A STUDY OF SUSTAINABLE FEATURES AND PRACTICES
IN THE COMMERCIAL INTERIOR ENVIRONMENT

BY
YANG DU

A THESIS PRESENTED TO THE GRADUATE SCHOOL OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ARCHITECTURAL STUDIES
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To my parents, friends and colleagues
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<tr>
<td>HVAC</td>
<td>Heating, Ventilation, Air Conditioning</td>
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<td>LEED</td>
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<td>EPA</td>
<td>Environmental Protection Agency</td>
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<tr>
<td>NRDC</td>
<td>Natural Resources Defense Council</td>
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<tr>
<td>ICPA</td>
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<tr>
<td>LED</td>
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<tr>
<td>LCA</td>
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<td>IEQ</td>
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<tr>
<td>NC</td>
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<tr>
<td>CI</td>
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<tr>
<td>VOC</td>
<td>Violate Organic Compound</td>
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<td>FSC</td>
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Abstract of Thesis Presented to the Graduate School of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Master of Science in Architectural Studies

A STUDY OF SUSTAINABLE FEATURES AND PRACTICES IN THE COMMERCIAL INTERIOR ENVIRONMENT

By

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Chair: Donna L. Cohen
Co-chair: William Tilson
Major: Architecture

As the economy booms and commercial business prospers in a higher frequency in most developed countries or prosperous districts in developing countries, commercial buildings are increasingly demanded. However, generally commercial buildings can be 40 percent more energy consuming than other types of buildings, which in turn increases environmental pollution, air contamination and resource wasting problems.

A sustainable commercial interior environment can contribute hugely to healthy environment as well as to social, economic, and cultural development. Hence, the exploration of sustainable features in commercial interiors is of high importance. Under such circumstances, commercial interior design has made a great progress towards sustainability in many aspects in these last two decades.

Since commercial interior design has great improvement nowadays, the significance of figuring out the features that make it sustainable is increasingly
highlighted. Such research could give interior designers a guideline and remind commercial interior managers of how to manage their properties. This essay examines the features in commercial interior design that are sustainable in order to explore methodologies for achieving a sustainable commercial interior environment.

Practices differ based on specific restrictions, confines, conditions and considerations. Through interviews and secondary research, this essay synthesizes and outlines the factors that account for the differences between the theory and applications of sustainable design. Designers, researchers and even the general public will benefit from this paper either on the sustainable commercial interior design features, strategies and restrictions or on the strengthened sustainable mind.
Commercial interior environment

Concept

Commercial interior environment is the indoor space which possesses commerce-related characteristics such as sale, wholesale, finance, security, and other features. In a broader sense, it refers to the internal environment of the tertiary industry architectures. In the chivalrous terms of commercial indoor environment it refers to the indoor places for the provision of commodity exchange and commodity circulation such as shopping malls, department stores, restaurants, and hotels.

Commercial interior environment relates to the interaction among people, objects, and the environment, including the corresponding physical and spiritual feelings in the environment.

Commercial interior design is the process of creating and overseeing the construction or renovation of a commercial space. Involving much more than simply decorating the interior of the space, commercial design will address issues such as the choice of building materials, the layout and placement of interior walls, plumbing and power systems, and even coordinating communications with construction professionals, owners, and service providers (Tatum, 2014).

Features

Commercial buildings and interior spaces have become irreplaceable portions of
city construction with variation, vibrancy and positive social function, which have been important symbols of domestic and regional economic developed level. (Han, 2002)

Commercial interior space is an important place for people to be on intimate terms with public events, making the city vibrant.

Another energy-related feature for commercial building and its interior is that the daily population flow rate is much higher and the area is much bigger than any other category of buildings, meaning that the total amount of required energy is much higher due to the population involved and area overwhelmed.

Commercial space is one of the most dynamic spaces. Competition between commodities motivates economic development. There is increasing emphasis on shaping the environmental design to create a comfortable and pleasant place for the public.

**Energy Consumption Problems in Commercial Environment**

It seems like a paradox that commercial interior environments including large markets, restaurants, hotels, or even entertainment venues are sustainable due to large energy consumption in these commercial interior spaces in the past and nowadays.

Excluding the possibility of building managers using the most energy-efficient technology, most commercial places are designed to be colorful and glittery in order to attract the attention of consumers; this requires a lot of lighting. As a result, the energy consumed is severely high. Restaurants use about 5 to 7 times more energy
per square foot than other commercial buildings, including office buildings and retail stores. High-volume, quick-service restaurants (QSRs) may even use up to 10 times more energy per square foot than other commercial buildings (United States Environmental Protection Agency, 1, 2012). Meanwhile, a poorly-designed space slows down air cycling as well as squanders space. In Leadership in Energy & Environmental Design (LEED) 2009 for commercial interiors rating system (USGBC Member, 2008), a requirement about minimum indoor quality performance has been put up with. Also using an air conditioning system, taking advantage of air cycling from natural resource is more energy efficient.

Next, some problems on furniture, greenery and materials also cause environmental problems. Using local materials is a sustainable way but many commercial interior managers choose to use artificially synthesized materials. Because of this, many greenhouse gases including carbon dioxide are generated.

“In 1999, two colleagues and I worked out what it takes to meet a single family’s annual needs. Each year, for a four-person, middle-class household, industry extracts, process, refines, manufacturers, burn and pumps and wastes four million pounds of material. That’s approximately 20 times an average person’s body weight per day. Of this vast flow of stuff, only 7% gets into products at all, only 1% into durable products, and only 0.02% into durable products that later get recycled, remanufactured, or reused. Thus, the U.S. materials flow is about 99.98% pure waste” (Lovins, 2005).

According to Chinese energy service network, the following data can be gathered. The total energy consumption in the table of the office and hotel is
approximately 2.86GJ/m², where air conditioning, lighting, and office equipment account for 30%. While in shopping malls, restaurants, and other public recreation spaces, restaurant air conditioning energy consumption is 0.496GJ/2 on average. Air conditioning contains 22.33%–79.41% in total energy consumption. In Hong Kong and Taiwan, air conditioning and lighting energy consumption account for 85% (Luo, 2014). Thus, indoor energy consumption that occupies the largest proportion of total consumption is lighting energy consumption and air conditioning energy consumption. In addition, office equipment, elevators, and escalators occupy a little portion of the energy consumption.

**Sustainable Scope in Commercial Interior Environment**

In the past, companies have avoided the green movement for many reasons—lack of education, denial, and the belief of an associated hefty cost being among these reasons (Julie Holst, 2010). Nevertheless where there is insight, there is a way. Benefits of achieving sustainability are becoming more apparent, including the coupling of environmental responsibility and profit maximization. This has enhanced the green movement among organizations as well as individuals (Julie, 2010).

From 1980s some European countries put forward the concept of sustainable interior design (Chen, 2010). The “sustainable design” concept is proposed in the 1980s by some developed countries in Europe out of the European mid-term time. UNESCO in 1993 with the International Building Designers Association had co-sponsored the world conference named “design for the sustainable future”; its
theme is: “all kinds of human activities should be paid attention to sustainable
development on ecology, environment, energy and land use in the future.” Today, this
concept has been gradually integrated into modern interior design as well as
commercial interior design.

Alisa Templeton (2011) claims that health concerns, planet, personal
responsibility, client goals, and educational exposure to sustainability and other
features motivate sustainable thoughts towards interior design. Due to analysis above,
the situation of consumption in commercial interior is alleviated to a large extent by
some sustainable means.
CHAPTER 2
LITERATURE REVIEW

Environmental Problems

Upon the completion of the second industrial revolution in 1940s and 1950s, the scientific and technological innovations have advanced significantly. The growth of technology and economy led to unprecedented social development, yet the environmental issues became a growing international problem. Industrial progress was at the expense of environmental quality. Meanwhile, the mishandling subject of industrial waste and toxic gases was hazardous to natural environment and human planet. As the results, sustainable development issues have gradually attracted people's attention.

Nowadays, we are still battling a large number of environmental issues that need to be resolved. For example, air pollution, climate change, drinking water contamination, environmental effects and toxicology, loss of biodiversity, filamentous bacteria, legionella, ozone toxicology and so on. (Anup, 2015)

Out of many key factors affecting the sustainable development of the environment, the construction quality of the built environment has decisive significance. What covers most area of the urban land is architecture. Building and building energy consumption and exceeded pollution including air contaminations and indoor air pollution are threatening the environment and consuming the resources of the earth rapidly, affecting next generations’ living conditions. In the various types of buildings, there is a class of building designed for commodity
exchange and commodity circulation, which determines more energy demand needed to be consumed to support the commercial operation than residential uses. That is the commercial building. So we should spare no effort to make a progress in commercial interior design to decrease buildings’ negative impact on our living environment.

Sustainability

History and development of Sustainability

The original meaning of the word, sustain, is “to hold up from below”, which is from the Latin word *sustinere*. (Bonda, 2007) Paola Sassi (2006) defined “Sustainability is not an academic pursuit or even a professional activity: it is a way of life affecting everything an individual does. Knowing the kind of relationship we want to have with the global and local environment is the first consideration; this is also our top priority to achieve this relationship. To move from theory into practice, it is necessary to understand the impacts associated with our work and life related activities” (Paola, 2006)

In 1970, the first Earth Day was proposed, providing ordinary citizens with their responsibilities to formally fight against environmentally degradation. The year experienced 20 million Americans demonstrate in the streets, parks and auditoriums. In 1990 Earth Day went global, inspiring 200 million people in 141 countries protecting the environment. In the year of 1993, the U.S. Environmental Protection Agency (EPA) and Natural Resources Defense Council (NRDC) were established.
From the international standpoint, since 1970s, the international community has set an environmental consciousness-awakening program. Driven by this trend, the world’s designers began to incorporate their design works with the environmental concepts, which were embraced by nature and returning to green design. The so-called green design concept was proposed in the 1980s, which was fitting to the concept of environmentalism promoted by international communities. It also emphasized on the relationship between human beings and the living environment and strengthened the designers’ ecological awareness. The famous American theorists Victor Papanek once wrote a book named Design for the Real World, a book emphasized that the need for designers to use limited resources on the earth and preserve the environment. Victor also put forward that the designers have to protect the environment and resources, which is the "limited resources" theory. (Yang, 2014)

**Sustainable minds, conferences and laws**

In the year of 1972, the United Nations (UN) Conference on the Human Environment Program (UNEP) paid special attention to the relationship between economic development and environmental degradation. In 1983 the UN established the World Commission on Environment and Development. Both of conferences placed good influences on commercial interior design. (Bonda, 2007)

As LEED standard was made for sustainability, commercial interior has its own indicator as well. A well-designed commercial interior design project typically
incorporates many sustainable design features while LEED standards also motivate
commercial interior design to be more sustainable. The LEED Green Building Rating
System is a voluntary and consensus-based program for high-performance and
sustainable buildings development. Based on well-founded scientific standards,
LEED emphasizes the state of art strategies for sustainable site development, water
and energy conservation as well as a guide for selecting construction materials that
are easily renewed and manufactured to promote indoor environmental quality. In
particular, the USGBC LEED for commercial Interior (LEED-CI) is the most
remarkable measurement for sustainable commercial interior project. (Deepa, 2009)

Base on the result from LEED-CI certification, certificated commercial interiors
should reach 21-26 credits. Silver commercial interiors should attain 27-31 credits.
Gold commercial interiors should get 32-41 credits and eventually platinum
commercial interiors should be 42 credits and above. (Helen, 2005) Those detailed
contents are examples of sustainable minds in the green movements nowadays.

Additionally, the American Society of Heating, Refrigerating, and Air Conditioning
Engineers (ASHRAE) and the U.S. Green Building Council (USGBC) have been
developing and documenting the best practice standards and balanced approach for
sustainable green buildings. Comprehensive design standards for developing new
and retrofitting existing buildings were also developed by USGBC. (Ann, 2005) In
1998, USGBC launched first pilot, which is LEED version 1.0 in August followed by
another issue in 2000 that USGBC launched LEED Green Building Rating System
version 2.0. In a decade’s development, USGBC launches the App Lab, part of its
LEED Automation Program and in 2012, its commercial expansion targeted industry, warehouses, and distribution centers, which made a great progress in sustainability.


