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# supply chain guidelines: vision and ecodesign action list

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# preface

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# summary

This guideline aims to inspire fashion companies that wants to transform their supply chain to become sustainable. It intends to inform about the current available knowledge that research can offer and hopefully provide some answers to the issues that refrain companies from starting the transition.

The first chapter gives an overview of environmental impacts associated with textile production in relation to the carrying capacity of the earth. The recommendations for the textile industry to keep within the planetary boundaries are:

- by 2030 reduce emissions of greenhouse gases from textile use by 50%, and by 2050 be carbon-neutral;

- by 2030 textile companies have knowledge of main suppliers' water sources and recipients, and the mean monthly river flows. By 2050, the control variable is suggested to blue water withdrawal as % of mean monthly river flow and cooperation with other local users.

- by 2030 phase out all persistent organic pollutants (POP) from textile production and minimize use of chemicals as well as responsible handling of chemicals.

The second chapter discuss the methodology used for developing the guidelines. The technique of back casting was used to create a vision for how a sustainable supply chain living up to the recommendations above could look like. The next step was to collect a series of technical solutions that can reduce the environmental impacts, both via industry dialogue and literature sources.

Finally, the Results chapter presents the actions that have been identified as feasible with today's available technology and with high efficiency in reducing environmental impact. The results chapter also quantifies the effects that the proposed actions would have. All proposed actions are linked to technologies which are available in bulk scale today.
The guidance document ends with the Ecodesign Action List where the intent is for a company to in a systematic way see what actions are possible, starting with the actions of highest impact reduction potential first and saving the less efficient (but still efficient) actions for last.

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# 1. introduction

Today we live in an unsustainable way using more resources than the planet has capacity for in the long term (United Nations, 2015). In this report, we look at the sustainability problem with fashion production (Sandin, Roos, Spak, Zamani, & Peters, 2019; The Ellen MacArthur Foundation, 2017) from three different perspectives: global warming, water depletion and the use of chemicals.

## 1.1 global warming

Global warming, or climate impact, is one of the planetary boundaries that humanity has already transgressed (Rockström et al., 2009). Research published by the Intergovernmental Panel on Climate Change (IPCC) has shown that the planet can manage a global 2 degree increase of temperature (but preferably less than 1.5 degree) compared to the level before industrialization (in 1850–1900). The increase in the concentration of carbon dioxide and other greenhouse gases in the atmosphere gives a warmer planet, therefore emission of greenhouse gases must be limited. Instead, since year 2000, the global concentration of carbon dioxide has increased by 20 ppm in the atmosphere per decade (Allen et al., 2018).

"The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius." (United Nations, 2016)

The effects of global warming will for example be rising sea levels (IPCC, 2014) and an ice-free Arctic Ocean during summer (Notz & Stroeve, 2016). What we need to do to reach the 2 degree target is to reduce our future greenhouse gas emissions. Approximately 70 percent of all greenhouse gas emissions globally are directly accountable to the use of fossil energy sources, such as oil, coal and natural gas (IPCC, 2014). Reduction of our energy use and a change of energy sources will be crucial in order to reduce emissions.

The energy supply from a global perspective is mainly from fossil-based sources with high greenhouse gas emissions per kWh produced, see Figure 1. This will have to change for the industry to be sustainable. Moving the entire energy sector to a low greenhouse emission production will take time. A driving force to improve the speed of this progress is to request sustainable energy.

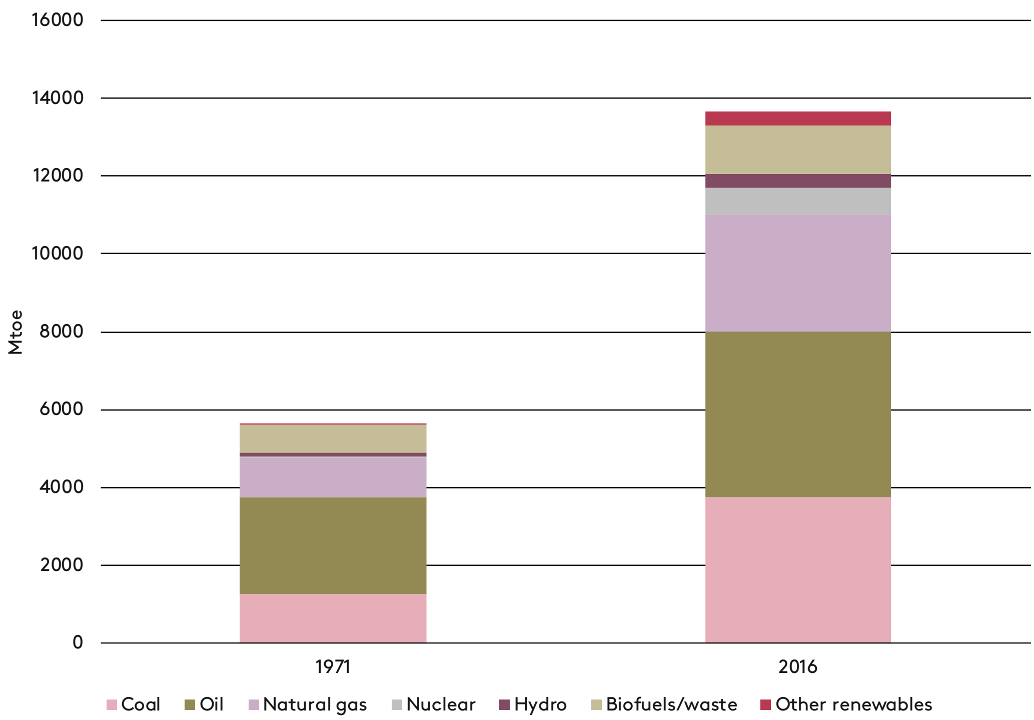



figure 1. Data from International Energy Association (IEA) on the energy supply from different sources 1971 and 2016.

# 1.2 water depletion

Water scarcity is basin-specific and depends on how much water is available and how many actors that use the water (Roos, Zamani, Sandin, Peters, & Svanström, 2016a). Both geographical and seasonal conditions play an important role.

Cotton cultivation requires large amounts of water for irrigation that are consumed (i.e. not returned after use to the same watershed). An infamous example of the effects of too heavy water consumption for cotton irrigation is the water reduction in the Aral Sea (Saiko & Zonn, 2000).

When water is used instead in processes in the textile preparation (e.g. in the wet treatment), the water can be returned to the watershed where it was retrieved. However, the process water will be more or less contaminated and often unusable for organisms and as drinking water for humans.

# 1.3 use of chemicals

There are several reasons for improving the current use of chemicals. Firstly, many chemicals have properties that make them hazardous to people and the environment. Hazardous chemicals should be substituted with better alternatives if possible and handled with caution if use cannot be avoided (United Nations, 2002, paragraph 23).

Exposure to hazardous chemicals can be direct or indirect. Examples of direct exposure are when workers in the factories inhales solvents, or, when waste water containing chemicals is emitted to a river. Indirect exposure can for example be shedding of micro-sized textile fibers during washing, carrying chemicals with them.

