To my family and all those along the way who have help me achieve my educational accomplishments
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In 2006, buildings accounted for forty percent of energy used by the United States and the European Union. Energy consumption of these structures is a growing concern with respect to the efficiency of buildings operational procedures and the way in which resources are used to run these buildings. The construction industry is a sector that is focusing more on sustainable structures that operate at the most efficient way possible with respect to consuming natural resources and operational costs.

The Environmental Protection Agency (EPA) defines a green building as the “practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction.” Green building is a step in the right direction to address the concern the world has with energy consumption and sustainable structures. A sustainable structure is one that uses the least amount of resources possible while operating at a highly efficient level with respect to its effect on the environment.
Green building is difficult and more strenuous than the normal construction process. The individuals involved in the construction process not only have to be licensed and well-experienced contractors, they also have to be certified green builders. Nonetheless, green building is the direction the industry is heading.

The developed world has grasped the concept of green building at a higher rate of efficiency than that of the underdeveloped world. In particular, the United States is a country that is at the forefront of the green building movement. With the development of LEED (Leadership in Energy and Environmental Design), the United States was one of the first companies to establish a governing body to gauge the efficiency of sustainable design. The U.S. Green Building Council (USGBC) was established in 1993. The founding members of this organization deemed it necessary to implement a system to define and measure green buildings. A committee was soon formed to gauge the true nature of a green building. The first committee was composed of architects, realtors, a building owner, a lawyer, an environmentalist and industry representatives. The first LEED Pilot Project Program, also referred to as LEED Version 1.0, was launched at the USGBC Membership Summit in August 1998 (USGBC 2010). After extensive modifications, the LEED Green Building Rating System Version 2.0 was released in March 2000. This rating system is now called the LEED Green Building Rating System for New Commercial Construction and Major Renovations, or LEED-NC (USGBC 2010). This is the current system that is used throughout the United States to measure green building performance. It receives constant changes to make buildings as efficient as possible.
In addition to the rating system that the United States uses, Germany has recently developed a certification system to measure the efficiency of green building. According to the German Sustainable Building Council (DGNB), along with the German Federal Ministry of Transport, Building, and Urban Affairs (BMVBS), a German Sustainable Building Certification has been created. Its purpose is to cover all topics that encompass sustainable construction and in turn rewards a building through the categories of bronze, silver, and gold. When a building is being examined to receive one of these classifications, six criteria are taken into account; ecology, economy, socio-cultural and functional topics, techniques, processes, and location.

This thesis has served to show the correlation between the techniques and motives that the United States uses as compared to that of the Global Construction market, with an emphasis being put on the German construction market. A case study is presented to show the similarities between a “green” certified building within the United States, and a building of similar qualities within Germany. The study shows that both buildings exhibit tremendous sustainable techniques. However, throughout the process of construction, both project teams could have looked to more outside influences to achieve maximum sustainability.

The findings of this study can be used to show that a greater emphasis needs to be put on aligning a Global certification system to approve sustainable buildings. Allocating ideas that revolve around green building on an international scale would serve to significantly improve the worldwide environment with respect to the construction industry.
CHAPTER 1
INTRODUCTION

The concept of sustainable design has been a part of construction practices for generations. There is not a definite date in the history of construction that can be attributed to when individuals began to practice efficient and environmentally friendly building techniques. However, with respect to state of present day construction within the United States, the USGBC is at the forefront of green construction within the United States. The Leadership in Energy and Environmental Design (LEED) is the main rating system that is used to judge the sustainable qualities of a built structure. With this being the main practice within the United States, other countries such as Germany have developed their own rating system. With the growing trend of developed countries working together with respect to world crisis decisions, governmental obligations and financial investments, the idea that countries would work collectively to establish a universal building code with respect to sustainable design is the next logical step. More specifically, the underlying question that must be resolved is with what frequencies do U.S. construction companies look to foreign influence for ideas in green construction.

Problem Statement

With respect to technological advancements, the world has never been more unified with respect to sharing information. Governments of numerous nations interact on a daily basis. Ideas that are relative to financial decisions and political ramifications are exchanged frequently. Global issues such as environmental awareness and the steps that are being taken to properly care for the health of the planet are at the forefront of numerous countries political agendas. The United States has been involved in the green building movement for numerous years. However, the amount of
information they receive from foreign entities is unclear. There is growing need to have a more substantial understanding with respect to a foreign influence that U.S. contractors apply when building green structures. The U.S. construction industry would benefit tremendously from attaining the most amount of green construction knowledge as possible. The objectives of this research study are to:

• Determine the amount of foreign influence that construction companies have on U.S. construction firms.
• Determine the relationship between a LEED certified building within the United States and a building that exhibits similar sustainable qualities within the European Union.
• Determine if the aforementioned comparison is relative to the fact that U.S. contractors due in fact look to foreign influence through a questionnaire.
• Determine the awareness that U.S. contractors exhibit with respect to green building practices that are practiced throughout the global construction market.
• Determine the direction that society as whole is taking to unify the green building and sustainable design movement.

This research was conducted in order to determine the amount of outside influence U.S. construction firms experience with respect to green building. Using sustainable design and a comparison of green building initiatives as context, this study reviews the aspects of sustainable design and its contributing factors. Through the distribution of a questionnaire to domestic construction professionals, the attitude of the industry was gauged. After the questionnaire is returned and the results are assessed, a logical step can be taken to either promoting the relatively same behavior or if an increase in the awareness of the global construction market needs to occur. U.S. construction firms can become more educated with respect to the green building movement and the correct steps can be taken in order to ensure a unified building movement that can truly help the natural environment.
Limitations

The conclusions that can be reached from the data found in this research study can be open to differing opinions and interpretations. The sampling size of the construction professionals that answered the questionnaire is an extremely small fraction of the domestic construction industry. The questionnaires that were administered were done so with the utmost respect to the human subjects that were used and as well as the scientific process, however, certain limitations must be presented.

The first limitation that is abundantly clear is the amount of companies that answered the questionnaires. The questionnaires were distributed to random construction companies that are domestic construction firms. This significantly narrowed the accuracy of the answers to the questionnaires. With that being said, the data was unable to be analyzed on a statistical level.

The next limitation that must be presented is the bias of the sampled population. Human subjects always exhibit differing opinions. Whether due to the fact that the sampled construction professional works on a specific type of construction project such as hospitals, or the regional partiality that a southern construction worker exhibits, the results will differ dramatically.

The final limitation that will be presented is the capability the sampling size has to enhance their knowledge with respect to green construction and sustainability. Certain construction professionals that responded to the questionnaire could in fact have better opportunities to enrich their understanding of green construction and sustainable design.
In review, the introduction provided an overview of green construction within the United States and the possible direction the global construction is headed with respect to amalgamating sustainable building ideas. The problem statement was then presented to familiarize the reader with the goals of the research agenda. Finally, the limitations to the study were presented, which allow future research opportunities. The next chapter will discuss aspects of sustainable construction and green building practices.
CHAPTER 2
REVIEW OF LITERATURE

Overview

The construction industry is synonymous with the green movement. With the implementation of LEED, a genuine regard to improve efficiency of construction and the constant media scrutiny with respect to the state of the environment, construction firms exhibit sustainable building techniques. Since the beginning of the green movement, construction firms have slowly instilled more proficient and environmentally friendly building practices. These were done with either principles adopted from rival companies or techniques that had been established through years of construction knowledge. However, with the amount of construction that takes place in the global building industry, new techniques are being developed at a constant rate. Even though materials and climates are different throughout the world, base concepts are the same. Therefore, ideas with respect to more efficient and economical sustainable building techniques need to be shared. The amount of coordination and allocation between U.S. construction firms and the global construction market needs to be discovered. Within the growing green construction movement, U.S. contractors need to utilize as many resources as possible so that environmentally friendly buildings are commonplace with every type of construction.

Sustainable Construction

The construction industry has a monumental impact on the world and the environment. According to Torcellini, Pless, Deru & Crawley D. (2006), “Commercial and residential buildings use almost 40% of the primary energy and approximately 70% of the electricity in the United States” (Torcellini, Pless, Deru, & Crawley D., 2006, p 3).
This statistic demonstrates why the construction industry has had to adopt sustainable building practices, for they consume the majority of the energy in the United States. Sustainable construction is the key to protecting our environment.

The basis for the concept of sustainable construction is to construct a building that is environmentally friendly; one in which renewable resources are used and the building is able to generate a considerable amount of energy for its own benefit. This definition is extremely broad and it cannot truly encompass the entire basis for sustainable construction. However, the United States has been successful in implementing programs and governing bodies such as LEED and the USGBC to promote and achieve sustainable construction throughout the country.

