

# Reducing the environmental impact of clothes cleaning

BIO Intelligence Service in  
collaboration with Giraffe and  
Intertek

A research report completed for the Department for  
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# **Reducing the Environmental Impact of Clothes Cleaning EV0419**

## **Final Report to the Department for Environment, Food and Rural Affairs**

**December 2009**

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**BIO Intelligence Service** was established in 1989, and is one of Europe's leading consulting firms in the field of environmental management. BIO develops recommendations for clients in the private and public sectors to tackle their environmental challenges. BIO has a strong technical expertise in the field of eco-design, life cycle assessment, and health & nutrition analysis. BIO has considerable experience in dealing with the complexities, from media specific (pollution of air, water, soil, etc.) to cross-media issues (resource conservation, energy efficiency, waste management, integrated product design, etc.). BIO helps the decision makers to draw-up and implement policies to follow the path of sustainable development by making them available state-of-the-art tools and methods developed through in-house research. In the context of this project, BIO has an extensive experience in establishing life cycle impacts for a wide range of products, identifying the improvement potential and the trade-offs in applying different improvement options. BIO has a strong team of 50 consultants with diverse expertise and skills.

**Giraffe Innovation Limited** was described by The Guardian business pages as one of the UK's top green businesses due to its extensive experience in delivering a wide range of sustainably driven projects to UK and global organisations. Giraffe was described by The Manufacturer Magazine as 'Britain's leading eco-design consultancy'. Giraffe undertakes, complex Life Cycle Assessment and carbon footprinting projects for clients in Hong Kong, Sweden, France, USA, Korea and the UK covering textiles, computers, telephones, toys, set top boxes, food and cosmetics packaging, and other domestic products. Giraffe also provides senior management support and coaching including advice on the legal compliance obligations and business benefits of EU Environmental legislation.

**Intertek** is a leading international provider of testing and certification services to a wide range of global and local industries and has a network of more than 1030 laboratories and offices with over 23,000 people in 110 countries around the world. Intertek is a FTSE 250 listed company which floated on the Stock Exchange in July 2002. Intertek Research & Performance Testing is part of the Commercial & Electrical Division of Intertek and employs 40 people at the Milton Keynes site. This laboratory, established by the UK Consumers' Association nearly 50 years ago, is one of Europe's leading consumer product research and testing facilities with an acknowledged expertise in performance testing of Wet, Cold and Cooking appliances, Consumer Electronics and ICT products.

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## Glossary

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|                      |   |
|----------------------|---|
| A.I.S.E.             | International Association for Soaps, Detergents and Maintenance Products  |
| Anti-crease          | Fabric treatments to reduce or remove the amount of ironing required to achieve a crease-free finish on a garment   |
| Bio-films            | Bio-films consist of communities of bacteria and fungi which build up on the internal surfaces of the washing machine under certain conditions  |
| Builder              | Builders are chemicals used in detergents to bind to free ions present in water, softening the water and improving the effectiveness of wash, and to avoid the precipitation of insoluble salts that cause encrustation of fabric |
| Compact powders      | Detergent powders with greater concentration (lower levels of filler) than regular powder   |
| Concentrated liquids | Detergent liquids with higher concentrations than regular liquids   |
| Defra                | Department for Environment, Food and Rural Affairs  |
| EA                   | Environment Agency  |
| EuP                  | Energy using product  |
| Easycare             | Fabrics with properties that reduce the care requirements, such as anti-crease  |
| ISO 3758             | International standard on clothes labelling: <i>Textiles -- Care labelling code using symbols</i>   |
| kWh                  | Kilowatt hour   |
| LCA                  | Life Cycle Assessment   |
| Mt                   | Megatonne   |
| MTP                  | Market Transformation Programme   |
| Phosphorus load      | Quantity of phosphorous emitted to the environment  |
| REACH                | Registration, Evaluation and Authorisation of Chemicals   |
| rpm                  | Revolutions per minute  |
| SCP                  | Sustainable Consumption and Production  |
| TWh                  | Terawatt hour   |
| VOC                  | Volatile organic compound   |

# Executive Summary

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## Introduction

The project seeks to analyse current methods of clothes cleaning, identify improvement options, trade-offs and recommendations for stakeholders to reduce the impact of clothes cleaning. It is an independent Defra-commissioned study. The main areas investigated include:

- Fibre and fabric characteristics
- Garment durability
- Sustainable building design
- Washing and drying appliances
- Low or non-solvent dry cleaning
- Detergents and their packaging

In particular, the project identifies the:

- Current status, environmental impacts and trends of clothes cleaning
- Best options to reduce the environmental impacts of clothes cleaning, and those options that will make little difference
- The effectiveness and trade-offs of each option

## Context

Clothes cleaning processes are a source of various environmental impacts, linked to the consumption of water, energy, detergent and solvents. Examples of resultant impacts include water pollution, eutrophication, greenhouse gas emissions and potential toxicity impacts.

The UK Sustainable Clothing Roadmap, a clothing industry initiative co-ordinated by Defra, aims to improve the sustainability of clothing, by gathering evidence on its sustainability impacts, and working with a wide range of stakeholders across the clothing supply chain to implement improvement actions. One of the action areas for the Roadmap is clothes cleaning, and the aim of this study is to inform stakeholders about the best options to reduce the environmental impact of clothes cleaning.

Factors identified as relevant to this aim are:

- **Impacts** – the relative environmental impacts of washing, drying, ironing and dry cleaning
- **Consumer behaviour** – the frequency of washing, cleaning practice, convenience, time restrictions, comfort, cleanliness, extent of clothes soiling and fashion
- **Technology** – type of fabric, appliances, detergent and dry cleaning process
- **Geographical** – climate, water type, nature of soiling on clothes
- **Health** – type and degree of soiling and fabric hygiene
- **Economic** – relative costs of clothes, appliances, detergents, dry cleaning, water and energy
- **Legislative and market initiatives** – current status and future developments of EU and UK legislation and initiatives

## Results

There are many parameters associated with clothes cleaning, such as frequency of clothes washing, wash temperature and duration of ironing, that affect the scale of environmental impacts of clothes cleaning and are significantly determined by consumer choices. Certain areas of consumer behaviour are more open to change, while other areas are likely to encounter resistance due to these embedded habits. There have also been many areas of development outside of the influence of consumers that could achieve reductions in the environmental impacts of clothes cleaning.

It was recognised that consumer behaviour was a key but variable factor influencing the scale of environmental benefit possible from a number of options considered. To avoid overestimating the environmental benefits achievable through options requiring consumer behaviour change, it was assumed that uptake by consumers may be limited. This is a precautionary approach. In reality if consumer uptake and behaviour change is responsive to the options their environmental benefits will be greater enhanced<sup>1</sup>.

Following initial review of many options, the following improvement measures were selected for investigation, and their potential benefits and trade-offs are summarised below. Benefits and trade offs were calculated using the UK government grid electricity carbon footprinting factor<sup>2</sup>, one TWh of electricity equates to 0.43 Mt of CO<sub>2</sub> emissions equivalent and equates to approximately £133 million of consumer electricity bill costs. 1 kWh would therefore cost approximately 13 pence to consumers<sup>3</sup>. The total UK final electricity consumption in 2008 was 342 TWh<sup>4</sup>.

### Line drying of clothes

- Increased line drying during summer months could result in an estimated energy saving of 0.9 TWh (equivalent to 0.4 Mt CO<sub>2</sub> emissions) per annum in the UK.
- It is estimated that a UK household using a washing line to dry its clothes, in place of a tumble dryer, for six months of the year could save between approximately £15 to £23 per annum.
- Outdoor drying requires good weather, while indoor drying could lead to energy losses through escaping heat (through ventilation).

### Washing appliance spin drying efficiency<sup>5</sup>

- Spin drying clothes in a washing machine is a far more energy efficient method of removing water from textiles than tumble drying. Washing machines with higher spin speeds are currently more expensive, but savings for consumers could be achieved over the lifetime of the appliance (in terms of cost savings via reduced electricity bills); however, there is a lack of information on whether constant use of high spin speeds might damage a washing machine or shorten its lifetime.
- Increasing spin speeds in washing machines from 1000 rpm to 1600 rpm would reduce net energy consumption by 13 percent (approximately 0.7 TWh, equivalent to 0.3 Mt CO<sub>2</sub> emissions) per annum in the UK through efficient water extraction and subsequent reduction in tumble drying.

<sup>1</sup> Defra (2008) Public Understanding of Sustainable Clothing

<sup>2</sup> <http://www.defra.gov.uk/environment/business/reporting/pdf/ghg-cf-guidelines2008.pdf>

<sup>3</sup> Based on an estimated annual electricity consumption of 3,300 kWh and bill of £440. Source: Quarterly energy prices: September 2009, at: <http://www.decc.gov.uk/en/content/cms/statistics/publications/prices/prices.aspx>

<sup>4</sup> <http://www.decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx>

<sup>5</sup> Greater spin drying efficiency is a function of higher washing appliance drum spin speed, longer spin cycle duration and larger drum diameter



### Washing and drying appliance efficiency

- A shift of all washing appliances by one energy rating class of the current EU energy label upwards would result in a saving of 5 percent of energy consumption currently used in washing (approximately 0.2 TWh, equivalent to 0.09 Mt CO<sub>2</sub> emissions) per annum in the UK.
- The average lifetime of appliances is estimated as being 12 years for washing machines and 13 years for tumble dryers. Any early replacement of a model may negate any possible efficiency improvements of a new model due to the additional waste, resources and energy in manufacturing the new model and disposing of the old.
- Washer-dryers constitute approximately one sixth of the UK washing machine market, but are not included in an EU Eco-design of Energy using Products study (these studies seek to improve appliance efficiencies), therefore there is an opportunity to seek inclusion in order to drive improvement of their efficiency.
- Humidity control features (a moisture sensor) in tumble dryers may currently be over-priced by manufacturers; increased use would improve energy efficiency through automatic appliance shut-down when clothes are dry.

### Low temperature washing

- If all UK citizens currently washing their clothes at 40°C instead washed them at 30°C, the UK would save of 12 percent of the energy that is currently consumed on clothes washing annually (approximately 0.5 TWh, equivalent to 0.22 Mt CO<sub>2</sub> emissions) per annum in the UK. Lowering wash temperature could therefore potentially be more beneficial than increased washing machine efficiency. Cost savings to a consumer of reducing their wash temperature from 40°C to 30°C could be in the region of £3 per annum.
- Low-temperature detergents perform well across a range of environmental indicators.
- Bio-films, which are caused by build up of bacteria and fungi in machines, may develop within the appliance if routine higher-temperature servicing of the appliance is not established, but the environmental impacts of this servicing would not be significant, and there would still be a net environmental benefit.
- Poor bleaching may affect washing performance at temperatures less than 30°C.

### Detergent form and dosing

- LCA data on detergents used in 2001 suggest that compact powders and concentrated liquids perform better than regular powders and liquids across a range of environmental indicators.
- Updated figures for the UK detergent market, show that compact powders in 2001 are now commonly used, representing 40 percent of the market and that new super concentrated liquids 16 percent of sales.
- Due to lack of data, this study has not assessed the effect of chemical composition across the wide range of detergents available on the market; however, the EU Ecolabel for detergents could provide a means to assist consumers in making low-impact choices.

### Reduced ironing through anti-crease fabrics

- Anti-crease finishes applied to fabrics can make ironing easier, reducing the time taken to iron, or even replace the need to iron clothes, thereby reducing overall energy use.

- However, the benefits of anti-crease treatments need further investigation due to uncertainty over end of life disposal issues from treatment chemicals may pose problems.

The resulting key conclusions are:

- Wash at 30°C to be encouraged as there is an existing trend and further adoption would reduce environmental impacts significantly, however the effectiveness of washing at 20°C is uncertain and should be further investigated.
- Encourage the development and validation through independent LCA analysis of detergents with reduced environmental impacts. A concentrated detergent product has been shown to have a lower impact than a less concentrated detergent across a range of environmental indicators; further concentration may therefore provide further environmental benefits.
- Line drying to be promoted, as this would reduce the need for mechanical drying and hence reduce impacts.
- Increasing spin drying efficiency of washing machines to reduce mechanical drying would reduce energy consumption.
- Uncertainties of benefits of anti-crease easycare textiles mean that further research should be conducted to investigate consumer behaviour related to their use, and the extent of heat treatment required to activate anti-crease, in order to be certain of benefits.
- Appliance efficiencies are being driven by EU legislation (EU Ecodesign of Energy Using Products (EuP) and Energy Labelling) and benefits of changing to newer appliances (for wider consumer access to features such as greater spin drying efficiency) in the short term is likely to be small, depending on the impacts of early disposal of the old model.
- The omission of washer-dryers in the EU Eco-design of EuP process may hold back the development of significant proportions of the UK washing and drying appliance markets, as washer-dryers are a commonly purchased appliance in the UK and the market for these may grow with the rise in single-person households.
- The upcoming review of the international standard on clothes labelling (ISO 3758) provides an opportunity to influence both manufacturers and consumers, through encouraging manufacturers to standardise clothes care label terminology and simplify guidance for consumers to promote good practice to achieve environmental benefits. The label should be positioned to be clearly visible to consumers, as stakeholders expressed concern that clothes care labels are currently placed in locations where they may not be noticed and hence are less likely to be used.

## Recommendations

Four significant routes by which reductions in the environmental impacts of clothes cleaning might be achieved are highlighted. These are:

- treatment of the clothing fabric to reduce its care requirements (e.g. anti-crease);
- developing appliances to reduce energy and water use;
- encouraging changes in consumer behaviour; and
- editing of choices through regulation or market initiatives.

### Supply side: Technology development

- Further investigation into clothing that requires less washing, drying and ironing, such as easycare fabrics, to be certain of benefits, and harmonised labelling to increase identification and understanding
- Design appliances with clearly displayed low-temperature wash and efficient cycle options to aid consumer choice
- Design appliances that provide information or feedback to the consumer about the energy use, and if possible the added cost due to increased electricity consumption, of the wash cycle they selected
- Encourage manufacturers to fairly price humidity control features in tumble dryers to encourage consumer purchase of appliances incorporating this feature
- Encourage participation by detergent manufacturers in the International Association for Soaps, Detergents and Maintenance Products (A.I.S.E.) partnership, to benefit from their laundry sustainability projects, and the use of the EU Ecolabel

### Demand side: Consumer behaviour and raising awareness

- Build on success of 'Wash at 30°C' campaign in promoting lower temperature washing, through widening collaboration on this initiative between industry, regulators and retailers, and promoting strong sustainability and economy-focused marketing at point-of purchase
- Raise awareness of the importance of accurate detergent (over and under) dosing
- Raise awareness to increase spin speeds, possibly through the 'Wash at 30°C' campaign or A.I.S.E.
- Raise awareness to increase the practice of line drying, through the 'Wash at 30°C' campaign or A.I.S.E., evaluate comfort of clothing after line drying and consider routes to provide line drying equipment free of charge
- Raise awareness of the EU Ecolabel for detergents
- Participate in the current ISO 3758 clothes care labelling review to encourage provision of information about use of concentrated detergents and line drying, and to place the label in a more visible position on clothing

### Policy, law and market instruments: Driving the market and choice editing

- Investigate means to encourage installation of clothing washing lines through routes other than the Code for Sustainable Homes, potentially through the Building Regulations or Planning Regulations
- Pursue the inclusion of washer-dryers and requirement for moisture sensors in the EU Eco-design of Energy using Products process and support appliance efficiency initiatives such as that of the Energy Saving Trust

Knowledge gaps: For further research

- Easycare fabric properties and benefits
- Number of households with space for outdoor line drying facilities
- Net impacts of indoor line drying
- Effect of spin speed on washing machine lifetime and maintenance costs
- LCAs of detergents of similar form, but different chemical makeup
- Effectiveness of washing clothing at 20°C

Please see section 5.6 for detailed recommendations of areas for further investigation.

## **Methods**

The methodology combined an extensive review of the literature, stakeholder insight and quantitative analysis, to find practical and effective methods to reduce the environmental impact of clothes cleaning. Workshops were convened to present findings and analysis, to provide a forum for stakeholder input.

## **Limitations**

The commercial sensitivity of some of the information investigated meant that accessing detailed Life Cycle Assessments (LCAs), and even basic manufacture data, was challenging for many technologies.

There is uncertainty associated with the validity of the conclusions drawn from analysis that uses fixed behaviour assumptions, as 'real' behaviour during clothes cleaning will be somewhat variable.

# 1 Introduction, objectives and context

---

## 1.1 Introduction

As part of Defra's Sustainable Consumption and Production (SCP) programme, ten product roadmaps are being trialled to identify life cycle sustainability impacts and improve performance across a range of environmentally 'challenging' products, one of which is clothing.

Co-ordinated by Defra, the UK Sustainable Clothing Roadmap aims to improve the sustainability of clothing, by gathering evidence of its environmental impacts, and working with a wide range of stakeholders across the clothing supply chain. Building on existing interventions, actions to improve the sustainability of clothing have been identified in a clothing roadmap action plan<sup>1</sup>. To underpin these actions, Defra has commissioned three evidence projects investigating the environmental impacts of the life cycle stages of clothing:

- 'The role and business case for existing and emerging fibres in sustainable clothing', looking at the sustainability impacts of different fibre types used in clothing
- 'Reducing the environmental impact of clothes cleaning', looking at the in-life use of clothing
- 'Maximising the re-use and recycling of UK Clothes and Textiles', looking at the end of life re-use and disposal of clothing

This research project, 'Reducing the environmental impact of clothes cleaning', focuses on identifying the most effective options to reduce the energy water and chemical intensity of clothes cleaning. The research has involved active engagement with clothing roadmap stakeholders as well as synthesising existing research and evidence. Stakeholders were engaged through participation in a virtual steering group (see annex section 6.1 for a list of members), to include their input, provide data and comment on draft documents. This process was designed to make the research as current and relevant as possible, and to ensure realistic recommendations were made.

## 1.2 Objectives

The objectives of this project are to:

- Review the status of existing cleaning methods and technologies
- Identify and analyse the best improvement options to reduce the environmental impacts of clothes cleaning, using a fact-based life cycle approach
- Assess the effectiveness of improvement options in practice, in particular for those requiring consumers to adopt new practices (for example, read and follow the instructions on care labels, separate clothes by fibre type for washing)
- Highlight and assess trade-offs associated with improvement options
- Determine likely or possible trends impacting clothes cleaning
- Make recommendations for consumer facing instruments, awareness campaigns and regulatory or legislative interventions that could be made to reduce overall environmental impacts
- Describe the limitations of the analysis and conclusions

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<sup>1</sup> <http://www.defra.gov.uk/environment/business/products/roadmaps/pdf/sustainable-clothing-action-plan.pdf>

### 1.3 Scope

The project assessed the following areas where environmental impacts could potentially be reduced:

- Fibre and fabric characteristics
- Garment durability
- Sustainable building design
- Washing and drying appliances
- Low or non-solvent dry cleaning
- Detergents and their packaging

The focus of the study was on *domestic* clothes washing, rather than industrial or commercial cleaning<sup>1</sup>. During analysis, due to the high variety and number of improvement options identified, a preliminary and predominantly qualitative analysis was performed to identify options with the greatest feasibility and potential, which were then analysed in greater detail. Garment durability and dry cleaning were two areas that were not investigated further following the preliminary analysis.

### 1.4 The environmental impacts of clothes cleaning

Clothes cause environmental impacts throughout their life cycle, covering a wide range of environmental issues.

- **Resource consumption**, due to the use of fossil fuels (transport, electricity and manufacturing of synthetic fibres) and water (cultivation of crops, wet processes during the manufacturing process and cleaning during the use phase).
- **Greenhouse gas emissions**, which are mostly linked to the use of fossil fuels.
- **Solid and hazardous waste generation**, from the manufacturing stages, use phase (packaging waste from clothes and laundry detergent), and end of life disposal.
- **Air and water pollution**, including air acidification due to SO<sub>x</sub> emissions (fossil fuel combustion) and NO<sub>x</sub> emissions (electricity production). Water eutrophication impacts are mainly generated by laundry effluents during use phase, wet processes during the manufacturing phase and the use of fertilizers during crop cultivation.
- **Toxicity issues**, covering aquatic, sedimentary and soil toxicity due to the use of chemicals during crop cultivation (defoliants and pesticides) and impacts generated by clothes cleaning (laundry detergent production and the use of electricity).
- **Biodiversity loss and land-use**, linked to crop cultivation, animal farming and improper farming practices.

Clothes cleaning processes are a source of various environmental impacts, linked to the consumption of water, energy, detergent and solvents. Examples of such impacts include resource use, water pollution, eutrophication, greenhouse gas emissions and potential toxicity impacts.

Evidence gathered in *Mapping of Evidence on Sustainable Development Impacts that Occur in the Life Cycles of Clothing*<sup>2</sup> identifies existing research that quantifies these impacts. One such LCA calculates the proportion of life cycle energy consumption during the use phase, with 80 percent of energy consumed during the use phase of men's cotton briefs, and 76 percent of energy consumed during the use phase of polyester trousers<sup>3</sup>. Approximately two

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<sup>1</sup> Industrial laundry is not investigated in this report as it was assumed unlikely for consumers to wash communally on a large scale in the immediate future.

<sup>2</sup> Defra (2008) Mapping of Evidence on Sustainable Development Impacts that Occur in the Life Cycles of Clothing

<sup>3</sup> Marks & Spencer (2002) Streamlined Life Cycle Assessment of Two Marks & Spencer plc Apparel Products

thirds of use phase energy is estimated to be used during washing (including heating water) and one third for drying<sup>1</sup>.

Other evidence gathered in France has shown that the use and maintenance of a pair of jeans contributes more than 60 percent of primary energy consumption, 'human toxicity' (emissions to air, water and soil that present a risk to humans) and production of household waste when considering the total life cycle of the jeans. In addition, the use phase contributes between 35 and 59 percent of climate changing greenhouse gases and water eutrophication, and between 10 and 34 percent of ozone layer depletion and water consumption<sup>2</sup>.

