Energy for Business

Innovate and Collaborate with the University of Nottingham



David Nieper Ltd

Greenhouse Gas Emissions from Stages of Garment Manufacture

European Union
European Regional Development Fund

Executive Summary

This report has been written by the Energy Innovation and Collaboration team at the University of Nottingham for David Nieper (www.davidnieper.co.uk), a clothing and garment manufacturer based in Alfreton, Derbyshire. This report covers the energy and greenhouse gas emissions for the UK operation of David Nieper, shown in blue in Figure 1. It also covers an analysis of the difference in greenhouse gas emissions between a UK manufactured garment with direct-to-customer retail (as per David Nieper) as opposed to overseas manufactured garment sold via a high street retailer.

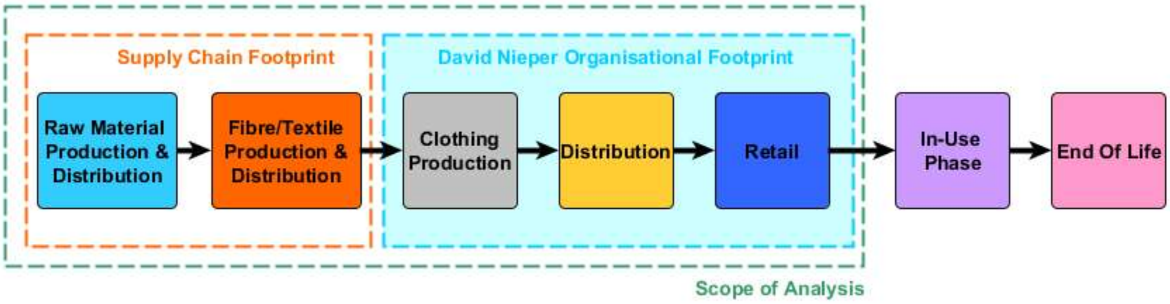


Figure 1. The various stages within the life of a garment showing the scope of this analysis. (Adapted from reference [1])

David Nieper uses an average of **5.16 kWh of energy per garment**. The greenhouse gas emissions are an average of **1.46 kgCO_2e per garment,** with their solar PV generation included. This does not include the carbon embodied in the raw materials nor the energy used for distribution. The output from the solar PV systems is approximately 12.7 % of the total energy used on-site.

When the production processes used at David Nieper are compared to overseas production then the greenhouse gas emissions are in the region of **9.6 to 18.1 %** less, shown Figure 2. This is an estimated range and a more detailed assessment is beyond the scope of this investigation, as it requires detailed analysis of the carbon footprint for the supplied fabrics in addition to a detailed assessment of a competitor brand. The standard business model is overseas production, distribution to UK logistics centres and then retail via UK high street retailers. The David Nieper business model uses direct sales (through printed catalogues) with garments produced to order in the UK. This helps to reduce carbon emissions by reducing distribution and transportation emissions, reducing the emissions associated with retailers and reducing waste from over-production.

The business model of David Nieper aims to reduce the carbon emissions due to clothing production, clothing distribution and retail, however, Figure 2 shows that the carbon footprint for these activities are dwarfed by the upstream activities to supply the fabrics, which account for over 70% of the carbon emissions.

To influence the in-use and end-of-life phases of a garment, David Nieper should look to providing informative labelling and promote the longevity of their products.

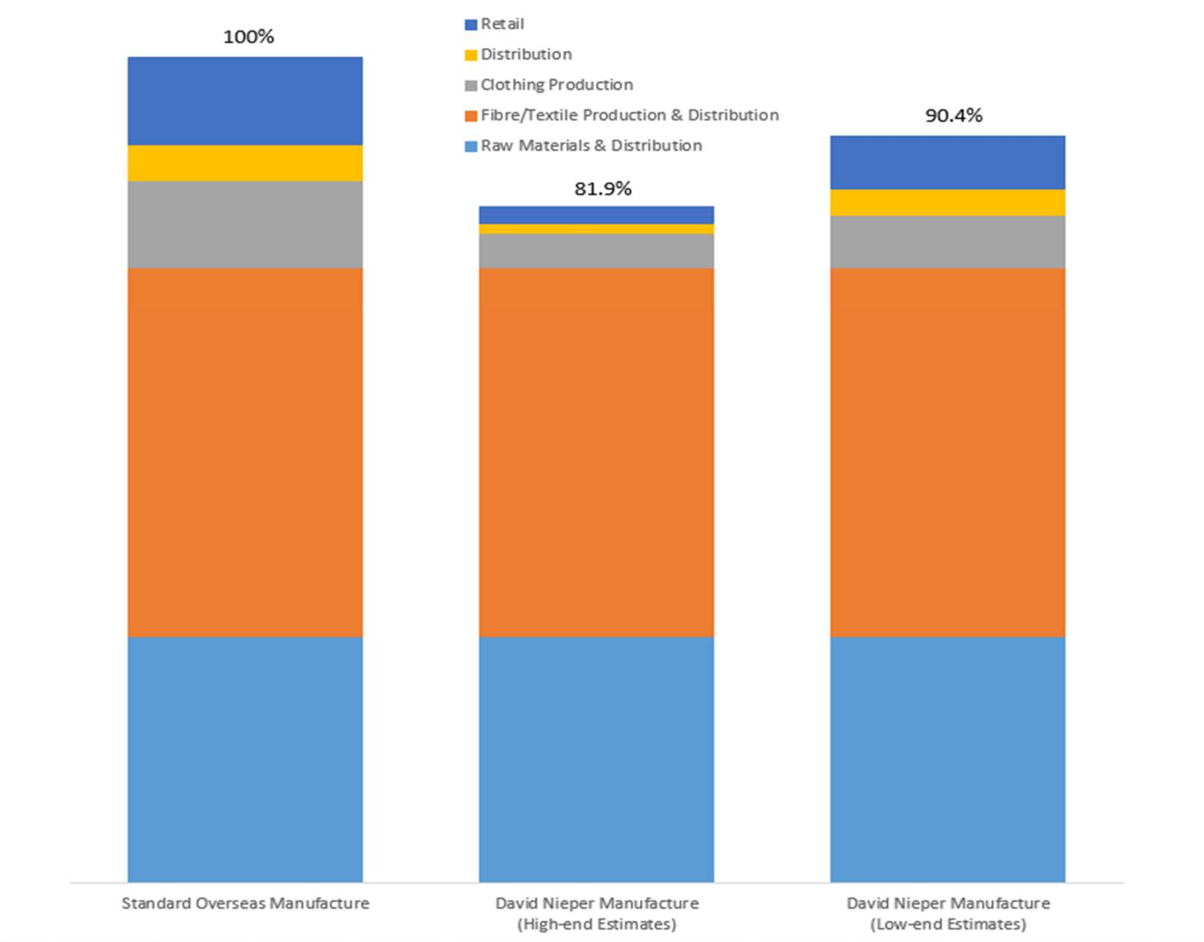


Figure 2. Comparison of greenhouse gas emissions between standard overseas and David Nieper production techniques.

Some recommended improvements at David Nieper for both greenhouse gas reductions and for environmental considerations include:

- Encourage suppliers to have a greenhouse gas emission analysis.
- Change suppliers to low-energy options, where possible.
- Reduce number of mail order catalogues printed, where possible.
- Investigate the solar PV system, which, for the system on factory 1, has low production values in summer 2018.

- Join the Sustainable Clothing Action Plan, which looks at waste reduction
- Join the European Ecolabel scheme, which looks at labelling garments with carbon emissions, similar to an electrical appliance energy rating.

Contents

List of Figures

List of Tables

1. Introduction

1.1. Company Overview

David Nieper Ltd (www.davidnieper.co.uk) are a clothing and garment manufacturer based in Alfreton, Derbyshire. They design and produce a range of womenswear, knitwear, nightwear and lingerie, which are hand made in the UK. They produce around 180,000 garments a year. They use various different fabrics sourced from Europe, with raw materials from around the world. Their focus is on quality, fit and comfort and they produce garments to order, using “just-in-time” manufacturing. They only supply direct to customers (through a mail order catalogue and website) and do not have or supply any retail establishments. They have a fitting service for manufacturing garments to exact sizes. They employ around 240 staff, with 40 in the offices and 200 within the factory. Production is in two shifts from Monday to Friday, between 6 am and 10 pm. David Nieper have manufactured within the UK for the past 55 years, while the majority of UK fashion designers have taken manufacturers overseas.

David Nieper aim to minimise energy use, and hence reduce their carbon footprint, with measures including:

- Four solar photovoltaic (PV) arrays, totalling 178.2 kW_p, on different buildings producing electricity to help offset the building energy use.
- A rainwater harvesting system for around 90 % of their internal water requirements.
- A waste management policy to ensure all paper, card and plastic is recycled and kitchen waste is composted. They have implemented a zero landfill policy with their refuse company, enva.

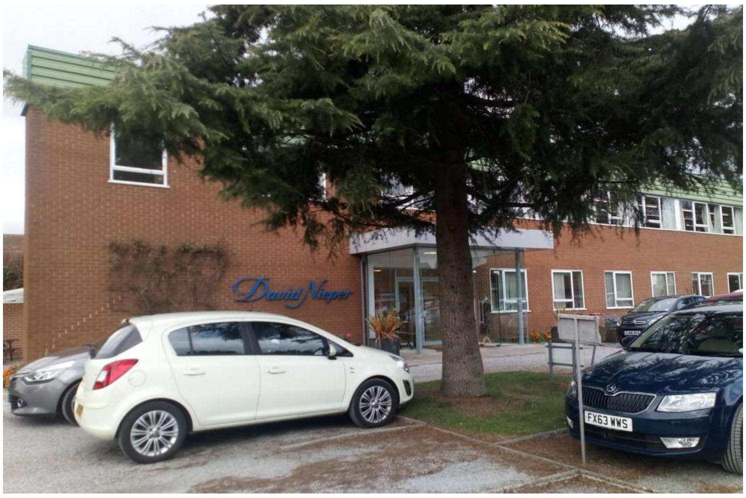


Figure 3. David Nieper main premises.

1.2. Project Overview and Scope

David Nieper are interested in comparing the carbon footprint of a garment manufactured by them in the UK to one manufactured overseas (i.e. Asia). This analysis aims to help David Nieper identify areas of operation that can reduce further the carbon footprint of their garments, leading to more sustainable manufacturing practices.

The supply chain for the garment manufacturing industry is very complex. In this report, the greenhouse gas emissions of David Nieper's operations are calculated using energy bill and production data, as shown in the blue box in Figure 4.

David Nieper does not have direct influence upon the supply chain footprint, but can exert some indirect influence through choice of suppliers. The report presents an analysis of the greenhouse gas emissions, including their supply chain, for a garment produced by David Nieper, compared to a garment produced in Asia.

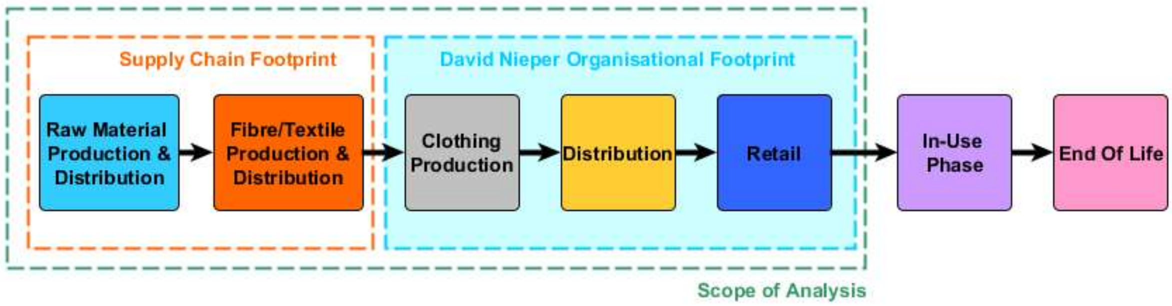


Figure 4. The various stages within the life of a garment showing the scope of this analysis. [1]

The in-use phase and end-of-life is outside the direct influence of David Nieper (as for any clothing manufacturer), so will not be included in the main analysis. These areas greatly affect the lifetime greenhouse gas emissions, so best practice information from sector reports is highlighted.

2. Factory Overview

David Nieper have two sites with four different factory areas. This section has a brief overview of the areas and the main energy loads in those areas.

2.1. Factory 1: Office, Sewing, Training, Design, Graphics, Cafe & Despatch

Figure 5. Sewing area.

Factory 1 has a floor of around 160 sewing machines used for different tasks. Each product is produced by small teams, who follow the garment through all manufacturing stages, which means the employees must be multi-skilled. Factory 1 also includes the offices for the business, which included the design and graphics departments. There is also a shop and café. As production of a garment is a highly skilled process, David Nieper have a training school within this building to provide local highly skilled workers. Items are also despatched from this building and they send out between four and five thousand orders per week. Despatch is (via Royal Mail in the UK) who provide daily bulk collections.

2.2. Factory 2: Knitwear

Figure 6. Knitwear area. Linking machines (left) and knitting machines (right).

In the knitwear area, there are 10 linking machines and 7 automatic knitting machines. This area also includes the photography studio.

2.3. Factory 3: Fabric Cutting & sewing

Figure 7. Cutting machines (left) and sewing and training (right).

Factory 3 has computer numerical control (CNC) cutting machines for cutting the fabric to the base shapes. These machines fit as many items as possible within the fabric using specialist computer design software. There is an additional sewing and training area with approximately 70 assorted sewing machines.

