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AN ANALYSIS OF COMMON PRACTICES: SUSTAINABILITY IN DISTRIBUTION CENTERS

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ABSTRACT

Environmentally sustainable building practices have become increasingly popular over the past few years. With a growing need for corporate social responsibility, companies have often turned to the United States Green Building Council's Leadership in Energy and Environmental Design certification process to confirm their sustainable construction procedures. This thesis, in full, contains a background and current standards on the United States Green Building Council's certification system, going into depth how environmentally friendly construction is properly accredited. This thesis also contains summaries of sustainable practices from companies, large and small, across different industries and how these practices collectively come together into the most common environmentally friendly distribution center standards. Areas such as lighting, cooling, waste and recycling, water use, and equipment are explored. This thesis will provide a framework for any company, large and small, interested in getting started or renovating their distribution process with the aid of commonly used sustainable building practices.

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Chapter 1

Introduction

Over the past few years, the demand for and trend toward more environmentally friendly structures and construction has grown immensely. Whether in structures as small as family homes or buildings as tall as skyscrapers, this push toward environmentally sound construction is extremely apparent in society today. Along with the everyday person, businesses face both internal and external pressures from the media, consumers, the industry, and the government to follow these trends. As socially responsible entities in the world today, businesses must adapt to these pressures.

In terms of the supply chain, efficiency comes hand in hand with environmental sustainability in distribution centers and warehouses. The supply chain is one of the largest areas for exploration in sustainable construction and improvement practices. This thesis will give companies, large and small, information for identifying the most common practices to ensure environmental sustainability within the supply chain. Specifically, this research is based on practices in distribution centers. While there is an abundance of research about sustainable building practices, there is no single, comprehensive guide made for companies who are looking to improve their structures or even get started moving towards environmentally sound distribution centers. The intent of this thesis is to compile the most common practices toward building or improving structures to fit the standards of sustainable construction into this single, comprehensive guide that can be used across different industries.

This thesis includes a thorough background on the United States Green Building Council's (USGBC) certification system called Leadership in Energy and Environmental Design (LEED). Through this certification process, companies noted in the appendix have already taken the steps to build and/or reconstruct sustainable distribution centers. The main portion of this thesis includes interviews with companies who have undergone changes in their distribution centers due to this trend of environmental responsibility. Also noted in the appendix are the interview questions asked to over ten companies in the research process. The end product of this thesis includes a summary of five of these interviews, outlining the most popular and successful ways to incorporate sustainability into distribution centers in a supply chain network. Sustainability categories outlined are lighting, cooling, waste and recycling, water use, and equipment. The next section of this thesis will outline the history of the USGBC's sustainable certification process, LEED.

Chapter 2

LEED and the USGBC

The way that the world views construction is beginning to change at a rapid rate. At the forefront of this change is the United States Green Building Council (USGBC) and its certification system for green building, known as Leadership in Energy and Environmental Design (LEED). Companies are not only seeing a consumer push for environmentally friendly construction, but also a corporate obligation to build in a socially responsible way.

In 1993, three men established the USGBC: Rick Fedrizzi, David Gottfried, and Mike Italiano (History, 2016). Combined, these three men have decades of international and environmental experience. At the core, their mission was, "to promote sustainability in the building and construction industry" (History, 2016). Initially, the council started with sixty corporate and nonprofit firms and now is home to elected officials, builders, environmentalists, teachers, students, and everyday citizens (History, 2016). Firms are run by the consumers that create profit, and the USGBC stands as a platform for concerned consumers, individuals or groups, to voice their opinions about sustainable construction in the business world.

In March 2000, LEED was adopted by the USGBC (History, 2016). LEED stands as the USGBC's type of report card for sustainable building. More specifically, LEED is built on its national and international projects based on environmental and health performance (History, 2016). Today, LEED is the single most popular and widely used certification system for sustainable building in the world (Green, 2015). As a third-party rating system, LEED is able to provide a standard method for constructors to follow who are looking into sustainable building. LEED can be applied to both existing structures and brand new construction. Also, the

certification system can be used for commercial, institutional, and residential structures (Richards, 2015).

LEED Specifics

LEED certification can be applied to many different types of projects and has multiple rating levels. As seen in Table 1, there are five categories of projects that LEED teams assess, with each containing subcategories of construction. Each one of these categories is then broken down into categories to be rated for points such as water savings, energy efficiency, materials selection, and indoor environmental quality (About, 2015).

Table 1. LEED Project Categories

Project Category	*Type of Construction*
1. Building Design and Construction (new construction or major renovation)	• New construction • Core and shell renovation • Retail • Hospitality • Data centers • Warehouses and distribution centers • Healthcare centers
2. Interior Design and Construction (complete interior fit-out)	• Commercial interiors • Retail interiors • Hospitality interiors
3. Building Operations and Maintenance (improvement work or little to no construction)	• Existing buildings • Schools • Retail • Hospitality • Data centers • Warehouses and distribution centers
4. Neighborhood Development (new land development or redevelopment)	• Residential use • Nonresidential use • Mix of both
5. Homes (any type of residence)	• Single family homes • Low-rise multi-family (one to three stories) • Mid-rise multi-family (four to six stories)

The rating process for LEED projects is broken into a combination of credit categories. Specific prerequisites allow structures to earn points, which then determines the level of LEED certification (LEED, 2016). As seen in Table 2, there are nine main credit considerations when rating a LEED project.

Table 2. LEED Credit Considerations

Integrative Process	Incorporating diversity into teams in the pre-design period
Location and Transportation	Having projects in dense areas with access to many transportation options; Sites with development constraints
Materials and Resources	Reducing waste and using sustainable building materials
Water Efficiency	Using water, inside and outside, in a smarter way to reduce potable water consumption
Energy and Atmosphere	Building better and smarter with innovative strategies
Sustainable Sites	Minimizing damage or impact on ecosystems and water resources
Indoor Environmental Quality	Having better indoor air quality with access to natural light and good views
Innovation	Utilizing sustainable building expertise and design measures
Regional Priority Credits	Addressing regional priorities for environmentally friendly building

The process for getting certified is relatively simple and has four main steps. First, projects must be registered to begin the process (Choose, 2016). Second, an application must be prepared and submitted by a project manager (Choose, 2016). Third, projects go through a strenuous review process with preliminary design, final design, preliminary construction, and final construction reviews (Choose, 2016). Last, if a project passes all four of these reviews, it is certified. Once a project is certified, it is rated generally certified, silver, gold or platinum. These ratings come from the credit points earned in the categories shown in Table 2. LEED projects can gain as little as 40 points to be certified but need 80 or more points to be considered a platinum project (Choose, 2016).

For projects to be certified, there are a few costs associated. For non-members and members, registration fees cost about $1,000 (Choose, 2016). Certification fees start at $2,250 (Choose, 2016).

LEED Today

The most current version of LEED certification, LEED v4, was introduced in 2013. Rick Fedrizzi, CEO and founding member, states that the one main goal of LEED v4 was, "to raise the bar in a way that challenges the building industry to reach higher than ever before" (Long, 2014). Fedrizzi also goes on to claim the support of his USGBC team by stating that this environmental goal is in their nature (Long, 2014). The CEO acknowledges that the changes made in LEED v4 are not easy for companies to adopt, but the upgrade pushes the limits of sustainability (Long, 2014).

