Material change for a better environment

Summary report

Environmental assessment of consumer electronic products

A review of high volume consumer electrical products through Lifecycle Assessments, to compare their relative environmental impacts and identify future trends.

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

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

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Front cover photography: WRAP, 2009

Contents

Key study findings

This study by WRAP (Waste & Resources Action Programme) reviewed and compared the findings of Life Cycle Assessments (LCAs) and other studies for 15 individual consumer electronic products, chosen to illustrate a range of items across different product categories, with different material contents and energy use scenarios. The main findings were:

- Environmental impacts of consumer electronic products occur mostly in two phases of the lifecycle: the use phase, and the materials/process phase;
- Products with their greatest impacts in the materials/process phase show broadly it would be beneficial to extend their lifetime;
- The combined impact of the use phase was the greatest over all of the products. It is determined by the product's power demand, frequency of use, and product lifespan;
- The impact of the materials/process phase was the second greatest. It is determined by the mass of the product, and the ratio of electronic components. The larger the ratio of electronics, the greater the energy requirement. In some cases the materials/process phase is more significant than the use phase;
- The high energy-users can still have large potential savings in materials as they contribute the greatest total materials impacts across the range. Improvements in energy-efficiency are becoming harder to achieve in some of these categories;
- Distribution and end of life phases are a negligible impact for all products in the total lifecycle impacts; and
- When comparing lifecycle impacts against UK sales in 2009, televisions contributed the greatest overall impact of more than 250,000 Terajoules (TJ) of energy - 45% of the total of all the products studied.

Consumer electronic products: what are their relative environmental impacts?

Washing machines or laptops, mobile phones or electric drills: what are the impacts everyday consumer products have on our environment?

Everyday consumer electricals

WRAP commissioned WSP Environmental Limited (WSP) to source and assess available LCAs and environmental assessments, relating to the highest volume consumer electrical products currently purchased in the UK.

The project set out to establish a means of comparing the environmental impacts by assessing their relative energy requirements in Megajoules (MJ) and global warming potential in CO_2 equivalent (CO_2 eq).

In addition, the work attempted to identify current trends and to model future product trends in relation to lifecycle impacts.

The 15 products studied were:

- Refrigerator
- 32” LCD Television
- Washing machine
- Microwave oven
- Vacuum cleaner
- Laptop computer
- Set top box
- Hairdryer
- Kettle
- Lawn strimmer
- Electric drill
- Blender
- Mobile phone
- Digital camera
- Electric toothbrush

Product lifecycle phases

The study looked at the impacts of five product lifecycle phases:

- Materials – extraction of raw materials, such as ore mining, choice of materials and manufacture of components;
- Process – assembly of product components and packaging, such as plastic injection moulding or metal casting;
- Distribution – engineering and transport to the consumer/retailer;
- Use – electricity demand, including any consumables during its lifetime, installation and maintenance; and
- End of life – disposal, including reuse, recycling, incineration and landfill.

Overall, the study found that for all electrical products, the primary environmental impacts occurred at either the materials/ process or use phases of their lifecycle. Five products had their greatest impact in the materials/process phase.

Are products use or materials/process dominant?