What are the consequences of using hazardous chemical substances? There are some substances that are known to cause cancer, mutations and damage to our reproduction capacity, for example by causing malformations and infertility. Substances that are either carcinogenic, mutagenic or reproduction toxic (CMR substances) are very harmful to humans. Environmentally hazardous substances are those that are both toxic to different organisms and at the same time remain in nature for a long time (i.e. are persistent).

Further, some substances have properties that will accumulate the substance in the biological organisms exposed to them (i.e. are bio-accumulative). Substances that are both persistent, bio-accumulative and toxic (PBT substances) are often called persistent organic pollutants (POP). Secondly, reducing the amount of chemicals used in industrial processes means that less chemicals end up in the wastewater, thus reducing the amount of polluted water that needs to be purified or discharged. In addition, chemicals are often made from fossil raw materials and the production of the chemicals means that energy is used. If chemical use is reduced, energy use is also avoided. A sustainable use of chemicals is therefore about safe chemicals handling, reducing the amounts of chemicals used, and making other choices about which chemicals are used (UNEP, 2006).

# 1.4 how large is the environmental impact of the Swedish textile consumption today?

Looking at climate impact, the yearly emissions caused by the Swedish fashion consumption averages to 3.27 million tonnes carbon dioxide equivalents, with 80% stemming from the textile production. It is the wet treatment step that has the greatest climate impact, see Figure 2. This is due the large amount of energy required to heat the process water, which is often from fossil energy sources. For water scarcity, cultivation of cotton fiber, has the greatest impact, see Figure 3. In some studies, washing and drying garments during the use phase has been important for both climate impact and water scarcity, but in Sweden, the influence is limited partly because we have good access to water and fossil-free electricity (Roos, Zamani, Sandin, Peters, & Svanström, 2016b). Toxicity impacts are dominated by cotton cultivation and wet treatment, see Figure 4.

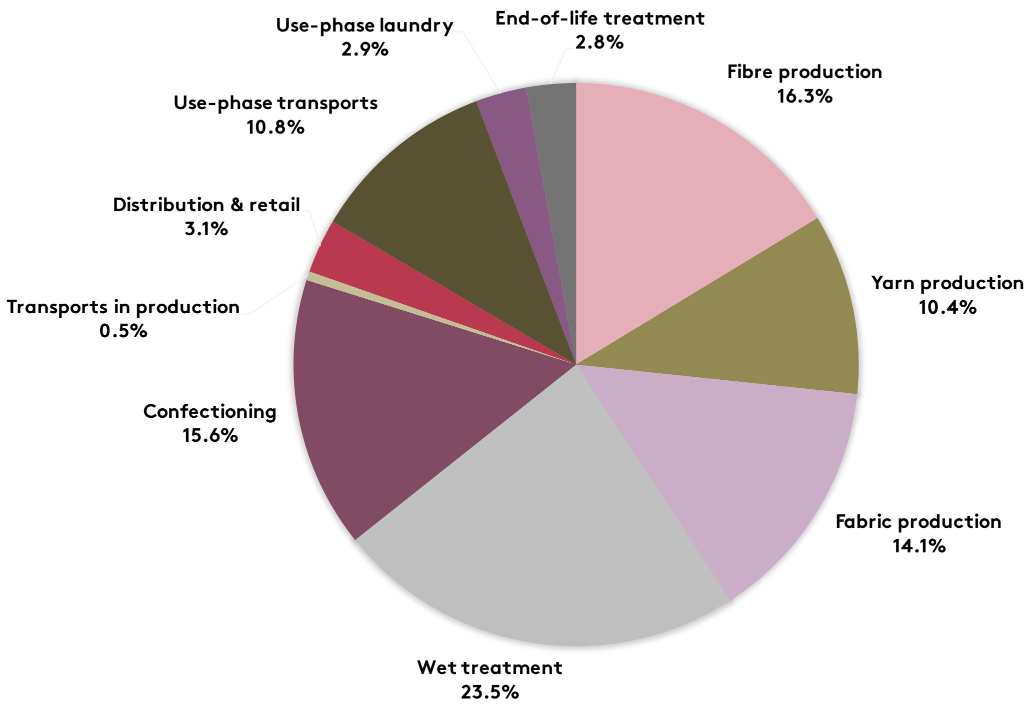



figure 2: Climate impact of Swedish clothing consumption, contribution of life-cycle phases. Figure from Sandin et al. (2019).

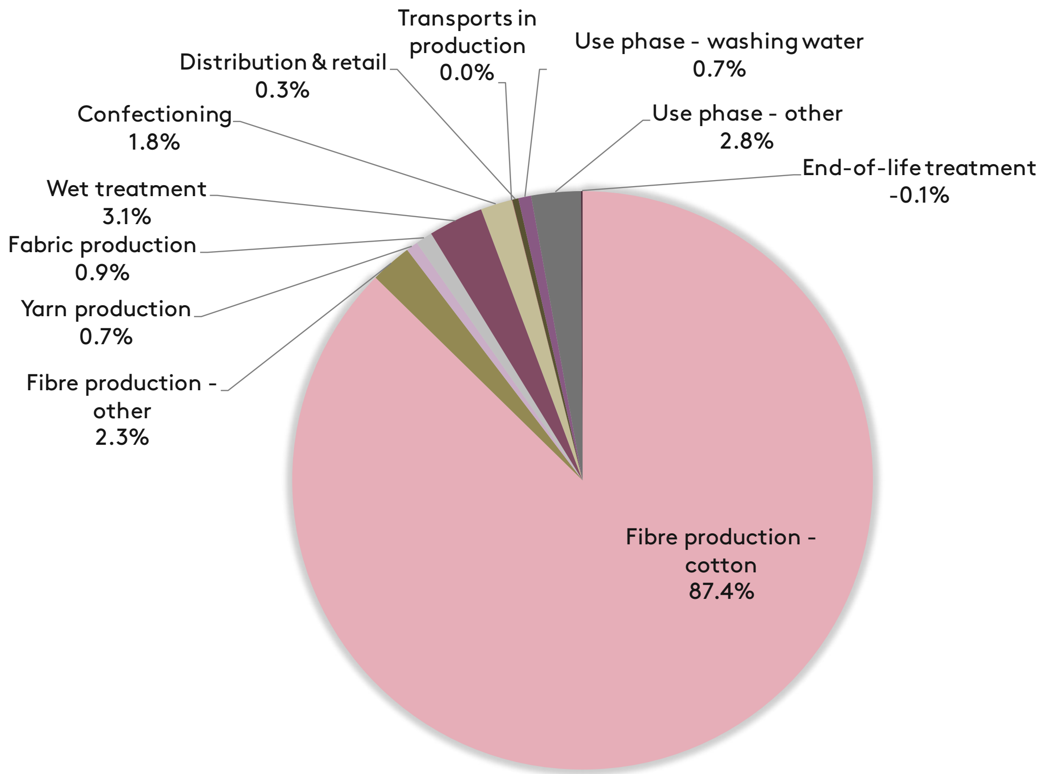



figure 3: Water scarcity impact of Swedish clothing consumption, contribution of life-cycle phases. Figure from Sandin et al. (2019).

