK Net Cost/Benefit (FTE) | ...of which to Local Authorities | ...of which to Reuse organisations |
|---|---|---|---|
| Reuse pathway | 149 | 5 | 144 |
| *- of which collection* | - | - | - |
| *- of which site operation* | 144 | - | 144 |
| *- of which disposal of residuals** | 5 | 5 | - |
| | | | |
| Preparation for reuse pathway | 199 | 27 | 173 |
| *- of which collection* | 45 | - | 45 |
| *- of which site operation* | 128 | - | 128 |
| *- of which disposal of residuals** | 27 | 27 | - |
| | | | |
| Disposal pathway | 345 | 345 | - |
| *- of which landfill* | 315 | 315 | - |
| *- of which incineration* | - | - | - |
| *- of which recycling* | 30 | 30 | - |
| | | | |
| Displacement effects | - | - | - |
| | - | - | - |
| **TOTAL full time equivalents** | 694 | 377 | 317 |

Notes:
negative figures denote loss of employment
for preparation for reuse, it is assumed that volunteer labour is used in both collection and on site operations
* this includes the recycling of items unsuitable for reuse and the ultimate disposal of reused items at the end of their second life (75% recycling, 25% landfill)

Key points from the results are as follows:

- There are no displaced jobs associated with reusing televisions, as no large scale UK manufacturing is believed to exist.
- Most of the employment benefits associated with the end-of-life management of televisions are associated with local government, primarily in collection of TVs and their subsequent disposal in landfill.
- Both direct reuse and preparation for reuse create more jobs than either landfill or recycling.
- If volunteer employment were to be included in Table 14, net employment opportunities for the reuse organisations increase to over 3000.
- As with other criteria, there are uncertainties around 'business-as-usual' flows, and so these values should be treated with some caution in their absolute sense.

## 2.4 Conclusions: Televisions

Approximately 1.3 million televisions (6,700 tonnes) are reused in some form in the UK every year. This represents 13% of all televisions reaching the end of their life each year by weight. The remaining 87% are sent to recycling or landfill. The average weight of a reused television is considered to be lower than the average weight of a disposed television due to changes in technology (e.g. CRT televisions are more likely to be disposed of than reused).

The key environmental, financial and employment benefits associated with this reuse activity are:

- Current levels of reuse of TVs avoid 154,000 tonnes $CO_2$ eq per year.
- Providing 1 tonne of TVs for direct reuse (e.g. via a charity shop or online exchange) can result in a net GHG saving of 8 tonnes $CO_2$-eq. This is just over 100kg $CO_2$-eq per TV.
- Providing 1 tonne of TVs to a preparation for reuse network can result in a net GHG saving of 5.4 tonnes $CO_2$-eq net. This is about 66kg $CO_2$-eq per TV.
- As well as the carbon benefits, there are parallel resource and energy savings as a result of this reuse activity.
- Each TV reused can yield £9 net revenue to reuse organisations (discounting wider costs or losses to householders businesses)
- Households benefit by almost £500 million per year as a result of sale of items through reuse exchange and avoiding purchase of (more expensive) new items.
- The *net* employment impact of dealing with all TVs that reach the end of their life today (business-as-usual) is positive.

Whilst there are concerns over data quality, the results of this study show that there are environmental benefits from both the current end-of-life scenario for televisions and the scenarios that include an increased level of reuse. These benefits accrue almost entirely from the displacement new televisions through reuse. These benefits are greater than the impacts associated with transport and handling of the end-of-life televisions by preparation for reuse organisations and through direct reuse routes.

However, these environmental benefits come at a financial cost, primarily associated with costs to business through loss of sales of new televisions. However, within these overall net costs, benefits are accrued by the reuse organisations in terms of employment, financial benefits associated with second-hand television sales and potential savings on social welfare payments associated with the creation of training opportunities in reuse organisations.

These findings are not without their sensitivities, and the absolute values presented should be treated only as estimates. The following unknowns, or known variation in the different systems assessed, were found to have the potential to affect the overall conclusions in particular:

- the quantity of reused items displacing new items;
- the manufacturing burdens associated with new televisions.

It is recommended that any further work is focused on enabling better quantification of these issues.

