apparel impact institute

Taking Stock of Progress Against the Roadmap to Net Zero

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Foreword

In March 2023, the Intergovernmental Panel on Climate Change (IPCC) released the final installment of the Sixth Assessment Report (AR6), which further reinforces the potentially catastrophic consequences of rising greenhouse gas (GHG) emissions, and cites the damaging impacts the world is already experiencing with 1.1°C of warming.

The impacts of climate change will be disproportionately borne by the world's most vulnerable populations, which includes regions that are critical to the apparel sector. For example, according to climate scientists, climate change likely contributed to record-setting flooding in August 2022 in Pakistan that killed more than 1,500 people and displaced over 30 million people.[1] According to the government of Pakistan, roughly 40 percent of the country's cotton crop was lost or impacted by this flooding.[2] Such losses could hurt Pakistan's biggest export — textiles and apparel — which brings in roughly $20 billion annually.[3]

Yet, the IPCC report provides hope in the form of clear direction on what humanity must collectively do to avert the most damaging impacts from climate change: reduce GHG emissions by 43 percent by 2030, and to net zero by no later than 2050. We must rapidly transition away from fossil fuels, and invest to help countries adapt to climate change, which will include scaling regenerative and organic approaches to agriculture (including materials used in apparel and footwear).

As with all industries, the apparel sector contributes to the global carbon budget. Based on new analysis in this report, and data from the Sustainable Apparel Coalition, Worldly, and Textile Exchange, the sector emitted an estimated 897 million tonnes of carbon dioxide equivalent (CO_2e) in 2021 — which is roughly 1.8 percent of global GHG emissions.

Yet, apparel companies are taking serious steps to reduce their emissions. There are nearly 400 apparel companies that have commitments or approved science-based targets (SBTs) through the Science-Based Targets initiative — amongst the highest of any sector. The Sustainable Apparel Coalition recently rolled out a decarbonization program through which it will require members to set SBTs; SAC, Aii, and Textile Exchange will provide tools and support to help members deliver on these targets.

Companies across the value chain are taking bold steps to reduce their emissions across the value chain, a selection of which we include in this report. To illustrate, according to Textile Exchange's recently released *Material Change Insights 2022* report, 56 percent of all materials used by the over 400 surveyed companies are preferred, and 73 percent of these companies are testing circular business models such as rental.[4]

Delivering the necessary GHG reductions will require significant investment, and thus funding sources such as the Apparel Impact Institute's (Aii) $250M Fashion Climate Fund are critical. To help deploy these funds, Aii established a Climate Solutions Portfolio to deploy grants to proven GHG reduction solutions. At the time of this report, Aii was in the process of reviewing the first round of applications to this fund, and the interest is encouraging: Aii received 148 applications of which the most impactful have moved to the next round and get the opportunity to pitch to the Climate Solutions Portfolio Advisory Council.

While the task of driving GHG emissions to net zero is a daunting one, we are emboldened and inspired by the actions of organizations across the apparel value chain, and look forward to working together to build a more resilient, equitable, and prosperous apparel sector.

Lewis Perkins
President, Aii

Amina Razvi
CEO, Sustainable Apparel Coalition

Ashley Gill
Chief Strategy Officer, Textile Exchange

1 *Climate change likely helped cause deadly Pakistan floods, scientists find*, NPR, September 19, 2022. Accessed from the web on April 7, 2023.
2 Better Cotton Initiative Pakistan Flooding Update, October 25, 2022.
3 *Pakistan floods raise fears of hunger after crops wrecked*, AP News, September 25, 2022. Accessed from the web on April 7, 2023.
4 *Material Change Insights 2022*, Textile Exchange, April 2023. Accessed from the web on April 26, 2023.

1. Report Highlights

- Based on data from the Sustainable Apparel Coalition, Worldly, and Textile Exchange, we estimate apparel sector emissions to be 0.897 gigatonnes (Gt) of carbon dioxide equivalent (CO_2e) in 2021, or roughly 1.8 percent of annual global greenhouse gas (GHG) emissions.
- Adjusting for changes in key assumptions on fiber allocation (see section 3 below), this represents an increase of 0.87 percent from the 2019 estimate presented in the *Roadmap to Net Zero*.
- Assuming business-as-usual growth for the apparel sector, emissions are projected to be 1.266 Gt in 2030. To stay within a 1.5°C trajectory (45 percent reduction by 2030), the sector would need to reduce emissions from 0.889 Gt in 2019 to 0.489 Gt by 2030.
- The breakdown of emissions across the value chain for 2021 is nearly identical to that in the *Roadmap to Net Zero*: material processing (tier 2) is highest at 53 percent of total emissions, followed by raw materials (tier 4) at 23 percent, raw materials processing (15 percent), and finished goods assembly (8 percent).
- We include a selection of case studies of companies taking action to reduce GHG emissions across the six interventions identified in the *Roadmap to Net Zero*.

2. Context

In 2021, World Resources Institute (WRI) and Apparel Impact Institute (Aii) published *Roadmap to Net Zero: Delivering Science-Based Targets in the Apparel Sector*. In this report, WRI and Aii developed an estimate of annual apparel sector greenhouse gas (GHG) emissions and projected these emissions out to 2030. The authors also identified the specific ways in which the apparel sector can reduce GHG emissions to stay in line with a 1.5°C trajectory.

Using data from the Sustainable Apparel Coalition, Worldly, and Textile Exchange, WRI and Aii estimated apparel sector emissions to be 1.025 gigatonnes (Gt) of carbon dioxide equivalent (CO_2e) in 2019, or roughly 2 percent of annual global greenhouse gas (GHG) emissions. Material production was the biggest hotspot of emissions (52% of total), followed by raw material extraction (24% of total).

In the *Roadmap*, WRI and Aii identified six interventions that would help the sector deliver the reductions needed for a 1.5°C pathway:

1. Maximizing material efficiency
2. Scaling more sustainable materials and practices
3. Accelerating the development of innovative materials
4. Maximizing energy efficiency
5. Eliminating coal in manufacturing
6. Shifting to 100 percent renewable electricity

In developing the *Roadmap*, the WRI and Aii based the analysis on what they believed to be the most widely used and representative data in the apparel sector — fiber volume data from Textile Exchange and GHG impact data from the Sustainable Apparel Coalition (SAC) and Worldly. WRI and Aii used this data with the intent that they would refresh the calculations in future years.

BOX 1: STATE OF SCIENCE-BASED TARGETS IN THE APPAREL SECTOR

As of May 2023, nearly 400 apparel, footwear, and textiles companies had approved science-based targets or commitments to set them according to the Science-Based Targets initiative. This is a significant increase from the roughly dozen companies with approved targets or commitments in June 2019 when the SBTi published its apparel sector guidance, and an illustration of the collective ambition of the sector to address its climate footprint.

The current list of apparel, footwear, and textiles companies with approved targets and commitments can be found on the SBTi website: sciencebasedtargets.org/companies-taking-action

With this report, Aii[5] provides an estimate of GHG emissions for 2021 using fiber volume data from Textile Exchange for 2021 and GHG impact data from the Higg Materials Sustainability Index (MSI). Importantly, after deliberations with Textile Exchange and the SAC, Aii revised the assumptions on the percentage of fiber that is used in the apparel sector versus other uses such as home textiles, and re-calculated the 2019 GHG estimate to more accurately compare 2021 with 2019. We explain this change in more detail below.

