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Sustainable Textile Implementation for Alpas Athletix

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Table of Contents

Executive Summary

Alpas Athletix is a startup company from San Diego, CA founded by Kathy David. Later in 2019, Alpas Athletix intends to launch its first product: a patented strapless sports bra. Following the company's values, Alpas Althletix is interested in implementing an environmentally-friendly and sustainably made textile in its sports bra.

Implementing environmentally-friendly and sustainable textile is a sound business decision based on megatrends around the world and in the fiber, apparel, and sportswear industries. Generally, consumers increasingly prefer "green" products as awareness around environmental issues spreads. In response, companies in the apparel industry are using preferred fibers, investing in circular economy approaches, and working to extend the end-of-life of products. Governments are reacting too by regulating synthetic materials, banning mulesing in wool production, regulating pesticides in cotton production, and regulating deforesting for wood-based fibers. In the sportswear industry, health and wellness are at the forefront of trends, in the United States, due to increasing participation in sporting activities, acceptance of sportswear in many social settings, and sportswear’s representing of wealth.

In consideration of megatrends in the external environment and many scientific studies, Tencel is the suggested textile for the strapless sports bra because of its environmental and functional benefits. Tencel is a branded lyocell fiber produced by Lenzing. Additionally, Tencel is primarily made from eucalyptus trees and categorized as a manmade cellulose fiber (MMC). Tencel production does not source from endangered forests, has a low water footprint, relies on biofuels, is not wasteful, and does not compete with crucial agricultural land.

Tencel is compared to other popular fibers to ensure the right choice of fiber for the sports bra. Polyester, the most popular fiber, is petroleum-based, emits hazardous waste, uses

non-renewable energy, depletes abiotic resources, releases microplastics into the oceans, and is the most toxic fiber to humans. In contrast, cotton is biodegradable; however, it has the most significant water footprint, is the most toxic to freshwater and land ecosystems, requires valuable agricultural land, and retains little waste. Viscose, Tencel's largest competitor in the MMC market, is biodegradable, but is 20% sourced from endangered forests, is produced with toxic chemicals, and emits hazardous materials as waste—mostly in the air. Functionally, Tencel is stronger than viscose and equally as durable as polyester. Tencel is also as breathable as polyester and more breathable than viscose and cotton. Furthermore, Tencel is the most absorbent fiber, is more color retentive than cotton and viscose, and is easily the most hygienic fiber since it discourages bacteria growth.

After research determined Tencel as the choice fiber, a supplier, from Los Angeles, California, was located. The supplier, referenced by a Lenzing associate, offers only natural fabrics that are environmentally-friendly, sustainable, and made in America. Also, Tencel fabrics from the supplier are around the same prices as the materials currently used in the Alpas Athletix sports bra prototype.

In conclusion, I suggest implementing Tencel for the following reasons. First, Tencel bodes well with eco-awareness, health, and fitness trends, and does not face regulatory risks like polyester and cotton. Second, Tencel acts as a differentiator in the sports bra market and can command premium pricing. Third, Tencel is not more expensive to implement. I further suggest that a high-performance sports bra requires at least 50% polyester for water-wicking capabilities, while an athleisure product solely requires Tencel. Lastly, I reason that marketing should focus on specific aspects of Tencel's environmentally-friendly properties and functional properties to resonate stronger with consumer perceptions.

Introduction

Alpas Athletix is a startup company founded by Kathy David looking to launch its first product later in 2019. The first product will be a patented strapless sports bra, which is in its late development and near ready for the market. The sports bra's structure is an inner polyester layer, an outer nylon mesh, and a sturdy elastic polyester band. Alpas Athletix plans to launch its first product with a Kickstarter campaign to move the business to a lifestyle fitness brand with men's and women's athletic apparel. In the pursuit of its goal, Alpas Athletix realizes it may have to sell out to a larger company or license its intellectual property to other companies. Currently, the brand is self-funded but plans for investor intervention. Alpas Athletix is founded on the Tagalog dictionary definition of alpas—to become free and untied. Built into the company's values are self-expression, society and community, and love.

Problem Statement

In the interest of Alpas Athletix's values and business opportunities, Alpas Athletix desires to implement environmentally friendly textiles in its strapless sports bra. This report will address why Alpas Athletix should pursue environmentally-friendly textiles and how to apply the textiles.

External Environment

The external environment for Alpas Athletix is composed of the macro external environment and industry analyses for fiber, apparel, and sportswear. This report covers relevant megatrends in the external environment, a snapshot of the most popular fiber industries, a look at the most relevant apparel industry trends, and the major sportswear industry trends with

competitor analyses of three major sportswear industry players. Related topics encompass environmental impacts and sustainability.

Macro-environment

Consumers' increasing eco-awareness is pressuring companies to become greener in all facets of business according to a global megatrend analysis distributed by Euromonitor International (Adomaitis et al., 2017). Furthermore, economic growth and population growth contribute to faster depletion of resources and increased fear for the security of supplies for businesses. Businesses fear that supply chain disruptions will impact their bottom lines and their reputations, as resource depletion garners negative sentiment. Since external supply chain pressures are growing, businesses are not only guiding their practices with sustainability but making sure their suppliers are also complying with sustainable practices.

Additionally, companies are implementing circular economy models to satisfy pressures. In the circular economy, system outputs are reused as inputs to the system so that the outputs are not wasted. The circular economy model brings businesses improved reputations because of consumer preference changes toward sustainability (Adomaitis et al., 2017).

America’s populace is gaining interest in sustainability, but still lags behind other countries, explains the Sierra Club (“Sustainability,” 2017). In support of its claim, the Sierra Club states American children create 13 times as much ecological damage in their lifetimes as children in Brazil. Also, the average American consumes 35 times the amount of resources a person in India consumes and 53 times the amount of goods and services a person in China consumes. Even though Americans as a whole relatively do not operate sustainably, 75% of Americans express concern for helping the environment throughout their daily lives, a Pew Research center survey concludes ("Sustainability," 2017). However, the sustainability of

apparel is of less concern for Americans than for people from emerging countries. In America and the United Kingdom, 46% and 42% of people, respectively, find sustainability and environmental friendliness a high priority in apparel. In India, China, Mexico, and Italy, 81%, 60%, 69%, and 62% of people prioritize sustainability and the environment, respectively. All countries agree that fabric is the most impactful element of apparel to the environment and that cotton and wool are the safest fabrics while polyester and nylon are the least safe fabrics.

Industries

Fiber Industry

The fiber industry is composed of suppliers who sell a variety of fibers, categorized as either synthetic or natural, to textile manufacturers. The global fiber market rose production by 0.5% in 2018, and global fiber consumption rose by 1.2% (Lenzing Group, 2018a). This report focuses on cotton, wool, manmade cellulosic, and synthetic fibers because these are the most popular fibers in apparel.

Cotton

Cotton accounts for 25% of all global fiber production, but in 2018 to 2019 season, there was a decrease in the cotton harvest by 3% (Lenzing Group, 2018a). The yield decreased because of a continuous drop in cotton prices since mid-2018 and crop failures in the United States and India. Demand is predicted to be higher than supply, in 2019, for the fourth consecutive year as stock levels continue to reduce.