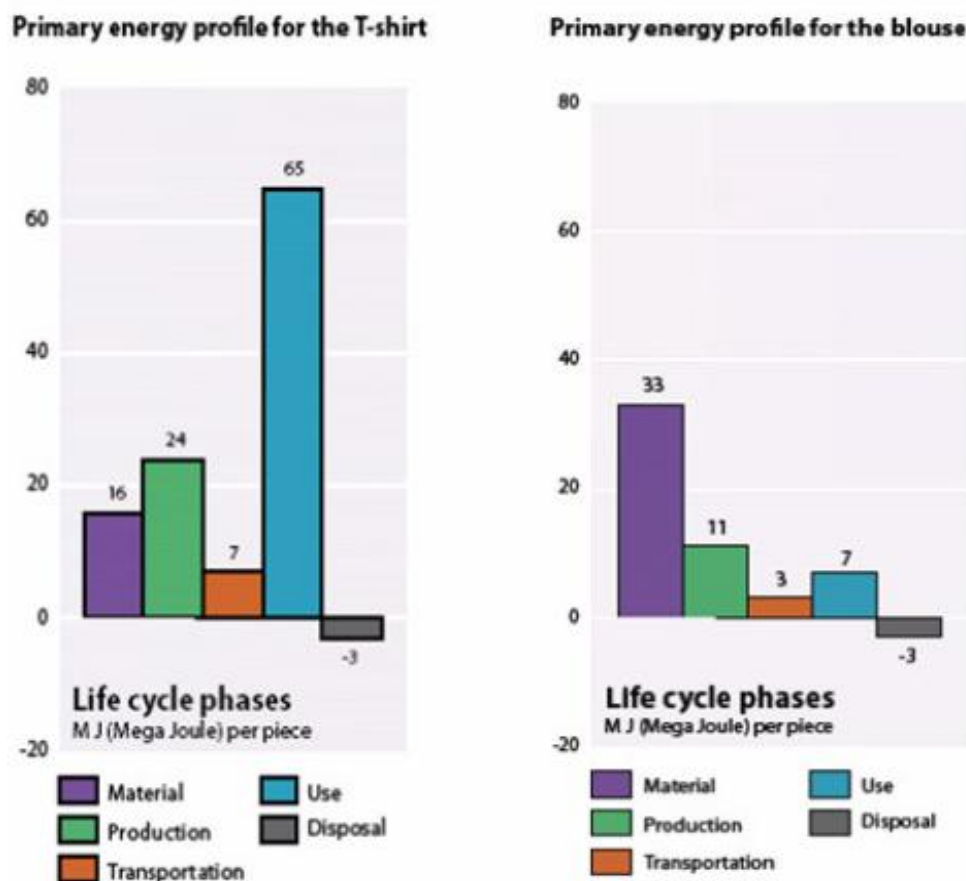


Figure 1: Energy profiles per life cycle stage of a cotton t-shirt and a viscose blouse<sup>3</sup>

The nature and physical property of the clothing fibre mix can also affect the result of an LCA. Figure 1 above presents the energy profiles for each life cycle stage of a cotton t-shirt and a viscose blouse, showing that environmental impact of the use phase varies according to fibre type. By assuming the clothes were dried by a tumble dryer, the study found that the use phase is the major source of energy consumption during the life cycle of a cotton t-shirt, but that it is less significant for the viscose blouse (which is easier to dry).

Figure 2 shows a break-down of the proportion of each environmental impact caused by the various clothes cleaning processes and, although this data is drawn from an LCA of a pair of jeans, it provides an illustrative example that the scale of the impacts of clothes cleaning processes vary across the indicators.

<sup>1</sup> American Fiber Manufacturers (1993) Resource and Environmental Profile Analysis of a Manufactured Apparel Product Life Cycle Analysis: Woman's Knit Polyester Blouse - Final Report Prepared by Franklin Associates

<sup>2</sup> BIO Intelligence Service (2006) Life cycle analysis of a pair of jeans

<sup>3</sup> University of Cambridge Institute for Manufacturing (2006) Well Dressed? The Present and Future Sustainability of Clothing and Textiles in the United Kingdom

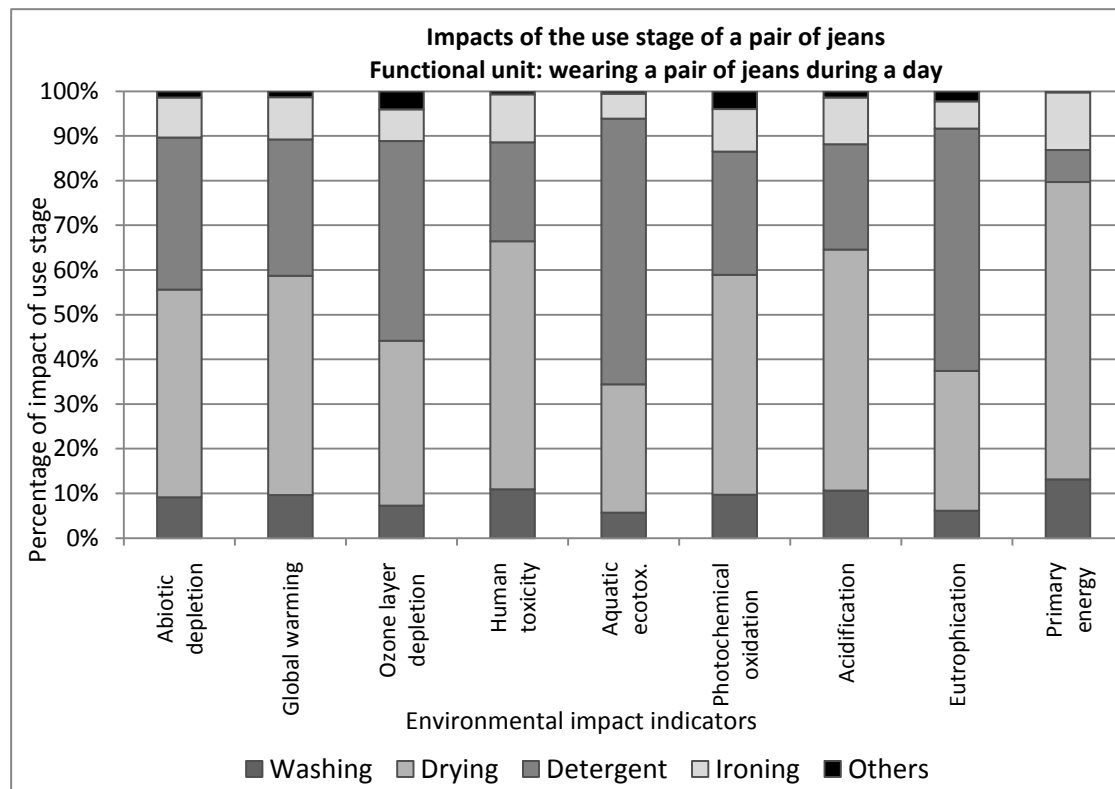


Figure 2: Example of the proportion of impacts caused by clothes cleaning processes during the use stage of a pair of jeans<sup>1</sup>

However, assumptions on clothes cleaning practice, such as frequency of clothes washing and wash temperature, can affect the final results of clothes cleaning studies (particularly LCAs). These figures should therefore be seen as variable, and an indication of the potential impacts of clothes cleaning rather than absolutes for all clothing types and consumers.

## 1.5 Consumer behaviour

The *Public Understanding of Sustainable Clothing*<sup>2</sup> concluded that certain patterns of consumer behaviour are more open to change than others. Importantly, one such adaptability identified was laundering behaviour, particularly when savings in domestic bills were demonstrated as being attainable. Furthermore, an inflexible attitude was found toward changing consumer purchasing preferences, for which fashion and good value were the priority. Conclusions from this study state:

- *People are aware of the environmental benefits of washing at reduced temperatures and line drying clothes but are constrained by their washing machine programme options, physical space and the weather.*
- *People may behave in a pro-environmental manner, such as line drying, but this may merely be an advantageous side-effect of their 'normal' routines. Many are aware of the cost of tumble drying, in economic terms more than energy terms, and many use line drying whenever possible.*
- *A range of factors influence how clothes are dried, including the smell and feel (softness) of dried clothes, the 'wear', and the internal and external environments (i.e. home space and weather).*

<sup>1</sup> BIO Intelligence Service (2006) Life cycle analysis of a pair of jeans. Assumptions made: Washed at 40°C in a C rated machine, ironed for 3 minutes, 6 years lifetime, worn 1 day per week, washed once every 3 weeks

<sup>2</sup> Defra (2008) Public Understanding of Sustainable Clothing



- *There is a reluctance to reduce the frequency with which clothes are washed because of the attraction of 'fresh' clothes and a fear of odour.*
- *There was evidence of many participants separating clothes prior to washing into 'whites' and 'coloureds', but less knowledge about potential cost savings from separating cotton and synthetic clothing in tumble dryers.*

UK households carry out, on average, between approximately 274<sup>1</sup> and 343 clothes washing loads per annum. This is a high number compared to the practice of several other European nations<sup>2</sup> and indicates that the impacts of UK clothes use stage may be particularly high, and that subsequent reductions could be significant, should initiatives to reduce clothes cleaning environmental impacts be successful.

## 1.6 The nature of the UK textile market

Textiles and clothing products comprise a relatively small proportion of UK GDP, at 0.78 percent. Over 75 percent of the UK's £12.5 billion of apparel imports came from outside the EU in 2007, with 30 percent coming from Hong Kong, China and Turkey combined<sup>3</sup>. These facts have an impact on the potential UK interventions at the production stage.

Sales of new clothing in the UK have increased by 60 percent in ten years<sup>4</sup>. The fast fashion and low-cost clothing sector, characterised by short garment lifetime, currently constitutes one fifth of the UK apparel market and has doubled its growth during the period from 1996 to 2005<sup>5</sup>. It is predicted that demand will continue to increase<sup>6</sup>, with key consumer trends including increased popularity of discount fashion, increased consumer awareness of sustainability issues, increased use of synthetic fibres and greater numbers of online purchases.

## 1.7 Legislation

Legislation has had an effect on the development of lower impact clothes cleaning technologies, particularly in relation to appliances, detergents and dry cleaning.

### 1.7.1 Clothes labelling

ISO 3758<sup>7,8</sup> is the international standard on clothes labelling and its purpose is to provide information to prevent irreversible damage to the article during the textile care process. The labels indicate information such as maximum wash temperature to avoid clothing damage. The standard is not mandatory, but it is expected that suppliers will use the care label that gives the best cleaning performance. The standard does include a 30°C wash and is currently under its 5 year review. Areas that may be covered are the newer dry cleaning technologies and lower temperature washing<sup>9</sup>. Stakeholders have suggested that clothes care labels may currently be placed where they are not noticed or used by consumers.

Although the ISO 3758 standard's purpose is to indicate maximum clothes care parameters, there is suggestion that garment manufacturers tend to 'under-label'<sup>10</sup>, by recommending washing and drying temperatures that are lower than the fabrics and dyes would normally stand, to give themselves a margin of error against the fabric failing. If under-labelling does

<sup>1</sup> Market Transformation Program (2006) BNW05: Assumptions underlying the energy projections for domestic washing machines

<sup>2</sup> [http://www.scienceinthebox.com/en\\_UK/research/washabits\\_pop\\_3\\_en.html](http://www.scienceinthebox.com/en_UK/research/washabits_pop_3_en.html)

<sup>3</sup> EURATEX Bulletin (2008)

<sup>4</sup> Defra (2007) Mapping the sustainable development impacts across the life cycle of clothing

<sup>5</sup> Defra (2008) Sustainable clothing roadmap briefing note: sustainability impacts of clothing and current interventions

<sup>6</sup> ONS (2005) Consumer Trends

<sup>7</sup> ISO 3758:2005 available at: [http://www.iso.org/iso/catalogue\\_detail?csnumber=21196](http://www.iso.org/iso/catalogue_detail?csnumber=21196)

<sup>8</sup> <http://www.carelabels.co.uk/caresymbols.htm>

<sup>9</sup> Source: Textile expert

<sup>10</sup> Source: Appliance industry contact

occur, it may inadvertently provide environmental benefits but be potentially disadvantageous when needing to wash clothing at a hot enough temperature to remove a particular stain. Some manufacturers state the real maximum temperature on clothes care labels, and additionally recommend a low temperature wash as a sustainable wash option.

### **1.7.2 EU Eco-design of Energy using Products (EuP) Lots 14 and 16 (washing machines and dryers) and the EU Energy Label**

#### Washing machines

The latest version of the draft implementing measure<sup>1</sup> was issued in April 2009. This has been approved by the EuP regulatory committee and is currently before parliament. If parliament approves then it could become law by the end of 2009. The specific requirements of the implementing measure will then be introduced progressively from July 2010 to July 2013. The requirements will be reviewed again in 2014.

From July 2010, minimum standards for cleaning performance and energy efficiency will apply. These will ensure that all washing machines with a rated capacity greater than 3 kg (over 99 percent of the UK market) have a cleaning performance and energy efficiency better than or equivalent to A class performance on the current EU Energy Label. This will allow the energy label to provide an incentive for manufacturers to further improve energy efficiency, beyond the current A class.

From July 2011, the performance of washing machines will have to take into account standby power and it will have to be measured with respect to three different washing conditions. These are based on 60°C and 40°C cotton programmes with full and half loads. They are intended to be representative of consumer use. This requirement is expected to drive improvements in performance particularly where the washing machine is not loaded to capacity - a common consumer habit.

From July 2013, the minimum standards introduced in 2010 will be tightened and washing machines will be required to have a 20°C programme. It is important to note that there is no requirement for this programme to be suitable for washing cotton fabric. Many washing machines already have a cold wash programme but in some cases this is only intended for woollens and / or other delicate items. The impact of this requirement as it stands may not be all that significant.

The expected energy saving across Europe from these measures is 2TWh per annum by 2020.

#### Tumble dryers

In line with the washing machine implementing measure, it seems unlikely that there will be any major design requirements in the implementing measure for tumble dryers. Minimum standards will probably be introduced to remove the least efficient dryers from the market.

It is possible that a requirement could be set for some form of sensor control because energy labelling in its present form provides no incentive to prevent energy wastage through over-drying.

#### Washer-dryers

These appliances are not included in the EuP process. As the number of washer-dryers sold per annum in the UK increased between 2002 and 2006 from 232,000 to 330,000<sup>2</sup>, and in consideration that the trend towards single-person households (flats/apartments/compact houses) may increase purchase of these appliances, the EuP process may be missing an opportunity to improve the efficiency of an increasing popular appliance type.

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<sup>1</sup> Implementing measures are EU-wide requirements relating to individual EuP products, product groups or functions of products (e.g. stand-by mode)

<sup>2</sup> Mintel Market Intelligence (2008) Laundry and Dishwasher Appliances

### 1.7.3 Phosphates in detergents

As stated in the 1992 review<sup>1</sup> by the Royal Commission on Environmental Pollution on the impacts of phosphate-based detergents on water quality, and in reports submitted in the context of the EU Water Framework Directive<sup>2</sup>, eutrophication remains one of the most important threats to fresh and marine waters. Since the introduction of the EC Urban Waste Water Treatment Directive<sup>3</sup>, waste water treatment has also improved. The Detergents Regulation allows Member States to maintain existing national measures, or to introduce new ones, to limit the phosphate content of detergents. Italy, Belgium, Czech Republic, Germany, Sweden, France and the Netherlands have already adopted legislation to reduce or ban phosphates in detergents with the aim of reducing eutrophication. Austria, Ireland, Denmark, and Finland rely on voluntary commitments by detergents producers to phase-out phosphate-based detergents.

Following the consultation by Defra on “Options for Controls on Phosphates in Domestic Laundry”<sup>4,5</sup>, in the summary published in July 2008, the UK water industry expects that the control of phosphates in domestic laundry cleaning products, to have significant positive impacts, including reduction in the size or need for additional treatment processes to remove phosphate at sewage treatment works. The UK market currently uses a low overall proportion of phosphate (under 10 percent<sup>6</sup>).

### 1.7.4 Registration, Evaluation and Authorisation of Chemicals (REACH)

REACH is a new European Community Regulation on chemicals and their safe use, including detergents (EC 1907/2006). It deals with the registration, evaluation, authorisation and restriction of chemical substances and entered into force on 1 June 2007. Since 1 December 2008, chemical substances manufactured in Europe in amounts of 1 tonne per annum or more have needed to be registered with the European Chemicals Agency in Helsinki (see section 6.2 of the annex for further details).

### 1.7.5 Code for Sustainable Homes

The UK Code for Sustainable Homes (‘the Code’) is mandatory rating system for new homes in the UK, from April 2008, that measures the sustainability of a new home against nine categories of sustainable design, rating the ‘whole home’ as a complete package using a 1 to 6 star rating system, and sets minimum standards for energy and water use at each level. The Code provides the public with information about the environmental impact of homes and their potential running costs, and offer builders a tool with which to differentiate themselves in sustainability terms<sup>7</sup>. Credit is available for internal or external line drying features<sup>8</sup>.

## 1.8 Market Initiatives

Several market initiatives also seek to reduce the impact of clothes cleaning technologies and practice.

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<sup>1</sup> Royal Commission on Environmental Pollution (1992) The Sixteenth Report on Freshwater Quality

<sup>2</sup> Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy, at: [http://ec.europa.eu/environment/water/water-framework/index\\_en.html](http://ec.europa.eu/environment/water/water-framework/index_en.html)

<sup>3</sup> Council Directive 91/271/EEC concerning urban waste-water treatment, at: [http://ec.europa.eu/environment/water/water-urbanwaste/index\\_en.html](http://ec.europa.eu/environment/water/water-urbanwaste/index_en.html)

<sup>4</sup> Defra (2008) Responses to the ‘Consultation on Options for Controls on Phosphates in Domestic Laundry’

<sup>5</sup> Water UK Response to Defra’s ‘Consultation on controls on phosphates in domestic laundry cleaning products in England’, at: [www.water.org.uk/home/policy/statements-and-responses/phosphates/response-to-defra-consultation-on-phosphate-control.doc](http://www.water.org.uk/home/policy/statements-and-responses/phosphates/response-to-defra-consultation-on-phosphate-control.doc)

<sup>6</sup> Water UK (2008) Response to Defra’s consultation on controls on phosphates in domestic laundry cleaning products in England

<sup>7</sup> Code for Sustainable Homes details at: <http://www.planningportal.gov.uk/england/professionals/en/1115314116927.html>

<sup>8</sup> Communities and Local Government (2008) Code for Sustainable Homes: Technical guide

### 1.8.1 Energy Saving Trust 'Recommended'

The UK's Energy Saving Trust manages the 'Energy Saving Recommended'<sup>1</sup> product labelling scheme, a registered certification mark that allows consumers to identify the most energy efficient products on the market (it targets the top 20 percent), including washing machines and tumble dryers. All marked products must meet or exceed the established criteria. For large household appliances the requirements are washing machine models of AAA rating (A for energy consumption, washing performance and spin drying efficiency) and tumble dryers of class B or better (or C class, if including automatic drying function).

### 1.8.2 Wash at 30°C

In September 2006, a leading consumer products manufacturer launched a 'Wash at 30°C' campaign through one of their leading brands, in which they suggested 1.6 billion kWh of electricity are wasted annually by running washing machines unnecessarily at 40°C. They claimed that clothes would still be clean when washed at 30°C, as their product technology allowed effective low-temperature washing. Another leading consumer products manufacturer has also promoted lower temperature washing to reduce environmental impacts and provide better clothes care<sup>2</sup>. It is recommended, however, that towels, underwear, sportswear, baby clothes, all bedding, and heavily stained items still be washed at higher temperatures, if they are able to withstand high temperature washing, to ensure they get completely and hygienically cleaned<sup>3</sup>.

The retail sector has been recommending that the majority of the garments they sell should be washed at 30°C rather than 40°C. Studies have shown that this small change reduces electricity consumption by washing machines by around 40 percent on average. One leading UK retailer changed the washing instruction labels on their clothes in March 2007 and have so far received no negative feedback from their customers. From July 2007 another UK retailer will continue to display their standard maximum washing temperature warning on their labels, but will add 'Think climate - wash at 30°C'<sup>4</sup>.

Considering the product communication via advertising and media towards 'cold' wash, it is expected that consumers will change their traditional habits with respect to laundry wash temperatures, and that an average reduction of 10°C can be achieved<sup>5</sup>.

### 1.8.3 EU Ecolabel for detergents

The EU ecolabel<sup>6</sup> has been established since 1992 and has more recently become seen as a European-wide symbol for products, providing simple and accurate guidance to consumers. The label sets specific standards for the manufacture and in use and end of life stages of laundry detergents (see section 6.2 of the annex for further details of the standards).

The EU Ecolabel for detergents has had limited impact in the UK market. According to the Ecolabel database, only 7 labelled detergent products are available in the UK (from 3 suppliers). One of these suppliers is a large retailer which sells its own-brand products exclusively at its retail outlets. Of the other two suppliers, only one product was found to be readily available.

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<sup>1</sup> <http://www.energysavingtrust.org.uk/Energy-saving-products/About-Energy-Saving-Recommended-products>

<sup>2</sup> Source: Leading consumer products manufacturer

<sup>3</sup> <http://www.reuk.co.uk/Wash-Most-Clothes-at-30-Degrees.htm>

<sup>4</sup> <http://www.reuk.co.uk/Wash-Most-Clothes-at-30-Degrees.htm>

<sup>5</sup> [http://www.scienceinthebox.com/en\\_UK/sustainability/activeafroid\\_en.html#two](http://www.scienceinthebox.com/en_UK/sustainability/activeafroid_en.html#two)

<sup>6</sup> [http://ec.europa.eu/environment/ecolabel/product/pg\\_laundrydetergents\\_en.htm](http://ec.europa.eu/environment/ecolabel/product/pg_laundrydetergents_en.htm)

#### **1.8.4 The International Association for Soaps, Detergents and Maintenance Products (A.I.S.E.)**

A.I.S.E. is the official representative body of this industry in Europe. Its membership totals 37 national associations in 42 countries, covering about 900 companies ranging from small and medium-sized enterprises to large multinationals<sup>1</sup>. Several voluntary initiatives have been developed and implemented over the years, notably the A.I.S.E. Code of Good Environmental Practice. This code was endorsed by the European Commission in Recommendation 98/480/EC. These initiatives aim to minimise the environmental impact of laundry detergent powders by promoting sustainable production and consumption of detergents and adequate consumer information.

Recently, the Laundry Sustainability Project 2 has been launched, aiming to optimise formulations, in order to lower recommended dosages, and optimise the use of packaging materials. Another aim of the project is to provide effective communication on correct use of new products (covering: avoid underfilling washing machine with clothing, correct dosing for water hardness and soiling, wash at low temperature, and save or recycle packaging). The project is estimated to have the potential to save 200,000 tonnes of powder detergents and 5,000 tonnes of packaging compared to a 2008 baseline<sup>2</sup>.

#### **1.8.5 Market Transformation Programme**

The Market Transformation Programme (MTP) develops evidence for the UK Government and businesses on energy using products. The purpose of the programme is to improve the resource efficiency of products, systems and services where these are critical to the delivery of Government commitments in areas including climate change, water efficiency and waste reduction<sup>3</sup> (see section 6.2 of the annex for further details).

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<sup>1</sup> <http://www.aise.eu/index.php?home=ok>

<sup>2</sup> A.I.S.E. presentation available at <http://www.aise.eu/go.php?pid=591&topics=17>

<sup>3</sup> <http://www.mtprog.com/>

## 2 Conclusions and Recommendations

This section describes the main conclusions and recommendations drawn from the study. Chapters 3 and 4 outline the methods, analysis and results in full detail.

### 2.1 Key elements of context

The project highlighted several factors that need to be considered when proposing recommendations for reducing the environmental impacts of clothes cleaning:

**Impacts:** the relative environmental impacts of washing, drying, ironing and dry cleaning.

**Consumer behaviour:** frequency of washing, cleaning practice, consideration of convenience, time restrictions, comfort, cleanliness, extent of clothes soiling and fashion.

