Environmental Sustainability Assessment Tool for Factories

by

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Abstract

General interest and international regulations have begun to create a world in which consumers demand to know how their products are made and companies must provide that transparency. With over 15,000 suppliers, Li & Fung wants to obtain better insight into its suppliers' environmental sustainability characteristics. The Sustainable Apparel Coalition's (SAC) Higg Index is currently viewed as the foremost way to assess a supplier's environmental sustainability; however, its facility module only applies to certain types of industries. Li & Fung requires a tool that encompasses its full supplier base and is short and robust enough to provide valuable insight into its supply chain and help it engage factories in decreasing their environmental footprints. This thesis discusses the methodology used to create such a tool and the information acquired during a successful pilot.

To facilitate integration and adoption, the categories and some of the questions and language are modeled after that in the Higg Index. However, this scorecard incorporates many different and more focused questions, and the majority of its answers are standardized to promote easy analysis post-assessment. Its scoring system is also quite robust, aiming to award points accurately and with attention to the information and quality of environmental initiative undertaken at a factory. Finally, it incorporates a novel benchmarking and visualization section, which not only will help the user compare factories, but also more clearly see the areas in which a given factory is excelling or needs improvement. This knowledge will then allow Li & Fung to engage with its suppliers and help them decrease their environmental impact.

The scorecard was piloted in 14 factories in the Shenzhen, Shanghai, and Hong Kong regions. Factory types included categories such as apparel, home textiles, umbrellas, and bags. Benchmarking was done across factory types to investigate commonalities and compare initiatives.

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Chapter 1

1 Introduction

This chapter will introduce the project by discussing its motivation, the problem statement, and the overall goals.

1.1 Project Rationale

Li & Fung operates one of the most extensive supply chains in the world with over 15,000 suppliers in 40 markets [1]. Given this extensive network in which costs due to unexpected disruptions or changes in regulatory frameworks can be significant, minimizing risk is of utmost importance. As an increasing number of discussions center around topics like natural resource depletion and climate change, suppliers operating without attention towards environmental sustainability present a higher risk for sourcing endeavors. Thus, ensuring sustainability and minimizing risk within its supply chain is of significant concern to Li & Fung.

The term ‘sustainable development’ was created in 1987 by the Brundtland Commission, which classified it as development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” [2]. With applications more for the commercial sector, in 1994, John Elkington developed the “triple bottom line”, (profit, people, and planet) as a way to measure sustainability performance [3]. Using this methodology to assess its economic, social, and environmental performances, a company can more accurately gain insight into its overall impact. This three-sided evaluation approach is mirrored in the Organization for Economic Co-operation and Development’s (OECD) representation of sustainable manufacturing, shown in the following figure.
When Li & Fung evaluates a supplier, it is aware of these different facets of sustainability, as its current supplier analytics tools incorporate economic, social, and environmental regulation information. During the supplier audits, the audit team works to answer key questions relating to topics such as wages, work hours, worker age, and building systems/structure. The audit’s environmental component investigates if a supplier complies with local and national regulations and whether it has the necessary environmental certifications. These evaluations are crucial to Li & Fung’s assessment of a supplier and help it ensure it enters relationships with organizations that comply with regulations and are socially responsible.

1.2 Problem Statement

While the company does evaluate whether a supplier is operating in compliance with legal rulings, there is no specific assessment of environmental sustainability. Therefore, it is unable to discern which suppliers use resources most efficiently and have the lowest environmental impact. By not having insight into the environmental segment of a supplier’s triple bottom line, Li & Fung faces higher risks when working with these parties. For example, suppose there are two suppliers that are located in the same region and produce identical products. However, one
has implemented a variety of water efficiency measures so its overall water consumption is significantly less than that of the other. Now suppose that every so often, there is a severe drought and water becomes much more expensive or is nearly impossible to acquire in adequate amounts. With knowledge on the water efficiency practices in place, the supplier that requires less water will pose less risk, potentially making it more appealing for Li & Fung to use in its supply chain. Therefore, Li & Fung requires a mechanism to assess the environmental sustainability of each supplier, thus increasing both its insight into supplier risk and its overall knowledge of its supply chain's impact. Once it obtains such a mechanism, it then hopes to use the knowledge gained to work with the suppliers, helping them become more environmentally sustainable.

1.3 Project Goals

The overarching goal of this research is to create and test a methodology to better evaluate the environmental sustainability of Li & Fung’s supplier base. Embedded within that objective are several overarching requirements for the tool:

1. Li & Fung is a member of The Sustainable Apparel Coalition (SAC), the organization that created the Higg Index, which is viewed as one of the primary ways to evaluate environmental sustainability in certain types of factories. Therefore, the tool created must be closely aligned with the Higg Index and preserve similar language and phrasing given its connection with retailer and brand objectives and already existing ties to the supplier base. Doing this will hopefully facilitate factory adoption.

2. It must be easy and fast to complete, but still present an accurate and valuable assessment.

3. It must be able to be integrated into Li & Fung’s existing factory analysis tools.

4. It must apply to Li & Fung’s full supplier base, which includes beauty products, bags, home textiles, apparel, etc.

Once the tool is created, it must be tested in real-world scenarios. Therefore, a pilot will be conducted at a variety of factory types to represent the company’s diverse supplier base.

1.4 Dissertation Overview

Chapter 1 has described the project’s context, its underlying reason, and the ultimate goal.
Chapter 2 provides a thorough background on Li & Fung and the methods it currently uses to analyze suppliers. It then proceeds to describe the current worldwide climate towards environmental sustainability as well as specific consumer demands for additional insight into products' impacts.

Chapter 3 presents a detailed literature review. It commences with a discussion of the environmental impacts related to manufacturing and proceeds to the methods employed to gauge, benchmark, or certify products, processes, or structures.

Chapter 4 details the methodology used to create the scorecard and the questions and scoring system within each of its segments. It follows with a discussion of the pilot's approach.

Chapter 5 discusses the data collection process used for the factory pilot. It also covers the variety of staff training that occurred.

Chapter 6 analyzes the pilot's data and shows benchmarking results divided by factory type.

Chapter 7 provides description of different environmental impact reduction techniques that factories can implement. Some techniques are all encompassing, while others apply to specific factory types.

Chapter 8 provides a short conclusion to the document.
Chapter 2

2 Background

This chapter presents a background of Li & Fung from its start in 1906 through the present. It also describes the company's compliance audit, which it uses to analyze suppliers, and goes into further detail about the environmental portion. The latter half of the section describes the world's current regulatory climate on environmental sustainability as it relates to production and what national and international organizations are doing. It finishes with an overview of what companies and end consumers are doing with regards to product environmental sustainability.

2.1 Background of Li & Fung

(Please note that the historical details presented in this section up until the paragraph discussing Spencer’s appointment as CEO all derive from Feng Bang-yan’s book A Hundred Years of Li & Fung: Supply Network Orchestrator for Asia and Beyond [5].)

In 1902, Fung Pak-liu graduated from Queen’s College in Hong Kong. Upon returning to his hometown of Guangzhou, he met Li To-ming, a Chinese merchant whose family owned a porcelain shop. In 1906, they decided to start a Chinese trading firm, calling it Li & Fung as “Li” means profit and “Fung” means plentiful. They started their business by focusing on porcelain and handicrafts, later expanding into areas such as bamboo and rattan products, jade, and what became its most important export product, fireworks.

To distinguish themselves from other export companies, Pak-liu emphasized product design and innovation. However, what ended up likely being one of the most significant factors in the company’s history was when Pak-liu went with the Chinese delegation to the Panama-Pacific International Exposition in 1915. It was on his journey back to Asia that he met Joseph Sipser of Ignaz Strauss & Co. Inc, which was a New York-based importer of Eastern products. Pak-liu’s and Sipser’s friendship blossomed and the former frequently traveled back to the US,
forging connections with other companies there. Over time, the amount of business Li & Fung did with US merchants skyrocketed.

Despite the onset of the Great Depression, Li & Fung maintained its trade connections primarily due to its relationship with Ignaz Strauss and its reputation for high-quality and thorough packaging during goods transportation. With its growing renown, in 1931, it was listed as one of Guangzhou's 28 leading import/export firms, and by the mid-1930s, it had 22 branches and subsidiaries.

In 1937, Japan invaded China and Pak-liu decided to move the business to Hong Kong where it was registered as Li & Fung (1937) Limited. Hong Kong, which is situated about 200 kilometers from Guangzhou near both the South China Sea and Pacific Ocean, was at that time a British colony, so it was more stable in the turbulent climate. It is also strategically located in the Pearl River Delta, which with its deep-water harbor, caused many to view Hong Kong as the gateway to Southern China.

In 1941, Japan attacked Hong Kong and declared it an occupied territory in February, 1942. In 1943, while returning to Guangzhou, Pak-liu suffered a stroke and died. In 1946, after the Japanese surrender in 1945, the management was restructured so that Fung Pak-liu's sons, Fung Hon-chu and Fung Mo-ying, became executive directors. With the death of his business partner and these changes, in 1947 Li To-ming sold his shares to the Fungs and disassociated himself from the company. Although it closed the Guangzhou branch in 1949, Li & Fung continued to grow and became the exporter of 2/3 of Hong Kong's rattan exports.

In the 1950s, Hong Kong's textile industry began to boom because many people from the Shanghai textile industry came there and brought with them highly efficient spinning machines. This allowed the region to become the world leader in cotton fabrics, yarn, and bedclothes exports. Because of its market position, Li & Fung began to export textiles and garments, sourcing from over 1,000 factories throughout Hong Kong.