## 3.0 References


Behrendt, S., Erdmann, L., Baldas, O., Wolfrum, K., von Gentner, J., and Stebis, L., (2004): *Ökologische Optimierung von Gebrauchtgeräten. Entwicklung von technischen Lösungen zur energieeffizienten Aufrüstung von gebrauchten Waschmaschinen*. WerkstattBericht Nr. 62. Berlin: IZT – Institut für Zukunftsstudien und Technologiebewertung http://www.izt.de/izt-im-ueberblick/team/name/behrendt/

Cooper T., (2004) Inadequate life? Evidence of consumer attitudes to product obsolescence . *Journal of Consumer Policy*. vol 27, pp. 421-449

Curran, T., (2008) *Household Bulky Waste Collection and Re-use in England,* University of Southampton; Southampton

DEFRA (2006) Carbon Balances and Energy Impacts of the Management of UK Waste Streams - WR0602 prepared by ERM, DEFRA; Londonhttp://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=14644

DEFRA (2008) *Municipal Waste Composition: Review of Municipal Waste Component Analyses - WR0119*, prepared by Resource Futures, DEFRA; London http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=15133

DEFRA (2011) *Longer Product Lifetimes EV0445* prepared by ERM, DEFRA; London http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17047

DEFRA and DECC (July 2011) *Guidelines to Defra/DECC's Greenhouse Gas Conversion Factors for Company Reporting* DEFRA; London http://www.defra.gov.uk/environment/economy/business-efficiency/reporting/

ecoinvent Centre (2007), *ecoinvent data v2.0. ecoinvent reports No.1-25*, Swiss Centre for Life Cycle Inventories, Dübendorf www.ecoinvent.org

Environment Agency (2011), Waste electrical and electronic equipment (WEEE) Collected in the UK in 2010 http://www.environment-agency.gov.uk/business/topics/waste/111016.aspx

EU WEEE Directive (2002/96/EC)

Fraunhofer IZM (2007) *EuP Preparatory Studies "Televisions" (Lot 5) Final Report on Task 1 "Definition* EUP Network; Germany http://www.eup-network.de/fileadmin/user_upload/Produktgruppen/Lots/Final_Documents/Lot_5_Final_Report_1-8.pdf

Goedkoop M.J., Heijungs R, Huijbregts M., De Schryver A.;Struijs J.,; Van Zelm R, (2009*) ReCiPe 2008, A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level; First edition Report I: Characterisation; 6 January 2009*, http://www.lcia-recipe.net

InfOrganisation (2006). *The Lifespan of Plasma, LCD, and Other Flat Panel TVs* http://www.flatpaneltv.org/article/flat-panel-tv-shopping-and-tips/the-lifespan-of-plasma-lcd-and-other-flat-panel-tvs.html

ICER (2004) *WEEE – Green List Waste Study* http://www.icer.org.uk/ExportsReportFinal.pdf

Market Transformation Programme (2008) BNW05: Assumptions underlying the energy projections for domestic washing machines http://efficient-products.defra.gov.uk/spm/download/document/id/569

Murray R, (1998) *Reinventing waste, towards a London waste strategy*, Environment Agency; Bristol

Sim (2010) *Charity Retail Survey 2010*, Civil Society Media; London

ONS (2011a) *Families and households* http://www.statistics.gov.uk/cci/nscl.asp?id=7482

ONS (2011b) *Product Sales and Trade Provisional Estimates 2010 Division 31 Manufacture of Furniture* http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=15278&Pos=&ColRank=1&Rank=208

Radio, electrical and television retailers' association (Undated) http://www.retra.co.uk/code-of-practice/code13.asp accessed 31st May 2011

TV Licensing (2011) *TeleScope A focus on the nation's viewing habits from TV Licensing* http://www.tvlicensing.co.uk/about/media-centre/news/report-reveals-latest-uk-tv-watching-trends-NEWS35/

WRAP (2006) *Develop a process to separate brominated flame retardants from WEEE polymers*, WRAP; Banbury

WRAP (2010) *Gate Fees Report 2010 Comparing the cost of alternative waste treatment options*, WRAP; Banbury http://www.wrap.org.uk/downloads/2010_Gate_Fees_Report.3cd0715f.9523.pdf