According to USGBC, LEED v4 is "bolder, more specialized, and designed for an improved user experience" (LEED, 2016). LEED v4 has a stronger focus on the materials credit category for rating and has a larger effect on human health and the environment. Indoor environmental quality and water efficiency are also more strongly addressed than in the previous versions. Another new aspect of the current version is a reward for companies and projects that participate in "demand response programs" (LEED, 2016).

In terms of market impact for 2015, it is estimated that almost fifty percent of new nonresidential construction would be green, amounting to a $130 billion opportunity (Green, 2015). As of August 2015, forty-three percent of all square footage looking to gain LEED certification was in international territory (Green, 2015). LEED's geographical footprint is

extremely large and is continually expanding. By 2018, it is estimated that eighty-four percent of single-family homes will be built on the basis of green projects, most with LEED sponsorship (Green, 2015). In 2015, the industry sectors with the "Highest Penetration of Green Building" were education, healthcare, and commercial or office buildings (Green, 2015).

Just recently, the top ten states with LEED projects in 2015 were published by the USGBC. Figure 1 shows, by state, the number of LEED projects pursued and certified in 2015.

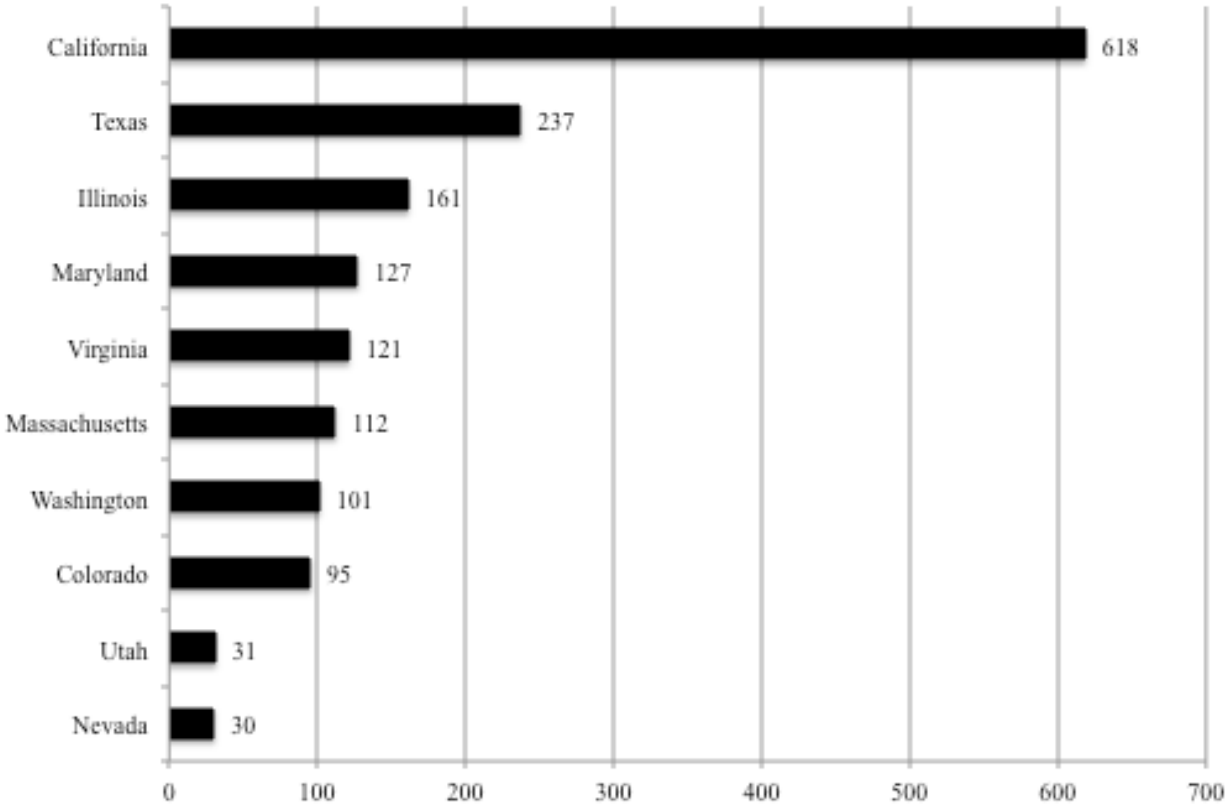


Figure 1. Top 10 States for LEED Certification in 2015

LEED Directory

One of the most prominent features of the USGBC's website is its LEED directory. Here companies, consumers, and everyday citizens can research different experiences that organizations have had with LEED certifications on all different levels. In the directory, researchers are able to filter by categories of projects and also by characteristics such as certification level, date, state, LEED version etc. This directory can serve as a useful tool for anyone interested in building or renovating with LEED or anyone doing research on the certification process. Moreover, if organizations do not necessarily want to be LEED certified, they are able to simply learn about environmentally sustainable building practices. On the USGBC's website, companies can also directly contact experts with general or specific questions regarding anything about certification. These specialized answering services are available by phone Monday through Friday, email, or mail and are available in English, Spanish, as well as Portuguese.

Appendix B contains a LEED O+M (operations and maintenance) scorecard of a certified distribution center, earning gold level LEED certification. Nichols, a company in Norton Shores, Michigan, is an independently owned paper, packaging, and sanitary supply company. Nichols scored the best in the category "regional priority credits."

Appendix C contains a LEED ID+C (interior design and construction) overview and scorecard of a LEED-platinum project at the USGBC headquarters in Washington DC. For projects to be considered LEED-platinum, they need to receive at least eighty points on the scorecard. The purpose of this project was to serve as a "living lab" to specifically teach why and how sustainable building is the best choice.

Both of these appendices represent only minor work in sustainability that has been done

by the USGBC in the past few years. Today, the USGBC continues to push for environmentally friendly construction efforts all across the country. The next section of this thesis will contain company interviews about sustainable distribution center practices.

Chapter 3

Warehousing Interviews

The following section will outline multiple interviews done across industries, with companies large and small. These interviews will outline practices in sustainable warehousing as well as steps taken to renovate or build facilities to LEED standards. The interview guide given to companies can be found in Appendix A, and highlights of the interviews are outlined in this chapter. These companies will remain anonymous and are labeled Company A, B, C, etcetera with the industry of the company provided.

Company A

Company A is a third party grocery distribution company, specializing in temperature-controlled warehousing and transportation. Company A has made many changes in terms of lighting, cooling, waste and recycling, and water use over the past few years with an aim toward more sustainable distribution centers (DCs). The company currently has one LEED certified warehouse that was built in 2015.

According to the employee in charge of all sustainability in the warehouses and distribution centers for the company, the first time they started making changes toward more green facilities was in 2000. These changes started with an energy strategy, aimed mainly at lowering costs. The company's temperature-controlled environment requires extremely large amounts of energy, and they were facing an energy bill of approximately eleven million dollars

at the time. Besides lowering the energy bill for the company, these changes toward sustainability were also aimed at reducing the DCs' carbon footprint. For Company A, ninety-five percent of the carbon footprint came from tier one. According to professors at Carnegie Mellon University, tier one carbon footprint emissions come from direct emissions from the organizations' direct factories and vehicles, whereas tiers two and three refer to more indirect uses of energy (Scott, 2008).