In addition, the year 2005 witnessed *Kyoto Protocol* came into effect that reinforced world countries focusing on environmental problems. (Luo, 2014)

**Sustainability V.S. Green**

From Rhonda S. Hammond’s claim, “green design incorporates efficient mechanical systems and high-performance technologies but still functions primarily through the use of fossil fuels. Sustainable design integrates the principles of green design and goes further to become a passive and active structure that is designed to maximize the use of sites’ natural renewable resources.” (Rhonda, 2013, P. 28)

“Sustainability” has a larger and more holistic definition than “green”. Since green design does not mention the future development as well as benefits of the next generations or its impact on economy and society. Green design highlights the concept of environmentally friendly, carbon reduction and resource retrenchment, which is largely covered by sustainability.
“Green is remarkably associated with processes that seek to ‘pick the low-hanging fruit’ that is available in sufficient supply in a country where waste remains a scandal in many realms of commerce and industry and where profligacy continues to be a proud and thoughtless feature of consumer lifestyle. In contrast, sustainability is tied to whole systems, of which individual consumer products and other commercial materials are a part.” (Yanarella, Levine & Lancaster, 2009, P. 296)

Yanarella (2009) compares the differences between green and sustainability in Table 2-1.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Green</th>
<th>Sustainable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relation to sustainability tripod</td>
<td>Only one leg (environmental improvement)</td>
<td>All three legs (environment health, economy vitality, social justice)</td>
</tr>
<tr>
<td>Focus</td>
<td>Individual components</td>
<td>Interplay of individual components and whole system</td>
</tr>
<tr>
<td>Tactics/strategy</td>
<td>Tactical application of activities that involve “picking low-hanging fruit”; promoting individual changes and reforms to make world less unsustainable</td>
<td>Strategic discovery of the proper scale that will make successive policy stops and actions easier and less costly by designing and implementing a sustainable, self-balancing system</td>
</tr>
<tr>
<td>Political orientation</td>
<td>Conventional, “pragmatic realist,” reformist</td>
<td>Innovative, visionary, revolutionary (“going to the roots”)</td>
</tr>
<tr>
<td>Scale</td>
<td>Individual devices, products, indicators, practices, buildings as most tractable level for greening</td>
<td>City region as the level at which human and social disequilibriums and ecological insults can be dynamically rebalanced</td>
</tr>
<tr>
<td>Risks or excesses</td>
<td>Greenwashing</td>
<td>Utopian fantasizing or top-down authoritarian policy action</td>
</tr>
<tr>
<td>Definition of success</td>
<td>Infinite progress of incremental improvements</td>
<td>Reduction of ecological footprint to a city region’s fair Earth-share</td>
</tr>
</tbody>
</table>

Table 2-1: Green V.S. Sustainability

Source: Yanarella, Levine & Lancaster, Green versus Sustainability, 10, 2009

**Rating systems**

Facing to the increased concentration on environment and resources, the social
communities, especially the construction industry, have had profound reflection and acts accordingly. In the 1970s and 1980s, sustainable development has been widely recognized by the international communities. The United States, Britain and other developed countries have had actions for energy conservation, environmental pollution reduction, resource consumption rate reduction, proposing series of sustainability-related recommendations. Till 1990s, the voice in the sustainable construction sector has grown much louder followed by the green architecture flourish.

In 1990, the British Research Establishment started BREEAM and was soon introduced to the world; in 1993, the United States established LEED Green Building Rating System based on BREEAM; in 1996, Canada began the Green Globe. Then in 21st century, the concept of sustainable development was also introduced to more countries such as Germany, Japan, France, Australia and they set up their own green building rating systems one after another. (Krishnan, 2004)

Designers began to think about the relationship between architecture and the environment, architecture and interior design and among various parts of the building. They also realized that the old output mode of architecture and interior design no longer existed. A holistically use of renewable resources and ecological concept is more acceptable and popular. Environmental sustainability is of great significance in order to stimulate economic sustainability and social harmony.
Comparison between LEED-CI and Three Star Rating System

In China, the voluntary Green Building Evaluation and Labeling (GBEL) program consists of a Green Building Design Label (GBDL) and the operational Green Building Label (GBL). Both labels possess the Three Star Rating System, with three-stars representing the highest rated green buildings and one-star standing for the lowest rated green buildings. (Khanna, Romankiewicz, Feng & Zhou, 2014)

The green building design evaluation system is composed of three types of criteria for each of the six categories including land efficiency, energy efficiency, water efficiency, resource and material efficiency, indoor environment quality and operational management. However, LEED is slightly different from Three Star Building Rating System. The following figures (Khanna et al., 2014) show China’s evaluation standards for commercial buildings and the comparison of China’s Three Star Building Rating System and LEED Rating System.

<table>
<thead>
<tr>
<th>Rating Level</th>
<th>Mandatory Items Included (20)</th>
<th>General Items</th>
<th>Preferred Items</th>
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<tr>
<td>★</td>
<td>Yes</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>★★</td>
<td>Yes</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>★★★</td>
<td>Yes</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 2-2: Criteria for green building design label rating evaluation for commercial buildings
Source: Nina Khanna, John Romankiewicz, Wei Feng and Nan Zhou, Comparative Policy Study for Green Building in U.S. and China, 8, 2014
Sustainable Commercial Interiors

Sustainability as a Concept of Commercial Interior Design

The sustainable design movement arguably had a great influence on the design community. It has reminded architectural designers of their impact on both humanity and environment. They are gradually learning that there is a better way to commercial design – making a transfer with integrated sustainable commercial interior design approaches. (Bonda, 2007)

Project managers and commercial interior designers learn to change the old procedures and know what the principal-driven factor is. As commercial interiors attract people’s attention, consuming more energy and the need for better economic support than any other categories of buildings, the “sustainability” concept is now in critical needs more than any other time before.
The United States recently has witnessed an overwhelming trend of using LEED-CI as a primary evaluating method to rate commercial interior’s sustainability. There is no doubt that such action has great benefit on environment and economy by saving energy and money in the long run.

In China, sustainable development as a clangorous catchword has already been spread abroad. China promulgated the first <green building evaluation criteria> in 2006. The standard is a multi-leveled green building evaluation system instead of a single-leveled acceleration. This criterion includes site, energy, materials, operation, management, water and other aspects of constructing a comprehensive building, which is characterized by emphasizing on the design process and energy consumption control. These have made an important contribution to China’s sustainable design concept in new architecture and interior design including commercial interior design.

According to Penny Bonda’s statement (2007), attendance at sustainable design conferences is a good first step to activate sustainable concept and promoting LEED acceleration is also an excellent way to get your stuff up to speed. These are two principals to achieve sustainable commercial interior design as well as green building design in the United States.

“5R and 3F” Principles

The principle of green design is known as “3R”, namely reduce, reuse and recycle, which has already been adopted in many developed countries. However, this
principle does not comprehensively conclude the whole procedure of environment protection and resource allocation. Put forward by Zhou (2010) in his book named "Research of Sustainable Interior Environment Design Theory", the “5R” principles are “revalue”, “renew”, “reduce”, “reuse” and “recycle” and “3F” principles refer to “fit for the nature”, “fit for the people” and “fit for the time”.

**Revalue:** Revalue principle means "revaluation", "rethink" and "recognition."

Since the industrial revolution, people started the destruction of the ecological environment on the Earth, eventually leading to the damage of human living environment. In today’s commercial interior environment, contagion of blindly following the trend, stuffing material and abuse lighting all result in the waste of resources, environmental damage and even cultural pollution. Only after careful consideration and revalue from the perspective of sustainable development, one can make clear the right direction of commercial interior design.

**Renew:** Renew principle refers to "update" and "transformation", meaning the renovation of the old things and can be reused. Commercial interior designers and researchers should develop technology and repair the old construction, which is also a kind of production and wealth creation. (Meng, 2011)

**Reduce:** From the point of new recycle resource and environment, it should meet the needs rather than "desire", and reduce the annual demand of the built environment. Balanced statement of supply and demand is a key feature of sustainability. (Meng, 2011)

**Reuse:** Establishing "remanufacturing industry” can take wastes as raw
materials. (Meng, 2011) Actually, reuse principle refers to reuse all available old equipment, used materials and utilized furniture instead of the new ones in an indoor environment. Redesign, for the indoor environment, means shortening its life cycle, wasting material resources, consuming more energy and so on. On the contrary, recycling is the best solution to this problem. In fact, there are many materials that can be processed. Such as floors, tiles, doors, windows and furniture. Some older products such as utilized steel also can be used for new construction. As long as designers are willing to discover these old materials and sufficiently applied them in the new indoor environment, it is possible to achieve sustainable development. (Zhou, 2010)

Recycle: Recycle is a refining and reusing process that is a little different from simple “reuse” and “renew” by combining them together. It refers to recycling a variety of scarce or even abundant resources to enlarge their availability as much as possible. Sewage generated in the commercial indoor environment after appropriate treatment can be applied again, such as plant watering, toilet flushing and so on, from which not only eases the tension of living water, but also enormously reduces the amount of portable water. Recycling is a useful way of protecting of resources.

“Fit for the nature”: It refers to fitting natural rules and regulations when doing activities including design activities. Nature protection is the top priority when processing built environment due to its high importance. Without considering contaminating the nature, human behaviors have already caused environmental problems like global warming and air pollution, attracting the public’s attention and
awareness of the nature’s significance.

“Fit for the people”: People are the subjects in the built environment and the designed buildings. No doubt, under the principle of fitting for the nature, people oriented design also plays an irreplaceable role. Declared by Jian Wang and Hu Qingming (2011) in the 7th international Conference on Public Administration (ICPA) Report, “people oriented” philosophy is inevitable due to the reason that it is the common pursuit of human society – an unacceptable way to achieve social sustainability.

“Fit for the time”: Twenty first century has its own characteristics with high-tech innovation, retrofit, rapid development and fierce competition on technology. With new age exposures a numerous future demands for the commercial interior environment and in many other fields, commercial interior designers should pay more attention to the customers’ needs and design for the future.

Techniques and innovations

The technical development and innovations encouraged brainstorming and new attempts in sustainable commercial interior design to resolve existing environmental issues and identify potential solutions for the future. Computer technology, automatic control technique, electronic information technology, as the representatives of modern high-tech applications in interior design, have a far-reaching impact on physical lighting, ventilation, temperature, humidity, indoor environment greening. Undeniably, it will eventually lead to a revolution in commercial interior design. The
characteristics of combining interior design with modern high technology mainly lay in energy-saving technology in the indoor spaces, comprehensive green technology and intelligent sensor technology. (Gao, 2000)

The following technological innovations contribute to sustainability: solar technology, vertical greenery and green wall systems, Heating, Ventilating and Air Conditioning (HVAC), insulation technology and etc. Using insulation as an example, there are many innovation of insulating materials and price ranges. Fiberglass batts, cellulose, fiberglass loose fill insulation, cotton batt and loose fill insulation, spray foam insulation and rigid foam insulation materials are the latest inventions that help achieving commercial interior sustainability. (Nielson & Wolfe, 2009)

**Current Situation of Sustainable Commercial Interiors**

**Positive Impact:** “Sustainable design is not just about cost. Good sustainable design offers economic, environmental and societal benefits.” (Kampschroer, 2009) It reduces water consumption, construction material usage and emissions to air. Sustainable commercial interiors use materials with lower embodied ecological and environmental burdens. They also utilize minimal amount of materials through efficient design, and recycled materials. Additionally, sustainable commercial interiors effectively reduce air pollution by lowering energy consumption. The reduction in use of fossil fuels results in lower greenhouse gas emission.

Sustainable commercial interiors reduce liability, increase productivity and property value, enhance comfort, and require lower energy, etc. (White Paper, 2006)
Sustainable commercial interiors provide superior value to the owners’ benefits by extending building life cycle and have positive impact on visitors’ health and performance, save a lot of energy and resource.

**Problems:** Although the concept of sustainability in commercial interior design seems like a flawless point, there are still challenges in commercial interior environment due to the gap between theory and practice. One of the most profound challenges is indoor air quality. Studies have shown there is an obvious correlation between the asthma disease and indoor air pollution. In the last 20 years, 70% of children asthma has been verified as a result of the indoor air pollution. (Toole, 2015)

There are some other problems for sustainable commercial interior design according to J. David Odom, Richard Scott and George. H. DuBose’s (2009) statement:

- The failure of new products to meet their promoted performance levels, which is more likely with new materials compared to proven materials found in traditional buildings.

- Accepting the higher standard of care that a green building might present. What is currently considered “best practices” may now become the new expected “standard of care.”

- Failing to recognize (or prepare for) the unknowns in cost and schedule impacts that a green building might present.

- Improved energy performance through increased insulation and the use of new
materials, which may change the dew point location in walls, resulting in damaging condensation and a reduced drying potential for wall assemblies. Lower-risk buildings emphasize the drying potential of the envelope over in creased insulation.

**Various sustainable interior Features**

**Space design and sustainability**

Human spend 90 percent of their time indoors, in which air pollution is 2 to 5 times more serious than what it is outdoor. So, architects and designers have a vital influence on occupant’s health by designing space to ensure a healthy indoor environment. Why is space design important to sustainability? Bradley (2010) said, “Without space there is no music. You have to leave room for the sounds to be distinguished from each other, to be heard for what they are.” No matter it is for two-dimensional design or three-dimensional design.