**Technology:** type of fabric, appliances, detergent and dry cleaning process.

**Geographical:** climate, water type, nature of soiling on clothes.

**Health:** encrustation of fabric and degree and type of soiling.

**Economic:** relative costs of clothes, appliances, detergents, dry cleaning, water and energy.

**Legislative and Market initiatives:** current status and future developments of EU legislation and other initiatives

The following table outlines the main options analysed.

| Option                                      | Current status  | Benefit or saving   | Trade-off  | Conclusion   |
|---|---|---|--|--|
| Reduced ironing through anti-crease fabrics | Ironing consumes 0.75 kWh/h per annum in the UK   | Reductions in primary energy, acidification and climate change could be recovered in short amount of avoided ironing  | End of life disposal issues from treatment chemicals could pose problems<br><br>Some impacts, such as ozone layer depletion and aquatic eco-toxicity would take longer to recover  | Ironing does not use a very high proportion of total primary energy used in the use stage of clothing, but reductions in its use may be relatively easy to achieve                           |
| Line drying of clothes                      | It is estimated that 32 percent of UK consumers use tumble dryers, even in summer, using 2.4 kWh to dry laundry load 60 percent | Line drying for half the year would give an estimated saving of 0.9 TWh per annum in the UK   | Requires space<br><br>Outdoor drying is limited to times of good weather<br><br>Indoor drying could lead to energy losses through escaping heat (through ventilation)  | Awareness raising and encouragement of line drying should be increased<br><br>Needs improved method of implementation (Code for Sustainable Homes would not provide significant improvement) |
| Washing appliance spin speed                | UK average selection for spin speed is 1062 rpm   | The Energy Saving Trust calculates that a shift from 1200 rpm to 1500 rpm could result in savings of 0.3 kWh per cycle<br><br>At UK scale, calculations shows that increasing spin speeds in washing machines from 1000 rpm to 1600 rpm can reduce net energy consumption by 13 percent per annum (approximately 0.7 TWh) through reduced mechanical drying | Potential damage to appliance, and reduced life<br><br>Potentially long payback, over the life of appliance, for consumers purchasing improved models with higher maximum spin speeds – if replaced early, savings may not be realised | Improvements need to be driven by manufacturer or supported by legislation, as no significant saving to consumer from marginal increases   |
| Appliance efficiency                        | The majority of washing appliances in the UK are A class  | A shift of all washing appliances to one class higher efficiency in the UK would result in a saving of 5 percent of energy consumption (approximately 0.2 TWh per annum)  | Appliance average lifetime is estimated at 12 years for washing machines and 13 years for tumble dryers, and early replacement may negate any possible efficiency improvements of a new model  | Push for inclusion of washer-dryers in the EU Eco-design of energy using products process, and support energy efficient schemes to drive greater efficiency improvements                     |

| Option                    | Current status  | Benefit or saving   | Trade-off   | Conclusion  |
|---------------------------|---|---|---|---|
| Low temperature washing   | Approximately 17 percent of UK households washed at 30°C in 2007, compared to only 2 percent of households in their 2002 and average UK washing temperature across all households has decreased from 43.5°C to 40.2°C | <p>If all wash cycles were reduced by 10°C, a energy consumption saving of 15 percent would be achieved and if all consumers washed at 30°C rather than 40°C, a energy consumption saving of 12 percent would be achieved (approximately 0.5 TWh per annum)</p> <p>Low-temperature detergents perform well across a range of environmental indicators</p> | <p>One risk is that bio-films may develop within the appliance if routine higher-temperature servicing of the appliance is not established, , but the effects of this servicing would not be significant</p> <p>Another risk is that poor bleaching/cleaning effect may affect washing performance at low temperature</p> | The trend toward washing at 30°C should be driven by awareness raising and detergent labelling  |
| Detergent form and dosing | Development of more concentrated detergents and detergents that are effective at low temperature has reduced their environmental impacts and enabled reduction of the impacts of clothes washing                      | Compact powders and concentrated liquids have been shown to be less impacting across a range of environmental indicators (but results are drawn from a single study, so caution needs to be taken when drawing conclusions)   | Compact powders may be harder to dose correctly than regular powder   | <p>Promote further development of concentrated detergent formulations</p> <p>Raise awareness of dosing accuracy issues (both over and under-dosing)</p> |



The following sections describe in more detail the conclusions drawn from the results for the options that were investigated in more depth.

## 2.2 Anti-crease

Key UK statistics:

- Ironing consumes an estimated 1.5 TWh per annum in the UK<sup>1</sup>

Table 2, 'Break-even factor between reduced ironing benefits and impacts of anti-crease finishing' (see section 4.2.1) shows that, for some environmental impact categories, the impacts due to anti-crease finishing could potentially be recovered to a break-even point through a small amount of avoided ironing, but that other environmental impacts of the anti-crease treatment would be more difficult to recover.

However, these figures need to be considered with caution, given the broad assumptions made and that data on consumer behaviour related to frequency and duration of ironing was not available. Potential benefits of anti-crease may also be reduced, given factors such as:

- End of life disposal issues (i.e. the additional impact of the anti-crease chemicals upon disposal)
- Anti-crease performance is potentially more effective if tumble dried
- The reduced need to iron when line drying outdoors
- Potential applicability of finishes to only a narrow range of garment types i.e. menswear

For these reasons, and due to uncertainty over the figures, we consider that the benefits of anti-crease treatments need further investigation.

## 2.3 Line drying

Key UK statistics:

- It is estimated that tumble dryers consume 5.8 TWh per annum in the UK
- 70 percent of UK consumers claim to 'always' or 'often' line dry outdoors in summer<sup>2</sup> but 32 percent people use their tumble dryers when the washing line could be used<sup>3</sup>

Increasing line drying has the potential to provide significant benefits, with an estimated potential energy saving of 0.9 TWh per annum in the UK.

If the weather is poor, or a home lacks outdoor space, indoor line drying could be a substitute. However, for indoor clothes drying, a balance needs to be achieved between allowing the build-up of damp to escape through ventilation and retaining heat inside the home. A change in consumer behavior may also be required (although most claim to line dry when possible), as many use tumble dryers.

The Code for Sustainable Homes is not likely to provide significant benefits through provision of line drying features, so other methods to encourage the provision of line drying should be identified, possible using the Building Regulations<sup>4</sup> or Planning Regulations<sup>5</sup>. Raising awareness may be the best method to achieve uptake of line drying, as the cost of line drying to consumers would be small. The cost of tumble drying has been estimated at £30

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<sup>1</sup> Market Transformation Programme (2008) IBNW24: Innovation Briefing Note on domestic laundry drying products

<sup>2</sup> PriceWaterhouseCoopers (2009) Ecodesign of Laundry Dryers Preparatory studies for Ecodesign requirements of Energy-using-Products (EuP) – Lot 16, Draft final Report

<sup>3</sup> Energy Saving Trust, Habits of a lifetime, European Energy Usage Report

<sup>4</sup> These regulations apply to most new buildings and many alterations of existing buildings in England and Wales:  
<http://www.communities.gov.uk/planningandbuilding/buildingregulations/>

<sup>5</sup> <http://www.planningportal.gov.uk/england/genpub/en/1115314175501.html>

per annum in the UK (equivalent to the release 312kg of CO<sub>2</sub>)<sup>1</sup> and a rough calculation shows that line drying in the summer, in place of tumble drying, could provide a £23<sup>2</sup> saving for a consumer. Consumers may respond to messages that focus on potential financial and environmental savings.

## 2.4 Washing appliance spin speed

Key UK statistics:

- It is estimated that tumble dryers consume 5.8 TWh per annum in the UK
- The average lifetime of washing machines is approximately 12 years<sup>3</sup>, and 13 years<sup>4</sup> for tumble drying appliances

The current UK average selection for spin speed for washing machines is 1062 rpm, but encouragement of the public to maximise spin speed could lead to energy savings through reduced need to tumble dry. Increasing spin speeds in washing machines from 1000 rpm to 1600 rpm has been calculated to reduce net energy consumption (i.e. sum of additional energy consumed by washing appliance and reduced energy consumption of tumble dryer) by 13 percent per annum, approximately 0.7 TWh, in the UK.

Payback in costs (i.e. through reduced energy bills) for consumer purchase of the more expensive appliances with greater spin speeds is long, but over the life of the washing machine may provide a saving for consumers. Raising awareness of the monetary savings associated with increased spin speed may therefore provide environmental benefits. However, further research is required to determine whether appliance lifetime will be reduced due to constant high spin speed selection, or whether this might lead to additional maintenance costs for consumers..

## 2.5 Washing appliance efficiency

Key UK statistics:

- Number of washing machines in the UK is approximately 21 million (approximately 13 million rated A or A+ class under the EU energy label)
- Number of tumble dryers in the UK is approximately 11.5 million
- Number of washer-dryers in the UK is approximately 4.1 million<sup>5</sup>
- It is estimated that washing machines consume 4.5 TWh per annum in the UK
- It is estimated that tumble dryers consume 5.8 TWh per annum in the UK
- From July 2010, the EU Eco-design of Energy using Products (EuP), Lot 14, proposes that minimum standard for washing machines will be A class

Washing and drying appliances have an important role in reducing the environmental impact of clothes cleaning through greater efficiency and low-impact cycle options. The EU Energy Label has been effective in improving efficiencies, with the majority of UK washing appliances now being rated A-class. EuP Lot 14 developments for washing machines are expected to drive improvements in energy efficiency and result in energy saving across Europe of 2 TWh per year by 2020.

The omission of washer-dryers in the EuP studies is an important issue that needs to be addressed, given that they cover approximately a sixth of the UK washing machine market

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<sup>1</sup> [http://www.biggreenswitch.co.uk/around\\_the\\_home/dry-clothes](http://www.biggreenswitch.co.uk/around_the_home/dry-clothes)

<sup>2</sup> Based on 148 drying cycles per year; 2.41 kWh average tumble dryer energy consumption; and 1 kWh = 13 pence

<sup>3</sup> Market Transformation Programme, (2007) Briefing note BNW05: Assumptions underlying the energy projections for domestic washing machines

<sup>4</sup> Market Transformation Program (2008) BNW06: Assumptions underlying the energy projections for domestic tumble dryers

<sup>5</sup> Market Transformation Program "what if tool" (2009)

and just over a quarter of the UK tumble dryer market. Their omission from the EuP process could sideline the development of more efficient models of this appliance type, while manufacturers concentrate on washing machines and tumble dryers.

However, reducing the washing temperature selected by consumers has been shown to save more energy than improvement of washing appliance efficiency (figure 5, in section 4.4.2, showing the difference to be approximately 10 percent, or 0.46 TWh per annum in the UK), so focus should be placed on achieving lower temperature washing in the UK.

## **2.6 Low temperature washing appliances and detergents**

Key UK statistics:

- A UK household carries out on average carry out between approximately 274<sup>1</sup> and 343<sup>2</sup> clothes washing loads per annum
- It is estimated that washing machines consume 4.5 TWh per annum in the UK
- Shift from 2 percent to 17 percent of domestic washes at 30°C in the UK between 2002 and 2007<sup>3</sup>
- From July 2010, the EU Eco-design of Energy using Products (EuP), Lot 14, proposes that minimum standard for washing machines will be A class

Following campaigns on washing at 30°C, 17 percent of UK households claimed to wash at 30°C in 2007, compared to only 2 percent of households in their 2002 survey. Since 2003 a leading consumer products manufacturer has actively marketed a low-temperature wash detergent across Europe, and 27 percent of all its users washed at 30° in 2007, which is twice the average of other leading brands, hence demonstrating that behaviour change may be achievable through effective awareness-raising. Communication should be focused on: save energy, achieve high cleaning performance and support the environment.

For reduced impacts in the short term, the figures indicate that lowering wash temperature would provide large reductions in the impacts of washing, and these could potentially be achieved in a short amount of time if consumers not using 30°C cycles are encouraged to do so.

The research has shown that low temperature detergents have no significantly higher environmental impacts than regular formulations, even when used at the same temperature, and perform better than regular formulations in across many indicators. The evolution of detergent formulations enabling an effective cold wash have not resulted in any environmental or human toxicity trade-offs, and indirectly that misused cold wash formulations do not entail additional environmental burdens, when compared to traditional detergents.

There is evidence that temperature reduction below 30°C might not be feasible, due lack of bleaching, particularly as 30°C programmes in the UK are actually washing clothes at temperatures very similar to 'cold' washes in warmer countries. Development of novel formulations may overcome this problem, but currently the effectiveness of washing at 20°C remains uncertain. There is a need to ensure that washing at lower temperatures produces satisfactory results and is safe.

Using only low temperature programmes routinely may lead to the accumulation of bio-films. Using the correct dose of detergent, leaving the door open between washes and carrying out a service wash at 60°C or steam cleaning cycle are strategies that can be used to prevent bio-films. However there is no independent data to verify the effectiveness of this strategy.

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<sup>1</sup> Market Transformation Program (2006) BNW05: Assumptions underlying the energy projections for domestic washing machines

<sup>2</sup> [http://www.scienceinthebox.com/en\\_UK/research/washabits\\_pop\\_3\\_en.html](http://www.scienceinthebox.com/en_UK/research/washabits_pop_3_en.html)

<sup>3</sup> IPSOS Habits and Practices Studies (2002 and 2007)

Using a servicing regime to reduce bio-films would still result in approximately 10 percent reduced energy consumption, compared to regular 40°C washing.

In consideration of the results, washing at 30°C should be maintained as focus for awareness-raising to reduce washing temperatures, while investigation of the effects of 20°C washing in the UK should be investigated openly, based on up to date data, to reassure the public that it will effectively and hygienically clean clothing.

## **2.7 Detergent form and dosing**

Key UK statistics:

- The following are the sales proportions for the UK detergent market: powders 40 percent, concentrated liquids 4 percent, super concentrated liquids 16 percent, gels 5 percent, tablets 20 percent and liquid tablets 15 percent.

Figure 9, 'Results of LCA of five phosphate free detergents' (see section 4.5.1), shows that compact powder and concentrated liquid detergent formulations perform better than regular powder, powder tablets and liquid tablets when considered across a range of impact indicators. Such results shouldn't be considered as representative of all detergents forms, nevertheless, the analysis indicated that compact powder and concentrated liquid detergents are environmentally preferable, and this is essentially driven by the lower use of chemicals per wash.

Table 4 (see section 4.5.1) demonstrates that there is an opportunity to increase the market share of concentrated detergents in the UK. Improved user information has been developed for packaging already, for example through the A.I.S.E. partnership, so manufacturers and retailers should be encouraged to join this initiative. Issues such as the negative impacts of under-dosing (leading to ineffective cleaning and build-up of limescale in appliance) should also be highlighted.

Further investigation into the impact of detergent chemical makeup, perhaps through further LCA studies, is required in order to develop greater certainty of the benefits of the many detergents available, and any new detergents developed. The use of the EU Ecolabel for detergents as a consumer guide to detergents products with low environmental impact should be recommended, although it is currently available on only a small number of products in the UK.

## **2.8 Key conclusions and summary**

The key conclusions are:

- Wash at 30°C to be encouraged as there is an existing trend and further adoption would reduce environmental impacts significantly. However, the effectiveness of washing at 20°C is uncertain and should be further investigated.
- Encourage the development and validation through independent LCA analysis of detergents with reduced environmental impacts. A concentrated detergent product has been shown to have a lower impact than a less concentrated detergent across a range of environmental indicators; further concentration may therefore provide further environmental benefits.
- Line drying to be promoted, as this would reduce the need for mechanical drying and hence reduce impacts.
- Increasing spin drying efficiency of washing machines to reduce mechanical drying would reduce energy consumption.
- Uncertainties of benefits of anti-crease easycare textiles mean that further research should be conducted to investigate consumer behaviour related to their use, and the extent of heat treatment required to activate anti-crease, in order to be certain of benefits.

- Appliance efficiencies are being driven by EU legislation (EU Ecodesign of Energy Using Products (EuP) and Energy Labelling) and benefits of changing to newer appliances (for wider consumer access to features such as greater spin drying efficiency) in the short term is likely to be small, depending on the impacts of early disposal of the old model.
- The omission of washer-dryers in the EU Eco-design of EuP process may hold back the development of significant proportions of the UK washing and drying appliance markets, as washer-dryers are a commonly purchased appliance in the UK and the market for these may grow with the rise in single-person households.
- The upcoming review of the international standard on clothes labelling (ISO 3758) provides an opportunity to influence both manufacturers and consumers, through encouraging manufacturers to standardise clothes care label terminology and simplify guidance for consumers to promote good practice to achieve environmental benefits. The label should be positioned to be clearly visible to consumers, as stakeholders expressed concern that clothes care labels are currently placed in locations where they may not be noticed and hence are less likely to be used.

## **2.9 Recommendations**

In light of the analysis, results and current policy, the following recommendations are proposed. Four significant routes by which reductions in the environmental impacts of clothes cleaning might be achieved are highlighted: alteration of the characteristics of clothing; developing appliances to reduce cleaning burden; encouraging changes in consumer behaviour to less impactful practice; and editing of choices through regulation or market initiatives.

The objective of these routes is not solely to define precise policy options, but to give some direction to stakeholders on what actions could be considered to reduce the environmental impacts of clothes cleaning.

| Options  | Priority <sup>1</sup> |
|--|-----------------------|
| <b>Supply side: Technology development</b>   |                       |
| Further investigation into clothing that requires less washing, drying and ironing, such as easycare fabrics, to be certain of benefits, and harmonised labelling to increase identification and understanding   | ++ (?)                |
| Design appliances with clearly displayed low-temperature wash and efficient cycle options to aid consumer choice   | ++                    |
| Design appliances that provide information or feedback to the consumer about the energy use, and if possible the added cost due to increased electricity consumption, of the wash cycle they selected  | +                     |
| Encourage manufacturers to fairly price humidity control features in tumble dryers to encourage consumer purchase of appliances incorporating this feature   | +++                   |
| Encourage participation by detergent manufacturers in the International Association for Soaps, Detergents and Maintenance Products (A.I.S.E.) partnership, to benefit from their laundry sustainability projects, and the use of the EU Ecolabel                         | +++                   |
| <b>Demand side: Consumer behaviour and raising awareness</b>   |                       |
| Build on success of 'Wash at 30°C' campaign in promoting lower temperature washing, through widening collaboration on this initiative between industry, regulators and retailers, and promoting strong sustainability and economy-focused marketing at point-of purchase | +++                   |
| Raise awareness of the importance of accurate detergent (over and under) dosing  | +++                   |
| Raise awareness to increase spin speeds, possibly through the 'Wash at 30°C' campaign or A.I.S.E.  | +                     |
| Raise awareness to increase the practice of line drying, through the 'Wash at 30°C' campaign or A.I.S.E., evaluate comfort of clothing after line drying and consider routes to provide line drying equipment free of charge   | +++                   |
| Raise awareness of the EU Ecolabel for detergents  | +++                   |
| Participate in the current ISO 3758 clothes care labelling review to encourage provision of information about use of concentrated detergents and line drying, and to place the label in a more visible position on clothing  | +++                   |
| <b>Policy, law and market instruments: Driving the market and choice editing</b>   |                       |
| Investigate means to encourage installation of clothing washing lines through routes other than the Code for Sustainable Homes, potentially through the Building Regulations or Planning Regulations   | +++                   |
| Pursue the inclusion of washer-dryers and requirement for moisture sensors in the EU Eco-design of Energy using Products process and support appliance efficiency initiatives such as that of the Energy Saving Trust  | ++                    |

<sup>1</sup> These priorities were assigned in light of the researchers' thoughts of the options, in context of their potential environmental benefit, the extent of consumer behaviour change required to action them, and existing initiatives that may provide initial momentum to future actions

## 3 Methods and approach

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The methodology was designed to combine an extensive review of the literature with stakeholder insight and quantitative analysis, to find practical and effective methods to reduce the environmental impact of clothes cleaning.

### 3.1 Task structure

Next figure describes the research structure of the project, which provided a framework for logical and coherent analytical progression.



Figure 3: Analysis schedule

### 3.2 Literature review

The scope of the project was limited to existing information and data in the literature and provided by stakeholders. Therefore, to map the status of existing methods and technologies used in clothes cleaning, and identify relevant technologies to enable reduction of the environmental impact of clothes cleaning, an extensive literature review was conducted. Table 1, and the tables on pages 36 to 38, provide insight into the wide range of technology areas and processes/products investigated. The review also provided context and information to support analysis, to enable the selection and assessment of best options to investigate further, and highlight possible future trends impacting clothes cleaning. Some of this background data is included in the annex, sections 6.4 and 6.5. However, it was agreed that the purpose of this report would be to focus on the analysis of the best options.

A framework to gather data was created, to ensure homogeneity in the data and issues investigated for each technology identified. These allowed effective comparison in the subsequent stages of analysis, and included:

- A description of the technology
- The environmental impacts of the technology
- Market status
- Technical maturity
- Market trends, barriers to growth and opportunities for development
- References and sources

### 3.3 Interim report and stakeholder consultation

Stakeholders were contacted during and post completion of the literature review, to provide further data and insight. This supplemented the information gathered during the literature review, and provided insight to deepen understanding before consideration of recommendations.

An interim report collated the information gathered during the literature review and stakeholder consultation, covering all issues outlined in the project specifications, and provided a basis for progress review and feedback. The report was distributed to all stakeholders and a participative workshop was held to enable stakeholders to review the research, debate the issues face-to-face, comment on the rationale for the choice of the best options for further investigation and provide further evidence and data.

Following the interim reporting stage, due to the large number and variability of technologies identified during the review and, in some cases, lack of sufficient data, it was agreed that analysis of selected “best” options would be the focus of further investigation. These would be the options that had significant potential to reduce environmental impacts and were considered to have a high likelihood of adoption.

### **3.4 Analysis and assessment of best options**

The process of focusing on the most practical and achievable options, or best options, involved several factors of assessment: analysis of the potential to achieve environmental improvement, barriers and opportunities to development (for example, whether the technology required is commonplace and easy for consumers to adopt) and the availability of LCA data to further analyse the option. Information on the remaining options would be summarised for future reference.

The best options were then analysed, using data extracted from existing LCAs and research to estimate the environmental impact and highlight trade-offs. Uptake statistics, such as market trends, were used to extrapolate results to provide an approximated change in environmental impacts of a UK-wide shift to the proposed option, in consideration of opportunities and barriers. The reliability and hence firmness of conclusions were discussed.

### **3.5 Final consultation, recommendations and dissemination**

A final consultation period, involving stakeholder feedback, provided the opportunity for review and input into the final report conclusions, to ensure that assumptions and recommendations were appropriate and applicable in practice. Feedback was collated and fed back into the final report, which includes agreed recommendations for supply and demand side measures, regulatory interventions and suggestion for further work.



## 4 Results

### 4.1 Preliminary technology and options review

Table 1 provides a summary of the technology areas identified during the preliminary review and assessment of options to reduce the environmental impact of clothes cleaning. It describes the processes or characteristics to enable the options and includes a qualitative indication of data available to perform the environmental analysis (data identified during the literature review).