This report also includes case studies from companies that are taking action to reduce emissions across the six interventions. These examples are intended to illustrate the reductions that are possible today — and provide direction and inspiration to other companies to take action. These are by no means the only examples of companies taking steps to reduce emissions — Aii will compile and share more examples in the future.

5 Aii is the sole author of this report

3. Methodology: Calculating Apparel Sector GHG Emissions

Overview

For calculating apparel-sector GHG emissions for 2021, Aii took the same approach as taken in the *Roadmap* report.

We started with fiber weight[6] data compiled by Textile Exchange in their most recent *Preferred Fiber and Materials Market Report*[7] (published in October 2022). This covers global production weights of the various fibers and materials used in textiles in 2021.

For each fiber type, we used Textile Exchange assumptions on the percentage of all fiber that is used in apparel versus other categories such as home textiles. See box 2 below for an explanation of how the allocation percentages differed between the *Roadmap* and this report and the implications for the overall calculations.

For each fiber type, we multiplied the allocated total fiber weight by the GHG emissions factor for each process stage in the MSI:

- Raw material, such as cotton farming to gin
- Yarn formation, or spinning fiber into yarn
- Textile formation, such as knitting or weaving yarn into fabric
- Preparation, such as scouring
- Coloration
- Additional coloration and finishing, including heat setting

BOX 2: REVISED ASSUMPTIONS ON FIBER ALLOCATED TO APPAREL

Ideally, we would calculate sector GHG emissions by gathering primary data for all entities and activities across the value chain: brands, manufacturers, mills, material processors, cotton farms, logistics providers, and more. Since such data does not exist, we used secondary data to estimate apparel sector emissions.

In the analysis in the *Roadmap*, we assumed (with input from expert stakeholders) that 66 percent of all fibers were used in apparel, with the balance going to home textiles and other uses. For this report, we used different allocation assumptions based on new fiber-specific estimates from Textile Exchange based on a broader stakeholder consultation and data review. For example, the percentage allocation for this report for polyester is 55 percent, cotton (all types) 70 percent, wool 45 percent, and man-made cellulosics 50 percent. The full list of fiber percentage allocations is included below in table 1.

Using these revised percentages resulted in a significant change in emissions from 2019 to 2021, and thus we re-baselined the 2019 emissions figure with the new fiber allocations. We acknowledge that the data for the fiber allocation to apparel are estimates and will continue to evolve over time as new and better data become available. The transition to fiber-specific percentages is a step towards continuously improving the data model used for this report.

Making this change is an acknowledgement that the quality of the sector's impact data can be further improved. Conducting our GHG emissions analysis annually will allow us to continue to refine and improve the data, for example by accessing primary data through the Higg Facility Environmental Module (FEM).

6 We use "weight" in this document for consistency with the *Roadmap* report. Textile Exchange uses "volume" in their *Preferred Fiber and Materials Market* report.

7 Source: *Preferred Fiber and Materials Market Report*

3. Methodology: Calculating Apparel Sector GHG Emissions

Since the MSI does not include data on finished goods production (tier 1), we used a simplified process from Quantis' World Apparel & Footwear Life Cycle Assessment Database (WALDB) as a proxy. As with the *Roadmap*, we excluded emissions from the following sources:

- **Corporate offices and other buildings:** Emissions from these sources are typically small relative to product- and manufacturing-related emissions.
- **Consumer use:** While some studies find that emissions from washing and drying can be significant, measuring use phase emissions is challenging given a lack of actual consumer data. It is also difficult for companies to have a direct influence on how consumers care for their apparel.
- **End of life:** Estimating emissions from landfilling or incinerating apparel is challenging, though they are very likely insignificant relative to supply chain emissions.
- **Downstream transportation:** Based on analysis of companies with approved SBTs, downstream transportation (in other words, retailer to consumer) comprises roughly 2 percent of total emissions (see figure 3 in the *Roadmap*).

TABLE 1: FIBER ALLOCATION TO APPAREL

Fiber	Percentage Allocation to Apparel
Cotton	70%
Wool	45%
Down	25%
Viscose	50%
Lyocell	50%
Modal	50%
Polyester	55%
Nylon	46%
Acrylic	75%
Elastane	67%
Polypropylene	67%
Hemp	1%
Flax	60%
Silk	90%
Alpaca	95%
Jute	1%
Acetate	5%

3. Methodology: Calculating Apparel Sector GHG Emissions

3.1 Key Assumptions and Limitations

3.1.1 RAW MATERIAL EXTRACTION

Scope: Emissions related to extracting fossil fuels for conversion into synthetic fibers and growing natural fibers such as cotton and wool.

According to the PFMR, roughly 113 million tonnes (Mt) of fiber were produced for textiles in 2021 — which is roughly double the amount of fiber produced in 2000 (58 Mt). Unlike in the *Roadmap*, acetate fiber, jute, and coir were included in our analysis given new Textile Exchange data, although the amounts of these materials used in apparel are minor. Based on the fiber percentage allocations shown in the appendix, the starting point for fiber used in apparel was 61.9 million tonnes of fiber, which is an increase of 0.9 percent from 2019.

Polyester was the most used fiber type in 2021, representing 54 percent of total global fiber production, with cotton second at 22 percent, followed by man-made cellulosic fibers (MMCF) at 6.4 percent and nylon at 5 percent. This analysis excludes leather as we only evaluated apparel (and not footwear) and the MSI does not have data on production processes for leather apparel.

For tier 4, we multiplied the weights of each fiber type by the corresponding emissions factor from the MSI and summed these for the tier 4 figure.

3.1.2 RAW MATERIAL PROCESSING

Scope: Spinning fiber into yarn.

Our analysis focused on spinning fibers into yarn and did not include the processing of other intermediate materials, such as metal for zippers, as that data is not readily available. We will aim to include more of these trims and other inputs in future analyses.

As with the *Roadmap*, we made the following assumptions for converting fiber into yarn:

TABLE 2: ASSUMPTIONS FOR YARN TYPES

Fiber	Assumptions
Polyester	67% filament yarn 33% staple fiber ring spun yarn
Nylon	90% filament yarn 10% staple fiber ring spun yarn
Polypropylene	60% filament yarn 40% staple fiber ring spun yarn
Acrylic	100% staple fiber ring spun yarn
MMCF (Viscose Rayon,Modal, Lyocell)	100% staple fiber ring spun yarn
Cotton	75% staple fiber ring spun yarn 25% staple fiber rotor spun yarn
Wool	100% staple fiber ring spun yarn

We assumed yarn density of 200 decitex for all fiber types, and used the same fiber loss rates as we did in the *Roadmap*.

3. Methodology: Calculating Apparel Sector GHG Emissions

3.1.3 MATERIAL PRODUCTION

Scope: Textile formation, preparation, coloration, and additional coloration and finishing.