2.4. Factory 4: Catalogue Printing

Figure 8. Catalogue printing and production.

David Nieper design, print, produce and send out their own catalogues. These are produced in different sections and sent out using selective marketing to their customers. This room had a large multi-stage printing machine, a cutting machine and a folding and stapling machine. They print in the region of 10 million catalogues per year.

3. David Nieper Organisational Footprint

3.1. Energy Use

The site at David Nieper is mainly electric, which supplies the majority of loads, with a gas boiler supplying heating and hot water. Monthly electricity bills were obtained for the three production factories and for the catalogue printing facility. Data was obtained for the period of January 2017 until July 2018, with this study focussing on data from 2017. Gas bills for the three gas supplies for this period were also obtained. Production data was also obtained for the same period. The electricity use is shown in Figure 9 and the total garment production data is shown in Figure 10, with averages shown as an additional orange line. The solar PV energy export offsets some of the energy requirements at all sites. It has been assumed that 60 % of the energy from the PV systems is used onsite, shown in Figure 9.

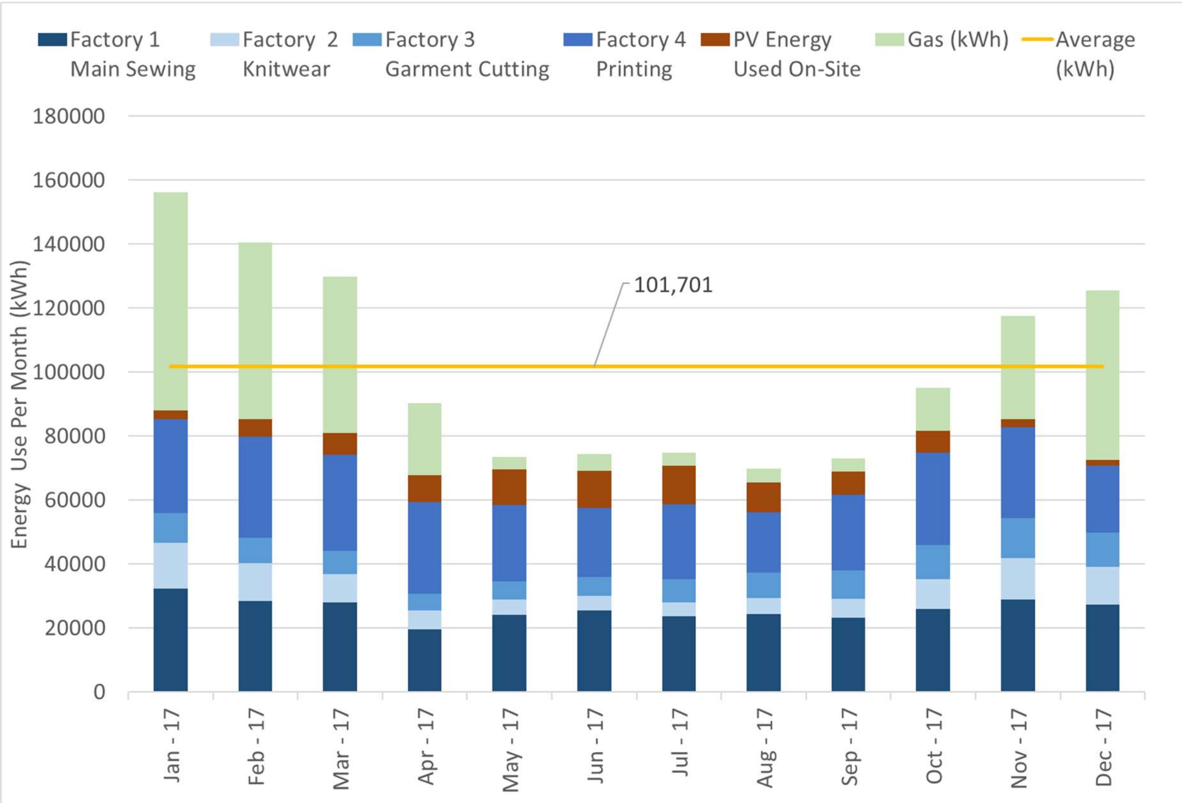


Figure 9. Energy use at the four factory sites in 2017.

Figure 9 shows that the majority of electricity is consumed in the main sewing factory and printing catalogues. The main sewing factory has many more people working within it and includes the office and despatch activities. The printing factory is running large-scale printing equipment with associated high energy consumption. The knitwear factory has low energy consumption as it only has a few staff and is mainly comprised of computer controlled knitting machines, which are relatively low power. Knitwear also needs to be finished within the main sewing area, so a finished garment will include energy used within all the factory sites. Gas use follows the colder months, as would be expected as it provides heating.

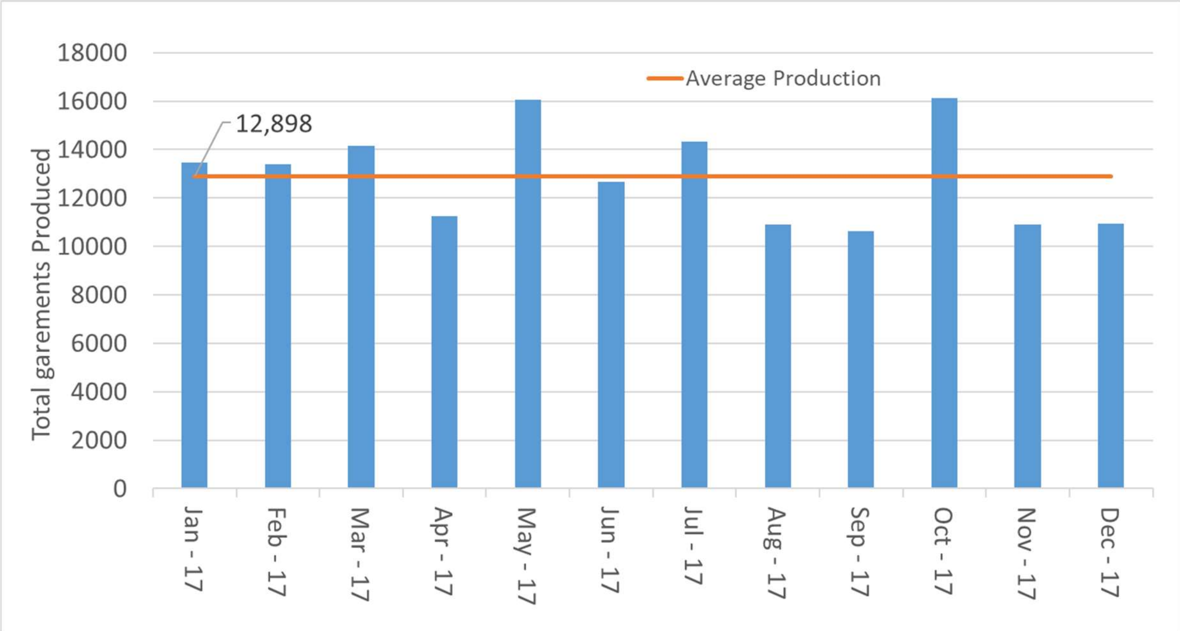


Figure 10. Production data for 2017 - total number of garments.

Using the production data and the energy usage data, the average energy used per garment has been calculated at **8.03 kWh**, which is shown in Figure 11.

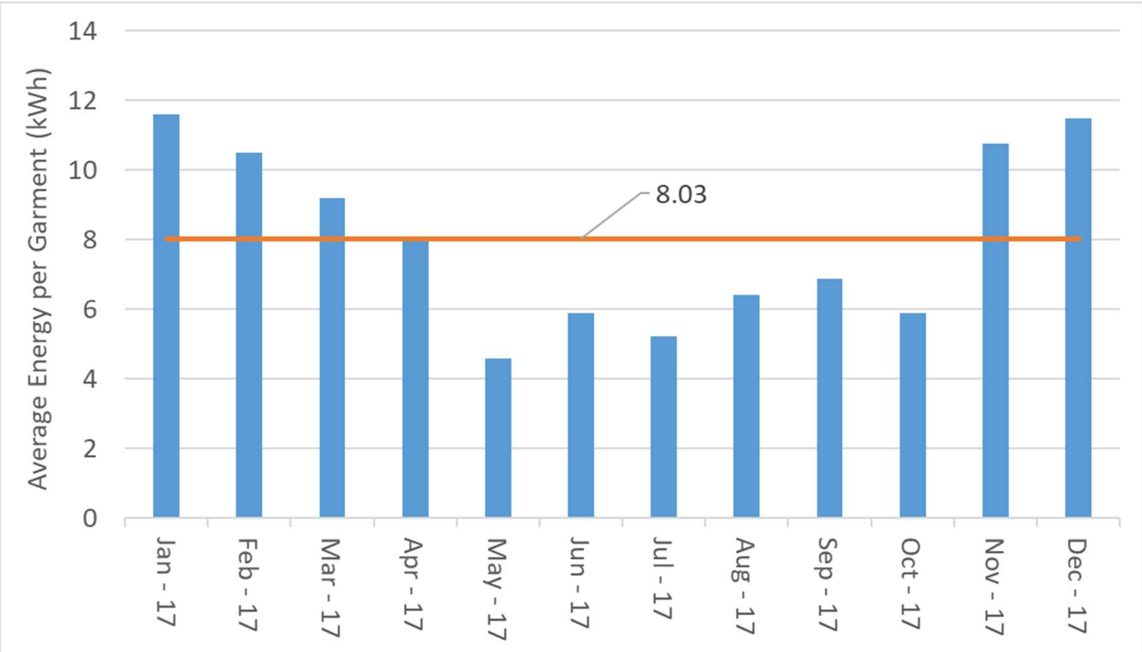


Figure 11. Energy use per garment produced (kWh).

David Nieper have four solar photovoltaic (PV) arrays with one on each of the factories. There are three 50 kW_p systems and one 28.2 kW_p system, totalling 178.2 kW_p. The energy generated by these arrays is shown in Figure 12. The solar PV data came as bills for various periods, the shortest period being three days and the longest being four months. The solar PV data was averaged to produce the monthly data shown. In 2017, the solar PV arrays provided 15.9 % of the total electrical energy used over the whole site. This basic estimate is a total energy balance calculation. In reality, as the plant is only manufacturing from Monday to Friday, some of the excess solar PV energy during the weekends will be exported to the grid.

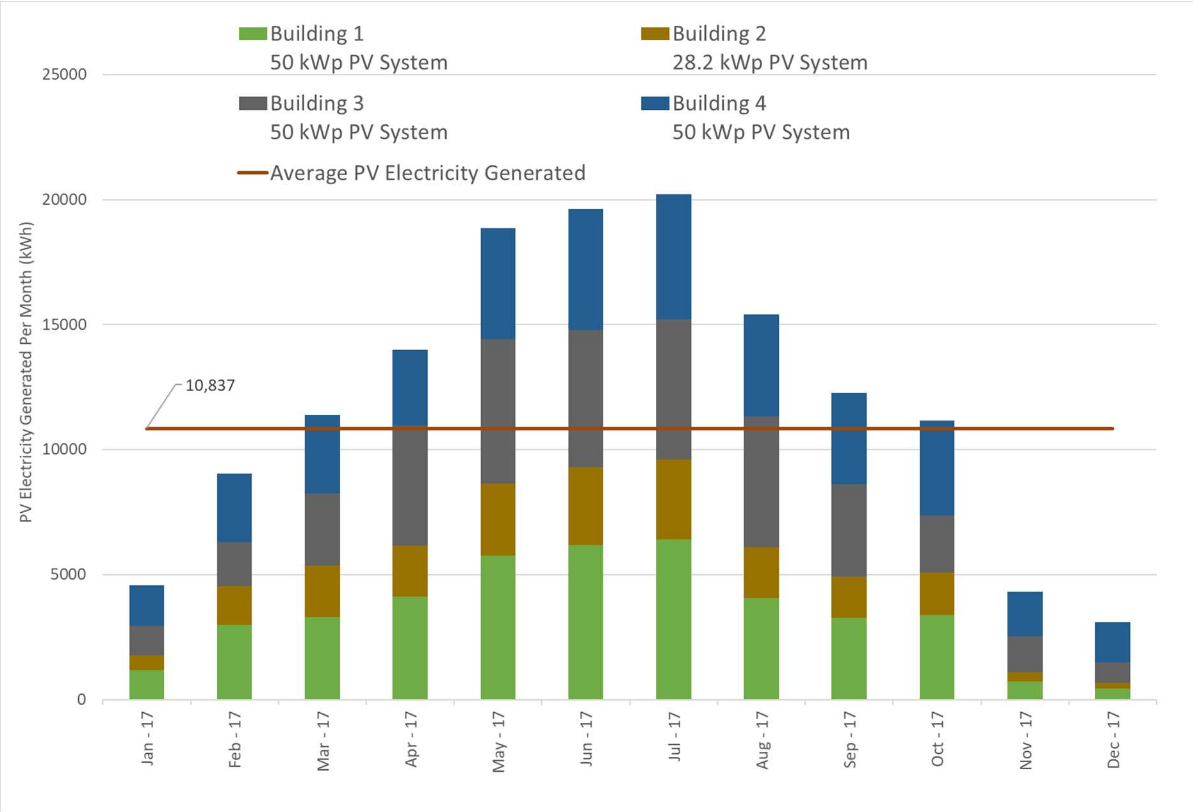


Figure 12. Solar PV energy generation for 2017 at David Nieper in kWh.

