MANUFACTURING

ENGINEERING OUT FASHION WASTE

Institution of MECHANICAL ENGINEERS

Annual growth in global demand for clothing is projected to increase from 1.5% in 2016 to between 3.5 and 4.5%[1] by the end of 2018, and is likely to continue to grow beyond this. The increase in demand makes the environmental challenges for the industry more prominent – an industry already associated with high water and chemical use, and greenhouse gas emissions, not to mention poor labour conditions.

In order to improve the environmental impact of the clothing industry, the Institution of Mechanical Engineers recommends:

1. **The UK Government in collaboration with the fashion industry should invest in initiatives which provide incentives for the development of more environmentally friendly fibres.** Supporting existing projects and investing in research and development can make a significant impact on improving the sustainability and efficiency of textile manufacturing.
2. **The UK Government should work with the fashion industry and manufacturers to develop a comprehensive framework to tackle 'greenwashing', or false sustainability claims.** Corporate Social Responsibility is an essential element of a brand's identity in today's market.
3. **The UK Government, fashion industry and manufacturers should support the development of mechanical and chemical fibre recycling technologies, particularly those which are able to separate blended fibres.** A WRAP report has identified relatively few barriers to the uptake of the textile fibre recycling technologies.

ENGINEERING OUT FASHION WASTE

BACKGROUND

In 1804, Joseph Jacquard drew on previous inventions to create a device which fitted to looms, thereby simplifying the process of manufacturing textiles with complex patterns. It was an automatic method which significantly revolutionised the fashion industry, triggering violent riots by the Luddites who were resistant to the new technology.

Since then, engineers have facilitated the growth of textile-making into a £66bn fast-fashion UK industry[2]. They have played a role in telescoping production cycles so that brands can churn out the latest creations by designing, building, installing and maintaining warehouse conveyor belts. In addition to changes in processes, new, cheaper materials have been developed, such as polyester, a synthetic fibre.

Global demand for clothing is projected to increase annually between 3.5 and 4.5%[2]; this is mainly due to millions of individuals in developing countries entering the middle classes and spending their increasing disposable income. This increase in demand makes the environmental challenges for the industry more prominent. Fashion is an industry already associated with high water and chemical use, and greenhouse gas emissions, not to mention poor labour conditions.

Today, companies need to address the ever-increasing volume of waste, if not, the detrimental environmental effects of the clothing industry will continue to increase as more clothes are mass produced to meet increasing demand. It has been estimated that there are 20 new garments manufactured per person each year, and that consumers are buying 60% more clothes than in 2000[3]. This waste occurs not simply at the end of an item's lifecycle, but also during the processing and production phases; in 2016 alone, this process or 'supply chain' waste was estimated to be at over 800,000 tonnes[4].

Increasingly, major fashion brands – not just the likes of Stella McCartney – are becoming more conscious of the impact of their environmental footprint, and are progressively relying on engineers to play a more prominent role in designing out waste, across a garment's lifecycle. This involvement of engineers can for example, manifest in areas such as the research of fabrics. Fabrics designed not to shed microfibres when washed, or looking at how efficiencies in the cutting process, which currently sees 60bn m^2 of cut-off material discarded on factory floors each year.[5] This report highlights some examples of the encouraging steps companies are taking in collaboration with engineers, to make fashion waste last 'so last season'.

