中国纺织工业联合会
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CNTAC Office for Social Responsibility of CNTAC

2020

EcoCosy® Climate Leadership White Paper

Preface

In 2005, China National Textile and Apparel Council ("CNTAC") established the first national corporate social responsibility department, the Office for Social Responsibility, dedicated to promoting corporate social responsibility and sustainable development in the textile and apparel industry.

In 2019, the SDG Team of the Office for Social Responsibility of CNTAC ("CNTAC-SDG") upgraded the Carbon Stewardship 2020 Initiative to Climate Stewardship 2030 Initiative ("Initiative"), in response to the United Nations Framework Convention on Climate Change ("UNFCCC") Fashion Industry Charter for Climate Action signed by CNTAC in 2018. The Initiative will exercise industry leadership to help companies formulate climate action roadmap, in order to guide production and consumption and help companies obtain new growth opportunities. Meanwhile, the Initiative provides the textile and apparel industry's solution to China's Intended Nationally Determined Contributions, and explores the value of a Community of Shared Future for Mankind with the power of the industry.

In June, 2019, CNTAC-SDG and Sateri jointly launched the EcoCosy® Climate Leadership Program. The Program invites Sateri's value chain partners to join the Climate Stewardship 2030 Initiative and explore how upstream companies in the industrial chain can drive emission reduction and energy conservation at downstream companies through product emission reduction. Results of the first phase of the Program have been summarized in the EcoCosy® Climate Leadership White Paper 2020 ("White Paper").

The White Paper will help stakeholders understand the basics of China's textile and apparel industry, including contributions in carbon emission reduction from the upstream sectors of the industrial chain, companies' energy conservation and emission reduction actions, and the crucial role of stakeholders in emission reduction of the industrial chain. In addition, the White Paper hopes to explore new pathways for industrial chain partners to jointly address climate change and realize low-carbon transformation, and to measure contributions from the Chinese companies in the decarbonization of the global fashion industry chain. On the basis of the White Paper, CNTAC-SDG looks forward to feedbacks from the stakeholders in order to drive the EcoCosy® Climate Leadership Program forward and clarify goals for the next program phase.

The White Paper is prepared by CNTAC-SDG (main participants: Hu Kehua and Sun Lirong) with technical support from CECEP Environmental Consulting Group. CNTAC-SDG would like to extend special thanks to the following organizations and individuals for their generous support for the EcoCosy® Climate Leadership Program and the White Paper (listed in no particular order):

- Climate action companies: Sateri, Zhejiang Saintyear Holding (Group) Co., Ltd., Zhejiang Charming Holding Co., Ltd., Suzhou Pure-Fiber Textile Technology Co., Ltd., Xuzhou Huasheng Textile Co., Ltd., Huixian Jinyu Textile Co., Ltd., Fujian Xinhuayuan Group, Linz (Nanjing) Viscose Yarn Co., Ltd., and Shandong Long Run Textile Co., Ltd.

- Industry technical experts: Qiao Yanjin (China Textile Information Center,CTIC), Yan Yan (CNTAC), Feng Xin (Sateri), Xiang Yajuan (Sateri), Liu Tao (Sateri), Zhang Xiaolei (Sateri), Zhong Lei (CNTAC-SDG), Li Shite (CNTAC-SDG)

- Climate change experts: Chai Qimin (National Center for Climate Change Strategy and International Cooperation), Zhao Junfeng (CECEP Environmental Consulting Group), Zhao Lijian (Carbon Trust), Huang Peng (Carbon United Great Certification Ltd.)

Due to time constraints, the White Paper contains limitations on data availability, which will be improved in future versions of the White Paper.

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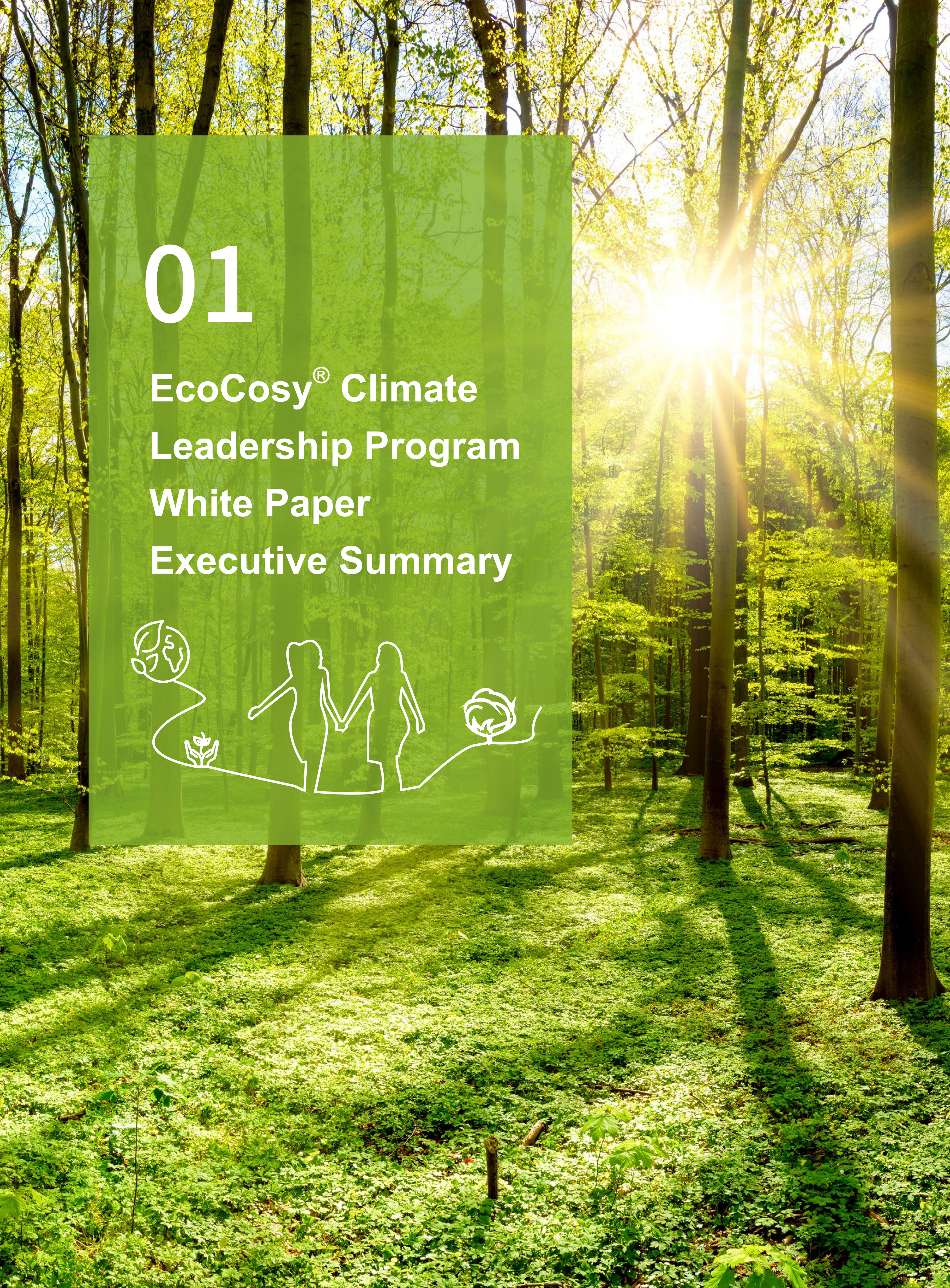
EcoCosy® Climate Leadership Program White Paper Executive Summary



Textile and Apparel Industry in China is Vital to Industry-Wide Low-Carbon Transformation on a Global Scale

The textile and apparel industry is one of the major greenhouse gas emitters, contributing to about 10% of global carbon emissions while also being impacted by climate change. The industry's carbon intensity and massive, multi-level supply chain add to the complexity of industry-wide emission management. With the changing climate, companies in the textile and apparel industry on one hand need to face the risk of changing client demands and government policies, and on the other need to transform their growth mode to adapt to new business rules and take initiatives in future development. To increase the momentum of industry-wide low-carbon transformation, the textile and apparel industry launched the milestone Fashion Industry Charter for Climate Action in 2018 during COP24. The Charter recognizes that current business models will not be sufficient to reach the climate neutrality goal in the second half of the 21st century, and a more systemic change is needed.

As the world's largest textile producer and a supporter of the Charter, China plays an important role in combating climate change and in driving low-carbon transformation of the global textile and apparel industry. Manufacturers, fashion brands and industry associations in China have taken initiatives in reducing carbon emissions through technological innovation and cross-sector collaboration.

As one of the initial supporters of the Charter, China National Textile and Apparel Council initiated the "Climate Stewardship 2030" initiative based on the Charter, that creates the climate action roadmap for companies in the industry. The Council enhances industry-level efforts to guide production and consumption and assist companies in finding climate solution, creating shared value in emission reduction, promoting sustainable business mode, and obtaining new development opportunities through climate risk mitigation. One of the focus areas is on developing alternative textile fiber materials to conventional polyester and cotton fiber, which are known to cause negative environmental impacts. Viscose fiber, the main type of regenerated cellulose fiber, is manufactured from nature-derived raw material and when produced sustainably has the potential to be one of the best alternatives to conventional fibers.

One of the focus areas is on developing alternative textile fiber materials to conventional polyester and cotton fiber

EcoCosy® BV Series Enables Downstream Companies to Reduce GHG Emissions with Product Innovation

Manufacturers such as fiber, yarn and fabric mills produce a majority of industry-wide GHG emissions and therefore face great challenge in emission reduction. To better understand the climate positive measures upstream suppliers are taking and how these actions can facilitate industry-wide decarbonization, China National Textile and Apparel Council initiated the multi-year EcoCosy® Climate Leadership Program in 2019 as a key component of the "Climate Stewardship 2030" initiative.

The EcoCosy® fiber series is developed by Sateri, a major viscose producer, through technological breakthroughs and innovation and helps improve user-friendliness and product sustainability. The fibers' superior quality can also help increase energy efficiency and productivity during downstream yarn and fabric manufacturing processes, potentially generating carbon emission reduction.

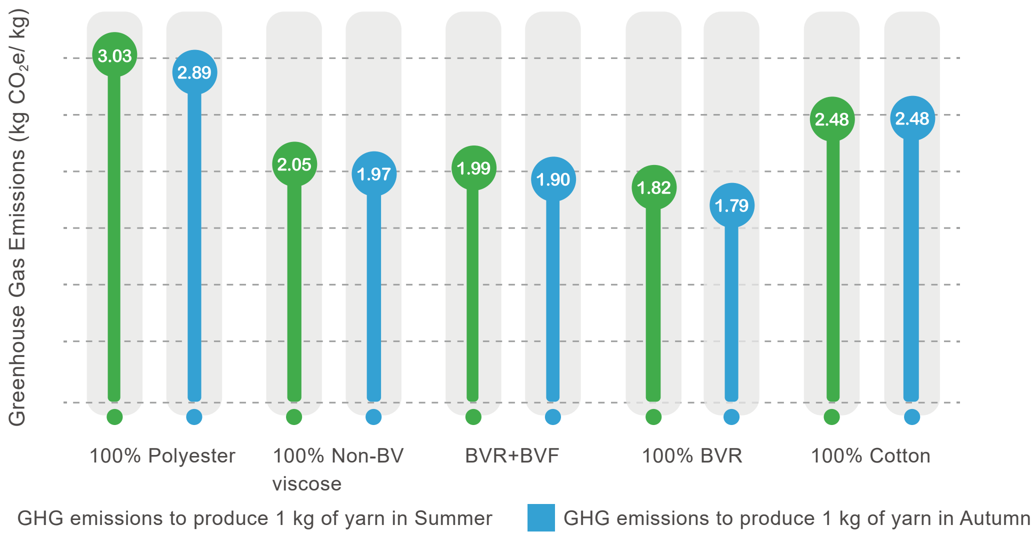
EcoCosy®

To evaluate downstream decarbonization potential of EcoCosy® fiber products and to explore additional energy efficient measures adopted by industry chain partners, a baseline survey was planned and conducted at selected yarn and fabric companies in the first year of the EcoCosy® Climate Leadership Program to collect information on company energy consumption and carbon emission. The research has two dimensions, including (1) comparing carbon emissions from products made of distinct materials, and (2) encompassing emissions derived from the manufacturing process as well as chemical and energy inputs and outputs. Issues on data availability due to time constraints and other factors will be improved in future versions of the White Paper.

The following companies participated in the baseline survey: Zhejiang Saintyear Holding (Group) Co., Ltd., Zhejiang Charming Holding Co., Ltd., Suzhou Pure-Fiber Textile Technology Co., Ltd., Xuzhou Huasheng Textile Co., Ltd., Huixian Jinyu Textile Co., Ltd., Fujian Xinhuayuan Group, Linz (Nanjing) Viscose Yarn Co., Ltd. and Shandong Long Run Textile Co., Ltd.

Quantitative analysis suggests that EcoCosy® BV fibers generate the lowest carbon emissions during yarn production compared to cotton, polyester and non-BV viscose fibers, as shown in the figure below. The result aligns with feedbacks gathered from yarn companies during the baseline survey and interviews, where companies reported that good stability and spinnability of BV fibers have contributed to high productivity and energy savings during production. Since the main source of energy used by yarn mills interviewed is purchased electricity, produced largely from fossil-based resources, decreasing electricity consumption can help reduce carbon emissions per unit product.

Comparative GHG Emissions from Yarn Production (40 Ne, Compact-Siro Spinning)



During the interviews, companies also commonly mentioned that additional financial commitment tends to be their main consideration when evaluating the feasibility of particular carbon emission reduction measures. Through its technological breakthroughs and product innovation, EcoCosy® BV series enables downstream yarn and fabric companies to increase productivity and energy efficiency without additional capital investment. The resulted energy cost savings can motivate the companies to get more involved in the EcoCosy® Climate Leadership Program, such as attending climate workshops and stakeholder roundtables, strengthening industry-wide decarbonization capacity.

In addition, Sateri and its subsidiary initiated an innovative experiment to optimize equipment settings for yarn production using EcoCosy® fibers to help improve productivity and energy efficiency. Sateri has shared the findings with its yarn customers and fabric manufacturers, many of whom were inspired by this culture of innovation and have come up with unique ways to reduce energy consumption and carbon footprint.

Besides its downstream emission reduction potential, EcoCosy® has displayed a leadership role in driving industry-wide decarbonization, connecting its upstream and downstream partners in moving towards a low-carbon, sustainable development. EcoCosy®'s community outreach efforts and collaboration with fashion brands help bridge different stakeholders along the industry chain. By reaching out to the end consumers and fashion brands, EcoCosy® helps raise green consumption awareness and enhance downstream recognition and demand for climate positive products, creating incentives for upstream manufacturers to develop innovative ways to incorporate decarbonization into production activities. Meanwhile, by actively engaging in COP25 and other events, Sateri and its downstream value chain partners shared their efforts and achievements in low-carbon production and sustainable consumption with the international community, helping drive the low carbon transformation of the global fashion industry.

02

Climate change and the textile and apparel industry

2.1 Climate change: Big picture

Since the Industrial Revolution, concentration of greenhouse gases ("GHGs") such as carbon dioxide ("CO_2") in the earth's atmosphere has been rising steadily, along with mean global temperature. Impacts of climate change, from shifting weather patterns to rising sea levels are global and unprecedented in scale[1], threatening human health and the well-being of the society and the planet.

As the world becomes increasingly aware of the urgency of climate change mitigation, countries are making great efforts to reduce GHG emissions[2] and planning for a low carbon economy at the international, national and sector-specific levels.

At the international level

countries have gathered at climate summits and established common goals towards a low carbon future.

At the national level

China has developed policies and measures to combat climate change.

Different industry sectors

including the textile and apparel industry, are incorporating steps to reduce GHG emissions throughout the industrial chain.

2.1.1 International community: Paris Agreement

The Paris Agreement ("Agreement"), reached in 2015 during the 21st United Nations Climate Change Conference ("COP21"), for the first time brings all nations together to combat climate change and transition towards a sustainable low carbon future. The Agreement sets the goal of keeping global temperature increase this century well below 2 degrees Celsius above pre-industrial levels[3].

2.1.2 China's efforts in combating climate change

In 2015, China submitted the Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions ("INDC") to the Secretariat of the United Nations Framework Convention on Climate Change ("UNFCCC"). In the INDC, China established climate-related goals to be achieved by 2030, including lowering CO_2 emissions per unit of gross domestic product by 60% to 65% from the 2005 level, and reaching the peak of CO_2 emissions around 2030 or earlier[4].

To realize the goals listed in the INDC, China has developed series of policies and measures, such as building energy efficient and low-carbon industrial system, formulating GHG emission accounting standards, developing circular economy, and promoting carbon emission trading system.

1： https://www.un.org/en/sections/issues-depth/climate-change/

2： "GHG emissions" and "carbon emissions" are used interchangeably in this White Paper

3： UNFCCC: What is the Paris Agreement

4： http://www.scio.gov.cn/xwfbh/xwbfbh/wqfbh/2015/20151119/xgbd33811/Document/1455864/1455864.htm; http://www.china.org.cn/environment/2015-06/30/content_35950951_3.htm

2.2 Role of the textile and apparel industry

The first industrial revolution originated in the textile industry, but the industrialization process's overexploitation of the natural environment and resources is unsustainable, and mankind is saddled with tremendous historical and governance deficit. The textile and apparel industry has long supply chains and consumes intensive energy during raw material production, garment manufacturing, and product distribution and consumption processes[5]. The industry is one of the major GHG emitters, generating about 10% of global carbon emission[6].

At present, China has the world's most comprehensive modern textile industry manufacturing system, and the manufacturing capability of different industrial chain sectors is among the top in the world. In 2018, China's fiber processing volume reached approximately 54.6 million tons, accounting for more than 50% of the world's total; China's textile and apparel exports reached 276.73 billion US dollars, about 35% of the world's total[7]. Domestically the textile industry is the sixth largest energy consuming industry sector, with main sources of GHG emissions coming from coal consumption and electricity consumption[8]. As the international and domestic community establish goals of moving towards a low carbon economy, companies and organizations in the textile and apparel industry in China are taking initiatives to enhance environmental responsibility and at the same time adapt to new business models shaped by climate change.

At present, China has the world's most comprehensive modern textile industry manufacturing system, and the manufacturing capability of different industrial chain sectors is among the top in the world.

China's fiber processing volume reached approximately 54.6 million tons, accounting for more than 50% of the world's total.