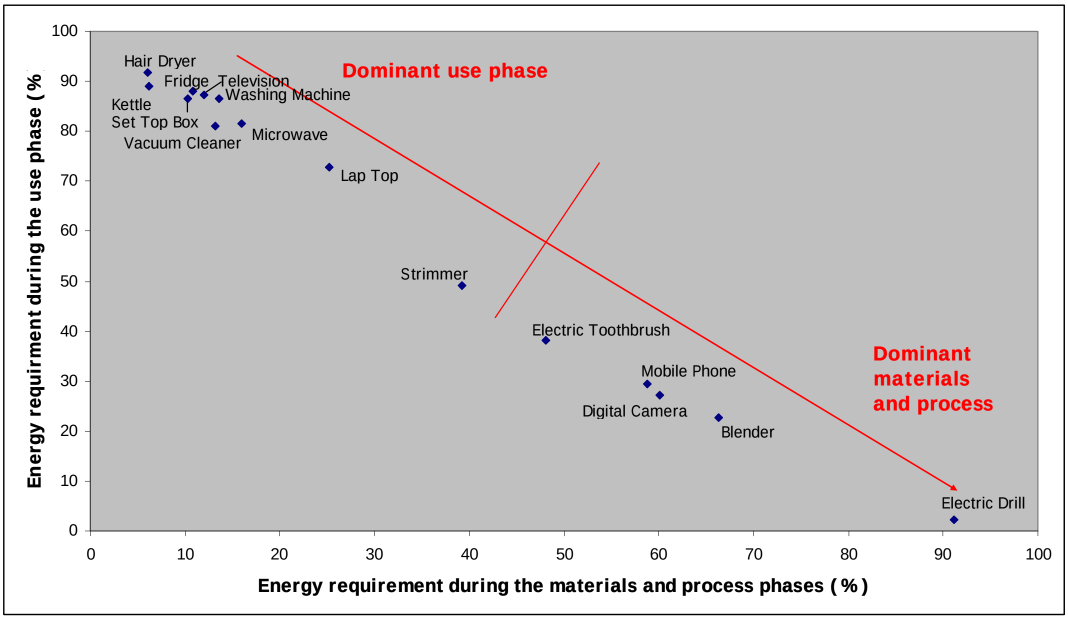
The products in the study appear in one of two categories as illustrated below:

- Products with predominantly high use phase impacts (49-90% of total lifecycle impact); items such as vacuum cleaners, kettles and hairdryers; and
- Products with predominantly high materials/process stage impacts (48-90% of total lifecycle impact); such as mobile phones, blenders and electric drills.

Some products such as the laptop, electric toothbrush and garden strimmer showed a more equal contribution. Whether the environmental impact was more ‘use dominant’ or ‘materials/process dominant’ was determined by five key factors:

- Mass of material used in manufacture;
- Proportion of electronic components;
- Power demand;
- Frequency of use; and
- How long the product is used.

Figure 1 Products by energy requirement in the use phase against materials and process phase (% of total lifecycle energy).



Methodology

From an initial list of popular, high volume consumer electrical products available in the UK, 15 were shortlisted. They were selected because they represented a wide mix of products from a range of category types, usage patterns, power demands and sizes.

A 'typical' product model was then selected to represent each category, based on mid-range key specifications, cost and volume sales. Detailed desk-based research was carried out to find any relevant and robust LCA studies from sources such as the Energy using Product (EuP) Directive, Government studies, academic institutes, industry, industry trade bodies and WRAP's own databases.

Key stakeholders from the electronics sector, including major manufacturers and trade bodies, contacted during the course of this study, helped build up a comprehensive database of LCA and other data for the products selected.

The study used EuP (Energy using Products) EcoReport methodology to compare lifecycle data. Where robust data was not available, a lifecycle assessment tool was used to provide generic and comparable lifecycle data.

For each product, the environmental impact also took into account the overall volume of products entering the market by using UK unit sales figures from November 2008 to October 2009.

The current and future technological development of products were assessed to identify and model future impact trends.

Assessing environmental impacts

The study used two main parameters to assess the environmental impact of each product:

- Energy Requirement, expressed in Megajoules (MJ) – the energy required at each lifecycle stage, based on the combustion of fuels used for energy generation; and
- Global Warming Potential, expressed in kilograms of carbon dioxide equivalent (kg CO_2 eq) – the method developed by the IPCC (Intergovernmental Panel on Climate Change) to express the potential contribution of different gases to the greenhouse effect.

Study limitations

The EuP EcoReport methodology used in this study to assess the majority of consumer electronic products is limited by the number of materials and processes included in the assessment database and the general assumptions made, specifically about distribution and end of life.

In addition, these findings were limited by the availability and completeness of Lifecycle assessment data for many of the consumer electronic products looked at, which varied greatly.

