



W4TEX: Strengthening Women's Representation in Senior Textile Positions

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UNIT 3 – TRANSPORT & DISTRIBUTION

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INTRODUCTION TO THE TOPIC

The global textile industry has been skyrocketing over the last decades, especially since fast fashion and online shopping have become so popular. The sector operates through an extensive supply chain network that responds efficiently to modern world demands by connecting producers, manufacturers, distributors, and consumers.

Although the manufacturing process of textiles has drawn much attention in terms of their environmental impact (think of water pollution, chemical waste, and energy consumption), the overall environmental degradation caused by the sector's transportation and distribution systems cannot be overlooked. From sourcing the necessary raw materials for production to delivering the textile end products, each stage of transport/distribution relies heavily on fossil fuels like petroleum, motor and aviation gasoline, and diesel, all of which contribute primarily to greenhouse emissions.

Typically, textile products are transported by air, sea, rail, and road. Each one of these modes has a different impact on the environment. Air freight is one of the fastest means of transportation/distribution of materials and products, but it generates the highest level of emissions concerning the travelled distance. Shipping (sea transportation) is convenient for trading as it can handle large amounts of products at the same time (imagine that an average container ship can carry up to 15000 containers) but contributes greatly to environmental pollution (oil spills in the oceans, ballast water discharge, emission of sulfur oxides/ carbon dioxide). Rail transport is more sustainable compared to the rest, but it is not always viable for long-distance shipments as rail infrastructure is limited in certain regions. Road transport is usually used for regional distribution, which contributes to congestion and air pollution. As textile demand accelerates and consumers demand constantly faster delivery of the products they purchase, the frequency of shipments intensifies, and with it so do the catastrophic effects it has on the environment.

The pollution generated from the transportation/distribution of textile products refers not only to gas emissions but to packaging and inefficient logistics too. This is because packaging often uses materials like plastics or cardboard, which are unsustainable. As for logistics, it's considered to be harmful to the environment as many times there is inefficient use of space (e.g. partially loaded trucks) or the shipping routes used are not the fastest or most necessary ones. All of these contribute to pollution and exorbitant resource and energy consumption.

It is now more than ever necessary to address the challenges posed by textile transport and distribution if creating a sustainable textile sector is our goal. Solutions to these problems include optimization of supply chains, promotion of local raw material sourcing, and production/distribution of end products, and transitioning to eco-friendly transport modes.

This module explores the detrimental effects of textile transport and distribution and the mitigation measures required to effectively respond and promote sustainability in this section of the sector.

To better understand the topic of this module, the following are some definitions of relevant key concepts:

| | |
|--------------------------|---|
| Air Pollution | The contamination of the atmosphere by chemical, physical or biological agents that modify its natural characteristics. |
| Blockchain Logistics | The process of tracking items across the entire supply chain, from raw materials sourcing to global shipments. |
| Carbon Footprint | The total amount of greenhouse gases, such as carbon dioxide and methane, released into the atmosphere contribute to air pollution. |
| Circular Economy | An economic system aims to minimize waste and use resources effectively by promoting reuse, recycling, and sustainability in production methods. |
| Eco-friendly Packaging | It refers to the use of sustainable packaging solutions, such as biodegradable and recyclable/reusable materials, to minimize pollution and manage waste. |
| Fast Fashion | A business model prioritizing rapid manufacturing and distribution of products at low costs. |
| Greenhouse Gas Emissions | The release of gases into the atmosphere from burning fossil fuels like CO ₂ , methane, and nitrous oxide. |
| Intermodal Transport | A logistics model that combines different transportation modes like air, road, and sea, aiming to enhance efficiency in the transportation/distribution of goods while reducing the environmental impact. |
| Supply Chain | The process of sourcing raw materials as well as of producing and distributing products. |
| Sustainable Logistics | The limiting of the environmental impact on transportation and distribution by route optimization, the use of eco-friendly vehicles, and waste minimization. |

DETRIMENTAL EFFECTS OF TRANSPORT & DISTRIBUTION OF TEXTILE ON THE ENVIRONMENT

Environmental impacts

Transportation and distribution systems of the textile industry rely primarily on fossil fuel consumption. From raw materials sourcing to end-product distribution, the sector generates vast amounts of gas emissions that have a long-lasting negative effect on air quality, ecosystems, and resource consumption.