Numerous individuals working together to achieve a single goal of an environmentally friendly structure attain sustainable construction. Specifically, the original USGBC was formed with the typical individuals that are responsible for a construction project; the owner, architects, engineers and construction professionals. This committee worked together to establish a baseline for the proper techniques and practices that are involved in creating a sound, sustainable building. Ideas from all areas of the project were shared. This is the key to sustainable construction, entities from different backgrounds working together to share knowledge of the construction process so that the most efficient building can be accomplished. This notion is not only true within a local and domestic scale, but globally as well.

The beginning of sustainable construction starts with sustainable design. The purpose of sustainable design is to decrease the negative effects a building has on the environment, and to enhance the vitality and wellbeing of not only the building but also
the individuals who occupy the structure. Sustainability attempts to decrease the consumption of non-renewable resources, reduce the amount of waste that the building produces, and to generate an environmentally friendly atmosphere (Horn 2010).

According to Horn, there are six basic principles of sustainable design:

- Optimize size potential
- Minimize non-renewable energy consumption
- Use environmentally preferable products
- Protect and conserve water
- Enhance indoor environmental air quality
- Optimize operational and maintenance practices

The key concept behind sustainable design is to incorporate ecologically sound decisions at each phase of the design process. This is vital so that the negative impacts that will occur on the environment will be lessened and the health of the occupants within the building will not be compromised due to a faulty and unsafe design.

Sustainable design must be a constant factor throughout the building process; it must transpire from the time an owner realizes the need for a specific structure, to the completion of the punch list for a finished building.

Sustainable design is not an easy process. It requires many factors and competent individuals to truly be successful. The duration of a construction project is a strenuous and laborious activity. In addition, sustainable design makes this process even more demanding. It is a constant balance between tradeoffs and compromise between all the individuals that are part of the construction process. Owners must be willing to sacrifice numerous goals of the project, while the project management team will more than likely have to concede financial benefits to appease an owner. This is just one scenario that could occur if a construction project were too incorporate sustainable design.
The first part of any construction project is the idea to construct a building, road or bridge. There can be many other items that fall under building construction, but the foundation for any construction project is to build something out of basic materials. This is when sustainable design has to be incorporated. An owner has to be willing to understand that the project they wish to conceive with the help of a design team and a construction firm has to be dictated not just by their personal requirements, but also by the notions that make sustainability a possibility.

New construction however is not the only process that sustainable construction can be incorporated into. Additional factors that are taken into account when selecting the site for a proper sustainable construction project are the reuse or rehabilitation of existing buildings. Even if the majority of owners prefer new construction, modifying an existing building can greatly benefit the environment. Altering the energy use of an outdated building and improving the overall makeup of the structure is essential to promoting sustainable design. However, incorporating sustainable ideals into the design phase is similar and concurrent with both new construction and pre-existing renovations.

Once the owner firmly believes in the ideals of sustainability, a construction project can properly proceed to the design phase. This is the phase of the project that all parties involved must begin on the same page. The project management team must work together with the engineer and the architect to propose a structure that will be sustainable and environmentally friendly.

The first step in the design process should be selecting an appropriate site to begin a building. The main items that are involved in site selection are location,
orientation, and landscaping of a building, because they affect the local ecosystems, transportation methods, and energy use (WBDG 2010). The best way in which a building will cause the least damage to the current ecosystem is the ideal approach that the individuals who are responsible for site selection must take. In addition, current transportation routes must be incorporated into the design process so that the least amount of new traffic will occur on the site. Finally, the amount of energy use that is required for the building to operate must be kept at a minimum.

Protecting the existing ecosystem is vital to producing a sustainable structure. This can be accomplished by properly selecting a location for the building that requires the least amount of excavation and the destruction of the local ecosystem. However, if site clearing must occur, the orientation of the building must be conducive to the least amount of damage to the natural landscape as possible. Finally, when dealing with protecting the local ecosystem, the landscaping that will occur for the building must incorporate as many of the existing plant life as possible. In addition, when planning the landscaping, the use of as many indigenous plants as possible is crucial to sustainable development.

The second item that must be properly incorporated with sustainable techniques is the transportation issues. With respect to new construction access roads and parking facilities must be built to accommodate the occupants of the new structure. When designing the transportation routes, simplicity and accessibility must be the key items that are integrated. Access to existing roads is an obvious part of to the construction process. However, the least amount of new roads that have to be built is ideal for sustainable construction. The number of these new roads that must be built must be
kept at a minimum. With less traffic around the building site, less pollution is created. If the building is extremely large, than a parking garage would be of tremendous benefit. Vertical construction causes less damage to the surrounding area than a sprawling parking lot.

Finally, the amount of energy use that is required for the optimal operation of the building and the detrimental effects of energy consumption must be considered in the design process. The most advantageous position a building can face is if the majority of the windows face the direction in which energy use is optimized. If the building is located in an area where it is cold for the majority of the year, than an east to west orientation is optimal so that natural light and warmth can be incorporated into the structure. However, if the building is located in a relatively warm climate, than a north to south orientation with respect to the location of the majority of the windows is ideal. This will be financially and environmentally beneficial because less energy will be used to run the HVAC system of the building.

Within in the pre-construction phase, there are limitless possibilities that must be discussed to reduce energy-use. Items such as the type of windows, roofing material and the exterior walls must be decided upon. Convincing the owner to use materials that promote less energy use and in turn save energy is vital to sustainability. However, many of these items are more expensive than traditional means and they require meticulous convincing on behalf of the design and construction team, and reluctant sacrifice with respect to the owner.

During the design phase, it will be more conducive to the entire approach of construction if the owner can be convinced that sustainability is the best possible route
to take with the building process. The best way to maximize the potential of a successful sustainable building is for the owner to choose the design-build approach to construction. According to Kose and Sisel (2007), “Design-build is perhaps the best-suited delivery method to minimize the adverse environmental impact of any project. Each member of the project team has unique knowledge of alternative sustainable strategies as well as the corresponding relationship with other elements of the program. Engaging all parties early in a collaborative manner maximizes the likelihood that the best strategies emerge and that execution closely follows strategic intent”. All parties involved within the construction process have differing areas of expertise. With the design-build process, these notions can be presented and incorporated into construction process with more ease than if they were done in the field.

Traditional methods of project delivery are not ideal when dealing with sustainable design. If the project is not design-build then the builder is almost always put into a reactive position; one in which they have to respond to the sustainable ideas that were developed by the design team while in the field. This in turn puts the design team in a vacuum, for they will not receive input from the supply chain (Kose & Sisel 2007). This creates an unnecessary step in the construction process because a trial and error process occurs in which the designer demands sustainable building practices and the builder has to waste time on how these requests will affect the actual construction process, financial aspects and the time in which it takes to erect a certain structure. If this process is met with delays and it impacts the construction process, then the design team has to go back to the drawing board and arrive at a new agenda for sustainable design. This activity causes massive delays in the project, it consumes vital resources,
and it will drastically affect the overall budget of the project, which the owner is most concerned about. Using the design-build process is ideal for a sustainable building; it will greatly improve the actual construction process because it will make it easier for the builder to coordinate delivery of materials and the actual erection of these materials, two items that will be discussed later.

By including the builder at the earliest stage possible, all parties involved will benefit. The project management team will be able suggest different materials and approach that the design team had not previously thought of to insure the most logical and efficient construction process. By achieving this, the “evaluation of alternatives can be considered fully in the context of all project filters: programmatic requirements, constructability, economic viability and sustainability. The result is faster decision making and more environmentally friendly outcomes” (Kose & Sisel 2007).

In addition, the entire construction team can become more acquainted with one another at the earliest stage possible so that differences and compromises can be worked out with least amount of redo work as possible. Correcting mistakes on the jobsite affects the financial aspects of the project and worker productivity. Proper coordination in the design phase will make sustainability a reality and it will maximize profitability by reducing mistakes during the actual construction process.

Upon the completion of the design phase, actual construction can commence. This is the most important part of any project that attempts sustainability. Implementing the ideas that were brought forth throughout the design is not as easy to accomplish once the structure is erected in the field. Sustainability is straightforward on a conceptual level. However, once the actual construction begins, problems will arise that
were not necessarily accounted for in the design phase. Dealing with these issues is the key to creating a successful sustainable project. Throughout the duration of construction compromised has to be exhibited by all parties that are part of the construction process.

During the design phase all individuals that are involved with the construction process could have agreed upon certain sustainable building practices on paper, however once construction begins, motives can drastically change. During the construction process, the project manager has a contractual obligation to the owner to generate a building of high quality, which is constructed on time and within a pre-established budget. It is the responsibility of the project manager and their assembled team to organize the construction process by micromanaging the subcontractors and all other parties that are involved in the development of a building. This in turn pertains to employing sustainable building practices that were agreed upon during the pre-construction phase.

Being able to predict the problems that will arise with sustainability issues will be extremely beneficial to the construction process. A project manager must be able to properly coordinate the installation and erection of all materials that are necessary to create a sustainable structure. There are many different ways in which the construction team must foresee a possible setback with construction and in turn use preventive judgment to assess these problems.

