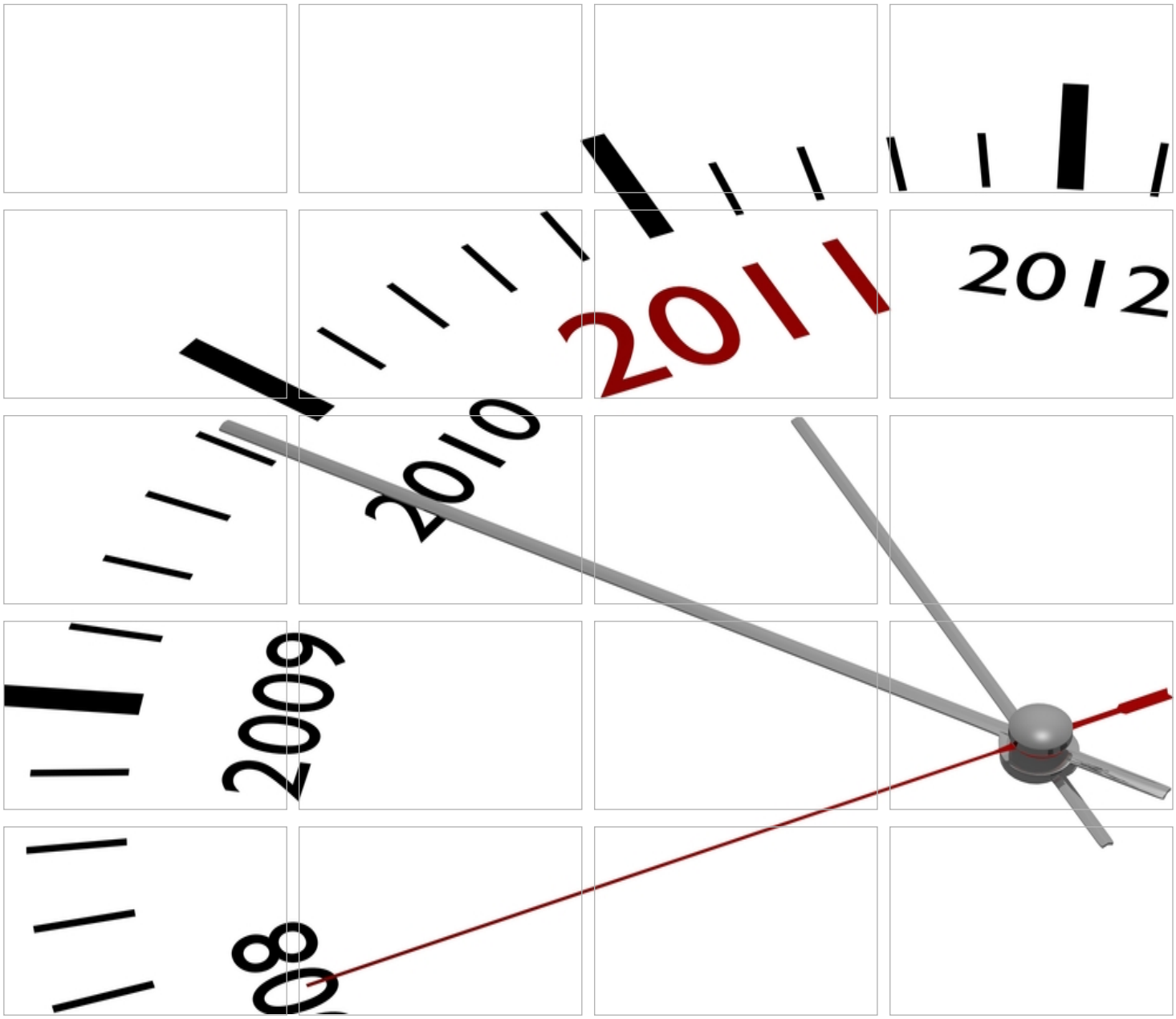

Longer Product Lifetimes

Chapter 2 – Life Cycle of Nine Products

Final Report

Defra

Longer Product Lifetimes

Chapter 2 – Life Cycle of Nine Products

Final Report

February 2011

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For and on behalf of
Environmental Resources Management

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Position: Partner _____

Date: February 2011 _____

CONTENTS

1 INTRODUCTION

1.1 STRUCTURE OF CHAPTER

This is the second chapter in Environmental Resources Management (ERM) Limited's report for Defra on Extended Product Lifetimes.

Chapter 1, *The Scoping Report,* explains the background to this research into extending product lifetimes, the rationale for Government intervention and other work, policies and initiatives which consider lifetime extension in an environmental context. It goes on to describe the process and the selection of nine example products for detailed review in the remainder of the project. The nine products are a washing machine, toaster, inkjet printer, laptop computer, mobile phone, domestic carpet, T-shirt, office flooring tile and sofa.

This Chapter, Chapter 2, *Life Cycle Impact of Nine Products*, describes in detail the product life cycle assessments (LCAs) which quantified the environmental benefits associated with extending the life of these example products. It also provided a first estimate of the total quantity of waste (in tonnes) which could be prevented in the UK if around 10% of the selected products were subject to take-up of lifetime extension.

Chapter 3, *Impact Assessment of Potential Measures*, focuses on what practical steps or measures could be put in place to extend the life of products. It presents ERM's approach to establishing and to evaluating these potential measures, along with conclusions as to how these measures could be designed to ensure they are effective in extending product lifetimes.

