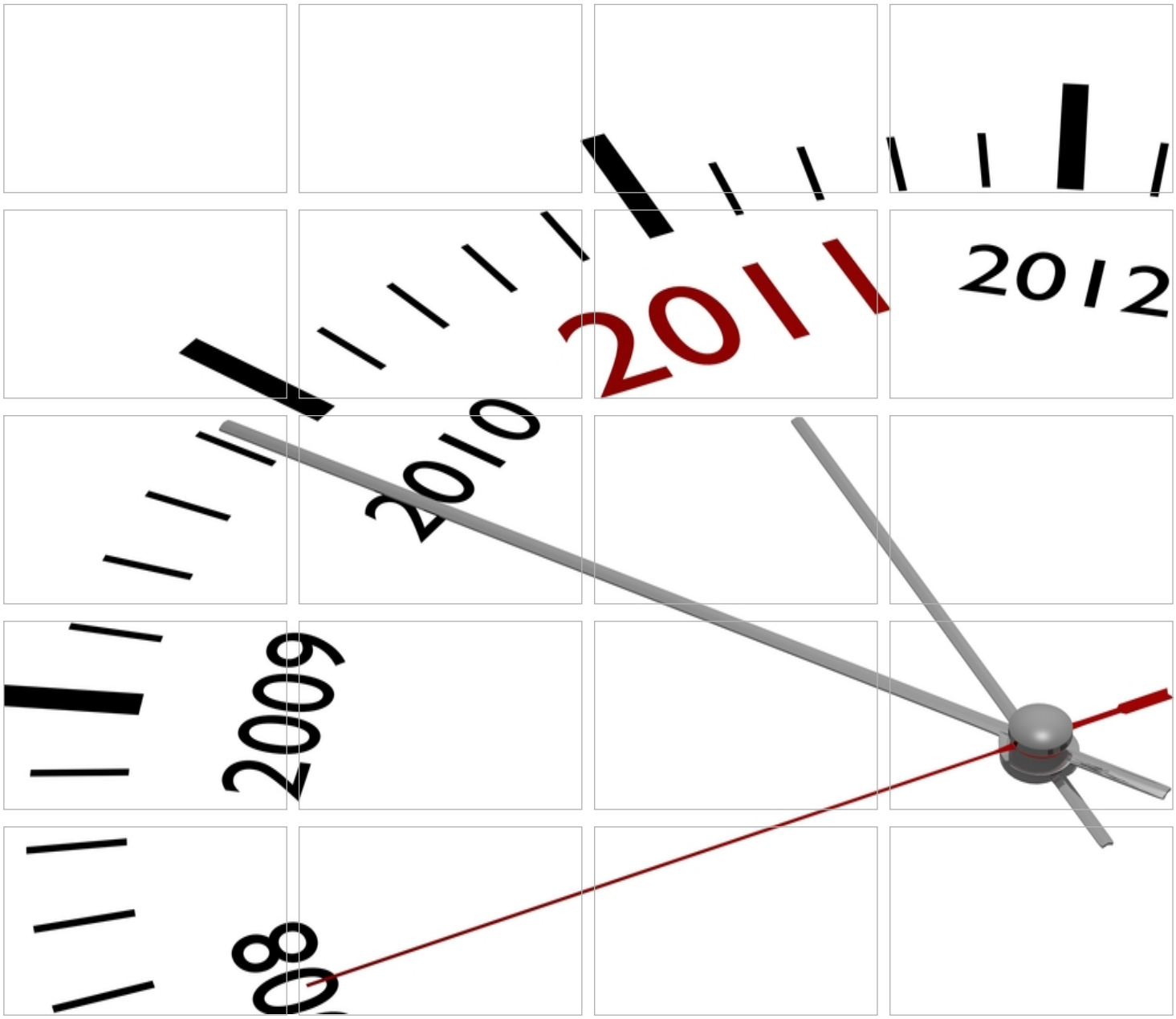

Longer Product Lifetimes

Chapter 1 – Scoping Exercise

Final Report

February 2011

Delivering sustainable solutions in a more competitive world

ERM

Defra

Longer Product Lifetimes

Chapter 1 – Scoping Exercise

Final Report

February 2011

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For and on behalf of
Environmental Resources Management

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CONTENTS

1 INTRODUCTION

1.1 STRUCTURE OF CHAPTER

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

This Chapter, *The Scoping Report,* explains the background to this research into extending product lifetimes, the rationale for Government intervention and describes other work, policies and initiatives which consider lifetime extension in an environmental context. It provides a summary of the provisional findings of Defra's parallel study on consumer attitudes. It goes on to describe the selection process of nine example products for detailed review in the remainder of the project.

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 1: Introduction

Section 2: Background and Rationale

Section 3: Evidence and Literature Review

Section 4: Parallel Study on Public understanding of Product lifetimes and Durability

Section 5: Identification of products for examination in the study

Annex A: Summary of Literature Review
Annex B: Products and Shortlisting Process

2 BACKGROUND AND RATIONALE

2.1 SUSTAINABLE PRODUCTION AND CONSUMPTION (SCP)

We live in a world of 6 billion people, with the global population's impact on the planet's resources growing annually. We are making, transporting, buying, using and throwing away more products than ever before. And in the process emitting more greenhouse gases, producing more waste, abstracting more water, destroying more forests, habitats and depleting biodiversity. As our population grows, to perhaps 9 billion people by 2050, and as countries become more prosperous, our global resources will not easily be able to cope with the demand.

We need to consider ways in which we could reduce UK consumption levels whilst maintaining growth and quality of life, and without meeting high levels of resistance. One possible way of doing this is to extend the life of the products that we consume.

Defra's overall vision is to develop policy options which will not only help to reduce our impact on the environment, but will also help business to develop more sustainable and enduring business models for the longer term.

2.2 ECONOMIC RATIONALE FOR INTERVENTION

Our economic decision making, and through it, the distribution of our goods and services, is usually governed by the framework of the market. It is the free functioning of the market, with its intricate mechanisms and independent actions, which helps facilitate and guide changes in our national income and wealth. Where the market functions effectively, the generally adhered to rationale is that intervention will bring net economic costs.

However the market system is not without its faults. For instance, where a competitive market fails to deliver the efficient amount of goods and services (that is the amount which best meets people's needs and preferences, given scarce resources), adherence to the free market doctrine can paradoxically reduce the potential for economic benefits. Where markets fail to distribute goods and services in an efficient and effective manner then, 'market failure' has occurred, and there may be a rationale for intervention.

The first reason for government intervention in a free market is therefore when market failure has occurred. However there is a risk that where the free market has failed, the government intervention itself may also fail. In order to justify an intervention, there must be an expectation that the intervention itself might succeed – this will depend firstly on how big the market failure is, and secondly on the public sector's ability to implement an effective remedy.

The following examples of market failure are relevant in the context of sustainable consumption and production. and together provide potential rationale for intervening to try to achieve longer product lifetimes:

- **Imperfect information**. Both consumers and producers require complete information if they are to make efficient choices and decisions about what to buy and supply to the market. There are a number of related elements to this, such as *information asymmetry and adverse selection.*

  Information asymmetry describes a situation in which buyers and sellers have different information about a product (for example, a seller knows that an item such as a t-shirt, only has a short life expectancy, but a buyer does not, or a buyer does not appreciate the full negative impacts across the production process, inflicted on labour and the environment).

  Adverse selection arises in a situation where buyers cannot accurately gauge the quality of the product that they are buying (in this instance, a low quality laptop might be sold at a price similar to that of a high quality laptop, because the buyer cannot distinguish between them, and low quality goods might drive high quality more durable goods out of the market, because the buyer cannot appreciate the benefits of the higher priced item relative to the cheaper and lower quality goods).

  Wherever such information problems are experienced, the result would be a misallocation of resources. In certain markets it has been possible to address concerns over asymmetric information through information labelling.

- **Externality**. Markets deliver efficient amounts of goods and services when producers and consumers (termed, 'agents') bear the full costs of their activity. But if one agent imposes a cost or benefit on the other which is not charged or compensated for, there is said to be an 'externality', and either too much, or too little, of a good or service is produced.

  For example, a manufacturer imposes 'negative externalities' if in supplying and shipping its products, it creates carbon emissions, noise or other pollution which are not reflected in the price of the good. If the social and environmental costs imposed are not included within the market price of the good produced, then the market price charged will be artificially low, the market is distorted (there is market failure) and too much of the good is supplied and demanded.

  Examples of government intervening to address externalities include the EU Emissions trading scheme (applying to European energy and industry sectors only), the 'polluter pays principle' (via which BP is expected to fund the Gulf of Mexico clean up) or through planning and other regulations, by which production, over flights or mining are restricted.

- **Imperfect competition** such as monopoly (when there is only one supplier to the market) or oligopoly (where a small number of firms dominate a market) exists where one or a small number of sellers are able to control the supply and price of a good or service. Rational argument suggests that in certain markets where a small number of producers or retailers exert disproportionate power, it could be difficult to introduce innovative (eg longer lasting) products to the market place; in such a scenario, products of this nature would be under supplied. Monopoly and oligopoly is a well known market failure, regulated by central government through the Office of Fair Trading.

Prior to public sector intervention taking place, it is desirable to have an understanding of the scale of the problem of market failure, and also of whether the intervention is likely to be successful. Public sector intervention is likely to be effective it if seeks to address the cause of the market failure itself, and work within, rather than seek to replace, the market.

2.3 *LONG TERM UNSUSTAINABLE BUSINESS MODELS*

Beyond the immediate economic arguments against certain existing business models, there are also considerations concerning the availability of finite resources in the future. The 'consumer society' is one that has become accustomed to purchasing more goods and services in order to satisfy its wants and needs. Typically, the current business model for consumer products is based on supplying more of these goods and services in order for the company concerned to grow and to deliver increased profitability.

For example, Defra has identified double-digit growth in the sales of some clothing types (1) – the phenomenon of 'disposable fashion'. Products with a short lifetime inherently fit this model best, as consumer wants and needs are satisfied only briefly. Nevertheless, there are also frequent complaints from consumers about the lack of durability, maintainability and reparability of some product types.

In addition to being environmentally unsustainable, accelerating consumption rates, as we see with for example for clothing, cannot be a sustainable business model. Products and services depend on a range of finite resources for their production and delivery. For some finite resources it is anticipated that supply will outstrip demand in the future, raising costs and compromising the overall levels of possible consumption.

2.3.1 *More sustainable business models through extending product lifetime*

Business has already demonstrated that it can offer value in terms other than volume. There are examples of successful business models that are based on

(1) DEFRA (2007) Mapping of Evidence on Sustainable Development Impacts that Occur in the Life Cycles of Clothing. Environmental Resources Management (ERM) Ltd. http://randd.defra.gov.uk/

delivering longer product lifetimes, and/or on some other alternative to increasing the volume of sales. These include, but are by no means restricted to the following:

- In some sectors, brand reputation is built upon quality, durability and product lifetime. This is clearly the case for the German and Japanese automotive industries, where companies have used high mileage vehicles in advertising as a symbol of the value they provide to customers. This kind of model suggests that for some product types, consumers already have an understanding that certain goods are likely to be more durable than others, and in these cases, the argument for policy interventions is weak. However as consumers appear to be aware of what reasonable expectations of product durability should be for some products, but not for others, this suggests that well planned policy interventions might encourage better consumer understanding with regard to other product types, particularly where durability is of concern to consumers.
- The business model behind printers and copiers is not built on a high frequency of sale of the main unit – but in this case the principal means of generating turnover is sales of ink, toner cartridges and servicing contracts in the case of commercial photocopiers. Government interventions may be able to encourage similar models for other types of products, though any interventions here would need to ensure that consumers are not innately driven by a desire to have the 'latest thing' or encouraged by copier, printer, mobile phone and other companies to upgrade and discard products prior to the end of their useful lives.
- Design for remanufacture and reuse is becoming more commonplace, particularly in the electronics sector and for Business to Business (B2B) goods, where the investment in componetry is high and the product contains precious materials. The sector has also been subject to extended producer responsibility legislation. The experience of companies active in this area, such as Hitachi, Samsung and Siemens may suggest analogous opportunities in other product groups.

