Clothing

Global consumption of clothing results in around 330MtCO_2 of emissions, with emissions from the use of clothing resulting in an additional 530MtCO_2 per year. New consumption-based approaches to emissions, together with production-based measures, could reduce emissions from clothing in Europe by over 30% against a business as usual forecast, even with a moderate (2% pa) growth in clothing consumption.

Key facts

- **Globally significant emissions**
  The purchase and use of clothing leads to the release of over 850MtCO_2 per year (around 3% of global production CO_2 emissions), including both embodied emissions in the clothing, and emissions arising from clothing use (washing, drying, ironing).

- **Large international carbon flows**
  Over half of clothing production emissions move across an international border between production and consumption (sale) of the clothing. These flows between countries drive significant differences between clothing production and consumption emissions, and per-person emissions from clothing consumption, in many countries.

- **The UK clothing sector**
  Demand for clothing in the UK drives the production of almost three times more emissions outside of the UK than it drives domestically (excluding use phase emissions), with China being the most significant source of these international emissions. Natural fibres dominate the global clothing sector, with cotton accounting for around one-quarter (by weight) of fibre used in clothing.

- **The importance of longevity**
  Today, use phase emissions account for around 50% of a typical t-shirt's life cycle emissions. Significant decarbonisation opportunities exist for both embodied and use phase emissions arising from clothing; however, the longevity of clothing exerts a strong influence over future scenarios for the life cycle emissions of clothing.

Implications for business

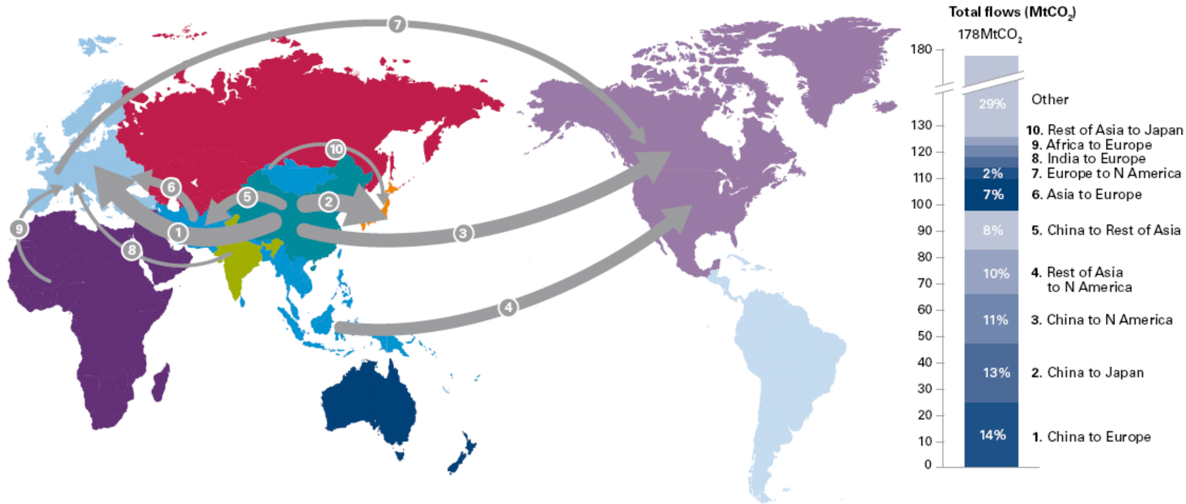
New consumption-based actions focused on the clothing industry have the potential to complement today's production-focused approach, delivering further reductions in emissions for the clothing sector by 2020. Whilst EU clothing sector emissions could be reduced by around 21% versus 'business as usual' by 2020, additional consumption-based approaches could increase this by a further 13%, a 50% improvement. Key initiatives open to businesses include:

- **Product carbon footprinting**
  The scale roll-out of product carbon footprinting for the clothing sector by 2020 (focussing initially on consumers in developed countries). This will likely encompass a range of measurement, accreditation and communication approaches.

- **Improving clothing longevity**
  A focus on increased longevity of clothing, focusing on the environmental and quality benefits of buying clothes that last longer.
  Further coordinated campaigns to wash clothes at 30°C or lower, involving broad education, clothing manufacturer tagging of clothes, and detergent and appliance manufacturer coordination.

The international trade in clothing drives significant flows of emissions between producer and consumer countries

Major global flows of embodied emissions in clothing

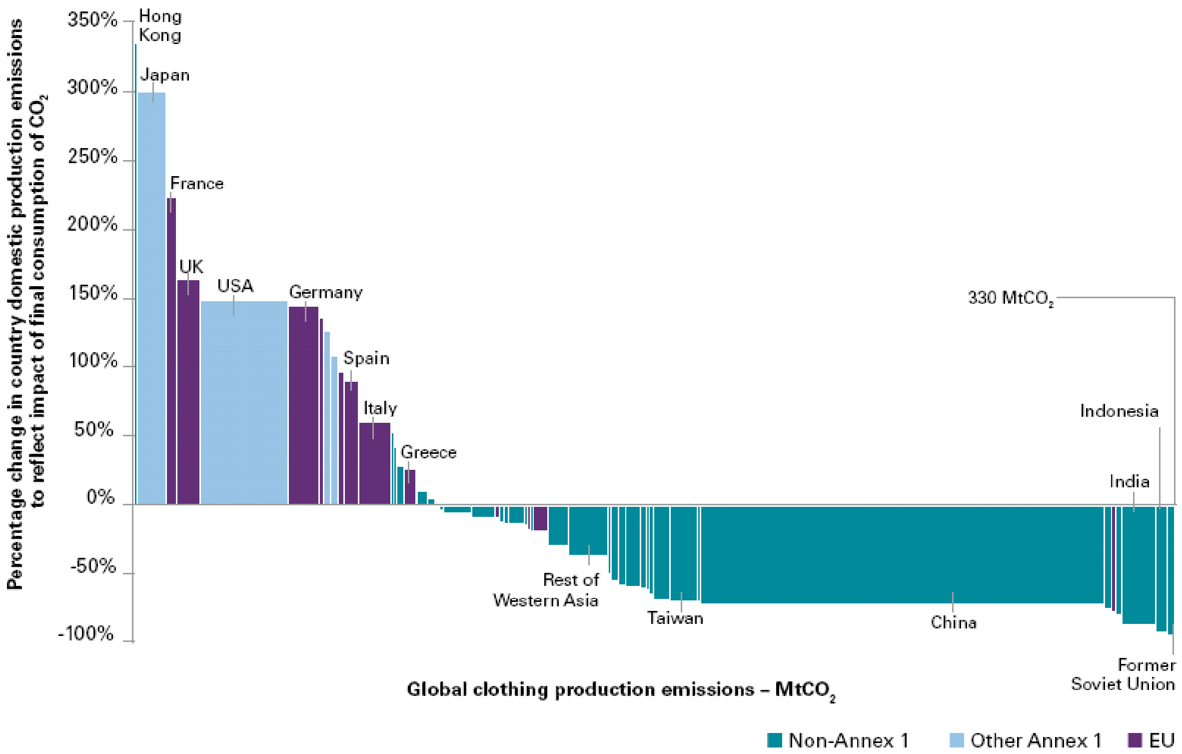


Note: Excludes emissions associated with consumption in the same region as production.
Source: Carbon Trust Analysis; CICERO / SEI / CMU GTAP7 MRIO Model.