5: UNFCCC: Milestone Fashion Industry Charter for Climate Action launched

6: UNECE: UN aims to put fashion on path to sustainability

7: Guide to Sustainable Economics, Volume 9-11, 2019

8: Energy-related GHG emissions of the textile industry in China (Huang et al., 2017)

◉ 2.2.1 Climate change and the textile and apparel industry

Apart from impacts on a global scale, the changing climate is also affecting specific industry sectors, including the textile and apparel industry[9]. Affected by government agencies, consumers, fashion brand clients and other stakeholders, the textile and apparel industry is facing various challenges brought by climate change. Policy changes, such as stricter GHG emission requirements, will affect the operation of textile industry chain companies; changes in consumer demand will affect companies' profitability and business model. In 2016, the fashion brand H&M reported a drop in its winter garment sales as a result of an unusually warm autumn[10]. Some retail stores also reported winter clothing sales drop due to the mild weather. Besides brands and retailers, manufacturers who trade in cotton and other natural fabrics are too affected as different weather patterns are changing people's clothing preferences[11].

Rising temperatures and extreme weather events such as flooding are also affecting workers at the garment factories. In Bangladesh, during monsoon season, heavy rains and extreme temperatures can damage factory buildings and create breeding grounds for water-borne diseases, harming workers' well-being and potentially impacting their productivity and the performance of the textile industry as a whole[12].

9： "Textile and apparel industry" and "fashion industry" are used interchangeably in this White Paper

10： http://www.thefashionlaw.com/home/fashion-brands-are-feeling-the-effects-of-climate-change

11： http://www.thefashionlaw.com/home/fashion-brands-are-feeling-the-effects-of-climate-change

12： https://www.greenbiz.com/article/climate-change-threatening-garment-industry

2.2.2 Decarbonization of the industrial chain: Challenges and opportunities

Global clothing production has approximately doubled between 2000 and 2015, driven by a growing middle-class and the rise of the "fast fashion" culture[13]. Global textiles production currently generates 1.2 billion tons of GHG annually, and the amount is likely to increase by more than 60% by 2030[14]. The industry's carbon intensity, rapid growth and massive supply chain add to the complexity of industry-wide emission management. At the same time, climate change is changing the business environment and pattern of market competition, affecting not only the operation of companies themselves, but also their supply chain and market demand. With the new generation of consumers' increasing awareness of environmental protection, companies' attitude and action in addressing climate change have received wide attention[15].

Despite the challenges posed by climate change, stakeholders within the textile and apparel industry also have opportunities to improve production and energy efficiency through innovation and collaboration. Measures such as switching to renewable energy sources and raw materials, enhancing material use efficiency and product durability, and consumer education can all help lower GHG emission throughout the industrial chain, and at the same time reducing production and operational cost.

2.2.3 UNFCCC Fashion Industry Charter for Climate Action

Three years after the Paris Agreement was reached, during COP24 held in Poland in December 2018, leading fashion brands, retailers and organizations launched the Fashion Industry Charter for Climate Action ("Charter"). The Charter contains the vision for the fashion industry to actively contribute to the realization of the goals set in the Paris Agreement, including achieving climate neutrality in the second half of the twenty-first century. The Charter recognizes that current business models will not be sufficient to meet the carbon neutral goal, and a more systemic change is needed[16]. As a supporting agency of the Charter, China National Textile and Apparel Council ("CNTAC") will collaborate with the signatories and other supporting agencies to address issues ranging from decarbonization of the production phase to exploring circular business models[17].

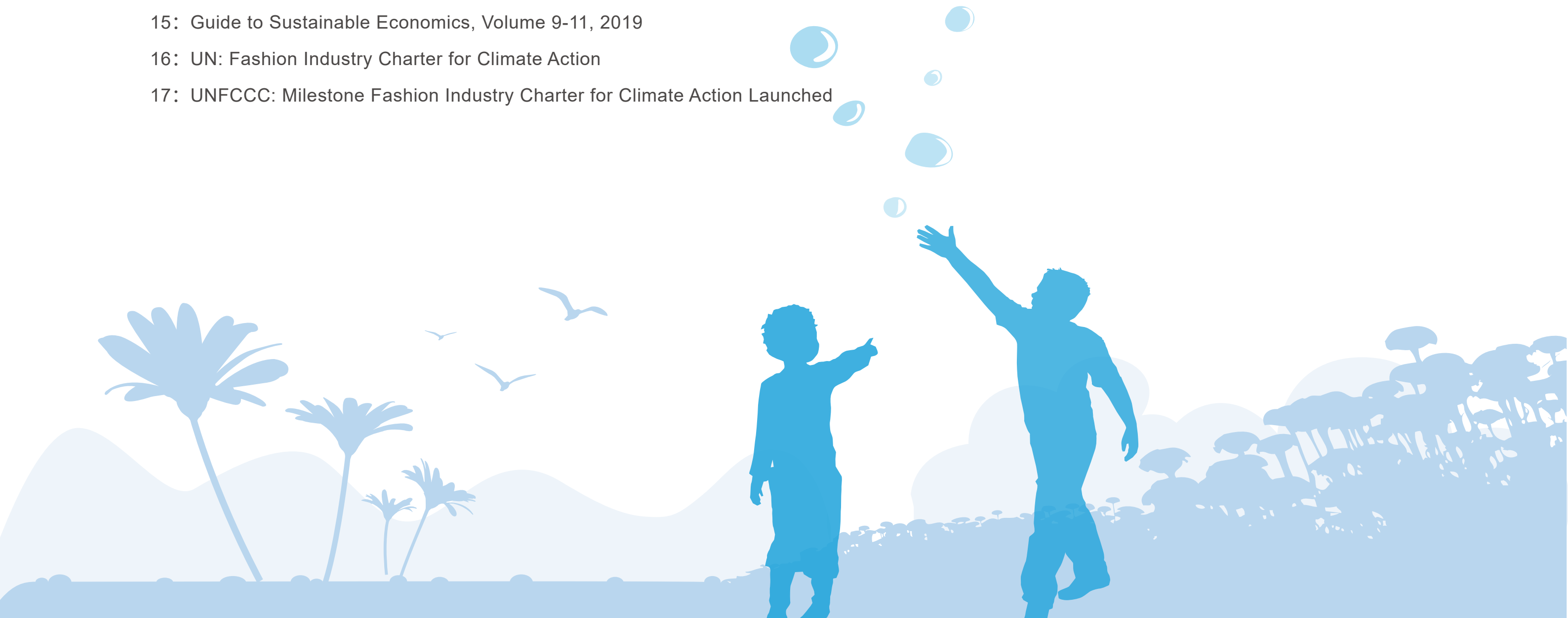
13：Ellen MacArthur Foundation: A new textiles economy (2017)

14：https://unfccc.int/news/fashion-industry-un-pursue-climate-action-for-sustainable-development

15：Guide to Sustainable Economics, Volume 9-11, 2019

16：UN: Fashion Industry Charter for Climate Action

17：UNFCCC: Milestone Fashion Industry Charter for Climate Action Launched



2.3 New business model

2.3.1 Circular economy vs. Linear economy

As demand and production continue to rise in the textile and apparel industry, the traditional “take-make-dispose” linear model of production and consumption will put more strain on the environment[18], such as releasing more GHGs into the atmosphere. The negative environmental impacts could be mitigated by switching to a circular business model, where clothes are worn longer, and textile wastes are recycled and reused[19].

2.3.2 Nature-based solution: EcoCosy® Climate Leadership Program Background

Among different actions to combat climate change, nature-based solution is one of the most effective ways, according to the Executive Director of the United Nations Environmental Programme[20]. Nature-based solutions are actions that protect, sustainably manage, and restore natural or modified ecosystems, and are inspired by processes and functioning of nature[21, 22]. In China's fashion industry, strengthening the application of nature-based raw materials is fashion industry’s exploration for lowering industry-wide carbon emissions and developing climate solution based on nature-based approach, by source tracing starting from the raw materials.

The production of textile raw materials is closely related to agriculture and forestry. The positive guiding role fashion industry can play in the sustainable development of textile raw material production cannot be ignored. The fashion industry can transfer downstream sectors’ low-carbon demand to upstream sectors, and influence the planting and production mode and selection of planting locations, indirectly promoting the protection and restoration of natural or artificial ecosystems. Cotton, silk and wool products for example, through downstream and upstream interaction along the industrial chain, can affect the upstream planting and production processes of cotton, mulberry and silkworm, and pasture and sheep, helping form natural decarbonization mechanisms[23].

18：https://www.researchgate.net/publication/326546054_Circular_Economy_-_Challenges_for_the_Textile_and_Clothing_Industry

19：https://www.researchgate.net/publication/326546054_Circular_Economy_-_Challenges_for_the_Textile_and_Clothing_Industry

20：UN News: Nature ‘one of the most effective ways’ of combatting climate change

21：UN News: Nature ‘one of the most effective ways’ of combatting climate change

22： https://www.nature-basedsolutions.com/

23：Office for Social Responsibility of CNTAC Official WeChat Account: China’s Fashion Climate Leadership Project Launches on National Low-Carbon Day, 2019/6/20

At present, fibers from sustainably managed forest resources have been applied in the textile industry. This type of cellulose fiber can be produced from fast-growing wood materials in different regions and different climatic conditions. In fact, the discussion of cellulose fiber, cotton and synthetic fiber has always been a hot topic in the industry[24].

To better understand how upstream suppliers in the textile industry use nature-based solution to help curb GHG emissions, and how their actions can radiate climate positive impacts to the downstream sectors along the industrial chain, CNTAC initiated the EcoCosy® Climate Leadership Program ("EcoCosy® Program") in 2019.

EcoCosy® is a **new viscose brand** launched in 2019 by Sateri, a major viscose fiber producer, and includes BV fiber portfolios, Colour™ and antibacterial fibers for use in textiles and non-woven products.

Developed through **technological breakthroughs** and **innovation**, EcoCosy® offers improved versions of traditional viscose products based on the "**premium quality, preserving ecology, and preferred partners**" attributes[25].

The BV fiber series generates superior product qualities such as **high tenacity, longer lasting, better dyeing uniformity, and stability against deformation.** According to Sateri's 2018 sustainability report, all EcoCosy® products are **manufactured with materials sourced from certified or regulated wood pulp suppliers and contain 100% United States Department of Agriculture (USDA) -verified renewable biological ingredients**, which can help **reduce overall GHG emissions more effectively** than traditional fossil fuel-based products[26].

The multi-year EcoCosy® Program hopes to shed light on how fibers derived from natural materials can help reduce GHG emissions downstream in yarn and fabric manufacturing processes, and how one company's climate positive actions can inspire its upstream and downstream partners and drive industry-wide decarbonization. The program is further discussed in the following sections.

24：Office for Social Responsibility of CNTAC Official WeChat Account: China's Fashion Climate Leadership Project Launches on National Low-Carbon Day, 2019/6/20

25：Sateri 2018 sustainability report

26：Sateri 2018 sustainability report

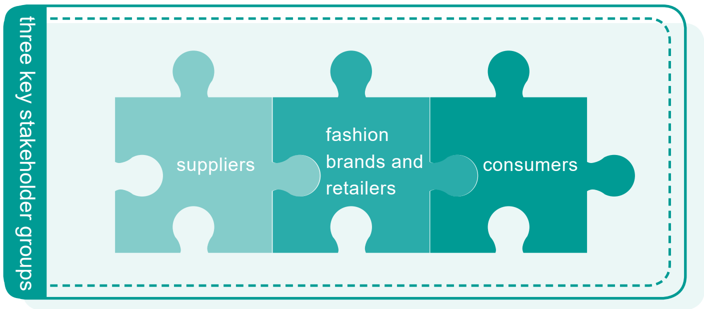
03

EcoCosy® Climate Leadership Program: Industry chain analysis

3.1 Stakeholder engagement

While most of the founding signatories of the Charter were fashion brands and retailers, the Charter reveals the importance of emission control efforts from the upstream suppliers by recognizing that most climate impact within the fashion industry comes from manufacturing of products and materials. The CEO of the fashion brand PUMA points out that more than 90% of the company's carbon footprint is generated in shared supply chains[27]. It is also worth noting that the use phase, such as washing, drying and ironing generates nearly 40% of a garment's lifecycle GHG emissions, as reflected in Business for Social Responsibility (BSR)'s 2009 report[28]. As a result, changes in consumer behavior are crucial for realizing industry-wide emission reduction goals in addition to actions from other stakeholders.

To better understand the current landscape of carbon emission reduction activities across the industry, this section introduces typical stakeholder engagement activities led by or targeting at three key stakeholder groups, including fashion brands and retailers, suppliers, and consumers.



3.1.1 Fashion brands and retailers

More and more leading fashion brands and retailers are setting specific targets for their carbon reduction and taking corresponding actions. For example, Nike has set a target of *"a 30 percent reduction in aggregate greenhouse gas emissions by 2030"* and a vision *"to achieve net-zero emissions by 2050"* [29]. To reach the target, Nike adopted 100% renewable energy sourcing plan in partnership with RE100[30] and launched a circular design guide to help designers create products sustainably.

Since the majority of this industry's GHG emissions are generated within raw material production, supply chain processing and assembly, and in customer product care and end of life disposal, for fashion brands and retailers, they have to measure and manage emission outside their organizations. The fact that these impacts are outside the direct control of any single company requires brands and retailers to work together and engage with suppliers, governments, financial organizations and consumers. As said by the CEO of Burberry, "*While we have committed to becoming carbon neutral in our own operations, achieving a 30 percent reduction in greenhouse gas emissions across the entire global fashion industry by 2030 will require innovation and collaboration.*[31]"

Leading fashion brands have suppliers carbon emission measurement systems to start with, like Gap Inc., as part of many sustainability initiatives that advocate for collective actions. Yet, as could be found from public information disclosures by these brands and retailer, they have rather limited influences in tackling material carbon emission impacts from upstream due to the multi-level complexity of the supply chain. In common practice, brands and retailers could only have effective leverage to Tier 1 and Tier 2 suppliers for both access to emission data and capacity building. Besides, brands often do not have deep understanding about the actual challenges facing the upstream suppliers[32] including those related to promoting sustainable, low-carbon development, which is another limitation brands or retailers face when engaging their suppliers.

27：UNFCCC: Milestone Fashion Industry Charter for Climate Action launched

28：BSR, Apparel supply chain carbon report (2009)

29： https://news.nike.com/news/un-climate-change-fashion-industry-charter

30：RE100 is a global corporate leadership initiative bringing together influential businesses committed to 100% renewable electricity. Led by The Climate Group in partnership with CDP, RE100's purpose is to accelerate change towards zero carbon grids, at global scale.

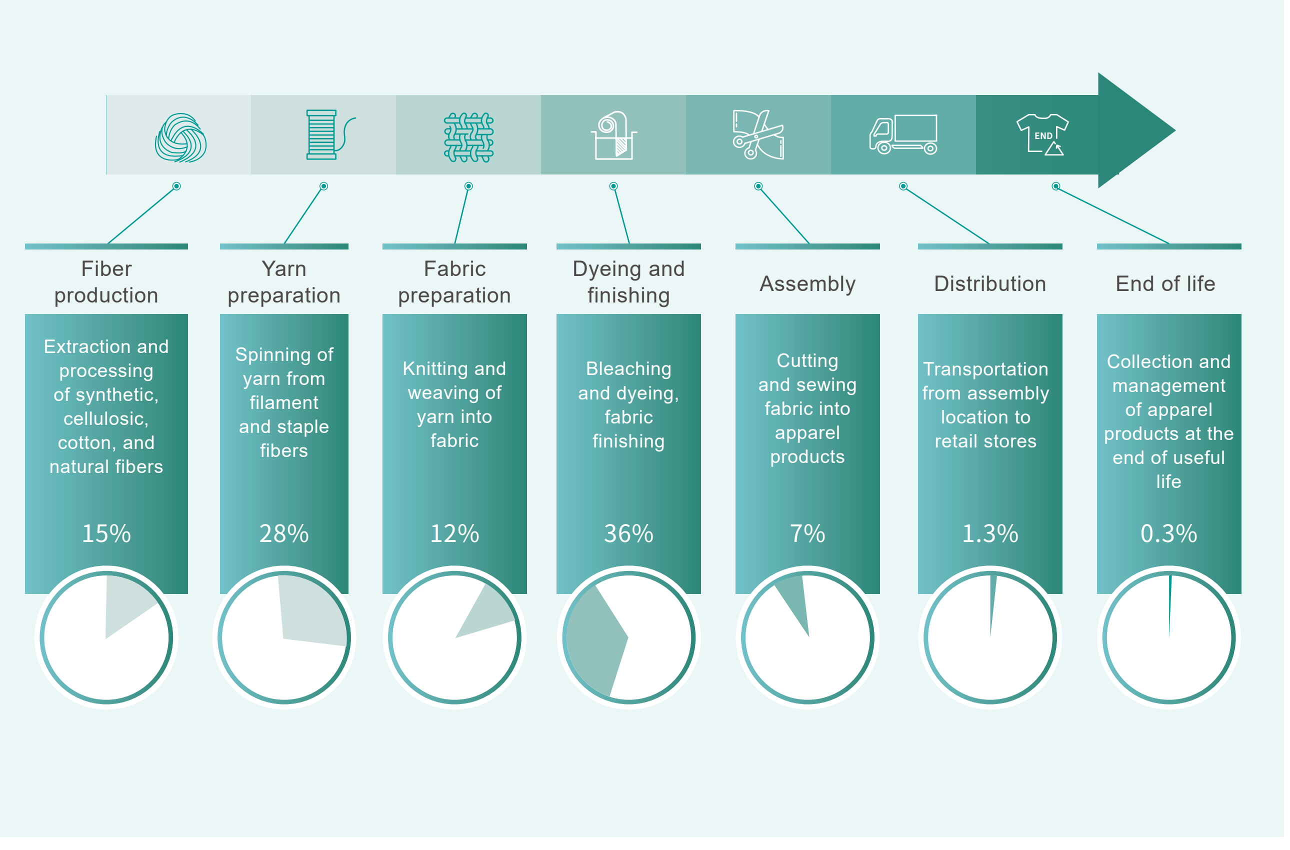
31：https://www.un.org/sustainabledevelopment/blog/2018/12/milestone-fashion-industry-charter-for-climate-action-launched/

32：CV Sustainability Report 2018

3.1.2 Importance of upstream suppliers: Yarn and fabric mills

According to the 2018 study conducted by Quantis on the environmental impact of the global apparel industry, the first three of seven life cycle stages of apparel, fiber production, yarn preparation and fabric preparation account for more than 50% of total GHG emissions in the life of garments (excluding use phase emissions)[33]. Emissions from each life cycle stage are summarized below in Figure 1. As a result, upstream suppliers including yarn and fabric mills face great challenge in curbing GHG emissions. This is also why in this White Paper, wider attention shall be drawn to the discussion around how GHG emissions during yarn manufacturing are influenced by the type of raw materials, fibers in this case, and their impacts further downstream during fabric production.