These examples present a rationale for, and means by which to, increase product lifetime. Nevertheless, they all offer consistent product function. A focus on functionality is likely to be important in identifying the full range of opportunities for life-span improvements across all product types. There may be functions that business delivers to consumers where the products and the way they are delivered should change if lifetimes are to be increased.

Defra and BIS have recently stated a wish to develop an evidence base for applying new business models to existing markets across a range of product sectors. In particular, they wish to explore opportunities that improve the efficiency of material use and the durability of products at the design stage, through process improvements in manufacturing and the development of

product service systems ("goods to services") that facilitate repair and refurbishment rather than outright replacement [1] .

2.4 *ENVIRONMENTAL RATIONALE FOR EXTENDING PRODUCT LIFETIME*

The lifetime of a product has significant effects on its overall lifecycle impact. The longer a product lasts, the greater the timescale and function over which the raw materials, manufacture, retail and distribution and end of life impacts are spread, and hence the less significant these impacts will be. Hence, extending product lifetimes is one possible strategy for reducing product impacts and delivering SCP.

However, there are some tradeoffs. The trend is for product standards to rise over time and, consequently, older products become less energy and materially efficient in their use than more modern versions. Increasing product lifetime may, therefore, not have a net benefit where the in-use impacts are both a significant portion of the whole lifecycle impacts, and are likely to continue being rapidly reduced by product design in the future. Furthermore, there is a possible outcome in which the benefit of 'dilution' of the fixed environmental impacts identified above is more than counterbalanced by increased use phase impacts – for example if a more durable vehicle was to be heavier and less fuel efficient. Counter-productive mechanisms for increasing product lifetime must be identified and discouraged.

(1) "Less is more": Business Opportunities in Waste & Resource Management.
http://www.defra.gov.uk/environment/waste/documents/opportunities-waste-manage.pdf

3 EVIDENCE AND LITERATURE REVIEW

3.1 ERM'S APPROACH

ERM carried out an initial review of evidence and published literature to provide a context for the work.

The review aimed to consider the following themes:

- policy measures and legislation concerning the extension of product lifetime;
- trends regarding product lifespans;
- strategies by which product lifespans may be extended; and
- case studies and public/private sector initiatives in the subject area.

ERM undertook a carefully screened search focusing on key terms (and variations of them) through search engines and relevant industry/research network databases.

These terms included:

- extending/increasing product lifetime and lifespan;
- product service systems;
- design for durability, reuse, repair and remanufacture; and
- product lifecycle management etc

ERM developed a substantial list of references through discussions with contacts and literature searches. The review looked at studies that had examined product lifetime holistically, including those with a life cycle perspective and other approaches such as ecological payback modelling. Any data relevant to modelling lifetime scenarios such as premature discard rates were recorded. Instances where extending product lifetime had been identified as advantageous were also highlighted, together with justification of, and evidence for, this advantage.

A spreadsheet database was used throughout the review to record a summary of the content of publications reviewed and organisations contacted. The spreadsheet was developed to record the following information:

- type of evidence;
- source of evidence;
- authors;
- publication date; and

- the principal findings relevant to extending product lifetimes.

Where quantitative analysis was identified, the types of product analysed and the proposed method to extend product lifetime were recorded. An assessment of the robustness and comprehensiveness of the research was performed for the most promising studies.

The findings of the initial evidence review are presented in full in *Annex A*.

The main findings of the evidence review are summarised in the following sub-sections.

In each case, ERM has summarised the findings of the main reports and initiatives and provided reference to the main original reports or websites.

Section 3.2	Policy measures, legislation and voluntary initiatives.
Secton 3.3	Why do products become obsolete?
Section 3.4	How do designers and manufacturers define the lifetime of a product?
Section3.5	How can the lifetime of a product be extended?
Section 3.6	Which products and services have the greatest environmental impact?
Section 3.7	Are product lifetimes extending or reducing?
Section 3.8	Life cycle studies concerning the extension of product lifetimes.
Section 3.9	Secondary data sources for the study
Section 3.10	Should product lifetimes be reduced? - trade-offs between impacts associated with the production and use of products
Section 3.11	Increasing the utilisation of products during their lifetime.
Section 3.12	Life cycle costs for lifetime extended products.

3.2 POLICY MEASURES, LEGISLATION AND VOLUNTARY MEASURES

3.2.1 *European Level Initiatives*

Overall, SCP actions such as extending product lifetime are supported principally by the European Commission's Sustainable Consumption and Production and Sustainable Industrial Policy (SCP/SIP) Action Plan (1),

(1) European Commission (2008) COM(2008) 397 final on the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan. http://ec.europa.eu/environment/eussd/pdf/com_2008_397.pdf

Integrated Product Policy [1] and the UK Government Sustainable Development Strategy [2].

In terms of specific legislation, the Waste Framework Directive (2008/98/EC) [3] and the European Directives [4] on the eco-design of Energy-using Products (EuP) and energy-related products (ERPs) are especially relevant.

For instance, waste prevention is the first priority for waste management in the Waste Framework Directive. It is defined as:

"*measures taken before a substance, material or product has become waste, that reduce: (a) the quantity of waste, including through the re-use of products or the extension of the life span of products…*"

The Directive also defines the concept of extended producer responsibility in it as:

"*one of the means to support the design and production of goods which take into full account and facilitate the efficient use of resources during their whole life-cycle including their repair, re-use, disassembly and recycling without compromising the free circulation of goods on the internal market*"

The EuP and ERP Directives establish a framework for the setting of ecodesign requirements for energy-using and energy-related products. Of particular relevance is the Part 1 Guidance for each which defines a list of ecodesign parameters for products. These parameters are considered in the establishment of so-called 'Implementing Measures' for product categories, aimed at improving their environmental performance over the life cycle.

One of the environmental aspects listed for consideration in ecodesign is:

"*extension of lifetime as expressed through: minimum guaranteed lifetime, minimum time for availability of spare parts, modularity, upgradeability, reparability*"

The European Commission has already established a working plan and a series of preparatory studies to define ecodesign standards for EuP and ERP [5].

To date, the main focus for the developing ecodesign standards has been in setting targets for improving the energy efficiency of these products over time,

(1) http://ec.europa.eu/environment/ipp/
(2) Securing the Future - UK Government sustainable development strategy
http://www.defra.gov.uk/sustainable/government/publications/uk-strategy/index.htm
(3) DIRECTIVE 2008/98/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 November 2008 on waste and repealing certain Directives
(4) DIRECTIVE 2005/32/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 6 July 2005 on establishing a framework for the setting of ecodesign requirements for energy-using products amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC and DIRECTIVE **2009/125/EC** OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 October 2009 on establishing a framework for the setting of ecodesign requirements for energy-related products
(5) http://efficient-products.defra.gov.uk/cms/eup#prepstudies

rather than other life cycle aspects such as extending product lifetime. For instance, since January 2010, domestic appliances and office equipment may consume no more than 1 watt in standby mode under EU ecodesign standards. Inefficient set top boxes, TV's, fluorescent office lamps, incandescent lamps, fridges and street lamps will be prohibited from the European market in 2010 [1] .

Of the nine products that have an EU ecodesign Directive passed, only domestic lighting and office/ street lighting have lifetime specifications. For some products, the preparatory studies identify the extension of product lifetime as a potential means of improving resource efficiency, for example, in the case of imaging equipment (ie printers and copiers) [2]. These may subsequently inform the development of the ecodesign standards and these may take the form of 'Implementing Measures', which may include 'voluntary agreements' with the industry in their implementation. A number of voluntary agreements have been drafted, for example for set top boxes, machine tools, imaging equipment such as printers/copiers, medical imaging equipment, sound and imaging equipment.

EU Directives on Public Procurement [3] provide a legal framework for setting green public procurement criteria for a range of different products. The criteria draw heavily on performance and functional requirements from specifications of European, international and national voluntary eco-labels (see next section).

Lastly, the EU Sale of Consumer Goods and Associated Guarantees Directive (99/44/EC) [4] is notable in that it demands that a two-year guarantee applies for the sale of all consumer goods sold in Europe. If a defect is detected when, or in a reasonable period of time after, the sale is made, then buyers can demand a full refund.

3.2.2 UK Initiatives

Since 1997, the Market Transformation Programme (MTP) [5] has supported the development and implementation of government policy on sustainable products and services in the UK. Work has been conducted on all major domestic appliances and traded goods in the commercial sector (12 sectors and 27 product categories).

(1) http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/index_en.htm
(2) EuP Preparatory Studies "Imaging Equipment" (Lot 4) Final Report on Task 8 "Scenario, Policy, Impact, and Sensitivity Analysis", Fraunhofer IZM. www.ecoimaging.org
(3) Directive 2004/18/CE (Consolidated version of 15.09.2008) and Directive 2004/17/CE (Consolidated version of 15.09.2008) http://ec.europa.eu/environment/gpp/legal_framework_en.htm
(4) http://europa.eu/legislation_summaries/consumers/protection_of_consumers/l32022_en.htm
(5) http://efficient-products.defra.gov.uk/cms/market-transformation-programme/

Most recently, the MTP consulted on proposals for indicative product standards and targets for EUP sold in the UK to 2030 with a focus on improvement relating to energy efficiency during their use (1).

The analysis covered the following product areas:

- Consumer Electronic Products
- Domestic Appliances Products
- Domestic Central Heating Systems
- Domestic Lighting Products
- Air Conditioning Products
- Information and Communication Technology Products
- Motors & circulators
- Commercial Refrigeration
- Non-domestic Lighting Products
- Servers and Data Centres
- Domestic Cooking Appliances
- Motor-driven systems
- Non-Domestic Heating
- Other product areas such as TV monitors, electronic photo frames

The consultation also states that the Government is considering complementary policies focussed around encouraging responsible, energy-saving consumer behaviour, avoiding the potential for a "rebound effect"; as well as investigating the life-cycle effects, balancing the waste and economic effects of earlier or later product replacement with the energy efficiency benefits. It also goes on to say that the Government is currently examining different approaches to sustainable consumption policy, to complement its product policy work, with a focus on consumer behaviour and replacement cycles.

Product Roadmaps

Product Roadmaps (2) for 10 different product categories (Clothing, Domestic lighting, Electric motors, Fish and shellfish, Milk, Passenger cars, Plasterboard , TVs, Windows and WCs) have recently been established by Defra. These aim to better understand the environmental and sustainability impacts of a particular product and the ways in which these impacts can be mitigated. The work has included the development of environmental life

(1) Saving energy through better products and appliances: a consultation on analysis, aims and indicative standards for energy efficient products 2009 - 2030. http://www.defra.gov.uk/corporate/consult/energy-using-products/index.htm
(2) http://www.defra.gov.uk/environment/business/products/roadmaps/

cycle studies and a programme of stakeholder engagement for each product group.

In relation to this project, the supporting evidence studies that underpin the roadmap do cover lifetime extension issues, but not in any great detail. For instance, for windows, a number of proposed means for extending product lifetimes are suggested. For lighting the advantages of LED lamps are expressed in terms of their increased durability, as well as their improved energy efficiency in their use. For passenger cars, further research is recommended to establish optimal lifetime of cars in view that significant reductions in vehicle lifetime CO2 are realistic, with further improvements to be realised with the reduction of the carbon intensity of the UK electricity supply.