Preferred cotton was once a niche, but from 2012 to 2016, preferred cotton increased from 6% percent to 19% of total cotton production ("Preferred," 2018). Preferred cotton is expected to reach a quarter of cotton production due to expected increases in preferred cotton

initiatives, including BCI (better cotton initiative) cotton, fair trade cotton, and cotton made in Africa ("Preferred," 2018).

Wool

Wool is the most abundant animal-based fiber in terms of production ("Preferred," 2018). Global production, however, has been declining as much as 50% since 1990 (Lenzing Group, 2018a). Initiatives, though, have been increasing to make more preferred wool, like the Responsible Wool Standard ("Preferred," 2018). Unfortunately, preferable wool composes 1% of all wool production ("Preferred," 2018).

A ban on mulesing in New Zealand may lead to bans elsewhere ("Preferred," 2018). Mulesing is the removal of wool-bearing skin around the buttocks of the sheep to prevent flystrike (PETA, 2015). The scar tissue that forms does not produce any wool, so flies are less likely to infest the animal with flesh-eating maggots. The National Farmers Federation of Australia claims "mulesing remains the most effective practical way to eliminate the risk of ‘flystrike' in sheep." However, the animal rights organization PETA strongly opposes mulesing because it is considered a cruel and painful procedure for sheep.

Manmade Cellulosic (MMC)

The MMC market is on the rise with production volume doubling from 1990 to 2017 (Lenzing Group, 2018a). MMCs have a 6.3% market share of total fiber production volume. MMCs include viscose, acetate, lyocell, modal, and cupro ("Preferred," 2018). Viscose holds 80% of the MMC market with Acetate and Lyocell following at 13% and 5%, respectively ("Preferred," 2018). MMCs are typically wood-based but are occasionally made from natural materials like bamboo. Viscose and lyocell are the future of the MMC market.

The market for MMCs continued to grow and rose by 3.4% in 2018 (Lenzing Group, 2018a). The growth is attributed to higher supply in Asia, although stricter environmental regulation in China has slowed production due to the closure of old factories (Lenzing Group, 2018a).

Synthetics

Synthetic fiber is the largest group of fiber, totaling 63% of global fiber consumption (Lenzing Group, 2018a). However, the production volume of synthetic polymer fibers, like polyester, saw a weak increase of 1.5% in 2018 compared to the years prior.

The weak increase was due to a few reasons. Stock levels reduced in China because of increased prices in the first eight months of 2018 (Lenzing Group, 2018a). Also, in China, a ban was placed on importing certain types of plastic waste, including polyethylene terephthalate (PET, a synthetic resin used to make polyester), which caused prices to increase and a decrease in rPET (recycled polyester material) production volume ("Preferred," 2018). Crude oil and natural gas extracted from the Earth create PET, whereas rPET is created from recycled plastics and uses 75% less energy in production (EarthHero, 2019).

Another threat to the synthetic fiber industry is government regulation ("Preferred," 2018). For example, California and Connecticut governments are pushing for mandatory labeling of synthetic fibers because the states want to spread awareness about the microplastic issue, mentioned in detail later in this report (see section Fast Fashion).

Apparel Industry Trends

Digital

Apparel is one of the largest growing categories in digital commerce, explains a Euromonitor International megatrends analysis (Adomaitis et al., 2017). The report mentions an

estimated $1.3 trillion of goods was purchased over the internet in 2017, representing 9.6% of all goods sold. Euromonitor International addresses that in 2018, digital platforms continued to dominate as the fastest-growing channel for apparel sales ("Apparel," 2019). Larger platforms, like Amazon and Walmart, are expanding their online private-label brands in response to the importance of internet retailing. Furthermore, the rise of digitally native vertical brands (DNVBs) is a product of growing digital commerce. DNVBs, like Allbirds or Everlane, start online and rely on advertising with social media and direct-to-consumer selling for success. After some growth, DNVBs move offline into physical storefronts to develop their brands and create an omnichannel approach—where different methods of shopping, like online and in-store, are combined to enhance the purchasing experience for consumers. An example of an omnichannel strategy is allowing a customer to order a product online and then pick it up at a nearby store.

Fast Fashion

Fast fashion is rapidly produced inexpensive apparel by large brands responding to the latest fashion trends. According to a report assessing the fashion industry's future by the Ellen MacArthur Foundation, 80 billion clothing items are manufactured every year, 400% more than 40 years ago (Herrmann, 2017). The availability of clothing has led consumers to purchase five times more garments in 2018 compared to 1980. The report suggests fast fashion trends are encouraging consumers to buy more, wear less, and dispose clothing more often. Globally, the expanding middle class has created demand for a higher frequency of inexpensive apparel purchases (The Economist, 2018). In fact, by 2050, global clothing sales are estimated to triple.

Fast fashion is leading to large amounts of waste and negative environmental impacts. The Ellen MacArthur report claims half of all clothing is thrown away within one year, and in the last 15 years, on a global scale, clothing is used 36% less (Herrmann, 2017). Low-income

countries tend to use clothing significantly more, unlike in the United States, which uses clothing to 25% of the global average. Globally, consumers lose out on $460 billion of value each year by disposing of clothing (Herrmann, 2017). In a Greenpeace survey, 60% of German and Chinese citizens admit to owning more clothing than they require (Wahnbaeck & Roloff, 2018).

The overproduction and overuse of clothing puts pressure on resources, pollutes the natural environment, and creates negative societal impacts. Fashion is considered the most polluting industry in the world behind oil (The Economist, 2018). In a report from Global Fashion Agenda and The Boston Consulting Group, it is suggested that the benefit to the world economy would be $192 billion if the fashion industry addressed its environmental and societal issues (Eder-Hansen et al., 2017). The report also estimates that by 2030, water consumption, energy emissions, and waste creation will increase by 50%, 63%, and 62%, respectively. As of right now, textile production produces more carbon dioxide than all international flights and maritime shipping endeavors combined (The Economist, 2018).

The Ellen MacArthur report pegs microplastics emitted from synthetic fibers as another central issue of mass-produced apparel (Herrmann, 2017). Synthetic garments release microplastics so small when washed that water treatment centers hardly can filter the released plastic. A team at Plymouth University concluded in a study that per wash, synthetic materials emit up to 700,000 microfibers (Paddison, 2016). The microplastics released in washing cycles total a half-million tons of added pollution to the ocean every year, or 50 billion plastic bottles (Herrmann, 2017). Science is still developing around the effects that microplastics have on living organisms. Conclusively, microplastics now exist in marine life and humans, which can toxify bloodstreams and clog digestive tracts (Paddison, 2016).

Sustainability & the Circular Economy

Due to so much wasted clothing, sustainability and the circular economy approach are essential for the apparel industry. Sustainability in fashion encourages consumers to buy fewer clothes and dispose clothing less often through using durable, high-quality, and sustainable textiles. Over 90 companies, which equate to 12.5% of the global fashion market, committed to the 2020 Circular Fashion System proposal from Global Fashion Agenda to take action with a circular economy approach about the waste issue in the fashion industry (Global Fashion Agenda, 2019). The circular economy approach encourages companies to reduce waste through re-use. In a circular economy, retained outputs of a system are inputted back into the system. In the fashion industry, the circular economy approach can look many ways, including resale of refurbished products, sale of highly durable goods that last a long time and are easily repairable, short-term rentals, and rental subscriptions (Herrmann, 2017). In production, companies can implement the circular economy approach, as well. For example, companies may filter cooling water and reuse it, or they may retain byproducts and use the byproducts as renewable energy. In essence, the circular economy approach in fashion hopes to reduce the environmental impact of the fashion industry and benefit the world economy for a more sustainable way of living.

