Sustainable Built Environments
Senior Capstone

Sustainable Existing Buildings

Through LEED Operations and Maintenance

Janice Eda
Mentor: Colby Moeller

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Abstract

LEED, Leadership in Energy & Environmental Design, assists our building industry to become more sustainable. This paper examines three case studies of existing buildings which have evolved to become LEED certified through the rating system of LEED: Operations and Maintenance. Understanding how older generation buildings may still rejuvenate and become sustainable will provide benefits for the people, planet, and profit. As with many things, there are some drawbacks when it comes to LEED certification such as their fees and universal approach for credits acquired.

Introduction

Buildings consume most of the earth's energy, resources, and accounts for a significant portion of greenhouse gas emissions (Lechner, 2009). They are a leading contributor to global warming. To help guide existing buildings in becoming sustainable and energy efficient, Leadership in Energy & Environmental Design (LEED) methods of design strategies can be used as a reference guide.

LEED uses a rating system to help us understand potential opportunities for a building to reduce environmental issues and impacts, therefore becoming more sustainable. It is important to recognize what LEED has to offer because of the many goals it aims to achieve. These goals include: reducing contribution to global climate change, enhance human health and well-being, protect and restore water resources along with biodiversity, promote sustainable and regenerative material resources, build a greener economy, and enhance social equity of community (Leadership in Energy & Environmental Design, 2017). Leadership in Energy &

Environmental Design will assist our future generations through awareness and implementing options available for buildings to be more sustainable, regardless if it is for new construction or an already existing.

This study will be defining and addressing the different types of LEED rating systems and categories in order for a building or development to be certified. Examining three LEED certified case studies in particular, LEED: Operations and Maintenance for existing building, will help assess to comprehend methods and strategies for an existing building to become sustainable through energy efficiency along with its financial benefit. These three case studies will be located in the United States to allow for comparison to see if there are any similar approaches or patterns used among them.

Literary Review

About LEED

In 1993, the U.S. Green Building Council (USGBC) was established in order to promote sustainability-focused practices in the building and construction industry. By 2000, LEED, Leadership in Energy & Environmental Design, had become the green building rating system for the entire building industry. These LEED-certified buildings provide public recognition for leadership in sustainability and are attracting more tenants, employees, and occupants. This results in increasing revenues, energy and resource savings, and lowering operating cost. There are four LEED certification levels: Certified, Silver, Gold and Platinum. This is based on prerequisites and credits a project meets. The USGBC also developed alternative LEED credits to

provide more options in addressing unique circumstances and accommodate advancements in science and technology (Leadership in Energy & Environmental Design, 2017).

There are different types of rating systems to choose from to be LEED certified. These rating systems are: building design and construction, interior design and construction, building operations and maintenance, neighborhood development, and homes. Having many options for a project to choose from makes it flexible for all types of buildings and at all phases of development and life-cycle to participate. In the General Services Administration's portfolio, LEED Gold buildings consume a quarter less energy and generate 34% lower greenhouse gas emissions (Leadership in Energy & Environmental Design, 2017).

How It Works

Prior to registering for LEED certification, the project team must determine which rating system to pursue. If more than one rating system applies, the project team needs to decide on which system to follow. In order for a project to pursue LEED certification there are minimum program requirements to qualify. This regulation alone could be a drawback as to why few buildings are becoming LEED certified. The requirements are: all LEED projects must be in a permanent location on existing land and applies to all land within the LEED project; the LEED project must use reasonable LEED boundary which includes all contiguous land that is associated with the project and supports its typical operations; and the LEED project must comply with project size requirement (LEED Reference, 2013). These size requirements are as followed:

- LEED BD+C and EB: O&M Rating Systems-a minimum of 1,000 square feet (93 square meters) of gross floor area.

- LEED ID+C Rating Systems-a minimum of 250 square feet (22 square meters) of gross floor area.
- LEED Neighborhood Development Rating Systems- contain at least two habitable buildings and be no larger than 1500 acres.
- LEED for Homes Rating Systems-be defined as a "dwelling unit" by all applicable codes (LEED credit library, 2017).

Once a project is verified and meets requirements, the following step is to make certain it can comply with all prerequisites found within certain categories for the chosen rating system (LEED v4 Rating System, 2014).

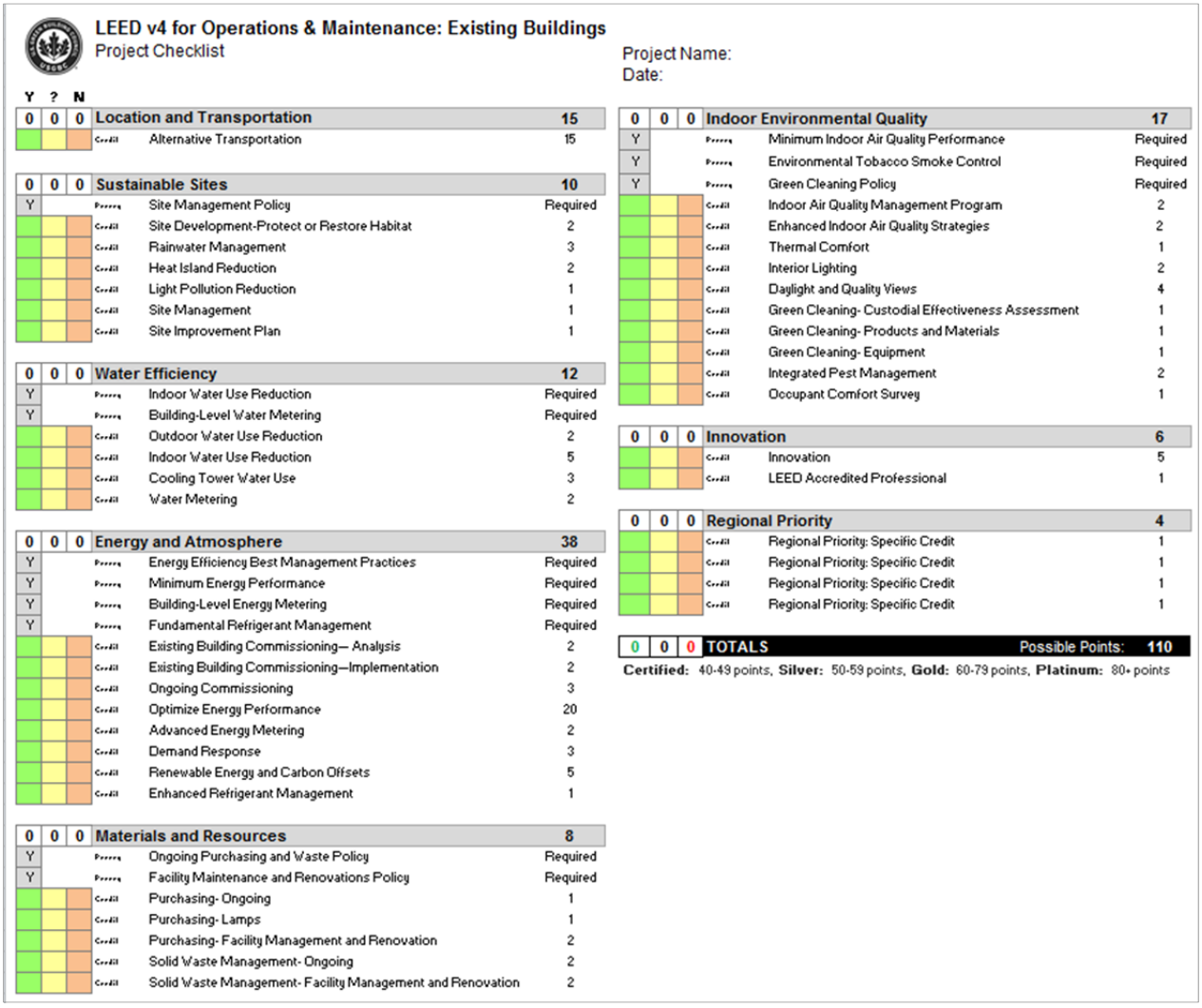
LEED projects earn points from categories that address important factors of green buildings (Leadership in Energy & Environmental Design, 2017). These credit categories are: integrated process, location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation, and regional priority (LEED Reference, 2013). Each rating system has its own set of guidelines and scorecard to follow. The scorecard consists of prerequisites, possible credits for methods applied to project, and points earned from each category. Prerequisites and credit methods vary from scorecard to scorecard. There are no limitations on which credits to use, allowing flexibility and a building to have its own identity and characteristics. The total points earned from credits received, determines the LEED certification level (Samarasekera, 2017).