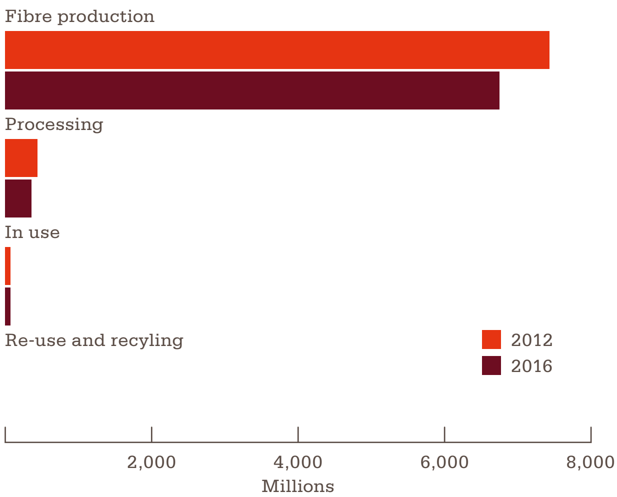
DYEING TO LOOK GOOD

Fashion is both a thirsty industry and one which results in extensive water pollution. In 2015, its processes consumed 79 billion m^3 water (the equivalent of 32 million Olympic-sized swimming pools), a figure which is expected to increase by 50% by 2030[6].

Even the most common items in our wardrobes involve water-intensive processes. A pair of 501 Levi's jeans will use 3,781 litres in its full lifecycle, from growing cotton and its manufacture through to consumer care and end-of-life disposal. By way of comparison, that's the equivalent of over 25,000 cups of tea*. Yet, as **Figure 1** shows, the most water-intensive process is at the fibre production stage.

One of the reasons that such a common item of clothing uses so much of the world's resources during the production stage, is that it is composed of cotton, a crop which has a large water footprint. This is due to the irrigation processes and the use of substantial amounts of pesticides and fertiliser. Globally, cotton accounts for approximately 30% of all textile fibre consumption[7]. Indeed, such is the environmental impact of cotton that in 2006, an Environment Agency study found that the production of tote bags, which are commonly marketed as being more sustainably friendly than standard plastic bags, actually had more of a detrimental impact to the environment. It found that re-using a single plastic bag three times had the same environmental impact as using a cotton tote bag 393 times[8].

Figure 1: Water footprint of clothing in the UK (m^3) in 2012 and 2016, comparing lifecycle stages[9].



*Based on the assumption that one cup of tea is 150ml

Water is also used during the manufacturing process to remove excess dye, a procedure which can result in widespread pollution, often in countries that do not have appropriate environmental frameworks in place. According to the World Bank, dyeing and treatment of clothing account for 17–20% of all industrial pollution. Chemicals which seep out of the treatment process leach into groundwater and infiltrate our freshwater sources. Studies have estimated that two thirds of China's rivers and lakes have been polluted by the 9 billion litres of contaminated water discharged from textile factories[11].

Synthetic fabrics are not much greener than cotton. Above all, polyester, derived from oil, doesn't biodegrade after disposal and, every time it is washed, sheds miniscule fibres which then go on to have a detrimental impact on our oceans[13]. However, consumers can still play a role in mitigating the environmental impact of washing by changing their own behaviour. Washing clothes at a lower temperature or using tumble dryers less often does have an impact. According to WRAP (Waste & Resources Action Programme), emissions associated with how people wash clothes have decreased in recent years because of changes in habits.

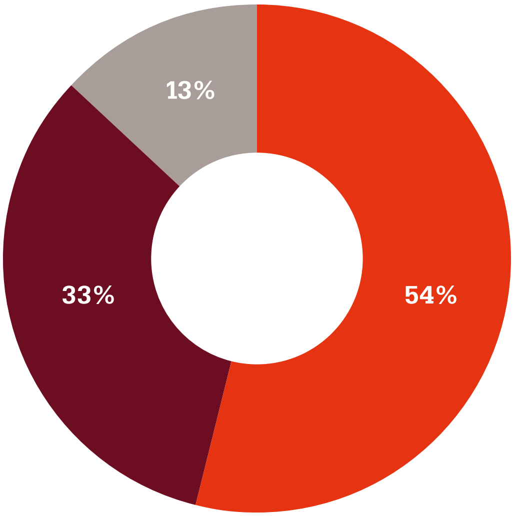


Figure 2: Water footprint calculates the amount of water used to produce the goods we use and has three components: green, blue and grey water. These provide a picture of the water use, by outlining the source of the water used, either as rainfall/soil moisture or surface/groundwater, and the volume of freshwater required for assimilation of pollutants.