Dr. Chaim H. Tejman’s Grand Unified Theory (2001) has demonstrated that: “In space, different energy levels appear from time to time. Their activity brings about the appearance of swirls, which cause changes of time and space. The appearance of energetic activity causes the appearance of space, which causes the appearance of time. The disappearance of energy also means the disappearance of space and time. In theory, it is possible to say “No energy, no space, no time”, but it is impossible to describe the existence of space and time without energetic activity.”

Since every space has energy and energy consumption is closely related to space design, open space or coherent space is the best choice. Open and coherent
space makes the most of natural resources like lighting and moving air, which facilitates the energy using less manual lighting system while promoting natural ventilation. Well-designed interior space also takes advantage of physical principles including reflection and scattering to sunlight and wind from outdoors. Designers should take the first step by grasping the space design when processing interior design.

**Energy and atmosphere**

**Daylighting**: Daylighting is one way to bring natural light into the interior space with renewable energy to indoor environment. The U.S. Department of Energy (2012) claimed that there are two basic means to introduce natural light: top lighting and side lighting. To implement top lighting, a space should have roof access. The simplest form of top lighting is the use of skylights followed by a more complex way concluding the utility of roof monitors with vertical glazing. Side lighting refers to introducing daylight into the interior spaces through vertical fenestration such as windows. Sunlight through the vertical fenestration can be reflected on floor, ceiling, wall and furniture. As a result, the condition of window decides the quality of side lighting.

According to Anne E. Grimmer and Jo Ellen Hensley’s assertion (2012), there are some strategies for taking advantage of daylight:

- Retaining features that provide natural light to corridors, such as partial glass partitions, glazed doors and transoms.
- Reopening windows to bring natural light and ventilation into the interior.
• Adding skylights or dormers on secondary roof elevations where they are not visible or are only minimally visible so that they do not negatively impact the building’s character.

• Adding a small light well or light tubes, where necessary and appropriate, to allow more daylight into the interiors.

• Inserting a small atrium, only when necessary, to allow more daylight into the interiors.

With highly complicated buildings, a daylighting consultant can help with orientation, geometry, glazing locations, size, specification and shading devices. (Bonda, 2007) Additionally, Bonda (2007) mentions that all great daylighting design starts with the following procedures:

• Maximize south and north façade.

• Select high-performance glazing.

• Maximize quality views for task areas and share the daylight.

• Calculate the optional size and number of windows and toplighting for even illumination while minimize heat gain.

• Utilize high ceilings and tall windows.

• Use high reflectance values for surfaces.

• Shade south façade.

• Integrate the electric lighting and controls for optional energy savings.

• Avoid direct sunlight in task areas.
**Skylight:** Sixty-two percent of commercial environment is under the roof and is possible of top lighting through skylights. (Bonda, 2007) The Daylighting Collaborative, Energy Center of Wisconsin claimed “Skylight aren’t usually need to achieve good results until you get beyond 25 feet of the perimeter windows.” Thus, skylight plays a key role in introducing daylight into interior spaces without the help from windows.

There are some types of skylights. One of them is unventilated glass skylight that is the most technologically sophisticated horizontal lighting type. It is widely used in commercial buildings including large hotels, shopping malls, and office buildings. Because unventilated glass skylight is not subject to the ventilation mode and its corresponding structural constraints, there is more freedom on the span and the corresponding spatial form while the cost is relatively lower. However, the unventilated glass skylight can cause interior overheating because of unventilated feature. In summer, the users often set up simple shading device under the skylights in order to reduce the impact of sunlight on the indoor environment. (Li, 2004)

Airy glass skylight can meet the lighting requirements while is also available on both "ventilation", "pull the wind up" and other Indoor environmental quality adjustment functions, yet it owns more complex structure. Due to its high ceiling space for hardly manual control, it requires corresponding mechanical and electrical control equipment, and thus demands greater costs than other skylight glasses.

The third type of daylighting by skylight is using a dome or other protruding glass skylight roofs. It can increase additional lighting space volume under the cover.
Lastly, horizontal lighting is a special mode of glass skylight roof. In this mode, the construction of the wall and roof are melt as a whole. Typical examples are "glass pyramid" or "glass hemisphere." (Li, 2004)

**Windows**: Windows, as a side lighting strategy, bring 7000 to 10000 foot-candles of light on bright days into the interiors. It is the most common practice of saving energy and reduces greenhouse gases by using sunlight instead of electricity. Clear glass windows may allow excessive amount of light in causing discomfort and overheating in eyes. A suggested solution is to substitute the clear glass with the low-emissivity glass or apply films on the interior window surface known as window tinting. (Bonda, 2007) According to the World Film Association, “clear single pane glass will reject 23% - 28% of the ultraviolet light from the sun. Insulated glass is slightly better, rejecting 36% - 41%. Window films installed on glass reject 95% - 99% of solar ultraviolet light.”

Another method is to utilize window coverings to reflect sunshine. Roller shades, Roman shades, horizontal blind and vertical blind are some perfect choice when buying window coverings.

**Light shelves**: Light shelves reflect the sunlight onto the ceiling and bounce it down on the floor, lighting the interior space in a more comfortable and less heating. They can avoid the problem of glare and exploit daylighting through windows like diffusers facilitating windows’ illumination depth up to 1.5-2.0 times higher than what it was before.
Light shelves also offer the facilitation of shifting the sunlight from the window in an overhead direction, improving the quality of illumination. (Wulfinghoff, 1999) Exterior light shelves or the combination of interior and exterior light shelves are more efficient solutions than just interior light shelves. Nevertheless, without the architectural conditions, constructing interior light shelves in a commercial interior project setting is still the best option.

**Lamps and lighting:** In 1970s, Philips Company in Dutch developed the first generation of tombarthite energy saving lamps. In the early 1980s electronically commutated fluorescent lamps (energy saving lamps) was first created. Then in the early 1990s, the United States first proposed the “Green Lighting” program. The world's governments and agencies responded to the U.S.'s calling, protecting the environment and implying to effective measures to sustainable development. In China, the implementation of China’s “Green Lighting Project”, increased the depth of energy-saving research, and vigorously promoted the use of energy-saving lamps, which is a strong impetus to the usage of energy-saving products. (Wang, 2003)

In fact, not all of the lighting is effective, but partly is absorbed by the reflective plate on the lampshade and partly by the ceiling and walls. Lampshade’s role is to improve the utilization of electric light. Thus, rationally use of lampshades is quite important to efficient lighting. The reflectance of light efficiency is greatly decided by lampshade material. Different lampshade materials have a corresponding reflective efficiency rate varying from 50% to 92%. New nano lampshade products can
decrease the oxidation, chemical corrosion and other problems on the lampshade-reflecting surface, improving lighting reflection rate up to 90% and above. And nano lampshade’s initial installation price is close to the normal one. Therefore, by giving priority to efficient nano lampshade can reduce more than half of the energy consumption. (Zhao, 2014)

Incandescent lamps have low initial cost, focusing on the beam and pleasing color. Yet they generate a tremendous amount of heat and their utility life is relatively short. A similar lamp type to the Incandescent lamp is Halogen lamp. It offers bright lights yet it also heats up quickly. The technology of Fluorescent lights has significantly improved in the last decade with extended usage as well as energy efficient. “The lamp that is perhaps generating the greatest buzz at the moment is the LED (light-emitting diode).” (Bonda, 2007, P. 83) On the plus side, they are super directional, so light can be focused on where it is necessary. They have long lasting life yet do not generate much heat because of their small sizes. They are not designed for general illumination and ambient lighting.

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>Efficacy (Im/W)</th>
<th>CRI</th>
<th>Color Temp (K)</th>
<th>Life (hours)</th>
<th>Life Cycle Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>8–20</td>
<td>100</td>
<td>2700</td>
<td>800–3,000</td>
<td>High</td>
</tr>
<tr>
<td>Halogen</td>
<td>12–24</td>
<td>100</td>
<td>2800–3100</td>
<td>2,000–5,000</td>
<td>High</td>
</tr>
<tr>
<td>Fluorescent tubes</td>
<td>49–89</td>
<td>49–90</td>
<td>2700–6500</td>
<td>7,500–24,000</td>
<td>Low</td>
</tr>
<tr>
<td>CFL</td>
<td>40–87</td>
<td>85</td>
<td>2700–5400</td>
<td>8,000–10,000</td>
<td>Low</td>
</tr>
<tr>
<td>LED</td>
<td>1–40</td>
<td>60</td>
<td>n/a</td>
<td>10,000–80,000</td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 2-3: Lamp characteristics by types
Source: Environmental Building News, 6, 2002
<table>
<thead>
<tr>
<th>Type (code)</th>
<th>Common ratings (watts)</th>
<th>Colour rendering</th>
<th>Colour temperature (K)</th>
<th>Life (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact fluorescent lamps (FS)</td>
<td>5–55</td>
<td>good</td>
<td>2,700–5,000</td>
<td>5,000–10,000</td>
</tr>
<tr>
<td>High-pressure mercury lamps (QE)</td>
<td>80–750</td>
<td>fair</td>
<td>3,300–3,800</td>
<td>20,000</td>
</tr>
<tr>
<td>High-pressure sodium lamps (S–)</td>
<td>50–1,000</td>
<td>poor to good</td>
<td>2,000–2,500</td>
<td>6,000–24,000</td>
</tr>
<tr>
<td>Incandescent lamps (l)</td>
<td>5–500</td>
<td>good</td>
<td>2,700</td>
<td>1,000–3,000</td>
</tr>
<tr>
<td>Induction lamps (XF)</td>
<td>23–85</td>
<td>good</td>
<td>3,000–4,000</td>
<td>10,000–60,000</td>
</tr>
<tr>
<td>Low-pressure sodium lamps (LS)</td>
<td>26–180</td>
<td>monochromatic yellow colour</td>
<td>1,800</td>
<td>16,000</td>
</tr>
<tr>
<td>Low-voltage tungsten halogen lamps (HS)</td>
<td>12–100</td>
<td>good</td>
<td>3,000</td>
<td>2,000–5,000</td>
</tr>
<tr>
<td>Metal halide lamps (M–)</td>
<td>35–2,000</td>
<td>good to excellent</td>
<td>3,000–5,000</td>
<td>6,000–20,000</td>
</tr>
<tr>
<td>Tubular fluorescent lamps (FD)</td>
<td>4–100</td>
<td>fair to good</td>
<td>2,700–6,500</td>
<td>10,000–15,000</td>
</tr>
<tr>
<td>Tungsten halogen lamps (HS)</td>
<td>100–2,000</td>
<td>good</td>
<td>3,000</td>
<td>2,000–4,000</td>
</tr>
</tbody>
</table>

Table 2-4: International Lamp Coding System (ILCOS) short form coding system for some lamp types
Source: Forster, Type of Lamps and Lighting, 2011

**Controls:** Interior lighting controls regulate the electric lighting in interior spaces, managing the building’s lighting systems. Efficient controls of interior lighting could offer comfort while achieving energy consumption. According to U.S. Department of Energy (2012), daylighting controls are divided into two types: automatic daylight controls and manual daylight controls. Automatic daylight controls can be either continuous or stepped dimming. Continuous dimming controls typically offer a better control over lighting output and bring a smoother output level transfer. On the other
hand, stepped dimming controls are less expensive, and do not provide a smooth and continuous dimming system. They generally save less energy compared to continuous dimming. The manual control provides a wall switch that allows the general lighting to be turned on and off. The installation of manual control is not suggested around places such as stairwells, corridors and other spaces where turning the lights on and off would be inconvenient. Instead, lighting is better to be controlled separately by automatic controls.

There are four main types of occupancy sensor technologies, which are passive infrared (PIR), Ultrasonic (US), Audible and Hybrids. PIR detects body heat with many advantages over other technologies such as inexpensive, resistant to false-on and can be mounted on ceilings. US detects high-frequency sound wave signals as motion. Audible detects noise while the Hybrids combine two or more technologies such as PIR and US, or PIR and Audible together. (Bonda, 2007)

**Water conservation**

Interior water consumption can be divided into two categories: flushing water and flowing water. Generally, water consumption in interior space is based on three areas: indoor water like flushing and flowing water, irrigation water and process water such as water in heating and cooling systems, dishwasher, and icemaker.

There are several strategies when conserving interior water: applying water-saving appliance, monitoring water use, recycling water, stormewater management and collecting water by plants. Using water-efficient appliance and
fixtures are the efficient way to achieve water conservation. Declared by Green Building (2014), now WaterSense and EnergyStar have identified fixtures, water systems, high-performance and water-efficient appliances and accessories that can reduce water consumption.