Categories

Apart from the integrative process, which is established during predesign, this study will use the LEED Operations and Maintenance for Existing Building scorecard, (shown in figure 2),

to inform the types of credits used within each category. Credits or points earned from all categories (figure 2) will determine the projects certification level (figure 1): Certified 40-49 points, Silver 50-59 points, Gold 60-79 points, and Platinum 80+ points (About, 2017). LEED O+M for Existing Buildings have a total of 110 points possible.

Figure 1: Certification levels



LEED v4 for Operations & Maintenance: Existing Buildings
Project Checklist

Project Name:
Date:

Y	?	N			
0	0	0	**Location and Transportation**		15
			Credit	Alternative Transportation	15
0	0	0	**Sustainable Sites**		10
Y			Prereq	Site Management Policy	Required
			Credit	Site Development-Protect or Restore Habitat	2
			Credit	Rainwater Management	3
			Credit	Heat Island Reduction	2
			Credit	Light Pollution Reduction	1
			Credit	Site Management	1
			Credit	Site Improvement Plan	1
0	0	0	**Water Efficiency**		12
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
			Credit	Outdoor Water Use Reduction	2
			Credit	Indoor Water Use Reduction	5
			Credit	Cooling Tower Water Use	3
			Credit	Water Metering	2
0	0	0	**Energy and Atmosphere**		38
Y			Prereq	Energy Efficiency Best Management Practices	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
			Credit	Existing Building Commissioning– Analysis	2
			Credit	Existing Building Commissioning–Implementation	2
			Credit	Ongoing Commissioning	3
			Credit	Optimize Energy Performance	20
			Credit	Advanced Energy Metering	2
			Credit	Demand Response	3
			Credit	Renewable Energy and Carbon Offsets	5
			Credit	Enhanced Refrigerant Management	1
0	0	0	**Materials and Resources**		8
Y			Prereq	Ongoing Purchasing and Waste Policy	Required
Y			Prereq	Facility Maintenance and Renovations Policy	Required
			Credit	Purchasing- Ongoing	1
			Credit	Purchasing- Lamps	1
			Credit	Purchasing- Facility Management and Renovation	2
			Credit	Solid Waste Management- Ongoing	2
			Credit	Solid Waste Management- Facility Management and Renovation	2
0	0	0	**Indoor Environmental Quality**		17
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
Y			Prereq	Green Cleaning Policy	Required
			Credit	Indoor Air Quality Management Program	2
			Credit	Enhanced Indoor Air Quality Strategies	2
			Credit	Thermal Comfort	1
			Credit	Interior Lighting	2
			Credit	Daylight and Quality Views	4
			Credit	Green Cleaning- Custodial Effectiveness Assessment	1
			Credit	Green Cleaning- Products and Materials	1
			Credit	Green Cleaning- Equipment	1
			Credit	Integrated Pest Management	2
			Credit	Occupant Comfort Survey	1
0	0	0	**Innovation**		6
			Credit	Innovation	5
			Credit	LEED Accredited Professional	1
0	0	0	**Regional Priority**		4
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
0	0	0	**TOTALS**	Possible Points:	110

Certified: 40-49 points, **Silver:** 50-59 points, **Gold:** 60-79 points, **Platinum:** 80+ points

Figure 2: LEED O+M: Existing Building scorecard checklist

1. Integrative process

    Encourages project team to explore and discover connections between different building systems and processes (LEED v4, 2017). This process is usually done before construction and during the pre-design phase of a project through collaboration of the project team.

2. Location and transportation

    The intent is to reduce pollution and land development effects from automobile use for transportation (LEED v4 for Building, 2016). Understanding the awareness of occupants' travel patterns will help develop policies and incentives that can encourage changes in transportation habits. When occupancy accounts for receiving credits, users are placed into two groups: regular building occupants and visitors (LEED Reference, 2013). This category ranges from 1-15 credits in regards to *alternative transportation,* through the use of survey and distinguishing different means of transit (LEED v4 for Building, 2016). Some examples could include: walking distance, trip counts instead of transit stops, absolute than relative parking requirements, and bicycle networks in addition to bicycle storage (LEED v4, 2017).

    In some instances, this could cause a drawback in not receiving more credit, due to a projects location and regional environment which would not allow for occupants to travel by alternative means of transportation such as by foot or bicycling. Also, vice-versa where alternative means of transit would receive additional credit although it would not be used such a building on top of a hill with bicycle storage or walking paths (Bray & McCurry, 2006).