The concentration of production and consumption of clothing in different countries drives significant flows of emissions embodied in the global clothing sector, with the top 10 trade corridors for the international clothing industry shown above. All but one of these emissions flows routes (Europe to North America) originates in developing regions, with China-Europe, China-Japan and China-North America being the top three trade corridors for embodied carbon in clothing.

Global embodied carbon flows support extreme differences in production and consumption of clothing emissions by country

The impact of a consumption perspective on emissions from clothing



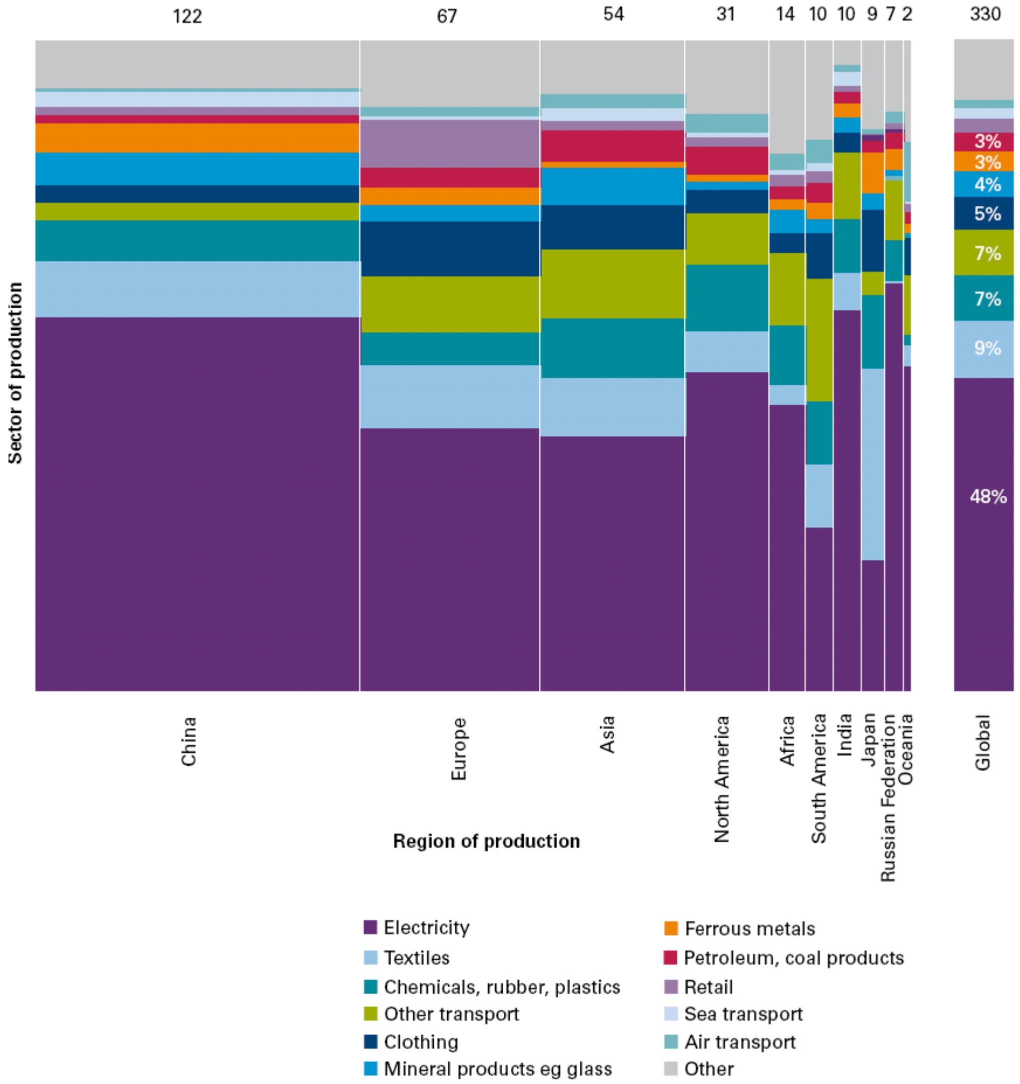
Note 1: Top 50 clothing producing countries (96% of emissions from global clothing production).
Note: Includes both direct and indirect CO_2 emissions (excludes non-CO_2 GHG emissions from cotton production).
Source: Carbon Trust Analysis; CICERO / SEI / CMU GTAP7 MRIO Model.

International trade in clothing has a major impact on the net import or export of emissions embodied in clothing for individual countries. (In this chart, the x-axis represents global clothing production emissions (with the width of each country bar proportional to the country's clothing production emissions), while the y-axis shows the relative impact of net trade in clothing on each country's total consumption of emissions in this sector including the effect of both imports and exports of emissions in the clothing sector.)

China is both the largest producer of emissions in the global clothing sector, and one of the world's largest exporters of emissions embodied in clothing (72% of emissions arising from the Chinese clothing industry are embodied in clothing exported to other countries). At the same time, the USA is the world's largest importer of emissions embodied in clothing (in absolute terms), while Hong Kong, Japan, France and the UK are the world's top four importers of emissions embodied in clothing relative to domestic production.

One-third of clothing production emissions arise in China; electricity use drives more emissions than any other sector

Emissions from the production of clothing, by region and sector of emissions ($MtCO_2$)