When the total solar PV energy is included and subtracted from the electricity usage data, then the average grid electrical energy drops to **5.16 kWh per garment**, shown as the line in Figure 13.

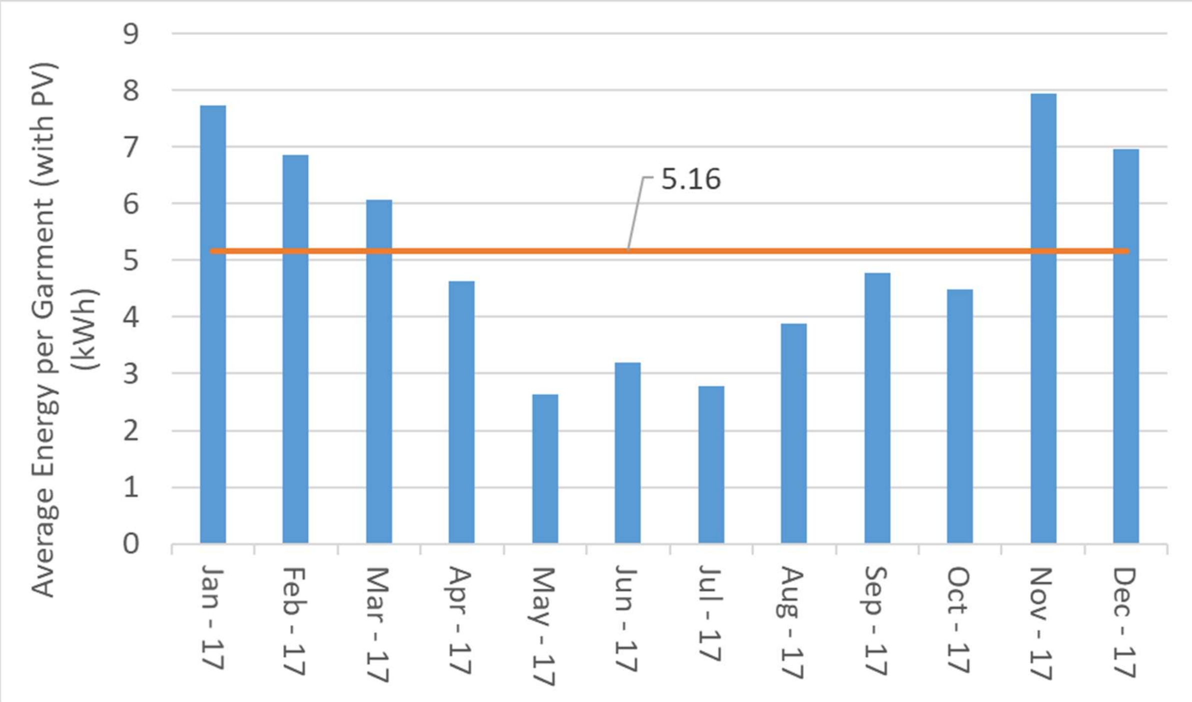


Figure 13. Energy used per garment (after subtracting PV electricity) (kWh).

3.2. Greenhouse Gas Emissions

Using the greenhouse gas (GHG) conversion figures from the UK government [2], the figures given in Table 1 show the carbon dioxide equivalent (CO_2e) emissions for 2017. This shows the total electricity used on-site, the total gas used on-site, the solar PV electricity generated and the difference required from UK grid electricity.

Table 1. Greenhouse gas calculation for David Nieper energy use in 2017.

Source	Amount per year (kWh)	Conversion factor (kg CO_2e per kWh) [2]	Greenhouse Gas Emissions (tonnes CO_2e)
Electricity Used	819,189		
PV Electricity	- 143,910		
Grid Electricity	675,279	0.28307	191.1
Gas Used	314,882	0.18396	57.9
Total:			**249**

The total equivalent carbon dioxide emissions from the electricity used at David Nieper is approximately 249,000 kg CO_2e per year, or **249 tonnes CO_2e per year**. This is their organisational footprint, as shown in blue in Figure 4. Over 27% of these emissions are related to the factory printing the catalogues. The average energy used per garment can be converted, using the factor given in Table 1, to give the greenhouse gas emissions per garment. Figure 14 shows the greenhouse gas emissions per garment of the gas and electricity used (with solar PV generation included), with an average of **1.46 kgCO_2e per garment**.

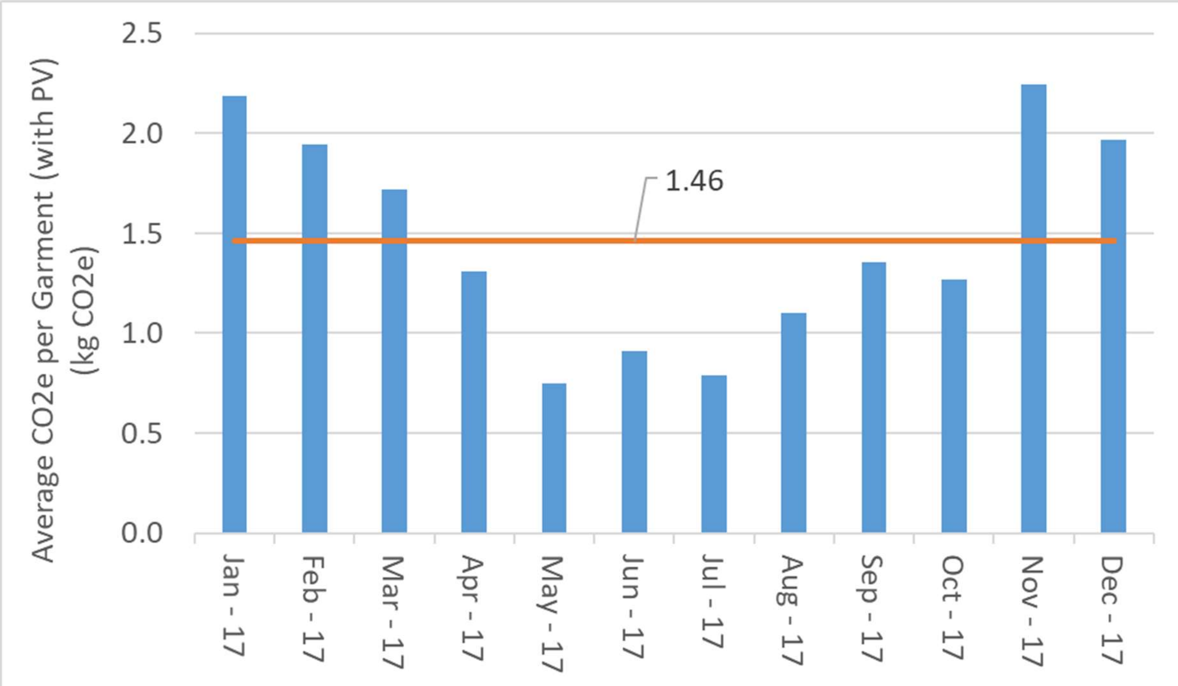


Figure 14. GHG emissions from energy consumption (after subtracting PV generated electricity) from David Nieper factories per garment in 2017.

4. Carbon Footprint Assessments

Measuring and understanding your organisation's carbon footprint is one of the first steps needed to cut carbon and energy costs – it enables you to measure subsequent savings, and it helps you to identify areas of energy wastage.

A carbon footprint is measured in kilograms of carbon dioxide equivalent (kg CO_2e). The CO_2e allows the different greenhouse gases to be compared on a like-for-like basis relative to one unit of carbon dioxide (CO_2). It covers all six Kyoto GHG emissions (CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6)). For larger companies, such as those quoted on the stock market, performing a carbon footprint of the business activities is a legal requirement.

This project investigates the product carbon footprint of a garment, which is the total sum of greenhouse gas emissions produced throughout a product's lifecycle up to the point of sale, including raw materials, production, distribution and retail, as shown in Figure 4.

There are three main assessment procedures for carbon foot printing, which are:

- Greenhouse Gas Protocol [3]
- International Organization for Standardization (ISO) 14067 [4]
- Publically Available Standard (PAS) 2050 [5]

The Greenhouse Gas Protocol is a widely used standard that sets out how to account for GHG emissions. It categorises emissions into three groups or 'scopes':

- **Scope 1**: Direct emissions that result from activities within the organisation's control. This might include on-site fuel combustion, manufacturing and process emissions, refrigerant losses and company vehicles.
- **Scope 2**: Indirect emissions from any electricity, heat or steam purchased and used.
- **Scope 3**: Any other indirect emissions from sources outside your direct control. Examples of scope 3 emissions include purchased goods and services, use of sold goods, employee commuting and business travel, outsourced transportation, waste disposal and water consumption.

Under the GHG Protocol, all organisational footprints must include scope 1 and 2 emissions. There is more flexibility when choosing which scope 3 emissions to measure and report, and these can be tailored to reflect the company's environmental and commercial goals.

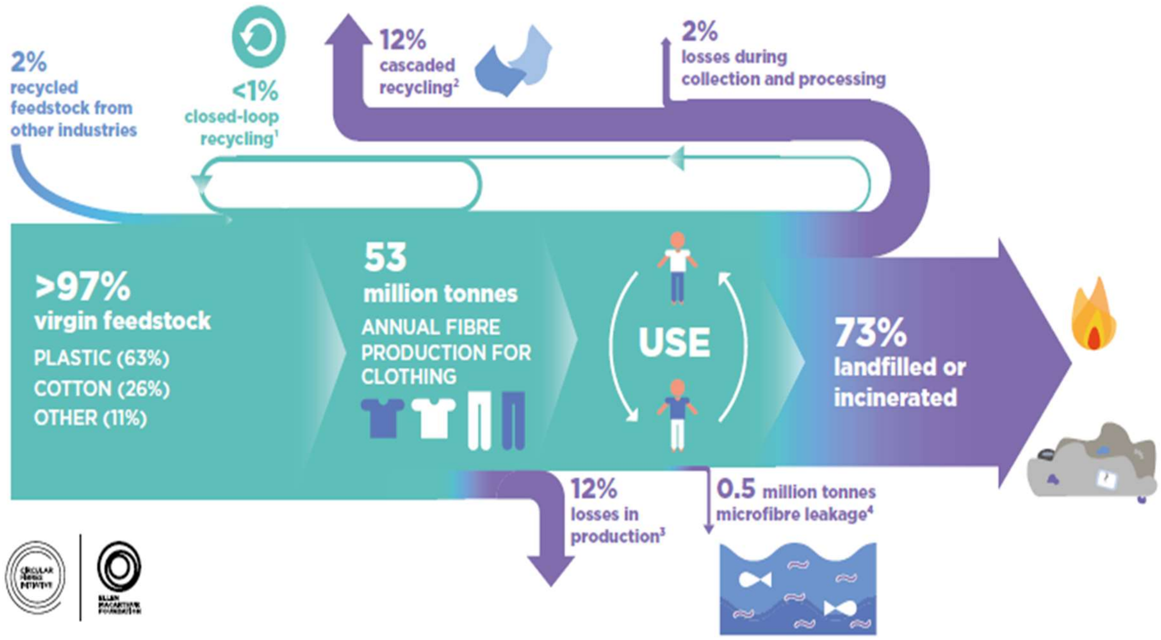
Organisations commonly include waste sent to landfill and employee business travel from scope 3.

5. Background on Carbon Emissions from Garment Industry

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

- **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 in-use phase).
- **Greenhouse gas emissions,** which are mostly linked to the use of fossil fuels.
- **Solid and hazardous waste generation,** from the manufacturing stages, in-use phase (packaging waste from clothes and laundry detergent), and end-of-life disposal.
- **Air and water pollution,** including air acidification due to sulphur oxide (SO_x) emissions (fossil fuel combustion) and nitrogen oxide (NO_x) emissions (electricity production). Water 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. [6]

In 2015, worldwide greenhouse gas emissions from textiles production totalled 1.2 billion tonnes CO_2e, which is more than those of all international flights and maritime shipping combined [7]. This is projected to rise by over 60 % by 2030 [8]. An overview of global material flows for clothing is shown in Figure 15.



1 Recycling of clothing into the same or similar quality applications
2 Recycling of clothing into other, lower-value applications such as insulation material, wiping cloths, or mattress stuffing
3 Includes factory offcuts and overstock liquidation
4 Plastic microfibres shed through the washing of all textiles released into the ocean

Figure 15. Global material flows for clothing in 2015 [7].

Clothing manufacture and retail in the UK is the fourth largest pressure on natural resources after housing, transport and food [9]. The direct carbon footprint of clothing contributes approximately 2 % to the UK's total direct carbon footprint in 2009 [1]. The total annual carbon footprint of all garments, both new and existing, in use in the UK in 2016 is approximately 23.2 million tonnes of CO_2e [9]. Total clothing in-use in the UK (data from 2009) is in the region of 2,488,396 tonnes, with 2,239,556 tonnes imported and around 10 % (248,840 tonnes) manufactured in UK [1]. The majority of clothing is manufactured outside the UK and it is estimated that approximately 32 % of the CO_2e emitted occurs within the UK (contributing to the UK's direct carbon footprint) and 68 % occurs abroad [1]. The carbon footprint of each garment, both new and existing, in use in the UK in 2009 ranges from around 1 to 17 kg CO_2e [1].

