A QUANTITATIVE ANALYSIS OF GREEN-BUILDING FEATURES INCORPORATED IN LEED-CERTIFIED CAMPUS BUILDINGS

by

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This dissertation was prepared under the direction of the candidate's dissertation advisor, Dr. Dianne A. Wright, Department of Higher Education Leadership, and has been approved by the members of her supervisory committee. It was submitted to the faculty of the College of Education and was accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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ABSTRACT

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Higher education is an idyllically positioned organization from which meaningful dissemination of knowledge and interdisciplinary research is capable of actuating practices that resource consumption. Paradoxically, the construction, maintenance, and operations of the built environment, including the built campus environment, have contributed to the decline of raw resources and degradation of environmental processes. An opportunity exists to bridge the knowledge gap between the design and construction phase and the operations and maintenance phase of the green certified building life cycle, while examining the parts that contributed to the green-certification of the whole building. The purpose of this research was to 1.) identify green-building features and determine their frequency of implementation in new capital (NC) LEED-certified, campus buildings to effectuate operations and maintenance cost savings, indoor wellbeing, and environmental stewardship, and 2.) determine the relationships of green-building feature usage across building, institutional, and LEED characteristics. The study used archival data to document the green efforts of each building with the study's sample of 195 buildings on the campus of 107 universities and colleges, in the United States, between 2007 and 2017.

The study's findings indicated that the public institutions earned the LEED certification more often than private institutions and the sample was void of two-year community colleges. The sample was restricted for green-building features that (a) reduce economic cost, (b) improve indoor wellbeing, and (c) increase environmental stewardship. The results and implications are discussed.

DEDICATION

I dedicate this work to my grandmother, Korisha Dolly Mohammed. Thank you for showing me the extraordinary beauty in the birds and trees.

A QUANTITATIVE ANALYSIS OF GREEN-BUILDING FEATURES

INCORPORATED IN LEED-CERTIFIED CAMPUS BUILDINGS

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I. INTRODUCTION

Labor and technology will not be the limiting resources of economic development, in the future (Cortese, 2003). The development of trade and industry will be influenced, by the availability of natural resources and environmental processes (Ottman, Stafford, & Hartman, 2006; Stephens, Hernandez, Román, Graham, & Scholz, 2008), as well as societal health, political stability, and social equity (Cortese, 2003). This imbalance between societal usage of natural resources and the earth's ability to replenish these resources intensified concurrently with the Industrial Revolution and has persisted ever since (Rockström et al., 2009; Stephens et al., 2008). One example is the increased pressure on freshwater resources (Kounina et al., 2013).

The increased consumption rate of natural resources, by an expanding human population, has led to the impoverishment of natural variation within the structure and function of global natural systems (Holling & Meffe, 1996). As a result, the natural environment has become less resilient to natural and anthropogenic disturbances (Rockström et al., 2009). This is of great concern since human society progresses within, is reliant upon, and is an entity of the natural environment (Bossel, 1999). The challenges concerning modern natural resource consumption are considered complex, independent, and interdisciplinary (Everett, 2008; Hjorth & Bagheri, 2006). Nevertheless, addressing these challenges are essential to ensuring the perpetuation of natural resources for future generations (Goodland, 1995; Hales, 2008; Roper & Beard, 2006).

To achieve even moderate environmental amelioration will require considerable amendments in human thinking and behavior (Redclift, 2005). Higher education is an idyllically positioned societal organization from which meaningful dissemination of knowledge and interdisciplinary research is capable of actuating practices that reduce natural resource consumption and waste production (Stephens et al., 2008; van Weenen, 2000). Paradoxically, the construction, maintenance, and operations of the built environment, including the built campus environment, have contributed to the decline of natural resources and degradation of natural processes (Rappaport, 2008; Riddell, Bhatia, Parisi, Foote, & Imperatore, 2009; Savanick, Strong, & Manning, 2008). Buildings in particular consume energy and natural resources at each of their life cycle stages from the design and construction of the building through operation and maintenance to finally demolition (Akadiri, Chinyio, & Olomolaiye, 2012). The Princeton Review (2013), reported there were over 4,300 universities and colleges in the United States on which the campus building densities varied from, “one to several hundred buildings” (p. 10).

In an effort to minimize the use of natural resources and improve the quality of life for the campus community, building practitioners and higher education decision makers are shifting their concentration to green-certified building practices (Fischbach, 2007; Galayda & Yudelson, 2010; Martin, 2012). *Green* initiatives refer to progressive actions taken to develop and incorporate sustainable development on the built-campus environment (Rappaport, 2008; Sharp, 2002). The acquisition of green certification for new capital projects through third-party green building rating systems has become one of those green campus initiatives (The Princeton Review, 2013). Leadership in Energy and Environmental Design (LEED) rating system has become the national standard in the United States for new capital projects (von Paumgartten, 2003). A little over 300 universities and colleges have reported requiring LEED certification for new campus projects (The Princeton Review, 2013).

Green building rating systems, through a set of design and construction benchmarks, offer potential benefits along the lines of the three principles of sustainable development (Chance, 2012; Cidell, 2009). The three principles of sustainable development include economic sustainability, societal sustainability, and environmental sustainability (Goodland, 1995). Sustainable development has emerged as a process for transforming current patterns of natural resource consumption and waste production for the purpose of minimizing environmental degradation (Young & Dhanda, 2013). Sustainable development was defined, by Brundtland (1985) as using the current natural resources and services in such a way that future populations will not go wanting or have their way of life compromised. Hjorth and Bagheri (2006) viewed sustainable development as a dynamic process defined by neither static objectives, nor steadfast methods used to attain specified goals. In addition, the process of sustainable development was founded on three principles in order to attain equilibrium between the needs of human development and advancement, and the conservation of natural systems and resources (Newport, Chesnes, & Linder, 2003; United Nations General Assembly, 1972).

Corporate organizations were early pioneers in the sustainability movement and undergirded their work on a mutual focus of the three principles of sustainable development to measure sustainable performance (Slaper & Hall, 2011). The nested model of sustainable development is the current accepted conceptual model used to reveal the complexity of spatial scales within and between the three principles of sustainable development (Giddings, Hopwood, & O'Brien, 2002). Slaper and Hall (2011) advocated the use of the nested model of sustainable development because it reinforces the existence of and relationships between those marginal societies and economies that are often times overshadowed by widely-accepted and recognized ones.

Cost efficiency and effectiveness is one of five desirable consumer benefits generally related with sustainable products (Ottman et al., 2006). Cost savings through performance efficiency underpin the financial sphere of green buildings (Akadiri et al., 2012). Moreover, a common economic intent of green building practices and features is to improve profitability throughout the complete life-cycle of the building (Eichholtz, Kok, & Quigley, 2010; Matisoff, Noonan, & Mazzolini, 2014; Richardson & Lynes, 2007). A social condition of a sustainable building is to reduce or eliminate society's economic consumption pressures on remaining natural resources (Akadiri et al., 2012). The values conferred on the natural environment, by society, and how various factions of society perceive these values are fundamental for understanding the intricate relationships between socio-economic practices and the environment (Koester, Eflin, & Vann, 2006; Redclift, 2005; Wilk, 2002). Furthermore, the call for conservation practices and management of raw goods and services have been recognized, by the building industry (Roper & Beard, 2006).

Green building efforts of higher education in the United States, specifically green building features implemented during the design and construction phases contributing to the green certification of the whole building and ultimately, how the building performs during its operation and maintenance phase, have not been examined. Most research focusing on green construction in higher education are single cast studies. An absence exists of investigations conducted of sustainable campus buildings on multiple institutional campuses. There remains a need to understand what green building features are being incorporated for the purpose of operational cost savings, occupant indoor wellbeing, and environmental stewardship, and the relationships of the green building features among building use by occupancy, institutional funding types, and LEED characteristics.

Statement of the Problem

The built campus environment has been referred to as a *microcosm* punctuated with opportunity to investigate problems surrounding sustainable development, by means of implementing innovative ideas and methods (Cortese, 2003; Mansfield, 1998; Stephens et al., 2008). The green building trend has persisted, and according to McGraw-Hill Construction (as cited in Fischbach, 2007, para. 1), "…the fastest growing sector for green building" is higher education construction. Higher education capital projects have begun shifting away from resource-intensive motivations and leaning toward curbing institutional natural resource metabolism (Glicksman, 2003; van Weenen, 2000). This transition is highlighted in Galayda and Yudelson's (2010) report where; in 2009, more than 3,000 higher education projects registered for LEED certification.

However, ambiguities continue to surround the operational performance of LEED-certified buildings including unreliable data gathering techniques (Eichholtz et al., 2010; Hart, 2009), inconsistent methods of analyses (Miller, Pogue, Saville, & Tu, 2010;

Pitts & Jackson, 2008; Scofield, 2009a), research limited in industry scope (Cidell, 2009; Cupido, Baetz, Pujari, & Chidiac, 2010), and integration of building life cycle phases (Nyikos, Thal, Hicks, & Leach, 2012; Sinha, Gupta, & Kutnar, 2013).

Data gathering methods have been cited, specifically, as an associated flaw of LEED-certified building performance evaluation studies and were considered unreliable because LEED certification is obtained prior to the collection of creditable performance data (Eichholtz et al., 2010; Hart, 2009; Newsham, Mancini, & Birt, 2009). One possible bias related to data gathering identified by Hart (2009) was commercial building owners where the primary source for obtaining a building's performance data was the building's owners. It is suspected that green-conscious building owners might be more willing to participate in such research. Another possible bias related to data gathering has been the sponsorship of green building research (Hart, 2009). More specifically, financial performance data related to green buildings are "limited and consists mainly of industry-initiated case studies" (Eichholtz et al., 2010, p. 2494).

Janda (2011), noted that all buildings are the same size, nor are they used in the same manner. Consequentially, building resource consumption comparisons are considered analytically complicated (Roper & Beard, 2006). Shriberg (2002a), described the existing evaluation and analytic methods for measuring LEED-certified buildings' resource conservation, and found these methods lacked rigor and validity necessary for establishing credible benchmarks. There is no widely recognized method of comparison or well-organized body of information to assist building practitioners in determining if LEED buildings are performing as expected (Miller et al., 2010; Pitts & Jackson, 2008; Scofield, 2009a; Thurston & Eckleman, 2011).

However, whereas, the higher education green building market is considered a "mature green market", and has a longer green building market history than many other industries, including healthcare (Naik, 2013, para. 18); most LEED post-occupancy performance research are situated within the boundaries of the commercial industry. Further, little is known about how the operations and maintenance performance of the whole LEED-certified campus building is impacted by its parts, namely the green building features (Bosch & Pearce, 2003; Cidell, 2009; Cupido et al., 2010). Eichholtz et al. (2010) recommended that it is best to identify the payoffs from green design features within the scope of the industry they are being persuaded in order to gain a more competent understanding of the green design building features.

The examination of LEED-certified buildings is also limited in industry scope (Cidell, 2009). Much of the research that focused on post-occupant building performance are almost exclusive to the commercial building industry (Akadiri et al., 2012; Eichholtz et al., 2010; Kohler & Moffatt, 2003; Miller et al., 2010; Newsham et al., 2009; Roper & Beard, 2006; Scofield, 2009a; Turner, 2006). More recently, however, universities and colleges have adopted organizational-specific strategies for building design, construction, and operations to mutually achieve success along the three principles of sustainable development: the economy, human society, and the natural environment (Newport et al., 2003; Ottman et al., 2006; Slaper & Hall, 2011). Most related studies, however, remain isolated in focus and rarely addressed the three principles of sustainable development simultaneously (Corcoran, Walker, & Wals, 2004; Fien, 2002).

Research concentrating on sustainable development within higher education is extensive and exists within the purview of curriculum (Everett, 2008), finance (Levy &

Dilwali 2000), organizational practice (Sharp, 2002; Shriberg, 2002b), organizational role (Corteses, 2003, Mansfield, 1998), partnerships (Alshuwaikhat & Abubakar, 2008), policy (Kemp, Parto, & Gibson, 2005), research (Fien, 2002), and transportation planning (Balsas, 2003). Further, while there have been studies that coalesced the three principles of sustainable development, their focus was primarily on idiosyncratic efforts, by institutional terms of fostering an organizational acceptance of issues associated with green campus initiatives (Alshuwaikhat & Abubakar, 2008; Koester et al., 2006; McMillin & Dyball, 2009).

Nevertheless, the long-term value of green buildings on campus is a necessary consideration for the following factors: (a) many institutions' debt doubled between 2000 and 2011, in the United States, yet financial borrowing for campus construction continued within higher education (Martin, 2012); (b) campus greening efforts draw media and public attention to the institution (Rappaport, 2008); and (c) the built campus environment has had and will continue to have an impact on the local natural environment (Savanick et al., 2008). An opportunity exists to bridge the knowledge gap between the design and construction phase and the operations and maintenance phase of the green certified building life cycle, while examining the parts that contributed to the green-certification of the whole building.

Purpose of the Study

The purpose of this research was to 1.) identify green-building features and determine their frequency of implementation in new construction (NC) LEED-certified, campus buildings to effectuate operations and maintenance cost savings, indoor wellbeing, and environmental stewardship, and 2.) determine the relationships of green-building feature usage between building, institutional, and LEED characteristics. Giddings et al. (2002) nested model of sustainable development was used to frame and position the research questions affording the opportunity to describe the green-building features within the three principles, as these parts contribute to the whole building's cost-savings, indoor wellbeing satisfaction, and environmental stewardship performance. This descriptive study examined what green-building features were incorporated during the design and construction phases leading to the building's green third-party rating. Data were gathered from archival documents sources. The data were gathered from three sources in an effort to advance the higher education community's understanding of green building design and construction features implemented in LEED-NC campus buildings.

Research Questions

The research questions driving this proposed study are as follow:

Economic Principle:

1. What were the most common green-building features implemented to influence the cost-savings of NC LEED-certified buildings on universities and colleges campuses?

2. What were the differences in green building features that influenced cost-savings between institutional funding types? And between LEED levels of certification?

Social Principle:

3. What were the most common green-building features implemented to influence occupant indoor wellbeing?

4. What was the relationship between campus buildings earned LEED Indoor Environmental Quality credit category scores and building occupant use categories?

Environmental Principle:

5. What were the most common green-building feature implemented to influence environmental stewardship?

6. What were the relationships between green buildings' gross square footage and building characteristics? And institutional characteristics? And LEED characteristics?

Significance of the Study

Through the results of this study, the researcher hoped to provide opportunities for distinguishing usage patterns and trends of green design and construction features, by building, institutional, and LEED characteristics, within each of the three principles of sustainable development. For the purpose of credibility, green buildings must live up to any claims made with regard to customer benefits and environmental conservation (Ottman et al., 2006). According to Shriberg (2002a), for green buildings to remain credible in other aspects of consumer demand, universities and colleges must translate environmental reductions into economic savings and provide a comfortable healthy space for the institution's citizenry to work and learn. Approximately 4 million students attended a university or college campus with a green building policy, as reported, by the Center for Green Schools' *2013 Year-End Report Card* (U.S. Green Building Council, Center for Green Schools, 2013). Between 2002 and 2009, 13% of all LEED project certifications occurred on university and college campuses (Galayda & Yudelson, 2010).

It has become evident through the literature review that an opportunity exists to identify usage patterns and trends of green design and construction features that contributed to the certification of LEED-certified campus buildings, and determine the relationship of green buildings features among building, institutional, and LEED characteristics. There is considerable potential for higher education leaders, more specifically campus facilities planners and managers, to better understand the gains of green building features.

Conceptual Framework: Nested Model of Sustainable Development

To identify usage patterns and trends of green building features implemented in LEED-NC campus buildings within each of the three principles [economy, society, and environment] of sustainable development, and determine the relationships of green-building feature usage among building, institutional, and LEED characteristics; this research applied the nested model of sustainable development. This conceptual model afforded a multidimensional opportunity of examining the operational commonalities and best practices trends of green building features, through the three principles of sustainable development. The nested model of sustainable development was the conceptual model chosen for this research because it is suggested to reveal the complexity of spatial scales within and between the three principles (Giddings et al., 2002). Slaper and Hall (2011) advocated the use of the nested model of sustainable development; since, it reinforces the existence of and relationships between those marginal societies and economies that are often times overshadowed, by widely-accepted and recognized ones.

Integration of parts. Integration is an integral element of the process of sustainable development to attain equilibrium between the needs of human development and advancement, and the conservation of natural systems and resources (Newport et al., 2003; United Nations General Assembly, 1972). Corporate organizations, as early pioneers, in the sustainability movement undergirded their work on a mutual focus of the three principles: the economy, human society, and the natural environment, to measure sustainable performance (Slaper & Hall, 2011). The synergism of the three principles expanded the limits of corporate performance that allowed for greater productivity, agility to respond to new demands, and setting and achieving quality benchmarks (Mattioda, Fernandes, Detro, Casela, & Canciglieri, 2013). Beside private industry, private non-profit organizations, and government agencies have adopted sustainable development principles and practices that emphasis comprehensive accounting of the three principles (Newport et al., 2003).

Early theoretical models of sustainable development incorporated the three principles of sustainable development in a Venn diagram; each sector was represented as a circle (Giddings et al., 2002). The three circles interconnected and were of equal size (Giddings et al., 2002; Young & Dhanda, 2013) (See Figure 1). The structural configuration of the model was a major weakness. It did not affirm the complex interconnections and dimensions of sustainable development (Giddings et al., 2002). Without an all-inclusive approach seeking balance between economic gains, societal concerns, and environmental conservation led to the illusion of separation and autonomy among principles, and created opportunities for precedence to be given to one principle over another (Giddings et al., 2002; Slaper & Hall, 2011). Traditionally, any discussion or practice pertaining to sustainable development gave preference to either the environment (Newport et al., 2003), or the economy (Giddings et al., 2002). Industries, including higher education, have recognized prioritizing any one principle will diminish innovation and lessen the organization's competitive ability in the global market (Mattioda et al., 2013; Sharp, 2002; Velazquez, Munguia, Platt, & Taddei, 2006).

Figure 1. Early theoretical models depicted the three sectors of sustainable development: the economy, human society, and the natural environment using equal-sized circles (Giddings, Hopwood, & O'Brien, 2002).