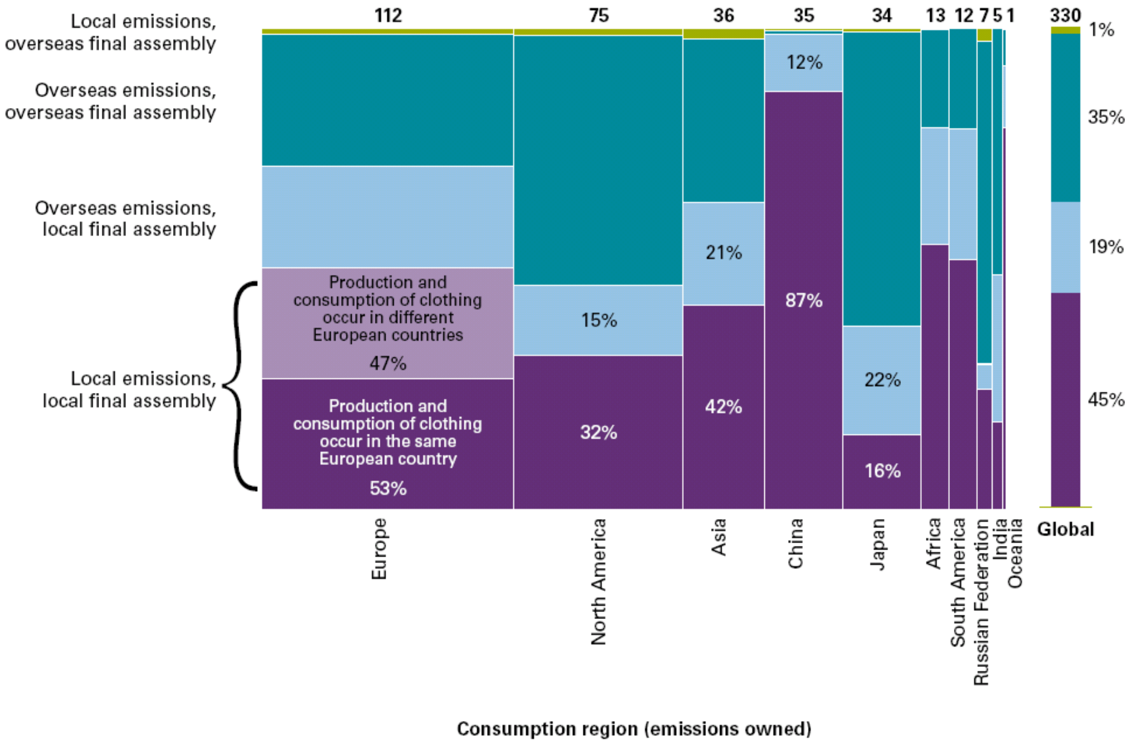


Note 1: Electricity emissions are not allocated to sectors as Scope 2 emissions, but are displayed fully within the electricity sector.
Source: CarbonTrust Analysis; CICERO / SEI / CMU GTAP7 MRIO Model.

Emissions from the global clothing sector occur across a wide range of regions and sectors: China is the largest producer of emissions associated with global cotton production, while almost half of all CO_2 emissions embodied in global clothing production arise from the generation of electricity. In the short term, energy efficiency in the electricity consuming processes of clothing production would be the main opportunity for emissions reduction. Longer term, reducing the carbon intensity of electricity generation will be key in lowering the embodied emissions arising from clothing production (and from the use-phase of clothing). However, the clothing sector is unlikely to be the driver of a global effort to decarbonise electricity generation, as electricity use in all aspects of clothing production accounts for just 1.5% of emissions from the global electricity generation sector. Overall, a reduction in emissions from textile production of around 25% might be possible in the medium term, comprising 15% from an increase in energy efficiency and 10% from increased electricity from renewable energy sources.

Over half of global clothing sector emissions flow across an international border between production and consumption

Global consumption of clothing emissions, by region of consumption ($MtCO_2$)

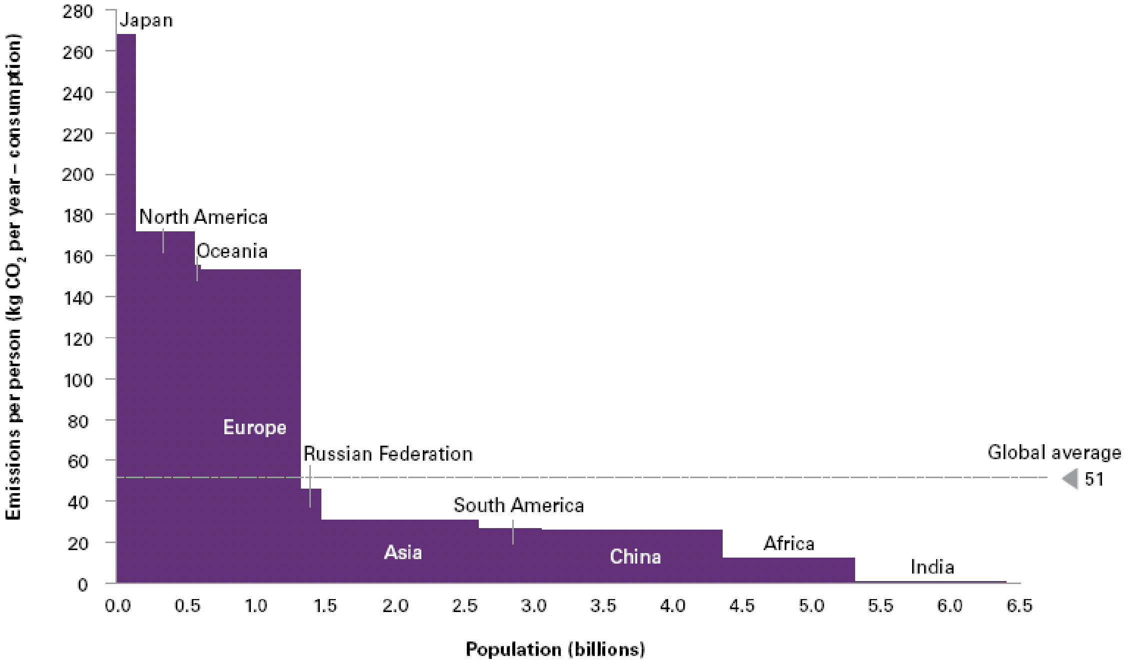


Source: Carbon Trust Analysis; CICERO / SEI / CMU GTAP7 MRIO Model.

On average, around 45% of global clothing production emissions occur in the same region as consumption of the clothing, with China exhibiting the highest proportion of domestic demand for clothing being met by domestic production, at 87% of its consumption emissions being produced domestically. This regional view masks some inter-country flows. On an individual country (rather than aggregate regions) basis, around 65% of embodied emissions in the clothing sector are exchanged between countries through trade. In Europe the significance of the exchange of emissions embodied in traded clothing is even higher, with around 75% of all emissions arising from the consumption of clothing in Europe being produced outside of the country where the clothing is purchased.