It can be seen in Figure 16 that the majority of carbon emissions are from the extraction of raw materials, fibre, yarn and fabric production, and the washing and drying cycles while the garment is in use [1]. Other studies suggest that the in-use phase accounts for 40-80 % of life cycle GHG impacts [10].

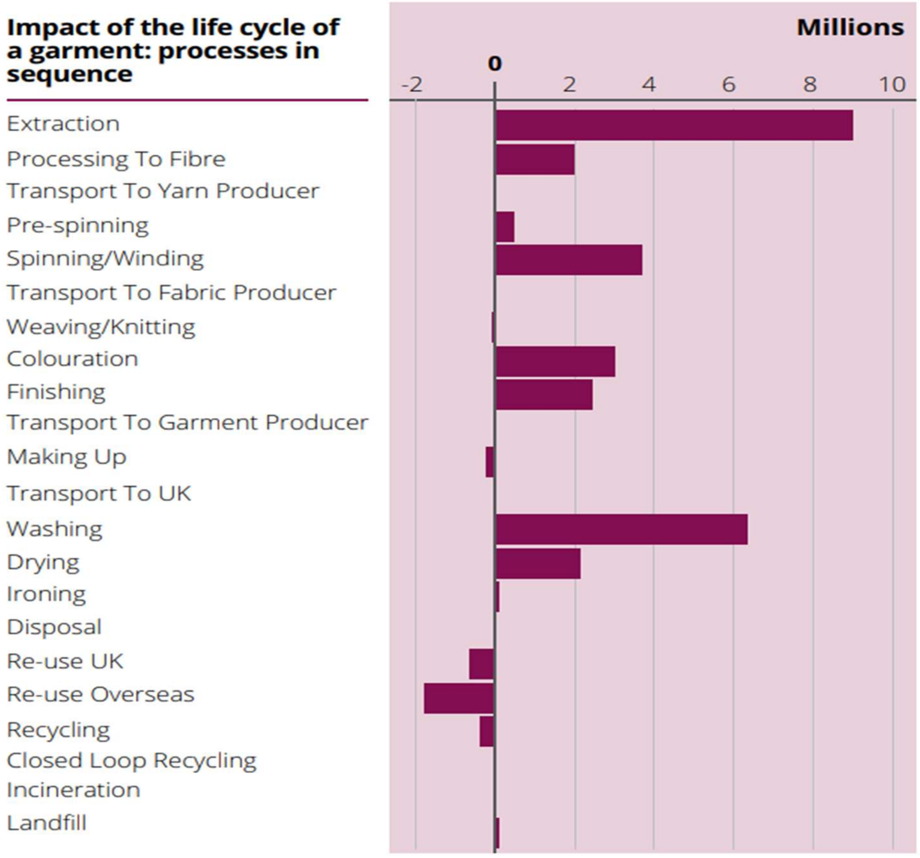


Figure 16. Total tonnes CO_2e emissions from stages of garment production supplied in the UK [9].

Figure 17 shows the sources of GHG emissions of UK clothing by sector and region. It can be seen that electricity is the dominant source of GHG emissions for clothing sector in the UK (compromising 43 % in total) and that more than two-thirds of the emissions from UK clothing consumption occur in other countries.

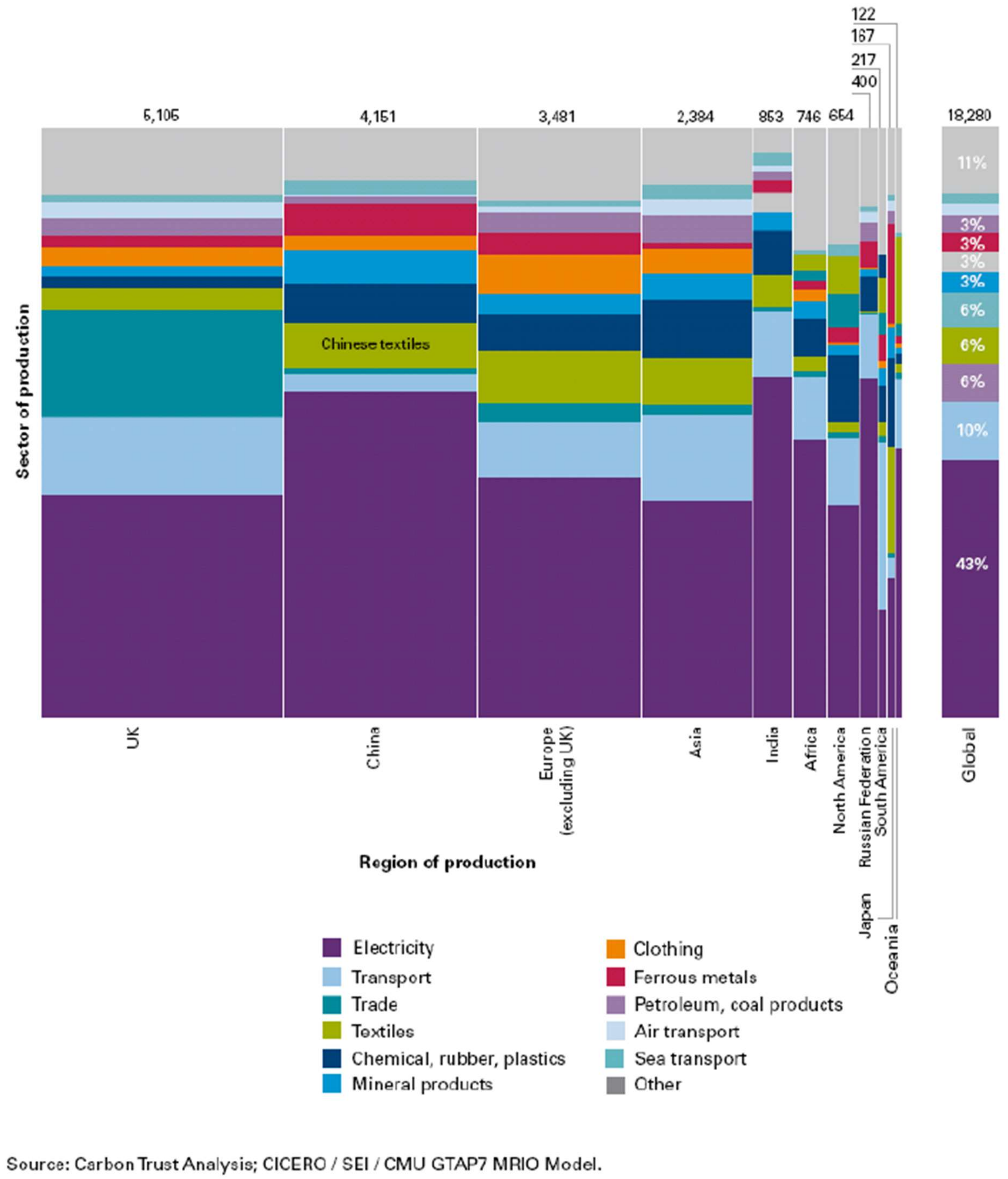


Figure 17. Sources of GHG emissions arising from clothing consumption in the UK by region and sector in 2011 (kt CO_2e) [10].

The manufacture and supply of textiles and apparel (finished garments), is a highly complex interconnected system with a number of pathways. The dominant pathway to the UK is from embodied emissions in apparel from China. Figure 18 shows the main flows of GHG emissions, both in terms of textiles and apparel from China to the UK. Over half of clothing production emissions move across an international border between production and consumption 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 [10]. The UK is the fourth largest importer of emissions embodied in clothing relative to domestic production [10].

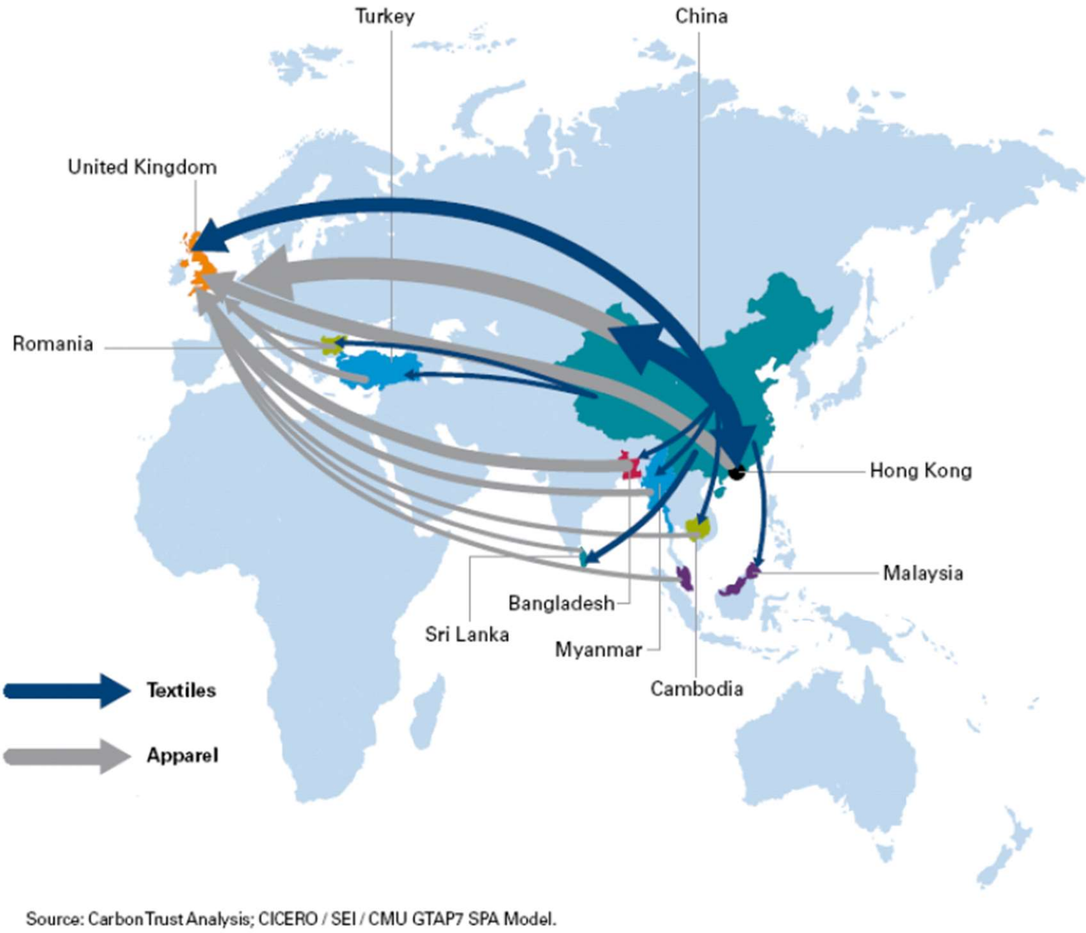


Figure 18. Embodied emissions pathways for Chinese textiles supplied to the UK. [10]

6. Analysis of Greenhouse Gas Emissions from Stages of Garment Manufacture

There are a number of production stages from raw material to the end-of-life of a garment, as has been shown in Figure 4. For example, the life-cycle carbon emissions from a T-shirt used for 50 “wears” is shown in Figure 19. This figure gives a starting point to the percentages of GHG emissions within a garment lifecycle, which is used in this report as the baseline of the emissions from a standard overseas manufactured garment.

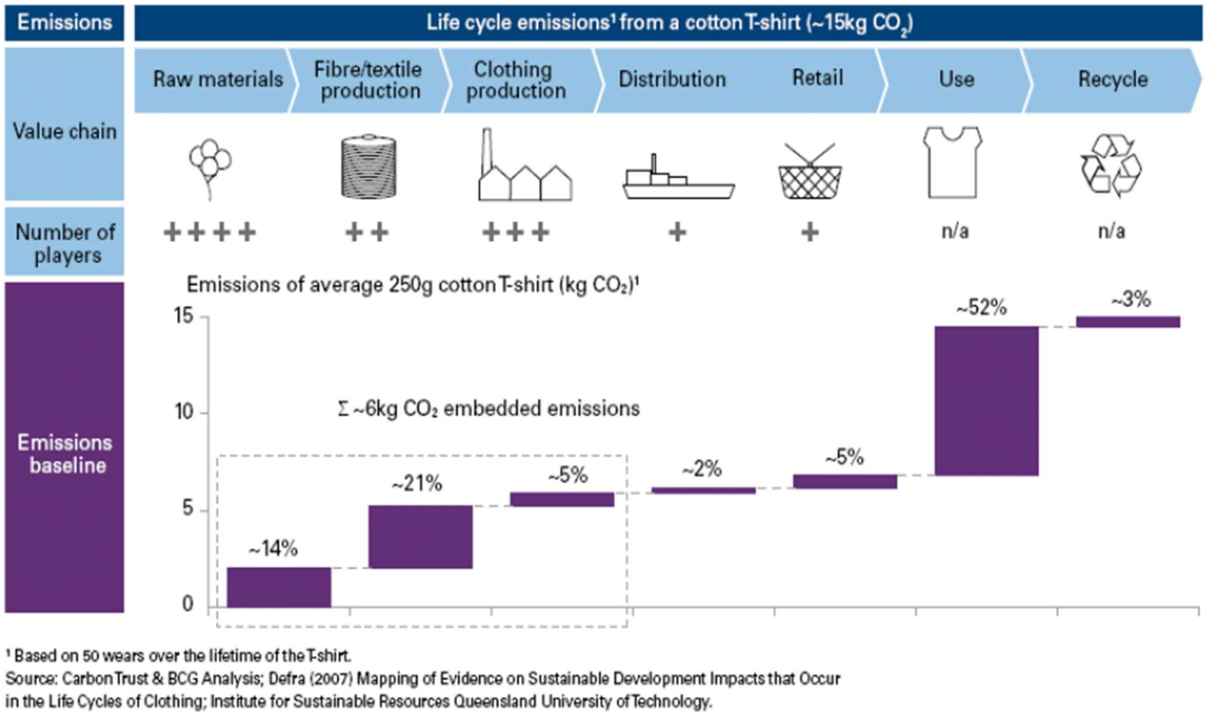


Figure 19. Life cycle emissions from different stages for 50 'wears' of a cotton T-shirt [10].