Table 1: Overview of options investigated and qualitative information on data availability

|                                    | Technology area                           | Process or characteristic | Data available to perform environmental analysis |
|------------------------------------|---|---------------------------|--|
|                                    |   |                           | (from +++=much data to +=little data)            |
| <b>Fibres and fabrics</b>          | Common fibre characteristics              | -                         | +++  |
|                                    | Reducing the care impact of common fibres | Bioprocessing             | +  |
|                                    |   | Plasma treatment          | +  |
|                                    |   | Fiber structure           | ++   |
|                                    | Quick-dry                                 | Novel fibre               | ++   |
|                                    | Anti-bacterial                            | Fiber coatings            | +  |
|                                    |   | Fiber treatments          | ++   |
|                                    |   | Novel fibre               | +  |
|                                    | Anti-crease                               | Fiber treatments          | ++   |
|                                    | Anti-stain                                | Nano-structure            | +  |
|                                    |   | Fibre coatings            | ++   |
|                                    |   | Intra-fibre treatment     | +  |
| <b>Garment durability</b>          | Colour fastness to improve dye permanency | -                         | +  |
|                                    | Adhesives                                 | -                         | +  |
| <b>Sustainable building design</b> | Water hardness                            | -                         | ++   |
|                                    | Grey water recycling                      | -                         | ++   |
|                                    | Line drying                               | -                         | ++   |

|   | Technology area                        | Process or characteristic                               | Data available to perform environmental analysis<br>(from +++=much data to +=little data) |
|---|--|---|---|
| <b>Washing and drying appliances</b><br><br>(please see section 6.5 in the annex for further details)   | Washing                                | Vertical axis washing machine                           | ++  |
|   |  | Horizontal axis washing machine                         | +++   |
|   | Drying                                 | Air vented tumble dryer                                 | +++   |
|   |  | Air condenser tumble dryer                              | +++   |
|   |  | Heat pump condenser tumble dryer                        | +++   |
|   |  | Gas-heated tumble dryer                                 | +++   |
|   |  | Drying cabinet with heater, fan and air condenser       | ++  |
|   |  | Drying cabinet with heater, fan and heat pump condenser | ++  |
|   |  | Drying cabinet with heat pump condenser only            | ++  |
|   | Combined washing and drying            | Washer dryer  | ++  |
|   | Early stage technologies               | Polymer pellets (Xeros washing system)                  | ++  |
|   |  | Steam   | ++  |
|   |  | Ultra sound   | +   |
|   |  | Ozone   | +   |
|   |  | Silver ions   | +   |
| <b>Low or non-solvent dry cleaning</b><br><br>(please see section 6.4 in the annex for further details) | Synthetic solvent dry cleaning systems | DF2000 (petroleum based)                                | +   |
|   |  | Green Earth (silicone based)                            | ++  |
|   |  | Rynex (Propylene glycol ether)                          | +   |
|   |  | Pure dry (hybrid solvent)                               | +   |
|   |  | Jet clean – Ipura (hydrocarbon based)                   | +   |
|   |  | Dry solv (n-propyl bromide)                             | +   |
|   | Water based systems                    | Generic water systems                                   | +   |
|   |  | Green Jet   | +   |
|   |  | Icy water   | +   |
|   | CO <sub>2</sub> based systems          | Generic CO <sub>2</sub> systems                         | +   |
|   |  | Solvair (CO <sub>2</sub> and solvent mix)               | +   |

The following summary tables (pages 36-38) describe the assessment of the technology areas. They include description of the environmental benefits, trade-offs, conditions to achieve benefits and feasibility of the options, and the rationale for deciding on those options we took further (shaded cells) and those we withdrew from further consideration. The availability of data to perform environmental analysis, as described in table 1 above, was also an influence during the selection of options.

The areas chosen for further analysis include:

- Anti-crease fabrics, as they have a high probability of consumer acceptability; consumers will simply need to iron less. Ironing is thought to be the clothes cleaning activity consumers dislike the most, so initiatives to reduce this may have a good probability of success.
- Line drying of clothes, as this is a low cost option which is likely to be acceptable to consumers (although it involves some additional effort). As machine drying has a large environmental impact, significant benefits could be gained through reducing the use of tumble dryers.
- Appliances – efficiency, spin drying efficiency and low temperature washing. Maximising spin drying efficiency to reduce subsequent mechanical drying could result in significant benefits and is unlikely to prove a challenging change in behaviour for consumers. However, this option requires appliances that feature these options.
- Washing at 30°C, as this is already being promoted, and there could be opportunities to encourage this practice without significant change to behaviour for those with washing appliances that have a 30°C wash cycle.
- Detergent dosing, as consumer over-dosing or under-dosing could add to the impacts of clothes cleaning.

| Area               | Technology group                          | Potential benefit  | Conditions for environmental benefits  | Feasibility  | Trade-off   | Decision   |
|--------------------|---|--|--|--|---|--|
| Fibres and fabrics | Characteristic of common fibres           | Reduced requirement for washing, drying or ironing                   | Encouragement of fabric manufacturers and retailers to maximise the selection of fibres that enable reduced impacts: Consumers may need to sort clothes by fibre type before washing and tumble drying to achieve impact reductions. | Reduction in impact may be marginal. Difficult to assess which fibres provide the best balance of characteristics. Sorting of clothes into fibre types before cleaning may be problematic. Need to educate consumers about fibre properties and care. Eco-labelling schemes could be of benefit, but are costly to implement. Fashion and economy are priorities for consumers, over sustainability benefits, and likely to continue to drive the market | Use of only those fibres that have low clothes cleaning impacts would limit choice during fabrication/purchase of clothing to certain fibres                    | Not to be investigated, as not sufficiently beneficial to warrant further investigation. Also difficult to drive market or restrict consumer choice                                  |
|                    | Reducing the care impact of common fibres | Reduced requirement for washing, drying or ironing                   | Fibre treatments alter the characteristics of fibres to change their physical properties and maximise those characteristics that reduce the cleaning burden  | The treatment processes covered are not commonly used for this purpose. Reduction in impact may be marginal. Sorting of clothes into fibre types may be problematic. Need to educate consumers about fibre properties and care. Hard to assess, due to lack of data on treatment processes and on extent to which these are able to alter fibre characteristics  | Would limit choice during fabrication/purchase of clothing to products containing those fibres, and there may be detrimental impacts due to treatment processes | Not to be investigated, as not sufficiently beneficial to warrant further investigation. Also difficult to drive market or restrict consumer choice                                  |
|                    | Quick dry                                 | Less energy used during drying                                       | Reduced impact through faster drying, as fibres are less absorbent. Quick drying clothes would need to be separated before tumble drying, to get maximum benefit   | These products are commonly available and benefit would not require change in consumer behaviour when line drying. Sorting of clothes into fibre types may be problematic  | Would limit choice during fabrication/purchase of clothing to products containing those fibres, and there may be detrimental impacts due to treatment processes | Separating clothes is not likely to be an attainable consumer behaviour change; assessing the trade off when using a humidity sensor is not possible due to lack of manufacture data |
|                    | Anti-bacterial                            | Reduced frequency of washing (hence also reduced drying and ironing) | Reduced bacterial growth (and reduced odour) could lower the frequency of clothes washing. Success is heavily dependent upon consumer behaviour  | Consumer behaviour very hard to change - consumers value freshness and not reduced bacterial - unlikely to reduce frequency of washing, particularly as anti-bacterial garments are likely to be mixed in with regular garments in practice in the domestic environment. Are starting to be used widely by military and healthcare sectors   | Would limit choice during fabrication/purchase of clothing to products containing those fibres, and there may be detrimental impacts due to treatment processes | Not to be investigated, as not sufficiently beneficial to warrant further investigation. A potential area for future development and further research                                |
|                    | Anti-crease                               | Less energy used during ironing                                      | Some of the treatments require tumble drying of garment to function properly   | Consumer will simply need to iron less. Ironing thought to be the clothes cleaning activity consumers dislike the most, so initiatives to reduce this may have a good probability of success   | Would limit fabrication/purchase of clothing to certain products, and there would be detrimental impacts due to treatment processes and at end of life          | No significant behaviour change is needed; to investigate further. Simplified LCA to assess the impacts of anti-crease treatments compared to reduce ironing benefits                |
|                    | Anti-stain                                | Lower washing impacts  | Less staining, therefore easier to wash, hence less impactful. Success is heavily dependent upon consumer behaviour  | Consumer behaviour very hard to change - unlikely to reduce frequency of washing, particularly as anti-stain garments are likely to be mixed in with regular garments in practice in the domestic environment  | Would limit fabrication of clothing to certain products, and there may be detrimental impacts due to treatment processes  | Not to be investigated, as not sufficiently beneficial to warrant further investigation  |

| Area                        | Technology group               | Potential benefit  | Conditions for environmental benefits   | Feasibility  | Trade-off  | Decision  |
|-----------------------------|--------------------------------|--|---|--|--|---|
| <b>Garment durability</b>   |                                | Reduction in the overall impact of the clothing                            | Clothes kept for longer. Success is heavily dependent upon consumer behaviour   | Fashion is a far greater consumer purchasing priority than the potential environmental benefits of more durable clothing, and ensuring all garment manufacturers improve the quality of their products is unfeasible | Would limit fabrication/purchase of clothing to certain products, and there may be detrimental impacts due to finishing processes  | Insufficient evidence of benefit to warrant further investigation and barrier of behaviour change     |
| <b>Sustain. home design</b> | <b>Reducing water hardness</b> | Less detergent needed to neutralise hardness. Greater appliance efficiency | Installation of water softening equipment and some maintenance by consumer. Maintain maximum appliance efficiency by stopping mineral build-up on appliance's internal surfaces | Costly to install water softeners and hardness already neutralised through additives to detergents; some consumer upkeep may be required   | The impacts of the manufacture of water softening system and its maintenance   | Not to be investigated, due to cost and existing measures to neutralise water hardness                |
|                             | <b>Greywater systems</b>       | Reuse of washing machine water; less potable water consumed                | Installation of greywater system, connecting a drainage system to the washing appliance. Some additional steps in the washing process for the consumer to take                  | Complex and costly to set up; some consumer upkeep required. Evidence that use of greywater increases environmental impact and that it is more cost effective to save water than to reuse grey water <sup>1</sup>    | The impacts of the manufacture of greywater drainage equipment   | Not to be investigated, due to cost and potential increased environmental impact                      |
|                             | <b>Line drying</b>             | Reduced energy consumption, as mechanical drying reduced                   | Installation of line drying equipment. Outdoor line drying provides maximum benefit as ambient heat energy used in indoor line drying. Change in behaviour may be required      | Outdoor line drying dependant on the weather and having space, indoor line drying reliant on space and means of ventilation. Relies on some change in consumer behaviour, as many use tumble dryers                  | Loss of heat from households when ventilating indoor drying areas (to prevent damp). Increased ironing when not tumble dried. Reduced comfort of clothes when not line dried in a breeze | To investigate further; simplified LCA to assess the impact of line drying compared to tumble drying. |

<sup>1</sup> Crettaz, P., Joliet, O., Cuanillon, J.-M. and Orlando (1999) Life Cycle of assessment of drinking water and rain water for toilet flushing. Aqua 48(3), pp.73-83

| Area   | Technology group                                 | Potential benefit   | Conditions for environmental benefits   | Feasibility   | Trade-off   | Decision   |
|--|--|---|---|---|---|--|
| <b>Appliances</b><br><br>(please see section 6.5 in the annex for further details)   | <b>Washing (and combined washing and drying)</b> | Spin cycle could remove more water, therefore less drying required and energy saved | Higher-speed spin, longer spinning cycle and greater drum diameter; may require re-design of appliance control mechanism, and new appliance for larger drum       | There may be scope for consumers to be encouraged to maximise the spin speed to reduce subsequent drying impact. Issue of cost to consumer of purchasing new appliance. Market is already following a path toward greater energy efficiency (EuP, energy labelling) | Potential damage to appliance or clothing if continually used at maximum spin speed? Could cause more creasing and hence require more ironing                                 | To be investigated; simplified LCA to assess the impact of increased spin speed and subsequent reduction in drying impact                    |
|  | <b>Drying</b>                                    | Greater efficiency results in less energy used by appliance                         | More efficient appliance; requires no change in consumer behaviour  | Issue of cost to consumer of purchasing new appliance. Market is already following a path toward greater energy efficiency (EuP, energy labelling)  | The impacts of the manufacture of new appliance   | To be investigated; simplified LCA to assess the comparative impacts of established and new dryer technology                                 |
| <b>Dry cleaning</b><br><br>(please see section 6.4 in the annex for further details) |  | Low impact solvent  | Selection of dry cleaning establishment that uses equipment with low impact solvent   | Limited availability of new processes using low impact solvents and high capital costs to set them up pose significant barriers   | Effectiveness of the cleaning process and the impacts of the manufacture of new equipment   | Limited LCA data to compare dry cleaning alternatives. Not sufficiently feasible to warrant further investigation                            |
| <b>Detergents</b>  | <b>Wash at 30°C</b>                              | Reduced energy consumption  | Washing appliance that has a 30°C wash cycle and detergent that is effective at 30°C; requires consumer purchase of the detergent and selection of the 30°C cycle | Feasible, as long as the washing appliance has a 30°C wash cycle  | Premium products are more costly; communities of bacteria and fungi may build up on the internal surfaces of the washing machine under persistent damp conditions (bio-film). | To be investigated; simplified LCA to assess the impact of reduced wash temperature and impacts compared to a traditional scenario           |
|  | <b>Dosing</b>                                    | Less detergent used, less detergent residue in the environment                      | Awareness and understanding of consumer to accurately dose the detergent; a packaging or information system to enable this  | Has been developed on packaging already. Greater complexity in packaging changes may be reflected by higher detergent price   | Packaging potentially more complex, harder to recycle and hence has a greater impact  | To be investigated; simplified LCA to assess impacts of incorrect dosage and means of ensuring correct dosage if novel packaging is required |

## 4.2 Fibres and fabrics

Different fabrics, produced from different fibre mixes and woven in particular patterns, have varying performance characteristics, such as resistance to soiling, resistance to creasing, water absorption and anti-bacterial properties. There are also many easycare fabrics, a term used to describe fabrics that have some sort of particular physical or manufactured characteristic that reduces the care required by clothes, through resistance of odours, stains or crease. There is no standardised performance for easycare clothing, and the terminology is used loosely to cover a wide range of fabrics.

The 'advanced' textiles market contains a high number and variety of technologies, many having protected status, and constitutes a relatively small portion of the textile used clothing for the consumer market. Some of these advanced textiles use nanomaterials, such as silver, titanium dioxide and zinc oxide, to create an anti-microbial and selfcleaning layer over fibres, effectively reducing odour and the requirement for frequent washing. These nanomaterials materials possess enhanced catalytic abilities due to their highly stressed surface atoms, which are very reactive. With the use of nano-sized particles, the number of particles per unit area is enormously increased. Promotion among fashion designers might help to increase the penetration of these advanced textile products into the mainstream. But other drivers are unlikely to have much effect in an area where people's choices tend to be swayed by fashion.

Issues may arise at the disposal or end of life stage with coatings and treatments that have been applied to fibres or fabrics, to give them the various properties, as discussed above. Results from Defra research project 'Maximising the re-use and recycling of UK Clothes and Textiles' highlight the legislative and practical issues associated with trade in second hand clothing and final disposal. When recycling fibres or disposing of clothing after use through landfill or incineration, materials added at the production stage may pose toxicological or other environmental impacts. The recently published Royal Commission on Environmental Pollution report *Novel Materials in the Environment: The case of nanotechnology*<sup>1</sup> concludes that there may also be safety implications when using nanotechnology, other than from manufacture impacts or end of life disposal, and that these need to be further quantified on a case by case basis.

Some of the easycare and advanced fabrics would rely on reduced frequency of clothes cleaning, to gain any environmental benefits. However, technology that aims to reduce environmental impacts through reduced frequency of clothes cleaning is likely to fail in those aims, as changing consumer behaviour in this respect has been shown to be highly inflexible, with priorities of freshness and hygiene. For example, anti-bacterial treatments have a comparatively well-established market presence but market research data shows that drivers for these products are not related to sustainability priorities, but are related to freshness.

As the majority of smart fibres were considered unlikely to significantly reduce the environmental impacts of clothes cleaning, they were not analysed in depth. Nevertheless, anti-crease fabrics were investigated in detail due as using anti-crease was considered a feasible approach to reduce the need to iron. Please see the table on page 36 for a background summary and explanation of why this area was investigated, and why the others were not taken further.

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<sup>1</sup> Royal Commission on Environmental Pollution (2008) *Novel Materials in the Environment: The case of nanotechnology*

## 4.2.1 Anti-crease fabrics

### - *Benefits and potential trade-offs*

These fabrics remove, or at least reduce, the amount of ironing required to achieve a crease-free finish on a garment. One of the benefits of anti-crease fabrics in achieving environmental benefits is that they do not require significant change in consumer behaviour, only that consumers iron for a shorter time. Ironing consumes an estimated 1.5 TWh per annum in the UK<sup>1</sup>.

Anti-crease properties are achieved through use of chemicals that cross-link cellulose fibres. This creates bonds that limit the deformation of the fabric to reduce creasing. Typical chemicals used in anti-crease finishing treatments include urea-formaldehyde prepolymers, melamine or glyoxal derivatives<sup>2</sup>. As with other finishing treatments, residual chemicals in the treated anti-crease fabrics may be detrimental to the environment, as they can be highly toxic substances, particularly when disposing of the anti-crease fabric at end of life.

Assuming that 140 g/kg of cross-linking agent is needed<sup>3</sup> to finish a shirt, and that ironing consumes 0.75 kWh/h, the next table presents break-even points between the impacts of finishing a 250g shirt with anti-crease treatment, and the impacts of ironing it for 1 minute. In other words, these results show the number of minutes of ironing an anti-crease shirt needs to save, compared to a regular shirt, in order to recover the impacts of the anti-crease finish.

Table 2: Break-even factor between reduced ironing benefits and impacts of anti-crease finishing<sup>4</sup>

| Environmental impact  | Break-even factor - number of minutes of avoided ironing required to recover impacts of anti-crease finish |
|-----------------------|--|
| Primary energy        | 16   |
| Acidification         | 14   |
| Climate change        | 12   |
| Ozone layer depletion | 68   |
| Human toxicity        | 24   |
| Aquatic eco-toxicity  | 43   |
| Eutrophication        | 26   |

The figures show that primary energy, acidification and climate change impacts of the finishing treatment can be recovered in a few minutes of avoided ironing. The figures also show that for some environmental impact categories, such as ozone layer depletion and aquatic eco-toxicity, the impacts due to additional finishing could potentially be more difficult to recover. These estimates are clearly based on very rough assumptions and should be interpreted with care, as no quantitative evidence on consumer behaviour has been identified to give an indication of the likely practical effect of anti-crease finish on the duration of ironing.

### - *Extrapolation to UK scale: national savings potential*

Due to lack of consumer data on ironing practice and market data on easycare products, extrapolation to the UK scale for these benefits is not feasible.

<sup>1</sup> Market Transformation Programme (2008) IBNW24: Innovation Briefing Note on domestic laundry drying products

<sup>2</sup> Lacasse K., Bauman W., Textile chemicals, Environmental data and facts

<sup>3</sup> Data given by a finishing chemical manufacturer (Huntsman), for a moist crosslinking process with dimethyldihydroxy ethylene urea (DMDHEU) which has been modelled as formaldehyde urea due to unavailable life cycle inventories.

<sup>4</sup> See annex, section headed "Simplified assessment of ironing and anti crease treatment", for calculation assumptions



#### - **Barriers and opportunities**

Ironing is thought to be the clothes cleaning activity that consumers dislike the most<sup>1</sup>, so initiatives to reduce are likely to have a high probability of achieving uptake. However, anti-crease finishes have a negative effect on the tensile strength of fabric, therefore they are typically applied to heavier weight fabrics, such as menswear, which have been popular. These treatments appear to be less popular for womenswear, where customer dislike of the aesthetics seems to outweighing the advantage of easy care properties. Womenswear is also typically made from much lighter weight fabric and are inherently weaker, hence not always suitable for these finishes<sup>2</sup>.

Anecdotal evidence, provided at the stakeholder workshop, claimed that some anti-crease fabrics also require heat treatment (tumble drying) to function effectively, potentially negating the savings made through avoided ironing. Furthermore, outdoor line drying may reduce the ironing required for untreated clothing in any event (as breezes soften the fabric and release wrinkles), hence increased line drying might reduced the value of anti-crease in reducing environmental impacts. These factors have not been considered in the simplified model above and the results, which may be an overestimate of the benefits of anti-crease, should be evaluated in consideration of these complexities. A full LCA covering the entire anti-crease finishing processes and quantification of subsequent reductions in ironing achieved by consumers would be needed to make more robust analysis, including an assessment of the consequences of the finishing treatment chemicals at end of life disposal of the garment.

### **4.3 Sustainable building design**

Designing or retro-fitting particular building features could provide consumers with more sustainable clothes cleaning options and encourage them to change their normal behaviour patterns.

For example, mineral deposits that are present in hard water supplied to a building can build up on the surface of heating elements or within piping, affecting appliance efficiency and can also impair effective clothes cleaning. It is claimed that limescale causes wasted electricity and gas, as heating elements become increasingly ineffective, and that approximately 1mm of limescale can decrease the efficiency of a gas boiler by 10 percent<sup>3</sup>. Detergents contain chemicals that neutralise water hardness, so the effect on washing appliances will be less severe<sup>4</sup>, however incorrect dosing may lead to limescale build-up. No quantified data on the effect of limescale on washing appliance efficiency was identified. Systems that are claimed to soften water without chemical input are also available on the market<sup>5</sup> and the impact of limescale will vary according to the local hardness of water.

Water hardness was not assessed in detail, but other initiatives, such as the UK Code for Sustainable Homes, were considered further. Please see the table on page 37 for a background summary and explanation of why line drying was investigated, and why other areas were not taken further.

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<sup>1</sup> Defra (2008), Public Understanding of Sustainable Clothing

<sup>2</sup> Source: Leading clothing retailer

<sup>3</sup> <http://www.hydroflow.com/hs38.html>

<sup>4</sup> [http://www.washerhelp.co.uk/limescale\\_2.html#cl\\_q1](http://www.washerhelp.co.uk/limescale_2.html#cl_q1)

<sup>5</sup> <http://www.britishgas.co.uk/pdf/HydroFlow.pdf>

### 4.3.1 Line drying of clothes

#### - **Benefits and potential trade-offs**

Energy is needed to dry wet clothes whether or not an appliance is used. According to the Market Transformation Programme at least 2.4 kWh is needed to dry a 5 kg laundry load 60 percent wet, in a tumble dryer. No other energy source is needed when the laundry is dried on an outside clothes line besides direct sun or wind, or in a unheated or heated room, where residual heat is provided (i.e. heat would be wasted in any case). Line drying can therefore limit the impacts of the drying stage. Line drying features are not expensive to install and line drying is already a common behaviour, with 70 percent of UK consumers claim to 'always' or 'often' line dry outdoors during the summer<sup>1</sup>.

Consumer advice websites such as *Big Green Switch* provide explanations of the issues and practice of line drying, including some quantification of the environmental impacts of line drying, tips to ensure the most efficient drying techniques and guidance for situations where line drying is only possible indoors. A typical tumble dryer cycle emits 1.5kg of CO<sub>2</sub>, therefore a household doing four washes per week and using the tumble dryer for every wash would emit 312kg of CO<sub>2</sub> and save £30 of electricity per annum<sup>2</sup>.

It is preferable to line dry clothing outdoors, both to use energy from the sun and take advantage of breezes that will reduce stiffness in clothing to make them feel more comfortable. There is anecdotal evidence that line drying gives clothing a 'fresh' smell, which is valued by consumers. The weather in the UK could present a problem for outdoors line drying, with an average 150 days of rain a year in the driest areas to just over 200 days in the wettest areas<sup>3</sup> (although it may be possible to dry clothes outside when it rains for part of the day), and this does not account for the days without rain but with temperatures too low to dry clothes. There are however garments and home textiles that require a heat treatment to maintain performance, or give best appearance, which may not be suitable for line drying

Indoor line drying uses energy generated by central heating, can lead to stiff clothing and can cause damp problems if the drying space is not ventilated adequately. Although Part F of the Building Regulations<sup>4</sup> required ventilation in dwellings, to provide fresh air, additional ventilation to compensate for the build up of humidity from clothes drying may lead to loss of heat in the home and hence wasted energy. Heat exchangers may be able to reduce this loss<sup>5</sup>, but would require additional cost.