3. Sustainable sites

This section involves the environment surrounding the building and its relationship among buildings, ecosystems and ecosystem services. The focus is integrating the site with local and regional ecosystems, and preserving the biodiversity which natural systems rely on (LEED v4, 2017). Methods used are low-impact developments that minimize construction pollution and mimic natural water flow patterns to manage rainwater runoff (LEED Reference, 2013).

There is a prerequisite of site management policy that does not receive credit. The project can receive up to 10 credits in this category in regards to: site development-protect or restore habitat, rainwater management, heat island reduction, light pollution reduction, site management, site improvement plan (LEED v4 for Building, 2016).

4. Water efficiency

Roughly 19% of all energy used in this U.S. state is consumed by water treatment and pumping (LEED Reference, 2013). The purpose of this category is to evaluate the buildings total water use (LEED, 2017). There are three major components: indoor water, irrigation water, and water metering (LEED Reference, 2013). Some examples are: cooling towers, appliances, fixtures, fittings, process water, and irrigation. Some of the credits encourage the reuse of water, such as reclaimed wastewater, graywater, condensate, process water, and rainwater, for irrigation, toilet flushing and more (LEED v4, 2017).

This category has two prerequisites involving water efficiency and reductions in potable water use alone: indoor water use reduction and building-level water metering.

There are 12 total possible credits which recognize the use of non-potable and alternative sources of water (LEED Reference, 2013). These credits are: outdoor water use reduction, indoor water use reduction, cooling tower water use, and water metering. Each section varies in credit amounts (LEED v4 for Building, 2016).

There could be a disadvantage in this category due to some buildings not having such equipment like a cooling tower, which would cause a loss in credits or an added expense of investment to implement one to the building for LEED credit. Or in some situations a cooling tower would not be beneficial or necessary to have. Also, depending on the size of a project reducing indoor water usage through change of fixtures and plumbing could be an expensive investment that could cause loss in credits if updates are not fully completed.

5. Energy and atmosphere

Twenty percent of all points are allocated to building energy efficiency (LEED v4, 2017). The goal is to reduce energy usage, design for efficiency, and supplement the energy supply with renewables. Metering and ongoing commissioning that include monitoring system performance, allows staff to track energy use and identify issues on a consistent basis for optimizing system performance and verify equipment operation (LEED Reference, 2013).

This category has the highest amount of credits possible of 38 and consisting of four prerequisites. These prerequisites involve: energy efficiency best management practices, minimum energy performance, building-level energy metering, and fundamental refrigerant management. The possible credits awarded are: existing

building commissioning—analysis, existing building commissioning—implementation, ongoing commissioning, optimize energy performance, advanced energy metering, demand response, renewable energy and carbon offsets, and enhanced refrigerant management (LEED v4 for Building, 2016). Optimize energy performance has the highest amount of credits able to receive for this rating system, containing of 20 points.

Although this method is a great way to improve and reduce energy, for some older buildings, would mean major renovations of new mechanical systems which could be out of budget for a building owner to invest. Some of the credits may seem more costly to do than obtain such as the commissioning credits. Another is continuous staff training to upkeep methods for optimizing system performance which takes time away from work.

6. Materials and resources

Commercial and institutional buildings account for approximately 35% to 45% of total municipal solid waste. This portion focuses on the entire life-cycle of the building, products, and material. The extraction and manufacturing, transportation, operations, maintenance, and disposal can cause environmental and human health harms. Several credits depend on tracking product purchasing decisions and to reduce the embodied energy of materials types (LEED Reference, 2013).

Two prerequisites are required for this section: ongoing purchasing and waste policy, and facility maintenance and renovations policy. There are eight credits possible in this portion regarding: purchasing- ongoing, purchasing- lamps, purchasing- facility

management and renovation, solid waste management- ongoing, and solid waste management- facility management and renovation (LEED v4 for Building, 2016).

Some projects may be at a hindrance in receiving some credit due to the location on where some of these facilities are located for purchasing. For example, some of the projects ongoing purchases may cost less than what purchases to receive LEED credit are. Another possible issue could be the product available is unable to meet certain criteria credit due to causing embodied energy.

7. Indoor environmental quality

Better indoor environmental quality can improve the building's value, enhance productivity, decrease absenteeism, and reduce liability for building designers and owners (LEED v4, 2017). This category is meant to develop policies and programs based on proven methods that prioritize the health and comfort of the building occupants and measure performance with well-established indicators. It also focuses on optimizing existing HVAC systems and minimizing sources of contaminants, such as cleaning products and laser printers (LEED Reference, 2013).

There are three prerequisites: minimum indoor air quality performance, environmental tobacco smoke control, and green cleaning. The total of 17 possible credits are: indoor air quality management program, enhanced indoor air quality strategies, thermal comfort, interior lighting, daylight and quality views, green cleaning-custodial effectiveness assessment, green cleaning- products and materials, green cleaning- equipment, integrated pest management, and occupant comfort survey (LEED v4 for Building, 2016).

This category may cause a disadvantage for a project because of its surrounding environment and climate region. For instance, a project may have greater contaminated outside air quality than inside the building resulting to complicating some of the carbon dioxide monitoring system indicators and making credits difficult to earn (Bray & McCurry, 2006). Since credits are not climate specific, projects may lose out on points and possibly a higher certification level because its environment makes strategies challenging to use such as daylighting and quality views.

8. Innovation

This portion is meant to recognize projects for innovative and exemplary building features or practices that generate environmental benefits beyond those addressed or specified in the other credit categories (LEED Reference, 2013). There are six possible credits available. Five of these credits come from encouraging projects to achieve exceptional or innovative performance such as new technologies introduced to the marketplace, and up- to-date scientific research influences building design strategies (LEED v4, 2017). The additional credit is by having a LEED accredited professional being part of the project team (LEED v4 for Building, 2016).

Credits could easily be lost in this section by not executing innovative enough features to a building that are groundbreaking to qualify for credit. Although it is not necessary, not attaining a LEED accredited professional can cause a downfall of a missed credit which could possibly cost the building's certification.

9. Regional priority

   Although not a requirement, this option identifies distinct local environmental, social equity, and public health priorities specific to the location of their projects (LEED v4, 2017). Credits are received for addressing those issues such as naturally occurring, man-made, and environmental concerns or assets (LEED Reference, 2013). The USGBC website has a search engine to lookup regional priority credits available within a region based on zip code. It is also specified by rating system and type.

LEED Rating Systems

Each LEED rating system has its own concept and core values. Here is an overview of what each rating system consist of and the types of buildings that can register for its certification. There are some instances which a specific type of building qualifies for multiple rating systems. It is up to the project team to determine which to pursue.