Voluntary Environmental Labelling and Standards

Product consumer labelling schemes, such as Type III Environmental Product Declarations (1), have already been developed for the reporting of the life cycle environmental credentials of products. In particular, the EU Ecolabel (2) and Nordic Swan Ecolabel (3) have established Product Category Rules (PCR) which define product durability standards for selected products, some of which are phrased in product lifespan terms. For some products, these labels also require that spare parts are made available by the manufacturer for a number of years after purchase and set standards concerning product design for reducing the impacts of the ecolabelled products at their end of life.

For the electronics sector, the Institute of Electrical and Electronics Engineer (IEEE) has established the P1680 family of standards for the environmental assessment of electronic products (4) Amongst others, a specific criteria on product longevity / life cycle extension is defined in standards for personal computers, imaging equipment and TVs. These cover minimum warranty periods, how long spare parts must be available for and modular design/upgradeability.

In the UK, standards for electronics reuse are being developed. PAS141 for is expected to define a process and test standards to facilitate the reuse of more WEEE. (5)

3.3 WHY DO PRODUCTS BECOME OBSOLETE?

With very few exceptions, products or components contained within products will eventually wear out, fail or be simply lost or discarded. A certain level of 'waste' has been, and will always be, generated by society.

(1) http://www.environdec.com
(2) http://ec.europa.eu/environment/ecolabel/ecolabelled_products/product_categories_en.htm
(3) http://www.svanen.nu/Default.aspx?tabName=CriteriaEng&menuItemID=7056
(4) http://grouper.ieee.org/groups/1680/
(5) http://www.berr.gov.uk

However, in the 20th century there is some evidence that leading industrialists viewed planning or design of in-built obsolescence into products as a means of selling more units and increasing economic activity. The theory has been contended many times by industry. Nevertheless, in the context of some degree of asymmetric information existing between buyers and sellers (see *Section 2.2* above) it is possible that a company might operate such a business model, and not be punished for doing by the unwitting buyers of its products.

A theory of 'planned obsolescence' of products was described by the cultural critic Vance Packard in his 1960 work '*The Waste Makers*' (Cooper, 2004). His work describes how a product can be pre-planned to wear out at a given time, or become outdated in a consumer's mind by a 'better' performing or aesthetically pleasing product entering the market.

Two general types of product obsolescence were, and continue to be distinguished within the literature. These are 'technological obsolescence' in which a product becomes outdated/unusable and 'psychological obsolescence' (a subjective consumer decision).

In his 2004 paper, '*Inadequate Life? Evidence of Consumer Attitudes to Product Obsolescence*' (1) Tim Cooper, a leading UK academic in this field, extended the theory to include a third category referred to as 'economic obsolescence'. This is a condition where the consumer places little economic value on the product because it either becomes more expensive to maintain or repair compared to a purchasing a new product.

The paper also provides an insight into status of appliances at the point they are discarded. A table of the results from a consumer survey provided in the paper are presented in *Table 2.1.* It provides an indication of the relative proportion of appliances 'Beyond repair', 'In need of repair' and 'Still functioning' for different types of appliances at their discard.

This data shows that there is scope for extending their life through their retention and further use of a proportion of the appliances within the home and/or their subsequent repair/reuse.

Table 3.1 Condition of discarded appliances from consumer survey (Cooper, 2004)

Product category	Beyond Repair (%)	In need of repair (%)	Still functioning (%)
Electric Cookers	29	23	48
Microwave Ovens	36	22	42
Refrigerators and Freezers	43	19	37

(1) Cooper (2004) Inadequate Life? Evidence of Consumer Attitudes to Product Obsolescence. Journal of Consumer Policy 27: 421–449, 2004

Product category	Beyond Repair (%)	In need of repair (%)	Still functioning (%)
Washing machines, Dishwashers and Tumble Dryers	52	26	22
Vacuum Cleaners and Carpet Cleaners	53	21	26
Small work or Personal care	66	19	15
Hi-fi and Stereo	30	21	49
Radio, Personal Stereo and CD	54	20	27
Televisions	43	24	33
Video Equipment	41	25	34
Telephones, faxes	40	16	44
Mobile Phones and Pagers	27	13	59
Computers and Peripherals	29	12	59
Toys	42	17	41
Home and Garden Tools	61	17	21
All products	46	21	33

3.4 HOW DESIGNERS AND MANUFACTURERS DEFINE THE LIFETIME OF A PRODUCT?

It is difficult to generalise as to how product designers reach decisions concerning the functional and quality requirements of products and hence, how long the products are designed to last.

A 'typical' product development process is likely to establish product reliability requirements at the outset, alongside a range of other development priorities and quality objectives. Such objectives may have been determined in the project brief, or may be determined by the project team during its initial stages. Whether requirements relating to the different categories of product obsolescence described earlier are also considered at this stage is conjecture.

Life cycle based ecodesign tools may be used at this stage in some instances to inform designers as to the environmental and social risks and impacts of potential product development alternatives, alongside analysis of costs.

A project 'tolerance' concerning reliability may even be defined, rather than a minimum single value. The function that the product performs is likely to determine how such a reliability objective is phrased. For example, for the design of a continuously used product such as a fridge, a statistical 'mean time to failure' may be established for a given level of product performance. A washing machine or its main components may be designed to last, on average, a thousand standard test cycles. Light bulbs might be designed to deliver a number of hours of use at a specified luminosity.

For complex products, component suppliers will provide items to the specification required, together with reliability guarantees and proof of compliance with other environmental standards.

Compromises may need to be made at each stage in the process in any aspect of the design, by project members, by the project manager, or the project director, depending on the decision-taking authority/project tolerances determined at the outset.

A level of final product testing will be undertaken before product launch. Monitoring data on consumer returns/failure rates or market research data from the field may be used to inform the brief or specification for the development of subsequent product models, or new product ranges.

3.5 HOW CAN THE LIFETIME OF A PRODUCT BE EXTENDED?

WRAP's (2009) strategic research '*Meeting the UK climate change challenge: The contribution of resource efficiency*' (1) provides an indication of the possible economic and environmental benefits to be had by a range of SCP actions. Most notably, this research describes four strategies of relevance to the extension of product lifetimes on the demand side. These are:

- Lifetime Optimisation - ensuring that products are used by households for their full useful life (ie retention/repair of products in the home until they are defunct);
- Shift from Goods to Services - reduction in ownership or goods, delivered instead by the service sectors (ie Product Service Systems/remanufacturing);
- Restorative Economy - extending the life of products by improving their durability (ie purchase/design for durability).
- Reducing Food Waste – the reduction in edible food waste produced within households (ie buy to use/preservation techniques); and

For these strategies, the study estimates that in the region of 1.2 billion tonnes of CO_2 could be saved over the next forty years by 'quick win' measures which could be implemented in selected product groups (listed in *Table 2.4*). Estimates for consumer financial savings are also provided by the study.

3.6 WHICH PRODUCTS AND SERVICES HAVE THE GREATEST ENVIRONMENTAL IMPACT?

ERM identified a number of studies which indicate the highest impacting products/economic sectors over their product life cycle.

The studies identified in our review include:

- European Commission (2006) Environmental Impact of Products (EIPRO) [(2)]: Analysis of the life cycle environmental impacts related to the final consumption in the EU-25;
- WRAP (2009) Meeting the UK climate change challenge: The contribution of resource efficiency; and
- European Commission (unpublished) Service Contract for the drafting of environmental technical specifications for use in Green Public Procurement.

Key findings from these studies are listed below.

EIPRO Study

The EIPRO study is based on the monetary value of products. It uses an input-output approach to indicate the magnitude of the environmental impacts of different product/sectors in the European economy.

Table 3.2 shows the estimated relative contribution to global warming potential of the different product sectors. The top three contributing 'products' for each category are also presented in this table.

(1) WRAP (2009) Meeting the UK climate change challenge: The contribution of resource efficiency http://www.wrap.org.uk/downloads/Final_Report_EVA128_SEI_1_JB_SC_JB3.c03bc484.8038.pdf
(2) European Commission (2006) . Environmental Impact of Products (EIPRO): Analysis of the life cycle environmental impacts related to the final consumption of the EU-25. http://ec.europa.eu/environment/ipp/pdf/eipro_report.pdf

Table 3.2 Products with high environmental impact (EIPRO, 2006)

Categories	Contribution to Global Warming Potential by %	Top three products in each category (for GWP burden)
Food & drink, tobacco & narcotics	31.1%	1. Meat packing plants 2. Poultry slaughter and processing 3. sausages and other prepared meat products
Clothing, footwear and & textiles	2.4%	1. Apparel made from purchased materials 2. Laundry, cleaning, garment services 3. Shoe repair; shoes, except rubber
Housing, furniture, equipment and utility use	23.6%	1. Heating equipment (use of), except electric and warm air furnaces 2. New residential single unit structures, nonfarm 3. Washing with household laundry equipment
Healthcare	0.3%	1. Drugs 2. Doctors and dentists 3. Hospitals
Transport	18.5%	1. Motor vehicles (use of) and passenger car bodies 2. Automotive repair shops and services 3. Automotive rental and leasing, without drivers
Communication	2.1%	1. Telephone, telegraph communications, and communication services 2. Postal service; (use of) 3. Communication equipment
Recreation	6.0%	1. Household audio and video equipment (use of) 2. Other amusement and recreation services 3. Household use of pesticides and agricultural chemicals
Education	0.5%	
Restaurants, hotels	9.1%	
Miscellaneous	5.2%	Includes use of other non specified household appliances

Table 3.3 lists the top impactful products identified in the EIPRO study with respect to global warming potential.

Table 3.3 List of top products for global warming potential (EIPRO, 2006)

List of top products for global warming:
1. Driving motor vehicles and passenger car bodies
2. Eating and drinking places
3. Meat packing plants
4. Heating equipment, except electric and warm air furnaces
5. Poultry slaughtering and processing
6. New residential 1 unit structures, nonfarm
7. Sausages and other prepared meat products
8. Fluid milk
9. Washing with household laundry equipment
10. Cheese
11. New additions &alterations, nonfarm, construction
12. Use of household fridges and freezers
13. Apparel made from purchased materials
14. Telephone, telegraph communications and communications services
15. Edible fats and oils
16. Use of electric lamp bulbs and tubes
17. Automotive repair shops and services
18. Beauty and barber shops
19. Use of household cooking equipment
20. Use of household appliances
21. Other amusement and recreation services
22. Bottled and canned soft drinks
23. Bread, cake and related products
24. Drugs
25. Frozen fruits, fruit juices and vegetables
26. Cigarettes
27. Vegetables
28. Roasted coffee
29. Maintenance and repair of farm and nonfarm structures
30. Water supply and sewerage system
31. New residential garden and high-rise apartments
32. Postal service
33. Prepared fresh or frozen fish and seafood

WRAP Study

Whilst the EIPRO study provides an indication of the high impacting products in the economy it does not identify products where it may be possible to mitigate the impacts through extending product lifetime

The WRAP study, however, has recently used a comparable type of input-output analysis as the EIRPO study to provide an indication of the possible resource efficiency savings of SCP measures.