Alternatively, the nested model of sustainable development as presented, by Giddings et al. (2002) shifted the three circles so that they completely overlap one another, but most importantly the diameter of each circle varies on the realities and constrains of the three individual principles (See Figure 2). The circle representing the environment is the largest of the three, and is the foundation on which the other two principles are nested within. Humans (*Homo sapiens sapiens*) are just one of the many extant species inhabiting planet Earth and survival of the species is ultimately dependent on the natural environment. The intermediate circle represents society and is perceived as a subset of the environment (Gidding et al., 2002).

As, all human interactions occur within the environment; in turn, the consequences of these social actions impact natural systems and processes (Giddings et al., 2002; Norton & Toman, 1997; Sharp, 2002; Young & Dhanda, 2013). The smallest circle represents the economy. The economic sphere is a subset of society where production and consumption of man-made goods are perceived as a social interaction (Gidding et al., 2002; Sinha et al., 2013). Ultimately, the life cycle of these man-made goods begin and end in the environment (Mattioda et al., 2013).

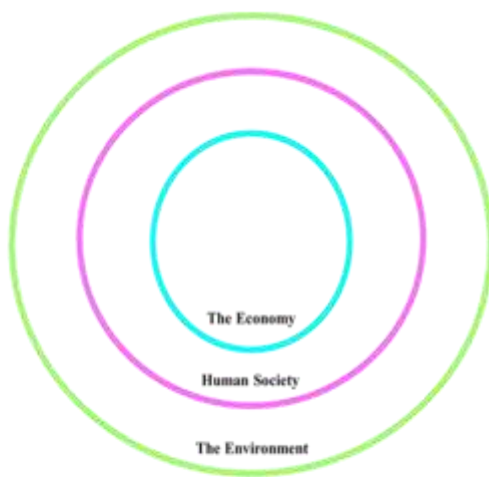


Figure 2. The nested model of sustainable development is depicted using circles of varying diameters in an effort to represent the realities and constrains of each principle (Giddings, Hopwood, & O'Brien, 2002).

Definitions

Brownfield – defined, by the U.S. Environmental Protection Agency (n.d.; para. 1), as "a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant".

Comfort - is the “absence of unpleasant sensations, which has a positive effect on well-being” (Feige, Wallbaum, Janser, & Windlinger, 2013, p. 12).

Disaster Resiliency - as defined, by Kapucu and Khosa (2013) as a concept focused on, “capacity building for physical structure and system and the social community that helps to respond and recover from disaster effectively” (p. 6).

Disaster Resistance - as defined, by Kapucu and Khosa (2013) as, “pre-disaster plans and mitigation strategies that improve infrastructure and institutions by making systems resistant to disastrous effects” (p. 6).

Durability - is defined as the “ability of a building or any of its components to perform the required functions in a service environment over a period of time without unforeseen cost for maintenance or repair” (Sinha et al., 2013, p. 47).

Effectiveness - as defined, by McCormick (1981), is a measure of the success in achieving a clearly stated objective.

Efficiency - as defined, by McCormick (1981), as cost effectiveness. An efficient solution is one that is most effective, yet at a minimum cost.

Embodied energy - as defined, by Akadiri et al. (2012), is the total energy required for the development of a building.

Facility Management - as defined, by Lavy (2008), as professionals responsible for the maintenance and performance of the built environment.

Green buildings – defined, by Roper and Beard (2006), as those buildings that have minimum adverse impacts on the built and natural environment, in terms of the buildings themselves, their immediate surroundings and the broader regional and global setting.

Indirect Energy - as defined, by Akadiri et al. (2012), is the total energy required to extract, harvest, recovery, manufacture, and transport a particular building material.

Leadership in Energy and Environmental Design (**LEED**) – defined, by von Paumgartten (2003), as the U.S. Green Building Council's (USGBC) Green Building Rating System for measuring new buildings' design, construction, and operations. Furthermore, Owen, Macken, Rohloff, and Rosenberg (2013) defined the LEED Green Building Rating System as an independent sustainable-building accreditation system.

Natural ventilation - is "the process of replacing air in any space to provide high indoor quality without the use of mechanical means" (Akadiri et al., 2012, p. 144).

Passive energy design – are specific building features utilized to, "help achieve thermal and visual comfort inside the building, so that there is significant reduction in energy consumption by conventional air conditioning and artificial lightning" (Akadiri et al., 2012, p. 135).

Performance - in context of building materials and furnishings, "refers to how well the material does its intended job" (Sinha et al., 2013, p.47).

Public-Private Partnership – as defined, by The National Council for Public-Private Partnership (n.d.) as,

> a contractual arrangement formed between public and private sector partners. These arrangements typically involve a government agency contracting with a private partner to renovate, construct, operate, maintain, and/or manage a facility or system, in whole or in part, that provides a public service. Under these arrangements, the agency may retain ownership of the public facility or system, but the private party generally invests its own capital to design and develop the

properties. Typically, each partner shares in income resulting from the partnership. Such a venture, although a contractual arrangement, differs from typical service contracting in that the private-sector partner usually makes a substantial cash, at-risk, equity investment in the project, and the public sector gains access to new revenue or service delivery capacity without having to pay the private-sector partner (16th definition in the Glossary List).

Resources conservation – defined, by Akadiri et al. (2012) as, “the management of the human use of natural resources to provide the maximum benefit to current generations while maintaining capacity to meet the needs of future generations” (p. 132).

Site energy - “is the amount of heat and electricity consumed by a building as reflected in utility bills” (Eichholtz et al., 2010, p. 27).

Source energy - is the mixture of transmission, delivery, and production losses for primary and secondary energy consumed by a building (Eichholtz et al., 2010).

Sustainability – defined, by Hjorth and Bagheri (2006), as a moving target; a concept whereby the desired ends of achieving harmony between the economy, society, and environment are continuously altered as understanding between nature and human society improves.

Sustainable development - as defined, by Brundtland (1985), as the use of current natural resources and services in such a way that future populations will not go wanting, or have their way of life compromised. Hjorth and Bagheri (2006) viewed sustainable development as a dynamic process, defined by neither static objectives nor steadfast methods used to attain specified goals.

Triple bottom line (**TBL**) **-** defined by Slaper and Hall (2011), as an accounting framework that integrated three dimensions of functionality: the economy, human society, and the natural environment.

Whole-system approach – defined, by Koester et al, (2006), as a comprehensive approach for institutionalizing a particular issue in all dimensions of an institution, including the academic content, administrative policies, and facilities management arenas.

Limitations

This research identified usage patterns and trends of green design and construction features implemented in LEED- NC campus buildings within each of the three principles [economy, society, and environment] of sustainable development as well as examined relationships of the green building features among building, institutional, and LEED characteristics. The research was limited to the cohort of universities and colleges in the United States listed in The Princeton Review's *Guide to 322 Green Colleges*. These institutions possess formal policy requiring LEED certification for all new capital projects and, by using this cohort, the research is able to control for the varying degrees of green building participation that may result in budgetary constraints, leadership participation and campus-community awareness, and campus resource usages.

A second limitation was time. Due to temporal constrains, a multidimensional snap-shot of the usage of green building features implemented in LEED-certified campus buildings was documented for one decade and these green building features were examined from a post-occupant perspective, rather than investigating the whole life cycle of a building. A third limitation was the environmental factors of each institution.

Environmental factors have a physical influence on the structural integrity and operational efficiency of buildings. The universities and colleges are geographical scattered, and no two geographic locations occurring at identical temporal intervals share exact environmental processes and systems, such as annual precipitation and solar radiation.

Finally, at the time of the research study the researcher was a student at one of the proposed participant institutions. Therefore, the circumstance also raised the question of possible researcher bias. However, every effort was taken on the part of the researcher to avoid any researcher influence on the data.

Delimitations

An important delimitation was the researcher's choice of focus or scope in regard to the overall topic of green-building features that allowed for campus construction to earn third-party rated green certification. The selected focus was on the identification of usage patterns and trends of green design and construction features implemented in LEED-certified campus buildings examined through the three principles sustainable development. This research was not designed to question operational policy or the process of implementing green buildings on university and college campuses. Moreover, no attempt was made to compare the study sample population of institutions with other regions of the world or other green building rating systems.

Chapter Summary

The intent of the study was to identify usage patterns and trends of green design and construction features implemented in NC LEED-certified campus buildings, within each of the three principles [economy, society, and environment] of sustainable development, and examine the relationships of green-building feature usage among building, institutional, and LEED characteristics. The nested model of sustainable development was used to guide and position the research questions, and provided a multidimensional understanding of green building features. A quantitative research design was used to examine the usage patterns and trends of green building features implemented in NC LEED-NC campus buildings among universities and colleges in the United States. This focus allowed for an in-depth descriptive analysis of LEED-NC buildings moving beyond generalities and providing a detailed account of what green building features were used spatially and temporally to achieve sustainability of the whole building's post-occupancy performance.

II. REVIEW OF THE LITERATURE

The purpose of this study was to identify usage patterns and trends of green building features implemented in new construction (NC) LEED certified campus buildings, within each of the three principles [economy, society, and environment] of sustainable development. In addition, the study examined the relationships of green-building feature usage among building, institutional, and LEED characteristics.

The world population is increasing exponentially and is expected to approach 8.9 billion, in 2050 (Cohen, 2003). Global energy consumption and manufacturing activities are expected to triple, by 2056 (Akadiri et al., 2012). Resultantly, those industries that are resource-intensive are reflexively seeking innovative interdisciplinary methods of reducing and reusing natural resources to ensure organizational viability and advancement (Sinha et al., 2013; Stephens et al., 2008). Currently, the building industry is one of the largest global resource consumer and waste producer (Akadiri et al., 2012; Sinha et al., 2013). Half of all buildings in the United States expected to be constructed within the 21st century will be built, by 2030 (Retzlaff, 2009).

Higher education has accepted the gauntlet to facilitate sustainable development initiatives, and is transforming the paradigms and assumptions in which the built campus once operated (van Weene, 2000). In this process, institutions are addressing resource consumption and waste production through the design, construction, and operations of green campus facilities (Chance, 2012; Levy & Dilwail, 2000; Richardson & Lynes, 2007; Simpson, 2003). The presence of LEED-certified buildings on higher education campuses are a reflection of institutional support for sustainable building initiatives (Cupido et al., 2010). From student housing to recreation centers, campus buildings are seeking to reduce natural resource consumption and waste production, while simultaneously creating a healthy indoor environment for campus citizens (Fischbach, 2007; Shriberg, 2000). Green initiatives, such as sustainable building practices, are not only environmentally beneficial, but also capable of enhancing institutional image (Chance, 2012; Rappaport, 2008). Inherently, sustainable building practices can imply social awareness and responsibility by the organization that may lead to a stimulation of long-term operational cost savings, peer distinction, and resource conservation associated with the construction, and maintenance and operation (Eichholtz et al., 2010; Rappaport, 2008).

Green building rating systems, through a set of design and construction benchmarks, offer potential benefits along the three principles of sustainable development, i.e., economic saving, indoor wellbeing, and environmental conservation (Chance, 2012; Cidell, 2009). In the United States, the LEED rating system has become the national standard for new capital projects (Hart, 2009; von Paumgartten, 2003). Universities and colleges have employed LEED rating systems in their construction planning, in an effort, to recognize and enhance the sustainability of new campus facilities (Rudden, 2010). The McGraw-Hill Construction (2013) *New and Retrofit Green Schools SmartMarket Report* study found 75% of the higher education participants required building policies that stipulated LEED certification for new capital projects. The density of LEED certified buildings have increased on campuses in the United States; consequently, through the creation and adoption of institutionally-distinct, sustainable building missions and policies (Cupido et al., 2010; Hart, 2009). In 2009, a sustainable benchmark study conducted, by Yudelson Associates, showed between 2002 and 2009, 15% of all campus projects were registered under the LEED rating system (Galayda & Yudelson, 2010). Additionally, 84% of the higher education participants of the *New and Retrofit Green Schools SmartMarket Report* study obtained either LEED or another third-party green certification for new capital projects between 2000 and 2012 (McGraw-Hill Construction, 2013).

Sustainable Development

Currently, humanity is engaged in a struggle between social and economic advancement, and conservation of extant natural resources. The aggregate efforts of conscious human design to control nature were best recognized and articulated, by Rachel Carson, who in 1963 stated, "But man is a part of nature, and his war against nature is inevitably a war against himself" (Quaratiello, 2004, p. 113). The realization that environmental degradation would destabilize society's ability to expand economic prosperity and social justice has led to concerns for creating a sustainable future (Clugston & Calder, 1999).

Domestic and international leadership took notice of the public's demand for a cleaner environment, in the 1960s and 1970s. In the United States, the Environmental Protection Agency (EPA) was established as an independent agency of the federal government assigned to improve and safeguard the quality of the environment (U.S. Environmental Protection Agency, 2013). In 1972, the United Nations Conference on the Human Environment, also known as the Stockholm Conference, was held to discuss the ramifications of increasing global development on Earth's natural systems (U.S.

Environmental Protection Agency, 2013; Wright, 2002). The meeting produced the Declaration of the United Nations Conference on the Human Environment which introduced the strategy of sustainable development (United Nations General Assembly, 1972; U.S. Environmental Protection Agency, 2013). The declaration also emphasized the need for environmental literacy for all and for communication media to take an active role in reducing environmental decline through their broadcasted programs (United Nations General Assembly, 1972). In 1985, the Brundtland Commission, also known as World Commission on Environment and Development, singularized sustainable development as the use of current natural resources and services in such a way that future populations will not go wanting, or have their way of life compromised (Brundtland, 1985; U.S. Environmental Protection Agency, 2013).

Later in 1990, through the Talloires Declaration, education for sustainability at universities and colleges across the globe was formally promoted (Shriberg & Tallent, 2003). It was also the first sustainability declaration requiring higher education leaders to actively support and inculcate environmental literacy through curriculum, research, operations, and outreach programs (Shribert & Tallent, 2003; Wright, 2002). This study's focus was built upon the nucleic themes found in the three aforementioned declarations: (a) ensuring viable economics, (b) fostering awareness of sustainability, and (c) participating in reducing environmental decline.

Institutions of higher education have embraced the idea of sustainability, through the creation and adoption of institutionally-distinct missions and guiding documents (Velazquez et al., 2006). Furthermore, how universities and colleges recognize and frame their commitment to achieving sustainability varies in respect to the institution's interpretation of *sustainability*, and the type of sustainable development approach agreed upon, by the individual institution (Shriberg, 2002a). Universities and colleges in the United States have taken progressive action to develop and incorporate initiatives fostering sustainability on the built-campus environment; these efforts have also been referred to as campus *greening* initiatives (Rappaport, 2008; Sharp, 2002).

Building policy is central to the extent at which an institution will pursue or participate in green building projects (Cupido et al., 2010). To further facilitate the sustainability of building projects, there is an increased interest among prospective students with regard to policy and practice (The Princeton Review, 2013). The Princeton Review has annually published a list of universities and colleges that demonstrated an outstanding commitment to sustainability. One of the green rating criteria was the determination of "whether new buildings are required to be certified LEED Silver" (The Princeton Review, 2013, p.7).

Initially, green initiatives were projects and activities generated solely to address environmental issues, such as reducing on-campus, greenhouse gas emissions (Rappaport, 2008). Contemporary green initiatives, however, reflect the economic, social, and ecological issues and needs of the campus (Newport et al., 2003; Savanick et al., 2008; Shriberg, 2000; The Princeton Review, 2013). For green initiatives to be successful, a holistic approach has been prescribed involving all dimensions and levels of an institution (Alshuwaikhat & Abubakar, 2008; Koester et al., 2006; McMillin & Dyball, 2009; Newport et al., 2003; Velazquez et al., 2006).

Green Building Initiatives

Design and construction of green buildings are important attempts to achieving exceptional performance along the three principles of sustainable development (Cidell, 2009; Glicksman, 2003). According to many authors (e.g., Birt & Newsham, 2009; Kohler & Moffatt, 2003; Sinha et al., 2013), such efforts are necessary since the building sector in the United States is the largest natural resource consumer and a major waste contributor. The cause and persistence of this type of resource consumption and waste production behavior may stem from an absence of official industry guidelines and standards, and the fact that there is no unified governing body (Hart, 2009). Another important aspect of the building industry with respect to material consumption is its size (Akadiri et al., 2012; Sinha et al., 2013). It is the largest economic industry in the United States, including over 10,000 firms employing over 4 million people (Hart, 2009). Yet, the same elements (i.e., lack of restrictions and industry fragmentation) that has led to the minimization of natural resources is paradoxically responsible for propagating myriad forms and functions of buildings in the United States (Hart, 2009).

Today, much attention and encouragement is being given toward green building practices, by building practitioners and policy makers, as they shift their concentrations to solutions that limit natural resource consumption and waste production (Glicksman, 2003). In addition, confidence in the function of green buildings has been fueled, by extension of the knowledge base (Chance, 2012; Cupido et al., 2010), and greater experience gained through practical application (Rudden, 2010; Way, Matthews, Rottle, & Toland, 2012). Modern, sustainable-building practices germinated in 1973 with the Committee on Energy, formed by the American Institute of Architects (AIA) (Hart, 2009). The AIA was also instrumental in producing the first reference guide for sustainable building products, with support from the Department of Energy and the United States Environmental Protection Agency (Hart, 2009).

Dichotomy of higher education's green building initiatives. Despite issues surrounding the definitional vagaries of the terms *sustainability* and *sustainable development*; universities and colleges have nimbly integrated the essence of the principle concepts of sustainable development [the conservation of economic, societal, and environmental capital] into their pedagogy and operational practices (Hjorth & Bagheri, 2006; Koester et al., 2006; Shriberg, 2000; Slaper & Hall, 2011). Institutions of higher education have pursued idiosyncratic approaches through their campus operations for a variety of purposes including safeguarding institutional financial viability, quality of life for present and future generations, and natural resources conservation (Ferrer-Balas et al., 2008; Newport et al., 2003). Support for and implementation of on-campus practices intended to reduce patterns of natural resource consumption and waste production have simultaneously cultivated solidarity and distinction among universities and colleges (Everett, 2008; Wilk, 2002).