Building Design + Construction

92.2% of LEED-certified new construction projects are improving energy performance by at least 10.5%, according to an analysis of 7,100 projects (Building Design Construction, 2017).This type of rating system provides a sustainable healthy environment, resource-efficient, and a cost-effective building. This is for new construction buildings or major renovation and must include the entire building's gross floor area in the project. At least 60% of the project's gross floor area must be complete by the time of certification, except for LEED BD+C: Core and Shell (LEED v4 Rating, 2014).

This category includes buildings of: new construction and major renovation, core and shell development, data centers, healthcare, hospitality, retail, schools, homes and multi-family low-rise and mid-rise, and warehouses and distribution centers (Building Design Construction, 2017). An example of a platinum certified project is the DPR Construction San Francisco ZNE in 2016. Gold certified in Pasadena, CA is the Caltech Thomas Lab Renovation in 2016. Silver certification is S&C Electric Building 14 in Chicago, IL 2015 (Projects, 2017).

Interior Design + Construction

We spend approximately 90% of our time indoors. This type emphasizes the interior space of a building for human comfort. Area of focus includes a healthier space, being able to breathe easily, views of nature and daylight, and to become more productive (Interior Design Construction, 2017). These spaces are a complete interior fit-out. At least 60% of the project's gross floor area must be complete by the time of certification (LEED v4 Rating, 2014).

This category includes buildings of: commercial interiors, hospitality, and retail (Interior Design Construction, 2017). An example of a platinum certified project is the Thornton Tomasetti San Francisco Office in 2016. Gold certified in Seattle, WA is the Paladino Seattle in 2014. Silver certification is 1155 Avenue of the Americas 11th Floor in New York, NY 2016 (Projects, 2017).

Homes

Homes are an important building in our lives. This rating system focuses on homes to be built healthy with safe building materials and provide clean indoor air. The outcome becomes a

comfortable home with less energy and water usage. As a result, leads to lower utility bills each month. These certified green homes are selling quicker and for more money.

This category includes buildings of: single family homes and multifamily projects up to eight stories (Homes, 2017). An example of a platinum certified project is 310 6th Street in Union City, NJ in 2017. Gold certified in Bowling Green, OH are the BGSU Greek Replacement Housing in 2017. Silver certification is Two PNC Plaza in Pittsburgh, PA 2017 (Projects, 2017).

Neighborhood Development

This option considers the entire community to be a sustainable well-connected neighborhood. It can involve projects at any stage of the development process, from planning through construction such as plan certification, and built project certification. Such projects are local grocery store found within walking distance, comfortable sidewalks and road-friendly, high-performing green buildings, parks and green space (LEED for Neighborhood, 2017).

An example of a platinum certified project is Ward Village in Honolulu, HI in 2013. Gold certified in Denver, CO is the South Sloans Lake in 2016. Silver certification is Terrapin Row Development in College Park, MD 2016 (Projects, 2017).

Operations & Maintenance

Many older buildings around the world are inefficient and consume too many resources. This option is meant for improvements to no construction and must include the entire building. To qualify for this option, buildings must be fully operational and occupied for at least one year (LEED v4 Rating, 2014). It encourages buildings to use less energy, water and natural resources, improve indoor environment, and uncover operating inefficiencies (Fax, 2017). As a result, it

increases the building's value, higher lease rates, and decreased utility costs (Leadership in Energy & Environmental Design, 2017). What is unique about this rating system is a recertification requirement every five years or as frequent as annually. This makes sure the existing building is performing as intended.

This category includes buildings of: existing buildings, data centers, hospitality, retail, schools, and warehouse and distribution centers (Building Operations Maintenance, 2017). An example of a platinum certified project is the Downey Energy Resource Center in Downey, CA 2015. Gold certified in Seattle, WA is the Paladino Seattle in 2014. Silver certification is 1155 Avenue of the Americas 11th Floor in New York, NY 2016 (Projects, 2017).

LEED for Existing Buildings: Operations & Maintenance

LEED for Existing Buildings is a sub-division option of operations and maintenance. It is meant for buildings that have been in operations for at least 12 continuous months and requires three months of tracking operational data (Fax, 2017). This data establishes efficiency goals and can evaluate monthly trends in energy use intensity. It is aimed to identify ways to reduce loads and environmental harms of each system without increasing others. Once determined, the project can create a list of areas that may require significant change, moderate change, and low- or no-cost change in operating practices (LEED Reference Guide, 2013). This LEED certification option helps identify and solve inefficiency building problems to perform best sustainable practices over the lifespan of the building. Areas of focus include using less energy, water and natural resources, improve the indoor environment, uncover operating inefficiencies, and how building is occupied and operated by its managers. The outcome will

reduce cost of building operations, environmental impacts, and healthier workspaces (Fax, 2017).

Some of the credits received require a performance evaluation period. This consists of at least three months, but no more than 24 months and must overlap and conclude within 30 days of each other. This information and method provides insight on whether current systems are meeting the building's heating and cooling needs. There is a 60-day grace period for certification application to be submitted from the last day of the performance evaluation period. The certification work plan rule of thumb is: select rating system, check minimum program requirements, define LEED project scope, develop LEED scorecard, assign roles and responsibilities for team members, determine performance period, develop documentation, perform quality assurance, review, and submit for certification (LEED Reference Guide, 2013).

Unlike other LEED rating system certification, projects certified under operations and maintenance must file for recertification. This occurs at least once every five years or annually to maintain their certification (Fax, 2017). It is recommended that project teams continue to track building performance during the certification review process (LEED Reference Guide, 2013). Historic buildings may also become certified under this rating system with specific metrics that highlight and promote preservation activities as green building strategies (Fax, 2017).

Methodology

Carl Elefante said, "The greenest building is…one that is already built." (Elefante, 2007) Buildings are a large contributor to global warming and consume the most energy. They

consume 48 percent of all energy in the United States which comes from operating the buildings heating, cooling, and lighting (Lechner, 2009). To help resolve this issue, understanding sustainable methods and strategies for existing buildings could be an answer. Implementing the U.S. Green Building Council program of LEED, Leadership in Energy & Environmental Design, can make a difference for the environment, people, and economy. Examining three LEED certified case studies for particularly existing buildings in the United States will demonstrate what the already built building can become.