There are many different types of sustainable building practices that have to be accounted for during the construction process. The first item that can be addressed is using materials that reduce energy consumption and promote natural power to a building, which revolves around solar power, window selection and location, and
landscape elements (WBDG 2010). During the design phase, the construction team selects specific locations for the aforementioned items. Once construction begins, the project manager must be able to successfully coordinate with the sub-contractors that are involved in the installation of these items. For example, a problem that could arise during construction is if the roofing contractor has not previously worked with a solar panel contractor before. Specific items will have to be installed on the roof that will permit the installation of solar panels. If the roofing contractor did not install precisely what the plans called for with respect to the solar installation, than the project management team will have a problem to deal with. They will have to able to work with the both contractors so that both items can be successfully accomplished and sustainable design will occur.

It is ideal to not only include the builder early in the construction process, but the craft workers, suppliers, and installers as well. By incorporating these individuals, the correct project specifications can be met and the builder can be sure that they are in fact qualified to erect and supply sustainable building techniques and materials. This will eliminate many untested strategies because the sub-contractors will be overly qualified and will have experience with what is being asked of their services. Project managers should be encouraged to look for any means possible to improve the construction process, whether it is an example of a similar project within their own company for this specific strategy, or a possible foreign entity that practices the same approach.

The most beneficial tool that is used during the construction process is BIM (Building Information Modeling). BIM is able to create a four-dimensional model of a desired building. With the use of this program, the project team is able to input
construction data throughout the building process. This program will illustrate an
erection of the building; deduce the schedule parameters and present site logistics.
However, the most important item that BIM presents for a sustainable building project is
a clear depiction of future energy usage for the building. BIM is also able to illustrate
water run-off for a building so the most logical steps can be taken to lessen the amount
of water that is wasted in this process.

BIM is the preeminent tool that the project team must use to put into operation
sustainable design. This program can foresee problems before they exist and react to
the actual building process. It is a reactive software program that can serve to greatly
benefit the entire construction team. With energy usage being the main goal of
sustainable construction this program is ideal to implement throughout the building
process.

During the construction process, sustainability becomes a realization. The project
manager is obligated to undertake every means possible to find the most ideal way to
achieve a sustainable structure; whether this is through domestic opportunities or
foreign resources.

Sustainable building techniques are not cost efficient in the eyes of certain owners.
However, the long-term effects with respect to the financial savings and the efficiency of
the building can be used as enticing factors for any owner wishing to erect a sustainable
structure. According to a survey conducted by PricewaterhouseCoopers, the world’s
largest professional services firm, “sustainability has now ‘reached the tipping point’,
citing a 2006 global survey of their clients in which 70% of chief executives of mid-sized
to large companies believe that sustainable strategies are directly linked to their
profitability and two-thirds believe such strategies will remain a high priority going forward” (Kose & Sisel 2007). Considering that PricewaterhouseCoopers is a member of “The Big Four” auditors, which is a group of companies that are the four principal international financial firms in the world that handle audits for publicly traded companies and privatized businesses as well, this is a very profound statement. Once an owner has been convinced of the profitability that is directly linked to sustainable building practices, the construction projects that they desire will always exhibit green building practices.

However, due to the growing nature of the construction industry with respect to sustainable design, sustainable building materials are becoming increasingly more expensive due the economic principle of supply and demand. Even though many materials are becoming more common within the building sector and thus the cost of these items is going down, there is still a large discrepancy between the cost of sustainable construction and it being worth it for the owner as opposed to standard construction practices. However, an owner can be convinced of the benefits of sustainable construction with the promising concept of lifecycle cost analysis (LCA). LCA makes it so that the construction does not just look at the basic information that revolves around the material selection such as the procurement cost, but that they also exam “all environmental costs “cradle to grave” or further still “cradle to cradle” (Kose & Sisel 2007). By using this construction tool, a project team will be able to offer the owner many different options to show the benefits of choosing sustainable design. Once the entire lifetime of a product is realized, an owner can come to the realization that multiple benefits will occur that will compensate for the higher upfront costs of choosing the
sustainable design material.

LCA can serve to show the benefits of sustainable design. It can help with the selection of specific materials that need to be used, the time it takes to manufacture them, distribution, the proper method of disposal, and the most ideal way in which to conduct the delivery and transportation of the item. LCA, along with BIM are advantageous instruments to convince an owner to choose sustainable design.

There are many different tools that can serve to show the benefits of sustainable construction to an owner. The goal of the majority of individuals that are involved in the construction process, whether it is the owner, the design team or the construction team, is to make a profit financially. There are many different ways in which all parties that are vested in this process can achieve this objective. In addition, it is a priority of all those involved to assemble every resource possible to achieve the optimal sustainable building. Financial implications are the driving force behind any construction project. In spite of this, the most beneficial outcome of any sustainable project is to create a structure that is both environmentally friendly and promotes the wellbeing of the inhabitants of the structure.

Sustainable construction, in the short term, is more expensive than the traditional building approach. However, the massive amounts of benefits that this process creates are immeasurable; with an emphasis on the environmental aspects. The main concern with the construction sector is the amount of carbon it creates for the environment and the hazard repercussions that are synonymous CO2 emissions.

With the growing concern of the amount of energy that is consumed by humans throughout the world and the effect that energy consumption has on the environment,
the built environment creates the best opportunity to diminish the amount of human-generated carbon emissions. According to architect and researcher Hal Levin, who chairs the Project Committee on Carbon Emissions Tool Development of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), “Buildings are the biggest and lowest-hanging fruit in dealing with greenhouse gases in the atmosphere, since carbon emissions from buildings generally follow energy use, we’ll go a long way simply by making buildings more energy efficient.” (Malin 2008). While using the ASHRAE Standard 90.1, an example of properly maintaining and implementing a sustainable HVAC system in the state of Florida can be presented (Figure 2.1). However, there is even a discrepancy when dealing with a building code to successfully implement efficient an HVAC system. Reducing damaging energy outputs is crucial to sustainable design. This process begins with the design process and proper understanding of a specific regions building code and design parameters.

The best way that a building can improve the environment and in turn lower the amount of greenhouse gases that it produces is to reduce its energy output. Energy, which is used to directly power a building, is the most common contributor to a building’s carbon footprint. Therefore, electricity is the most common form of energy used onsite (Malin 2008). With respect to the type of fuel that is used to provide power to a building, coal is the most common used fuel. Half of the electricity in the United States of America is created by burning coal, which in turn is the most carbon-intensive fuel in the world (Malin 2008). Reducing the amount of energy that is used to power a building is the most logical and effective way to decrease its carbon footprint throughout its life cycle. According to Cryan, “Carbon embodied in a building typically represents
13% to 18% of the carbon emissions over the life of the building” (Malin 2008). Many factors were taken into account to arrive at that figure, including the amount of carbon dioxide that was created in the manufacturing and delivery of the materials to a construction site, the actual construction, its corresponding activities, and the amount of carbon that is released into the atmosphere due to earth-moving.

There are many ways in which a building can reduce the energy it consumes. First, the way in which a building aligns with respect to the sun is crucial. The majority of the windows should either face away from the sun or vice versa, depending upon the building’s geographical location. Ideally positioning the building to use the sun to power solar panels is also necessary to moderate the amount of energy that is consumed. If a building is able to harness solar power, massive amounts of energy can be saved and in turn not used to create carbon. Second, the HVAC operating system needs to operate at the most logical and ideal level. The ducts must be kept in a confined and conditioned area so that energy is not wasted. Also, proper insulation and the sealing of windows and doors will help to reduce the amount of energy consumed which in turn reduces the carbon footprint of a building. Finally, properly monitoring the energy that revolves around a building’s water heater is also a beneficial way to cut down on energy consumption. Using cold water when it is not necessary to use hot water saves energy and reduces a building’s carbon footprint. Reducing the amount of energy that a building consumes is critical to reducing the carbon footprint that it creates during its life cycle. There are many items that are very simplistic in nature that can drastically reduce the amount of carbon dioxide that a building generates and in turn reduce the energy that is required to operate the building.
The next aspect of sustainable construction is the ability to properly provide a way in which to successfully monitor the sustainable building materials that were incorporated into the building. The efficient and successful operation of green construction practices within any structure is crucial to maintaining an environmentally friendly building. Monitoring a building’s operating systems is pivotal to achieving sustainability.

Using programs such as BIM and energy simulators such as Energy10 are tremendous ways to monitor the amount of energy that is consumed by a building. In addition, with the help of these programs, specific materials can be simulated throughout the buildings structure to arrive at the most efficient output level possible. Constant maintenance is required with all building structures; however it is especially vital for a sustainable design.

The final approach that must be taken to achieve maximum sustainability is adeptly decommissioning the building. Prior to demolish, an extensive environmental assessment needs to occur so that all hazardous materials can be recognized and a proper course of action can be organized. In addition to this assessment, an inventory needs to be taken of all known operating equipment within the building. Once these two items have been accomplished, the actual demolition can begin.