The products considered in WRAP's analysis are presented in *Table 3.4* according to the four resource-efficiency strategies described relevant to this lifetime extension study in *Section 3.5*

Table 3.4 Product categories considered in WRAP (2009) study

Lifetime optimisation	Goods to services	Restorative Economy	Reducing Food Waste
Clothes	'High-end' hiring of clothing	Clothes	Meat
Household appliances	Glassware and tableware	Household appliances	Dairy
Glassware	Tools and equipment for house and garden	Glassware & tableware	High-fat foods
Tableware	Purchase of vehicles	Household utensils & equipment	Sugary foods
Household utensils	Telephone and audio equipment	Vehicles	
Household tools and equipment		Communication products	
Vehicles		Photo & information processing equipment, and	
Telephone and telefax equipment		Cultural & recreational durables	
Audio-visual			
Photo and information processing equipment			
Cultural and recreational durables			

Table 3.5 presents work conducted for the European Commission concerning which products to consider for the development of green public procurement criteria (GPP) (1). It provides a priority list of products, and itself draws upon a number of product prioritisation exercises to develop the listing.

Table 3.5 Priority products for GPP (European Commission, 2008, unpublished)

Products/Services Considered for GPP Criteria Development: Primary
Mobile phones, excluding chargers
Energy supply: CHP
Heating system, boilers, gas central heating, under floor heating
Water-using products: taps, showers, toilets and urinals
Climate control: heat pumps/ Air con systems, cellar cooling equipment
Street lighting and traffic signals
Building materials: windows
Building materials: internal surface / wall materials; plasterboard, chipboard
Hard floor coverings
Tissue paper
Logistics services
Products/Services Considered for GPP Criteria Development: Secondary
Roads and footpaths
Teleconferencing, greening of events
Brown goods: TVs, DVD, set-top boxes
Refrigeration cabinets, water cooling devices, vending machines
Ovens and cooking appliances in institutional settings (hospitals, schools, prison, etc.)
Institutional cleaning: washing machines and detergents
Vacuum cleaners

ERM was also asked to comment on the evidence found concerning the extension of product lifetime in the highest impacting products.

The top three highest impact sectors of the EIPRO study (see *Table 3.2)* for global warming potential are given as:

- Food and drink, tobacco and drugs (predominantly production of meat, poultry dairy, fruit and vegetables);
- Housing (heating, construction of flats, laundry); and

(1) European Commission (unpublished) Service Contract for the drafting of environmental technical specifications for use in Green Public Procurement –*Product Choice and Kick-off Meeting Note* . AEA Energy & Environment, January 2008

- Transport (motor cars, rental vehicles).

Food, Drink and Tobacco

In relation to the food, drink and tobacco sector, WRAP's *Love Food hate waste* campaign (1) and its promotion of 'use by' labels, rather than 'best before' product quality labels as the determinant for the discard of out of date food is a noteworthy initiative aimed at extending the lifetime of foodstuffs in the home. The carbon footprinting of food products through their supply chains through PAS2050 supported by the Carbon Trust is also notable. The evidence review, however, was not charged with analysing whether this work has identified opportunities for extended the lifetime of products over the supply chain.

Lastly, research in the food and drink sector has shown that packaging can prevent waste, hence avoid the embodied impacts of food and drink. For example:

- Europen (2009), the European Organisation for Packaging in the Environment, quote US department of Agriculture research that concluded processed (packaged) fruit and vegetables suffer only half the waste of that suffered by fresh fruit and vegetables in the retail chain and home environment combined (16% versus 32%).

- The UK Advisory Committee on Packaging has also stated an unwrapped cucumber loses moisture and becomes dull and unsaleable within 3 days. Just 1.5 grams of wrapping keeps it fresh for 14 days. Selling grapes in trays or bags has reduced in-store waste of grapes by 20%. In-store wastage of new potatoes reduced from 3% when sold loose to less than 1% after specially designed bags were introduced (2).

Housing and Transport

For housing, efforts to reduce the environmental impacts of these groups have focused on energy efficiency standards for new buildings, retrofit of existing building stock a range of energy saving equipment, and replacing the least energy efficient products contained in them. As part of a government stimulus package in response to current economic downturn, the UK scrappage scheme for vehicles and the least efficient boilers are noteworthy since these have reduced product lifetime in these product groups. Although no formal life cycle studies underpin these schemes, life cycle costs and carbon reduction calculations (3) (4) indicate the scale of benefits that are

(1) http://www.lovefoodhatewaste.com/save_time_and_money/food_dates
(2) Packaging in the Sustainability Agenda: A Guide for Corporate Decision Makers. European and ECR http://www.gs1belu.org/files/ECRGuide_Sustainablepackaging.pdf
(3) Boiler Scrappage Scheme. http://www.energysavingtrust.org.uk/Home-improvements-and-products/Heating-and-hot-water/Boiler-Scrappage-Scheme
(4) Vehicle scrappage scheme drives down emissions of new cars http://www.guardian.co.uk/environment/2010/mar/09/vehicle-scrappage-new-cars-emissions

achievable/have been achieved by the schemes by removing the least energy efficient stock from circulation.

3.7 *EXTENDING OR REDUCING PRODUCT LIFETIMES?*

Although there is a popular belief that functional appliance life spans have long been in decline, firm evidence has been lacking (Cooper, 2004). Since product lifetimes are not routinely measured or estimated, there is extremely limited quantitative data available in the public domain regarding trends concerning product lifetime.

The MTP's *What if? Tool* presents trend data on estimates for lifespans for the products included within MTP's programme. ERM has examined these data for the review and although it is clear that these are not complete or kept updated for many product categories, certain trends were observed.

With the following exceptions, lifetime trends presented in the *What If?* Tool are constant over the historical and forecast period:

- a clear historical reduction in the lifetime of boilers (23.07 years in 1980 to 12.38 years predicted in 2020);
- a short and recent reduction in product lifetime of TVs and set top boxes; and
- a recent increase in the product lifetime of light bulbs.

Product lifetime estimates were also recently published by the MTP in its recent consultation document for various product groups (1). For instance, for a domestic combination boiler the reported lifetime in the consultation document is 11.2 years for 2009 and forecast to be 11.1 years in 2020. The consultation notes that that development cycles for consumer electronic products are short and getting shorter, and that many products become obsolete before they are worn out, stimulating their upgrading and early replacement. However, the data in the consultation were examined and lifetime forecasts for 2020 relative to the present estimates for lifetimes were on the whole identical, or showed only minor differences.

Another source of circumstantial evidence concerning product lifetimes is that which can be gleaned from the waste industry. For example, in relation to clothing, it is noteworthy that textile waste is considered to be the fastest growing waste stream in the UK (2). However, firm evidence is limited since the composition of waste is reported on a materials basis, as opposed to a product basis. The examination of the waste stream also presents difficulties

(1) Saving energy through better products and appliances: a consultation on analysis, aims and indicative standards for energy efficient products 2009 - 2030. http://www.defra.gov.uk/corporate/consult/energy-using-products/index.htm
(2) Defra (2009) Economic and Environmental Costs and Benefits and Market Evaluation of European Union GPP Criteria against UK Sustainable Standards – Textiles, February 2009

since products may be reused in many different ways before disposal and because fundamentally, there is a time lag between the purchase and the disposal of products that makes analysis complex.

3.8 LIFE CYCLE STUDIES CONCERNING THE EXTENSION OF PRODUCT LIFETIME

Whilst there is a considerable body of evidence concerning the life cycle impacts of product and services the initial evidence review only identified a very limited number of quantitative environmental life cycle assessment studies which compared more durable products or alternative ways of delivering products, with the conventional volume-based business models.

These included studies on the remanufacturing of engines, upgrading the components of personal computers, batteries, laundry services, lighting and the refurbishment of washing machines (see *Table 3.6*). Each study established there were potential environmental benefits to be gained from these alternative strategies.

ERM identified a significant amount of qualitative academic research on extending products and the characteristics, constraints and types of products which would be potentially suited to alternative business models.

These include:

- Mont (20004) suggests the successful development of a PSS requires that manufacturers and service providers extend their involvement and responsibility to phases in the life cycle, which are usually outside the traditional buyer–seller relationship, such as take back, recovery, reuse and refurbishment and remanufacturing. A classification of a product-service system is defined in this publication

- UK quantitative studies performed by the Centre for Remanufacturing and Reuse (1) have concluded from preliminary analyses that carbon savings are possible across the life cycle for a range of remanufactured products. For instance, Kerr (2003) (2) indicates that GHG emissions were a approximately a third of those for a remanufacturing a Fuji Xerox photocopier, relative to their primary manufacture.

- A number of qualitative and semi-quantitative studies highlight the potential for preservation techniques on the extension of short lived perishable products, such as food. For example, refrigeration, freezing, heat treatment techniques, packaging use/modified atmosphere packaging avoid wastage in the food supply chain, or in the home, so avoiding 'embodied environmental impacts' associated with the

(1) http://www.remanufacturing.org.uk
(2) Kerr, W.; Ryan, C. (2003). Eco-efficiency gains from remanufacturing: A case study of photocopier remanufacturing at Fuji Xerox Australia. Journal of Cleaner Production, 9, 75–81.

production of food. For instance, Watkins (2006) indicates the benefits of a preservative, methylcyclopropene (1-MCP) on delaying the degradation and extending the shelf lives of fruits and vegetables. (1). Research conducted for WRAP indicates that storing fruit and vegetables in the fridge and in bags made the food last longer (2).

ERM did not identify published industry research in the subject area of extending product lifetime with the exception of research/advocacy of the remanufacturing of photocopiers. Perhaps this absence is notable.

(1) Watkins, C. (2006) The use of 1-methylcyclopropene (1-MCP) on fruits and vegetables. Biotechnology Advances, 24, 389-409.
(2) Johnson, D., Hipps, N. and Hails, S. (2008) Helping Consumers Reduce Fruit and Vegetable Waste: Final Report. WRAP, Banbury, UK.

Table 3.6 Comprehensive and quantitative lifecycle studies concerning extending product lifetime which were identified in the review

Reference	Subject	Principal findings
Smith, V. and Keoleian, G. (2004) The Value of Remanufactured Engines. Journal of Industrial Ecology, 8(1-2), 193-221.	Quantified the economic and environmental benefits of remanufactured gasoline engines	The remanufactured engine could be produced with 68% to 83% less energy and 73% to 87% fewer carbon dioxide emissions, but found that a 1% decrease in efficiency can negate the environmental benefits.
Atlantic Consulting and IPU (1998) CLA Study (Version 1.2), EU Ecolabels for Personal Computers. http://ec.europa.eu/environment/ecolabel/about_ecolabel/reports/lcastudy_pc_1998.pdf	Full LCA which analyses life cycle impacts of PCs and quantitatively measures the benefits of different improvements in the PC design	Replacing key components of a PC can extend first lifetime to reduce first overall environmental impact. The scenario measured was replacing the motherboard after 3 years and inserting larger hard disk, and using the computer for another 3 years.
Natural Resources Management Centre at Cranfield University (2008) WR0106: Achieving household waste prevention and promoting sustainable resource use through product service systems. Defra,.	Exploratory research into potential of Product Service Systems (PSS) to prevent waste on new housing developments. Products studied were an electric drill, lawn mowers, vacuum cleaner and washing machines	1. Environmental assessment gave evidence that PSS reduce waste of all products assessed, but more research required. 2. Social and economic assessment showed of consumer demand for PSS, but concern over cost; all products bar examined linen show a positive business model. 3. eco-labels could help in the uptake of PSS. Data in technical annex 3 (not available)
Little, M., Thomas, B. and Collins, M. (Unpublished) Little, M., Thomas, B. and Collins, M. (2010, Unpublished) Environmental Life Cycle Assessment (LCA) Study of Replacement and Refurbishment options for domestic washing machines. ERM. WRAP,	Full ISO standard peer reviewed LCA comparison of whether it is preferential to immediately replace or refurbish washing machines	Immediate replacement of A to C rated machines with A++ is advised, but very few are currently available in the market. Therefore, with the exception of water use, refurbishment of an A rated machine is environmentally preferential to immediate replacement with an A or an A+ rated machine. Preferential scenarios for C rated machines depends on length of second life and the impact category under consideration.
Goedkoop, M.J., van Halen, C.J.G., te Riele, H.R.M., Rommens, P.J.M., (1999) Product Service systems Ecological and Economic Basics.	Qualitative analysis of ten products and three product service systems (car sharing, laundrettes, vegetable deliveries)	Some products scored well on environmental benefit (launderettes and vegetable delivery), and others did not (Car sharing).
Kerr, W.; Ryan, C. (2003). Eco-efficiency gains from remanufacturing: Case study of photocopier remanufacturing at Fuji Xerox Australia. Journal of Cleaner Production, 9, 75–81.	First level assessment of environmental benefit of remanufacturing photocopiers to provide indication of benefit, as opposed to precise measurement.	A reduction factor of 3 in CO2eq emissions from remanufacturing of photocopiers was estimated.
Navigant Consulting Europe (2009) Lifecycle assessment of ultra efficient lamps. Defra,	LCA of different efficient lighting systems including information on lifetime of products.	The incandescent lamp (lifetime hours 1,000) has lowest efficiency and T5 system has most attractive profile (lifetime hours 24,000).
Parsons D (2007): The Environmental Impact of Disposable Versus Re-Chargeable Batteries for Consumer Use. International Journal of Life Cycle Analysis 12 (3) 197–203	LCA of disposable and rechargeable batteries	Rechargeable batteries preferred in three scenarios assessed (nickel metal hydride, nickel cadmium and disposable alkaline battery)