Sportswear Industry

The sportswear industry is a subsection of the apparel industry that includes sporting apparel and footwear. Sportswear is a $117 billion industry in the United States and is expected to grow just over 5% each year from 2019 to 2023 ("SPORTSWEAR," 2019). In this section of the report, there is an analysis of significant industry trends and an analysis of a few major players.

Trends

The health and wellness trend is driving growth in the sportswear industry, according to a Euromonitor International Analysis ("SPORTSWEAR," 2019). The analysis explains that increases in participation in athletic activities and broader acceptance of wearing athletic apparel in social settings are the leading causes of the health and wellness trend. Also, consumers are shifting their identities around fitness, creating a mentality that athletic equipment is essential to a fitness-centric identity. Furthermore, wearing athletic apparel expresses that the user is a fitness-minded individual, but not at the expense of comfortable clothing. The increasing importance of athletic apparel in social settings has created the athleisure segment in the sportswear industry, which is a massively growing segment.

Health and fitness is not just a symbol for one's fitness-centric identity, but health and fitness, explained by Euromonitor International, is increasingly associated as a symbol for wealth ("SPORTSWEAR," 2019). This trend opens up opportunities for premium athletic wear because consumers view premium athletic apparel as an investment to shape a healthy and fitness-centric identity. Due to the fitness-centric movement, traditional premium apparel brands' sales are steadily decreasing as consumers are choosing premium athletic apparel brands.

The third-largest trend from Euromonitor International's analysis is that Streetwear is growing in popularity because a segment of activewear is designed to be fashionable yet casual ("SPORTSWEAR," 2019). The popularization of streetwear is mostly in part to celebrities, fashion media, and social media. Premium clothing brands, especially athletic brands like Fila and Champion, are transforming activewear into sports-inspired fashion. Limited edition collaborations are a popular method for large brands to tap into the cult followings particular designers or other brands possess.

Major Players

Nike Inc., Lululemon Athletica Inc., and Columbia Sportswear Co. are three of the top ten major players in the United States sportswear industry ("SPORTSWEAR," 2019). Respectively, the companies have 19.4%, 1.9%, and 1.7% market share in the industry. This report examines these companies because they are all major players and are mostly different from each other.

Nike Inc. produces sporting equipment for a wide variety of sports, apparel for various sporting activities, sports-inspired lifestyle products, and footwear for sporting and leisure. Nike Inc. relies on research, design, and development to maintain its core competencies of quality, performance, and innovation in its products ("Nike," 2019). A Hoovers company profile article assesses that Nike Inc. plans to move forward by increasing its digital presence, furthering omnichannel integration, and increasing innovation ("Nike," 2019). The article explains that falling foot traffic and increasing online competition are threats to sporting goods companies, encouraging Nike Inc. to further its development in connecting more directly with its consumers, rather than relying on retailers, malls, and online sellers. In response to the threat, Nike is expanding its direct online presence and building a variety of apps to tap into different segments. For example, Nike launched its SNKRS app to enhance the shoe buying experience with augmented reality and to appease "sneakerheads" as the go-to source for collecting and trading sneakers. In support of its omnichannel approach, Nike redeveloped its apps to allow consumers to transition his or her buying experiences to physical retail outlets, through product reservations, curbside pick-ups, etc. Also, specific Nike locations base their product selections from regional consumer preference data. Regarding Nike Inc.'s innovation, Nike is reducing its styles by 25% so that it can offer new lines to its customers to target a wider variety of customer needs. In

sustainability, Nike Inc. is committed to making its products less toxic, using and creating renewable energy in its factories, making a more significant portion of its products from recycled synthetic materials, and switching to preferred cotton from traditional cotton ("FY18," 2018).

Lululemon Athletica designs and sells yoga-inspired clothing with a "coolness" factor that is in-line with the health and wellness trend. Its products are designed to be worn as a status of wealth and healthy living since it creates premium-priced products. Lululemon Athletica operates retail locations and an eCommerce platform, respectively contributing 70% and 20% of revenue ("Lululemon," 2019). In a Hoover company profile report, Lululemon Athletica is said to rely on community, product materials, and design. Lululemon Athletica integrates a sense of community throughout all facets of its business. Lululemon Athletica promotes its products using local brand ambassadors, social media, and grassroots initiatives to penetrate its reputation into communities. Seeing that Lululemon Athletica's primary source of revenue is a storefront, it relies on interaction with communities to fuel traffic. Also, adhering to the theme of community, Lululemon Athletica's innovation drives its vertical retail strategy and direct connection with its customers, which allows Lululemon Athletica to collect and integrate customer feedback into its products easily and quickly. Lululemon Athletica's current plan is to expand its men's line, expand internationally, and invest in its digital operations ("Lululemon," 2019). Lululemon Athletica's digital presence will create an omnichannel strategy that will enhance the user's interaction with its storefronts, thus expanding its reach into communities. Lululemon Athletica’s efforts in sustainability are optimizing energy and carbon use across its entire supply and value chains, using preferred materials in its packaging, and recycling in its stores and distribution centers (Lululemon Athletica, n.d.). Recycling efforts include textile recycling, which

Lululemon Athletica claims it resells, donates, or recycles 90% of damaged or excess products, to further the end of life of materials.

Columbia Sportswear Co. produces and sells upscale outdoor apparel targeting the "outdoorsy" individual. Its performance apparel is the most substantial part of its revenues, but sportswear accessories and footwear do contribute too ("Columbia," 2019). Columbia Sportswear Co. distributes products mostly through wholesale distribution; however, does sell products through its storefronts and website. A Hoover company profile report explains Columbia Sportswear Co.'s most considerable growth has come from its direct-to-consumer eCommerce channel ("Columbia," 2019). Columbia Sportswear Co. engages in many marketing strategies, including television, print, social media, and events ("Columbia," 2019). Columbia Sportswear Co.'s success comes from its high product quality and collaboration ("Columbia," 2019). Columbia Sportswear Co. incorporates collaboration throughout many aspects of its business. For example, it offers its products through many sales channels, including sporting goods stores and big-box retailers. Also, Columbia Sportswear Co. is attempting to imbed style in its reputation through collaborations with designer companies, like Kith, to align with the casual streetwear trend. Columbia Sportswear Co. focuses on events as a means for collaboration, like its sponsorship of the Ultra-Trail du Mont-Blanc trail running race, one of the most prestigious ultra-races in the world. Further part of Columbia Sportswear Co's strategy, it. hopes to enhance the customer experience across all channels, including digital. In this pursuit, Columbia Sportswear Co. envisions a direct-to-consumer channel that takes advantage of an omnichannel approach. Due to declines in cold-weather focused products, Columbia Sportswear Co. wants to expand into other product lines that target different segments ("Columbia," 2019). Regarding sustainability, Columbia Sportswear Co. focuses on this aspect of its business because

its "outdoorsy" customers care for the environment (Columbia Sportswear, 2019). Columbia Sportswear Co. focuses on the materials it uses and conserving water by holding its suppliers to high standards. Columbia Sportswear Co. primary relies on recycled synthetic materials that are dye-free and responsibly sourced down. Columbia Sportswear Co. uses high-quality materials to increase its products' ends of life.