In the 1960s, Fung Mo-ying's children joined the family business and in the early 1970s, Fung Hon-chu's children, Fung Kwok-king (Victor) and Fung Kwok-lun (William), both Harvard University educated, did too. Victor and William thoroughly evaluated the company's structure and operations and went about providing solutions to help modernize it, create a board of directors, and increase its efficiency before it went public in 1973. Towards the end of the 1970s, Victor and William began to shift the main function of the company. Realizing that customers no longer wanted only a liaison between themselves and the supplier, but rather a production
manager, the brothers modified the company's internal structure into product groups to provide a more comprehensive and tailored experience for its customers. So, they structured the company so that it could be involved in all parts of the production process—from marketing, providing product ideas and designs, and financing, to product quality control, final goods packaging, and transportation.

In 1989, there was a management buy-out and Li & Fung was privatized. Victor and William set out to create a more specialized company and sell the non-core businesses that had been acquired over the years. Upon doing that, they divided the firm into a retail and an export trading side, the former divided again into product groups: textiles (in the US), textiles (outside the US), fashion accessories, plastic wares, sporting goods, and handicraft. This allowed them to expand their role in the supply chain and offer more specialized services to their customers, while simultaneously giving each product group a certain level of autonomy. They also expanded Li & Fung's sourcing from just Hong Kong to China, Korea, Taiwan, Thailand, Philippines, Malaysia, Singapore, and Indonesia.

In 1992, Li & Fung's trading side was restructured and incorporated as Li & Fung Ltd (today called Li & Fung Trading) so it could be listed. During this process, new management was instated with Victor as the non-executive board chairman and William as the managing director. During the remainder of that decade and up through the present, Li & Fung acquired multiple other companies to expand its sourcing network, maintain its market position, and increase profits.

Victor is the Honorary Chairman and William is the Group Chairman, with the rest of the management team comprised of various individuals in leadership positions within the company. In July 2014, Victor's son, Spencer, was appointed CEO.

The company currently operates one of the largest global supply chains in the world. It has ~25,000 employees in over 300 locations in 40 markets and works with a supplier base of about 15,000 [1].
According to its 2015 Interim Report, the countries it sources the most from are China, Vietnam, and Bangladesh.

In the first half of 2015, it achieved a $182,000,000 core operating profit with a $8,626,000,000 turnover [6]. Figure 4 shows the turnover percentage by region, and one can see that the company's primary customers are in the US and Europe.
Throughout the years, Li & Fung has prided itself on being a family business and its commitment to modernization and customer experience has helped it grow to the company that it is today. Its supplier relationships have been and continue to be one of the underpinnings of this success.

2.2 Background of Compliance Audit

In order to commence business with Li & Fung, a supplier must meet criteria presented in the company’s Supplier Code of Conduct and comply with applicable local laws. The Supplier Code of Conduct is “based on the International Labor Organization’s core conventions and the California Transparency in Supply Chains Act” [7]. One of the methods used to evaluate a supplier’s performance is by conducting a factory compliance audit. The audit consists of four sections: labor, health & safety, environment, and security. It typically takes one to two days and can be completed by a member of Li & Fung’s Vendor Compliance and Sustainability (VCS) team. This auditor does tasks like tour the factory, examine records, and evaluate different building components to gather information and complete the audit.

If a factory achieves a sufficient score, it is added into Li & Fung’s internal supplier database and merchandisers can begin sourcing from it. To maintain a compliant network of factories, Li & Fung auditors conduct regular announced and unannounced audits to update factories’ compliance evaluations at intervals based on a given factory’s previous audit score. Should a factory fail an audit, the VCS team can work with the management to determine how it can improve to meet the required criteria, after which it will be re-audited.

2.3 Description of Environmental Portion of Compliance Audit

Environmental compliance is one of the four pillars of Li & Fung’s compliance evaluation. However, the majority of the audit focuses on the other three pillars. While the environmental section does help determine if a factory is abiding by regional laws and if it has the appropriate certifications, it does not ask questions related to environmental sustainability. Therefore, if there are two identical factories, but one is powered solely by renewables and the other by coal, they will both achieve the same environmental compliance score. Thus, Li & Fung does not currently have a mechanism to assess and compare the environmental sustainability of its suppliers. As energy markets change and due to the dynamic nature of environmental initiatives, this lack of insight presents a knowledge gap that is associated with potential factory risk.
2.4 Current Environmental Sustainability Regulatory Climate

In September 2015, leaders in the United Nations adopted its 2030 Agenda for Sustainable Development, and on January 1, 2016, its 17 Sustainable Development Goals (SGDs) went into effect. Goal 12 is to “Ensure sustainable consumption and production patterns” [8]. Incorporated into that tenet are subtopics:

- By 2030, achieve the sustainable management and efficient use of natural resources
- By 2020 achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment
- By 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse
- Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle
- By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature [8].

Governmental organizations have also started discussing ‘sustainable manufacturing’. The United States Environmental Protection Agency (EPA) classifies it as “the creation of manufactured products through economically-sound processes that minimize negative environmental impacts while conserving energy and natural resources” [9]. The Department of Commerce has a similar definition, “the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound” [10]. Under its Sustainable Manufacturing American Regional Tours (SMART) Program, it organizes factory tours across the US with the goal of enhancing visibility into and knowledge of sustainable manufacturing.

In 2008, the European Commission created its Sustainable Consumption and Production and Sustainable Industrial Policy (SCP/SIP) Action Plan, which was endorsed by the Council later that year. The document emphasizes the necessity to adopt more sustainable production and
consumption trends. Within the Plan, it outlines a need for leaner production, which it hopes to achieve by actions focused on: increasing the efficiency with which resources are used; monitoring and increasing eco-innovation; and updating the EU Eco-Management and Audit Scheme (EMAS), which is used by organizations to measure, analyze, and improve their environmental performance, so it is adopted by more companies and is less costly and presents less of an administrative burden.

The International Organization for Standardization (ISO) has also made efforts to improve awareness of sustainable manufacturing. The ISO is comprised of 162 member countries and creates and publishes international standards with over 19,000 currently published [11]. Focusing on educating the end consumer about a product’s environmental impact, it created an ecolabelling standard. The ecolabel standard family contains three standard types, with Type III being the most detailed. Type III (ISO 14025:2006) ecolabels must have “quantified environmental data for a product with pre-set categories of parameters based on the ISO 14040 series of standards, but not excluding additional environmental information” [12]. Therefore, products with these labels give consumers quantifiable information on the item’s impact, thus enabling them to compare across products.

As resources become more strained, governmental organizations and inter-governmental organizations are urging action on environmental sustainability, with one of the main categories being environmental sustainability in manufacturing. Although such initiatives may not necessarily incite all companies to operate differently, they enhance general awareness of the issues, provide a platform for discussion, and potentially signal impending regulations. As those movements grow, consumers become more educated and will likely start demanding more environmentally sustainable production methods.

2.5 Current Consumer Demand for Visibility into Product Sustainability

Considering the three categories within sustainability, as defined in Figure 1, it is possible to discuss the drive towards it on a more brand and end-consumer level. During the 1900s, laws related to social sustainability existed primarily at the national level; however, with the advent of the global supply chain and manufacturing moving to developing nations, the countries lacked the regulatory bandwidth to enforce labor, health and safety, and environmental standards [13]. Although various groups tried to create mechanisms that would foster more socially sustainable supply chains, driving change was very difficult. Significant changes only really started to occur after Jeff Ballinger published an article on the wages and factory
conditions of Nike’s subcontractors in 1992. This caused significant unrest as people began to boycott and protest the company. In 1998, Nike CEO Phil Knight said in a speech,

The Nike product has become synonymous with slave wages, forced overtime, and arbitrary abuse. I truly believe the American consumer doesn’t want to buy products made under abusive conditions [14].

The following year, it joined a number of other companies and organizations to create the Fair Labor Association, and it has made significant changes to improve working conditions and wages of the factory employees [15]. Since then, the company has strived for supply chain transparency and improvement of working conditions, and many regard it as a leader in social responsibility and sustainability.

In 2013, Bangladesh ranked second only to China in clothing exports [16], and the Rana Plaza collapse there sparked renewed controversy over labor, health, and safety conditions. With the advent of fast fashion, in which brands identify current trends and produce a limited quantity of garments that are quickly manufactured and stocked on store shelves, brands continue to search for lower-cost ways to produce the items so they can pass off that low price to the end consumer. Bangladesh has one of the lowest minimum wages, as is shown in Figure 5.

![Minimum monthly wages in the clothing industry in 2014, selected countries](image)

*Temporary rate for industrial zones, currently under review. Source: ILO compilation based on national sources. ILO Regional Office for Asia and the Pacific/Regional Economic and Social Analysis Unit, 10 Feb. 2014.*

Figure 5: Minimum monthly wages in the clothing industry in 2014, selected countries [17].
While much attention has been given to the social aspects of sustainability, attention to the environmental aspects has only been more recent. Realizing the extent to which manufacturing has a significant environmental impact, many apparel companies have begun initiatives to reduce their footprint. For example, VF Corporation, an organization that produces such brands as Timberland, North Face, and Nautica, developed its CHEM-IQ\textsuperscript{SM} Program, in which it aims to examine the chemicals used in its supply chain and eliminate the most hazardous. Thus far, VF has eliminated 28 hazardous chemicals, which represents a total of 74 metric tons, and about 2\% of its total chemical use \cite{18}. In August 2012, Johnson & Johnson pledged to remove carcinogens and other toxic chemicals from its adult cosmetic brands by the end of 2015.