The firm had three main approaches to reduce costs and energy use. The first approach was to look at how energy was used as a company and how it could be improved from an operational standpoint. The company saw this approach as the "low-hanging fruit" – an obvious, easy fix to a large problem. This operational and process-based approach allowed the company to analyze how they could reduce their carbon footprint in their DCs for no cost at all such as shutting off lighting when not in use or reallocating all of the current trash bins for different types of recycling.

The second approach was focused on early technology in lighting. Previously, the company used 400-watt halide bulbs and 450-watt high-pressure sodium (HPS) bulbs, which was the industry standard until the early 2000s. In some industries, HPS bulbs are very beneficial for their heat emission (High, 2014). However, Company A only has temperature-controlled DCs, and these bulbs were creating extreme amounts of heat, causing larger cooling costs for facilities. The first step to reduce the costs associated with the HPS bulbs was to install motion-sensor HPS bulbs. This way lights would be on for fifty percent less time than they were before, lowering the heat emissions created from the bulbs. The final step was to make the switch from HPS bulbs to light-emitting diode (LED) bulbs with motion sensors in all of the DCs. LED lights are extremely common in today's day and age and are commonly found in products such as energy

efficient TVs. LED lights also have an extremely long life cycle, spanning about twenty years on average, which reduces the costs to replace them (What, 2015). The LED lights in Company A's facilities emit little to no heat at all and give off a better quality of light while using less energy for picking product.

The third approach was to change the way that DCs were cooled by using variable frequency drives (VFD) as well as eliminating ammonia as a refrigerant in the facilities. VFDs are a type of motor controller that uses electricity to control and vary the frequency and voltage supplied to any sort of motor (Hartman, 2014). Having temperature-controlled warehouses, Company A uses hundreds of motors to run refrigerators and freezers in their facilities which contributes to sixty to seventy percent of their power bill. VFDs are used to monitor and control these machines to use as little energy as possible. VFDs give Company A visibility into how much energy is going toward cooling their facilities. Using an optimal VFD can decrease facility energy costs by as much as seventy percent (Hartman, 2014). Using VFDs would allow Company A to reduce their carbon footprint while also reducing costs.

Prior to these sustainable changes, Company A was using ammonia as a refrigerant. Today in their DCs, they are using carbon dioxide (CO_2) to cool their facilities anywhere from negative sixty to thirty degrees. Carbon dioxide systems were a contributor to reducing Company A's energy costs. Besides using the carbon dioxide, Company A spent more money on condensers to convert gas to liquid, which lowered electricity use. One conclusion that Company A arrived at while making sustainable changes in their DCs was that there are major tradeoffs to be analyzed. There often comes a time where "environmentally friendly" disputes "financially friendly." While using condensers was more sustainable for the company, it also created large costs in the category of cooling.

As for other categories of sustainability, Company A focused on waste and recycling as well as water use in their facilities. The main waste items that Company A recycles are paper, cans, and shrink wrap used in their DCs. They do not have a great deal of waste generated because they are only a third party provider. Company A finds pressure from customers that deal directly with consumers to recycle, and it is extremely important for them to be viewed positively in the eyes of the public as a sustainably responsible company. In terms of water use, the refrigerated facilities do not use much water except for the evaporative condensers and domestic facilities such as employee bathrooms. As far as the condensers go, the company is constantly finding ways to reuse the water, and as of right now over two thirds of the water goes down the drain. They are starting to look into rain harvesting off of the roof and the parking lots at their warehouses. However, the company has a large use for potable water and not brown water, so they are finding it difficult to implement rain harvesting. Potable water is clean and filtered water, while brown water is water that can be reused in the facility's day to day operations.

In terms of LEED certified facilities, Company A currently has only one. This facility was built for LEED, not renovated, in January of 2015 in Tennessee. In general, the company described the process as very difficult. Due to the type of industry that Company A is in, freezers and refrigerators need to be airtight and well-insulated. A great deal of the points for LEED accreditation come from the category "indoor environmental quality," which has to do with taking outside air and bringing it in for any type of use. However, freezers cannot do that, so Company A struggled with this category. In addition, this category of rating is one of the cheapest to implement, making other changes more expensive for Company A.

Company A achieved a silver LEED rating, after originally aiming for gold but finding it too expensive and restrictive to achieve. Their biggest cost when trying to achieve LEED certification had to do with testing to address the indoor air quality issue. After these tests were performed, consultants were used, and the USGBC was petitioned, Company A failed with their indoor air quality issues, and gained zero points in this category.

As for the value-added factors of building to LEED's standards, Company A does not see many benefits. The facility in Tennessee was built mainly to satisfy one of Company A's biggest retail customers. Since Company A does not deal directly with the consumer, they do not see much pressure from the outside to build or renovate to LEED's standards. There are no plans to build or renovate for LEED in the near future due to the high costs and the fact that refrigeration is difficult to fit into the USGBC's categories of rating. This goes back to the tradeoffs that Company A was facing when making sustainable changes, and LEED certification seems to be too financially unfriendly at this time for the company.

Company B

Company B is a northeastern grocery retailer that prides themselves on excellent customer relations as well as sustainable and socially responsible practices in their distribution centers and entire network. Company B has two distribution centers with both regular storage as well as temperature-controlled storage. Unlike Company A who saw immense pressure from consumers to act sustainably, Company B sees more of an internal pressure to act in an environmentally friendly way. The Director of Sustainability at Company B claimed that the retailer aimed to "do the right thing for employees and for the environment as long as it makes

sense financially." For example, Company B went into detail about how solar energy previously did not make financial sense, but now it is an affordable way to save energy and is widely used in one of the distribution centers. Company B described their practices as dynamic, constantly looking for ways to save money while also helping the environment. As far as pressure from consumers, Company B's customers appreciate their transparency with their sustainability efforts and seem to be appreciative that the company is doing things that actually make a difference in the environment.

Company B started making changes toward more sustainable distribution centers in 2007 and 2008. At this time, Company B felt that there were good incentives from local utility companies as well as the federal government to operate in a sustainable way. At this point, Company B started to mainly focus on energy reduction and tightening up insulation in their DCs.

The first major change that Company B made was moving away from the metal halide and high-pressure sodium bulbs to all LED lighting in their distribution centers. As discussed with Company A, HPS bulbs emit a large amount of heat, which is not ideal for temperature-controlled DCs. When changing to these LED bulbs, Company B saw a reduction in overall energy consumption, and the new bulbs increased the overall quality of the light emitted. This also moved Company B from a thirty-six month solution for lighting to a ten-year solution. Although changing all of the lights in the distribution centers was a multi-million dollar project, it allowed Company B to see a fifty percent reduction in their energy bill in the first year alone. Along with these new light-emitting diode lights, Company B took advantage of motion sensors in all areas of the DC, including office areas. Lights would turn off when their emissions were not needed.

Unfortunately, Company B did see some drawbacks from making the switch to fluorescent lighting. First of all, in temperature-controlled areas, they had to make sure that lights would react to motion sensors in the cold temperatures. Also, once the lights did turn on from the sensors, they were a bit delayed to reach full lighting capacity. This came with an operational delay; employees could not pick products as easily or safely without full lighting. Eventually, Company B worked around the temperature-sensitive sensors and was able to operate at full efficiency.