Per-person emissions arising from the consumption of clothing vary widely by region

Per person emissions from the consumption of clothing, by region (kgCO_2 per person per year)

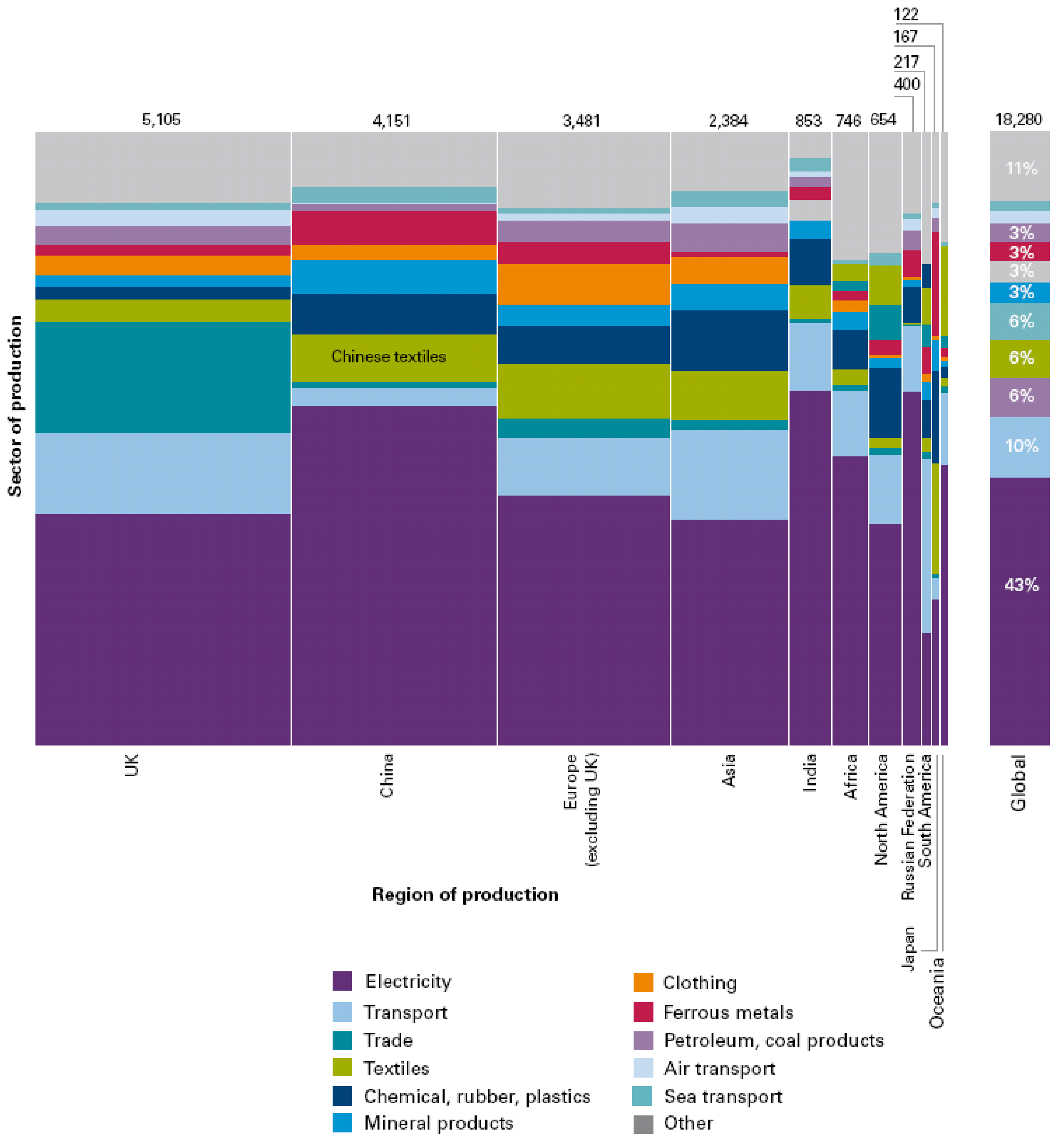


Source: Carbon Trust Analysis; CICERO / SEI / CMU GTAP7 MRIO Model.

Per-person emissions from the consumption of clothing by Japanese consumers are the highest of any region in the world, and are around five times higher than the global average. Per-person emissions from clothing consumption in Europe are slightly below those of North America, while per-person emissions in Asia, South America and China are well below average. The very low per-person emissions associated with clothing consumption in Africa and India suggest that there may be a significant unmet demand for clothing in these regions, and increasing wealth in these regions would be expected to support an expanding clothing market.

More than two thirds of emissions arising from clothing consumption in the UK occur overseas

Source of emissions arising from clothing consumption in the UK, by region and sector ($ktCO_2$)

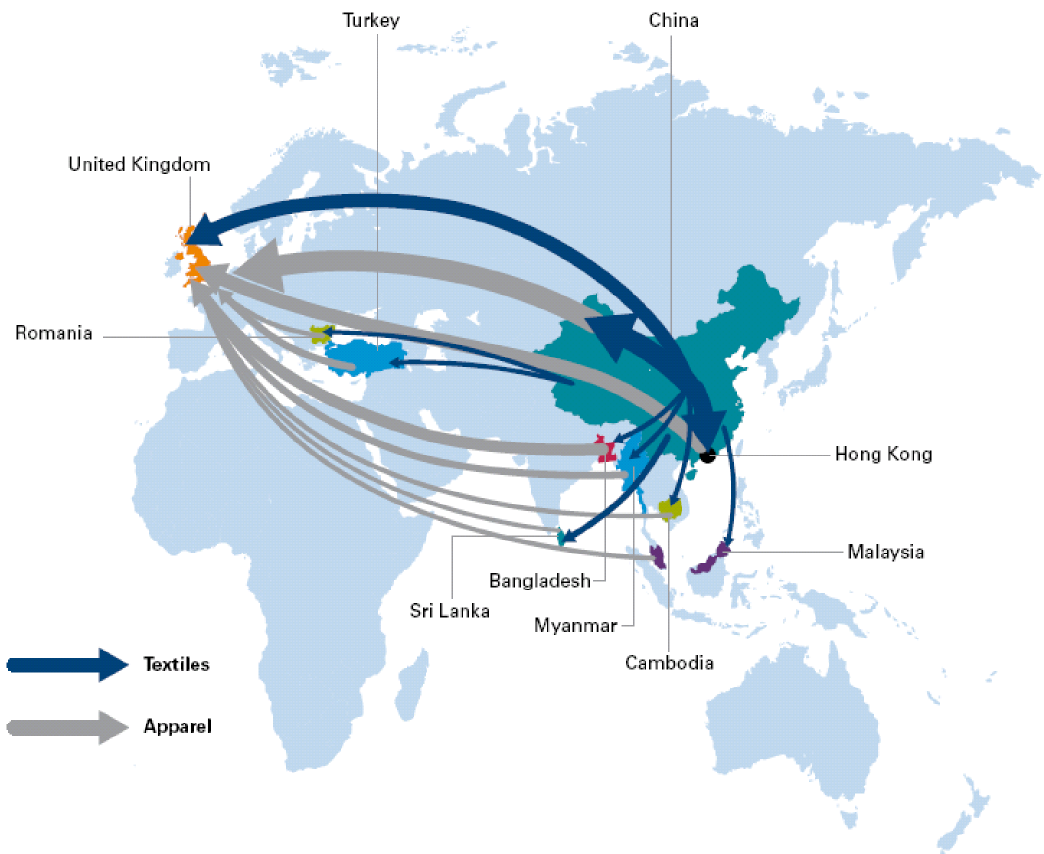


Source: Carbon Trust Analysis; CICERO / SEI / CMU GTAP7 MRIO Model.