Carbon emissions

As stated earlier, the transport and distribution of textile products release carbon dioxide into the atmosphere. Carbon dioxide (CO₂), also known as greenhouse gas, is a heat-trapping gas that results from the extraction and burning of fossil fuels (e.g., coal, oil), from wildfires and any other process (e.g., volcanic eruptions) that involves gas release and high temperature/pressure. CO₂ emissions are harmful to the environment as they can trap heat in the Earth's atmosphere, contributing to the greenhouse effect. Global warming takes place, which leads to climate change and can cause severe changes in the weather and therefore disrupt the normal procedures taking place in the planet's ecosystem.

Let's have a look now at the ways carbon dioxide emissions happen in all different modes of textile transport and distribution:

- Sea freight

Most global textile shipments are handled by sea freight as it has proven to be the most cost-effective method of long-distance transport. Its environmental cost, however, is significant. Container ships (or cargo ships as they are known, although the term refers to all sorts of cargo rather than just containers) use bunker fuel of low quality. This specific type of fuel is high in carbon content. It releases sulfur and nitrogen oxides, which, when released into the atmosphere, initiate a reaction with water vapor, which results in acid rain. Additionally, according to the International Maritime Organization (IMO), sea freight is responsible for 3% of global CO₂ emissions. Many shipping companies adopt the so-called "slow steaming approach". The term refers to the practice of operating transoceanic container ships at extremely low speeds to reduce fuel



Figure 1 – Source: Freepik.com

consumption and emissions. Regardless, the increased consumer demand for textile products and fast fashion throws this approach off-track.

- Road transportation

This mode of transportation is ideal for regional distribution as it connects factories, warehouses, ports, airports, and retail outlets. It requires the use of trucks and long vehicles, which are powered by diesel engines that emit great amounts of CO₂ into the atmosphere. These emissions intensify due to the fragmented nature of road transportation (e.g. frequent stops) and the underutilized cargo space. The constant growth of e-commerce leads to an increased volume of trucks on the road, leading to further carbon emissions.



Figure 2 – Source: Freepik.com

- Rail transport

This mode of distribution is one of the most sustainable ones as it emits a significantly lesser amount of CO₂ per kilometer compared to the rest. Despite this, textile companies don't prefer this mode as it requires adequate rail infrastructure in all destinations, which is not possible for certain regions. Efforts are being made to expand the rail networking and infrastructure in Europe, but these require governmental funding, which in some cases is hard to get and can be very time-consuming. Rail transport still has a long way to go before becoming the go-to means of shipping sector.



Figure 3 – Source: Freepik.com

- Air Freight

Although air freight is not used extensively by the textile industry, it is the most carbon-intensive mode per distance covered. Airplanes use jet fuel in large quantities. This type of fuel produces CO₂, nitric oxide, and water vapor, all of which contribute to global warming and the creation of contrails (thin clouds of ice crystals). While research on the long-term effects of air freight on climate change is still ongoing, there is no doubt that high-altitude emissions have a



Figure 4 – Source: Freepik.com

more severe detrimental effect on the environment than surface-level ones. If consumer demand for time-sensitive deliveries is high, the textile sector will continue to rely on the specific mode of transport and distribution of its products.

Beyond CO₂ emissions that are a direct result of transport vehicles, there are indirect emissions from logistics (e.g., warehouses, sorting and distribution centers) as well as

the unsustainable packaging materials used (e.g., cardboard boxes, plastic wraps). Moreover, the “last-mile” section of distribution, which refers to the door-to-door delivery of products, is one of the most carbon-intensive segments as it requires great levels of fuel consumption due to the high number of individual deliveries.

Air pollution and public health

The fossil fuels used in textile transportation and distribution are a significant contributor to air pollution. The degradation of the quality of air poses a public health issue and impacts ecosystems, especially in areas with high industrial activity along transport routes.

There is a variety of air pollutants generated from textile transportation and distribution, some of which are:

- Nitrogen oxides

This type of air pollutant is primarily emitted from vehicles’ diesel engines and contributes to the formation of acid rain and smog, both of which can irritate living organisms’ respiratory systems.