Also in the category of lighting, Company B introduced daylight harvesting. Simply put, daylight harvesting is a way that companies can take advantage of the natural light from outside while dimming or completely shutting off lights inside facilities (Daylight, 2011). Company B expanded their use of skylights in their DCs and controlled the daylight through a scheme that shut off interior lighting on sunnier days. These daylight sensors are able to read available light and send signals to the control system to allow the desired light level from the fluorescent lights (Daylight, 2011). Company B also saw reductions in their energy bill from the addition of these skylight sensors. According to the United States Department of Energy, on average, lighting accounts for thirty-eight percent of energy usage in commercial buildings and recommends that if companies are looking to save money on energy consumption, to start with the lights (Daylight, 2011). This is exactly what Company B has been doing over that past ten years.

In terms of cooling for the temperature-controlled areas of the distribution centers, Company B introduced a "setback program." This program included motion sensors in order to let the temperature move five degrees away from zero when there was no activity in the area. This practice is known as flywheel floating at Company B. Any sort of activity in the temperature-controlled areas would produce heat, creating a need for a lower general

temperature in order to avoid damaging food products. With these new motion sensors, Company B was able to avoid product damage while allowing energy savings. Company B's flywheel floating system does create product safety concerns, but this is constantly monitored due to the frequent temperature changes in the DCs.

Like Company A, Company B uses carbon dioxide, which is a natural refrigerant, to cool their facilities. Today, carbon dioxide is the industry standard for cooling in temperature-controlled facilities due to its abilities to transfer heat and react to pressure changes (CO_2, 2015). Carbon dioxide also has very low reaction rates to many materials, making it much safer to work with than traditional refrigerants (CO_2, 2015). For Company B, the carbon dioxide system was much less complex with less building materials needed.

In their facilities, Company B has put a large amount of effort into equipment efficiency. Today, they are using high-efficiency motors as opposed to standard-duty motors. In 2009 and 2010, Company B moved to a hydrogen fuel cell program in order to get away from using lead acid batteries. Previously, equipment in the DCs needed to be to be charged every eight hours and took a full sixteen hours to charge. With over eight hundred pieces of equipment in each DC, this energy consumption was significant. Hydrogen has no charging time at all, and only needs a two-minute fill that lasts twenty-four hours. This fill is much like a gasoline pump for a car. Not only did Company B see a reduction in their energy bill and carbon footprint, but also saw a significant increase in productivity in the work force. Like with all new technologies, there was a learning curve for employees. The hydrogen technology produces condensation that creates a slip, trip, and fall hazard that has been slightly reduced by creating a heated cell in the fuel cell to reduce this condensation. Overall, from the fuel cell technology, Company B has seen an increase in productivity and a decrease in energy consumption.

As of right now, Company B is not able to harvest the condensation that comes from the fuel cell. The amount of condensation from the fuel cell program is not currently enough to be useful in any way, but the company is constantly looking for ways to use this small amount of water. Company B has given consideration to rain harvesting off the roof of the DCs, but this has not yet been implemented to save on water use. Although they do not do this at their DCs, it is being implemented at some of their store locations.

In terms of waste and recycling, Company B uses color-coded recycling bins around the DC for paper, cardboard, shrink wrap, plastic, and other materials. The largest problem they see with this is employees putting garbage in bins that are strictly for recycling. Company B sees large opportunities with new employees to teach them what to do correctly in terms of recycling. Also with reusable and recycled materials, Company B recently switched to iGPS pallets. Traditional wood pallets have been used since the 1940s, but plastic iGPS pallets aim to reduce costs, product damage, and carbon use in the supply chain (How, 2015). These pallets are the first all-plastic pallets with RFID chips installed within the pallet (How, 2015). They weigh thirty percent less than the traditional wood pallet, creating savings along the entire supply chain (How, 2015). Company B is able to reuse these pallets that they now own from the iGPS company. Company B has seen a large improvement from switching to these pallets. They are reusable, washable, and most importantly stackable. This means that they save space in the DCs. Company B has also found that these pallets break far less often than the traditional wood pallet, lowering the amount of waste produced each day in the distribution centers.

As for LEED certified distribution centers, Company B currently does not have any. When building their second distribution center, Company B tried to consider the value of building to LEED standards versus the cost to get to that point. As an environmentally conscious

company, Company B decided not to build to LEED standards but still build very sustainably. They did not see that they would have any value added by building by LEED's standards, and decided to focus on being sustainable by their own standards. The company has no plans to build for LEED certification in the future.

Company C

Company C is a retail clothing company with a presence all across the United States. The first time Company C started looking into sustainable distribution practices was in the early 2000s. Company C currently has six distribution centers that are all over one million square feet. In the eyes of their consumers, Company C wanted to be perceived as a leader in the world of sustainability as well as an upstanding company internally.

Company C follows the patterns of Companies A and B in terms of sustainable solutions for lighting in distribution centers. In the early 2000s, Company C moved away from halide and HPS bulbs and moved toward fluorescent bulbs. According to one of their sustainability experts, this change was three-fold. First of all, these lights are much more environmentally friendly. Second of all, they are much cheaper to operate and allowed the company to cut down on their energy bill. Third of all, and most importantly for Company C, there is no heat production from fluorescent bulbs. Although their facilities are not temperature-controlled like the grocery Companies A and B, all six of Company C's distribution centers are located in very warm climates – even deserts. The temperature control for clothing does not need to be monitored heavily, but the working conditions for employees do need to be monitored. The old lighting systems at their DCs produced a large amount of heat, which called for more immense cooling

systems in order for employees to have a safe working environment. Today, Company C is able to cut down on costs for lighting as well as cooling with the new bulbs. Like Company B, Company C is also starting to look into daylight harvesting. With distribution centers in warm, sunny climates, there are many opportunities to take advantage of this newer technology.

With three distribution centers in California, Company C takes a deep interest in water-saving activities and recycling of materials. Because California has a heavy drought season, all employee facilities in the distribution centers are equipped with motion sensor faucets and toilets. No water is used for any operating process in the distribution centers, so drought guidelines only need to be followed in employee facilities. Due to the nature of distribution centers, there are no lawns that need to be watered – only blacktop is present on their grounds. Company C recycles all of their waste in their DCs as well as their stores. In the distribution centers, the materials that are recycled most often are paper, boxes, and plastic. At Company C, employees follow these recycling guidelines very well, and they do not see much of a learning curve.

With the Californian distribution centers, Company C is able to take advantage of the return policy for plastic recycling, and they try to do so as often as possible. In distribution, most of Company C's recycled plastics are in the category of rigid plastic packing containers (RPPCs). The California RPPC law was enacted in 1991 and was aimed to reduce the amount of plastic waste in landfills in the state as well as promote the reuse of plastic for consumer needs (California's, 2016). Companies must be certified to participate in this recycling effort, and Company C has taken advantage of this (California's, 2016). Company C also takes advantage of recycling incentives in their employee facilities. For most glass bottles, plastic bottles, and aluminum cans, companies can receive five cents per container (Cashing, 2016). For materials

totaling twenty-four ounces or more, Company C can receive ten cents per container (Cashing, 2016). With three distribution centers in California totaling over three million square feet, Company C has many employees. This allows many opportunities for recycling as well as these refunds from the state.

