SUSTAINABLE ENERGY FOR ALL

THREADS OF TRANSFORMATION

FASHION, ENERGY & WOMEN AT THE INTERSECTION OF CLIMATE ACTION

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Acronyms

AI	Artificial Intelligence
CO_2	Carbon dioxide
CO2e	Carbon dioxide equivalent
°C	Celsius
CDP	Carbon Disclosure Project
DPP	Digital Product Passport
ESG	Environmental, Social & Governance
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse gas
H&M	Hennes & Mauritz
IFC	International Finance Corporation
ILO	International Labour Organization
IT	Information Technology
kcal	Kilocalories
kg	Kilogram
kWh	Kilowatt hours
KPI	Key Performance Indicator
LEED	Leadership in Energy and Environmental Design
LCA	Life Cycle Assessment
LMICs	Low- and Middle-Income Countries
MEPS	Minimum Energy Performance Standards
NCAP	National Cooling Action Plan
NGO	Non-governmental organization
PV	Photovoltaic
PPP	Public-private partnership
R&D	Research & Development
RBF	Results-based financing
SEforALL	Sustainable Energy for All
STEM	Science, Technology, Engineering and Mathematics
SME	Small and Medium-sized Enterprise
SDG	Sustainable Development Goal
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USD	United States Dollar
WHO	World Health Organization

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Executive Summary

The pursuit of Sustainable Development Goal (SDG) 7 (access to affordable, reliable, sustainable and modern energy for all) and SDG5 (achieve gender equality and empower all women and girls) are fundamental to driving economic growth, social inclusion and environmental sustainability.

Despite progress, as of 2022, 685 million people globally, primarily in low- and middle-income countries (LMICs), and heavily concentrated in Sub-Saharan Africa, remained without access to electricity.[1] UN Women estimates that if current trends continue, 341 million women and girls will lack electricity by 2030, 85 percent of them in Sub-Saharan Africa.[2] Understanding progress made towards advancing SDG7 and SDG5 requires a comprehensive look at the ecosystems and supply chains in which energy operates and the gendered implications therein.

The fashion industry, valued at USD 1.7 trillion and contributing about 2 percent of global Gross Domestic Product (GDP), employs more than 300 million people along its global value chain.[3] While the industry drives economic opportunity, serves as an expression of culture and demonstrates an interconnected globalized world, it also contributes heavily to environmental degradation. The resource-, energy- and labour-intensive supply chain means that the industry, particularly the fast fashion industry, is responsible for an estimated 2-8 percent of global carbon emissions and nearly 20 percent of global wastewater.[4] Women, who make up a substantial portion of the industry's workforce (approximately 60 percent),[5] are disproportionately affected by these environmental impacts, facing challenges such as limited access to resources, low earnings and vulnerability to climate-related events.

The interconnected challenges of energy poverty, climate change and gender inequality require integrated, sustainable solutions. By transitioning to renewable energy sources, reducing waste and mitigating climate impacts, the fashion industry can drive significant progress toward multiple SDGs—including SDG5 (gender equality), SDG7 (affordable and clean energy), SDG8 (decent work and economic growth), SDG12 (responsible consumption and production) and SDG13 (climate action). By empowering women—who are essential to the industry's operations—and ensuring equitable access to sustainable energy, the fashion industry can shift towards a model that promotes both economic growth and environmental resilience, ultimately paving the way for a more equitable and sustainable future.

Threads of Transformation: Fashion, Energy & Women at the Intersection of Climate Action highlights the interconnected challenges and opportunities for the fashion sector to capitalize on to transition to a sustainable future.

Environmental Impacts of the Fashion Industry

The fashion industry is characterized by complex supply chains, intensive production and manufacturing processes, and significant demand on natural resources. As a result, it contributes significantly to environmental degradation, including air and water pollution, greenhouse gas (GHG) emissions and textile waste. The fast fashion business model exacerbates these challenges, relying on unsustainable practices like the high-water

consumption rates of excessive raw material usage and agricultural cultivation, including cotton, and a reliance on fossil fuels consumed in the use of synthetic fabrics. If the status quo continues within the industry, it is predicted that by 2030, GHG emissions will increase by more than 60 percent and nearly 73 percent of textiles will be made from fossil fuels.[6]

Practices in the fashion industry are resulting in water scarcity, resource depletion and rising carbon emissions, with the industry generating approximately 92 million tonnes of waste annually and using up 4 percent of global freshwater. These challenges are particularly impactful in regions already facing water and natural resource scarcity.[7] The combined impact of these environmental challenges underscores the urgent need for systemic changes across the entire supply chain, coupled with robust policy interventions and enhanced partnerships, to transform the fashion sector into a model of sustainability and resilience.

Sustainable practices and policy interventions across the entire supply chain are essential for mitigating environmental harm and addressing the social inequities that have long plagued the fashion industry. Adopting circular business models, which have the potential to increase their market share from 3.5 percent to 23 percent of the global fashion market by 2030,[8] using alternative fibres and natural materials, and investing in new technologies can lower the sector's environmental impact. The UN Framework Convention on Climate Change (UNFCCC)'s *Fashion Industry Charter for Climate Action* represents international action towards collective commitment within the fashion sector to significantly reduce GHG emissions.

Recommendations for stemming the environmental impact of the fashion industry:

- Strengthen environmental conservation practices by implementing stringent water stewardship regulations, promoting water-saving technologies, transitioning to the use of sustainable raw materials and fibres, and encouraging regenerative agricultural practices.
- Enhance fashion supply chain transparency and accountability through mandatory reporting standards on environmental impact and labour practices, and adherence to internationally recognized traceability frameworks.
- Promote circular fashion models by investing in recycling technologies, incentivizing textile reuse and upcycling, and educating consumers on these alternatives.
- Drive sustainable consumption through consumer education via public awareness campaigns, social marketing strategies, and standardizing labelling systems that communicate the environmental and social impacts of garments.

Fashion's Renewable Energy Imperative

The fashion industry is energy-intensive, consuming approximately one trillion kilowatt hours (kWh) of electricity annually, equivalent to a quarter of electricity consumption in the US in 2023.[9] This massive energy demand is exacerbated by the fast fashion business model, which depends on rapid production cycles accounting for 15-30 percent of energy costs and typically relies on inefficient, fossil fuel-based energy sources.[10] Adding to the complexity, most major fashion brands currently lack public renewable energy targets for their supply chains and transparency in energy procurement. Moreover, the industry's global supply chain relies heavily on LMICs that produce 90 percent of the world's clothing.[11] Many of these countries face challenges with grid access and reliability, which are critical for the energy-intensive processes in garment manufacturing. These issues are further compounded when countries attempt to integrate renewable energy sources, which often require stable grid infrastructure and innovative technologies to support variable generation from, for example, solar and wind.[12] Limited investment in grid modernization, storage systems and technologies in LMICs creates additional barriers in deploying large-scale renewable energy solutions along the fashion supply chain.[13]

Despite these challenges, transitioning to renewables is crucial to achieve the SDGs. Considering that energy costs can account for up to 25 percent of operational expenses,[14] the declining costs of renewable energy offer long-term potential savings. Implementing sustainability measures to reduce emissions from Tier 2 productions processes, which include fabric production, dyeing and finishing, and accounting for 40-70 percent of Scope 3 emissions,[15] has been found to be cost-neutral,[16] leading to simultaneous reductions in both emissions and operational expenses. Beyond cost savings, renewable energy sources offer significant environmental benefits, enhance energy diversification, security and system stability, and reduce reliance on fossil fuels.

Empowering women-led small and medium-sized enterprises (SMEs) is pivotal to accelerating the energy transition across the fashion industry. Women-led SMEs account for 90 percent of businesses within Africa's fashion sector, and renewable energy access can significantly enhance the productivity and economic gains

of these enterprises. There is a critical opportunity to catalyze inclusive economic growth and gender equality by integrating renewable energy solutions into the value chains of women-led SMEs across the continent.[17]

Beyond the economic benefits of renewable energy integration, empowering women in the renewable energy sector contributes to broader societal gains. Women in leadership roles within energy enterprises have been associated with enhanced innovation, better financial performance and more effective risk management. Moreover, women's involvement in energy decision-making processes leads to more inclusive and sustainable energy solutions.[18]

To effectively drive the energy transition within the fashion industry, it is essential to support and empower women-led SMEs. This includes providing access to financing, technical training and leadership opportunities, thereby ensuring that women can fully participate in and benefit from the shift towards renewable energy.

Recommendations for powering the energy transition within the fashion industry:

- Promote renewable energy adoption in the fashion industry by offering targeted financial incentives, establishing robust energy efficiency standards and fostering public-private partnerships (PPPs) for green infrastructure.
- Invest in innovation and training for sustainable fashion by funding research & development (R&D) into sustainable materials and production, the development and deployment of energy-efficient machinery, supporting women-led innovation, and developing educational curricula focused on green skills and clean energy technologies.
- Invest in renewable energy solutions for women entrepreneurs, particularly in LMICs, by scaling targeted interventions that provide reliable and affordable clean energy, offering financial incentives like concessional loans and capacity-building, and developing innovative investment strategies for women-led SMEs.

Gender at the Intersection of Fashion, Climate & Energy

Women disproportionately bear the burden of climate impacts and limited energy access, while simultaneously comprising the majority of the fashion industry's workforce. In Africa, women have historically been central to fashion and textile production and consumption. For example, women workers make up nearly 80 percent of Ethiopia's apparel industry and 80 percent of Lesotho's ready-made apparel sector.[19] For many women in the region, manufacturing jobs are the primary alternative to working in small-scale agriculture.

Women encounter low wages, poor working conditions and environmental hazards from textile production and waste. Complex supply chains, in which production is often shifted to countries with weaker regulations, obscure responsibility for labour abuses and environmental damage, disproportionately affecting women in LMICs. This disparity is compounded by structural barriers that minimize women's influence over the industry's direction. Women are often concentrated in low- or zero-income, informal roles like cooking, sewing and childcare, while men tend to occupy technical and better paid positions.[20] Despite representing 70-80 percent of global consumer spending in fashion, only

14 percent of major fashion brands have female executives.[21] Similarly, women remain underrepresented across the energy sector: they make up just 22 percent of the traditional energy workforce, 32 percent in renewables, only 10 percent of energy sector start-up founders, and hold just 19 percent of senior management roles. There exists a clear pattern of segregation into non-technical roles and limited access to higher-paying, leadership positions.[22]

In fashion production regions, climate change and energy access inequalities further burden women workers and entrepreneurs, hindering productivity and economic empowerment while increasing climate vulnerabilities. Environmental degradation and limited access to modern energy services frequently disrupt women's work where production relies on manual processes and inconsistent power supply. These challenges reduce productivity and expose women to risks to health and safety from air pollution and extreme temperatures.[23] Addressing gender disparities is crucial for creating a more equitable and sustainable fashion transition.

Recommendations for addressing the gendered impacts of the fashion industry:

- Integrate gender-responsive approaches into climate and energy policies by mandating the collection of gender-disaggregated data, incorporating gender-specific impact analyses into policy formulation and ensuring women's active participation in decision-making processes.
- Enhance gender equality in the fashion sector by enacting and enforcing legislation for equal pay and workplace safety, investing in comprehensive capacity-building programmes for women's leadership and sustainability, establishing quotas or targets for women in executive roles, and creating pathways for women to transition from informal to formal employment.
- Embed women's reskilling and upskilling in green skills programmes to ensure they can participate in and fully benefit from the transition towards renewable energy and energy-efficient technologies within the evolving fashion industry.

1 Introduction

The pursuit of Sustainable Development Goal (SDG) 7 (access to affordable, reliable, sustainable and modern energy for all) and SDG5 (achieve gender equality and empower all women and girls) are fundamental to driving economic growth, social inclusion and environmental sustainability.[24]

Despite progress, as of 2022, 685 million people globally, primarily in low- and middle-income countries (LMICs), and heavily concentrated in Sub-Saharan Africa, remained without access to electricity.[25] UN Women estimates that if current trends continue, 341 million women and girls will lack electricity by 2030, 85 percent of them in Sub-Saharan Africa.[26] This energy access gap significantly impedes progress in other key development areas such as education, health, decent work and gender equality, directly linking the global push for sustainable energy to the fight against climate change and pursuit of economic equity.

The fashion industry serves as a compelling case study for the urgent need to transition to clean energy. The USD 1.7 trillion industry employs more than 300 million people along its value chain worldwide,[27] which includes agriculture and fibre production, manufacturing, and retail, and is both a driver of economic opportunity and a significant contributor to environmental degradation.

Rapid growth in global clothing consumption and the rise of fast fashion have transformed the fashion industry, with consumers now buying over 80 billion new garments annually—a fourfold increase over the past two decades.[28] Economically, the fashion industry represents roughly 2 percent of global Gross Domestic Product (GDP) as of early 2025 and is projected to reach a value of USD 3 trillion by 2030.[29] This growth is reflected in the industry's projected Compound Annual Growth Rate of 5.5 percent between 2020 and 2050, outpacing many other industries.[30]

Yet, while the economic opportunity is evident, the industry's complex supply chain consumes vast amounts of water, chemicals and energy. Its energy-intensive production processes alone account for approximately 10 percent of global carbon emissions—exceeding the combined emissions of aviation and maritime shipping—and nearly 20 percent of global wastewater is generated by the sector.[31] The wider emissions of the fashion industry, including production, manufacturing, transportation, consumer use and disposal, are estimated to be between 2 and 8 percent of total global carbon emissions; it is difficult to pinpoint an exact percentage given complexities in the supply chain, methodologies in measuring and limited transparency in reporting.[32] As the industry's greenhouse gas (GHG) emissions are projected to increase by more than 60 percent by 2030, the urgency to adopt sustainable practices is clear.[33]

These impacts are not distributed equally along economic or social lines. Among the major consumer markets, China, Germany, Japan, the UK and the US, the economic benefits of consumption outweigh the disparities of production. For instance, in the US, the largest

fashion consumer with an industry valued at approximately USD 358.70 billion,[34] the average consumer purchases new clothing every 5.5 days.[35] Yet, many LMICs—particularly in Sub-Saharan Africa—are the primary sites of production, producing 90 percent of the world's clothing.[36] There, garment assembly consumes vast amounts of raw materials and limited access to reliable electricity severely restricts local manufacturing capabilities, compelling reliance on imported finished goods.

In sharp contrast to the US, the entire garment and shoe industry in Sub-Saharan Africa is valued at USD 31 billion, with the leading manufacturers being Ethiopia, Kenya, Lesotho, Madagascar, Mauritius and Swaziland.[37] The African continent exports raw materials worth USD 15.5 billion annually, primarily to be processed and manufactured elsewhere. Paradoxically, African countries then import finished textiles, clothing and footwear (valued at USD 23.1 billion each year).[38] This trade imbalance highlights the challenges faced by LMICs in capturing value within the global supply chain, one in which despite their significant contributions to production, high-income countries reap most of the economic benefits.

In terms of its social impact, the fashion industry is a labour-intensive sector, creating employment opportunities across all stages of its supply chain.[39] According to the International Labour Organization (ILO), approximately 94 million people worldwide are employed in the garment sector.[40] However, the complex global supply chain and informal aspects of the fashion sector make it difficult to grasp the total size of the workforce. The Ellen MacArthur Foundation has the highest estimates, finding that the clothing industry employs more than 300 million people along the value chain, including in its design, distribution and retail divisions.[41] Estimates that include farming, processing, treating, finishing and logistics contributions to the fashion industry find the worldwide workforce to total 430 million people, largely based in Asia.[42]

Notably, less than 2 percent of the industry's approximately 75 million factory workers worldwide earn a living wage,[43] with garment workers experiencing unsafe conditions, labour exploitation, discrimination and gender-based harassment or violence, and wage theft. These conditions are exacerbated by the fast fashion supply chain, which prioritizes maximum efficiency and speed for profits to the detriment of its workers.[44]

Women, primarily those aged 18-35, form the backbone of the fashion industry's workforce, comprising

over 60 percent of all garment workers globally, with this figure rising to nearly 80 percent in Bangladesh and Cambodia.[45] Approximately 42 million women are employed in the garment sector across Asia, holding positions across the entire value chain including in design, manufacturing and retail.[46]

Despite making up the majority of the fashion industry's workforce, women are disproportionately concentrated in low-wage, informal roles. Gender disparities remain; women earn less than men on average and are underrepresented in supervisory and management positions in proportion to their share of total employment in the sector.[47] In many LMICs, women engage in informal, energy-intensive activities such as tailoring, embroidery and dyeing—sectors that not only demand substantial energy but also contribute disproportionately to negative health impacts and environmental degradation.

The situation of fashion industry workers is even more precarious for those in informal employment—or those whose economic activities, enterprises and jobs are neither regulated nor protected by the state, including home-based workers.[48] In Sub-Saharan Africa, the fashion industry's informal workforce is particularly significant, with women constituting 70-80 percent of the workers.[49] Many workers in the informal sector earn low wages, have few or no legal protections, experience limited opportunities for advancement or further education, and face issues presented by infrastructure, including housing, electricity and transportation.[50] However, despite the fashion industry's dependence on women's participation, and also because of it, women in the industry disproportionately face numerous barriers, chief among them inequitable access to reliable, affordable and sustainable energy.

The interconnected challenges of energy poverty, climate change and gender inequality require integrated, sustainable solutions. By transitioning to renewable energy sources, reducing waste and mitigating climate impacts, the fashion industry can drive significant progress toward multiple SDGs—including SDG5 (gender equality), SDG7 (affordable and clean energy), SDG8 (decent work and economic growth), SDG12 (responsible consumption and production), and SDG13 (climate action). By empowering women—who are essential to the industry's operations—and ensuring equitable access to sustainable energy, the fashion industry can shift towards a model that promotes both economic growth and environmental resilience, ultimately paving the way for a more equitable and sustainable future.