Collectively, institutions are demonstrating environmental stewardship as they minimize their campuses' ecological footprint; influencing market demands through economically and environmentally prudent procurements and investments; and increasing environmental literacy and awareness among the campus community (Dahle & Neumayer, 2001; Fiksel, Livingston, Martin, & Rissing, 2013; Riddell et al., 2009). Conversely, distinction has arose from the diversity of campus facilities practices and processes implemented, by each institution, in an effort to minimize their respective institutional natural resource metabolism (Ferrer-Balas et al., 2008; Levy & Dilwali, 2000; Velazquez, Munguia, & Sanchez, 2005).

The varying degrees of interest and support obtained from university and college leaders to promote LEED certification has contributed to institutional distinction with regards to green-building practices (Cupido et al., 2010; Stephens et al., 2008). The success of institutionalizing and progressing green campus practices has depended on the level of support and focus received from campus leadership (Everett, 2008; Richardson & Lynes, 2007; Shriberg, 2000; Simpson, 2003). This factor of commitment to sustainable development actions has been used to rate institutions as evident, by The Princeton Review's *Guide to Green Colleges*. The rating can be considered an external pressure because it has created a novel dimension of competition within the industry of higher education and may prompt procrastinating institutions to adopt sustainable practices and policies in an effort to remain viable (Ferrer-Balas et al., 2008; Fischbach, 2007; Matisoff et al., 2014; Young & Dhanda, 2013).

The diversity of green campus infrastructure, activities, and initiatives in combination with increased student interest in social and environmental responsibilities have also supported this external market pressure. Today's students are concerned about the environment, their health, and economic alternatives that may lead to shifts in social patterns of resource consumption and waste production (Ferrer-Balas et al., 2008; van Weene, 2000). For this reason, universities and colleges have concentrated on constructing attractive campuses in an effort to lure prospective students (Fishbach, 2007; Martin, 2012). The quality of campus facilities was shown to be a determinant of student recruitment and retention; however, it is important to note, "…that the quality of facilities will not have an impact on student choice unless it is incorporated in the higher-education institution's marketing strategy" (Vidalakis, Sun, & Papa, 2013, p. 499).

Paradoxically, seeking organizational distinction through the realities of capital construction have financially burdened many institutions (Martin, 2012). Garnered knowledge from corporate performance and product development can assist higher education in a lesson on preoccupation with status (Mattioda et al., 2013; Ottman et al., 2006). In that a stimulus, such as rank and rating, has the potential to overshadow other consumer-valued benefits including performance, affordability, and convenience (Ottman et al., 2006; Wilk, 2002). It is the attention to consumers' needs within niche markets and mainstream appeal that underpins an organization's competitive success in the national and global markets (Kim & Mauborgne, 2005; Mattioda et al., 2013; Ottman et al., 2006).

Those institutions that sought to emphasize environmental concerns during expansion processes of their built-campus environment are recognized as vanguards of their industry (Miller et al., 2010; Shriberg, 2000). Through innovative philosophies and behaviors, these universities and colleges have begun to alter their natural resource consumption patterns and have created new market niches and opportunities within the industry of higher education (Kim & Mauborgne, 2005; Wilk, 2002). Green buildings, on university and college campuses, have created opportunities to showcase the institution's progressive attitude toward current and future challenges, in hopes of attracting and retaining students and faculty (Cupido et al., 2010). More specifically, planning, design, construction, and operations of buildings certified, by LEED Green Building Rating System, reflects the institution's commitment to lessen its environmental impacts (The Princeton Review, 2013; von Paumgartten, 2003). A major strength of green building practices is perhaps the integrative opportunities to explore and understand the organizational gains from green building features (Everett, 2008; Stephens et al., 2008).

Leadership in Energy and Environmental Design (LEED)

Currently, there are over 40 sustainable building programs in the United States (Sinha et al., 2013). In the commercial building sector, the U.S. Green Building Council's (USGBC) LEED is the market leader in green building rating systems (Birt & Newsham, 2009; Cidell, 2009; Hart, 2009; Retzlaff, 2009; Scofield, 2009a; Sinha et al., 2013). The LEED Green Building Rating System is an independent green-building accreditation system (Owen et al., 2013). LEED rating systems evaluate a building's design and construction using flexible approaches to improve performance across the three principles of sustainable development (Sinha et al., 2013). In respect to the flexible approaches of the LEED system, the USGBC has strived to invoke willing commitment from building practitioners, by providing the ability, to choose standards that best fit their needs. Mutually, the rating system provides value-innovation and ensures governmental regulations are being met (Cidell, 2009; Hart, 2009; Retzlaff, 2009). According to Cidell (2009),

> LEED standards were developed not only to improve the profiles of individual buildings, but to encourage the design and construction industries to develop innovative solutions that could be used on other projects, thus changing the face of the entire building industry. (p.3)

Since the introduction of LEED rating system's pilot version in 1998; the rating system has undergone three revisions: LEED New Construction (LEED-NC) v2.0 in 2000, LEED-NC v2.2 in 2005, and LEED v3.0 in 2009 (Cidell, 2009; Hart, 2009). A forth version, LEED v4, was released on June 2013; it incorporated the most extensive credit requirement since the origin of LEED (Malin, 2012).

Initially, LEED rating system was originally developed for and applied to new commercial construction, but LEED v4 has diversified to now include 22 different rating systems (U.S. Green Building Council [USGBC], n.d.). The most current version of LEED rating systems is composed of a combination of eight credit categories, which include (a) location and transportation, (b) sustainable sites, (c) water efficiency, (d) energy and atmosphere, (e) material and resources, (f) indoor environmental quality, (g) innovation in design, (h) regional priority, and (i) integrative process credit (USGBC, n.d.). Within each credit category there are perquisites, as well as a variety of optional credits to satisfy added design and construction accountabilities (USGBC, n.d.). Each of the LEED rating systems and its related blend of credit categories, "…will have a different cost impact" (Morris, 2007, p. 56). For example, operational savings from utility costs may translate in few power plants being built (von Paumgartten, 2003).

As credit specifications are met the project earns points; the number of points vary per credit and between credit categories (Hart, 2009, USGBC, n.d.). The total number of points accumulated, by a project, is used to define its level of LEED certification (USGBC, n.d.). Certification is awarded according to the following levels: Platinum, Gold, Silver, and Certified; LEED Platinum certification is the highest level awarded to a building (USGBC, n.d.).

Distribution of LEED-certified buildings. Spatially, LEED rating systems have proliferated internationally with registered projects in over 100 countries (Cidell, 2009). LEED has also been recognized and adapted for use in over 40 countries (Owens et al., 2013; Sinha et al., 2013). Altomonte and Schiavon, (2013) reported the global density of LEED certified buildings, as of February 2013, resulted in approximately 15,183 buildings. In the United States, LEED-certified commercial buildings are highly concentrated in the Pacific Northwest, the Rocky Mountains, the Upper Midwest, and along the East Coast (Cidell, 2009). Whereas, the regions with the least number of LEED-certified commercial buildings included Southern California, the Great Plains, the Ohio River Valley, and the South (Cidell, 2009). As of 2007, southern cities, such as Miami, New Orleans, and Nashville, reported no LEED-certified commercial buildings (Cidell, 2009). Phoenix, AR; and Gainesville, FL were found to possess the highest number of LEED-certified commercial buildings (Cidell, 2009). The University of Florida located in Gainesville, FL is responsible for the city's green building status (University of Florida, n.d.). The university pioneered green building practices, in the state of Florida, through the design and construction of the first LEED-certified Gold building, in the late 1990s (University of Florida, n.d.; van Weenen, 2000). Later in 2009, University of Florida was ranked number one for LEED project registrations, by the USGBC (University of Florida, n.d.)

Within higher education, the sustainable building market is far more established than in either the commercial or healthcare sectors (Naik, 2013). In 2010, 571 campus building projects in the United States achieved LEED-certification (Galayda & Yudelson, 2010). Forty-nine percent of all LEED-NC v2 belonged to institutions classified as doctoral/research universities, by Carnegie Classifications (Chance, 2012). Interestingly, doctoral/research universities account for only 6.4% of all higher education institutions in the United States (Chance, 2012). Associate colleges trailed behind universities in their commitment and application of LEED standards, but as of 2009, have increased their involvement in green building practices (Chance, 2012).

Private university and colleges were early adopters of LEED standards (Hart, 2009). Twenty-one percent of LEED-NC registrations occurred at private universities and colleges, as of 2005 (Hart, 2009). In 2011, Harvard University, a private Ivy League research university, held the greatest number of LEED-certified buildings than any other higher education institution in the United States with 53 buildings (Melton, 2011). Most of Harvard's building projects were renovations rather than new construction; since, new construction space is limited in Cambridge, Massachusetts (Melton, 2011).

A survey, by the United Negro College Fund's Building Green program, in its report *Minority-Serving Institutions Green Report*, found only three of the study's 52 participating higher education institutions that served a large percentage of minority students achieved LEED-certification (UNCF Institute for Capacity Building, 2010). Those institutions included Clark Atlanta University and Spelman College each have one LEED certified Silver building, and Los Angeles Trade-Technical College has one LEED certified Gold building and two LEED certified Silver buildings (UNCF Institute for Capacity Building, 2010). Collectively, higher education is mindful of the challenges of sustainable development today as well as cognizant of financial saving, industry recognition, and environmental benefits associated with LEED ratings (Hales, 2008; Hart, 2009; Reid & Davis, 2011).

Economic Sphere: Green Building Features

LEED-certified buildings are of considerable interest to higher education as participation in greening new capital projects offer the potential to reduce operational cost (Velazquez et al., 2005). A variety of factors, however, inhibit the implementation of green practices and features, including the need to achieve short-term cost reductions. During the design and construction phases, short-term cost reductions sometimes takes precedent and when such actions occur green practices and features are most often eliminated from the project (Rudden, 2010; Velazquez et al., 2005). Another factor that inhibits the implementation of green practices and features is unreliable data gathering related to LEED assessments. Cash-strapped institutions are often unwilling to explore green rating systems because of ambiguities surrounding data gathering and data sources (Everett, 2008; Retzlaff, 2009).

Initial investments and operating costs. Facilities operational costs are an imperative element of the institution's financial sphere, and these facilities are operating at a cost of approximately $200 billion annually (Levy & Dilwali, 2000). Financial ambiguities surrounding initial-investment costs associated with green building features may inhibit higher education decision makers from choosing LEED standards for future capital projects (Levy & Dilwali, 2000). A general perception of LEED-certified buildings is they cost substantially more than a conventional building design (Glicksman, 2003; Morris, 2007; Pitts & Jackson, 2008). According to BuildingGreen Inc. (2011), the construction cost premium of achieving LEED certification can range between 2% and 15% of the original project cost. Those projects at the higher construction cost premium range were involved in "on-site renewable energy generation" (BuildingGreen Inc., 2011, para. 13). Nevertheless, the accomplishment of LEED certification without adding to the overall cost of a project is a realistic goal; one achieved with the use of a knowledgeable design team and tractable goals (BuildingGreen Inc., 2011).

The reluctance to incorporate sustainable building features arise when initial construction costs are perceived as added extra cost (Pitts & Jackson, 2008). Also, timetable constraints contribute to the issue of diminishing or removing sustainable building features (Ries, Bilec, Gokhan, & Needy, 2006). Therefore, particular attention to long-term operational savings is required when examining the investment costs of project's materials and systems (Ries et al., 2006). Pitts and Jackson (2008) posited, "Green design features may reduce operating costs such as energy costs, maintenance and repairs, water costs, and legal and insurance costs. These cost reductions increase net operating income" (p. 117). Efforts to prevent discounting or completely ignoring operational cost savings associated with green design and construction practices and features will require improving knowledge and skills in the area of green buildings (Levy & Dilwali, 2000; Ottman et al., 2006; Rappaport, 2008). Literacy on sustainable building performance has the potential to ensure long-term operational cost savings generated by green-building features are not obscured, by myopic decision making (Janda, 2011; Koester et al., 2006; Selman, 1995).

Much of the literature, on the added up-front costs with respect to investing in LEED certification was discussed from a commercial perspective. Nonetheless, considerable efforts were dedicated to analyzing the costs and benefits associated with the initial investment of green building features. von Paumgartten (2003), reported green building certification, such as LEED, can lower the life-cycle cost of the building, by

25%. A study, by Roper and Beard (2006), used the life-cycle cost of green buildings to determine operational savings associated with green building features. A 2% initial investment in green features was found to translate into operational savings, as great as 20%, throughout the life of the building (Roper & Beard, 2006).

Langdon (2004) compared the construction costs of implementing LEED standards to higher education buildings and found no statistical difference in the average construction costs of LEED and non-LEED buildings. The study also found LEED-certified Gold campus buildings were capable of achieving this level of certification, merely through, the application of simple sustainable techniques (Langdon, 2004). Nyikos et al. (2012) reported LEED-certified buildings operated at a median savings of $0.40 per square foot, when compared to non-LEED buildings. Also, when the total cost of green building features was examined the median value was $5 per square foot and showed no cost variation, when compared to other building features, such as roofing, paint, and carpet options (Nyikos et al., 2012). The results presented in the Nyikos et al. (2012) study were the specified median values; these values best embodied the normal distribution, as the distribution was not evenly spread about the average.

Utilities costs. Perhaps the most substantial fiscal impetus for choosing LEED standards is operational savings generated from lowered utility costs; since, utility costs have risen faster than general inflation (Nyikos et al., 2012; Turner, 2006). According to Rappaport (2008), higher education's energy consumption in the United States reflects current trends of increased energy consumption; collectively, universities and colleges spend an approximate $2 billion on energy per year. The LEED rating system specifically addressed energy and water conservation through its credit categories, specifically, Energy and Atmosphere and Water Efficiency. For example, the Energy and Atmosphere credit category, under LEED v2.2, were the most easily calculated and presented the strongest market evidence for LEED-certified buildings' energy efficiency (Langdon, 2004). Additionally, Water Efficiency credit category, under LEED v2.2, WE 3-1 & WE 3-2: Water Use Reduction – 20 Percent Reduction & 30 Percent Reduction, specified the use of low flow fixtures such as, "lavatories and showers, motion sensor operated devices, reduced flush or dual flush toilets, and waterless or reduced flush urinals" to achieve cost and consumption reductions, with respect to potable water (Langdon, 2004, p. 15).

Chance (2012) noted, that of all the LEED categories, Energy and Atmosphere credit category were the least used. Fewer new capital projects pursued the maximum number of energy cost reduction points because of the required green building energy operations literacy and expertise (Langdon, 2004). Prerequisite knowledge and consideration of integrating sustainable features at an early stage of the construction project are recommended to successfully achieve energy efficiency (Langdon, 2004). To ameliorate the problem of new capital projects earning LEED certification without achieving energy-saving credits; LEED v3.0 redistributed the point values to require higher point totals for the following categorical credits: Sustainable Sites, Energy and Atmosphere, and Water Efficiency (Birt & Newsham, 2009; Chance, 2012). By altering the point system, LEED could better reveal the potentials to reduce or improve a building's operational costs and environmental impacts (Chance, 2012). The alteration of points was done in an incremental fashion, in order to gradually eliminate problematic elements of the rating system, and to avoid negatively impacting those projects registered through earlier versions of LEED (Chance, 2012).

A number of studies have strived to quantify utility savings of LEED-certified buildings, in terms of environmental conservation (energy and water consumption), using post-occupancy data. Turner (2006) examined 11 LEED-certified buildings; two of the 11 were higher education buildings categorized as multi-family residential buildings and functioned as college housing, classrooms, labs, and offices. All of the study's sample buildings consumed less energy than if they were built to standards set, by regulatory codes alone; the higher education buildings showed 21% and 28% less energy consumption (Turner, 2006).

In 2008, the National Building Institute (NBI) examined energy performance of 121 LEED-NC buildings; all buildings in the study reported a median energy savings of 24%, when compared to non-LEED buildings (Turner & Frankel, 2008). The study's performance data were widely scattered, which revealed several buildings used more energy, while others used less energy when compared to LEED-baseline standards (Turner & Frankel, 2008). NBI (2008) stated, the distributional scatter may have resulted from alterations in operational practices, equipment, construction modifications, and other issues not accounted for in the predicted baseline model (Turner & Frankel, 2008). The NBI study gave rise to other energy-performance studies seeking to understand cost savings associated with LEED-certified buildings.

Scofield (2009a) identified two analytic issues associated with the NBI study's comparison between *median site energy* usage of LEED buildings and *mean site energy* usage of non-LEED buildings, which were a.) potential for biases that skew only one distribution; and b.) there was no meaningful size inference since the study sample consisted of various sized buildings. Gross square feet (gsf)-weighted means (gsf-weighted means = total energy used by the sample buildings/total gsf) were recommended for calculating energy consumption when building size vary in a sample (Scofield, 2009a, 2009b). In the same study, Scofield (2009a) also re-analyzed the NBI's energy consumption data and found LEED buildings when compared to non-LEED buildings consumed on average 17% less site energy, but equal usage of source energy (Scofield, 2009a). When Scofield (2009a) further disaggregated the data, by LEED certification levels, LEED-certified Gold and Platinum buildings used 31% less site energy and 13% less source energy compared to non-LEED buildings.

Newsham et al. (2009) also re-examined NBI data, and found 100 LEED buildings consumed 18-39% less energy per floor area, when compared to non-LEED buildings. To add rigor to their comparative study, Newsham et al. (2009) used a series of statistical tests to pair a LEED building with a non-LEED building based on physical variables including age, size, climate zone, and activity type. The results showed 28-35% of LEED buildings consumed more energy than their non-LEED matches (Newsham et al., 2009).

Another study, by Scofield (2009b), reassessed the Newsham et al. (2009) and NBI studies, in respect to the application of building-weighted means. When the Newsham et al. (2009) study's methodology was repeated using gsf-weighted means, the findings showed no significant difference between LEED-certified buildings' site energy and source energy consumption, when compared to non-LEED buildings (Scofield, 2009b). Additionally, large LEED buildings reported less energy savings when compared to smaller LEED buildings, and smaller LEED buildings consumed less energy than non-LEED buildings (Scofield, 2009b).

Nyikos et al. (2012) described a 30% median savings for energy and water costs associated with LEED-NC buildings. The electricity savings were reported at 3.83 kWh per square foot, fuel savings were 6.08 kBtu per square foot, and water consumption was 1.33 gallons per square foot (Nyikos et al., 2012). Despite the high density of studies examining energy cost and consumption of LEED-certified buildings; it is important to note, there still is no universal formula for calculating the associated cost savings investment of green building features (Eichholtz et al., 2010; Morris, 2007).