Figure 1. GHG emissions at different life cycle stages of apparel[34]



Note: 1) The life cycle approach used in this study does not account for use phase emissions. 2) Percentage of GHG emission from each stage may be different in other studies due to different calculation methods.

33: Measuring fashion: Insights from the Environmental Impact of the Global Apparel and Footwear Industries study (Quantis, 2018)

34: Compiled from data in Measuring fashion-global impact study (Quantis, 2018)

Compared to Tier 1 and Tier 2 suppliers, upstream suppliers are less involved in brands and retailers' carbon emission information disclosure scheme or other joint initiatives that seek solutions against climate change. Carbon emission reporting, be it mandatory or voluntary, remains a niche practice among upstream suppliers.

In the raw materials stage or more specifically fiber production stage – and today that overwhelmingly means either synthetics (mainly polyester) or cotton – the negative climate impacts are not very well known to mass audience compared to dyeing and finishing stage. Polyester, as a plastic, is made from oil, and extracting and processing the raw material to make it is highly energy intensive. While as an agricultural crop, cotton's carbon footprint is lower than that of polyester, but fertilizer use releases nitrous oxide, a GHG with 300 times more warming power than CO_2. In addition, 1 kg of cotton (equivalent to a pair of jeans and a t-shirt) production can take more than 20,000 liters of water and 73% of global cotton harvest comes from irrigated land[35]. Thus, for upper stream suppliers, combatting climate change requires innovation in raw materials that are more environmentally friendly and more adaptive to current ecosystem.

Alternatives for raw materials might also bring along positive impacts in carbon emission reduction during the next stages of apparel life cycle, which means stakeholder engagement initiated from a top down approach could be more effective. Although being the least engaged suppliers by brands and retailers in sustainable supply chain program, upstream suppliers have begun to take proactive actions in carbon emission reduction. The EcoCosy® Climate Leadership Program is an example of upstream suppliers' decarbonization attempts through product innovation and is discussed in detail in following chapters.

35：https://www.commonobjective.co/article/can-fashion-stop-climate-change

3.1.3 Engaging consumers: Sustainable consumption campaign

Consumer is an important downstream component of the fashion industry chain. Consumer demand is directly related to the order requirements of fashion brand customers, and further affects other upstream companies. In recent years, driven by media advocacy and various campaigns organized by civil society organizations, consumers are more and more aware of the sustainability related implications of their decision making in consumption. More people want to know where and how the garments are made, and how they can contribute to a sustainable future. In textile and apparel industry, criticism around "fast fashion" has long been a hot topic. It is argued that fast fashion is fundamentally unsustainable for the environment. For fashion industry to make a positive impact on the climate, the culture needs to change and it is of critical importance how consumers make their choices. Creating an ecosystem that promotes and invests in sustainable and responsible consumption has to be part of the industry's toolkit for tackling climate change. Improving consumer awareness of sustainability through sustainable apparel product consumption can also promote low-carbon awareness in other industries.

There are different actors that are contributing to this global campaign for sustainable consumption and this section mainly focuses on how private sector engages with consumers, enabling their customers to make sustainable choices. This is because the sheer size and scale of private sector players means businesses could reach out to customers more directly and influence them more profoundly. Every single action from brands or retailers for instance, no matter how small, makes a huge collective difference.

Besides efforts made by brands and retailer, more systematic actions should be adopted across all organizations in the value chain as the "stories" are complex, varied, and dynamic. For consumers to make informed decisions and become responsible, they need to have access to more information and be able to communicate with business actors from both upstream and downstream. Sateri and partners within the EcoCosy® Climate Leadership Program are providing information of the downstream especially yarn and fabric manufacturing with field research in its first year. Since the upstream stakeholders are not yet included in the program, the upstream carbon footprint of fiber production is reviewed through existing researches. However, the data from different sources vary significantly so that the upstream carbon footprint is not discussed in this research which can be studied in future when possible. The background information of upstream is discussed below with information from public report instead.

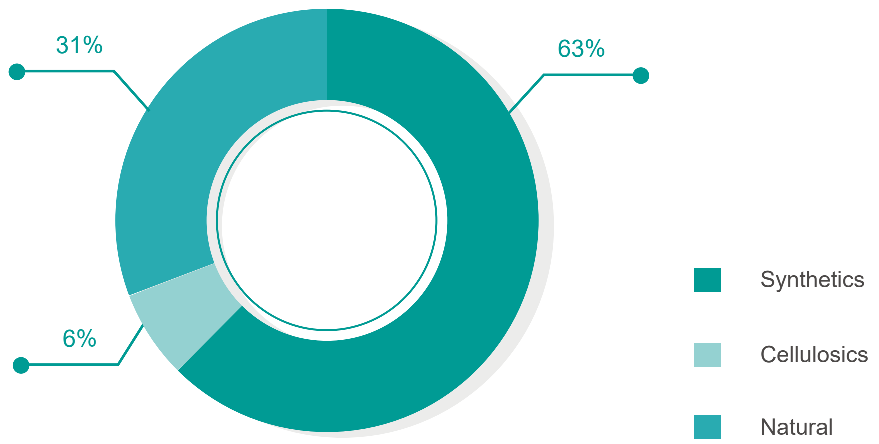
3.2 Major fiber products: Backgrounds and characteristics

The global fiber market mainly consists of synthetic fiber, cellulose fiber and natural fiber[36]. As shown in Figure 2, synthetic fibers dominated the world fiber market in 2018, followed by natural and cellulose fibers. The term "cellulose fiber" is often used to describe regenerated cellulose fiber[37], although other materials such as cotton are also fibers consisting of cellulose. Within each of the three major fiber categories, cotton is the most widely produced natural fiber[38], polyester is the most important synthetic fiber[38], and viscose is the dominant regenerated cellulose fiber[40].

The Fiber Year 2019 report suggests that recent dynamics in world fiber consumption have changed in favor of manmade cellulose fiber considering its expansion since 2000[41]. In 2018, global cellulose fiber and synthetic fiber consumption increased by 2.7% and 2.3%, respectively, while natural fiber consumption experienced a 0.2% decline[42]. Figure 3 presents the trend in market share of the three major fiber types. Manmade fibers (cellulosics and synthetics) tripled their share in 2018 compared to the 1965 level, with synthetics' share decreasing slightly from the peak level in 2015[43].

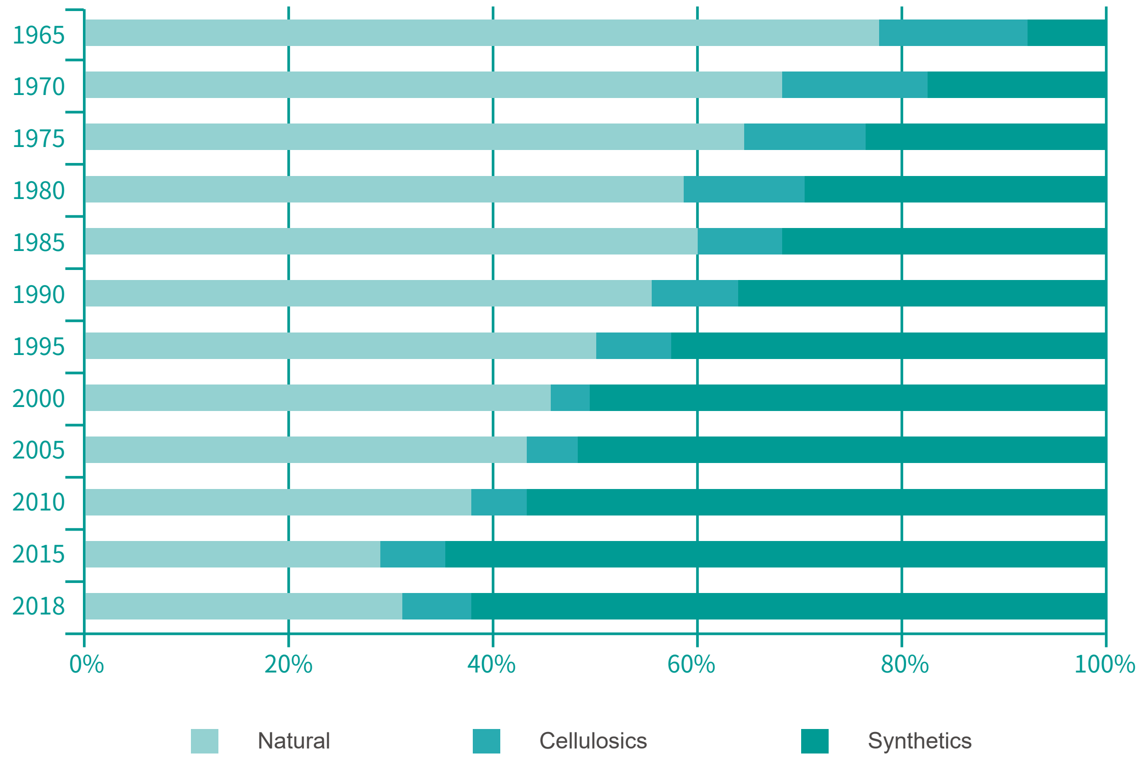
When comparing different fibers for their sustainability performance, it is unlikely that one or a few fiber types alone can constitute a sustainable fiber supply. Rather, fiber diversity enhances sustainable fiber supply. Choosing the right fiber for the right application and using it to its full potential are the key to optimize the fiber's environmental performance[44].

Figure 2. World fiber market in 2018 (source: The Fiber Year 2019)



36: The Fiber Year 2019
37: Fiber Bible Part 2 (Sandin et al., 2019)
38: https://learn.genetics.utah.edu/content/cotton/what/
39: https://www.sciencedirect.com/topics/engineering/polyester-fibre
40: https://www.sciencedirect.com/topics/engineering/regenerated-cellulose-fibre
41: The Fiber Year 2019
42: The Fiber Year 2019, Statistical Appendix 9.3.
43: The Fiber Year 2019
44: Fiber Bible Part 2 (Sandin et al., 2019)

Figure 3. Market share of three major fiber types over time (source: The Fiber Year 2019)



3.2.1 Natural fiber: Cotton

Cotton is one of the oldest fibers under human cultivation and is the most used natural fiber for textiles[45]. Cotton fibers grow on the surface of the seed of cotton plant[46]. The fiber is soft, strong and absorbent,[47] and is popular in apparel fabrics due to its low cost and comfort properties[48]. Production of cotton involves the use of freshwater, pesticides and fertilizers and may cause negative impacts to human and the environment. Cultivation of cotton requires large amounts of water and can cause water stress[49]. As shown in Figure 4, cotton fiber production consumes significantly more freshwater than synthetics, cellulosics and other natural fibers. Use of pesticides and fertilizers can contribute to environmental toxicity and eutrophication[50]. While organic farming may help mitigate some of the impacts by limiting pesticide and fertilizer use, it may generate lower yield and enhance land-related stress[51]. The majority of cotton is produced conventionally today[52].

45：Fiber bible part 1 (Rex et al., 2019)

46：https://www.sciencedirect.com/topics/materials-science/cotton-fiber "Structure and properties of textile materials"

47：https://www.sciencedirect.com/topics/engineering/cotton-fibre "Natural textile fibres"

48：https://www.sciencedirect.com/topics/engineering/cotton-fibre "Fire protection in military fabrics"

49：Fiber Bible Part 2 (Sandin et al., 2019)

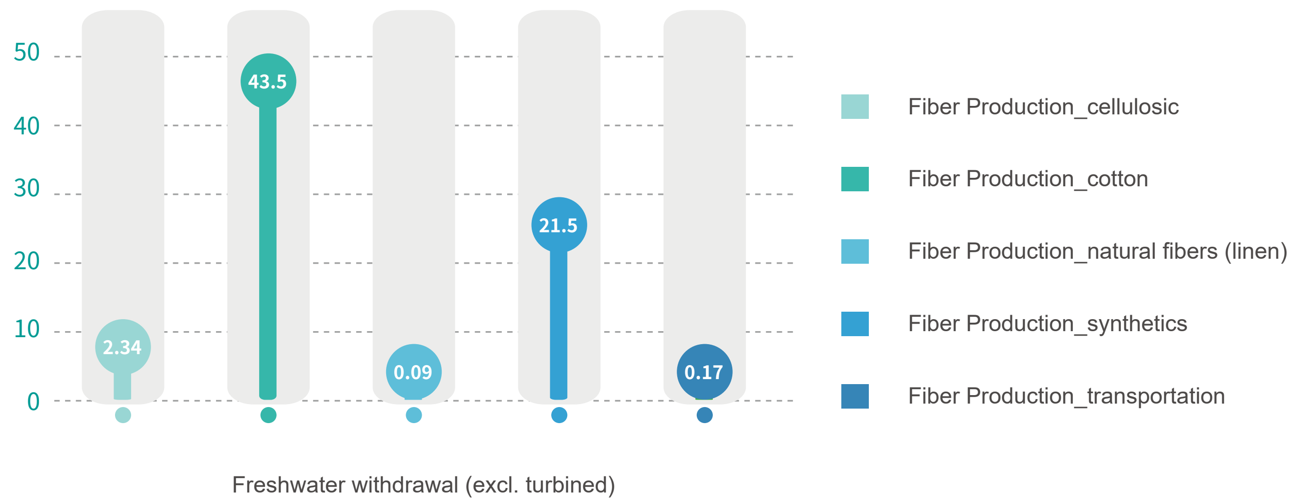
50：Fiber Bible Part 2 (Sandin et al., 2019)

51：Fiber Bible Part 2 (Sandin et al., 2019)

52：Measuring fashion: Environmental Impact of the Global Apparel and Footwear Industries Study (Quantis, 2018)

Figure 4. Freshwater consumption during fiber production (source: Quantis 2018)

Freshwater withdrawal by fiber type (10^9 m^3)



3.2.2 Synthetic fiber: Polyester

Synthetic fibers are most commonly produced from crude oil; it can also be produced from plants such as sugar cane, and waste materials such as discarded plastic bottles[53]. Polyester makes up 82% of synthetic fibers and currently dominates the textile market[54]. Polyester fiber is strong and stiff, with good abrasion and chemical resistance, making it appropriate for both textile products and industrial applications[55]. Despite its desirable properties, polyester fiber is often questioned due to its mostly non-renewable fossil resource origin. Recently there also have been concerns on the release of microplastics from synthetic fibers, regardless of the material origin, into the environment, and the subsequent uptake in animals and humans[56].

53：Fiber bible part 2 (Sandin et al., 2019)

54：Fiber bible part 1 (Rex et al., 2019)

55：https://www.sciencedirect.com/topics/engineering/polyester-fibre

56：Fiber bible part 1 (Rex et al., 2019)

3.2.3 Regenerated cellulose fiber: Viscose

Although cotton and synthetic fibers dominate today's fiber market, production of these fibers are known to cause negative environmental impacts, as discussed above. To mitigate these impacts, the textile and apparel industry needs to optimize the production of the established fibers while developing new alternatives[57].

Regenerated cellulose fiber is often claimed to be a sustainable alternative to cotton[58] and is the third most common fiber type in the global market. It uses cellulose that mainly derives from wood or plant fibers as raw material[59]. Two essential steps involved in the production of regenerated cellulose fiber are chemical or physical dissolution of the raw cellulose material, and regeneration of cellulose through a spinning process[60].

Viscose is the major type of regenerated cellulose fiber, accounting for more than 93% of the regenerated cellulose fiber market[61].

Many of the comfort properties possessed by regenerated cellulose fibers are similar to those of cotton, since the two fibers are both derived from cellulose. For example, neither fiber will create static electricity as synthetic fibers do[62].

A key environmental concern associated with viscose production is the large chemical consumption of sodium hydroxide and sulphuric acid, and the handling of the chemical by-product, sodium sulphate. Regardless, with closed chemical loops and use of renewable energy during production, viscose can be among the best alternatives to polyester and conventional cotton fiber[63].

3.2.3.1 EcoCosy® viscose fiber products

Through technological breakthroughs, Sateri developed the EcoCosy® BV viscose fiber series, optimized for different downstream spinning applications. In addition to improved fiber qualities such as high tenacity and better dyeing uniformity, all raw materials used to manufacture EcoCosy® BV fibers are sourced from certified or regulated suppliers, contributing to ecological preservation[64]. High wear resistance and shape stability of BV fibers products[65] can help extend product lifespan, reducing textile wastes and promoting a circular business model. The following chapters delve deeper into the climate change mitigation potential of EcoCosy® BV fibers.

57：Fiber bible part 2 (Sandin et al., 2019)

58：Fiber bible part 1 (Rex et al., 2019)

59：https://www.sciencedirect.com/science/article/pii/B9781845699314000040

60：https://www.sciencedirect.com/science/article/pii/B9781845699314000040

61：https://www.sciencedirect.com/science/article/pii/B9781845699314000040

62：Fiber bible part 1 (Rex et al., 2019)

63：Fiber bible part 2 (Sandin et al., 2019)

64：Sateri 2018 sustainability report

65：Sateri 2018 sustainability report

04

Methodologies to evaluate EcoCosy® BV fibers' decarbonization potential

4.1 Quantitative analysis

4.1.1 Standards of carbon footprint assessment

In this research, PAS 2395:2014 "Specification for the assessment of greenhouse gas emissions from the whole life cycle of textile products" is referred to carry out analysis on the relevant processes. But it is important to point out that this research is not a complete life cycle assessment, and the specific reasons are as follows (see Appendix 1 for a detailed description of PAS 2395:2014 and other methodologies involved in this study).

A generalized product carbon footprint calculation formula is shown on the right. The formula is also applicable in evaluating carbon footprints of textile products.

$$CF=\sum EF_i \times P_i$$

CF: the total amount of carbon emission

EF_i: the emission factor of activity i

P_i: the intensity of activity i

4.1.2 Goal

In the first year of EcoCosy® Climate Leadership Program, the research is focused on the downstream of fiber production with consideration of participants, data availability and time constraint, as well as consultation feedback from experts in climate change research, carbon emission verification and textile industry. Improvements will be made responding to the constraints to form a more complete value chain analysis in the future version of the White Paper. The research is designed to answer the following questions: whether there is and how much GHG emission reduction EcoCosy® BV could contribute to the downstream, and what good practice can be shared among peers to reduce energy consumption as well as GHG emissions.