In commercial interior spaces, the following water-saving strategies contribute to sustainability: (Bahar, 2015)

- Install and maintain sensors or meter control fixtures
- Install flow restrictor, aerators on lavatory, sink and shower
- Install dual flush toilet and low flow urinal
- Install dry fixtures, waterless urinals and composting toilet
- Water reuse, rain, gray, reclaimed water
- Install water meter
- Use efficient fixtures
- Use non-potable water
- Install sub meters

**Sustainable material**

The selection of sustainable materials should be considered in three phases: pre-building, building and post-building phases. According to Jong Jin Kim and Brenda Rigdon’s (1998) research, sustainable materials have many features: pollution prevention measures in manufacturing, waste reduction measures in manufacturing, recycled content, embodied energy reduction, use of natural materials,
reduction of construction waste, local materials, energy efficiency, water treatment and conservation, use of non-toxic or less-toxic materials, renewable energy systems, longer life, reusability, recyclability, biodegradability and so on.

In the procedure of processing raw materials, the energy is used to some extent, which is called the “embodied energy”. Varying materials have different amount of embodied energy. For example, natural materials such as stone and timber have less embodied energy. Concrete, plastics and steel have higher embodied energy amount in the various construction materials. (Ayalp, 2012)

In the pre-building phase, waste reduction and pollution prevention should be seen as the highest priority. Interior designers should attempt to opt recycled contents and natural materials with embodied energy reduction. During the building phase, reduction in construction waste is what the construction team can achieve. Also using materials, they should also focus on energy efficiency, using non-toxic materials and materials that have longer life. In post-building phase, materials reusability, recyclability and biodegradability decide the interior environment’s sustainability level on material side. (Kim & Brenda, 1998)

Building material has a major contribution to sustainable building during the stage of construction period. In many sustainable characteristics of the material, life-cycle is an important assessment that evaluates material’s utility, maintenance and recycling capacity. The Sustainable Material Management Coalition (2014) claims: when we consider interior environmental effects, we often narrowly focus on one or two concerns, being guided by generic principles such as “recyclable,”
“biodegradable,” “recycled content,” “organic,” or “zero waste” that sometimes don’t offer us much understanding of the general variation of influence that the production, use, and management of products can entail. However, we can better understand the product and material by “life-cycle thinking,” which recognizes the significant of potential environmental effects at each period of a product’s life.

In Pearson’s (2014) statement, two free resources are available to help demystify life-cycle assessment (LCA) for different audiences. The Athena Guide to Whole Building LCA in Green Building Programs is intended to help designers understand LCA provisions across various rating systems and codes. The other one - Guidance on Life Cycle Thinking and Its Role in Environmental Decision Making explains life cycle thinking and provides examples of how LCAs can be used properly and how poorly chosen boundaries for this type of assessment can lead to misleading results. Both of them emphasize LCA’s potential to bring light to the environmental impact those material, products, or whole buildings may have, they also remind readers that LCA should be viewed as a limited estimating tool.

**Textiles and carpet**: “The perfect life cycle has come closest to being achieved by an upholstery fabric.” (Bonda, 2007) Nowadays, the textiles’ manufacturing process is more environmentally friendly and the textiles are designed to completely eliminate waste and toxins. Instead, they are environmentally optimized. One kind of textiles named Climatex textile is made out of biological nutrient, which can be decomposed into soil at the end of its life without toxins. Another example of environmental friendly
textile is the Interface Fabric’s Terratex fabrics which made of one hundred percent recycled contents or compostable materials. They meet or even exceed the industrial standards and still are considered as recyclable material. Commercial interior textures have various types and standards. Designers should pay attention to their environmental features and the products’ components. Lastly, it is essential to choose the most appropriate textiles for the commercial interiors.

A carpet is a category of textile floor covering made of pile attached in the back. It is usually made of wool or some other man-made materials such as nylon, acrylic, polyester and polypropylene. Carpet is often discarded before the product met its end life. There is a worldwide environmental group called fibers and carpet manufacturers who develop efficient ways to recycle these contents. Worldwide associations and carpet manufacturing companies have gradually been focused on improving the quality and sustainability of the carpet by producing reusable and recyclable carpets.

**Stone, wood and bamboo:** In the process of commercial interior renovation, it is preferred to use stone as building material. Stone is a durable, low-carbon, high-grade decoration materials, guiding fashion trend and beautifying the environment. In particular, it does not require kiln firing. Instead, only the harmless refine of the original stone is needed. Stone is recognized as low-carbon material in solving environmental pollution problems.

Wood, a harvested material that requires a minimum amount of energy-oriented processing, possess a low level of embodied energy comparing to other materials
such as plastic, concrete, steel or aluminum. Wood also does not release carbon
dioxide to the atmosphere unless it is burned down. Furthermore, wood as a
renewable resource, can easily to be found in nature and could be recycled after
construction. Wood products such as plywood, paper, and particleboard are used
extensively throughout the interior environment. (Kim et al., 1998)

Bamboo as a building and interior material, not only connecting human's living
and nature together, yet it also improves the relationship between nature and human
by building a low-carbon environment. Bamboo's feature of strength and stiffness is
the most balanced out of all material. Bamboo is known for its high durability
and preservation with another feature - bending. As a result, it can be bended into
other shapes besides its original still shape. (Janssen, 2000) Due to its strength and
stiffness characteristic, bamboo has a fabulous quality of anti-seismic. From evidence
in April 1991 shows that an approximately 7.5 Magnitude earthquake can even not
destroy 20 bamboo houses. Also, as a fast-growing material, bamboo has recycling
capability. Such characteristics above make bamboo sustainable.

**Plastic decorative panel**: Decorative panel is a light-weighted, strong,
sound-insulated, transmitting, fire-insulation, flexible and easily installed material. The
promotion of plastic decorative panel not only replaces the traditional consumption of
disposable resources of interior materials yet it also creates harmony in the
environment when meeting the modern decoration. In general, plastic decorative
plate is widely used in modern architectural and interior decoration. Its sustainability
embodies three aspects. First, it can substitute for those raw materials that are energy consuming or scarce. Second, it is safe and clean. Lastly, due to its characteristics such as lightweight and easy to furnish, using plastic decorative panel saves money on transportation and installment. (He, 2013)

**Interior greenery**

There is no doubt that interior greenery is one of the sustainable features in indoor environment as it cleans and improves air quality. Indoor plants can alleviate many problems of indoor environmental quality (IEQ), and hence facilitate good health of interior occupants. Also by providing a more appreciate indoor environment, greenery creates a more relaxed and comfortable interior space for the building occupants.

By its own ecological characteristics, greenery can regulate the indoor climate, purifying the interior environment. It can also help to adjust the indoor temperature and humidity with cost saving on electrical billing. Furthermore, plant can absorb or mitigate pollution. Almost all the plants can absorb a certain amount of toxic gases. By absorbing the toxins, it reduces the density of indoor air toxic gases and decreases the harmful degree. By adsorbing particles inhaled in the air, greenery ultimately can motivate interiors achieve goals of clean air.

When indoor plants are decorated besides the window or the doors, they act as an effective barrier to prevent voice transmission, block sunlight and absorb radiation of the sun. If the interior greenery is put around the electrical furniture, it can absorb
electromagnetic radiation produced by household appliances so as to reduce radiation damage to human bodies.

**Indoor environment and air quality**

**Passive natural ventilation:** Ventilation is another kind of indoor air purifying method, eliminating indoor heat. It is one of the most economical and effective dehumidifying means. Ventilation means is divided into two kinds: natural ventilation and air conditioning based ventilation. Under the guidance of green and sustainable design, designers should choose natural ventilation as long as they can. Natural ventilation’s biggest advantage is that when indoor air quality is improved, the dependence on air conditioning systems is also reduced. Meanwhile, it reduces energy consumption and improves indoor air quality. Effective natural ventilation devices generally are as follows: First, the windows direction and the wind direction is consistent, making the maximum use of natural wind. Second, increase the openness of the interior space; as such space design is in favor of lighting and air permeability. Lastly, ventilate through apertures in the walls at the corner, which can increase the indoor air circulation to some extent.

Passive ventilation design forms relaxed and comfortable commercial interior environment. It acquires natural wind instead of mechanical equipment. (Zhang, Wu, Jiang, Liu & Zhou, 2010) During this ventilation period, not only the energy consumption of the interior is decreased, but a better thermal-controlled environment. While traditional interior ventilation by windows and doors has some disadvantages
such as letting in polluted air, noise and dusts to interior building. There is a new method of passive natural ventilation by equipping a ventilation device. Ventilation device is composed of one two-layer pipe buried in soil. One side is installed with an exhaust outlet pipe and the other side is a fresh air inlet pipe. The ventilation device is painted dark to motivate absorbing solar energy and increasing pressure and contributes to ventilation. (Zhang, et al., 2010)

Figure 2-2: Pebble layer ventilation principles in winter and summer
Figure 2-3: Oxygen-enriched air conditioning system

**Heating, cooling, insulation and HVAC system:** Heating and cooling is significant to commercial interiors due to its adjustable capability of indoor temperature.

Insulation stops hot air penetrating through the wall and keeps constant temperature in the interior. Surrounding temperature can impact the comfort of building occupants. In order to design a better heating, cooling and insulation environment, designers should consider the use of Heating, Ventilation and Air Conditioning (HVAC) system. HVAC is particularly important in medium to large commercial, industrial and office
buildings with regulating temperature and humidity.

Figure 2-4: Components of Horizontal Flow Forced-Air Systems
Source: University of Kentucky, Heating, Ventilation, Air Conditioning (HVAC)

Figure 2-5: Sealed Mechanical Room Design
Source: University of Kentucky, Heating, Ventilation, Air Conditioning (HVAC)
**Health and toxins:** Air quality has directly impacts on human’s health. Interior designers are highly responsible for environmental and social sustainability, living safely as well as reducing toxins in interior environment. Biological, chemical and physical toxins constitute the indoor toxins. Biological toxins mainly are fungi, bacteria, viruses and bioorganic ingredients. As respiratory infection bodies, they hide in conditioner pipes and many other dusty corners, also causing skin diseases. Chemical toxins are over 500 kinds of harmful compounds such as formaldehyde, benzene, ammonia, radon, vinyl chloride and heavy metals, causing indoor health risks. In addition, toxic gases can be relieved from some furniture greatly impacting human health. Other typical physical toxins are noise pollution, light pollution, electromagnetic pollution and radioactive substances. (Sun, 2013)

**Humanization and comfort**

Humanization and comfort mainly refer to designing for human, feeling comfortable in listening and in visualization. Commercial interior design can be viewed as a piece of artwork. The concept of "humane" is the key to succeeding the interior design. With the emergence of new business models, commercial interior design has evolved with change and requirements in design concept, content, functionality, form and features. Business model typically is the driver to the content, ideas and other aspects of commercial interior design. Emphasizing the design of humanity is based on the study of consumer psychology and corporate culture. In
order to achieve social sustainability, designers should enhance the humanization and coordination content, truly giving people physical and psychological care and comfort. (Liu, 2005)

Furthermore, humanization also refers to as living environment of minimal voice pollution and light pollution. This is a part of social sustainability.

**Safety and security**

Barrier free design and fire control attract more designers’ attention in the recent years as human privilege and personal safety has become part of design requirement. As for barrier free design in U.S., designers emphasize more than designers in overseas. However, an overwhelming idea of barrier free design for disabled people propagates in most regions in overseas. Accessible design purpose is to meet the requirements of mobility of the elderly, disabled and other mobility-suffocated people. Simultaneously, it ensures the mobility of children, and pregnant women without security risks. Throughout the design process, the sense of innovation and humanism love is sufficiently incarnated, which is exactly social sustainability. Fire control and safe exits are equally important to sustainability. (Jian, Hui, Zhao & Lifeng, 2011)
CHAPTER 3
METHODOLOGY

Research purpose

The purpose of this research is to determine what features contribute to sustainability in the commercial interior environment. Additionally, this research also finds out the differences between the sustainable practices and sustainable theories, and reasons behind the variation. The research explores the common and different sustainable features, as well as some common and different practice reasons, in order to give readers a better sense of sustainable commercial interior environment and to motivate interior designers to design in a sustainable way.

Research overview

Two case studies are selected in Shenzhen, China and Orlando, Florida, USA. The research is conducted by using collected information from the case studies. The two cases in China and USA are commercial interior projects respectively designed by Steven Holl Architect and Perkins + Will. The following methodologies including features observed in two case studies, interviews of the designers and observation of LEED on the percentage of the sustainable components, analyze these commercial interior spaces.