Our analysis for tier 2 covered:

- Textile formation (knitting or weaving yarn into fabric)
- Preparation, such as scouring
- Coloration
- Additional coloration and finishing, such as heat setting

We assumed 40 percent knit and 60 percent woven for all fiber types for textile formation. For preparation, we applied default MSI emissions factors for each fiber type. The sources for these emissions factors can be found in the public version of the MSI. For coloration, the default MSI emissions factors were again applied for each fiber type:

- Synthetic fibers: Batch dyeing with disperse or cationic dyes
- Cotton and MMCF fibers: Batch dyeing with direct, sulfur, vat, or reactive dyes
- Wool: Batch dyeing with acid dyes

Companies wanting to refine their analysis can select specific coloration methods in the MSI.

As with tier 3, calculations use fiber loss rates from the MSI (via Textile Exchange) for tier 2.

3.1.4 FINISHED GOODS MANUFACTURING

Scope: Final assembly of products, including cutting and sewing of fabric into garments.

As with the *Roadmap*, we calculated finished goods manufacturing emissions using a standard emission factor per kilogram of finished product using data from Quantis' WALDB. The process includes GHG impacts from electricity consumption (80 percent of the GHG impact), thermal energy, and minor sources such as tap water. Calculations used the electricity mix representing the top apparel manufacturing countries, which is consistent with the MSI.

Calculations assumed an average fabric loss rate of 20 percent for finished goods.

4. The Results

Given the above assumptions, we estimated total apparel sector GHG emissions for 2021 to be 896.9 million tonnes of carbon dioxide equivalent (CO_2e), or 0.897 Gt. Based on global annual GHG emissions of 49.7 Gt,[8] this represents roughly 1.8 percent of global GHG emissions.

The percentage breakdown of emissions across the value chain was nearly identical to 2019.

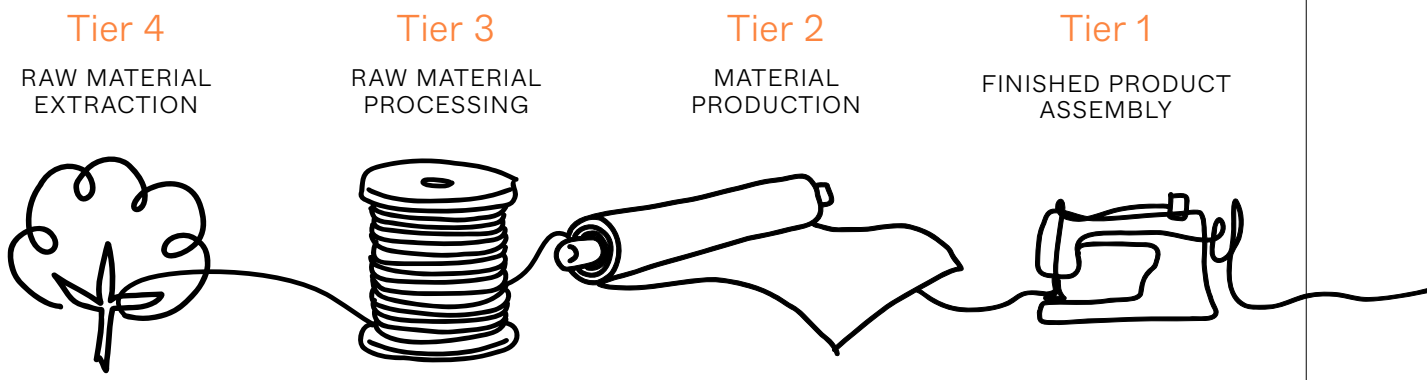
As mentioned above, we recalculated the 2019 emissions figure using the revised fiber allocation percentages from Textile Exchange (see Table 1), though we used the MSI emissions factors from the *Roadmap*. The revised calculation for 2019 is 889.2 million tonnes CO_2e (0.889 Gt).

The change in emissions from 2019 to 2021 — an increase of 0.87 percent — can be explained by several factors:

- The growth in fiber used in apparel was small — 0.9 percent increase from 2019 to 2021.[9]
- Raw material (tier 4) GHG intensity remained essentially constant — changes in usage of some sustainable fibers were offset by changes in the fiber mix overall.
- Electricity intensity (average grid mix) for other processing stages (tiers 2 and 3) improved by roughly 0.9 percent.
- The GHG intensity of coloration and finishing also improved slightly, by about 1.9 percent and 1.6 percent respectively.[10]

FIGURE 1: APPAREL SECTOR GREENHOUSE GAS EMISSIONS, 2021

Total Apparel GHG Emissions: 896.94 tonnes CO_2e (0.897 Gt)



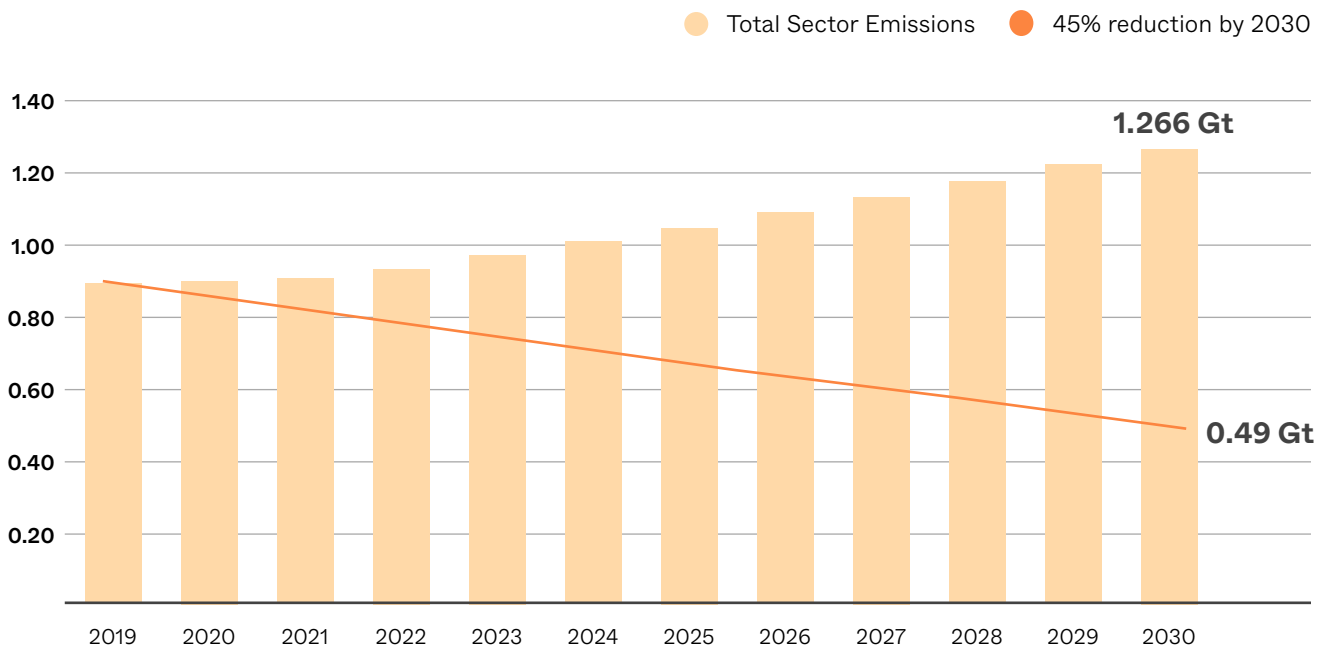
8 2021 data on global GHG emissions is not available, and thus we used the 2019 figure (ourworldindata.org/greenhouse-gas-emissions)
9 In 2019, 61,196 thousand tonnes of fiber were used; this figure was 61,293 thousand tonnes in 2021.
10 These data points are taken from GaBI which limits our ability to understand the exact drivers. However, we assume that this reflects reductions in emissions intensity of electricity and thermal energy of the input energy sources.