The chapter contains the following sections:

Section 2:	ERM's Modelling Approach
Section 3:	Summary of results and conclusions from the analysis of individual products
Section 4:	Assessing the Potential Environmental Benefits for UK market
Section 5:	Conclusions

This report is supplemented with separate reports for each product. These are included in *Annex C: Life Cycle Optimisation Model – Results for Each Product* These provide details of the data and assumptions used for each of the products, the results of sensitivity analyses performed and conclusions specific to each product.

2 ERM'S MODELLING APPROACH

To do this work ERM developed a Life Cycle Optimisation (LCO) model which balances estimated production and end of life burdens for each product examined against use phase impacts over a 50 year time period.

In terms of environmental impacts, three impact indicators were considered:

- Global warming potential (GWP);
- Resource depletion; and
- Water use

For each example product, the LCO model compared two reference product scenarios – one entailing an example 'typical' lifetime and the other for an 'extended' lifetime. In each case, we looked at the different phases of the product life cycle namely: production (raw materials and assembly), consumer use, refurbishment (if undertaken) and disposal (via recycling, incineration or landfill).

ERM conducted sensitivity analysis to establish whether the conclusions drawn from the reference scenarios would be likely to hold true under different circumstances. For instance, potential variations in the assumed lifetime extension period for the products were explored. The benefits gained by alternative lifetime extension strategies were also examined for some products.

2.1 ASSUMPTIONS FOR THE LCO MODEL

It was necessary to make a number of assumptions in the LCO model, these included:

- the fact that energy-using products may be replaced with more efficient models at the end of life.

- the way electricity is generated in the future (and the corresponding environmental impacts of electricity generation) as the UK moves towards reduced dependence on fossil fuel energy sources.

- forecasted trends in the energy efficiency of products (eg Market Transformation Programme (MTP) forecasts) and other developments such as trends concerning the miniaturisation or increase in size of products. However it was not possible to include radical 'paradigm shifts' in technology in the analysis (for example, technology shift or convergence with another products) due to lack of knowledge about the future, limited data availability, and methodological complexity.

ERM used immediately available product data, or assumptions for each of the life cycle stages of the different products for the scoping LCAs. As such, the analysis provides high level directional information concerning the environmental impacts of extending product lifetime, but the results should be interpreted with caution in light of the limitations in data availability and rigour of the analysis.

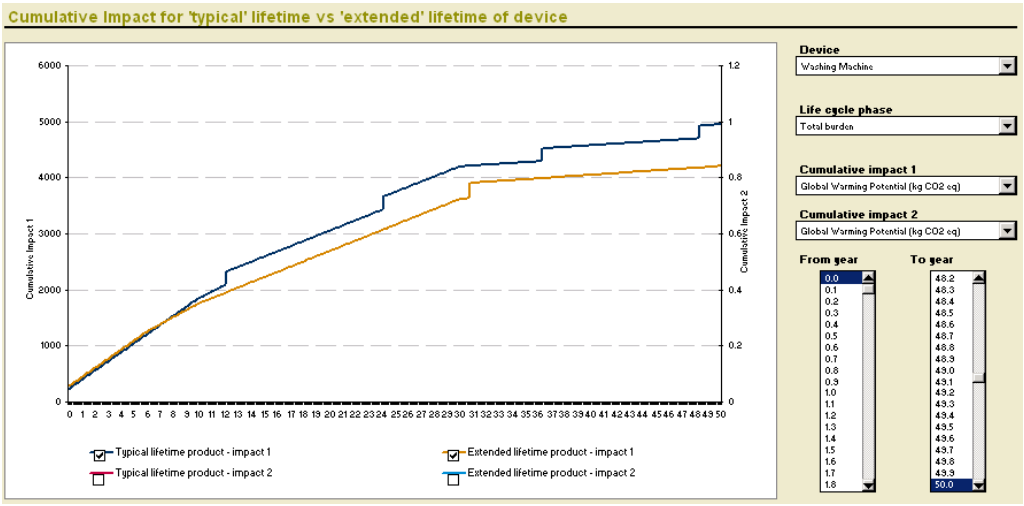
2.2 *EXAMPLE: WASHING MACHINE*

For each product, ERM produced an estimate of the cumulative impacts resulting from the use of either the typical and lifetime extended product over a 50 year period from 2010.

Figure 2.1 shows an example chart for the reference scenario analysis for a washing machine.

The more durable washing machine (yellow line) is marginally more impactful to produce (as shown at the very outset) than the example typical product (blue line). However, additional impact this is overcome as the typical product is more frequently replaced (represented as steps in the chart). Impacts associated with energy and water use in this example, are depicted in the chart by the incline between each product replacement. The gap between the curves highlights the magnitude of potential savings from pursuing the extended product lifetime strategy at a point in time. For example, in this case these are estimated to amount to approximately 0.75 tonnes CO2 eq for global warming potential for the provision of one product to the market after 50 years.

Figure 2.1 Cumulative GWP comparison over time between typical and extended lifetime washing machine



3 RESULTS AND CONCLUSIONS FROM THE ANALYSIS OF ALL INDIVIDUAL PRODUCTS

3.1 OVERALL CONCLUSIONS

This section provides a summary of the results from conducting the analysis for each of the nine sample products. Full reports for each individual product are provided in *Annex C – Life Cycle Optimisation (LCO) Model: Results for Each Product.*

Overall the findings of the separate product studies indicate the following:

- **Product lifetime extension is likely to reduce environmental impacts across the lifecycle for the vast majority of products examined.** This is with the possible exception of the analysis for domestic carpets for GWP and water use which did not indicate benefits. It is noted that potentially significant uncertainties are evident in the research base for this product group (1).