Tencel

Tencel is a brand name of the man-made cellulose fiber lyocell produced by Lenzing AG. Lyocell fiber derives from wood pulp, primarily eucalyptus. Lyocell classifies as a subcategory of rayon, but the production method for the cellulose is entirely different from other rayon fibers, like viscose (Chen, 2015).

In 1982, Tencel was branded by Courtaulds, a United Kingdom company, who figured out how to commercialize the process of developing lyocell full-scale by 1992 at a plant in Mobile, Alabama (Chen, 2015). Courtaulds initially branded lyocell fiber as Tencel. Efforts had been made prior by Eastman Kodak Inc., but the attempts failed. Lenzing, an Austrian company, a producer of viscose, began producing lyocell in 1990 and eventually acquired the Tencel Group as well as the plant in Alabama. Today Lenzing is the world's largest provider of lyocell fiber producing over 90 times more lyocell fiber per week than Courtaulds produced in 1992.

Tencel boasts many benefits, both beneficial for the environment and the user. This section will cover in detail the environmental impacts and functional benefits of Tencel while comparing Tencel to other popular fibers.

Environmental Impact

Sourcing

Tencel originates from responsibly sourced wood-pulp. Lenzing follows a principle developed in Central Europe a few hundred years ago that explains, "one should not take more wood from the forest than it can regrow. (Lenzing Group, n.d.a).” Lenzing sources more than half of its wood pulp from its plants and the rest from international partners who adhere to Lenzing's sustainability principles (Lenzing Group, n.d.a). None of Lenzing's wood procurement sources from primeval forests in Canada, Russia, the Amazon region, Indonesia, or West Africa. Most of Lenzing's wood suppliers are recognized as FSC and PEFC certified, meaning the suppliers operate sustainably. Small volumes of Lenzing's wood supply comes from small-scale businesses that cannot afford expensive and expansive certification procedures, but Lenzing's wood procurement and forestry experts make sure these small suppliers operate by Lenzing's standards. In total, more than 99% of Lenzing's wood used at its plants, or its suppliers' pulp plants, is certified. Suppliers must also guarantee that its procedures meet international guidelines for sustainable business management, and they comply with Lenzing's human rights standards.

Lenzing ensures its trustworthiness as a fiber source by pursuing external awards and certifications. Lenzing is a founding member of the Sustainable Apparel Coalition (SAC), an initiative of the world's leading textile brands (Lenzing Group, n.d.a). SAC is well known for the Higgs Index, a toolset for measuring the sustainability of products in the value chain. Another partner for Lenzing is Canopy, a Canadian forest conservation organization.

Water

Tencel, in comparison to most fibers, does not use much water. Wood used for Tencel is grown in natural and semi-natural forests, which are part of the natural water cycle, meaning no additional water is needed to grow the trees (Lenzing Group, n.d.b). Lenzing and its suppliers understand that sustainable deforesting practices are crucial for their water footprints because forests significantly help stabilize an ecosystem's water supply. Forests prevent water shortages from little precipitation and protect ecosystems from flooding (Lenzing Group, n.d.b). In the processing of Tencel, more than 99% of the water used to separate the fiber from the pulp is retained and reused in the next batch of pulp (Lenzing Group, 2018b). The water used for cooling purposes is mostly filtered then returned to the environment (Lenzing Group, 2018b). In 2018, Lenzing extracted 112 million m^3 of water, 87% of that being surface water, and returned nearly 90% of the water to rivers and other water extraction sites. Of the recovered water, 35% was cooling water.

In a conjoint life cycle assessment (LCA) of popular fibers from Group Science, Technology and Society (STS), Copernicus Institute, and Utrecht University, MMCs and polyester do not use as much water as cotton and viscose (Shen & Patel, 2010). The study reports more than 99% of the water used by cotton is for irrigation, 70% of which comes from groundwater, and 30% from surface water. Excluding cooling water, cotton requires anywhere from 100 to 500 times the amount of water than MMCs. The LCA explains that cotton irrigation is not retained and can pose serious issues to the environment as it spreads pesticides and other harmful chemicals, which can lead to environmental harms like soil salination. Also, because irrigation water usually does not get returned, water shortages can happen downstream in rivers. In perspective, Tencel used around 300 m3 of water per ton of fiber for production, while cotton

used 4300 m3 to 6800 m3 of water per ton of fiber solely for irrigation (Shen & Patel, 2010). Compared to viscose, the biggest competitor in the MMC market, Tencel production requires one-third of the process water needed in viscose production.

Energy

Tencel's production uses ample amounts of energy for either process heat or electricity for machinery. Lenzing's claims its largest production plant and a few other plants mainly use bioenergy (Lenzing Group, 2018b). In Lenzing's sustainability report, Lenzing describes that leftover wood scraped of its useful natural resources for fiber, is used for thermal energy and electricity (Lenzing Group, 2018b). The plants that are not fully supported by biofuels rely on natural non-harmful gasses and fossil fuels, which Lenzing makes significant efforts to reduce the usage of fossil fuels every year. Since 2014, Lenzing has reduced fossil fuel consumption by nearly 5% and dedicated more of its energy to renewable energy (biomass, wind, solar, hydro, waste, etc.). In total energy consumption, Lenzing has reduced its usage by 2% since 2014 through optimization processes.

In comparison to other fibers, Tencel requires near the same amount of total energy output as polyester per ton of staple fiber with cotton needing the least amount of energy (Shen & Patel, 2010). Even though polyester and Tencel are similar, the LCA report explains Tencel uses more biofuel (Shen & Patel, 2010). Per one ton of staple fiber, based on 2012 estimations, Tencel production energy usage is half biofuel, while polyester production in Europe uses around 99% non-renewable energy. In cotton production, approximately 50% to 60% of energy use is from non-renewables.

Waste

Tencel production favorably manages waste compared to other fibers. Wastes emitted by fiber production are air emissions, water effluents, and chemicals.

Tencel's production releases a small amount of air emissions compared to the other fibers. Tencel production relies on renewable energy and does not emit much into the air due to closed-loop processes (Lenzing Group, 2018b). In the LCA, viscose in Asia contributed about the same carbon emissions as polyester per ton of fiber, resulting in a 3.8 to 4.1 cradle-to-factory gate global warming potential (GWP) (Shen & Patel, 2010). In comparison, Tencel scored a 0.05 GWP factor. In 2018, 65% of all viscose production came from China, meaning viscose production mostly comes from sources that emit harmful air pollutants (Lenzing Group, 2018b). GWP is the total carbon dioxide and carbon dioxide equivalents per ton of fiber (Shen & Patel, 2010). Lenzing, who produces viscose as cleanly as it can, admits that viscose is responsible for the sulfur emissions reported on its sustainability report: carbon disulfide (CS_2), hydrogen sulfide (H_2S), and sulfur dioxide (SO_2). Carbon disulfide is linked to congenital disabilities, higher levels of coronary disease, and cancer, as studied by the trends around people who live near viscose factories (Agency of Toxic Substances and Disease Registry, 1996). Polyester contributes to higher human toxicity, near three times as much as viscose, due to emissions of polycyclic aromatic hydrocarbons (PAH) during production (Shen & Patel, 2010). 90% of polyester's impact on human toxicity is from PAH. PAH is confirmed by the EPA as cancer-causing and is an ingredient of coal tar, crude oil, roofing tar, plastics, and pesticides (Agency of Toxic Substances and Disease Registry, 2011). PAH forms during the burning of coal, oil, garbage, and tobacco.