Green building features and building valuation. Another fiscal incentive associated with LEED certification is the increased valuation of the building (Newsham et al., 2009). LEED-certified buildings command higher selling prices, rent, and occupancy rates when compared to non-LEED buildings (Aiello, 2010). More specifically, the selling prices for green-certified buildings were 16% higher than conventional buildings (Eichholtz et al., 2010). Rent was estimated at 3% higher per square foot for green-certified buildings (Eichholtz et al., 2010). According to Matisoff et al.(2014) and Pitts and Jackson (2008), the effect of high performance secured, by green building features and processes, increases a building's value. To recognize the performance impact of green design features, Roper and Beard (2006) recommended, "…to go well beyond the first-cost budget mindset to see how real costs plus opportunity cost equate to building value" (p. 94). There is research indicating green building design features have the potential to improve a building's valuation (Vidalakis et al., 2013). Sustainable building features, specifically, in the form of solar lighting, drinking-water filtration systems, and replacements or improvement of heating, ventilating, and air conditionings (HVAC) have generated operational savings (Fischbach, 2007; Matisoff et al., 2014; Pitt & Jackson, 2008; Rappaport, 2008; Ries et al., 2006). It is important to note that location is a major influencer of the green commercial building's economic value. According to Eichholtz et al. (2010), "…the percent increase in rent or value for a green building is systematically greater in smaller or lower-cost regions or in less expensive parts of metropolitan areas" (p. 3). The residential building market also places a higher price premium on location rather than on green building features (Pitts & Jackson, 2008). Even the size of a green-certified, commercial building contributed to its selling price; larger buildings and those that have achieved a high level of green certification [Gold or Platinum levels] sell for a higher price per square foot (Eichholtz et al., 2010).

From the perspective of higher education, campus-building valuation was directly tied to the building's performance (Vidalakis et al., 2013). In 2007, education construction was valued at $53 billion (Fischbach, 2007). Faculty and staff were diagnostically more critical of campus buildings then the students; this is considering faculty and staff spend a greater amount of time using those buildings (Vidalakis et al., 2013).

The integrity and market values of green certified buildings cannot be maintained indefinitely; particularly, if these buildings do not deliver on their expected benefits (Birt & Newsham, 2009). Any evidence on the financial performance of green-certified buildings were limited to anecdotal research initiated within the building industry (Eichholtz et al., 2010; Pitts & Jackson, 2008). A caveat to additional investments in building performance efficiency is that eventually an optimal investment threshold will be reached and exceeded; when it does market advantages, such as additional price premiums will be eliminated, and performance efficiency will become inconsequential to the organization (Matisoff et al., 2014).

Green building features and policy. The relationship between LEED certification added up-front costs and operational savings is quite complex, and "…can leave campus decision-makers in a quandary as they strive to balance the needs of the present and future with the fiscal constraints that exist at any given point in time" (Rasmussen, 2011, p. 63). Hence, sustainable building policies are necessary for governing the degree to which an institution will pursue environmental change and participate in sustainable projects (Cupido et al., 2010).

Cupido et al. (2010) conducted a survey on sustainable policy adoption and commitment to LEED certification. The 213 study participants were senior facility officials of APPA's (formerly the Association of Physical Plant Administrators) member institutions (Cupido et al., 2010). The study found operating costs were the primary impetus for adoption, implementation, and compliance of the LEED rating systems on campuses (Cupido et al., 2010). Greater than 85% of the participants possessed or were in the process of adopting formal sustainability building policies (Cupido et al., 2010). Among those institutions that already possessed green building policies, LEED rating system was the most popular rating system over Green Globes and Building Research Establishment Environmental Assessment Method (B.R.E.E.A.M.) (Cupido et al., 2010). Among those participants with policies requiring LEED certification, the Silver level of certification was identified as the most commonly pursued (Cupido et al., 2010). A majority of the study's participating institutions without green building policies indicated that if they were going to commit to a green assessment system LEED rating systems was the top choice, with Silver the most common certification level (Cupido et al., 2010). Sixty percent of the participants without a policy indicated governing protocols were voluntary at their institution (Cupido et al., 2010). Cupido et al. (2010) stressed the use of short, concise policy documents for the reason that they are more likely to be read and implemented than verbose, intricate documents. The study also found consulting and green building costs were the participants' main resistance to policy adoption and implementation (Cupido et al., 2010).

Green building features, and building codes and legalities. Mandatory building codes further impact the financial investment of LEED certification during the design and construction phase (Aiello, 2010). Greater knowledge and awareness of governmental regulatory codes and standard of care is of particular importance to ensure financial and related legal issues do not transpire during the operational phase (Aiello, 2010). Moreover, local building codes are constantly being amended and altered, and what are considered voluntary standards today, may later become mandatory regulations (Aiello, 2010). Still, it is local governments, through their building codes and regulations, credited for bolstering LEED certification in the United States. (Gottfried & Malik, 2009). Local governments are capable of supporting sustainable building practices because of their geographical positioning and organizational structure (Retzlaff, 2009). Mutually, these two features positively affect compulsory implementation of regulations, proactive response to regional and local environmental conditions, and empower local sustainable activism (Retzlaff, 2009).

A drawback to local building codes is the lack of attention to sustainable externalities of a new construction project (Retzlaff, 2009). For example features such as, "…sustainable planting requirements, siting, connectivity, and consistency with regional plans", are absent from local building and energy codes (Retzlaff, 2009, p. 69). Whereas, green rating standards do address a building within the context of its community, since various design elements are measured and valued differently (Eichholtz et al., 2010; Retzlaff, 2009). Effectually, earlier adopters of LEED building standards resist fines, costly readjustments, and related permitting issues (Gottfried & Malik, 2009). Within higher education, those early adopters of LEED rating systems are considered better equipped to cope with future compliance changes (Aiello, 2010). From a corporate perspective, organizations that have set their own benchmarks; rather than just adhering to state-based regulations have achieved operational uniformity throughout multiple locations, and enhanced their organizational image (Cidell, 2009). According to Nathan Gauthier, Assistant Director of the Office for Sustainability at Harvard, "Universities normally would not use cheap construction methods that barely meet code, because they need to live with their decisions for a very long time" (as cited in Aiello, 2010, p. 76).

The longevity of campus building sites are a cause for concern regarding property contamination that could involve premises liability (Heft, 2009). An institution could be in violation of its duties as a landlord or property-owner to manage reasonable, benign buildings or grounds; as in the case of improper containment and disposal of contamination which resulted from historical campus usages (e.g., current student housing once served as laboratory facilities) (Heft, 2009; Kaplin & Lee, 2007).

According to Kaplin and Lee (2007), “The majority rule that landowners are liable only for those injuries on their property that are foreseeable remain intact, but courts are differing sharply on what injuries they view as foreseeable” (p. 93). This challenge then becomes substantial to campus building managers, as incomplete archives of campus historical usages are the result of paltry recording keeping and environmental assessments when performed only provide superficial feedback (Heft, 2009).

LEED versions 2.1 through 4.0 has a specific credit category called Sustainable Site (SS), to avert premises liability associated with a project’s site selection (Langdon, 2004). Unfortunately, any attention to soil pollution is isolated to the construction phase of a building’s life cycle, and analytic tools applied during the operational phase of a building, such as Life Cycle Analyses (LCA) do not address post-occupant soil and water contamination at the building site (Akadiri et al., 2012). Several other liability issues surrounding campus building operations that are of great consideration included adhering to and maintaining environmental health and safety regulations as to mold and indoor chemical pollutants, conforming to disability standards and regulations, adopting natural disaster management plans, and maintaining auxiliary systems that safeguard research and satisfy animal welfare standards (Akadiri et al., 2012).

Green building features: Capital and operational budgets. Public universities and colleges in the United States have historically depended on government appropriations for institutional revenue that fed the capital budget for campus construction (Paulsen & Smart, 2001). Between 2000 and 2006, approximately 8,000 campus buildings were registered for LEED certification, and education construction was the fastest growing sustainable building sector (Fischbach, 2007). Between 2006 and

2009, campus renovation and construction saw a steep decline (Rudden, 2010). In 2007, higher education construction project costs were estimated at $14.5 billion (Chance, 2012). By 2009, higher education capital costs had decreased to approximately $10.7 billion, the lowest value since the 2001 recession (Rudden, 2010).

In the late 2000s, campus construction ebbed as a result of state budget shortfalls concurrence with declining housing prices (Hiltonsmith & Draut, 2014). Between 2008 and 2012, forty-nine out of 50 states reduced higher education funding (Hiltonsmith & Draut, 2014). North Dakota was the only state that did not reduce per-student funding (Hiltonsmith & Draut, 2014). Whereas, Arizona, California, Nevada, Illinois, and New Jersey imposed the largest percent decrease to higher education funding per full-time equivalence (FTE) (Hiltonsmith & Draut, 2014). Public universities and colleges responded to the revenue shortfall from the state, by increasing student charges (e.g., tuition; fees; and room and board), freezing salaries, and cutting services (Hiltonsmith & Draut, 2014).

According to Martin (2012), a large portion of modern institutional debt can be credited to campus construction. The total debts acquired, by approximately 500 universities and colleges in the United States doubled between 2000 and 2011, as a result of construction and upgrades (Martin, 2012). Institutions of higher education incurred these hefty debts, in an effort, to improve the aesthetics of the built-campus environment for the purpose of remaining competitive within the industry (Martin, 2012). The surge in campus construction was to accommodate academic and housing needs attributable to expanding enrollment (Chance, 2012; Stephens et al., 2008).

To obtain an unabridged picture of true cost and financial benefits of green building features, both capital expenses and facilities operating budgets must be acknowledged (Chance, 2012). Due to the uniqueness of higher education's budget, six types of budget components were identified, by Meisinger and Dubeck; they included operating budgets, capital budgets, restricted budgets, auxiliary enterprise budgets, hospital operations budgets, and service center budgets (as cited in Paulsen & Smart, 2001). Two of the six budgetary components comprise the funding for a building from cradle to grave; they are the capital and operations budgets (Paulsen & Smart, 2001). According to Paulsen and Smart (2001), "Separate capital budgets usually deal with facilities plans, but there is substantial spillover into the operating budget for utilities, maintenance, and related expenditures" (p. 503). This fiscal *spillover* is an evolutionary attribute of the interconnectivity between the four phases of a building's life cycle: planning, design, construction, and operations/maintenance (Bosch & Pearce, 2003).

Higher education capital and operational budgets are autonomously managed; so, resultantly any new construction becomes an added pressure to the operating budget due to extra utilities and maintenance costs (Glicksman, 2003; Langdon, 2004; Paulsen & Smart, 2001). Other issues associated with compartmentalization of capital and operations budgets, include outdated utility systems that are often used to operate newly constructed facilities, operational savings are rarely reinvested for continual sustainable initiatives and advancements, and operational savings could negatively impact the department's future budget allotment (Chance, 2012). The current funding mechanism has inhibited a holistic approach to connecting the physical built environment to the system of utilities that sustain long-term operations (Chance, 2012).

Currently, many campus facilities are in need of renovation and repair; for most have existed in the same location for over a century (Heft, 2009). They were built during an age when environmental standards were either inadequate compared to today's requirements or nonexistent (Chance, 2012). These buildings are becoming inept at meeting the needs of today's academic challenges (Cowan, 2013; Lavy, 2008). Also, older facilities are more costly to operate (Lavy, 2008). Forty-four percent of public university and college operating expenditures were reportedly paid for, by tuition in 2012; whereas, in the late 1980s, tuition covered around 20% of operating expenditures (Hiltonsmith & Draut, 2014). The rise in green-certified construction on university and college campuses is a reflection of the present financial state of higher education (Stephens et al., 2008). Green building practices have emerged as one of five recession-driven facilities initiatives implemented, by universities and colleges (Rudden, 2010), as operating costs are rising and a campus building's life expectancy is greater than 60 years (Chance, 2012).

Paying for green building features: Fees, donations, and revolving capital funds. Universities and colleges have innovatively applied various fiscal schemes and strategies to implement LEED standards, while simultaneously attempting to reduce or even eliminate capital costs associated with these building projects (Rappaport, 2008; Rudden, 2010). Institutions have become creative and self-reliant on financing sustainable building projects, through various funding schemes. For example, Colorado State University's Rockwell Hall-West achieved LEED Gold certification, in 2010, at a cost of $17.5 million (Colorado State University, 2010). A mixed funding approach was employed using student fees and donations, through the College of Business (Colorado

State University, 2010). At Colorado State University, all building projects funded, by students, are expected to achieve LEED Silver certification, at minimum, in accordance with the Associated Students of Colorado State University referendum (Colorado State University, 2010). Rockwell Hall-West was projected to reduce water consumption, by 42% and energy usage, by 29% (Colorado State University, 2010).

Another source of funding for capital expenditures is student fees. For example, California State University Fullerton's Student Recreation Center is a LEED Gold certified two-story, 95,000-square-foot building (California State University, Fullerton, 2009). The building's total cost of $41 million was completely funded, by student fees (California State University, Fullerton, 2009; Fischbach, 2007). Also, any revenue generated from facilities operations are recycled into the maintenance of the recreation center and its programs (California State University, Fullerton, 2009).

The College of the Atlantic generates all of its new building projects' construction, operation, and maintenance costs, through fundraising (Rappaport, 2008). Harvard provides up-front capital, through the Harvard's Green Campus Loan Fund (GCLF) (Aiello, 2010). The GCLF is a revolving capital fund for LEED-certification and other sustainable campus initiatives are repaid through the related savings from cost-effective green building features (Aiello, 2010). In addition to providing direct funding for green building features, Harvard University's GCLF has lessened accounting disputes between operational and capital expenses allowing for greater willingness between departments to share information and other resources (Aiello, 2010). This funding mechanism has allowed the organization to provide and maintain the channels for exchanging information and other resources, essentially during economic downturns (Aiello, 2010).

Municipal bonds. Another alternative to financing capital projects is municipal bonds. Institutions have taken advantage of the low rates of municipal bonds, as in the case of Build America Bonds (Arvedlund; 2012; Springfield, 2012; Wang, 2013). The Build America Bond program was part of the American Recovery and Reinvestment Act of 2009 which permitted public higher education institutions to receive a federal subsidy in an effort to reduce total capital cost (U.S. Department of Education, 2009). The federal government has agreed to subsidize 35% of the interest of Build American Bonds (U.S. Department of Education, 2009). Additionally, the act specified that states, through the State Fiscal Stabilization Fund, may use up to 18.2% of its allocated funds for the purpose of facilities upgrades and new construction that is consistent with a recognized green building rating system (U.S. Department of Education, 2009). These monies were distributed to the states in an effort to lessen the need to raise public university and college tuition and fees (U.S. Department of Education, 2009).

Public-private partnership. An external driver of sustainable campus initiatives and a major source of research funding for higher education is private partnerships (Ferrer-Balas et al., 2008). As higher education is an agent of change; partnerships afford institutions financial autonomy to participate in innovative technology (Stephens et al., 2008). Also, partnerships allow institutions to take charge of their curriculum and research agendas, by upholding, “their position as an honest broker of information analysis and dissemination” (Stephens et al., 2008, p. 327). As funding from various entities, such as state appropriations, endowments, student fees, and capital campaigns, continue to slow or decline private partnership becomes a financial beacon to those institutions seeking assurance on investments (Rudden, 2010). Buildings are long-term financial investments (Akadiri et al., 2012); so it is understandable that campus and community stakeholders insist on green building features designed to reduce maintenance and operations costs.

Public-private partnerships, as defined by The National Council for Public-Private Partnership (The National Council for Public-Private Partnerships [NCPPP], n.d.), is a contractual agreement between public and private-sector partners (NCPPP, n.d.). Currently, 10 types of partnerships are recognized, by the NCPPP (n.d.), and higher education is taking advantage of these relationships to finance capital projects. Florida Atlantic University (FAU) partnered with Balfour Beatty Capital Group in 2010 to construct and operate the resident halls of Innovation Village (Florida Atlantic University, 2010). Balfour Beatty Capital Group provided the funds for much of the facilities' design and construction, through the acquisition of tax-exempt bonds worth $3.4 million (Florida Atlantic University, 2010). The benefits to FAU included new revenue streams, an improved sustainable living environment, and access to funds for capital projects (Florida Atlantic University, 2010). FAU's Innovation Village Apartments was awarded LEED Gold certification, in 2013 (Florida Atlantic University, 2010). Balfour Beatty Capital Group benefitted from this mutual partnership, by generating a revenue stream, from maintaining and operating the institution's resident halls (Florida Atlantic University, 2010).

Montclair State University's The Heights is a student housing complex and the first public-private partnership established under the New Jersey Economic Stimulus Act

(Montclair State University, n.d.). The project was funded by tax-exempt bonds issued, by the state's Economic Development Authority (Montclair State University, n.d.). The university has partnered with Provident Group-Montclair Properties who will own, manage, and maintain the facilities until the bonds are paid in full (Montclair State University, n.d.). This student housing complex was registered for LEED Silver certification (Montclair State University, n.d.).

Social Sphere of Green Building Features

As society develops and advances, economic patterns have become more resource-intensive adding greater pressure to sensitive ecological systems (Kemp et al., 2005). The population of the United States, for instance, represents approximately 4% of the global human density (Sinha et al., 2013). However, Americans consumes an estimated 24% of global natural resources, and the building industry in the United States is estimated to consume 14.4% of global goods and services (Sinha et al., 2013). The development of just one building consisted of more than 60 essential materials and over 2,000 distinct products; each with its own lifecycle and individual manufacture/repair/discard practices (Kohler & Moffatt, 2003; Sinha et al., 2013). A social condition of green building features is to reduce or eliminate society's economic consumption pressures on remaining natural resources (Akadiri et al., 2012). The values conferred on the natural environment, by society, and how various factions of society perceive these values are fundamental for understanding the intricate relationships between social practices and the environment (Koester et al., 2006; Redclift, 2005; Wilk, 2002).