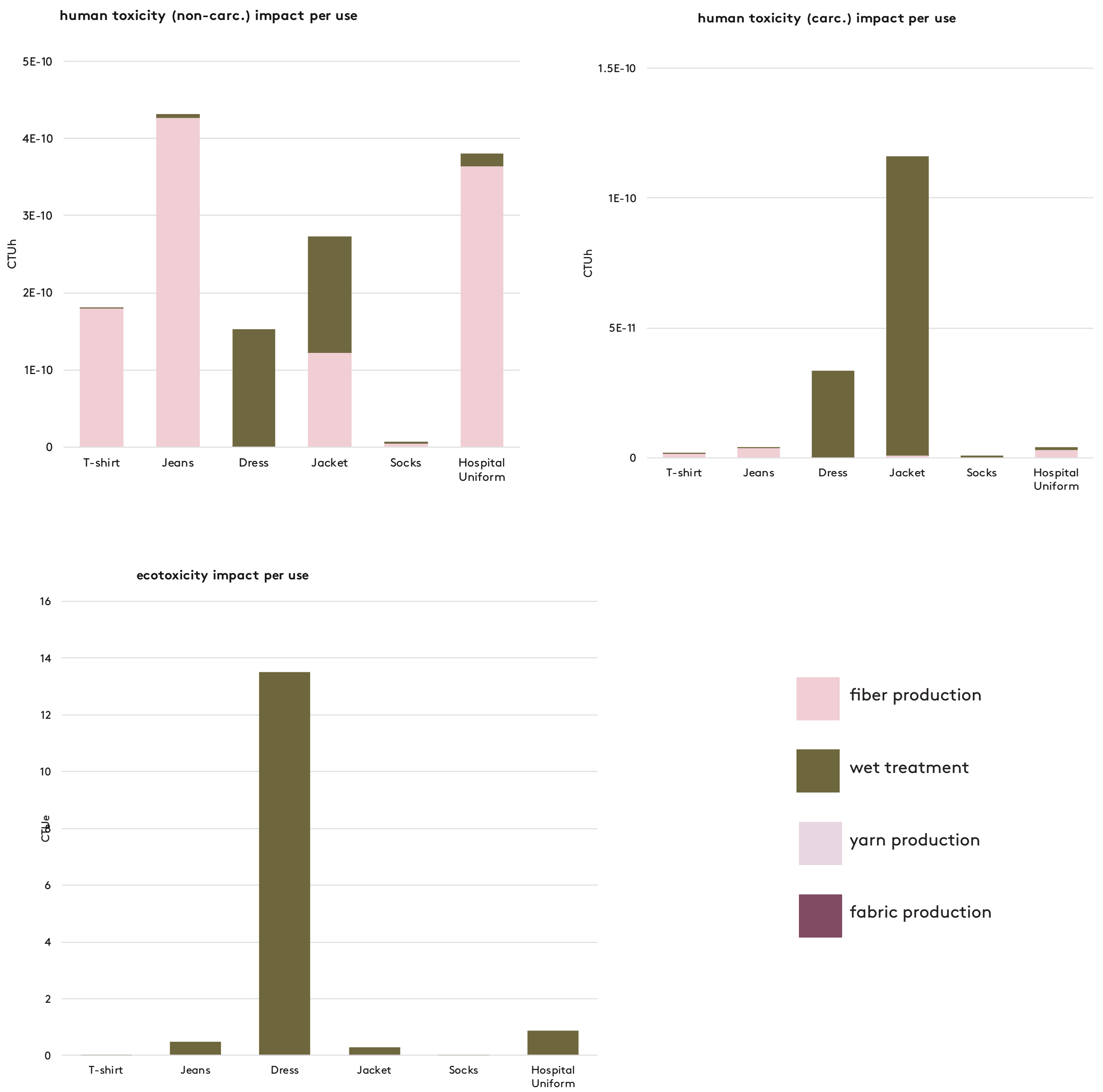



figure 4. Toxicity impacts from the Swedish fashion consumption (human toxicity divided into non-cancer and cancer impact, and ecotoxicity). Figure from Sandin et al. (2019).

# 1.5 what does the textile industry need to do?

What is the role of the textile industry in this? There are different perspectives on what responsibility the textile industry should take for sustainable development (Sandin, Peters, & Svanström, 2015). Either one can reason that the textile industry should take a greater responsibility than the rest of the industrial sector as fashion is consumed for pleasure, but there are also those who believe that the opposite would be true, as clothing is an essential need for human beings. In this report, we assume that the fashion industry should take the same responsibility as all other industries (Roos et al., 2016a), therefore a vision should include:

- by 2030 reduce emissions of greenhouse gases from textile use by 50%, and by 2050 be carbon-neutral;

- by 2030 textile companies have knowledge of main suppliers' water sources and recipients, and the mean monthly river flows. By 2050, the control variable is suggested to blue water withdrawal as % of mean monthly river flow and cooperation with other local users.

- by 2030 phase out all persistent organic pollutants (POP) from textile production and minimize use of chemicals as well as implement responsible handling of chemicals.

Research indicates that the most effective way of reducing the environmental impact is to make sure that the garment is used more times, see Figure 5. Then the environmental cost of the production is "spread" over more uses, i.e. the environmental cost per use is reduced.

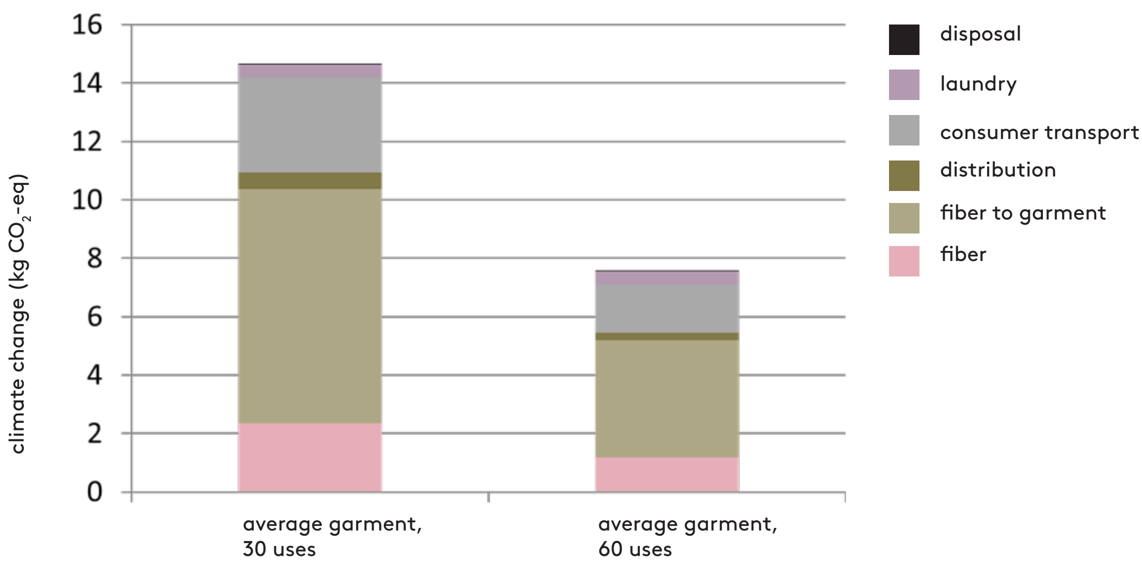



figure 5. The climate impact is reduced by nearly 50% when doubling the life span of the garment.