2 Environmental Impact of the Fashion Industry

The environmental impact of the fashion industry is significant and multifaceted, with far-reaching consequences for climate change, water resources and waste generation.

This impact disproportionately affects women, who make up the majority of the industry's workforce and are often disproportionately affected by climate-related disruptions.[51] By some estimates, fashion sector greenhouse gas (GHG) emissions are expected to rise by more than 60 percent by 2030, largely due to energy- and resource-intensive production processes and complex supply chains.[52]

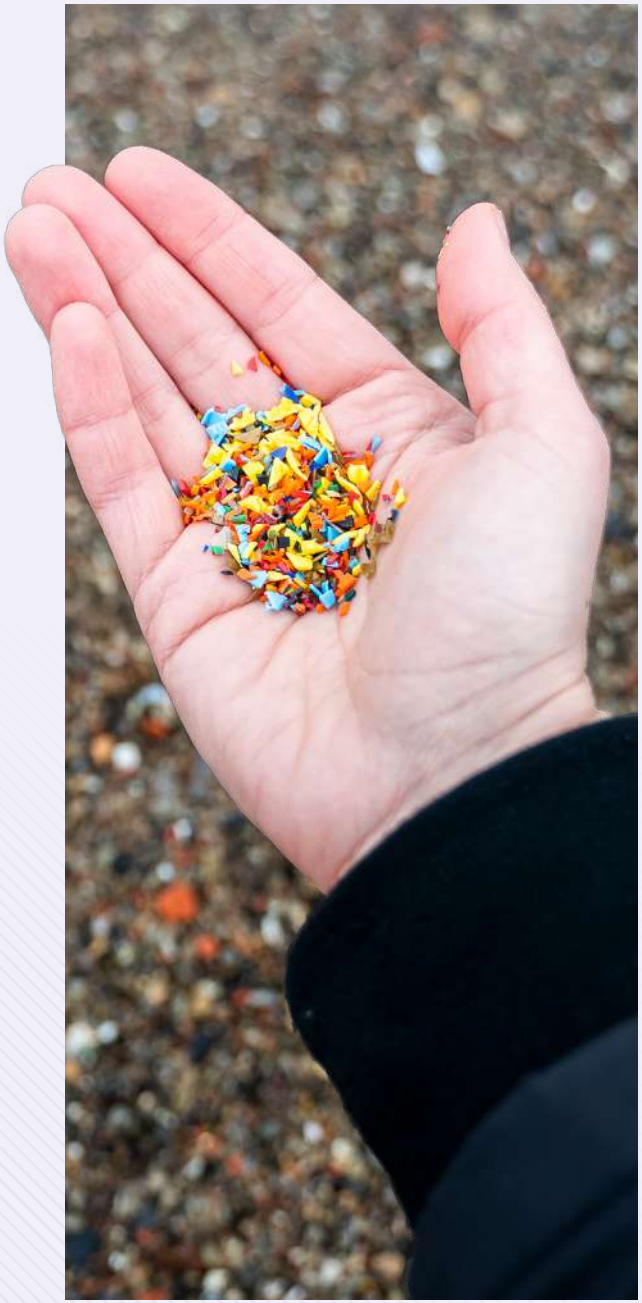
The Environmental Cost of Production

The first facet of the fashion industry's complex global supply chain is textile production, the process by which both natural and synthetic fibres are made. The growing demand for clothing, fuelled by the fast fashion business model, requires a continuous throughput of natural resources. Nearly 90 percent of clothing is made from either cotton or polyester, with the production of both linked to significant impacts on health and the environment.[53]

The production of cotton is both a significant source of employment, providing income for over 250 million people worldwide and employing nearly 7 percent of all labour in developing countries,[54] and a source of environmental stress, occupying 2.5 percent of the world's arable land.[55] Cotton requires large amounts of water and pesticides to grow. Producing just one cotton t-shirt requires the equivalent of 5,400 standard 500 ml bottles of water, enough to meet the daily drinking needs of 1,600 people, and producing a pair of jeans requires 16,000 standard 500 ml bottles of water, enough to meet the daily drinking needs of 4,750 people.[56]

Additionally, more chemical pesticides are used to grow cotton than any other crop. The production of cotton consumes an estimated 200,000 tonnes of pesticides (16 percent of global use) and 8 million tonnes of fertilizers (4 percent of global use) annually, both of which can contaminate nearby water bodies.[57]Cotton production also releases fine particulate matter, a major form of air pollution that negatively impacts both the environment and human health.[58] These pollutants contribute to respiratory diseases, cardiovascular problems and premature deaths, particularly in areas where air quality is already poor.

Moreover, recent years have seen an exponential increase in the use of synthetic fibres, with polyester now surpassing cotton as the most widely used fabric in fashion.[59] One reason for this is the effect of climate change on the availability and quality of raw materials essential for fashion production. Cotton is highly susceptible to changes in water availability and temperature. Droughts and floods in major cotton-producing regions, such as China, India and the US, disrupt planting and harvesting cycles, leading to supply shortages and increased prices.[60] By contrast, synthetic fibres like poly-



ester or nylon do not require water for growth, although water is used in their production processes. However, the carbon emissions associated with synthetics are significantly higher than those from cotton, as synthetics are derived from fossil fuels such as unrefined petroleum products. Estimates place the production of one polyester t-shirt at around 5.5 kilograms (kg) of carbon dioxide equivalent (CO_2e) emitted, compared to 2.1 kg of CO_2e for a cotton t-shirt.[61]

Synthetic fibres are a major contributor to the fashion industry's reliance on fossil fuels, accounting for 1.35 percent of global oil consumption, which is higher than Spain's annual oil use. Estimates find that if this trend continues, nearly 73 percent of textiles will be made from fossil fuels by 2030, with the primary fibre being polyester.[62] These numbers are difficult to accurately pinpoint as only one-third of brands disclose their annual fibre mix breakdown, obscuring their environmental impact. These production processes place a significant strain on the environment, driving degradation to keep up with the demand for fast fashion.

Water Consumption & Pollution

Water usage is a critical concern in the fashion industry, which is the second-largest consuming industry of water globally.[63] The scale of this consumption is staggering: in 2015, the industry used 79 billion cubic metres of water (enough water to fill 32 million Olympic-sized swimming pools), with an average of 200 tonnes of water used to produce one tonne of textiles.[64] In 2019, the fashion industry's annual water usage increased to 93 billion cubic metres (equivalent to 37 million Olympic-sized swimming pools), enough to meet the daily needs of five million people. This increase is attributed, in part, to the growing fast fashion business model, which saw clothing production double between 2000 and 2014.[65]

Most of the industry's water usage is associated with cotton cultivation and wet processes in manufacturing, such as bleaching, dyeing, printing and finishing. Annually, textile production uses an estimated 44 trillion litres of water for irrigation, about 3 percent of global irrigation water use, with 96 percent of this attributed to cotton.[66]

The fashion industry is responsible for 20 percent of global industrial wastewater, primarily due to harmful textile treatment and dyeing processes.[67] The production of textiles involves the use of around 8,000 synthetic chemicals, many of which are toxic—such as heavy metals, azo dyes and formaldehyde.[68] These chemicals are often discharged directly into rivers in textile hubs like Bangladesh, India and parts of East Africa, areas with already fragile ecosystems due to climate crises and natural disasters, further exacerbating biodiversity issues.

Further, the industry's water consumption exacerbates challenges in regions already facing water scarcity. The sector's excessive water usage has severe implications for freshwater resources, representing 4 percent of global freshwater depletion, particularly in regions already facing water scarcity.[69] In China, 80 to 90 percent of fabric, yarn and plastic-based fibres are made in water-scarce or water-stressed regions.[70] Further, in drought-prone areas like India's Punjab region and Uzbekistan, excessive water use for cotton farming has led to the depletion of rivers and underground aquifers.[71]

Local communities often bear the brunt of these consequences, as water used in textile production limits its availability for their essential needs.

Another cause for alarm is the release of microfibres and microplastic contamination, which further contribute to water pollution, having impacts on both environmental and human health. Synthetic fabrics like polyester, acrylic and nylon make up 60 percent of global clothing production and are a significant source of microplastic contamination. With each wash, these fabrics shed microplastics—tiny particles less than 5mm in size—into water systems. Washing clothes causes around 500,000 tonnes of plastic microfibres to be released into the ocean annually.[72] Approximately 35 percent of microfibre pollutions in oceans are estimated to originate from washing clothes.[73]

These microplastics accumulate in marine environments, harm aquatic organisms and eventually enter human food chains. If current trends continue, it is estimated that between 2015 and 2050, more than 22 million tonnes of plastic microfibres could enter the ocean.[74] Concerns about the health impacts of microplastic ingestion, including endocrine disruption, decreased reproductive health and cancer, have been raised.

DEEP DIVE:

FASHION'S IMPACTS ON HEALTH LINKED TO THE ENVIRONMENTAL IMPACTS OF THE FASHION INDUSTRY

The fashion industry inflicts severe environmental and health impacts by degrading water systems, air quality and ecosystems. The industry produces 20 percent of global industrial wastewater, primarily due to harmful textile treatment and dyeing processes.[75] Synthetic chemicals used during production are often discharged directly into rivers in textile hubs such as Bangladesh, East Africa and India. For example, Dhaka's Buriganga River is contaminated with untreated wastewater from over 300 factories, with chromium levels exceeding 10 times the safe limit set by the World Health Organization (WHO). Chromium, used in leather tanning, can lead to skin irritation, kidney disease and lung cancer.[76] It has also been linked to negative impacts on fetal growth and development and adverse birth outcomes.[77] Despite a 1995 mandate for effluent treatment plants, many factories bypass these regulations to cut costs.[78]

Synthetic fabrics like polyester, acrylic and nylon shed microplastics with every wash.[79] These microplastics accumulate in marine environments, harm aquatic organisms, and eventually enter human food chains. If trends persist, over 22 million tonnes of plastic microfibres could enter the ocean between 2015 and 2050,[80] posing risks of endocrine disruption, impaired reproductive health and cancer.[81]

High water consumption for textile production further strains regions already facing scarcity. In drought-prone areas like India's Punjab region and Uzbekistan, excessive water use for cotton farming depletes rivers and underground aquifers, undermining local communities' access to clean water.[82]

This depletion, combined with polluted water, compromises healthcare services in many LMICs—especially in South Asia and Sub-Saharan Africa—where facilities often lack reliable electricity and clean water, leaving them ill-equipped to provide basic medical services and sanitation and unable to respond to climate risks like droughts, floods and extreme temperatures.[83]

The cycle of environmental degradation and inadequate healthcare disproportionately affects vulnerable populations, notably women and children. Sustainable fashion initiatives that promote a circular economy and reduce harmful chemical exposure can improve women's health and empowerment.[84] As many textile workers, predominately women, face hazardous conditions that can lead to chronic health issues,[85] adopting sustainable practices (e.g., using non-toxic dyes) and fair labour practices safeguards their well-being and advances gender equality through education, skill-building and fair wages.[86]

To address these issues, the fashion industry can shift to solutions aimed at reducing water and air pollution while improving health outcomes, such as using drought-tolerant fibres like hemp,[87] as well as recycled cotton and recycled water in textile production.[88] Biodegradable fibres, natural materials like organic cotton, particularly with Global Organic Textile Standard (GOTS) or Organic Content Standard (OCS) certifications, and bamboo can mitigate microplastic pollution.[89] In manufacturing, transitioning to renewable energy sources like solar and off-grid solutions can reduce air pollution and power healthcare facilities,[90] while advanced water treatment systems powered by clean energy can secure safe drinking water and sanitation. With effective policies and regulations, these measures could significantly lower the industry's environmental footprint and improve public health for vulnerable communities.

Bridging Production & Retail: Environmental Impacts of Logistics

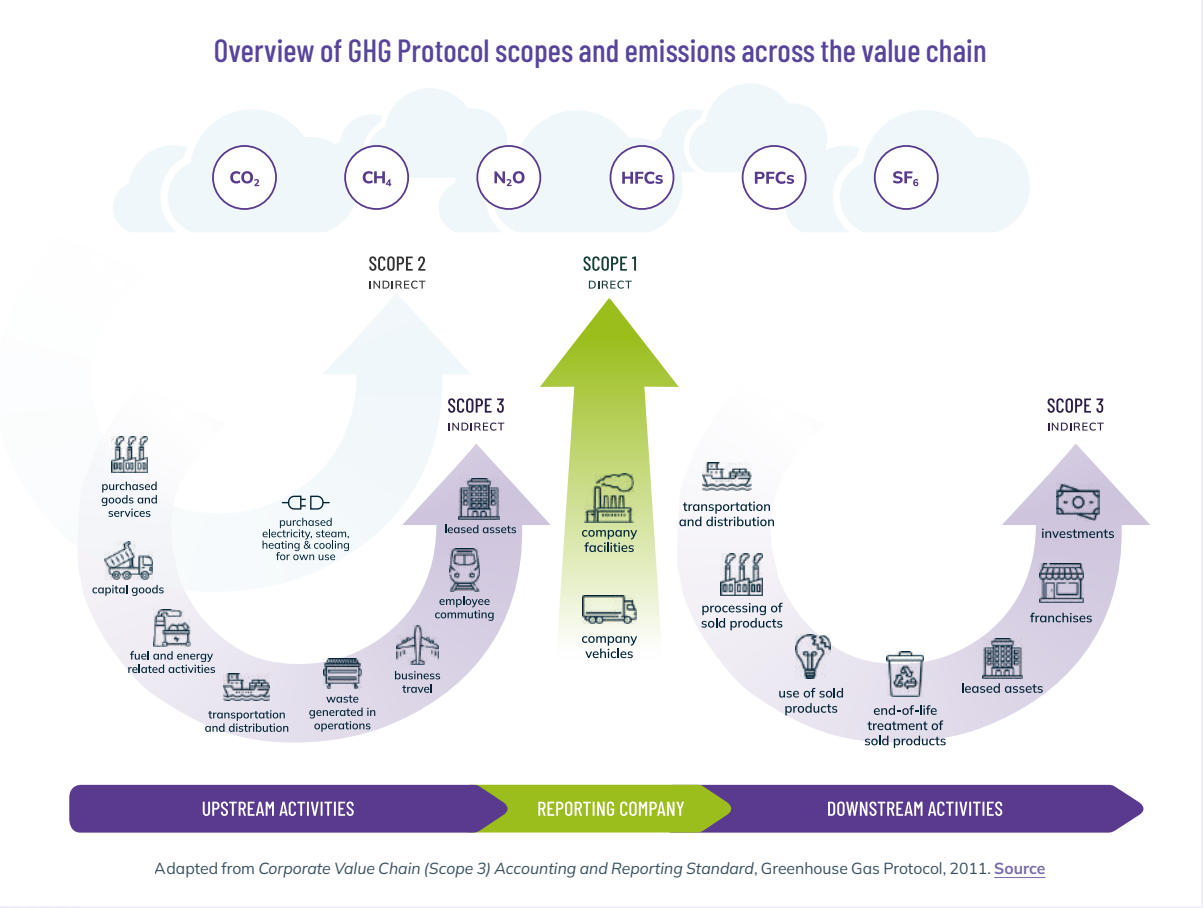
As shipments journey from production and manufacturing hubs in LMICs to global retailers, the environmental cost of transporting vast volumes of textiles becomes increasingly evident. The reliance on container shipping—accounting for around 90 percent of the annual movement of garments—has a significant carbon footprint along the fashion supply chain, with international shipping responsible for roughly 2 percent of global energy-related carbon dioxide (CO_2) emissions and oil-based fuels meeting over 99 percent of the total energy demand.[91]

Compounding this issue is the emerging trend towards the use of air cargo, particularly driven by the surge in online shopping within the fast fashion model. Although faster, air transport dramatically escalates emissions; estimates indicate that moving just 1 percent of garment transportation from ship to air cargo results in a 35 percent increase in carbon emissions.[92] This duality—efficient yet environmentally taxing logistics for retail fashion versus the eventual return flow for waste management—exemplifies the complex challenges facing the industry.

The pressure to reduce lead times and satisfy consumer demand often collides with the imperative to mitigate the environmental impacts of the fashion industry. As the conversation around sustainability intensifies, industry stakeholders are increasingly exploring innovative solutions, such as greener transportation alternatives and localized production, to rebalance this intricate supply chain.

Scope 3 Emissions in Complex Fashion Supply Chains

Fast fashion drives immense indirect (Scope 3) emissions across its entire value chain—from raw material production to product disposal. Unlike Scope 1 and Scope 2 emissions, which are associated with direct emissions from a company's operations and energy use, Scope 3 emissions constitute the largest share of the fashion industry's environmental impact and are challenging to measure and manage due to the global nature of supply chains.