The most important aspect of demolition is safety and properly recycling of the materials. Although this process will take longer than the traditional construction approach to demolition, diligence in the disposing of items and reducing the amount of hazardous materials is crucial to protecting the environment.
Benefits of Sustainable Construction

Within the next twenty-five years, CO₂ emissions from buildings are predicted to grow faster than any other sector (emissions from commercial buildings are expected to increase by 1.8 percent through 2030), according to the U.S. Green Building Council (Garris 2007). Commercial construction cannot continue to operate under this level. New ways in which a building’s carbon footprint can be reduced are being developed and implemented into construction projects all over the world. It has been found that if fifty percent of new commercial buildings were built to use fifty percent less energy, more than six million metric tons of carbon dioxide would be saved annually for the life of the buildings, which would be extremely relevant to a building that has a fifty to a hundred year life (Garris 2007). There are multiple methods in which a building can reduce its energy consumption.

The simplest and easiest component to control is the way in which a building uses light. Using occupancy sensors for rooms that do not have a high traffic rate is a logical way to reduce energy consumption. Harnessing natural light as means of illumination is also a way to diminish the amount of a building’s energy consumption. Reducing ways in which energy is used is the simplest and most logical way to reduce a building’s carbon footprint.

Monitoring the hours of operation that an HVAC system uses is another way in which a building’s carbon footprint can be reduced. Controlling the temperature setting in certain zones is crucial to cutting back on energy consumption. Using thermostats that can be programmed for the most ideal temperature setting whether it is dictated off the amount of traffic a certain area of a building receives or the time of day. Controlling
the amount of energy that a building's HVAC system consumes is key in reducing the carbon footprint of that building.

Educating the occupants of a building about the impact they have on the quantity of energy that is consumed is another way in which a building's carbon footprint can be reduced. Changing the behavior of the individuals that frequent a building is crucial to limiting energy usage. Providing simple ways in which energy can be saved is a cheap and beneficial way to minimize the amount of carbon dioxide a building produces. Demonstrating the benefits that individuals can make by shutting off lights, fans and other items that consume electricity when they are not being used is crucial to reducing the carbon footprint. Emphasizing specific numbers of percentage of energy usage that create change in energy consumption is a necessary and motivational factor in reducing energy consumption (Garris 2007).

**Global Construction**

Aside from the United States, numerous countries practice sustainable construction. In particular, Germany has developed a system similar to LEED, the DGNB. Even though this program is in its infancy, it shows the direction that sustainable construction is moving. With the development of LEED and the DGNB, countries throughout the world have begun to recognize the importance of sustainable construction since the notorious “Earth Summit” in 1992.

From June third to the fourteenth in 1992, the United Nations organized a conference on the environment and sustainable development in Rio De Janeiro, Brazil. This conference is known as the “Earth Summit”, and it is credited with being one of the first global initiatives to recognize the importance of green construction and the detrimental impact buildings have on the environment. One hundred and seventy two
countries attended the conference. The program that was development at this conference was termed Agenda 21, due to the fact that the conference was concerned about the direction the world was heading into the 21st century with respect to the environment and the impact that humans have on the world.

Agenda 21 can be broken into four broad sections; social and economic dimensions, conservation and management of resources development, strengthening the role of major groups and means of implementation (United Nations 2010). These four sections are composed of numerous chapters that discuss in depth the role of sustainability and the ideal way to handle the future of the environmental impact that humans have on society.

In a broad sense, the first section discusses measures to improve the overall dynamic of human living conditions. Items that are discussed are ways in which to reduce poverty, promote the health of individuals, and to assess the many issues that accompany the dynamics of differing populations and demographics. In addition, with respect to the construction industry, the notion to promote sustainable development and that the environment has to be a factor when dealing with decisions in building development.

The conservation and management of resources for development section focuses on preserving the environment and ways in which to reduce the detrimental actions that occur on an everyday basis. Topics include atmospheric protection, reducing the amount of deforestation that occurs throughout the world, and the protection of biodiversity (United Nations 2010). This section serves to protect the
delicate natural environments and to control the massive amounts of pollution that occurs throughout the world.

The third section, strengthening the role of major groups, revolves around involving numerous groups about the plight of the environment. Strengthening the roles of the individuals within this section serves to enlighten those that can seriously help the ideal of sustainable development.

The final section is the means of implementation. This is the most important section for it illustrates the ways in the environment can be improved. This section served to educate the public about the detrimental effects that humans have on the environment and ways in which that action can be changed. The main goal was to improve the amount of information that is available with respect to sustainable development. It sought to establish governing bodies, financial institutions and ways in which to improve scientific and technological advancement with respect to sustainable development.

Following the implementation of Agenda 21, the general assembly of the United Nations held a review session of the progress made by the aforementioned conference. It occurred in 1997, five years after the original conference. The members that attended this conference came to the conclusion that many aspects of Agenda 21 were not being fulfilled. The main problems that were presented were the topic of increasing globalization, a serious gap in the income of individuals throughout the world, and an overall decline in the global environment. A new General Assembly Resolution (S-19/2) promised further action (United Nations 2010).
Following the conference in 1997, again the UN met in 2002, this time in Johannesburg, South Africa. After the conclusion of this conference, the “Johannesburg Plan of Implementation” occurred, which confirmed the full UN commitment to Agenda 21. This was a step in the right to direction for sustainable development.

Sustainable construction is a magnificent concept on paper. However, until a full-scale adoption of sustainable development is forced upon the entire world, many of these practices will be for nothing.

**Environmental Impacts of Construction**

The process of erecting a structure and then the actual energy required for a building to operate is extremely taxing on the environment. According to Butcher (2009), “the U.S. Department of Energy's Buildings Energy Data Book, by 2025 buildings worldwide will be the largest consumer of global energy — more than the transportation and industry sectors combined” (Butcher 2009). The National Science and Technology Council have developed an agenda to help with concept of making the construction industry produce net zero energy buildings. They developed six major aspirations that will enable "the major transformational advances needed for energy, water and material use for net-zero energy, high-performance green buildings." (Butcher 2009). These concepts are

- Develop the enabling measurement science to achieve net-zero energy, sustainable high-performance building technologies;
- Develop net-zero energy building technologies and strategies;
- Develop the scientific and technical bases for significant reductions in water use and improved rainwater retention;
- Develop processes, protocols and products for building materials that minimize resource utilization, waste and life-cycle environmental impacts;
• Develop the knowledge necessary to support scientifically sound and building-specific standards and codes that address the health and comfort of building occupants; and enable the technology transfer for net-zero energy, high-performance "green" buildings.

With the involvement of the U.S. federal government, the building sector will not have a choice but to acknowledge the disadvantageous practices that the construction industry has on the environment.
Interpretation of ASHRAE Standard 90.1-2007 with Respect to Buildings in Florida

Purpose: The principle of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standard 90.1-2007 is to install an environmentally friendly HVAC system within a certain building design by properly incorporating logical ideals within the design process.

Reasoning: Within the 90.1 standard, specific HVAC restrictions are presented with respect to the buildings design. These ideals are as follows:

- Explicit elements and constraints that are not specifically addressed within standard 90.1 shall follow the building's original design exactly.
- If an element of the building's HVAC design is addressed specifically, then the minimum efficiency level that is allowed by the standard shall occur.
- All components of the HVAC system and the requirements to heat water with respect to the standard shall also express the minimum efficiency levels.

Florida Building Code Interpretation: When specifically dealing with single packaged vertical air conditioners (SPVAC) and single packaged vertical heat pumps (SPVHP), direct interpretation of the standard is required. More specifically, when dealing with the Florida Building Code, a packaged rooftop heat pump unit must operate at less than 65,000 BTU/h. However, there is a large discrepancy with the interpretation of this specific standard. Essentially, the standard is contradicting the desired requirements of an efficient HVAC system.

The basis for the required efficiency of the system is making it so that an HVAC system would have a more efficient system than the minimum requirements listed within the standard. Standard 90.1 requirements are for a system to be more efficient than the minimums required within the exact bylaw of standard 90.1. The standard is making a comparison between two systems that do not share the same minimum operating requirements.

Conclusion: This inconsistency within an ASHRAE standard is substantial proof that a universal building code should be developed so that numerous individuals working together can collaborate to make an efficient set of requirements for a sustainable structure.

Figure 2-1. Interpretation ASHRAE Standard 90.1-2007
Sustainable construction is a term that is synonymous with new construction projects. This is the direction of global construction. New techniques in green construction are developed continuously, whether it is a new way to construct an interior wall or a more efficient way in which to hang air ducts. Not only are these practices developed on a global scale, but also they are honed within domestic, regional and local construction markets. Specific countries have even begun to rate the efficiency and beneficial aspects of these green building techniques.