Procurement efforts and green building features. Higher education institutions are major procurers of goods and services, both in terms of quantity and diversity (Thurston & Eckelman, 2011). This is quite noticeable from the built campus environment; collectively, over 240,000 buildings represented five billion square feet of floor space, in 2008 (Finlay & Massey, 2012). Universities and colleges, through their procurement efforts, have the potential to foster market capacity for sustainable materials and products (Joseph & Tretsiakova-McNally, 2010); motivate conservation-oriented consumption behaviors (Everett, 2008; Levy & Dilwali, 2000; Redclift, 2005); and lessen institutional levels of consumption (Everett, 2008; Redclift, 2005; Wright & Wilton, 2012). For these reasons, sustainable buildings should meet a number of product requirements, in particular (a) durable building materials that translate into lower maintenance and operations care, and related costs (Pitts & Jackson, 2008; Sinha et al., 2013); (b) transportation intensity through the procurement of local materials (Akadiri et al., 2012); and (c) facilities procurement choices that exemplify the organizational commitment toward the idea of sustainability (Joseph & Tretsiakova-McNally, 2010).

Durability: A characteristic of green building features. Currently, there is a market demand for environmentally-responsible products (Chance, 2012; Matisoff et al., 2014; Morris, 2007). Approximately, 88% of higher education institutions specified sustainability was an imperative for recent procurements regarding building materials and products (Chance, 2012). A common integrative approach of assessing building materials along the three principles of sustainable development involved observation and measurement of all materials' life-cycle activities (Mattioda et al., 2013). Sinha et al. (2013) identified the life-cycle of materials into four phases: the raw-material phase, manufacturing phase, operation phase, and disposal phase to determine their capacity to deliver higher performance and durability. At the operations level, attention is given to a multitude of practices integrating performance, resource consumption, and pollution (Sinha et al., 2013).

Durable materials satisfy the criteria of affordability with respect to performance (Joseph & Tretsiakova-McNally, 2010). A building material is considered durable when the longevity of its service life is greater than other materials on the market with similar or exact functions (Akadiri et al., 2012). Operational cost of replacement and repair is minimized with the use of durable materials (Akadiri et al., 2012). Durable materials also support material efficiency because fewer repairs require less raw resources (Joseph & Tretsiakova-McNally, 2010).

Besides having an influence on natural resource extraction, harvest, or recovery, procurement of building materials and products can also modify society's consumption patterns with regard to pollution (Akadiri et al., 2012). By becoming aware of the supply chains of building materials and products, institutions can avoid high-polluting manufacturers and suppliers (Thurston & Eckelman, 2011). Also, consumer demands for sustainable products have the potential to offset environmental costs; for instance, the use of post-consumer products can adequately translate into waste reduction throughout the products' life-cycle (Mattioda et al., 2013). However, there are multitudes of processes and parties along the supply chain of a particular building material or product (Sinha et al., 2013). The end customer of the supply chain may not have complete disclosure to the life-cycle information for each and every product (Bala, Muñoz, Rieradevall, & Ysern, 2008); nor does institutions of higher education have the resources and tools to examine the supply chain of each product (Thurston & Eckelman, 2011).

LEED rating systems has devoted an entire credit category to building materials and resources (LEED, n.d.). LEED 2009 (v3) building materials and resource credits were based on individual phases of a product's life cycle (USGBC, n.d.). Whereas, the most recent version of LEED, v4.0, attempts to assesses the whole life cycle of a building's products, and rewards projects for reducing and reusing building materials (USGBC, n.d.). For instance, LEED v4.0, Building Product Disclosure and Optimization - Raw Materials Extraction credits reward one point for selecting manufacturers that disclose the following information: social and environmental impacts associated with extraction practices, land use, and any sourcing effects (USGBC, n.d.). Another credit can be achieved, by reusing or recycling, as much building material as possible; this reduces or eliminates the extraction of raw natural resources (USGBC, n.d.).

A comprehensive review of LEED 2009 (v3) conducted by Sinha et al. (2013) discerned a lack of consideration given to building materials and products' whole life cycles, and limited third-party validation required for materials other than wood. To rectify these issues, LEED v4.0 has taken into account the limitations associated with the tremendous effort of identifying supply chains and diminished the undertaking with the inclusion of three new Material and Resources credits (USGBC, n.d.). Points can be earned per credit when manufactures and suppliers disclose information regarding ingredients, sourcing of raw materials, and product life-cycles that reduce environmental impacts (USGBC, n.d.).

Transportation intensity involved with procuring green building features. The organizational choice to use locally sourced goods and services for fabricating, maintaining, and operating a LEED-certified building has the potential to diminish the campus community's procurement costs and consumption impacts on the natural environment. Locally sourced goods and services are better equipped at withstanding the regional microclimate, supporting local economies, and are less energy and cost intensive when compared to imported products (Akadiri et al., 2012). However, emissions generated from campus procurement supply chains are often ignored or overlooked; yet, roughly 85% of campus procurement accounted for indirect emission (Thurston & Eckelman, 2011). Emissions resulting from fossil-fueled transportation are a chief contributor of photochemical smog; this and other air pollutants are lessened when travel between supplier and consumer is shortened (Akadiri et al., 2012). The necessity for reporting indirect emissions included stakeholders' attentiveness in calculating comprehensive organizational greenhouse-gas emissions, increased awareness of emission reduction objectives, and the ability to provide emissions information and environmental risks associated with procurement supply chains upon request (Thurston & Eckelman, 2011).

LEED-certified buildings, through the Materials and Resources credit category, have attributed points for choosing materials and products that were locally harvested, extracted, and/or manufactured (USGBC, n.d.). Incentives for choosing locally sourced and manufactured products included supporting local economies, and lessening immediate impacts to the natural environmental (USGBC, n.d.). Specific reference to transportation intensity was made in context to local procurement, in both versions v3.0 and v4.0 (USGBC, n.d.).

Other than transportation associated with green building feature procurement, attention has been given to commuter transportation, in context with campus planning. A dilemma exists between access and mobility and maintaining the idiosyncratic qualities of campus communities with regard to commuter transportation (Balsas, 2003). Particular issues perpetuating this problem included, "federal requirements concerning air quality, increasing congestion, lack of land for parking, the high cost of constructing parking structures, pressures to reduce traffic's impact on financial resources" (Balsas, 2003, p. 35). Under the newest version of LEED for New Construction and Major Renovations v4.0, an entire credit category was designated to transportation and project site selection (USGBC, n.d.). There were seven specific credits, and *access to public transportation and advocacy for new projects constructed in areas with existing infrastructure* were the two highest earning credits (USGBC, n.d.). Whereas, sensitive land protection, bicycle facilities, reduced parking footprint, and green vehicles were the lowest earning credits (USGBC, n.d.).

Greening building procurement behavior**.** Reducing an institution's consumption of raw natural materials is a holistic method connecting the campus community and the manufacturers and suppliers (Simpson, 2003). The demands for sustainably-responsible goods and services, by the end customers, can echo along the supply chain (Bala et al., 2008). When institutions demand specific building materials and products because of their intergenerational benefits to the economy, society, and the natural environment; they are simultaneously encouraging the concept of sustainability through the supply chain of these goods and services (Akadiri et al., 2012; Bala et al., 2008). Rappaport (2008) opined that higher education specifically procure only those goods and services that are the most efficient, even those with a price premium, as this type of procurement behavior also means insisting that others practice green efficiency. Those manufacturers and suppliers that strive for and disclose their eco-friendly methods are proactively equipped for changes in codes and guidelines or consumer demands (Bala et al., 2008; Thurston & Eckelman, 2011). In addition, developing partnerships with manufacturers and suppliers can result in organizational cost savings associated with contract negotiations, and legal reviews and audits (Thurston & Eckelman, 2011); embodying the concept of sustainability through the operations of the organization (Everett, 2008); and fostering local employment (Bala et al., 2008).

Most apparently, the actor in a building's supply chain that heavily influences its operational performance and supports campus awareness about sustainability is the building's occupants (Chance, 2012; Janda, 2011; Rappaport, 2008; Simpson, 2003). Occupants' behavior is unpredictable; buildings are often used in ways not foreseen, by the design, construction, or facilities operations teams (Cidell, 2009; Janda, 2011; Thurston & Eckelman, 2011). When designing a building for net-zero energy consumption, the occupants and their actions are an integral focus included in the planning process (Janda, 2011). This allows the designers to understand the connections between the building users and the following three influencers, building envelope, plug loads, and micro-generation on a building's energy consumption (Janda, 2011).

From the purview of campus occupants in relations to energy consumption, students, faculty, and administrators are the major influencers on a building's energy consumption (Rappaport, 2008). Energy consumption is attributable to personal habits (Janda, 2011), institutional policies (Bala et al., 2008), or lack of awareness (Rappaport, 2008). Most often utility costs, such as electricity, is hidden from these stakeholders either in the organizational overhead or in student fees (Rappaport, 2008). Hence, outreach should capture both the broad campus (Newport et al., 2003), and the individual user (Simpson, 2003). Repetitive, lucid communication diffused throughout the organization, through various media sources, on sustainability-awareness and literacy are relevant to improving energy efficiency (Chance, 2012). Also, any text communications should characteristically be short, easy to understand, and lack the use of technical jargon (Newport et al., 2003).

A number of universities and colleges have begun providing consumption feedback using various methods to bring awareness to the building's occupants (Chance, 2012). Institutions apply social marketing programs to encourage energy conservation, such as switching off computers (Rappaport, 2008). Showcasing real-time energy consumption is another technique intended to help foster individual and collective occupant consciousness (Rappaport, 2008). The aim of displaying building occupants' resource consumption adds to the occupants' knowledge (Janda, 2011). Cost savings were found when resource consumption was reflected back to the occupant as either direct or indirect feedback approaches (Janda, 2011). Direct consumption feedback from real-time meters and monitors translated into savings between five and 15%, while forms of indirect feedback, such as utility bills, generated savings ranging between zero and 10% (Janda, 2011). Also, behavioral shifts with respect to resource conservation coincide with economic lulls; therefore, it is advantageous to promote and expand energy conservation policies, when energy prices are high and budget are constrained (Simpson, 2003). Otherwise, the incentive to save resources is ignored, when utility costs are low (Simpson, 2003).

Occupant productivity and green building features. An essential requisite of a green building is to reduce or eliminate harm with regard to the occupants or the environment (Akadiri et al., 2012). With current society spending an average of 80 to 90% of their time indoors, occupant work space must be taken into account with respect to green building features given that minute increases in productivity can have a substantial financial impact on the organization (Ries et al., 2006; von Paumgartten, 2003). A positive relationship was found to exist between employee productivity, and green building features and practices (Feige et al., 2013; Ries et al., 2006; von Paumgartten, 2003). Matisoff et al. (2014) reported a 21% increase in occupancy productivity for LEED-certified buildings when compared to conventional buildings. That resulted in occupant productivity gains estimating between $40 and $600 billion annually (Matisoff et al., 2014). This is of great value to higher education decision makers; since, over 80% of business expenses go toward workforce salaries and benefits (Feige et al., 2013; von Paumgartten, 2003). Additionally, universities and colleges expenditures for the built environment is the second greatest cost, after faculty and staff salaries (Vidalakis et al., 2013).

Besides financial gains, occupant productivity has the potential to positively contribute to the social integrity and performance of an organization (Feige et al., 2013; Matisoff et al., 2014). Occupant satisfaction levels alter with the social aspect of indoor comfort (Feige et al., 2013). Even though comfort is influenced, by myriad indoor environmental factors; building occupants' level of comfort can be categorized into one of three comfort groups: physical comfort, functional comfort, and psychological comfort (Feige et al., 2013). When occupant comfort is examined through satisfaction levels, physical comfort is most specifically explored (Altomonte & Schiavon, 2013; Birt & Newsham, 2009). Physical comfort directs attention to the, "biological responses and body dimensions: protection and security, light and illumination, indoor quality, climate, noise, and ergonomics" (Feige et al., 2013, p. 11).

Indoor environmental quality and occupant health. Lower absenteeism was found to be a justification for investing in green building features; since, absenteeism is a consequence of health issues contributing to reduce productivity (Miller et al., 2010; Ries et al., 2006; Roper & Beard, 2006). According to Roper and Beard (2006), improved indoor environmental quality can lead to lower absenteeism, lengthy tenure with an organization, and a reduction in filed lawsuits or insurance claims. Poor indoor quality can result in a malaise known as sick building syndrome (SBS); most symptoms afflict the eyes, nose, and mouth (Fisk, Mirer, & Mendell, 2009; Jung, Liang, Lee, Hsu, & Su, 2014; Roper & Beard, 2006). A few indoor components that contribute to SBS include, (a) accumulation of dust and outdated vacuum cleaners that lack High Efficiency Particulate Air (HEPA) filters affect the indoor air quality; (b) cleaning agents, paints, adhesives, sealants, and furnishing should be free- or low-volatile organic compounds (VOC) as to reduce the need for air scrubbers, and (c) structural issues causing leaks and sustained humidity (Akadiri et al., 2012; Jung et al., 2014; Roper & Beard, 2006).

Jung et al. (2014) examined the relationship between 11 human physiological dimensions and one biomarker to measure allostatic load, and the indoor environmental quality of 115 office occupants belonging to 21 corresponding Taiwanese office spaces. The biomarker used in this study was 8-OHdG, an oxidized nucleoside found in urinary (Jung et al., 2014). The study's results found associations between indoor environmental quality and allostatic load on certain physiological systems; such as, carbon dioxide (CO_2) levels on the neuroendocrine system, and lighting on the metabolic system (Jung et al., 2014). A correlation was found to exist between 8-OHdG and the following SBS symptoms: "eye dryness or irritation, eye tiredness, and vomiting" (Jung et al., 2014, p. 5). Also, allostatic load could serve as a prognosticator for SBS, since it statistically established allostatic load scores were associated with the risk of SBS (Jung et al., 2014).

Indoor environmental quality and occupant satisfaction. Green buildings are often marketed with the expectation that they will improve organizational satisfaction and productivity through a healthier, more comfortable indoor environment (Akadiri et al., 2012; Birt & Newsham, 2009; Pitts & Jackson, 2008). Safety is also a major concern of occupant health as green buildings should not effectuate risk to its occupants (i.e., structural instability and fire hazards) (Akadiri et al., 2012). Various indoor environmental qualities have the potential to influence occupant levels of satisfaction including, "…thermal, acoustic and visual parameters, by air quality, and by other features of the workspace- and of the building- such as view, furniture layout, amount of privacy, cleanliness and level of personal control over the internal environment" (Altomonte & Schiavon, 2013, p. 66). Furthermore, productive capacities of occupants have been linked to indoor satisfaction (Altomonte & Schiavon, 2013). Research has focused on occupant satisfaction, health, and productivity in commercial LEED-certified buildings (Altomonte & Schiavon, 2013; Birt & Newsham, 2009; Elbaum, 2010; Feige et al., 2013; Lee, 2011; Ries et al., 2006).

A case study conducted, by Ries et al. (2006), examined various benefits perceived by employees as they relocated from a conventional building to a LEED-certified commercial building. Occupant productivity data were collected directly from employees of the company, through pre- and post-relocation survey responses. As perceived by the occupants, the view from the work space and lunch room, size of the work space, and ambient air temperature and humidity were found to positively affect productivity (Ries et al., 2006). Employee satisfaction was also measured from the perspective of occupant workspace and of the building in general (Ries et al., 2006). Aspects of the occupants' workspace that showed an increase in satisfaction included occupant workstation size, visual and acoustic privacy, and ability to modify the workspace to meet individual needs (Ries et al., 2006). Satisfaction was also associated with the LEED-certified building's appearance and design which included fire and safety features, and the lunch area and its location within the building (Ries et al., 2006). The study used absenteeism data to determine occupant health and safety, and in general showed no significant difference between the old facility and the LEED-certified facility (Ries et al., 2006). More specifically, however, the study found a significant decline in production workers' compensation after the relocation into the LEED-certified facility (Ries et al., 2006).

Another indoor environmental quality aspect of LEED certification involved enhancement of natural light to improve productivity and satisfaction (Akadiri et al., 2012; Langdon, 2004). Akadiri et al. (2012) defined natural light as, "levels of daylight which are sufficient to see properly without glare or excessive contrast" (p. 144). Cidell (2009) reported a positive relationship between K-12 students' test scores and natural lighting; also, student absenteeism was reduced when natural light was increased. However, no effects were found between natural lightning and the test scores of university and college students (Cidell, 2009).

Lee (2011) examined LEED certification levels, and their relationship to lighting and acoustic qualities on occupant satisfaction and job performance. Data used in the study was acquired primarily from the Center for the Built Environment (CBE) as secondary data which included 15 LEED-certified office buildings (Lee, 2011). The study showed occupants in LEED Platinum buildings were more satisfied with the quantity of light, visual comfort, and higher perceived job performance compared to Gold and Silver rated buildings (Lee, 2011). LEED Gold buildings received the lowest satisfaction scores mainly due to dark workspaces, insufficient electric lighting, and reflections on computer screens (Lee, 2011). In regard to acoustic quality and occupant performance, LEED Platinum, Silver, and Certified buildings showed greater satisfaction than Gold buildings (Lee, 2011). Among all four LEED certification levels, sound privacy was the main acoustic issue (Lee, 2011).

An occupant satisfaction analysis conducted, by Altomonte and Schiavon (2013) found LEED-certified commercial buildings scored significantly higher on the following indoor environmental quality parameters: air-quality, building maintenance, colors and textures, workspace and building cleanliness compared to non-LEED-certified buildings of similar age, size, and function. The study, however, showed LEED ratings had no statistical impact on occupant satisfaction, nor did indoor quality parameters that included temperature, furniture adjustability, and furniture comfort demonstrated empirical difference when compared to non-LEED-certified buildings (Altomonte & Schiavon, 2013).

With respect to temperature, occupants' thermal comfort is considered an essential objective when designing a building for LEED ratings (Akadiri et al., 2012). Environmental factors (e.g., ambient air, radiant, and surface temperatures; humidity; air circulation and speed; and human elements of clothing and activity levels) and the building's design and construction features (e.g., reflective roofing, low-E windows, window tinting, and solar shading) are expected to influence thermal comfort and energy efficiency (Akadiri et al., 2012). Also the orientation of a building on its designated site enables thermal comfort optimization, as cardinal-direction positioning harnesses seasonal heat gain and natural light (Akadiri et al., 2012).