<sup>1</sup> PriceWaterhouseCoopers (2009) Ecodesign of Laundry Dryers Preparatory studies for Ecodesign requirements of Energy-using-Products (EuP) – Lot 16, Draft final Report

<sup>2</sup> <http://www.biggreenswitch.co.uk/aroundthehome/Dry-clothes-natural-way/article-927687-detail/article.html>

<sup>3</sup> [http://www.metoffice.gov.uk/education/secondary/students/bi\\_climate.html](http://www.metoffice.gov.uk/education/secondary/students/bi_climate.html)

<sup>4</sup> [http://www.planningportal.gov.uk/uploads/br/BR\\_PDF\\_ADF\\_2006.pdf](http://www.planningportal.gov.uk/uploads/br/BR_PDF_ADF_2006.pdf)

<sup>5</sup> <http://www.energysavingtrust.org.uk/business/Business/Building-Professionals/Helpful-Tools/Hard-to-treat-homes/Matrix/Heat-recovery-room-ventilators>

- **Extrapolation to UK scale: national savings potential**

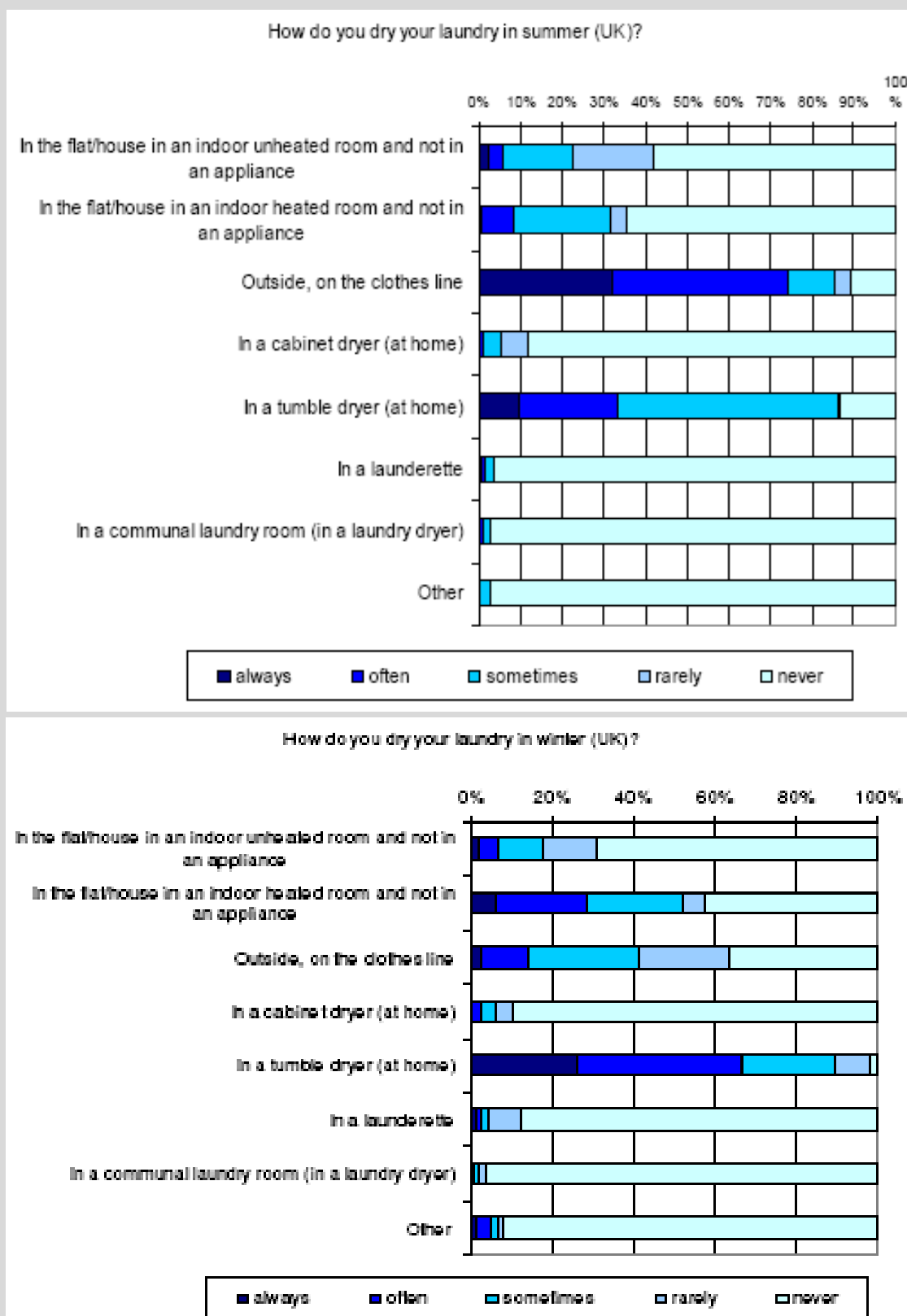


Figure 4: UK laundry drying practice in the summer and winter<sup>1</sup>

<sup>1</sup> PriceWaterhouseCoopers (2009) Ecodesign of Laundry Dryers Preparatory studies for Ecodesign requirements of Energy-using-Products (EuP) – Lot 16, Draft final Report

According to the Energy Saving Trust<sup>1</sup>, 32 percent people use their tumble dryers when the washing line could be used. This habit is again demonstrated in Figure 4, above, which shows that many UK consumers are claiming to line dry their clothes outdoors in the summer, but over 30 percent always or often use a tumble dryer in the summer. However, Figure 4 also shows that in the winter few manage to dry their clothes outside. The data indicates that there is potential to increase outdoor line drying, particularly during summer. Assuming that tumble dryers are used 148 times per annum in the UK, that line drying can be done for half of every year, and that 32 percent of consumers who do not line dry during this period change their habits (and use a clothes drying line), this would give energy savings of 0.9 TWh<sup>2</sup> per annum in the UK. A UK household might expect to save approximately £23<sup>3</sup> per annum.

- **Barriers and opportunities**

The UK's Code for Sustainable Homes includes provision and credit under its point system for line drying space<sup>4</sup>. The Code's technical guide<sup>5</sup> states that indoor drying space is likely to be limited to rooms such as bathrooms and utility rooms and that they must comply with Building Regulations Approved Document F – Ventilation (2006)<sup>6</sup>. However, the Code only became operational on a voluntary basis in April 2007 and only affects new UK housing. Due to the time taken to design, plan and build a house, there are not many Code homes built as yet (information on changes in clothes cleaning habits due to building design not yet available).

A regulatory impact assessment of the Code in 2006<sup>7</sup> predicted 200,000 new houses by 2014. Assuming that 80 percent of these would have line drying features, which encouraged an estimated 50 percent of residents to reduce the frequency of tumble drying by 50 percent (to 74 times per annum), the Code homes line drying features would result in a saving of approximately 14 GWh per annum in the UK in 2014. This is a small figure compared to the national saving potential and indicates that the Code will not significantly reduce impacts.

Questions have also been raised over the functionality of line drying. Concerns that line drying within the home may lead to a stiff and uncomfortable feel of clothing were raised at stakeholder workshops. Furthermore, some garments and home textiles require a heat treatment to maintain performance or give best appearance, often best achieved by hot tumble drying. These include men's washable suits (where ironing may result in glazed seams and reduce the life), low-iron anti-crease garments (see section 4.2.1 above) and water repellent or stain repellent garments (which require a heat treatment to regenerate performance)<sup>8</sup>. Therefore, not all clothing may be suitable for line drying.

Thus, the wider factors that motivate or deter householders to line dry their clothes need to be investigated in greater detail.

<sup>1</sup> Energy Saving Trust, Habits of a lifetime, European Energy Usage Report

<sup>2</sup> See annex, section headed "Simplified assessment of line drying of clothes", for assumptions

<sup>3</sup> Based on 148 drying cycles per year; 2.41 kWh average tumble dryer energy consumption; and 1 kWh = 13 pence

<sup>4</sup> [http://www.planningportal.gov.uk/uploads/code\\_for\\_sustainable\\_homes\\_techguide.pdf](http://www.planningportal.gov.uk/uploads/code_for_sustainable_homes_techguide.pdf)

<sup>5</sup> Code for Sustainable Homes: Technical guide - October 2008  
<http://www.communities.gov.uk/publications/planningandbuilding/codeguide>

<sup>6</sup> [www.planningportal.gov.uk/england/professionals/en/1115314110382.html](http://www.planningportal.gov.uk/england/professionals/en/1115314110382.html)

<sup>7</sup> Communities and Local Government (2006) Proposals to introduce a Code for Sustainable Homes - Regulatory Impact Assessment – December 2006:

<http://www.communities.gov.uk/publications/planningandbuilding/proposalsintroduce>

<sup>8</sup> Reference: Industry expert

## 4.4 Washing and drying appliances

Washing and drying appliances' performance are important factors in clothes cleaning, as their water and energy efficiency can significantly reduce the environmental impacts of clothes cleaning.

The main washing and drying technologies have been reviewed, including washing machines, tumble dryers and washer-dryers, as well as many other novel clothes cleaning technologies such as listed in table 1 (see section 4.1). These novel technologies were found to have either a low market share, or are currently under development. They were considered to have less potential to affect wide-ranging environmental benefits in the short-to-medium term, therefore were not investigated in detail (see annex section 0 and 0 for further details and description of novel technologies and their impacts).

The horizontal axis washing machine, which dominates the UK market, offers the most efficient currently available option for washing clothes. Vertical axis energy consumption is generally greater than 0.39 kWh/kg and water consumption around 20 litres/kg<sup>1</sup>. Typical horizontal axis washing machines use 0.19 kWh/kg and 8 litres/kg<sup>2</sup>. Its efficiency has been improved significantly over the last 13 years through technical improvements driven by the European energy labelling scheme. Further potential enhancements have been identified by the EU Eco-design of energy using products process preparatory studies and it is expected that these will be incorporated into new models in the next two or three years as manufacturers respond to the challenges of an upgraded energy label that is expected to be introduced in the coming months.

The heat pump condenser tumble dryer is the most efficient available option for drying clothes (after outdoor line drying) with energy consumption of 0.34 kWh/kg<sup>3</sup>, while air condenser dryers consume 0.56 kWh/kg<sup>4</sup>. Now that key patents have expired on the heat pump condenser design, market competition should spur further developments and lower prices to make this a realistic alternative to existing less efficient designs.

Please see the table on page 38 for a background summary and explanation of why the options analysed in 4.4.1 were selected, and annex section 6.5 for further details of technologies not investigated.

### 4.4.1 Washing appliance spin speed

#### - *Benefits and potential trade-offs*

Spin drying efficiency varies from one washing machine to another, depending on the spin speed, the duration of the spin and the diameter of the drum. In this analysis we review the potential benefits of increased spin speed, using maximum spin speed<sup>5</sup> figures, as this is considered the most straightforward means for consumers to increase spin drying efficiency (assuming that a greater spin speed is available). The current UK average selection for spin speed is 1062 rpm<sup>6</sup>, but this is far from the maximum available on UK washing appliances of approximately 2000 rpm.

Spin drying clothes in a washing appliance is a far more energy efficient method of removing

<sup>1</sup> Source: Leading appliance manufacturer - vertical axis washing machine specifications

<sup>2</sup> Source: Leading retailer - horizontal axis washing machine specifications

<sup>3</sup> Source: Leading retailer - heat pump condenser tumble dryer specifications

<sup>4</sup> Source: Leading retailer - air condenser tumble dryer specifications

<sup>5</sup> Washing appliance manufacturers are legally bound to ensure that the maximum spin speed, which is always the quoted spin speed on the energy label, is held for at least one minute during the spin cycle.

<sup>6</sup> ISIS (2007) Preparatory Studies for Eco-design Requirements of EuPs, LOT 14: Domestic Washing Machines and Dishwashers

water from textiles than heated tumble drying. The table below shows the residual moisture content (RMC) typically obtained with various spin speeds with cotton and synthetic textiles<sup>1</sup>. It also shows how RMC relates to the energy label spin drying performance class and the energy savings that could be achieved on subsequent tumble drying. Increasing spin speed provides more potential benefits for cotton loads than synthetics as cotton tends to retain more water.

Table 3: Energy saving on drying due to increase spin speed<sup>2</sup>

| Energy label spin drying performance class | Approximate Spin speed (rpm) | Cotton RMC | Synthetics RMC | Expected energy saving on drying compared to C class spin drying performance (%) |
|--|------------------------------|------------|----------------|--|
| A  | 1600                         | 45         | -              | 29   |
| B  | 1400                         | 50         | -              | 21   |
| B  | 1200                         | 54         | -              | 14   |
| C  | 1000                         | 63         | -              | 0  |
| Not applicable                             | 800                          | -          | 40             | 37   |
| Not applicable                             | 600                          | -          | 50             | 21   |

The Energy Saving Trust calculates<sup>3</sup> that a shift from 1200 rpm to 1500 rpm could result in savings of 0.3 kWh per cycle, which is in line with these estimates. However, there are potential trade-offs associated with this option, as higher speed spinning puts more stress on the appliance, potentially causing damage and lowering its lifetime. Subsequent repair or replacement might offset these benefits; however these eventualities were not assessed in the study.

**- Extrapolation to UK scale: national savings potential**

There is currently an estimated base of 15.7 million tumble dryers (including washer-dryers) in the UK. According to the Market Transformation Programme (MTP), tumble dryers are used 148 times per annum on average in the UK. With average energy consumption of 2.51 kWh per cycle in 2007, this gives a total UK energy consumption of 5.8 TWh in 2007. Annual benefits of increasing the average spin speed of washing appliances at the UK level are presented hereafter. This analysis supposes that half of the washing loads are composed of cotton, with the other half being composed of synthetics, and that all appliances are equipped with a moisture sensor or that timer controlled appliances are correctly used.

<sup>1</sup> Again, please note that spin speed and RMC are inversely proportional but the relationship varies from one washing machine to another, also depending on the duration of the spin and the diameter of the drum.

<sup>2</sup> It is assumed that the moisture content in the clothing before drying is the same as that after washing, i.e. no moisture loss due to evaporation between the two processes. The energy savings were calculated using a formula taken from the EuP Lot 16 study. The relationship given between spin speed and residual moisture content is only an estimate as it varies from machine to machine.

<sup>3</sup> Market Transformation Program, <http://www.mtprog.com/>

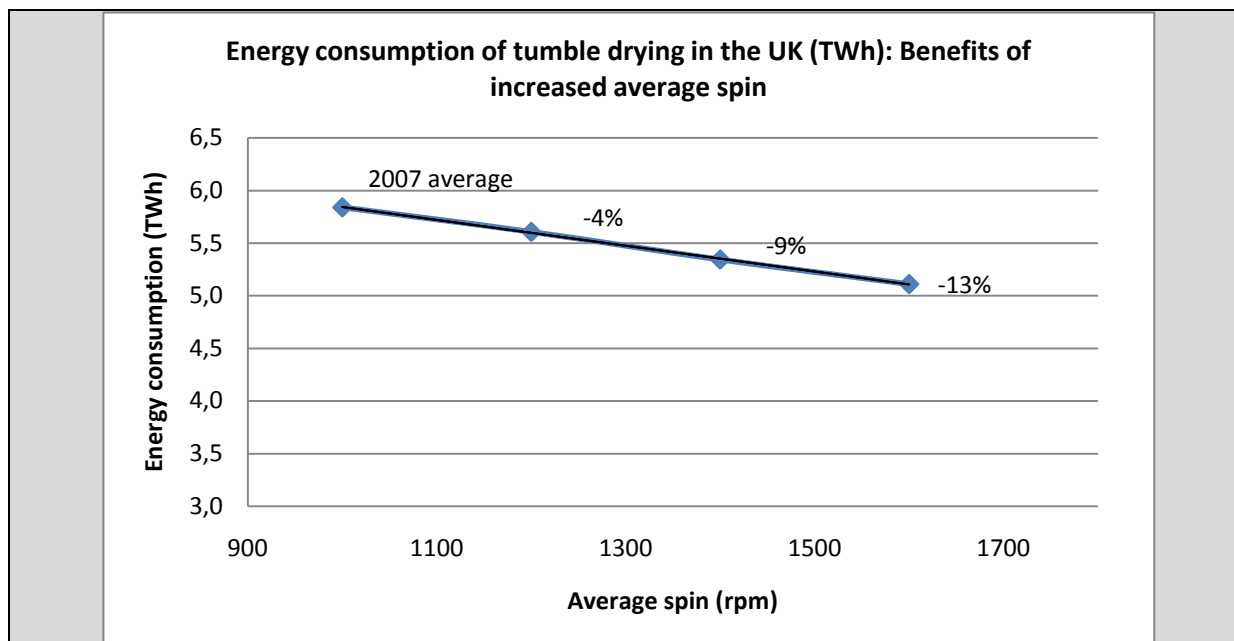


Figure 5: Per annum benefits of increasing average spin speed in the UK

#### - **Barriers and opportunities**

These benefits can only be achieved if the drying time in a tumble dryer is optimised. Some timer controlled tumble dryers indicate how long to dry a capacity load for and give different options according to the spin speed of the washing machine. In such cases, the user really would need to be pro-active and interested in reducing drying times to reap the benefit of higher washing machine spin speeds. Machines equipped with a moisture sensor make the correction automatically<sup>1</sup>. The EU Energy Label does not specifically promote sensor-equipped dryers in favour of timer-controlled dryers. However, a C-rated dryer may qualify for the UK Energy Saving Recommended scheme if it has a moisture sensor<sup>2</sup>. Recent appliances are often equipped with such device, but cost an estimated extra £50 to £100 more than timer controlled machine. The Eco-design of Energy using Products Lot 16 report states that humidity control features (a moisture sensor) in tumble dryers would cost approximately £17 to £43 (although the combination of heat pump dryers and humidity control may be too expensive)<sup>3</sup>, so the increase in appliance price may not reflect the true cost to manufacturers of installing a moisture sensor. There may be an opportunity to encourage all manufacturers to install such a device in tumble dryers, where practicable, to reduce prices and improve energy efficiency.

Slower spin speeds means that washing machines are cheaper, quieter, more stable and potentially last longer, as mechanical pressure on bearings, motors and suspensions are lower. Additionally, figures show that the difference in post-cycle clothing moisture content between a 1200 and 1400 rpm washing machine is low. Normally only cottons are spun at the top speeds, while most other fabrics would be likely to be spun at similar speeds, regardless of the washing machine's maximum available spin speed.

According to a leading UK retailer<sup>4</sup>, 2500 tumble dry cycles are needed for consumers to gain real economic benefits, through electricity savings on drying, from higher spin cycles in washing machines. Using these figures, and assuming that a UK household carries out 148 tumble dry cycles per annum, pay-back would take just under 17 years. However, the Energy

<sup>1</sup> Or alternatively if people adjust the drying time following increased spin speed.

<sup>2</sup> A moisture sensor is not required for ESR status if the energy label of the appliance is A or B.

<sup>3</sup> PricewaterhouseCoopers (2009) Preparatory studies for Ecodesign requirements of Energy-using-Products (EuP) – Lot 16: Final Report. Assumption: £1 = €1.17

<sup>4</sup> <http://www.whitegoodshelp.co.uk/wordpress/washing-machine-spin-speed-efficiency-figures-and-drying-costs/>

Saving Trust has estimate that buying a 1500 rpm spin washing machine, compared to a 1200 rpm model, will result in 0.3 kWh energy saving per cycle. During the average lifetime of the washing machine (12 years<sup>1</sup>) the consumer might hope to save approximately £70<sup>2</sup>, if using the higher spin speed for every wash cycle. An increase in cost to a consumer for an appliance with maximum spin speed of 1600 rpm, compared to a 1200 rpm model, was estimated at approximately £26 in 2007<sup>3</sup> and this saving might provide a strong enough incentive to purchase the more efficient machine. However, the saving would be significantly reduced if the washing machine were to be replaced before its full lifetime and, as discussed, higher speed spinning may put more stress on the appliance, potentially causing damage and lowering its lifetime

There are concerns that higher spin speed may also damage clothes and increase creasing of clothes, with evidence that lightweight clothing loses tear and tensile strength after increased agitation during washing<sup>4</sup>. More creases in clothing may lead to more ironing and therefore the net benefits of higher spin speed may be reduced.

#### **4.4.2 Washing appliances efficiency and low temperature washing**

##### **- *Benefits and potential tradeoffs***

###### *Efficiency*

Reductions in the energy and water consumption of washing and drying machines would reduce the environmental impacts of clothes cleaning without any changes in consumer behaviour. There are existing initiatives that aim to improve the efficiency of washing and drying appliances. Developments to the EU energy label, through measures set out in EU Eco-design of Energy using Products (EuP) Lot 14, are expected to drive improvements in energy efficiency (energy savings of 2TWh per annum in Europe by 2020).

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<sup>1</sup> Market Transformation Programme, (2007) Briefing note BNW05: Assumptions underlying the energy projections for domestic washing machines

<sup>2</sup> Assuming 1 kWh = 13 pence

<sup>3</sup> ISIS (2007) Preparatory Studies for Eco-design Requirements of EuPs, LOT 14: Domestic Washing Machines and Dishwashers. *Assumption*: £1 = €1.17

<sup>4</sup> Source: Leading retailer; verbal communication



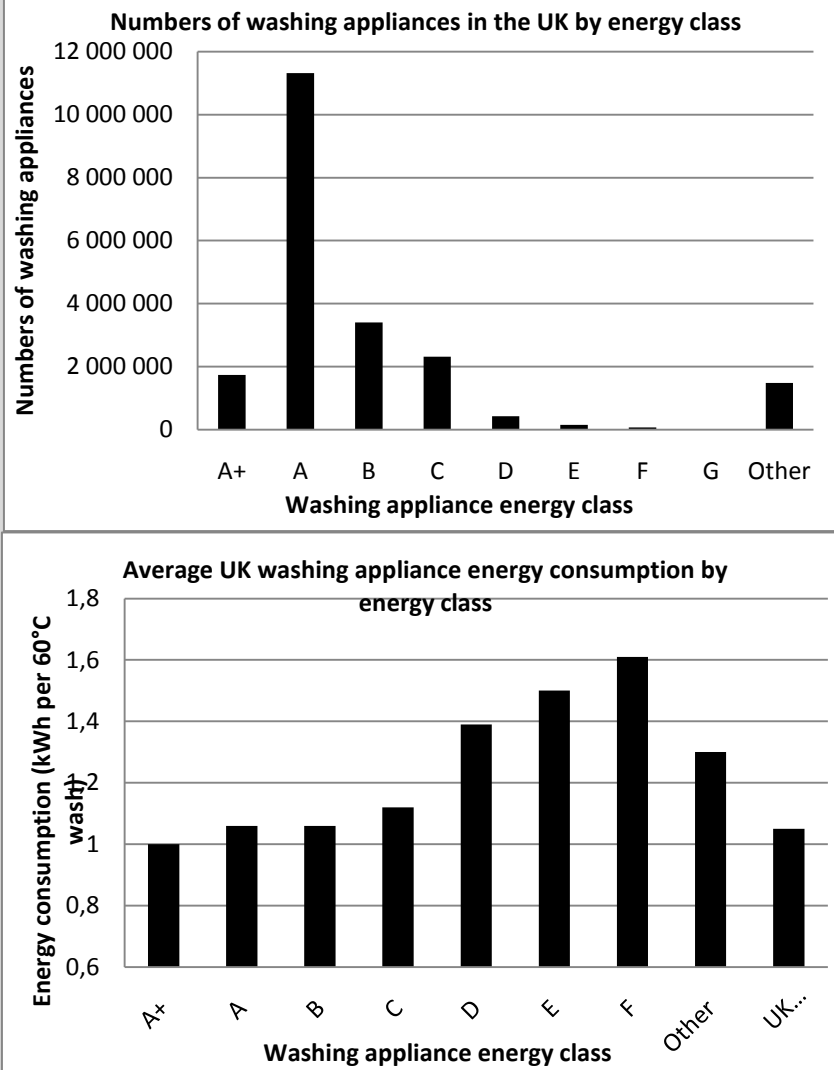


Figure 6: Numbers of washing appliances in the UK, and energy consumption of washing machines at 60 degrees centigrade, by energy class in 2009<sup>1</sup>

#### *Low temperature washing*

As shown by most LCA evidence, energy consumption during washing and drying has a significant contribution to the overall impacts of clothes. As most of the energy consumed during washing is used to warm water, reducing the temperature of washing could provide significant benefits. According to MTP, washing at 40°C instead of 60°C saves 40 percent energy, and 60°C compared to 90°C saves 40 percent<sup>2</sup>.