- **The benefits largely result from 'avoiding' manufacturing and supply chain impacts because lifetime extended products are kept in service for longer, so do not need to be replaced as frequently**.

- **Since the manufacturing of consumer products is predominantly undertaken outside the UK, the majority of the benefits would be reported as being realised outside the UK** (eg in national greenhouse gas emissions inventory reporting etc). However, it is noted that GWP, Resource depletion (and to a lesser extent water availability) are global environmental issues and consumption in the UK influences the size of this impact.

- **Lesser environmental benefits will also be realised in the UK due to reduced final waste volumes** (avoiding the need for waste management capacity in the UK and elsewhere). These tend to be comparatively small relative to avoided production impacts to be gained through lifetime extension.

- **Product refurbishment impacts were shown to be negligible in size relative to the benefits that can be gained through avoiding manufacturing impacts through lifetime extension**.

- **For the energy-using products foreseen improvements in their energy efficiency do not compromise the rationale for intervention for lifetime extension**. This is because the maximum extended lifetimes are

(1) The domestic carpet analysis noted uncertainty in the impacts associated with the production of UK wool for the durable wool carpet examined in the research (relative to the surrogated process for US wool production which had to be used in the analysis).

comparatively short relative to the typical product. The modelling incorporated improved efficiencies each time the product was replaced, and when accounted for in the modelling this translated into comparatively small improvements each time a product was replaced. It was indicated in the research that the decarbonised energy grid forecast will somewhat reduce the effect of energy efficiency innovation in the future.

It must be noted however regarding this finding that vehicle, boiler and TV products were not selected as products for further analysis in this study because it was anticipated, given their high energy, that foreseen energy efficiency innovation in these product groups had the potential to outweigh the benefits of lifetime extension.

- **The findings were generally consistent for both GWP and resource depletion impact indicators. Water use only showed negligible differences between the typical and extended lifetime product.**

- **Where benefits for lifetime extension were identified, these were confirmed under all the different sensitivity analyses performed in the research**. The magnitude of the benefits achievable was largely determined by the assumptions concerning the lifetime extension periods of the typical and extended products in the sensitivities. It is noted however that the modelling incorporated foreseen reasonable alternative circumstances rather than radical technology shift.

4 ASSESSING THE POTENTIAL ENVIRONMENTAL BENEFITS ACROSS THE UK MARKET

4.1 SCALING UP PROCESS

ERM's life cycle modelling work aimed to quantify the environmental benefits of extending the life of one product rather than a proportion of UK products on the market. To provide an indication of the environmental impact on the UK market a simple 'size of prize' estimate for the benefits of extending product lifetime was performed. This assumes a notional 10% of the product stock for a particular product category was changes from typical products to extended lifetime products.

An indicator for the potential waste prevented in the UK was also calculated. This covers the prevented discarded product and packaging waste and, if the processes take place in the UK, the production waste, and additional refurbishment and potential servicing waste burdens.

The method also provides a basic order of magnitude indication for the effect on the respective UK waste arising for the product group. For this estimate, the following assumptions were made:

- 10% of the estimated UK product sales were changed to the lifetime extended product, assuming the UK market comprised only typical products;
- The market is not expanding or contracting, nor are products stockpiled; and
- In the case of products which are known to be refurbished and exported at the end of their life (eg mobile phones) it is assumed that this is UK waste arising.

4.2 RESULTS: POTENTIAL ENVIRONMENTAL BENEFITS ACROSS UK MARKET

Table 4.1 provides the results for the products studied and the potential global warming potential, resource depletion and water use savings for product group based on the 10% change to the market.

Table 4.2 provides an estimate of the waste prevented based on this 10% change to the market.

Please note: Given the uncertainty associated in the estimates for UK sales and stock and their prediction into the future, the limits of the scoping LCA modelling and the methodological approach used for the 'size of prize' calculations, these are not accurate estimates. It was not possible to investigate the level of uncertainty associated with these estimates in this research. However, ERM does consider the approach as a means of providing a first indication of the order of magnitude of the benefits of altering 10% of the market to longer-lived products.

The analysis indicates the following:

- It is evident that the size of the estimated benefit varies by product considerably. This is due to the life cycle modelling, the scope of the product category covered in each estimate, assumed product ownership and the size of annual sales (as determined by the lifespan).

- The greatest benefits to be gained for GWP from lifetime extension would be for the T-shirt in which circa 100,000 tonnes of CO_2 eq would be reduced per annum through a 10% change in the market. The majority of this saving would be reportable in the host manufacturing country supplying the material and garment ie non-UK although this is a global environmental issue.

  In context, a comparable saving would be achieved by reducing UK annual small car vehicle mileage by 800 million km (or circa 80,000 vehicles, from a UK fleet of 25 million car vehicles [(1)]).

  Approximately 2000 tonnes of waste T-shirts would not need to be managed each year if the market was changed by 10%.
  In context, ~1 million tonnes of post-consumer clothing is estimated to arise in the UK per annum.

- Changing the toaster market by 10% would save net ~4000 tonnes of CO2 eq and prevent ~60 tonnes of waste per annum.

- With the exceptions listed below, benefits are indicated for the other products analysed between this range.

There are two instances where no overall benefits are observed:

1. For domestic carpets, the wool-based durable carpet scenario over the typical nylon-based product results in a net increase in impacts for GWP and water use, but not for resource depletion and waste production. For this product it is noted that the scoping LCA is potentially limited because it was necessary to use a surrogate production impact for US wool for the UK which may or may not be representative.