- Sulfur oxides

Container ships using low-grade bunker fuel release to the atmosphere sulfur oxides, which, as in the case of nitrogen oxides, contribute to the formation of acid rain and cause respiratory problems.

- Black Carbon

It is a material produced by the incomplete combustion of coal tar or fuel products. It is one of the major contributors to global climate change and is known for its ability to pollute the air.

- Particulate Matter (PM)

PM2.5 and PM10 are pollutant agents released from vehicle exhaust. These unseen-to-the-bare-eye particles penetrate deep into the lungs and bloodstream causing respiratory and blood-related health issues.

The health consequences of exposure to air pollution due to textile transport specifically for vulnerable groups like children or the elderly, include:



Figure 5 – Source: Freepik.com

- Respiratory diseases such as asthma, bronchitis, and chronic obstructive pulmonary disease (COPD).
- Cardiovascular problems (e.g., heart attacks, strokes, hypertension).
- Cancer, specifically lung cancer.
- Premature mortality: Based on research by the World Health Organisation (WHO) and the European Environment Agency (EEA), the transportation of products and the air pollution it causes contributes to millions of premature deaths annually on a global level.
- Neurological effects, as emerging research suggests that air pollution and long-term exposure to it may be a source of contribution to cognitive dysfunctionality, while it can increase the risk of neurodegenerative diseases (e.g., dementia) and even limit children's development.



Figure 6 – Source: Freepik.com

The level of noise pollution and health risks associated with transportation in general in the EU is one of the highest in the world, according to the European Environmental Agency. Textile transport and distribution plays a major role in this unfortunate fact as its shipment activities continue to grow rapidly, especially after e-commerce was introduced to consumers. There was a 44.6% rise in freight transport between 1995 and 2022, and data shows that this number will continue to grow along with its detrimental effects if nothing changes.

Marine pollution and ecosystem degradation

The effects of textile transportation on marine life and the maritime ecosystem in general cause extended concern. Excessive shipping and logistical operations are responsible for marine pollution in the following ways:

- Microplastics pollution

Microfibres from textile products, specifically synthetic ones like nylon or acrylic, are being shed into the oceans during transportation through improper handling. These microfibres are essentially microplastics that, once they enter waterways, are ingested by maritime life, from plankton to fish. Eventually, they end up on our plates through the fishery. Even though microplastics can be less than 5 millimeters long, the impact they have on the environment is disproportionate to their size.



Figure 7 – Source: Freepik.com

- Oil spills and chemical leaks

As mentioned earlier, the transportation of textiles via the sea requires fossil fuels. There have been numerous times that accidents took place and large amounts of oil were spilt into the oceans, causing a catastrophic effect on maritime life. Additionally,

there is always the danger of chemicals like dyes or water repellents used in textiles leaking into the waterways during transportation. Such an unfortunate occasion would harm all aquatic life and ecosystems. When oil is leaking into the sea, it essentially blocks the sunlight that phytoplankton needs for photosynthesis. Underwater plants die, and sea creatures that rely on them for food begin to suffer the consequences, too. Additionally, as sea animals rise above the sea surface gasping for air, they inhale oil, which affects their lung functionality. These effects have a more severe effect on the maritime ecosystem if the leaked material is a chemical. Textile dyes and inks, for instance, can cause long-term effects in a similar way to oil spills to all marine lifeforms. Eventually, just in the case of microplastic pollution, the contamination of the seafront finds its way of reaching humans, too.

- CO₂ emissions

Container ships burn heavy fuel oil. This type of fuel, when burning, releases large quantities of polluting agents like CO₂, nitrogen, and sulfur oxides into the atmosphere. Once the released gases react with vapour, they become acid rain. Acid rain can alter the pH levels of seawater and affect marine life, as many aquatic animals cannot physically tolerate such acidic environments and die or suffer from slower development. Other sea organisms that are in their food chain begin to struggle to survive. It is an endless cycle, affecting all marine life in every way.