The UK provides a case-study of emissions production and consumption in the clothing sector. Consumption of clothing in the UK results in around 18.3MtCO_2 emissions globally, with 28% of these emissions occurring in the UK and a further 23% occurring in China. All other European countries combined contribute 19% of total emissions arising from consumption in the UK. In common with the global view of emissions in the clothing sector, electricity is the dominant sector of emissions arising from clothing consumption in the UK and is responsible for 43% of total UK clothing consumption emissions.

Complex international supply chains support the UK's consumption of clothing

Embodied emissions pathways between Chinese textile production and UK clothing consumption

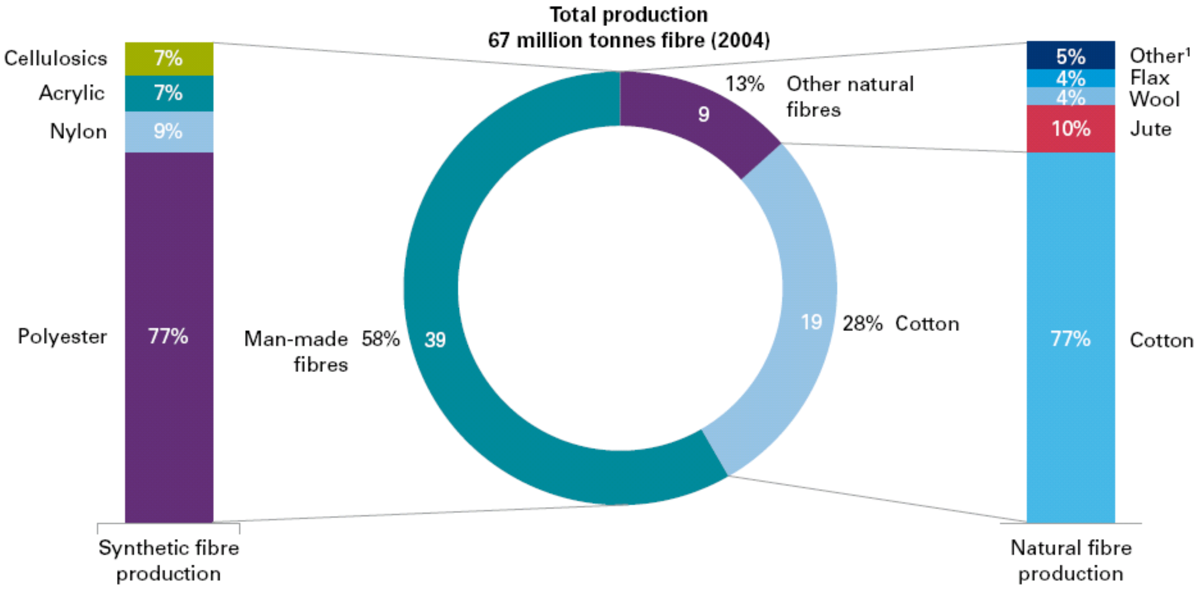


Source: Carbon Trust Analysis; CICERO / SEI / CMU GTAP7 SPA Model.

International flows of embodied emissions due to clothing consumption in the UK may follow a large number of pathways. Taking the example of emissions from the Chinese textile sector, the dominant pathway for these emissions flowing to the UK is through emissions embodied in finished clothes that are exported from China to the UK. However, there are a large number of alternative pathways: emissions from the Chinese textile sector may flow to the UK embodied in exports of textiles to the UK, or through textile exports to third countries that then use the textile to manufacture clothes that are ultimately exported to the UK. Hong Kong, Bangladesh and Sri Lanka, together with a wide range of other countries, are involved in the conversion of Chinese textiles to final clothing for the UK market. It is the combination of these, and many other pathways, that contributes to the overall emissions embodied in the consumption of clothing in the UK.

The majority of fibre in clothing is synthetic; cotton accounts for three-quarters of natural fibre use in clothing

Fibre use in clothing, 2004



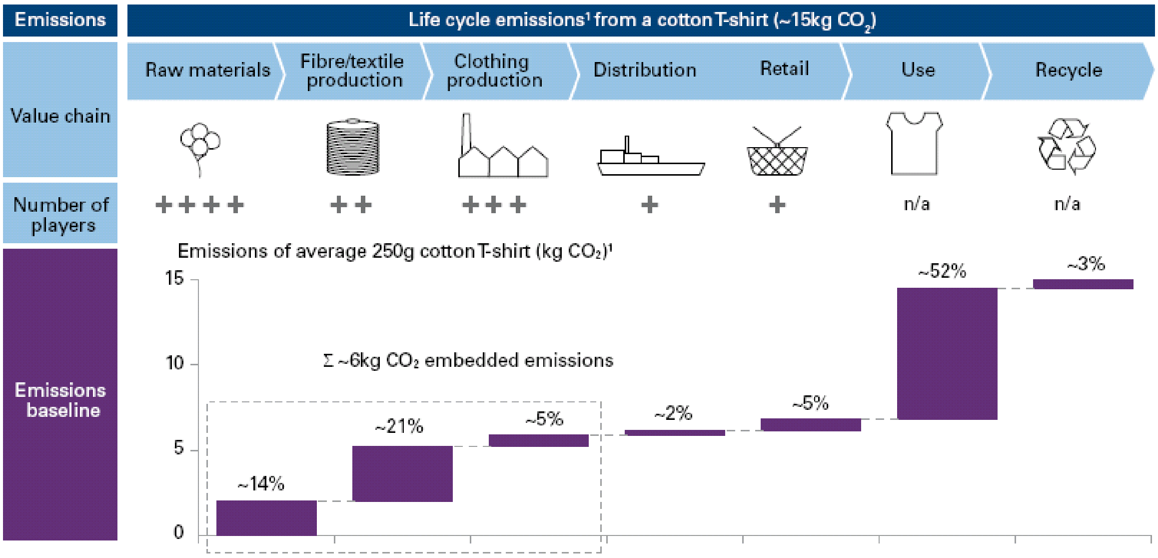
[1] Other includes hemp, silk, kapok, ramie, sisal, coir.
Source: Defra, University of Cambridge Institute for Manufacturing.

Cotton and polyester fibre dominate global clothing fibre inputs (by weight of fibre), together supplying over 85% of all fibre used in clothing. Cotton meets 28% of fibre demand, and is by far the dominant source of natural fibres used in clothing (77% of natural fibre use); similarly, polyester makes up 77% of synthetic fibre production.

The production of natural fibre has almost doubled in the 30 years to 2007, with cotton delivering the majority of this increase. At the same time, global demand for all fibres has also increased: between 1990 and 2004, much of the global increase in fibre use was met by synthetics, predominantly polyester. Overall, this has resulted in cotton meeting a smaller proportion of global clothing fibre demand (on increasing volumes of fibre use).