Peer distinction and green building features. The quality of the campus environment is critical for creating added value, by enhancing the institution's marketability, strengthening institutional identity, and facilitating the recruitment of quality staff and students (Vidalakis et al., 2013). Roper and Beard (2006) claimed, "Organizations that ponder their environmental responsibility and then take action are capable of building more secure and prosperous positions, within the global economy" (pg. 100). In the past, higher education measured its success and achieved competitive clout, through the core lens of academia (Chance, 2012). Vidalakis et al. (2013) found that university and college students placed greater importance on the institution's academic programs when compared to the built campus environment.

Nevertheless, sustainability is a growing influential factor of student choice (Newport et al., 2003; The Princeton Review, 2013). A quality campus environment is a major factor when recruiting and retaining talented students (Vidalakis et al., 2013; von Paumgartten, 2003). The impetus driving green campus construction has been the growing interest in environmental responsibility among prospective students (The Princeton Review, 2013). Universities and colleges are currently seeking the highest levels of LEED certification as a means of demonstrating commitment to and leadership in sustainable development practices (Langdon, 2004; Matisoff et al., 2014). Still to have an influence on student choice, Vidalakis et al. (2013) suggested that facilities operations and maintenance be incorporated into the institution's marketing strategy. Furthermore, the assortment of sustainability reports and ratings may influence where faculty will choose to teach (Rudden, 2010). An opportunity exists to showcase green building innovations to prospective students as well as retain current students and faculty (Cupido et al., 2010).

The LEED rating system is widely accepted and understood among campus stakeholders (Chance, 2012). This provides higher education leaders with a parameter for describing their institution's value to the public (Chance, 2012). Whereas, the LEED certification provides a market signal; LEED credit scores offer verification of performance (Matisoff et al., 2014). Organizations that signal a sustainable image may be able to increase demand and market share, while simultaneously influencing the price they charge (Matisoff et al., 2014). Matisoff et al. (2014) found most building practitioners sought LEED certification levels as a means to expand marketability in preference over improving operational performance. Nevertheless, it was suggested that new construction commits to offering improved occupant productivity and greater operating efficiency for the purpose of remaining competitive within a respective industry (Aiello, 2010; Matisoff et al., 2014).

Environmental Sphere of Green Buildings Features

Living within ecological limits would require the reduction of those human activities that negatively impact the environment while simultaneously enhancing the resilience of natural processes and systems (Goodland, 1995, Redclift, 2005). Practitioners are cognizant that buildings consume resources; yet, most practitioners do not afford sustainability much consideration during the design and construction process (Janda, 2011). "The general trend in American building has been to consume more and more energy and resources in the name of making life better" (Janda, 2011, p. 17). For example, within the residential building sector, new homes in the United States are 57% larger in size when compared to homes built a few decades earlier (Janda, 2011). Grander demands are also being made on student housing for private bed and bathrooms, social space, laundry, and fitness facilities, by current university and college students (La Roche, Flanigan, & Copeland, 2010). Building features used to improve occupant satisfaction in the past are now considered standard features, such as HVAC (La Roche et al., 2010). Central air-conditioning has become a common device for providing indoor climate satisfaction (Janda, 2011).

Consequently, the building industry is responsible for much of the extraction, harvest, or recovery of natural resources (Mbohwa & Mudiwakure, 2013). Buildings consume energy and natural resources at each of its life cycle stage−from the design and construction of the project through operation and maintenance to finally demolition

(Akadiri et al., 2012). Globally, building construction consumes 25% of all the wood harvested (Roper & Beard, 2006). Fifty-five percent of wood not allocated for fuel is used for building construction (Eichholtz et al. 2010). Joseph and Tretsiakova-McNally (2010) reported globally 25% of the harvested wood; 40% of stone, sand, and gravel; and 16% of water annually are consumed, by the construction industry. Approximately, 3 billion tons of raw resources are converted into major structural components, such as foundations, walls, pipes and panels (Joseph & Tretsiakova-McNally, 2010). As a result, the industry generates 50% of global greenhouse gas emissions and contributes to acid precipitation (Joseph & Tretsiakova-McNally, 2010). Globally, infrastructure and building construction consumes 60% of the raw materials extracted from the Earth's crust (Sinha et al., 2013). In the United States alone, the built environment accounts for 65% of all energy consumption (Sinha et al., 2013). Resultant carbon dioxide (CO_2) emissions from the built environment accounted for roughly 35% to 40% of total emissions (Sinha et al., 2013).

To further exacerbate the health of the environmental sphere, total territory occupied, by buildings in the United States are estimated to increase from 9.9 to 14.8 billion square meters, by 2030 (Boschmann & Gabriel, 2013). Ignoring the signs of environmental degradation today is sure to become a tremendous burden on future construction projects (Chance, 2012). Sustainable rating systems have been criticized for, "…being market driven, one-size fits-all approaches that fail to adequately address underlying environmental sustainability issues" (Boshmann & Gabriel, 2013, p. 222).

Energy consumption and green building features. Fossil fuels have been the staple energy source, since the Industrial Revolution. Depletion of nonrenewable energy sources and an increase of greenhouse gas emissions are the consequences of increased energy usage. As much as 30% of global, greenhouse gas emissions resulted from the global building industry's activities (Eichholtz et al., 2010). Most greenhouse gas emissions, approximately 76%, were derived from purchased electricity which was used for lighting, cooling, and heating the building (Boschmann & Gabriel, 2013). Approximately, 70% of building energy consumption in the United States was in the form of electricity (Cidell, 2009). Most buildings in the United States were regarded as energy inefficient and accounted for roughly 40% of energy usage (Hart, 2009). Cidell (2009) reported similar energy usage with 39% for buildings in the United States. From a commercial standpoint, energy usage constituted approximately one-third of operating expenses; much of which can be managed through the design and operations of a building (Eichholtz et al., 2010). Ries et al. (2006) reported a 33% decrease in energy usage for LEED-NC when compared to a conventional building. Turner (2006) found LEED-certified buildings used less energy when compared to their baseline (near to-code) benchmarks.

According to Simpson (2003), energy consumption associated with campus operations has consequential impacts on the environment. It is forecasted that as these greenhouse gases accumulate they may heavily influence the world's climate (Canadell et al., 2007; Rockström et al., 2009; Young & Dhanda, 2013). Construction, operations, and maintenance of higher education facilities consume more energy than buildings in other sectors (Chance, 2012). An underlying contributor of campus buildings' high energy consumption is a lack of ownership and responsibility for the learning environment due to compartmentalization between departments (Chance, 2012; Draves, 1995). In an effort to reduce cost, many institutions have concentrated on securing energy supplies; however, such actions will not resolve issues related to atmospheric pollution (Glicksman, 2003; Roper & Beard, 2006). Glicksman (2003) suggested rather than directing efforts toward supply-side energy solutions, it would be best to address methods of limiting consumption in the building sector. Hence, higher education institutions have endorsed green building features based on the merits of resource and energy usage (Rappaport, 2008).

A flaw with early versions of LEED rating systems was energy-performance credits were based on predicted performance at the time of building design rather than post-occupancy energy performance data (Newsham et al., 2009). Green building rating schemes provided certification based on as-designed performance (Birt & Newsham, 2009). Certification was also possible without achieving points within the Energy and Atmosphere category (Birt & Newsham, 2009). However, the newest version of the LEED rating system, v4.0, was updated to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards (ASHRAE 90.1-2010) for new construction projects which highlight natural lighting controls, automatic shutoff controls, occupancy sensors, and plug load controls to achieve energy efficiency (Building Efficiency Initiative, 2013).

Water usage and green building features. Another environmental issue of utmost concern is the depletion of water resources (Rockström et al., 2009). According to the Organization for Economic Cooperation and Development (OECD), it is predicted that half of the expected human population will reside in water stressed areas, by 2030 (Koeller & Hammack, 2010). Currently, over 100 countries rely on desalination to meet consumption demands for freshwater (Waidyasekara, De Silva, & Raufdeen, 2013). Building construction and operations rely heavily on water (Akadiri et al., 2012). More specifically, "…construction of the built environment consumes approximately 16% of available fresh water" (Mbohwa & Mudiwakure, 2013, p.450). Water is also consumed throughout the life cycle of building materials (Akadiri et al., 2012). Mbohwa and Mudiwakure (2013) listed commonly used building materials and their associated water consumption (see Table 1). Still, water conservation technologies and approaches are often the most overlooked features of a building design (Akadiri et al., 2012).

Table 1

Associated Water Use during the Production of Conventional Building Materials

Materials	Water Use
Cement	3.6 tonnes of water/tonnes of dry cement
Clay bricks	0.5tonnes of water/tonnes of clay brick product
Glass	----
Steel	300tonnes of water/tonne of steel

Note. This information was obtain from Mbohwa and Mudiwakure (2013).

Currently, water management has been another environmental concern of LEED rating systems. Earlier versions of LEED ratings for new construction employed certain features, such as low-flow toilets and shower heads, sinks with automatic shut-off valves, collection and use of rainwater, and drought-tolerant indigenous landscaping to reduce water consumption (Akadiri et al., 2012; Enck, 2013; Lynch & Dietsch, 2010). Turner (2006) reported four out of seven LEED-certified commercial buildings consumed less water than estimated, by the buildings' baseline benchmarks. According to Koeller and Hammack (2010), plumbing fixtures and fittings endorsed, by the LEED rating systems were more efficient than those specified, by the Energy Policy Act (EPAct) of 1992. To further reduce water consumption, LEED v4.0 extended the types of water-savings technologies to include cooling towers and water-efficient appliances (Enck, 2013). Cooling towers are heat removing devices which utilize water to remove heat either through the process of evaporation or exposure to air (Enck, 2013; Koeller & Hammack, 2010). A common application for cooling towers is to deliver cool water to a building's air-conditioning. When the water is re-circulated through multiple cooling cycles less potable water is consumed, and there is little need to return high-temperature waters to local aquatic ecosystems (Enck, 2013; Koeller & Hammack, 2010). Also, all new construction rated under LEED v4.0 will require water efficient appliances; for instance in commercial kitchens, the pre-rinsing of dishes uses more water than the actual dish washing process (Enck, 2013). The act of pre-rising consumes on average 3.2 gallons per minute (gpm) (Enck, 2013). LEED v4.0 requires pre-rinse spray values to use ≤ 1.3 gpm; this is 0.3 gpm less than the maximum legal flow rate specified, by the Energy Policy Act of 2005 (EPAct 2005) (Enck, 2013).

Through LEED Water Efficiency credits higher education campuses are attempting to increase campus stakeholder awareness and behavior by making conservative practices visible, as in the case of Emory University. The university has applied rainwater harvesting, stormwater harvesting, and graywater systems to a cluster of LEED Gold certified residential halls; they include, Few Residence Hall, Evans Residence Hall, and Longstreet-Means Residence Hall (Lynch & Dietsch, 2010). Runnels were used to make the collected water more visible as it travels through the landscape, captured rainwater or graywater are used to flush all toilets in the residential hall, and by capturing rainwater in underground cisterns stormwater runoff was reduced, by 39% compared to pre-development settings (Lynch & Dietsch, 2010).

However, considerable research efforts in the area of water consumption associated with green buildings is sparse due to a lacked of available databases (Turner, 2006). Also, most research are limited to individual institutional cases studies (Lynch & Dietsch, 2010; Koeller & Hammack, 2010).

Regional priorities and green building features. The placement of a building is another consideration of LEED standards (Cidell, 2009). LEED new construction ratings, since 2000, have anticipated natural environmental conditions and have provided flexible credit requirements to alleviate costly infrastructure damage (Langdon, 2004). For instance, the local weather patterns and soil horizons have the potential to greatly impact flooding (Langdon, 2004). So to reduce standing water caused by impervious surfaces surrounding a newly constructed and certified building, LEED v2.2 and v3.0 specified through Sustainable Site credit 6-1: Stormwater Management - Quantity Control, any captured precipitation be either retained for future usage, such as for landscape irrigation; or allowed to infiltrate through the subsurface material recharging the local aquifers (USGBC, n.d.).

The use of native, drought-tolerant plants for the building's surrounding landscape is promoted through LEED-NC system (Langdon, 2004). The purpose of using native plants is to reduce or eliminate potable water costs associated with irrigation systems while achieving an aesthetic landscape (Langdon, 2004). Interestingly, the surrounding landscape of a building lends to its overall aesthetics which can positively influence psychological wellbeing and improve productivity of the building's occupants (Akadiri et al., 2012).

The effects of natural disasters is a considerable environmental element on a building's operational resilience (Insurance Institute for Business & Home Safety, 2012). From a building industry perspective, disaster mitigation strategically focuses on reducing infrastructure damage and the loss of human lives (Akadiri et al., 2012; Kapucu & Khosa, 2013). The effects of Hurricane Katrina, in 2005, spurred the Department of Homeland Security (DHS) to require universities to develop an emergency plan (Kapucu & Khosa, 2013). The storm affected 31 universities and colleges, with Florida International University being one of those institutions (Kapucu & Khosa, 2013). Due to the university's location in Southeast Florida, a region susceptible to hurricanes, disaster-resistant features were included in the Nicole Wertheim College of Nursing and Health Sciences building's design (Florida International University, n.d.). The building is the institution's first LEED-certified building; it earned Silver certification in 2010 and was outfitted with backup power systems, debris-impact windows, tension cables and wind-resistant enclosures for roof-mounted equipment, and doormats designed to prevent water penetration (Florida International University, n.d.). These green building features were implemented to improve the endurance of the infrastructure to ensure campus operations would not be interrupted by the effects of a hurricane (Florida International University, n.d.).

Also, those institutions situated along the St. Andres and New Madrid fault lines are vulnerable to the effects of earthquakes. Specifically, the University of California, San Francisco's Ray and Dagmar Dolby Regeneration Medicine Building was equipped with seismic base isolation; a design feature that lessens the impacts of an earthquake while protecting the structural integrity of the facility and human lives (Kopochinski, 2011). The building achieved LEED Gold certification in 2011 (Kopochinski, 2011).

Yet despite efforts to design and construct green buildings in less consumptive ways, regional conditions are often ignored and greater attention is usually given to ubiquitous LEED design features, such as low VOCs paints (Cidell, 2009).

Operations and Maintenance Phase of Green Building Features

The diffusion of LEED rating systems within the building industry was credited to organizational learning and interdisciplinary collaboration (Chance, 2012). Organizational learning is continually being enhanced by USGBC, through constant feedback, data analysis, and policy amendments to ensure creditability (Chance, 2012). LEED guidelines, when adopted early in the design process, will certainly influence the involvement of interdisciplinary practices (Denzer, & Hedges, 2011; McGraw-Hill Construction, 2013). The commitment of an interdisciplinary team, involving the design and construction practitioners, building users, and facilities professionals impacts the operational and maintenance stage of the resulting green building (Akadiri et al., 2012; Bosch & Pearce, 2003; McGraw-Hill Construction, 2013). A benefit of an interdisciplinary team is prerequisite and additional point-earning features and practices are less likely to be omitted during the building's design or construction, or evaded during its maintenance and operation practices (Bosch & Pearce, 2003; Morris, 2007).

Undeniably, it is up to campus facilities operations and maintenance departments to oversee green buildings perform as intended (Bosch & Pearce, 2003; Wright & Wilton, 2012). To validate this organizational role, facilities and sustainable staff (18%) were ranked second to executive management (33%), but slightly higher than design/construction/engineers (17%) as influencers of sustainable practices by higher education respondents of the McGraw-Hill Construction 2013 *Education Green Building SmartMarket Report* (McGraw-Hill Construction, 2013).

Facility management as defined, by the International Facility Management Association (IFMA) is, “a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology” (Lavy, 2008, p. 304). Facilities operations and maintenance departments given their organizational positioning and respective authority are most apt at knowledge creation concerning successful incorporation and implementation of green building features (Cupido et al., 2010; Wright & Wilton, 2012).

Facilities cost savings and green building features. Universities and colleges in the United States were early adopters of LEED certification. Higher education understood the gains that can be conveyed, by green rating systems; these gains include long term cost savings, wellbeing of society, and environmental resilience (Hart, 2009). From a cost-saving perspective, an estimated 50% to 75% of the facilities budget is allocated for facility operations (Roper & Beard, 2006). Already, university and college campus facilities departments operate under stringent budgets (Everett, 2008). Wright and Wilton (2012) surveyed 37 Canadian higher education facilities directors and found finances were a crucial issue facing their institutions.

With insufficient funds for staff and repairs, the built campus will suffer and operations cost may dramatically increase (Wright & Wilton, 2012). To further contribute to the financial burden, the budgetary dichotomy of higher education may adversely influence the prioritizing of initial costs over long-term operational savings (Chance, 2012; Langdon, 2004). Simpson (2003) posited there can be no incentive to design, construct, operate, and maintain a green building; especially if there is no communication and knowledge sharing between the department responsible for constructing the building and the department paying the building's operating costs.

Regional and local information to guide practice, and identification of comparable and measurable performance variables are necessary to assist facility professionals with financial decision making (Cupido et al., 2010; Retzlaff, 2009). Cupido et al. (2010) found those institutions with a sustainable building policy showed confidence in lowering facilities operational costs. Integration of facilities operations with academic mission and administrative financial strategies was also recommended to strengthen an institution's ability to proactively assess and respond to economic impediments (Rudden, 2010). However, there remains a gap between comparable regional conditions and cost-benefit building performance variables adopted, by universities and colleges in the United States (Cidell, 2009; Cortese, 2003; Rappaport, 2008).

Occupant wellbeing. Green building practices are considered a social responsibility to the campus citizenry and society at large (Everett, 2008). According to Rappaport (2008),

> The value of campus greening goes well beyond resources saved; greening generates interest and invites members of the academic community to think differently about societal values, goods consumed, and the infrastructure for shelter and mobility, raising questions about how human needs can be met in new ways. (p. 15)

Campus facilities operations and maintenance departments functionally ensure operational reliability for the purposes of fulfilling the institution's academic mission (Rappaport, 2008; van Weenen, 2000); protecting the campus citizenry from harmful conditions (Mbohwa & Mudiwakure, 2013; Rappaport, 2008); and preserving campus aesthetic and cultural standards (Rappaport, 2008; Way et al., 2012). This allows for the alignment between campus facilities operations and maintenance departmental mission and that of the university or college (Cupido et al., 2010).