Each of the case studies uses the rating system of LEED Operations and Maintenance for Existing Buildings, but has different certification levels: platinum, gold, and silver. These projects are: Energy Resource Center in Downey, California; UCSB Resource Center in Santa Barbara, California; and Two PNC Plaza in Pittsburgh, Pennsylvania. Researching different certification status will help discover and analyze common used strategies to be beneficial in value. Also, at the same time determine if the process of LEED certification has any drawbacks with its certification stature, determining applicable credits, or if approach method outweighs its cost. This investigation will be a qualitative analysis (Baxter and Jack, 2008).

Case Studies:

Platinum- Energy Resource Center - Downey, CA

LEED Facts for LEED O+M: Existing Buildings (v4)	
Certification awarded May 2015	
Platinum	**82**
Location & Transportation	13/15
Sustainable sites	4/10
Water efficiency	11/12
Energy & atmosphere	30/38
Material & resources	5/8
Indoor environment quality	11/17
Regional priority credits	4/4

Table 1: Energy Resource Center facts

The Downey Energy Resource Center is located in Downey, California and initially built in 1957. It was reconstructed in 1995 with 60 percent of the demolition materials, 550 total tons, reused in new structure or recycled (C, 1996). Approximately one-third of the building was demolished (So Cal Gas, 2013). The project size is 46,261 square feet, located at 9240 Firestone Blvd, Downey, CA. (Downey…Green Building, 2017).

On May 26th 2015 Downey Energy Resource (ERC) scored 82 points out of 110 points total giving it LEED Platinum certification (Shown in Table 1). Further analysis can be found in Appendix A. This building was first LEED certification in 2009. It received LEED Certified level using version LEED Existing Building 2008. In 2013, the building recertified and achieved LEED Gold certification with updated version LEED for Existing Buildings 2009. Since 2015, it has been certified to the most current version of LEED v4 Operations and Maintenance Existing Buildings

and awarded LEED Platinum certification. This building has also been recognized and awarded AIA/COTE top ten green projects (Downey…Green Building, 2017).

This project reached LEED certification due to the integration of design and building technology. These strategies pertain to: lighting, heating, cooling, insulation, and energy management control systems. The approaches optimize energy efficiency while maintaining a high-quality performance space (Energy Resource Center, 1995). The building's cooling energy was reduced by 54 percent (Energy…Case Study, 2017). It uses less energy than the national average by 51.39 percent and 60 percent of its employees use energy-efficient transportation, including bicycling, low-emission vehicles, and carpooling (Aiello, 2015).

Major energy efficiency methods applied are mechanical upgrades like high-efficiency air filtration system. ERC uses both natural gas and electric systems to maximize the effectiveness and lower energy costs (Energy…Case Study, 2017). These systems include: zero-chemical Dolphin water treatment system, high-efficiency air handlers, indirect/direct evaporative cooling, desiccant units, natural gas absorption chillers/heaters, and package units (So Cal Gas, 2013).

Lighting techniques is another contributing factor to energy use reduction such as energy efficient light bulbs, monitor and sensing devices. New dimmable lighting systems were installed to control light levels throughout the facility (So Cal Gas, 2013). 40 percent of lighting requirements were reduced from daylighting approaches of skylights, low-e and translucent window walls. Natural lighting reduced as much as 80 percent of the electrical day lighting (Energy…Case Study, 2017).

The ERC has reduced water usage outdoor by 40.7 percent and 54 percent indoor (Consulting, 2013). This is 38.3 percent less than other commercial buildings its size. The accomplishment for water efficiency involved low-water-use fixtures, low-flow toilets, drought tolerance plants, and water-efficient irrigation fixtures (Energy Resource Center, 1995). Sustainable landscape strategies included use of California native plants, drip irrigation, and bio swales to divert rain water back into the soil (So Cal Gas, 2013).

The roof also plays an important role in reducing cooling loads. Portions of it is rigid-foam insulated providing an R-value of 38 and reduces heat transfer by 50 percent. Another is a highly reflective white roof coating which in return decreases the buildings air conditioning requirements. This strategy also reduces heat absorption up to 40 percent and decreases urban heat island effect (Energy…Case Study, 2017). Rooftop solar thermal was also implemented (Aiello, 2015).

80 percent of the building accounts for recycled and reused materials making this building more sustainable (Energy Resource Center, 1995). Items include: concrete, roofing materials, asphalt, metal, ceiling tiles, wood flooring, electrical equipment and mechanical systems (Energy…Case Study, 2017). One avoidance were materials that "off-gas" harmful chemicals. Some recycled products used are: wood floor from an old Banana Republic warehouse, confiscated weapons and used oil filters melted to make reinforcement bars for walls, veneer lobby wall from recycled aircraft aluminum, staircase salvaged from Warner Brothers set movie *Disclosure*, scraps of yellow PVC pipe added to concrete mix to give color to entry walkway, and reception desk countertop made of 100 percent recycled glass (California, 2014).

Another reason ERC achieved LEED certification is the innovative technologies used. There is an automated energy management system that monitors the buildings key conditions involving temperature, airflow, lighting, energy use, etc. and adjusts them for better efficiency. In addition, the HVAC systems are monitored for performance, inspections, and maintenance, and have CO2 sensors (Energy Resource Center, 1995). Interestingly, three skylights in the building incorporate a sun-tracking system that uses mirrors, reflective light ducts, and efficient diffusing lenses to create a technologically advanced interior lighting system for daytime use (Energy…Case Study, 2017).

This project cost $7.9 million and estimates saved $3.2 million in land, utility infrastructure, and building material costs (California, 2014). Additional savings results from recycled and repurposed building materials. When the investments are paid over the buildings life cycle and energy savings calculated, the benefits outweigh the cost and are grander (Energy…Case Study, 2017). The energy-efficient lighting systems and strategies consist of a 2-5 year payback (Energy Resource Center, 1995). This upgrade is projected to save $21,000 to $30,000 annually in electricity (California, 2014).

Gold- UCSB Student Resource Building - Santa Barbara, CA

LEED Facts for LEED O+M: Existing Buildings (v4)	
Certification awarded Mar 2016	
Gold	**71**
Location & Transportation	15/15
Sustainable sites	3/10
Water efficiency	5/12
Energy & atmosphere	30/38
Material & resources	2/8
Indoor environment quality	8/17
Regional priority credits	3/4

Table 2: UCSB Student Resource Building facts

UCSB Student Resource Building (SRB) was originally built in 2007 as new construction with sustainability in mind. It was awarded LEED Silver certification using the rating system of new construction (Division, 2014). The building is 68,413 square feet located at Ocean Rd, Santa Barbara, Isla Vista, CA (UCSB Student, 2017). The new construction replaced an existing parking lot and constructed with an ideal building orientation for day-lighting, climate control, and natural ventilation (University, 2017).