#### **- Extrapolation to UK scale: national savings potential**

The MTP currently estimates a base of 25 million washing machines (including washer-dryers) in the UK. Considering an average use of 274 times per household per annum in the UK, and taking into account energy consumption per energy class with current temperature settings<sup>3</sup>, washing machines total UK energy consumption is estimated at approximately 4.5 TWh per annum.

<sup>1</sup> Market Transformation Programme, "What if" (2009), <http://whatif.mtprog.com/>

<sup>2</sup> Market Transformation Programme, (2007) Briefing note BNW05: Assumptions underlying the energy projections for domestic washing machines

<sup>3</sup> Market Transformation Programme, "What if" (2009), <http://whatif.mtprog.com/> and (2007) Briefing note BNW05: Assumptions underlying the energy projections for domestic washing machines

In order to assess the improvement potential that may be achieved if more efficient appliances were used in the UK<sup>1</sup>, and compare it to energy gains that could be achieved by reducing washing temperature, improvement scenarios have been produced and are presented in the following figure.

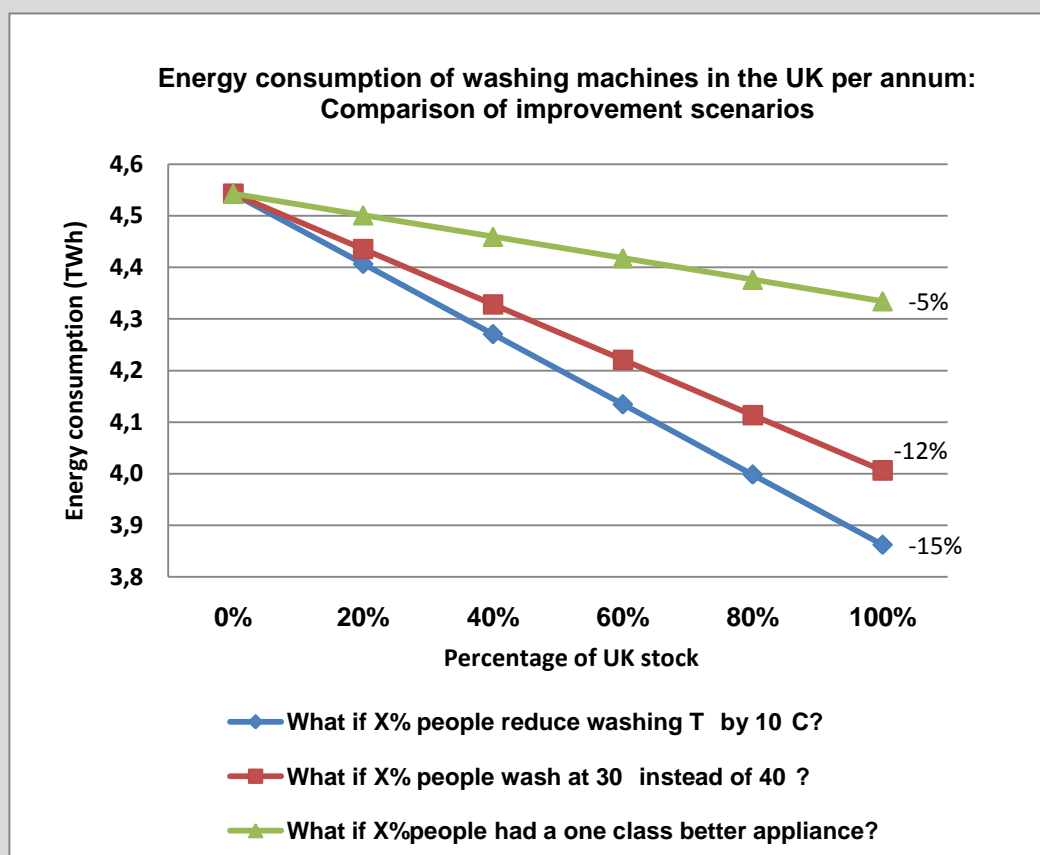


Figure 7: Comparative assessment of different improvement scenarios of energy consumption per annum of washing machines in the UK<sup>2</sup>

This scenario analysis tends to show that lowering washing temperature could potentially be more beneficial, saving approximately 12 to 15 percent energy consumption, than having more efficient appliances; a shift of all washing appliances by one energy rating class of the EU energy label upwards would result in a saving of only 5 percent of energy consumption<sup>1</sup>. A rough calculation shows that cost savings to a consumer shifting from 40°C to 30°C wash temperature could be approximately £3 per annum<sup>3</sup>. In regards to efficient appliances, large improvements are unlikely to be achieved in the short term, but design developments driven by legislation and market initiatives, such as EuP and appliance labelling will continue to improve efficiencies. From July 2010, EuP Lot 14 proposes that minimum standard for washing machines will be A class.

<sup>1</sup> This does not take into account time for replacement and the fact that more efficient machines might be available in the future.

<sup>2</sup> See annex, section headed "Energy consumption of washing machines in the UK per annum: Comparison of improvement scenarios", for data and assumptions used

<sup>3</sup> Based on: a washing machine cycle at 60°C uses 1.05 kWh on average in the UK; 40°C uses 40% less energy per cycle; 12% energy saving at 30°C compared to 40°C; saving per wash equals approximately 0.076 kWh; 1 kWh = 13 pence; 274 washes per annum. Sources: Market Transformation Program and <http://www.whitegoodshelp.co.uk/wordpress/washing-machine-spin-speed-efficiency-figures-and-drying-costs/>

#### - **Barriers and opportunities**

Combined washer-dryers, covering approximately a sixth of the UK washing machine market and just over a quarter of the UK tumble dryer market<sup>1</sup>, have not been assessed by EU EuP studies. As there is a trend towards smaller households, there may be an increased market share of this appliance in the future. Currently, no preliminary EU study is planned, so washer-dryers should in theory become an exception that is not covered by EuP. The preliminary study team for EuP Lot 16 has stated that washer-dryers should be addressed by the EC Director-General Energy and Transport in the future, possibly through an Impact Assessment study. There may therefore be quite a delay before any progress on this. Meanwhile, potential energy saving developments on washer-dryers could be lost, while manufacturers concentrate on washing machines and tumble dryers.

The purchase of a new washing or drying appliance often follows the breakdown of an older machine (average lifetime of approximately 12 years for washing machines<sup>2</sup> and 13 years for tumble dryers<sup>3</sup>). In the event of unexpected break-down of an appliance, consumers are unlikely to have anticipated the high costs of purchasing a new appliance, and hence may tend to purchase a low cost and potentially less efficient model; however, there is an opportunity to promote the purchase of efficient appliances, using a life cycle cost<sup>4</sup> argument, and thereby encourage consumers to adopt a long term perspective.

There may however be trade-offs associated with replacing products early, as the impact of the manufacture of the old model may never be recovered through the greater efficiency of the new model. The effectiveness of washing at low temperature, in terms of the cleaning ability and effect on bacterial, has been questioned and is discussed in detail in section 4.5.2, 'Wash at lower temperature'.

## 4.5 Detergents

Detergents are chemical compositions that are used during clothes washing to clean clothes, and can also perform functions such as neutralisation of water hardness. The quantity of detergent used affects the washing performance and subsequent contaminant level of the used washing water.

Eutrophication of natural water resources is a significant environmental issue, and one of the main causes of this is phosphorous, which is used as an ingredient in products that are released into the environment after use, such as detergents, and migrate into the water system. Since the late 1980s there has been a gradual reduction in the amount of STPP (sodium tripolyphosphate,  $\text{Na}_5\text{P}_3\text{O}_{10}$ ) used in detergent builders and a switch to 'alternative' non-phosphate based builders, such as Zeolite<sup>5</sup> (which are thought to pose little additional human health risks, pending further investigation<sup>6</sup>), such that today only 10 percent of UK laundry detergents contain phosphates. The total phosphorous load to water for England, Wales and Scotland lies between 33,000 and 68000 tonnes per annum<sup>7</sup>. It is also estimated that households contribute between 61 and 73 percent of the total phosphorous load in water, but domestic laundry contributes only 7.5 to 10 percent. Since 66 percent of

<sup>1</sup> Market Transformation Program, "What if" (2009), <http://whatif.mtprog.com/>

<sup>2</sup> Market Transformation Programme, (2007) Briefing note BNW05: Assumptions underlying the energy projections for domestic washing machines

<sup>3</sup> Market Transformation Program (2008) BNW06: Assumptions underlying the energy projections for domestic tumble dryers

<sup>4</sup> The life cycle cost of an appliance includes the initial capital cost and running costs during the life of the appliance (and end of life disposal costs, if any) – an efficient appliance may have a higher capital cost, but a lower lifetime cost due to reduced energy consumption (hence lower running costs)

<sup>5</sup> <http://www.zeolites.eu/downloads/Zeolites.pdf> and <http://www.jstor.org/pss/25040958>

<sup>6</sup> [http://ec.europa.eu/health/ph\\_risk/committees/04\\_scher/docs/scher\\_o\\_057.pdf](http://ec.europa.eu/health/ph_risk/committees/04_scher/docs/scher_o_057.pdf)

<sup>7</sup> Defra (2006) Identifying the Gap to the Meeting WFD and Best Policies to Close the GAP

phosphate is derived from human sewage, phosphate removal from sewage would be required even if a total ban on phosphates in laundry detergents was introduced.

The detergent industry estimates that following a phosphate ban reformulations to phosphate free alternatives would cost the industry £10 to 15 million one-off capital costs and £5 to 8 million in annually recurring costs, despite the fact that 90 percent of laundry detergent are now phosphate free. The industry has stated that a reduction to below 0.4 percent could be achieved by 2015<sup>1</sup>. As the UK market is predominantly phosphate free (at least 90 percent<sup>2</sup>), this target should be easily achieved by the majority of manufacturers.

Please see the table on page 38 for a background summary and explanation of why the options analysed in 4.5.1 were selected.

#### 4.5.1 Detergent form and dosing

##### - *Benefits and potential tradeoffs*

The last few years has seen the development of compact powders with lower levels of builder<sup>3</sup> than regular powder. In the 1990's, the recommended dosage of compact powder was 85 g, which was approximately half that of the typical 'regular' powders at the time. Various concentrations of liquid formulations have also been developed, as well as detergent tablets and liquid tabs that may help to limit incorrect dosing. Tablet formulations are very similar to compact powders, but are formed into solid blocs with the addition of a binder (often surfactants). Concentrated liquids are concentrated detergents in liquid form and liquid tabs are fixed amounts of liquid detergent encased in a dissolvable package. The table below describes an estimate of the the UK detergent market, and shows how concentrated forms have increased in market share. The UK is thought of as a leader in development of concentrated detergents<sup>4</sup>.

Table 4: Forms of detergent used in the UK<sup>5,4</sup>

| Detergent form              | Typical recommended dosage | Typical 2001 market share (%) | Typical 2009 market share (%) |
|-----------------------------|----------------------------|-------------------------------|-------------------------------|
| Powders                     | 122 g                      | 49                            | approx. 0                     |
| Concentrated powders        | 80-85 g                    | 0                             | 40                            |
| Concentrated liquids        | 75 ml                      | 16                            | 4                             |
| Super Concentrated liquids  | 37 ml                      | n/a*                          | 16                            |
| Gels (highly concentrated)  | 37 ml                      | n/a*                          | 5                             |
| Tablets                     | 86 g                       | 28                            | approx. 0                     |
| Concentrated tablets        | 66 g                       | n/a*                          | 20                            |
| Liquid tablets              | 54 g                       | 7                             | approx. 0                     |
| Concentrated liquid Tablets | 39 ml                      | n/a*                          | 15                            |

\*n/a – not available

<sup>1</sup> Defra (2008) Summary of Responses to the Consultation on Options for Controls on Phosphates in Domestic Laundry

<sup>2</sup> Water UK (2008) Response to Defra's consultation on controls on phosphates in domestic laundry cleaning products in England"

<sup>3</sup> Builders are chemicals used in detergents to bind to free ions present in water, softening the water and improving the effectiveness of wash, and to avoid the precipitation of insoluble salts that cause encrustation of fabric. Source: [http://www.scienceinthebox.com/en\\_UK/glossary/builders\\_en.html](http://www.scienceinthebox.com/en_UK/glossary/builders_en.html)

<sup>4</sup> Source: leading consumer products manufacturer

<sup>5</sup> Source: P&G market data; written communication

These different detergent forms may have varying environmental impacts. In 2001, a leading consumer products manufacturer performed an LCA of five phosphate free detergents used at same temperature in the UK<sup>1</sup>. Although this data is not reflective of some of the newest detergent forms, and includes the previous 'regular' (less concentrated) powder form, it provides an indication of environmental impacts of various detergent forms, but any conclusions should not be considered as definitive, and could be challenged in other contexts.

Results of this analysis are presented in the next figure, where the impacts of each detergent formulation are compared against regular powder.

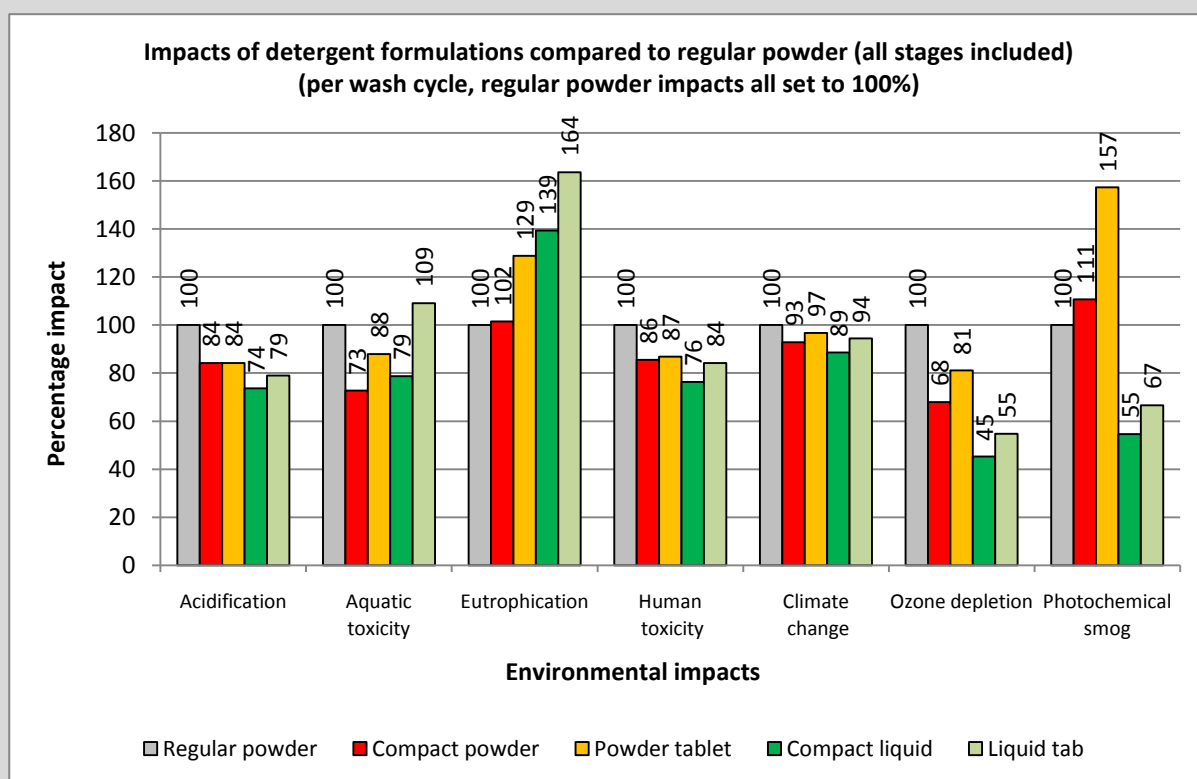


Figure 8: Results of LCA of five phosphate free detergents<sup>2</sup>

Such results should also not be considered as representative of all detergents under the broad form descriptions. From a life cycle perspective, there is no single detergent formulation clearly outperforming the others on all indicators, since the use stage (washing) dominates most indicators. Nevertheless, the analysis indicated that concentrated powder and concentrated liquid detergents are environmentally preferable, and this is essentially driven by the lower use of chemicals per wash. Interesting trends can be drawn<sup>3</sup>:

- Concentrated detergents are better, or at least as good, as regular powder. This is due to the development of new, more weight-efficient formulations<sup>4</sup>
- Unit-dose systems tend to perform worse than concentrated version of the same physical form used at recommended amounts. Packaging explains some of these additional impacts
- Liquids tend to perform better than powders across most indicators, apart from

<sup>1</sup> G. Van Hoof et al. (2003) Comparative Life Cycle Assessment of Laundry Detergent Formulations in the UK - impacts of temperature selection not considered

<sup>2</sup> The eutrophication indicator used in the LCA takes into account chemical oxygen demand, which is driven by organic chemicals, so eutrophication figures are high, although the formulations analysed were phosphate-free. Dosages (g): regular powder 122; compact powder 75; powder tablet 86; compact liquid 78; liquid tab 54.

<sup>3</sup> Ecolabelling Denmark (2009) Revision of Ecolabel Criteria for Laundry Detergents

<sup>4</sup> This conclusion is similar to the one given in: Saouter E, et al (2002) The Effect of Compact Formulations on the Environmental Profile of Northern European Granular Laundry Detergents; International Journal of LCA (1) 27 – 38

eutrophication, where liquid tablets and concentrated liquids perform worse (due to organic chemicals in their formulations) and on aquatic eco-toxicity (where liquid tabs tend to have higher potential impacts due to perfume contribution, as higher perfume levels are required to provide a similar level of fresh scent)

Variation in consumer behaviour means that over-dosing may lead to an increase of the environmental impacts associated with the production and water-treatment stage of the detergent life, while under-dosing may not lead to clean enough clothing hence the washing cycle could be repeated, leading to an unnecessary use of electricity and water, and could lead to the establishment of bio-films and limescale<sup>1</sup> (see section 4.5.2 for further discussion of bio-films and section 4.3 for discussion of limescale), thereby potentially reducing efficiency and increasing operating costs.

The next table compares the environmental impact of consumer dosed detergents (i.e. detergents that are not tabulated) to detergents that have a fixed dosage (i.e. in powder or liquid tablet form). As powder tablets and liquid tablets have a fixed dosage, it is possible to calculate the percentage overdose of detergent required by the consumer to have similar impacts across various environmental impacts. The table demonstrates the 'break even points', i.e. where the environmental impact of overdosing a non-tabulated detergent meets the impact of a fixed dose detergent.

Table 5: Dosage break-even points between selected detergent forms

| <b>Environmental impact</b> | <b>Compact powder<br/>needs to be<br/>overdosed above the<br/>recommended dose<br/>by the following % to<br/>match the impacts of<br/>a powder tablet</b> | <b>Regular powder<br/>needs to be<br/>overdosed above the<br/>recommended dose<br/>by the following % to<br/>match the impacts of<br/>a powder tablet</b> | <b>Concentrated liquid<br/>needs to be<br/>overdosed above the<br/>recommended dose<br/>by the following % to<br/>match the impacts of<br/>a liquid tablet</b> |
|-----------------------------|---|---|--|
| Acidification               | 0   | n/a   | 44   |
| Aquatic toxicity            | 14  | n/a   | 47   |
| Eutrophication              | 37  | 40  | 23   |
| Human toxicity              | 0   | n/a   | 33   |
| Climate change              | 14  | n/a   | 17   |
| Ozone depletion             | 50  | n/a   | 25   |
| Photochemical smog          | 46  | 75  | 100  |

n/a: not applicable; in other words, the powder tablet already performs better than regular powder when dosed as recommended.

The table shows that when correctly dosed, concentrated detergents tend to perform better than unit dose detergents. Though overdosing can significantly increase the environmental impact of the powders or concentrated liquid, a large amount of overdosing is required to have the same level of impact as their tabulated counterparts. For example, a compact powder would need to be overdosed by 50 percent to perform worse across all indicators, compared to a tablet form. Similarly, for photochemical smog, regular powder would need to be overdosed by 75 percent to have similar impact as a powder tablet and concentrated liquids by 100 percent compared to liquid tab.

**- Extrapolation to UK scale: national savings potential**

Using data for detergents used in 2001 (please refer to Figure 8 above), the following table describes an estimation of the reduced environmental impacts due to a change in detergent

<sup>1</sup> <http://www.washerhelp.co.uk/limescale.html>

forms, from 122 g of regular powder to 75 g of compact powder, for a single wash cycle.

Table 6: Estimation of the impacts of average UK wash assuming recommended dosage<sup>1</sup>

| Reference:<br>environmental<br>indicators                 | Regular powder | Compact powder | Benefits of compact<br>powder compared to<br>regular powder (%) |
|---|----------------|----------------|---|
| Acidification (gSO <sub>2</sub> eq)                       | 0.17           | 0.16           | 9   |
| Aquatic toxicity (m3 PW)                                  | 30.97          | 26.56          | 14  |
| Eutrophication (gPO <sub>4</sub> eq)                      | 0.78           | 0.79           | -1  |
| Human toxicity (gBW)                                      | 6.95           | 6.41           | 8   |
| Climate change<br>(gCO <sub>2</sub> eq)                   | 1019.87        | 983.12         | 4   |
| Ozone depletion (ug<br>CFC-11eq)                          | 43.88          | 35.55          | 19  |
| Photochemical smog<br>(gC <sub>2</sub> H <sub>4</sub> eq) | 0.80           | 0.84           | -5  |

These results show that there are varying benefits, and some potential detrimental effects, of using the compact detergent in place of the regular product across the impacts measured. If all UK households were using this specific regular powder, and then moved to the compact form, a saving of 0.2 Mt CO<sub>2</sub><sup>2</sup>. This is a very rough figure to give some idea of the magnitude of these particular results on the UK scale, and will therefore not be used to draw conclusions.

#### - **Barriers and opportunities**

Choice of detergent formulation and avoiding overdosing of detergent may have significant environmental benefits. The current International Association for Soaps, Detergents and Maintenance Products (A.I.S.E.) laundry sustainability initiative is estimated to have the potential to save 200,000 tonnes of powder detergents over the course of two years<sup>3</sup> through effective communication of dosing requirements to consumers. Promoting accurate dosing of detergent is clearly of importance, as previously discussed. Auto-dosing of detergent is available in certain washing appliances, but is limited to liquid detergents<sup>4</sup>.

There are advantages in using unit-dosing methods (there is little chance of under dosing with these), but there are some negative environmental issues:

- Producing the tablets requires more energy than producing regular powders
- The tablet or liquid requires wrapping material
- Consumers may overdose in hard water areas, being restricted to adding a minimum of one additional tablet

Moreover, as the analysis tends to prove that bulk detergents can potentially be less impacting than unit-dose when used wisely, this even strengthens the need to increase consumer awareness for accurate dosing, rather than relying on unit-dose methods. While being aware that it is difficult to draw strong conclusions from a single study, further concentration of detergents could also prove an important opportunity in reducing the impacts of clothes cleaning.