Global Water Footprint
2,495 litres for a 250g shirt

- The amount of surface water and groundwater required (evaporated or used directly) to produce an item.
- The amount of rainwater required (evaporated or used directly) to produce an item.
- The amount of freshwater required to dilute the waste water generated in manufacturing, in order to maintain water quality, as determined by state and local standards.[10]

WORSE FOR WEAR

Energy is an essential operational input in the industrial manufacturing chain of textiles, and is required both to make the fibres used in the yarn and to weave those yarns into fabric. The amount of energy used to weave yarns into a textile is fairly constant, whether the yarn be wool, cotton, nylon or polyester, the thermal energy required per metre of cloth being 4,500–5,500 Kcal and the electrical energy required per metre of cloth being 0.45–0.55kWh. By way of comparison, that's the electrical energy equivalent of a 13W light bulb being on for over 34 hours*.

Not only is fashion extremely energy-intensive, it is one of the most polluting industries, producing 1.2 billion tonnes of CO_2 equivalent (CO_2e) in 2015, more emissions than international flights and maritime shipping combined[14]. This high-energy consumption accrues throughout each stage of a garment's lifecycle: production, transportation, use and disposal. Indeed, the energy footprint of each garment increases when produced in countries such as China and India, that rely heavily on coal-fuelled power plants.

Factory location means fashion is an international business. Garments can often start their life in countries located in the Southern Hemisphere, far away from their end-users. This long-distance transportation of clothes further increases the emission of CO_2. 77% of EU imports of textile and clothing come from Asia[15], which means that clothes have a global transport footprint.

However, the exact environmental impact of a garment changes considerably, depending on the fibre composition. Polyester, derived from crude oil, is energy-intensive and 70% of total energy occurs at the production phase[17]. As **Figure 3** indicates, other synthetic fibres emit even more CO_2 than polyester; acrylic is 30% more energy-intensive in its production than polyester, and nylon produces an even higher figure.

Besides driving energy savings in the supply chain, a brand can also find opportunities for energy savings in its own operations. Machinery modifications and the implementation of technological advancements, can result in the development of new methods that can help meet the challenge of energy savings.

Figure 3: Energy used in production of various fibres[16]

Fibres	Energy used to make the fibre (MJ/KG)
Flax	10
Cotton	55
Wool	63
Viscose	100
Polypropelene	115
Polyester	125
Acrylic	175
Nylon	250

*A 13W light bulb uses 0.013kWh

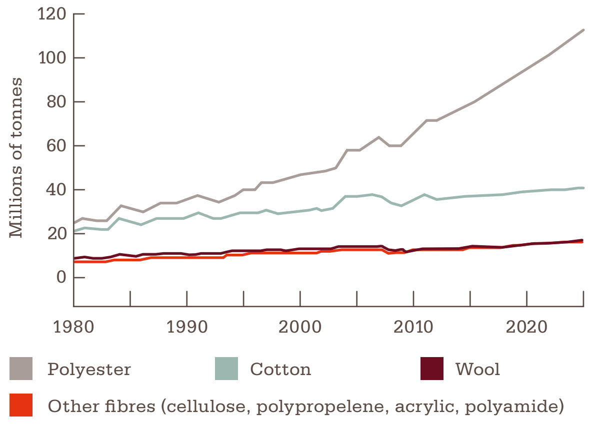
WASTE NOT WANT NOT

The fashion industry operates on a largely linear business model, with the British sending an enormous 235 million items of clothing to landfill in one season alone, rather than donating the items[18]. Clothes are not designed for longevity but for short lifecycles, which encourages consumers to buy new items. A study by Barnado's Retail found that the majority of fashion purchases are worn just seven times before being disposed of[19]. Few items are recycled and most clothes end up as waste. As WRAP highlights, in 2012, there were 350,000 tonnes of clothing in household residual waste[20]. This is approximately 30% of the 1,130,000 tonnes of clothing bought in the UK each year[21] and the figure is rising.