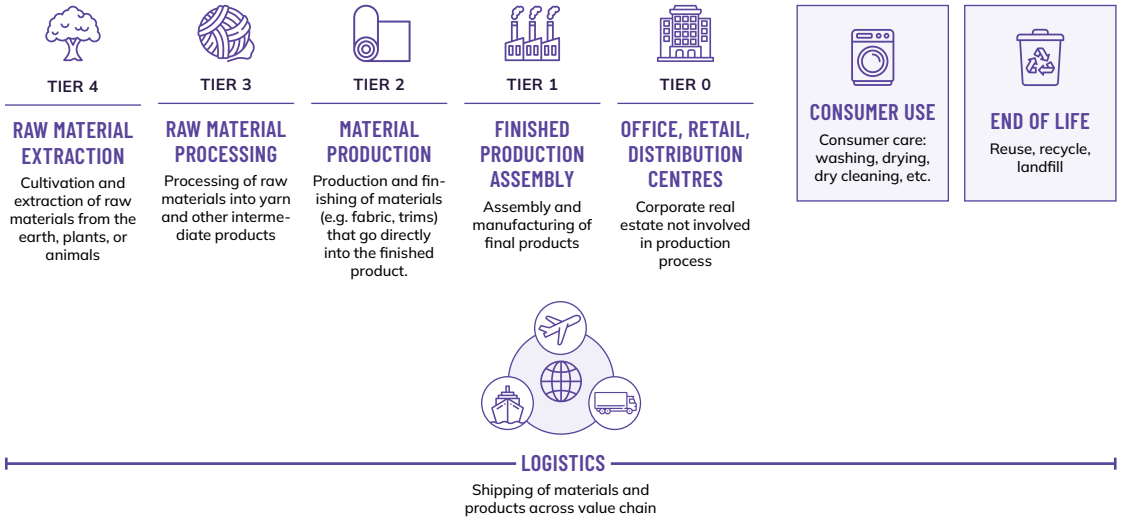


Adapted from *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*, Greenhouse Gas Protocol, 2011. Source

On average, corporate supply chain emissions (Scope 3) are 26 times greater than operational emissions (Scopes 1 and 2)—and in the fashion industry, the ratio is even higher.[93] Scope 3 emissions include emissions from raw material production, dyeing and finishing, manufacturing, transportation, product use, and disposal that are not directly controlled by fashion companies, occurring in production and manufacturing factories and workrooms

continents away from where brands design and sell their clothing. In fast fashion, Scope 3 emissions can account for a range of approximately 96 to 99 percent of the brand's total emissions.[94] Since the industry relies on multi-tiered supply chains, transparency is often limited, and the degree of influence that brands have over upstream and downstream partners can vary significantly.

The fashion supply chain has been categorized into Tiers. Tier 4 accounts for raw materials, where high fossil fuel inputs elevate emissions; Tier 3 is the transformation of raw materials into fibres; Tier 2 includes fabric production, dyeing and finishing; and Tier 1 encompasses the final garment manufacturing. While estimates vary, Tier 2 emissions account for the largest of Scope 3 emissions, ranging from 40-70 percent of emissions.[95]



Adapted from *Why Scope 3 Accounting is Broken in the Fashion Industry*, Carbon Trail, n.d. Source

Although Scope 3 emissions have widely been recognized as an industry-wide challenge, most brands struggle with accountability: 92 percent of 250 major fashion brands lack a public renewable electricity target for their supply chains and only 10 percent are transparent about their energy procurement at the supply-chain level.[96] Fashion companies typically set targets for direct Scope 1 and 2 emissions,[97] but with limited capacity to influence Scope 3 emissions, it is difficult to accurately account for these emissions and maintain a manageable level of transparency.

A 2024 report by the global not-for-profit Fashion Revolution that seeks collective awareness of the processes that enable clothes to reach consumers, finds that of 117 brands, only 105 disclosed their progress, with 56 reporting emissions reductions. However, seven brands reported increases in Scopes 1 and 2 emissions, while 42 brands reported increases in Scope 3 emissions.[98] For instance, Hennes & Mauritz (H&M) is aiming for a 56 percent reduction in both Scopes 1 and 2 and Scope 3 by 2030 (from a 2019 baseline) but has only achieved a 7 percent cut in Scope 3 so far (excluding consumer use).[99] As is the case for most companies, H&M's Scope 3 emissions are 90 times the emissions of its operations.

In another example, the Stella McCartney brand reported that in 2023, 99 percent of total emissions were Scope 3 emissions generated through the "*sourcing and production of raw materials, production of finished goods, waste in production and transportation*." The brand reported that 56 percent of these Scope 3 emissions arose through "*purchased goods and services*," where most upstream Scope 3 emissions lie for many brands. In line with its commitment to environmental

sustainability, Stella McCartney has committed to reducing absolute Scope 3 emissions by 46.2 percent by 2030 (from a 2019 baseline) and achieved a 22 percent reduction of emissions in 2022 (compared to the 2019 baseline). The main drivers of the brand's success have included "*a reduction in emissions from purchased goods and services as well as upstream transport and distribution*."[100]

Although most major brands now acknowledge the urgency behind Scope 3 accountability, progress stalls at the supplier level. Securing brand buy-in is only the first step: while some large manufactures have set science-based targets for emissions reductions, many small and medium-sized enterprises (SMEs) lack the knowledge and resources to do so. Manufacturers have a limited ability to influence their Scope 3 emissions, which are largely determined by brand choices.[101] Further, many small and mid-sized suppliers operate on thin margins and lack the technical expertise or capital needed to invest in efficient machinery, renewable energy or digital tracking systems. Without structured, ongoing technical and financial support from their multinational customers—such as co-funded upgrades, co-designed capacity-building frameworks and training programmes, and access to low-cost financing—suppliers struggle to accomplish meaningful low-carbon transformations.

The vast, complex supply chains of fast fashion pose significant challenges to managing and reducing Scope 3 emissions. While innovative solutions and strategic decarbonization (particularly targeting Tier 2 processes) could yield cost-efficient emission cuts,[102] the lack of transparency and fragmented supplier relationships mean that current efforts are insufficient. Achieving meaningful reductions will require coordinated actions among brands, suppliers, investors and governments, along with major investments and technological advancements.

End-of-life Textile Waste & Environmental Degredation

The fast fashion business model contributes significantly to textile waste as product life cycles shorten to keep up with evolving trends, with approximately 92 million tonnes of waste generated annually.[103] The average US consumer discards approximately 80 pounds of clothing and textiles annually, occupying nearly 5 percent of landfill space.[104] Across the EU, 82 percent of textile waste is post-consumer waste, with the remainder attributed to waste generated from manufacturing or unsold textiles.[105] Estimates find that for every five garments produced, the equivalent of three end up in a landfill or are incinerated each year.[106]

Very little clothing is recycled.[107] Approximately 500,000 tonnes of used clothing are exported from the US each year, the majority ending up in LMICs, ostensibly for sale in second-hand markets. However, clothing that is not sold in markets becomes waste, and many LMICs lack robust municipal waste systems.[108] Textiles that end up in landfills decompose and release methane gas, which is 28 times more potent than carbon dioxide. Further, for the development of one hectare of a landfill site, between 30 and 300 animal or plant species are lost, impacting the biodiversity of the region.[109] More than USD 500 billion is lost every year due to a lack of recycling and clothes being thrown into landfills.[110]

Advancements in recycling and end-of-life management now feature automated sorting, advanced chemical fibre separation and innovative applications for textile waste. Additionally, prioritizing waste reduction and directing investments towards pollution-prevention technologies, as well as carbon footprint assessment and reduction, have been identified as essential steps in addressing textile waste and end-of-life disposal.[111]

The environmental impact of the fashion industry is multifaceted, encompassing complex supply chains, intensive production processes and significant resource demands that extend from raw material sourcing to garment disposal. The combined challenges of high carbon emissions, excessive water consumption, mounting textile waste and rising cooling demands underscore the urgent need for systemic changes. Sustainable practices across the entire supply chain—coupled with robust policy interventions—are essential for mitigating environmental harm and addressing the social inequities that have long plagued the industry. Future research and coordinated global action are imperative to transform the fashion sector into a model of sustainability and resilience.

3 Energy Intensiveness of the Fashion Industry

The fashion industry is one of the most energy-intensive sectors worldwide, with significant energy demands at all stages of its supply chain. Annually, the global textile sector consumes approximately 1 trillion kWh of electricity to produce approximately 60 billion kg of fabric.[112] This consumption is roughly equivalent to a quarter of the electricity consumed in the US and an eighth of the electricity consumed in China in 2023.[113]

These figures underscore the immense energy requirement and associated environmental impact of the industry. In fact, the fashion sector is cited as using the most non-renewable resources at "*a total of 98 million per year including oil for the production of synthetic fibres, fertilizers for growing cotton and chemicals for the production, dyeing and finishing of fibres and textiles.*"[114]

To further illustrate the energy demands of the sector, the thermal energy required to produce one metre of fabric ranges from 4,500 to 5,500 kilocalories (kcal), while the corresponding electrical energy consumption varies between 0.45 and 0.55 kWh.[115] Note for comparison that one kcal of energy can raise the temperature of one kg of water (one litre) by one degree Celsius (°C). China—a major hub for clothing manufacturing—produced approximately 2.53 billion metres of fabric in July 2024 alone, with the country accounting for over 43.6 percent of global textile exports in 2022.[116]

Textile production encompasses several energy-intensive stages, including spinning, weaving, knitting, dyeing and finishing. Together, these processes contribute to approximately 80 percent of the total energy consumption in the fashion industry.[117] Specifically, dyeing and finishing processes are responsible for 36 percent of energy emissions, yarn preparation accounts for 28 percent, fibre production for 15 percent, fabric preparation for 12 percent, and assembly for 7 percent.[118] Notably, distribution and end-of-life disposal of products consume energy at various stages, including transportation, incineration and landfilling, requiring greater Life Cycle Assessment (LCA) to pinpoint exact energy usage. The energy usage in each stage of supply chain activities highlights the urgent need for a transition to cleaner energy sources in all supply chain locations to reduce environmental damage.

A fundamental challenge facing the textile sector is poor energy efficiency. The fashion industry is plagued by one of the lowest efficiencies in energy use across manufacturing sectors, with estimates that approximately 50 percent of energy input to textile manufacturing is lost through the production line. Most of the wasted energy is derived from fossil fuel sources, creating a dual problem where energy is both unsustainable in source and wasteful in application. With energy costs representing 15-20 percent of total production expenses in textile manufacturing, inefficiencies directly impact economic viability while simultaneously increasing environmental harm.[119]

For instance, productivity in India's garment factories is estimated to decrease by 3 percent for each degree increase in temperature beyond 29°C, with poor ventilation further exacerbating the issue and even contributing to workplace tensions.[120] In industrial settings, passive cooling measures (such as enhanced ventilation, cool roofs and natural shading) can lower indoor temperatures and improve working conditions.

The rise of the fast fashion business model exacerbates these energy challenges, as rapid production cycles necessitate more energy-intensive manufacturing. The emphasis on low-cost production often leads to less efficient use of cheaper and more polluting energy sources. Alarmingly, fast fashion consumes more energy during production than during transportation to reach consumers, amplifying the impact in countries where these garments are manufactured.[121]

Fossil Fuel-Intensive Energy Mix in Manufacturing Countries

High-income countries, especially in Europe, are increasingly adopting renewable energy sources such as solar, wind and hydropower in their factories and grids, driven by strict regulations and attractive incentives.[122] By contrast, low- and middle-income countries (LMICs)—many of which are central to global fashion production—face distinct challenges in this transition. These challenges include limited access to financing, entrenched fossil fuel infrastructures and policy or regulatory hurdles. However, it is important to note the significant progress being made in several LMICs as countries are accelerating their renewable energy deployment. For instance, a reported 87 percent of power investment in 2024 was directed into clean energy projects.[123]

Notably, the primary sources of electricity and energy in the largest manufacturing countries are coal, oil and gas, with each fossil fuel type producing varying emissions (e.g., coal produces higher emissions than gas).[124] In Bangladesh, where the garment sector employs more than 4 million people and exports goods worth USD 43 billion to 167 countries (84 percent of Bangladeshi export revenues come from apparel alone),[125] natural gas constitutes the majority of the country's energy mix, with renewable energy making up less than 2 percent of total energy consumption.[126] The industrial sector, which consumes 27 percent of the country's total energy, contributes heavily to the country's reliance on fossil fuels. The textile sector alone accounts for about one-third of industrial energy use and produces significant greenhouse gas (GHG) emissions.[127]

Likewise, India, the world's second-largest coal consumer and second-largest textile manufacturer,[128] provides

another stark example. The country's textile industry is valued at over USD 200 billion and contributes approximately 2 percent to India's GDP.[129] In the fiscal year 2023, about 72.74 percent of the total energy consumed by textile companies in India came from conventional fuels, primarily coal. Renewable energy accounted for only around 3 percent of energy consumption.[130]

Notably, however, India has emerged as a global leader in clean energy investment, as renewable electricity is growing at a faster rate in India than in any other major economy, with new capacity additions on track to double by 2026.[131] In 2022, the renewables share of electricity generation in India reached 22 percent.[132]

Life Cycle Aspects of Energy Consumption in the Fast Fashion Industry

Beyond production, significant energy is consumed during the use and end-use phases of garments. One of the most energy-intensive processes related to clothing consumption is laundry. Washing machines, dryers and other laundry practices require substantial energy, which, in many households, especially in LMICs, often comes from non-renewable sources including coal, natural gas, oil, firewood and kerosene. Washing machines and dryers account for 10 percent of residential energy consumption, with most of the energy consumed for hot water used for washing.[133] Tumble dryers use an average of between 1,800 to 5,000 watts of energy, dependent on the load and cycle configurations, equal to approximately 1.8 to 5 kWh of electricity.[134] Notably, washing machines are estimated to require 20 billion cubic metres of water per year globally (equivalent to 8 million Olympic-sized swimming pools).[135]

The energy implications of laundry are particularly concerning in the context of fast fashion, where lower-quality garments often require more frequent washing, drying and ironing—each step consuming energy. Since lower-quality garments wear out faster, they are replaced more often, leading to repeated cycles of production, transportation and disposal, all of which further increase energy use.[136] The cumulative energy footprint of low-quality clothing is much higher than it is for better quality garments that last longer and need less frequent care. This cycle of buying, washing and discarding accelerates energy consumption both at home and throughout the supply chain, amplifying the environmental impact.

Additionally, synthetic fabrics, which dominate fast fashion, typically release microplastics during washing, creating additional environmental concerns beyond energy consumption. This underscores the need for both energy and water efficiency to take a key place in the conversation around the sustainability of the fashion industry.

Energy efficiency measures offer the dual benefit of reducing overall energy consumption and alleviating the burden on households—especially women. For instance, energy-efficient washing machines and dryers, particularly those powered by renewable energy, can reduce the time and energy required for household laundry tasks, freeing up time for other activities.[137]

The disposal of textile products creates an additional layer of energy consumption concerns. Estimates find that nearly 85 percent of all textiles are sent to landfills annually, meaning that the energy embedded in these products is wasted.[138] Where textiles are incinerated, which was the case for 3.2 million tonnes of textile waste in the US in 2018,[139] additional energy is consumed while GHG emissions are released. The industry produces an estimated 80-150 billion garments annually, most designed for short-term use before disposal, creating a system where energy and resources are continually wasted.[140]

The Role of Renewable Energy in the Fashion Industry

The fashion sector's journey to net zero will require roughly USD 1.4 trillion in financing, spanning renewable energy deployment, next-generation materials and the coal phase-out.[141] As energy can represent up to 25 percent of a textile factory's operating costs,[142] the long-term savings of wind, solar and other renewables are increasingly compelling. Between 2020 and 2021 alone, onshore wind fell in cost by 15 percent, offshore wind by 13 percent and solar photovoltaic (PV) by 13 percent.[143] In 2024, for the first time, global spending on renewable power, grids and storage surpassed investment in oil, gas and coal,[144] signalling that the fashion industry is well-positioned to capitalize on these trends.

Although brands are increasingly adopting renewable energy technologies and sustainable production methods to reduce their carbon footprint and technology presents promising solutions, implementation remains difficult, especially for small and home-based enterprises.

Challenges to Renewable Energy Adoption

While major fashion houses and multinational corporations can leverage economies of scale and existing

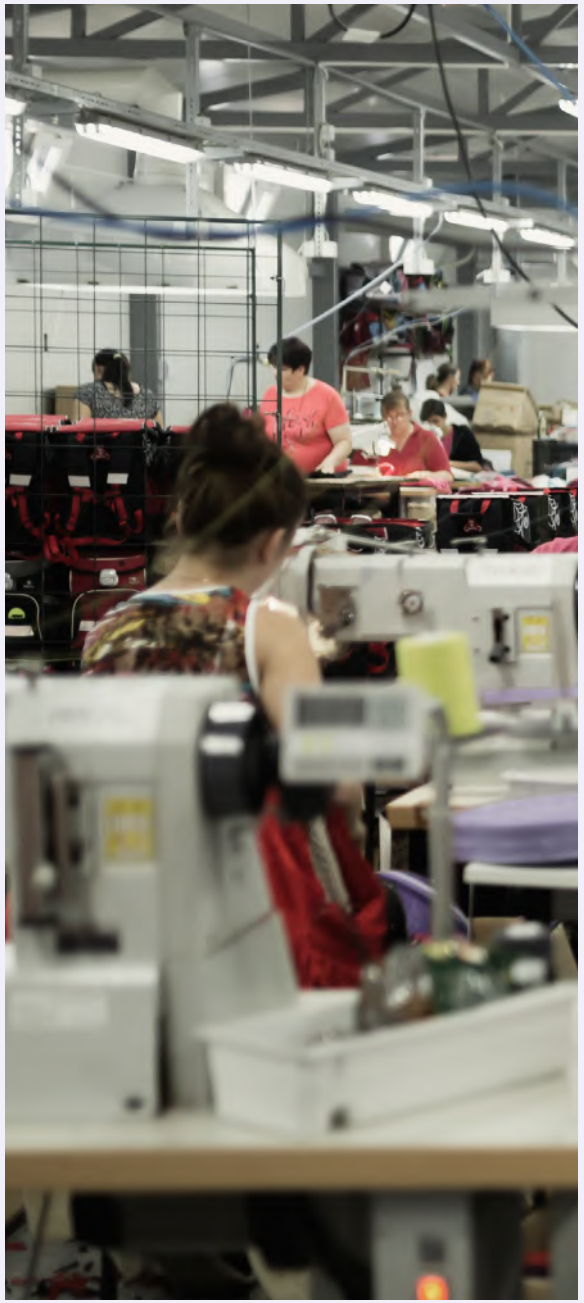
resources to invest in renewable energy solutions, small-scale suppliers in climate-vulnerable countries face a range of barriers. Small and medium-sized enterprise (SME) suppliers in LMICs such as Bangladesh, Indonesia and Vietnam, tend to rely on national grid or off-grid power, where generation and infrastructure costs are covered by utilities rather than individual companies. However, unreliable supply and economic considerations like high tariffs can often compel manufacturers to maintain diesel generators as backup, driving up both emissions and expenses.