WRAP (2010) Closed-loop recycling – opening the door to cost savings http://www.wrap.org.uk/retail_supply_chain/research_tools/research/weee_plastics.html

WRAP (2011) *A methodology for quantifying the environmental and economic impacts of reuse.* WRAP; Banbury

# Appendix A

**Table A1** Environmental criteria – data sources, quality and assumptions

| Name | Datapoint | Unit | Data Quality Score | Source | Justification |
|---|---|---|---|---|---|
| GHG emissions – landfill | 50 | kg $CO_2$-eq per tonne | High | Impacts from the landfilling of WEEE were modelled using data from the Environment Agency's WRATE tool. It is assumed that no emissions result directly from landfill of WEEE, as it contains no biodegradable material. This figure includes emissions from landfill operations only.<br>Collection distance assumptions taken from 'Carbon Metric For The Scottish Government' project.<br>Modelled as 50km round trip in 21 tonne refuse collection vehicle. | A sound data point is used. As little or no landfill gas is produced in the degradation of inert materials, much of the uncertainty regarding emissions from landfill is avoided. |
| Resource depletion - landfill | 0.3 | kg Sb e per tonne | High | | |
| Energy demand – landfill | 710 | MJe per tonne | High | | |
| GHG emissions – washing machine recycling | -780 | kg $CO_2$-eq per tonne | High | Washing machine recycling was taken to be by shredding followed by metals recycling. The shredding of a washing machine was modelled with an 80% recovery rate of metals (ERM, 2009). Metals were assumed to be recycled, while other materials (concrete, glass and plastics) were assumed to be sent to landfill.<br>Ferrous metal recycling was modelled in line with the 'low grade' scenario as set out in DEFRA (2006). This impact factor represents the recovery of ferrous metal scrap for use in the electric arc furnace reprocessing route. The production of primary steel via a blast furnace is offset, assuming 10% loss in production (1kg recovered material offsets 0.9kg virgin).<br>Non-ferrous metal recycling was modelled in line with the 'high grade' scenario set out in DEFRA (2006). This impact factor represents the production of secondary aluminium from scrap that requires no cleaning or pretreatment. The production of primary aluminium is offset, assuming 10% loss in production | Data used are from a sound source. However, assumptions have been made regarding the quality and processing of recycled materials. |
| Resource depletion – washing machine recycling | -4.800 | kg Sb e per tonne | High | | |

| | | | | | |
|---|---|---|---|---|---|
| Energy demand – washing machine recycling | -7600 | MJe per tonne | High | (1kg recovered material offsets 0.9kg virgin). Data for these processes are sourced from the Ecoinvent database. | |
| GHG emissions – TV recycling | -9 | kg $CO_2$-eq per tonne | Medium | TV recycling was taken to be by mechanical dismantling, followed by recycling of the extracted components. The bill of materials and maximum recyclability of these components was taken from (Fraunhofer IZM, 2007) for a 29" CRT TV.<br>Metal and plastic components were modelled using data from the Defra Carbon Balance study, while Ecoinvent inventories were used for electronic and CRT components. | Data regarding materials and recycling rate are from a sound source. However, assumptions have been made regarding the quality and processing of recycled materials. |
| GHG emissions – washing machine recycling | -780 | kg $CO_2$-eq per tonne | High | Washing machine recycling was taken to be by shredding followed by metals recycling. The shredding of a washing machine was modelled with an 80% recovery rate of metals (ERM 2009). Metals were assumed to be recycled, while other materials (concrete, glass and plastics) were assumed to be sent to landfill.<br>Ferrous metal recycling was modelled in line with the 'low grade' scenario as set out in DEFRA (2006). This impact factor represents the recovery of ferrous metal scrap for use in the electric arc furnace reprocessing route. The production of primary steel via a blast furnace is offset, assuming 10% loss in production (1kg recovered material offsets 0.9kg virgin).<br>Non-ferrous metal recycling was modelled in line with the 'high grade' scenario set out in DEFRA (2006). This impact factor represents the production of secondary aluminium from scrap that requires no cleaning or pretreatment. The production of primary aluminium is offset, assuming 10% loss in production (1kg recovered material offsets 0.9kg virgin). Data for these processes are sourced from the Ecoinvent database. | Data from a sound source is used. However, assumptions have been made regarding the quality and processing of recycled materials |
| Resource depletion - washing machine recycling | -4.800 | kg Sb e per tonne | High | | |
| Energy demand - washing machine recycling | -7600 | MJe per tonne | High | | |