Using EcoFly

Where there was no data, the study used the software tool EcoFly, developed by WSP, to obtain comparable outline LCA data for the products.

Given a product's bill of materials and lifecycle information, such as energy consumption and expected lifespan, EcoFly can calculate the energy use, carbon emitted and waste generation, estimating other generic product lifetime data. This however, cannot be considered as extensive as a full LCA study.

High and low profile products

For the more common, 'higher profile' products – such as televisions, washing machines, refrigerators, mobile phones and vacuum cleaners that have been the subject of EuP preparatory studies – suitable LCA studies were available.

However, LCA data for 'low profile', or less frequently used products – such as hair dryers, lawn strimmers, blenders, kettles and microwaves – was limited, incomplete or deemed insufficient quality for this comparison, therefore in these cases the lifecycle assessment tool was used.

While many large consumer electronics manufacturers carry out some level of lifecycle assessment of their products, they regard this as commercially sensitive. Sometimes LCA overviews are published on company websites as part of their corporate social responsibility (CSR) obligations, but in some cases WSP found it difficult to verify the quality and completeness of the data.

In cases where full LCAs were not available, the research used journal overviews, book chapters and articles for reference in addition to EcoFly.

Overall results

The study found that in consumer electronic products, the global warming potential and energy requirement parameters are very closely related.

The primary impacts related to consumer electronics occur from the energy consumed during their use and embedded materials. As more energy is required by a product the longer its lifespan, its impact expressed as CO_2 eq increases.

So, for all products examined, the lifecycle profiles for energy requirement and global warming potential differed only slightly.

Materials and process phases

The contribution of these phases to overall lifecycle impacts varied significantly between products, from 6% in the kettle to 91% in the electric drill. This was directly related to the complexity and/or mass of the product; the bigger the item or the more complicated and numerous its electronic components, the greater its energy requirement. Items such as the kettle show decreased impacts in materials due to this being balanced against very high power requirement and frequency of use.

Electronic components

There is, however, another factor to take into consideration: the comparative energy requirement of plastics and metals compared to electronic components. Electronic components such as large integrated circuits can require 140 times more energy to produce than plastics such as PVC.

So, for example, though a washing machine typically weighs 50kg and a television typically 15kg, they require similar levels of energy to produce, because only about 0.2% by weight of a washing machine consists of electronic components, while in a television it is almost 10%.

Use phase

The energy requirement of a product in the use phase is determined by three factors: its power demand, usage patterns and estimated functional lifespan. So, the more energy a product uses and the longer it is in operation and the more frequently it is used, the greater the total energy required.

Not surprisingly, this means that products with low power demand and frequency of use such as digital cameras, have lower energy requirements during this phase, compared to high power demand, high frequency use products, such as kettles and hairdryers.

Individual products

The full study examined the environmental impacts and potential future technologies associated with 15 consumer electronic products. In this brief summary report, an overview of the results for four products were selected, broadly reflecting the range of study results and are illustrated below.

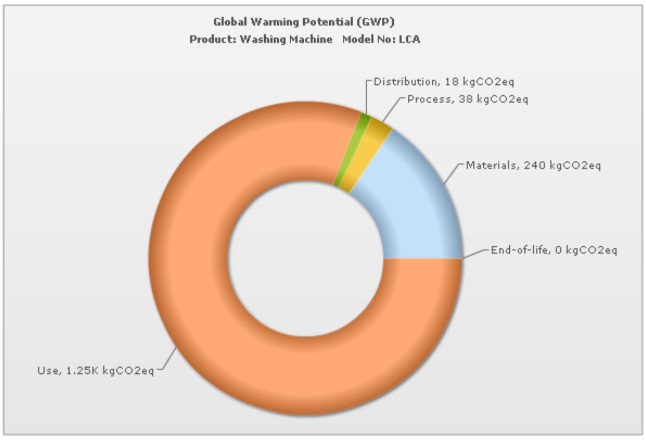
Washing machine

For a typical washing machine product the use phase is where the greatest environmental impacts occur, accounting for 87% of the energy requirement over its lifecycle. Government and industry progress has been focused on this area for some time, leading to steady improvements in energy efficiency, especially since European energy labelling was introduced.