In an effort to reduce its water consumption, Levi's has developed its Water<Less\textsuperscript{TM} system. Jeans produced via this method, use 96\% less water in the finishing process, and the company has saved over 172,000,000 liters of water thus far \cite{19}. Since 2012, Adidas has been using DryDye technology for some of its polyester fabrics. This method allows it to produce a shirt using no water, 50\% fewer chemicals, and 50\% less energy \cite{20}. By the end of 2014, the company had saved 100,000,000 liters of water and it plans to introduce the technology into its footwear line in 2016 \cite{20}.

Focusing on the materials used, the North Face has been producing its famous Denali fleece jackets using bluesign\textsuperscript{®} certified fabrics since 2009. One of the fabrics, Repreve, is manufactured from postconsumer plastic bottles, and each year, it keeps 30,000,000 million bottles out of landfills and saves 40 pounds of carbon dioxide per yard of polyester \cite{18}. Patagonia has a number of environmental sustainability programs, one of which involves working with the TAL Group, a large garment manufacturer, to collect pieces of cotton scrap from the factory floor and combine it with virgin organic cotton, thus reducing its waste stream. According to the company, scraps from 16 virgin cotton shirts can be combined to create one reclaimed cotton shirt \cite{21}. Housewares giant, Ikea, has also focused on sourcing more sustainable material, and as of 2014, 41\% of its wood was FSC-certified or recycled \cite{22}.

While many brands, including those mentioned above have been trying to decrease their environmental impacts, end consumers have also begun to increase demand for more sustainable products. According to a Philadelphia-based fashion designer, "People are more aware of how the fashion industry has impacted the environment and there are more eco-friendly choices now than there used to be" \cite{23}. This statement is reinforced by a 2012 study done by Ryan Partnership Chicago/Mambo Sprouts Marketing, which shows that in 2011, green apparel gateways were footwear, active/workout wear, and women's casual wear with 69\% of shoppers considering eco-sustainability at least sometimes when purchasing clothes \cite{24}. 57\% of those
buying eco-sustainable credit their knowledge of a product's sustainability to its tag and 61% say they are interested in Apparel Sustainability Rating or Index [24]. The study shows that the desire to purchase sustainably is expected to increase in 2012. Nielsen conducted a study in 2014 that polled 50,000 online consumers in 60 different countries. It found that the tendency to buy from socially responsible companies was the strongest in the Asia-Pacific region at 64% and the weakest in Europe at 40% with sustainable purchases most influenced by the packaging and that Millennials were the most responsive to sustainability actions [25]. It also reviewed 20 brands across 9 countries and showed the brands that have packaging with sustainability claims have annual average sales increase of 2% and those that have marketing efforts promoting their sustainability initiatives show an average annual sales increase of 5%; whereas 14 brands without such measures only see an annual average sales increase of 1% [25]. Kline & Company evaluated the cosmetics market and determined that in 2014, global sales of natural personal care products increased by 10% as consumers become more aware of chemicals present in beauty products and opt for a more green alternative [26].

2.6 Summary

This chapter commenced with a history of Li & Fung from its inception in 1906 to its current status in 2016. It then discussed the company's compliance audit, which is used to analyze all suppliers, and the environmental section within it. That was followed by a synopsis of the current climate with regards to environmental sustainability regulation, which shows increasing awareness of and interest in achieving more sustainable production methods. Finally, environmental sustainability with respect to brand initiatives and consumer demands was discussed, showing that consumers are beginning to become more aware of the associated environmental issues.
Chapter 3

3 Literature Review

This section provides a review of recent literature related to environmental impacts associated with manufacturing as well as methods used to assess environmental sustainability. The second section discusses several methodologies in detail.

3.1 Information on Environmental Impacts of Manufacturing

As previously mentioned, Li & Fung works with over 15,000 suppliers across a variety of sectors, sourcing products such as apparel, cosmetics, housewares, accessories, and furniture. Therefore, it is necessary to understand the environmental impact associated with manufacturing these types of products. When discussing the environmental impact of manufacturing, common issues typically highlighted consist of things like greenhouse gas emissions, water consumption, chemical utilization, wastewater generation, and waste production. While some studies use a life cycle analysis (LCA) to evaluate environmental impact, this project focuses on the factory-level and not the product. As the type and style of garment and thus the materials and processes used in its manufacture can change very often, completing a comprehensive LCA on each seemed of little value, especially when the product may be obsolete in several weeks. Additionally, each factory operates differently; therefore, the same unit manufactured at two different factories may have entirely different LCAs for each. If that is the case, determining what the less environmentally sustainable factory can do to decrease its impact when it likely will not produce that product for much longer seems futile. Individual factories, however, while producing changing styles, typically have continuous production plans. It is also relatively simpler to obtain certain metrics at the factory-level, thus facilitating analysis. Finally, if one evaluates on a factory-level, specific areas of improvement can be identified and the factory can engage in both short- and long-term strategies to reduce the environmental impact for all units it produces.
In viewing the factory as a system, one can focus on the related energy and material flows. Figure 6 depicts the incoming and outgoing flows of a factory, when it is viewed as a complete system.

![Figure 6: Flows of a factory system.](image)

It is through these various streams that this paper will investigate environmental impact. While there is a specific focus on apparel, as that is Li & Fung's largest sector, the overarching strategy is meant to apply to all of the company's sectors.

### 3.1.1 Air Emissions

Air pollution derives from many sources including transportation, manufacturing, energy production, and wood combustion. According to the World Health Organization (WHO) the pollutants causing the most public health concern are particulate matter (PM), carbon monoxide (CO), nitrogen dioxide (NO₂), ozone (O₃), and sulfur dioxide (SO₂); however, there are others such as carbon dioxide (CO₂), volatile organic compounds (VOCs), and heavy metals.

- **Particulate Matter (PM)** – are liquid or solid particles that typically result from combustion, industrial processes, grinding, and dust formation. Dust can be generated in a variety of different factory processes including fiber processing and fabric cutting. Particulates with a diameter <10 microns can be dangerous, as particles of that size can
become stuck in the lungs and very small ones can even enter the bloodstream. Adverse health effects include early death, heart attacks, asthma, and difficulty breathing [27].

- **Carbon Monoxide (CO)** – results from the combustion process and depending on the exposure concentration, can cause health symptoms ranging from dizziness to death [28].

- **Nitrogen Dioxide (NO₂)** – is a member of the nitrogen oxide (NOₓ) family and is formed in combustion processes. Health impacts include reduced lung function [29], and it is also a factor involved in the creation of ground-level ozone.

- **Ozone (O₃)** – ground-level ozone is created in reactions involving sunlight, volatile organic compounds (VOCs), and NOₓ. Exposure can cause lung diseases and asthma [29].

- **Sulfur Dioxide (SO₂)** – is a member of the sulfur oxides (SOₓ) family and is created when sulfur-containing fossil fuels or ores are burned. Exposure can cause irritated eyes and lungs and increase people’s susceptibility to respiratory illnesses [29].

- **Volatile Organic Compounds (VOCs)** – are carbon-based chemicals that have high vapor pressures at ambient temperature. They can be released by a variety of products such as paint, upholstery, and cosmetics [30]. In the textile industry, VOCs are emitted by solvents used to clean, print on, and finish textiles and by other chemicals like formaldehyde, ammonia, and methanol [31]. In the creation of plastic items, VOCs can be emitted during heat-intensive processes, such as forming and compounding [32]. Health impacts can range from eye, nose, and throat irritation to cancer and central nervous system damage [33].

Regardless of whether a factory generates power onsite or purchases it from a third party, if it is fossil-fueled, it will emit air pollution. Then, in addition to those air emissions, depending on the type of processes present at the factory, whether they be wood painting, perfume creation, plastics production, or textile printing, it is highly likely other air pollutants are also created.

### 3.1.2 Water Consumption

Water is becoming a key topic in development discussions as overall demand for water is expected to increase 55% by 2050, with demand in the manufacturing industry increasing by 400% [34]. Figure 7 shows that many areas are already experiencing water stress.
Total renewable water resources per capita (2013)

Note: The figures indicate total renewable water resources per capita in m³.
Source: WWAP, with data from the FAO AQUASTAT database (http://www.fao.org/nr/water/aquastat/main/index.stm) (aggregate data for all countries except Andorra and Serbia, external data), and using UN-Water category thresholds.

Figure 7: Geographic portrayal of water resources [34].

While Li & Fung does not work with factories in all industrial categories, water is a key resource in its supply chain. Within the garment industry, water can be used to grow the raw materials, wash and dye the fibers, and aid in the finishing process. For example, to produce the cotton required to make a t-shirt, it can require up to 2,700 liters of water [35]. According to 2014 estimates, cotton is responsible for about 2.6% of the global water use [36]. It is estimated that with about 28,000,000,000 kilograms of textiles being dyed annually, and 100-150 liters required to process a single kilogram, over 5,000,000,000,000 liters of water are used each year [37]. Although many suppliers do not use significant amounts of water because they are not involved in water-intensive process, water consumption is a key factor in the overall environmental impact of manufacturing.

3.1.3 Chemicals

Chemicals are used in a variety of different capacities depending on the product manufactured. The garment industry makes substantial use of chemicals, which it employs in textile dyeing and finishing. It is estimated that over 8,000 synthetic chemicals are used in those processes, of which about 72 are toxic [36], [38]. After completion of the dyeing process, 10-20% of dye remains, which then goes on to contribute to wastewater pollution [37]. Chemicals used in the garment and other industries include:

- **Heavy metals** – This category comprises metals such as lead, mercury, chromium, cadmium, and arsenic. Hexavalent chromium can be used to dye textiles and can be
found on leathers tanned with trivalent chromium, which oxidizes due to factors such as pH and heat, thereby converting it to hexavalent chromium [39]. Hexavalent chromium is carcinogenic to humans [40] and if in wastewater emitted into the environment, is bioaccumulative in and toxic to aquatic species [41].