| | | | | | |
|---|---|---|---|---|---|
| GHG emissions – TV recycling | -72 | kg $CO_2$-eq per tonne | Medium | TV recycling was taken to be by mechanical dismantling, followed by recycling of the extracted components. The bill of materials and maximum recyclability of these components was taken from 'EuP Preparatory Studies "Televisions" (Lot 5)' (Fraunhofer IZM, 2007) for a 29" CRT TV.<br>Metal and plastic components were modelled using data from the Defra Carbon Balance study, while Ecoinvent inventories were used for electronic and CRT components | Data regarding materials and recycling rate from a sound source are used. However, assumptions have been made regarding the quality and processing of recycled materials. |
| Resource depletion – TV recycling | -0.27 | kg Sb e per tonne | Medium | | |
| Energy demand – TV recycling | 1777 | MJe per tonne | Medium | | |
| GHG emission – collection for preparation for reuse | 147 | kg $CO_2$-eq per tonne | Medium | Modelled as a 100km round trip travelling in a medium-sized van for all collection routes. The Ecoinvent inventory for Transport, van <3.5t was used. | Assumed same for all collection routes – based on the assumption that collection networks are all likely to be nationally based, and that a refuse collection vehicle is unlikely to be used for discarded washing machines. This assumption was found not to be sensitive in results. |
| Resource depletion – collection for prep for reuse | 0.9 | kg Sb e per tonne | Medium | | |
| Energy demand – collection for preparation for reuse | 2120 | MJe per tonne | Medium | | |
| GWP of washing machine refurbishment | 25 | kg $CO_2$-eq per tonne | Medium | Previous ERM/WRAP study, Data from FRN suggests that a typical, financially economical refurbishment requires the following replacement parts:<br>- a set of stainless steel bearings;<br>- aluminium alloy and stainless steel spider;<br>- carbon brushes; and<br>- hoses; plus | A reliable source is used for details of a 'standard' refurbishment.<br>There is a degree of uncertainty surrounding the lifetime extension afforded by refurbishment. This is discussed in the sensitivity analysis in this chapter. |

| | | | | | |
|---|---|---|---|---|---|
| ARD of washing machine refurbishment | 0.1 | kg Sb e per tonne | Medium | - two test cycles - a 60°C cycle without a load (motor not connected to the drum) and a 40°C cycle with a load.<br><br>It is assumed that refurbishment extends the lifetime of a washing machine by six years. This is a reasoned assumption based on DEFRA (2011)<br><br>These materials and processes were modelled using data from Ecoinvent | |
| MJF of washing machine refurbishment | 260 | MJe per tonne | Medium | | |
| GWP of preparation for reuse | 281 | kg $CO_2$-eq per tonne | Low | Modelled using cost data from FRN and US Input/Output database-<br><br>£149 per tonne on rent, £19.66 per tonne on electricity<br><br>US I/O database is from 1998<br><br>1 2010GBP = 1.59 2010USD<br>1 2010 USD = 1.338 1998USD (Inflation adjusted)<br><br>1 2010GBP = 1.1883 1998 USD | While cost data are from a reliable source, the Input/Output database uses sector-wide data to estimate environmental impacts based on dollars spent on services |
| ARD of preparation for reuse | 1.64 | kg Sb e per tonne | Low | | |
| MJF of preparation for reuse | 2680 | MJe per tonne | Low | | |
| GWP of Charity Shop | 173 | kg $CO_2$e per tonne | Medium | Based on primary data collected through Charity Retail Association, Charity shops spend £1299 on electricity. At 12p per kWh, this equals 11MWh. Divided by donated sales, this equates 357kWh per tonne. DEFRA / DECC (2011) stat that 1 kWh consumed equates to 0.48kg kWh, therefore 173kg CO2 eq emitted per tonne of goods sold. | Source is generic to all items sold through a similar shop. |
| ARD of Charity Shop | 3.3 | kg Sb-eq per tonne | Medium | | |
| MJF of Charity Shop | 5842 | MJ-eq per tonne | Medium | | |