Water effluents discharged by fiber production can be harmful, but Tencel discharges non-harmful water effluents. Tencel's closed-loop pulp extraction process uses water to dissolve the wood pulp into a fiber, which creates renewable byproducts (Lenzing Group, 2018b). 40% of the wood turns into pulp, 10% turns into non-harmful byproducts like acetic acid, furfural, xylose, and soda, and 50% turns into a black liquor completely recycled to use as bioenergy. This bioenergy is the primary source of energy that the pulp dissolving stage of Tencel uses. The byproducts that 10% of the wood pulp releases, like xylose, are completely recovered and are renewable chemicals used in many processed foods and beverages.

Fiber production uses many toxic chemicals, but Tencel production is completely non-toxic. Tencel's dissolving process relies on the solvent NMMO, which is a non-toxic, organic, and biodegradable chemical that is over 99% retained after the batch of pulp dissolves (Lenzing Group, 2018b). The retained NMMO is part of a closed-loop process that resuses the retained NMMO in the next installment of pulp. As mentioned above, viscose uses and emits many harmful chemicals in its production. Viscose cellulose uses CS_2 and sodium hydroxide in treatment and precipitates with CS_2, where H_2S discharges as waste (Shen & Patel, 2010). All of these chemicals are toxic and significantly contribute to viscose's impact on human toxicity. More toxic to humans than viscose is polyester, a large part due to the dye used for polyester. The dyes used for polyester do not decompose, are insoluble in water, and produce leftover waste that is difficult to treat (Uren, 2018). Cotton is highly toxic, as well, but for different reasons. Cotton is the worst fiber for aquatic toxicity, terrestrial toxicity, and eutrophication (Shen & Patel, 2010). In these areas of toxicity, cotton is almost 200 times more toxic than Tencel. Also, cotton is second to polyester as the worst fiber for human toxicity. Cotton's toxicity ranks high because it is the most pesticide-intensive crop globally. The LCA attributes most of

the toxicity caused by cotton to one particular insecticide: aldicarb. Aldicarb was banned in 2010 in the United States by the Environmental Protection Agency (EPA), but because cotton farmers rely heavily on aldicarb, the EPA released its ban in 2016 (Attaway, 2016). The harmful chemicals used in cotton harvesting absorb into the soil and linger in the unretained irrigation. Also, the chemicals used in cotton production often remain in the fabric and are released during the lifetime of the garment (Green Choices, n.d.). Organic cotton is typically better due to the low use of synthetic pesticides and moderate use of organic pesticides, but organic pesticides are still mostly toxic. Rotenone is a natural pesticide used in cotton growing that links to Parkinson's disease (Hendriksz, 2017). Also, the Natural Science and Engineering Council of Canada found that in a study of four synthetic pesticides and two organic pesticides, the organic pesticides tested as more toxic than two of the synthetics. The toxic chemicals used in cotton farming also make cotton the worst fiber for acidification and eutrophication (Shen & Patel, 2010). Acidification is the lowering pH levels of the oceans and eutrophication is excessive nutrient density in bodies of water, like lakes, that cause plant life to grow and the death of animal life, mostly due to irrigation runoff.

Land

Land is a valuable resource that is significantly impacted by cotton when compared to the other fibers. The LCA asserts that cotton uses 300% to 500% more land than Tencel per one ton of staple fiber (Shen & Patel, 2010). Polyester uses little land relative to the other fibers because it is entirely synthetic and produced in factories. The LCA specifies that cotton uses agricultural land versus Tencel, which uses forest land. Cotton occupies 2.4% of the world's agricultural land but can only occupy dry and arid land (Pesticide Action Network UK, n.d.). The problem with taking up agricultural land is that cotton competes with foods for agricultural space, when other

natural fibers, like Tencel, do not inhabit valuable land for important foods. Agricultural land relies on irrigation, which can significantly harm the environment, as explained above in this section.

In a case study, the Aral Sea, a water basin shared by Kazakhstan and Uzbekistan, was once the fourth largest lake in the world, but due to significant agricultural water consumption of the two rivers that feed the basin, it has now shrunk 90% of its size since 1960 (Krivonogov et al., 2014). The main crop in the area is cotton. The lake was also deemed a health hazard because of chemical waste from the irrigation. This led to a deterioration of the economy that surrounded the lake.

Functional Benefits

Thermal Regulation

In activewear, thermal regulation is an essential functional property for the user. Thermal regulation is the ability of the body to maintain its core internal temperature, which various fibers can affect uniquely. Tencel achieves superior thermal regulation performance through its absorption capacity and its breathability, as proven by a series of scientific studies sponsored by Lenzing (Lenzing Group, 2012).

Tencel's absorption capabilities are far superior to cotton, viscose, and polyester. From one of the studies, an electron-microscope photograph demonstrates that Tencel distributes absorbed water uniformly across its pores because it has a consistent pore-structure on a nanometer-scale, whereas the other fibers do not (Figure 1). Viscose and cotton have a coarse pore system and a wide array for pore sizes, which causes an ununiform distribution of water. The pore-structure difference allows Tencel to absorb 70% of its weight versus cotton, which can absorb up to 40% of its weight. In another sponsored study, the sweating guarded hot plate test

was used to compare the moisture management of a polyester and cotton mix with a Tencel and polyester mix, to gauge the performance of cotton versus Tencel when mixed with polyester (Lenzing Group, 2012). A sweating guarded hot plate test simulates the heat and moisture transfer of the human body by emitting water vapor and measuring the absorption of the fabric in a controlled environment. The three fabrics tested were a 65/35% polyester/Tencel blend, a 65/35% polyester/cotton blend, and an 80/20% polyester/Tencel blend. The 65/35% blend with Tencel and polyester showed 55% more water vapor absorption than the 65/35% blend with cotton and polyester. The 80/20% blend with Tencel and polyester showed 40% more water vapor absorption than the 65/35% polyester/cotton blend. In polyester blends, less Tencel is needed to create the same amount of moisture management as cotton. Tencel's moisture management is essential to some blends because less fiber is necessary for moisture management, and more polyester can be used to increase the durability and water-wicking capabilities of the blend if needed. For thermal regulation absorption is essential because moisture management keeps the body dry while creating a natural air-conditioning for the human body (Lenzing Group, 2012). Polyester is hydrophobic, unlike natural hydrophilic fibers, meaning polyester is unable to absorb water. Polyester is inherently weak at absorbing water because it is petroleum-based—oil cannot mix with water.