With the growing movement directed at achieving environmentally friendly buildings the United States was one of the first countries to employ a rating system to gauge to the sustainable attributes of a construction project. This rating system was developed by the USGBC and given the moniker LEED. The United States has taken the necessary steps to promote maximum sustainability within the construction sector; however they are not the only country that has developed a system of this magnitude. Germany has developed a very similar system that was developed by the BMVBS and given the moniker DGNB. Both these rating systems exhibit similar qualities that will be discussed. However, due to the relative infancy of the DGNB, a sustainable building located within Germany that was completed prior to the adoption of the DGNB will be presented. The “West 4” building will be used to show the environmental and sustainable aspects of construction within the European Union.

**DGNB Rating System**

The DGNB rating system is available for administrative and office buildings (DGNB 2010). The current certification system is based off the 2008 version, while the 2009
version is being developed. The certificate serves to show the ways in which a certified building contributes in a positive manner to the environment (DGNB 2010). Its purpose is to help the builder reach the goals of sustainability through proper planning and timing of the construction process. In addition, the rating system strictly revolves around German building codes and the entire European building sector.

The goal of the certification is to reach maximum sustainability. Not only does it look at the construction process, but it also examines the entire life cycle of the building, which is crucial to truly achieving a sustainable structure. The award is based on a broad spectrum of analysis, and it gives leeway so that the owner and the construction team are able to meet the desired goals of sustainability. It consists of 62 individual criteria. The certificate is justly flexible; it can be updated at any time. It also awards more than a certification for just green building; it assesses the economic performance, as well as socio-cultural and functional aspects of buildings.

The Capitol Area East End Complex Block 225 Building Sacramento, California

Hensel Phelps Construction Company constructed this building and the Fentress Bradburn Architect firm achieved the design. It is a six-story office complex building that serves to house the California Department of Education (CDE), amongst many other entities. It is comprised of 336,008 square feet on 2.2 acres (Ogden 2010).

This building has received many outstanding accolades (Figure 3.1). It is the first LEED 2.0 gold rated building in the world, as well as the first LEED certified government building in the state of California (Figure 3.2). It is also referred to as one the original buildings to incorporate numerous sustainable building techniques at the beginning of the design period.
This building can be described as an innovator in many aspects with the rewards and certifications that it has received, however the most beneficial items can be attributed to the sustainable techniques that were implemented into the building. It was the first state office building to use the practice of building-integrated photovoltaic (BIPV), an Integrated Pest Management (IPM) system and under floor air distribution (UFAD) (Ogden 2010). This building also surpassed the requirements of the California Energy Code, Title 24, by more than forty percent (Figure 3.3).

This office complex was one of the first buildings to incorporate the use of solar energy into the actual design of the building. Sustainability was one to the main goals of the construction team and it is abundantly clear in the numerous materials and techniques that were used within the buildings construction. By using BIPV, the idea of the building creating its own energy was at the forefront the designer’s goals. Integrating solar panels into the design phase was innovative. It was done in a similar fashion such as accounting for the amount of ductwork during pre-construction. This was done as opposed to installing the panels post-construction. By incorporating the photovoltaic system into the design for the first time, sustainable design took a giant leap in progression.

The Capitol Area East End Complex also installed an IPM. According to the Environmental Protection Agency, “Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest
damage by the most economical means and with the least possible hazard to people, property, and the environment”. This concept epitomizes the goals of sustainability, which is to preserve and improve the welfare of the environment. By limiting the amounts of toxic chemicals with respect to pesticides, the construction team was able to incorporate an innovative idea to reduce detrimental affects to the surrounding landscape and the buildings occupants themselves.

The most beneficial and sustainable design item that was installed in this building however, is the use of a UFAD. A UFAD is an HVAC system that is based under the floor, as opposed to the conventional overhead ducts and vents (Webster 2004). This system was developed in West Germany in 1970 to compensate for the massive amount of heat transfer that was located in the new centralized and modular furniture buildings that were developed on the 1950’s (Webster 2004). UFAD serves to cool the massive amounts of electronics that are present in modern day offices almost individually, which drastically reduces the amount of energy that is consumed.

UFAD is composed of a series of chambers that is located within a raised floor. Zones are setup throughout the floor space so that individual users can directly control the airflow that they receive. As opposed to a typical VAV system, UFAD systems exhibit a floor to ceiling airflow that takes advantage of the natural buoyancy of heat that is emitted from the computers and other electronic devices located in workstations (Webster 2004). This is designed to remove pollutants and heat from the area. Air is then returned to via light fixtures and return grilles to the next floor. This system is extremely beneficial due the amount of energy it consumes to circulate air, as opposed to a conventional HVAC system.
The Capitol Area East End Complex accomplished many objectives to be considered a sustainable building and in turn receive numerous awards and recognitions. This building is very innovative in the technology it employed and the way in which it was able to successfully achieve a LEED certified building.

**The “West 4” Green Office Building in Munich, Germany**

The Munich-based architect, BKLS Architekten, designed the “West 4”. It is 48,000 (516,667 square feet) square meter office complex, with retail space spread throughout (Arvonen & Pyhälahti 2007). It is composed of four “head-end” buildings, which are accompanied by three courtyards each that are lined with trees and shrubbery. It received the ecological certificate of the Bavarian state, which is the German LGA certificate (Arvonen & Pyhälahti 2007). The building is visually appealing with many of the architectural pleasing aspects such as the use of glass within the entranceways and the use of pent roofs.

The building itself employs many sustainable techniques. The first item is the use of solar energy panes that are located on the roof. These panels don’t necessarily serve to power the actual “West 4” building. Conversely, they generate energy for the actual city of Munich, a practice that is also exhibited in many construction projects throughout the United States. This is the epitome of sustainable construction for the building actually creates energy for outside sources and thus contributes to the local wellbeing of the surrounding community. This process is extremely beneficial for the environment.

To generate the cooling system for the building, “West 4” uses the concept of concrete-core activation, which uses the natural groundwater to cool the building. This system is highly beneficial because it is able to replace the entire air conditioning system throughout the summer (Arvonen & Pyhälahti 2007). This process saves
countless amounts of energy expenditures and it cuts down significantly on the amount of energy the building actually needs to operate.

During the winter months the concrete-core activation system is not sufficient to provide the desired amount of heat for the building. Geothermal power is implemented instead. Geothermal energy comes from heat that is located in the Earth's interior. This type of heat can either be found in steam or hot water directly beneath the building or surrounding area. This is a great form of sustainable energy due to the fact that the amount of heat extraction is very miniscule compared to the amount of heat located within the Earth. The geothermal energy is used to power the heat pump for the building.

This building also implemented various aesthetically pleasing aspects to the overall design. Sustainability for this building was not just based on renewable resources and declining energy usage to improve the environment. Many foreign techniques that are not necessarily prevalent in U.S. construction were used. These items included space psychology, geomantic design, and vital energy. The building was divided into four core items; fire, water, earth, and air (Arvonen & Pyhälahti 2007). The concept for this revolves around the notion that the environment has a direct impact on the health and vitality of the human inhabitants of a structure.

The courtyard area was designed to resemble a tranquil Bavarian river landscape. Many aspects of the building were designed to be aesthetically pleasing and thus promote wellness for the individuals that occupy the space. The concept of geomantic design was used throughout the building’s design and position. This design concept is similar to feng shui, which orients buildings and their features to promote
balance and serenity. The architects even choose to install actual cables for Internet connection throughout the building as opposed to a wireless LAN network to minimize the amount of radiation within “West 4”. The developers of “West 4” were successful in not only creating a sustainable structure that limited the detrimental effect on the environment; they were also able to create a building that promoted the health of its occupants.

The Future of Sustainable Construction

Sustainable construction practices have occurred for generations. The concept of erecting a structure with maximum efficiency not only during the building process, but also during the life cycle of the building is not a new and foreign concept throughout the construction sector. However, with the development of technology and the growing awareness of the state of the natural environment, sustainable design is term that is as synonymous with construction in the present day as concrete.

Numerous methods to improve the aspects of a building are being developed on a constant basis. Specific countries have established governing bodies to gauge the effectiveness of these designs. However, there is not a universal standard to look for when developing a sustainable structure. A database of every known sustainable technique has not been presented. The majority of construction firms throughout the world look to their domestic counterparts and their own companies for ideas that revolve around sustainability. The world has to realize the practicality of developing a universal standard for sustainable construction. The way in which a building is constructed under sustainable building design is likely to change soon.
Capital Area East End Complex Block 225 Interpretation of LEED Gold Certification

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**Total Score** 43/69

Figure 3-1. Category Points of the LEED New Construction Version 2.0 Gold Certification for the Capitol Area East End Complex located in Sacramento, California.
Capital Area East End Complex Block 225 Interpretation of LEED Platinum Certification

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**Total Score**  71/85

Figure 3.2 USGBC LEED Platinum Certification award for existing buildings for the Capitol Area East End Complex located in Sacramento, California.
The California Energy Code

The following is a summary of a set of standards that the state of California adopted in the year 2008 with respect to residential construction and commercial construction. The set of codes was inferred as title 24, part 6 of the California code of regulations. The California Energy Commission was responsible for implementing these standards.