| | | | | | |
|---|---|---|---|---|---|
| GWP of free exchange | 0.01 | kg $CO_2$-eq per tonne | Low | Assumption – nominal amount | Uncertain datapoint, but it makes an insignificant contribution to the results. |
| GWP of paid exchange | 0.01 | kg $CO_2$-eq per tonne | Low | Assumption – nominal amount | Uncertain datapoint, but it makes an insignificant contribution to the results. |
| GWP of television displacement | 497 | kg $CO_2$-eq per item | Medium | Modelled based on the following sources and assumptions.<br><br>**Raw materials** (Fraunhofer IZM, 2007) –<br><br>Materials 32" screen LCD kg<br>Plastics (injection moulded) 4.97<br>Ferro/steel 11.01<br>Electronics 1.47<br>LCD & CCFL 2.43<br>Non-ferro (cable) 0.69<br>Other 0.33<br><br>**Manufacture** -<br><br>Included in component inventories, energy use in assembly assumed to be negligible.<br><br>**Transport** (DEFRA 2011) -<br><br>Shipping from South Korea to the UK (19,544km) followed by 500km road transport for distribution within the UK<br><br>Ecoinvent datasets applied for all inputs and transport.<br><br>Modelled in Sima Pro 7.2.4 using the ReCiPe (v 1.04) impact assessment method. | Data for the displacement of new televisions are taken from the 'EuP Preparatory Studies "Televisions" (Lot 5)' report, which is a source of high quality data. However, given the diversity of televisions available the result represents an 'average' television set and is therefore subject to variability. |
| ARD of television displacement | 3.5 | kg Sbe per item | Medium | | |
| MJF of television displacement | 5870 | MJe per item | Medium | | |

<table>
<tr>
<td>GWP of washing machine displacement</td>
<td>216</td>
<td>kg $CO_2$-eq per item</td>
<td>Medium</td>
<td rowspan="3">Modelled based on the following sources and assumptions.<br><br>Raw materials (DEFRA 2011) -<br><br>Cast iron – 11.2kg<br>Chromium steel – 2.5kg<br>Low alloyed steel – 18.6kg<br>Aluminium – 2.2kg<br>Chromium – 1.8kg<br>Other non ferrous – 1.3kg<br>PP – 7.9kg<br>ABS – 1.2kg<br>EPDM Rubber – 1.7kg<br>Other plastic – 1.6kg<br>Concrete – 18.2kg<br>Glass – 1.8kg<br>Misc – 2.3kg<br><br>Manufacture (DEFRA 2011) –<br><br>Electricity 28.98kWh<br>Electricity 0.346kWh<br>Heat 14.79kWh<br><br>Transport (DEFRA 2011) -<br><br>648km by road (50%) and rail (50%)<br><br>Ecoinvent datasets applied for all inputs and transport.<br><br>Modelled in Sima Pro 7.2.4 using the ReCiPe (v 1.04) impact assessment method.</td>
<td rowspan="3">Data for the displacement of new washing machines are taken from DEFRA (2011) which is a source of high quality data. However, given the diversity of washing machines available the result represents an ‘average’ washing machine and is therefore subject to variability.</td>
</tr>
<tr>
<td>ARD of washing machine displacement</td>
<td>1.9</td>
<td>kg Sbe per item</td>
<td>Medium</td>
</tr>
<tr>
<td>MJF of washing machine displacement</td>
<td>3450</td>
<td>MJe per item</td>
<td>Medium</td>
</tr>
</table>