Regarding resource depletion, much more resources are used as fuels compared to materials in the production (Sandin, Roos, Spak, et al., 2019). Figure 6 illustrates where fuels are consumed and how much fuels are consumed in petrol equivalents, i.e. in case fuel oils would be the only fuel used. In reality, other fuels are also used, such as coal and natural gas, so Figure 6 is only made for the illustrative purpose. Seven kg petrol is needed to produce one kg cotton t-shirts. The conclusion that can be drawn is that replacing fossil energy is seven times more important than replacing fossil materials.

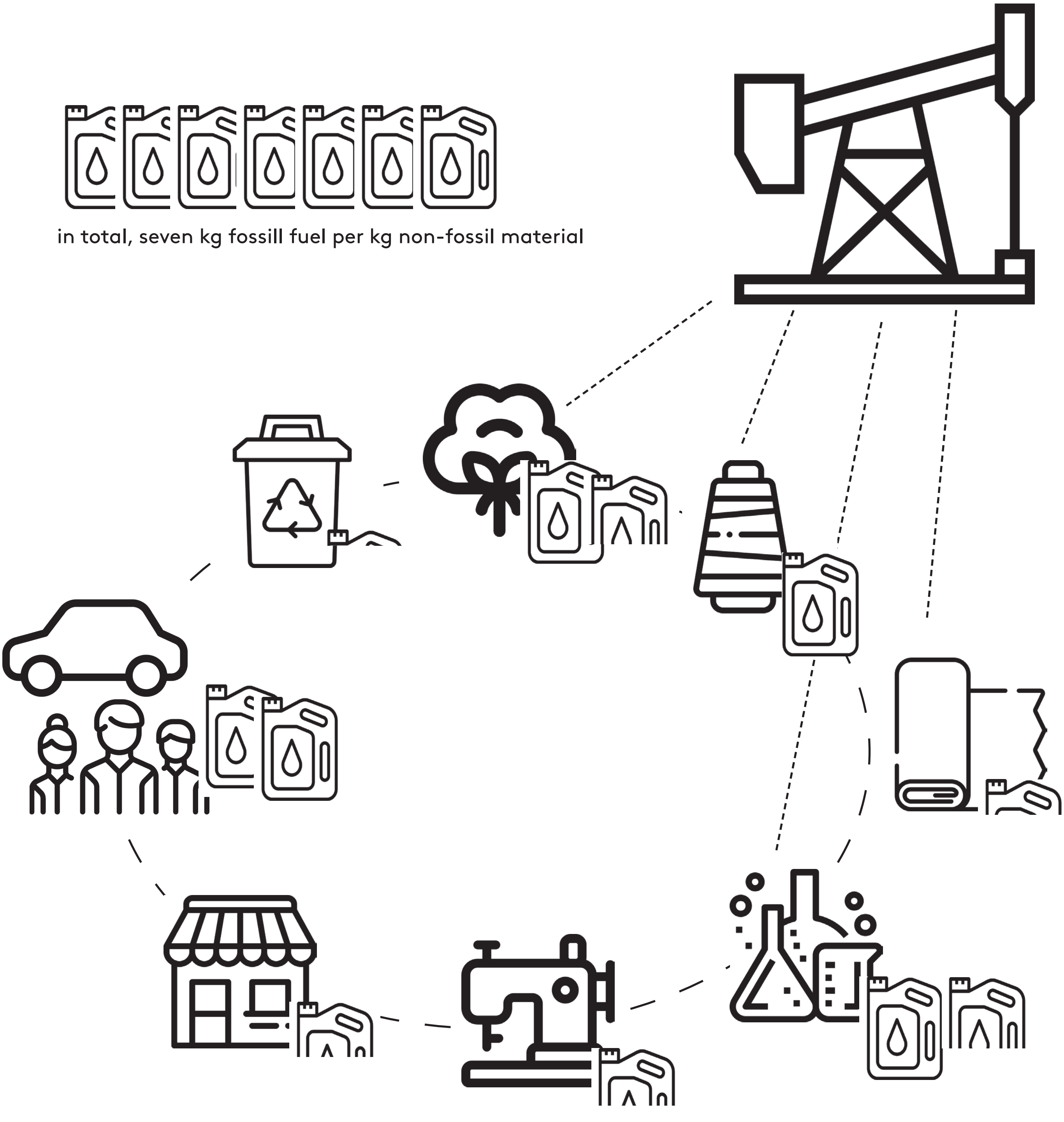



figure 6. A schematic description of where and how much (possibly fossil) energy is used in the production of 1 kg cotton t-shirts.

There are also other ways to reduce the environmental burden from the production itself and focus on the production steps with large impact, such as the wet treatment. An important parameter is at what temperature the water is used. In the wet dyeing process, the water can be heated up to 160 degrees Celsius. Heating the water requires a great deal of energy, which in turn strongly contributes to the greenhouse effect if fossil-based. A reduction in water use in the textile preparation therefore has several positive effects: reduction in energy use, water use and also reduced amounts of contaminated waste water from the process.

Another way to reduce the impact of the wet treatment is to avoid wet dyeing by adding color pigments already when the fiber is manufactured, so called dope dyeing, spin dyeing or solution dyeing. All fibers that are extruded (man-made) can be manufactured this way, for example polyester, nylon, viscose and modal.

The Ecodesign Action List in chapter 3.2 summarizes the practical advices resulting from the research in the program Mistra Future Fashion.

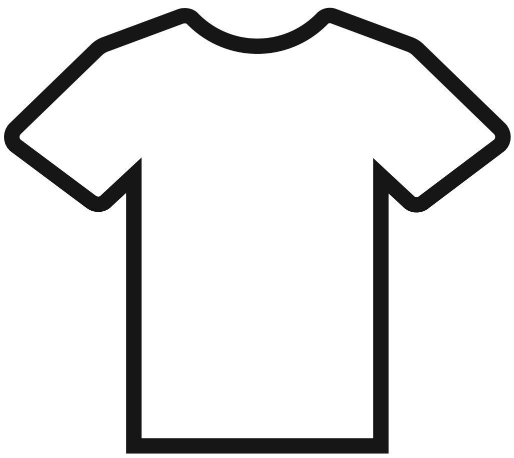


figure 7. A cotton t-shirt. Average use 30 times, including 15 washes. Sandin et al. (2019).

# 2. how do we transform into a sustainable fashion supply chain?

The methodology behind the development of this guidance document is twofold:

1. visualization of what sustainable fashion production can look like via back-casting; and

2. development of practical advice on the most efficient measures to get there.

The total environmental load must not exceed the earth's carrying capacity, as has been mentioned in the report's first chapter. The available means to reach sustainability were shown to belong to either of three factors (Figure 8), introduced by Commoner, Ehrlich, and Holdren already in the 1970s (Commoner, 1972; Ehrlich & Holdren, 1972).