- Noise pollution

The noise generated by container ships is a major disruptor to the life of marine species. Prolonged exposure to it can lead to excessive stress on sea animals and can even disrupt their feeding patterns or cause them disorientation and communication issues. Especially intelligent marine species like dolphins or orcas have reportedly suffered the effects of noise pollution in the water. Marine biologists have reported



Figure 8 – Source: Freepik.com

occasions where some of these animals have followed abnormal courses to their usual sea routes due to disorientation caused by noise pollution. Sea animals change their mitigation patterns and even breeding because of how loud their environment gets. The acoustic impact on the dolphins is so severe that it can make them deaf. As the loud and frequent sound waves produced from container ships intensify and they get exposed to these conditions more and more often, their ear bones explode, their organs fill up with painful air bubbles, and they eventually lose their ability to hear. Scientists have noticed that sea animals communicate at higher volumes of their voice when in noisy environments in a desperate effort to overcome the noise. Even their ability to use their sonar sense (echolocation ability) is being affected by the sound waves that disturb the water's surface.

- Imbalanced ecosystem due to invasive species

Ballast water from container ships acts as a means of transport for foreign microorganisms that travel through it from one maritime ecosystem to another. These species invade the new ecosystem and often affect native ones by causing disruptions to their food chains and dynamics. Invasive species are a real-life but forgotten threat to the oceans. They pose a variety of ecological, economic and health consequences both for sea animals and humans. They can risk the extinction of prey species, they can outcompete native species for resources, change their physical structure, and introduce new diseases to sea-life populations. The damage of aquaculture affects humans in the long run, not only because it influences our economic resources (e.g., fishery) but, most importantly, because it affects our clean water and nutritious food. Therefore, the impact that invasive sea species have on us expands to our greater ecosystem and environment that reach beyond waterfronts.

Energy consumption and resource depletion

The needs that textile transportation has in terms of energy and resource depletion intensify environmental challenges. These two issues are critical and intertwined with the resourcing of raw materials, manufacturing, and logistics. Each one of these stages demands vast amounts of energy derived mostly from fossil fuels that contribute largely to environmental pollution.

- Material sourcing to manufacturing

Extracting and transporting raw materials (e.g., cotton, wool) for textiles from sourcing areas to manufacturing hubs requires large amounts of fuel, especially when this transportation is transoceanic.

- Manufacturing for retail

This stage requires a variety of transportation modes that are combined each time in the most cost- and time-effective manner to respond to consumers' demand. This means that the CO₂ emissions from fuel consumption can be extremely high.

- Last-mile delivery (from manufacturing to retail)

Distributing end products to customers' doorsteps requires many individual trips, and therefore, the need for fuel intensifies. The constant rise in e-commerce makes things worse from this point of view, as there are more and more delivery trucks out there trying to reach individuals and deliver their orders. These deliveries may require more than one trip per customer (e.g., the customer is out of the home, returning products to the warehouse).



Figure 9 – Source: Freepik.com

Apart from energy consumption, the environmental challenges that textile transportation and distribution pose also contribute to the depletion of natural

resources. Such resources used in the textile industry are fossil fuels, water, and minerals.

It is clear by now how heavily reliant all modes of transportation are on fossil fuels and how much their consumption contributes to environmental degradation. Additionally, water is a basic element of the textile sector as it's being used for cooling and fuel extraction of industry's power plants, for dyeing processes, and implicitly used in sea transport. On the other hand, minerals like natural gas or coal are vastly used in textile warehouses and distribution centers for lighting, automation and climate control. Finally, we must mention the need for raw materials (e.g. asphalt, concrete) required for developing and maintaining the necessary infrastructure for textile transport and distribution (e.g. ports, airports, roads). All these make the need for extracting raw materials more intense and lead to the depletion of natural resources.



Figure 10 – Source: Freepik.com

Waste and pollution from packaging

Textile products, like most products, require extensive packaging to ensure that they are not damaged during transport and distribution. As one can imagine, this contributes greatly to environmental degradation as it generates waste. Plus, the materials used for packaging are not always sustainable, meaning that they're not biodegradable, reusable or recyclable. The detrimental effects that textile packaging has on the environment can be divided into three main areas: excessive consumption of materials, resource depletion, and pollution.



Figure 11 – Source: Freepik.com

- Excessive consumption of materials

While there is no specific data regarding the textile sector and the waste packaging it generates, research shows that the fashion industry produces more than 180 billion polybags (a form of packaging made from plastic) per year. In addition to that, we must also count other forms of packaging used in the sector, such as cardboard, labels, and synthetic fillers that are being made using non-recyclable materials. Even the methods used for producing packaging products to be used in the textile sector are not sustainable most of the time. The materials, required energy, and methods of production for packaging can be accounted for contributing to waste as long as these are being characterized on non-eco-friendliness.