The purpose of these revisions was to provide the state of California with an abundant of energy for present and future generations. This will be achieved through the use of environmentally friendly energy production. California realized that energy efficiency is the optimal way to achieve the desire reducing greenhouse emissions and the states carbon footprint.

The California Energy Commission arranged this code in response to the Global Warming Solutions Act of 2006. This called for the state to reduce its greenhouse pollutants to the levels that it experienced during the year 1990.

The main goal of the commission was to realize energy efficiency in all aspects of the construction sector. Its goal is to update the standards over time so that the system is constantly improving. In respect to this aspect, electricity consumption will be reduced and the demand for energy will also be condensed.

Sustainable construction and the green building initiative are present throughout the built environment. California is at the forefront of this movement with respect to taking an aggressive approach to promoting energy efficiency and promoting building code to successfully achieve sustainable construction.

Figure 3-3. California energy code title 24 (Courtesy of the state of California)
CHAPTER 4
METHODOLOGY

Introduction

The purpose of this report is to discuss the frequency with which U.S. construction firms adapt to green building techniques thru foreign development. Commercial construction firms will be targeted within in this study. The methodologies that will be used in this study reflect that of the statement listed within the introduction. The purpose of the statistical techniques that will be demonstrated will attempt to find if U.S. commercial construction firms implement foreign sustainability techniques. More specifically, an emphasis will be put on the amount of foreign influence that US contractor’s exhibit and the overall direction of the sustainable building market. The process that will be demonstrated in finding the statistical data for this study is as follows:

1. Material that is relative to green building and sustainability was gathered to show its relationship to the construction industry.

2. The data will be analyzed and categorized to the relevance of the study.

3. The location from which the data was found will be identified.

4. Both qualitative and quantitative survey questionnaires will be administered to deduce the fundamental question in this report

5. The questionnaires will be administered to obtain the data.

Questions Designed

Demographic Question: This question is designed to gauge the timeframe in which the specific company has been involved in the green construction movement and the frequency with which they implement sustainable design.

Question#1 is designed to obtain the qualitative information needed on how construction companies obtain sustainable building techniques. Its purpose is to
determine the amount of foreign sustainable building techniques that United States construction contractors implement into certain construction projects. The questionnaire will include questions that will make construction professionals explain if they look outside of the United States for new ways to implement sustainable construction.

Questionnaire # 2 will serve to determine a comparison between a LEED certified building within the United States and sustainable building within a foreign construction market. The questionnaire will include questions that will attempt to ascertain if the construction professional is aware of green building standards within the European construction market and the importance of the United States within global sustainable movement.

Questionnaire # 3 is designed to determine the long-term financial benefits of building sustainable structures. These questions will serve to show if it is financially beneficial for their company to use sustainable building techniques.

Questionnaire # 4 is to determine the direction of the Green building movement on a worldwide scale. It will serve to show if the construction professional believes that the United States is a leader throughout the global construction market with respect to sustainable design. It will also gauge the direction that the construction professional feels the green building movement is headed.

The demographic question is setup up so that the participant can respond in a quantitative manner with respect to how their company has participated in the green building movement. The next question is arranged so that a more qualitative response can be given with the respect to the direction with which there company and they individually feel how sustainable building techniques are achieved on a global basis.
The third question is presented so that the subject can respond to the notion of how profitable it is to achieve a sustainable building. The final question is used to determine the direction the participant feels the green building movement is headed in the future.

The demographic question and the first question will be arranged in a manner that responses will be based on a personal level and they will involve a written opinion. The responses from these questions will be used to determine a written response with respect to the results that are given.

The second question will have responses that vary from the knowledge the individual has of outside influence on green building within the United States. The individual will have a choice of five options based on this scale. The final two questions will have responses that vary from total agreement to utter disagreement. The individual will have a choice of five options based on this scale. After each questionnaire is collected the data will be entered into charts to show the amount of individuals surveyed and the responses those individuals gave. These three questions will be able to present the frequency with which US contractors look to foreign influence with respect to the green building movement.

**Questionnaires Conducted**

These questionnaires will be implemented electronically. Once initial contact has been made, either by phone or through email, the questionnaires will then follow. The purpose of the demographic questions and the four additional questions will be to obtain a grasp on the frequency with which U.S. construction firms use foreign techniques to obtain sustainable and green building structures.
CHAPTER 5
RESULTS

The participant’s responses are analyzed and presented within two separate sections of the Results chapter. The section titled Response Analysis provides responses to each survey question in a very broad and encompassing manner. The responses are separated into five separate sections; the participants employer information, the frequency of developing new sustainable techniques, a comparison of domestic and foreign construction, financial benefits, and the direction of sustainable development. The analyses of the responses are arranged so that average, minimum and maximum responses can be presented and discussed. Upon the conclusion of separating the responses, the answers were then deduced to arrival at a logical conclusion of the domestic and global construction market.

The Descriptive Analysis section will present aspects of the direct rating system of both LEED and DGNB. However, it was more conducive to compare only the CAEE Complex with the LEED NC version 2.0 and the DGNB due to the fact that the “West 4” was built before the inception of the DGNB rating system in 2009. It was necessary to show comparable sustainable techniques between a building in the U.S. and that of the European Union. This information was presented once it was deemed difficult to arrive at a logical conclusion from the participants in regards to a direct comparison of a LEED certified building and a structure that was certified under a European rating system. This section will serve to show if there is overall trend with regards to a similar comparison between a LEED building and one of the DGNB.

The principal dilemma of the Results chapter in this study is the limited number of responses to the questionnaires that were administered. Throughout the research
process, only 4 questionnaires were returned at of a possible 40 that were distributed to the domestic construction market. It was in turn difficult to have a correct analysis of the overall trend that the domestic construction market is headed with respect to global sustainable development and design.

Response Analysis

Participant Occupation

The occupation of the participants included 4 general contractors from the domestic region that was administered questionnaires (Figure 5-1). The responses that were given made it possible to arrive at the conclusion that general contractors were aware of LEED and the practice of sustainable design.

Participant Job Title

There was not a specific question designated to deduce the position of the specific participant, but due to previous knowledge, the questionnaires consisted of 1 owner, 2 project managers and an assistant project manager (Figure 5.2). Due to the varied level of response and the specific direction that the questionnaire was attempting to deduce, the owner’s responses were of the most value due to the fact of the overall awareness of the construction industry.

Company location

The goal of the questionnaire was to gain an overall perspective of the frequency with which US contractors look to foreign influence for sustainable design. Therefore, the questionnaires were administered throughout the United States. However, the responses that were returned were from contractors that reside in the state of Florida.
Sustainable Participation

The demographic section of the questionnaire was designed to gain perspective on the familiarity of the construction professional has with green construction and the sustainable building movement. The participant was asked to respond to how many years their company has been associated with sustainable construction (Figure 5.3) and the amount of LEED certified buildings their respective company has built (Figure 5.4).

Development of New Techniques

The first question is designed to ascertain the types of resources U.S. contractors use to develop or improve their sustainable design techniques with respect to foreign influence (Figure 5.5).

Non-domestic Sustainable Resources

The last part of the first question revolved around the amount of foreign influence that US contractors recognize with respect to sustainable development (Figure 5.6).

Domestic Construction vs. Foreign Construction

The second question demonstrated the knowledge U.S. contractors have about the domestic LEED certification and the standards of sustainable construction within Europe (Figure 5.7 and Figure 5.8).

Financial Incentives

The third question examines the financial benefits of sustainable construction and the general consensus of the U.S. construction professional (Figure 5.9 and Figure 5.10)
The Direction of Sustainability

The final question is the basis for this research analysis. The direction of construction and sustainable design are two terms that are synonymous with one another. However, with respect to U.S. contractors, the overall direction of sustainable construction on a global scale is bleak. The participants were able to recognize that U.S. construction is not the leader in sustainable design, yet they do not acknowledge looking at outside and foreign influence with respect to sustainable design (Figure 5.11).

The Correct Path for Sustainable Design

The majority of the participants do feel that a global initiative will occur in the future with respect to sustainable design and the green building movement. All participants that responded agree that this will transpire (Figure 5.12).

Unified Sustainable Certification

The respondents feel that a global awareness with regards to the importance of sustainable construction is inevitable. However, they do not feel that a universal standard will be established that judges the sustainability of the entire construction sector (Figure 5.13). The participants perhaps agree with the current system of their respective countries implementing their particular certification system.

Descriptive Analysis

The questionnaire was used to present the response analysis. The aforementioned information was able to be presented by the analysis of the individuals responses to the questions that were presented. By using the case study between the buildings that were located in the United States and Germany respectively, a descriptive analysis of the research was possible.
Once a proper evaluation of both buildings occurred, the Capitol Area East End Complex (CAEE Complex) vs. “The West 4”, a direct comparison that is dictated by the individual rating systems was attempted. However, once it was inferred that the “West 4” was not certified under the DGNB due to the fact that the DGNB was developed in 2009 and the intricacy of comparing buildings of such similar nature, the CAEE Complex was the only building used to present a descriptive analysis of a building certified under the LEED scale and the similar aspects that it shares with one that is located within the European Union, specifically Germany. By using the requirements of a LEED certified building and one that is licensed under the DGNB, a proper analysis is possible.