4. The Results

As we noted in the *Roadmap*, given the state of impact data in the apparel sector, we refer to our result (0.897 Gt) as a reasonable but not definitive estimate of apparel sector emissions. We thus caution readers against making firm assertions based on our analysis (e.g. "the apparel sector is 1.8 percent of global GHG emissions"). We believe our result is the best estimate of sector emissions, and we will continue to work on gathering better data so that we can refine our calculations in the future.

Assuming business-as-usual growth for the sector, emissions are projected to be 1.266 Gt in 2030. This reflects annual growth rates of 5 percent for synthetics and MMCF and 1 percent for cotton and other natural fibers.[11] To stay within a 1.5°C trajectory — achieving 45 percent reduction by 2030 — the sector would need to reduce emissions from 0.889 Gt in 2019 to 0.489 Gt by 2030. Given the business-as-usual projection to 1.266 Gt, the sector must reduce emissions by 0.777 Gt by 2030, and even more by 2050.

FIGURE 2: PROJECTED GHG EMISSIONS FOR THE APPAREL SECTOR, 2019–2030



11 We base this assumption on data from Fiber Year Consulting and previous stakeholder feedback. WRI and Aii used the same assumption in the *Roadmap*.

5. Efforts to Decarbonize the Apparel Sector

In the *Roadmap*, WRI and Aii identified six key interventions for how the apparel sector can reduce GHG emissions:

1. Maximizing material efficiency

2. Scaling more sustainable materials and practices

3. Accelerating the development of innovative materials

4. Maximizing energy efficiency

5. Eliminating coal in manufacturing

6. Shifting to 100 percent renewable electricity

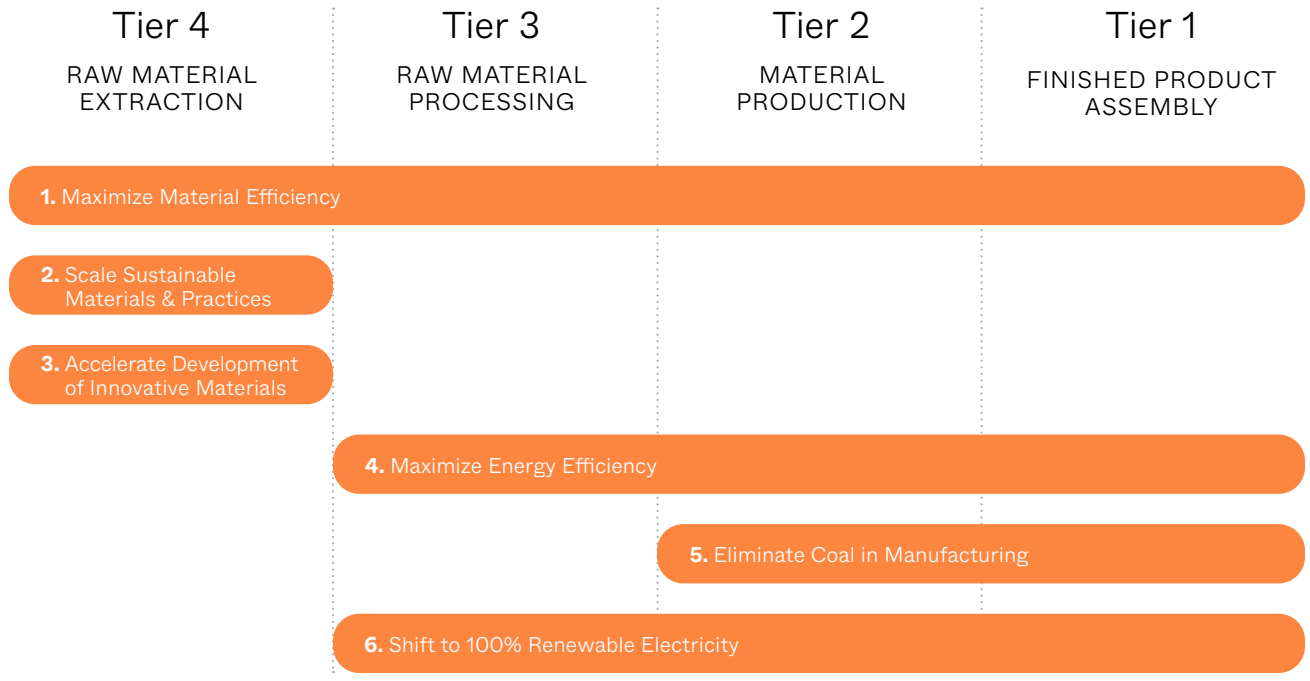
In the *Roadmap*, we noted the tiers in the value chain for which these six interventions are most relevant — see figure 3 below.

We also described the potential for circular business models such as rental and resale to reduce emissions. As we described in the *Roadmap*, it is very challenging to measure the GHG impacts of such business models because actual consumer behavior data is hard to obtain. Consumers may say via surveys that they do not buy new apparel items when they rent or buy used items, but emissions will only be reduced if consumers actually buy fewer new products.

In this report, we present examples of individual company and collaborative efforts to reduce GHG emissions. These examples are based on publicly-available information and engagement with select companies, and also informed by Aii knowledge. The intent in sharing these examples and case studies is to demonstrate that decarbonization at pace and scale is possible. These case studies are by no means the only examples of good practice in the sector.

We did not re-calculate the amounts of GHG reductions for each intervention as we did in the *Roadmap* (see section 7) as our focus for this report was on revising the total footprint and sharing company examples. Also, we did not have any changes to the underlying assumptions that would have made this re-calculation worthwhile.

FIGURE 3: KEY INTERVENTIONS FOR REDUCING EMISSIONS TOWARDS NET ZERO



5. Efforts to Decarbonize the Apparel Sector

5.1 Increase Material Efficiency

Through design, material selection, and methods of manufacturing, companies can reduce the amount of material that ends up as waste. In effect, this minimizes the GHG emissions going into the production of raw materials, for example, by requiring less cotton to make the same amount of products. This has implications across the value chain. For example, with higher material utilization in cut and sew, less yarn would need to be spun, less fabric would need to be dyed, and so on.

ASOS
For summer 2022, ASOS launched a Circular Design Collection — its second such collection — which uses 3D printing to reduce samples and "zero waste design" for some designs to eliminate offcuts, which through conventional pattern making can be 15 percent per item.[12]

H&M
Like other brands, H&M is testing and using 3D design tools to decrease physical samples and improve pattern efficiency. Over 200 patternmakers and product technologists across H&M Group have received training in design software that calculates fabric consumption, which has helped the company reduce fabric waste for H&M's 20 biggest dress styles by 12 percent.[13]

Nike
In September 2022, Nike launched Nike Forward, a new apparel innovation that requires fewer steps than traditional knits or wovens, which significantly reduces the carbon footprint of the material per garment by an average of 75 percent compared to traditional knit fleece used by Nike.[14]

Dystar
Efficiency can also reduce emissions in the chemicals that are used to dye and finish products, for example Dystar reports that its Cadira® reactive dyes can reduce GHG emissions by 30 percent compared with conventional reactive dyeing.