This document is focused on the impact from the textile supply chain which mainly is connected to the first factor: reducing the environmental impact per product. However, by optimizing the design and quality of the garment towards a longer life length also the second factor is influenced affected: reducing the number of produced products per person, although the latter is not part of the scope in this report.

$$\text{Total environmental impact} = \frac{\text{Environmental impact}}{\text{Product}} \times \frac{\text{Number of products}}{\text{Person}} \times \text{Amount of people}$$

figure 8. The Ehrlich and Holdren equation from 1972 still guides us (Commoner, 1972; Ehrlich & Holdren, 1972).

## 2.1 back casting for creating a vision of the future

One way to solve this problem is to start with visualizing the goal, in our case a sustainable fashion value chain, and then define which steps we need to take in order to reach our goal. This approach is called back casting (Holmberg & Robèrt, 2000; Robinson, 1982) and will be used in this report to show different examples of how we can transform into a sustainable fashion industry.

The description of what a sustainable fashion supply chain would look like was developed in a paper by Roos et al. (2016a). Sustainability was there defined as keeping within the Planetary Boundaries, a concept developed by Rockström et al. (2009).

The vision of the transformation to 2030 is illustrated in a simplified way in Figure 9. The squares represent the yearly amount of garments currently consumed by the average Swede (50 pieces). The area of the squares equals the environmental burden for each of these garments. Today we produce textiles in a wasteful manner and not according to the best technology available which gives a large burden (large area). The vision is that this will change to 2030 leading to smaller burden per garment in average (small area). The reduction of garments per person due to longer life length of the future garments is shown as a reduction in number of boxes. Together this will lead to a decreased environmental burden of the industry in line with the goals described in chapter 1.5.

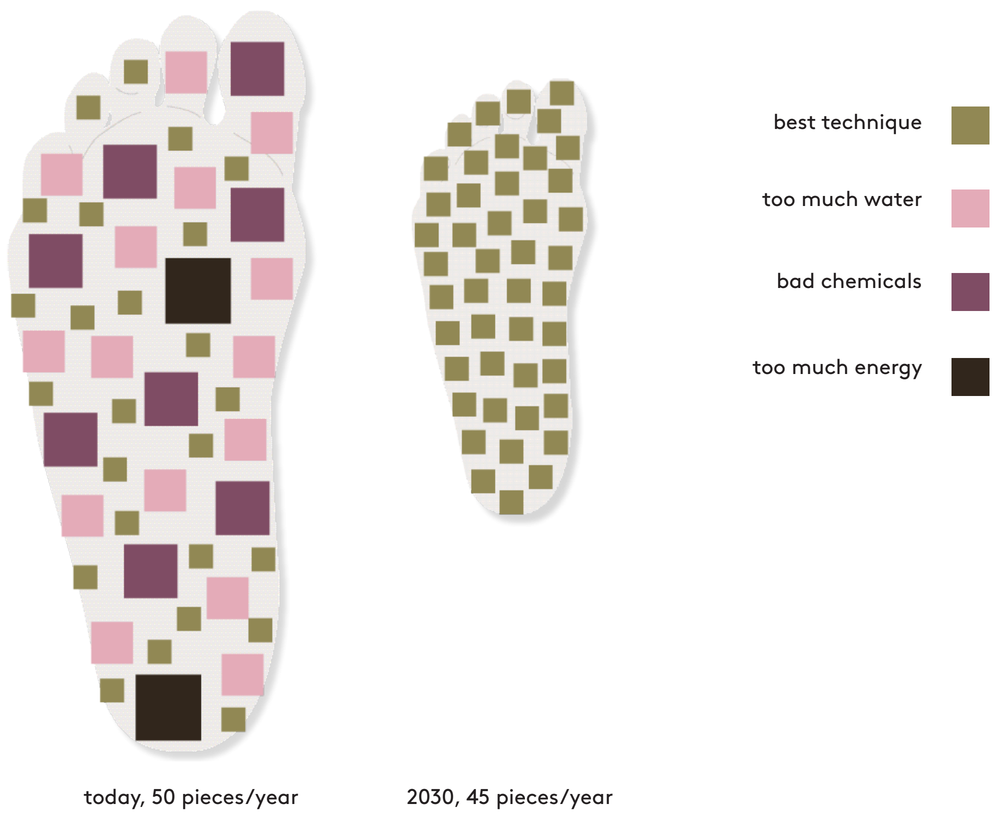


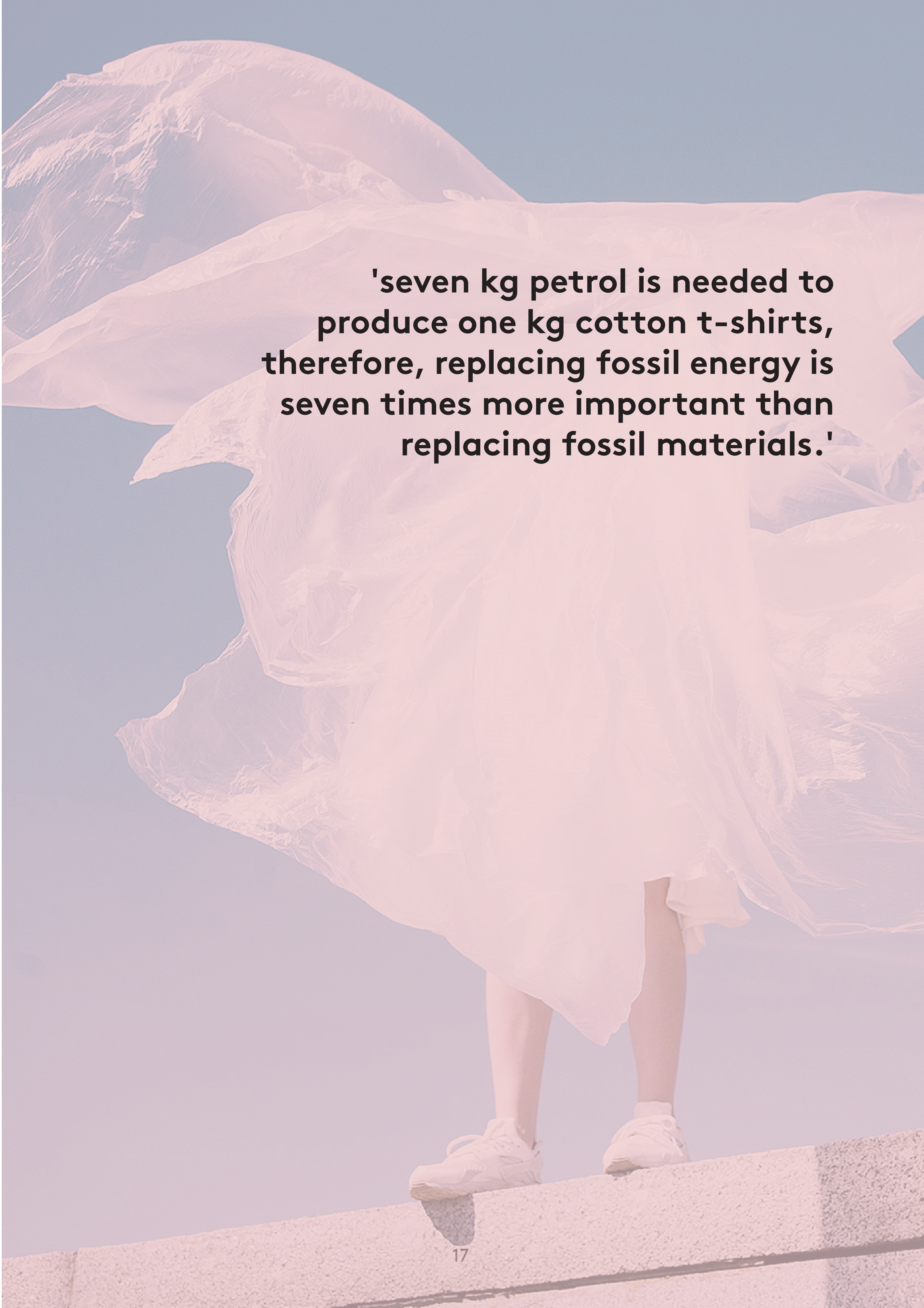

figure 9. The total environmental impact (the total area) will be reduced to 2030.