3.9 SECONDARY DATA SOURCES

ERM identified a limited number of published quantitative life cycle studies which concerned extending product lifetime (see *Table 3.7*). ERM assessed the robustness of other promising material identified in the evidence review. Robustness was considered in terms of the credibility, reliability, objectivity and transferability of data sources (see *Table 3.7*)

Table 3.7 Other potential secondary data sources for the life cycle modelling

Data source	Content	Robustness
European Commission DG TREN - Preparatory Studies for Eco-design Requirements of EuPs http://efficient-products.defra.gov.uk/cms/eup#prepstudies	Product life cycle studies on range of EuPs, including indication of product lifetime. Studies include base case data for products, design options as well as social and economic studies; for most products, there is no indication of designing to extend product lifetime or how design options extend product lifetime.	Covers full range of EuPs. Circa 30 products studies have been completed or are commissioned to date. Work has been undertaken by independent research organisations. European structured, averaged data and information is presented in each study which was gained through a multi-stakeholder engagement process.
Integrated Product Policy Pilot Projects http://ec.europa.eu/environment/ipp/pilot.htm	Life cycle analysis on a number of products eg mobile phone, teak furniture etc towards informing ways of reducing their environmental impact.	European averaged data and information is presented is presented in each study which was gained through multi-stakeholder engagement process.
Ecolabel studies http://ec.europa.eu/environment/ecolabe	Life cycle studies performed to inform development of Ecolabel criteria eg PCs	Comprehensive independent research for covering European averaged products
Environmental product declarations http://ec.europa.eu/environment/ipp/pdf/epdstudy.pdf http://www.environdec.com	Use life cycle methodology to make declaration. Numerous Type II EPDs have been performed, a proportion of which have been published.	Individual product category rules determine requirement for analysis and reporting.
International Journal of LCA http://www.ecomed.de/lca	Study paper and synopses, signposting to full LCA studies	Journal peer reviewed papers and ISO standard life cycle assessments
Defra evidence base http://www.defra.gov.uk	Considerable body of evidence on resource efficiency, waste prevention, product roadmaps	Product roadmaps developed for 10 product categories (Clothing, Domestic lighting, Electric motors, Fish and shellfish, Milk, Passenger cars, Plasterboard , TVs, Windows and WCs). These aim to better understand the environmental and sustainability impacts of products and ways in which these impacts can be mitigated. Work has included environmental life cycle studies and wide stakeholder engagement.
Market Transformation Programme http://efficient-products.defra.gov.uk	Supports the development and implementation of government policy on sustainable products and services in the UK. Recently consulted on proposals for indicative product standards and targets for EUP sold in the UK to 2030 - focus on improved energy efficiency during use.	'What if?' tool holds assumptions about the average use phase impacts and distribution of lifetimes of a range of energy using UK products beginning from 1980 onwards.
WRAP resource efficiency research and specific product studies. http://www.wrap.org.uk	Considerable body of evidence on waste management and recycling, materials sectors, resource efficiency and sustainable products.	Range of UK focussed independent research
Biffaward Programme on Sustainable Resource. www.massbalance.org	Aims to provide accessible, well-researched information about the flows of different resources through the UK economy based either singly, or on a combination of regions, material streams or industry sectors.	More than 60 different mass balance projects have been funded by Biffaward. These are large UK-focussed research projects, involving comprehensive research with multi-stakeholder engagement.

3.10 *REDUCING PRODUCT LIFETIMES - TRADE-OFFS BETWEEN IMPACTS ASSOCIATED WITH THE PRODUCTION AND USE OF PRODUCTS*

The evidence review highlighted that for some remanufactured products, product performance, subsequent to remanufacturing/repair has been highlighted as important: In other words, whether a product subsequently works as 'good as new', or as 'bad as old'. For instance, Smith and Keoleian (2004) (1) show that a remanufactured automotive engine could be produced with 68% to 83% less energy and 73% to 87% fewer carbon dioxide emissions, but their modelling indicates that a 1% decrease in efficiency can negate these environmental benefits.

Lifetime optimisation modelling has illustrated that are trade offs between impacts in the use phase of products and their extended use due to energy efficiency innovation. For some continuously-used energy-using products, where use-phase impacts dominate the life cycle impact profile, the environmental benefits of extending lifetime have been challenged in the literature. For instance, Chul Kim et al (2006) (2) showed that optimal lifetime of a refrigerator ranged from 2-7 years from energy perspective, 2-11 years from GWP perspective, and 18 year from economic cost perspective, based on MTP historical trends and energy projects for this product group. From MTP's What if? Tool, the average lifetime of a fridge is estimated as 17.49 years.

Van Nes and Cramer (2006) (3) conclude on the basis of lifetime optimisation modelling that that extending product lifetime is desirable in all instances, except where there is a significantly more efficient new product available.

Truttmann and Rechberger's (2006) (4) scenario modelling for 8 EEE products (dishwasher, fridge, washing machine, microwave, TV, DVD player, PC and monitor), concluded efficient recycling achieves a higher contribution to resource conservation than reuse of electronic household appliances if lifetimes were extended by 50%.

Little et al (Unpublished) (5) conclude it is preferential to immediately replace C and A rated EU energy efficient washing machines (6) at the end of their life with the most efficient energy rated washing machines available on the market (A++). But the study suggests that refurbishment of an A rated machine is preferred over its immediate replacement with market-dominant A

(1) Smith, V. and Keoleian, G. (2004) The Value of Remanufactured Engines. Journal of Industrial Ecology, 8(1-2), 193-221.
(2) Chul Kim, H., Keoleian, G. and Horie, Y. (2006) Optimal household refrigerator replacement policy for life cycle energy, greenhouse gas emissions, and cost. Energy Policy, 34, 2310-2323.
(3) van Nes, N. and Cramer, J. (2006) Product lifetime optimization: a challenging strategy towards more sustainable consumption patterns. Journal of Cleaner Production, 14(15-16), 1307-1318
(4) Truttmann, N. and Rechberger, H. (2006) Contribution to resource conservation by reuse of electrical and electronic household appliances. Resources, Conservation and Recycling, 48, 249–262.
(5) Little, M., Thomas, B. and Collins, M. (2010, Unpublished) Environmental Life Cycle Assessment (LCA) Study of Replacement and Refurbishment options for domestic washing machines. ERM. WRAP, Banbury, UK.

(6) http://www.energy.eu/focus/energy-label.php

and A+ machines, and depending on the lifetime extension subsequently achieved by the refurbishment, it may be beneficial to refurbish C rated machines. Research for the Walloon Waste Agency (2008) showed that continuing to use a C rated washing machine for an additional 5 years is not beneficial over its immediate replacement with a new machine (1).

This kind of research offers the potential for drawing fascinating policy implications. For example if a frequently or continuously used product having an A+ energy rating is only part way through its useful life, then there may be a switching point at which it will be worth replacing it, with a new, and higher efficiency product. Conversely it may be environmental beneficial to keep a product in-service for longer in other circumstances. For example, in the situation in which the product is infrequently used, the future energy efficiency innovation is predicted to be minimal and/or where the energy that is consumed by the product is predicted to become significantly environmentally cleaner to produce in the future.

However due to variations in the amount and nature of materials and energy consumed in the manufacture and disposal of products, the switching point will vary, depending on the product itself, the proposed replacement product, the fossil fuel/renewable/low carbon fuel mix of fuel used to manufacture and power the products and so on. In practice, these reasons make identifying a precise, or fit-for-purpose indicative switching point an extremely difficult task , doubly so because each consumer uses his or her product differently, and none use them under the laboratory conditions envisaged by the testing agencies.

Many other studies illustrate the dominance of use phase impacts for continuous/frequently used products and high energy-using products, and where these are coupled with significant future product energy efficiency standards, there is a strong likelihood prolonged lifetime extension will not be viable over the life cycle.

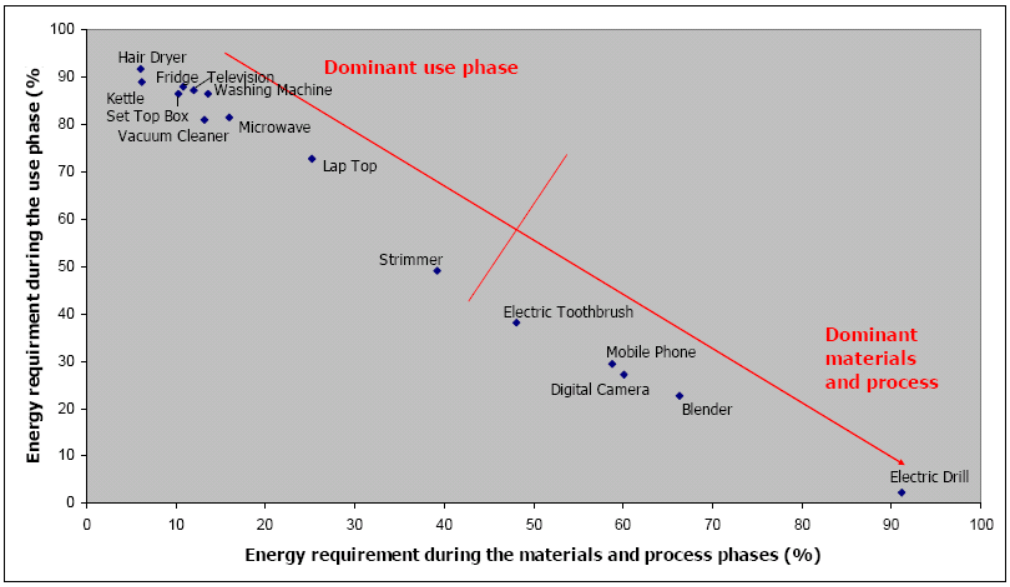
3.11 INCREASING THE UTILISATION OF PRODUCTS DURING THEIR LIFETIME

From a resource efficiency perspective it is possible in theory, to reduce the relative production and disposal impacts associated with infrequently used products, such as DIY products and other household products, through increasing the intensity of their use during their lifetime.