It is worth noting that the textile industry is one of the longest and most complicated industrial chains, bringing into play actors from industry (i.e. agricultural, chemical fibres, textile, apparel, non-conventional), retail services and waste management [11], which makes detailed analysis very difficult.

Figure 20 shows the standard overseas manufacturer lifecycle compared with a David Nieper produced garment lifecycle. Some of the steps are relevant to both overseas and local production, while David Nieper have full control over the garment production and distribution stages and have direct influence over the stages before. They only have limited control over the ‘in-use’ and ‘end-of-life’ phases. In this section, each stage is investigated, along with a basic comparison between standard overseas manufacturing and David Nieper manufacture, including the main issues relating to greenhouse gas emissions.

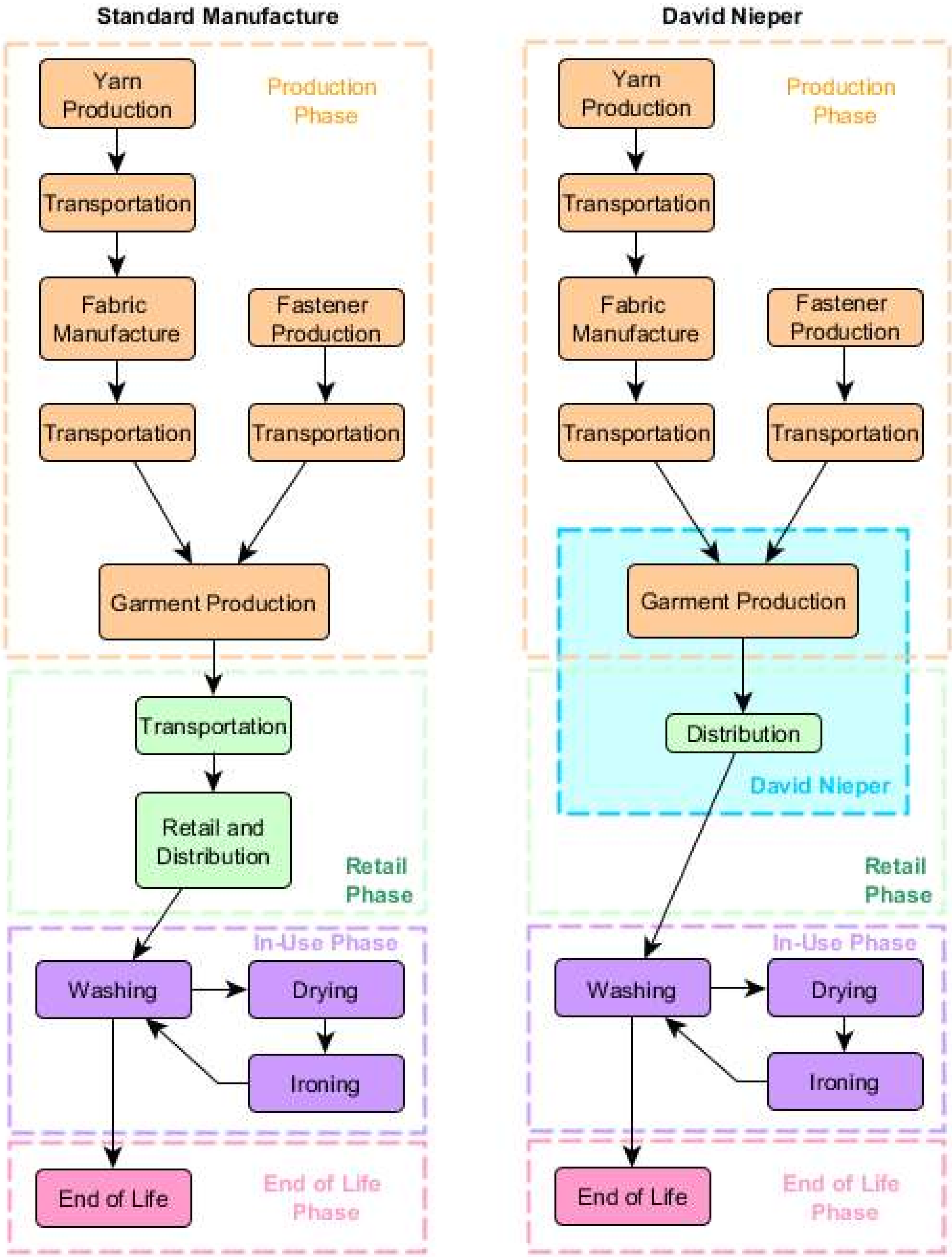


Figure 20. Garment life-cycle comparison between standard manufacture and David Nieper.

6.1. Raw Materials and Fibre/Textile Production

Raw Materials

Cotton and polyester fibres 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 [10]. Figure 21 shows the various different types of fibre used in clothing within the UK.

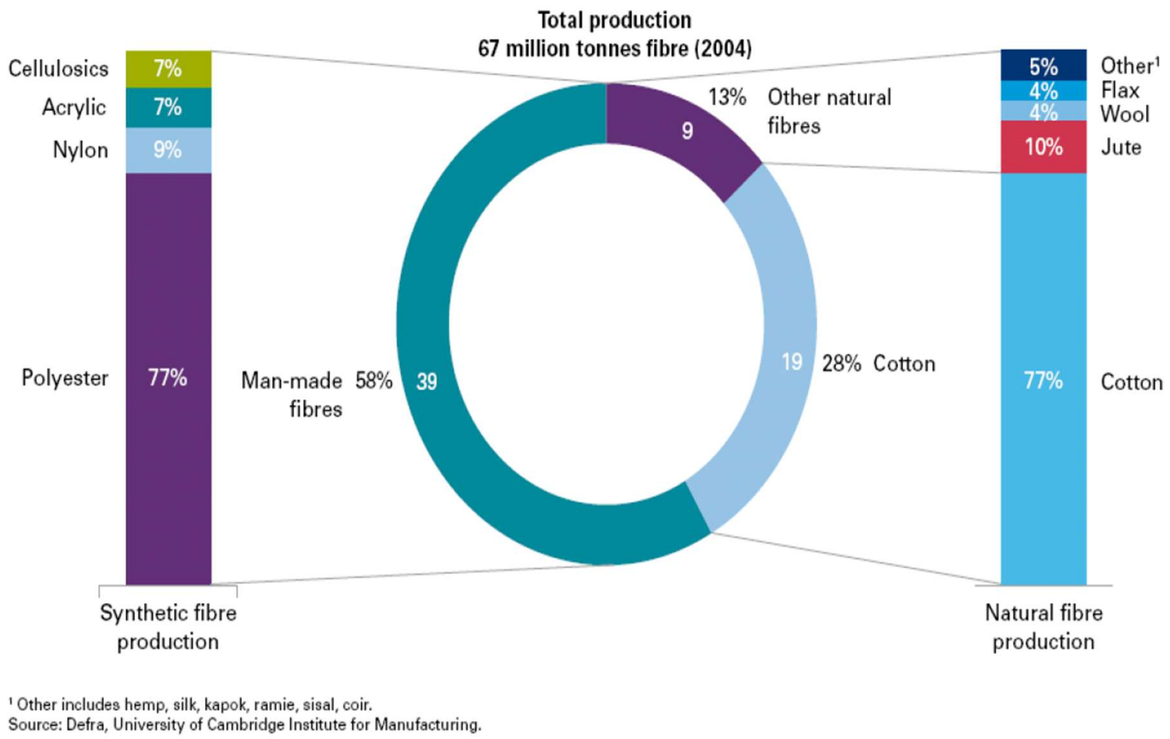


Figure 21. Types of fibre used in clothing (2004) [10].

Generally, raw materials will come from the same sources for both manufacturing types, overseas and David Nieper. As shown in Figure 19, raw materials make up around 14 % of the garments lifecycle carbon emissions. While David Nieper try to source materials from suppliers with a known reliable and sustainable track record, they have no carbon footprint data for the raw materials used by their textile suppliers, hence there are no estimated carbon savings for David Nieper compared to overseas in this area.

Fibre and Textile Production

One of the dominant life-cycle stages of a garment is fabric production (comprising weaving/knitting etc. and treatment of fabric), representing 21% of total life cycle GHG impacts [1]. Amongst all the fibre types, the contribution of cotton to the total carbon footprint is the largest (42%), primarily due to the large proportion of cotton used in the UK (43%) [1].

11 % of the garments produced at David Nieper are knitwear, produced directly from yarn and hence have no external fabric production energy usage, just the energy used on-site for their knitting machines. David Nieper mainly use natural fibres and textiles from a range of sources. They have a good relationship with their suppliers and try to work with suppliers with good accreditation for manufacturing and environmental sustainability. An overview of these is shown here, in Table 2.

Table 2. Yarn and textile suppliers' information.

Item	Region	Information
Yarn - Cashmere	Inner Mongolia	Supplier based in Italy. Accreditations: ISO 14001:2004, BS OHSAS 18001, Associazione Tessile e Salute Supplied by 100% renewable energy.
Yarn - Cotton	China	Production in Italy. Supplier based in Italy. Accreditations: UNI EN ISO 14064, EN ISO 9001, ICEA GOTS, Better Cotton Initiative
Yarn - Cotton, yarns, silks, alpaca, linen	Peru	Supplier based in Italy. Accreditations: ICEA GOTS, Better Cotton Initiative
Yarn - Merina, Cashwool	Australia, South Africa, New Zealand	Supplier based in Italy. Accreditations: Compliant with REACH, Oeko-Tex Standard 100 Certificate, Associazione Tessile e Salute
Yarn - Geelongora	UK, China, Mongollia, Peru	Supplier based in UK. Accreditations: Caregora™ the first responsible and reliable angora fabric.
Fabric for printing	Greece	Supplier in Austria. Accreditations: ISO, Oeko-Tex Standard 100, GOTS, Agrocert, Pure Wear.

David Nieper have no carbon footprint data for the fabrics and yarns from their suppliers, but try to source materials from suppliers with a known reliable and sustainable track record. Hence, there are no directly accountable carbon savings for David Nieper compared to overseas.

Dyes

In the textile industry, up to 200,000 tonnes of dyes are lost to effluents every year during the dyeing and finishing operations, due to the inefficiency of the dyeing process [12]. The textile industry consumes a substantial amount of water in its manufacturing processes used mainly in the dyeing and finishing operations of the plants. The wastewater from textile plants is classified as the most polluting of all the industrial sectors, considering the volume generated as well as the effluent composition [12].

David Nieper do not perform any dyeing processes themselves and their textiles are obtained pre-dyed, so the emissions from the dyeing process are associated with the fabric suppliers. In future expansion, David Nieper are looking to include dyeing processes for textile production, but this is outside of the scope of this report.

Fastening Production

In addition to the textiles, various fasteners and extra components are required. While it is very difficult to find information on this with regards to clothing manufacture overseas, David Nieper use Jones Buttons (https://www.jones-buttons.com/), a local supplier in Nottinghamshire.

6.2. Garment Production

Clothing production only accounts for between 2 % [1] to 5% [10] of a garments total carbon footprint emissions.

The supply chain for overseas garment manufacture is very complex and materials and garments can be moved between a number of different countries before reaching their sales destination. There are typically many people involved with garment production with specific tasks performed by different people (i.e. button holes sewn by one person, arms added by another and so on).

At David Nieper, “just-in-time” manufacturing is used, with garment production only occurring when an item is ordered, hence no stock is held. This greatly reduces the waste from carrying excess stock and they sell 98% of their items at full price. Their process includes cutting, sewing and dispatch, all done in-house. One employee follows the garment through all stages of production.

Cutting

Due to their intricate shapes and varying sizes, the cutting of apparel into the necessary shapes can result in large amounts of fabric loss. This fabric must then be disposed or reused for other applications. In 2016, this process or ‘supply chain’ waste was estimated at over 800,000 tonnes [9] worldwide. Estimated cutting losses for briefs and underpants is in the region of 16% losses, with other underwear, nightwear and hosiery having around 18%

losses [11]. Recovering fabric waste during production is seen as one area to improve for a reduction of greenhouse gas emissions [11].

David Nieper utilise state of the art computer numerically controlled (CNC) cutting machines with software developed to minimise the cutting losses from this process. One such machine is shown in Figure 22.

Figure 22. The CNC cutting machine used at David Nieper.

Sewing

The sewing phase of garment production will typically be relatively similar between the overseas production and David Nieper production. Both utilise electricity for powering the various sewing machines and for overhead lighting. David Nieper do have up-to-date machines with DC motor control and LED lighting used throughout. The main aspect that would affect the emissions from this stage would be the carbon intensity of the local electricity supply network. A comparison can be made using data from 2011, as shown in Table 3, although these numbers have changed in recent years. It can be seen that the UK has significantly lower carbon emissions per unit of electricity used, compared to China, Bangladesh and Turkey, therefore production in the UK will have lower direct carbon emissions. Please note that the UK electricity grid carbon intensity is presently around 0.28 $kgCO_2e$ per kWh (in 2018) and the values that are shown here are used to represent the differences, rather than the specific values.