- **Chlorine** – in the form of sodium hypochlorite (NaClO) and sodium chlorite (NaClO₂) can be used to bleach textiles. While hydrogen peroxide can be used as a bleaching agent, chlorine-containing bleaches can produce adsorbable organic halogens (AOX) [42]. It can also be used as one way to treat wool in order to prevent the barbed scales on wool fibers from interlocking when machine-washed, thus allowing the garment to maintain its size and feel [43]. The wastewater produced during this process contains significant amounts of AOX, which include dioxin, one of the most toxic substances [43].

- **Azo dyes** – are used to color products such as food, cosmetics, textiles, and carpets. The dyes can decompose to produce aromatic amines, some of which are carcinogenic [44]. Such aromatic amines include benzidine, 3,3'-dimethoxybenzidine, and p-aminoazobenzene.

- **Phthalates** – used in plastics to enhance flexibility and can also be found in cosmetics, shampoo, moisturizers, and toys [45]. In a 2012 study done by Greenpeace, researchers found that all samples containing plastisol printing contained phthalates with di-2-ethylhexyl phthalate (DEHP), diisononyl phthalate (DINP) and benzyl butyl phthalate (BBP) being the primary phthalates in the four items that contained the highest concentrations [46]. While scientists are still unsure of the health effects, they believe some may be carcinogenic or endocrine disrupting [46].

- **Nonylphenol ethoxylates (NPEs)** – are used as wetting agents, emulsifiers, and in fabric finishing processes. When the fabric is washed or the wastewater is released into the environment, they degrade into nonylphenols, which are bioaccumulative endocrine disrupters [46].

- **Dimethyl fumarate (DMF)** – is an anti-fungal used to stop mold from growing on and deteriorating furniture and shoes during transport. As it has been associated with skin allergies, acute eczema, and skin burns, it has been banned from being in products sold in EU markets since 2009 [47].
• **Perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA)** – are fully fluorinated organic compounds that have long carbon chains. Their unique structures provide them with lipid- or water-repellant characteristics that can be valuable in certain textile treatments. They do not easily degrade in the environment and the US EPA has listed them as “likely carcinogenic” [48].

• **Formaldehyde** – is used to give clothing permanent press qualities, improve color fastness and stain resistance, and slow the growth of mildew [49]. This chemical has been classified as carcinogenic, as studies of workers exposed to significant concentrations have found it to cause myeloid leukemia and other cancers [50].

• **Bisphenol A (BPA)** – while this chemical is typically associated with the plastics industry, it is also used in textiles. It is used in the finishing process for synthetic fibers in order to give them qualities such as higher temperature tolerance and reduced static electricity [51]. Although a firm ruling on its toxicity to humans has not occurred, many scientists believe it is an endocrine disruptor, mimicking estrogen and potentially causing issues such as early onset puberty and birth defects [52].

As organizations learn more about the human and environmental impact of various chemicals, there are increasingly more regulations to reduce or ban some of the most toxic ones. However, depending on the mode of environmental transport, if a chemical is not banned in all regions, it may still affect the environment and public health of those that have eliminated it.

### 3.1.4 Wastewater

Wastewater produced by factories typically falls into two categories: domestic and industrial. Domestic effluent can be transferred to the municipal water treatment system and undergoes the same treatment as wastewater generated in households. Industrial effluent requires additional treatment, as it has certain pollutants not typically found in domestic effluent that must be removed by other processes. As worldwide water consumption increases, so too does wastewater generation. It is estimated that textile dyeing and treatment produces 17-20% of industrial water pollution [36]. Thus, to preserve the world’s stock of fresh water, organizations are aiming to generate less wastewater and reuse much, if not all of what is produced.
3.1.5 Solid Waste
Waste generated in factories can include non-hazardous things such as: paper, cardboard, plastic, and fabric, as well as hazardous substances such as chemicals and oil/lubricants. While not all factories produce both types, those that do tend to segregate them in order to comply with local or national regulations. The non-hazardous stream is typically mixed into the overarching municipal solid waste (MSW) stream, and as of 2012, global urban MSW production was 1,800,000,000 tonnes/year, and it is expected to double by 2025 [53]. While MSW includes many more waste types that just that from factories, overall waste generation keeps increasing. Researchers project that China’s, one of the world’s key manufacturing centers, solid waste generation will increase from its 2005 level of 520,550 tonnes/day to 1,400,000 tonnes/day in 2025 [54]. They also expect that while East Asia is the fastest growing region for waste, in 2025 that is likely to shift to south Asia and then around 2050 to Africa [54].

3.2 Information on Current Methods to Assess Environmental Sustainability
As more organizations and people champion the need to reduce anthropogenic environmental impact, methods to assess environmental sustainability are being created. These methods vary considerably with some geared towards a specific industry and others focusing on specific products. The four assessment methodologies discussed in this report span various categories and each specializes in something slightly different.

3.2.1 US Green Building Council's LEED Certification Program
Perhaps one of the most well known tools to assess a facility’s environmental impact is the U.S. Green Building Council’s Leadership in Energy & Environmental Design (LEED) certification program. This program awards certificates to edifices that “save money and resources and have a positive impact on the health of occupants, while promoting renewable, clean energy” [55]. Prior to the assessment, the project is classified into one of the following five categories:

- Building Design and Construction
- Interior Design and Construction
- Building Operations and Maintenance
- Neighborhood Development
- Homes
The classification then determines the project's rating system. Within the rating system, there are credit categories that contain ways in which a project can acquire points towards achieving a LEED certification. In the Building Design and Construction class, the applicable credit categories are: Location and Transportation, Sustainable Sites; Water Efficiency; Energy and Atmosphere; Materials and Resources; Indoor Environmental Quality; Innovation; and Regional Priority. Based on the number of points accrued, a project has the potential to earn 'certified', 'silver', 'gold', or 'platinum' status.

To pursue certification, a project must select the applicable classification, pay a fee, and complete and submit an application. The scorecard documenting points accrued is written in Microsoft Excel and is accessible on the U.S. Green Building Council's website, (http://www.usgbc.org/leed).

While some may consider LEED more applicable to non-manufacturing facilities, many industrial companies are pursuing certification. For example, Colgate, according to its 2015 Sustainability Report, has “nine LEED-certified facilities and over ten additional LEED projects underway” [56] in regions such as China, Vietnam, the US, and Thailand. Additionally, apparel factories in countries such as China and Bangladesh, which has a LEED-platinum denim factory, are starting to pursue certification [57].

### 3.2.2 The Sustainable Apparel Coalition’s Higg Index

Focusing specifically on the apparel, footwear, and home textile industries is the Sustainable Apparel Coalition (SAC). Walmart and Patagonia founded the SAC in 2009 with the vision of having “an apparel, footwear, and home textiles industry that produces no unnecessary environmental harm and has a positive impact on the people and communities associated with its activities” [58]. Its member base now extends worldwide and spans such categories as brands, retailers, manufacturers, governments, NGOs, and academic groups.

The SAC's primary output is the Higg Index, which is a self-assessment that evaluates a brand's, product's, or facility's sustainability. The Index, which is a Microsoft Excel-based spreadsheet, is comprised of two distinct components for each module (currently there is a brand and a facility module), one on social and labor sustainability and the other on environmental sustainability. The environmental sustainability section comprises seven sub-categories: Environmental Management System (EMS) or Program, Energy Use, Water, Wastewater Effluent, Waste, Emissions to Air, and Chemicals, each with its own set of questions that are divided into three levels. As questions get more focused on areas in which a
factory has demonstrated sustainability progress, the levels increase. Therefore, factories with minimal initiatives will most likely answer only Level I answers; however, they are not prohibited from answering Level II or III questions. The points accrued in those sub-categories are combined to generate an overarching environmental score.

The SAC’s network of organizations has established a list of key outcomes it hopes to achieve by 2020 in order to obtain its overarching vision. These outcomes are:

- The sustainable practices born out of the Higg Index assessments deliver unprecedented business value and sustainability impact.

- The Higg Index is accepted and adopted worldwide as the trusted, industry standard tool for measuring and improving sustainability in our supply chains.

- Apparel, footwear, and home textiles product lifecycles have achieved transparency. Companies and people at every step of design, production and distribution take full accountability for environmental and social impacts.

- Shoppers use the Higg Index to evaluate and influence the product choices they make.

- Other industries look to the Sustainable Apparel Coalition as a model for their own shifts to sustainability [58].

### 3.2.3 The Sustainability Consortium and Walmart’s Sustainability Index

In 2009, Walmart introduced its own 15-question sustainability assessment to evaluate its suppliers [59]. It later partnered with The Sustainability Consortium (TSC) to create the Walmart Sustainability Index, which it has piloted in the United States and six international markets [60]. The Index is based on the product category level and focuses on environmental and social issues related to a given product. To complete the Index, a supplier must register on the SAP Product Stewardship Network and purchase a license for the TSC Toolkits used to complete the Index surveys [59]. It has made several updates to the 2015 TSC questionnaires, including capping the number of questions per assessment at 15 and trying to align it with tools created by other organizations, including the Sustainable Apparel Coalition [59].

As of 2013, Walmart had 190 categories with plans to continue increasing that number [61]. In its 2015 Report, it announced that 1,300 of its suppliers were using the Sustainability Index and in 2014, 65% of the products sold in Walmart US stores had been assessed using the Index
3.2.4 bluesign® System

bluesign® Technologies AG was founded in 2000 and is headquartered in Switzerland. Its aim is to connect chemical suppliers, textile manufacturers, and brands with the goals of:

- Uniting the textile supply chain
- Eliminating substances posing risks to people and the environment from the beginning
- Responsible use of resources
- Safety for people and the environment \[63\].