In this research, the downstream analysis was conducted in the apparel chain of China, with the focus on two dimensions:

Applying to four products originated from three types of materials

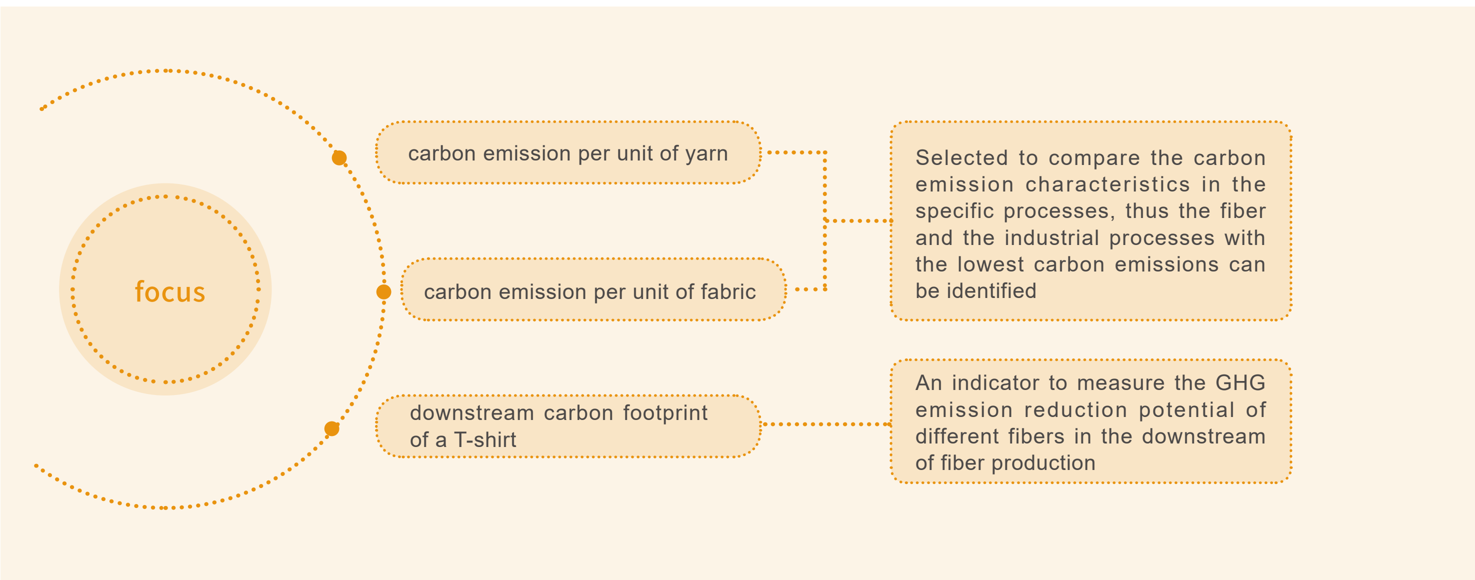
two dimensions

Encompassing emissions derived from production processes as well as chemicals and energy inputs and outputs.

The two focus dimensions enriched the analysis, allowing comparison among the GHG emissions from manufacturing T-shirts made of diverse fibers, namely cotton, polyester and viscose.

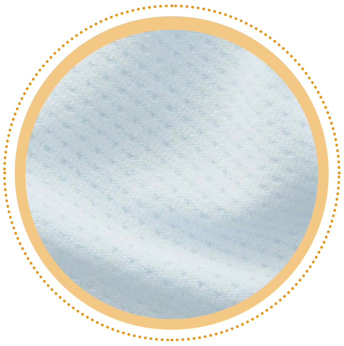
4.1.3 Indicator selection

The focus is primarily on three indicators, namely the carbon emission per unit of yarn, the carbon emission per unit of fabric and the downstream carbon footprint of a T-shirt. The first two indicators are selected to compare the carbon emission characteristics in the specific stages, thus the fiber and the industrial processes with the lowest carbon emissions can be identified. The downstream carbon footprint of a T-shirt is an indicator to measure the GHG emission reduction potential of different fibers in the downstream of fiber production. As for the selection of yarn specifications and spinning processes, based on the universality of application in production and data availability from the companies surveyed, data collected in this research are mainly based on yarn products of 30 and 40 Ne produced by Ring Spinning, Compact-Siro Spinning and Vortex Spinning technologies.



4.1.4 Sample screening

Textiles are made from three major fiber types including natural fibers, regenerated cellulose fibers and synthetic fibers. A representative material is selected from each of the three fiber categories. Cotton is selected to represent natural fibers. Polyester is selected to reflect the performance of synthetic fibers. Additionally, viscose is a representative for regenerated cellulose fibers. In consideration of the broad variety of viscose, T-shirts made from EcoCosy® BV fibers and another non-BV viscose are both involved for comparison. The next chapter will discuss the four types of T-shirts respectively.



natural fibers

regenerated cellulose fibers

synthetic fibers

4.1.5 System boundaries

When setting the system boundaries for the selected downstream stages, the principles stated in PAS 2395:2014 are referred. More details are discussed in the appendix.

4.1.6 Functional unit

The functional unit was defined as "wearing a 250g T-shirt for two years", estimated to be a reasonable lifetime for a T-shirt. During the use phase, the T-shirt is estimated to be washed 50 times in total during its lifetime.

4.1.7 Data collection

A lot of research supported the conclusion that GHG emissions generated from production processes were country-specific depending on factors such as differentiated developmental levels, energy infrastructures and consumer behaviors[66].

Consequently, local data were prioritized in the calculation of GHG emissions for accurate results. In this research, we utilized a combination of methods to obtain data throughout the full production chain of a T-shirt, including field research and acquiring data from public literature and reports, which is common practice in a lot of existing carbon footprint research. More details are discussed in the appendix.

66： A spatially explicit life cycle inventory of the global textile chain (Steinberger et al., 2009).

4.2 Qualitative analysis

Building upon the quantitative analysis, this White Paper also provides qualitative assessments of EcoCosy® BV products' downstream emission reduction potential and the brand's leadership role in promoting industry-wide decarbonization. Qualitative analyses mainly draw upon yarn and fabric companies' experiences using EcoCosy® BV during production and the resulted energy savings. EcoCosy® and Sateri's efforts in connecting the upstream and downstream sectors along the industrial chain are also discussed, reflecting the brand's leadership role in driving industry-wide sustainable and low-carbon development. Decarbonization measures adopted by the industry chain partners are also discussed.

05

Quantitative analysis of EcoCosy® BV fibers' decarbonization potential

5.1 GHG emission reduction potential of EcoCosy® BV in yarn production

Figure 5. Comparative GHG emissions from yarn production (40 Ne, Compact-Siro Spinning)

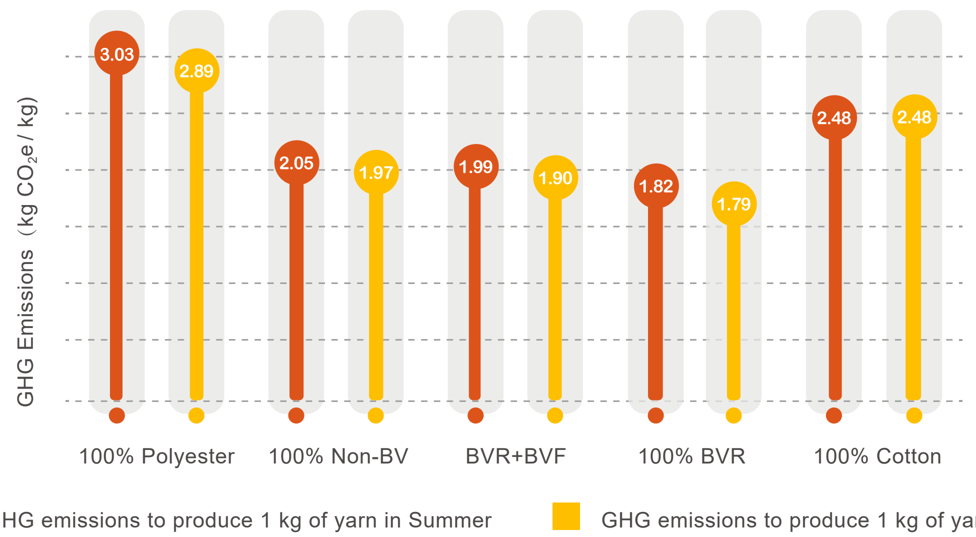


Figure 5 shows the GHG emissions for different types of fibers generated in the yarn production stage. The data of cotton, BV, non-BV and polyester fibers were all calculated from energy consumption of yarn factories according to the methodology stated in the appendix. To exclude impacts of unnecessary variables, all the GHG emission data were collected from yarn thickness of 40 Ne and Compact-Siro Spinning technology. The GHG emissions presented in Figure 5 were all converted based on 1 kg of yarn.

As the results indicated, GHG emissions from manufacturing polyester yarn ranked the highest among all types of fibers, reaching 2.96 kg CO_2 equivalent on average. In comparison, cotton yarn production ranked as the second highest in Figure 5, calculated as 2.48 kg CO_2 equivalent. Generally, viscose fibers emitted the least GHGs in the conversion from fiber to yarn, with the results ranging from 1.79 to 2.05 kg CO_2 equivalent.

Within the viscose category, non-BV viscose generated a seasonal average of GHG emissions as 2.01 kg CO_2 equivalent; 100% BVR generated a seasonal average of GHG emissions as 1.81 kg CO_2 equivalent; BVR in blends with BVF produced an average GHG emissions of 1.95 kg CO_2 equivalent.

To sum up, viscose fibers are more climate friendly than cotton and polyester fibers, suggesting great emission reduction potential in the yarn production phase. The main reason for the variation was the difference in electricity consumption. Electricity consumption was the primary source of GHG emissions in the yarn factories, and BV consumed less electricity than polyester, cotton and non-BV viscose due to higher yarn strength and less broken ends. Accordingly, BV outrun the other fibers in climate impacts.

Another notable finding was that GHG emissions were season specific in this field study. As observed from Figure 5, GHG emissions to produce 1kg of yarn in summer was slightly higher than GHG emissions to produce the same amount of product in autumn. This was because most of the yarn factories surveyed in the field research were based in southern China and when the temperature and humidity level became too high for production in summer, the refrigeration and air-conditioning system would be applied by yarn factories to ensure product quality and also provide a decent environment for employees.

In this case, GHG emissions varied with different seasons in a year. The cotton yarn showed no difference across seasons because the factory was based in Shandong, in northern China. However, in the later discussion of carbon footprints related to different fibers down the fiber production value chain, a seasonal average of GHG emissions will be utilized to simplify the question.

Figure 6. Comparative GHG emissions from yarn production (40 Ne, Ring Spinning)

Figure 6 demonstrates GHG emissions derived from yarn production phase with yarn thickness of 40 Ne and Ring Spinning technology. Although due to accessibility of data sources, only two series of emission data were presented, it can be concluded that BV viscose outperformed non-BV viscose in climate impact. The characteristics that GHG emissions in summer were slightly higher than those in autumn can also be observed from the figure.

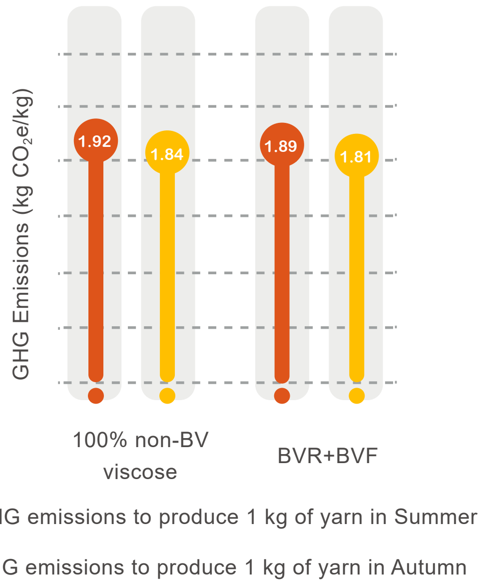


Figure 7. Comparative GHG emissions from yarn production (30 Ne, Compact-Siro Spinning)

Figure 7 presents the GHG emission results when a different yarn thickness, 30 Ne and a different spinning technology, Ring Spinning were applied in yarn production phase. As indicated by Figure 7, polyester emitted much more GHGs than BV in consistence with the conclusion given by Figure 5. In addition, summer emissions were a little higher than autumn emissions as previously explained.

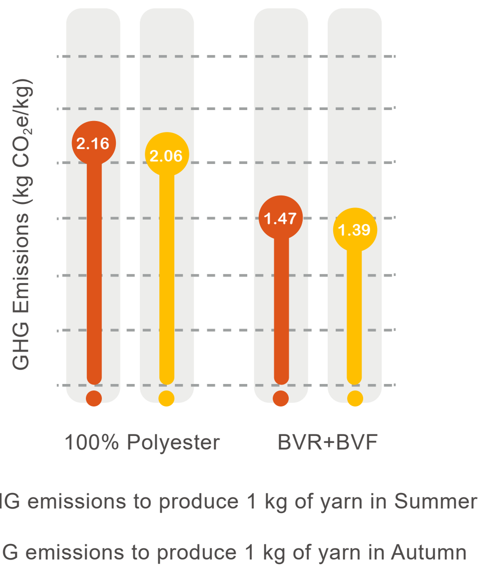
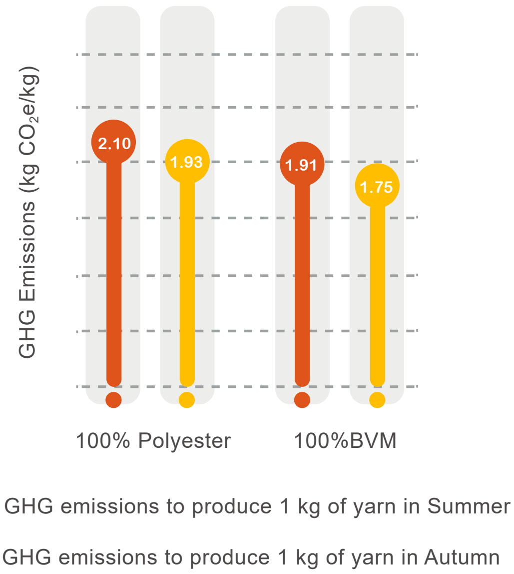


Figure 8. Comparative GHG emissions from yarn production (40 Ne, Vortex Spinning)

Figure 8 focuses on GHG emissions generated from Vortex Spinning and the yarn thickness was fixed at 40 Ne. It can be interpreted from Figure 8 that polyester emitted more GHGs than BV in yarn production, which was in line with the previous analysis. As a result of climate conditions, yarn production consumed more electricity in summer than in autumn, leading to slightly higher summer GHG emissions for each type of fibers.



5.2 GHG emission reduction potential of EcoCosy® BV in fabric production

Figure 9. Comparative GHG Emissions from fabric production

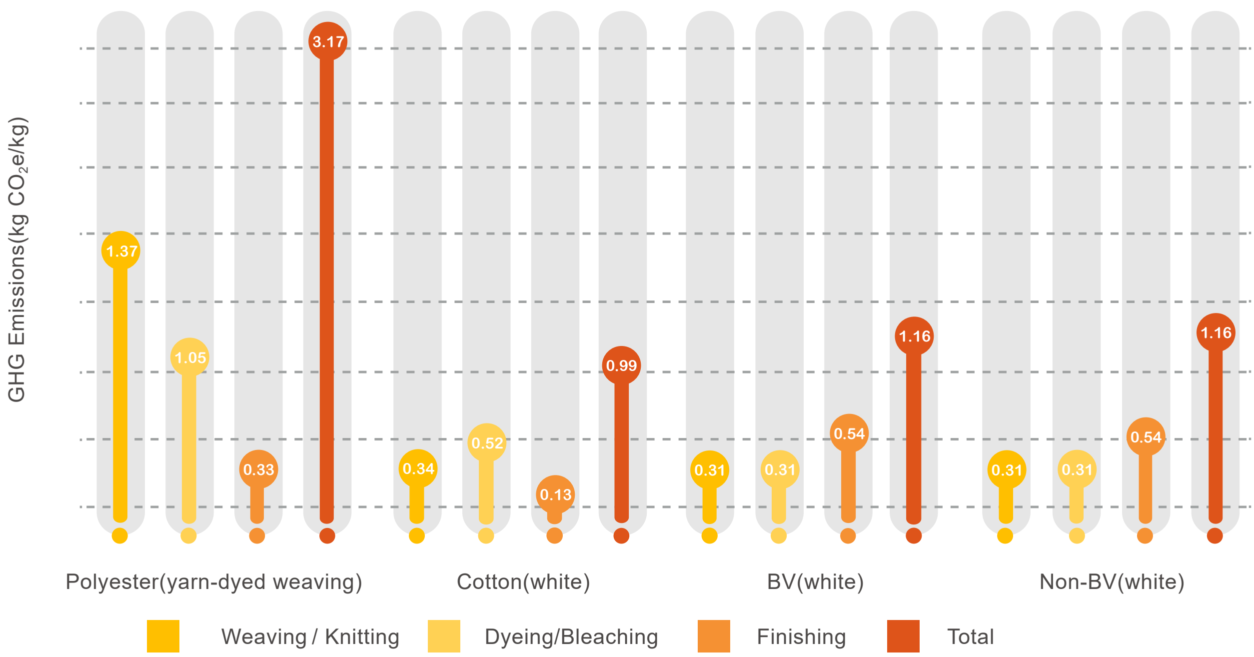


Figure 9 shows the GHG emissions generated in the fabric production stage by various types of natural, regenerated cellulose and synthetic fibers. As demonstrated by the figure, polyester emitted the greatest GHG emissions as 3.17 kg CO_2 equivalent in the fabric production process compared with other fibers. In contrast, cotton generated 0.99 kg CO_2 equivalent of GHG emissions per kilogram of product from fabric production.

Regenerated viscose such as BV and non-BV had no observable distinction, both generating 1.16 kg CO_2 equivalent of GHG emissions per kilogram of product in the conversion from yarn to fabric, as the factory did not differentiate BV from Non-BV to set different production parameters by the investigation date.