# 2.2 ecodesign - development of practical advice

The advices to actions which have high potential in reducing environmental impact build on both field experience and literature.

The list of feasible actions to reach a sustainable fashion supply chain with today's technology have been compiled via industry dialogue regarding the possibility to implement measures for the different steps in the textile production chain.

For these measures, a number of life cycle assessment (LCA) studies, performed both within the Mistra Future Fashion program and externally have been reviewed to determine the potential for reducing the environmental impact in three impact categories: climate change, water depletion and toxic impacts (Jönsson et al., 2018; Olsson, Posner, Roos, & Wilson, 2009; Peters, Sandin, Spak, & Roos, 2018; Peters, Svanström, Roos, Sandin, & Zamani, 2015; Roos, 2012, 2013; Roos & Larsson, 2018; Roos & Posner, 2011; Roos et al., 2016a, 2016b; Sandin, Roos, & Johansson, 2019; Schmidt, Watson, Roos, Askham, & Poulsen, 2016; van der Velden, Patel, & Vogtländer, 2014).



'seven kg petrol is needed to produce one kg cotton t-shirts, therefore, replacing fossil energy is seven times more important than replacing fossil materials.'

# 3. results

This chapter presents the results of the back casting: a visualization of what sustainable fashion production can look like in 2030, followed by practical advice on the most efficient measures to get there.

# 3.1 vision for a sustainable fashion supply chain 2030

There are several ways to reduce the climate impact of the fashion supply chain and cut the greenhouse gas emissions by half, shown in Figure 10. By combining different actions, the total reduction of environmental impact can be reduced. In the scenario used in this guide seven different actions are needed in order to half the climate impact by 2030 and at the same time reduce the water use and chemical use/toxicity:

1. Changing the source of electricity used in the manufacturing to renewable sources such as wind-, solar- and water-power. In Figure 10, the present state represents the figures from Sandin et al. (2019) where the electricity mix of the current countries producing the garments consumed in Sweden. 50% of this electricity is replaced by equal shares of solar power and wind power, will give a reduction of the climate impact of 20% in total.

2. Replacing all synthetic piece dyed fabrics with dope dyed fabrics, will result in a reduction of 16% in total climate impact.

3. Using bio-based fuels (wood chips) for heat in factories, will give a reduction of the climate impact of 9% in total.

4. Increasing the life length of garments by 10%, will give a reduction of the climate impact of 9% in total.

5. Reducing the cutting rates from 20 % to 10 % will give a reduction of the climate impact of 5% in total.

6. Placing stores and engage with customers, so that 50% of the customers that transport themselves to the store with car today instead ride a bus (50%) or bike (50%), will give a reduction of the climate impact of 3% in total.

7. Half of the cotton is replaced with viscose. This action is not aimed at reducing the climate impact but for reducing the water use and the chemical use

Two different actions for reduction of toxic impacts were investigated: dope dyed synthetic yarns and replacement of cotton, see Figure 10. As the availability of organic cotton is still very low, the substitute for cotton is in this case polyester that represents a feasible bulk scale.

It should be noted that all of the actions proposed uses technologies which are available in bulk scale today. It would therefore be possible to use the actions on all of the relevant garments produced, thus reaching the vision for 2030. Today, a large variation of different production technologies are used, where some are at the level of best environmental performance (European Commission, 2003) or close to, while some are not, therefore leading to a large environmental footprint. To lower the climate footprint 50%, we need to use the best available production technologies from the environmental perspective, and at the same time lower the amount of garments produced, with 10%.

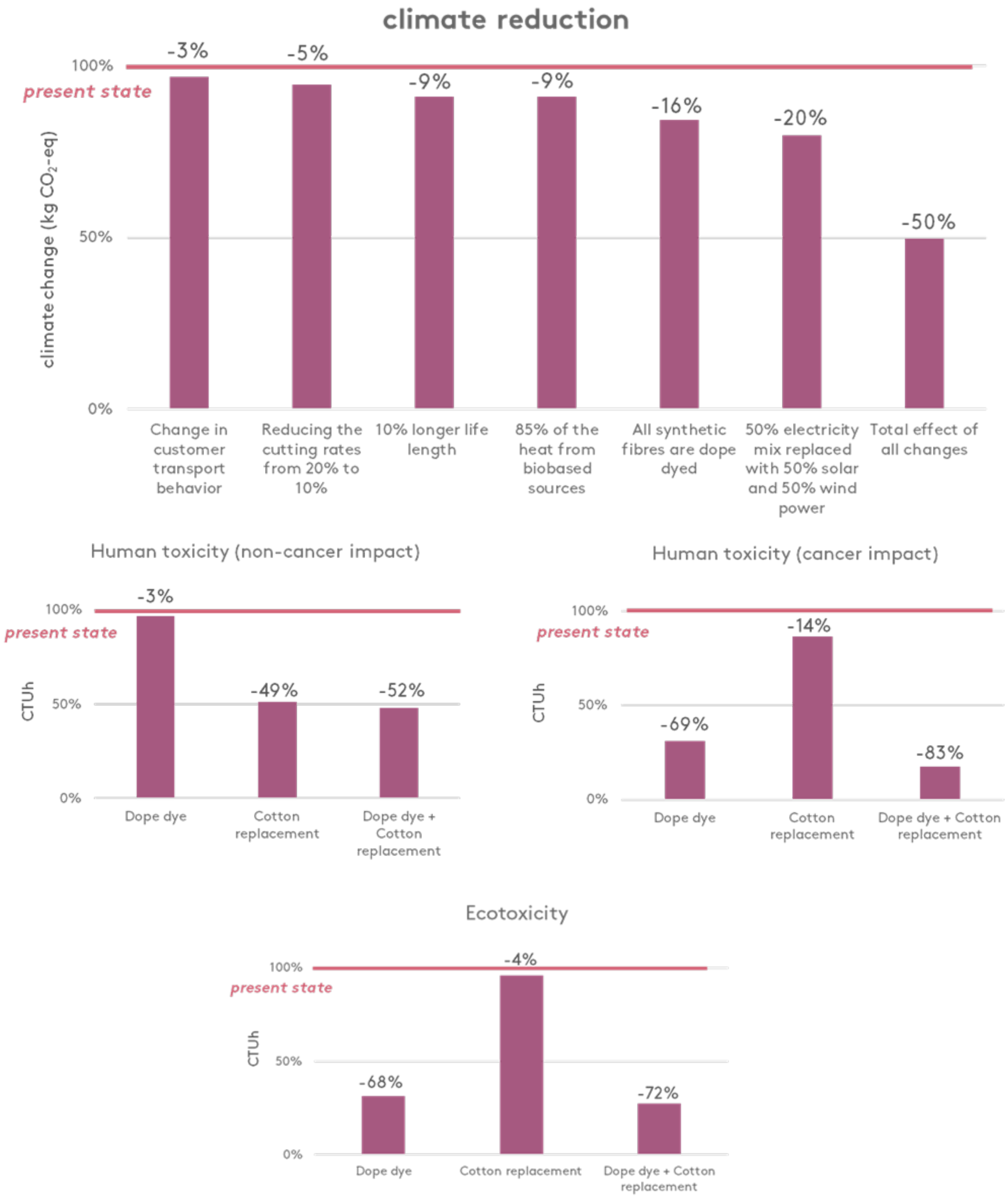



figure 10. The reduction of climate impact for each action and the effect of all actions combined.