Table 3. Carbon intensity for different countries [13].

Country	Carbon Intensity: kg CO_2e per kWh (2011 values)	Percentage Difference to UK
UK	0.5085	0 %
China	0.9746	+ 91 %
Bangladesh	0.6371	+ 25 %
Turkey	0.8656	+ 70 %

Table 3 shows that production in China would release around 90% more GHG emissions than using the same energy in the UK. This means that production for David Nieper, in the UK, would be around 47 % less than the same in China (based on 2011 levels, but assumed similar difference in levels in 2018).

The difference of David Nieper manufacture is estimated to be in the region of 40 - 60 % less than overseas manufacture. Clothing production is around 10.6 % of the greenhouse gas emissions within the scope of this analysis of this report. Using David Nieper manufacturing techniques, this is estimated to be reduced to between 4.3 and 6.4 %.

6.3. Distribution

In recent years, due to the lower cost of production outside the UK, offshore sources of textile products have an increasing appeal for UK retailers. Long distance transportation has become an important part of the textiles market. The transportation of goods can be carried out by four major means – air, water, rail and road. The distribution of textile components can occur throughout the whole production cycle. For example, fibres may be exported to one country for processing, to another for finishing, and the resulting fabric may be exported to yet another country for manufacturing of the final product. As transportation processes occur several times throughout the production process, it is very challenging to represent the greenhouse gas emissions from the distribution of textile products during their production cycle.

Table 4 shows example port-to-port distances involved with transporting goods from three of the main overseas garment manufacturing countries. It is worth noting that textiles, yarn and fastenings are still produced overseas and therefore must be transported to David Nieper in the UK. As the items are for wholesale supply, they can be packed in a more efficient manner (eg. rolls of textiles) and hence the carbon footprint from distribution of raw materials could be lower than distribution of fully manufactured garments.

Table 4. Shipping distances to the port of Southampton, UK, from different countries.

Country	Shipping Distance to UK, Southampton (km)
China (Shanghai)	21,694
Bangladesh (Chalna)	16,123
Turkey (Kumport Terminal)	6,226

Distribution is also required to either deliver the garments to the retailer or, in the case of David Nieper, direct to the customer. Typically garments will be sent from the overseas garment manufacturer (mainly China), either through sea or air transport, to a logistics supplier within the UK which are then transported to the retailer. The distribution stage produces around 5% of the life-cycle carbon footprint emissions [1]. With respect to the distribution phase, air freight contributes to about 90 % of the GHG impact, despite it's relatively small share (transporting around 8 % of the textiles) [11]. Reducing airfreight would have a large impact in the carbon emissions of this stage, although most suppliers try to avoid airfreight as it also has a high economic cost.

As already mentioned, David Nieper despatch direct to their customers. They use Royal Mail despatch services. Each order is individually packaged in recycled cardboard packaging, shown in Figure 23, which usually has lower carbon emissions than typical retail packaging, although it is difficult to find data for this.

Figure 23. Orders ready for despatch at David Nieper.

It is very difficult to assess the carbon savings from this difference in distribution types. Research covering the ‘last mile’ delivery for online or traditional retail has shown that, on average, when a customer shops by car and buys fewer than 24 items per trip (or fewer than 7 items in the case of bus users) then home delivery will emit less CO_2 per item purchased [14]. The distribution phase of a garment lifecycle emits around 4.3 % of the lifecycle carbon emissions within the scope of this analysis. David Nieper direct distribution would reduce this figure by an estimated 25 - 75 %, to between 1.1 to 3.2 %.

6.4. Retail

The clothing retail industry emits between 1% [1] to 5 % [8] of life-cycle carbon footprint emissions of a garment, although accurate data of energy consumption specifically for clothing retail outlets is difficult to find. Having retail outlets requires energy for:

- Transportation and distribution to the retail store,
- Heating and air conditioning within the store,

- Lighting within the store,
- Maintaining stock levels, with associated waste if items not sold.

While there is a large variation in the size of high street retailers, an average retailer in the UK uses 28,000 kWh of energy annually [15]. Information about sales from retailers is difficult to obtain, so it is difficult to calculate the energy used per item sold. David Nieper do not use any retail outlets, which means that the carbon emissions from their garments ought to be lower than any manufacturers that use retail outlets.

David Nieper print their own catalogue, which adds around 36 % to their greenhouse gas emissions at the site, although many retail outlets also do this. David Nieper use targeted marketing to deliver the specialist sections of the various clothes ranges, trying to ensure only the relevant catalogue sections are sent to customers, rather than full catalogues. They have also invested in their online web-based presence, which reduces the requirements for catalogue printing.

Clothing retail comprises around 10.6 % of a garments carbon emissions within the scope of this analysis. It is estimated that David Nieper use around 40 – 80 % less energy for this activity than a standard retail shop, although this needs more detailed analysis. This means that the retail greenhouse gas emissions of David Nieper are between 2.1 and 6.4 % of the total.

6.5. In-Use Stage

The in-use stage takes into account consumer behaviour and the use patterns of garments. The in-use stage is not directly influenced by David Nieper, so this stage is outside of the scope of analysis of this report. This section has been included for information and discussion only.

Many of the best options for reducing the carbon footprint are consumer oriented, which emphasises the importance of users behaviour on the overall environmental performance of textiles [11]. For example, the “in-use” phase emissions account for around 50% of a typical t-shirt lifecycle emissions. Figure 24 shows the carbon emissions of a typical cotton T-shirt over one year with 50 wears, showing the large GHG savings from re-use of the same garment, showing that longevity of clothing exerts a strong influence over the lifecycle emissions of clothing [10]. An average weighted lifetime of clothing in the UK is around 2.2 years [1] to 3.3 years [16]. The average UK consumer now buys 60 % more clothing items a year, and keeps them for about half as long, in 2016 compared to 2003 [17]. WRAP have “designing for durability” as one of their energy reduction measures [1].

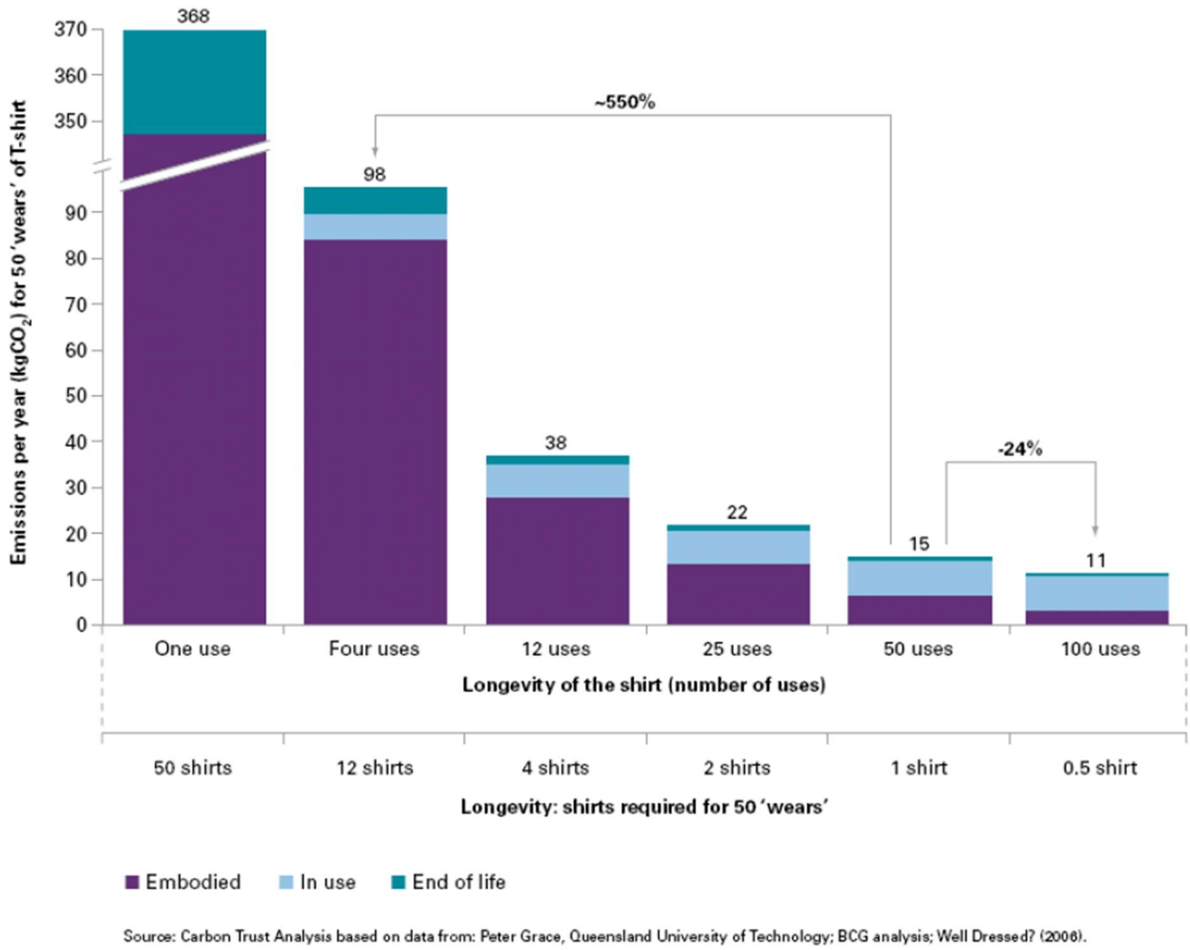


Figure 24. Emissions arising over one year from 50 wears of a cotton T-shirt with varying longevity [10].

David Nieper produce high quality garments to exact sizes. They put emphasis on the longevity of the garments they produce. Each garment is manufactured by a small team, typically two people, who oversees the whole process from cutting to finishing, with their name on the final garment label. Recently (in October 2018), David Nieper performed customer research survey with a questionnaire. This was sent to 100 customers, with 90 respondents. The estimated number of garment uses during its lifetime can be seen in Figure 25, with "30+ times" being the largest percentage.

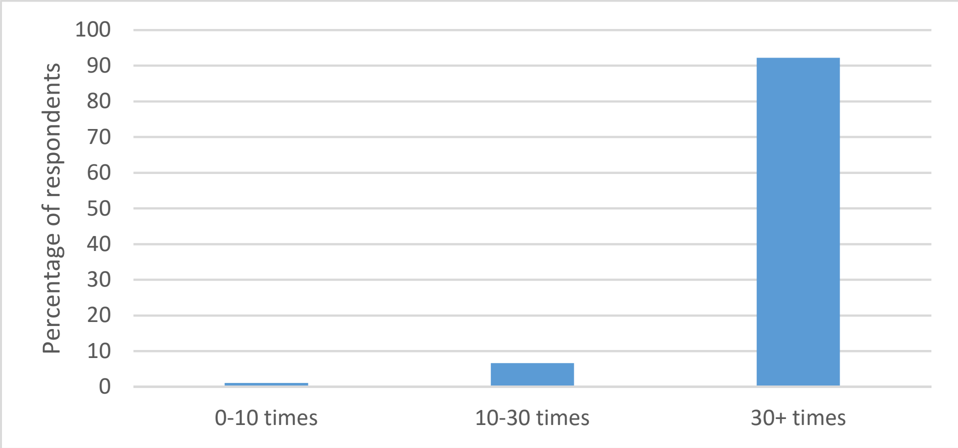


Figure 25. Number of garment uses.

From this survey, respondents also estimated the average lifetime of the garments they bought from David Nieper, with the average of these lifetime estimates being 9 to 10 years. This value cannot be directly compared to the UK average, as the demographics of the respondents also needs to be taken into account. This was not possible with the limited data available here.

With regards to the cleaning phase of the garments, the best options for GHG emission reduction are [11]:

- reducing washing temperature
- reducing tumble drying
- optimising the load of appliances
- improvement of washing/drying appliances efficiency.

If all UK citizens currently washing their clothes at 40°C instead washed them at 30°C, the UK would save of 12 % of the energy that is currently consumed on clothes washing annually. David Nieper recommend washing at 30 ^{o}C on their clothing labels, apart from lingerie and some fine knitwear garments which are hand-wash only.

Micro-plastics

One issue relating to the in-use phase of synthetic fibres in garments is the release of micro-plastics. Micro-plastics are small pieces of plastic invisible to the human eye. Primary micro-plastics are directly released into the environment as small particles, whereas secondary micro-plastic largely stem from the degradation of larger plastic waste after entering the ocean. The main sources of primary micro-plastics are tires, synthetic textiles, marine coatings, road markings, personal-care products, plastic pellets, and city dust. Thus, the sources range from household to commercial activities conducted on land and at sea. The full consequences of increasing amounts of micro-plastics in the world oceans are not conclusively known. However, the suspected consequences include human health concerns due to the accumulation of micro-plastics in the food chain as well as the absorption of toxicants in plastic travelling through the environment [8]. It has been estimated that the global textiles industry accounts for a release of around 500 thousand tonnes of micro-fibre plastic into the oceans, shown in Figure 15.

6.6. End-of-Life Stage

As with the "in-use" stage, the "end-of-life" stage is not directly influenced by David Nieper, so is outside of the scope of analysis of this report. It is mentioned here for information and discussion only.