In remote or rural areas, extending the grid is often cost-prohibitive—geographical conditions, low population density and long distances from existing electrical infrastructure make grid expansions unattractive. As a result, many factories in remote areas depend on standalone energy systems like diesel generators to meet their needs.[145]

The global nature of fashion supply chains creates additional challenges in implementing consistent renewable energy strategies. Fashion brands source materials and manufacture products in various countries, each with their own regulations, energy infrastructure and market conditions. Suppliers often work under intense pressure from brands to keep labour costs low and deliver products at cheaper prices to buyers in high-income countries. While brands have made commitments to sustainability, often, these commitments have not been accompanied by sufficient financial support for small manufacturers to change their energy sources and business practices, especially those in vulnerable regions.[146] Often, many brands see emissions as generated along the supply chain and indicate that suppliers should bear the responsibility of reducing emissions. This is compounded by a belief among many brands that since they do not own their own factories, their investment in renewable energy in factories in LMICs may benefit other brands as well.[147]

As a result, many local suppliers, particularly in rural areas with limited grid connectivity, are left to bear the upfront and long-term costs of transitioning to cleaner energy sources without adequate support, creating an unfair burden on manufacturers in these regions. Suppliers in LMICs with no brand support to make the necessary investments for the transition to renewable energy may find equipment to be cost-prohibitive due to upfront investments and lengthy payback periods. As such, there is often a reluctance to invest in expensive sustainability technologies.[148]

Further, suppliers operating as SMEs often face significant challenges in securing loans for investments in renewable energy and sustainable technologies due to limited credit histories or insufficient collateral. These challenges are even more severe for women-led SMEs, which face a range of systemic barriers to accessing finance. These include restrictive laws and regulations, discriminatory banking practices, social and cultural norms, low financial literacy, and lack of awareness around financing options. There are also structural biases within financial institutions, as there exists a widespread perception that women-led businesses are higher risk, and there is a lack of financial products specifically designed to meet the needs of women entrepreneurs.[149] Suppliers experience a wide range of difficulties in the transition to affordable, modern, reliable and sustainable energy, with a disproportionate impact on women within the sector.



Most major fashion brands that report to the Carbon Disclosure Project (CDP) (the mandated reporting mechanism for the UN Framework Convention on Climate Change (UNFCCC) *Fashion Industry Charter for Climate Action*), do not have a public renewable energy target for their supply chains, and only a small fraction are transparent about their energy procurement at the supply-chain level.[150] To set meaningful sustainability targets, brands need to collaborate with suppliers and impact measurement experts to collect data, providing transparency and traceability of products. Tracking carbon emissions across the entire supply chain—especially from Tier 3 suppliers who process raw materials—is essential. This comprehensive mapping of the value chain enhances data visibility, enabling brands to set realistic sustainability targets, prioritize decarbonization efforts and assess their impact.[151]

Further, differences in how companies report sustainability metrics make it harder to measure and compare progress. Without adherence to established climate target setting standards, such as those from the Science Based Targets initiative, and robust reporting mechanisms like the CDP, brands and suppliers may lack accountability and transparency in reporting on renewable energy use, emissions reductions and other key sustainability indicators.

Additionally, the lack of uniform regulations across regions—regarding renewable energy incentives, carbon pricing and energy policies—creates an uneven playing field. Inconsistent policies can delay or discourage investment in renewable energy and sustainable technologies, making it difficult to adopt a unified approach to sustainable production. This also increases the risks of companies always choosing loosely regulated countries.

There is great potential for expanding collaboration within the fashion industry. Bringing together financial institutions and brands ('customers' of suppliers) to collaborate on sustainable finance models could yield high benefits. These models can build financial products and incentives for suppliers who demonstrate progress in their sustainability efforts, for example, through vehicles like CDP disclosures. Offering financial benefits for such progress emphasizes the reallocation of capital to environmentally- and energy-friendly actions, especially where corporate sustainability budgets alone tend to fall short.

The energy demands of the fashion industry are vast and multifaceted, driven by energy-intensive production processes, fast fashion dynamics and a fossil fuel-dominated energy mix in key manufacturing regions. The substantial contributions from Scope 3 emissions, coupled with significant energy usage in garment use and disposal, emphasize the urgent need for systemic change. Transitioning to renewable energy sources, improving energy efficiency across the supply chain and enhancing transparency in energy procurement are critical steps toward reducing the industry's environmental footprint. Addressing these energy challenges is also essential for advancing gender equality and sustainable economic development, ensuring that the transformation of the fashion industry is both environmentally and socially inclusive.

4 Gender at the Intersection of Fashion, Climate & Energy

The fashion industry's environmental impact and energy challenges intersect significantly with gender considerations, creating a complex landscape where women bear disproportionate burdens while simultaneously driving innovation. Chapter 4 examines how gender dynamics influence and are influenced by the fashion industry's climate and energy practices.

Critically, women face a disproportionate burden of climate impacts and limited energy access despite making up the majority of the industry's workforce. Meanwhile, structural barriers posed by social and cultural norms and beliefs, and institutionalized through legal and financial discrimination, create a system where those most affected by the industry's practices have the least influence over its direction.

Gendered Composition of the Fashion Workforce

The global fashion industry relies heavily on women's labour, particularly in production and manufacturing. Most garment workers in low- and middle-income countries (LMICs) are women, and they face numerous challenges including low wages, poor working conditions, and limited knowledge of regulations and legal rights. Further, women are exposed to environmental hazards associated with textile production and waste. As most textile production has shifted to countries with cheaper labour and less stringent regulations, complex supply chains obscure responsibility for labour abuses, gender-based violence and environmental damage, with women in LMICs bearing disproportionate consequences of these challenging conditions.

Social norms perpetuate the gender gap in the fashion industry. In many societies, women are more likely to engage in low- or zero-income, informal activities, often centred around domestic tasks such as cooking, sewing and childcare, while men typically occupy technical and better paid roles.[152] This pattern is evident in the garment sector, where women are largely concentrated in the lowest-paid jobs, while men tend to hold more technical or higher-skilled roles, such as supervisors or machinists, or positions in cutting departments, which are often considered unsafe. Women's labour is largely concentrated in the least profitable parts of the supply chain, such as manual garment production and low-level administrative work.

Beyond labour roles, women are also underrepresented in decision-making positions. Despite women accounting for 70-80 percent of global consumer spending in fashion,[153] a 2021 study by the media company Business of Fashion found that only 14 percent of major fashion brands are run by female executives.[154] Additionally, as of July 2023, only 13 of 86 retail companies had a female CEO.[155]

Climate Challenges & Gender Implications

In regions central to fashion production, including those in Sub-Saharan Africa and Asia, climate change and energy access inequalities create additional burdens for

women workers and entrepreneurs, limiting productivity and economic empowerment while exacerbating climate vulnerabilities. Women in these regions frequently face disruptions caused by environmental degradation and limited access to modern and productive energy uses, which creates a cycle of challenges.

As climate change increases extreme weather events, temperatures, and the frequency of natural disasters, fashion workers are affected. In Cambodia, over 64 percent of garment workers, the majority of them women, reported that they experienced at least one climate change-related impact at work or outside the factory annually, with many citing pollution, extreme heat, flooding and fire.[156] As women make up the majority of the fashion workforce, they are disproportionately exposed to the impacts of climate crises.

Water scarcity further compounds women's challenges in the fashion sector, as women often bear the primary responsibility for securing water for household needs. When the fashion industry pollutes water sources and reduces the availability of clean freshwater, women must travel longer distances or spend more time working for water, intensifying their workload and depriving them of time to engage in other productive or educational activities. Additionally, water scarcity restricts women's ability to engage in water-dependent sectors of the informal fashion market, such as tie and dye production. For instance, the historical and growing tie and dye production industry in Sub-Saharan Africa requires significant amounts of water for dyeing fabrics.[157] When water is scarce, women who rely on this craft for their livelihoods face reduced production capacity in income, further exacerbating gender inequalities in the fashion sector.

Moreover, as women are in direct contact with emissions from production and manufacturing processes across the fashion supply chain, air quality becomes a major issue for their health. The production of synthetic fibres, expected to continue to rise, not only increases carbon emissions but also poses health risks associated with poor air quality and air pollution. Employees tend to work in textile production sites with no ventilation, breathing in toxic substances or inhaling fibre dusts or sand.[158] Gender disproportionately plays into this exposure as women are on the front lines of textile manufacturing.

Extreme heat poses an additional risk for garment factory workers. Cornell University's Global Labor Institute found that in 100 factories in Bangladesh, Pakistan and Vietnam, workers are increasingly exposed to dangerous work conditions made worse by rising

temperatures.[159] This increase in extreme heat also exacerbates the need for cooling inside factories, which in turn significantly increases energy demand. As women constitute the primary workforce in these factories, they are disproportionately affected by these hazardous conditions and the increased demand for cooling.

The fashion industry both contributes to and suffers from climate change, creating a cyclical disruption. Hurricanes, floods and heat waves have devastating effects on manufacturing hubs and logistics networks. For instance, in 2020, Bangladesh faced severe flooding that disrupted factory operations and delayed shipments. Similarly, extreme heat in Pakistan has impacted labour productivity and the efficiency of textile mills.[160] The International Labour Organization (ILO) finds that productivity can fall by as much as 20 percent in extreme heat conditions, which impacts the transition of garments from manufacturing to distribution.[161]

These challenges are particularly consequential for women-owned fashion businesses or women working in the informal workforce as small-scale textile production or home-based garment workers, especially in regions most vulnerable to droughts or floods. These businesses often operate with few resources and limited resilience to economic shocks, making them more susceptible to the disruptions caused by climate change.[162] The instability of raw material supplies and the increased risk of operational disruptions can hinder their ability to maintain production, meet demand and sustain profitability.

DEEP DIVE:

COOLING IN THE FASHION INDUSTRY

Rising global temperatures are set to double cooling emissions by 2050, reaching 6.1 billion tons of CO2e.[163] Over 1.1 billion people lack access to effective cooling, while an additional 2.9 billion rely on inefficient cooling systems. This cooling gap disproportionately impacts vulnerable populations, especially women and girls, increasing their exposure to heat-related health risks.[164]

Major textile producers such as Bangladesh, China, India, Indonesia, Nigeria and Pakistan are among the countries with the highest populations without sustainable cooling solutions. In these regions, inadequate access to cooling in garment factories forces workers, many of whom are women, to endure extreme heat. In Dhaka, the temperature in upper garment factory floors often exceeds 30°C, topping 35°C on an average of 110 days a year. This both affects worker health, causing dizziness, headaches, fatigue and nausea,[165] and reduces productivity, with Bangladesh projected to lose 4.84 percent of working hours by 2030, equivalent to 3.833 million full-time jobs.[166]

Addressing these challenges is critical for sustaining the fashion industry and protecting its predominately female workforce. Initiatives like the Global Cooling Pledge aim to reduce cooling-related emissions by 68 percent by 2050, significantly expand access to sustainable cooling by 2030, and improve the global average efficiency of new air conditioners by 50 percent.

National Cooling Action Plans (NCAPs) and Heat Action Plans further support these efforts by: identifying vulnerable groups; promoting the adoption and increased stringency of Minimum Energy Performance Standards (MEPS); identifying potential financial mechanisms for cooling; and implementing measures such as early warning systems, cooling stations and urban infrastructure improvements. Together, these strategies not only mitigate carbon emissions but also enhance working conditions and empower women in the textile sector by safeguarding their health and productivity.

The Gender-Energy Nexus: Challenges in Fashion & Beyond

Insufficient access to modern and productive-use energy for women within the fashion sector and beyond intersects critically with issues of gender equality, economic development and environmental sustainability. Across Africa, women have historically played a significant role in the production and consumption of fashion and textiles. Women workers make up nearly 80 percent of Ethiopia's apparel industry,[167] and nearly 80 percent of the ready-made apparel sector in Lesotho.[168] For many women in the region, manufacturing jobs are the primary alternative to working in small-scale agriculture.

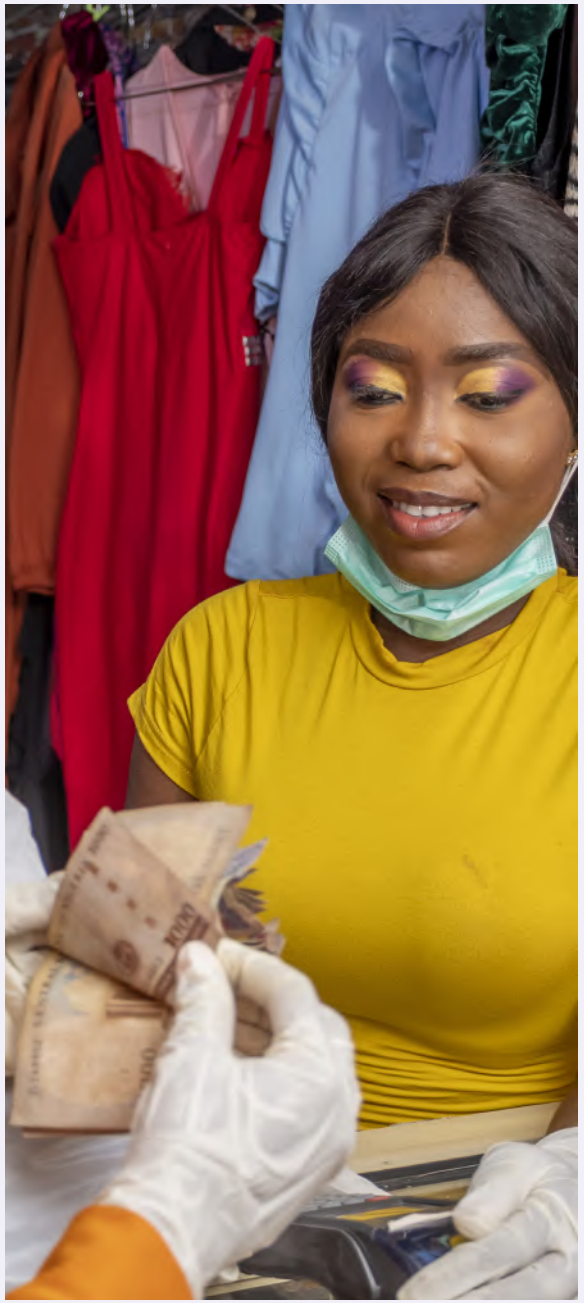
However, in areas with concentrated textile production, women frequently face limited access to modern energy services, creating a cycle of challenges. According to UN Women, if current trends continue, an estimated 341 million women and girls will still lack electricity by 2030, 85 percent of them residing in Sub-Saharan Africa.[169] Time spent securing household energy reduces opportunities for education and economic advancement, while unreliable electricity decreases productivity in energy-intensive fashion production. Limited access to modern energy stifles technological advancements and skill development, curbing women's contributions to innovation and energy solutions that address their specific needs and experiences.

Furthermore, unreliable energy access is directly linked to power, which can damage electricity-intensive machinery and materials for women working in SMEs or home-based settings. Limited access to reliable and affordable energy significantly hampers the operation of sewing machines, looms and other critical tools, forcing women to work longer hours to complete tasks with smaller renumeration and less earnings across their employment life cycle.[170] Often, inadequate energy access restricts opportunities for training and skills development in areas like energy-efficient technologies and technological upgrading in the garment sector.[171] In this case, energy inefficiency reduces income potential and economic empowerment while increasing production costs, ultimately diminishing market competitiveness.

The health and safety conditions of the fashion industry are equally concerning. Poor lighting leads to eye strain and accidents, while insufficient ventilation contributes to respiratory problems. Extended working hours necessitated by inefficient equipment contribute to fatigue and associated physical and mental health challenges, further compromising the wellbeing of women workers.[172]

Women-owned Enterprises & Renewable Energy Along the Fashion Supply Chain

Many women in the fashion supply chain operate in small-scale or home-based settings where access to reliable and affordable energy is severely limited. Approximately 60 percent of global apparel production is conducted by SMEs that may struggle with competing sustainability initiatives from brands and often lack the credit and guarantors to secure funding.[173] Across Africa, SMEs account for 90 percent of businesses in the fashion sector.[174] SMEs are key to economic development and job creation in Egypt, Ghana, Kenya, Malawi, Nigeria, Tanzania and Tunisia, where women play a critical role in textile production, from weaving and dyeing to the design and distribution of products.