# 3.2 ecodesign action list

The following checklist of supply chain actions for a textile company, starts with the actions with highest potential for impact reduction and saving the less efficient (but still efficient) actions for last. The intent is that a company shall start with action #1 and see what is possible to do in the own supply chain, then move to action #2 and so forth, see Table 1. Please note that the efficiency can vary depending on product and context and the ranking is based on life cycle assessment for a generic textile supply chain (Jönsson et al., 2018; Olsson et al., 2009; Peters et al., 2018, 2015, Roos, 2012, 2013; Roos & Larsson, 2018; Roos & Posner, 2011; Roos et al., 2016a, 2016b; Sandin, Roos, & Johansson, 2019; Schmidt et al., 2016; van der Velden et al., 2014). The action list does neither claim to be conclusive and very many other options are possible. Several of the advised actions are also repeated as the action can contribute to several aims.

table 1. A summary of the Ecodesign actions on how to move to a sustainable fashion supply chain. The effects of the different actions are shown both by the ranking and the size of effect divided between climate, water and chemicals

| Action | Climate | Water | Chemicals |
|---|---|---|---|
| 1. Increase life span (resulting in increased number of uses) | impact/ number of uses | impact/ number of uses | impact/ number of uses |
| 2. Better production technology | LESS ENERGY | LESS WATER USE | WASTE WATER TREATMENT |
| 3. Better energy sources | LESS FOSSIL FUEL | - | less toxicity |
| 4. Better chemicals selection and reduction of chemicals' use | LESS CLIMATE IMPACT | LESS POLLUTED WATER | LESS TOXICITY |
| 5. Better materials | - | LESS WATER USE | less toxicity |
| 6. Minimizing microfiber shedding | - | less polluted water | less toxicity |
| 7. Optimize transport and packaging | less fossil fuel | - | less toxicity |

**#1 Increase the life span**

To increase the life span (life length) of the products is the most efficient way to reduce the environmental burden. There are two different types of life spans: the technical and the practical (emotional) life span. The technical life span is dependent on material and construction quality such as wear resistance, color fastness etc. Usually synthetic fibers have outstanding durability properties compared to natural fibers (Rex, Okcabol, & Roos, 2019). The emotional life span is the time during which the product will have appeal to the user. A garment which still has good material quality but have gone out of fashion for the user will not be used.

Optimizing the garment design and quality therefore generate an opportunity to increase the service life. If longer service life can be achieved by some action, it can even be worth to increase the cost/environmental impact of production, as with increased use it will still reduce the environmental impact during the life-cycle. But this is only the case if the number of uses of the garment really increases, which is why the emotional life span must also be considered. Just as the economic cost, the environmental cost is "shared" over the number of uses (Figure 6).

Some garments do not even start their life, i.e. they are never sold or they are returned before they are used. Overproduction and return rates should be minimized.

**Actions:**

A. Analyze which factor(s) decides the life span:

- Do you know how many times does the average customer use the garment?
- Do you analyze causes of returns? (both unused garments and claims made after use)

B. Improve by:

- Define who the intended user is and how many times the garment is expected to be used and include in the design brief.
- Make the design more timeless/classic in collaboration with dedicated customers.
- Guarantee the life length (minimum 10 years?) of your garments.
- Construct the garments to reduce the seam slippage.
- Use fibers with good durability (this may also have a positive impact on micro plastics release).
- Use dyestuff with good durability.
    - o Optimal color for gussets, collars and other sensitive parts (shade/dyestuff)
- Select better options for parts that are likely to be worn out first:
    - o Prints with lower technical performance than the rest of the garment.
    - o Zippers
    - o Reflecting tapes
    - o Children's trousers (knee)
    - o For shoes, sewn soles instead of glued will improve technical life span.
- Provide spare buttons and other trims (often simpler if trims are standardized/carry over)
- Offer mending services for customers
- Take back and resell garments second-hand

#### #2 Better production technology

For textiles, about 50% of the climate impact is caused by textile processing (yarn production, fabric production and wet treatment, see Figure 3). If less material (finished textile goods) is needed to produce a garment, less environmental impacts caused by processing the material will influence the environmental burden of the final product. One way to do this is to reduce cutting rates by using a different design of the product. For example, a fine pattern fabric can be cut in more ways than a large pattern fabric, leading to that the cutting can be more flexible and therefore more efficient.

The most energy consuming step, and also the step causing most chemical pollution, is the wet treatment (scouring, dyeing, finishing etc.). Sometimes the first dyeing process of a fabric does not give the expected result, and the dye house has to redo the dyeing process. Doing so means that the productions step will have twice the environmental burden. Hence, it's very important to reduce the amount of rework in order to reduce the environmental impact, using e.g. "right first time" techniques (Karmakar, 1999). In e-commerce, possibly shades of colors on garments in the same product groups can be accepted because the customer does not see several garments together when buying the garment. This means that there might be a higher acceptance of difference shades between batches which could also reduce the amount of rework.

Another option is to remove dyeing completely by using dope/solution dyed fibers which also give the advantage that there will be no rework (increased "right first time" rate) and color match between batches.

The term economy of scale is both applicable for economic and environmental impacts. Having large production series means that the possibility to make them as "eco-efficient" as possible is much higher. One can have a long series of garments in the same color for example, if collections for men's, women's and children's wear use the same color. It goes without saying that it is important that the number of garments isn't overproduced. Producing products which will not be used is not acceptable from an environmental point of view.

Automated dosing systems means that the amount of chemicals used will be more consistent leading to both less errors in the production and less amount of chemicals used. Also, the exposure to factory workers gets much lower with an automated system (UNIDO, 2013).

Wastewater treatment is vital in the textile production to reduce the amount of freshwater ecotoxicity from the production processes. A wastewater treatment plant (WWTP) needs to be equipped with several process steps in order to take care of all the emissions, both mechanical, chemical and biological treatment. Having a WWTP is of course not enough, it also has to be used and not only during audits. One way of securing this is to choose suppliers which offer transparency regarding their production processes.