The end-of-life phase includes the reuse, recycling and final disposal (i.e. incineration or landfilling) of textile products. Within the garment industry, waste occurs from issues with production (typically 3 to 5 % wastage [16]) and also wastage from excess stock at the end of a season. The vast majority of waste either goes to landfill or is incinerated, shown in Figure 26 [8]. Around 300,000 tonnes of used clothing goes to landfills in the UK every year [17], which is around 30 kg of clothing and textiles sent to landfill per person per year [18].

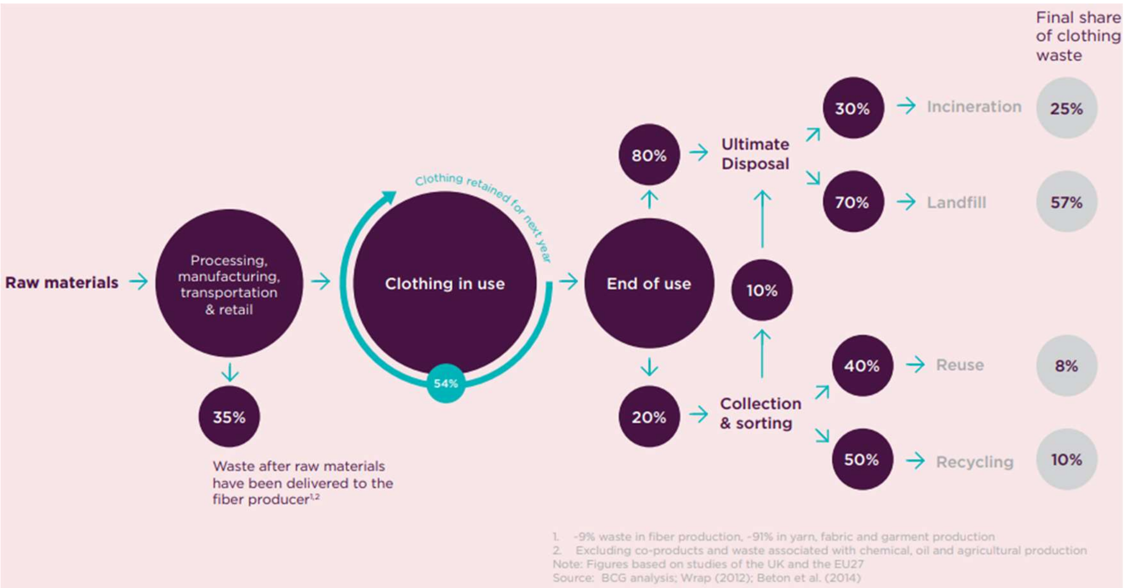


Figure 26. Waste streams within the garment industry [8].

David Nieper are a "just-in-time" manufacturer, which means that orders are produced on demand in the correct size. They hold very little stock and so do not have a problem with excess stock at the end of a season or when a new catalogue is printed. "Just-in-time" production is given as one method for carbon footprint reduction within the WRAP energy efficiency measures [1]. “Just-in-time” manufacturing means that David Nieper have no overproduction and 98 % is sold at full price, the remaining stock is sold to David Nieper factory workers each season in a garment sale. Anything left goes to Barnardos charity shops and underwear goes to a charity distributing to women and children in Africa (http://www.smallsforall.org/).

6.7. Employment

As the garment manufacturing industry in the UK has shrunk, so too has the number of people employed, with a knock effect with skills. In 1978 around 360,000 people were employed in the manufacture of wearing apparel in the UK, this has fallen, by 2017, to 34,000 [19], a 90 % reduction. Figure 27 shows the significant drop in employment in the textile and apparel manufacturing industry from 1978 to 2014.

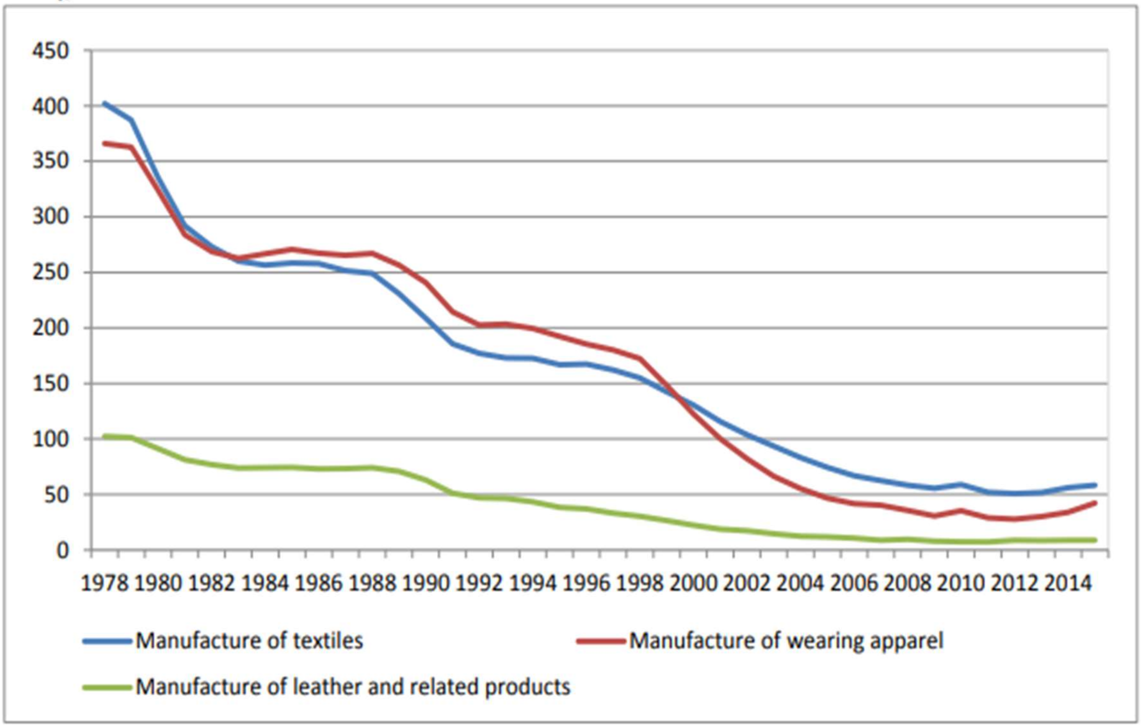


Figure 27. UK textile and apparel manufacturing industry jobs from 1978 to 2014 (number of jobs in thousands) [20].

Overseas production has driven a steady drop in wages for labour by outsourcing to countries with lower wages. David Nieper are trying to address this skills shortage by running a training school within the factory and supporting a local educational establishment.

7. Lifecycle Carbon Assessment

Performing a full lifecycle carbon footprint assessment for a product or a service is a very detailed piece of work. If David Nieper are to take this analysis further, then employing the facilities of a specialist is recommended. There are many specialist companies, with a small sample given in Table 5.

Table 5. Carbon lifecycle analysis service companies.

Company	Website
Anthesis	https://www.anthesisgroup.com/product#footprinting
Ricardo	https://ee.ricardo.com/sustainable-business/life-cycle-assessment
Bureau Veritas	https://www.bureauveritas.co.uk/services+sheet/service_sheet_13460
Carbon Footprint	https://www.carbonfootprint.com/productlifecycle.html
CO_2 Compliance	http://www.co2compliance.co.uk/consultancy-solutions/life-cycle-analysis/

Please note: This list is just an example of companies that may be able to perform lifecycle carbon assessments. Inclusion in this list is NOT a recommendation or endorsement of their services.

8. Process Improvements

This report has covered the main aspects relating to the greenhouse gas emissions from the production methods employed at David Nieper along with a comparison to overseas manufacture. In this section, some aspects where there could be improvement, both from reduced greenhouse gas emissions and environmental considerations, to the techniques employed at David Nieper are discussed.

8.1. Supply chain for raw materials

The textiles, fabric and yarn used at David Nieper are supplied by various supply companies (listed in Table 2). Raw materials and textile production contribute to around 35 % of the total lifecycle greenhouse gas emissions of a garment. The supply chain for these materials is very complex, with products being processed in different countries. One improvement, already started by David Nieper, would be to ask questions to their suppliers and keep records of the supply routes and material sources within the various stages of their supply chain. It may be that suppliers are not willing to release this information due to commercial reasons, but better suppliers should be open to supplying this information. Better supply companies may also have already performed a carbon assessment for their activities. This would make a more in-depth carbon assessment easier to achieve.

8.2. Catalogues

David Nieper design, print and despatch their own catalogues, which consumes about 27 % of the energy used over the whole site. This has traditionally been their main advertising method and many of their customers are very happy with this interaction. Many of David Nieper customers are of an older age and are more used to physical catalogues and telephone or mail ordering. David Nieper have implemented on-line web-based sales as well, which will have lower carbon emissions than a physical catalogue. Any reduction of catalogue printing would help reduce the carbon emissions of their activities. David Nieper use FSC accredited paper stock for printing. Using recycled paper and vegetable dyes for these catalogues would help reduce their environmental impact. Looking at the waste streams from catalogue printing and ensuring that all waste is re-used or recycled is also important.

It is interesting to note that each of the 10 million catalogues printed requires 0.03 kWh of electrical energy and releases 0.0087 kgCO_2e per catalogue. This does not include the energy embodied in the paper or inks used.

8.3. Lifecycle carbon assessment

David Nieper could commission a full lifecycle carbon assessment (LCA). This would give more detail on actual carbon emissions for each stage of the process, rather than the comparative study performed here. An accurate LCA would be difficult to perform, as knowledge of all the various inputs to the complex supply chain would be required. If this was performed, it gives a baseline from which David Nieper can track any changes they make and hence assess the effectiveness of GHG savings for different projects.

8.4. In-use phase

Around 50 % of the embodied GHG emissions arise for the in-use phase of a garment. Any changes to customer behaviour would help reduce the GHG emissions from this phase. Some techniques that David Nieper could employ to help adjust consumer behaviour could be:

- Join the Sustainable Clothing Action Plan (http://www.wrap.org.uk/sustainable-textiles/scap) which is organised by The Waste and Resources Action Programme (WRAP) in the UK.

- Join the European Ecolabel scheme (http://ec.europa.eu/environment/ecolabel/) [11]. This is an EU wide scheme for having carbon emission 'ratings' on clothes, similar to the energy ratings on electrical devices. Two thirds of consumers across the UK, France and Germany would like to see a recognisable carbon footprint label on products [21].
- Include more detailed and educational information on in-use energy reduction strategies (such as lower temperature washing). Information could be supplied with each order showing what David Nieper is doing to help reduce emissions and explain what customers can do.
- Potentially running clothes fixing sessions – helping people to increase the longevity of their clothes.

9. Discussion and Recommendations

The supply chains for the textile and garment industry are incredibly complex, with materials crossing many different boundaries throughout the garments production. This makes an accurate lifecycle carbon assessment very difficult. This report has tried to highlight some of the key pieces of information and sources of data.

David Nieper uses an average of **5.16 kWh of energy per garment**. The greenhouse gas emissions are an average of **1.46 kgCO_2e per garment,** with their solar PV generation included. This does not include the carbon embodied in the raw materials nor the energy used for distribution. The output from the solar PV systems is approximately 12.7 % of the total energy used on-site.

The standard business model is overseas production, distribution to UK logistics centres and then retail via UK high street retailers. The David Nieper business model uses direct sales (with printed catalogues) with garments produced to order in the UK. This helps to reduce carbon emissions by reducing distribution and transportation emissions, reducing the emissions associated with retailers and reducing waste from over-production.

When the production processes used at David Nieper are compared to overseas production then the greenhouse gas emissions are in the region of **9.6 to 18.1 %** less, shown in Figure 28. This is an estimated range between high-end estimates (best case) and low-end estimates (worst case). A more detailed assessment is beyond the scope of this investigation, as it requires detailed analysis of the carbon footprint for the supplied fabrics in addition to a detailed assessment of a competitor brand.