Where women can, they do adopt renewable energy sources. Solar-powered sewing machines and lighting have enabled women tailors to increase their productivity and income. The ILO reports that in rural African communities, access to solar-powered sewing machines has increased the income of women entrepreneurs by up to 50 percent. These machines are particularly impactful in regions where electricity is either unavailable or unreliable, helping women maintain consistent production schedules.[175]

Another notable example comes from India where a large portion of the population relies on micro-enterprises for their livelihoods. In the state of Maharashtra, approximately 21 percent of women with micro-enterprises are tailors. When solar energy was used to power their sewing machines, it led to a 25 percent increase in energy efficiency, and tailors saw their annual incomes rise by an average of 39 percent after incorporating solar power into their operations.[176]

These small-scale, distributed renewable energy solutions are particularly effective for home-based operations and micro-enterprises, providing a means to improve productivity without relying on costly and often unreliable grid electricity. However, scaling these solutions to industrial levels presents significant challenges, especially for small manufacturers. The adoption of energy-efficient machinery and renewable energy systems, such as solar panels, is often hindered by their high upfront costs. This challenge is particularly acute for women-led SMEs, which frequently face limited access to capital and financing. In addition, many of these enterprises lack adequate knowledge about available technologies and financing options, making it difficult to invest in solutions that, while costly initially, offer significant long-term savings.[177]

Research finds that women-owned SMEs, including in the fashion sector, typically use a mix of energy carriers (grid electricity, fuel and, increasingly, off-grid renewable energy). However, there are clear patterns based on ownership structure, with sole female-owned enterprises typically relying on two energy carriers, such as a combination of grid electricity and fossil fuel (55 percent of cases), while a small portion (10 percent) use solar PV. Female-female co-owned enterprises follow a similar pattern, with 35 percent relying solely on grid electricity. Female-male co-owned businesses, however, tend to be more diverse in their energy use, with a significant portion adopting three or more energy carriers, such as combining grid electricity with fuel, solar PV and even biofuels or solar-driven heat pumps.[178]

These data suggest that female-male co-owned enterprises often have greater access to essential resources, such as capital and technical expertise. This advantage enables them to experiment with a broader range of renewable energy solutions, than is possible for solely female-owned or female-female co-owned businesses. Women-led enterprises frequently adopt more conservative energy strategies, relying on grid electricity and fuel, due to the significant upfront costs and technical complexities associated with renewable energy systems.

This is correlated with the challenge of financing for women-led SMEs in the renewable energy sector. According to the International Finance Corporation (IFC), the global finance gap for SMEs led by women in emerging markets is valued at an estimated USD 1.7 trillion.[179]

In the fashion industry, where women dominate the workforce, financing constraints remain a significant barrier. Opportunities such as solar-powered sewing machines, energy-efficient production methods and sustainable manufacturing practices have the potential to transform the sector. However, limited financial literacy, discriminatory lending practices and lack of collateral often prevent women entrepreneurs from accessing the capital needed to adopt these innovations.

Compounding these challenges is the widespread disparity in economic rights. Globally, an estimated 2.4 billion women do not have the same economic rights as men. These restrictions include laws that limit women's ability to work at night or in certain jobs and industries, rules that require a husband's permission to get a job, difficulties applying for a passport, and obstacles to opening a bank account. Additionally, many countries lack laws that criminalize sexual harassment at work, prevent gender-based discrimination in financial services or ensure equal pay. As of 2022, 178 countries still had legal barriers that stop women from fully participating in the economy. This systemic inequality further excludes women-owned and -led enterprises from financial opportunities, stifling their growth and innovation potential.[180]

Some initiatives are beginning to address these gaps. For instance, targeted grants and financing programmes provide technical training and facilitate access to capital —like the Ford Foundation's initiatives in the informal economy and the support of the International Renewable Energy Agency (IRENA) for women in clean energy. However, the scale of these efforts requires growth given the enormity of the challenge.[181]

A comprehensive approach is essential, combining policy reforms, investment in gender-focused financial programmes and capacity-building initiatives. This includes advocating for gender-responsive energy policies that prioritize women's needs in the energy transition agenda. Such policies should ensure that women have equal access to renewable energy resources and clearly outline opportunities available to them in the energy sector—for example, offering tax exemptions to female-owned enterprises importing renewable technologies. By addressing structural barriers and expanding access to financing, it will be possible to unlock the full potential of women in both the renewable energy and fashion industries.

Technical Knowledge Gap & Career Advancement Barriers

A critical obstacle for both the fashion and renewable energy sectors is the shortage of women with the technical skills and opportunities needed to implement, operate and maintain clean energy technologies—skills that are essential as factories and suppliers begin to integrate renewable energy solutions, energy-efficient technologies and monitoring systems across their production lines.

In many rural or off-grid garment production hubs, mini-grids and off-grid technologies are emerging as viable electrification solutions,[182] yet local workforces—especially women—often lack the training to install, troubleshoot or manage these systems, as well as the financial literacy, entrepreneurial skills and other professional development skills necessary for operating in the broader green workforce.[183]

For instance, across Africa's solar PV sector, women occupy only 24 percent of Science, Technology, Engineering and Mathematics (STEM) roles and 22 percent of other technical positions.[184] This underrepresentation is the result of a combination of male-dominated industry culture, stereotypes about women in hands-on or physically demanding work, and societal expectations around gender roles.

This creates a cycle in which young women are discouraged from studying STEM subjects, leading to a lack of awareness about available jobs and opportunities. As a result, many women forego pursuing technical education due to the perceived lack of employment prospects in male-dominated industries such as energy.[185] This gender gap in technical knowledge has significant implications for the fashion industry's ability to adopt and maintain energy-efficient technologies. This cycle relegates many women to informal, poorly paid and often unpaid work, where they face significant barriers to career progression.

The lack of technical expertise among largely female factory workforces has serious consequences for the fashion industry's sustainability goals. Without in-house skills to install and operate energy-efficient machinery, factories often delay or forgo upgrades. Instead, they depend on external service providers—leaving women-led SMEs exposed to unpredictable costs and potential service interruptions. At the same time, limited technical capacity blocks the adoption of advanced processes—such as chemical recycling of post-consumer fibres or innovative dyeing techniques—that rely on precise energy management.

The skills gap not only stifles innovation but also weakens the overall impact of sustainability initiatives. To fully harness renewable energy and scale green solutions, women must be trained to own, operate and maintain clean energy systems. Connecting female energy technicians with fashion SMEs and investing in targeted capacity building programmes will help the industry meet its sustainability ambitions and ensure that women share equitably in the transition's economic and environmental benefits.

Underrepresentation of Women in Fashion's Decision-Making

Women remain underrepresented across decision-making in the fashion industry. While there has been some progress in the representation of women in leadership roles, such as a 95 percent increase in female CEOs in the apparel industry reported in 2020, overall advancement remains slow. For instance, although women

design 40 percent of womenswear brands, they hold only 14 percent of leadership positions in the largest fashion companies.[186]

It is not only at the top reaches of C-suites that women are underrepresented in leadership positions. In Bangladesh, approximately four out of five production line workers are women, whereas only one in 20 supervisors are women.[187] Women who do pursue upward mobility often encounter numerous challenges, including increased stress and responsibilities, harassment and violence, and societal pressures that discourage career advancement. They may also face the risk of being ostracized from their communities or losing family support, particularly when they take on new roles that are at odds with traditional gender expectations.[188] Family and community dynamics are particularly important for women who may lose access to childcare if their families do not support their professional aspirations.

Additionally, women often struggle to secure leadership positions due to social norms and gender biases within the workplace. For example, factory managers may prefer to employ men for positions requiring machine operation or leadership roles, falsely believing that only men possess qualities like confidence, assertiveness and control—traits that are often considered *masculine*. Women are also frequently held to higher skill standards than their male counterparts, making it more difficult for them to advance.[189]

The lack of women in leadership roles is a critical issue, and it is essential for the industry to take deliberate action to close the gender gap. By addressing the barriers to women's career progression and creating long-term, gender-responsive pathways for advancement, the fashion industry can unlock the full potential of its workforce, improving both women's lives and the industry's performance.

Underrepresentation of Women in The Energy Sector

In parallel to the challenges faced by women in the fashion industry, women in STEM fields encounter significant barriers to entry and progression. While women are increasingly pursuing education and careers in science and technology, they remain underrepresented in key technical roles, particularly in fields such as engineering, information technology and renewable energy. The ILO reports that men occupy 72 percent of positions in Information Technology (IT), science, and engineering across 121 countries.[190]

This gender gap extends to the energy sector, where women are underrepresented in technical jobs, leadership positions and decision-making roles. In the traditional energy sector, women account for only 22 percent of the workforce,[191] and they represent less than 11 percent of energy patent applications.[192] The situation is similarly dire in the renewable energy sector, where women make up just 32 percent of the workforce globally, and most are concentrated in non-technical and administrative roles, with few advancing to higher-paying technical or managerial positions.[193] In Sub-Saharan Africa, for instance, women hold 25 percent of leadership roles and 26 percent of middle- and lower-level management roles.[194] Barriers to women's participation and advancement in energy and STEM careers include gender bias, limited access to education and training, legal discrimination, and lack of support for work-life balance.

The underrepresentation of women in the energy and STEM sectors not only affects their career progression but also has broader implications for the industries themselves. Women's lived experiences, particularly as primary consumers of energy and caretakers of families, provide valuable insights into sustainable energy solutions and climate change mitigation strategies. However, their exclusion from decision-making processes results in missed opportunities to address these critical issues from diverse perspectives.

Integrating gender-inclusive policies into the fashion industry can drive both sustainable growth and improved working conditions. The British Fashion Council stresses that greater gender inclusivity is essential for fostering innovation, particularly when addressing environmental concerns.[195] In the fashion industry, where issues like excessive energy consumption and waste management are critical, women's leadership is essential for transformative change. With their understanding of the industry as workers and consumers, women can offer valuable perspectives on energy use, waste reduction and ethical production, helping create a more sustainable and equitable fashion ecosystem.

Similarly, gender equality in the energy sector is vital for achieving sustainable energy goals. The underrepresentation of women in energy leadership limits the development of energy solutions that reflect the needs of all stakeholders. Including women in energy policy discussions and decision-making processes can lead to more inclusive, equitable and sustainable energy access, particularly in underserved communities.

To address the gender disparities in fashion, STEM and energy, it is crucial for stakeholders to take gender-responsive actions that create better access to resources, training, finance and social protections. In the fashion industry, this means improving working conditions for women in the informal sector, ensuring access to childcare, providing opportunities for skills development and creating pathways for women to transition from informal to formal employment. For women in STEM and energy, policies that address gender bias, promote access to education, encourage mentorship and coaching, and support work-life balance are essential for encouraging women's participation and progression.

Modelling future skills requirements across both technical and non-technical domains allows for the design of proactive, gender-responsive training programmes, mentorship initiatives and policy interventions. Focusing on developing the forecasted expertise—from smart grid management and community engagement in energy to digital design and sustainable marketing in fashion—is essential for creating diverse pathways for women in higher-value roles, thereby advancing both gender equality and sustainable development across both sectors. Annex 1 details projected skills required for the growing sustainable energy and sustainable fashion sectors.

Challenges to Transparency & Participatory Decision-Making in Fashion

Importantly, while the industry continues to expand and evolve, almost no fashion brand discloses how it engages with workers and communities affected by the climate crisis. A recent Fashion Revolution report reveals a stark disconnect between major brands and the communities they impact. Of 250 fashion companies surveyed, an alarming 94 percent failed to disclose their engagement with stakeholders affected by climate

strategies. This lack of transparency means that the voices of workers and local communities are largely absent from climate policy discussions. By not incorporating the experiences of those on the front lines of climate change, fashion brands are missing crucial insights that could inform more effective and equitable climate strategies. Further, without buy-in from affected communities, climate policies may face obstacles in implementation and fail to address the most pressing local concerns.[196]

The lack of transparency and community engagement in the fashion industry is a particular concern for women, who are disproportionately affected by climate change and unsustainable practices, as well as vastly underrepresented in global decision-making forums. This exclusion is particularly problematic because women have firsthand experience with the localized impacts of climate change. In many regions most affected by environmental changes, such as areas facing water scarcity and shifting agricultural patterns, women serve as primary caretakers of households and natural resources. Consequently, their perspectives are essential for developing climate solutions that are both sustainable and socially just.

The failure to involve women in climate strategy discussions represents a missed opportunity for more inclusive and innovative solutions. Women, especially those working in grassroots organizations or community-level initiatives, possess a wealth of knowledge and practical experience in managing environmental changes. Their insights can lead to more resilient and effective climate strategies. Research shows that increased female representation in leadership positions positively impacts environmental policies and practices.[197] For instance, countries with more women in Parliament are more likely to ratify environmental treaties and adopt climate change policies. Further, companies with more women on their boards tend to improve energy efficiency, reduce overall environmental impact and invest in renewable energy; women leaders tend to prioritize proper waste management and reduce misuse of water, energy and resources.[198] By not engaging with these communities, fashion brands are not only failing to address pressing local concerns but are also overlooking the potential for co-creating sustainable solutions that are more likely to gain traction and have lasting impacts. This oversight undermines the industry's ability to develop comprehensive and effective approaches to addressing climate change and sustainability challenges.

5 Opportunities & Challenges in the Transition to Sustainable Fashion

RENEWABLE ENERGY ADOPTION

The Business Case for Renewable Energy and Energy Efficiency

Fashion brands across the globe face mounting pressure from various stakeholders—investors, employees, customers and others—to align their operations with sustainability goals and reduce their environmental impact.[199]

Beyond meeting these expectations, renewable energy adoption offers tangible business benefits. According to McKinsey & Company, implementing sustainability measures can drive significant cost efficiencies, with up to 50 percent of Tier 2 emissions reductions potentially being cost-neutral. This means brands have the potential to achieve savings in both emissions and operational expenses.[200]

Collaborating with suppliers on energy efficiency initiatives can offset more expensive sustainability efforts, such as material innovations. Additionally, reducing waste and overproduction through effective inventory management enhances sustainability while generating cost savings. This creates a compelling business case for renewable energy adoption beyond pure environmental considerations.

Strides Made by Global Fashion Brands

Global fashion powerhouses have begun making substantial investments in renewable energy. H&M Group, with a global operating profit of USD 1.33 billion in 2023,[201] and BESTSELLER, reporting global operating profits of USD 752 million through July 2024,[202] are making strides in integrating renewable energy into their operations.

H&M Group and BESTSELLER have partnered with Copenhagen Infrastructure Partners (CIP) to invest in an offshore wind project near Cox's Bazaar in Bangladesh. Set to commence operations in 2028, this project is projected to reduce emissions by approximately 725,000 tons annually while supporting Bangladesh's goal of sourcing 40 percent of its energy from renewables by 2041. Beyond environmental benefits, this initiative is set to foster job creation, stabilize the local energy supply and reduce reliance on fossil fuels, demonstrating how large-scale renewable energy investments can deliver substantial positive impacts on both climate objectives and local economic development.[203]

Opportunities for Small & Medium-Sized Enterprises

The benefits of renewable energy adoption extend well beyond large corporations. In many low- and middle-income countries, (LMICs), the textile sector consists predominantly of small and medium-sized enterprises (SMEs), which often have higher rates of women ownership than larger firms. This creates a significant opportunity to advance gender equity alongside sustainability goals.

In Egypt, Ghana, Kenya, Malawi, Nigeria, Tanzania, and Tunisia, the textile industry has significant potential to adopt renewable energy solutions, particularly for processes that require heat in the range of 30°C to 180°C—a range ideally matched to many solar thermal and biomass systems, which have been increasingly recognized as practical, cost-effective solutions for decarbonizing textile production across Africa.[204] Solar thermal collectors can supply hot water or steam for key textile processes such as dyeing, bleaching and washing. Biomass systems and biofuel-fired boilers can also provide the heat necessary for the processes, using locally available agricultural residues as fuel. Additionally, electric heat pumps can be used to upgrade ambient or waste heat for drying and finishing operations.[205]

Currently, 71 percent of SMEs in these countries rely primarily on grid electricity, with 14 percent combining grid electricity with fossil fuels. This dependence creates a clear opportunity to expand solar PV systems, micro-hydro solutions and other renewable power options to lower energy costs, reduce reliance on polluting fuels and minimize environmental impact.[206] For women-led SMEs in the textile sector, renewable energy adoption provides a pathway to increased productivity, reduced operational costs and greater sustainability.

Gender Dimensions of the Energy Transition

To maximize the benefits of renewable energy adoption, the fashion and energy sectors must prioritize the integration of women at every level of the transition. Women are key stakeholders as manufacturers, designers, retailers and technicians, as well as within their communities and regions. Their participation in renewable energy initiatives not only promotes inclusivity but also enhances innovation and economic outcomes.

Research demonstrates that gender diversity in the workplace leads to improved decision-making,[207] increased profitability[208] and innovative solutions.[209] Women's leadership specifically results in the adoption of more sustainable practices.[210] As women often

serve as primary energy managers in households, they have firsthand knowledge of energy use, needs and challenges at community and individual levels.[211] This insight drives more effective and user-centric energy solutions tailored to the actual needs of families and communities. For instance, women entrepreneurs in the clean energy sector are more likely to address energy poverty and access issues in their communities, recognizing the specific needs of women and children.[212] As women-led SMEs remain integral to the fashion sector, it is imperative to empower women entrepreneurs and leaders to drive the adoption of renewable energies.

Creating an Enabling Environment

Fashion brands, financial institutions and policymakers must collaborate to ensure women entrepreneurs have access to the resources, training and financial support they need to transition to renewable energy. Targeted investments in small-scale renewable solutions and energy-efficient technologies should be coupled with capacity-building programmes. These programmes must focus on technical training, financial literacy and leadership development tailored to women-led enterprises in the textile sector.

Moreover, partnerships between governments, private sector actors, investors and non-governmental organizations (NGOs) are essential to creating enabling environments for renewable energy adoption. This includes developing gender-responsive financing mechanisms, offering incentives for renewable energy projects and addressing structural barriers that limit women's participation in the energy and fashion industries.

By committing to these efforts, the fashion industry can significantly reduce its environmental footprint while empowering women entrepreneurs to lead the way in sustainable development. Such an approach ensures that the renewable energy transition is not only environmentally sustainable but also inclusive and equitable, fostering long-term socioeconomic progress in emerging markets.