**Actions:**

A. Improve efficiency:
- Reduce cutting rates
- Reduce rework in the production facilities

B. Cleaner production:
- Use solution dye/dope dye technology to remove the dyeing step completely.
- Automated dosing systems for less exposure to chemicals for the workers.
- Waste water treatment plant (WWTP) with mechanical, chemical and biological treatment.

C. Select suppliers that:
- Have environmentally certification or declaration schemes for production facilities
- Keep their waste water treatment plant (WWTP) turned on (also after audits...)
- Offer transparency regarding:
- Sub-suppliers' environmental performance
- Energy use and sources
- Social sustainability and labor conditions

#### #3 Clean energy sources

Globally, 70 percent of the climate impact is directly caused by fossil fuel use (IPCC, 2013). Thus it is essential to influence the textile supply chain actors to use more sustainable energy sources by for example installing solar and/or wind power plants at the site or buy "green" electricity. Use of bio fuels instead of fossil fuels like coal for heating and using electric trucks at warehouse instead of diesel trucks are other ways to improve the environmental performance. Companies can also contract new suppliers based on what energy they are using. Having a supplier in Laos or Lithuania means that they already have access to more sustainable energy.

The difference of emissions of carbon dioxide per kWh of energy is largely depending on what kind of technology is being used to produce it, see Table 2.

table 2. Global warming potential figures for different energy sources and countries.

| Global warming potential for different electricity sources (g CO2-eq./kWh*) | | Global warming potential for state grid electricity in different countries (g CO2-eq./kWh) | |
|---|---|---|---|
| Coal power plant | 1,057 | China | 1,140 |
| Oil power plant | 916 | Korea | 638 |
| Natural gas power plant | 600 | Laos | 211 |
| Wind power plant | 14 | Lithuania | 195 |
| Solar panel | 84 | Sweden | 11 |

**Actions:**

A. Drive change at your suppliers' facilities to more sustainable energy sources:

- Solar panels or wind turbine installation
- Use of bio fuels
- Electric trucks at warehouses

B. Select suppliers that are already using better energy sources:

- E.g. at Laos, high amount of water power, or the Nordic region (Table 2).

**#4 Better chemicals selection and reduction of chemicals' use**

The phasing out of persistent organic pollutants (POP) means that long term toxic effects are being reduced dramatically. An application where several POP substances are used is durable water repellent (DWR) treatments, where chemicals such as fluorinated hydrocarbons (PFAS) and silicone polymers are still common.

Biocides and pesticides are used in various ways in textile production. These substances are per definition toxic and the use should be kept at a minimum unless the application is a so called essential use (Cousins et al., 2019). Antibacterial treatments in final products should for example not be considered an essential use and should therefore not be used. Biocides used in transport can in most cases be replaced by packing and keeping the goods dry and cool.

To follow up on the chemicals used in the production it in important to choose suppliers which are transparent. The supplier should be willing to forward safety data sheets (SDS) on all of the chemicals used. This should be supported by a good chemicals management system.

**Actions:**

A. Phase out (unless essential use):
- Persistent organic pollutants (POP)
- Durable Water Repellent treatment – use fluorine/silicon free unless PPE[1] applies
- Antibacterial treatment
- Transport fungicides – keep dry and cool instead

B. Improve by:
- Use dry processes instead of wet processes (e.g. solution dye/dope dye)
- Reduce rework
- Automated dosing systems
- Are there any unnecessary effect chemicals in the garments? (softeners, "easy care" etc.)

C. Select suppliers that:
- Offer safety data sheets
- Offer transparency about what chemicals they use
- Have a good chemicals management work in place

1. Personal Protective Equipment Regulation (EU) 2016/425

#### #5 Better materials

Producing conventional cotton fibers leads to high water consumption and use of biocides. Therefore, reducing the use of cotton in the textile products either by mixing it with other fibers produced from forest like modal and viscose or replace it with polyester fiber. Set the fibers' life-cycle performance at center stage – including their fit-for-purpose and effects on subsequent production, user behavior
and end-of-life options.

**Actions:**

A. Replace conventional cotton:
- Can you use e.g. 50/50 forest fiber and cotton fiber?
- Can you use polyester instead of cotton?

B. Select sustainable fibers:
- Set the fibers' life-cycle performance at center stage – including their fit-for-purpose and effects on subsequent production, user behavior and end-of-life options.
- Avoid GMO cotton
- Use fibers with good durability
- Use fibers that can be solution/dope dyed
- Watch out for green-wash! The claim of being "green" must be accompanied by some explanation of in what way, and in case of claims to be "better" – how much better?

C. Avoid unnecessary materials:
- Are there any unnecessary functions in the garments?

D. Standardize trims, attachments, hang tags etc.:
- Increase control for "high risk" materials
- Simplify exchange of buttons etc. in the use phase.

**#6 Avoid microplastics**

Micro-sized plastic particles (microplastics) are generated in textile production processes as "dust" from synthetic materials (Roos, Levenstam Arturin, & Hanning, 2017). In the use phase, the dust carried by the garment is washed off and enters the wastewater system. Also, fiber breakage in the use phase can cause additional microplastics generation.

During production, dust is also generated from cellulosic or protein-based fibers which can be a working environment problem (Hesperian, 2015), However, the natural fibers have a different behavior in the environment compared with synthetic fibers and not seen as a problem in the use phase of textiles (Jönsson et al., 2018). Therefore, the actions below focus on microplastics from synthetic fibers.

**Actions:**

A. Reduce microplastics generation in the production of the garment:
- Are there any unnecessary brushing operations?
- Use laser or ultrasound cutting if possible.

B. Reduce the amount of microplastics shed from the garment:
- Use materials/constructions that shed less upon mechanical stress during use

C. Reduce the amount of microplastics being carried by the garment:
- Ensure good air quality in the facilities.
- Remove dust from synthetic fibers with dry methods such as vacuum cleaning.

#### #7 Lower the impact of transport and packaging

Freight and packaging has usually very low environmental impact (Sandin, Roos, Spak, et al., 2019). However, airfreight has a comparatively high climate impact and for companies with a high share of airfreight from suppliers, this is an important aspect. To keep the goods from molding, biocides (anti-mold agents or fungicides) are used. Most of the anti-mold agents that are very toxic to humans are banned by law and in the generic case not used (Roos, Jönsson, & Posner, 2017). However, if the chemicals management is lacking, the use of anti-mold agents may be of very high importance.

Actions:

A. Reduce air freight:

- Can there be a total ban of air freight in the company?

B. Reduce anti-mold agents (fungicides):

- Pack and store in dry conditions
- Keep dry and cool
- Unpack as soon as goods arrive(humidity, temperature and time drives mold growth)

C. Optimize packaging materials:

- Make sure the packaging does its work and protects the goods
- Reduce the size of the packaging and the amount of packaging material
- Do not use hazardous chemicals (for instance prints)

**'In the scenario used in this guide seven different actions are needed in order to half the climate impact by 2030'**

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Mistra Future Fashion is a research program that focuses on how to turn today's fashion industry and consumer habits toward sustainable fashion and behavior. Guided by the principles of the circular economy model, the program operates cross disciplinary and involves 60+ partners from the fashion ecosystem. Its unique system perspective combines new methods for design, production, use and recycling with relevant aspects such as new business models, policies, consumer science, life-cycle-assessments, system analysis, chemistry, engineering etc.

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