Its bluesign® system focuses on verifying a product's materials in advance of the production process. So, it works with the various parts of the supply chain to ensure that its criteria for ingredients, manufacturing processes, and finished products are attained, thereby producing a safe product with a reduced environmental footprint.

Its certification system contains two separate options: bluesign® product and bluesign® approved fabric. To achieve the former, a product must have its suppliers and manufacturers bluesign® certified as well as its materials certified as resource saving and sustainably manufactured. To achieve the latter, a product must have at least 90% of its fabrics be bluesign® certified and its suppliers and manufacturers must be listed as bluesign® system partners \[64\]. bluesign® system partners include brands like prAna, Haglofs, Burton, and Jack Wolfskin \[65\].

3.3 Summary

This chapter provided a detailed literature review in support of the project. It began by investigating the environmental impacts associated with manufacturing processes and then discussed various ways currently used to evaluate those impacts. The methods highlighted in this chapter are: LEED Certification, the Higg Index, the Walmart Sustainability Index, and the bluesign® system. While such methods have helped increase awareness about the importance of environmental sustainability and enable organizations to measure impact, each is tailored to a specific sector or industry and each has its limitations. Because Li & Fung works with thousands of factories that span a number of industries, creating a dedicated tool that the company can use to evaluate all of its suppliers would be instrumental.
Chapter 4

4 Methodology

This chapter describes the methodology used to create the scorecard and corresponding scoring system. As the scorecard is proprietary information, specific details such as exact questions and point values are not disclosed. The second section of this chapter outlines the approach used for the scorecard's pilot.

4.1 Approach for Environmental Scorecard

As Li & Fung is a founding member of the Sustainable Apparel Coalition (SAC), a small number of suppliers it works with are already completing the Higg Index self-assessment. As the company works with many suppliers outside the SAC-related industries, even if 100% of the garment factories completed the Index, it would not cover Li & Fung's full supplier base. Additionally, the Higg Index is fairly long and could take suppliers a significant amount of time to prepare, and Li & Fung aims to minimize the added work, while still obtaining accurate and detailed information. Despite the Higg Index's inability to cover the full supplier base, reviewing the data garnered from the factories that have completed it can prove valuable in ascertaining what type and quality of information they are capable of supplying.

In reviewing the responses and data from 18 factories that completed the Index, certain qualities desired in the new assessment mechanism became identifiable. Overall, the characteristics required include:

- The need to have questions focus on the current state and initiatives
- The ability to ensure response accuracy
- The ability for the scoring system to correlate closely with the extent and type of initiatives
- The ability to benchmark across certain key performance indicators (KPIs)
• The ability to use the scorecard in any type of factory Li & Fung engages with, not just those manufacturing apparel

• The ability to have all factories follow the same path through the scorecard unless a certain category or group of questions is inapplicable

• The need for standardized answers to facilitate responding and result analysis

• The ability to integrate the results into Li & Fung's existing supplier analytics tools

• The need for the tool to be easy and quick to use.

Because the SAC is the apparel industry's most prominent alliance for supply chain sustainability and the Higg Index is its focal point [66], it was determined that the new scorecard should be similar to the Higg, but incorporate the above-mentioned improvements and a different completion methodology. Perhaps the way in which it is most similar to the Higg Index is that it contains the same seven environmental sustainability categories, which was done because they accurately capture the resources flowing into any given factory as well as the byproducts produced.

![Figure 8: Seven sustainability categories.](image)

By maintaining some of the same questions and similar a similar phrasing methodology, it will help aid in the adoption of the scorecard as well as integrate it into Li & Fung's existing internal supplier analysis tools. However, the new scorecard is quite distinct with regards to the information the questions ask for and the way points and the overall scores are calculated.
The new scorecard was crafted around the idea of energy and material flows, shown in Figure 6. The schematic depicts the incoming and outgoing flows of a factory, viewing it as a complete system. In trying to create a more environmentally sustainable factory system, the goal is to decrease or eliminate some of the inputs and outputs and create looped flows by reusing or recycling some of the wastes.

Mirroring the categories in the scorecard, the scoring system consists of seven sections, each with a unique total number of points. The points accrued in each section are then used to calculate the factory's score for that section. It is important to note that the more points a factory accrues, the more environmentally sustainable it is. Additionally, there is no overall score as high performance in certain areas could mask inferior performance in others. Thus, each of the seven scores is kept separate so it is clear as to where the factory is doing well and where it needs to improve.

The following section will detail the rationale behind the questions in each of the seven sections.

4.1.1 General Factory Information
This section contains general factory information. Key information includes details on factory area and facilities, number of workers, products produced, and factory processes. The data garnered in this section is used to classify and group factories as well as normalize other data acquired in subsequent sections of the scorecard.

4.1.2 Environmental Management Program
The objective behind this section is to learn if a factory has an overarching environmental sustainability plan and if so, what its key aspects are. It is not meant to gather specific data or detailed plans. It also gives the factory an opportunity to list any environmental certifications that go beyond just environmental compliance documents. If a factory does have a plan or certificate(s), it is highly likely that the factory will have various sustainability initiatives in place that will be featured in later sections of the scorecard.

Points can be accrued for this section if a factory has an environmental plan and how many questions related to that plan can be answered. Additionally, if a factory has a certificate, such as ISO 14001, it will receive points.
4.1.3 Energy Use

There are four main questions in this section all related to the current type and amount of fuel used, energy use improvement targets, energy audits, and energy efficiency measures. The goal of this section is to determine what and how much fuel is currently being used and what the factory is doing or has done to increase its efficiency, thus reducing fuel consumption. The question focusing on current fuel consumption provides a variety of different fuel type options and also enables a factory to distinguish fuel used for applications like transportation and cooking (i.e. in the canteen) from that used to power equipment in the factory itself.

The question investigating energy efficiency measures incorporates a variety of different possible ways a factory can reduce energy consumption and allows the respondent to select any that are applicable. The available options were gathered from existing options, efficiency mechanisms mentioned in previously analyzed responses, and general industry knowledge.

The scoring system for this section is fairly complex as there are a variety of different answers that can be given. In the fuel consumption question, points are awarded for knowing both the type and yearly amount of fuel consumed. However, if a factory is using renewables, it receives more points than one using fossil fuels such as coal. In the energy efficiency measures question, points are awarded on the perceived difficulty of a given measure. For example, it is likely easier and more common for a factory to use employee engagement/behavior to decrease its energy consumption than it is for them to install new direct drive sewing machines; however, the latter can have an energy reduction of 15% [67] per machine over conventional models, whereas the former may or may not have significant impact.

4.1.4 Water Use

This section is somewhat connected to the following section, Wastewater Effluent; however, it focuses on the factory’s water consumption practices. In examining water used, a more detailed flow diagram, Figure 9, is needed to better understand the inputs.
Again there are four main questions that evaluate the total amount of water used, its origin, water reduction targets, and existing water reduction measures.

Different amounts of points can be accrued for each of the questions and they are again partially based on amount of information furnished. Another factor influencing a factory's score is the water source. If the factory uses reclaimed water, it receives more points than if it does not use any recycled water. In this section, there is also coding embedded into the scorecard that will flag certain answers appearing suspicious. For example, if the total amount of water consumed does not equal the sum of the amounts from the different sources, a note appears informing the respondent.

4.1.5 Wastewater Effluent

Wastewater is connected to water use, chemicals used, and type of processes at the facility. Depending on the production processes, a factory can produce domestic wastewater, industrial wastewater, or both. If a factory produces domestic wastewater, it may be unnecessary to monitor certain water quality aspects; however, if it produces industrial effluent, certain water components are typically measured regularly. Therefore, the flow diagram for wastewater can resemble Figure 10.
The section contains six main questions that cover topics such as type of effluent produced, amount of effluent, if any is recycled/reused, if the effluent quality is measured and if so what for, if there are effluent reduction targets, and what measures have been taken to reduce or improve wastewater quality. It is important to note that some factories do not produce industrial wastewater effluent; therefore, in these cases, they are exempt from one of the questions and do not receive any point penalty. Specific information regarding industrial wastewater quality measurements will be discussed in the section relating to chemical management, as the process chemicals used nearly directly correlate to those that might be found in wastewater effluent.

Points are accrued in a similar manner as preceding sections. And, there are again mechanisms in place to prevent incorrect or inaccurate answers from being entered. For example, if total wastewater produced is higher than water used, a flag is raised as it is impossible to produce more wastewater than one consumes in fresh water. There is also a mechanism to prevent the amount of wastewater recycled from being higher than the amount of wastewater produced, as it would not be feasible for a facility to recycle more than it produces.

4.1.6 Air Emissions

Air emissions is a section that many factories are exempt from because they are not engaging in chemical processes, power generation, or other activities that occur onsite within the factory system and emit air pollution. Therefore, while there are four questions in this section, the first serves to differentiate between the two factory types. If a factory is a non-emitter, it may skip
the remaining questions without any point penalty. The remaining three questions focus on types of emissions, reduction targets, and measures used to reduce air pollution production. In the question related to emission type, greenhouse gases and other important pollutants such as PM$_{2.5}$, PM$_{10}$, and VOCs are included. As some factories that measure air pollutants do not distinguish between PM$_{2.5}$ and PM$_{10}$, a more generic ‘dust’ option was added.

While these constitute some of the main air emissions, certain factories may have various processes or chemicals that emit other air pollutants. For example, the United States Environmental Protection Agency defines six criteria pollutants that also include lead (Pb) and ozone (O$_3$). Thus, there is an area where the factory can incorporate any additional pollutants.

In this section, points are only accrued if a factory engages in processes that emit air pollutants onsite. If a factory does not, it receives a null score, which does not denote a zero point tally, but rather that the section is not applicable.