CIRCULAR FASHION MODELS

Understanding Circular Fashion Principles

Circular fashion models focus on reducing waste, reusing materials and promoting sustainability through extended product life cycles. By shifting away from the traditional linear model of "*take, make, dispose*," which presumes high availability of natural resources,[213] circular fashion offers an opportunity to reduce energy consumption, lower carbon emissions and promote renewable energy solutions across the supply chain. Rooted in three core principles—eliminating waste and pollution; keeping products and materials in use at their highest value; and regenerating natural systems—circular fashion provides a sustainable framework for transforming the industry.[214]

One of the most significant aspects of the circular fashion model is the life cycle of products. Operating under the traditional linear model, estimates indicate that only one percent of used clothing is recycled worldwide. By contrast, in the circular fashion model, garments and textiles are kept in circulation for as long as possible through practices such as recycling, upcycling, repairing and reusing. Research finds that the adoption of a circular economy approach by fashion companies, with investment in renewable energy sources, reusing

materials, and expanding the lifespan of clothing, could help to reduce emissions by between 30 to 50 percent.[215]

Circular Business Models & Growth Potential

Sustainability-first businesses in the fashion industry are experiencing significant growth. The circular fashion market, including resale, rental, repair and remaking models, is expanding. These circular business models have the potential to increase their market share from 3.5 to 23 percent of the global fashion market by 2030.[216]

Several companies have implemented successful take-back programmes where consumers return used items for recycling or repurposing. Patagonia has pioneered repair and reuse initiatives, encouraging consumers to extend product lifespans rather than purchase new items. Patagonia's circularity and consumer awareness strategy has extended the life of clothing by nine months, reducing carbon, waste and water footprints by approximately 20–30 percent each. The company has also resold more than 120,000 repurposed items, significantly cutting down on waste and emissions.[217]

The circular fashion model can scale globally and is especially relevant in regions with growing concerns over textile waste. Women-led SMEs in emerging markets can create businesses focused on garment repair, resale and upcycling, fostering a circular economy in their communities.

Energy Benefits of Circular Approaches

By designing clothes to last longer, the fashion industry can significantly reduce the need for energy-intensive new production. Producing a new garment requires substantial energy inputs, from manufacturing raw materials to dyeing and finishing. This shift toward recycled fibres or pre-loved clothing eliminates many of the high-energy processes associated with new textile production. Recycled fabrics require less energy to produce than new fabrics made from raw materials like cotton or polyester, which involve intensive energy inputs at every stage of production. By shifting to closed-loop recycling, circular fashion helps reduce energy consumption and lower carbon footprints.

Repair and upcycling businesses, particularly those led by women in small enterprises, typically consume far less energy than those manufacturing new garments. Encouraging consumers to recycle, repurpose or buy second-hand garments also significantly lowers overall energy use in the fashion supply chain.

Additionally, garment rental services can help reduce the need for constant production and the associated energy demand, particularly in fast fashion where clothing items may only be worn a few times. Resale models have been estimated to save up to 97 percent of energy compared to the production of new garments.[218] Efforts should be made to ensure financial accessibility, offering low-cost or flexible investment options for women entrepreneurs to adopt recycling technologies, repair services or eco-design practices. Policies that provide affordable financing and technical support will help create a more inclusive circular economy.

Circular models also create opportunities to integrate renewable energy sources into the fashion production process. Solar and wind energy, for example, can power factories engaged in recycling or garment repair

operations. Solar-powered upcycling businesses, particularly in regions with high solar potential, can reduce reliance on fossil fuels and contribute to the global energy transition.

Circular Fashion Model Implementation Challenges

Despite its potential, the transition to circular fashion faces several challenges. Research indicates that shifting to a circular economy in fashion and textiles is complex, requiring "*knowledge, significant financial investment in technological change, and greater consumer purchasing power in the production of products based on a circular economy*." New brands in the fashion industry often lack sufficient information to establish circular business models. In addition, young fashion designers report insufficient in-depth knowledge and financial resources to develop brands based on circular economy principles.[219]

Consumer awareness and acceptance represent another significant barrier. While the circular economy model supports sustainable development goals by promoting sustainable production and consumption, many consumers remain unfamiliar with or resistant to these concepts. Further, finding the right balance between sustainability and profitability presents an ongoing challenge. Although circular models can reduce costs in the long term, businesses must ensure their products remain profitable in the short term. Finally, identifying suitable materials and products for reuse and recycling poses technical challenges that require ongoing innovation and investment.

Potentiality Of The Circular Fashion Model

The circular fashion model is more than just a response to the need for sustainability—the model is integral to the energy transition in the fashion industry. By reducing energy demand through practices like reuse, recycling, repair and remanufacturing, circular fashion helps to lower the carbon footprint and reliance on energy-intensive processes. For women entrepreneurs and small businesses in emerging markets, circular fashion models present a significant opportunity to adopt clean energy solutions, increase energy efficiency and align with the global energy transition. Circularity provides an opportunity to foster innovation, reduce reliance on fossil fuels, integrate renewable energy into the fashion industry's supply chain and create new markets for women entrepreneurs. As the industry continues to evolve, embracing circularity can be a powerful tool to accelerate the transition to renewable energy and create a more sustainable, equitable fashion ecosystem for all.

INNOVATION & INVESTMENT

Innovation and investment in sustainable technologies and practices are crucial for driving meaningful change in the fashion industry, both in terms of reducing its environmental impact and fostering gender equity.

Product Innovation: Next-Gen Materials Redefining Sustainability

Innovation in sustainable materials has become a central focus in the fashion industry as it confronts the environmental harm caused by petroleum-based fabrics. According to the *Pulse of the Fashion Industry* 2018 report, two-thirds of the industry's negative sustainability impact stems from the raw material stage.[220] Addressing innovation at this phase is crucial for designing fashion sustainably, along with considering the environmental effects of usage, washing and end-of-life disposal.

Alternative fibres, such as hemp, bamboo, recycled cotton, organic linen and even food waste (think bananas, oranges and pineapples), are gaining attention for their lower environmental impact.[221] Natural materials like cork and seaweed are also being used to create ethical, vegan clothing.[222] Additionally, significant investments are being made in fibre recycling and innovative materials like mycelium leather, synthetic spider silk and biodegradable plastics.[223] Recycled cotton, for instance, made from waste materials like fabric scraps and used clothing and created through a mechanical recycling process, uses less water, pesticides and energy than virgin cotton.[224]

Globally recognized brands like Diane von Furstenberg, Reformation, Allbirds and Carhartt are embracing sustainable materials by sourcing from Lenzing Group. Lenzing's TENCEL™ and LENZING™ ECOVERO™ fibres, made from sustainably sourced wood and wood pulp, are reported to reduce carbon emissions and water usage by at least 50 percent.[225] TENCEL™ is produced from fast-growing eucalyptus trees on low-grade land, requiring far less space and water than cotton. The fibres are created using a closed-loop production process that recycles wastewater and low-level chemical solvents, resulting in a biodegradable and compostable end product. Due to these sustainable practices, TENCEL™ fibres have earned the European eco-label Oeko-Tex 100 certification, indicating low levels of harmful chemicals and by-products.[226]

The search for sustainable alternatives to leather has seen similar innovations. Livestock supply chains ac-

count for 14.5 percent of global greenhouse gas (GHG) emissions, with cattle responsible for most of this.[227] Sustainable alternatives like mycelium-based Mylo, Reishi (fungus roots) and plastic-free Mirum made from plants, minerals and food waste are gaining traction. High-profile brands like Stella McCartney, Adidas and H&M have embraced these alternatives.[228]

However, the adoption of innovative materials faces persistent challenges. A 2024 report from Sustainabelle Advisory Services found that limited investor understanding of the fashion industry is hindering funding for innovations, especially in the competitive alternative leather sector.[229]

Despite these challenges, investing in sustainable fibres and alternative materials is not just a matter of environmental responsibility but also a smart business move. Studies from Boston Consulting Group and Textile Exchange predict that brands that diversify their raw materials, particularly sustainable raw materials, could see a 6 percent profit increase, with a potential USD 100 million opportunity for brands with USD 1 billion in annual revenue. If fashion brands continue to prioritize cost-cutting and mass production, they risk depleting the supply of raw materials, leading to a material shortage by 2030, resulting in lower profits.[230] To avoid this, investment in sustainable materials innovation must accelerate.

DEEP DIVE:

SUSTAINABILITY IN FASHION & FOOD SYSTEMS

Fashion and food industries are deeply interconnected, facing shared challenges and opportunities, as both rely on raw materials and often compete for the same scarce resources.[231] Traditional production methods in both sectors are resource and energy intensive, often harmful to ecosystems.

The fast fashion business model has doubled the production of clothing in the last 15 years,[232] intensifying demand for cotton and other natural fibres. This surge has driven unsustainable farming practices as intensive cotton cultivation depletes soil nutrients, pollutes waterways, disrupts local ecosystems and displaces food crops, thereby exacerbating food insecurity.[233] Women in developing countries often bear the brunt of these unsustainable practices, unable to afford sustainable alternatives due to systemic barriers.[234]

Regenerative agriculture offers a promising solution by focusing on social health, biodiversity and carbon sequestration through practices like organic fertilization, crop rotation and diversified crop growth.[235] Notably, 86 percent of the top 60 global luxury fashion brands are now investing in regenerative approaches.[236] For example, SÖKTAŞ, an organic cotton supplier for brands like Stella McCartney, has captured significant carbon through regenerative practices on its 90-hectare farm.[237]

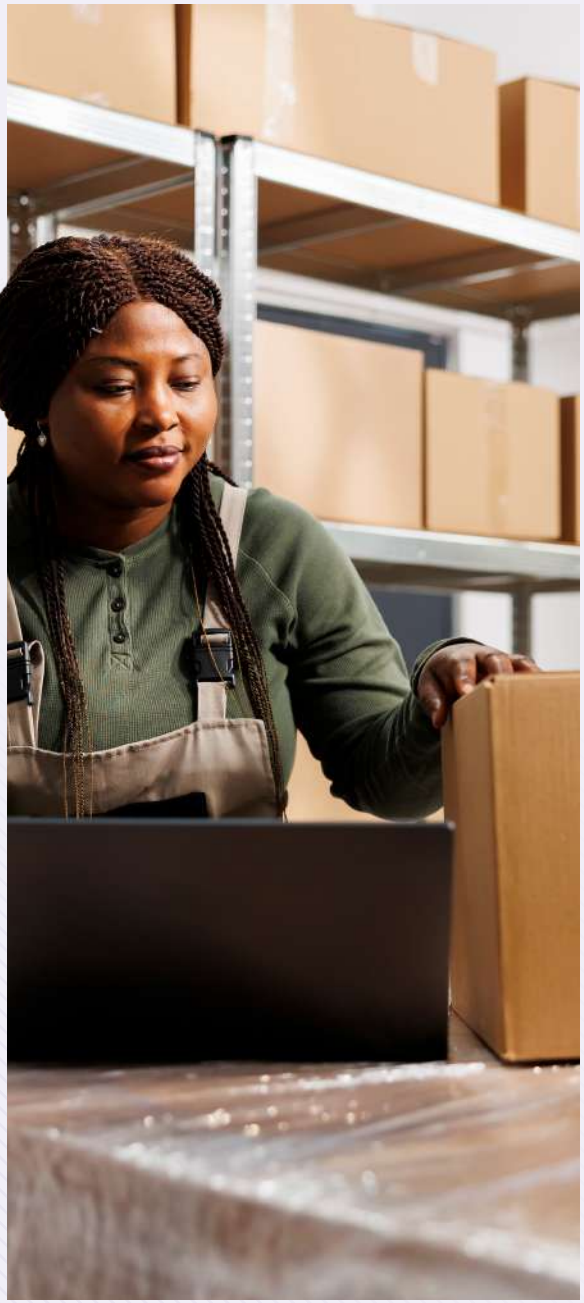
Regenerative agriculture powered by renewable energy can decrease reliance on diesel and synthetic fertilizers, while reducing the fashion industry's carbon footprint. Food waste biomass can even power textile factories, closing the loop between energy, food and fashion.

Improving the economic empowerment of women is crucial to this transition. When women are empowered through equal access to education, land, credit and decision-making, they tend to make decisions that benefit the environment, such as investing in sustainable farming practices or focusing on biodiversity. Gender-sensitive policies in agricultural supply chains are therefore key to ensuring equitable benefits from regenerative agriculture.[238]

Yet, as of 2022, only 1.4 percent of the world's cotton was grown using organic or regenerative methods, and full-scale adoption remains slow.[239] Fully embracing the shift to sustainability could repurpose the 2 percent of global cropland used for cotton to grow food for local populations.[240]

Innovations like S4S Technologies' portable, solar-powered machine that dries vegetables and spices while retaining nutrients, turning food crops into sellable products, demonstrate how renewable energy and gender equality can uplift farmers. This approach helps reduce agricultural waste in India and increases income for women farmers by 10-15 percent.[241] Harnessing similar innovations in fashion could drive sustainable practices, reduce waste and create economic opportunities for marginalized communities.

To achieve lasting change, we must view food and fashion as interconnected systems that prioritize environmental health, social equity and economic resilience.



Process Innovation: Technological Advancements in Fashion Supply Chains

In addition to focusing on what clothing is made from, it is crucial to consider the processes by which clothes are made. Technological advancements offer significant opportunities to reduce energy consumption, decrease fashion waste and improve the efficiency of production and distribution.[242]

Adopting circular practices encourages innovation in how energy is used across the fashion supply chain. For instance, the need for energy-efficient garment production can inspire the development of new technologies that reduce energy consumption in textile manufacturing, dyeing and finishing processes. These innovations can be applied not only in the context of circularity but also in the broader energy transition within the fashion industry. Energy-efficient machinery, such as low-energy sewing machines, solar-powered production lines or smart textile finishing equipment, can significantly reduce the overall energy demand of fashion production.

Digitization and Artificial Intelligence (AI) are further optimizing supply chain operations. AI can reduce energy waste by minimizing fabric scraps, streamlining logistics and enhancing supply chain transparency. Already, AI has been used in the fashion sector to improve demand forecasting, automate warehouse operations, optimize last-mile delivery and increase efficiency. Similarly, blockchain technology strengthens supply chain transparency by preventing counterfeiting, verifying ethical sourcing and supporting traceability.[243]

For example, Leila Salieva, co-founder of Sombrero Galaxy Agency, has merged fashion's creative branding with blockchain transparency and community-building, leveraging AI to optimize marketing strategies. Her work enables brands to build authentic digital identities, foster engaged communities and use data-driven insights for effective outreach. By integrating AI for content creation, sentiment analysis and chatbot optimization, she helps brands innovate and thrive in today's digital landscape.[244]

Similarly, innovations in recycling technology are helping address the industry's environmental impact. New methods recycle post-industrial and post-consumer waste into cotton or yarn, reducing costs, water and chemical use.[245] Chemical recycling of cotton textile waste is also emerging, though it is still in its early development stages and requires further refinement to be more energy and water efficient.[246] Recycling blended materials, such as polyester and cotton, is particularly challenging but an important area of progress.[247]

Technologies are also providing supply chain transparency and accountability in the fashion industry. Companies such as FibreTrace have developed photon-marker systems that enable brands to verify each step of the supply chain, ensuring accountability for sustainability claims.[248] FibreTrace is used by brands to show where clothing came from, how it arrived at retail stores and who made it.[249]

Challenges & Opportunities to Process Innovation

While technological upgrades drive more environmentally sustainable production, they also have the potential to displace low-skilled workers, particularly women in the garment manufacturing workforce. An International Labour Organization (ILO) study found that newly

created roles requiring specialized skills and offering higher pay are more likely to go to men, reflecting the structural barriers that women often face, such as a disproportionate share of care work and limited access to skill development.[250] However, companies can respond by reskilling and upskilling women to promote advancement in the sector.[251]

Further, women's representation in STEM and AI development is essential for creating solutions that benefit diverse populations and address gender-specific challenges in fashion's energy transition. Technological advancements will require sector-wide reskilling, particularly for designers who will increasingly experience the need to work with research & development (R&D) teams to develop sustainable design solutions.[252] Currently, women represent only 29 percent of science R&D positions globally, limiting their influence on innovations that could directly impact gender equity in the energy and fashion industries.[253] Ensuring women's involvement in technological, including AI, development is particularly crucial, as underrepresentation risks embedding biases into technologies that perpetuate inequalities.[254]

Start-ups, especially women-led fashion-tech companies, are crucial to developing these innovations. Female-founded start-ups are developing new technological solutions that transform how brands and consumers interact, launch products and meet market needs.[255] Despite this, women entrepreneurs generally face significant funding challenges, receiving 14 percent less investment than their male counterparts, with an additional 8 percent reduction if the investor has previously experienced a failure with a woman-led start-up.[256] This creates a barrier for female founders in securing the critical funding needed to drive these technologies forward.

By integrating advanced technologies with gender-responsive investments, the fashion industry can significantly reduce its environmental footprint while empowering women to take on leadership roles in the energy transition. Targeted initiatives—such as increased funding for women-led innovations, representation in R&D and gender-conscious technological solutions—ensure that innovation drives not only technological progress but also broader socioeconomic transformation. This holistic approach creates a sustainable and inclusive future for the fashion industry, aligning its practices with global decarbonization goals and fostering a more equitable and resilient economy.

Consumer Awareness & Behaviour

Consumer behaviour plays a crucial role in shaping the impact of the fashion industry on climate change. As awareness of the interconnectedness of energy use, environmental sustainability and gender increases, consumers are increasingly making purchasing decisions based on these factors. Global concerns about climate change have led fashion consumers to become more mindful of how their buying habits contribute to environmental degradation. Additionally, consumers are considering how issues of gender equality and inclusivity intersect with sustainable practices, prompting a shift toward more responsible and informed consumption patterns.

Today's consumers are more attuned to the environmental cost of fast fashion and are actively seeking brands that prioritize sustainability. Growing aware-

ness of the industry's role in contributing to the climate crisis has made sustainability a key consideration for many shoppers. Surveys indicate that a significant portion of consumers now factor sustainability into their fashion choices, with many willing to pay a premium for eco-friendly materials, ethical labour practices and brands that actively reduce their carbon footprint.[257] Around two-thirds of consumers worldwide report that they would switch, avoid or boycott brands based on their stance on controversial issues, including social standards and environmental responsibility.[258] Consumers are not only interested in how their fashion choices affect the planet but are also increasingly concerned with how brands address gender equality and inclusivity.