Limited recycling options to recover fibres means that nearly three fifths of all clothing produced ends up in incinerators, or landfills, within a year of being made[22]. Even if more unwanted clothes were to be recycled, there is not the market demand to absorb the volume of shredded or chemically digested fabric. Indeed, it has been estimated that less than 1% of material used to produce clothing is recycled within the clothing industry, with about 13% recycled for use in other areas[23].

With hundreds of thousands of tonnes of clothing going to landfill each year, there is a possible threat to local groundwater supplies. When it rains, water percolates through the rubbish, picking up chemicals and toxic substances in the process, including dyes and bleaches. When natural fibres, such as cotton, linen and silk, are buried in landfill, they act in a similar way to food waste, producing methane as they degrade.

Figure 4: World fibre production has been booming – with most of the increase in plastic-based polyester[24]



Synthetic fibres, such as polyester, nylon and acrylic, take even longer to biodegrade, taking hundreds, even thousands of years. This is all the more problematic, given that world fibre production is increasing, largely on account of the demand for plastic-based polyester.

Another destination for the fibres is our oceans. Synthetic fibres release miniscule strands, called microfibres, which are essentially microscopic pieces of plastic that are invisible to the naked eye. Each time an item of clothing is washed, these fibres make their way into our oceans, where they are swallowed by sea life and become incorporated into the food chain, ultimately ending up on our plates. One piece of clothing can release 700,000 fibres in a single wash[25]. An IUCN report calculates that 34.8% of releases of microplastics are due to the laundry of synthetic textiles.

CONCLUSION AND RECOMMENDATIONS

Ultimately, reducing the environmental footprint of the fashion industry is dependent on both engineers designing and delivering improved industrial processes, and the public changing their behaviours. Investing in research & development, whether examining the length of fibres or the way they are spun in order to understand shedding, or even researching a coating to limit fibre release – will have negligible impact unless we also change our shopping habits. Donating used clothes to charity and buying less, more durable clothing is the most effective method to reduce clothing waste. Building longevity into clothing will require a change in attitude to clothing and fashion from the public and the industry which has mastered and benefited from the economic cycle of fast fashion.

Besides their technical skills, engineers have a wider advocacy role in order to encourage this change in consumer habits. By contributing to the public debate on waste, engineers can emphasise the small steps that we all can make in order to reduce our footprint, particularly with regard to the aftercare of our garments. This might include advocating for individuals to wash their clothes at a lower temperature, use mesh laundry bags to catch threads, or install filters on washing machine waste pipes.

In order to improve the environmental impact of the clothing industry, the Institution of Mechanical Engineers recommends:

1. **The UK Government in collaboration with the fashion industry should invest in initiatives which provide incentives for the development of more environmentally friendly fibres.** Research & development investment can make a significant impact on improving the sustainability and efficiency of textile manufacturing. For instance, a research team under Herbert Sixta at the Aalto University, found an ionic liquid which can dissolve cellulose from wood pulp, producing a material that can be spun into fibres. When the liquid was applied to a poly-cotton blend, it dissolved the cotton, but not the polyester, allowing it to be filtered out. The dissolved cellulose could then be used to make stronger fibres.
2. **The UK Government should work with the fashion industry and manufacturers to develop a comprehensive framework to tackle 'greenwashing', or false sustainability claims.** Corporate Social Responsibility is an essential element of a brand's identity. It helps a company position itself as a responsible business and market itself to ethically conscious customers. However, sometimes a company's claims don't always add up. The UK industry should look to the Higg Index, a US industry self-assessment standard for assessing environment and social sustainability throughout the supply chain.
3. **The UK Government, fashion industry and manufacturers should support the development of mechanical and chemical fibre recycling technologies, particularly those which are able to separate blended fibres.** Fibres produced by mechanical recycling are shorter and inferior in quality to virgin fibres, which in turn makes them less valuable. Chemical recycling will play a more prominent role in recycling, as the method develops. A WRAP report[26] has identified relatively few barriers to the uptake of the textile fibre recycling technologies.

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