WRAP (2) has recently analysed the contribution of production impacts relative to use phase energy impacts, for a range of electronic products. A summary of this work is presented in *Figure 3.1*.

(1) RDC Environment (2008) Evaluation des beneficies environmentaux economiques et sociaux de differents scenarios de reutilisation des dechets par les enterprises d'economie sociale. For the Walloon Waste Agency, 2008
(2) WRAP (2010) Environmental assessment of consumer electronic products, Summary report www.wrap.org.uk

Figure 3.1 ***Typical electronic products by energy requirement in the use phase against materials and process phase (% of total life cycle energy)***



Notably, for a household electrical drill and a blender, production impacts dwarf those of use-phase impacts. This is principally because it is assumed that they are only very infrequently used in the home before they are disposed of. That is rather than these types of products being particularly resource-intensive products to produce. On average, such types of products may remain unused in home for long periods, or an average may only be used a very limited times before they are discarded.

Increasing the number times such a product is used (ie number of functions over life) is a means of spreading these production burdens over many users, for example through tool sharing, or tool or vehicle hire. Tool hire schemes are available for some DIY products, especially for commercial niche and costly tools. In theory, these could be extended and targeted at household, or provided as a PSS, if logistics are efficient/viable.

Sunedin and Bras (2005) suggest such functional sales give suppliers a better understanding of their product and incentivise designing the product for durability and easy disassembly for remanufacturing [(1)] .

Cranfield University Research for DEFRA [(2)] concluded that Waste electrical and electronic equipment (WEEE) waste could be prevented if services were delivered in PSS. Four household services were examined in the study (home improvement, garden maintenance, house cleaning, and laundry). The research showed that there was potential demand for these PSS from

(1) Sundin, E.; Bras, B. (2005). Making functional sales environmentally and economically beneficial through product remanufacturing. In: Journal of Cleaner Production 13, 913-925.
(2)Natural Resources Management Centre at Cranfield University (2008) WR0106: Achieving household waste prevention and promoting sustainable resource use through product service systems. Defra, London, UK.. http://randd.defra.gov.uk/

consumers, particularly for home improvement and gardening, Moreover, the study concluded that PSS would be a viable as a business model from for garden maintenance, home improvement and house cleaning, but not laundry.

These types of PSS examples offer an extremely interesting insight into how some product-services could be delivered in an extremely resource constrained future world, or one in which consumer values /lifestyle time constraints dictate. However, these examples are about reducing product ownership and intensifying the use of a product over its serviceable life, rather than extending their product lifetime. Hence, these types of PSS have not been considered further within this study.

3.12 LIFE CYCLE COSTS FOR LIFETIME EXTENDED PRODUCTS

An important finding of the initial evidence review is the lack of data in the public domain concerning the life cycle financial costs of lifetime extended products, relative to their less durable counterparts.

Some modelling and theoretical work has been undertaken, and this is published in journals. Which? Magazine (1) periodically publish product tests which include this information for selected product groups and some of the preparatory studies on Ecodesign for EUP also contain structured information. Preliminary work has also been conduced concerning the viability of remanufacturing products, for example from Centre of Remanufacturing and Reuse, and concerning the provision of lifetime costs information for consumers (2).

But it is clear that structured and actual life cycle costs data are generally not available. The WRAP (2009) study does provide some estimates for household expenditure savings which may result from extended product lifetimes although these estimates are not disaggregated in sufficient detail to be used within this study.

The notable exception to this paucity of life cycle costs data is for lighting products; where a life cycle cost calculations have been reported which clearly demonstrate the merits of energy efficient bulbs with extended lifetimes. This is principally because the electricity use of the new, longer lived products is much reduced over the current stock.

(1) http://www.which.co.uk
(2) Electrolux's Eco Save Guide, Envirowise (2001) Good Practice Guide 295 'Cleaner product design: Examples from Industry'. Didcot, UK.

4 PARALLEL STUDY ON PUBLIC UNDERSTANDING OF PRODUCT LIFETIMES AND DURABILITY

4.1 INTRODUCTION

In a parallel study to this work, Brook Lyndhurst has recently undertaken research for Defra regarding public understanding of domestic product lifetimes and their durability (1). This research involved canvassing the opinions of 12 focus groups in six locations across England (115 participants in total). The study examined purchasing and disposal decisions for recently bought products, expected lifetimes and consumer motivations for purchasing.

Draft findings have been presented from this work covering consumer understanding and expectations of product lifetimes, product lifetimes and consumer purchasing decisions, extending product life during use, discarding products and potential interventions for extending product lifetimes.

4.2 CONSUMER ATTITUDES TOWARD LIFETIME AND BEHAVIOURS WHICH DETERMINE PRODUCT LIFETIME

Of particular interest to this study, the survey showed that consumers are aware that a product's 'lifetime' is not fixed and that it is determined by both the inherent durability of a product and the actions taken by the owner in use.

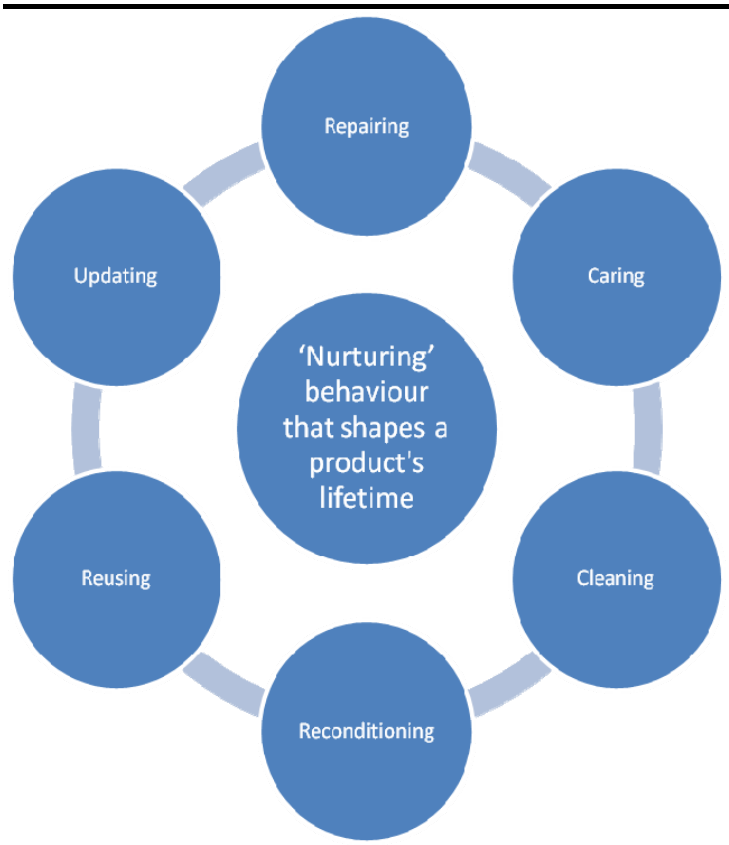
Brook Lyndhurst summarise a list of behaviours that shape a products lifetime during its use *(See Figure 4.1)*. However, the survey cited very few examples of such nurturing behaviour amongst its respondents. Example were given such as using lime scale remover in kettles and dishwashers, using spray on protectors on furniture, having boilers serviced regularly, steam cleaning carpets etc. A key driver for repair was established as where the product as perceived economic or sentimental value. One of the main barriers to repair was identified as where the cost of a replacement product was relatively low compared with repair costs (ie economic obsolescence).

In terms of attitudes towards products breaking, participants of all ages felt that products were no longer made to last, and many suggested that this was deliberate (in-built obsolescence). Mobile phones, small electrical appliances and washer/dryers were commonly reported as things that broke. People were found to be more likely to be annoyed if products broke and there expectation related to how much they had 'invested' in the products and how much they relied upon them.

(1) Defra Research Project DE01-022: Public understanding of product lifetimes and durability (2010, unpublished). Brook Lyndhurst, 26th March 2010.

Price, rather than other motivations such as durability was identified as the key determinant of purchasing decisions when buying product. Durability was not 'top of mind', but when prompted in the survey, it was considered a desirable product trait, and is implied by terms such 'quality', 'reliability' and even 'value for money'.

Figure 4.1 ***Behaviours that can extend product lifetime during their use***



4.3 *SURVEY OF THE MOST FREQUENTLY DISCARDED CONSUMER PRODUCTS*

Consumers were also asked which products they most commonly disposed of and asked to provide reasons why the products were discarded in a pre-task questionnaire (1).

TV's, Clothing and Kettles were identified as being the most commonly disposed of in the survey (See *Table 4.1)*

(1) Participants were asked to complete a booklet before the workshop outlining a product recently bought and disposed of for each room in their house, giving reasons for those purchase and disposal decisions

Table 4.1 Most commonly disposed products from pre-task questionnaire

Product	Count
TVs	37
Clothing	22
Kettle	21
Lamps	17
Bedding (including duvets, duvet covers and quilts)	16
Curtains	12
Tables (kitchen and coffee)	12
Microwaves	11

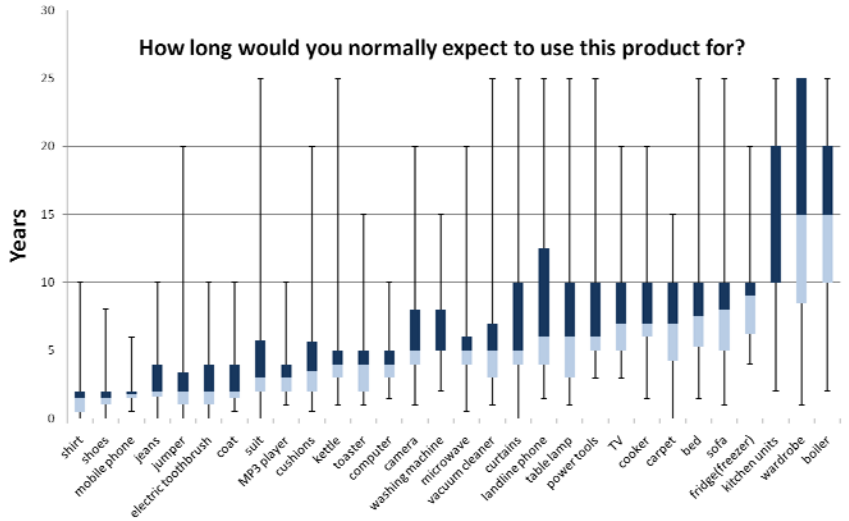
As a quantitative list of what is disposed of most commonly, however, the results are somewhat limited. Firstly because they depend on a consumer perception of what constitutes a product (for example, short term consumable products were not recorded in the survey). The survey also represents just a point in time rather than a longer-term average. For example for TV's, upgrading (ie digital switchover), size reduction (ie larger and slim line displays) and dysfunction were given by respondents as the main reasons for disposal. Secondly some products may be overrepresented in the survey. For example, it may also be that TV's were more readily identified in the survey because they are relatively expensive and bulky products. The authors also allude to some product groups being underrepresented and others overrepresented.

A range of furniture and furnishings, large and small appliances were recorded in the full listing of products, along with reasons for their discard. For example, the main reasons given for the discard of clothing were given as lack of use/space, age and shabbiness, and fashion. Only a small number of respondents described the reason for discard as being worn out. The majority of washing machines were described as broken at their discard, whereas the majority of sofas and carpets were discarded due to their appearance. Respondents identified that upgrading was the reason for discarding their mobile phones.