There is greater competition for manufacturers to produce A-rated models so less efficient (D-G rated) machines have disappeared from the market. More recently, there has been a move towards even more energy efficient A+, A++ and A+++ models. However, the majority of models in operation in 2020 are still anticipated to be A+.

Due to the improvements made in energy efficiency, a shift of focus towards the materials and production phase may take place. Consumer behaviour can also significantly reduce energy consumption and savings could be achieved by improving behaviour and use of lower-impact wash settings, and encouraging the replacing of less energy efficient machines with new appliances.

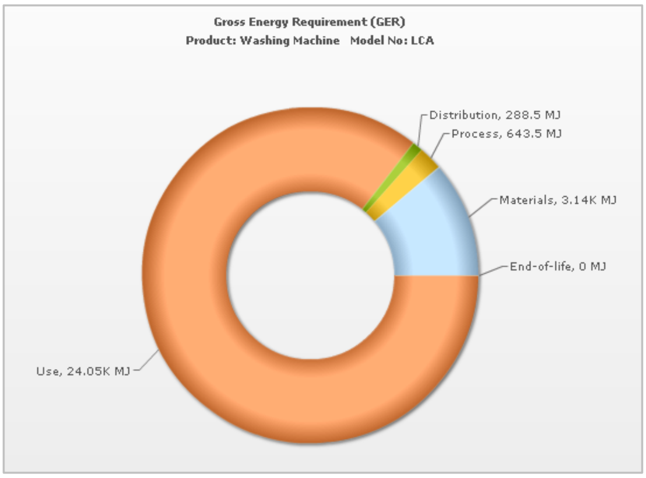
Figure 2 Global warming potential (kg CO_2eq) washing machine



LCA Impact Ranges (kg CO_2eq)

Materials:	195 - 285
Process:	21 - 49
Distribution:	2 – 34
Use:	988 – 1,508
End of life:	-55 – 1.5

Figure 3 Energy requirement (MJ) washing machine



LCA Impact Ranges (MJ)

Materials:	1,970 – 6,910 (11.3%)
Process:	99 – 900 (2.3%)
Distribution:	30 – 547 (2.1%)
Use:	13,860 – 48,000 (86.7%)
End of life:	-800 – 75 (-2.4%)

LCA data reference:

ISIS (2007) Domestic dishwashers and washing machines, Preparatory Study EuP Lot 14

Oko Institute (2004) Eco-Efficiency Analysis of Washing machines – Life Cycle Assessment and determination of optimal life span.

Laptop

The results for the typical laptop show the use phase contributes the greatest impact in its lifecycle, accounting for 73% of the energy requirement. The next highest impact is the material phase, which accounts for 25%, a considerably greater proportion than for other high energy users examined.

The research found a strong trend among consumers towards buying net books and note book computers, rather than desk tops, and a growing tendency to replace laptops almost as frequently as mobile phones, fuelled by falling prices and evolving technology.

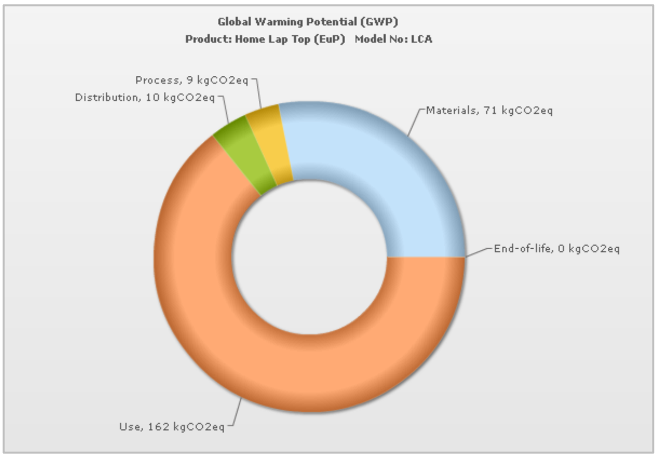
This move towards laptops from desktops offers several environmental benefits. Since they are smaller and lighter, manufacturing them produces fewer air emissions and they have less detrimental impact at disposal. They are also more efficient users of energy. Their processors use less power than desktops and as they are designed for battery use, they offer higher levels of power management.