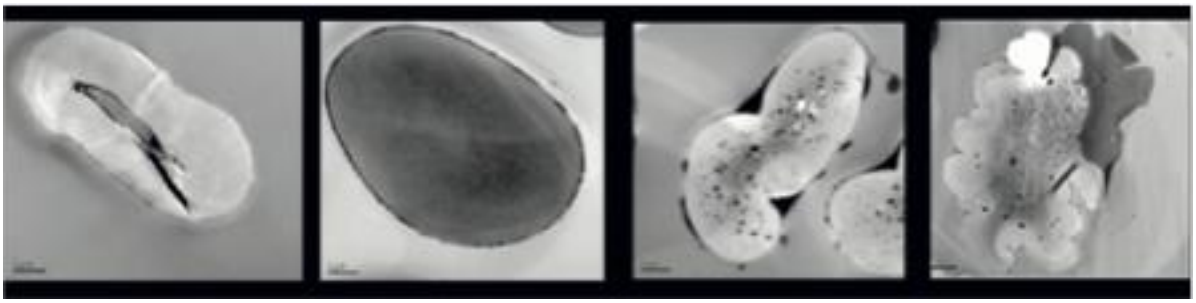

Figure 1. Electron microscope photograph of fibers showing absorption capabilities. Water appears black. Left to right: cotton, Tencel, modal, viscose (Lenzing Group, 2012).

Bacterial Growth

Human skin homes up to one million bacteria per centimeter squared and over 500 different species, explains one of the Lenzing sponsored studies (Lenzing Group, 2012). In activewear, the discouragement of bacterial growth is vital because sweat-inducing activities create a favorable environment for bacterial growth on skin. The textile used for activewear can affect the amount of bacterial growth. Tencel discourages bacterial growth compared to polyester, its main competitor in activewear. Certain bacteria lead to staining, odor, and performance degradation of the material.

Tencel's high absorbency contributes to less bacterial growth because there is less available moisture on the surface of the fiber for bacteria to grow. In a study, scientists measured how much bacteria and what species of bacteria were on the forearms of participants before they interacted with textiles (Lenzing Group, 2012). Some participants wore a polyester forearm sleeve, and some participants wore a Tencel sleeve, each participant wearing his or her sleeves eight hours per day for six days. Skin samples were collected after. Conclusions found that many more species of bacteria populated on the skin after wearing a polyester sleeve when compared to skin samples before the worn sleeve. With the Tencel sleeve, participants did not incur a more elaborate makeup of bacteria. Also, the composition of gram-negative bacteria on the forearm changed from 4.2% to 36.8% after participants wore the polyester sleeve. Tencel saw changes of 28.4% before the sleeve to 25.9% after the sleeve. Research suggests that polyester's attributes contribute to temporary changes in the microenvironment of the skin that enhances gram-negative bacterial growth. Gram-negative bacteria can be worse than gram-positive bacteria because they are more resistant against antibodies due to an impenetrable cell wall. Also, Bacillus subtilis, the odor-producing bacteria, is gram-negative.

In a separate study hosted by Lenzing, scientists measured the moisture content an environment requires for bacteria to grow (Lenzing Group, 2012). Bacteria can only grow in environments where the water activity, a unit ranging from 0 to 1, is greater than 0.9. Water activity is defined as the number of unbound water molecules ("Explain," n.d.). For example, in textiles, the water molecules unbound to the textile molecules is considered free water that can support the growth of bacteria. A unit of one represents pure water, and a unit of zero represents no water. Tencel, compared to cotton and polyester, can reach a higher percentage of moisture content before water activity reaches 0.9, an environment where bacteria can grow (Figure 2). Tencel absorbs water so well that it requires a higher number of water molecules before the water molecules are unbound. When enough water molecules are unbound, then bacteria can grow.

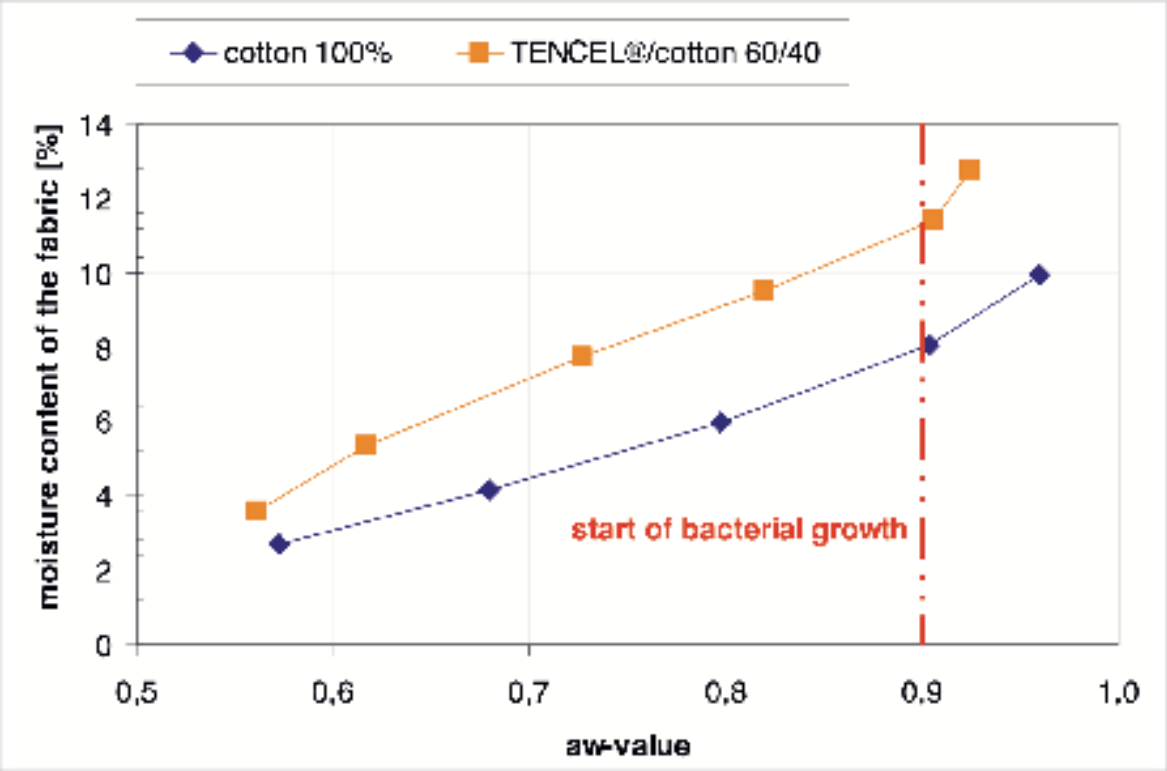

Figure 2. Chart demonstrates Tencel significantly impacting the start of bacteria growth, even when mixed with cotton (Lenzing Group, 2012).

Color Retention

Tencel fiber has attractive qualities for superior color retention capabilities. Tencel is a smooth fiber, which enables dyes to penetrate deep into the fiber structure (Lenzing Group, 2012). Deep dye penetration leads to a more brilliant color. Also, Tencel is typically dope-dyed, a method that improves colorfastness to prevent fading over time even after many washes. Another benefit of dope-dyed fibers is the reduction of water use and dyestuff use (IKEA, 2015). The dope-dyeing method reduces water usage by up to 80% and dyestuff usage of up to 20%.

Gentleness & Smoothness

Tencel is one of the gentlest fibers. At a microscopic level, a strand of Tencel is near perfectly smooth, producing enhanced comfort on the skin (Figure 3). Tencel's smoothness reduces friction on the skin, while its moisture absorbing abilities remove moisture on the skin that would cause increased friction (Lenzing Group, n.d.c). Also, Tencel's moisture removing abilities nearly removes all electrostatic charging, a benefit for people with sensitive skin over polyester.