2. For sofas, water use in the extended lifetime scenario of refurbishment through loose covers was shown to be very slightly (insignificantly) higher than the typical product. This is due to increased textile use. The additional water used would be borne abroad. In context, this indirect imported production water is negligible relative to water use in its original production; nevertheless, there is a net increase for the assumptions taken in the study.

(1) Assuming small car vehicle emission factor of 0.128kg CO2/km
http://directgov.transportdirect.info/Web2/Home.aspx and each vehicle in the UK travel 15,000 km per annum

Table 4.1 Summary of Potential Global Warming Potential, Resource Depletion and Water Use Savings achieved over a 50 year period.

Product	Summary description of products studied - Reference scenario		Sensitivity analyses undertaken	Approximate UK Annual sales	UK in-use stock estimate (assuming stable market)	Per year GWP savings when averaged over 50 years (Kg CO_2 eq.) per product	GWP Saving assuming 10% of stock changed (Tonnes CO_2 eq.)	Location of majority of environmental benefit	Per year resource depletion savings when averaged over 50 years (Kg Sb eq.) per product	Resource depletion Saving assuming 10% of stock changed (Tonnes Sb eq.)	Per year water use savings when averaged over 50 years (m3) per product	Water use,Saving assuming 10% of stock changed (m3)
	Typical product	**Extended lifetime product**										
T-shirt	Knitted T-shirt made from 100% cotton fibre 250 g 2 year lifetime 100 days of being worn Laundered 25 times over lifetime 100% incineration	Knitted poly-cotton (50% polyester / 50% cotton) T-shirt 250 g 3 year lifetime 150 days of being worn Laundered 38 times over lifetime 100% incineration	-Decreased lifespan (2 years) for the polycotton product to match that of the pure cotton T-shirt; -No tumble-drying scenario, ie only drying on the line instead; and -Wearing a T-shirt once, as opposed to four times, before laundering.	460 million sales per annum[1]	Assumed 2 year lifetime = 920 million stock	1.07	98,400	SE Asia	0.006	550	0.0014	131,000

[1] Well Dressed? The Present and Future Sustainability of Clothing and Textiles in the United Kingdom, Allwood J.M., Laursen, S.E., De Rodriguez, C.M., Bocken, N.M.P. (2006) University of Cambridge Institute for Manufacturing.

Product	Summary description of products studied - Reference scenario		Sensitivity analyses undertaken	Approximate UK Annual sales	UK in-use stock estimate (assuming stable market)	Per year GWP savings when averaged over 50 years (Kg CO_2 eq.) per product	GWP Saving assuming 10% of stock changed (Tonnes CO_2 eq.)	Location of majority of environmental benefit	Per year resource depletion savings when averaged over 50 years (Kg Sb eq.) per product	Resource depletion Saving assuming 10% of stock changed (Tonnes Sb eq.)	Per year water use savings when averaged over 50 years (m3) per product	Water use,Saving assuming 10% of stock changed (m3)
	Typical product	**Extended lifetime product**										
Sofa	Two-seater model with wooden frame, phosphorus-based flame retardant treated decorative cotton cover and melamine FR treated PUR foam 60kg 8 year lifetime Laundered 6 times over lifetime 30% incineration, 70% landfill	Typical sofa refurbished by replacing the cotton covers with phosphorus-based FR treated made-to-measure loose decorative cotton covers 60kg 12.5 year lifetime Laundered 9.375 times over lifetime 30% incineration, 70% landfill	-A decreased extended lifetime of two and a half years for the loose recovered product -Production of a more durable sofa with a longer first lifetime (14 years) followed reupholstering the sofa resulting in extended lifetime of 14 years		Two sofas per UK household =40 million stock[1]	2.9	11,600	Non UK	0.024	96	-0.024	-96,800

[1] An ERM reasoned assumption

Product	Summary description of products studied - Reference scenario		Sensitivity analyses undertaken	Approximate UK Annual sales	UK in-use stock estimate (assuming stable market)	Per year GWP savings when averaged over 50 years (Kg CO_2 eq.) per product	GWP Saving assuming 10% of stock changed (Tonnes CO_2 eq.)	Location of majority of environmental benefit	Per year resource depletion savings when averaged over 50 years (Kg Sb eq.) per product	Resource depletion Saving assuming 10% of stock changed (Tonnes Sb eq.)	Per year water use savings when averaged over 50 years (m3) per product	Water use,Saving assuming 10% of stock changed (m3)
	Typical product	**Extended lifetime product**										
Domestic Carpet	1m² of 100 % nylon carpet 2,633 g / m² 10 year lifetime Vacuuming once every month 100% landfill	1m² of 80 % wool 20 % nylon tufted carpet 3,150g / m² 15 year lifetime Vacuuming once every month 100% landfill	-Decreased lifespan (10 years) for the extended lifetime product to match that of the typical carpet; -Increased wool content for the durable product ie a 100% wool carpet as opposed to a wool-polyamide blend carpet; and -Altered backing for the durable product ie jute backing instead of a limestone/rubber system.	145 million m² sales per annum[1]	10 year lifetime	-4.028 (per m²)	-584,000	UK Impact	0.006 (per m²)	870	-0.00008 (per m²)	-11,600

[1] Estimate for domestic carpet market size in Flooring (Between 120-170m2 per annum): Towards a Resource Efficiency Plan (2009) Thomas, P. The Contract Flooring Association.