Currently, Company C does not have any LEED certified distribution centers. Although there are no plans in the near future to build to LEED standards, Company C plans to keep renovating their current facilities to be more environmentally friendly. In all of the communities where their distribution centers are located, Company C strives to work with local governments and consumers to create environmentally friendly facilities. For instance, the company built a new distribution center on the east coast within the past two years and made sure to build with all of the environmentally friendly advancements they had come across thus far. Company C is constantly learning and making improvements in terms of environmental sustainability in their distribution centers.

Company D

Company D is a food company that does not have their own stores. Rather, they distribute their product across many different industries, creating an extremely large distribution network with multiple distribution centers delivering product all over the world. The first time Company D started making changes toward sustainable distribution center practices was in 2006. Their first step was to investigate the LEED certification process as well as building a specific "Green Sustainability" facility that focused on innovations in environmentally friendly practices.

This facility was a separate office building located on Company D's corporate office campus and is completely dedicated to sustainability across their entire network.

Although their efforts in 2006 were dedicated to LEED investigation, Company D currently does not have any LEED certified distribution centers. It was heavily considered during an expansion project, but Company D did not go through with the process due to the inability to earn the amount of points needed as outlined by the USGBC. Instead, this expansion's sustainable efforts were primarily focused on recycling processes and waste generation from construction materials. During the construction process, there was a great deal of waste generated, and Company D focused on properly disposing that waste as well as recycling as many building materials as possible. Now and in the future, Company D constantly plans to focus on recycling efforts as well as maintaining their zero-waste landfill facilities.

In 2008, Company D built a new seven hundred thousand square foot DC in Utah, and in 2012, expanded a DC by one hundred thousand square feet in Pennsylvania. Through this construction, one of the main things that Company D focused on was white reflective roofing. Through these efforts, Company D saw a definite reduction in energy consumption per square foot in their DCs. According to Duro-Last, a white roofing company, a white roof system is a highly reflective and emissive roofing solution (White, 2016). With a white roof system, less heat is transferred into the building, thus saving on energy costs associated with cooling (White, 2016). Although this reflection system is not necessarily saving the environment itself, it allows Company D to be more energy efficient when cooling their facilities.

Also according to Duro-Last, white roofing systems create benefits in all climates, not just warmer ones (White, 2016). In some of the warmer climates, Duro-Last sees their roofing systems creating a seventy degree Fahrenheit reduction in roof temperatures on hotter days as

well as up to a forty percent reduction in energy use during peak times of the summer season (White, 2016). On the contrary, a disadvantage that Company D saw from the addition of the white roofs and building of efficient facilities was extremely high construction costs. According to one of the sustainability experts at Company D, "the value for increased energy efficiency items did not have an attractive financial rate of return." Company D was constantly challenged with cost containment as well as staying on a strict construction schedule while trying to come up with environmentally friendly solutions in their distribution centers.

Aside from the white reflective roofing systems, Company D has made renovations in heating and cooling in order to be more energy efficient. The company is now using more efficient heat pumps in their DCs in cooler climates. Along with the heat pumps, their motors and control operations are set on strict reset schedules in order to save heat and energy. Company D has also seen improved thermal resistance through the window arrangements, also known as fenestration, and shading equipment. Being a food company, temperature-control is an essential operation in their distribution centers. Company D has looked into insulation solutions, but has not made significant changes in this category.

Although Company D currently does not have any LEED certified distribution centers, they did significantly renovate an office in Pennsylvania in 2013 to LEED standards. Company D decided to pursue LEED construction in order to reorganize and restructure the work process in this office to be more environmentally efficient and competitive in the marketplace. These changes were not due to consumer pressure, company policy, or even industry trend. The renovations were strictly to help Company D be more efficient in their processes through new, environmentally friendly technologies.

However, like with every project, some challenges arose. Cost containment was the biggest issue for Company D, and they found that focusing on obtaining LEED certification caused the project costs to be even higher. They saw construction costs that were higher than any other renovation they had undergone in the past just because they were trying to build efficiently to the USGBC's standards. Another challenge that Company D faced during this renovation was developing new procedures for employees. At times, it seems that people are more difficult to change than the actual structure itself. Eventually, however, the employees did adapt. Company D claimed that the acceptance to the new, sustainable procedures was very positive after some initial reservation. After about a month in the new LEED certified facility, Company D started to see the comfort level improve and productivity increased significantly.

Moving back to the distribution centers, Company D has made some significant changes since 2006. In the DCs, Company D moved away from T-8 fluorescent lighting to T-5 high bay LED lighting with the support from ACT 129. High bay LED lights turn on instantly, have no flickering or warm up period, and are the ideal light to be connected to motion sensors (High, 2016). Act 129, as written by the Pennsylvania Public Utility Commission, was created in 2008 (Act, 2016). This act added several new sections to the existing Public Utility Code including adding an energy efficiency and conservation (EE&C) program (Act, 129). Through this act, Company D made changes to lighting in their distribution centers. Like many other companies, Company D has taken advantage of the motion sensor technology in their distribution centers across their entire network. Lifespan for these high bay lights range anywhere from fifty thousand to one hundred thousand hours as opposed to a twenty thousand to thirty-thousand-hour life span with the T-8 fluorescent lighting (T8, 2006).

In terms of water use in their distribution centers, Company D utilizes low flow fixtures as well as automatic operators in the employee facilities. Low flow water fixtures are designed to conserve and use less water per minute by producing a high-pressure stream with equal or stronger flow than traditional water fixtures (Low, 2010). Although the pressure is higher, less is expelled from the faucet, conserving water every single time the fixture is turned on (Low, 2010). For Company D, this change was a relatively low-cost and quick way to be more environmentally friendly while also saving on their water bill. Not only does less water come out of the faucet, but this also means that utility companies are saving on having to pump, treat, and dispose of water (Low, 2010). As with many sustainable solutions in distribution centers, changes come full circle and create savings and efficiencies across the entire life cycle of a resource.

In the future, Company D will continue to evaluate their facilities for function and cost effectiveness in their business model in order to meet company goals for sustainable distribution center practices. Company D is constantly evaluating their renovations and new construction efforts to see what is sustainably plausible for future changes. As for LEED certification, they are continuously analyzing whether or not this process is a cost effective solution to the building process. Even if it is not financially effective at the time, Company D is focusing on LEED components to reduce their carbon footprint as part of their evaluation process for all of their projects.

Company E

Company E is a global consumer goods retailer as well as grocery company. In the early 2000s, Company E started to think about sustainability as well as setting a goal to eventually be supplied by one hundred percent renewable energy across their entire network. They stand on a platform of "reducing, reusing, reassigning, and recycling." Company E has forty-five hundred stores in the United States alone as well as six hundred subsidiary stores. There is a distribution center in every single state, and Company E focuses on having a higher representation of DCs where there are higher concentrations of consumers.