Social media and digital platforms have been pivotal in educating consumers, making information about the environmental impacts of fast fashion and alternative, sustainable fashion choices more accessible. Influencers and activists who champion climate-conscious fashion have created a powerful space for informed consumer behaviour.[259] This, coupled with increasing transparency from brands about their sustainability efforts, has contributed to a broader societal shift toward more eco-conscious consumption.

Women are at the forefront of driving sustainable fashion choices. Research indicates that women are more likely to encourage friends and family to adopt environmentally friendly lifestyles and are more committed to supporting eco-friendly apparel brands.[260] Female consumers demonstrate stronger loyalty toward brands that align with their values of sustainability and social responsibility.[261]

Women play a primary role in managing household energy consumption, making decisions about overall energy usage and managing appliances. However, they might not always have the decision-making power to invest in energy-efficient technologies due to economic constraints or societal norms. Recognizing and addressing these challenges is crucial. Empowering women to make energy-related decisions not only makes business sense but also accelerates positive changes in energy systems. Companies and policymakers should focus on removing barriers to fully leverage women's potential in driving sustainable practices.[262]

McKinsey's latest *State of Fashion 2025* report finds that the climate crisis will continue to be a significant force in shaping both fashion supply chains and consumer behaviour. The growing costs of climate change and government actions to combat it mean that sustainability

will remain a top priority. Brands that approach sustainability with a long-term mindset—despite short-term challenges—will likely be rewarded with more efficient operations and a competitive edge in the marketplace.[263] As consumer awareness continues to evolve, the fashion industry will need to adapt to these shifting demands, balancing environmental responsibility, inclusivity and profitability.

Fostering consumer awareness about the environmental and social impacts of the fashion industry is crucial for driving meaningful change. By empowering individuals to make informed choices, there is an opportunity to collectively shift towards a more sustainable and equitable fashion landscape that prioritizes both environmental sustainability and gender equality.

POLICIES & REGULATIONS

International Sustainability Initiatives

The global fashion industry has begun to align around key international frameworks designed to address climate impacts and sustainability challenges. These collaborative efforts establish standards and commitments that transcend national boundaries.

Launched by the UN Framework Convention on Climate Change (UNFCCC) in 2018, the *Fashion Industry Charter for Climate Action* represents a collective commitment within the fashion sector to significantly reduce GHG emissions. The Charter's ambitious goal is to achieve net-zero emissions by 2050 in line with the 1.5°C target outlined in the Paris Agreement.[264] With signatories required to set science-based targets with a pledge to cut emissions by 50 percent by 2030, the Charter plays a pivotal role in driving global action.[265]

Transparency forms the foundation of this initiative. In 2022, 89 percent of signatories met the reporting requirements, disclosing climate-related data through the Carbon Disclosure Project (CDP). This reflects a significant increase in public reporting efforts and demonstrates a growing commitment to transparency and accountability. Though progress on renewable energy adoption has been slower, with only 15 percent of energy consumed by responding companies coming from renewable sources, the trajectory shows improvement.[266]

The Charter also emphasizes corporate advocacy, encouraging companies to influence policy development and collaborate with governments on strategies that align with global climate goals. For full compliance, signatories must reduce emissions, increase renewable energy sourcing and disclose comprehensive climate-related data, ensuring their actions are aligned with global targets and that consumers, businesses and decision-makers can make data-informed choices around fashion. This framework provides a clear roadmap for how policy, corporate responsibility and transparent reporting can collaborate to mitigate climate change impacts across the fashion value chain.

Public-Private Partnerships for Industry Transformation

Public-private partnerships (PPPs) have emerged as powerful vehicles for driving sustainability in fashion. By combining private sector innovation and capital with public sector policy frameworks and risk mitigation, PPPs enable collaborative solutions to systemic challenges, such as textile waste, harmful chemical usage and ethical supply chain management, to drive development.[267] These partnerships foster accountability through "*clearly defined roles, transparent governance*," and shared sustainability objectives.[268]

PPPs enable risk-sharing, as public funding de-risks early-stage investments in areas like sustainable technologies, circular economies and scalability of successful projects. Overarchingly, PPPs can facilitate the adoption of more sustainable production processes and overall supply chain management.[269] For instance, Stella McCartney's collaboration with the BioCircular Materials Alliance (2025) exemplifies cross-sector innovation. By uniting governments, non-governmental organizations (NGOs), and companies like Spiber Inc. (a biotech venture company developing sustainable materials), this PPP advances circular infrastructure using agricultural waste. McCartney's advocacy also influences global policy, embedding circular economy principles into industry standards.[270]

PPPs can also play a crucial role in supporting SMEs through both financing, as public investment can de-risk investments, and capacity-building. SMEs, which often lack resources for sustainability transitions, benefit from training, technical assistance and best-practice sharing, which can be facilitated by PPPs. This enhances the ability of SMEs to succeed in competitive markets.[271]

A successful case study is that of Dibella, a German textile enterprise, that partnered with Germany's Federal Ministry for Economic Cooperation and Development to address unsafe chemical storage at a Pakistani supplier. A two-year plan introduced Key Performance Indicators (KPIs) for sustainable material use, safer chemical

handling and worker training. The project culminated in Dibella achieving OKEO-TEX STeP certification, validating environmentally friendly production and fair labour practices.[272]

For women-led and women-based SMEs, these types of partnerships are particularly impactful as they work to de-risk investments and drive forward scalability in the fashion industry. A successful case study is the Rajasthan government's RAJEEVIKA initiative partnership with Rang Sutra, a private social enterprise, to support Marudhara Rangsaaz—a women-led textile producer company. Public-sector backing enabled project implementation, while private expertise provided capacity-building, training and market access for rural women producers.[273]

Moving forward, PPPs must ensure long-term alignment, community and beneficiary engagement, and policy integration with national sustainability agendas and the wider Sustainable Development Goals (SDGs). This model of engagement highlights the importance of cross-sector collaboration in advancing sustainability goals and shows how industry leaders can play a pivotal role in transforming fashion to ensure it is both economically viable and environmentally responsible.

Policy & Regulatory Frameworks In High-Income Countries

High-income countries have increasingly prioritized sustainability within fashion industries through a combination of regulations and incentives.[274] These policy frameworks target specific aspects of the fashion value chain and establish models that influence global standards.

For instance, the EU has taken a leadership position in regulating sustainability in fashion. Renewable energy sources such as solar, wind and hydropower are being integrated into manufacturing processes, reducing carbon footprints while fostering greener economies. In June 2023, Members of the European Parliament proposed stronger measures specifically designed to curb overproduction and excessive consumption of textiles. These proposals emphasize the requirement that textiles be produced in ways that respect human rights, uphold social and labour standards, ensure environmental sustainability, and maintain animal welfare.[275]

A cornerstone of this initiative is the introduction of new eco-design requirements for textiles and the implementation of the digital product passport (DPP). This digital tool enhances product transparency and traceability throughout supply chains,[276] enabling consumers and regulators to access detailed information about a product's environmental impact and manufacturing conditions. These combined efforts place greater responsibility on companies for their environmental footprint and establish a comprehensive model for the global fashion industry.

High-income countries have also committed to targeting specific aspects of the fashion industry that have a disproportionate impact on environmental degradation. Policy and regulation have increasingly targeted the industry-wide issue of over-stocking and excessive production. In July 2024, the EU approved the Ecodesign for Sustainable Products Regulation, which requires fashion companies to report unsold textiles beginning in 2025. By early 2026, the destruction of unsold goods will become illegal under this framework.[277]

This approach addresses a critical environmental concern highlighted in UK reports that document the harm caused by incinerating unsold stock. While incineration may recover some energy, the process significantly increases a product's overall climate impact by releasing additional emissions and pollutants, including harmful plastic microfibres from synthetic fabrics.[278]

Similar regulatory trends are emerging in the US. In August 2024, California became the first US state to implement an Extended Producer Responsibility programme specifically for textiles. This legislation requires apparel companies to develop comprehensive plans for the collection, repair and recycling of garments by 2030.[279] These policies represent a fundamental shift away from the disposable fashion model that has dominated the industry for decades.

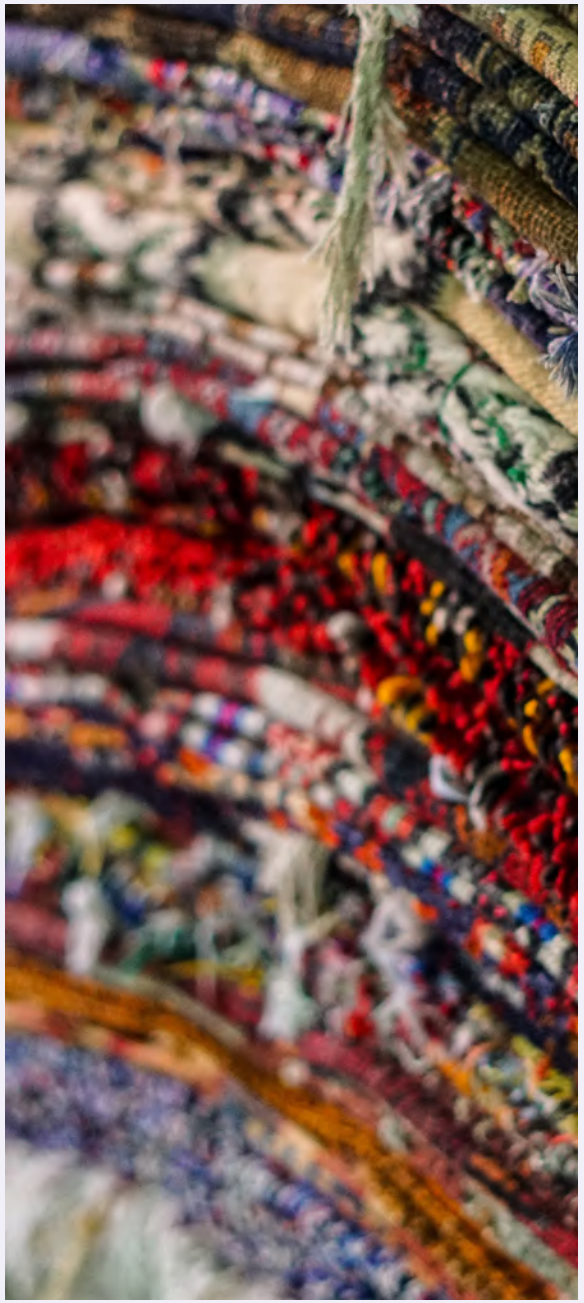
Policy, Regulatory & Incentive Frameworks in LMICs

Policies governing fashion, renewable energy, gender equality and environmental protection in LMICs present unique challenges and opportunities. These interconnected domains require integrated regulatory approaches that balance economic development with social equity and environmental sustainability.

In India, for example, the *Textile Policy 2024* includes financial incentives; the policy provides capital subsidies, credit-linked interest subsidies and wage assistance, alongside a gender quota requiring at least 1,000 women to be employed per 4,000 workers in new industrial units, thereby aiming to enhance women's participation in the industry. Electricity tariff subsidies for renewable energy sources support greener production processes, as conditional equipment cost assistance is offered if new technologies achieve a minimum of 10 percent energy and water savings compared to previous usage. Additionally, the policy prioritizes research and development (R&D) in smart and technical textiles, sustainable production processes and digital supply chain integration. This has the potential to drive adoption of green manufacturing, circular economy practices, and efforts to reduce the industry's carbon footprint. Importantly for women within the fashion sector, where women entrepreneurs lead nearly 15 million SMEs, predominately in manufacturing,[280] the policy has measures to upgrade the technological capabilities of SMEs, promoting their access to global markets and bolstering overall industry competitiveness.[281]

In Vietnam, various incentive policies to attract investors offering environmentally friendly technological solutions have been introduced, including Article 5 of Decree No. 23/2024/ND-CP, which "*offers a 5 percent preference during the bidding evaluation process to investors who propose environmentally friendly solutions aimed at minimizing pollution for high-risk projects, as stipulated by Environmental Protection Laws*."[282] The Bidding Law looks at the selection of investors to implement projects in the country.

Bangladesh is home to 229 Leadership in Energy and Environmental Design (LEED)-certified green factories. Awarded by the US Green Building Council, this certification is earned by projects that meet prerequisites addressing carbon, energy, water, health and indoor environmental quality.[283] The Government of Bangladesh provides financial incentives and support to factories aiming for LEED certification and now hosts 60 of the



top 100 highest rated LEED-factories across the world.[284] One factory with LEED Certification, Knit Asia, reports a savings of 3,300 tonnes of CO2e (the equivalent of 82,800 trees planted), and the reduction of energy-related carbon emissions by 257 tonnes CO2e from renewable energy use, demonstrating the benefits of this certification.[285]

Policy & Regulatory Opportunities for LMICs

The fashion industry in many LMICs provides considerable employment, particularly for women in the production and manufacturing sectors. However, working conditions in this sector often fall short of acceptable standards.[286] Implementing gender-sensitive policies is crucial to improve labour standards and create advancement opportunities for women across the value chain, including design, management, technology and sustainability.

Effective policy measures should include establishing grievance redressal mechanisms to address gender-related risks such as workplace harassment and discrimination. Equally important are social protection programmes, equal pay enforcement, workplace safeguards and occupational safety standards with appropriate training. These foundational policies can transform the industry from one characterized by exploitation to one that empowers workers and improves their quality of life.[287]

Further, as the industry evolves with increasing automation, robotics and AI integration, certain jobs may become obsolete while others emerge. To address this shift, businesses and governments should focus on providing lifelong digital training for women, enabling them to skill, reskill and upskill to meet changing industry demands.[288]

Policies promoting renewable energy adoption and eco-friendly practices can significantly support small enterprises, particularly those led by women, by lowering operational costs and boosting profitability.[289] In rural areas, transitioning to cleaner energy alternatives delivers multiple benefits: improving women's health, reducing time spent on resource collection and creating opportunities for education and entrepreneurial ventures.

The fashion sector in LMICs can leverage sustainable practices—reducing waste, recycling textiles and using eco-friendly materials—to both mitigate carbon emissions and tap into growing global markets for ethical products. As international demand for sustainable fashion increases, LMICs have an opportunity to position themselves as leaders in this space, diversifying their economies and creating more resilient business models.

By implementing policies that simultaneously empower women, improve labour standards, drive climate resilience and foster green economic growth, LMICs can develop fashion sectors that contribute to sustainable development while participating more equitably in global value chains. Transparency and accountability mechanisms remain essential to ensure these policies deliver their intended benefits and contribute to addressing broader challenges in climate change and social equity.

6 Conclusions & Recommendations

The fashion industry stands at a critical juncture where its economic significance intersects with pressing environmental and social challenges. Notable advancements in policy and regulations have begun to address these issues, particularly the environmental consequences of fast fashion.

However, the creation of truly sustainable solutions—environmental, economic, and social—requires further concerted effort. Central to this transformation is the strengthening of women's roles within the industry, given their pivotal position in both the production and consumption of fashion. To effectively tackle these multifaceted challenges, a more integrated and collaborative approach across all stakeholder groups is essential.

Integrate gender-responsive approaches into climate & energy policies

The fashion industry's gender dynamics significantly influence environmental and social outcomes. Women often bear the brunt of energy-intensive tasks and are disproportionately affected by climate change impacts. Gender-responsive policies are essential to ensure equitable and inclusive interventions that address women's specific needs and contributions.

- **Mandate gender-disaggregated data collection & analysis**: Governments should mandate the collection and analysis of gender-specific data in policy formulation processes to reveal the differential impacts of climate and energy policies on various demographics.
- **Incorporate gender-responsive policy integration**: Governments should revise existing and future climate and energy policies to include gender-specific impact analyses, establish measurable targets for women's empowerment within the climate, energy and fashion sectors, and identify funding mechanisms for policy implementation. National initiatives like National Determined Contributions (NDCs), Action Cooling Plans and Heat Action Plans should explicitly consider the unique needs of women, especially those in industries most affected by energy access and climate.
- **Foster cross-sectoral collaboration**: Policymakers should engage with private sector entities, international organizations, fashion brands, suppliers and women's advocacy groups to develop policies that reflect the lived experiences of those directly involved in or impacted by the fashion sector.
- **Ensure women's active decision-making**: Governments should facilitate women's substantive involvement in shaping gender-responsive climate and energy policies to ensure these policies effectively address diverse needs and vulnerabilities.

Promote renewable energy adoption in the fashion industry

The fashion industry's high energy demands, primarily from textile manufacturing and garment production, contribute significantly to greenhouse gas (GHG) emissions and disproportionately impact communities and regions that the bulk of these processes falls on. Transitioning to renewable energy sources is imperative to mitigate these impacts.

- **Incentivize renewable energy adoption**: Governments should offer targeted financial incentives, such as tax credits and subsidies, to encourage private sector investments in renewable energy technologies.
- **Incentivize off-grid systems**: Governments should provide grants, results-based financing and concessional loans—such as the Mission 300 subsidies model—[290] to de-risk investments by mini-grid developers and off-grid solar providers, reducing per-unit costs and accelerating deployment in remote areas.

> Mission 300, led by the World Bank Group and the African Development Bank, with Sustainable Energy for All (SEforALL) as its Secretariat, brings together African governments, the private sector and development partners to deliver affordable power, expand electricity access, enhance utility efficiency, attract private investment and strengthen regional energy integration–all aimed at driving economic transformation across the continent. Mission 300's central goal is to connect 300 million people in Africa to electricity by 2030. This effort is expected to power economies, improve essential services and spur job creation for Africa's rapidly growing population. The initiative also presents a significant opportunity to equip women and youth with the skills and resources needed to participate in and benefit from the continent's energy transition.