The LEED certification is broken into seven broad categories; sustainable sites, water efficiency, energy and atmosphere, material and resources, indoor environmental quality, innovation and design process, and regional priority. The DGNB is separated into six categories; ecological quality, economical quality, socio-cultural and functional quality, technical quality, process quality, and quality of the location. These rating systems are presented within Figures 5.14 and 5.15. Due to the fact that the rating systems differ in the amount of specification, the broad point scale that is used within the LEED certification will be used to present a direct comparison between the CAEE Complex under the LEED certification and the similar aspects it would share with DGNB. The DGNB uses a rating scale that is more in-depth and in turn uses weighted criteria to dictate full fulfillment of a specific quality. The LEED rating system, which is less specific, will be used to show a comparison.
**LEED vs. DGNB.** There are many similarities between these two rating systems when comparing the LEED Version 2.0 gold certified CAEE Complex with that of the DGNB. There are many comparisons that can be made between the sections titled sustainable sites, energy and atmosphere, and indoor environmental quality of the LEED certification system and the sections labeled ecological quality, economical quality, socio-cultural and functional quality, and quality of the location of the DGNB certification system. Figures 5.14 and 5.15 will be used to compare the aspects of LEED and DGNB.

The sustainable sites portion of LEED shares similar rating criteria with two sections of the DGNB, the socio-cultural and functional quality and the ecological quality requirements. Credits 4.1 and 4.2 of sustainable sites are comparable to criterion 30 and criterion 59 of the DGNB rating system. These specific aspects revolve around bicycle transportation and the ease with which this process is made easier through the construction process. These two specific aspects of each rating system show that the CAEE Complex could achieve the points that are presented within the DGNB evaluation matrix. Subsequently, sustainable sites credit 6.1 and 6.2 shares comparable aspects to that of criterion 5 of the DGNB. Credits 6.1 and 6.2 revolve around storm water management, while criterion 5 of the DGNB deals with eutrophication, which is an increase in water pollutants. These two credits would garner a point under the DGNB rating system.

The section titled water efficiency under the LEED certification system has five specific categories that revolve around water consumption and efficiency. However, the only comparable category within the DGNB was criterion 14, which deals with water
consumption and sewage issues. This specific category is the only noticeable point to deal with water issues while the CAEE Complex achieved five points within this specific section under LEED. LEED puts a higher emphasis on water consumption than the DGNB.

Within the energy and atmosphere section, the CAEE Complex achieved thirteen points that revolved around using the least amount of energy possible, implementing renewable energy and optimizing energy performance. However, when examining the DGNB matrix, the only comparable category was criterion 16, life-cycle building costs. This is a large discrepancy considering the emphasis that LEED aligns with energy use.

However, credit 4 under the energy and atmosphere section deals specifically with ozone depletion, which is the exact same requirement of criterion 2 under the DGNB. The CAEE Complex would be expected to attain the full point of criterion 2.

The final comparable aspect is indoor environmental quality credits 1, 2, 7.1, and 7.2 of the LEED certification system and criterion 19 and 20 of the DGNB. These aspects all deal with the thermal comfort of the air within the building and the relative cleanliness and health promotion of the structures interior. These items exhibit the fact that CAEE Complex would likely attain all aspects of the DGNB rating system with respect to this category.

When comparing specific line items from the LEED certified CAEE Complex project with aspects of the DGNB rating scale, there are many similar qualities. It appears that the building would qualify for many of the points associated with receiving DGNB certification. However, due to the complex and ambiguous nature of the DGNB
rating system, it is impossible to decipher just how many points it would receive and the degree of compliance that it would fall under.

While LEED shares many aspects with that of the DGNB, it is abundantly clear that the American based rating system focuses specifically on certain aspects, such as water efficiency and energy use for entire sections of its certification requirements. While these same aspects within the DGNB use just one criterion to satisfy a given requirement.

The research has concluded that when attempting a direct comparison between a LEED certified building and in turn using a European rating system such as the German DGNB to rate the same building, the LEED rating system is inferior to that of the DGNB. While LEED focuses mainly on reduced energy, water consumption and focusing on recycled materials throughout the construction process, DGNB focuses on aspects from pre-construction selection methods, specific design methods, numerous items to reduce energy and numerous other items that attempt to make the building as sustainable and environmentally pleasing as possible. The DGNB is a far superior rating system due to its complex and intricate rating system, the numerous items that it favors as opposes to the broad nature of LEED, and the way in which it is able to put more emphasis on certain items with respect to weighting certain items more so than others.
Figure 5-1. Occupation of the participant

Figure 5-2. Job title within company
Figure 5-3. Sustainable design participation in number of years

Figure 5-4. The amount of completed certified LEED buildings per company
Figure 5-5. The type of resources used by the participants

Figure 5-6. The amount of foreign influence for developing sustainability
Figure 5-7. Awareness of European sustainability compared to average U.S. contractor

Figure 5-8. LEED versus foreign sustainable standards
Figure 5-9. LEED implementation is beneficial financially

Figure 5-10. Implementation of new sustainable building techniques
Figure 5-11. U.S. construction is at the forefront of green construction movement

Figure 5-12. Sustainable construction should be a universal movement
Figure 5-13. Sustainable design should be judged under a universal standard
## LEED New Construction Version 2.0 Scoring Sheet

<table>
<thead>
<tr>
<th>Sub-Category</th>
<th>Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sustainable Sites</strong></td>
<td>26</td>
</tr>
<tr>
<td>Credit 4.1 Public Transportation Access</td>
<td>1</td>
</tr>
<tr>
<td>Credit 4.2 Bicycle Storage</td>
<td>1</td>
</tr>
<tr>
<td>Credit 6.1 Stormwater Design</td>
<td>1</td>
</tr>
<tr>
<td>Credit 6.1 Stormwater Design</td>
<td>1</td>
</tr>
<tr>
<td><strong>Water Efficiency</strong></td>
<td>10</td>
</tr>
<tr>
<td><strong>Energy and Atmosphere</strong></td>
<td>35</td>
</tr>
<tr>
<td>Credit 4 Ozone Depletion</td>
<td>1</td>
</tr>
<tr>
<td><strong>Materials and Resources</strong></td>
<td>14</td>
</tr>
<tr>
<td><strong>Indoor Environmental Quality</strong></td>
<td>15</td>
</tr>
<tr>
<td>Credit 1 Carbon Dioxide Monitoring</td>
<td>1</td>
</tr>
<tr>
<td>Credit 2 Increase Ventilation Effectivness</td>
<td>1</td>
</tr>
<tr>
<td>Credit 7.1 Thermal Comfort</td>
<td>1</td>
</tr>
<tr>
<td>Credit 7.2 Thermal Comfort</td>
<td>1</td>
</tr>
<tr>
<td><strong>Innovation and Design Process</strong></td>
<td>6</td>
</tr>
<tr>
<td><strong>Regional Priority</strong></td>
<td></td>
</tr>
<tr>
<td>Total Points</td>
<td>110</td>
</tr>
</tbody>
</table>

Figure 5-14 LEED NC version 3.0 scoring sheet
## DGNB Rating System

<table>
<thead>
<tr>
<th>Sub-Category</th>
<th>Weighted Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ecological Quality</strong></td>
<td>22.5</td>
</tr>
<tr>
<td>Criterion 2 Ozone Depletion</td>
<td>1</td>
</tr>
<tr>
<td>Criterion 5 Eutrophication</td>
<td>1</td>
</tr>
<tr>
<td>Criterion 14 Water and Sewage</td>
<td>1</td>
</tr>
<tr>
<td><strong>Economical Quality</strong></td>
<td>22.5</td>
</tr>
<tr>
<td>Criterion 16 Life Cycle Building Costs</td>
<td>1</td>
</tr>
<tr>
<td><strong>Socio-Cultural and Functional Quality</strong></td>
<td>22.5</td>
</tr>
<tr>
<td>Criterion 19 thermal Comfort in Summer</td>
<td>1</td>
</tr>
<tr>
<td>Criterion 20 Thermal Comfort in Winter</td>
<td>1</td>
</tr>
<tr>
<td>Criterion 30 Bicycle Comfort</td>
<td>1</td>
</tr>
<tr>
<td><strong>Technical Quality</strong></td>
<td>22.5</td>
</tr>
<tr>
<td><strong>Quality of the Process</strong></td>
<td>22.5</td>
</tr>
<tr>
<td><strong>Quality of the Location</strong></td>
<td>10</td>
</tr>
<tr>
<td>Criterion 59 Connection to Transportation</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 5-15 DGNB rating system
CHAPTER 6
CONCLUSION

Summary

The results of this research analysis presented the general viewpoint that US contractors associate with in regards to sustainable construction within the United States and the contributing foreign influence. The questionnaire that was developed was designed to gain an overall perspective of sustainable development and the green building movement. It was able to deduce if US contractors look to foreign entities for ideas when designing sustainable structures. It was the goal of the questionnaire to gauge if US contractors only look to LEED and the parameters that USGBC establishes, or if they look to outside influence to arrive at an extremely efficient and sustainable structure. Although the responses were very limited in quantity, an overall grasp of sustainable design movement and the process in which green building will be judged was able to can be ascertained.