Additionally, a study conducted by Vidalakis et al. (2013), reported campus facilities can impact student recruitment. Facilities professionals also can influence the campus community's consumption of energy and other resources by first determining how much building occupants acknowledge and know about their individual energy consumption or about other green buildings initiatives taking place on campus (Janda, 2011; Rappaport, 2008). Interestingly, awareness is more successful at reducing occupant consumption than design and construction strategies (Janda, 2011). Therefore, facility professionals are critically positioned to advocate for best practice sustainable technologies (Koester et al., 2006), and keeping up with major facilities trends (Cupido et al., 2010).

Environmental stewardship. One of the greatest challenges facing the 21st century is living off nature's interests, rather than its principal to achieve ecological sustainability (Cortese, 2003; van Weenen, 2000). Specifically, the capacity for the built campus to grow is constrained, by the laws of minimums (Bossel, 1999). Liebig's law of minimums is an ecological principle used to determine growth of a system not by the number of resources available to the system, but by the rarest resources (McKinney, Schoch, & Yonavjak, 2007). In this facet, Rappaport (2008) suggested, “If colleges are not building the most efficient structures possible, decision makers are not thinking long term” (p. 14). Most decision makers are aware of the environmental impacts associated with operating and maintaining the physical facilities to ensure continuity of the educational process (Riddell et al., 2009). The overall effectiveness of an institution’s purpose is undergirded by the capabilities of the facilities professionals to identify solutions to regional impediments and limiting resources (Everett, 2008; Lavy, 2008).

Campus facilities operations and maintenance professionals have expanded their department’s functional capacities to remain competitive within the industry as well as contribute to environmental stewardship (Akadiri et al., 2012; Bosch & Pearce, 2003; Koester et al., 2006; Lavy, 2008). Campus facilities operations and maintenance management’s contributions to environmental stewardship through the operations of LEED-certified buildings are limited to solitary performance variables such as: energy performance in an effort to offset greenhouse gas emissions (Birt & Newsham, 2009; Klein-Banai & Theis, 2013; Wilk, 2002); water consumption that lessens demand on local aquifers (Barrons, Davenport, Lucas, & Walsh, 2013; Turner, 2006); and the salvage and reuse of building materials to diminish the harvest of natural resources (Aiello, 2010; Bosch & Pearce, 2003).

Chapter Summary

This chapter summarizes the related literature relative to green certified buildings, i.e., LEED-certified buildings, and the green building features that collectively contributed to buildings’ achieving a green rating within the three principles of sustainable development. Understanding the challenges of forecasting a green building’s operations and maintenance performance, and acclimatizing newly constructed LEED certified buildings to meet education requirements, while maintaining campus facilities in order to attain the longest and most cost-effective life cycle involves exploring green building features. The role and function of facilities operations and maintenance departments are essential to determining if design features implemented in the design and construction processes early in a building's life cycle will influence the sustainability of the building's operational performance (Bosch & Pearce, 2003). Facilities managers are tasked with comprehending, "how the organization is performing, and how facilities management is contributing to the overall effectiveness of the organization" (Lavy, 2008, p. 305).

Attention to the technical approaches of designing and constructing a green building is quite extensive within the literature; whereas, an integrative translation of these technical approaches into operational performance have gone virtually unnoticed. Management for sustainability is unlike traditional environment management (Shriberg, 2002a). Much emphasis is placed on intermediate and long-term integration of mutually supportive and beneficial economic, social, and environmental variables to successfully pursuit sustainable management (Kemp et al., 2005). A capital project that facilitates sustainable development has the potential to control costs and improve institutional reputation and promote occupant safety, by maintaining a healthy indoor environment, while simultaneously conserving natural resources and convening their intrinsic values to the community (Akadiri et al., 2012).

This is of great importance to higher education, as many campus buildings are in need of major repairs and renovations. Aging buildings are responsible for wasted energy and are inadequate to meets the needs of the current workforce (Chance, 2012). However, most research on the subject of LEED-certified building performance were conducted within the general purview of the commercial industry. Moreover, LEED-certified building studies that have been conducted focus on the design and construction phase of the building's life cycle which makes it difficult to construct a complete life cycle performance discussion. Furthermore, no national studies have examined the relationship between geography and green building feature implemented for economic, social, and environmental benefits. Of those studies that involved LEED certified buildings on university and college campuses, many were limited to the application of idiosyncratic approaches used to measure energy and water consumption, and the production of carbon dioxide emissions. An even narrower research focus was found for the performance of LEED-certified campus buildings on multiple institutions. These studies analyzed and discussed each institution separately from the other, and remained mainly within the economic sphere of sustainable development. Although the review of literature provided insight into the context, practice, and features of LEED certified buildings; there still is much information that needs to be gathered.

This study aims were to identify usage patterns and trends of green building features implemented in new constructed LEED-certified campus buildings within each of the three principles [economy, society, and environment] of sustainable development, and the relationships of green-building feature usage among building, institutional, and LEED characteristics. This focus allowed for an in-depth operations and maintenance stage analysis of green buildings features moving beyond generalities, and providing a detailed account of what building features were incorporated in the design and construction phase of LEED certified buildings, in an effort to move closer to the sustainability of the campus.

III. METHODOLOGY

This nonexperimental, quantitative study examined the green-building features within the three principles of sustainable development [Economy, Society, and Environment] for the purpose of describing what features were implemented leading to the building's LEED recognition. Specifically, the aims of the study were to 1.) identify green-building features and determine their frequency of implementation in new capital (NC) LEED certified, campus buildings to effectuate operations and maintenance cost savings, indoor wellbeing, and environmental stewardship, and 2.) determine the relationships of green-building feature usage across building, institutional, and LEED characteristics. The methodology used was designed to answer the primary research questions, which were as follows:

1. What were the most common green-building features implemented to influence the cost-savings of NC LEED-certified buildings on universities and colleges campuses?

2. What were the differences in green building features that influenced cost-savings between institutional funding types? And between LEED levels of certification?

3. What were the most common green-building features implemented to influence occupant indoor wellbeing?

4. What was the relationship between LEED credit category: Indoor Environmental Quality scores and buildings' occupant use categories?

5. What were the most common green-building feature implemented to influence environmental stewardship?

6. What were the relationships between green buildings' gross square footage and building characteristics? And institutional characteristics? And LEED characteristics?

This Methods Chapter will be separated into five subsections. First, the research design will be introduced. Second, the characteristics of the study's sample will be described. Third, the process of data collection is explained and includes a description of the three forms of archival documents. Fourth, the study's procedure is described and lastly, the study's analyses of data were explained for repeatability.

Research Design

Since the first LEED certification was issued in 1996, numerous expectations associated with LEED-certified buildings have arose and perpetuated along the three principles of sustainable development (Aiello, 2010; Eichholtz et al., 2010). Some authors (Gottfried & Malik, 2009; Hart, 2009; Naik, 2013) suggested that the expected benefits surrounding LEED-certified buildings have stimulated a shift towards implementing green-building practices and features into the built-campus environment. Therefore, to understand and measure a green building's performance benefits, one must first examine what features were incorporated, with specific intent, to effectuate sustainable building performance. Green-building features were purposefully integrated into the design and construction phases to meet specific green strategies, which consequently, contributed credit points; ultimately, earning the whole building its LEED certification.

The researcher used archival documents, gathered from three sources that mutually contributed data for the research's primary focus of describing what green-building features were incorporated and their frequency of occurrence in new capital projects on higher education campuses, in the United States. Through the researcher's investigation of only green-conscious building owners, specifically, universities and colleges recognized by The Princeton Review's *Guide to 322 Green Colleges* (2013) for their commitment to sustainable development initiatives, the bias that green-conscious building owners were more agreeable to participate in green building studies, as identified by Hart (2009), was held constant. By holding the extraneous variable, ownership of a LEED-certified building, constant, the researcher was able to gather a wealth of archival documents consisting of what sustainable features were used to influence building performance.

Data retrieved from the archival documents were collected during an eight-month period on several independent variables, which included, LEED scores, building by occupant use, institution funding type, and LEED levels of certification. The dependent variables of this study were the green-building features and LEED credit scores.

Study's Sample

The sample of institutions in this study were universities and colleges in the United States. Specifically, higher education institutions recognized in The Princeton Review's *Guide to 322 Green Colleges* (2013) for their commitment to sustainable development. To secure such an acknowledgement, this cohort of universities and colleges participated in The Princeton Review's Green Survey, in 2012. More relevant to the study was that the Green Survey consisted of one particular question directly inquiring into the use of LEED rating systems for new capital projects (The Princeton Review, 2013). Universities and colleges not located in United States and those who reported not possessing new capital construction certified by LEED in The Princeton Review's *Guide to 322 Green Colleges* (2013) were eliminated, distilling the sample frame to 276 universities and colleges. This cohort was, further, limited to those higher-education institutions with at least one LEED-certified building, in the post-occupancy stage, on their campus. The Carnegie Classification of Higher Education (n.d.).was used to disaggregate the sample further by institutional funding characteristics: public and private institutions. All institutions were identified, by The Carnegie Classification of Higher Education (n.d.), as four year or above.

The 276 universities and colleges were further constrained by the availability of archival documents for each LEED-certified building on their campus. If documents from all three sources were not found for a building then the building was eliminated from the sample. The Sampling Procedures subsection will, in detail, explain the constraining efforts applied to generate the study's final sample.

Sampling procedures. To capture a snapshot of each building's general green features that led to the LEED certification, three documents were used to describe the type of green-building features and their frequency of usage. Prior to data collection, however, buildings located on the campus of the 276 universities and colleges of the sample were selected based on their capacity to meet a sequence of criteria. Each building had to be a new capital construction project and specifically identify under the LEED rating system as, *LEED building design and construction (LEED BD+C): New Construction*. No retrofitted or renovated buildings were examined in this study. Also, each building had to have already earned its LEED certification. This study only investigated campus buildings, in the post-occupant stage, having been certified under LEED versions 2.1 through 3.0. No building comprised in this sample received certification under the most current version of LEED (LEED v4).

Three documents were used to gather data on each building. The three documents originated from the following internet sources: 1.) LEED scorecards collected from the United States Green Building Counsel (USGBC) LEED online site; 2.) archival documents gathered on LEED certified buildings from official institution websites; and 3.) building professionals' case studies retrieved from building professionals' websites. The archival documents were retrieved in a cross-sectional fashion for each building. Once the archival document retrieval process for LEED certified buildings located on the campuses of the 276 universities and colleges was completed, any building lacking documentation chronicling its green-building features was systematically eliminated from the sample.

First, registered buildings were identified by conducting a search, by institutional name and institutional acronym, on the LEED website. From the 276 universities and colleges that reported '*Yes*' on The Princeton Review's Green Survey to having possessed LEED certification for any new capital projects, the web based search resulted in 768 LEED-registered buildings on the campuses of 195 universities and colleges. Eighty-one institutions were found to have no buildings registered and archived on the LEED official website.

Once LEED-registered buildings were identified by institution, a search for complete LEED scorecards were conducted for all 768 buildings. If, a building's scorecard did not include the following independent variables: level of certification, year of certification, version under which the building received its certification, and dependent variables: LEED credit scores; the scorecard was considered incomplete. Any building with an incomplete scorecard was eliminated from the sample. Hence, only 67% (n = 518) of those LEED registered buildings possessed a completed LEED scorecard archived on the LEED website.

Next buildings were sorted, by *possessing* or *not possessing*, institutional archival documentation. From that 518 buildings with a completed LEED scorecard, 242 buildings on the campuses of 126 institutions were archived on their respective institutional official website to have achieved the LEED certification and/or listed specific green-building features incorporated into each building.

Finally, buildings were sorted, by *possessing* or *not possessing*, building professionals' case study documentation. From the 242 buildings on the campuses of 126 institutions with a complete scorecard and institutional documentation, building professionals' case studies were found for only 206 buildings on the campuses of 110 universities and colleges. Hence, all three archival documents were found for 206 buildings. Eleven buildings were found to be renovations, through the readings, and were eliminated. This study examined the green-building features incorporated into 195 buildings during their design and construction on the campuses of 107 institutions. Archival documents retrieved from LEED, institutional, and building professionals' websites were employed to gather data for each of the buildings that comprise this final constrained sample. This heterogeneous population of 53 private institutions and 54 public institutions allowed for a larger "variability of characteristics" (Heppner &

Heppner, 2004, p. 114), to develop a more contextual description of the green-building features implemented to construct the whole LEED-certified building. See Figure 3 for the progressive scheme applied to constraining the sampling frame.

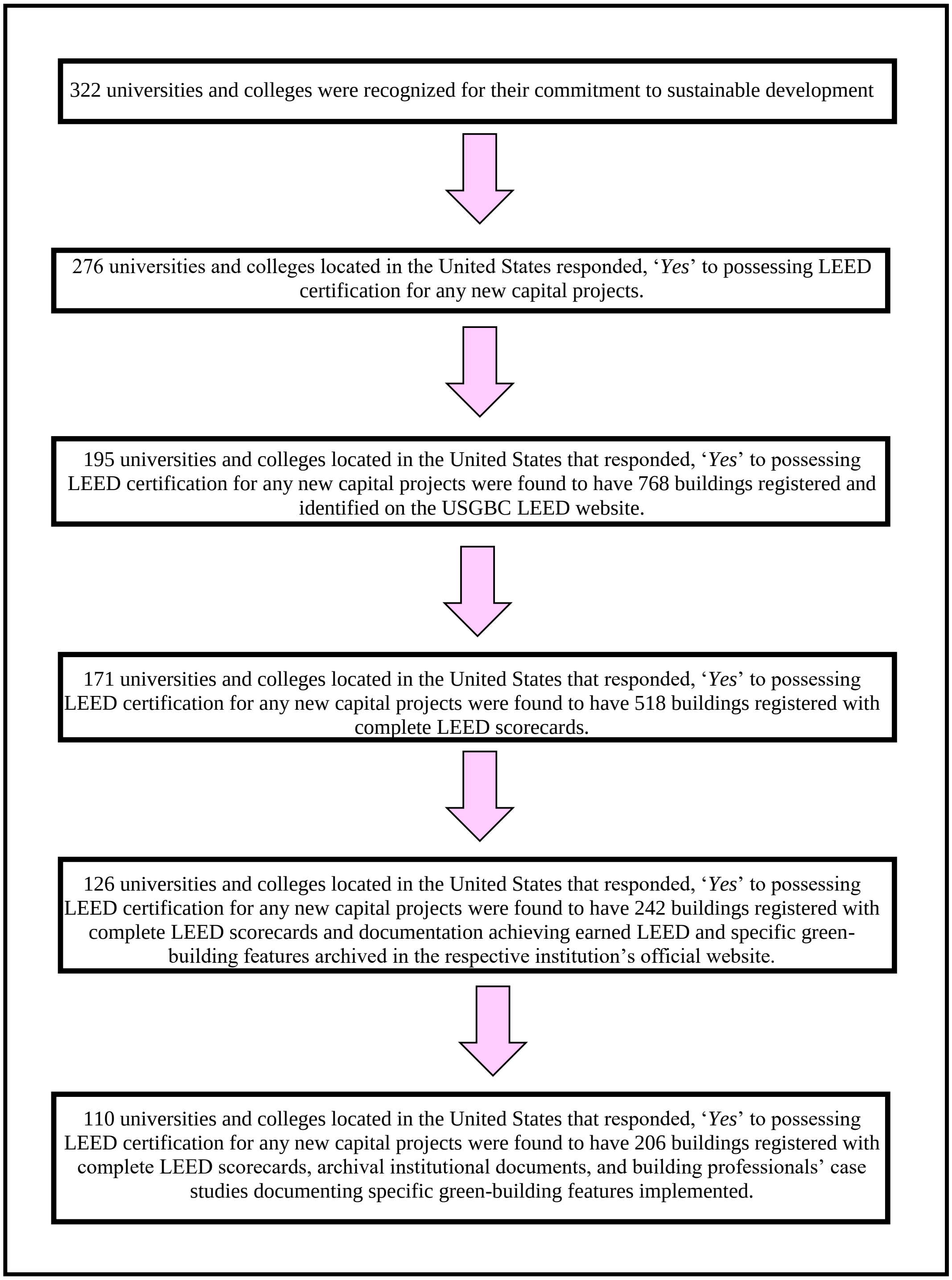


Figure 3. A representation of the constraining efforts applied to generate the study's final sample.

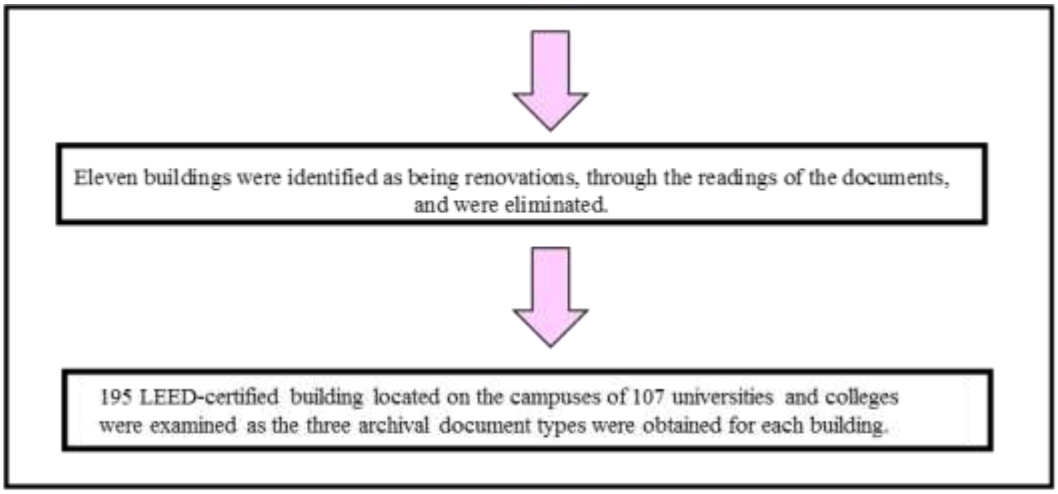


Figure 3 (continued). A representation of the constraining efforts applied to generate the study's final sample.