In addition, technical innovations such as: solid state memory; light emitting diode (LED) and organic light emitting diode (OLED) backlights and touch screens; and better batteries and cooling systems, offer opportunities for further energy saving.

However, the laptop's relatively high materials/process phase impact has also to be considered as well as the increasing rate of purchase. This is caused by the large range of materials and components used in manufacture, particularly components such as integrated circuits and Printed Circuit Boards (PCBs).

In fact, when looking at the overall impacts by product volume sales, the materials/process and distribution impacts of laptops are almost as high to those for refrigerators and washing machines.

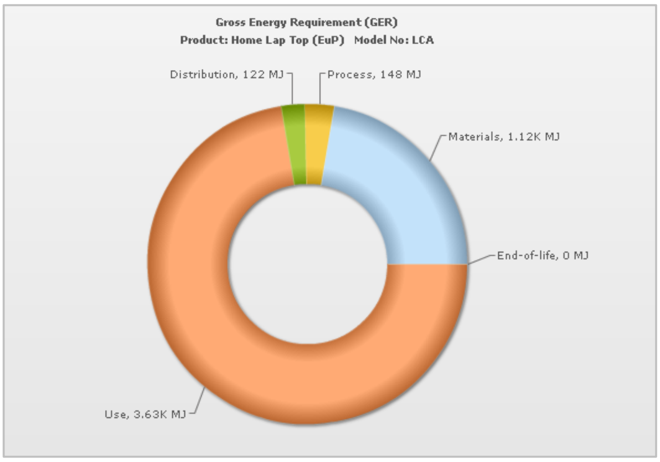
Figure 4 Global warming potential (kg CO_2 eq) laptop



LCA Impact Results (kg CO2eq)

Materials:	71
Process:	9
Distribution:	10
Use:	162
End of life:	-1

Figure 5 Energy requirement (MJ) laptop



LCA Impact Results (MJ)

Materials:	1,120 (22.4%)
Process:	140 (2.8%)
Distribution:	122 (2.4%)
Use:	3,630 (72.7%)
End of life:	-20 (-0.4%)

LCA data reference:

IVF Industrial Research and Development Corporation (2005): Personal Computers (desktops and laptops) and computer monitors, Preparatory Study EuP Lot 3

Mobile phone

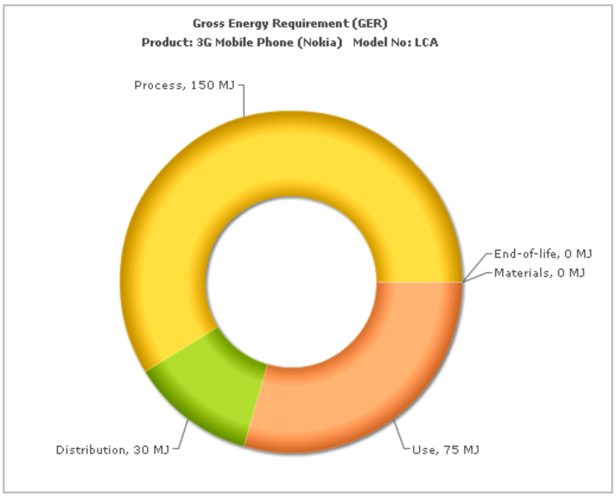
Today's mobile phone is a device for sending emails, taking photographs and videos, accessing the internet, storing music – and countless other activities. All of them increase the phone's electronic complexity and consequent environmental impact.

The study results show the materials/process phase contributes the greatest impact in the lifecycle of a mobile phone, accounting for 59% of the energy requirement. The next greatest impact is in the use phase, accounting for 29%.