4.4 CONSUMER EXPECTATIONS CONCERNING PRODUCT LIFETIME

Perhaps most noteworthy for this study the research asked the participants how long they would typically expect to 'use' different types of product for (before it broke, before it was replaced, or before it was no longer used). Findings from this aspect of the research are presented in *Figure 4.2*

Figure 4.2 *Findings of Brook Lyndhurst focus group expectation of product lifetimes (n = 113)*[1]



[1] Error bars show the maximum and minimum values given by participants in the survey (rather than confidence intervals). The top of the dark blue bar indicates the third quartile and the bottom of the light blue bar, the first quartile. The interface between the two coloured bar, indicates median value, the typical consumer expectation.

The research shows that consumers possess a wide range of views concerning the expectation of lifetime for individual products, although the width of the main bars indicates there is more consensus for some product groups than others.

The views vary considerably for different types of products. Clothing and more rapidly innovating products such as mobile phones and MP3 players are notable at the lower end of the expectation spectrum. Some participants cited fashion and technology as a driver for product obsolescence in the survey, and frustration over needing to keep up with the latest technology and trends. Other participants set themselves apart as not being driven by fashion or technology.

Electrical and electronic appliances are dominant in the mid range, together with periodically replaced furnishing and decorative products. Large products that are used daily and are essential tend to dominate the upper end of the spectrum.

Again, it should be stressed that the findings are perceived expectations, rather than actual product lifetimes, and while the data is qualitative and limited by its scope, it does offer confirmation (not needed by seasoned observers of the clothes or electronics sectors for example) that there are some consumers who buy 'fast fashion' and technology items in the full knowledge that they will not last long. These consumers make their purchases as informed buyers and can be distinguished from others who may buy the same items, but who have only limited information and understanding of life cycle

issues, and are genuinely surprised and disappointed when the product fails to meet their expectations of durability. For well informed consumers such as the former group, labelling would offer little new information of value, but for others, labels giving more information on matters of durability or quality might offer valuable insights to inform purchasing decisions.

Interestingly, Brook Lyndhurst compare their findings for consumer expectations of product lifetimes for the various products examined to age of different discarded appliances, as recorded from interviews and focus groups work by Cooper and Mayers in 2000. The comparison suggests that product lifetimes, or at least consumer's expectations of product lifetimes, are consistently reduced relative to the lifetimes given in the research in 2000. Brook Lyndhurst is understandably cautious about the finding due to comparability between the work since they asked for length of *expected use*, while Cooper asked for both the age of discarded and broken products. But they go on to suggest there is also a distinct possibility that expected product lifetimes have actually shortened over the decade since Cooper's research was carried out. The example of the halving of lifetimes for mobile phones is given (from 4 to 2 years), suggesting the finding may well reflect an increase in the pace of technological change, the automatic 'upgrades' offered under contract, the decline in real prices of these items and, overall, their resultantly increasingly 'disposable' nature.

4.5 PROLONGING PRODUCT LIFETIMES

Participants were also asked in the Brook Lyndhurst workshops what they thought manufacturers could do to prolong product lifetimes.

Manufacturers (not 3rd parties) offering extended warranties *as standard* was a popular idea amongst participants. Examples of well-thought-of warranties included car warranties and the British Gas service agreement. In particular, the value of being given a replacement or 'courtesy' product while waiting for repairs to be carried out was raised, particularly for relied-upon items such as laptops and mobiles

Concerning repair, participants frequently raised the idea of 'in-built obsolescence' and the related cost of manufacturer's service/labour. Reducing the cost of labour charged for repairs was raised by some participants (the Dyson fixed-rate repair offer was mentioned as an example of good practice). Improving the amenability of products to DIY repair was an idea raised by some participants.

5 IDENTIFICATION OF THE PRODUCTS FOR FURTHER EXAMINATION IN THE STUDY

5.1 POTENTIAL PRODUCTS FOR FURTHER ANALYSIS

Following the initial evidence review ERM compiled a list of 70 products for consideration for further research. Defra wished a range of domestic and commercial products to be considered for extending their lifetimes.

ERM initially produced a long list of potential products. Many of the products included in the list were identified during the initial evidence review in the literature. In particular WRAP's (2009) research was influential, in respect of covering the potential strategies that are described for extending product lifetime in *Section 3.6.*

ERM held an internal brainstorming session within the LCA team with a detailed briefing of the projects objectives. The full list of 70 products is presented in *Table 5.1.*

In it products are grouped in categories according to their main characteristics (product type, size and propensity for technological innovation), rather than by the type of lifetime extension strategy. This is because multiple ways of extending lifetime were identified for each product in some instances (eg more durable design, reparability, PSS and upgradability, reuse etc). It is also intended that this simple categorisation could possibly aid the application of the findings from the further analysis of example products in the following section to other product types with similar characteristics.

Table 5.1 Full list of 70 potential products considered for further research into extending lifetimes grouped by product category

Energy using products					Non energy using products				
Rapid technological innovation			Typified by lower levels of technological innovation						
Large electronic appliances	**Small electronic appliances and fittings**	**Vehicles/ transport**	**Large electrical appliances**	**Small electrical appliances**	**Construction**	**Furniture & interiors**	**Household consumables**	**Clothing**	**Food products - preservation and packaging**
Printer-Scanner	Mobile phone	Passenger car	Washing machine	Toaster	Carpet tile office flooring	Domestic carpet	Toothbrush	T-shirt	Preservation of milk via UHT/HT/ packaging valve
Laptop computer	Digital camera	Combustion engine	Fridge/Freezer	Clothes iron	Toilets	Sofa	Wine glasses	Coat	Refrigeration of vegetables
Photocopier	MP3 player	Gearbox	Refrigerated display units	Electric power drill	Windows	Replacement kitchen unit doors	Batteries	Jumper	Packaging of Vegetables/Fruit/ Meat
TV	Digital terrestrial phone	Electric motors	Industrial air conditioning /heating systems	Lawnmower	Industrial equipment	Bed mattress	Disposable camera	Shirt	Preservation by freezing of fish
	Street lighting	Tyres	Cooker	Electric toothbrush		Curtains	CD/DVD	Suit	Bread – promotion of use by date, rather than sell by date
	Domestic light bulb		Dishwasher	Kettles		Cushions	Child/baby equipment	Shoes	Bread - modular packaging of
			Tumble dryer	Microwave		Garden furniture	Chopping board		Reusable packaging
			Domestic combi boiler	Vacuum cleaner		Office chair	Concentrated Detergent		Shopping bags/ bin bags
						Table lamp	Sports and recreational equipment		
						Wardrobe	Knives		
							Sauce pans		

5.2 SELECTION OF 7-10 PRODUCTS FOR FURTHER ANALYSIS

In terms of short listing the products for review, the project steering group (PSG) gave the overall objectives for this process. These were that the short listing process should identify:

- a range of example of products;
- a mixture of domestic and commercial products;
- products which demonstrate a range of product lifetimes within the same product type;
- products which cover a range of issues and are able answer specific questions; and
- Products which are capable of drawing out lessons for a wider range of products.

To achieve the short listing, ERM firstly developed five criteria which were agreed with the PSG. Sub criteria were developed to support each criterion. These criteria are listed in *Box 5.1.*

ERM then qualitatively ranked each of the 70 products against each of the criteria as either high, medium low in a spreadsheet database. This ranking was based on both the findings of the evidence review and judgement concerning the products.

It was not possible within the scope of the project to carry out a quantitative assessment of each product against each of the five criteria and their sub-criteria. Such a quantitative assessment would require detailed research for each of the 70 products in particular with respect to Criterion 1 and Criterion 2. Neither was it possible at this stage of the project to fully engage with industry stakeholders with respect to each of these 70 products.

Each criterion was given equal weighting in the ranking with the objective of selecting a range of different products and covering a range of issues. The products which achieved the most' high' and 'medium' rankings for the five criteria were selected for further research. The full list of the 70 products, including more comments made during the ranking and selection process for each criterion, is provided in *Annex B* of this report.

Following this work, the PSG was given the opportunity to comment on a draft list of 10 products. A range of comments were received; some challenging the individual rankings for each of the products, some in support , and some against the choice of products for further analysis. For instance, comments were received from the PSG that the highest ranked products within the household consumables product category were unlikely to constitute a significant waste issue, relative to the other product groups. At this stage the results of the parallel Brook Lyndhurst study on consumer

attitudes were also made available to this project, which were considered in the selection of the final list of products.

Finally, a meeting of the PSG was convened to discuss further the rationale for the selection of a final list of shortlisted products. A number of short-listed products were discarded and new ones added to at this meeting. In particular, given other government work on food waste and packaging, the PSG determined that the project should not cover include any food products. The PSG also wished the final list to include an item of clothing and a small electrical appliance within the example products.

The omission of vehicles and heating systems from ERM's final list, which are identified in the literature as some of the highest impacting product groups was also discussed at the meeting. It was determined for these products that there a strong likelihood that new product sales would be either more energy efficient during their use phase in future, and/or may undergo a fundamental technology shift (eg electric and hydrogen car etc, trigeneration boiler etc). TV's were also not included within the final list; as it was established that it was likely that future energy efficiency standards planned for these products had the potential to outweigh any benefits of prolonging their lifetime at this point in time.

Following this meeting, the final list of 9 example products was agreed as:

- Domestic carpet;
- Carpet tile office flooring;
- Printer/scanner;
- Mobile phone;
- Sofa;
- Laptop personal computer;
- Washing machine;
- T-shirt; and
- Toaster.

A categorisation framework for the example products, including a summary of the rationale for the selection of these products is provided in *Table 5.2.*

The table also identifies preliminary areas of research interest for the products within it. These areas are based on findings of the review and the initial thoughts of ERM. In energy instance, the key concerns are the practicability and economic viability of product with extended lifetimes, and the measures necessary to encourage consumers to purchase and maintain more durable products over their shorter-lived counterparts. It is anticipated these will be refined through further engagement with Defra, the PSG and ERM's

economist for the project, and following the stakeholder workshops that are planned for in Stage 2 of the project.

Box 5.1 Product selection criteria:

Criterion 1: Is the scope to reduce the environmental impact of the product high?
Is it a product:

- which has inherently high material requirements?
- containing precious metals (limited availability)?
- comprising a significant proportion of high embodied energy?
- with energy intense processing and assembly?
- which has significant disposal impact?
- with small (short?) use phase?

AND

- which has high volume sales?
- which is identified as a high impact product in the EIPRO (2004), AEAT (2008) public procurement and WRAP (2009) resource efficiency studies?

Criterion 2: Is it a product which already demonstrates scope for extended lifetime?
Is it a product:

- which a proportion of units are already viably reused, refurbished/repaired or part of PSS/leasing?
- which is typified by short and long lifetimes (eg different warranties offered)?
- sold with service contracts?
- which has parallel long lasting products (eg high quality alternatives)?
- which is driven by fashion ?
- with remaining scope for intervention?
- reasons for market failure?
- knowledge of end-users, barriers and change preferences, where it is possible to force change?

Criterion 3: Is it a product for which there is sufficient environmental data/evidence to support action?
Is it a product:

- which is part of Defra's Roadmap work?
- on which full ISO compliant Life cycle Assessments have been carried out?
- represented by Environmental Product Declarations?
- Is there data on the economic impacts of this product?

Criterion 4: Is it a product which has appropriate UK market engagement and penetration?
Is it a product:

- whose final assembly occurs near market – with scope for remanufacturing/repair?
- whose UK industry/trade bodies are engaged and motivated to make changes?
- which makes up a significant proportion of main public and private procurement contracts?
- which innovates quickly making intervention difficult?
- identification of policy drivers already in place.

Criterion 5: Is this a product which features highly in the public domain?
Is the product:

- an 'iconic' product?
- a product that frustrate the consumer with their short lifetime?