### 4.1.7 Waste

What type of refuse and what is done with it constitutes another key pillar of a factory’s standing with regards to sustainability. When evaluating the waste stream, one first needs to consider all the possible input materials (ie. raw materials), as those will be what constitute the waste stream. The list of possible raw materials was created based on answers supplied in previous surveys as well as experience walking through various factories and examining waste production. Thus, the incoming side of the flow diagram is shown in Figure 11.
Determining the possible inputs then corresponds to the waste outputs. Depending on certain regulations, different materials fall into hazardous and non-hazardous categories. Thus, the first question distinguishes whether the factory produces only non-hazardous waste, only hazardous waste, or both. The subsequent questions determine what specific wastes are listed as hazardous or non-hazardous, how much of each waste type (e.g., polyester, wood, etc.) is being produced, and how it is disposed. The third and fourth questions mirror those in prior sections by focusing on waste reduction improvement targets and methods that have been implemented to reduce waste or improve reuse/recycling.

Points are accrued again somewhat based on the amount of information a factory can supply. They are also impacted by the waste removal method to ensure appropriate segregation and disposal. Finally, points are also awarded if a factory has implemented reduction measures and has a future waste target plan.

4.1.8 Chemicals Management

This section consists of five main questions that focus on the chemicals used at the factory and their toxicity levels. The first question asks about a chemical inventory and what types of chemicals are used. To facilitate responding, there is a fairly comprehensive list of the various types of chemicals that can be used by a variety of factory types. The subsequent questions inquire about chemical restriction, reduction targets, already implemented reduction or substitution measures, and compliancy.

Points are primarily accrued from chemical reduction or substitution measures. As nearly all factories require oil/lubricants for the machines and oil can be classified as hazardous in some countries, it is nearly impossible for a factory to achieve the highest point rating in this section because there will almost inevitably be some requirement for oil/lubricant. However, the overall impact of using that chemical should not severely impact a factory’s score in that section because if a factory does not use any other chemicals, it can receive a null score for those questions, which will not adversely impact its score, but rather point out its lack of substantial hazardous chemical usage.

4.2 Approach for Scorecard Pilot

To verify and refine the scorecard, it was necessary to conduct a pilot. In order to add minimal disruption to the factory schedule, the team determined that the pilot would only be done at the same time as a compliance audit. These audits typically require a couple of days, and as one of
the scorecard's goals was to make it as easy and quick to complete as possible, the team decided that doing it at the same time as a Li & Fung team was there conducting a compliance audit would be ideal because the factory already has some of the necessary documents prepared.

It was also necessary to have a Li & Fung staff member accompany the primary investigator (PI) to the factories both to learn how to conduct the assessment and to translate between the local language and English. Because of their familiarity and experience working with factory management, these people were members of Li & Fung's audit team.

Although Li & Fung has suppliers in over 40 markets, as China contains the majority of them, the pilot was conducted there and in Hong Kong Special Administrative Region (SAR). This helped minimize regional variation and ensure uniform refinement.

To conduct a statistically significant assessment, given a population of ~15,000 suppliers, a confidence level of 95%, and a margin of error of 5%, a sample size of at least 375 was required. However, given time, geographical, and other constraints, the team decided that deploying the scorecard in at least 10 factories would be sufficient. While the data will not necessarily produce statistically significant results, by completing the pilot, the scorecard's efficacy can be tested and modified prior to full deployment. It also provides a way for Li & Fung to start engaging with some of the factories on environmental impact issues and an opportunity for the PI to instruct members of the Li & Fung team on ways to ask the questions, probe for relevant information, and walk through a factory with attention given to its environmental impact. Thus, the team decided a pilot including at least 10 factories would be sufficient to test and refine the tool prior to its full-scale deployment.

4.3 Summary

This chapter provided a thorough examination of the rationale used to construct both the questions in the scorecard as well as its scoring system. Detailed information for each of the sections: General, Environmental Management Program, Energy Use, Water Use, Wastewater Effluent, Air Emissions, Waste, and Chemicals Management was provided and discussed. Following that, the methodology on the scorecard's pilot was presented.
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Chapter 5

5 Data Collection

This chapter describes the procedure used to conduct the pilot and the staff training that disseminated its information to other involved groups within Li & Fung.

5.1 Description of Scorecard Pilot

The scorecard was piloted in 14 factories. As previously discussed, all factories were located in either mainland China or Hong Kong SAR, with more specific locations depicted in Figure 12.

To ensure similar data gathering techniques, the PI was accompanied by a single Cantonese-speaking individual in the southern region and by a Mandarin speaker in the northern region. The PI led all evaluations except for three, two of which were conducted by the Mandarin speaker after receiving adequate training from the PI and the third which was conducted by another individual after having been trained by the Mandarin-speaking colleague. By having only a small group of individuals conduct the assessments, it ensured minimal variation in the way an assessment was performed and questions were asked. It also allowed for substantial
training of the VCS team member so he/she would be fully capable of conducting an assessment himself/herself.

Each assessment consisted of a full factory walk-through, which was typically scheduled at the beginning of the visit. During the walk-through, certain specific aspects of the factory were examined. These consisted of things like: type of light bulbs used; type of irons used; whether or not daylight was used in various locations; how many lights were connected in a single string; if lights are on in rooms without employees or in which there is a significant amount of daylight; how well insulated pipes are; etc. This was followed by a conversation with the management to go through the scorecard’s questions. To acquire certain key metrics like electricity, water, and other fuel consumption, the team evaluated bills and calculated accurate yearly values. To determine the hazard level of any chemicals used, manuals like Material Safety Data Sheets (MSDS) were read.

As Li & Fung’s suppliers span a variety of different product types and this assessment must be applicable to all, a variety of factory types were included in the pilot. Although the majority of pilot factories produce apparel, other types include knitting, fabric dyeing/printing, bags, and umbrellas.

5.2 Description of Staff Training

During the pilot period, several staff training events were conducted in three different manners. Instruction style and topic differed depending on the location of the group being trained and how they will interact with the tool.

5.2.1 Remote VCS Team

About 20 members of the VCS team in Southern China received the first training. Due to the location, the instruction was done remotely via Webex. As some of this team may be involved with deployment of the scorecard and evaluation of factories, the meeting included a demonstration of how to use the scorecard and what insights it can provide into a factory’s environmental sustainability.

5.2.2 Local VCS Team Leaders

The second group to receive training was about seven Hong Kong-based VCS members. As this team was local, the instruction was done in presentation format. This group primarily consisted
of people in more senior positions who will likely not be deploying the scorecard. However, they will be interacting with the results, so it is necessary for them to understand how the tool works. Thus, a more in-depth tour of the tool was given and the ways in which points are earned and aggregated within the tool was discussed.

5.2.3 Field VCS Team

The final group to receive training was two more VCS members—one in Southern China and the other in Northern China. As they will be two of the people involved in the full-scale deployment of the tool, they received multiple hours of training helping to conduct the pilot. During this instruction, they learned things like how to conduct a factory walk-through focused on environmental sustainability and why the scorecard asks certain questions. As these individuals have received substantial training and are comfortable using the tool, they will be some of the people that help train their colleagues to conduct the assessment.

5.3 Summary

This chapter covered how and where the pilot was conducted. It also described several training programs given to various groups within Li & Fung who are already interacting with or will interact with the scorecard in the future.
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Chapter 6

6 Data Analysis

This chapter presents the lessons learned during the scorecard pilot and its results. As part of the pilot results analysis, there is a discussion on the information produced by benchmarking the factories with respect to electricity consumption.

6.1 Key Findings Regarding the Scorecard Pilot

The pilot represented a successful small-scale deployment of the scorecard. It helped identify adjustments that needed to be made, thereby enhancing the robustness of the final version. From a knowledge transfer perspective, it provided the opportunity for significant training on its use and the rationale behind it so it can be deployed on a larger scale after the completion of this project.

Referring back to Section 4.1, there were nine major goals for the scorecard, and upon completion of the pilot, it seems as though those goals have been achieved.

Table 1: Scorecard goals and mechanisms used to achieve them.

<table>
<thead>
<tr>
<th>Goal</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have questions focus on the current state and initiatives.</td>
<td>Questions were crafted to evaluate a factory on where it currently stands with regards to environmental sustainability, and less focus was given on what it hopes to achieve in the future.</td>
</tr>
<tr>
<td>Incorporate the ability to enhance or ensure response accuracy.</td>
<td>Providing standardized answer options was one mechanism to achieve this as was coding within the scorecard to visually notify the respondent if he/she had entered something blatantly incorrect.</td>
</tr>
<tr>
<td>Correlate the scoring system to the extent and type of initiatives.</td>
<td>Scoring was made very granular within each section and question so that points can be accrued based on type of initiative and amount of information provided.</td>
</tr>
<tr>
<td>Enable benchmarking across certain key performance indicators (KPIs).</td>
<td>Benchmarking was incorporated into the results and is done with regards to normalized electricity consumption across different factory types.</td>
</tr>
<tr>
<td>Have the ability to use the scorecard in any type of factory Li &amp; Fung</td>
<td>The pilot was conducted in both apparel and non-apparel factories. Questions and standardized</td>
</tr>
</tbody>
</table>
engages with, not just those manufacturing apparel. 