Product	Summary description of products studied - Reference scenario		Sensitivity analyses undertaken	Approximate UK Annual sales	UK in-use stock estimate (assuming stable market)	Per year GWP savings when averaged over 50 years (Kg CO_2 eq.) per product	GWP Saving assuming 10% of stock changed (Tonnes CO_2 eq.)	Location of majority of environmental benefit	Per year resource depletion savings when averaged over 50 years (Kg Sb eq.) per product	Resource depletion Saving assuming 10% of stock changed (Tonnes Sb eq.)	Per year water use savings when averaged over 50 years (m3) per product	Water use,Saving assuming 10% of stock changed (m3)
	Typical product	**Extended lifetime product**										
Office Carpet	1m² of modular carpet 4,400 g / m² 6 year lifetime Vacuuming 4 times a week 13% recovery, 13% incineration, 74% landfill	1m² of modular microtufted carpet 4,060 g / m² 10 year lifetime Vacuuming 4 times a week 13% recovery, 13% incineration, 74% landfill	-Decreased lifespan (6 years) for the extended lifetime product to match that of the typical carpet tile; -Intensive wet cleaning service at a frequency of three times over two years for the lifetime extended product; and -Refurbishment ie replacement of a proportion of the carpet tile during the first two years of use, rather than the whole product.	40 million m² sales[1]	6 years lifetime	0.74	17,800	Continental Europe/ UK	0.008	32	0.000006	144

[1] Estimate for carpet contract flooring market size in Flooring: Towards a Resource Efficiency Plan (2009) Thomas, P. The Contract Flooring Association.

Product	Summary description of products studied - Reference scenario		Sensitivity analyses undertaken	Approximate UK Annual sales	UK in-use stock estimate (assuming stable market)	Per year GWP savings when averaged over 50 years (Kg CO_2 eq.) per product	GWP Saving assuming 10% of stock changed (Tonnes CO_2 eq.)	Location of majority of environmental benefit	Per year resource depletion savings when averaged over 50 years (Kg Sb eq.) per product	Resource depletion Saving assuming 10% of stock changed (Tonnes Sb eq.)	Per year water use savings when averaged over 50 years (m3) per product	Water use,Saving assuming 10% of stock changed (m3)
	Typical product	**Extended lifetime product**										
Mobile Phone	Mobile phone with a lithium-ion (Li-ion) battery and charger adapter 81g 2 year lifetime 20% recovery, 15% stored for recycling, 65% landfill	Typical phone refurbished with minimal reprocessing 81g 6 year lifetime 20% recovery, 15% stored for recycling, 65% landfill	-The use of reduced environmental burden during the production stage reflecting a reduction in the size of products; -The increased use of the mobile phone reflecting a high energy use pattern; and -Use of a new generation mobile phone i.e. increased product weight and energy use	15 million sales[1]	2 year lifetime	11.5	34,500	SE Asia and Europe	0.086	258	0.053	160,200

[1] http://www.parliament.uk/documents/post/postpn291.pdf

Product	Summary description of products studied - Reference scenario		Sensitivity analyses undertaken	Approximate UK Annual sales	UK in-use stock estimate (assuming stable market)	Per year GWP savings when averaged over 50 years (Kg CO_2 eq.) per product	GWP Saving assuming 10% of stock changed (Tonnes CO_2 eq.)	Location of majority of environmental benefit	Per year resource depletion savings when averaged over 50 years (Kg Sb eq.) per product	Resource depletion Saving assuming 10% of stock changed (Tonnes Sb eq.)	Per year water use savings when averaged over 50 years (m3) per product	Water use,Saving assuming 10% of stock changed (m3)
	Typical product	**Extended lifetime product**										
Laptop	15" screen, 1.7GHz processor, good 3-dimensional graphic performance, 512MB RAM and 60GB HDD 2.80 kg 3 year lifetime 25% recovery, 75% landfill	Typical laptop upgraded by increasing memory (changing the integrated circuit (IC)) and changing the hard disk drive (HDD) 2.80 kg 5 year lifetime 25% recovery, 75% landfill	-MTP reference scenario for commercial laptops and longer service lifetimes (5 years + 5 years after upgrade); -Domestic use 5 years + 5 years for increased reused period; - 50% weight reduction for both products to reflect size reduction trend; and - MTP Policy scenario data for domestic laptops for 2010, 2020 and 2030 resulting in reduced electricity consumption.		17 million[1]	15.2	25,800	SE Asia	0.12	204	160	273,000

[1] MTP estimates for stock of laptops for 2010 (BNDICT PC01 and BNNDICT PC01 documents). http://efficient-products.defra.gov.uk/cms/product-strategies/subsector/cross-sector

Product	Summary description of products studied - Reference scenario		Sensitivity analyses undertaken	Approximate UK Annual sales	UK in-use stock estimate (assuming stable market)	Per year GWP savings when averaged over 50 years (Kg CO_2 eq.) per product	GWP Saving assuming 10% of stock changed (Tonnes CO_2 eq.)	Location of majority of environmental benefit	Per year resource depletion savings when averaged over 50 years (Kg Sb eq.) per product	Resource depletion Saving assuming 10% of stock changed (Tonnes Sb eq.)	Per year water use savings when averaged over 50 years (m3) per product	Water use,Saving assuming 10% of stock changed (m3)
	Typical product	**Extended lifetime product**										
Printer	Inkjet Multi-Function Printer (MFP) with 1 black starter cartridge and 1 colour starter cartridge 8.20 kg 3 year lifetime 9.5 pages/day Replacement of cartridges 20% recycling, 80% landfill	Inkjet Multi-Function Printer (MFP) with 1 black starter cartridge and 1 colour starter cartridge 8.20 kg 5 year lifetime 9.5 pages/day Replacement of cartridges 20% recycling, 80% landfill	-Reduced paper consumption (4 pages per day) to reflect a domestic usage pattern; -Increased paper consumption (15 pages per day) to portray a small home office commercial usage pattern; -Duplexing to reduce paper consumption; -Market Transformation Programme (MTP) reference scenario energy values for low-end use (ie representing domestic use); and -MTP reference scenario energy values for high-end (ie commercial) use.	3.5 million sales[1]	3 year lifetime	11	11,600	South-East Asia	0.098	103	0.000072	76