The following projects in China and USA have been selected:
1. Darden’s RSC, Orlando, USA
   Commercial interior – office

2. Vanke Center, Shenzhen, China
   Commercial interior – office

**Case study in Orlando and Shenzhen**

Two case studies of which one is in Shenzhen and the other is in Orlando are chosen due to their similar attributes - two of the top 100 prosperous cities in the world. The projects are Darden’s RSC in Orlando and Vanke Center in Shenzhen. The case studies are to analysis energy-efficiency features, sustainable materials, ventilation, and strategies of using natural energy instead of electricity. In addition, they are compared to each other and I conclude their common characteristics. From the data gathered by case studies, we can find out that sustainable features can save the specific energy consumption, as well as the similarities and differences among sustainable commercial interiors. Analysis procedure is below as figure 3-1 shows. Together with the information filtrated from three methodologies, a conclusion on sustainable features can be drawn after analysis.
Interview

Interviewing the designers and experts of the chosen case studies is important because the professional persons know about the energy consumption, technological innovations, and lighting information about the interiors as well as their cost, restrictions of construction, and many other practical information. For these interviews, information can be gathered about the sustainable commercial interior features, strategies design teams have tried to contribute to sustainability, and the reasons why practices vary of these projects.
I interviewed the interior designer of the Darden’s RSC, Joyce Fownes, the Principal of interior department of Perkins + Will in Atlanta. “As Interior Design discipline leader and the Corporate + Commercial + Civic market sector leader for the Atlanta office, Ms. Fownes has been instrumental in creating an organizational model that effectively incorporates interior design as an integral part of all architectural and interior projects. She has been responsible for building on this concept to broaden market focus and, through her unflagging commitment to the team approach, has facilitated the growth of the interiors discipline that supports all market sectors within an interdisciplinary approach.” (Perkins + Will, 2015)

During the interview, Ms. Fownes gave the best answers of 7 fundamental questions about sustainable interior features and 4 deeper questions about the “soft” side of the project. Ms. Fownes shared her insight on the sustainable interior design and on the applications of Darden’s RSC, one of the chosen commercial interior spaces for case study.

The second interview was processed from July 8th to July 10th in the year of 2015. In the interview, Mr. Zhang Bo, an interior designer, researched Vanke Center before, and knew Vanke Center project well was interviewed. His answers gave readers a clear sense of Vanke Center’s sustainable design strategies and helped figure out how Vanke’s sustainable commercial interior practice differed from the others.
CHAPTER 4
CASE STUDY AND INTERVIEW

Darden’s Restaurant Service Center (RSC), Orlando, the U.S.

Case study

Introduction and background

This case study explores Darden’s RSC (Restaurant Service Center), which is a 469,000 square-foot building located on a 57-acre, park-like site at the southwestern point in Orlando, Florida. The corporate headquarters of Darden’s RSC combine over 1300 employees and 6 distinct restaurant brands into a single 3-story building. Perkins + Will, the global sustainable design company that manages Darden’s RSC, claims that Darden’s headquarters are “not a landmark building, but a beautiful object in a park.”

By developing the concept of sustainable design, saving energy, and protecting the natural environment, Darden’s RSC has been awarded the "People's Choice" award in the first Lifecycle Building Challenge national competition. It was also awarded the Gold certification for leadership in the Leadership of Energy and Environmental Design (LEED) for New Construction (NC) by the United States Green Building Council (USGBC). As a result, Darden has proved to be one of the top LEED Gold NC buildings in Florida. (Perkins + Will, 2009) Darden aims to offer a big space for sustainable living and working that cultivates activities, and provides connectivity between the built environment, the natural environment, and the interactions among
occupants.

**Sustainable features**

**Space**

Space design in Darden Restaurant RSC is excellent making the most of sunshine reflection and wind to light the interior and ventilate the indoor space. A large and continuous space not only provides occupants with a broad horizon, but it also takes advantage of natural resources to save energy. In the center of the building, the hollow three-story hall is thoroughly lit by sunlight through a large skylight. Such an open design enables air to circulate more effectively throughout the entire space.

On the upper two levels, the office space is primarily accessed by enclosed stairs that offer favorable views and natural lighting to encourage employee use. Each office contains a chassis-based central core arrangement that allows for an open office environment that has easy access to natural daylight and favorable views. Thus, the excellent space design of Darden decreases energy consumption.

Figure 4-1 Space design in Darden’s RSC interior environment
Source: http://www.disdyn.com/2012/12/darden-restaurants/
Energy

Another sustainable factor that is worth mentioning is the energy feature. Building orientation, high-performance glazing, and lighting controls work together to reduce load on the cooling side. Efficient centrifugal chillers and energy recovery units were utilized to precondition outdoor air and cool the building and the adjacent data center, which decreases energy consumption by natural means. Another vital way to sustain the interior environment is the high-efficiency HVAC system with energy recovery units, efficient ambient task lighting, high-performance glazing, and a high albedo roof, all of which are incorporated to reduce overall energy consumption.

Darden’s HVAC system is composed of a chiller plant that includes chillers, cooling towers, pumps, ancillary equipment, all air handling units, terminal boxes, kitchen hoods, air to air energy recovery equipment, exhaust fans, controlling sequences, and all associated controls. Digging into Darden’s energy saving strategies, Indoor Hot Water system and equipment, as well as Lighting Control System are two fundamental ways to ensure the right utilization of energy. Additionally, it offers an Emergency Power System with fuel powered backup generators and automatic transfer switches.

To manage refrigeration for Darden’s RSC, the design team at Perkins + Will provides three highly efficient chillers to support the cooling system of the corporate headquarters. Their refrigerant does not contain chlorofluorocarbons (CFCs) and this minimizes their influence on global warming and climate change. In order to optimize energy performance in Darden, designers use an energy-efficient interior lighting
system for an overall 16% reduction in energy usage. The energy-efficient lighting system contains electronic ballasts, high performance lamps, occupancy sensors, and natural daylighting. Aside from increased equipment, duct and pipe insulation helps optimize Darden’s energy performance.

According to Darden’s 2013 statements on the concept of sustainable design, the main building has the following cutting-edge energy efficient features: First, Darden has a building orientation and U-shaped floor plan that limits western exposures to reduce the absorption of heat from the afternoon sun. Second, Darden has a floor-to-ceiling glass exterior that maximizes natural light to save energy on lighting, and this also keeps employees connected to nature. Third, high-performance windows let in more daylight and less heat. Fourth, Darden implements high-efficiency heating and cooling systems, which include a chilled water plant, energy recovery units, variable speed motors, and a computerized building management system that monitors and controls the mechanical and electrical equipment. Additionally, a highly reflective and insulated roof reduces heat absorption and cooling costs. Motion sensors that turn off lights save a lot of energy when rooms are unoccupied. Finally, a daylight harvesting system that monitors natural light levels, automatically dims artificial lighting to appropriate levels in order to reduce energy consumption.

**Interior water**

Interior water use for Darden’s RSC is also sustainable. Darden uses reclaimed
water to flush all urinals and toilets. All restroom sinks are equipped with automatic sensors that can control the amount of water used for flushing each time. Rainwater is a principal freshwater resource, so the ability to take advantage of it becomes an important aspect in sustainable management of water usage. Darden uses a storm drain system to make use of bioswales and pre-filter the runoff water on site. This runoff water, as well as the reclaimed water, is gathered in a storage tank, and piped to flush and flow fixtures by a four-pipe water transport system. Also the system filters out contaminants and recharges the groundwater.

Using these methods, the estimated annual potable water consumption can be reduced by as much as 1.8M gallons.

Material

More than 10% of Darden’s materials are manufactured from recycled materials. More importantly, 20% of these new materials can be reused and recycled once they are disassembled. For example, wood, glazing, steel, and some textiles are recyclable contents. Office furniture contains 100% recycled particleboard, up to 25% recycled aluminum, and up to 30% recycled steel. By interviewing Ms. Fownes, the principal of the interior department of Perkins + Will in Atlanta, I was informed that carpet, a major component of the projects office space, is a kind of recycling component. At the time, there was not as much available in other building products as there are now. Darden implements a recycling program at building occupancy to achieve environmental sustainability through material strategies.
Waste reduction

Darden separates and recycles construction debris, diverting more than 90% of the construction debris (equal to 2060 tons) away from the landfill, and diverting almost 12 tons of garbage away from the landfill through a single-stream recycling system. In addition, RSC comports food waste from the cafeteria, and advocates use of double-sided printers and copiers to reduce paper consumption. Teamwork, supervision, and dedication were paramount to the team’s success in surpassing the 75% threshold for both points attributable to this credit. Over 88% waste and debris were diverted away from the landfill.

Figure 4-2 Materials in Darden’s RSC interior environment
Source: http://perkinswill.com/work/darden-restaurants%2C-inc..html

Air quality

Since air quality is a vital factor for the health of the building occupants, it is emphasized in the interior design process. Darden also paid close attention to air quality adjustment. When choosing interior materials for decoration, low violate
organic compound (VOC) carpet, paintings, furniture, sealants, moveable walls, and many other interior materials are not opted for because they have a negative impact on environmental sustainability indoors and they harm building occupants’ health to a large extent. Darden is equipped with an air circulation system that circulates fresh exterior air to the interior space every hour. High-efficiency particular air (HEPA) filters in the air pipes and air ducts minimize allergens and airborne viruses. As a result, the HVAC system supplies sufficient thermal comfort for the building occupants and reduced VOC products provide a healthy workplace for the visitors and occupants. Natural daylight covers 75% of the work environment, which not only provides a brighter natural workspace, but also cuts down on energy consumption in the daytime.

Social and workplace features

Darden was designed to benefit employee health and well being, promoting collaboration and effective teamwork. Introduced in Sustainability at Darden (2010), the following workplace related features contribute much to Darden’s social sustainability:

- An onsite wellness center and doctors’ offices staffed by Florida Hospital personnel provide social support for the employees.

- An onsite 5000-square-foot fitness center with locker and shower facilities available to RSC employees for $10 per month.

- A dining facility is operated by Guckenheimer, who is the industry leader in
corporate food service with a good mix of indulgent and healthy options, including an outstanding salad bar.

* A three-story building and numerous break room areas promote interaction among employees.

**Safety**

In order to guarantee the mobility of disabled persons, barrier free designs such as elevators and slopes are used in Darden’s RSC. Fire extinguishers have been equipped at each floor in Darden. Low-emitting materials, low or non violate organic compound (VOC) carpet, paintings, furniture, sealants, moveable walls, and many other interior materials have been rejected for ensuring the health of building occupants. Darden is equipped with an air circulation system that circulates fresh exterior air to the interior space every hour, which provides the interior environment with better air quality and ensures the wellness of the occupants.

**Innovation**

As Ms. Fownes mentions in the interview, the innovation points that are around health and wellness are the most important feature in this sustainable design project from the interior perspective. Darden project was started in 2008 and the concepts around health and wellness were implemented then. This was not something that the design community was talking about seven years ago. It is a major current topic. To make this innovation come true, the design team constructed a quarter-mile walking
trail around the building. They also built prominent and open staircases to encourage walking instead of taking elevators, increasing the rate of walking and promoting a healthier lifestyle. In addition, a three-story building design and numerous break room areas promote interactions among employees. All these innovations satisfy the natural, social, economical, and scientific attributes of sustainable design.

Interview

In this interview, Ms. Joyce Fownes, who is one of the principal designers of Darden’s RSC was interviewed. Ms. Fownes is also the Principal of the interior department in Perkins + Will, Atlanta. This interview was processed during June 8th to June 18th in the year of 2015. Her answers give a sense of the direction in which Darden’s sustainable design is formed and how Darden’s sustainable commercial interior design differs from the others.

Q: It is highlighted that 20% of building materials are recycled components. What are those materials if in interior space?
A: Typically carpet, which is a major component of the project’s office space. At the time, there was not as much available in other building products like there are now.

Q: What do you think is the most important feature in this sustainable design project from interior perspective?
A: The innovation points that are around health and wellness. This project was started in 2008 and the concepts around health and wellness were imbedded then. This was not something that the design community was talking about at the time (this is a major current topic). This was seven years ago.

Q: What is the restaurant’s most notable sustainable characteristic compared to comparable projects?

A: It’s the integration and culmination of all of the sustainable characteristics that other firms/clients may not consider because the perception is that it will be too expensive. This is not the case. If we design smart starting at the site and the building orientation, all follows from there (or should).

Q: What are the decisive factors that make you and your team design in that way? (Economic consideration, local material, owner’s demand…)

A: Really it is part of our DNA and the foundation of who Perkins + Will is. We design for the broader goals of society which means that we want to help RESTORE, our environment as well as protect it. Our challenge is to be carbon neutral with our buildings by 2030. We measure ourselves every year on moving forward with this accomplishment.

We really research all of the best approaches to site, building orientation, systems and materials through the design process. Technologies change, so PVs may be more cost effective now but also require a lot of surface area. LED lighting is
another feature that we WOULD have used if it had been effective and cost effective
at the time. So, the long and short of it is, we run everything to ground and weigh out
the cost benefit analysis for all clients as we move through the design process.

Before answering these questions, Ms. Fownes offered some other materials
and information about her design team’s sustainable theories and strategies. The
information is attached in this paper. The attached materials answer the interview
questions below:

Q1. What interior features do you think contribute to Darden’s sustainability?