<table>
<thead>
<tr>
<th>Action</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allow all factories to follow the same path through the scorecard unless a certain category or group of questions is inapplicable.</td>
<td>Factories are not differentiated at the beginning of the assessment and are only excused from certain questions if they have a specific answer to a previous question within that same category.</td>
</tr>
<tr>
<td>Standardize answers to facilitate responding and result analysis.</td>
<td>The majority of the answers available to respondents are either in the form of dropdowns or in list format where the respondent can select the applicable items.</td>
</tr>
<tr>
<td>Enable the results to be integrated into Li &amp; Fung's existing supplier analytics tools.</td>
<td>The scores from each factory's assessment are aligned with the way Li &amp; Fung's current analysis tools are constructed.</td>
</tr>
<tr>
<td>Make the tool easy and quick to use.</td>
<td>Each section has between three and six questions. Each factory assessment in the pilot took 1.5-2 hours, including the time required for the factory walk-through.</td>
</tr>
</tbody>
</table>

### 6.2 Pilot Data Analysis

Within the set of pilot factories, trends emerged within the seven scorecard categories.

#### 6.2.1 Environmental Management Program

The majority of factories did not have environmental management programs in place and almost none had any type of overarching strategy. Several had certifications with the most common being ISO14001. An interesting observation is that factories able to answer questions in this section affirmatively tended to have additional sustainability initiatives detailed in future sections of the assessment.

#### 6.2.2 Energy Use

All factories satisfied at least part of their electricity demand by purchasing it from an outside source. The other main power source, which was used by a fraction of the factories, is coal. However, a couple of the entities using coal, typically for electricity or steam generation, were planning to phase it out by substituting that energy demand with either purchased electricity or an alternative fuel such as biomass. Many of the canteens required liquid petroleum gas (LPG); however, specific yearly quantities were typically not tracked. Other fuels consumed include diesel and gasoline, which were used to power factory vehicles.

Only a few of the factories had multi-year energy reduction strategies; however, all had instituted measures to reduce their electricity consumption. Two of the most common ways factories were reducing their consumption was through the installation of energy efficient lighting and employee engagement. While only a few factories had replaced or were planning to
replace all lights with LEDs in the near future, many had replaced some regular lights with T8 or T5 ones. The most common type of employee engagement was encouraging people to turn off lights when they leave an area or are no longer working at a desk. The effectiveness of this measure was evaluated during the factory walk-throughs, and despite the supposed engagement, many areas without activity still had many if not all of the lights activated. In a couple of the factories, lights could be individually actuated so that if a person was working at one desk in a line of empty desks, the whole line of lights could be off except for the one over the person’s station. Similar scenarios with short strings of lights were observed at a couple other factories.

Another common efficiency tactic was transitioning to direct drive sewing machines. In these machines, the power provided by the motor goes directly to the actual sewing mechanism rather than being transferred to a gearbox and pulley system. This can have substantial energy savings. Other efficiency initiatives include: using electric rather than steam irons; renovating the boiler; maintaining the steam traps; incorporating heat exchange or recovery; and optimizing the compressed air system.

### 6.2.3 Water Use

All sites measured water consumption and procured their water from either the municipal supply or a third party water supplier. Water was typically consumed for more domestic applications such as in the toilets, sinks, and canteen; however, it could also be consumed for steam generation, washing, and plastic spraying. Water consumption did not seem to be of much concern for the majority of the factories, likely because many only use it for domestic purposes. However, one of the couple of factories with a higher consumption due to its processes said that it has an overarching goal to reduce its water consumption. When factories did implement water consumption reduction tactics, they primarily focused on things like promptly fixing leaks. One of the factories with substantial consumption had implemented a strategy to reuse water in one of its processes and another was capturing steam trap condensate for reuse.

### 6.2.4 Wastewater Effluent

The majority of factories only emitted domestic wastewater effluent. Thus, it could be discharged into the regular wastewater stream. Those that produced both domestic and industrial effluent included factories that do knitting, dyeing, printing, and industrial metal processing. Factories producing industrial effluent all have either the government or a third party monitor the wastewater quality. The water quality aspects measured seem to correspond to the factory processes, with common ones being pH, biological oxygen demand (BOD), and
chemical oxygen demand (COD), while more factory-specific ones include zinc, ammonia, and iron concentrations.

None of the factories reported any long-term goals with regards to reducing wastewater or improving its quality, and only a couple had implemented such measures.

### 6.2.5 Air Emissions

The vast majority of factories claim to have no processes that emit air pollutants, and those that did most often had onsite coal-fueled power generation. It is quite logical that factories not engaging in substantial chemical processes or power generation would not have air emissions. Thus, unless they significantly alter their operations, this section is irrelevant to them. Only a few of those that do emit were able to list their emissions. The facilities with coal power generation had either switched to a cleaner burning coal, such as anthracite, or were retiring their power plant due to the increasing regulation related to that type of generation. Therefore, if those factories do dismantle their plants, they may no longer be emitting air pollutants onsite.

### 6.2.6 Waste

While all factories were able to describe their waste streams and how they disposed of the solid waste, only one was able to quantify the types of waste discarded. Additionally, very few actually had goals to reduce or recycle materials. This is likely because many of them are able to sell waste to outside contractors. The reselling agreements vary between factories; therefore, as they can generate revenue from waste production and resale, they may not have any true incentive to decrease it. When some staff were asked if they know what the resellers do with the refuse, they did not know.

### 6.2.7 Chemicals Management

Nearly all facilities used oil and lubricant to maintain their machines; however, very few seemed to view this as a 'chemical' even though in China it is classified as hazardous. When other chemicals were used, they were things like smoothing agents, detergents, bond, and stain remover. Thus, they do not have any significant initiatives to reduce chemical consumption. While it is likely reasonable that many of the factories do not use many if any dangerous chemicals, some that engaged in processes typically involving harsh chemicals were unable to provide lists of chemicals at the site. Thus, it is undetermined as to whether they are actually unable to document all of the chemicals or if they did not want to provide the assessment team with the information.
6.3 Data Benchmarking

Both evaluations of an individual factory as well as benchmarking by factory type were done to understand how factories rate. Based on the points accrued and the earnable points in a given section, a factory was scored on each. These scores take the following general form.

From this type of scoring, one can clearly see how a factory performs in each of the sections. By disassociating each section’s score, it is evident where a factory needs to improve because it receives a low score specifically for that section. If a certain section, such as Air Emissions, is not applicable to a factory, it does not receive a score, thus distinguishing it from a factory that receives a very low score for that section.

To determine how certain factory types perform based on certain KPIs, electricity consumption was normalized for each factory and plotted against all other factories. Purchased electricity was chosen as the indicator as that provides the majority, if not all of the power for the factories. For those that had supplemental generation, that power source was excluded, as determining the efficiency of the boilers would be too complex for this assessment. Fuel used for company vehicles or in the canteen was also excluded, as those are not directly involved with the production processes. One normalization factor was the number of factory employees. This was specified as the number of permanent workshop/warehouse employees. Thus the number of temporary employees was removed because not all factories have them. The administrative employees were also excluded because they may oversee or be involved with multiple factories as part of a factory network. Therefore, selecting the employees who actively engage with the
manufacturing process was done to standardize the numbers. Figure 14 shows the electricity per worker.

![Figure 14: Total Electricity per Factory Worker.](image)

(Note that factories in the pilot without accurate electricity or factory employee values were omitted as were some factories that were the sole member of their factory type.)

While this plot does not show distinct values for a given factory type, it does show that factories of the same type can sometimes aggregate around certain values. This trend is most evident in the cut-and-sew only factories.

The electricity consumption per factory area was also investigated as some energy auditing groups have provided information to factories with electricity per area as one of the metrics. Although the majority of factories were able to provide the facility’s overall area, determining what area to use proved quite complex. This was so because some factories have dormitories and/or canteens and/or administrative space. Because it would not be accurate to use the total area, as that could serve to dilute the electricity consumption per square meter if the factory has a dormitory and another does not, the area was specified to be the workshop/warehouse + administration area. Thus, much work was done to try and remove dormitory and canteen area from the calculations.
While this diagram does not include as many factories, it does show more aggregation within a given factory type. For example, one can see that both bag factories and apparel cut-and-sew factories tend to use the least energy per square meter. However, as the manufacturing process incorporates additional facets such as ironing, the electricity consumption increases. It is interesting that the knitting factories and the cut-and-sew with ironing factories use similar amounts of energy per square meter. It should be noted that the apparel factory, which appears to be an outlier, is likely such because it is a very small factory and the floor space is quite crowded with energy intensive processes. Thus, it is a very efficient use of factory area.

6.4 Summary

This chapter discussed the analysis of the assessment information as well as the benchmarking results that compare electricity consumption across factory types. There were interesting outcomes in both sections that help inform future strategies to reduce resource consumption and decrease pollution production.
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Chapter 7

7 Potential Remediation Techniques and Impacts

This section discusses the results and presents ways a factory can improve its assessment score. While some improvement methods are specific to certain factory types, others apply to all. Additionally, while modifying certain aspects of an individual factory's processes to become more sustainable may have an impact ranging from minimal to substantial depending on the current state and manufacturing processes involved, if sustainability measures are made by all factories, the results would be considerable. Because of its unique position in the supply chain, Li & Fung hopes to use the scorecard as a way to engage on the factory-level, thereby inciting overall change within the global supply chain.

7.1 Environmental Management Program

A best-in-class factory should have a documented energy management or overarching environmental program. Not only does this help start the conversation on how it can reduce its environmental impact, it also creates a roadmap for it to attain such goals, which will likely increase in importance as governments and brands start to require such plans.

7.2 Lighting

Upon analyzing the data garnered in the assessment, various ways to reduce a factory's environmental impact become apparent. Perhaps some of the easiest and most universal changes relate to a facility's lighting scheme. Although the factories' staff said they had taught employees to turn off lights if they are not in the room, there were many areas of the factories, such as warehouses, that had lights on with few if any workers in the area. Additionally, many of these areas had quite a bit of ambient light entering though windows. Thus, unless specific regulations state that there must be additional lighting in unoccupied areas for reasons such as safety, light utilization in locales with adequate daylighting or without active work processes should be minimized or eliminated. For the workspaces requiring lights, all lights should be
replaced with more efficient T8, T5, or LED lights, as factories that have installed those have reported energy savings.