In connection to a goal of one hundred percent renewable energy, Company E also is focusing largely on zero waste across global operations. Through distribution centers and stores today, eighty-one percent of materials are being recycled and/or diverted from landfills. Also in their distribution centers, office areas are promoting recycling efforts. No employees have individual garbage cans at their desks, and work areas in the distribution centers have decreased the number of trash receptacles. Instead, "trash separation centers" are used in all of the DCs, with separate bins for paper, metals, plastics, etc. Since there are very few general trash receptacles, employees have no choice but to recycle in the distribution centers. At first, like with any change, employee acceptance of policies was low. Eventually, employees began to adapt to the recycling changes in the distribution centers, and the sustainable practices are now the norm. As of right now, Company E is focusing most of their efforts on recycling in their distribution centers.

Looking at other materials, Company E is aiming to reduce packing materials in their distribution centers when shipping out to stores. Primarily in their food business, Company E packages their products on pallets with a corn-based, bioplastic material rather than typical

plastic trays covered in shrink-wrap. This material is completely biodegradable and is created from the polylactic acid (PLA) in corn (Royte, 2006). This bioplastic is a completely renewable resource, and many other food and consumer goods companies are taking advantage of this sustainable packing product in their distribution centers (Royte, 2006). This is not only a more energy efficient solution to packaging, but also creates much lighter pallets, reducing transportation costs for their dedicated truck fleet.

As for other categories in sustainability, Company E focuses on reusable energy in their facilities to meet greener standards as set by their sustainability office that has been utilized for the past five years. Company E is practicing sustainability in their distribution centers similarly to the other companies interviewed. For instance, Company E has taken advantage of skylight technology in order to harvest natural light. Besides natural lights, all LED lights are motion sensitive in their distribution centers. For lighting, heating, and cooling systems, holidays and working hours are taken into consideration in all of the distribution centers. With at least one distribution center in each state, Company E needs to be wary of differences in climates. For instance, similar to Company C, Company E has seen tremendous pressure from the state of California to abide by drought standards when using water in their facilities.

Across their entire supply chain, Company E is continuously looking for solutions for industry-wide issues in sustainability. Their goal is to strengthen their internal programs with their sustainability office at the core to drive sustainable progress globally. Although Company E does see pressure to act in an environmentally friendly way, most of the pressure is internally driven.

Chapter 4

Most Common Practices – Summary

Companies A through E started looking into sustainable distribution center practices in the early to mid-2000s. These practices commonly started with minor initiatives, aiming to have energy strategies to reduce the cost of energy emissions while being sustainable in the distribution centers. Companies A through E saw external pressures from consumers and/or the government to build and renovate distribution centers in an environmentally friendly way. These companies also felt an internal pressure from a corporate social responsibility standpoint to act in a sustainable way in their distribution centers.

LEED Certified Distribution Centers

As for LEED certified distribution centers, only one company, Company A, currently has taken advantage of the USGBC's certification process. Even though Company A did go through with the process, they found it extremely difficult to achieve certification as well as very expensive in their distribution centers. For the most part, other companies gave two main reasons for not having LEED certified distribution centers. First, some companies found it too difficult to earn the number of points necessary to achieve LEED certification. Second, some companies found the certification process to be too financially infeasible. In most cases of companies without a LEED certified distribution center, the financial burden of building to LEED's standards outweighed the benefits seen from the certification. None of these companies, A through E, have plans in the near future to achieve LEED certification through building a new distribution center or renovating an old one. Although not LEED certified, Companies B through

E still heavily focus on sustainable building and renovation efforts in their distribution centers. Even though these companies do not currently have LEED certified distribution centers, it is not to say that these companies do not have LEED certified facilities such as office buildings or stores throughout the rest of their network.

Recommended Sustainability Practices in DCs

The following table will outline the findings of environmentally sustainable distribution center practices found in the interviews with Companies A through E. These findings are current through April 2016. Many of these companies overlapped in terms of the environmentally friendly practices used in their distribution centers, and the suggested practices for each category will be outlined in the next section.

Table 3. Sustainability Findings in Distribution Centers

Sustainability Category	*Findings*
Lighting	• Motion sensor • Traditional light-emitting diode (LED) bulb • High bay LED bulb • Fluorescent bulb • Daylight harvesting
Cooling	• Variable frequency drive (VFD) • Carbon Dioxide (CO_2) refrigerants • Motion sensor setback program • White reflective roofing system • Insulation efforts
Waste and Recycling	• Dedicated recycling bins • iGPS pallet use • Elimination of trash bins • Corn bioplastic packaging
Water Use	• Rain harvesting • Low flow fixtures • Automatic operators
Equipment	• Hydrogen fuel cell technology • High-efficiency motors

In terms of recommendations for a company that is looking to get started, the following are the most commonly used and suggested routes to take when considering sustainability categories. These financially practical and environmentally friendly recommendations are based on the interviews with Company A through E as well as the background knowledge supplied throughout these interviews and research efforts. In the long run, each of these suggestions have

the ability to save companies money in their distribution center energy bills while also decreasing energy emissions and resource use.

Lighting

Most companies currently use some type of light-emitting diode (LED) bulb in their distribution centers versus the previously used halide bulb that emitted an immense amount of heat. LED lights emit little to no heat at all, creating savings on cooling as well, and their lifespans are much longer than that of a halide bulb. This lowers the costs and labor needed to replace bulbs in the distribution centers. LED lights also give off a seemingly better quality of light for picking product in the distribution centers and should be considered when choosing a sustainable lighting solution. Along with these LED lights, most companies utilize motion sensors for energy efficiency as well as a reduction in the electric bill. Motion sensor technologies are relatively affordable and can be easily implemented in any distribution center across any industry.

Cooling

Although white reflective roofing, as explored by Company D, created many energy efficiencies, the construction costs are immense. If a company is not looking to spend as much money on cooling efforts, there are other solutions. For cooling, a motion sensor setback program is an affordable way to save energy while cooling facilities. This program will allow air conditioned and refrigerated distribution centers to increase temperatures by a few degrees

during off hours, holidays, weekends, etc. For temperature-controlled distribution centers, the recommended refrigerant is carbon dioxide (CO_2) as opposed to ammonia.

Waste and Recycling

Dedicated areas or bins for waste and recycling in distribution centers are the most effective way to implement a recycling strategy. Although there is very little cost to reallocate trash bins and recycling bins, employees' resistance to change is one of the most difficult factors in the new recycling initiatives. In distribution centers, employees need to be trained from the beginning of their employment to recycle common materials such as cardboard, plastics, metals, etc. in the proper areas around the distribution center. At this time, it may not be plausible to completely eliminate all trash bins in distribution centers due to the amount of waste generated in receiving, storing, picking, and packing processes.

Company B's switch from classic wooden pallets to iGPS pallets in their distribution centers is also an efficient way to eliminate waste generation. These pallets can be recycled and reused throughout any supply chain network. There is also a very small learning curve when switching from one pallet to another due to the fact that there is seemingly no change for employees.

Water Use

Most companies have looked into rain harvesting in their facilities. However, in distribution centers, if any water is needed at all, it is typically needed in the form of potable water. If distribution functions do not need water, most water used in the DCs is used in the

employee facilities. Here, low flow, high-pressure fixtures are recommended with automatic operators. These fixtures create a higher-pressure stream while actually cutting down on the amount of water coming from the faucet. This way, less water will be used for environmental sustainability. This will also drive savings in any company's water bill. These faucets are relatively affordable to install and do not require large amounts of construction, from which many companies can benefit.