Product	Summary description of products studied - Reference scenario		Sensitivity analyses undertaken	Approximate UK Annual sales	UK in-use stock estimate (assuming stable market)	Per year GWP savings when averaged over 50 years (Kg CO_2 eq.) per product	GWP Saving assuming 10% of stock changed (Tonnes CO_2 eq.)	Location of majority of environmental benefit	Per year resource depletion savings when averaged over 50 years (Kg Sb eq.) per product	Resource depletion Saving assuming 10% of stock changed (Tonnes Sb eq.)	Per year water use savings when averaged over 50 years (m3) per product	Water use,Saving assuming 10% of stock changed (m3)
	Typical product	**Extended lifetime product**										
Toaster	Toaster with no availability for repairs/spares 1.6kg 5.5 year lifetime No servicing 14% recycling, 72% landfill	Two slice durable toaster with steel casing and free repairs during two year warranty period and availability of modular spares thereafter for indeterminate period. 16.5 year lifetime 14% recycling, 72% landfill	-The use of medium usage profiles (four times a day); -The use of high usage profiles (six times a day); -The use of 0.1% improvement in energy efficiency over time in energy efficiency innovation for both products; and -The use of future -of-life scenario for the duct in line with WEEE ets.		28.5 million[2]	1.4	3,920	South-East Asia	0.012	34	0.0115	32,800

Product	Summary description of products studied - Reference scenario		Sensitivity analyses undertaken	Approximate UK Annual sales	UK in-use stock estimate (assuming stable market)	Per year GWP savings when averaged over 50 years (Kg CO_2 eq.) per product	GWP Saving assuming 10% of stock changed (Tonnes CO_2 eq.)	Location of majority of environmental benefit	Per year resource depletion savings when averaged over 50 years (Kg Sb eq.) per product	Resource depletion Saving assuming 10% of stock changed (Tonnes Sb eq.)	Per year water use savings when averaged over 50 years (m3) per product	Water use,Saving assuming 10% of stock changed (m3)
	Typical product	**Extended lifetime product**										
Washing Machine	6kg load 'A' rated washing machine 12.09 year lifetime 260.1 cycles/year No servicing 85% recovery, 15% landfill	6kg load 'A' rated ISE 1606W washing machine 30.8 year lifetime 260.1 cycles/year Servicing every 6 years 85% recovery, 15% landfill	-MTP Policy scenario reflecting an increased rate for energy efficiency innovation; -Drop off in the energy efficiency representing a lack of servicing, relative to a product serviced more frequently; and -Decreased life spans of both products reflecting uncertainties in typical product lifetimes.		22.5 million[3]	14.8	33,300	Europe/ South East Asia	0.14	315	0.270	60,718.5

Table 4.2 Potential Prevented Waste Arisings in the UK by Sample Product

Product	Summary description of products studied - Reference scenario		Approximate UK Annual sales	UK in-use stock estimate (assuming stable market)	Total waste arising prevented in UK over 50 years (kg) per product	Per year waste prevented in UK (kg) per product	Total annual waste prevented in UK assuming 10% of stock changed (tonnes)
	Typical product	Extended lifetime product					
T-shirt[1]	Knitted T-shirt made from 100% cotton fibre 250 g 2 year lifetime 25 t-shirts required over the 50 years	Knitted poly-cotton (50% polyester / 50% cotton) T-shirt 250 g 3 year lifetime 16.7 t-shirts required over the 50 years	460 million sales per annum	Assumed 2 year lifetime = 920 million stock	2.1	0.0415	1,910
Sofa[2]	Two-seater model with wooden frame, phosphorus-based flame retardant treated decorative cotton cover and melamine FR treated PUR foam 60kg 8 year lifetime 6.25 sofas required over the 50 years	Typical sofa refurbished by replacing the cotton covers with phosphorus-based FR treated made-to-measure loose decorative cotton covers 60kg 12.5 year lifetime 4 sofas required over the 50 years	Assumed 5 million sales per annum based on 8 year lifetime	2 sofas per UK household =40 million stock	135	2.7	13,500
Domestic Carpet[3]	1m² of 100 % nylon carpet 2,633 g / m² 10 year lifetime 5 carpet products required over the 50 years	1m² of 80 % wool 20 % nylon tufted carpet 3,150g / m² 15 year lifetime 3.3 carpet products required over the 50 years	145 million m² sales per annum	10 year lifetime	5.4	0.11	1,600
Office Carpet[4]	1m² of modular carpet 4,400 g / m² 6 year lifetime 8.3 carpet products required over the 50 years	1m² of modular microtufted carpet 4,060 g / m² 10 year lifetime 5 carpet products required over the 50 years	40 million m² sales	6 years lifetime	-0.5	-0.009	-36