Saitex
Saitex's Smart-Indigo™ system utilizes an electrochemical-dye bath preparation that reduces CO_2 emissions by 90 percent, energy use by 70 percent, and water consumption by 30 percent.

5.2 Invest In and Scale Sustainable Materials and Processes

According to Textile Exchange, "preferred" is used to categorize a fiber or raw material that "delivers consistently reduced impacts and increased benefits for climate, nature, and people against the conventional equivalent, through a holistic approach to transforming production systems." In 2023, Textile Exchange is developing detailed assessment criteria for preferred materials.

For this publication and the examples included below, sustainable materials are those with lower GHG emissions on a per unit basis compared with conventional alternatives. We recognize that there are other important environmental and social attributes to consider when evaluating materials, but we concentrate on GHG emissions given the focus of this report.

The use of sustainable materials is common across the apparel sector, and we could have included dozens of company examples here. For space reasons, we have included commitments and examples from the following companies:

H&M Group
- In 2021, 80 percent of materials were recycled or sourced in a more sustainable way (e.g. BCI cotton). H&M Group's goal is 100 percent by 2030.
- H&M Group tripled the share of recycled materials used in its garments from 5.8 percent to 17.9 percent in 2021 (the goal is 30 percent by 2025).
- By 2020, H&M Group achieved its goal to source 100 percent more sustainably-sourced cotton.[15]
- In 2021, 63 percent of all polyester was recycled, which is an increase from 8 percent in 2019 (the goal is 100 percent by 2025).[16]

ISKO
- Currently, 85 percent of fabric contains recycled materials.
- ISKO's R-TWO fabric consists of 50 percent recycled or reused materials, including pre-consumer cotton and recycled polyester, the latter of which is converted on-site from waste PET at ISKO facilities.
- ISKO has a goal to use 100 percent bluesign® approved chemicals by 2025.[17]

12 Source: ASOS webpage
13 Source: H&M Group Sustainability Disclosure 2021
14 Nike has made public the life cycle assessment of Nike Forward
15 This includes cotton sourced through BCI, in-conversion organic cotton, regenerative cotton, and cotton from other innovative sources
16 Source for all data: H&M Group Sustainability Disclosure 2021
17 Source for all data: ISKO 2022 Sustainability Impact Report

5. Efforts to Decarbonize the Apparel Sector

lululemon

- In 2021, 38 percent of the materials in lululemon products were from more sustainable sources (lululemon's goal is at least 75 percent by 2025).
- In 2021, 50 percent of all polyester used was from recycled sources — lululemon's goal is at least 75 percent by 2025.
- In the same year, 37 percent of cotton was sourced from responsible platforms[18] (the goal is 100 percent by 2025).
- lululemon has a goal to source 100 percent renewable or recycled content nylon for its products by 2030, and has a multi-year partnership with Genomatica to develop bio-based nylon and other materials.[19]

PUMA

- In 2022, 48 percent of polyester used across apparel, accessories, and footwear was from recycled sources.
- In the same year, 99.8 percent of all cotton used was BCI or recycled.[20]

PVH

- In 2021, 44 percent of all materials were from sustainable materials (recycled and sustainably sourced materials).
- 28 percent of polyester was sustainably sourced (goal of 100 percent by 2030).
- 54 percent of cotton was sustainably sourced (goal of 100 percent by 2025).

BOX 3: COLLABORATIVE EFFORTS TO INCREASE SUSTAINABLE MATERIALS

Textile Exchange has a variety of initiatives underway to increase the usage of sustainable materials. To name one, the 2025 Recycled Polyester Challenge[21] was launched in 2021 by Textile Exchange and the UN Fashion Industry Charter for Climate Action to increase the use of recycled polyester. The over 130 brands and suppliers that have signed up to the Challenge have committed to use at least 45 percent recycled polyester by 2025.

Textile Exchange is also working on "life-cycle assessment plus" studies for mohair, wool, and cashmere, and will expand this to include polyester, cotton, and leather in 2023 with the aim of producing better data and sharing it with other organizations.

Signatories to the Fashion Industry Charter for Climate Action have committed to source 100 percent of priority materials that are both preferred and low climate impact by 2030, while signatories to the CEO Fashion Pact have committed that 25 percent of materials will be lower climate impact by 2025.

BOX 4: A NOTE ON USING LIFE CYCLE ASSESSMENT DATA FOR PRODUCT CLAIMS

In 2022, the Norwegian Consumer Authority (NCA) ordered that Norwegian brand Norrøna stop using Higg MSI data to make environmental claims about products with organic cotton, noting that the claims were "likely to be false and untruthful" given that the underlying data comes from global averages for the impact of organic cotton compared with conventional cotton. The NCA also notified H&M, and joined with the Netherlands Authority for Consumers and Markets (ACM) to issue guidance on using MSI to make claims. The SAC is taking a number of steps[22] to respond to the actions of the NCA and ACM.

As described in section 3 above, we use life cycle assessment data from the Higg MSI to estimate the overall GHG emissions of the apparel sector — not to make specific comparisons between products or materials. We have been explicit about the limitations of this approach and the importance of compiling higher quality and primary data in the future. Until we have such data, we believe that using the MSI and Textile Exchange fiber mass data is the best option for estimating apparel sector emissions.

18 lululemon takes a portfolio approach to achieving more sustainable cotton that includes organic, recycled, regenerative & other third-party certified platforms.
19 Source for all data: lululemon 2021 Impact Report
20 Source for all data: PUMA Business and Sustainability Report 2022
21 Source: The 2025 Recycled Polyester Challenge
22 Source: Statement from the SAC Regarding the Norwegian Consumer Authority and Environmental Claims

5.3 Accelerate the Development of Innovative Materials

In the *Roadmap*, we used the phrase "next generation" to designate preferred materials that are earlier in their commercialization than more widely-available materials such mechanically-recycled polyester (from PET bottles) and BCI cotton. Such next generation materials include recycled fibers from textiles, plant-based leather, and bio-based alternatives to synthetics.

Textile Exchange's annual PFMR is a good resource for identifying innovators and suppliers working on next-generation materials. For example, the 2022 PFMR lists eight suppliers offering bio-based polyamide (nylon) fibers and yarns, and another 12 offering bio-based chemicals and resins for polyamide.

Given that most next generation materials are in their early stages of development, it is not easy to determine their GHG impacts on an absolute basis and relative to incumbent materials (e.g. fossil-fuel based synthetics). Most of these materials are not yet included in data sets such as the Higg MSI. Of the materials that are included in the MSI, it is not possible to claim that all next generation materials have lower GHG impacts. For example, mechanically-recycled polyester has a lower GHG score than chemically-recycled polyester, while fossil-fuel based polyester has a lower GHG scope than the partially bio-based option in the MSI.