Equipment

Although only Company B went into their sustainable efforts in equipment in distribution centers, their solution is recommended. By switching all equipment to a hydrogen fuel cell technology, money, energy, and time can be saved. While the implementation of the fuel cell technology can be a large investment, electricity is almost completely taken out of the charging process for equipment. This, in turn, creates long-term savings for any company. This solution is also extremely environmentally sustainable and only produces a small amount of condensation as a byproduct. Hydrogen has no charging time at all as opposed to a sixteen-hour charge time that only lasts eight hours with a lead battery. This allows significant increases in productivity in the distribution centers. The "charging" factor for the hydrogen fuel cell equipment is much like pumping gasoline in a car with a quick, two-minute fill that lasts twenty-four hours.

Like with waste and recycling efforts, there is a notable learning curve for all employees. In distribution centers, employees are using equipment all day long, and need to be trained properly with the new technology to avoid any potential hazards. This training period may take some time, but eventually productivity will resume.

Conclusion

The growing demand for sustainable practices across a company's network is extremely evident through this research. In all areas, including the main areas highlighted – lighting, cooling, waste and recycling, water use, and equipment – consideration of sustainable construction or renovation has been highly considered or undertaken by every company that participated in this research. Typically, when making these environmentally friendly changes, companies aim to see an energy efficient outcome as well as a significant financial cost benefit. These renovations must meet government regulations as well as satisfy consumer preference and company policies on sustainability.

As of right now, LEED certification is something that has not been as prominent in companies' distribution centers. Although many companies have looked into this process, few have gone through with the USGBC's certification in their distribution centers. As stated by most companies that participated in this research, the benefits of this certification process did not necessarily outweigh the financial burden of the renovations or construction efforts in the distribution centers.

As outlined in Chapter 4, the most common and/or financially-feasible practices in sustainability in distribution centers are shown in Table 4.

Table 4. Concluded Sustainable Practices

Sustainability Category	***Concluded Practice***
Lighting	Light-emitting diode (LED) bulb with motion sensor
Cooling	Motion sensor setback system
Waste and Recycling	Dedicated recycling areas with less trash bins
Water Use	Low flow fixtures with automatic operators
Equipment	Hydrogen fuel cell technology

Whether using the LEED certification process or not, there are certainly ways that companies can easily and affordably incorporate sustainability into their distribution centers.

Appendix A

Company Interview Guide

1. When was the first time you started making changes or renovations toward more green facilities?

2. Do you currently have any LEED certified distribution centers?
    a. How was the process in general?

3. Have you built new facilities? Elaborate.
    a. What are some benefits you have seen from this?
    b. What are some disadvantages?
    c. What were the biggest challenges you faced?

4. Have you renovated old facilities? Elaborate.
    a. What are some benefits you have seen from this?
    b. What are some disadvantages?
    c. What were the biggest challenges you faced?
    d. Did employees adapt to change?
    e. What was the reason for making these changes?
        i. Consumer interest?
        ii. Trend?
        iii. Company policy?

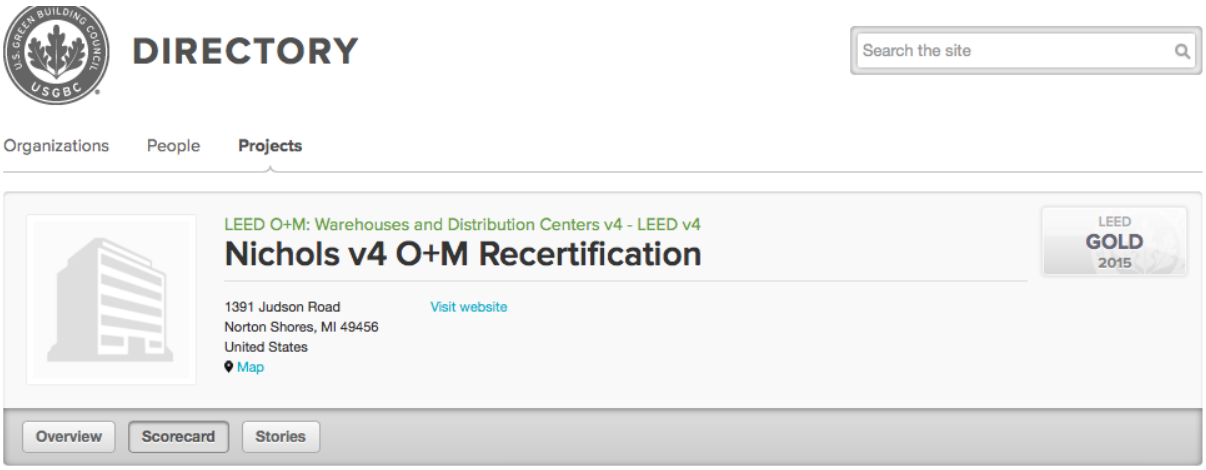
5. Which areas have the biggest changes?
    a. Lighting
    b. Heating and cooling
    c. Waste and recycling
    d. Water use
    e. Building supplies
    f. Equipment
    g. Employee facilities

6. Are there plans in the future to keep renovating or building for LEED certification?

Appendix B

Nichols LEED Scorecard

Source: http://www.usgbc.org/projects/nichols-v4-om-recertification



LEED Facts

for LEED O+M: Warehouses and Distribution Centers (v4)

Certification awarded Oct 2015	
Gold	**60**
Location & transportation	4/18
Sustainable sites	4/10
Water efficiency	8/12
Energy & atmosphere	25/38
Material & resources	4/8
Indoor environmental quality	7/17
Regional priority credits	4/4

LEED Scorecard

Gold 60/92

LOCATION & TRANSPORTATION		**4 OF 18**
Credit	Alternative transportation	4 / 15
SUSTAINABLE SITES		**4 OF 10**
Credit	Site development - protect or restore habitat	0 / 2
Credit	Rainwater management	3 / 3
Credit	Heat island reduction	0 / 2
Credit	Light pollution reduction	1 / 1
Credit	Site management	0 / 1
Credit	Site improvement plan	0 / 1
WATER EFFICIENCY		**8 OF 12**
Credit	Outdoor water use reduction	2 / 2
Credit	Cooling tower water use	0 / 3
Credit	Water metering	1 / 2
Credit	Indoor water use reduction	5 / 5
ENERGY & ATMOSPHERE		**25 OF 38**
Credit	Existing building commissioning—analysis	2 / 2
Credit	Existing building commissioning—implementation	2 / 2
Credit	Ongoing commissioning	0 / 3
Credit	Advanced energy metering	0 / 2
Credit	Demand response	0 / 3
Credit	Renewable energy and carbon offsets	4 / 5
Credit	Enhanced refrigerant management	1 / 1
Credit	Optimize energy performance	16 / 20

MATERIAL & RESOURCES — 4 OF 8

Credit	Solid waste management - ongoing	2 / 2
Credit	Solid waste management - facility maintenance and renovation	0 / 2
Credit	Purchasing - lamps	1 / 1
Credit	Purchasing - ongoing	0 / 1
Credit	Purchasing - facility maintenance and renovation	1 / 2