Under dosing, on the other hand, might lead to ineffective cleaning action during the wash

<sup>1</sup> G. Van Hoof et al. (2003) Comparative Life Cycle Assessment of Laundry Detergent Formulations in the UK (note: *the impacts of temperature selection are not considered in this analysis*)

<sup>2</sup> Based on: results of table 6; 20,893,111 washing machines in the UK; 274 wash cycles per year; 36.75 gCO<sub>2</sub>eq saving per wash.

<sup>3</sup> A.I.S.E. presentation available at <http://www.aise.eu/go.php?pid=591&topics=17>

<sup>4</sup> [http://www.reasonwashingmachine.com/washing\\_machine.html](http://www.reasonwashingmachine.com/washing_machine.html)



cycle and build-up of limescale in the washing machine due to insufficient amount of detergent builder to counteract water hardness, and subsequent surfactant reaction to form insoluble salts (please see annex section 6.6).

## 4.5.2 Wash at lower temperature

### - *Benefits and potential tradeoffs*

Recent detergent LCA publications conclude that approximately 80 percent of the environmental impact of detergents is in the use phase and 8 to 18 percent is due to manufacturing<sup>1</sup>. As illustrated in figure 9, energy consumption and GHG emissions in the use phase are highest followed by processing of raw materials. Effluent emissions to water are dominant in the disposal phase. Waste at the use phase is associated with the ash from power stations for energy generation. From an energy perspective, the highest impact is in at the consumer laundry stage and this is dependent upon the temperature of the wash. This is a function of the washing temperature the appliances provides and the consumers choice of wash temperature cycle. This is well known by the detergent producers who are currently researching and developing detergents that perform well at 30°C or lower.

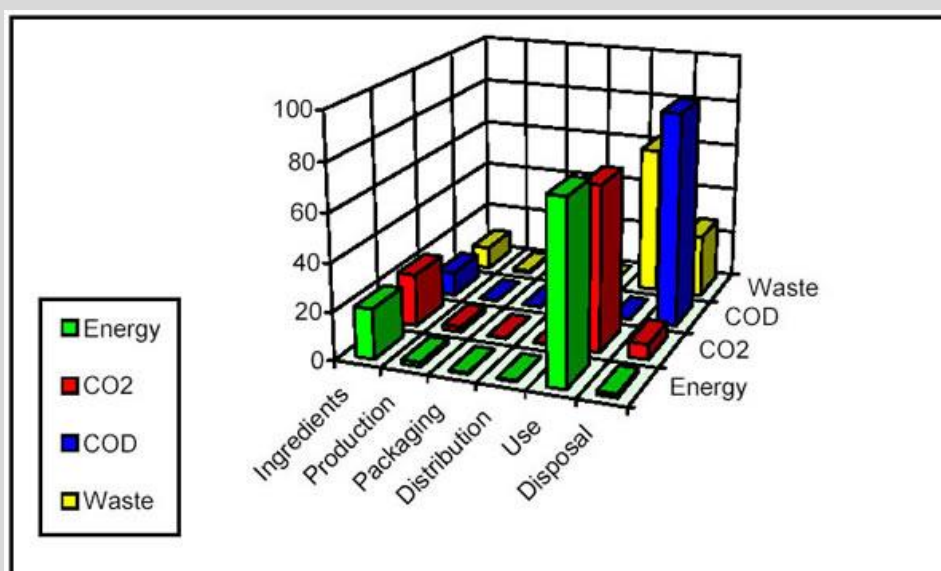


Figure 9 - Selected environmental impacts of detergent life cycle stages<sup>2</sup>

Reducing the temperature of a washing cycle does not require a significant change in consumer behaviour, but it does rely on the availability of a low temperature cycle on the washing appliance, and a detergent that works effectively at low temperature.

The objective of this section is to analyse the benefits of using low temperature detergents and wash at cold temperature and assess if low temperature detergents have greater impacts than traditional ones when used at the same temperature, from a life cycle perspective. This second question aims at assessing if low temperature detergents can add additional burdens if not used at cold temperature. The analysis is based on a leading consumer products manufacturer's LCA on a range of detergents (available in France) that wash effectively at low temperature, which compared 2001 powders and liquid detergents that were not formulated for clothes washing at low temperature, to low temperature detergents of 2006<sup>3</sup>. This case study shouldn't be seen as representative of all detergent

<sup>1</sup> Ecolabelling Denmark (2009) Revision of Ecolabel Criteria for Laundry Detergents

<sup>2</sup> <http://uk.cleanright.eu/sustainability/assessment-and-progress/sustainability-and-lca.html>

<sup>3</sup> P&G (2006) Comparative Life Cycle Assessment (LCA) of Ariel "Actif à froid" (2006), a laundry detergent that allows to wash at colder wash temperatures, with previous Ariel laundry detergents (1998, 2001)



formulations, but nevertheless, as presented in the next set of figures, it shows that using powder or liquid formulations at low temperature provide environmental benefits across almost all indicators.

In the following diagrams, the 2001 detergents are represented by the shape with darker shading, and the 2006 lower temperature washing detergents are represented by the lighter shading above. Each point of the diagram represents an environmental impact. The impacts of the 2001 detergents is set at 100 percent for all indicators, and the comparative impact of the 2006 detergents is represented by the percentage figures that can be seen along each of these environmental impact scales. Hence, in the following diagram, the 'cold wash' powder from 2006 has 80 percent of the climate change impact of the 2001 powder.

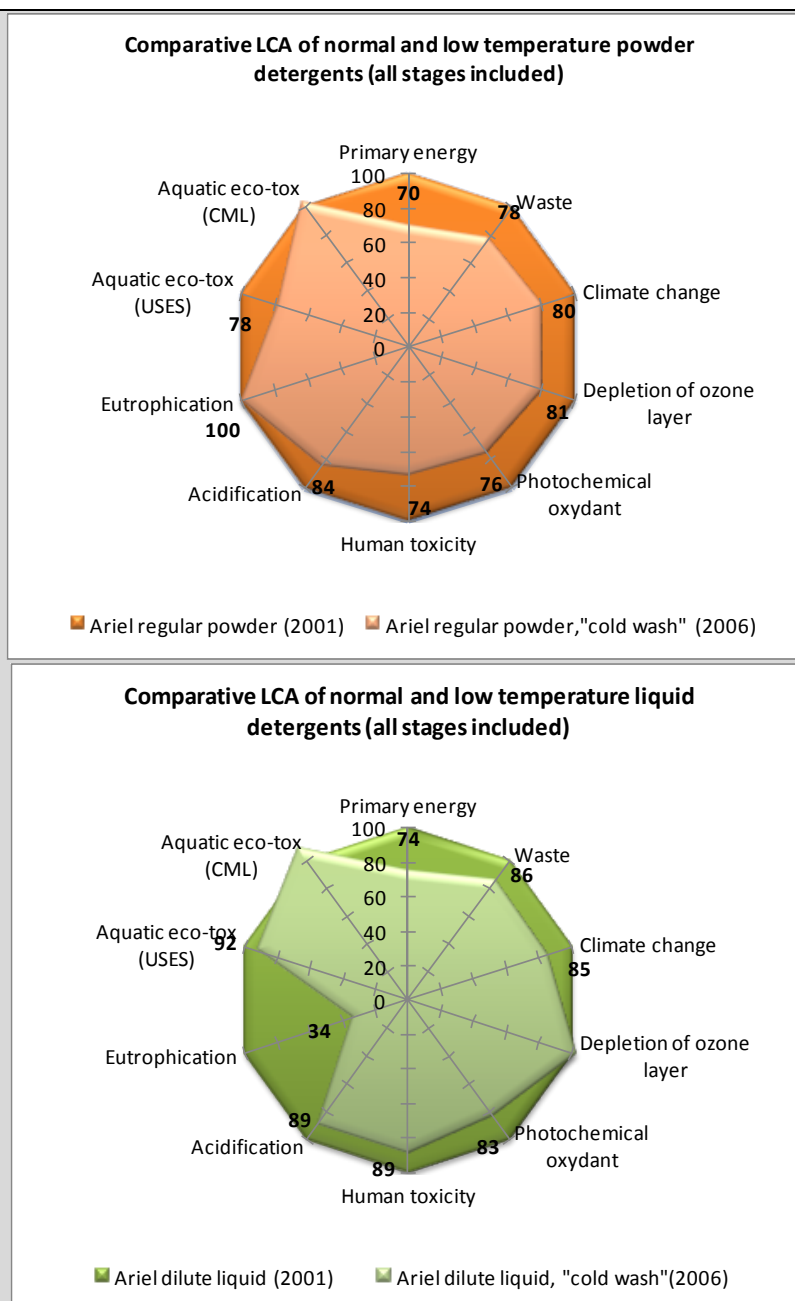


Figure 10: Comparative LCA of normal and low temperature powder and liquid detergents<sup>1</sup>

Excluding the use stage (and hence the impacts related to temperature selection), as shown overleaf, the comparison shows that the cold wash formulation performs even better than the traditional one in terms of solid waste, climate change potential, photochemical oxidation and acidification potential as presented in the next figure.

<sup>1</sup> P&G (2006) Comparative Life Cycle Assessment (LCA) of Ariel "Actif à froid" (2006), a laundry detergent that allows to wash at colder wash temperatures, with previous Ariel laundry detergents (1998, 2001)

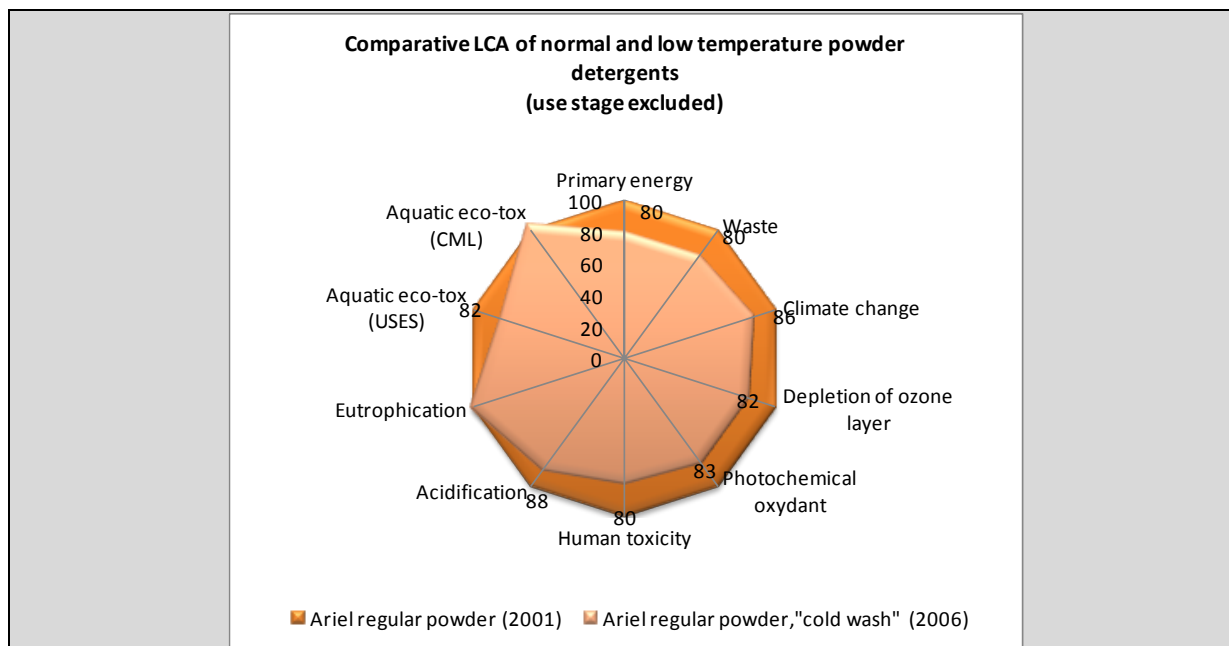


Figure 11: Comparative LCA of normal and low temperature detergent excluding the impacts of temperature selection<sup>1</sup>

Overall, the analysis shows that the evolution of detergent formulations enabling an effective cold wash have largely not resulted in any environmental or human toxicity trade-offs, and that cold wash formulations used at the same (i.e. higher) temperature as the 2001 detergents do not entail additional environmental burdens.

**- Extrapolation to UK scale: national savings potential of reducing washing temperature**

The LCA case study examined is relative to the French context, therefore the results were not applicable to the UK context. All assumptions behind the original analysis (such as transport distance and electricity modelling) would be different for the UK. Nevertheless, the benefits of washing at lower temperatures are likely to be higher in the UK than those presented in figures 10 and 11, as the electricity consumption during washing and electricity has a greater impact in the UK than in France (as France predominantly relies on nuclear energy).

According to the manufacturer, the use of low temperature detergent has enabled a saving of 60 000 tonnes of CO<sub>2</sub> (between 2002 and 2007)<sup>2</sup>.

**- Barriers and opportunities**

Mainstream consumer demand for more sustainable cleaning products is growing rapidly. There is evidence that these consumers will buy environmental products only if they first meet key consumer needs such as quality, performance, convenience and price. Following campaigns on washing at 30°C, an IPSOS survey reported that 17 percent of UK households washed at 30°C in 2007, compared to only 2 percent of households in their 2002 survey<sup>3</sup>. The average UK washing temperature across all households has decreased from 43.5°C in 2002 to 40.2°C in 2007<sup>4</sup>. A leading consumer products manufacturer has actively marketed a low-temperature wash detergent across Europe since 2003 and 27 percent of all of the detergent users washed at 30° in 2007, twice the average of other leading brands.

<sup>1</sup> P&G (2006) Comparative Life Cycle Assessment (LCA) of Ariel "Actif à froid" (2006), a laundry detergent that allows to wash at colder wash temperatures, with previous Ariel laundry detergents (1998, 2001)

<sup>2</sup> Building sustainability into the heart of P&G's laundry and cleaning brands, Mark Stalmans

<sup>3</sup> IPSOS Habits and Practices Studies (2002 and 2007)

<sup>4</sup> [16:05:00] Adrien Beton: [http://www.wbcds.org/DocRoot/RQYTbUwZIWSSjCfvq5QU0/PGArielcoolclean\\_full-edited.pdf](http://www.wbcds.org/DocRoot/RQYTbUwZIWSSjCfvq5QU0/PGArielcoolclean_full-edited.pdf)

Communication for this campaign focused on three clear and consistent messages: save energy, achieve high cleaning performance and support the environment.

Despite the fact that it is common practice in some countries such as Spain, to use cold water programmes, there is evidence that temperature reduction below 30° might not be feasible. Indeed, it should be noted that in countries where the ambient temperature is often 20 to 25°C, 'cold water' is not as cold as it normally is in the UK (typically 10 to 18°C). Furthermore, actual temperatures in the drum of a washing machine are normally 3 to 5°C lower than the set temperature, thus 30°C programmes are actually washing at temperatures very similar to cold washes in warmer countries.

A potential trade-off of low temperature washing is the formation of bio-films. Anecdotal evidence<sup>1</sup> has confirmed scientific evidence<sup>2</sup> that bio-films have been a serious problem in the USA but have affected very few UK consumers. Users of liquid detergents are more likely to suffer from this (due to lack of bleaching agents in this detergent form). Bio-films consist of communities of bacteria and fungi which build up on the internal surfaces of the washing machine under persistent damp conditions (see appendix section 0 for further details). A strategy is proposed by detergent manufacturers and independent consumer advice to those few consumers whose washing appliances develop bio-films<sup>3</sup>:

- Always use the correct dose of detergent as recommended by the manufacturer.
- Always leave the door open between washes to allow the internal surfaces to dry out.
- Once per month (or as frequently as the washing machine manufacturer recommends) carry out a service wash at 60°C using a bleaching detergent or carry out a steam cleaning cycle.

Washing 274 times at 40°C (a temperature at which bio-film are less likely to develop<sup>2</sup>) would consume approximately 4.4 Gwh per annum in the UK, while washing 274 times at 30°C and 12 times at 60°C (to service the appliance) would consume approximately 4 GWh<sup>4</sup>. So washing at 30°C while using a servicing regime to reduce bio-films would still result in approximately 10 percent reduced energy consumption, compared to washing at 40°C year round.

Washing performance at low temperatures are less effective at bleaching clothes because the oxygen-based bleaches used in detergents need to be warm to become active. Detergent manufacturers state that they have developed new technologies to replace oxygen bleach and enable effective washing at low temperature. New non-bleach detergents can achieve overall levels of performance at low temperatures, comparable to that from products with bleach, but often with a different cleaning profile (better at cleaning certain kinds of stains, worse on others).

However, there is still uncertainty amongst stakeholders on the effectiveness of low temperature washing, such as its ability to remove bacteria and clothes lice from clothing and concerns that aggressive bleaching systems may damage clothing. As much of the data into clothes washing used in this report has been carried out by detergent manufacturers, questions over its independence have been raised. Research has shown that, in general, washing at higher temperature with bleaching agents is more effective at reducing bacteria in laundry<sup>5</sup>. Nevertheless, 30°C washing is practiced by approximately 17 percent of UK

<sup>1</sup> Source: Leading consumer products manufacturers; evidence communicated at workshop

<sup>2</sup> Munk, S. et al (2001) Microbial survival and odor in laundry, Journal of Surfactants and Detergents, Vol. 4, No. 4

<sup>3</sup> [http://www.washerhelp.co.uk/usage\\_2.html#cl\\_q1](http://www.washerhelp.co.uk/usage_2.html#cl_q1)

<sup>4</sup> Based on data in tables 8 and 9 in annex section 6.3; used average for washing machine energy consumption for the respective temperatures.

<sup>5</sup> Terpstra, P. M. J. (2006) Interference between hygiene properties and energy saving for low energy European laundering processes, at: [http://mail.mtprog.com/CD\\_Layout/Day\\_1\\_21.06.06/1615-1800/ID3\\_Terpstra\\_final.pdf](http://mail.mtprog.com/CD_Layout/Day_1_21.06.06/1615-1800/ID3_Terpstra_final.pdf)

consumers<sup>1</sup>, and there have been no reports of wide-spread problems associated with washing at this temperature.

The detergents industry has stated that levels of performance at low temperature do not match the ability of bleach to remove bleachable stains at higher temperatures, such as for the cleaning of heavily soiled garments. The industry advises use of a bleach-based product and higher temperatures when washing heavily soiled laundry, clothing for the immunologically challenged (those at high risk of infection) or in the event of persistent infectious illness in a household, in order to provide the required hygiene level<sup>2</sup>.

As further developments are made in detergent technology, moves to clarify testing and results of any research into their effectiveness and environmental impact (including up to date LCAs) would help to reassure the public that low temperature washing does effectively and hygienically clean clothing, without causing new environmental impacts through novel chemical formulations and without damage to clothing.

#### **4.6 Garment durability**

Improving clothing performance, such as colour fastness and quality of final assembly (i.e. stitching/adhesives), could extend the life of clothes and in effect reduce the 'total' impact of the clothing. Poor durability characteristics may also affect comfort or appearance during lifetime, and lead to early disposal by consumer. However, manufacturing finish is largely determined by product end-use requirements and fashions, such as colour and comfort, rather than indirect environmental benefit through reduced impacts of clothes care. As manufacture of fibres and fabrics shifts to other nations, the ability of UK governing bodies to influence the textiles manufacturing sector will reduce. The textile market patterns and trends described in the introduction (see section 1.6) indicate that options to reduce the environmental impact of clothes cleaning through improving durability of clothing are likely to be challenging.

Although durability is an important aspect of clothing to improve in consideration of its whole clothing life cycle, particularly for garment types such as underwear and workwear that are typically heavily used, it is less important for this report on clothes cleaning. Due to the indirect effect of clothes' durability on the impact of clothes cleaning, garment durability has not been further investigated in this study.

However, it is important to emphasise that garments being destroyed through inappropriate washing, including the use of the wrong detergent or cycle, could be minimised to improve clothing durability, and that educating consumers on how to effectively wash their garments is therefore important. Furthermore, the impact of novel clothes cleaning techniques, technologies or detergents on the overall durability of clothing (including abrasion, tensile and tear strength, colour and shrinkage) should be considered in addition to the environmental benefits provided by any new developments. Clothes care labelling could provide an important link between low-impact developments in clothes washing and consumer awareness, in order to provide sound guidance on the trade-offs between wash options and to ensure garment durability.

Please see the table on page 37 for a background summary and explanation of why garment durability was not investigated in detail.

#### **4.7 Low and non-solvent dry cleaning**

Dry cleaning uses solvents, often highly toxic chemicals, to clean clothes that would be damaged by normal wet cleaning methods. The use of these solvents can lead to generation of volatile organic compounds and solvent waste. Tetrachloroethylene (PERC) is the predominant dry cleaning solvent. The risk assessment of PERC, produced by the

<sup>1</sup> IPSOS Habits and Practices Studies (2002 and 2007)

<sup>2</sup> Source: Leading consumer products manufacturers

Environment Agency, identified a need for limiting the risks associated with its use; however, moves by the US Environmental Protection Agency to ban PERC use in certain buildings have recently been set back<sup>1</sup>.

One means to reduce the use of toxic chemicals is for dry cleaners to use alternative, safer dry cleaning solvents. In the USA, where dry cleaning of clothes is considerably more popular, there are at least four other non water based alternatives and three others that require water as a carrier. Differing regulatory burdens for the use of dry cleaning solvents in the USA and Europe may act as a barrier to technology transfer between the two (for example some compounds have VOC status in one but not the other). One of the major providers of dry cleaning in the UK has chosen to use 'Green Earth' which is a Methyl Siloxane based system. Although this is branded as a non-solvent system in the US, where siloxanes are considered as non-organic, siloxanes are defined as organic solvents in the EU and hence 'Green Earth' cannot be considered as non-solvent technology. There are also environmental and health concerns associated with siloxanes<sup>2,3</sup>. The EC is also currently looking at whether n-Propyl Bromide should be proposed for addition under the Montreal Protocol<sup>4</sup>.

The only alternative that is non solvent based which has recently been introduced is a CO<sub>2</sub> based method, and there is some evidence to show that this system is least impactful on the environment<sup>5</sup>. Other systems identified have only a very limited user base or are emerging technologies.

Data was difficult to locate for dry cleaning and the other systems identified have only a very limited user base or are emerging technologies, with no independent studies being carried out. There is also evidence of a trend away from consumer use of dry cleaning<sup>6</sup>, including a decrease in the trade of dry cleaning solvents over the past three years<sup>7</sup>. Therefore dry cleaning has not been investigated further. See section 6.4 of the annex for a list of dry cleaning technologies and their associated environmental issues.

Please see the table on page 38 for a background summary and explanation of why dry cleaning was not investigated.

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<sup>1</sup> <http://www.laundryandcleaningnews.com/story.asp?sectionCode=138&storyCode=2052986>

<sup>2</sup> <http://www.sft.no/publikasjoner/2269/ta2269.pdf>

<sup>3</sup> <http://www.norden.org/en/publications/publications/2005-593/publicationfile>

<sup>4</sup> [http://ec.europa.eu/environment/ozone/pdf/sec\\_2366\\_en.pdf](http://ec.europa.eu/environment/ozone/pdf/sec_2366_en.pdf)

<sup>5</sup> <http://e-collection.ethbib.ethz.ch/eserv/eth:22881/eth-22881-01.pdf>

<sup>6</sup> <http://www.guardian.co.uk/business/2008/jan/30/fooddrinks.smoking>

<sup>7</sup> Peter Newport, Clothes Cleaning Meeting presentation

## 5 Limitations

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### 5.1 Introduction

Accessing detailed LCAs, and even basic manufacture data, was challenging for many technologies. The nature of the fibre and fabric market in particular, with a large amount of sensitive proprietary intellectual property, creates a difficult environment for analysis and evaluation.