That said, there have been a number of promising developments since the publication of the *Roadmap* in 2021. To name a few:

LanzaTech
Headquartered in the United States, LanzaTech captures and transforms carbon dioxide emissions into various materials including sustainable fuels, fabrics, and packaging. LanzaTech has three commercial plants in operation and has an additional six under development. Over the last several years, LanzaTech has announced collaborations with apparel and footwear brands lululemon, ON, and Zara, as well as Sumitomo Riko Company and Bridgestone.

Lenzing
Lenzing, an Austria-based specialty cellulose fiber producer, has developed a portfolio of next generation materials with lower impact. For example, Lenzing offers commercial scale TENCEL™ REFIBRA™ fibers containing 30 percent recycled cotton waste and 70 percent wood pulp, and also developed TENCEL™ lyocell fibers consisting of 20 percent hemp pulp and 80 percent wood pulp. A TENCEL™ limited edition denim collection containing this hemp / wood pulp fiber was developed with Candiani Denim in 2022. To reduce the downstream impacts of dyeing, Lenzing has developed dope-dyed TENCEL™ modal fibers with "Eco Color" technology which lowers energy use and GHG emissions. This innovation was extended to the denim category with dope-dyed fibers incorporating the indigo color known as TENCEL™ Modal Indigo fibers. Also, to advance post-consumer textile recycling, Lenzing has partnered with Swedish forestry company Södra and aims to process 25,000 tons of textile waste per year by 2025.

Natural Fiber Welding
MIRUM® is a 100 percent plant-based leather alternative that Natural Fiber Welding claims has a significantly lower GHG footprint than leather and synthetic leather alternatives such as polyurethane.[23] Brands such as Allbirds, Camper, and H&M are using MIRUM®.

Renewcell
In 2019, this Swedish company launched Circulose®, a branded dissolving pulp made from 100 percent cellulosic textile waste and used to create various MMCF fibers. In 2022, Renewcell started running a new 100 percent textile-to-textile recycling plant with a 60,000 tonnes per year production capacity, and it will increase this to 120,000 tonnes per year by 2023/24 and to 360,000 tonnes by 2030 given strong demand. Renewcell has several fiber producing partners including Sateri and Brila Cellulose, and entered into a multi-year offtake agreement with Lenzing in 2022. Brands including Filippa K, H&M, Levi's, and Zara have created products with Circulose®. H&M is also an investor in Renewcell.

US Cotton Trust Protocol
Launched[24] in 2020, the US Cotton Trust Protocol aims to bring quantifiable and verifiable goals and measurement to key sustainability metrics of US cotton production. In its second annual report (covering August 1, 2021 to July 31, 2022), the Trust Protocol reported a 25 percent reduction in energy use and 21 percent reduction in GHG emissions from its grower members. There are over 1 million acres of cotton product enrolled in the Trust Protocol, over 800 mill and manufacturer members, and over 40 brand members.

There are many other examples that we could highlight — we offer the above to illustrate innovations of different types that are moving to scale. For additional examples, see Fashion for Good's website.

23 Source: Natural Fiber Welding website (and LCA)
24 Source: US Cotton Trust Protocol

5. Efforts to Decarbonize the Apparel Sector

5.4 Maximize Energy Efficiency

As described in the *Roadmap*, there are opportunities to reduce energy consumption through efficiency across tiers 1 through 3, and the potential energy savings are facility — and process — dependent. For example, factories that have already invested in energy efficiency will have fewer opportunities for reductions, and certain processes such as dyeing may be more ripe for efficiency gains than others.

Reducing energy consumption should be the first step for companies, as this will reduce costs and the amount of energy that will be needed from lower carbon sources such as rooftop solar (less energy demand means fewer onsite solar or renewables from other sources). Given the cost savings, companies of all types and sizes are taking action on energy efficiency — we offer a few examples here to illustrate.

Arvind Mills
Through a variety of efficiency measures including installing new boilers and energy-efficient motors, implementing ISO50001 standards, capturing and reusing waste heat, and switching from incandescent light bulbs to LEDs, Arvind Mills reduced[25] total non-renewable energy use by 9 percent between 2016/17 and 2019/20 — despite a growth in units produced.

Elevate Textiles
With its approved science-based target, Elevate Textiles will reduce its scope 1 and 2 emissions by 46.2 percent on an absolute basis by 2030 (2019 base year), and it will reduce absolute scope 3 GHG emissions from fuel and energy related activities, purchased goods and services, and processing of sold products 46.2% within the same timeframe. Through investments in energy efficiency and renewable energy, Elevate Textiles has reduced its energy consumption 19 percent between 2016 and 2021, and total GHG emissions by 13 percent over the same period.[26]

Lenzing
Energy efficiency is a core element of Lenzing's strategy to meet its science-based climate change target, and the company takes measures including replacing inefficient pumps, optimizing current technologies, planning efficiently, and adhering to strict maintenance scheduling and immediately responding to malfunctions and leaks. Through such efforts, Lenzing has reduced its primary energy consumption from 43.1 million Gigajoules in 2014 to 42.45 million Gigajoules in 2021 — a reduction of 1.5 percent. Over the same period, Lenzing revenues increased 18 percent, thus decoupling energy consumption from business growth.[27]

TAL Apparel
Based on its modeling, TAL Apparel can reduce scope 1 and 2 emissions by 9% on an absolute basis by 2030 through simple energy efficiency measures and upgrading old equipment on a planned schedule. Such measures include upgrades to chillers, boilers, and air compressors, insulation, optimizing machine settings, and reusing waste heat. Since 2009, TAL has primarily used energy efficiency to improve its overall GHG intensity by 23% across its factories.[28]

BOX 5: CLEAN BY DESIGN: REDUCING COSTS AND GHG EMISSIONS

Created by the Natural Resources Defense Council in 2007, Clean by Design is an Aii program that is focused on scaling up energy, water, and chemicals efficiency in textiles manufacturing, including wet processors. The Clean by Design process consists of ten best practices, for example installing meters and detecting leaks, recovering heat from hot water, and improving insulation. In a 2021 study of 67 wet processing facilities that participated in Clean by Design, the average annual energy efficiency savings were 12.6 percent, average annual GHG emissions reduction 10.8 percent, and water savings 11.5 percent.[29]

5.5 Eliminate Coal in Manufacturing

Coal is a commonly used fuel in textile mills and other manufacturing facilities for thermal processes such as heating water for dyeing fabric and generating steam. Thermal energy is generally the majority share of energy consumed in textile mills — the balance from electricity.

As we described in the *Roadmap*, coal is valued as a fuel for thermal processes given its high heat content, abundance, and low cost relative to alternatives. Natural gas emits less CO_2 than coal, but it is not available or affordable in some countries. Biomass may produce fewer GHG emissions, but this depends on a variety of factors including the nature of the crop being used and the amount of carbon it sequesters before harvest.

Signatories to the UN Fashion Industry Charter have agreed to phase out coal from owned and supplier sites (tier 1 and 2 for brands, immediate sub-suppliers for manufacturers)

25 Source: Arvind Mills: Evaluating Our Progress
26 Source: Elevate Textiles 2022 sustainability report
27 Sources: Lenzing 2021 sustainability and annual reports, 2014 annual report
28 Source: Case study from TAL Apparel
29 Source: Case study by Planet Tracker and Aii

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as soon as possible and by no later than 2030, and no new coal power from January 2023. The UN Fashion Charter has a coal phase-out action group that is working together to evaluate fuel replacement strategies across shared suppliers.