Q2. What kind of techniques and innovations do you use when designing Darden’s
interior space?

   a. Lighting
   b. Material
   c. Air (Ventilation, Filtration, HVAC systems, Heating and cooling, air quality)
   d. Interior greenery
   e. Water
      (Water conservation: flow restrictor, dual flush toilet and low flow urinal)
      (Water reuse, rainwater, gray water, reclaimed water)
   f. Humidity and climate comfort testing tools
   g. Other innovations

Q3. Can you introduce Darden’s lighting system and its energy conservation
strategies?
Q4. What sustainable materials do you use when designing Darden’s RSC?

Q5. What sustainable strategies do you use on saving water?

Q6. What sustainable strategies do you use on air quality?

Q7. What sustainable strategies do you use on heating and cooling?

Ms. Fownes’ answers are closely related to the design practices and applications that differ from sustainable commercial interior features. Meanwhile, the answers expose some rational reasons as to why these practices vary from sustainable theories.

In conclusion, sustainable commercial interior features can be gathered through the case study and related interview of Darden’s RSC: space, energy, water, material, waste reduction, air quality, occupants’ comfort, safety, and innovation.

As for the practical reasons why Darden’s design application is unique from other projects is mainly because of the following aspects:

• The innovation points that are around health and wellness.

• It’s the integration and culmination of all of the sustainable characteristics that other firms/clients may not consider because the perception is that it will be too expensive.

• Perkins + Will’s design DNA.

• Research all of the best approaches to site, building orientation, systems and materials through the design process.

• Technologies change.
• Cost benefit.

• Clients’ benefit - Weigh out the cost benefit analysis for all clients.

Vanke Center, Shenzhen, China

Case study

Introduction and background

Located in Yantian District, Shenzhen, the Vanke Center has a total construction area of 80200 square meters. As an independent and complex mixture, the building itself includes the Vanke headquarters, apartments, hotels, SOHO apartments, condominiums, an international conference center, and many other relative functions.

Vanke Center was designed by Steven Holl Architects, and was a winner of the Institute Honor Award for Architecture in 2011. It is also called the “horizontal skyscraper” because the architects connected several multi-function buildings together in a horizontal manner; columns support the whole building. As a result, the Vanke Center retains the natural exterior environment. Because of the project's unique architectural and structural designs, the columns support 4-5 layers in the building, which makes it the world's first “house built on a cable-bridge” design concept. The Vanke Center has courtyards, water landscape, green spaces, and natural hills maximizing the open space and providing an excellent environment for the employees and visitors.

Under the standards of sustainable design concept, the Vanke Center headquarters benefit from a raised base by incorporating daylighting, skylights, and
many other sustainable design components. Without a doubt, Vanke Center has become the first LEED Platinum certified building in southern China.

**Sustainable features**

Figure 4-3 Space design, energy, water and materials in Vanke Center interior environment
Source: http://www.viewpictures.co.uk/Details.aspx?ID=152913&amp;TypeID=1
http://en.urban.pkusz.edu.cn/index.php?m=content&amp;c=index&amp;a=show&amp;catid=1219&amp;id=114
https://www.flickr.com/photos/aiational/5343397870

**Space**

Interior design in the Vanke Center project is worth appreciating due to its combination of art and sustainable design concepts. Homogeneously interspersed sections, such as various spaces in the rectangular “box,” make the space interesting and continuous. In this long and narrow space, almost all of the walls are angled toward to the floor. And from the top to the very bottom, the width of the interior spaces and the brightness of the indoor environment vary considerably. As for the lighting design, this kind of narrow and long space is more conducive to reflecting natural light as well as promoting indoor ventilation. Like a natural vent, a long and narrow space generates more natural-wind suction because of the differences between indoor and outdoor air pressures when the wind passes through. Designers
hope that the natural lighting could be mixed with direct and indirect lighting to form natural and comfortable lighting effects. Such interior design not only meets the requirements of natural lighting, but also greatly increases the natural ventilation, allowing the building to fully meet the LEED platinum certification requirements of at least 75% daylighting.

Energy

The air-conditioning system has a more developed ice storage system. Ice is made at night when electricity usage is at its lowest point in the day. However, when electricity usage is at its peak in the daytime, the ice is used to cool the interior environment. This method takes advantage of the price differences between using electricity at night and using electricity in the daytime.

The interior and exterior shading system uses glass curtain walls, horizontally fixed shading panels, and electric sunshades, which allows for sufficient indoor lighting and a comfortable interior temperature without using much electricity. Electric sunshades can automatically adjust the visor angle depending on the sun’s altitude, and this ensures that the indoor lighting and indoor temperature is kept at an optimal level. In the summer, when the visors are closed, the Vanke Center can meet the lighting needs for 90% of the interior spaces without the use of artificial lighting. (Li, 2015)

When it comes to solar energy, the Vanke Center utilizes the most efficient photovoltaic technology. The total area of the solar photovoltaic panels mounted on
the roof is approximately 4000 square meters.

The interior lighting system is also designed to save energy. The electrical system at Vanke Center is always yielding to the use of natural lighting. However, when using light bulbs, indoor lighting is controlled: motion sensors can detect a person’s movement throughout the building. When people leave, the sensors turn the lights off automatically, and vice versa.

In the offices and meeting rooms, energy efficient lighting equipment is used, including T5 fluorescent lamps and LED lights. Additionally, the use of intelligent lighting control systems, which integrate dimmers, motion sensors, timers, and other features, contributes to the conversation of energy in the interior space and promotes environmental sustainability.

**Interior water**

In order to improve the conservation of water resources, the Vanke Center recycles all otherwise wasted water. Through biodegradation treatment that uses artificial wetlands, Vanke then uses this treated water for local irrigation and other purposes such as cleaning, flushing, and flowing. The daily water treatment capacity can reach 100 tons per day.

In the interior building environment, Vanke utilizes advanced water-saving appliances and conservation methods; a few examples include using low-flow toilets and waterless urinals to flush, and utilizing automatically controlled low-flow faucets, efficient showerheads, etc... Sewage and rainwater can be harvested on the roof
using a water collection system.

**Material**

In interior spaces, designers mostly use bamboo instead of wood. Bamboo is a fast-growing plant that has a better ability to sequestrate carbon than wood, and is plentiful in most regions in China, especially along the Yangtze River. Also, the office furniture, doors, and tables are also made of bamboo. As is known to the public, excellent bamboo-derived products can last for 15 years, and most of them are very cheap. The Vanke Center is constructed with numerous renewable materials, as well as wooden materials certified by the international Forest Stewardship Council (FSC). Meanwhile, Vanke makes good use of local materials within a radius of 500 miles, greatly reducing energy consumption and transportation costs.

Furthermore, the 200mm aerated concrete wall, the 150mm overhead reinforced concrete floor, adjustable aluminum-alloy visors, and hollow double-layers glass all provide the Vanke Center with better insulation.

**Waste reduction**

According to the standards given by LEED certification, the Vanke Center has satisfied the requirements of construction waste management, which requires that 75% of waste be diverted from disposal. Meanwhile, Vanke has 10% recycled content as well as rapidly renewable materials such as bamboo and wooden furniture. Carpets are recyclable materials that can be reused, and therefore they generate no waste in
their lifecycles.

**Air quality**

As is mentioned in the "space" part, the building structure and interior space is well designed for ventilation. Long and narrow spaces mitigate the barriers in between, providing a natural ventilation passageway, and to a large extent this increases indoor air quality. Also, Vanke headquarters in Shenzhen are equipped with an outdoor air delivery monitor, which is an increased ventilating method that enhances interior air circulation. Moreover, low-emitting materials in paints, coatings, and composite wood and agrifiber products make the interior air fresher and safer.

The air-conditioning system contains an ice storage system. The benefits of this ice storage system are that a lot of energy can be saved and the air quality, interior temperature, and humidity can be controlled to provide a more comfortable environment.

**Interior greenery**

The design team pays close attention to refreshing the indoor air by planting trees and interior greenery. In office areas, large numbers of plants are placed beside the office tables. In addition, some negative spaces such as building corners or leaning walls can benefit from bamboo plants. The following two pictures set good examples of the Vanke Center’s interior greenery efforts.
Safety

Low-emitting materials in paints, coatings, and composite wood and agrifiber products make the interior air fresher, safer, and greatly benefit the health and wellness of the building occupants. Indoor chemical and pollutant source control has the same effect as the low-emitting materials. The barrier free design enables disabled occupants to have full mobility around the building, and the fire control system guarantees the safety of the occupants and social sustainability.

Innovations and technologies

The Vanke Center's technological breakthroughs and innovations are showcased in the building design itself. The designer, Steven Holl once said: “For me, emphasis on eco-building concept is not a command or requirement. In contrast, it has already become my instinct when thinking about design issues.” In the interior environmental design process, technology and innovation play an extremely
important role.

There is a keen innovation in the use of shading. In order to allow the shades to filter out heat from the sunshine while simultaneously letting in sunlight and wind, the famous German company named Transsolar designs them based on the concept of dendritic orientations. (Zhu, 2011) Transsolar pays close attention to the elevation angle of the sun throughout the year, and they combine this with shading strategies including the vertical fix, the horizontal fix, and electrically adjustable handles. When the sunshine is introduced into the room through the blinds, some lively and mottled patterns are left on the walls and floor, creating beautiful interior scenery.

Also, the air-conditioning equipment that utilizes an ice storage system is another innovation in Vanke design. Last, but not least, the use of fast-growing plants such as bamboo is very unique in constructing a natural and comfortable living/working environment for the occupants.

Interview

In the interview, Mr. Zhang Bo, an interior designer, researched Vanke Center before, and knew Vanke Center project well was interviewed. This interview was processed from July 8th to July 10th in the year of 2015. His answers gave readers a sense of Vanke Center’s sustainable features and Vanke’s practical reasons why it differed from the others.

Q: What do you think is the most important feature in this sustainable design
project from interior perspective?

A: The most impressive spot is the water recycling system and the use of fast-growing material. Firstly, there is a fundamental aspect of the water cycling system. Interior water recycle system is combined with the whole building and landscape’s water environment to improve the overall water cycling process. Simultaneously, designers fully take the geographical advantages of Shenzhen into account because there is abundant rainfall in the city of Shenzhen. This water strategy has considerable implications for the ecological and sustainable development for Vanke Center in the future.

Secondly, the utility of fast-growing materials is another specialty. Just like Chinese architect Wang Shu always advocates, renewable materials should be more used in applications. In Vanke Center headquarter, the use of bamboo instead of wood and timber is an upscale interior design breakthroughs and innovation.

Q: What is Vanke Center’s most notable sustainable characteristic compared to comparable projects?

A: The interior shading system. The interior shading system is divided into glass walls and blinds. Blinds are meticulously designed with the consideration of the integrated sun elevation angle in Shenzhen, providing the most comfortable lighting condition for the interior environment.

The curtain wall. Because air circulation, sunshine and many other exterior components should interact with the interior contents through the curtain walls, and
walls also decide insulation, energy storage and loss. Vanke has a relatively high-integrated curtain wall system.

Vanke center is designed in an international perspective, being around the cultural brand of Vanke center. It has its own original and unique features either in interior design and building design. Additionally, based on its location, climate condition and landscape feature, Vanke Center not only shows the designers’ international vision, but also reflects the Chinese characteristics and regional advantages.

**Q: What are the decisive factors that make the designers design in that way?**

A: A comprehensive consideration of economy, building space, function and aesthetic requirements. However, the main consideration is the customer’s needs and understanding the customer’s demand. Vanke center design is based on Shenzhen’s economic, social, cultural and environmental conditions. In addition to the basic design concept of environmental protection, Vanke Center sufficiently refers to the traditional Chinese thought of “Man and Nature”. So in addition to the ecological design concept, the needs of the customers and the development of culture are taken into account.

Mr. Zhang’s answers revealed Vanke Center’s design practices and the reasons why these practices varied from the sustainable theories, which is analyzed blow.

In conclusion, from the case study and the related interview of Vanke Center,
sustainable commercial interior features for this project can be concluded as the following ones: space, energy, water, material, waste reduction, air quality, interior greenery, safety, technologies and innovations.

As for the practical reasons why Vanke Center’s design application is unique compared to other project is mainly because of the following aspects:

- International perspective
- Location
- Climate condition
- Regional advantages
- Economy
- Technical capacity
- Building space and function
- Aesthetic requirement
- Customer’s demand
- Economic consideration
- Social consideration
- Cultural consideration
- Environmental conditions

**Conclusion**

After researching two commercial interior case studies: Darden Restaurant Service Center and Shenzhen Vanke Center, their sustainable features and practices
are figured out and listed in the “case study” and “interview”, followed by the emphasis of reasons why these sustainable practices differ. In the following chapter, comparison between these two study cases and interviews is processed to analysis the research results related to sustainable features and applications.
CHAPTER 5
DISCUSSION AND ANALYSIS

Case Study Comparison

Table 5-1 shows some differences between the sustainable design and sustainable features of Darden RSC and Vanke Center mainly based on case study. This comparison is also relative to the interview questions (Q1-Q7) shown in Appendix A and B.