On March 21st 2016, UCSB Student Resource Building was awarded LEED Gold certification using the current version LEED v4 O+M Existing Building. It achieved a total of 71 points out of 110 points possible (UCSB Student, 2017) (Shown in Table 2). Further analysis can be found in Appendix B. The reason for this accomplishment is due to better operations involving lighting, heating, and cooling (Georgescu, 2011). Some processes included surveying users which informed excess sunlight on one side of the building. As a result, certain windows were tinted and building became more thermal efficient and occupant comfort. Other

evaluations comprised of performing energy audits, updating cleaning and maintenance policies, and replacing aerators on sink faucets (Jacobs, 2015). The project was certified by students taking a LEED Lab course on campus led by the two instructors (Buente, 2016).

Improvements led to 37 percent energy reduction compared to similar buildings (Division, 2014). Daylight strategies maximize more than 75 percent of the buildings lighting because of narrow floor plates, large north-facing glass, high indoor volumes, and clerestory windows (University, 2017). The SRB uses 89 percent of alternative transportation and has more than three hundred bicycles parking (Division, 2014). Pervious paving used in fire lanes fosters rainwater permeability. Reclaimed water accounts for the majority of irrigation. The landscape features drought tolerant native plants grown at the University from seeds and a grove of trees to the south cools the prevailing breezes entering the building. The Child Care Center garden reduces heat island effects and enhances natural ventilation (University, 2017).

The UCSB Student Resource Building uses three forms of energy sources: electrical, gas, and chilled water. This consists of radiant floor and baseboard panel heating, natural ventilation from atrium and clerestory windows, and mechanical ventilation. The roof has a mounted weather station to tune the operation of the clerestory windows. Also, there are exterior sunshades to manage heat gain and glare. The HVAC system is connected to the campus chilled water loop, eliminating the need for cooling towers (University, 2017). A large contribution to better energy efficiency associated with adjusting the HVAC scheduling (Georgescu, 2011).

Other developments involved lighting modifications such as LED lighting retrofits and water efficiency (Jacobs, 2015). Efficient plumbing fixtures include waterless urinals, timer faucets, dual flush toilets, and low flow water fixtures (University, 2017). Technology of motion

operated lighting control and real-time energy use monitoring metering reduced energy usage (Georgescu, 2011). Adjusting the interior lighting schedule estimates saving about $3,200 annually (Jacobs, 2015).

Interior materials applied are flooring with high recycled content, low VOC paints, FSC certified woods, highly recycled acoustical tiles, and furniture upholstery of wool and recycled nylons. This project cost $21.1 Million in total and was ineligible for state funding due to building function used as student-centered programs and no academic spaces. Finances were paid largely by an increase to student fees which the students themselves voted for (S, 2017).

Silver- Two PNC Plaza - Pittsburgh, PA

LEED Facts for LEED O+M: Existing Buildings (v4)	
Certification awarded Jan 2017	
Silver	**50**
Location & Transportation	13/15
Sustainable sites	2/10
Water efficiency	2/12
Energy & atmosphere	22/38
Material & resources	3/8
Indoor environment quality	4/17
Regional priority credits	2/4

Table 3: Two PNC Plaza facts

The Two PNC Plaza is a 34-story office space building originally built in 1975 then acquired by PNC in the early 1990s (Post-Gazette, 2017). It is a project size of 605,000 square feet located at 620 Liberty Avenue Pittsburgh, PA. On January 17th 2017, Two PNC Plaza received LEED Silver certification on the most current version LEED v4 O+M Existing Building. It achieved 50 points out of 110 points possible (Two PNC Plaza Green, 2017) (Shown in Table 3).

Further analysis can be found in Appendix C. Since 2009, this building has been going through upgrades in particular to lighting retrofits (Group, 2012).

Two PNC Plaza is 30 percent more efficient than a comparable building in the United States and have reduced utility bills by more than 20 percent (Financial, 2012). Lighting retrofits and occupancy sensors have contributed to 10 percent reduction in energy consumption (Group, 2012). It has completed 8 ½ floors and has started renovations on another 8 ½. It will be 55 percent more efficient than energy code requirements (Post-Gazette, 2017).

The efficiency method has been optimized lighting (Group, 2012). The project has taken a five-point approach. This involves: installed LED lights with motion sensors in parking garages and stairwells, eliminating light fixtures and reducing current to remaining fixtures by 50 percent of most floors, reducing ambient light levels by half in office spaces, and programmed lights to automatically shut off during evening hours (2011 Shine, 2015). Other upgrades are the workplace finishes and restrooms (Post-Gazette, 2017).

There is an importance of combining both technological and operational behavioral approaches for building to be more sustainable (2011 Shine, 2015). An example, are installed occupancy sensors, which prompt lights to shut off automatically in unoccupied spaces. The building monitors energy consumption to track the performance over time (Group, 2012). These improvements plan to achieve energy savings of $15 million over five years (2011 Shine, 2015). The renovations payback will outweigh more over the next 40 to 50 years. The undergoing upgrades will not be completed until late 2019 or early 2020 (Post-Gazette, 2017).

Discussion/Results

LEED Facts for LEED O+M: Existing Buildings (v4)	
Certification awarded May 2015	
Platinum	**82**
Location & Transportation	13/15
Sustainable sites	4/10
Water efficiency	11/12
Energy & atmosphere	30/38
Material & resources	5/8
Indoor environment quality	11/17
Regional priority credits	4/4

LEED Facts for LEED O+M: Existing Buildings (v4)	
Certification awarded Mar 2016	
Gold	**71**
Location & Transportation	15/15
Sustainable sites	3/10
Water efficiency	5/12
Energy & atmosphere	30/38
Material & resources	2/8
Indoor environment quality	8/17
Regional priority credits	3/4

LEED Facts for LEED O+M: Existing Buildings (v4)	
Certification awarded Jan 2017	
Silver	**50**
Location & Transportation	13/15
Sustainable sites	2/10
Water efficiency	2/12
Energy & atmosphere	22/38
Material & resources	3/8
Indoor environment quality	4/17
Regional priority credits	2/4

Table 4: Comparison of case study facts

Regardless whether a building was constructed in the mid 1970's, 1990's or just ten years ago, as analyzed with these three case studies, there are strategies and methods available to make them sustainable. Among all three case studies (Table 4), the greatest contributor involved optimizing energy performance which also provides the most credit possible. As this rating system is titled, operations and maintenance, each project was improved by readjusting schedules and monitoring the energy use of lighting, sensor readings, and mechanical systems. Other sustainable opportunities for existing buildings, as ERC accomplished more compared to the other two case studies, is water efficiency and indoor environmental quality. The performance period evaluation for this LEED certification definitely informs the building owner and manager areas of improvement. Nonetheless, all the projects have room for improvements and can be achieved in phases as did Energy Resource Center and UCSB Student Resource Building leading to a higher certification level.