To sum up, viscose fiber produced much less GHG emissions than polyester fiber but a bit more GHG emissions than cotton fiber in the fabric production stage.

As reflected by Figure 9, the fabric manufacturing stage can be further divided into three main steps：

weaving / knitting | **dyeing** | **finishing**

In the weaving / knitting process, polyester generated approximately 5 times of GHG emissions than viscose and cotton. The variation was caused by two factors. One factor was the different production technologies adopted by the fabric factories interviewed. Weaving was utilized by an interviewee company to manufacture polyester fabric and it was widely reported by literature that weaving was the most energy intensive process using both electricity and compressed air[67]. Comparatively, the cotton and viscose fabric were manufactured in another interviewee company applying the knitting technology. The energy required for knitting was reported to be considerably less than that for weaving, which was also demonstrated by Figure 9. The other factor was that the polyester fabric was woven with dyed yarn while the cotton and viscose fabrics were knitted with bleached yarn. Both factors contributed to the difference.

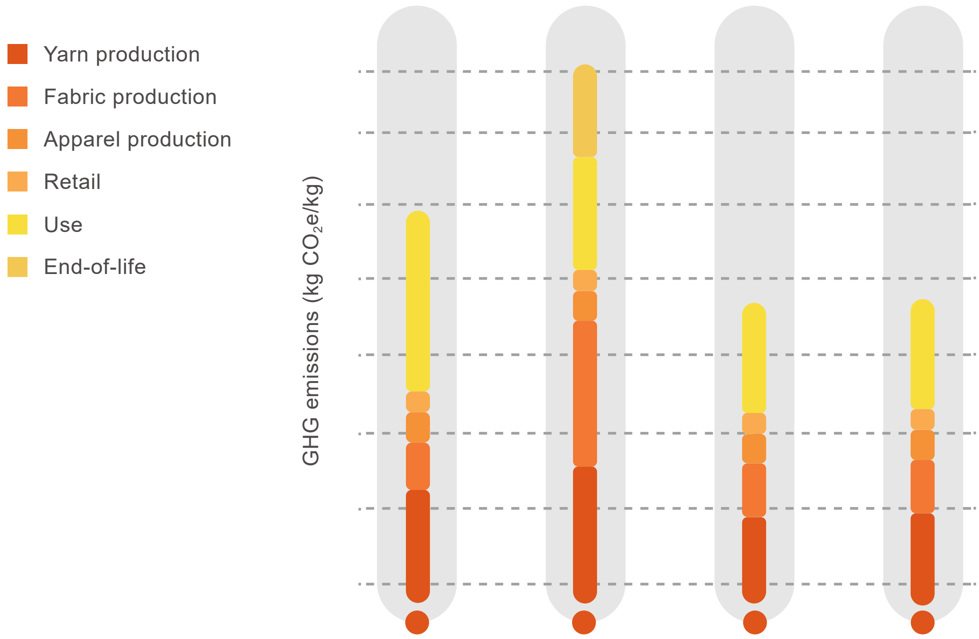
For white fabric manufacturing, dyeing process was mainly used to bleach the fabric. In the dyeing and bleaching process, polyester fabric made with dyed yarn consumed much more energy than other fibers as a result of complex pre-processing. Therefore, GHG emissions of polyester fabric ranked as the highest in the dyeing process.

With regards to the finishing phase, differences in GHG emissions generated from different fibers were small.

67：Modelling of Carbon Footprint of Polyester Sports Shirt (Moazzem et al., 2016).

5.3 GHG emission reduction potential of EcoCosy® BV in the downstream of fiber production

Figure 10. Comparative GHG emissions in the downstream of fiber production



	Cotton	Polyester	BV	Non-BV Viscose
End-of-life	0.00	2.03	0.00	0.00
Use	3.90	2.40	2.40	2.40
Retail	0.46	0.46	0.46	0.46
Apparel production	0.67	0.64	0.64	0.64
Fabric production	0.99	3.17	1.16	1.16
Yarn production	2.48	2.96	1.86	2.01

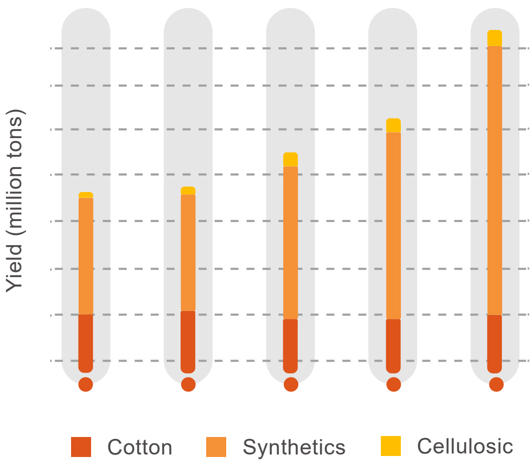
Figure 10 demonstrates the comparative results of GHG emissions in the downstream of fiber production, which starts from yarn production to incineration of T-shirts manufactured using different types of fibers. Since energy consumption in the yarn production stage was relevant to the yarn count and manufacturing technologies, all calculations have been conducted for a T-shirt produced from 40 Ne of yarn by Compact-Siro Spinning technology.

As evidenced from Figure 10, a polyester T-shirt generated the highest level of GHG emissions as 11.66 kg CO_2 equivalent for each kilogram of product in its downstream. T-shirts made of regenerated fibers including BV and non-BV viscose were the most climate friendly textiles, reducing GHG emissions by approximately 40% in comparison with polyester and generated 6.52 and 6.67 kg CO_2 equivalent of GHG emissions respectively. Cotton generated more GHG emissions than viscose as 8.50 kg CO_2 equivalent.

Based on the results, a remarkable conclusion was that a viscose T-shirt generated the lowest GHG emissions in the downstream of fiber production among competitive products. In contrast, a polyester T-shirt generated the highest GHG emissions among all the fibers studied.

5.4 Quantifying GHG emission reduction potential of EcoCosy® fibers in yarn production

Figure 11. Global fiber production for apparel in different years (Source: Quantis, 2018.)



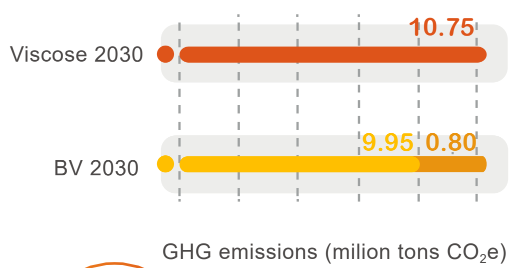
	2005	2010	2016	2020	2030
Cellulosic	2.71	2.71	5.10	5.10	5.35
Synthetics	41.90	41.90	54.40	67.00	96.90
Cotton	21.30	22.90	20.40	20.40	21.40

Figure 11 presents the historic yield of cotton, synthetics and cellulosic fibers and predicts the yield of these fibers in the future. From the figure, we can conclude that synthetics is the primary fiber used in the apparel industry, accounting for the largest proportion. Additionally, the yield of synthetics grows rapidly as predicted by the existing trend. Although cellulosic fiber undertakes a similar growth rate as synthetics and nearly doubles from 2010 to 2030, the production is relatively small in comparison with other fibers.

Figure 12. Comparative GHG emissions from viscose and BV yarn in 2030

Figure 12 presents an intuitional insight into GHG emission reduction potential of BV fibers in the yarn production phase. The basic assumption is to substitute all the fibers intended for apparel industry in the viscose fiber production sector with BV fibers. Then here are the questions—how many GHG emissions can be reduced thereby and how can the emission reduction be evaluated in an easy-to-understand way?

According to the estimated production of cellulosic viscose in 2030 provided by Quantis (2018)[68], if all the viscose was displaced by BV, the GHG emission reduction could reach 0.8025 million tons of CO_2 equivalent even only in the yarn production phase. To interpret the reduction more clearly, the estimated GHG emission reduction is equal to the carbon storage of 4,848,485 Mongolian scotch pines, which cover 4,368 hectares, in 30 years[69].



The estimated GHG emission reduction

The GHG emission reduction is equal to the carbon storage of 4,848,485 Mongolian scotch pines, which cover 4,368 hectares, in 30 years[69].

68: Measuring fashion: Environmental Impact of the Global Apparel and Footwear Industries Study (Quantis, 2018)

69: China Green Carbon Foundation, 2019.

06

Qualitative analysis of EcoCosy® BV fibers' decarbonization potential

In order to further understand the emission reduction potential of BV fiber products in the production process, as part of the EcoCosy® Climate Leadership Program, CNTAC conducted a baseline survey of selected yarn and fabric companies in the fourth quarter of 2019. In the form of case studies, this chapter includes information obtained from discussions with the management and employees at the surveyed companies and from production workshop visits, so as to explore the emission reduction potential of EcoCosy® BV fiber products in the downstream sector of the industrial chain, and the brand's leadership role in industry-wide decarbonization actions. In addition, this chapter shares the innovative energy-saving and emission reduction measures adopted by industry chain partners.

6.1 Regenerated cellulose fiber: Nature-based solution

Regenerated cellulose fiber is a man-made fiber applied in the textile and apparel industry. Since regenerated cellulose fiber uses renewable raw materials derived from nature, it plays an important role in transitioning to a circular, sustainable economy[70]. Viscose and other regenerated cellulose fiber materials, when produced sustainably with renewable energy sources, can be among the best alternatives to conventional fibers[71].

China is the largest global producer and consumer of viscose, and in 2018 produced more than two thirds of the world's viscose[72]. Sateri is the largest maker of viscose fiber in the world with four manufacturing facilities in China[73], and sources raw material used in fiber production (dissolving wood pulp) primarily from sustainably managed plantations[74]. Through innovation and cross-sector collaboration, the company developed the EcoCosy® BV fiber series, customized for different spinning applications.

As discussed in Chapter 5, EcoCosy® BV fibers were found to consume less electricity per ton of yarn output and generate less GHG emission compared to polyester, cotton and non-BV viscose fiber. During the knitting process in fabric manufacturing, EcoCosy® BV fibers were also found to contribute to lower carbon emissions compared to cotton. Section 6.2 below delves into the factors that may have contributed to BV fibers' higher energy efficiency during yarn and fabric manufacturing, from information gathered during interviews with yarn and fabric producers in the course of the EcoCosy® Program.

70: 13th Five-year plan of regenerated cellulose industry

71: Fiber bible part 2 (Sandin et al., 2019)

72: Collaboration for Sustainable Development of Viscose (CV) 2018 sustainability report

73: https://www.sateri.com/zh/corporate/who-we-are/; http://www.jjxw.cn/2019/1023/410499.shtml

74: Sateri 2017 Sustainability Report

6.2 EcoCosy®'s downstream emission reduction potential

Most yarn producers interviewed reported that good stability and spinnability of BV fibers have contributed to high productivity and energy savings during yarn manufacturing. Since the main source of energy used by yarn mills interviewed is purchased electricity, produced largely from coal combustion which generates carbon emissions[75], decreasing electricity consumption can help reduce carbon emissions per unit product.

Case studies and feedbacks from companies

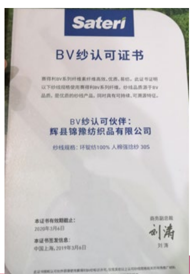
- *Suzhou Pure-Fiber Textile Technology Co., Ltd.* ("Pure-Fiber") finds that BV fibers can adapt to a wider range of humidity levels and temperatures during yarn production. While non-BV viscose fibers may require a yarn production environment of 55% humidity and 30°C, BV fibers can maintain its performance under 58% humidity and 32°C. As a result, yarn mills may reduce air conditioning use in summer (without compromising employees' work condition), which generates energy saving and emission reduction.

  EcoCosy® BV's premium qualities, combined with advanced yarn manufacturing technologies, can generate downstream cost savings and environmental positive impacts in fabric production. Using EcoCosy® BV fibers, Pure-Fiber utilizes its specialties in vortex spinning and produces yarns with high tenacity and resistance to fuzzing and pilling. With products of these superior qualities, the company was able to meet customer needs for waterless dyeing in fabric manufacturing, a technology that helps generate significant water and energy savings, reducing downstream carbon emissions.

- *Fujian Xinhuayuan Group* ("Xinhuayuan") found that BV fibers tend to reduce the number of imperfections and yarn breaks during spinning compared to non-BV viscose fibers. When there is an imperfection in the yarn, extra time is needed to cut off the defect and reconnect yarn strands, decreasing production efficiency and increasing energy consumption per unit of output. The company estimated that BV fibers generate about 200 imperfections per one million meters of yarn manufactured, while other viscose fibers generate 350-400 imperfections. The company reported a 4-5% net increase in production efficiency due to decrease in the number of imperfections. Higher efficiency helps shorten unit production time, thereby decreasing energy use and the associated carbon emission.

- *Zhejiang Charming Holding Co., Ltd.* ("Charming") reported that yarns made from EcoCosy® BV tend to have higher tenacity, which enables a 20% speed increase of the knitting machine and contributes to energy savings as a result of improved productivity.





Photos taken at surveyed companies

75：Energy related GHG emissions of the textile industry in China (Huang et al., 2016)

6.3 EcoCosy®'s leadership role in industry-wide decarbonization[76]

6.3.1 From EcoCosy® fiber to upstream sector

Sateri's products, including the EcoCosy® BV series uses raw materials from sustainably planted and managed plantations, which can contribute to climate change mitigation and biodiversity conservation. In 2018, 98.5% of total wood pulp sourced by the company came from CFCC®/PEFC™ certified or controlled suppliers, a continued improvement from 71% in 2016 and 91% in 2017. In particular, 100% of the raw material used by EcoCosy® BV products come from certified or regulated suppliers. By implementing its Pulp Sourcing Policy and other responsible sourcing management strategies, Sateri continues to promote transparency and accountability among its upstream suppliers. The EcoCosy® brand also developed an exclusive virtual certificate technology, which facilitates traceability management and the development of transparent supply chains.

CFCC35000105 PEFC/01-31-551

100% of the raw material used by EcoCosy® BV products come from CFCC®/PEFC™ certified or regulated suppliers

6.3.2 From EcoCosy® fiber to downstream yarn and fabric companies

Besides the upstream partners, EcoCosy® plays an important role in leading the downstream sectors, from yarn mills all the way to consumers, to raise climate awareness and reduce carbon footprint.

Through technological breakthroughs, EcoCosy® enables downstream manufacturers especially yarn mills to improve productivity, enhance energy efficiency, and decrease carbon footprint while maintaining product quality, as discussed in Section 6.2 and Chapter 5. The resulted energy cost savings can potentially motivate the companies to get more involved in the EcoCosy® Climate Leadership Program and participate in future activities such as decarbonization capacity building workshops and stakeholder roundtables, further raising company-wide decarbonization awareness and capacities and enhancing information sharing among industrial chain partners.

Additionally, as will be discussed in Section 6.4.1, Sateri initiated a spinning speed boosting test at a subsidiary yarn company, Linz (Nanjing) Viscose Yarn Co., Ltd. ("Linz (Nanjing)"). The test found that BV fibers could maintain performance under a spinning speed 20% higher than that normally adopted by yarn producers, contributing to increased productivity and energy efficiency. Sateri shared this finding with its yarn customers, who were inspired to experiment with other equipment settings during production and operation for higher energy efficiency, and many came up with

76: Unless otherwise specified, information and pictures in this section that are specific to EcoCosy® and Sateri are from Sateri 2018 sustainability report, and from companies participating in the baseline survey and interviews.

unique ways to reduce energy consumption. With the help of yarn customers, Sateri EcoCosy®'s culture of innovation and continued improvement can be relayed further downstream to motivate fabric manufacturers to think outside the norm and develop new ways to improve energy efficiency and reduce carbon emission.

In addition, Sateri has launched the BVY project, where the company issues a BVY certificate to selected yarn customers to prove their products have used the EcoCosy® BV fibers and are of superior quality compared to ordinary yarn products. The certificate can help fabric manufacturers identify yarn products that have used BV fibers, which are sourced from sustainably managed forests and responsibly produced. Sateri has also started providing similar certification to selected fabric companies to help meet downstream fashion brands' expectations on product quality and sustainability. With the BVY and similar certification systems, EcoCosy® can extend its climate friendly impacts further downstream and help stimulate transparent management and traceability across the entire industry chain.

Besides the BV series, fabric manufacturers also reported the great potential of energy, water and dyes saving by using Colour™ Viscose. Sateri's Colour™ Viscose is made with spun-dyeing process, which injects the dye into the liquefied cellulose pulp before the fibers are formed so that the color is locked in and evenly spread. A quantitative GHG emission reduction potential could be measured and reported in the future with better data availability such as clearer dyes and chemical mix used in different phases.

6.3.3 From EcoCosy® fiber to downstream consumers and fashion brands

EcoCosy®'s efforts in promoting sustainability and decarbonization continue beyond yarn and fabric companies – the brand has been striving to bring climate positive impacts to garment consumption and end-of-life handling phases of the industry chain. In 2019, EcoCosy® participated in the 520 Social Responsibility Day initiative in China along with several Chinese fashion brands; the participants organized campaigns and discussions on promoting green consumption and environmentalism among consumers. The activities received positive feedbacks from the public, and some said that they would pay more attention to fabric types and product quality when making purchase decisions in the future[77]. Sateri also devotes efforts in waste reduction by conducting innovative research on recycled fibers with domestic and foreign research institutes and technological partners.

Fashion brand is another crucial downstream sector in the industry chain and has direct impact on consumer purchase behavior. EcoCosy® is developing partnership with a Chinese fashion brand to help connect the upstream and downstream sectors on decarbonization efforts. Some yarn and fabric companies mentioned during interview that cost is a major concern when they decide whether to implement certain climate and environmentally friendly measures. When these actions may create economic burden on the company, management would be more likely to proceed with the measures if there is strong market incentive and customer recognition. By initiating communication with the fashion brand, EcoCosy® may help connect the manufacturing sectors and fashion brands, and strengthen downstream recognition and demand for energy efficient and environmentally friendly products, creating incentives for upstream manufacturers to adopt measures that have environmental benefits but may not bring immediate economic returns. A favorable policy environment is also helpful, which will be discussed further in Section 7.3.

77: EcoCosy® Official WeChat Account: The hiking of an egg, 2019/5/14

6.3.4 Bridging stakeholders along the industrial chain

One of the main goals of the EcoCosy® Climate Leadership Program is to enhance communication and information exchange among industrial chain partners through roundtables talks and workshops. At the stakeholder roundtable held in November 2019, Sateri invited yarn and fabric companies as well as fashion brand to a daylong event and shared progress of the EcoCosy® Program. The event received positive feedbacks from the participants who viewed it as a valuable opportunity to communicate with and learn from the peer group and other industry partners.