**Table A2** Financial cost data sources, quality and assumptions

| Name | Datapoint | Unit | Data Quality Score | Source | Justification |
|---|---|---|---|---|---|
| Cost of landfill | 70 | £/tonne | High | Based on WRAP (2010). Median value excluding landfill tax and haulage | Up-to-date source, so data quality considered high |
| Cost of recycling | TV -£60 Washing Machine £100 | £/tonne | Medium | Based on data from MDJ Light Brothers | Charity rags and shop collections can command a considerably higher price, but the conservative value was assumed in all cases. |
| Cost of incineration | 92 | £/tonne | Medium | Based on WRAP (2010)Median value excluding haulage | Up-to-date source, but potential for variability so data quality considered medium |
| Cost of bulky waste collection | TV £378 Washing Machine £99 | £/tonne | Medium | Based on review of all Local Authority information on bulky waste charges, assumed to represent costs | Considered to be a reasonable assumption, with relatively little influence on the results |
| Cost of civic amenity collection | 300 | £/tonne | Medium | Wastesavers | Considered to be a reasonable assumption, with relatively little influence on the results |
| Cost of other collection | 40 | £/tonne | Medium | Eunomia calculation – cost of fortnightly residual collection with wheeled bin | Considered to be a reasonable assumption, with relatively little influence on the results |
| Preparation for reuse – site rental | 149 | £/tonne | High | Based on data supplied by FRN and REalliance as part of this study | Specific data from sound source, but likely to be variable, so considered to be medium data quality. |
| Site maintenance | 20.90 | £/tonne | Medium | Based on data supplied by REalliance as part of this study | Reasonable assumption with little significance for the results. |

| | | | | | |
|---|---|---|---|---|---|
| Labour costs of preparation for reuse – employed | 9.45 | £/hour | Medium | Data from FRN. Calculated using FRN data of £117890 per year for 9 staff of whom 65% are FT and 35% are part time. Assuming the FTs work a 35 hour week and the PTs work a 17.5 hour week, working 48 weeks per year gives an hourly cost of £9.45. This value correlates well with the value given by CREATE, £18,000 per annum, which gives an hourly rate of £10.72 and is the same as that calculated for Oxfam Wastesaver using different data. | Reasoned datapoint, although based on assumptions |
| Labour costs of PFR – volunteer labour | 0.9 | £/hour | Medium | Data from FRN gives a value of £681 per volunteer per annum. Assuming a 17.5 hour week (half time) and working 48 weeks per year gives a cost of £0.81 per hour. However, for consistency, we take the average of this and the Wastesavers figure. Data from Oxfam Wastesaver, relating to clothing, shows a slightly higher hourly cost for volunteers of £0.99. | Reasoned datapoint and good agreement, although based on assumptions. |
| Labour costs of PFR – welfare to work | 1.32 | £/hour | Medium | Calculated using the value of £20,000 per annum to employ 9 FTEs at Oxfam Wastesaver, assumed to work 48 weeks a year and 35 hours per week. | Reasoned datapoint, although based on assumptions |
| Labour costs of PFR – learning difficulties | -0.75 | £/hour | Medium | Data from FRN gives a cost of £681 per year per volunteer. On an hourly basis, assuming a 17.5 hour week, this is £0.75. | Reasoned datapoint, although based on assumptions |
| Utility costs of preparation for reuse | 19.66 | £/tonne | High | Data from FRN collected for this study. | Reasoned datapoint, although based on assumptions |
| Cost of customer drop-off | 0 | £/tonne | Low | | Some uncertainty around this value. |
| Cost of doorstep collection | TV £588<br>Washing Machine £249 | £/tonne | High | FRN based on a cost of £7-£10 per item | Relatively good agreement between different sources |
| Cost of dedicated reuse banks | TV £294<br>Washing Machine £69 | £/tonne | Medium | FRN - £5 per item - based on average weight | Some uncertainty around this value. |
| Cost of other collection | TV £294<br>Washing Machine £69 | £/tonne | Low | FRN – assumed to be the same as reuse banks | Some uncertainty around this value. |