Individual companies are taking action to shift away from coal in the value chain, for example:

Arvind Mills
In its 2019 sustainability report,[30] Arvind Mills reported that it had switched from coal to "renewable biomass" for 40 percent of its mills. It also described its use of waste cotton stalks for energy production, which reduces the use of coal in Arvind mills and reduces air pollution from the current practice of farmers dumping or burning cotton stalks in fields.

H&M Group
In support of its UN Fashion Charter commitment to phase out direct use of coal used in onsite boilers at supplier sites, H&M Group will not onboard any new suppliers from January 2022 if they have on-site coal boilers in their factories. The company is helping suppliers transition away from fossil fuels by investing directly in building renewable energy generation, such as solar thermal. In November 2022, H&M Group announced that it set an annual budget of around SEK 3 billion (roughly US$290 million) to decarbonize its value chain. In Indonesia, H&M Group collaborated with HSBC, WWF, and World Resources Institute on a project to address barriers to transitioning to biomass boilers. In Cambodia, H&M Group launched an app to trace boiler biomass feedstock.

Lenzing
Roughly 50 percent of all energy used by Lenzing comes from renewable sources. Lenzing's TENCEL™ lyocell fiber plants operate with low-carbon fuels such as natural gas and biomass, and Lenzing's Nanjing, China has embarked on a transformation to eliminate coal and move towards 100 percent natural gas — which will reduce the facility's GHG emissions by roughly half.

lululemon
As a signatory to the UN Fashion Charter, lululemon is working to phase out direct use of coal used in onsite boilers at supplier sites. In addition to being part of the UN Fashion Charter Coal Phase-Out Action Group, lululemon was part of a coal phase-out working group led by Aii and RESET Carbon. The goal was to better understand the technological feasibility of direct onsite coal phase-out including identified pathways for minimizing and eventually eliminating coal usage from manufacturers' operations. The group focused on Vietnam to start and completed a full supplier analysis to identify the top 20 coal consumers within Vietnam. The group then conducted interviews and administered a questionnaire to the top 20 sites to study boiler performance and technological feasibility. The result was the creation of a feasibility assessment tool to identify the heat demand required for the manufacturing process and identify applicable low-carbon fuel or thermal technology alternatives. The tool also was supported by a pathways logic model that considered production activities and the capacity, age, and efficiency of the boiler to determine the best plan for the facility's transition.

Nike
At the end of its fiscal year 2021, all tier 1 finished goods suppliers in Nike's extended supply chain eliminated direct use of coal by focusing on removing, optimizing, or decentralizing centralized steam boilers. This contributed to a 10% reduction in energy use per pair of footwear manufactured between 2015 and 2020.

As a signatory to the UN Fashion Charter, Nike also has a goal to eliminate coal from tier 2 materials suppliers by 2030. In fiscal year 2021, Nike joined an initiative with Aii and seven other brands working pre-competitively to explore collaboration to eliminate coal from tier 2 materials suppliers. Currently, nearly all tier 2 materials suppliers in Nike's extended supply chain have coal elimination plans in place.

BOX 6: RESEARCH ON ELECTRIFYING THERMAL PROCESSES

In 2022, Global Efficiency Intelligence published a techno-economic analysis[31] of electrifying thermal processes in the textile industry in China, Japan, and Taiwan. The authors found that electrification can substantially reduce total annual energy demand in the textile industry in these three countries under four electrification technology pathways: industrial heat pumps, electric steam boilers, electric thermal oil boilers, and electric processing equipment.

To illustrate, deploying industrial heat pumps in textile wet-processing plants at full scale (100 percent) could reduce the fuel used in the textile sector in those countries by around one-third. The resulting GHG benefits are dependent on the emissions intensity of the electricity grid. For example, in China, 100 percent adoption of electric steam boilers and industrial heat pumps would reduce GHG emissions by 29.8 and 24.9 million tonnes per year.

30 Source; Arvind Mills 2019 Sustainability Report
31 Source: Global Efficiency Intelligence Techno-Economic Analysis

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5.6 Shift to 100 Percent Renewable Electricity

In addition to transitioning away from coal for thermal energy consumption, companies across the value chain will need to shift to 100 percent renewable electricity for the sector to deliver on SBTs. Looking at the supply chain of brands (given this is where the vast majority of emissions exist), the breakdown of energy between thermal and electricity varies by tier. Tier 3 energy is nearly all electricity, tier 2 is mostly thermal, and tier 1 is mostly electricity.

BOX 7: FUNDING THE TRANSITION TO RENEWABLE ENERGY IN EMERGING MARKETS

In November 2022, a number of wealthy countries announced[32] the Just Transition Energy Partnership (JTEP) with Indonesia to support the latter's efforts to transition its power sector to renewable energy and reduce GHG emissions in line with a 1.5°C trajectory. Through JTEP, Indonesia will work to cap power sector emissions at 290 megatons of CO_2 in 2030, down from a baseline value of 357 MT CO_2. It will also accelerate the deployment of renewable energy so that renewables comprise at least 34 percent of all power generation by 2030 (roughly double the current plans). To achieve these targets, JTEP will mobilize an initial US$20 billion in public and private financing over a three-to-five-year period.

In December, the Group of Seven (G7) industrialized nations announced they would provide US$15.5 billion in public and private finance to help Vietnam transition away from coal. The deal will help Vietnam peak its GHG emissions by 2030 (compared with a previous 2035 projection), limit peak coal capacity to 30.2 gigawatts (GW) (versus a planned 37 GW), and source 47 percent of its electricity from renewable energy by 2030.

These investments will help reduce the GHG emissions intensity of the electricity grids in Vietnam and Indonesia, which are key manufacturing countries — Vietnam is the second largest exporter of textiles (US$38.91 billion in 2020) while Indonesia is amongst the top 15 (US$11.94 billion).

Signatories to the UN Fashion Industry Charter have committed to source 100 percent of their electricity from renewable sources (with minimal other environmental or social impacts) for owned and operated emissions by 2030. Signatories also commit to developing and implementing climate policy advocacy plans that promote the adoption of renewable energy.

Individual companies are taking action to shift towards 100 percent renewable energy, for example:

Arvind Mills
Between 2016/17 and 2019/20, Arvind increased its use of renewable electricity by 3.6 times (to 115,069 MWh in the latter period). Arvind has 22 MW of solar generation capacity across its operations, which includes a 16 MW array at Arvind's Santej facility in Gujurat, India — which is the country's largest rooftop solar installation at a single location. This investment in renewable energy has helped Arvind reduce direct GHG emissions by nearly 14 percent and indirect GHG emissions by 15 percent between 2014/15 and 2018/19.[33]

Lenzing
Shifting to renewable energy for production facilities is a key pillar in Lenzing's drive to decarbonize and meet its science-based target. As of 2022, six Lenzing production facilities are powered by 100 percent renewable electricity from the grid, and the company has inaugurated its first onsite solar photovoltaic plant in Lenzing, Austria that generated 5,500 megawatt hours per year in 2022. In addition, four more projects are in development that will add 7 MW peak PV power to Lenzing in 2023.

lululemon
In 2021, lululemon signed a 10-year virtual power purchase agreement (VPPA) with Enel Green Power, a developer and long-term owner and operator of renewable energy plants, that will allow lululemon to use 100 percent renewable energy in its owned and operated facilities in North America. lululemon is also working to increase the use of renewable energy in its supply chain. For example the company has partnered with the Clean Energy Investment Accelerator (CEIA) and Aii to create tools and resources to support renewable energy adoption in Vietnam and across the apparel supply chain. lululemon is also working to establish manufacturing renewable energy goals in collaboration with our suppliers.