<table>
<thead>
<tr>
<th></th>
<th>Darden Restaurant Service Center</th>
<th>Vanke Center</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Orlando, the United States</td>
<td>Shenzhen, China</td>
</tr>
<tr>
<td><strong>Design team</strong></td>
<td>Perkins + Will</td>
<td>Steven Holl Architect</td>
</tr>
<tr>
<td><strong>LEED certification</strong></td>
<td>Gold</td>
<td>Platinum</td>
</tr>
<tr>
<td><strong>Floor count</strong></td>
<td>3 floors</td>
<td>4-5 floors</td>
</tr>
<tr>
<td><strong>Floor area</strong></td>
<td>469,000 square feet</td>
<td>1,296,459 square feet</td>
</tr>
<tr>
<td><strong>Completion</strong></td>
<td>2009</td>
<td>2009</td>
</tr>
<tr>
<td><strong>Principal use</strong></td>
<td>Office</td>
<td>Office, apartment, hotel, condominiums</td>
</tr>
<tr>
<td><strong>Sustainable features</strong></td>
<td>Space, energy, interior water, material, waste reduction, air quality, social and workplace features, safety innovations</td>
<td>Space, energy, interior water, material, waste reduction, interior greenery, air quality, safety, technologies and innovations</td>
</tr>
<tr>
<td><strong>Difference</strong></td>
<td>Social and workplace features</td>
<td>Interior greenery</td>
</tr>
</tbody>
</table>

Table 5-1 Comparison of case study

Sustainable commercial interior features

As is seen from the table, first of all, the general information and site conditions of these two projects are different. Darden's RSC is located in Orlando, which is one of the top 100 economic advanced cities in the world. Similar in the world rating but different in location, Shenzhen, which is in the southern China, offers a great site to
Vanke Center. As one of the top 100 advanced cities in the most potential advancing country, Shenzhen has different site and climate conditions from Orlando that causes practice diversities to some extent. These diversities are analyzed in the interview comparison table. Darden’s RSC is designed by a worldwide famous sustainable design company: Perkins + Will. The building is with 3 floors and 469,000 square feet area, and was completed in the year of 2009. Serving as an office building with restaurant in for Darden’s employees, Darden’s RSC is certificated the Gold in LEED by USGBC. It deserves to be an excellent sustainable building in the United States. Designed by Steven Holl Architect and was completed in the same year as Darden’s RSC, Vanke Center has approximate 3-time-bigger floor area and LEED’s Platinum certification, being a notable sustainable building in China.

Second, as for the various sustainable commercial features of these two commercial interiors, the common components are listed: space, energy, interior water, material, waste reduction, air quality, safety and innovations.

Broad and continuous space not only provides occupants a broad horizon, but also takes good advantage of natural resource saving quantities of energy both in Darden’s RSC and Vanke Center. Energy strategies such as building orientation, high-performance glazing, efficient centrifugal chillers and lighting controls make energy more efficient. For interior water usage, utilizing reclaimed water to flush urinals and toilets and equipping restroom sinks with auto sensors that control the amount of flushing water for each time, are beneficial to water conservation. Rainwater is a significant freshwater resource, so Darden and Vanke take advantage
of this resource to save water and increase the water efficiency.

Additionally, they both utilize renewable materials as well as wooden materials certified by the international Forest Stewardship Council (FSC), and renewable furniture including carpets. By applying renewable materials and resources, Darden and Vanke have both reduced 75% building waste or even more. Moreover, low-emitting materials in paints, coatings, and composite wood and agrifiber products make the interior air fresher and safer. Combined with high-level ventilation system, air quality in these two projects reach a high standard. The humanized features in the both of Darden and Vanke are embodied in air safety, barrier free design for the disabled and fire control for the building. Above all, it is the innovation supported by technology that makes the entire design concept come true.

Features synthesized above are common features to these two sustainable design projects. Nevertheless, there still are differences. Seen from Table 5-1, Darden is specialized in social and workplace features while Vanke has its unique feature of interior greenery. Darden benefits employee health and well being, promoting collaboration and effective teamwork. It has an onsite wellness center and doctors’ offices providing social supports for the employees. It also has an onsite 5000-square-foot fitness center, a dining facility, a three-story building, and numerous break room areas promoting interaction among employees. In contrast, Vanke Center’s difference lies in interior greenery. A large number of plants are introduced in office areas at some spaces such as corners of the building.
Interview Comparison

Table 5-2 shows some differences in the sustainable practices and the reasons of the practice variation of Darden RSC and Vanke Center mainly based on the interview. This comparison is also related to the interview questions (Q8-Q11) shown in Appendix A and B.

<table>
<thead>
<tr>
<th>Most important sustainable features (Practice differences)</th>
<th>Darden Restaurant Service Center</th>
<th>Vanke Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical reasons</td>
<td>Health and wellness</td>
<td>Interior water (Water recycling system) Material (fast-growing materials) Energy (curtain wall)</td>
</tr>
<tr>
<td>Sustainable needs</td>
<td>Design DNA</td>
<td>International perspective, location, climate condition, regional advantages, building space and function, aesthetic requirement, customer’s demand, economic consideration, social consideration, cultural consideration, environmental conditions, technical capacity</td>
</tr>
<tr>
<td>Research results</td>
<td>Technology changed</td>
<td></td>
</tr>
<tr>
<td>Cost and benefit</td>
<td>Clients’ benefit</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>Design DNA</td>
<td>International perspective, location, climate condition, regional advantages, building space and function, aesthetic requirement, cultural consideration</td>
</tr>
<tr>
<td>In common</td>
<td>Customer’s demand and clients’ benefit, economic consideration/cost, social consideration, sustainable/environmental consideration, technical capacity</td>
<td></td>
</tr>
</tbody>
</table>

Table 5-2 Comparison of interview

Sustainable commercial interior practices

The most important features that the designers pay attention to are different, making the project applications and practices differ. What can be found in the case study of Darden’s RSC and Vanke Center are health and wellness of Darden and water, material, and energy of Vanke Center. Perkins + Will is proud of Darden’s sustainable feature of “health and wellness” (HW) and HW was a breakthrough in 7 years ago concentrating the building occupant’s physical wellness. Just as Ms.
Fownes said in the interview: “This project was started in 2008 and the concepts around health and wellness were imbedded then. This was not something that the design community was talking about at the time. This was seven years ago.” The feature of HW makes a big progress on social sustainability. Simultaneously, strategies used on improving “health and wellness” encourage energy saving, interior interaction and environmental sustainability.

Compared to Darden, Vanke Center’s design team is more concerned about water, material and energy. In order to be more sustainable, the design team innovates interior and exterior water cycling system including a wetland filtration system. In addition, fast-growing materials including bamboo are used in the interior space. The curtain wall, which is designed as leaves, contributes extremely to the building’s energy efficiency.

From the comparison, the social feature of concerning occupant’s health and wellness is a new finding. LEED focus more on environmental sustainability instead of social benefit. In contrast, another rating system named Well Building Standard, highlighting elements of air, water, nourishment, light, fitness, comfort and mind, is more similar to the feature of “health and wellness”. HW, a sustainable feature that ensures the human privilege, is a breakthrough in interior design.

**Practical reasons**

Digging into the reasons why these two projects differ from each other, some reasons can be found. What in common are the following reasons: Customer’s
demand and clients’ benefit, economic consideration and cost, social consideration, sustainable/environmental consideration, technical capacity.

Darden contributes the most to customer’s benefit. Ms. Fownes regards it as one of the most notable features of Darden’s RSC and it is also concerned in Vanke Center project. By offering strategies for occupants such as providing a hospital, a fitting center or a restaurant, occupant’s wellness can be guaranteed.

Economic consideration and cost benefit are significant to a project because even though technologies are available or design ideas are impressive, without the support of money, they cannot be realized.

Also, social consideration and environmental consideration have been taken into account. Darden is designed to benefit employee health and well being, promoting collaboration and effective teamwork. Vanke Center has the barrier free design for the disabled or who has difficulties in mobility and the interior fire control system are quite consummate, guaranteeing people’s privileges and social sustainability. Environmental consideration is revealed in the project’s attribute: they both are LEED certificated sustainable projects.

Technical capacity is fundamental as money and economic support. In these two projects, high-performance windows, high-efficient heating and cooling system, chilled water plant, energy recovery units, variable speed motors, highly reflective and insulated roof, motion sensors, daylight harvesting system, and other methods that improve building efficiency are based on technologies.

After analyzing the common reasons, the following paragraphs synthesize the
different reasons for Darden’s RSC and Vanke Center design. The reasons are: Design DNA, research results, international design perspective, location, climate condition, regional advantages, building space and function, aesthetic requirement, and cultural consideration.

Design DNA varies depending on the design team of a project. The design team’s DNA always motivates them to develop a project in their own ways. It is Perkins + Will’s DNA of sustainability that facilitates their successful commercial interior design of Darden. In addition, research process before design decides how many aspects will be paid attention to in a project due to the problems figured out in the researching process.

Location, climate condition, regional advantages, and cultural consideration are general site conditions. Although in the interview of Darden’s RSC, these factors are not mentioned, they are involved in the whole project. These refer to:

1. Under what circumstances can buildings and interior spaces be constructed?
2. What are the inborn advantages of the site of the project?

International design perspective and aesthetic requirement are higher aims of the design team of Vanke Center. By the concept of “horizontal skyscraper”, designers connect multiple building bodies together, being lifted by columns. Vanke Center becomes the world's first “house on a cable-stayed bridge”, an International scope of architectural design. Its curtain walls and window system generate mottled shades in the interior environment, not only reaching the standard of international level but also fulfilling the aesthetic requirement.
Labrador commercial interior project

Introduction

Labrador project is an urban planning and landscape design project. Commercial area as one of the site plans has been developed specifically. The Labrador commercial interior project site is located in the east of the Labrador site. The designed commercial building is with mix use of offices, stores, and a coffee bar and the sustainable interior space is a store selling art works and providing green open spaces to the public.

Design purpose

It is designed to explore the secrets hiding behind indoor environment, buildings, and outdoor environment, and to find out the connections among them, which create a livable and vibrant community. It also aims to building ecological linkages and circulations including water management, green infrastructure, green transportation, and bicycle lanes. Above all, researching the sustainable commercial interior environment in the project’s commercial area is the most significant purpose.

Site analysis

Labrador site is located near the Labrador Park in the southern Singapore and has good transportation conditions with 2 MRT stations. Singapore has a high density
of population of 7,713 people/Km2 (World Bank, 2015). Also, commercial centers near the site are prosperous. There are 2 commercial centers in the east and the west of the site.

**Design analysis**

The project aims to create a livable community as well as livable and sustainable commercial interiors. Based on the “cells in the green vein” concept, the Labrador commercial interior project has been developed as the pictures show in the following pages. The blue region is the commercial area, which is also the site of the commercial interior project. There is a commercial building with mix use of offices, stores, and a coffee bar and the sustainable concept is involved in a store selling art works and providing green open spaces to the public. After taking several practice concerns including customer’s demand, economic consideration, social consideration, environmental conditions and technical capacity into account, the interior project is designed under the concept of flowing space in the green vein.

There is a skylight and an open three-story hall that maximize interior daylighting as well as indoor ventilation. It is equipped with motional sensors, human body sense detectors, a high-efficiency heating and cooling system, and high-performance windows that let in daylight but not heat. Reclaimed water is used instead of portable water. Also, interior water system is combined with a stormwater system through green roofs and the water columns. Concerning the utilization of the materials, low or non-violate organic compound materials and recycled materials such as wood and
bamboo are the best choices for this store. The interior environment diverts more than 75% of construction debris away from the landfill via reuse or recycling. As for indoor air quality, natural ventilation is the best strategy. An opened skylight on the roof can absorb natural wind into the interior spaces and the 3-story floors that are central-opened are good for ventilation. Also low-emitting materials make the interior air fresher and safer. Additionally, vertical green walls on each floor can absorb carbon dioxide, and an open space on the top floor with a green roof refreshes indoor air.