In addition, there are opportunities at end of life for refurbishment and reuse, either in domestic or overseas markets, as well as growing interest in finding new uses for mobile phones at the end of their initial use phase. Key parts such as processing power and memory can be reused in new applications. If this trend takes off, it could mean a reduction in the impact of the materials and process phase due to the extension of lifetime.

WRAP anticipates that advances in mobile phone technologies will offer further resource efficiency opportunities, such as lightweighting and convergence with other items like cameras and MP3 players as the specifications of these items improves. Longer term, research suggests that developments could be focussed in the materials phase and lead to reduced impacts. Other areas include innovations such as self-charging mobile phones and components derived from more sustainable materials such as recycled plastic.

Figure 6 Energy requirement (MJ)* mobile phone



LCA Impact Ranges (MJ)

Materials/Process:	132 – 880 (58.8%)
Distribution:	28 – 31 (11.8%)
Use:	75 – 587 (29.4%)

*Material and process phases are combined. CO_2 eq data for the mobile phone was unavailable.

LCA data reference:

Singhal P (2005a): Integrated Product Policy Pilot Project – Stage I Final Report: Life Cycle Environmental Issues of Mobile Phones. NOKIA, Espoo, Finland

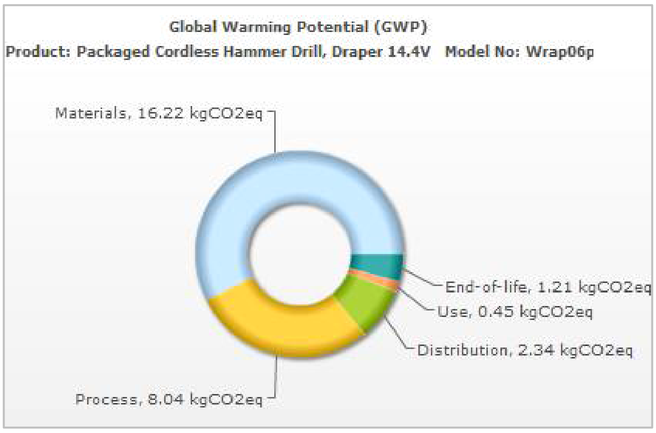
Electric drill

The results for the electric drill show the materials/process phase contributes the greatest impact in the lifecycle for any of the products studied, accounting for 91% of the energy requirement. The use phase impact for drills is very small, accounting for only 2% due to their occasional use. For this reason, it is clear that improvements should focus on the materials and process phases.

There are two types of electric drills: corded and cordless. Cordless drills have become increasingly popular as battery technology has improved, from the original lower voltage NiCds of 7.2V to higher voltage nickel metal hydride and lithium ion batteries up to 24V. More power has led to increases in the use phase.

One manufacturer claims that 97% of the components of its lithium ion cordless drill can be recovered and recycled, although the study was not able to verify data to support this.

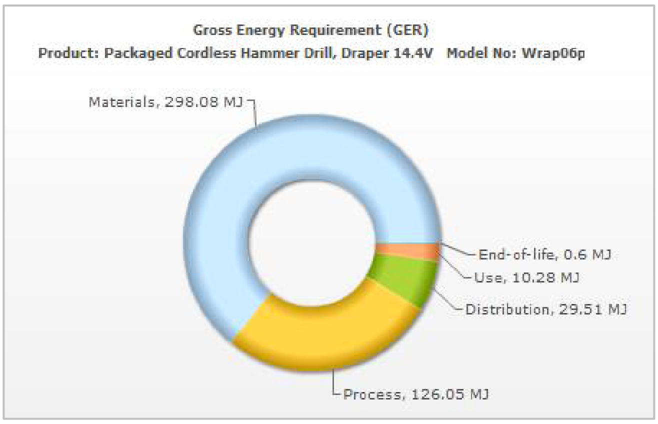
Figure 7 Global warming potential (kg CO_2 eq) electric drill



LCA Impact (kg CO2eq)