H&M Group
In 2021, 95 percent of the electricity used in H&M's operations came from renewable sources, and the company is committed to reaching 100 percent by 2030. H&M Group has signed power purchase agreements (PPAs) for several solar parks located in the UK and Spain, and in 2022, signed Sweden's largest solar PPA. In total, H&M Group

32 Source: G7 nations to provide Vietnam with $15.5 bln to cut coal use
33 Source: Arvind 2019 sustainability report

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has secured a capacity of 200 MW of renewable electricity, which will result in an indicative annual output of 300 GWh.

H&M Group also aims to have 100 percent renewable electricity in its supply chain by 2030. To meet this objective, the company engages with policy makers in key production markets to enable the build-out of renewable electricity through PPAs where these are not available. H&M Group also supports suppliers with direct investments in on-site solar PV and guidance on how to source renewable electricity in relevant markets.

Nike

Nike has a 2025 target to reach 100 percent renewable energy for its owned and operated facilities. In fiscal year 2022, Nike met 93 percent of these energy needs with renewable energy through its use of PPAs and various onsite solar projects. For example, in Greater China, Nike expanded onsite renewable electricity coverage at its logistics center adding new wind turbines to the existing rooftop solar power. Nike expects this will produce 14,000 MWh per year helping the facility reach 100 percent renewable electricity coverage.

Nike is increasing renewable energy use in its extended supply chain. For example, since 2019, it has offered an onsite solar PV consulting program to suppliers in key markets. Since the program started, 190 MW of rooftop solar has been contracted at 64 facilities. Nike is also working to support suppliers to procure offsite renewable electricity. In fiscal year 2022, Nike worked with local suppliers and Indonesia's state-owned electricity company to facilitate a bundled Renewable Energy Certificate (REC) agreement. Suppliers have access to verified and traceable renewable electricity at a competitive, fixed price for ten to fifteen years. The REC will help suppliers in Indonesia reduce electricity emissions by more than 55 percent.

BOX 8: COLLECTIVE ACTION ON RENEWABLE ENERGY: CLEAN ENERGY INVESTMENT ACCELERATOR

Jointly led by Allotrope Partners, World Resources Institute, and the U.S. National Renewable Energy Laboratory, the Clean Energy Investment Accelerator[34] works to unlock clean energy investment across commercial and industrial sectors in target countries (Vietnam, Indonesia, the Philippines, Mexico, and Colombia).

In 2021, CEIA supported five apparel manufacturers for three major global brands to solicit proposals for rooftop solar on eight manufacturing facilities across Vietnam. The winning bids offered discounts between 8 to 20 percent compared to existing electricity retail tariffs. A similar RFP issued by CEIA, Aii, and IDH is assisting nine apparel manufacturers from six brands, and has received proposals with discounts ranging from 10 to 44 percent.

BOX 9: COLLECTIVE ACTION ON POLICY

The ability for companies to access a sufficient and consistent supply of renewable energy varies by country, and can present hurdles to companies meeting their GHG reduction goals. In a number of countries, the construct of a PPA allows companies to access larger volumes of renewable energy. For example, in 2021, lululemon signed a virtual PPA to reach 100 percent renewable energy for its North American operations, with the power coming from wind farms in Texas. Companies including Nike, VF Corporation, and others have done similar deals.

To date, Vietnam — a key apparel and footwear manufacturing country — has not had a PPA option given the nature of its electricity system. Yet, in part through apparel industry engagement[35] with policy makers over recent years, Vietnam will be testing a direct PPA scheme — likely in 2023. This pilot, for 1,000 MW, will hopefully create a pathway for manufacturers to access greater volumes of renewable energy in the country.

For Asia Pacific more broadly, in November 2022, roughly a dozen companies including Amazon, Apple, Nike, and Samsung joined together to create the Asia Clean Energy Coalition,[36] which aims to help policymakers, utilities, and energy regulators innovate and deploy cost effective clean technologies across the Asia-Pacific region.

34 Source: Clean Energy Investment Accelerator
35 Sourcing Journal, *Renewable Energy Would Give Vietnam 'Competitive' Sourcing Advantage, H&M and Nike Say*
36 Source: ACEC launches to rapidly drive corporate clean energy procurement in Asia

6. Call to Action and Next Steps

While apparel sector emissions increased slightly from 2019 to 2021, momentum to address climate change continues to build across the sector. Companies understand the imperative to set bold, science-based targets and are taking action to reduce emissions. Companies such as those cited in this report are taking action individually and collectively through organizations including Aii, the SAC, Textile Exchange, the UN Fashion Charter.

In addition to providing a refreshed update of sector emissions, the purpose of this report is to share concrete actions that companies and the sector are taking to reduce GHG emissions across the value chain. We encourage companies reading this report to evaluate what they can do to reduce their climate impacts across the six interventions shared above:

1. **Look for opportunities to maximize material efficiency**, in the process reducing waste of all kinds, including carbon.
2. **Increase the use of sustainable materials and practices** — Textile Exchange has deep expertise and a variety of resources and tools to support companies in this transition.
3. **Explore and invest in the development of innovative materials** — such materials are becoming more readily available.
4. **Maximize energy efficiency** — particularly in the supply chain. Programs such as Aii's mill efficiency program are proven to reduce energy and emissions and are readily deployed.
5. **Eliminate coal in manufacturing** — this will be a big challenge, but the growing number of companies committing to coal phase out will help stimulate lower carbon alternatives.
6. **Shift to 100 percent renewable electricity** — in your own operations, and engage your suppliers to make the shift as well. This too will be a challenge, but consider joining the growing number of companies that are engaging policy makers in countries such as Vietnam to develop more favorable regulatory landscapes for renewable energy.

Aii will update the GHG analysis on an annual basis using a similar approach and data sources (Worldly, SAC, and Textile Exchange). As we did with revising the fiber allocation assumptions for this report, we will continue to refine the underlying data so that our estimate improves over time. We presented a number of ways to do this in the *Roadmap to Net Zero*, for example using sources of primary data such as the Higg Facility Environmental Module. We recognize that stakeholders want a definitive data point for apparel sector emissions, but as we described in the *Roadmap*, our estimate — which we believe to be a reasonable estimate — should be viewed as directional given gaps in data availability and quality.

We will also continue to track and share examples of leading practice so that companies just starting on their decarbonization journeys will see that there are concrete actions they can take in the near term. We expect to see a continued increase in such companies given the drive towards SBT commitments and action through organizations such as the SAC and UN Fashion Industry Charter for Climate Action.

We welcome feedback on this report, including recommendations on how we can further improve the data and additional examples of leading practice. Please contact us at info@apparelimpact.org to share your thoughts.