More emissions arise from the use phase of clothing than from all other clothing supply chain activities combined

Life cycle emissions from 50 "wears" of a cotton t-shirt (assumes global average carbon intensity of cotton production, a useable lifetime of 50 uses, and hot water washing after each use)



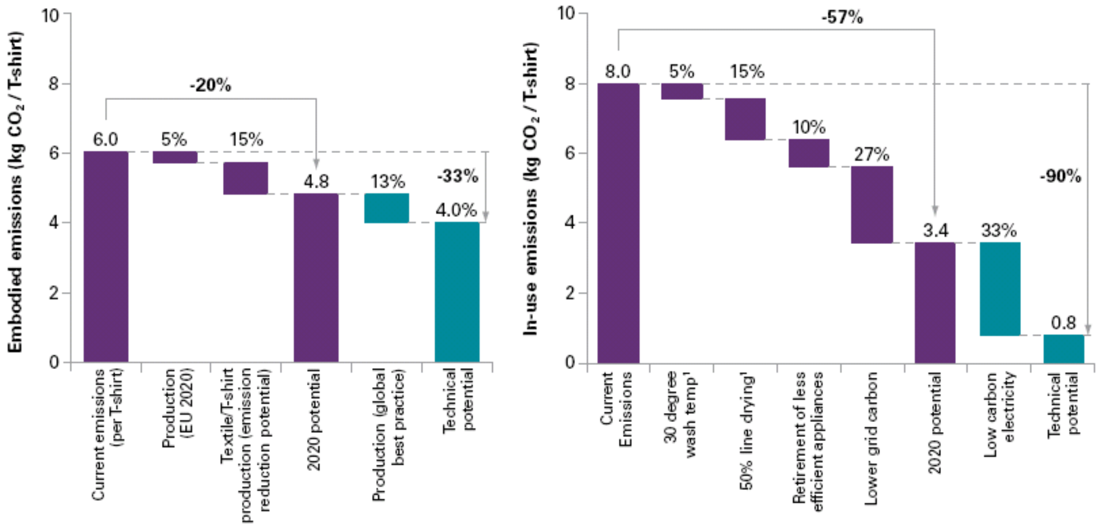
[1] Based on 50 wears over the lifetime of the T-shirt.
Source: Carbon Trust & BCG Analysis; Defra (2007) Mapping of Evidence on Sustainable Development Impacts that Occur in the Life Cycles of Clothing; Institute for Sustainable Resources Queensland University of Technology.

The global production of clothing results in around 330MtCO_2 being produced annually, which is about 1.2% of global human CO_2 production emissions. In-use emissions from clothing, principally arising from washing and drying, but including ironing and dry-cleaning, cause a further ~530MtCO_2 to be emitted, equivalent to around 2% of global emissions.

A typical t-shirt sold today is expected to be responsible for around 15kgCO_2 over its lifetime, with around half or more of these emissions arising during the use phase (washing, drying and ironing) of the t-shirt. The relative importance of production and use phase emissions is highly dependent on assumptions regarding longevity – see later analysis of this issue. Of the remaining embodied emissions, around half arise from the production of fibre and textile that are inputs to the clothing sector. Emissions from the growing of cotton account for ~14% of the life cycle emissions of the t-shirt.

There is significant opportunity for emissions reduction across the life cycle of clothing

Emissions abatement opportunities in the clothing sector: (left) embedded emissions abatement potential; (right) in-use emissions abatement potential



¹ Switch to 30°C washing and 50% tumble dry reduction, and grid carbon intensity of 300gCO_2/kWh.
Note: In-use emissions based on 50 washes per shirt. Excludes emissions from distribution and retail phases.
Source: Carbon Trust & BCG Analysis (including sector and expert interviews). University of Cambridge Institute of Manufacturing 2006: Well Dressed?

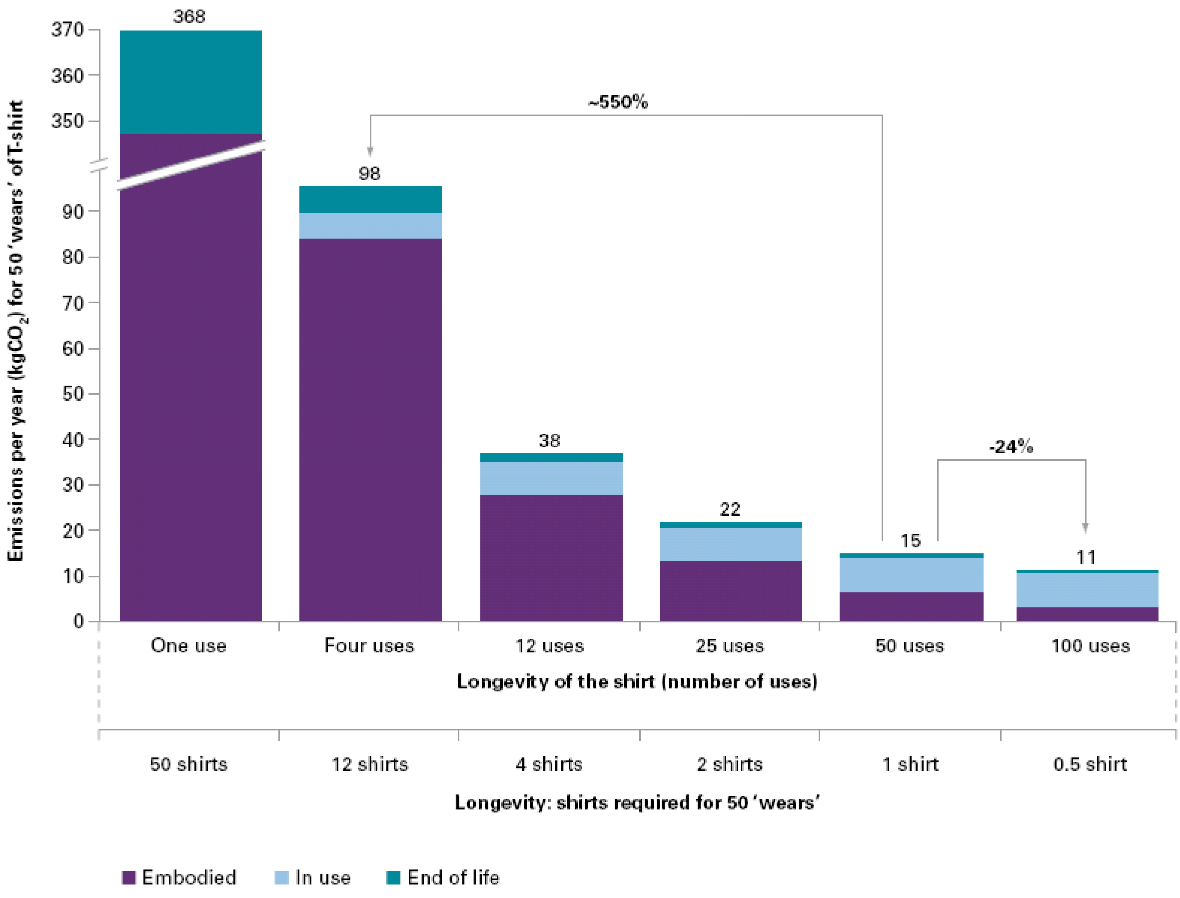
There are opportunities to reduce both the embodied emissions and use-phase emissions associated with the consumption of clothing.