Table 5.2 A categorisation framework for the sample products, including a summary of the rationale for the selection of the products

Product	Product category	Consumer lifetime expectations (Brook Lyndhurst, 2010	Domestic or commercial product	Main reason(s) for obsolescence	Life cycle environmental impacts	Specific market issues and consumer attitudes findings	Scope for lifetime extension	Preliminary areas of research interest
Domestic carpet	Furniture /Interiors	Long (4-10 years) *Median = 7 Range = 0-15*	Domestic	-Psychological (aesthetics/perceived lack of hygiene, and wear)	-Production impacts dominate, synthetic carpets are made from fossil fuels, natural fibres also have a significant carbon footprint -Bulky waste - An estimated 500,000 tonnes of carpet waste ends up in landfill each year in the UK - Domestic and commercial carpets make up approximately 25% (approx. 520,000 tonnes) of all textile consumption in the UK	-Market differentiation exists in terms of durability of design and sold to consumer in terms of quality -UK manufacturing base and design knowhow exists -EPDs have been made in product group to differentiate products -Generally a high investment product which consumers are reliant upon on a daily basis. Consumer expectations concerning lifetime have therefore have been shown to be to be generally high	-Potential for '*Restorative Economy*' (increased durability) in domestic market -Product is often sold in terms of quality (feel and wear) and differentiation exists in terms of pile weight and material type (natural and synthetic fibre, which influences durability). -Extended warrantees are already provided in a proportion of the market	-Could product lifetime be extended by measures aimed at increasing durability, with demonstrable environmental benefits and without detriment to UK economy? -If so, what measures are necessary on the consumer side to encourage people to buy more durable carpets?
Carpet tile office flooring	Construction	Not known	Commercial	-Stylistic obsolescence (periodic office refurbishments) -Obsolescence due to wear in most frequently used areas of office	-Production impacts dominate -Bulky waste - Domestic and commercial carpets make up approximately 25% (approx. 520,000 tonnes) of all textile consumption in the UK	-Market differentiation being tested in terms of increased durability, modular design, repair and aftercare service -EPDs have been made in product group to differentiate products -Business is reliant on the product's durability for its period of installation, so depending on its use, expectations are likely to be high	-Potential for Shift to '*Goods to Services*' in commercial market (ie enhanced relation with producer over product lifetime/ reduction in ownership of product) -Aftercare service for commercial flooring exists in terms of tile selective replacement and also on material durability of product.	-Can an aftercare service viably extend product lifetime? -What are the constraints on supplying a more durable carpet in the commercial marketplace and can these be overcome?
Printer-scanner	Large electronic appliance *(Rapidly innovating)*	Medium (3-5 years) *Median = 4 Range=1.5-10 (Computer as analogue)*	Commercial and domestic	-Economic, in built obsolescence (starter cartridges, low unit pricing) in some brands -Technological (Innovating with respect to functionality, memory requirements)	-Intermittently-used product -Use phase to dominance (due to energy and paper use), but is dependent on degree of use - Limits to fuser energy efficiency innovation may be close - EUP preparatory study notes high turnover in product group, so waste volume implications	-Business models are generally reliant heavily of servicing revenue (the sale of toner cartridges) -Market is typified by many players, technological innovation and product functional diversity. Set of replacement toner cartridges are often costly relative to replacement of new printer -Waste problem/market failure (example of imperfect competition) -Range of pricing experienced in unit costs. Can be a low investment product, with high expectations likely concerning reliability, so likely to frustrate user -Voluntary agreement in progress for imaging equipment/Digital Europe initiative product	--Potential for Shift to '*Goods to Services*' in domestic market (ie enhanced relation with producer over product lifetime) -Home printer essentially provides same function as commercial reprographic product. The later are provided as a PSS, the former are one off sales which rely on sales of toner cartridge as part of the business model (which can be provided by another) -EUP preparatory study notes potential for lifetime extension and resource efficiency for this product group	-In the domestic market, what measures are necessary to deliver printers in a more sustainable manner, perhaps akin to the successful commercial office copier product service system? (Ie life cycle costs information on the consumer side and the availability of cartridges, remanufacturing arrangements on the producer side)
Mobile phone	Small electronic appliance *(Rapidly innovating)*	Short (1.5-2 years) *Median = 1.8 Range = 0.5-6*	Commercial and domestic	-Technological (New functionality) -Economic (availability of leasing arrangements, rather then unit cost) -Psychological (new functions/fashion)	-Production impacts are high (rare metals, componetry), but use phase impacts may be significant dependent on use -Unclear regarding future product trends ie miniaturisation and energy use (increasing functionality) - Telephone and telefax equipment are included as priority product groups in product environmental impact studies	-Manufacturers and retailers have control over product (leasing), but have generally given responsibility to third party -Some doubt in literature that WEEE recycling targets will be met for this product group -Consumers are typified by two types of user: latest technology and where phone is only used as a phone. A cascaded use/re-deployment of phones may be possible in the UK in theory -Generally a low investment product (leasing arrangements). Low consumer expectations concerning product life (due to technology/fashion), but high consumer expectations concerning reliability whilst in use	-Potential for '*Lifetime Optimisation*' (ie further and more formalised reuse of phones to ensure products are used for useful life) -Leasing and third party takeback redeployment and recycling arrangements for redundant phones already exist (ie simple refurbishment and resale)	-How effective are the current arrangements and how could these be further improved from an environmental perspective without adversely affecting competition/stifling innovation?

Product	Product category	Consumer lifetime expectations (Brook Lyndhurst, 2010	Domestic or commercial product	Main reason(s) for obsolescence	Life cycle environmental impacts	Specific market issues and consumer attitudes findings	Scope for lifetime extension	Preliminary areas of research interest
Sofa	Furniture /Interiors	Long (5-10 years) *Median = 8* *Range = 1-25*	Domestic	-Psychological (aesthetics and wear), -Economic (re-upholstery/replacement cover costs relative to new purchase)	-Production impacts dominate -Large bulky waste with potential for waste prevention/reuse -Textiles are cited in the WRAP and EIPRO environmental impact studies as a priority product group	-Market differentiation in terms of durability in design/warrantees at original point of sale -Contributes significantly to waste stream, but no producer responsibility -Generally a high investment product which consumers are reliant upon daily. Expectations concerning lifetime have been shown to be high. Consumers may want to increase product life	- Potential for '*Lifetime Optimisation*' (new covers/reupholster to ensure products are used for useful life) -Replacement covers and reupholstering services are available -(Limited) reuse via third sector	-Does simple refurbishment of a large household furniture product make environmental and economic sense? -If so, what measures are necessary to stimulate this in practice?
Laptop computer	Large electronic appliance *(Rapidly innovating)*	Medium (3-5 years) *Median = 4* *Range = 5-10*	Commercial and domestic	-Economic (lower priced alternatives relative to repair), -Technological (memory and processing power, software)	-Intermittently-used product, so use phase dominance of life cycle impacts dependent on degree of use -Consumption of personal computers is increasing across the EU with laptops sales increasing at a very significant rate from a roughly estimated 6 million in 2000 to 31 million units in 2008 (EuP preparatory study data)	-Market differentiation in terms of durability in design/warrantees/ecolabels, leasing arrangements in commercial sector, but not in domestic sector -Generally a high investment product (once software costs accounted for) which consumers are reliant upon daily. Expectations concerning lifetime have been shown to be mid range	-Potential for '*Lifetime Optimisation*' (repair/upgrading to ensure products are used for useful life) -Key lifetime limiting components can be upgraded (reprocessor speed, memory etc) and are done so in some formal, third party and informal arrangements	-Is upgrading of componetry worthwhile and practicable in both commercial and domestic contexts? -What producer measures would be necessary to facilitate routine upgrading? (ie product design, availability of components)
Washing machine	Large electrical appliance	Medium (5-8 years) *Median = 5* *Range = 2-15*	Commercial and domestic	-Economic (lower priced alternatives relative to costs of repair, limited warrantee periods) -In built obsolescence (suspected at lower end of market due to design of integrated drums and other less reliable components)	-Intermittently-used product – Use phase is dominant for life cycle impacts, but there is potentially asymptotic trend in energy efficiency innovation -The use of washing machines in households is in the top 35 highest impact product groups in the EIPRO study, and the use of household appliances is a priority product group in the WRAP resource efficiency study	-Market differentiation already exists in terms of durability/cost/branding -Aftercare repair arrangements and extended warrantees are sold routinely with products -Servicing infrastructure and knowhow exists -Although product labelling exists, consumers have a lack of information on the full lifecycle impacts of products when products are purchased -A mid range investment product which consumers are reliant upon daily (breakdown was shown to frustrate user). Expectations concerning lifetime are shown to be mid to upper range	-Potential for '*Restorative Economy*' (increased product durability) -Potential for '*Lifetime Optimisation*' (repair and servicing) -Potential for '*Goods to services*' (aftercare services, leasing arrangements) -Enhanced product with component durability and design for repair, remanufacture has been demonstrated, but have been limited in their application to date in a domestic market context	-Are more durable, repairable products viable from a costs and life cycle perspective over an extended lifetime? -Could better consumer information/packages encourage consumers to buy more durable products and manufacturers to make more durable products? eg on first year failure rates for products, life cycle costs, extended manufacturer warrantees
T-shirt	Clothing	Short (0.5-2 years) *Median = 1.5* *Range = 0-10* *(Shirt as analogue)*	Commercial and domestic	-Psychological (fashion, infrequent use and availability of space in home), -In built obsolescence (quality of fabric, design)	-Use phase impacts tend to dominate (laundering, ironing) for cotton T-shirt, but may not dominant in other more durable types of T-shirt eg Polycotton blends, microfibre -Textiles are cited as a priority product in EIPRO and WRAP resource efficiency study, with very high embodied impacts (cotton and synthetic textile manufacture)	-Is both a fashion product and functional product -Disposable fashion, with limited efforts to date for clothing warrantees -Reduction in production costs has caused a rebound effect in recent years enabling greater consumption/ownership of low end clothing -Design influences impacts; these could be communicated to consumer -Low investment product, with low consumer expectations of product life	-Potential for '*Restorative Economy*' (ie increased durability to extend lifetime) -Potential for '*Lifetime Optimisation*' (ie retention of higher end product in home, overcoming psychological obsolescence/deposable fashion, to ensure product is used for useful life,) -Producers can manufacture more durable T shirts such as polycotton T-shirts -Warrantees are now offered on some supermarket clothing such as school wear	-Can more durable clothing such be developed as alternatives to less durable design which show merit over the life cycle? -What measures are necessary to encourage consumers to buy more durable designs and keep them? (ie use of extended warrantees)
Toaster	Small electrical appliance	Medium (2-5 years) *Median = 4* *Range = 1-15*	Domestic	-Economic (lower priced alternatives relative to repair), -Psychological (aesthetics, fashion/stylistics)	-Use phase impacts tend to be dominant -Discardable item without dedicated takeback route -Toasters are generally disposed straight to the waste stream, and therefore constitute a loss of ferrous and non ferrous material with high embodied environmental impacts	-Market differentiation exists in cost/quality -Comparatively simple product generally used until breaks, but components can be easily replaced -UK product design base -Range of pricing. Small appliances were found to frustrate the user when they break. Higher cost products likely to need to be supported in terms of aftercare in order to meet consumer expectations	-Potential for '*Lifetime Optimisation*' (repair, aftercare) for small electrical appliance -Aftercare service exist eg Morphy Richards, Dualit etc supply of replacement parts such as timers, heating elements) and some products are specifically designed for repair	-Is simple repair of a small appliance practicable? -If so, what additional measures are necessary to encourage such arrangements?