| | | | | | |
|---|---|---|---|---|---|
| Revenue generated from sale – preparation for reuse | TV £2515 Washing Machine £887 | £/tonne | Medium | Data from FRN collected for this study. | Generic value for all textiles, and relatively old for cost data |
| Displaced new purchase – avoided cost | TV £799 Washing Machine £419 | £/unit | Low | Mean of 15 most popular items from http://www.kelkoo.co.uk/ on 7th Feb 2011 | Good data source, but not specific to T-shirts |
| Cost of running charity shop | 1410 | £/tonne | Low | Sim (2010) Charity Retail Survey 2010 | Mixed data sources |
| Cost of free exchange | 1 | £/tonne | Low | Nominal value | Assumption |
| Cost of paid exchange | 1 | £/tonne | Low | Nominal value | Assumption |
| Revenue generated from sale – direct reuse | TV £3666 (online) £2941 (charity shop) Washing Machine £1145 (online) £1037 (charity) | £/tonne | Medium | Online sale prices from WRAP (2011b)<br>Sale prices through retail assumed to be the same as through Preparation for Reuse in the absence of other data | Reasoned estimate |

**Table A3** Employment data sources, quality and assumptions

| | | | | | |
|---|---|---|---|---|---|
| Labour of landfill | 0.00007 | FTE/tonne | Low | Based on three unnamed studies | Source references unavailable |
| Labour of recycling | 0.0004 | FTE/tonne | Low | Based on Murray, 1998 | Source references unavailable |
| Labour of incineration | 0.00017 | FTE/tonne | Low | Based on three unnamed studies | Source references unavailable |
| Labour of bulky waste collection | 0.010 | FTE/tonne | Low | Based on Caroline Lee-Smith assumption, but adjusting for higher collection cost of textiles (Oxfam vs FRN data) | Assumption |
| Labour of civic amenity collection | 0.0076 | FTE/tonne | Low | Assumed as dedicated reuse banks (prep for reuse pathway) – but reference unavailable | Assumption/source references unavailable |
| Labour of doorstep collection | 0.010 | FTE/tonne | Low | Based on Caroline Lee-Smith assumption, but adjusting for higher collection cost of textiles (Oxfam vs FRN data) | Assumption |
| Labour of dedicated reuse banks | 0.0076 | FTE/tonne | Low | Based on assumptions for washing machines, but adjusting for higher collection cost of textiles (Oxfam vs FRN data) | Assumption |
| Labour of other collection | 0.0015 | FTE/tonne | Medium | AWC residual – National Assembly for Wales (2001) | Reasonable source, but likely to be variable. |
| Preparation for reuse – Labour of initial checking | 0.0007 | FTE/tonne | Low | Calculated using WRAP assumptions regarding hours/tonne (13 hours, based on 0.2 mins per item) and assuming a 35 hour working week/48 working weeks per year | Assumptions based on original low quality data |
| Preparation for reuse employment intensity | 0.02 | FTE/tonne | Medium | Calculated using hours/tonne and assuming a 35 hour working week and 48 working weeks per year | Assumptions based on original medium quality data |
| Labour composition – employed | 29 | % | Medium | Data on labour composition from FRN | Single source so data quality reduced |
| Labour composition – volunteer labour | 45 | % | Medium | Data on labour composition from FRN | Single source so data quality reduced |
| Labour composition – welfare to work | 26 | % | Medium | Data on labour composition from FRN | Single source so data quality reduced |
| Labour composition – learning difficulties | 0 | % | Medium | Data on labour composition from FRN | Single source so data quality reduced |
| Onward employment benefits from PFR orgs | 0.063 | FTE/tonne | Low | Based on figures from FRN | Large uncertainties in calculations |
| UK Employment Intensity of Displaced Products | 0 | FTE/tonne | Low | There does not appear to be any remaining production of washing machines in the UK http://news.bbc.co.uk/1/hi/wales/north_east/8081186.stm | Low quality source of data, although unlikely to be significant |
| Labour of free exchange | 0 | FTE/tonne | Medium | Assumed will be negligible | Reasoned assumption |
| Labour of paid exchange | 0 | FTE/tonne | Medium | Assumed will be negligible | Reasoned assumption |

**Waste & Resources**
**Action Programme**

The Old Academy
21 Horse Fair
Banbury, Oxon
OX16 0AH

Tel: 01295 819 900
Fax: 01295 819 911
E-mail: info@wrap.org.uk

Helpline freephone
0808 100 2040

www.wrap.org.uk/benefitsofreuse

recycle