Mobile Phone[5]	Mobile phone with a lithium-ion (Li-ion) battery and charger adapter 81g 2 year lifetime 25 mobile phones required over the 50 years	Typical phone refurbished with minimal reprocessing 81g 6 year lifetime 8.3 mobile phones required over the 50 years	15 million sales per annum	2 year lifetime	7.3	0.15	225
Laptop[6]	15" screen, 1.7GHz processor, good 3-dimensional graphic performance, 512MB RAM and 60GB HDD 2.80 kg 3 year lifetime 16.7 laptops required over the 50 years	Typical laptop upgraded by increasing memory (changing the integrated circuit (IC)) and changing the hard disk drive (HDD) 2.80 kg 5 year lifetime 10 laptops required over the 50 years	5.7 million sales per annum (assuming 3 year timeframe)	17 million	25	0.5	285
Printer[7]	Inkjet Multi-Function Printer (MFP) with 1 black starter cartridge and 1 colour starter cartridge 8.20 kg 3 year lifetime 16.7 printers required over the 50 years	Inkjet Multi-Function Printer (MFP) with 1 black starter cartridge and 1 colour starter cartridge 8.20 kg 5 year lifetime 10 printers required over the 50 years	3.5 million sales	3 year lifetime	59	1.19	420
Toaster[5]	Toaster with no availability for repairs/spares 1.6kg 5.5 year lifetime 9.1 toasters required over the 50 years	Two slice durable toaster with steel casing and free repairs during two year warranty period and availability of modular spares thereafter for indeterminate period. 16.5 year lifetime 3 toasters required over the 50 years	5.2 million sales per annum (assuming 5.5 year lifetime)	28.5 million	6	0.12	62
Washing Machine[8]	6kg load 'A' rated washing machine 72.3kg 12.09 year lifetime 4.1 washing machines required over the 50 years	6kg load 'A' rated ISE 1606W washing machine 80kg 30.8 year lifetime 1.6 washing machines required over the 50 years	1.9 million sales per annum (assuming 12.1 year lifetime)	22.5 million	166	3.3	630

(1) Only end-of-life stage takes place in the UK and is therefore included in the waste 'size of prize' calculations

(2) Production, refurbishment and end-of-life stages take place in the UK and therefore included in the waste 'size of prize' calculations

(3) Assembly and end-of-life stages take place in the UK and therefore included in the waste 'size of prize' calculations

(4) Production, installation and end-of-life stages take place in the UK and therefore included in the waste 'size of prize' calculations

(5) Refurbishment and end-of-life stages take place in the UK and therefore included in the waste 'size of prize' calculations

(6) Refurbishment, servicing and end-of-life stages take place in the UK and therefore included in the waste 'size of prize' calculations

(7) Servicing and end-of-life stages take place in the UK and therefore included in the waste 'size of prize' calculations

(8) Refurbishment and end-of-life stages take place in the UK and therefore included in the waste 'size of prize' calculations. Although the assembly of the typical washing machine is also assumed to take place in the UK, the waste burden during this life cycle stage is not included due to the unavailability of the relevant data.

5 CONCLUSIONS

5.1 HEADLINE CONCLUSIONS FROM LCO MODELLING

The modelling indicates that extending product lifetimes is likely to result in environmental benefits in most instances. Manufacturing and supply chain impacts are saved when products are kept in service for longer. These were not outweighed by the additional impacts associated with refurbishment /increased servicing or additional the impacts of increased product durability.

From an environmental perspective there is an argument for optimised lifetime extension strategies for all consumer products and in particular, for products in which manufacturing, supply chain and waste management impacts dominate over the life cycle.

This rationale for lifetime extension assumes the consumer actually uses a more durable product for longer. No good of course to buy a more durable product or a better preserved product but then replace it at the same frequency as the old product, or for that matter, refurbish a product then replace it almost immediately after. The risk of discarding or stockpiling products is greatest for those products which are innovating most rapidly or are subject to fashion (rather than 'workhorse' products for instance). It is however appreciated that a second hand cascaded use for product is of merit as different users have different functional requirements/desires.

An important finding of the study is that for the energy using products examined in the research the predicted improvements in energy efficiency do not overcome the 'avoided' manufacturing impacts which are consequent as a result of extending product lifetime. The extended lifespans used in this work are comparatively short in lifetime (they do not cross family generations for example), so scope for technological 'lock-in' is actually limited.

This research however did not examine products such as vehicles, heating systems and TVs because it was identified (although not quantified) that foreseen and paradigm shift types energy efficiency innovation had the potential to outweigh the benefits of lifetime extension. For such products which show the highest levels of dominance of use phase impacts and exhibit scope for energy efficiency innovation, the case for lifetime extension is not unequivocal. There is an argument from a life cycle thinking perspective that this may also be the case for continuously-used products, for example lighting, fridges etc since any innovation in the use phase in these product groups will be results in a proportionately greater effect on the cumulative impacts for the product. There is also an argument for further research for Energy Related Products (EPR) and other products which influence energy consumption (for example tyres, saucepans etc) where seemingly more durable material and design alternatives have the potential to deleteriously affect the size of the use phase footprint.

Lastly, for ICT products that are currently experiencing the highest levels of innovation, of which the mobile phone is an example in this research, a limitation of the modelling is that the benefits of product convergence is not quantified in the analysis. In essence, the mobile phone is an example product that has the potential to rapidly dematerialise product/services provided by multiple existing products in the marketplace (eg camera, diary, entertainment, videoconferencing, Sat Nav, maps, banking services etc. **It is hypothesized (although not tested) that within a short timeframe, extending the life of some products such as a Smart mobile phones has the potential to hinder the potentially significant environmental benefits of product convergence (ie not having to supply multiple products, since the phone fulfils many functions/products/services)**. However, for the mobile phone it is also shown in the current research that the second hand cascade reuse of such products in different markets results in benefits.

5.2 TRANSFERABILITY OF FINDINGS TO OTHER PRODUCT TYPES

ERM was asked to provide commentary on transferability of the findings from the example products to other types of products.