- Resource depletion

Packaging in its conventional form is responsible for natural resources depletion as it requires massive amounts of raw materials (e.g. paper made from cut-down trees), water, and energy to be produced. Paper packaging, in particular, is responsible for the deforestation of major areas, while plastic, metal and glass packaging require tremendous amounts of energy to produce.

- Pollution

The European Environmental Agency (EEA) ranked the impact of textile products' transportation and distribution on the environment in the 4th highest position following sectors like food, consumption and mobility. This ranking highlights the level of impact that the textile sector's specific activities have on climate change and calls for people's attention as it is often overlooked as of minor importance.

The fossil fuels and natural resources needed for packaging production in the sector contribute to pollution, but the degradation of the environment carries on after their production, too, as their material is not sustainable. Additionally, the chemicals and dye/inks used in packaging often leak into the environment, leading to further ecological degradation. These substances can reach into groundwater and soil and contaminate/ pollute our food and water supply.



Figure 12 – Source: Freepik.com

Textile packaging is overall an environmental polluting factor as it contributes to unsustainability not only via its production but also through its nature and its consistency. It can be controlled, and its effects can be minimized, but it requires sustainability efforts from zero basis, meaning that its cycle of material sourcing and production must be re-evaluated and approached in a more eco-conscious scope.

Contribution to climate change

The environmental impacts of textile transport and distribution as presented so far are detrimental to the planet's sustainability. The level of pollution due to the sector's activities is getting higher and higher as consumers' demand rises. The effect that transporting and distributing textile products has on the ecosystem goes deeper than just adding to pollution. It is altering the planet.

Following, we have gathered some of the most common ways that have been observed to contribute to the degradation of the ecosystem and are a result of the activities of the textile industry in relation to the transport and distribution of its products. The information presented has been obtained from official sources in the EU.

Relevant data on the textile sector and climate change

- Greenhouse emissions from textile transport and distribution

According to the European Parliament, textile transport and distribution generate approximately 270 kg of greenhouse emissions per person. That is a whopping 121 million tons of CO₂ emissions across the EU population. This is a characteristic example of the level of impact that textile transport and distribution have on climate change.



Figure 13 – Source: Freepik.com

- High sector ranking

The European Environmental Agency (EEA) ranked the impact of textile products' transportation and distribution on the environment in the 4th highest position following sectors like food, consumption, and mobility. This ranking highlights the level of impact that the textile sector's specific activities have on climate change and calls for people's attention as it is often overlooked as of minor importance. Additionally, the same official source has pointed out that according to their research, textile production and consumption in Europe requires 1.3 tons of raw materials and more than 100 cubic meters of water per person. Of course, these numbers include the transport and distribution phase, even indirectly, as they are necessary components of the overall process that takes place from sourcing the raw materials to getting the product to the customer.



Figure 14 – Source: Freepik.com

- Dangerously increasing transportation emissions due to fast fashion

Major fashion brands like Inditex (which owns brands like ZARA), face constantly higher demand for their products, a level of demand that is in line with the impressive rise in e-commerce. Even though many companies maintain their offices and warehouses in the EU region, they choose to perform their manufacturing processes in areas where labour hands are cheaper. Such areas are countries like India or China. As a result, the need for transportation and distribution of raw materials and textile products intensifies and the distances covered are continuously growing. The European Environmental Agency in one of its 2022 reports pointed out that approximately 75% of the EU textile industry's greenhouse gas emissions were released outside the borders of the EU and specifically in Asia. It becomes clear that the effects of textile transport and distribution on the environment not only are detrimental but have escalated as they now refer to a global scale.

MITIGATION MEASURES

The extent of the negative effects that textile transport and distribution have on the environment is such that it calls for immediate solutions. The following are some of the mitigation measures suggested to minimize the detrimental effects on the environment.

Sustainable Logistics

Sustainable logistics in textile transport and distribution refers to the efficient handling of the load of shipments taking place in all stages of the products: from raw material sourcing to the delivery of purchased goods to the customer. The following are some examples of ways this can be achieved.