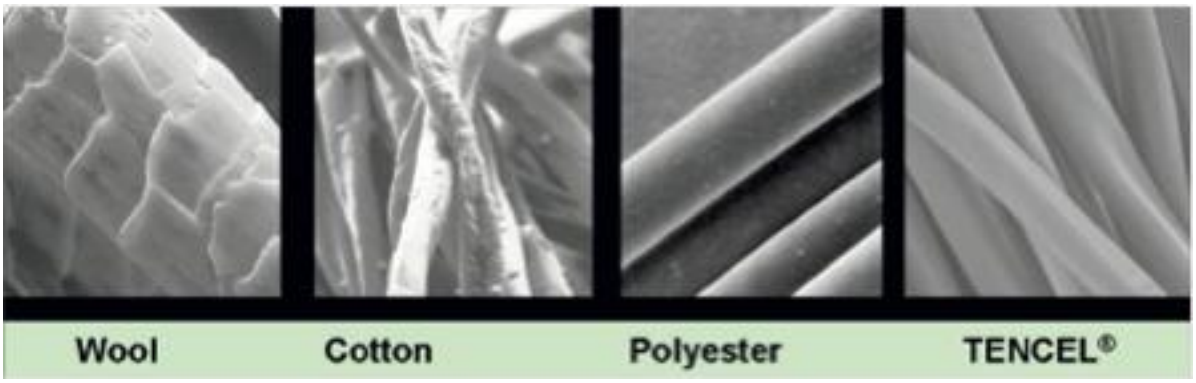

Figure 3. Electron microscope photograph of fibers shows smoothness of fibers (Lenzing Group, 2012).

Strength

The strength measurement of fiber typically uses two metrics: tenacity and elongation (Chen, 2015). Tenacity is also known as tensile strength. Tensile strength is the resistance of material breaking under tension ("Tensile," n.d.). In more detail, tensile strength is the capacity for material to withstand loads that elongate the material. Tenacity uses a unit of force per denier (g/denier) as its measurement. Denier is the weight per unit length expressed in grams of nine kilometers length of the fiber ("Denier," n.d.). Elongation is a percentage of the starting length of the fiber before breaking (Chen, 2015). Tenacity and elongation metrics test in dry and wet states.

The most durable fibers based on tenacity in dry conditions by rank are polyester, Tencel, viscose, and cotton (Chen, 2015). In Figure 4, a chart is provided to show specific measurements in g/denier. Interestingly, Tencel is similar to polyester in tenacity and does not reduce substantially in wet conditions, unlike viscose, which becomes significantly weaker. The fibers ranked in elongation from best to worst are polyester, viscose, Tencel, then cotton. The chart in Figure 4 also provides specific measurements for elongation. Polyester has a significantly higher elongation rate than the other fibers.

Tensile Strength and Elongation

Fiber	**Tenacity (g/denier)**		**Elongation (%)**	
	Dry	**Wet**	**Dry**	**Wet**
Viscose	2.6–3.1	1.2–1.8	20–25	25–30
HWM	4.1–4.3	2.3–2.5	13–15	13–15
Tencel	4.8–5.0	4.2–4.6	14–16	16–18
Cotton	2.4–2.9	3.1–3.6	7–9	12–14
Polyester	4.8–6.0	4.8–6.0	44–45	44–45

Figure 4 (Chen, 2015).

Implementation

Considering all the information provided above, Tencel is the suggested environmentally-friendly textile for application in the Alpas Athletix sports bra. Before implementing Tencel into the sports bra, there are a few considerations. First, what does the supply chain entail? Second, how costly is implementation? Last, how difficult is implementation?

Lenzing, the producer of Tencel, does not sell textiles, it sells lyocell fiber to textile producers. After contact with Lenzing, a representative supplied a list of textile suppliers in North America that represented Lenzing's values. After contacting multiple textile producers, the best-suited supplier of Tencel was Eagle Fabrics from Los Angeles, CA, for numerous reasons. Eagle Fabrics prides itself on providing only environmentally friendly, sustainable, non-toxic, and non-synthetic textiles. Also, Eagle Fabrics produces everything in America with a transparent supply chain. Also, Eagle Fabrics and Alpas Atheltix are both located in Southern California, which expedites communications and shipments, and reduces the carbon footprint of Alpas Athletix.

Next to consider is the price differentiation of Tencel fabrics versus the fabrics that already exist on the prototypes. Kathy David, the founder of Alpas Atheltix, confirmed that the price differences between the Tencel fabrics and the fabrics currently used are almost identical.

The final criteria to meet is ease of implementation. Kathy David confirmed that switching out fabrics in the production process is simple and requires no extra parts. The only requirement is that Tencel needs to handle extreme heats in production, which it does.

Suggestions

In conclusion, implementing Tencel into the Alpas Athletix strapless sports bra is my suggestion. Tencel satisfies macro-environmental trends and trends in relevant industries, is more sustainable and environmentally friendly than other popular fibers, is functionally sound, is easy to implement, and is not costly.

Consumers are increasingly becoming more aware of the environmental impacts of their decisions, and plenty of science is coming out about the effects that synthetics and cotton have on the environment. As science becomes more developed and relevant, governments will have to respond, as they already are, leaving an opportunity for sustainable and environmentally friendly products to gain rapid traction. Due to risks polyester and cotton face, using Tencel before it becomes widespread can act as a differentiator to large companies like Nike Inc. and Lululemon Athletica and give Alpas Athletix a near first-mover advantage in sustainably made and high performing sports bras.

Tencel is not just environmentally sound, but functionally beneficial too. Tencel is as strong as polyester, more absorbent and breathable than cotton, the most hygienic fiber, the gentlest fiber for sensitive skin, and as color retentive as polyester without the need for a water-intensive dyeing process. However, well-made polyester wicks water away better than any fiber, which is necessary for high-intensity activities. Lenzing suggests mixing Tencel with at least 50% recycled polyester to create a textile that effectively pulls moisture off of the skin and wicks the moisture away. This fabric mixture could be used for a high-performance sports bra, whereas a purely Tencel sports bra serves as an athleisure piece suitable for everyday wear, yoga, jogging, etc.

Tencel fabrics are around the same price as the synthetic fabrics already used in the Alpas Athletix strapless sports bra. Natural fibers and environmentally friendly products tend to be thought of as pricier alternatives to synthetic products in apparel, so an environmentally friendly and natural sports bra may entice consumers to spend a premium price. Consumers' willingness to pay more increases the margins of the sports bra. Also, Tencel would be easy to implement in Alpas Athletix production process.