### 5.2 Clothes cleaning and consumer behaviour

The individual has a key role in determining the environmental impacts of clothes cleaning. Parameters such as wash temperature and drying method are ultimately decided by the individual consumer. Clothes cleaning practice is built on habits that are formed through domestic education and learning, hence it can be deeply embedded behaviour.

One of the limitations of existing clothing LCAs is that they only consider a fixed set of behaviour assumptions for a small range of clothing. This is unlikely to reflect the true nature of clothes cleaning, where certain clothes types are washed more frequently than others<sup>1</sup>, and where some clothes are used until they begin to fall apart, whilst others are disposed of soon after they have gone out of fashion.

Consumer behaviour data is important in creating accurate LCAs; subsequent assessment of environmental impacts and prioritisation relies on these behaviour assumptions. Variability in behaviour presents uncertainty into any conclusions and this behaviour is hard to quantify accurately – little consumer behaviour data was found in the literature.

### 5.3 Specific issues

Fibres and fabrics: Protection of information and data on novel technologies proved to be a hindrance to comparison, as data on certain manufacture inputs was not accessible.

Durability: Only a limited number of technologies identified and little consumer behaviour data on clothes disposal.

Sustainable building design: Uncertainty over the benefits of reducing water hardness.

Washing and drying appliances: Uncertainty over the effect of higher speed spinning on the maintenance and lifetime of washing appliances. Difficulty contacting appliance manufacturers.

Dry cleaning: Information provided by the manufacturers of the alternatives is very limited. Suppliers were in general not able or willing to supply data on energy consumption, solvent usage, chemical composition, cycle times, therefore findings and analysis were based on US data.

Detergents: LCA data is a little dated and does not include some of the latest detergent forms. Uncertainty also exists over the extent of overdosing of detergents. No data on anaerobic degradation of surfactants was found in the literature.

### 5.4 Has the research met its objectives?

The project seeks to analyse current methods of clothes cleaning, identify improvement options, trade-offs and policy directions to reduce the impact of clothes cleaning, using a fact-based life cycle approach.

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<sup>1</sup> SIFO(2003), An investigation of domestic laundry in Europe – Habits, hygiene and technical performance

It has prioritised the clothes cleaning processes with greatest impacts and highlighted the importance of consumer behaviour. Many technological options have been investigated, and supply and demand-side recommendations made, as well as potential policy options.

One area not investigated is commercial clothes cleaning. Stakeholders have highlighted issues such as corporate clothing maintenance guidelines (e.g. NHS guidelines on disinfection and their conflict with low temperature washing and alternative methods of disinfection)<sup>1</sup>. Another issue not considered in depth is the nature and individual cleaning requirements of the various types of clothing stain that occur, including non bleachable stains, such as body sebum, which may require high temperature washing to be effectively removed and may eventually lead to customer returns to the retailer in the event of continued ineffective low temperature washing<sup>2</sup>.

Some of the complex interrelations between clothes cleaning stages have not been modelled within our analysis, including the reduced need to iron if line drying outdoors and the requirement for heat treatment for some anti-crease fabrics. We have provided suggestions to improve the evidence base and for further investigation below.

## **5.5 Robustness of the evidence and findings**

As discussed in the introduction, the comparability of the existing LCAs and the variability of results when altering key behaviour parameters may affect the validity of these studies in reflecting and analysing actual behaviour. For instance, as there is uncertainty due to variation in the number of times certain garments are washed, the large impact of the use phase shown in many clothing LCAs is subject to high variation. Concerning detergents, few published LCAs were found and this limits the extent of the conclusions drawn, considering the high variety of products available in the market.

Much of the data was provided by industry, hence is not independent. While it has provided good indication of some of the impacts of clothes cleaning, due to the number of relationships and trade-offs between the different clothes cleaning processes (and products or appliances used) and their effect on the quality of the cleaning process, it would be beneficial to consumer trust and transparency if such research was carried out or verified by an independent body.

However, through the independent and objective review of the literature and stakeholder input, the project team has drawn out achievable options that it believes have a high probability of reducing the environmental impacts of clothes cleaning.

## **5.6 Suggestions to improve the evidence base**

- Investigate the effects of anti-crease fabrics in greater depth with detailed a LCA, that assesses the effectiveness of anti-crease fabrics (and whether heat or tumble drying is required) as well as any change in consumer behaviour resulting from its use and likely impact of line drying
- Anti-bacterial fabrics are starting to be used widely by military and healthcare sectors to reduce the need for washing on a large scale. This is a potential area for future development, but requires investigation of effectiveness of anti-bacterial action, acceptance and behaviour change (i.e. would consumers/organisations wash their clothing less frequently?)
- Evaluate and compare easycare clothing and investigate consumer behaviour in relation to mixing them with regular clothing types during clothes washing and drying, and compare subsequent easycare performance
- Investigate the effect of line drying on the comfort of clothing and whether this affects lifetime or increases wash frequency

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<sup>1</sup> Source: Commercial launderer

<sup>2</sup> Source: Leading retailer



- Investigate the prevalence and impact of limescale build-up on washing appliances' heating elements
- Research the effects on the durability of appliances and clothing washing machines are continuously spun at higher-speeds
- Evaluate the likely uptake of washing at 60°C once a month in combination with 30°C washing, and its effectiveness in avoiding the build up of biofilms
- Investigate the effectiveness of 20°C washing and publish research data to allow public scrutiny of methods and results
- Investigate the opportunity to match washing machine symbols with care label symbols and whether this would assist consumers by harmonising guidance
- Carry out (independent) LCA analysis of new detergent forms as developed
- Investigate whether fabric detergents and softener adversely impact textile coatings
- Investigate the effects of fabric softeners, which are used by 74 percent<sup>1</sup> of the British public

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<sup>1</sup> [http://www.scienceinthebox.com/en\\_UK/research/washabits\\_pop\\_3\\_en.html](http://www.scienceinthebox.com/en_UK/research/washabits_pop_3_en.html)

# Annex

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## 6.1 Steering group

| Forename | Surname    | Organization   |
|----------|------------|--|
| Angus    | Pendrich   | Arcadia Group  |
| Adam     | Mansell    | British Apparel & Textile Confederation BATC & Home Laundering Consultative Council (HLCC) |
| Peter    | Newport    | Chemical Business Association  |
| Chris    | Reynolds   | Chemical Industries Association  |
| Lucy     | Yates      | Consumer Focus   |
| Derek    | McKelvey   | Deltec Inc Ltd.  |
| Jeppe    | Frydendal  | Eco-label Denmark  |
| Les      | Jacques    | Invista  |
| Richard  | Blackburn  | Leeds University   |
| Ian      | Morris     | Marks & Spencer  |
| Madeline | Southern   | Next Retail Ltd  |
| John     | Bailey     | P&G/Future Friendly  |
| Tim      | Sunderland | Skillfast-UK   |
| Clare    | Norman     | Tesco  |
| Andy     | Williams   | UK Cleaning Products Industry Association (High Level Group)                               |
| Graham   | Catton     | Unilever   |
| Sandy    | Black      | University of the Arts London + London College of Fashion                                  |
| Brian    | Bennett    | Independent  |

## 6.2 Legislation and market initiatives

### - Registration, Evaluation and Authorisation of Chemicals (REACH)

If a manufacturer is importing into the EU or manufacturing the substances themselves then they will have to register them with a central European Chemicals Agency who perform an assessment of the hazards and risks that the substance may pose and how those risks can be controlled. If the manufacturer buys the substances from within the EU then they are in fact a Downstream User. As such they need to ensure that their uses will be covered in the registrations made by the original substance manufacturers.

For a detergent this could mean an assessment of the hazards associated through release to water during its normal use or residues that may be present on clothing (and therefore have skin contact or accidental ingestion). Any substance that poses a particular threat that is deemed to require Community-wide action can be restricted. Restrictions take many forms, for example, from a total ban to not being allowed to supply it to the general public.

### - EU Ecolabel for detergents

The standard has been updated twice since its introduction and the latest update includes the following:

- All ingredients present in concentrations > 0.010 percent (w/w) have to meet specific ecological criteria.
- Compliance is required for preservatives, colouring agents and fragrances regardless of their concentration
- More stringent requirements to Total Chemicals, Critical Dilution Volume, biodegradability of organics (non-surfactants)
- Exclusion of phosphates and optical brighteners
- Strict requirements for sensitising substances
- Revision of packaging requirements
- Introduction of a scoring system in favour of products with reduced energy impact in the use phase (cold-water and low-temperature products)

### - Market Transformation Programme

The MTP supports UK Government policy on sustainable products and is managed by Defra's Sustainable Products and Consumers Division through a consortium of contractors. The programme covers products that consume large amounts of energy and water at the point of use and are responsible for a significant waste and hazardous materials arising at end of their useful life, including major domestic energy-consuming appliances<sup>1</sup>. MTP also develops policy strategies that improve the resource efficiency of domestic and commercial products<sup>2</sup>.

## 6.3 Data and assumptions used in calculations

### - Simplified assessment of ironing and anti crease treatment

- Mass of the shirt: 250g
- Anticrease crosslinking agent: 140 g/kg of dimethyldihydroxy ethylene urea (DMDHEU) for a moist crosslinking process.
- Ironing energy consumption: 0.75 kWh/h

<sup>1</sup> <http://www.mtprog.com/cms/about-mtp-background/>

<sup>2</sup> <http://www.mtprog.com/cms/product-data-what-if/>

The simplified LCA was calculated using the Ecoinvent 2.0 life cycle database and the CML2.2 life cycle impact assessment methodology. DMDHEU was used to model formaldehyde urea, as this exact chemical was not available in the life cycle inventory. The UK energy model was used to calculate the environmental impacts of energy used.

- **Simplified assessment of line drying of clothes**

This does not take into account the fact that these 32 percent people might overuse their tumble dryers, compared to the national average. Additional data on consumer behaviour and washing line ownership would be needed to provide more precise estimates.

- **Energy consumption of washing machines in the UK per annum: Comparison of improvement scenarios**

This data was used to calculate the energy saving potential of both greater washing machine efficiency and reduced wash temperatures. The number of washes per year, per washing machine, was assumed to be 274<sup>1</sup>.

Table 7: Temperature settings in the UK<sup>2</sup>

| Washing temperature (°C) | Proportion of UK residents using this temperature (%) |
|--------------------------|---|
| 30                       | 17  |
| 40                       | 73  |
| 50                       | 3   |
| 60                       | 6   |
| 70                       | 1   |

Table 8: Breakdown of washing machines by energy class, and totals of tumble dryers and washer-dryers<sup>3</sup>

| Energy class | Washing machine ownership | Tumble dryer ownership | Washer-dryer ownership |
|--------------|---------------------------|------------------------|------------------------|
| A+           | 1,736,758                 | -                      | -                      |
| A            | 11,319,764                | -                      | -                      |
| B            | 3,405,137                 | -                      | -                      |
| C            | 2,314,878                 | -                      | -                      |
| D            | 421,597                   | -                      | -                      |
| E            | 146,033                   | -                      | -                      |
| F            | 64,709                    | -                      | -                      |
| Other        | 1,484,235                 | -                      | -                      |
| Total        | 20,893,111                | 11,644,543             | 4,076,318              |

**Remark:** As the breakdown per energy class was not available neither for combined washer-dryers nor for the “other” category which represents appliances older than 1996, these appliances were assumed to have the same breakdown per energy class than washing machines. No breakdown for tumble dryers was found.

<sup>1</sup> Market Transformation Program (2006) BNW05: Assumptions underlying the energy projections for domestic washing machines

<sup>2</sup> IPSOS Habits and Practices, 2007 combined with P&G 2006  
[http://www.scienceinthebox.com/en\\_UK/research/washabits\\_pop\\_3\\_en.html](http://www.scienceinthebox.com/en_UK/research/washabits_pop_3_en.html)

<sup>3</sup> MTP-What if (2009), <http://www.mtprog.com>

Table 9: Energy consumption per energy class (kWh/cycle) <sup>1</sup>

| Energy class | Washing temperature |      |      |      |      |      |
|--------------|---------------------|------|------|------|------|------|
|              | 30°                 | 40°  | 50°  | 60°  | 70°  | 90°  |
| A+           | 0.50                | 0.60 | 0.80 | 1.00 | 1.17 | 1.40 |
| A            | 0.53                | 0.64 | 0.85 | 1.06 | 1.24 | 1.48 |
| B            | 0.53                | 0.64 | 0.85 | 1.06 | 1.24 | 1.48 |
| C            | 0.56                | 0.67 | 0.90 | 1.12 | 1.31 | 1.57 |
| D            | 0.70                | 0.83 | 1.11 | 1.39 | 1.62 | 1.95 |
| E            | 0.75                | 0.90 | 1.20 | 1.50 | 1.75 | 2.10 |
| F            | 0.81                | 0.97 | 1.29 | 1.61 | 1.88 | 2.25 |

**Remark:** Energy consumption for washing at 30°C was estimated to be half the energy of washing at 60°C. Other energy consumptions were linearly extrapolated.

*What if X% people had a one class better appliance?*

This calculation multiplies the proportion of the population washing at each temperature (Table 7) by the relevant energy consumption figures per energy class (Table 9) to find the current UK average energy consumption for each energy class of washing machine. It assumes that the class A+ was the efficiency ceiling when calculating energy savings through more efficient washing machines. Therefore, the maximum efficiency is 0.62 kWh per wash.

*What if X% people wash at 30 instead of 40?*

This calculation uses the figures in Table 7 as the '0%' status, then transfers the relative percentage of consumers washing at 40°C to washing at 30°C, and calculates total energy consumption using the energy consumption figures in Table 9. Energy class of washing machines are kept at the proportions given in Table 8.

*What if X% people reduce washing temperature by 10°C?*

This calculation uses the figures in Table 7 as the '0%' status, then transfers the relative percentage of consumers washing at x°C to washing at (x-10)°C, and calculates total energy consumption using the energy consumption figures in Table 9. Energy class of washing machines are kept at the proportions given in Table 8. It assumes that 30°C is the lowest washing temperature possible.

<sup>1</sup> MTP-What if (2009), <http://www.mtprog.com>, for washing at 60°C, 40°C and 90°C

## 6.4 Environmental issues associated with dry cleaning

| Technologies                                    | Environmental issues  |
|---|---|
| <i>Synthetic solvent dry cleaning systems</i>   |   |
| <b>DF2000 (petroleum based)</b>                 | VOC and flammability issues. No obvious benefit over PERC. Potential health risks with numerous mixed solvents.   |
| <b>Green Earth (silicone based)</b>             | VOC. Appears to have significant bio accumulative potential. Persistent in air, water, soil and sediments. Potential higher energy demands.   |
| <b>Rynex (Propylene glycol ether)</b>           | As there were concerns over its toxicity and carcinogenic potential it has been reformulated and now contains dipropylene glycol tert-butyl ether (DPTB). Currently, there is limited toxicity data available for DPTB. |
| <b>Pure dry (hybrid solvent)</b>                | VOC. Other factors unknown.   |
| <b>Jet clean – Ipura (hydrocarbon based)</b>    | Unknown.  |
| <b>Dry solv (n-propyl bromide)</b>              | Voc, Flammable and may impair fertility. Classified as harmful.   |
| <i>Water based systems</i>                      |   |
| <b>Generic water systems</b>                    | Higher water use. Impact depends on detergents used.  |
| <b>Green Jet</b>                                | No major concerns according to sources investigated.  |
| <b>Icy water</b>                                | As above.   |
| <i>CO<sub>2</sub> based systems</i>             |   |
| <b>Generic CO<sub>2</sub> systems</b>           | Potential higher energy demands. Limited LCA evidence suggests lowest overall impact.   |
| <b>Solvair (CO<sub>2</sub> and solvent mix)</b> | Potential higher energy demands. No major concerns with solvent used.   |

## 6.5 Novel clothes washing technologies

| Technology                                    | Current status  | Future status (trends)  | Environmental benefits and impacts   |
|---|---|---|--|
| <b>Polymer pellets (Xeros washing system)</b> | Under development. Note that the pellet system is not compatible with conventional washing machine technology - new designs or modifications to existing designs will be needed before the polymer bead system can be introduced. | Expected to come to market 2010 to 2011 initially for use in commercial laundries. If successful, a domestic version may then be developed. | Claims to use 50 percent less energy and 90 percent less water than typical washing machines. Also claims to leave the laundry 'damp' rather than 'wet' potentially reducing drying energy requirements. |

| Technology         | Current status   | Future status (trends)   | Environmental benefits and impacts  |
|--------------------|--|--|---|
| <b>Steam</b>       | In production - features on 'top of range' horizontal axis washing machines. | Small market share and premium product.  | Manufacturer claims this technology uses 35 percent less water and 21 percent less energy than A class energy efficiency equivalent.  |
| <b>Ultra-sound</b> | Experimented with 8 years ago. Not currently available on the UK market.     | Not likely to reappear due to the risk of damage to the fabric.                        | This technology might have been used to reduce or replace detergent but does not appear to have been a practical alternative.   |
| <b>Ozone</b>       | Available as a bolt-on mainly for commercial laundries.                      | Not likely to be adopted in domestic appliances due to a number of practical problems. | Potential energy savings because ozone works as a bleach at low temperatures. But heating is still required to achieve other cleaning functions. There is also a risk of damage to textiles and an additional cost in generating the ozone. |
| <b>Silver ions</b> | On sale in overseas markets.   | Unlikely to be acceptable in the UK because it discharges silver into the sewer.       | Silver could be a useful disinfectant to inhibit bacterial and fungal growth which can occur in washing machines that are only used at low temperatures. The adverse impact of discharging silver to the sewer may pose problems.           |

## 6.6 Definitions of clothes cleaning terminology

|                          |   |
|--------------------------|---|
| <b>Detergent builder</b> | Free ions (mainly calcium, $\text{Ca}^{2+}$ , and magnesium $\text{Mg}^{2+}$ ) present in water (particularly hard water) react with detergent ingredients, causing them to work less efficiently or precipitate from solution. The precipitate can form insoluble salts that become encrusted in the fabrics or deposit on surfaces inside the washing machine. Builders improve the quality of the water and wash by binding to the ions (softening the water). Sometimes more than one builder is used in a product to improve cleaning performance <sup>1</sup> . |
| <b>Polymer pellets</b>   | Dampened textiles are tumbled with a combination of detergent and polymer beads. The soils from the textiles transfer to the beads which are then removed. The process appears to be effective for the full range of stains and fabrics that is commonly treated in conventional washing machines. The beads can be reused up to 500 times. Periodically the beads have to be passed through a regeneration process.  |
| <b>Steam</b>             | Steam can be used to heat and dampen the laundry for washing. In theory this could reduce the amount of water used in conventional horizontal axis washing machines and thereby reduce energy consumption.  |

<sup>1</sup> <http://www.ceep-phosphates.org/Files/Document/30/detergentCompWithFunct.pdf> and [http://www.scienceinthebox.com/en\\_UK/glossary/builders\\_en.html](http://www.scienceinthebox.com/en_UK/glossary/builders_en.html)

|                                   |  |
|-----------------------------------|--|
|                                   |  |
| <b>Ultra-sound</b>                | Ultrasound is used to enhance or replace the detergent in the washing machine. In practice it is only effective on certain types of soiling and the ultra sound can cause damage to the fibres of the fabric.  |
| <b>Ozone</b>                      | Ozone can be generated by electrical sparking in air or by use of an ultraviolet lamp. Ozone is used as a bleaching agent and a sterilising agent. It has advantages over traditional washing bleaches because it works at room temperature. Ozone can be used for the following applications: enhancing the washing process, sterilising the washing machine, treating garments without wetting them to remove odours and bacteria, disinfecting the final rinse water from the washing machine so that it can be stored and used for the next wash or (in washer dryers) used as the coolant for the condenser.  |
| <b>Silver ions</b>                | Silver ions can be introduced to the wash liquor by electrolysis using a silver electrode. Silver has sterilising properties which are supposed to help remove bacteria in the laundry and in the washing machine. The build-up of bacteria and fungi in the washing machine can become increasingly significant for some users selecting cooler wash programmes.  |
| <b>Bio-films</b>                  | Bio-films consist of communities of bacteria and fungi which build up on the internal surfaces of the washing machine under persistent damp conditions. Growth is encouraged where washing machines are only used for low temperature washes and where detergent is frequently under-dosed. The organisms feed on residues from the washing process including soil from the textiles, and components of the fabric conditioner. Bio-films give rise to an unpleasant odour which affects the washing machine and the textiles that have been washed in it. Once a bio-film becomes established in a washing machine it can be very difficult to eliminate because of all the inaccessible surfaces where it can accumulate inside the machine. |
| <b>Heat pump condenser dryers</b> | These appliances cool the hot damp air from the laundry items to condense the moisture using the cold plate of a heat pump. The dried air is then re-heated by passing over the hot plate of the heat pump and returned to the drum. The heat pump reduces the amount of energy needed for the drying process because it recycles the air and it recovers heat (energy) from the condensation process on the cold plate.   |
| <b>Air condenser dryers</b>       | These appliances draw in ambient air, heat it over an electric element and pass it through a drum in which the damp laundry items are tumbled. Hot damp air from the laundry items is cooled to condense the moisture using ambient air. To some extent the energy inputted to the tumble dryer is conserved.  |
| <b>Washer-dryer</b>               | These are combination units that wash and dry the laundry in one drum. The design is similar to a horizontal axis washing machine and a condenser tumble dryer. A water-cooled condenser is normally fitted to remove the moisture during drying. Thus washer dryers use relatively high quantities of water and most of the energy input during drying is lost when the warm water from the condenser is discharged to the drain.   |



## 6.7 Definitions of environmental terminology

|                                  |   |
|----------------------------------|---|
| <b>Acidification</b>             | Air acidification consists of the accumulation of acidifying substances (e.g. sulphuric acid, hydrochloric acid) in water particles in suspension in the atmosphere. Deposited onto the ground by rains, acidifying pollutants have a wide variety of impacts on soil, groundwater, surface waters, biological organisms, ecosystems and materials (buildings). |
| <b>Eutrophication</b>            | Eutrophication is a process whereby water bodies, such as lakes or rivers, receive excess chemical nutrients – typically compounds containing nitrogen or phosphorus – that stimulate excessive plant growth (e.g. algae).  |
| <b>Global warming</b>            | Global warming refers to the increase in the average temperature of the Earth's surface, due to an increase in the greenhouse effect, caused by anthropogenic emissions of greenhouse gases (carbon dioxide, methane, nitrous oxide, fluorocarbons (e.g. CFCs and HCFCs), and others).  |
| <b>Life Cycle Analysis (LCA)</b> | Methodology aiming to assume the quantifiable environmental impacts of a service or product from the extraction of the materials contained within the components involved, to the treatment of these materials at end-of-life. This 'cradle-to-grave' methodology has been standardised at the international level through ISO 14044.                           |
| <b>Ozone layer depletion</b>     | The ozone layer acts as a filter, absorbing harmful short wave UV light. The thinning of the ozone layer over the Antarctic each spring can reach up to a 80-98 percent removal of this layer, hence the so-called 'ozone hole', mainly due to the anthropogenic emission of brominated and chlorinated substances like CFCs.                                   |
| <b>Photochemical oxidation</b>   | This pollution results mainly from chemical reactions induced by solar light between nitrogen oxides and volatile organic compounds (VOC), commonly emitted in the combustion of fossil fuels. It provokes high levels of ozone and other chemicals toxic for humans and flora.   |
| <b>Primary energy</b>            | Primary energy is raw energy available in nature. The main non-renewable primary energies are: oil, coal, natural gas, and nuclear energy.  |