Optimized transport networks & route planning

The goal here is to minimize the CO₂ emissions released into the atmosphere by:

- reducing the number of trips required by combining shipments according to destination.
- using effectively all modes of transportation through intermodal transport (using a combination of shipping methods per shipment, focusing on opting out for the most sustainable ones like rail or maritime transport where possible).
- integrating sorting and distribution hubs that use intermodal transport to minimize the number of redundant shipments.



Figure 15 – Source: Freepik.com

Use of low-emission vehicles & eco-friendly sources of energy

The objective is to replace, where applicable, all conventional vehicles with ones that are more eco-friendly, specifically on short-distance routes in urban areas. Sustainable types of vehicles for the purpose are considered electric or hybrid vehicles. Additionally, when using any type of vehicle for textile transportation and distribution, companies must invest in specific models that use alternative fuels like biodiesel, natural gas or hydrogen as these emit significantly less CO₂ compared to diesel-fueled engines of conventional vehicles.



Figure 16 – Source: Freepik.com

Green packaging & circular economy models in logistics

Non-sustainable packaging material contributes greatly to pollution, even though its influence is not thoroughly distinguished. When replaced with more eco-friendly solutions in logistics, it can minimize its detrimental effects. The following are some ways that packaging can support sustainability in textile transport and distribution:

- Reusable/recyclable and biodegradable materials: using recyclable paper, cardboard, and bioplastics instead of common versions of paper-based packaging and plastics can minimize waste generated.
- Minimal use of packaging: whenever possible, excessive packaging should be avoided. Not only does it reduce waste from its use, but it supports minimization of the volume of the overall shipments loaded on vehicles.
- Use of recyclable packaging systems like crates/ pallets, which can be used again and again, leading to effective waste management and circular economy systems in logistics.
- Use of eco-friendly inks and dyes for printing on packaging that don't affect the surrounding ecosystems when leaked.



Figure 17 – Source: Freepik.com

Digitalization and blockchain for transparency in logistics

Textile logistics can become more sustainable if digital technologies are used properly. The following examples provide an insight into how it can be achieved:

- Using Artificial Intelligence (AI), Internet of Things (IoT), and big data analytics to enhance shipments management by choosing the most efficient routes and modes of transport/distribution or obtain real-time inventory information.
- Ensuring effectiveness in warehousing operations by using automated systems that control inventory and flow of products to ensure non-excessive energy consumption, manage and minimize waste, and frequency of shipments.
- Collecting and analyzing data to be able to understand current and predict future needs of the textile sector in terms of transportation. This allows companies to plan effectively and in advance their needs and choices regarding means of transport to be used.
- Tracking carbon emissions during the whole textile transport and distribution process allows companies to measure, evaluate and act accordingly to reduce their environmental impact.



Figure 18 – Source: Freepik.com



- Using blockchain technology, companies in the sector can share data and communicate better. They can collaborate and battle non-sustainable practices in textile transport and distribution on a united front and, thus, achieve better results in less time.

CONCLUSION

The transport and distribution of textiles have a major detrimental effect on the environment. They contribute to air and noise pollution, resource depletion, and deterioration of health and well-being. These effects become more and more intensive as consumers' demand grows, and, unfortunately, it doesn't seem to slow down any time soon. E-commerce and fast fashion have become a modern necessity for people as they can be time and cost-effective.

The various modes used in textile transport and distribution share different characteristics and levels of pollution they cause. Combining them effectively can reduce their impact on the environment, but this should be accompanied by the simultaneously effective use of biofuels and alternative sources of energy.

Additionally, there's more to textile transport and distribution's polluting effects. Inefficient logistics, unsustainable packaging, and lack of circular economy models in the shipping of products play their part in environmental degradation.

There are several ways to mitigate these detrimental effects and reduce the environmental footprint of the textile supply chain. Some of the ways we examined are the optimization of transport networks, the use of low-emission vehicles, and the switch to more sustainable packaging solutions. Moreover, modern technologies such as digitalization and automation can also support mitigation efforts.

In conclusion, the impact that textile transport and distribution have on the planet's ecosystems is undeniable, as is the rise of customers' demand, which means that the need for shifting towards greener practices in the textile supply chain is more imperative than ever. The textile sector is taking steps to move towards sustainability but needs to become more conscious in terms of the effect its transport/ distribution activities have on the environment.

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