2019/11/28 Stakeholder roundtable

Case studies and feedbacks from companies

- *Zhejiang Saintyear Holding (Group) Co., Ltd.* ("Saintyear") was inspired by the spinning speed boosting test conducted by Sateri's subsidiary, Linz (Nanjing), and volunteered to conduct similar experiment for the weaving process during the stakeholder roundtable in November. The company has received inquiries in the past from fashion brand clients on quantitative measurements of company-wide efforts towards sustainability and decarbonization. By conducting the experiment, along with additional measures, the company looks forward to learning more about EcoCosy® BV fibers' potential to increase productivity and energy efficiency in fabric manufacturing, while enlarging the company's sustainability portfolio.

In addition, participants from yarn and fabric companies mentioned that Sateri EcoCosy®'s efforts in product innovation and in connecting with the downstream fashion brands are of particular importance for industry-wide decarbonization. A slower sub-sector growth in recent years combined with a lack of voice in product pricing, as the yarn and fabric companies suggested, have created financial difficulties for them to invest more in decarbonization activities. EcoCosy®'s innovative, high-quality fiber products help yarn and fabric manufacturers generate energy savings and emission reduction during production processes without exerting heavy financial burden on the companies. And by connecting with the fashion brands, Sateri can help encourage the brands to prioritize products made with higher energy efficiency and smaller carbon footprint when making future sourcing decisions, enhancing recognition of climate positive products and further incentivizing upstream manufacturers to develop decarbonization pathways.

EcoCosy® is an example of how a company's decarbonization efforts can reach beyond its direct sphere of impact and span the entire industry chain. Through different forms of actions, such as technological innovations, community outreach and roundtable talks, every sector within the industry have the potential to transmit climate positive impacts to not only its immediate upstream and downstream partners, but also sectors further up and down the industry chain.

6.4 Decarbonization actions from industry chain partners

6.4.1 Increasing productivity: Linz (Nanjing)'s experiment

Case studies and feedbacks from companies

Linz (Nanjing) Viscose Yarn Co., Ltd. ("Linz (Nanjing)"), as a subsidiary of Sateri, has conducted large amounts of experiments in the field of GHG emission reduction, providing valuable references of production technique and practical experience for Sateri's value chain partners.

Linz (Nanjing) thoroughly considered the characteristics of BV fiber products and conducted a spinning speed boosting test on BV fibers in actual production. Test results show that improving spinning speed from the normal 15,000 revolutions per minute (rpm) to 18,000 rpm can make full use of BV products' superior qualities. In particular, BVR fiber maintains its performance under the increased spinning speed and outperformed the control group with regular speed on the level of yarn imperfection. Daily productivity increased by approximately 19%. Electricity used for air conditioning decreased by 16% per ton of yarn produced, as unit production time shortened due to higher spinning speed, generating energy savings and decreasing carbon intensity per unit product. Results of this test were also supported by information gathered from other yarn companies during the interview, in that when using BV fibers, companies were able to increase productivity by increasing spinning speed.

Based on the experiment results, Linz (Nanjing) has adopted the 18,000 rpm spinning speed in its daily production after modifying the spinning machines to accommodate the increased speed. The speed boosting test helped the company generate energy savings, cost benefits and emission reduction, and is an example of how research and technological improvement can facilitate the textile industry's transition to low carbon production scenarios. Linz (Nanjing) shared its speed boosting test results in online courses provided on the ChinaYarn platform, helping industry partners improve economic efficiency while facilitating the industry's quality growth.

6.4.2 Improving equipment energy efficiency

For yarn companies, the main source of GHG emission is energy (such as electricity) consumption, which is also the main factor affecting the cost of products. Therefore, all companies interviewed are developing ways to improve energy efficiency by replacing old equipment or improving existing ones.

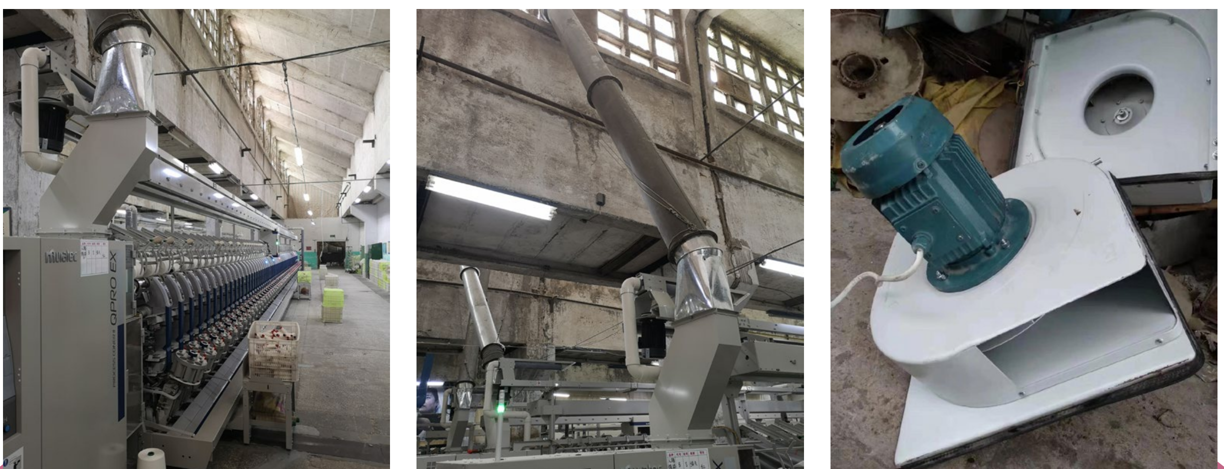
Case studies and feedbacks from companies

Huixian Jinyu Textile Co., Ltd. ("Jinyu") reported an estimated energy saving of 50% by replacing outdated equipment such as winders. In addition, the company made small modifications to fans in the spinning machines, which lowered equipment energy intensity and at the same time increased spinning efficiency.

Xuzhou Huasheng Textile Co., Ltd. ("Huasheng") improved equipment energy efficiency as well as air quality in the workshops and employees' working conditions by replacing air conditioning units.

Pure-Fiber achieved 1.5% reduction in equipment energy use by adjusting pressure settings on the air compressors.

Many companies have added motor speed control device to spinning and weaving machines and air conditioners so power use can be adjusted based on production needs.



Photos taken at surveyed companies and picture of modified equipment

6.4.3 Energy management and renewable energy

Energy use is an important source of GHG emissions. There are two approaches to reduce emissions generated from energy use. One is to improve energy efficiency through energy management; the other is to increase the proportion of renewables in the energy structure. The growth of renewable energy in the global energy structure is faster than expected, especially wind and solar energy. China has made great efforts and contributions in the field of solar power generation. In this regard, the companies interviewed have carried out relevant practices in improving energy efficiency and installing photovoltaic panels.

Case studies and feedbacks from companies

Both fabric companies interviewed, *Saintyear* and *Charming* have installed multi-class energy tracking systems, capable of measuring energy consumption of the entire company, per workshop, and down to large pieces of equipment.

Xinhuayuan is also in the process of developing a similar multi-level energy tracking system and the corresponding mobile application.

Pure-Fiber has implemented visual management of its energy use and developed an air compressor waste heat recovery project, which can provide hot water for approximately 120 employees and floor heating for office buildings.

Linz (Nanjing) has purchased precise measuring equipment from Japan. By measuring the real-time power, energy consumption of each machine can be calculated, achieving refined energy management.

Charming initiated the test run of a smart energy management system in mid-2019. The system can track energy consumption down to each manufacturing stage for every batch of fabric produced, and is estimated to generate 10% energy savings in the second half of 2019.

Both fabric companies, *Saintyear* and *Charming* have installed solar panels on the rooftop of their factories. *Charming* reported that using solar power helps reduce annual company-wide CO_2 emission and coal consumption by approximately 1,100 tons and 440 tons, respectively, and saves 165,000 RMB in electricity cost.

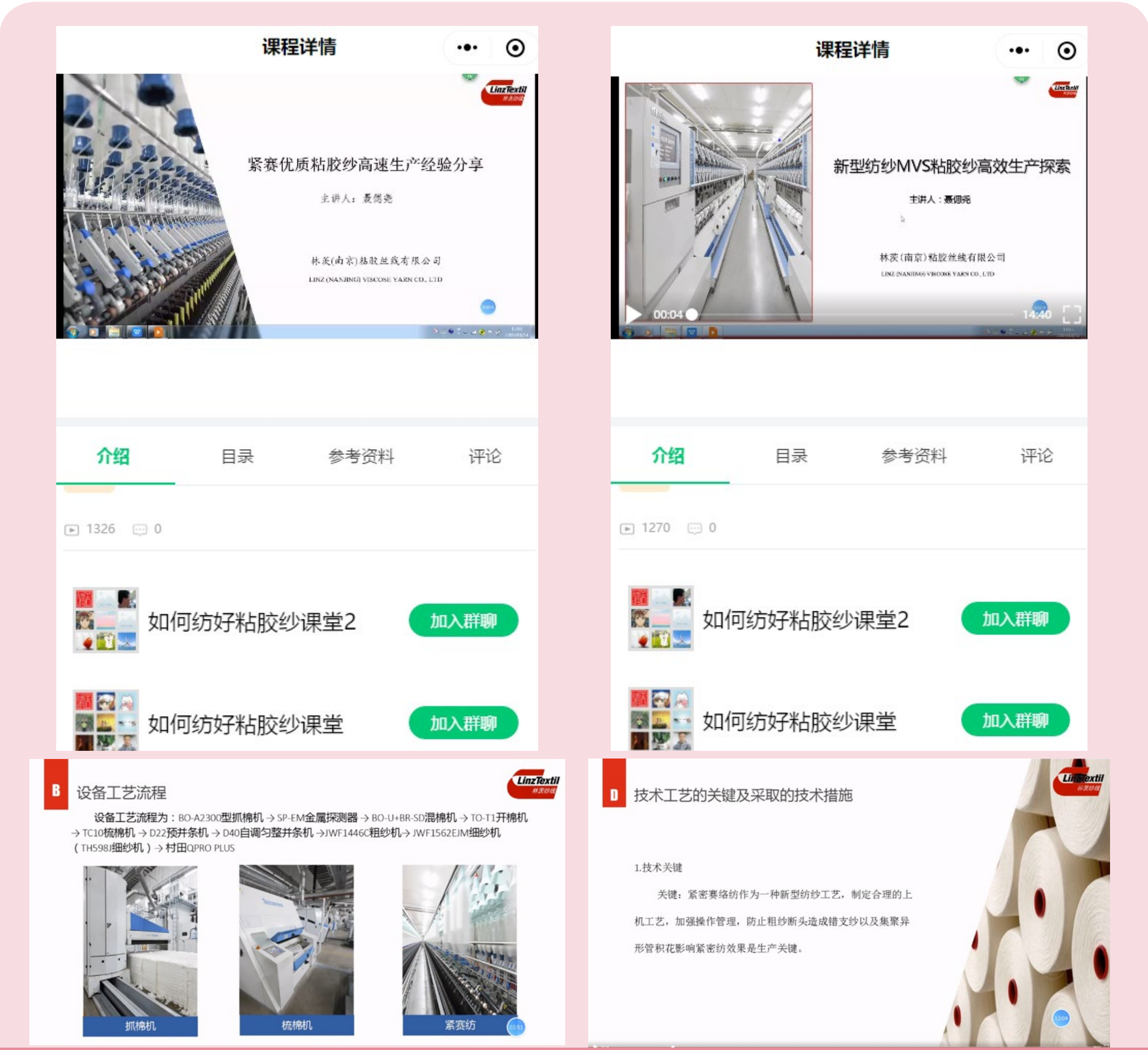


Companies' visual energy management system and photovoltaic equipment

6.4.4 Training and communication

Close communication among all stakeholders plays an important role in quality and sustainable development of the textile and apparel industry. Through sponsoring series of online courses, Sateri provides a high-quality learning platform for industry chain companies, helping them understand industry trend and essentials of cellulose fiber and yarn production, which optimizes product quality and contribute to the sound development of the entire industry[78].

Linz (Nanjing) was also invited to share its practical production experiences in the online course series (see screenshots of the course). Through Sateri's continuous communication with partners on product innovation and climate change issues, downstream value chain partners realize that BV products can improve yarn quality and productivity. The partners also see that product innovation and communication can facilitate sustainable development at both the company and industry levels, are key to enhancing companies' positioning and product promotion, and can improve the value of the company and its products, thereby gaining customer acknowledgement.



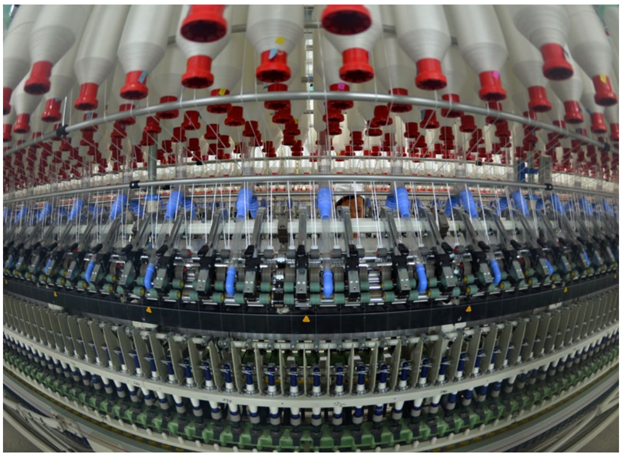
Screenshots of online course *How to manufacture quality viscose yarn*

78: Sateri Official WeChat Account: The Sateri Cup on how to manufacture quality viscose yarn——Improve product quality and innovation, consolidate foundations and increase efficiency, 2019/10/9

Case studies and feedbacks from companies

Jinyu encourages the management to attend training sessions and conferences to keep abreast of new technologies, including those that may help improve productivity and energy efficiency, and exchange information with industry peers. News and ideas acquired at these conferences will then be relayed to other employees, so the company as a whole is moving along with energy-related and other trends in the industry.

At *Xinhuayuan*, mid-level management from the technical and production departments holds regular discussions on major topics including safety, quality, productivity, and cost. Participants are encouraged to share opinions and are rewarded for insightful suggestions.



07

EcoCosy® Climate Leadership Program: Plan for a low carbon future

During the interviews with yarn and fabric companies as part of the EcoCosy® Program, several areas of improvement were noted, mostly related to energy data collection, and are discussed below along with proposed solutions. The program helps EcoCosy® set goals for its future decarbonization efforts, including closer collaboration with key industry partners, and also calls for support from other stakeholders.

7.1 Enhance energy data collection

7.1.1 Improve data quality and usability

During interviews with yarn and fabric manufacturers, the companies were requested to report data on energy consumption per unit product. All companies were able to fulfill the request, but the quality and usability of the data vary. Some companies were able to track energy use down to each piece of equipment and provide relatively accurate estimates of energy use per unit product. Other companies were only able to record total energy use per workshop and may need to employ more assumptions and estimations when calculating unit energy consumption.

In addition, some companies have separate data collection systems for production and energy consumption, managed by employees from different departments. This brings challenges when the two sets of data need to be combined to obtain energy use per unit of product, as the datasets may be collected and managed differently, such as on different time scales. Even though potentially useful datasets may exist, extra time and efforts need to be devoted to coordinating among department representatives and aligning the datasets.

7.1.2 Create incentive for detailed energy tracking

There appears to be a general lack of incentive to keep detailed records of energy consumption data for different types of products and at different manufacturing stages. Although all companies are capable of tracking energy consumption to certain levels, such as per workshop or per machine, few have been actively conducting regular and detailed survey of energy consumption for each product type. The benefit of recording unit energy consumption for different products at different production stages is the company can pinpoint a product or manufacturing stage that consumes the most energy, and then develop targeted methods to reduce energy intensity. The ultimate energy cost savings may outweigh the additional time and labor needed in the energy tracking and data analysis processes.

7.1.3 Establish guidelines and standards

The lack of consistencies in data quality and incentives for energy tracking may be improved by developing industry-specific guidelines and standards on the type of data to be recorded, data collection frequency and reporting framework. Ideally the guideline would not only provide guidance on energy data tracking within the same sector, such as yarn and fabric mills, but also enable cross-sector communication so that energy data for a certain yarn product can be linked with energy consumption during downstream fabric manufacturing. Streamlining data collection and data sharing processes among major sectors in the textile and apparel industry may help develop a holistic and more accurate view of energy consumption across the industry chain.

7.2 Collaborate with key stakeholders

EcoCosy® demonstrates how a fiber company can help decrease industry-wide carbon footprint by collaborating with the upstream pulp providers through sourcing management, by working with the downstream yarn and fabric companies on developing products that contribute to energy savings, and by joining fashion brands in organizing community outreach activities to promote low-carbon lifestyle. The upstream sectors can optimize their products for more efficient downstream production; the downstream sectors can in turn create incentives for suppliers to reduce energy intensity by seeking out and supporting suppliers committed to energy efficiency[79]. Each sector in the industry chain can potentially impact its upstream and downstream partners on their energy intensity during production and operation; significant carbon emission reduction would be best achieved through collaboration among all sectors within the textile and apparel industry.

Moving forward, on the upstream side, Sateri aims to ensure that 100% of purchased pulp is either CFCC®/PEFC™ certified or sourced from controlled wood by 2020[80]. On the downstream side, Sateri plans to continue its research on recycled fibers with research institutes and other technology partners[81] to help facilitate waste reduction and recycling at the end of a garment's life. And since the majority of energy use data gathered during the EcoCosy® Climate Leadership Program came from yarn companies, next Sateri plans to work closely with fabric companies to collect more data on BV fibers' energy consumption during fabric manufacturing to further evaluate the fibers' downstream energy saving potential. Sateri is also developing partnership with a renowned Chinese fashion brand, through which consumers will be informed of the EcoCosy® BV used in garment manufacturing and its environmentally friendly attributes.

With respect to product management, EcoCosy®'s virtual certification technology and the BVY project have laid solid foundation for improving transparency and traceability across the industry chain. Sateri plans to build upon these efforts and continue to promote traceability and sustainability of every component across its value chain, in the hope that these practices would provide insights to industry-wide transformation towards sustainable and low-carbon development.