- **Tailor gender-responsive finance models:** Finance institutions should develop and scale tailored microfinance and blended finance programmes offering flexible terms. At the same time governments and investors should leverage results-based financing (RBF) for outcome-based rewards and promote investment through a gender lens, alongside targeted training in financial literacy and business development.
- **Establish regulatory standards**: Governments should implement stringent energy efficiency standards across the fashion sector's value chain, incentivizing private sector compliance through public recognition or financial benefits.
- **Enhance energy efficiency**: Governments should embed ambitious, mandatory energy-performance standards for textile machinery, buildings and processes into their NDCs—complete with clear targets, roadmaps and investment commitments—aligned with SDG 7.3s target to double the global rate of efficiency improvement by 2030, and drive compliance through preferential financing, tax rebates and public recognition.
- **Foster public-private partnerships (PPPs)**: All stakeholders should work to foster collaborative initiatives between government bodies and private sector entities to drive the adoption of renewable energy solutions and the development of green infrastructure.

- **Invest in renewable energy technologies**: Governments, private sector, multilateral development banks and other investors should allocate resources to support the development and deployment of renewable energy technologies, including blockchain and AI, to reduce the industry's carbon footprint and stimulate green job creation.
- **Ensure equitable distributions**: All stakeholders should provide technical and financial assistance to low- and middle-income countries (LMICs) to develop robust renewable energy infrastructure for textile production, manufacturing and distribution.
- **Embed women's reskilling**: Governments, public and private sector actors, and other stakeholders should provide targeted reskilling and upskilling on the green skills necessary for women to fully participate in and benefit from the shift towards renewable energy and energy efficiency technologies within evolving sectors such as the fashion industry.

Enhance gender equality in the fashion sector

Gender inequality in the fashion industry, from supply chains to retail, oftentimes perpetuates exploitative labour for women with poor working conditions, limiting their economic empowerment and ability to transition to sustainable, healthy practices.

- **Mandate workplace equity:** Governments and corporations must enact and rigorously enforce legislation mandating equal pay for equal work; comprehensive safeguarding measures against sexual harassment and gender-based violence throughout supply chains; and robust policies such as paid parental leave and affordable childcare subsidies to ensure women's full and equitable participation in the workplace.
- **Launch capacity-building programmes**: All stakeholders—governments and corporations—should invest in comprehensive training programmes that enhance women's skills in leadership, management and sustainable practices. These initiatives should actively engage other stakeholders, including community members, politicians, policymakers, legislators and industry leaders, to cultivate a supportive environment that advances gender equality in the workplace.
- **Mandate supply chain transparency**: Governments should require companies to disclose detailed information on their supply chain's gender composition, wage gaps and safety protocols.
- **Empower women in decision-making**: Governments and industry leaders should ensure women's active participation in policy and strategic decision-making processes across climate, energy and fashion.
- **Implement quotas & targets**: Governments and companies should establish corporate quotas and targets for women in executive and decision-making roles, with governmental incentives for compliance.

Strengthen environmental conservation practices

The fashion industry's environmental impact extends across water, air and land resources, necessitating a holistic approach to conservation.

- **Implement water stewardship regulations**: Governments should enact stringent regulations on water usage and wastewater management to prevent contamination, including mechanisms for transparency and accountability.
- **Promote water conservation technologies**: All stakeholders along the fashion value chain, including brands and suppliers, should embrace the adoption of water-saving technologies and support research into sustainable materials and processes.
- **Transition to sustainable raw materials**: Fashion brands and suppliers must lead the transition to sustainable raw materials, prioritizing renewable and recycled fibres. Sustainable land management practices, including responsible sourcing of natural fibres, minimizing deforestation and reducing the use of harmful chemicals, should be implemented.
- **Establish air quality regulations**: Governments should enact and enforce regulations to limit air pollution from textile manufacturing and transportation, while promoting investment in emission-control technologies and renewable energy sources.

Enhance fashion supply chain transparency & accountability

A lack of transparency and accountability across fashion supply chains can conceal exploitative labour practices and environmental damage, making it difficult to understand and measure the scale of impact that the fashion industry has, and hindering effective intervention.

- **Establish mandatory reporting standards**: Governments should mandate comprehensive reporting on environmental impact and labour practices through independent audits for brands and suppliers.
- **Commit to international standards**: Brands and suppliers should adhere to internationally recognized standards, such as the UN Framework Convention on Climate Change (UNFCCC) *Fashion Compact*, to ensure supply chain traceability and full disclosure of the environmental impact of their products.

Promote circular fashion models

The traditional linear model of '*take-make-dispose*' is unsustainable due to its high resource usage and waste generation, both exacerbated by the rapid pace of fashion consumption.

- **Invest in recycling technologies**: Stakeholders in the public and private sectors should support the development of technologies that enhance textile recycling and reuse.
- **Incentivize textile reuse**: Governments should provide tax incentives or subsidies for businesses that promote recycling and upcycling, while businesses engage consumers through incentives to participate in these schemes.
- **Implement consumer education initiatives**: Fashion companies, governments and other key stakeholders should launch campaigns to educate consumers on the benefits of reusing, repairing and recycling garments.

Drive sustainable consumption through consumer education

Consumer behaviour, especially in fast fashion markets, significantly influences industry practices. Encouraging consumers to take ownership over their role in the fashion supply chain can promote more sustainable practices at the individual, community and corporate levels.

- **Launch public awareness campaigns**: Governments, brands and civil society should orchestrate campaigns highlighting the environmental and social consequences of fast fashion, advocating for more sustainable consumption behaviours.
- **Utilize social marketing strategies**: All stakeholders have the opportunity to leverage social influence to promote sustainable consumption behaviours.
- **Implement product labelling standards**: All stakeholders, including fashion brands and suppliers, should establish and adhere to standardized labelling systems that clearly communicate the environmental and social impact of garments.

Invest in innovation & training for sustainable fashion

There is a critical need for skilled professionals and innovative technologies to advance sustainable fashion practices, renewable energy technologies, climate change mitigation and gender equality.

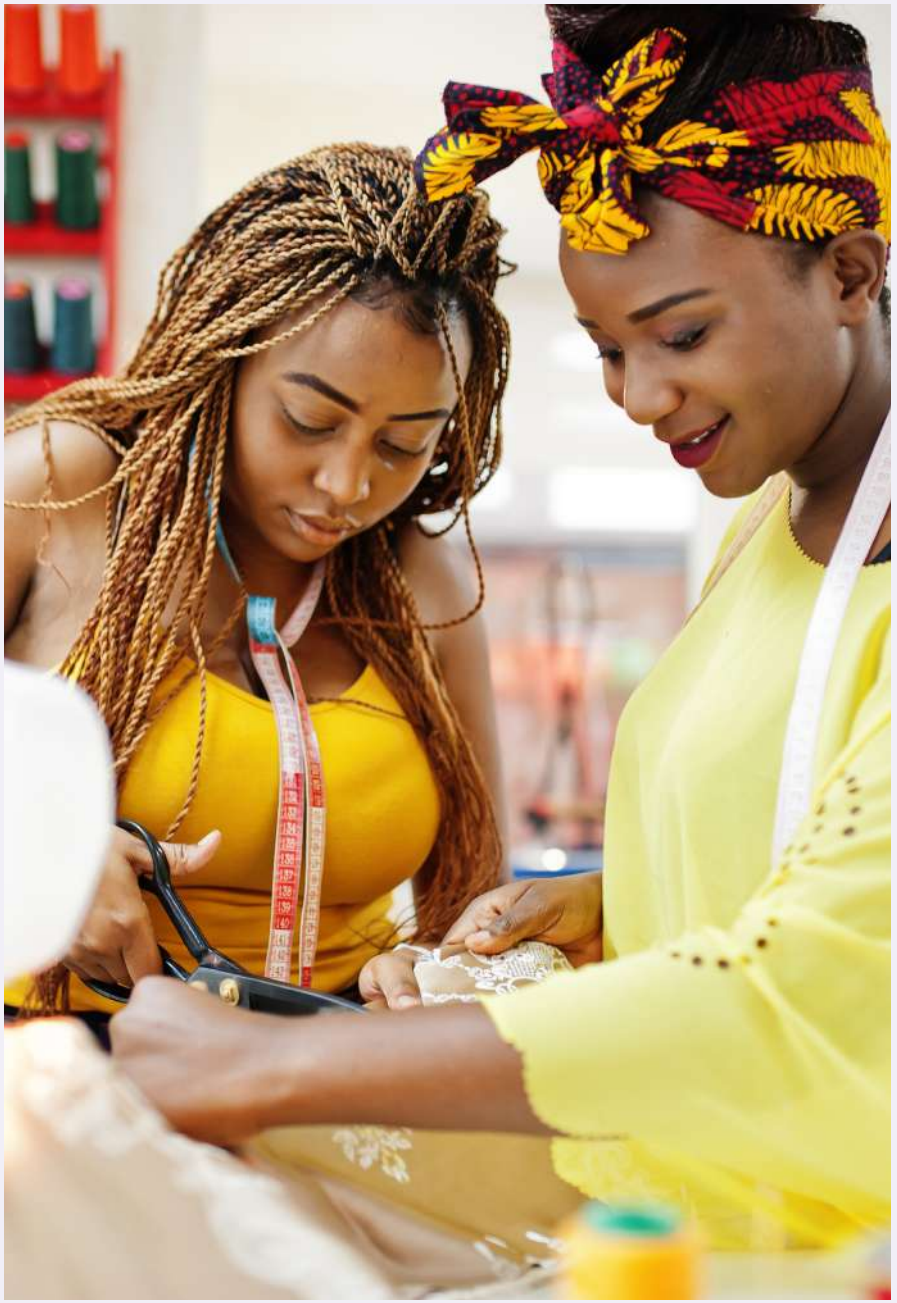
- **Fund research and development (R&D)**: Governments, the private sector, and investors should allocate funding for research into sustainable materials, production technologies and circular economy solutions.
- **Fund women-led innovation**: Public and private investors should prioritize funding for women-led businesses in technology, R&D and AI.
- **Develop educational curricula**: Governments, educational institutions and private sector entities should collaborate to develop training programmes on sustainable fashion practices and clean energy technologies.
- **Provide scholarships for women in Science, Technology, Engineering and Mathematics (STEM)**: Governments should work with educational institutions to establish scholarship programmes for women pursuing education in relevant STEM-related fields.
- **Facilitate technology transfer**: All stakeholders should support the effective sharing of knowledge and the transfer of sustainable technologies within the fashion industry, with a particular focus on supporting LMICs and SMEs, to help to ensure a more equitable and rapid transition.

Promote renewable energy adoption in the fashion industry through women-led SMEs

Women entrepreneurs within the fashion industry, particularly those operating in informal sectors and developing economies, frequently encounter significant energy access challenges. These limitations extend beyond mere inconvenience, directly impeding their productivity, constraining economic growth and undermining their overarching empowerment.

- **Scale targeted interventions**: All stakeholders should scale programmes providing reliable, affordable clean energy to women in the informal fashion sector, particularly in regions with unstable power supply.
- **Scale interventions for off-grid enterprises:** All investors should develop and expand targeted interventions—like concessional loans, pay-as-you-go solar home systems, mini-grid connections, and results-based grants—tailored to the unique needs of women operating away from stable grids, ensuring they can deploy and maintain decentralized clean energy solutions affordably and sustainably.
- **Invest in renewable energy infrastructure**: Governments, corporations, and public and private investors should prioritize investments in renewable energy infrastructure for women-led fashion businesses, particularly in regions with unreliable electricity.
- **Offer financial incentives**: Governments and public and private investors should provide subsidies and low-interest loans for women-owned enterprises adopting sustainable energy practices.
- **Develop innovative investment strategies**: Public and private sector actors should create investment strategies that support women-led SMEs in adopting renewable energy and energy-efficient technologies.

The fashion industry can leverage its economic influence to drive meaningful environmental and social change. The recommendations outlined underscore the necessity for a coordinated, multi-stakeholder approach, engaging governments, companies, civil society and consumers, to achieve a more sustainable and equitable future. By prioritizing these actions, stakeholders can collectively steer the fashion industry to promote the health and empowerment of people and the planet.



ANNEX 1

Forecasting essential skills for women in sustainable energy and fashion

The transition to sustainable energy and fashion presents immense opportunities and requires a forward-looking approach that examines the diverse expertise required for future success.

The energy sector, particularly renewable energy, is experiencing rapid growth, yet struggling with gender imbalance. The underrepresentation of women across both the traditional and renewable energy sectors—particularly within technical and leadership roles—persists, despite evidence showing that gender diversity correlates with innovation, improved sustainability performance and stronger financial results.

Simultaneously, the demand for 'green' talent is rising. LinkedIn data indicate that demand for 'green' talent rose approximately 5.9 percent annually from 2021-2024, and twice as fast as supply between 2023 and 2024.[291] Projections indicate that a significant global green skills gap will persist by 2050 if current trends continue, as only one in eight individuals has the 'green' skills required for the most in-demand green roles,[292] such as wind turbine technicians, solar PV installers, energy analysts and renewable energy consultants.[293]

As renewable energy systems become more sophisticated and integrated into industry and communities, necessary technical skills will include:[294]

- Advanced system integration: Proficiency in managing interactions between diverse renewable sources (solar, wind, hydro), energy storage and smart grid technologies.
- Quality control analysis: Experience in testing and inspecting products, services or processes for quality and performance.
- Operational analysis: Skills in analyzing requirements, procedures, materials and conditions to enhance operations.
- Data analytics for energy management: Skills in analyzing energy consumption data, optimizing grid performance and utilizing predictive maintenance algorithms using tools such as Python, Excel, GIS and AutoCAD.
- Energy efficiency auditing & implementation: Expertise in identifying and implementing energy-saving measures in various sectors, including industrial processes such as the fashion supply chain.
- Equipment selection: Expertise in specifying the types of tools, instruments and equipment necessary to carry out specific workstreams.
- Project management & financial modelling: Competencies in overseeing complex installations, assessing financial viability and securing funding.

Non-technical skills in the renewable energy sector:[295]

- Critical thinking, innovation & adaptability: Ability to leverage logic and reasoning to develop activities, analyze information, identify strengths and weaknesses in various solutions and problem-solving approaches, while seeking new opportunities.
- Policy advocacy & regulatory navigation: Understanding and influencing energy policy, navigating regulatory frameworks, and advocating for supportive environments for renewable energy deployment.
- Customer guidance: Ability to respond to customers' needs to determine types of support and interventions needed.
- Community engagement: Skills working with local communities to ensure projects meet needs, build local capacity and promote energy literacy.
- Marketing & communications: Effectively communicating the benefits of sustainable energy solutions to diverse stakeholders, including consumers, investors and policymakers.

Interventions to build these skills should focus on accessible and flexible learning formats (like part-time or online courses), upskilling resources, particularly for untapped talent pools in LMICs, and robust training programmes beyond technical skills.

The fashion industry's ongoing shift towards sustainability relies on adopting energy efficiency technologies, embracing circular economy models and ensuring ethical practices throughout the supply chain. Forecasting skill requirements for a sustainable fashion future point towards a need for expertise spanning technology, materials science, supply chain management, communication and data analysis.

As the focus continues to shift towards sustainable fashion, key technical skills will include:[296]

- Sustainable materials science: Understanding innovative, low-impact and biodegradable textiles; closed-loop recycling; the impact of textile production on ecosystems, water and climate; garment life cycles; and material properties and environmental impacts.
- Sustainable design: Skills to create functional, aesthetically pleasing garments using eco-friendly materials while minimizing production waste and maximizing longevity.
- Sustainable textile production: Expertise in environmentally and socially responsible dyeing and finishing techniques, including relevant qualifications and standards.
- Life Cycle Assessment (LCA): Skills in using LCA software to measure and improve the environmental performance of products and processes.
- Advanced textile recycling technologies: Knowledge of chemical and mechanical recycling processes.
- Energy-efficient machinery operation & maintenance: Technical skills for advanced, energy-efficient manufacturing equipment.
- Data analytics: Ability to measure and track sustainability performance by collecting, analyzing, and interpreting data on resource consumption and emissions to identify trends, set targets and track progress.

Essential non-technical skills for the sustainable fashion industry include:

- Communication & collaboration: Ability to clearly articulate sustainability benefits to various stakeholders, presenting data effectively, engaging in dialogue and fostering strong working relationships across the value chain.
- Supply chain transparency & management: Expertise in tracing materials, ensuring ethical sourcing, managing logistics sustainably, utilizing blockchain for traceability and mitigating supply chain risks to meet environmental and social standards.
- Sustainable marketing & consumer education: Understanding of consumer behaviour to communicate sustainability efforts, educating consumers about conscious consumption.
- Circular business model development: Competency to design & implement business models based on rental, resale, repair & recycling.
- Impact reporting & environmental, social & governance (ESG) compliance: Skills in measuring, verifying and reporting on ESG performance.
- Policy engagement & advocacy: Working to shape industry standards and governmental regulations related to sustainable and ethical fashion.
- Strategic thinking & innovation: Ability to analyze the environment, identify opportunities and risks, engage in long-term planning, and develop new materials, processes and business models through creative collaboration.

Cultivating these diverse competencies is crucial to achieve environmental goals and foster the innovation that gender diversity brings. Women's leadership, informed by both technical and non-technical understanding, is vital for driving transformative change in energy usage, waste reduction, ethical production and circularity within fashion.

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VIENNA HEADQUARTERS

Andromeda Tower 15th floor,
Donau-City-Strasse 6,
1220 Vienna, Austria

NEW YORK OFFICE

575 Lexington Ave,
New York,
NY 10022, USA

SEFORALL.ORG

wyff@seforall.org
info@seforall.org

SUSTAINABLE ENERGY FOR ALL