In order to supply better social benefits to the building occupants, Labrador commercial interior design project has an on-site resting space, an on-site coffee bar, and a dining facility for resting and interaction among the occupants. Furthermore, there is no step in the interior spaces, which is a barrier free design for the disabled using wheels. And fire control system is for occupant’s safety. Last but the least, the project has 3 innovations including an open space on the top floor with a green roof, an on-site coffee bar with chatting areas and resting areas for the building occupants, and an open three-story hall with a skylight maximize interior daylighting as well as indoor ventilation. In conclusion, Labrador commercial interior project is proved to be a sustainable interior project with considering practical restriction and factors.
Site analysis

SITE ANALYSIS

Study Area

AREA: 746,000 m²
Perimeter: 4.06 Km.
Google earth 2015
Density of Singapore: 7,713 people/Km²

Existing Conditions:
- Berlayer Creek – mangrove preservation
- Bukit Chermin Hill – historical heritage
- 2 MRT stations

Labrador design project is located near the Labrador Park in Singapore. Its total area is 746,000 square meters and with a perimeter of 4.06 kilometers. There are three important existing conditions, which are mangrove preservation site along Berlayer Creek, a historical heritage site around Bukit Chermin Hill and 2 convenient MRT stations. Besides, Singapore has a high density of population of 7,713 people/Km² (World Bank, 2015).

Design concept

DESIGN ANALYSIS

Concept

"Cells in Green Vein"
Design analysis
**Practice concerns:**
customer’s demand, economic consideration, social consideration, environmental conditions, technical capacity, research results, international perspective, location, climate condition, regional advantages and aesthetic requirement.

**DESIGN ANALYSIS**
Commercial

**Introduction:**
This is a commercial building with mix use of offices, stores, and a coffee bar. The designed part is a store selling art works and providing green open spaces to the public.

**Concept:**
Flowing space in the green vein

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**LABRADOR COMMERCIAL INTERIOR DESIGN STRATEGIES**
Sustainable feature - *space*

- a skylight a hollow three-story hall and skylight maximize interior daylighting as well as indoor ventilation.
LABRADOR COMMERCIAL INTERIOR DESIGN STRATEGIES
Sustainable feature - energy

- motion sensors and human body sense detectors that turn off lights when rooms are unoccupied.
- a high-efficiency heating and cooling system.
- high-performance windows that let in daylight but not heat.

LABRADOR COMMERCIAL INTERIOR DESIGN STRATEGIES
Sustainable feature - interior water

- toilets and an irrigation system that use reclaimed water.
- restroom sinks with auto on/off sensors.
- interior water system combined with a stormwater system through green roofs and the water columns.
LABRADOR COMMERCIAL INTERIOR DESIGN STRATEGIES
Sustainable feature - material

- low or no-VOC paint, carpet, furniture, moveable walls, sealants and other building materials.
- 20% of various new materials can be reused and recycled once they are disassembled.
- renewable materials as well as wooden materials certified by the international Forest Stewardship Council (FSC).
- using fast-growing materials.

LABRADOR COMMERCIAL INTERIOR DESIGN STRATEGIES
Sustainable feature - waste reduction

- diversion of more than 75% of construction debris from landfill via reuse or recycling.
- More than 10% of materials are manufactured from recycled material.
LABRADOR COMMERCIAL INTERIOR DESIGN STRATEGIES

Sustainable feature - **air quality**

- natural ventilation.
- air ventilation system that circulates fresh outside air into the building every hour.
- low-emitting materials in paints, coatings, and composite wood and agrifiber products make the interior air fresher and safer.

---

Sustainable feature - **interior greenery**

- vertical green walls on each floor that absorb carbon dioxide and refresh indoor air.
- an open space on the top floor with a green roof.
LABRADOR COMMERCIAL INTERIOR DESIGN STRATEGIES
Sustainable feature - social and workplace

- an on-site resting space for interaction among the occupants.
- an on-site coffee bar for the building occupants, including chatting areas and resting areas.
- a dining facility.

LABRADOR COMMERCIAL INTERIOR DESIGN STRATEGIES
Sustainable feature – safety

- low-emitting materials safeguard occupant’s health.
- Indoor chemical and pollutant source control.
- No step in the interior spaces, a barrier free design for the disabled using wheels.
- fire control system.
The most notable interior feature - health and wellness

Interior design in a green building mostly has some common sustainable features such as energy saving, water efficiency, green materials and etc. However, a concept of health and wellness is strengthened in Labrador commercial interior design project which is also combined with other sustainable strategies including space, energy, water, material, greenery, safety, and innovation. The design strategies such as an on-site resting space, an on-site coffee bar, and a dining facility for occupants to rest and interact, and the entire use of low-emitting materials for occupant's health are all “health and wellness” strategies.

“Health and wellness” contributes to social sustainability. Instead of resource protection and environmental sustainability, the concept of health and wellness concentrates on human benefits, which is the most notable feature in this project.
CHAPTER 7
CONCLUSION

Sustainable features and variety in practice

Environmental problems caused by economy booming and commercial business can no longer be taken for granted. The issue is that generally commercial buildings consume 40 percent more energy than the other types of buildings, and nowadays this should no longer be the case. Under the guidance of environmental laws, regulations, and legislations, these problems have been mitigated to a large extent. One such case is the United Nations Human Environment Program (UNHEP) monitoring the relationship between economic development and environmental degradation, as well as establishing the World Commission on Environment and Development to control air contamination, environmental pollution, and resource waste.

A sustainable commercial interior environment can contribute significantly to a healthy environment and social and economic development. It can be more energy efficient, more water efficient, and less wasteful with resources. Therefore, the results of exploration of sustainable features in commercial interiors are of high importance.

Based on literature review, case study, interview, and application of Labrador commercial interior project, the sustainable features that benefit environmental health and social and economic sustainability have been figured out. Simultaneously, practice variation reasons have been revealed through case study and interview.
The sustainable features:

- Space
- Energy
- Interior water
- Material
- Waste reduction
- Air quality
- Interior greenery
- Safety
- Innovations
- Technology
- Social and workplace features

Practice variation reasons:

- Customer’s demand and clients’ benefit
- Economic consideration/cost
- Social consideration
- Sustainable/environmental consideration
- Technical capacity
- Design DNA
- Research results
- International perspective
- Location
- Climate condition
- Regional advantages
- Building space and function
- Aesthetic requirement
- Cultural consideration

The sustainable feature of health and wellness is worth highlighting. Using non-polluting/lesser-polluting materials instead of high-polluting materials can avoid indoor air pollution. Utilizing wood, cork plywood, and decorative panels can reduce indoor formaldehyde emissions. In addition, choosing proper paint and furniture including water-based paint instead of oil-based paint can reduce the volatile organic compounds in the interior space. Existing air pollution should be filtered out of the indoor environment. Meanwhile, we should take some measures to prevent the pollutants disseminating into the indoor environment. For instance, new particleboard and hardwood plywood can distribute large amounts of formaldehyde. To solve this problem, formaldehyde absorber can be used to cover the surface.

Usage of interior greenery and recycled materials also contributes to the health and wellbeing of the occupants. Promoting the use of harmless materials, as well as environmentally friendly, safe, and green building materials in the interior space can create a healthy atmosphere.
The rest of the sustainable features are very common elements for a building’s green quality. Energy can be saved by taking advantage of daylighting through skylights, and by using efficient lightbulbs, lamps, light shelves, windows, and lighting control.

Interior water is an important resource, and it can be efficiently conserved through water-saving appliances, monitoring water use, recycling water, stormwater management, and water collection by plants.

Material is another vital feature. Sustainable materials have many features: pollution prevention measures in manufacturing, waste reduction measures in manufacturing, recycled content, embodied energy reduction, use of natural materials, reduction of construction waste, use of local materials, energy efficiency, water treatment and conservation, use of non-toxic/less-toxic materials, renewable energy systems, longer life, reusability, recyclability, biodegradability, etc.

Similar to sustainable materials, waste reduction is closely related to building materials. Some wooden materials and furniture as recycled contents reduce waste and environmental pollution.

Air quality, interior greenery, and safety have connections to each other. Interior greenery is beneficial to interior air quality. Moreover, good air quality contributes to building occupant’s safety. When designing an interior space, such three elements can be regarded as a whole.

Innovation always refers to some energy, water, air circulation, or social connected design strategies that differ from the traditional resource saving and
environmental protected strategies. Technology is the foundation of any design breakthroughs when processing a building design. Without the new technology of the curtain walls in Vanke Center project, it could never have such amazing energy efficiency.

All of the sustainable features presented above are the contents of the sustainable theory. However, in the hundreds of thousands of sustainable interior and green building projects, each project is diverse in various situations. This paper has figured out some of the reasons why.

Customers’ demand and client’s benefit may restrain the design. Client’s benefit is related to the cost of the building. The economic consideration of the client and the designer plays a principal role in commercial interior design because money is the fundamental support for technology improvement. Also, the design DNA of sustainability dictates the design team’s sustainable strategies. Research results including location, climate condition, regional advantages, cultural characteristics, and environmental conditions also outline the interior features. High-volume rainwater regions have better climate conditions than those low-volume rainwater regions. With abundant rainwater harvesting, the interior water recycling system can be combined with the outdoor rainwater harvesting system.

International perspective and aesthetic requirement are two practical reasons that motivate designers to build a more acceptable interior space, one that satisfies customer and provides the public with visual comfort, greatly increasing the positive effect on human behaviors.
Lastly, commercial interior space as a part of the building space is always under the restriction of the building space. Better building structures, such as a huge hall or continuous interior space, facilitate natural ventilation and daylighting.

In conclusion, a sustainable commercial interior environment can contribute significantly to healthy environment as well as to social and economic development. It should be energy efficient, resource conservative, and environmentally friendly. On the one hand, the sustainable features can inspire interior designers to do better design works. On the other hand, practice varies based on different situations making the sustainable theory ivory-towered. Designers need to be concerned about the factors driving the practice, avoiding problems and designing more amazing interiors under the inspiration of sustainable theory. Therefore, sustainability is of high importance in the future of design with the application of combining sustainable theory and practice.
Conducted Interview Questions

Interviewee: 

Interview Date: 

Please answer the following questions to the best of your ability.

Q1. What interior features do you think contribute to Darden’s sustainability?

Q2. What kind of techniques and innovations do you use when designing Darden's interior space?
   a. Lighting
   b. Material
   c. Air (Ventilation, Filtration, HVAC systems, Heating and cooling, air quality)
   d. Interior greener
   e. Water
      (Water conservation: flow restrictor, dual flush toilet and low flow urinal)
      (Water reuse, rainwater, gray water, reclaimed water)
   f. Humidity and climate comfort testing tools
   g. Other innovations

Q3. Can you introduce Darden’s lighting system and its energy conservation strategies?

Q4. What sustainable materials do you use when designing Darden’s RSC?
Q5. What sustainable strategies do you use on saving water?

Q6. What sustainable strategies do you use on air quality?

Q7. What sustainable strategies do you use on heating and cooling?

Q8: It is highlighted that 20% of building materials are recycled components. What are those materials if in interior space?

Q9: What do you think is the most important feature in this sustainable design project from interior perspective?

Q10: What is the restaurant’s most notable sustainable characteristic compared to comparable projects?

Q11: What are the decisive factors that make you and your team design in that way?

(Economic consideration, local material, owner’s demand…)
Conducted Interview Questions

Interviewee: 
Interview Date: 

Please answer the following questions to the best of your ability.

Q1. What interior features do you think contribute to Vanke Center’s sustainability?

Q2. What kind of techniques and innovations do you use when designing Vanke Center’s interior space?
   a. Lighting
   b. Material
   c. Air (Ventilation, Filtration, HVAC systems, Heating and cooling, air quality)
   d. Interior greenery
   e. Water
      (Water conservation: flow restrictor, dual flush toilet and low flow urinal)
      (Water reuse, rainwater, gray water, reclaimed water)
   f. Humidity and climate comfort testing tools
   g. Other innovations

Q3. Can you introduce Vanke Center’s lighting system and its energy conservation strategies?

Q4. What sustainable materials do you use when designing Vanke Center?
Q5. What sustainable strategies do you use on saving water?

Q6. What sustainable strategies do you use on air quality?

Q7. What sustainable strategies do you use on heating and cooling?

Q8: What do you think is the most important feature in this sustainable design project from interior perspective?

Q9: What is the restaurant’s most notable sustainable characteristic compared to comparable projects?

Q10: What are the decisive factors that make you and your team design in that way?

(Economic consideration, local material, owner’s demand…)
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BIOGRAPHICAL SKETCH

Yang Du graduated with honors from Nanjing Normal University (NNU), Nanjing, China, in the year of 2013 with a Bachelor’s degree in exhibition design. In those four years, she researched design principles including “close to nature” and “meeting the needs of people.”

In the same year, she was enrolled in Huazhong University of Science and Technology (HUST), Wuhan, China for her Master’s degree. She studied in the College of Architecture and Urban Planning in HUST, majoring in environmental design.

With her interest in sustainable design, Yang Du started her second Master degree at University of Florida (UF) in the year of 2014. The excellent professors and advanced facilities in the College of Design, Construction, and Planning at UF gave her opportunities to gain better knowledge of sustainability. With determination, dedication, and diligence, Yang Du has confidence to study better and combine the sustainable theories with the practices.