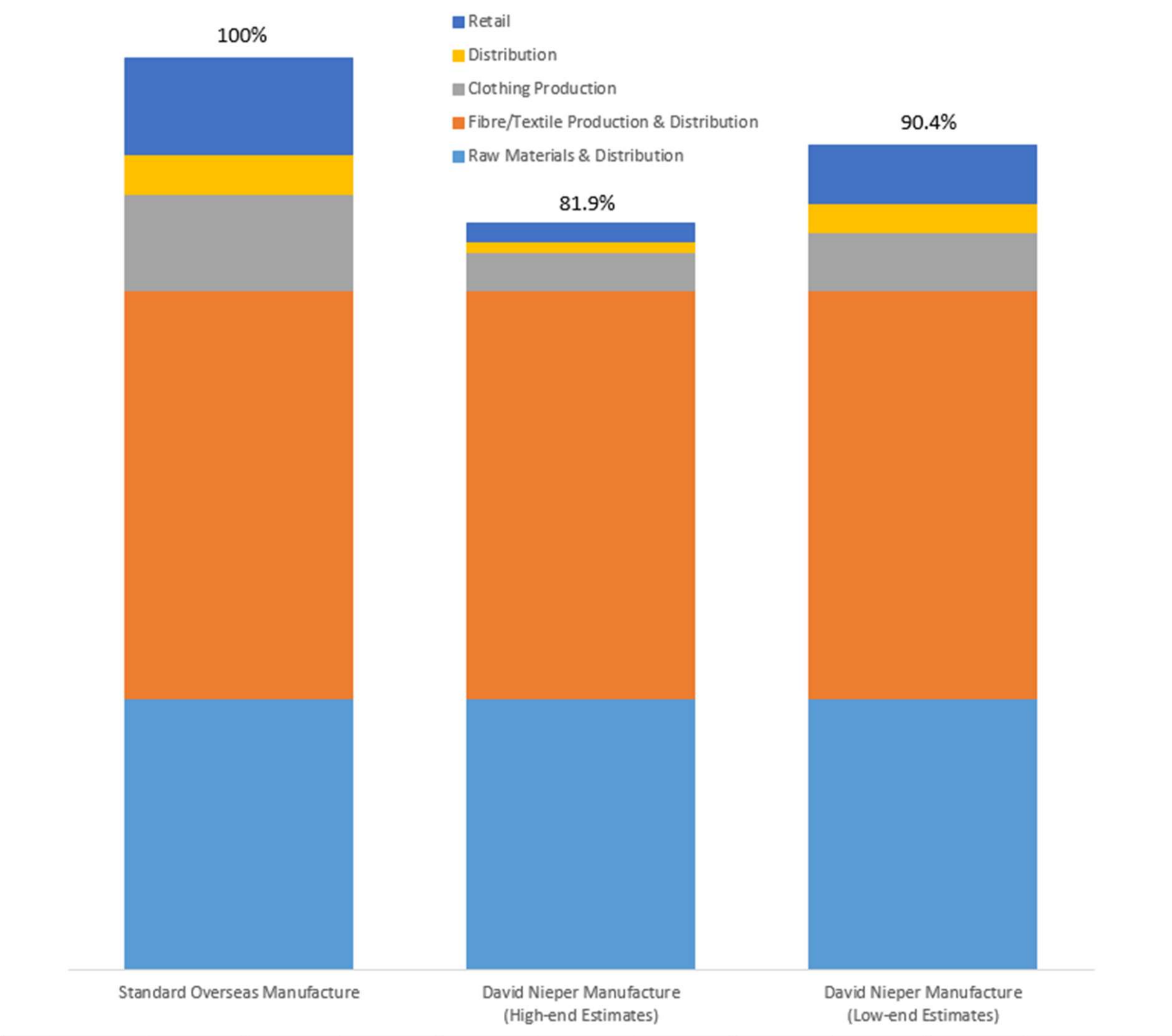


Figure 28. Comparison of GHG emissions as a percentage change between standard overseas, high end and low end estimates for David Nieper.

The business model of David Nieper aims to reduce the carbon emissions due to clothing production, clothing distribution and retail, however, Figure 28 shows that the carbon footprint for these activities are dwarfed by the upstream activities to supply the fabrics, which account for over 70% of the carbon emissions.

David Nieper have control over lifecycle aspects which cover about 12 % of the full lifetime GHG emissions of a garment (covering production, distribution and retail), while they can also have direct influence over the raw materials (through discussions with their suppliers). To influence the in-use and end-of-life phases of a garment, David Nieper could look to providing informative labelling and promote the longevity of their products.

Some recommended improvements at David Nieper for both greenhouse gas reductions and for environmental considerations include:

- Encourage suppliers to have a carbon footprint analysis.
- Change suppliers to low-greenhouse gas emission options, where possible.
- Reduce number of mail order catalogues printed, where possible.
- Join the Sustainable Clothing Action Plan, which looks at waste reduction
- Join the European Ecolabel scheme, which looks at labelling garments with carbon emissions, similar to an electrical appliance energy rating.

Please note: This report is not a full lifecycle carbon assessment. This report is to give information, ideas and signposting for future carbon foot-printing work.

10. References

1. WRAP. *A Carbon Footprint for UK Clothing and Opportunities for Savings*. 2012; Available from: http://www.wrap.org.uk/sites/files/wrap/Appendix%20IV%20-%20Carbon%20footprint%20report.pdf.
2. UK GOV. *Government emission conversion factors for greenhouse gas company reporting*. 2018 [cited 2018 2/7/2018]; Available from: https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting.
3. World Resources Institute. *Green House Gas Protocol*. 2004; Available from: https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf.
4. ISO. *Carbon footprint of products — Requirements and guidelines for quantification and communication*. 2012; Available from: http://www.lis.edu.es/uploads/c86b9902_9dbc_4928_bf66_a2013075ffe5.pdf.
5. BSI. *PAS 2050 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services*. 2011; Available from: https://shop.bsigroup.com/forms/PASs/PAS-2050/.
6. BIO Intelligence Services. *Reducing the environmental impact of clothes cleaning*. 2009 [cited 2018 19/10/2018]; Available from: http://randd.defra.gov.uk/Document.aspx?Document=EV0419_8628_FRP.pdf.
7. Ellen McArthur Foundation, C.F.I. *A New Textiles Economy: Redesigning fashion's future*. 2017 [cited 2018 15/11/2018]; Available from: https://www.ellenmacarthurfoundation.org/publications/a-new-textiles-economy-redesigning-fashions-future.
8. Global Fashion Agenda & The Boston Consulting Group. *Pulse of the Fashion Industry*. 2017 [cited 2018 24/10/2018]; Available from: http://globalfashionagenda.com/wp-content/uploads/2017/05/Pulse-of-the-Fashion-Industry_2017.pdf.
9. WRAP. *Valuing Our Clothes: The cost of UK fashion*. 2017; Available from: http://www.wrap.org.uk/sites/files/wrap/valuing-our-clothes-the-cost-of-uk-fashion_WRAP.pdf.
10. Carbon Trust. *International Carbon Flows: Clothing*. 2011; Available from: https://www.carbontrust.com/media/38358/ctc793-international-carbon-flows-clothing.pdf.
11. European Commission's Joint Research Centre. *Environmental Improvement Potential of textiles (IMPRO Textiles)*. 2014; Available from: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/environmental-improvement-potential-textiles-impro-textiles.
12. Farah Maria Drumond Chequer, et al. *Textile Dyes: Dyeing Process and Environmental Impact*. 2012 [cited 2018 25/10/2018]; Available from: http://cdn.intechopen.com/pdfs/41411/InTech-Textile_dyes_dyeing_process_and_environmental_impact.pdf.
13. Ecometrica. *Electricity-specific emission factors for grid electricity*. 2011 [cited 2018 24/10/2018]; Available from: https://ecometrica.com/assets/Electricity-specific-emission-factors-for-grid-electricity.pdf.
14. J.B. Edwards, A.C.M., S.L. Cullinane,. *Carbon Auditing the 'Last Mile': Modelling the Environmental Impacts of Conventional and Online Non-food Shopping*. 2009 [cited 2019 25/3/2019]; Available from: http://www.greenlogistics.org/SiteResources/ee164c78-74d3-412f-bc2a-024ae2f7fc7e_FINAL%20REPORT%20Online-Conventional%20Comparison%20%28Last%20Mile%29.pdf.

15. Carbon Trust. *Retail: Energy management - the new profit centre for retail businesses*. 2017 [cited 2018 20/11/2018]; Available from: https://www.carbontrust.com/resources/guides/sector-based-advice/retail-and-distribution/.
16. The Guardian. *Fashion must fight the scourge of dumped clothing clogging landfills*. 2017 [cited 2018 24/10/2018]; Available from: https://www.theguardian.com/fashion/2017/jul/29/fashion-must-fight-scourge-dumped-clothing-landfill.
17. EcoChic. *The fashion industry's issues at a glance*. 2014 [cited 2018 24/10/2018]; Available from: https://static1.squarespace.com/static/582d0d16440243165eb756db/t/59df03502994caa6a870c9ee/1507787603580/EcoChic+Design+Award+2017_AdditionalResources_EN_Final.pdf.
18. University of Cambridge Institute for Manufacturing. *Well dressed? The present and future sustainability of clothing and textiles in the United Kingdom*. 2006 [cited 2018 25/10/2018]; Available from: https://www.researchgate.net/publication/282249347_Well_Dressed_The_Present_and_Future_Sustainability_of_Clothing_and_Textiles_in_the_United_Kingdom.
19. Fashion United. *UK fashion industry statistics*. 2017 [cited 2018 25/10/2018]; Available from: https://fashionunited.uk/uk-fashion-industry-statistics.
20. Julie Froud, et al. *COMING BACK? Capability and Precarity in UK Textiles and Apparel* 2017 [cited 2018 25/10/2018]; Available from: https://foundationaleconomycom.files.wordpress.com/2017/02/coming-back-capability-and-precarity-in-uk-textiles-and-apparel-march-2017.pdf.
21. Carbon Trust. *Is it time for a reinvigoration of product carbon footprint labelling in Europe?* 2016 [cited 2018 24/10/2018]; Available from: https://www.carbontrust.com/news/2016/11/is-it-time-for-a-reinvigoration-of-product-carbon-footprint-labelling-in-europe/.

11. Appendix

Energy Usage Data

	Energy Used (kWh)							
Month - Year	Building 1 Main Sewing	Building 2 Knitwear	Building 3 Garment Cutting	Building 4 Printing	PV Energy Used On-Site*	Gas (kWh) MSN: K0059915D6	Gas (kWh) MSN: K1141514D6	Gas (kWh) MSN: 8420066810
Jan-17	32264.0	14327.0	9350.2	29400.5	2747.0	32092.3	12616.6	23340.0
Feb-17	28523.2	11816.0	7776.0	31799.3	5424.2	26360.3	7694.2	21081.3
Mar-17	27858.5	9020.0	7192.5	30033.1	6835.7	22137.2	3725.4	23124.9
Apr-17	19637.2	5814.0	5194.2	28711.1	8400.2	14547.3	1228.5	6683.5
May-17	24140.7	4780.0	5527.1	23894.0	11314.8	313.3	635.0	2891.1
Jun-17	25450.0	4548.0	5884.6	21537.0	11766.4	2064.5	402.0	2776.7
Jul-17	23543.7	4452.0	7194.5	23421.4	12123.6	2078.9	441.6	1443.5
Aug-17	24257.4	5165.0	7820.7	19014.7	9239.8	2340.7	447.5	1443.5
Sep-17	23185.5	5975.0	8815.7	23638.7	7362.9	2245.0	435.9	1409.9
Oct-17	25915.2	9306.0	10634.5	29000.1	6694.3	3985.3	1064.2	8473.7
Nov-17	28886.5	13010.0	12495.2	28287.0	2582.0	15709.3	8479.7	8200.4
Dec-17	27300.5	11845.0	10642.5	20904.4	1855.1	26709.0	17786.3	8473.7

*Assume 60 % on-site

Energy Generation Data

	Energy Generated (kWh)				
Month - Year	**Building 1 50 kWp PV System**	**Building 4 50 kWp PV System**	**Building 3 50 kWp PV System**	**Building 2 28.2 kWp PV System**	**Total PV**
Jan-17	1178.5	1615.4	1200.0	584.4	4578.3
Feb-17	2972.8	2736.6	1750.0	1580.9	9040.3
Mar-17	3286.0	3138.6	2900.0	2068.2	11392.8
Apr-17	4108.4	3037.7	4800.0	2054.2	14000.3
May-17	5771.4	4450.9	5750.0	2885.7	18857.9
Jun-17	6189.3	4826.7	5500.0	3094.7	19610.7
Jul-17	6395.6	4987.6	5625.0	3197.8	20206.0
Aug-17	4059.1	4061.0	5250.0	2029.5	15399.7
Sep-17	3268.6	3668.5	3700.0	1634.3	12271.5
Oct-17	3377.6	3790.8	2300.0	1688.8	11157.2
Nov-17	718.6	1775.4	1450.0	359.3	4303.3
Dec-17	449.7	1617.2	800.0	224.9	3091.8

Production Data

Month - Year	Production
Jan - 17	13462
Feb - 17	13395
Mar - 17	14151
Apr - 17	11256
May - 17	16044
Jun - 17	12656
Jul - 17	14336
Aug - 17	10891
Sep - 17	10612
Oct - 17	16109
Nov - 17	10921
Dec - 17	10937
Jan - 18	14569
Feb - 18	13142
Mar - 18	14003
Apr - 18	16391
May - 18	13336
Jun - 18	15244
Jul - 18	15901

Comparison of GHG Emissions

Production Phase	Standard Overseas Manufacture	David Nieper Manufacture (High-end Estimates)	David Nieper Manufacture (Low-end Estimates)
Raw Materials	29.8%	29.8%	29.8%
Fibre/Textile Production	44.7%	44.7%	44.7%
Clothing Production	10.6%	4.3%	6.4%
Distribution	4.3%	1.1%	3.2%
Retail	10.6%	2.1%	6.4%
Total:	100.0%	81.9%	90.4%

Client: **David Nieper Ltd**

Project Reference: **EIC-UON-168**

Report Title: **Greenhouse Gas Emissions from Stages of Garment Manufacture**

Version: **16.0**

Prepared By: **Matthew Little**

Signed: **Date:** **25/4/2019**

Checked By: **Gulcan Serdaroglu**

Signed: **Date:** **29/11/2018**

Academic Check: **Prof. Gavin Walker**

Signed: **Date: 10 May 2019**

The University of Nottingham, represented by the Energy Innovation & Collaboration team, accepts no liability whatsoever for any use made by the Client of data contained within this report nor does it advise on the use of any contractors or suppliers, it simply suggests that they may be considered by the client to supply goods or services.

European Union
European Regional
Development Fund