Embodied emissions reductions could arise from energy efficiency in the electricity consuming processes of clothing production, while longer-term gains would be supported by the decarbonisation of both raw material production and decarbonisation of electricity supplies. (A case study of reducing embodied emissions is included for Continental Clothing: see page 16.)

There are a range of opportunities for emissions reduction from the use phase of clothing, with core strategies around appliance efficiency and lower temperature washing remaining significant areas of reduction. Again, decarbonisation of electricity supplies offers a major opportunity to drive deep emissions reductions in the use phase of clothing.

Longevity of clothing has a major influence over the life cycle emissions arising from clothing

Emissions arising over one year from 50 "wears" of a cotton t-shirt, with varying assumptions regarding longevity of the t-shirt



Source: Carbon Trust Analysis based on data from: Peter Grace, Queensland University of Technology; BCG analysis; Well Dressed? (2006).

The longevity of clothing has a key role to play in minimising the emissions arising over the clothing life cycle. Emissions from the use phase of clothing currently play a dominant role in the overall greenhouse gas impact of clothing, and this is where much of the current focus of emissions reduction is directed. However, the dominance of use-phase emissions is highly dependent on assumptions regarding the longevity of the garment, and therefore the number of "wear and wash" cycles the garment goes through before it is disposed.

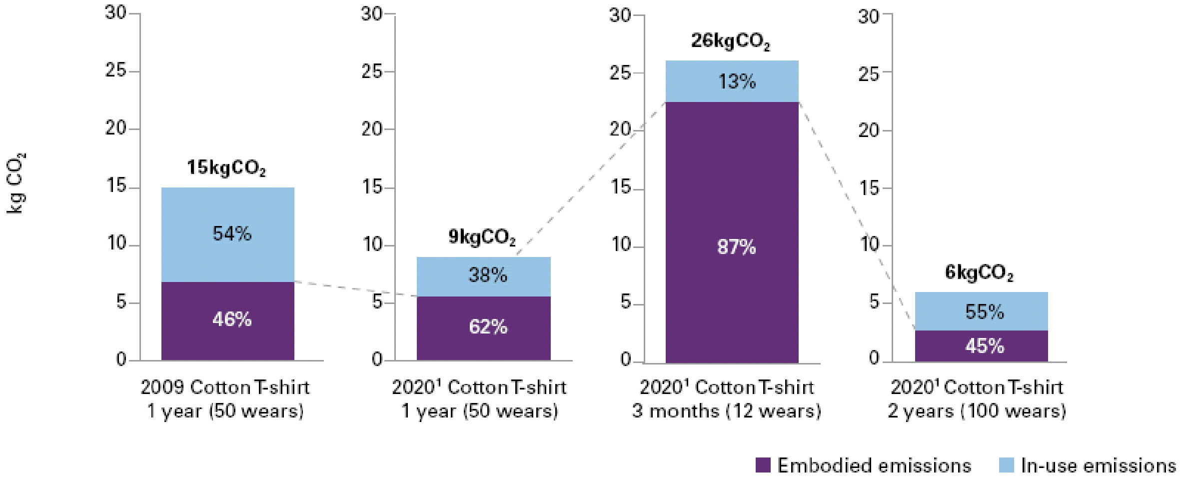
Changing the number of wash and wear cycles for a garment, whether through clothing quality or fashion choice, will have a significant impact on the overall lifecycle of clothing, and could significantly affect the global emissions arising from the clothing sector. In an extreme case where a shirt is used only once, 50 new shirts would be required for 50 "wears" (i.e. wearing a shirt one day per week for a year). If the shirt lasts for 50 uses, then only one shirt is purchased in a year to be worn once per week (i.e. 50 "wears" from the one t-shirt).

With a shirt that lasts one year, use phase emissions tend to dominate the life cycle emissions from clothing (this is even more apparent where the shirt lasts more than one year). However, as longevity decreases, clothing needs to be replaced on a more regular basis. A shirt that only lasts six months (25 "wears") will need to be replaced twice each year, doubling the embodied emissions over the year compared to a longer lived shirt that lasts for 50 cycles. Doubling the useful life of clothing from one year to two years reduces emissions over the year by 24%, while reducing the longevity of a shirt from one year (50 uses) to only 1 month (4 uses) increases emissions over the year by around 550%.

The effect of longevity has major implications for clothing retailers, who to some extent seek to increase sales by regularly changing design and fashion style. While this is not in itself a high-carbon activity, were such changes to lead to reduced clothing longevity (even if this means that the shirt is discarded for aesthetic rather than functional reasons) then the impact on the overall emissions arising from the life cycle of clothing could be very significant. Equally, the provision of high quality, long-lived clothing offers a very real opportunity to reduce emissions associated with clothing over the longer term. With over 50 items of clothing purchased every year by each person on average in the UK, it suggests that at least some articles of clothing are discarded before the end of their natural life.

Estimates of future life cycle emissions from clothing vary widely with assumptions of longevity

Annual CO_2 emissions associated with wearing and washing a t-shirt once per week, and purchasing a new t-shirt after its maximum use



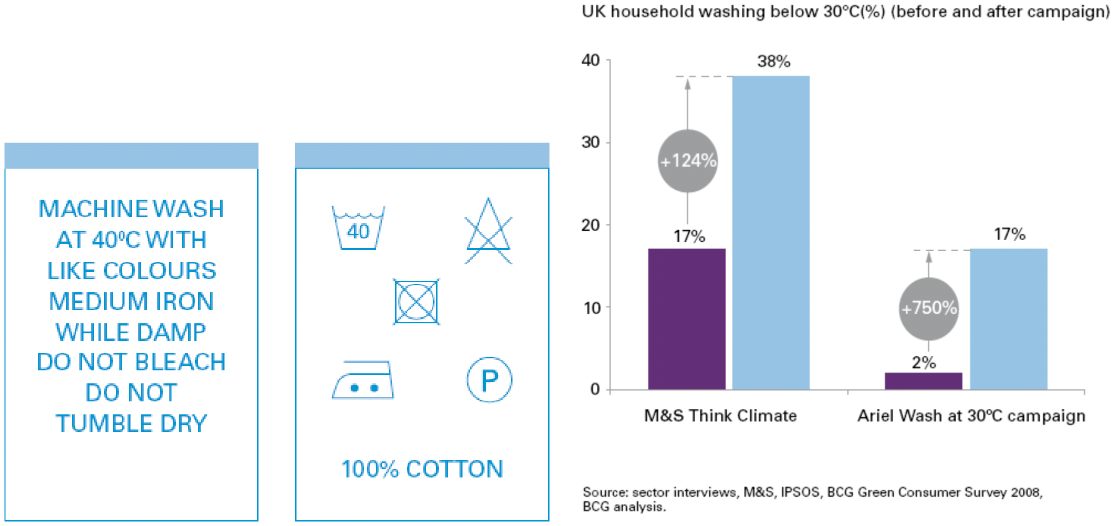
[1] Assumes a 20% reduction in production emissions, distribution & retail unchanged, 30% reduction in use-phase emissions, and a carbon intensity of electricity of 300gCO_2/kWh.
Source: Carbon Trust Analysis; Peter Grace (2009).