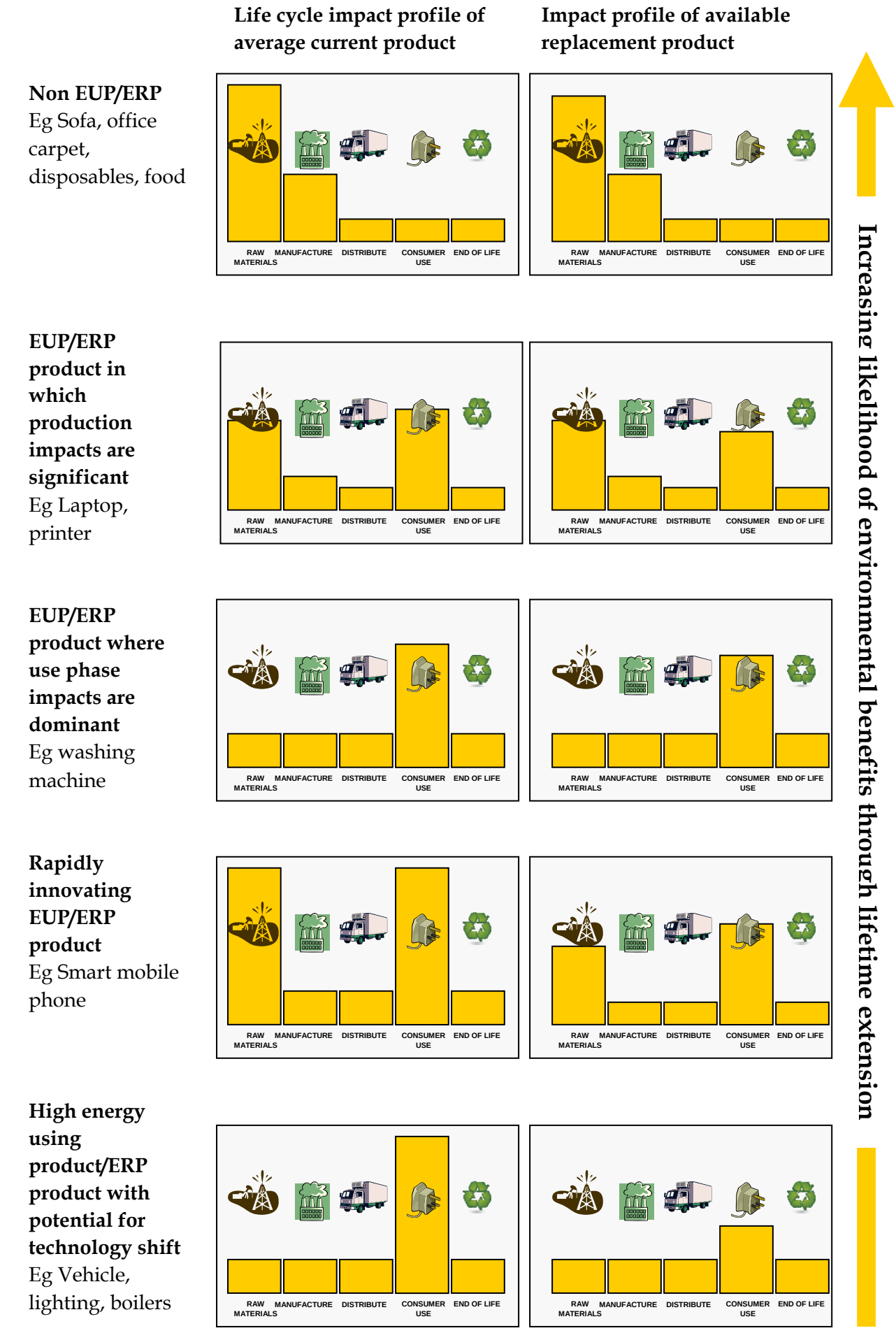
The quantitative analysis is specific to the example products and the quantified benefits are not transferable to other products groups. However, the direction of the findings is relevant.

With reference to the list of 70 products originally considered in the research (*see Table 4.1 of ERM's Scoping Report*) the findings for the nine products indicate that lifetime extension strategies will probably result in environmental benefits for these products too. This is provided that the replacement product has not become radically and abruptly resource efficient. There is also a high likelihood that benefits would also result for other groups of products which were not examined in the study (ie household consumables and food products).

It is noted again that the research did not examine products such as vehicles, heating systems and TVs because it was identified (although not quantified) that foreseen and paradigm shift types energy efficiency innovation had the potential to outweigh the benefits of lifetime extension.

Figure 2.1 provides an indication of the types of products which are most likely to result in environmental benefits based on their current and near future life cycle impact profile. Product types which show the highest likelihood of benefits are shown toward the top of the schematic.

Figure 5.1 *SUMMARY OF TRANSFERABILITY FINDINGS*



5.3 *FINAL COMMENTS*

From an environmental perspective a rationale lifetime extension was indicated for the most products analysed in this research. However, the modelling and its findings are not definitive. It is appreciated that products that are energy intense in their use phase and show scope for improved energy efficiency, or paradigm technology shift are the least likely to show benefits from lifetime extension strategies, although it was not possible to examine this further in the research. The findings for the domestic wool-based carpet study show there also to be potential exceptions to the rule, and environmental trade offs to be considered.

As such the completeness of the evidence base on which to form a universal policy in support of longer product lifetimes, or even for product groups that show the most potential for benefits through lifetime extension can still be challenged. For this reason, and the stated limitations of this modelling in this research, further life cycle optimisation studies are suggested on both a product category and individual product basis in order to further expand and confirm the evidence base for this subject.