In early 2018, Sateri and nine other viscose producers along with the China Chemical Fibers Association formed the Collaboration for Sustainable Development of Viscose ("CV")[82]. The association helps improve the transparency of the viscose industry and technical exchange among its members. The association also engages other key stakeholders such as pulp suppliers, brands and government agencies in developing its 2025 roadmap for sustainable development of the industry[83]. Detailed discussions on expert committees such as CV are presented in Section 7.3.

79: https://www.commonobjective.co/article/the-issues-energy

80: Sateri 2018 sustainability report

81: Sateri 2018 sustainability report

82: Sateri 2018 sustainability report

83: Sateri 2018 sustainability report

7.3 Call for support from other industry chain stakeholders

7.3.1 Expert committees

To effectively unite different sectors within the industry chain for carbon emission reduction, industry associations such as CNTAC and CV play a crucial role as they serve as a platform for information sharing and capacity building. They also facilitate the establishment of standards and guidelines that help drive and streamline industry-wide decarbonization efforts.

CV initiated the development of the Scope and Calculation Methods of Key Performance Indicators for Sustainable Viscose Staple Fiber Production[84]. CNTAC has developed standards on corporate social management. Despite these achievements, there appears to be a lack of more detailed guidelines on energy use tracking and data reporting, tailored for different industry chain sectors and manufacturing processes. Expert committees may build upon the existing guidelines and develop more targeted ones that help streamline energy use comparison across companies within the same sector, such as among fabric mills. It would be helpful for the guidelines to also enable energy tracking across different sectors, such that upstream companies can better evaluate the energy saving potential of their products during manufacturing processes further downstream, and downstream companies can choose suppliers that provide the most energy efficient products.

As CNTAC, CV and other groups work on strengthening information sharing and data reporting, they may refer to successful examples from other industry sectors. For example, the Electronics Industry Citizenship Coalition ("EICC") has developed a standardized industry accounting tool for GHG emissions to help streamline emission measurement in the supply chain[85]. EICC also utilizes a shared database for data reporting and access, which promotes shared understanding of allocation and responsibility issues related to supplier GHG emissions and existing institutional weaknesses[86]. The textile expert committees may draw on other industries' experiences and develop a set of tools unique to the textile and apparel industry.

To that end, it may be of equal importance for the expert committees within the textile and apparel industry to collaborate with those from other industry sectors that have overlapping business practices, such as paper and agriculture. The paper and textile industries are both involved in wood pulp sourcing, and the agriculture sector supplies cotton and flax for natural fiber production. In order to raise climate change awareness throughout the industry chain starting from raw material providers, inter-industry communication would be valuable as well as intra-industry collaboration.

84：http://www.cvroadmap.com/reportcn

85：Value chain approaches to a low carbon economy (BSR, 2009)

86：Value chain approaches to a low carbon economy (BSR, 2009)

7.3.2 Policymakers

Policymakers can also help drive the low-carbon transformation of the textile and apparel industry by creating incentives for increasing energy efficiency during production and operation. As pointed out in the 2009 BSR report, government policy is a central part of the solution to global GHG emission reduction, as the nature of the problem is market failure on a global scale[87]. And significant GHG emission reduction may require putting a price on carbon[88], which can help incentivize businesses in the textile and apparel industry to pursue low-carbon practices such as developing energy efficient production techniques, tracking energy use data regularly, replacing outdated equipment, and building employee awareness.

Government aid on switching to renewable energy sources and energy recycling, which are already in place at some locations in China, and research funds for developing new technologies that contribute to higher productivity and efficiency are other means to create financial incentives for energy savings and carbon emission reduction among stakeholders in the textile and apparel industry.

With collaborative efforts from the upstream and downstream sectors along the industrial chain and other stakeholders such as expert committees and government agencies, China's textile and apparel industry would be able to make a smoother transition towards low-carbon, sustainable development and strengthen its role in industry-wide climate change mitigation on a global scale.

87：Value chain approaches to a low carbon economy (BSR, 2009)

88：Value chain approaches to a low carbon economy (BSR, 2009)

Appendix I System boundaries and data collection

Footprint Theory was mainly founded to assess the impact of anthropogenic activities on the ecological environment, subdivided into Ecological Footprint, Carbon Footprint[89] and Water Footprint. Based on the concern to tackle climate change and to quantify the climate impacts of industrial activities, Carbon Footprint has become the biggest hotspot in the field of "footprint" research.

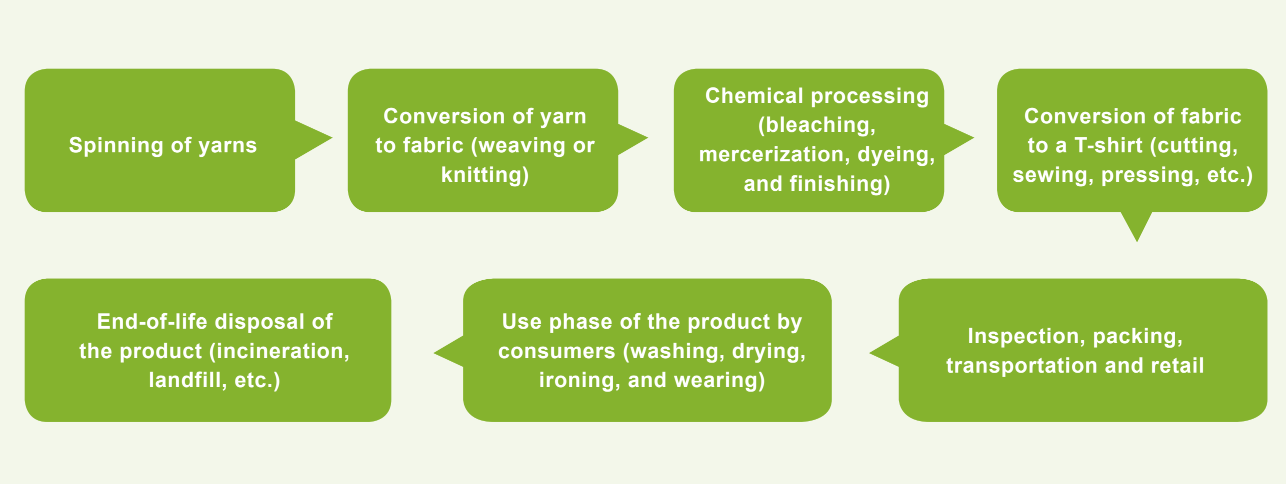
A strand of important standards and specifications has been developed to address issues emerged in carbon footprint assessment practices. GHG Protocol (Product Life Cycle Accounting and Reporting Standard), published in 2004 by World Resources Institute and the World Business Council for Sustainable Development, proposed a standardized methodology for enterprises to measure and disclose their corporate GHG emissions. PAS 2050: 2008 (Specification for the assessment of the life cycle greenhouse gas emissions of goods and services), issued by British Standards Institution, specified requirements for assessing the life cycle GHG emissions of goods and services. The two technical guidance documents are of great importance when carbon footprints are measured on a generic product scale. In comparison, PAS 2395:2014 is a tailored version of PAS 2050:2008, which specifically evaluates GHG emissions from the life cycle of textile products and serves as a supplement to PAS 2050[90].

Considering the participants, data availability and time constraints, and with consultation feedback from experts in climate change research, GHG emission verification and the textile industry, this study focuses on the downstream of fiber production. The system boundary and data acquisition information of this study are as follows.

1.System boundaries

The boundary of this study included carbon emissions in the downstream after fiber production of a T-shirt.

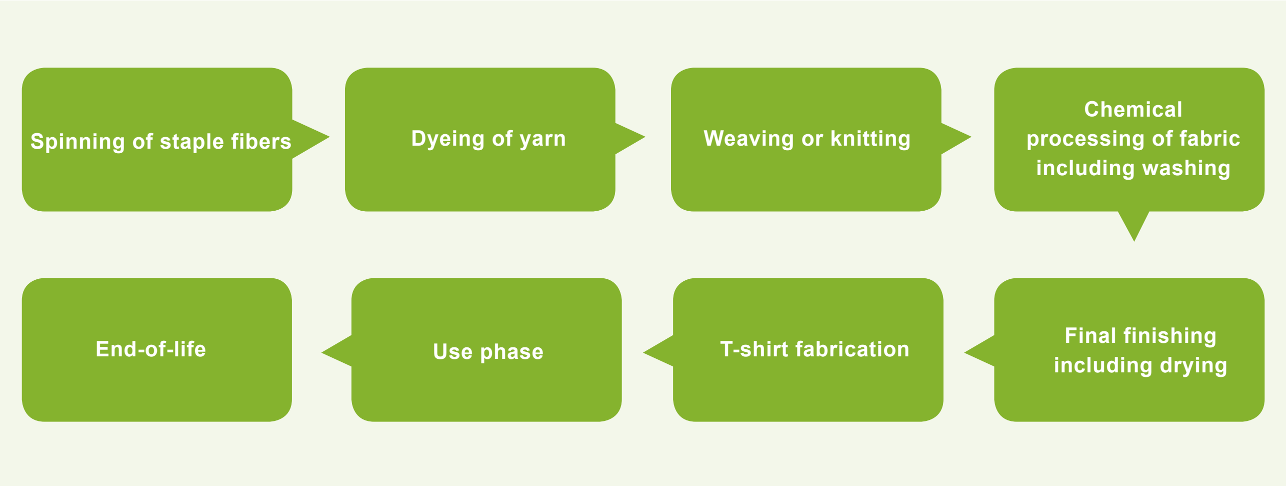
Specifically, the following processes are considered in the value chain of a cotton T-shirt:



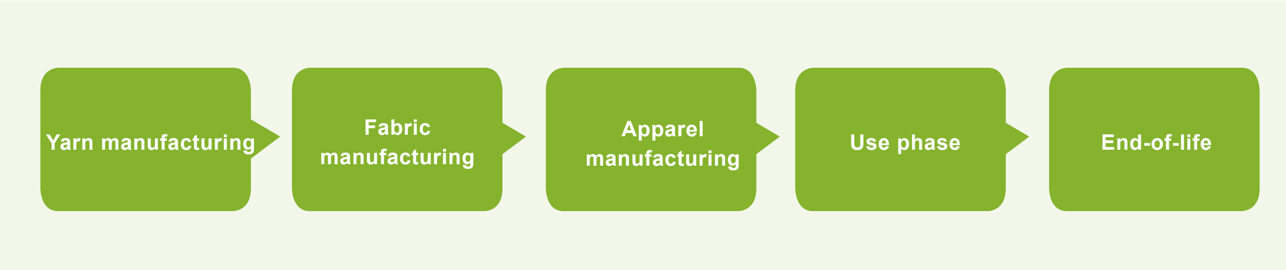
89:Carbon Footprint, according to the definition by Carbon Trust, refers to a methodology to estimate the total emission of greenhouse gases in carbon dioxide equivalents from a product across its life cycle from the production of raw material used in its manufacture, to disposal of the finished product (excluding in-use emissions). In other words, Carbon Footprint can be demonstrated as a technique for identifying and measuring the individual greenhouse gas emissions from each activity within a supply chain process step and the framework for attributing these to each output product (Carbon Trust, 2007).

90: Handbook of Life Cycle Assessment (LCA) of Textiles and Clothing (Senthilkannan et al., 2015).

In terms of a polyester T-shirt, the general production processes are listed as the following:



The production phases of a viscose T-shirt are listed as the following:



According to PAS 2395: 2014, some source categories of low and medium contributions to the overall GHG emissions are taken out of consideration when setting the system boundaries.

In the yarn production phase, the impacts of materials for spinning such as air for cleaning, plastic wrap and lubricants were assessed to be low levels by PAS 2395. On the contrary, energy use for spinning including electricity and fuels used for yarn formation are estimated to be an important contributor to the lifecycle carbon footprint analysis. Therefore, in line with the standard, we only included GHG emissions generated from electricity and diesel.

In the fabric production phase, the materials for weaving are evaluated as a low-impact source of GHG emissions, specifically including oils and lubricants, water and packaging. However, with regards to energy use for weaving and knitting, fuels, heat and electricity are all major contributors to GHG emissions and cannot be excluded from accounting. In the finishing process, materials such as resin, catalyst, softener mix, water and packaging are identified as a low-impact source category. Conversely, the impacts of energy use from all energy used for finishing fabrics are evaluated to be crucial to calculation. In the bleaching process, energy consumption contributes a high level of GHG emissions while materials for bleaching, namely NaOH, H_2O_2, air, specialty stabilizer, etc. as well as treated water containing detergents, fabric softeners, complexing agents, chemicals used for water treatment, etc. are evaluated as low-impact contributors. Only high-level contributors are considered when computing the downstream GHG emissions.

In summary, our calculations in the yarn production and fabric production stages are in line with the principles stated in PAS 2395: 2014.

2.Data collection

A lot of research supported the conclusion that GHG emissions generated from product production processes are country-specific depending on differentiated level of development, energy infrastructure and consumer behaviors, etc.

Consequently, local data is prioritized in the calculation of GHG emissions for accurate results. In this research, we utilized a combination of methods to obtain data throughout the full production chain of a T-shirt which is common practice in a lot of existing research.

By survey, interview and site visit, the primary energy consumption data and production records of yarn manufacturing and fabric manufacturing stages were directly collected from six yarn factories (Linz (Nanjing) Viscose Yarn Co., Ltd., Fujian Xinhuayuan Group, Suzhou Pure-Fiber Textile Technology Co., Ltd., Huixian Jinyu Textile Co., Ltd., Shandong Long Run Textile Co., Ltd., and Xuzhou Huasheng Textile Co., Ltd.) as well as two fabric factories (Zhejiang Saintyear Holding (Group) Co., Ltd. and Zhejiang Charming Holding Co., Ltd.), which are the downstream buyers of Sateri's products. Appendix I Section 3 includes background information of the above yarn and fabric factories.

In the downstream, the GHG emission data of T-shirt fabrication, transportation, retail, use, and end-of-life disposal were generally acquired from published literature and reports, specified in the following table. Most of the chosen data sources are based in China, timewise as close to the year of 2019 as possible. Please refer to Table 1.

Table 1. Summary of data sources

Production Stage	Data Source	Region	Year of Data
Cotton			
Yarn manufacturing	Field research	China	2019
Fabric manufacturing	Field research	China	2019
Apparel manufacturing	WRAP, 2012	UK	2012
Transportation	WRAP, 2012 and assumptions	UK	2012
Retail	WRAP, 2012	UK	2012
Use phase	Moazzem et al., 2016	Australia	2016
End-of-life	Guo, 2014	Netherlands	2014
Polyester			
Yarn manufacturing	Field research	China	2019
Fabric manufacturing	Field research	China	2019
Apparel manufacturing	WRAP, 2012	UK	2012
Transportation	WRAP, 2012 and assumptions	UK	2012
Retail	WRAP, 2012.	UK	2012
Use phase	Moazzem et al., 2016	Australia	2016
End-of-life	Guo, 2014	Netherlands	2014

BV			
Yarn manufacturing	Field Research	China	2019
Fabric manufacturing	Field Research	China	2019
Apparel manufacturing	WRAP, 2012	UK	2012
Transportation	WRAP, 2012 and assumptions	UK	2012
Retail	WRAP, 2012	UK	2012
Use phase	Moazzem et al., 2016	Australia	2016
End-of-life	BSR, 2009	US	2009
Non-BV Viscose			
Yarn manufacturing	Field Research	China	2019
Fabric manufacturing	Field Research	China	2019
Apparel manufacturing	WRAP, 2012	UK	2012
Transportation	WRAP, 2012 and assumptions	UK	2012
Retail	WRAP, 2012	UK	2012
Use phase	Moazzem et al., 2016	Australia	2016
End-of-life	BSR, 2009	US	2009

2.1Yarn manufacturing

The GHG emission data from yarn production phase of fibers were collected from six yarn factories. To control influence of irrelevant variables, the yarn count of 30 Ne and 40 Ne were chosen for comparison. The investigated spinning technologies included Ring Spinning, Compact-Siro Spinning and Vortex Spinning.

There are two major sources of GHG emissions in the yarn factories, electricity and diesel consumption. Electricity was utilized to operate the machines involved in spinning, air conditioning, illumination, and compressors, thus electricity consumption data was collected for further calculation. Diesel was used as forklift fuels for internal transportation. Yarn loss rate during spinning was mostly disclosed as 2% during field research, however no GHG emission was generated since the recycling of residues was a common practice.

2.2 Fabric manufacturing

The GHG emissions from fabric production stage were relevant to manufacturing technologies adopted by fabric factories, namely knitting and weaving. It was widely acknowledged that weaving consumes more energy and therefore emits more GHGs than knitting due to complex pre-processing procedures. Our data for cotton and viscose fabric manufacturing were acquired from Charming while data for polyester fabric manufacturing were acquired from Saintyear.

Knitting, dyeing and finishing were three main processes involved in the fabric production stage. The recorded statistics included energy consumption, namely electricity, steam and natural gas, and resource consumption namely tap water and chemical usage, all distributed to 1 kg of undyed fabric.

2.3 Apparel manufacturing and Retail

The GHG emissions from apparel manufacturing, transportation and retail were all based on a report issued by WRAP (2012). According to existing literatures, apparel production stage takes up a relatively low percentage in the lifecycle carbon footprints of garments. In this report, 668 kg CO_2e/ ton, 642 kg CO_2e/ ton and 642 kg CO_2e/ ton were respectively generated from cotton, polyester and viscose garment production processes. The GHG emissions from retail were not relevant to fiber type, therefore a carbon footprint of 462 kg CO_2e/ ton was applied to all types of fibers.

2.4 Transportation

As for transportation, it was stated in WRAP (2012) that distribution contributed 5% to the total carbon footprint, which is not significant. In the downstream analysis starting from yarn production, products made from different fibers are transported identically in terms of origin, destination and modes. Therefore, the emission of transportation is not included in the comparative analysis.

2.5 Use phase

In the use phase of a T-shirt, GHG emissions were mostly generated during washing, drying and ironing. Nonetheless, GHG emissions in the use phase were largely dependent on consumer behavior. In this report, machining washing, line dry and steam ironing were the assumed scenarios for GHG emission evaluation. In the washing phase, according to Moazzem et al. (2016), a washing machine of 7 kg load consumes 66 liters of tap water, 30 grams of detergent and 0.3 kWh of electricity per cold wash. Detergent extraction energy was estimated as 0.28 KWh for 30g detergent and the emission factor for detergent production is 0.11 ton CO2/GJ. In the drying phase, air drying was the most widely accepted garment care habits and thus generated no GHG emissions. In the ironing phase, ironing time was referred from WRAP (2012), which reported the average ironing time of a sportswear was 0.033 hours. The product parameters of a garment steamer were collected from a certain brand of steamer sold in the market in 2019. The power was 1,500 W and the steam flow was 20 g/min.