Over time, the ratio of embodied to in-use emissions for clothes could change quite radically, depending on the scenario of reductions in in-use emissions (through decarbonised grid, increased energy efficiency of appliances and also washing at lower temperatures), reductions (if any) of embodied carbon of clothes (through action across the clothing supply chain) and any changes to the longevity of clothing.

By 2020, the combined effects of decarbonising cotton production and lower use-phase emissions would see the life cycle emissions of a cotton t-shirt fall from 15kgCO_2 to 9kgCO_2 (assuming 50 wears over a 1 year life span). Under this scenario, the importance of use phase emissions decreases relative to the embodied emissions in the t-shirt. Applying the same conditions, but reducing the longevity of the t-shirt in 2020 to three months (rather than one year), sees a large increase in the emissions arising from the provision of 50 "wears" of a t-shirt over one year (rising from 15kgCO_2 to 26kgCO_2 per year). This increase is dominated by embodied emissions arising from the need to replace the t-shirt four times through the year. Conversely, if the longevity of the t-shirt increases from one to two years, then the life cycle emissions over the year fall to just 6kgCO_2. It is possible that the embodied emissions of clothing will rise relative to the in-use emissions, to become the higher category of emissions and the key area of focus for overall emissions reductions.

Communication and education can be successful in raising consumer awareness of low carbon clothing

(Left) Example clothes tag and care label; (right) Consumer reactions to low temperature washing initiatives



Over the typical one-year lifetime of a shirt, use phase emissions account for over half the total emissions arising from the use of the shirt. Of these emissions, 80% arise from washing and tumble drying of clothing. Simple measures such as providing care tags that encourage (for example) lower temperature washing have been used by some manufacturers. There is evidence to suggest that educational campaigns to change behaviour on washing can work to effect change. Consumer reaction to the M&S Think Climate campaign raised consumer uptake of low temperature washing by 124% from 17% to 38% uptake. The Ariel Wash at 30°C campaign similarly raised consumer uptake for washing at 30°C from 2% to 17 %, a 750% increase.

Achieving further uptake of lower temperature washing will require co-ordination across appliance manufacturers (producing washing machines that can wash at lower temperatures), detergent manufacturers (producing detergents that are effective at cleaning clothes at lower temperatures) and retailers and brand owners (providing information and education to consumers around the viability and benefits of low temperature washing).

Case study: Continental Clothing

Background

Continental Clothing was the first business-to-business (B2B) company to participate in the Carbon Trust's product carbon footprinting and labelling initiative. The project gave new insights about how carbon footprint assessment and communication can uniquely benefit B2B companies; how the analysis can be done cost effectively by a smaller business; and how a textile company can reduce carbon emissions across its supply chain. It is also an early example of a company rolling out the initial pilot to other product lines in their portfolio and even to partners up and down the supply chain.

Motivation

Continental Clothing has a strong commitment to sustainable production and had already initiated several measures to reduce carbon emissions as part of this broader sustainability agenda (including the use of organic farming and natural irrigation, renewable energy, waste minimisation, biodegradable packaging and a no-airfreight policy). Product carbon footprinting allowed Continental to provide its customers with independent, credible and verified CO_2 data for the production of their EarthPositive® shirts.

The process and experience

Continental calculated its initial product footprints in record time (November to December 2007), at minimal cost, demonstrating the opportunity SMEs have to execute quickly. Vertical integration and locally-sourced supply also contributed to the speed of the pilot: Continental owns its entire processing facility in the Tamil Nadu region of India and sources 100% organic cotton from a single set of local producers. This made the data collection process very quick. A two-stage interview process – where the first day involved visiting a site and learning about the process and activities, and the second day focused on data collection – proved to be very effective.

Scope of the analysis

The carbon footprint calculation for EarthPositive® shirts reflects all stages of the shirt life cycle from growing organic cotton through to the arrival of the products in the UK. As specified in the PAS 2050, B2B companies like Continental Clothing can exclude the distribution, retail, use and disposal phases of their products' life cycles since these phases can be hard to predict as their products may be used by different customers in very different ways.

Impact

Using renewable energy also reduces the company's exposure to oil price rises. Continental can therefore offer price stability to customers during a time when competitors have had to increase their prices. The use of renewable electricity, together with the 'no airfreight' policy, provides a considerable carbon benefit to Continental over many rivals. Through their product carbon footprinting work, Continental identified further opportunities to reduce carbon emissions of their EarthPositive® range including:

- Increase energy efficiency of machines
- Change suppliers to ensure lower-carbon inputs
- Understand low carbon alternatives in manufacturing sub-processes, including spinning, water treatment, dyeing and finishing.

Next steps

Continental is currently expanding the footprinting model to include decorative options (e.g. screen printing, embroidery, heat transfers) and more complex fabrics (e.g. blends, technical washes, distressing process) and is helping to educate consumers by sharing this information with tips to reduce emissions on its website and the labels themselves. Continental is continuing its work in low carbon production in a number of areas, including the development of new (low carbon) supply chains, improved carbon modelling in their processes better informed product development, and improved customer engagement and product differentiation.

Acknowledgement

The analysis presented here was prepared by the Carbon Trust using data and support from:

- Dr Glen Peters: Centre for International Climate and Environmental Research (CICERO), Norway
- Dr Chris Webber: Carnegie Mellon University, USA
- Dr Jan Minx: Technische Universität (TU) Berlin, Germany
- The Stockholm Environment Institute
- Prof Peter Grace, Queensland University of Technology, Australia
- Boston Consulting Group
- Ricardo

The Carbon Trust receives funding from Government including the Department of Energy and Climate Change, the Department for Transport, the Scottish Government, the Welsh Assembly Government and Invest Northern Ireland.

The Carbon Trust is a company limited by guarantee and registered in England and Wales under Company number 4190230 with its Registered Office at: 6th Floor, 5 New Street Square, London EC4A 3BF.

Web-based content available: May 2011.

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Making business sense of climate change

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