Materials:	16.22
Process:	8.04
Distribution:	2.34
Use:	0.45
End of life:	1.21

Figure 8 Energy requirement (MJ) electric drill



LCA Impact (MJ)

Materials:	298 (64.1%)
Process:	126 (27.1%)
Distribution:	29.5 (6.5%)
Use:	10.28 (2.2%)
End of life:	0.6 (0.2%)

LCA data reference:

EcoFly ecodesign software tool v1.5 by WSP Environmental (2009) based on EuP EcoReport methodology

Key impacts of products examined

Figures 9 and 10 summarise the key relative environmental lifecycle impacts of the 15 electronic products examined.

Figure 9 Total energy requirement per product by UK unit sales (GfK: Nov 2008 to Oct 2009) collectively over their lifecycle

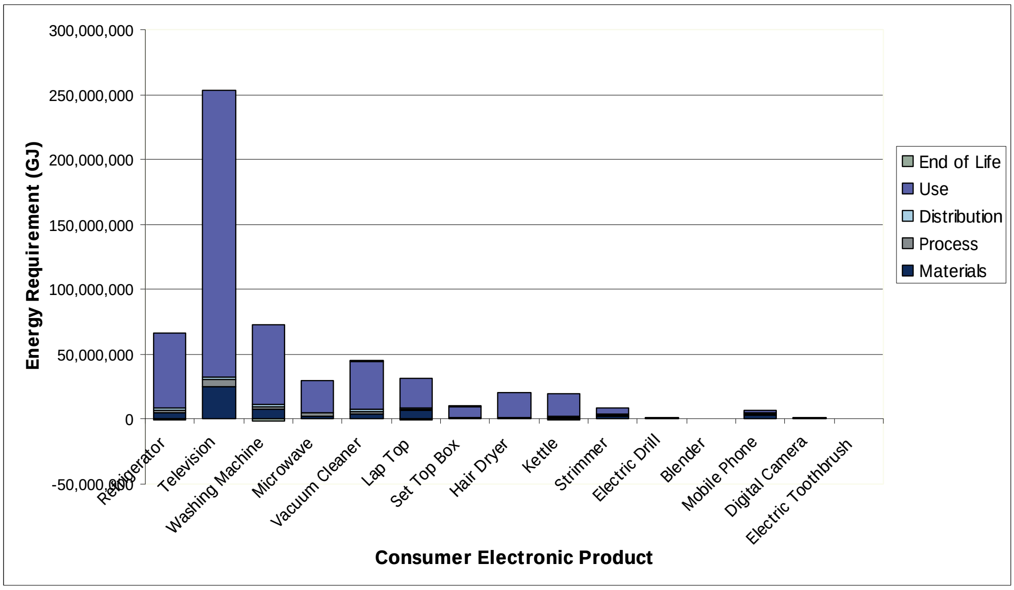
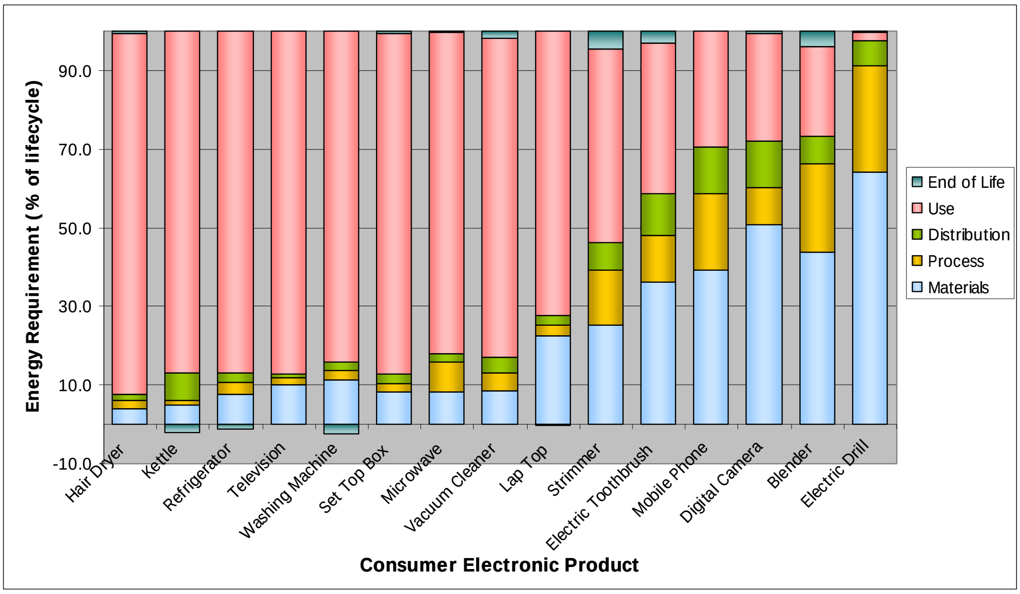