According to light manufacturer, Philips, its LED T8 InstantFit Lamps use over 41% less energy than its F32T8 lamps, which are in the T8 fluorescent family [68]. Depending on the number of lights in a given factory and the production processes, this could represent a significant portion of its overall energy consumption.

There are two more significant lighting modifications available. One is to have the workspace lights individually actuate. Therefore, if there is a worker surrounded by vacant workspaces, only the light illuminating his/her workspace can be activated, thus saving the electricity required to light unused areas. The second is to uncover/unpaint the exterior windows, thus allowing daylight to penetrate the work areas. Some factories said the windows were covered to prevent overheating, but that issue could be remedied by covering the windows with a transparent film that rejects solar heating, such as those provided by 3M. Not only would this reduce the amount of supplemental lighting required, but it would also likely improve worker morale because they would get to see the outdoors. The most significant and possibly costly modification is to reinstall the lights at the appropriate intervals and height above the workbenches so as to maximize the utilization of daylighting and provide the most efficient and effective illumination for the workers.

An optimized factory will utilize as much daylighting as possible and procure its remaining requirements from LED lights installed at the appropriate distance away from the workbenches. Wherever possible, these lights should be individually actuated to reduce the amount of unnecessary lighting. Finally, employees should be trained to turn off all lights in areas where work is not being performed.

7.3 Steam Utilization and Generation

If a factory engages in processes requiring steam or steam generation, there are several ways it can decrease its environmental footprint. A couple of the factories assessed were able to reuse some of the steam for other functions such as rice cooking. Thus, if factories can use waste steam as an input for another process that requires steam or heat, they will reduce their overall energy consumption. Another way they can reduce the energy consumed in steam production is by installing steam traps to reduce the loss of steam during the discharge of condensate and other gases. If a factory does this or already has steam traps, ensuring appropriate maintenance and cleaning is necessary to prevent efficiency reduction due to leaks caused by impurities in the
steam. Finally, to maintain adequate temperatures of both steam and hot water throughout the system, the factories can appropriately insulate the involved pipes, thereby reducing the amount of energy required to keep fluid at the desired temperature.

7.4 Sewing Machines

Factories with sewing processes can decrease electricity consumption by switching to direct drive sewing machines. Unlike the traditional sewing machine, the motor in direct drive machines is located in the machine itself and does not require a gearbox.

![Figure 16: Traditional sewing machine.](image)

![Figure 17: Direct-drive sewing machine.](image)

Thus, the power is more efficiently transferred to the sewing mechanism. According to information provided by Duerrkopp-Adler, sewing machines manufactured in 1990-2000 used significantly more energy than the optimized direct current drive ones that have been available since 2005 [71]. The specific Juki model shown in Figure 17 and found in at least one of the factories can save \( \sim 15\% \) [70] energy compared to the traditional counterpart. Other models of sewing machine can save up to \( 54\% \) [70] energy. If one assumes that an average garment
factory has 50 sewing machines that are operated for 48 hours per week [17] for a maximum of 52 weeks each year, a factory could have a noticeable reduction in its energy consumption by switching out all of its sewing machines. If this is done on a regional scale with multiple factories, it would compound that energy savings.

### 7.5 Irons

Many apparel and knitting factories have irons, which can either be steam or steam electric. The traditional steam iron, has boiler-generated steam provided to it via a steam hose. While still dependent on steam, the steam electric versions are higher efficiency because they have internal heaters that further heat the steam supplied by the boiler. Some factories have either switched to steam electric irons or have partially composed their iron fleets of the more efficient option. However, others have decided against doing so because the operators prefer the faster speed with which the traditional versions can emit steam. Although, it may take slightly more time with steam electric irons, adaptations can likely be made to incorporate them and thus reduce the total energy required to generate the necessary steam.

### 7.6 Waste

As the factories typically sell solid non-hazardous waste to a contractor, reduction may not necessarily be financially preferable. However, for hazardous waste, most must pay for removal. Some factories were able to dispose of hazardous oil/lubricant containers by giving them back to the supplier who could then reuse them. For hazardous waste that cannot be reused, efforts to reduce its production or substitute hazardous materials with non-hazardous ones should be made. Such efforts depend on the type of materials used, the processes they are used in, and the potential substitutes available.

### 7.7 Water

Most factories did not seem to be concerned with the amount of water consumed and for many, it is relatively minimal as the factory processes do not require it as an input. However, those that have water-intensive processes should make efforts to reduce their consumption. For example, dye factories can ensure processes are optimized so they are using the minimal amount of water required to dye materials. Alternatively, they can switch to techniques that require little or no water. Facilities that use spraying processes can potentially recycle some of the water remaining after spraying to use in future spraying, thus lowering water consumption as well as waste water production.
Regardless of a factory's water consumption volume, it should be cognizant of its usage. Thus, a best-in-class factory will ensure that it uses the minimum amount of water necessary by fixing leaks promptly, using low-flush toilets, installing water-saving aerators on the faucets, and encouraging employees to be conscientious about their water use. Best-in-class higher-use factories will also have optimized the processes to reduce the total amount of water required. And, they will, if possible, reuse or recycle the water instead of directly emitting it into the wastewater stream.

7.8 Summary
This section provided a variety of different ways factories can reduce their impacts. Many of these techniques are being used at some of the factories included in the pilot; however, more factories can adopt such measures and work can be made to increase the impact of such reduction efforts at factories where they currently exist.
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Chapter 8

8 Conclusion

As consumption increases, factory production rises and so too does its environmental impact. As concern about the environment grows, there is an impetus to engage in more sustainable manufacturing. Li & Fung works with over 15,000 suppliers around the world, and thus is ideally positioned to evaluate the environmental sustainability of its suppliers and work with them to decrease their impacts.

This research project has involved the creation of a scorecard to do such an assessment on the factory-level. By using a scorecard, a factory receives a more detailed score rather than just a pass or fail. In doing that, they can learn where they need to improve and they can track those improvements with subsequent assessments. It also enables Li & Fung to establish a dialogue with the suppliers, allowing them to help decrease the environmental impact of the overall supply chain. As products, and thereby processes and materials are constantly changing, doing the assessment at a factory-level provides a more holistic view of the facility's impact. As a single product can be produced in different factories, it is also likely more helpful to show a single factory its overall impact rather than the impact of one of its products, which may not constitute a significant portion of that factory's overall production volume or environmental impact.

The tool was tested in a pilot with the factory set primarily located in China. As China surpassed the US in 2013 as the country with the largest percentage of world manufacturing [72], it is a prime location for sustainable manufacturing advancements to be made. Constituting a significant portion of world manufacturing, if factories in China are able to become paradigms in environmental sustainable production processes, they will likely pave the way for the industry as a whole.

The data garnered from the pilot were aggregated and analyzed, and one of the analysis' results was the identification of improvements factories can make to enhance their sustainability. Due
to the success of the pilot, Li & Fung plans to deploy this assessment full-scale, which will enable it to acquire information and understand better the environmental sustainability of its suppliers.
**Glossary**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOX</td>
<td>Adsorbable Organic Halogens</td>
</tr>
<tr>
<td>BBP</td>
<td>Benzyl Butyl Phthalate</td>
</tr>
<tr>
<td>BOD</td>
<td>Biological Oxygen Demand</td>
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<tr>
<td>BPA</td>
<td>Bisphenol A</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon Monoxide</td>
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<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
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<tr>
<td>DEHP</td>
<td>Di-2-ethylhexyl Phthalate</td>
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<tr>
<td>DINP</td>
<td>Diisononyl Phthalate</td>
</tr>
<tr>
<td>DMF</td>
<td>Dimethyl Fumarate</td>
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<tr>
<td>EMAS</td>
<td>EU Eco-Management and Audit Scheme</td>
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<td>EMS</td>
<td>Environmental Management System</td>
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<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
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<td>KPI</td>
<td>Key Performance Indicator</td>
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<tr>
<td>LCA</td>
<td>Life Cycle Analysis</td>
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<td>LEED</td>
<td>Leadership in Energy and Environmental Design</td>
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<td>LPG</td>
<td>Liquid Petroleum Gas</td>
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<td>MSDS</td>
<td>Materials Safety Data Sheets</td>
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<td>MSW</td>
<td>Municipal Solid Waste</td>
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<tr>
<td>NaClO</td>
<td>Sodium Hypochlorite</td>
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<td>NaClO₂</td>
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<td>NO₂</td>
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<td>Nonylphenol Ethoxylate</td>
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<td>O₃</td>
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<td>Abbreviation</td>
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<tr>
<td>OECD</td>
<td>Organization for Economic Co-operation and Development</td>
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<tr>
<td>PFOS</td>
<td>Perfluorooctanesulfonic Acid</td>
</tr>
<tr>
<td>PFOA</td>
<td>Perfluorooctanoic Acid</td>
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<tr>
<td>PI</td>
<td>Primary Investigator</td>
</tr>
<tr>
<td>PM</td>
<td>Particulate Matter</td>
</tr>
<tr>
<td>SAC</td>
<td>The Sustainable Apparel Coalition</td>
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<td>United Nations Sustainable Development Goals</td>
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<td>VCS</td>
<td>Li &amp; Fung's Vendor Compliance and Sustainability Department</td>
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<td>VOC</td>
<td>Volatile Organic Compound</td>
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<td>WHO</td>
<td>World Health Organization</td>
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References


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