With the conclusion of analyzing the results, the overall consensus was that all participants that responded are aware of sustainable design and that they have participated in the construction of a LEED certified building. However, the responses with regards to the resources that US contractors use to achieve sustainable design are isolated. Only one participant responded to the actual tools that their company employs to achieve new sustainability ideas, and was a domestic source, the USGBC. Even with the narrow-minded ideals of the participants in this survey with regards to outside influence on sustainable construction, the majority of the participants feel that US sustainability practices are comparable with that of the European construction sector.
The consensus was split with regards to the profitability of implementing sustainable techniques.

The final analysis of the questionnaire is somewhat contradictory to overall progress of the sustainable building movement within the United States and the Global construction market. All participants agreed that the US is not the leader in sustainable design and the green building movement. However, when asked to present the resources they use to achieve sustainable design, the only responses revolved around domestic means. In addition, all respondents agreed that the direction of sustainable design will be a universal movement. Nonetheless, the participants were split on the ideal of sustainable construction being judged under one standard.

This research analysis presented many positive aspects with regards to the direction of the sustainable building movement. Of all the participants that responded, each construction professional is currently employed by a company that has built a LEED certified structure. The majority of the participants are aware of foreign sustainable practices and they feel that LEED is equal to the standards of European construction. The majority of the participants agree that sustainable design should be a universal movement.

In spite of this, numerous responses showed that the sustainable design is far from being labeled a global initiative. One in which the global construction market is able to work as one to achieve maximum efficiency in regards to sustainable design. Only one participant acknowledged the type of resources that their company employs, which is a domestic tool, the USGBC.
The participants were split on the financial benefits of sustainable construction, which is the main goal of any construction project. Even though the majority consensus was that the US is comparable to that of Europe with respect to sustainable development, the respondents unanimously feel that the US is not a leader in sustainability. The participants agree that sustainable development should be a universal movement; however the respondents are split on the fact that a universal certification system should be developed.

By and large, the results of this study dictate that US contractors need to look towards foreign ideas with regards to sustainable construction. It is exceedingly narrow minded to only look to improve the construction process of sustainable design by looking only at what is familiar. US contractors need to take initiative and align as many sustainable techniques as possible within their construction projects. There is untapped potential that is being developed on a global scale. The USGBC is leader in the green construction movement. However, it is not the only resource that is available to improve the environment with respect to sustainable construction.

The descriptive analysis and review of the case study show that while LEED focuses on many important aspects such as energy use and water consumption, the DGNB is far superior when attempting to erect the most sustainable structure possible. The intricacy of the DGNB shows the numerous aspects that encompass building a sustainable structure. In addition, the flexible nature of receiving points and the way in which certain items receive a higher priority than others shows that it is not like LEED in the sense that a point is either received or not. The research concludes that US
contractors should look to foreign rating scales such as the DGNB to improve sustainable construction within the United States.

Recommendations for Future Study

This research analysis was only comprised of 4 participants that were from the same region of the United States. To achieve a better understanding of the direction that the sustainable building movement is headed not only domestically, but in foreign sense as well, the questionnaire pool must be increased. In addition, contractors who specialize in foreign projects that are based in the United States would be ideal to administer the questionnaire.

Another aspect that could improve this study is to include regions of the world other than Europe and the United States. This would significantly improve the research analysis and thus gain a better perspective on the direction of the global sustainable building movement.

In addition, it would be logical to include a case study between a building that was certified under the LEED rating system and under a certification system that is not in its formative years such as the DGNB. Once the research had begun, a realization occurred that presented the difficulty in directly comparing a building that was certified under LEED and one of a similar certification system, in this particular case the DGNB. A recommendation for future research would be to use two rating systems that have been acutely developed and in turn find two buildings that share strikingly similar characteristics.

Furthermore, a proper understanding of the rating system that is comparable to LEED would be ideal. Even though the DGNB shares many similar aspects with its American counterpart, there are many ambiguous parts to the factors that are involved
in the German certification system. Proper research that revolves around complete understanding of similar system would be ideal.
Dear Construction Professional,

My name is Sean Waglow and I am currently enrolled at the University of Florida. I am a graduate student at the M.E. Rinker Sr. School of Building Construction. I am currently in the final semester of the graduate program to receive my masters of science of building construction. Part of my curriculum is to write a thesis. The topic I have chosen is “A Comparison of Sustainable Building Techniques Between the United States and the Global Construction Market”. As part of this process I will be conducting a questionnaire to construction professionals through out the United States to help ascertain the amount of foreign influence domestic construction companies experience with respect to sustainable construction. The answers provided for the aforementioned questionnaire will significantly benefit the research process.

Attached along with this email, are the questionnaire and a protocol consent form, which explains there are no risks associated with this questionnaire and your rights to being involved in this questionnaire. Please fill out your answers on the word document, save and attach in email reply to seanwaglow@ufl.edu. Implied consent will be assumed upon completion and return of the attached questionnaire by email.

It should not take more than a few minutes to fill out and it will significantly help with my research process. Please respond by Friday, February 19, 2010. Thank you for your time and help with the research process.

Sincerely,

Sean Waglow
Principal Investigator
/UF Graduate Student
APPENDIX B
QUESTIONNAIRE

Demographics questions
1) When did your company first implement sustainable building techniques?
2) How many LEED certified buildings have your company currently built?

Research question 1: Determine the amount foreign sustainable building techniques that United States construction contractors implement into certain construction projects.

3) What resources does your company use to develop new sustainable building techniques?
4) With respect to innovative techniques that are constantly being developed with respect to green building, how often do you look outside of the United States for ideas?
5) Does your company specifically look to countries in the European Union such as Germany, which recently started the German Sustainable Building Council (DGNB), for ideas in achieving LEED certified buildings?
6) Does your company employ sustainable building techniques developed in the European Union in projects in the United States?
   a. If yes, please describe them.
   b. If yes, please discuss how and where you learned them.

Research question 2: Determine a comparison between a LEED certified building within the United States and a sustainable building within a foreign construction market.

7) How aware are you of green building standards in Europe?
   a. Much more aware than the average U.S. contractor
   b. Somewhat more aware than the average U.S. contractor
   c. As aware as an average U.S. contractor
   d. Somewhat less aware than the average U.S. contractor
   e. Not very aware at all
8) Do you feel that LEED, the American standard for green building is
   a. Much better than standards in Europe.
   b. Better than standards in Europe.
   c. About the same as standards in Europe.
   d. Not as good as standards in Europe.
   e. Significantly inferior to standards in Europe.

Research question 3: Determine the long-term financial benefits of building sustainable structures.
9) Do you feel that implementing LEED standards is more profitable for your company?
   a. Strongly Agree
   b. Somewhat Agree
   c. Agree
   d. Slightly Disagree
   e. Completely Disagree

10) Do you feel that implementing as many innovative Green-building standards as soon as possible, whether foreign or domestic, is financially beneficial to your company?
    a. Strongly Agree
    b. Somewhat Agree
    c. Agree
    d. Slightly Disagree
    e. Completely Disagree

Research Question 4: Determine the direction of the Green building movement on a worldwide scale.

11) Do you feel that the American green building movement is at the forefront of the construction sector throughout the world?
    a. Strongly Agree
    b. Somewhat Agree
    c. Agree
    d. Slightly Disagree
    e. Completely Disagree

12) Do you believe the future of green building to be a universal movement, one in which all countries that implement environmentally friendly building techniques work as one?
    a. Strongly Agree
    b. Somewhat Agree
    c. Agree
    d. Slightly Disagree
    e. Completely Disagree

13) Do you believe that all construction projects, whether foreign or domestic, should be held under one universal standard with respect to green building practices?
    a. Strongly Agree
    b. Somewhat Agree
    c. Agree
    d. Slightly Disagree
    e. Completely Disagree
LIST OF REFERENCES


United Nations. (2010) Core Publications Agenda 21. UN Department of Economic and Social Affairs Division for Sustainable Development


BIOGRAPHICAL SKETCH

Before attending the University of Florida, Sean attended the University of North Florida to major in building construction. With a desire to receive higher education, Sean enrolled in the M.E., Rinker Sr. School of Building Construction to receive his master’s degree. This program enabled Sean to receive the highest education possible with respect to building construction. Upon graduation, Sean will work for a mid-level contractor and in turn better his knowledge of the construction industry.