Figure 10 Energy requirement per product unit (% of the lifecycle)



Looking to the future

Overall trends and changes

The research carried out into the market trends for each of the 15 products studied found that the use phase is dominant in most consumer electronics and that currently the main area for improvement is in energy use reduction. This focus is likely to be intensified by the introduction of 'smart meters' in UK homes by 2020.

There is, however, a noticeable and significant shift – affecting more than half the products assessed – towards materials and process impacts of products. Initiatives such as longer-life products and sourcing materials with a lower impact would have a beneficial effect on the materials/process phase.

The refrigerator has the single greatest impact across its lifecycle (48,500 MJ) per unit compared to the second, the television (28,129 MJ). However, whilst looking at the overall volume of units, the television has 45% of the total impacts of all the products studied. The materials/process impacts of laptop computers purchased in the UK is of a similar scale to the materials/process impacts for refrigerators and washing machines.

For low value/high volume products, the study found little evidence of product disassembly or the use of recycled materials. There was, however, an increasing interest among retailers in extending product lifetimes by refurbishing and repairing some products.

Availability of data

As little or no LCA data is publicly available for the 'low profile' products, there is a need to carry out further research on the lifecycle impacts of these products.

It would be useful to obtain detailed lifecycle analysis on smaller products, such as:

- Lawn strimmer/mower;
- Blender;
- Electric toothbrush/drill; and
- Digital camera.

Consumer behaviour

Consumer behaviour is clearly a key element in the use phase of a consumer electronic product. Though information on consumer behaviour was available for some ‘high profile’ products, it was unavailable for the ‘low profile’ products.

Where manufacturers had conducted research, due to commercial reasons they were often unwilling to share it. So there is a need for an independent and more detailed investigation into consumer use, for example to quantify the frequency of use and actual lifetime of products which would inform a more accurate assessment of the use phase.

Resource depletion

Electronic products commonly require relatively high levels of raw materials such as copper, silver, gold, indium, nickel, chromium and zinc.

While the EuP EcoReport methodology used in this study does not specifically define and quantify the use of depleting materials, this is an increasingly concerning issue, particularly in the case of copper, copper/zinc alloy and zinc/aluminum alloy.

Further research would be required to accurately measure the levels of these precious metals against future projections in sales and technologies, compared with projected global resources, to gain a better understanding.

Conclusion

In the products studied, the dominance of the use phase or material/process phase across the lifecycle varies. The products appear on a scale, depending on the dominance of the use phase to the materials/process phase, ranging from the kettle (the most dominant use phase) to the electric drill (the most dominant materials/process phase).

Of the products examined, the refrigerator, television and washing machine contributed the greatest overall lifecycle impact, equating to 75% of the total impact of all the 15 products studied.

The research shows that, although the dominance of the use phase looks set to continue in consumer electronics, there is a progressive shift towards the materials phase where it is likely increased attention will be focussed; extending product life and sourcing and selecting product materials with a lower overall impact will help.

WRAP aims to continue to engage with manufacturers and brands on technological advancements, consumer behaviour, product development and lifecycle impacts to help industry produce more sustainable products.

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