2.6 End of life

The end-of-life disposal can be divided into several options such as reuse, recycle, incineration, and landfill. At the end of the lifecycle, we adopted the results summarized by Guo (2014). If incineration without power production was chosen for disposal, waste cotton fibers generated no GHG emissions. In contrast, 1 kg of waste polyester fibers created 2.03 kg CO_2 equivalent of GHG emissions when utilizing the same disposal option. Regarding viscose fibers, BSR (2009) suggested no GHG emissions arose from the disposal stage in the lifecycle emissions calculation of a viscose garment.

3.Background information of surveyed companies

The completion of this White Paper and related research largely depended on the generous support from the participating companies, acknowledged here with brief company introduction.

- **Suzhou Pure-Fiber Textile Technology Co., Ltd.**

Pure-Fiber Textile is mainly engaged in the research and development, production and operation of vortex spun yarns. At present, the company possesses a production capacity of 116 vortex spinning machines, and plan to eventually reach a capacity of 174 vortex spinning machines, equivalent to 350,000 spindles. The total investment reaches approximately 1.1 billion RMB. The annual yield of yarns is about 70,000 tons and the annual sales revenue reaches 1.5 billion RMB.

- **Fujian Xinhuayuan Group**

Xinhuayuan Group has a total of 2 million spindles and 200 high-grade double twisters. Its subsidiary companies were awarded "China Viscose Yarn Characteristic Production Base", "China Viscose Blend Production Base" and "China Viscose Yarn Boutique Base". In 2016, Xinhuayuan ranked the 10th in textile industry comprehensive ranking and the first in non-cotton fiber application.

- **Zhejiang Charming Holding Co., Ltd.**

Zhejiang Charming Holding is a group company focusing on technological innovation with a conglomerate of high-grade fabric weaving, mercerizing, dyeing, printing, finishing as well as research and development of science and technology. The company has also built a first-class chemical analysis lab and a physical testing center. The company has 5 authorized invention patents and 45 utility model patents, and participated in the formulation of 6 national, industry and group standards and 1 provincial manufacturing standard.

- **Zhejiang Saintyear Textile Co., Ltd.**

Saintyear Textile mainly produces various kinds of pure cotton and high-grade yarn-dyed blended woven fabrics with a production capacity of 4 million meters per month. All fabrics are produced from high quality raw yarn and environmentally friendly dyestuff utilizing advanced equipment and technologies under strict quality management system. The products are characterized by good quality, high grade and high technology content, as well as broad pattern variety.

- **Linz (Nanjing) Viscose Yarn Co., Ltd.**

Linz (Nanjing) was founded in 2007. The company covers an area of 60 mu, with a building area of 15,150 square meters. The company possesses world-class spinning equipment - Trützschler grabbing carding production line from Germany, Rieter drawing production line from Switzerland, Murata vortex spinning machine from Japan, Rieter air spinning machine from Switzerland, warp and weft compact-siro spinning machine, and Murata winding machine, etc. The company also has advanced testing equipment for production management and quality control. The annual output is 8,000 tons of all kinds of medium and high-grade cellulose yarn, and the products are widely used in all kinds of knitted or woven clothing and decorative fabrics.

- **Huixian Jinyu Textile Co., Ltd.**

Jinyu has nearly 30 years of yarn production history with its products widely praised and sold throughout the whole nation, especially in the Jiangsu and Zhejiang markets. Currently, the company has a production capacity of 200,000 spinning spindles for compact-siro spinning, siro spinning and ring spinning, mainly producing highly twisted viscose yarns with yarn counts ranging from 16 to 80 Ne.

- **Xuzhou Huasheng Textile Co., Ltd.**

Huasheng Textile was founded in 2000, with an annual output of more than 35,000 tons of various specifications of siro spun and compact-siro spun viscose yarn, pure cotton yarn, chemical fiber yarn, and blended products. The company introduces the nation's first-class production lines and is equipped with complete sets of high-tech testing equipment. For consecutive years, Huasheng has been rated as a company with up-to-standard quality management and high contract credibility with AAA credit level.

- **Shandong Long Run Textile Co., Ltd.**

Long Run Textile, founded in 2011, is a modern technology-based textile company. At present, 180,000 spindles are all equipped with compact-siro spinning device. Long Run is awarded "National Textile New Material Yarn Product Development Base" and "National Textile New Material Yarn Trend Research Center". The company is positioned to manufacture functional and differentiated compact-siro spun yarns with high counts and superior product quality, with an annual output of nearly 20,000 tons of various types of yarns ranging from 10S to 180S. The product covers regenerated cellulose fiber series such as viscose, modal and lyocell, natural fiber blended series such as cotton, linen, silk, and wool, functional new fiber series such as moisture absorbing and self-heating, cool feel and quick dry, and antibacterial and hygienic, as well as colored yarn series made with spun-dyed fiber. The yarn products are widely used in knitted underwear, outdoor leisure clothing, weaving, warp knitting and other fields to provide customers with comprehensive product solutions.

Appendix II Frequently asked questions and answers

Purpose and main concepts of the White Paper

Why do we conduct the climate leadership program?

- Internationally, Fashion Industry Charter for Climate Action shows fashion brands' concerns on supplier climate issues.
- Domestically, the textile industry is the sixth most energy-intensive industry in China, facing the pressure of low-carbon transition.
- The textile industry has a long industrial chain and emission reduction requires collaboration. Raw material manufacturers have provided a new collaboration mechanism to voluntarily present their low-carbon advantages.

What are the characteristics and manifestation of EcoCosy®'s climate leadership?

- Based on product innovation, low-carbon production can be realized by adjusting the process parameters normally adopted by the industrial chain, benefiting value chain partners. Compared with equipment upgrades and green power procurement, low-carbon production achieved by adjusting process parameters requires relatively low financial commitment and tends to be easier to promote.

What are the companies' contribution to the climate leadership program?

- Companies in the value chain provided portions of their production data for measuring emissions, as well as production experiences with EcoCosy®'s products, helping drive low-carbon transformation of the industry. Meanwhile, partners in the value chain support each other to cope with the demand of downstream brands for low-carbon products and enhance their influence in the decision-making process.

What are the potential benefits for companies participating in the climate leadership program?

- The program will help companies consolidate partnership to jointly seize the opportunity for low-carbon transformation and earn customer recognition. Companies will benefit from the market resources of value chain partners and enjoy the dual benefits of energy cost savings and market expansion.

Concepts related to quantitative analysis

What is a Life Cycle?

- Consecutive and interlinked stages of a product system, from raw material acquisition or exploitation of natural resources to the end of life, inclusive of any recycling or recovery activity (e.g. a piece of clothing from raw material production to waste disposal, recycling).

  Reference: PAS 2050: 2008.

What is Life Cycle Assessment (LCA)?

- Compilation and evaluation of inputs, outputs and potential environmental impacts of a product system throughout its life cycle.

  Reference: PAS 2050: 2008.

What is the Methodology for Life Cycle Assessment of Carbon Footprint?

- A methodology to estimate the total emission of greenhouse gases in CO_2 equivalents from a product across its life cycle (including raw material extraction, processing, transportation, use and disposal of waste products, etc.)
- Life cycle assessment is commonly used in consumer products and provides important measurable indicators for comprehensive understanding of environmental and climate impacts in products and industries with long industrial chains. This research borrows the concept of life cycle assessment, combines data availability and concerns of downstream brand customers, and focuses on the "downstream of fiber manufacturing".

  Reference:

  Sun Qingzhi et al., Carbon Footprint and Textile Industry, *China Textile Leader*

What is the GHG Protocol?

- A set of standards, guidelines and toolkits jointly convened by the World Resources Institute and the World Business Council for Sustainable Development developed by enterprises, governments, NGOs, academic institutions and others.
- The world's most widely used international GHG accounting tool to help governments and business leaders understand, quantify, and manage GHG emissions.
- Provide GHG accounting standards and calculation tools at different levels, among which *Corporate Standard* is the most widely adopted GHG accounting methodology at the enterprise and organization level.

References:

https://ghgprotocol.org/sites/default/files/GHG-Protocol-Tool-for-Energy-Consumption-in-China-V2%201_0.pdf

http://www.wri.org.cn/resources/websites/%E6%B8%A9%E5%AE%A4%E6%B0%94%E4%BD%93%E6%A0%B8%E7%AE%97%E4%BD%93%E7%B3%BB

What is PAS 2050?

- A publicly available specification, developed by the British Standard Institute (BSI) and co-sponsored by the UK's Carbon Trust and the Department for Environment, Food and Rural Affairs (Defra), formally published in late October 2008.
- Also known as the *Specification for the assessment of the life cycle greenhouse gas emissions of goods and services*, PAS 2050 is the first global product carbon footprint standard that evaluates GHG emissions over the life cycle of products by a consistent method.

  Reference:

  http://www.tanpaifang.com/tanzuji/2012/0530/2445.html

What is PAS 2395?

- *Specification for the assessment of greenhouse gas emissions from the whole life cycle of textile products.*
- Published by the British Standard Institute (BSI).
- Unifies and defines in detail the methods, boundaries and data used to calculate and evaluate the carbon footprint of textile products.

  Reference:

  http://att.zstu.edu.cn/oa/darticle.aspx?type=view&id=20180309

What is a System Boundary?

- Set of criteria specifying which unit processes are part of a product system (e.g. the product system in the EcoCosy® program includes the whole life cycle from the production of raw materials to waste disposal such as incineration, landfill or recycling of garments).

  Reference: PAS 2050: 2008.

What is a Functional Unit?

- Quantified performance of a product system for use as a reference unit (e.g. The EcoCosy® program involves a 250g cotton T-shirt, worn for six months over two years, washed and ironed 50 times respectively during its life cycle).

  Reference: PAS 2050: 2008.

What are Greenhouse Gases?

- Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds.
- Common greenhouse gases include carbon dioxide, methane, nitrous oxide, etc.

  Reference: PAS 2050: 2008.

What is Scope 1?

- Direct emissions of greenhouse gases.
- Emissions generated by emission sources directly controlled or owned by the accounting enterprise (e.g. coal emissions from boilers owned or controlled by the enterprise, vehicle fuel emissions and process emissions).

  References:

  GHG Protocol 2004 version

  https://ghgprotocol.org/sites/default/files/GHG-Protocol-Tool-for-Energy-Consumption-in-China-V2%201_0.pdf

What is Scope 2?

- Indirect emissions of greenhouse gases.
- Calculating indirect emissions from outsourced power, steam, heating and refrigeration for the enterprise's own use (e.g. outsourced power, hot water, steam and refrigeration).

  References:

  GHG Protocol 2004 version

  https://ghgprotocol.org/sites/default/files/GHG-Protocol-Tool-for-Energy-Consumption-in-China-V2%201_0.pdf

What is Scope 3?

- Indirect emissions of greenhouse gases.
- Calculating all indirect emissions of the enterprise except scope 2, including emissions up and down the value chain (e.g. emissions from the production of purchased raw materials, emissions from the use of sold products, etc., such as emissions from the production of fabrics purchased by garment manufacturers).

References:

GHG Protocol 2004 version

https://ghgprotocol.org/sites/default/files/GHG-Protocol-Tool-for-Energy-Consumption-in-China-V2%201_0.pdf

What is Carbon Footprint?

- Carbon footprint is a method of analyzing the amount of direct and indirect carbon emissions in the life cycle of a product based on the LCA theory. At present, internationally there is no uniform definition of carbon footprint. The definitions of carbon footprint by various research institutions and researchers are shown in the table below.

Table 2. Definitions of Carbon Footprint

Institutions/ Researchers	Description of the definitions
POST (2006)	The amount of CO_2 and other GHGs emitted by a product or process over its lifetime.
Energetics (2007)	Total direct and indirect emissions of CO_2 from human economic activities.
ETAP (2007)	CO_2 equivalent of GHGs emitted during anthropogenic activities to measure anthropogenic impacts on the environment.
Wiedmann & Minx (2007)	On the one hand, the total amount of CO_2 emitted during the life cycle of a product or service; on the other hand, the total amount of CO_2 directly and indirectly emitted during an activity.
Carbon Trust (2008)	Estimation of the aggregate GHG emissions in carbon dioxide equivalents from a product across its life cycle (including raw material extraction, processing, transportation, use and disposal of waste products, etc.)

References:

https://www.carbontrust.com/resources/guides/carbon-footprinting-and-reporting/carbon-footprinting/

https://max.book118.com/html/2015/0827/24104945.shtm

What is CO_2 Equivalent?

- Unit for comparing the radiative forcing of a GHG to CO_2.

  Reference: PAS 2050: 2008.

What is a Product System?

- Collection of unit processes with elementary and product flows, performing one or more defined functions, that models the life cycle of a product.

  Reference: PAS 2050: 2008.

Terminology related questions

What is Intended Nationally Determined Contributions (INDC)?

- *Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions (INDC)*. In 2015, China submitted the INDC to the Secretariat of the United Nations Framework Convention on Climate Change. Some related goals and measures are summarized below:
- Based on its national conditions, stage of development, sustainable development strategy and international responsibilities, China established climate-related goals to be achieved by 2030, including "reaching the peak of CO_2 emissions around 2030 or earlier, lowering CO_2 emissions per unit of gross domestic product by 60% to 65% from the 2005 level"
- "We will form an energy-saving and low-carbon industrial system, adhere to the new road of industrialization and vigorously develop the circular economy..."
- "We will improve the statistical accounting system for GHG emissions. We will further strengthen climate change statistics and improve the GHG emission statistics system covering energy activities, industrial processes, agriculture, land use change and forestry, and waste disposal..."
- "We will improve the mechanism for social participation. We will strengthen enterprises' responsibility for low-carbon development and encourage them to explore low-carbon development models that save resources and are environmentally friendly."

  Reference:

  http://www.gov.cn/xinwen/2015-06/30/content_2887330.htm

What is UNFCCC Fashion Industry Charter for Climate Action?

- Issued in 2018 during COP24, the United Nations Climate Change Conference in Poland.
- Aligned with the goals of the Paris Agreement, the Charter contains the targets to reach climate neutrality in the second half of the twenty-first century and recognizes that current solutions and business models will not be sufficient to deliver on the current climate agenda and fashion industry needs to embrace a more systematic change.

- CNTAC is one of the 43 largest brands, manufacturers and trade associations in the world (the number is increasing as more stakeholders participate in the Charter) committed to implementing or supporting the Charter.
- Signatories of the Charter committed to reduce 30% aggregate GHG emissions (in Scope 1, 2 and 3) by 2030 against a baseline of no earlier than 2015.

Reference:

https://unfccc.int/sites/default/files/resource/Industry%20Charter%20%20Fashion%20and%20Climate%20Action%20-%2022102018.pdf

What is Nature-Based Solutions?

- Jointly issued by the World Bank, the International Union for Conservation of Nature, the World Wide Fund for Nature and other organizations, and vigorously promoted as a new concept around the world. Defined as an action to protect, sustainably manage and restore natural or modified ecosystems.
- Nature-based solutions point to sustainable development and rely on the power of nature.

Reference:

http://www.forestry.gov.cn/main/5460/20190215/092614262310830.html

What is Weaving?

- The method or process of interlacing two yarns of similar materials so that they cross each other at right angles to produce woven fabric. The warp yarns, or ends, run lengthwise in the fabric, and the filling threads (weft), or picks, run from side to side. Weaving can be done on a power or hand loom or by several hand methods.

Reference:

https://textilelearner.blogspot.com/2012/04/weaving-and-knitting-comparedifference.html?m=1

What is Knitting?

- Knitting is a technique to turn thread or yarn into a piece of cloth. Knitted fabric consists of horizontal parallel courses of yarn which is different from woven cloth. The courses of threads or yarn are joined to each other by interlocking loops in which a short loop of one course of yarn or thread is wrapped over the other course.

Reference:

https://textilestudycenter.com/knitting-terms-and-definition/

What is Siro Spinning?

- Siro spinning is similar to ring spinning in which two rovings are fed to drafting at the same time and twisted together as a double yarn, which is known as siro spinning.
- The advantages of siro spinning include less hairiness, high strength, wear resistance, softness and breathability.

References:

https://www.textilemates.com/siro-spinning-application/

https://wenku.baidu.com/view/5c747d1c5901020207409cf3.html

What is Compact-Siro Spinning?

- Compact-siro spinning technology is one of the most widely used spinning methods. It is conducted on a compact ring frame by simultaneously feeding two rovings into the drafting zone at a predetermined separation.
- Compact-siro spinning incorporates the features of both compact spinning and siro spinning systems. With the advantages of less hairiness and high strength, the spun yarn is an ideal raw material for high-grade textiles. Compact-siro spinning has many processes and relatively high energy consumption, but at the same time can increase the company's gross profit margin.

References:

Research on the Compact-Siro Spun Yarn Structure. (Su et al., 2015)

https://wenku.baidu.com/view/5c747d1c5901020207409cf3.html

What is Ring Spinning?

- Ring spinning is the most widely used form of spinning and possesses significant advantages compared to new spinning processes. The ring spinning machine is used in the textile industry to simultaneously twist staple fibers into yarn and then wind it onto bobbins for storage. The yarn loop rotating rapidly about a fixed axis generates a surface referred to as "balloon".
- Yarn produced with ring spinning has the advantages of less hairiness, higher strength and better quality.

References:

https://www.textileschool.com/317/ring-spinning-the-widely-used-yarn-formation-technique/

https://wenku.baidu.com/view/5c747d1c5901020207409cf3.html

What is Vortex Spinning?

- Vortex spinning is a technology which uses an air vortex to spin out the yarn. Fibers formed by these air flows possess a unique structure, which provides the yarn with a wide range of functionalities.
- In the process of vortex spinning, the transfer, gathering, twisting and yarn formation of the fibers are all accomplished by airflow. The structure of vortex spinning frame is simple, which cancels the high-speed rotating parts, and can twist the moving fiber strands with the aid of high-speed rotating airflow.
- The advantages of vortex spinning include high production speed and output, high production rate, etc. The yarn has good dyeability, breathability, pilling resistance, and abrasion resistance.

References:

http://www.muratec-vortex.com/vortex01.html

https://baike.sogou.com/v41843052.htm?fromTitle=%E6%B6%A1%E6%B5%81%E7%BA%BA

https://wenku.baidu.com/view/5c747d1c5901020207409cf3.html

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