Lastly, I suggest marketing the strapless sports bra not too vaguely. Of course, the sports bra will advertise as an environmentally friendly, sustainable, and functional product, but marketing efforts should focus on a few critical aspects to resonate stronger with the consumer. For example, Impossible Burger is seeing massive success in the investor world, compared to a plateaued competitor in Beyond Beef. The difference between the two companies is that Beyond Beef uses a vague marketing approach as a plant-based option and Impossible Burger markets as an animal-friendly option. Both are mostly the same product, but the animal-friendly marketing strategy resonates stronger with investors and consumers. For the sports bra, marketing it as a triple-threat non-toxic product for the land, water, and the human body is a potential idea that would resonate with consumers. Consumers most likely would prioritize a safe product for themselves and the earth over a product solely marketed as environmentally friendly because the term environmentally-friendly is vague and does not necessarily mean it is non-toxic to humans. An utterly non-toxic product would easily imply environmentally-friendly and sustainability in its nature, just as animal-friendly for Impossible Burger suggests that it is a vegetarian option. In these cases, “non-toxic” and “animal-friendly” are strong marketing signals to consumers because animals and safety emotionally resonate with consumers. A non-toxic marketing campaign would also expose other products and fibers on the market, increasing awareness

among consumers, and potentially convincing consumers to switch over from a competitor. A non-toxic marketing campaign is an example of narrowing a focus, but there are many potential focuses on Tencel, such as biodegradability, no emission of microplastics, chemically organic, not a contributor to deforestation, a low-carbon emitter, etc. In conclusion, an environmentally friendly sports bra should be marketed as environmentally friendly and sustainable, but with a focus that resonates with the company's values and consumers' emotions.

References

Adomaitis, K., Boumphrey, S., Cesniene, I., Evans, M., Hodgson, A., Marceux, P., . . . Saltenyte, U. (2017). *Global Economies and Consumers in 2017*[PDF]. Euromonitor International.

Agency for Toxic Substances and Disease Registry (ATSDR). (2011, March 03). Polycyclic Aromatic Hydrocarbons (PAHs). Retrieved July 20, 2019, from https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=25

Agency for Toxic Substances and Disease Registry (ATSDR). (1996). *Toxicological profile for Carbon Disulfide* [PDF]. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Apparel and Footwear in the US[PDF]. (2019, February). Euromonitor International.

Attaway, D. (2016, May 12). Aldicarb coming back to the agricultural pesticide mix. Retrieved July 23, 2019, from https://newsstand.clemson.edu/mediarelations/aldicarb-coming-back-to-the-agricultural-pesticide-mix/

Chen, J. (2015). *Synthetic Textile Fibers: Regenerated Cellulose Fibers*[PDF]. Austin: Elsevier Ltd.

Columbia Sportswear Company. (2019, February 21). *ANNUAL REPORT 2018 TO SHAREHOLDERS*[PDF].

Columbia Sportswear Company Profile[PDF]. (2019, March 4). Hoovers.

Denier. (n.d.). Retrieved July 23, 2019, from http://www.businessdictionary.com/definition/denier.html

EarthHero. (2019, July 16). What's the deal with rPET?: Recycling Plastic: EarthHero Blog. Retrieved July 20, 2019, from https://earthhero.com/whats-the-deal-with-rpet/

Eder-Hansen, J., Chalmer, C., Tärnerberg, S., Tochtermann, T., Seara, J., Boger, S., . . . Jäger, K. (2017). PULSE OF THE FASHION INDUSTRY[PDF]. Global Fashion Agenda & The Boston Consulting Group.

Explain what water activity is and how it relates to bacterial growth. (n.d.). Retrieved July 23, 2019, from http://www.foodsafetysite.com/educators/competencies/general/bacteria/bac5.html

FY18 NIKE, Inc. Impact Report[PDF]. (2018). NIKE, Inc.

Global Fashion Agenda. (2019). *Report 2019 Status Report*[PDF]. Global Fashion Agenda.

Green Choices. (n.d.). Environmental impacts. Retrieved July 20, 2019, from https://www.greenchoices.org/green-living/clothes/environmental-impacts

Hendriksz, V. (2017, June 07). 13 brands sign sustainable cotton pledge - but is organic cotton really better? Retrieved July 20, 2019, from https://fashionunited.uk/news/fashion/13-brands-sign-sustainable-cotton-pledge-but-is-organic-cotton-really-better/2017060724755

Herrmann, S. (2017). A NEW TEXTILES ECONOMY: REDESIGNING FASHION'S FUTURE[PDF]. Ellen MacArthur Foundation.

IKEA. (2015). *IKEA FACTS TEXTILE DYEING*[PDF]. Inter IKEA Systems B.V.

Krivonogov, S., Burr, G., Kuzmin, Y., Gusskov, S., Kurmanbaev, R., Kenshinbay, T., & Voyakin, D. (2014, March 1). *The fluctuating Aral Sea: A multidisciplinary-based history of the last two thousand years*[PDF]. Elsevier B.V.

Lenzing Group. (2012). *Scientific reports on wood, pulp and regenerated cellulose*[PDF]. Lenzing, Austria: Lenzing AG.

Lenzing Group. (n.d.a). Wood and Pulp. Retrieved July 20, 2019, from https://www.lenzing.com/sustainability/resources/wood-and-pulp/

Lenzing Group. (n.d.b). Water. Retrieved July 20, 2019, from https://www.lenzing.com/sustainability/resources/water/

Lenzing Group. (n.d.c). *Feels right, naturally*[PDF]. Lenzing, Austria: Lenzing Aktiengesellschaft.

Lenzing Group. (2018a). *Annual Report 2018*[PDF]. Lenzing: Lenzing Aktiengesellschaft.

Lenzing Group. (2018b). *Sustainability Report 2018*[PDF]. Lenzing: Lenzing Aktiengesellschaft.

Lululemon Athletica. (n.d.). Sustainability. Retrieved July 21, 2019, from https://info.lululemon.com/sustainability

Lululemon Athletica Canada Inc Profile[PDF]. (2019, March 13). Hoovers.

Nike, Inc. Profile[PDF]. (2019, March 4). Hoovers.

Paddison, L. (2016, September 27). Single clothes wash may release 700,000 microplastic fibres, study finds. Retrieved July 22, 2019, from https://www.theguardian.com/science/2016/sep/27/washing-clothes-releases-water-polluting-fibres-study-finds

Partnerships. (n.d.). Retrieved July 20, 2019, from https://www.lenzing.com/sustainability/partnerships/

Pesticide Action Network UK. (n.d.). Pesticide Concerns in Cotton. Retrieved July 20, 2019, from http://www.pan-uk.org/cotton/

PETA. (2015, October 20). Mulesing by the Wool Industry. Retrieved from https://www.peta.org/issues/animals-used-for-clothing/wool-industry/mulesing/

Preferred Fiber & Materials Market Report 2018[PDF]. (2018). Textile Exchange.

SPORTSWEAR IN THE US[PDF]. (2019, February). Euromonitor International.

Sustainability Concerns. (2017, October 13). Retrieved from https://lifestylemonitor.cottoninc.com/sustainability-concerns/

Tensile strength. (n.d.). Retrieved July 20, 2019, from https://www.dictionary.com/browse/tensile-strength

The Economist. (2018). In Fashion. Retrieved July 22, 2019, from https://films.economist.com/infashion/?utm_source=Paid media/&utm_medium=Economist Print QR Code&utm_content=Fashion naked truth&utm_campaign=In fashion

Uren, A. (2018, August). Material Guide: How Sustainable is Polyester? Retrieved July 20, 2019, from https://goodonyou.eco/material-guide-polyester-2/

Wahnbaeck, C., & Roloff, L. (2018). After the Binge, the Hangover[PDF]. Hamburg, Germany: Greenpeace e.V. Germany.