Questionable observations for certification from these case studies were recognized. UCSB student Resource Building lost credits for not needing certain implementations such as eliminating cooling tower needs resulting to attaining zero credits from section of cooling tower water usage. The various project sizes may also be a factor why a larger project may score lower points by reason of a greater financial investment. As square footage was discussed in each of the case studies, it is not surprising to discover that the smallest project received highest certification level of platinum, while Two PNC Plaza received a silver rating and is more than thirteen times the size of Downey Resource Center. All three projects received minimal points under the sustainable site category. It is unclear if this is due to the buildings not being new construction. Neither projects acquired credit from rainwater management or thermal comfort.

Cost may be a primary reason why not as many existing buildings are transforming to sustainability practices regardless of LEED certification. As it turns out, it is expensive and time consuming even with the proper project team members. Although it is an investment with a substantial payback all-around, it may just be out of budget and unattainable. (Certification fees, 2017). This could also be an issue why not many older high rise existing buildings participate in LEED or become more sustainable. Their upgrades are much more costly and so are the LEED certification fees (Certification fees, 2017). This may explain why only 1 percent of LEED activities are within gross square feet similar to Two PNC Plaza (Two PNC Plaza, 2017).

Conclusion

LEED is global with 160 countries and territories that participate (About, 2017). It is meant to accomplish global changes for a better environment and well-being for people by promoting sustainability and build a greener economy. Certification involves: register, submit, review, and certify (Leadership in Energy & Environmental Design, 2017). A positive thing about LEED is the effort and interests to update their guidelines and standards with the times as new methods, strategies, and technology improves.

There are benefits and drawbacks with LEED certification. Having a universal standard of credits to receive certification draws attention on whether this causes some buildings to lose points and lower certification levels due to its regional location, climate environment, and other circumstances. Another is how the same recognition of certification level is given to a building that is 46,000 square feet versus 600,000 square feet as seen in the case studies. Furthermore, not accounting buildings investment for upgrades and improvements, LEED certification fees involved have become expensive. Depending on the type a project its registering for, size, and review process, certification fees can start from $1,200 and easily reach more than $100,000 without including special circumstances or appeal fees if need be (Certification fees,2017). This may be a reason why some project owners and investors are unable or unwilling to follow the LEED certification trend.

Knowledge is power, and what USBGC has brought to society with awareness of sustainable practices and the LEED program is a start to rejuvenating our world. As the USGBC mentions, “LEED is meant to benefit the people, planet, and profit.” (Leadership in Energy & Environmental Design, 2017)

Recommendation/Limitation

By researching LEED and assessing three case studies, I would recommend composing a budget cost analysis of a project to determine how much influence its finances has for not pursuing certain credits to earn a higher certification level versus not being applicable for a particular credit. This would involve a more quantitative approach (Sage, 2010). A limitation while conducting this research involved limited data of the project's financial statement to better understand reasoning behind chosen and not chosen credits. I suggest taking the time to find case studies with all critical values and inputs.

Secondly, for existing buildings to become sustainable, I propose investigating how certified LEED Operations and Maintenance for existing buildings ensure enough funding for upgrades, improvements, and certification fees or how to overcome these financial issues. Another is to determine initial cost to begin LEED registration process and final certification cost. Also, verify if only existing buildings with successful revenue surpluses may become sustainable. This can help explain why not all older existing buildings are going through the change.

Lastly, I recommend exploring if regions of different climate types cause certain credits to not be achieved causing drawbacks or discouragement for LEED certification. Recognizing if there are common practices of methods and strategies used for all climate types or for only certain regions would be informative. This analysis cold better explain how climate could benefit or hinder a project in becoming LEED certified.

Appendix

1000045106, Downey, CA

Downey Energy Resource Center

LEED O+M: Existing Buildings (v4) — **PLATINUM, AWARDED MAY 2015**

SUSTAINABLE SITES		AWARDED: 4 / 10
Credit	Site development - protect or restore habitat	0 / 2
Credit	Rainwater Mgmt	0 / 3
Credit	Heat island reduction	1 / 2
Credit	Light pollution reduction	1 / 1
Credit	Site Mgmt	1 / 1
Credit	Site improvement plan	1 / 1

WATER EFFICIENCY		AWARDED: 11 / 12
Credit	Outdoor water use reduction	2 / 2
Credit	Cooling tower water use	2 / 3
Credit	Water metering	2 / 2
Credit	Indoor water use reduction	5 / 5

ENERGY & ATMOSPHERE		AWARDED: 30 / 38
Credit	Existing building commissioning—analysis	2 / 2
Credit	Existing building commissioning—implementation	2 / 2
Credit	Ongoing commissioning	3 / 3
Credit	Advanced energy metering	2 / 2
Credit	Demand response	0 / 3
Credit	Renewable energy and carbon offsets	0 / 5
Credit	Enhanced refrigerant Mgmt	1 / 1
Credit	Optimize energy performance	20 / 20

MATERIAL & RESOURCES		AWARDED: 5 / 8
Credit	Solid waste Mgmt - ongoing	2 / 2
Credit	Solid waste Mgmt - facility maintenance and renovation	0 / 2
Credit	Purchasing - lamps	1 / 1
Credit	Purchasing - ongoing	1 / 1
Credit	Purchasing - facility maintenance and renovation	1 / 2

MATERIAL & RESOURCES		CONTINUED

INDOOR ENVIRONMENTAL QUALITY		AWARDED: 11 / 17
Credit	IAQ Mgmt program	0 / 2
Credit	Enhanced IAQ strategies	1 / 2
Credit	Thermal comfort	0 / 1
Credit	Interior lighting	2 / 2
Credit	Daylight and quality views	2 / 4
Credit	Green cleaning - custodial effectiveness assessment	1 / 1
Credit	Green cleaning - products and materials	1 / 1
Credit	Green cleaning - equipment	1 / 1
Credit	Integrated pest Mgmt	2 / 2
Credit	Occupant comfort survey	1 / 1
Prereq	ETS Control for Projects in Japan	REQUIRED