INDOOR ENVIRONMENTAL QUALITY — 7 OF 17

Credit	Indoor air quality management program	0 / 2
Credit	Enhanced indoor air quality strategies	1 / 2
Credit	Thermal comfort	0 / 1
Credit	Interior lighting	0 / 2
Credit	Daylight and quality views	0 / 4
Credit	Green cleaning - custodial effectiveness assessment	1 / 1
Credit	Green cleaning - products and materials	1 / 1
Credit	Green cleaning - equipment	1 / 1
Credit	Integrated pest management	2 / 2
Credit	Occupant comfort survey	1 / 1

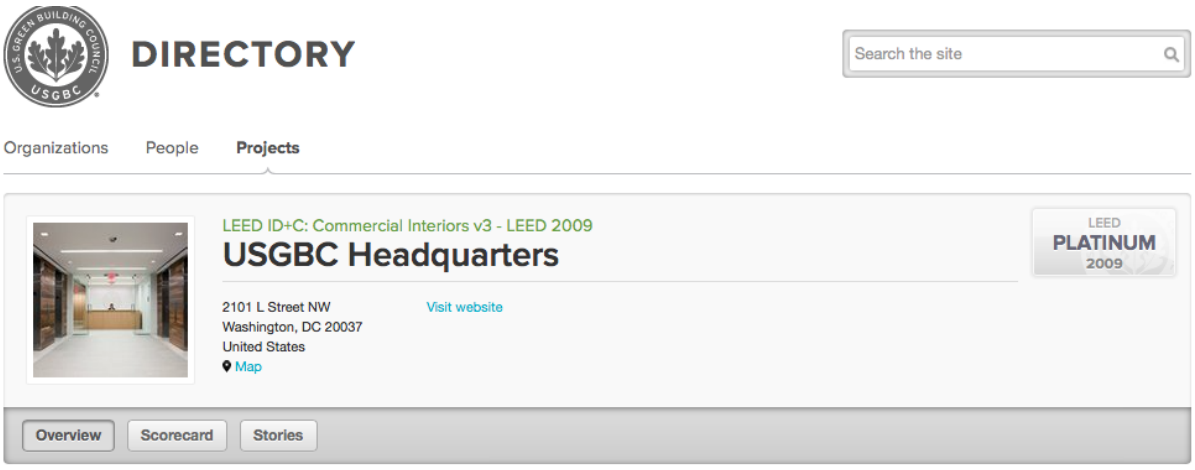
REGIONAL PRIORITY CREDITS — 4 OF 4

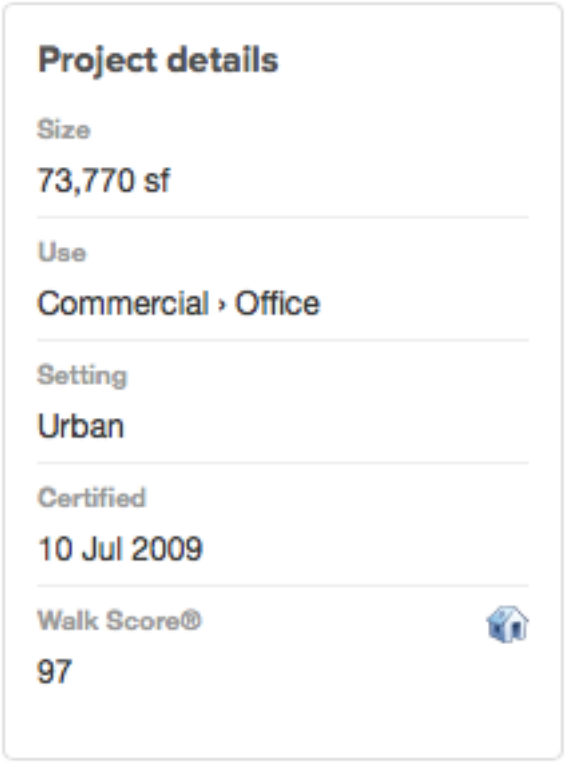
Prereq	Optimize energy performance	+1
Prereq	Solid waste management - ongoing	+1
Prereq	Rainwater management	+1
Prereq	Light pollution reduction	+1

Appendix C

USGBC LEED Overview and Scorecard

Source: http://www.usgbc.org/projects/usgbc-headquarters





LEED Facts

for LEED ID+C: Commercial Interiors (v2009)

Certification awarded Jul 2009

Platinum	**94**

Sustainable sites	19/21
Water efficiency	11/11
Energy & atmosphere	36/37
Material & resources	8/14
Indoor environmental quality	11/17
Innovation	6/6
Regional priority credits	3/4

We wanted our new office to demonstrate its coming of age through sophisticated and advanced green building design and technology, while serving as a living lab that teaches why and how green building is a superior choice.

The U.S. Green Building Council (USGBC) headquarters, located in Washington, DC, was the first building project to achieve certification under the 2009 version of LEED for Commercial Interiors. The building is owned by Charles E. Smith Vornado and, as per the lease agreement, the base building pursued LEED for Existing Buildings: Operations & Maintenance, which it achieved in December 2010. There are two other LEED-certified offices in the building: Cassidy Turley which achieved LEED Silver and RTKL which achieved LEED Platinum. The growth of USGBC mirrors the explosive growth of the green building industry in recent years. When the organization outgrew its previous space in less than two years, its leadership wanted the new office to demonstrate USGBC's coming of age while also serving as a living laboratory to teach the benefits and implementation of green building. USGBC leadership wanted the space to be classically modern and timeless. This was accomplished with natural light and flexibility in accommodating ongoing change through a mix of workstations and private offices. Reducing energy consumption played a key role in the design of the space, and, of course, it was a must for the new office to achieve LEED Platinum under the most recent version of the rating system.

Site context

The USGBC Headquarters is sited in Washington, DC, on the edge of the Golden Triangle Business Improvement District. It neighbors a university and two vibrant residential neighborhoods, Dupont Circle and Foggy Bottom. Numerous transportation options including both bus and rail, as well as restaurants and shops, are within steps of the office. The headquarters are situated on the fifth and sixth floors of a ten-story office building that is itself certified under the LEED for Existing Buildings: Operations & Maintenance rating system.

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Minor in Information Systems Management

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National Merit Scholarship

Experience:
PPG Industries **Pittsburgh, PA**
Distribution Analytics Intern – Architectural Coatings *May 2015 – August 2015*

- Developed and standardized company-wide processes to drive savings
- Compiled international distribution metrics to be updated by employees each month
- Collaborated with 23 distribution center managers and workers across the world
- Assisted in the first and second phases of the company-wide transition from a legacy system to SAP software systems

Demand Planning and Analytics Intern – Architectural Coatings *June 2014 – August 2014*

- Analyzed patterns and orders in daily inventory transfers internationally
- Developed a resourcing strategy focused on transportation and production savings
- Assisted in the organization of the monthly executive sales and operations planning presentation and meeting
- Collaborated with a team of demand planning and inventory control professionals

Activities:
Penn State Dance Marathon
THON Mailings Chairman – 2014
46 Hour Dancer – 2016
Women in Business
General Member – 2013, 2014, 2015
Alpha Sigma Alpha Sorority
Treasurer – 2013, 2014
Scholarship Chairman – 2013

Skills:
SAP Software, Cognos, Tableau, Microsoft Excel, Access, PowerPoint, Word