REGIONAL PRIORITY		AWARDED: 4 / 4
Credit	Renewable energy and carbon offsets	0 / 1
Credit	Optimize energy performance	1 / 1
Credit	Alternative transportation	1 / 1
Credit	Rainwater Mgmt	0 / 1
Credit	Outdoor water use reduction	1 / 1
Credit	Indoor water use reduction	1 / 1

LOCATION & TRANSPORTATION		AWARDED: 13 / 18
Credit	Alternative transportation	13 / 15

TOTAL	82 / 110

Appendix A: Downey Energy Resource Center scorecard

1000050773, Santa Barbara, CA

UCSB Student Resource Building

LEED O+M: Existing Buildings (v4) — GOLD, AWARDED MAR 2016

SUSTAINABLE SITES		AWARDED: 3 / 10
Credit	Site development - protect or restore habitat	2 / 2
Credit	Rainwater Mgmt	0 / 3
Credit	Heat island reduction	1 / 2
Credit	Light pollution reduction	0 / 1
Credit	Site Mgmt	0 / 1
Credit	Site improvement plan	0 / 1

WATER EFFICIENCY		AWARDED: 5 / 12
Credit	Outdoor water use reduction	0 / 2
Credit	Cooling tower water use	0 / 3
Credit	Water metering	0 / 2
Credit	Indoor water use reduction	5 / 5

ENERGY & ATMOSPHERE		AWARDED: 30 / 38
Credit	Existing building commissioning—analysis	2 / 2
Credit	Existing building commissioning—implementation	2 / 2
Credit	Ongoing commissioning	0 / 3
Credit	Advanced energy metering	0 / 2
Credit	Demand response	3 / 3
Credit	Renewable energy and carbon offsets	5 / 5
Credit	Enhanced refrigerant Mgmt	0 / 1
Credit	Optimize energy performance	18 / 20

MATERIAL & RESOURCES		AWARDED: 2 / 8
Credit	Solid waste Mgmt - ongoing	0 / 2
Credit	Solid waste Mgmt - facility maintenance and renovation	0 / 2
Credit	Purchasing - lamps	1 / 1
Credit	Purchasing - ongoing	0 / 1
Credit	Purchasing - facility maintenance and renovation	1 / 2

MATERIAL & RESOURCES		CONTINUED

INDOOR ENVIRONMENTAL QUALITY		AWARDED: 8 / 17
Credit	IAQ Mgmt program	2 / 2
Credit	Enhanced IAQ strategies	1 / 2
Credit	Thermal comfort	0 / 1
Credit	Interior lighting	0 / 2
Credit	Daylight and quality views	2 / 4
Credit	Green cleaning - custodial effectiveness assessment	1 / 1
Credit	Green cleaning - products and materials	1 / 1
Credit	Green cleaning - equipment	0 / 1
Credit	Integrated pest Mgmt	0 / 2
Credit	Occupant comfort survey	1 / 1
Prereq	ETS Control for Projects in Japan	REQUIRED

REGIONAL PRIORITY		AWARDED: 3 / 4
Credit	Demand response	1 / 1
Credit	Renewable energy and carbon offsets	1 / 1
Credit	Solid waste Mgmt - ongoing	0 / 1
Credit	Site Mgmt	0 / 1
Credit	Outdoor water use reduction	0 / 1
Credit	Indoor water use reduction	1 / 1

LOCATION & TRANSPORTATION		AWARDED: 15 / 18
Credit	Alternative transportation	15 / 15

TOTAL	71 / 110

Appendix B: UCSB Student Resource Building scorecard

1000057524, Pittsburgh, PA

Two PNC Plaza

LEED O+M: Existing Buildings (v4) — SILVER, AWARDED JAN 2017

SUSTAINABLE SITES		AWARDED: 2 / 10
Credit	Site development - protect or restore habitat	1 / 2
Credit	Rainwater Mgmt	0 / 3
Credit	Heat island reduction	0 / 2
Credit	Light pollution reduction	1 / 1
Credit	Site Mgmt	0 / 1
Credit	Site improvement plan	0 / 1

WATER EFFICIENCY		AWARDED: 2 / 12
Credit	Outdoor water use reduction	2 / 2
Credit	Cooling tower water use	0 / 3
Credit	Water metering	0 / 2
Credit	Indoor water use reduction	0 / 5

ENERGY & ATMOSPHERE		AWARDED: 22 / 38
Credit	Existing building commissioning—analysis	2 / 2
Credit	Existing building commissioning—implementation	0 / 2
Credit	Ongoing commissioning	0 / 3
Credit	Advanced energy metering	0 / 2
Credit	Demand response	0 / 3
Credit	Renewable energy and carbon offsets	3 / 5
Credit	Enhanced refrigerant Mgmt	0 / 1
Credit	Optimize energy performance	17 / 20

MATERIAL & RESOURCES		AWARDED: 3 / 8
Credit	Solid waste Mgmt - ongoing	2 / 2
Credit	Solid waste Mgmt - facility maintenance and renovation	0 / 2
Credit	Purchasing - lamps	0 / 1
Credit	Purchasing - ongoing	0 / 1
Credit	Purchasing - facility maintenance and renovation	1 / 2

MATERIAL & RESOURCES		CONTINUED

INDOOR ENVIRONMENTAL QUALITY		AWARDED: 4 / 17
Credit	IAQ Mgmt program	0 / 2
Credit	Enhanced IAQ strategies	2 / 2
Credit	Thermal comfort	0 / 1
Credit	Interior lighting	0 / 2
Credit	Daylight and quality views	0 / 4
Credit	Green cleaning - custodial effectiveness assessment	1 / 1
Credit	Green cleaning - products and materials	1 / 1
Credit	Green cleaning - equipment	0 / 1
Credit	Integrated pest Mgmt	0 / 2
Credit	Occupant comfort survey	0 / 1
Prereq	ETS Control for Projects in Japan	REQUIRED

REGIONAL PRIORITY		AWARDED: 2 / 4
Credit	Renewable energy and carbon offsets	0 / 1
Credit	Enhanced IAQ strategies	1 / 1
Credit	Solid waste Mgmt - ongoing	1 / 1

LOCATION & TRANSPORTATION		AWARDED: 13 / 18
Credit	Alternative transportation	13 / 15

TOTAL	50 / 110

Appendix C: Two PNC Plaza scorecard

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Reflection

This capstone brought to my attention more possible selections of what makes a building sustainable and the different sectors involved as a potential career. The capstone was meant to better educate and understand methods for an already built structure on becoming a part of the sustainable built environment, not necessarily by re-design, but through the buildings organs of operations and maintenance. Also, the analysis brings awareness that LEED certification not only provides sustainable practices, but also leads the building industry to a greener economy.