Data Collection

Archival documents from three sources were used to collect data for this study's descriptive investigation into green-building features. Data were collected during an 8-month period from June 2016 through January 2017 from the following archival documents: (a) LEED building scorecard, (b) institutional website news and press releases documenting the building's green rating, and (c) case studies authored by the building's architect, construction engineer, builder contractor, and/or builder. A cross-sectional internet search for the building's LEED scorecard was conducted followed by an internet search on official institutional websites for archival documents on the building, and lastly, an internet search for the building's case study presented by a building professional involved in the design and/or construction of the building.

LEED scorecards. The LEED scorecard was the primary source for obtaining the following variables: the number of points earned per strategy and credit category, the year the building was awarded LEED certification, the level of certification, and the LEED version under which the building was rated. LEED scorecards are the mainstay of the LEED rating program (WikiEngineer, n.d.). Numerical points of the scorecard guide the building's architect, contractor, and building owner during the LEED certification process. As the green-building features−components of the LEED requirements−are incorporated into the design and the construction of the building, the capital project team track anticipated LEED credits to determine where the project stands (WikiEngineer, n.d.).

LEED scorecards are catalogued in the USGBC LEED official site, https://www.usgbc.org/LEED/, for capital projects in various phases of the design and construction stages registered with LEED to earn a particular level of certification. The levels of certification are certified, silver, gold, and platinum levels and are founded on an aggregation scale of credit points earned, by each individual project, after its completion. However, since the introduction of LEED, the rating system has undergone three revisions. Table 2 identifies the number of points required to earn a particular level of certification by LEED rating versions.

Table 2

LEED Rating Versions for New Construction (NC) and Their Associated Credit Range for Certification

LEED-NC v2 (Scale 1 - 69)		**LEED-NC v3 (Scale 1 - 100)**	
Level of Certification	***Credit Point Range***	***Level of Certification***	***Credit Point Range***
Certified	26 - 32	Certified	40 - 49 Points
Silver	33 - 38	Silver	50 - 59 Points
Gold	39 - 51	Gold	60 - 79 Points
Platinum	52 - 69	Platinum	≥ 80 Points

Note. The LEED versions' level of certification point ranges were obtained from the USGBC LEED website. LEED-NC v2 included BD+C: New Construction v2 - LEED 2.1 and BD+C: New Construction v2 - LEED 2.2. LEED-NC v3 was BD+C: New Construction v3 - LEED 2009.

LEED NC project scores were guided by a variety of credit categories, which included, Sustainable Site, Water Efficiency, Energy and Atmosphere, Material and Resources, Indoor Environmental Quality, Innovation, and Regional Priority. Each credit category was segmented into strategies; if a project met the strategy's requirements it then earned a designated number of credit points. The number of credit strategies and the number of designated points varied among the credit categories, and by LEED versions. See Appendix A for a sample of the LEED v2.0 and LEED v3 scorecards for new construction. Deliberately, the design and construction teams, in conjunction with the building owners (universities and colleges), plan, design, and implement during construction green-building features, such as green roofs, clerestory skylights, occupancy sensors, etc., in efforts to meet the goals set by the credit strategies.

The LEED scorecards described the accomplished green design/construction strategies, intents, and goals. Therefore, completed LEED scorecards were the first document retrieved. Data gathered for the following independent variables were the year the building was awarded LEED certification, the level of certification, and the LEED rating version under which the building was rated. The dependent variables obtained from the LEED scorecards were the number of points earned per credit category. The keywords used to search the LEED site in order to identify certified buildings were the institution's full name and its acronym. For instance, to obtain LEED scorecards for all certified buildings on Florida Atlantic University's campuses, the keyword used was *Florida Atlantic University* on the first search and *FAU* on the second search. Then the search results were filtered by project. All building projects on the first five search result pages were examined for complete scorecards. If the search yielded less than five result pages then all projects were examined on all result pages.

University and college archival documents. Institutional archival documents chronicling new LEED-certified projects were retrieved from internet searches conducted on the official websites of the 276 universities and colleges comprising the initial sample. These documents collectively were used to gather data on green-building features. The types of archival documents, included, news and press releases; departments of facilities, student residents, and sustainability webpages; and profiles on the new project (e.g., University of California Santa Barbara LEED Project Profile) published on the institution's website. Institutional archival documents were dated from 2007-2017. This assortment of documents was used to gather information for the purpose of identifying the existence and frequency of specific green-building features.

The institutional archival documents were obtained from searches on the universities and colleges' official websites. To generate documents pertaining specifically to the building that achieved the LEED certification as well as, descriptions and lists of green-building features, the keyword, *LEED building* was used. All documents on the first five search result pages were examined for specific green-building features, each building's full name, the size of each building, and building's usage by occupancy. If the search yielded less than five result pages then all items were examined on all result pages.

Building professionals' case studies. Building professionals, such as architects, builders, contractors, engineers, and construction product manufacturers use case studies to emphasize efforts of green construction practices (McGinty, n.d.). Building case studies are used as marketing tools and are commonly found on building professionals' websites (Bright, 2014). Collectively, case studies were the third source collected and used to gather data. Building professionals' case studies added specificity to green-building features across multiple areas, including: state and local building codes and regulation, related technology, and why specific designs were selected. Also, these documents allowed for the collection of the building's use and gross square footage of each LEED-certified building. The case studies were generated using Google searches with the keyword *LEED* and *the name of the building*. All documents on the first five search result pages were examined for specific green-building features, the size of each building and building's usage by occupancy.

The documents were printed, sorted alphabetically by institution name, and sorted in binders; documents were also stored electronically on an external hard drive. The documents underwent three rounds of reading and highlighting, two round in the spring of 2017 and one round in summer of 2017, to capture the study's variables pertaining to the 195 buildings. Data were then manually inputted and saved onto an Excel spreadsheet. Collectively, the documents added detail to the variety of green-building features and their frequency of use employed to earn buildings situated on the greenest campuses in the United States, as rated by The Princeton's Review's *Guide to 322 Green Colleges* (2013), a third-party green certification.

Study Variables

Dependent variables. This study dependent variables were green-building features, LEED credit category: Indoor Environmental Quality scores, and LEED credit category: Sustainable Sites scores.

Independent variables. This study's independent variables were green-building features; Building by occupant use; Institutional funding type; and LEED levels of certification. The variable Institutional funding type was dichotomized into *Public* and *Private* institutions and institutions were classified into one of the two categories using the Institutional Lookup (Search by institutional name) function on The Carnegie Classification of Higher Education (n.d.) website (http://carnegieclassifications.iu.edu/lookup/lookup.php). The variable, LEED levels of certification, was the categorically designated LEED certification, including, Platinum, Gold, Silver, and Certified, and the variable's categorical codes are found in Table 3. The variable, building by occupant type, described the occupant use of the whole building and the coding scale was adapted from Romney's (1972) Higher Education Facilities Inventory and Classification Manual; this variable is found in Appendix C.

Table 3

Dependent and Independent Variables and Coding Scales

Research Questions	Dependent Variables	Coding/Scale	Independent Variables	Coding/Scale
Economic Principle: Research Question 1	Green-building feature employed to effectuate cost-savings	Categorical		
Economic Principle: Research Question 2	Green-building feature employed to effectuate cost-savings	Categorical	1.) Institutional funding type 2.) LEED levels of certification	1.) Categorical 1 = Private 2 = Public 2.) Categorical 1 = Platinum 2 = Gold 3 = Silver 4 = Certified
Social Principle: Research Question 3	Green-building feature employed to impact welling being	Categorical	1.) Institutional funding type 2.) LEED levels of certification	1.) Categorical 1 = Private 2 = Public 2.) Categorical 1 = Platinum 2 = Gold 3 = Silver 4 = Certified

Table 3 Continued

Research Questions	Dependent Variables	Coding/Scale	Independent Variables	Coding/Scale
Social Principle: Research Question 4	LEED credit category: Indoor Environmental Quality scores	Continuous	Building by occupant use:	Categorical 1 = Classroom Facilities 2 = General Use Facilities 3 = Healthcare Facilities 4 = Laboratory Facilities 5 = Mix-use/Multiuse Facilities 6 = Office/Administration Facilities 7 = Residential Facilities 8 = Special Use 9 = Study/Library Facilities 10 = Supporting Facilities

Table 3 Continued

Research Questions	Dependent Variables	Coding/Scale	Independent Variables	Coding/Scale
Environmental Principle: Research Question 5	Green-building feature implemented to influence environmental stewardship	Categorical	1.) Institutional funding type	1.) Categorical 1 = Private 2 = Public
			2.) LEED levels of certification	2.) Categorical 1 = Platinum 2 = Gold 3 = Silver 4 = Certified
Environmental Principle: Research Question 6	LEED credit category: Sustainable Sites scores	Continuous	1.) Institutional funding type	1.) Categorical 1 = Private 2 = Public
			2.) Building size (gross square feet)	2.) Continuous

Note. Research question 4's independent variable building by occupant use used the first digit from the room use coding found in Appendix C.

Procedures

A nonexperimental quantitative approach was applied to inform the study's research design. This study's research design was intended to identify green-building features within the three principles of sustainable development. Johnson and Christensen's (2004) definition of *nonexperimental quantitative research* was applied to justify the use of this research design to address the study's research questions: a.) the researcher examined the independent variables as they existed and without manipulation;

b.) the researcher looked back at what occurred during the design and construction phases, which attributed to the identification of the green-building features and the frequency of implementation; and c.) the researcher observed and made inferences about how green-building features related within and among various building, institutional, and LEED characteristics. Therefore, to best describe this study's Procedures, the subsection will further be segmented by the principles of sustainable development.

Economic principle. Data retrieved from the archival documents, specifically, institutional archival documents and building professionals' case studies, informed on green-building features implemented with the intended purpose of reducing financial costs associated with the operations and maintenance performance. Green-building features were the dependent variable for Research Questions 1 and 2. The archival documents contained information on building features and provided rationales for their use. Some documents even when as far as identifying the LEED credit categories and signalized the specific green-building features for which each category earned points, as in the case of the following buildings, Repass Ocean Science Center, Duke University and Inman Admission Welcome Center, Elon University.

After reading the documents, qualitative raw data, the green-building features, were entered into an Excel spreadsheet. Next the data were catalogued by the credit category strategy it best satisfied. The green-building features were classified into one of LEED version 2's six credit categories. Even though buildings in this data set were rated under LEED version 2009, the rationale for using version 2 was this LEED version did not include credit categories with repetitious strategies, as in the case of version 3. LEED version 3 added a credit category, Regional Priority consisting of five replicated strategies. These strategies were initially assigned to four of the original credit categories (Energy & Atmosphere, Indoor Environmental Quality, Sustainable Sites, and Water Efficiency). Appendix B lists LEED version 2 credit categories and their associated strategies.

The qualitative raw data were then numerically transposed for the purpose of quantitative analysis. A numerical coding schema, described by Epstein and Martin (2004) was applied to transpose the qualitative information into quantitative values. This type of coding schema was used because the process, "1) ensured that the values of the variables are exhaustive; 2) created more rather than fewer values, and 3) established that the values of the variables are mutually exclusive" (Epstein & Martin, 2004, p. 3). The coding process began with assigning the first numerical digit of the data values. The first numerical digit indicated the credit category the green-building feature item satisfied. LEED version 2's six credit categories; 1 = Sustainable Sites, 2 = Water Efficiency, 3. = Energy & Atmosphere, 4 = Material & Resources, 5 = Indoor Environmental Quality, and 6 = Innovation were assigned a numerical digit. The numerical ordering was based on the order the categories were listed on the LEED scorecard. Green-building features classified under a specific category were assigned that category's numerical value as its first digit. As an example, five green-building features incorporated for the intended purpose of reducing performance costs were identified for Virginia Commonwealth University's Rice Center Education Building; the green-building features included, 1.) geothermal heating and cooling; 2.) solar electric power generator; 3.) green roof; 4.) insulation that rely on soy-based products and recycled denim; and 5.) low-flow fixtures. Four green-building features were found to satisfy the following strategies: Energy &

Atmosphere credit 1 (EAc1) Optimize energy performance, Energy & Atmosphere credit 2 (EAc2) On-site renewable energy, and Energy & Atmosphere credit 6 (EAc6) Green power, and were assigned a 3 as their first digit. Whereas, the last item, low-flow fixtures, on the list satisfied the strategy, Water Efficiency credit 2 (WEc2) Innovative wastewater technology and was assigned a 2 as its first digit. To address reliability and validity of numerical transposing of data, once a green-building feature was assigned to a credit category the building's scorecard was then examined to verify that the building did indeed earn credit within that particular credit category.

Next, each green-building feature item within a credit category was assigned a second digit to represent subdivisions (Epstein & Martin, 2004). Green-building feature items were then alphabetically arranged to determine design, construction, and functional similarities among items and assigned the second digit to the quantitative data values. So in continuation of the Rice Center Education Building example, green-building features incorporated for the intended purpose of reducing performance costs were alphabetically sorted and assigned the second digit: geothermal heating and cooling (3,1), green roof (3,2), insulation that rely on soy-based products and recycled denim (3,3), and solar electric power generator (3,1). The last item, low-flow fixtures (2,1), was assigned a 2, since it conformed to a Water Efficiency strategy and the second digit represented the green-building feature subcategory, 1.

Social principle. Archival documents, specifically, institutional archival documents and building professionals' case studies, informed on green-building features implemented with the intended purpose of impacting indoor wellbeing. Green-building features were the dependent variable for Research Question 3. Green-building features incorporated to influence indoor wellbeing were identified and sorted numerically by credit category. The process of translating the qualitative data into a quantifiable form was similarly to that applied in Research Question 1. To address reliability and validity of numerical transposing of data, once a green-building feature was assigned to a credit category the building's LEED scorecard was then examined to verify that the building did indeed earn credit within that particular credit category.

Research Question 4's dependent variable was the numerical scores for LEED credit category: Indoor Environmental Quality. The scores were obtained from the LEED scorecards. The independent variable, building by occupant use, organized the buildings according to Romney's (1972) Higher Education Facilities Inventory and Classification Manual. The manual supplied specific higher education facilities definitions, descriptions, and limitations. Raw qualitative data (e.g. Student recreation center, Library, or Museum) were numerically transposed according to Romney's definitions and codes. After the data were identified, entered into an Excel spreadsheet, and sorted by occupant use, 10 facilities categories were identified. The operationalized definitions of the 10 facilities categories are found in Appendix C.

Environmental principle. Archival documents, specifically, institutional archival documents and building professionals' case studies, informed on green-building features implemented with the intended purpose of influencing environmental stewardship. Green-building feature was the dependent variable for Research Question 5. Green-building features incorporated to influence resource conservation were organized and numerical transposed using the procedure applied in Research Question 1. Green-building features implemented to increase environmental stewardship were organized and numerical transposed. The process of translating the qualitative data into a quantifiable form was similarly to that applied in Research Question 1. To address reliability and validity of numerical transposing of data, once a green-building feature was assigned to a credit category the building's scorecard was then examined to verify that the building did indeed earn credit within that particular credit category.

The dependent variable for Research Question 6 was the LEED credit category: Sustainable Sites numerical scores. The scores were obtained from the LEED scorecards. Building and institutional characteristics were the independent variables for Research Question 6. Building characteristic variable was the green building gross square footage and was obtained from institutional archival documents and building professionals' case studies. The study's sample green building gross square footage ranged from 800 square feet to 788,000 square feet. The institutional characteristic was the institution funding type (Private institutions = 1 and Public institutions = 2) collected from The Carnegie Classification of Institutions of Higher Education (n.d.) website.

Data Analysis

Descriptive analysis was conducted to provide an overview of the sample, by green-building feature types that afforded the ability to describe the cost-saving, wellbeing, and environmental stewardship relationships within and between building, institution, and LEED characteristics. Then inferential analyses were employed and were described by sustainable development principle.

Economic inferential analyses. This study examined the relationship between green-building features (dependent variables), and institutional types (independent variable) and LEED levels of certification (independent variable) by credit category. The independent variables offered information on institutional funding type and LEED levels of certification. The institutions' funding type, public or private institutions, were identified using The Carnegie Classification of Institutions of Higher Education. The internet search on Carnegie Classification of Institutions of Higher Education website (http://carnegieclassifications.iu.edu/lookup/lookup.php) was conducted through the site's Institution Lookup tab option. Institutions were searched by name to determine their funding type. LEED levels of certification were derived from the scorecards of each building.

Analyses of green-building feature data were conducted using independent *t* tests and analysis of variance (ANOVA) models. These statistical tests allowed for the comparison of the statistical differences between private and public institutions, and between levels of LEED certification for buildings certified under the LEED rating between 2007 and 2017.

Social inferential analyses. Independent *t* tests and ANOVA models were used to determine if any relationships of green-building features existed between institutional groups and between LEED levels of certification groups to determine whether the groups' means differed on the green-building features. ANOVA models were also used to determine whether a relationship existed between the independent variable, building by occupant use, and dependent variables LEED credit category: Indoor Environmental Quality scores.

Environmental inferential analyses. Independent *t* tests and ANOVA models were used to determine if any relationships existed between green-building features and institutional groups, and green-building features and LEED levels of certification groups to determine whether the groups' means differed on the green-building features. ANOVA models were used to determine whether a relationship existed between the independent variables green building gross square footage and dependent variable LEED credit category: Sustainable Sites scores.

IV. RESULTS

This descriptive study examined what green-building features were incorporated during the design and construction phases leading to the building's green third-party rating. Application of the Nested Model of Sustainable Development afforded the opportunity to describe the green-building features within the three principles, as these parts contribute to the whole building's cost-saving, indoor wellbeing satisfaction, and environmental stewardship performance. This study's aims were to identify specific green-building features and determine their frequency of implementation, as well as determine the relationships between building, institutional, and LEED characteristics and green-building feature usage. Archival data collected from the United States Green Building Council (USGBC) LEED website, official institutional websites, and building professional case studies were quantitatively transposed for statistical analysis. Within this chapter, an overview of the building data is first described. Secondly, the study's results are organized and presented within the sustainable development principles for which the green-building features were intended to effect.

Description of LEED-certified Campus Buildings

The study's sample of 195 buildings located on the campuses of 53 private higher education institutions and 54 public higher education institutions were described temporally over a 10-year period and spatially across the United States. The study's sample included only 4-year institutions. Private universities and colleges located in 25 states and one federal district were found to host 74 LEED-certified campus building on their campuses. Public institutions located in 23 states were found to host 121 LEED-certified campus buildings.

Description of buildings by institution funding type. Private institutions were found to be the forerunners of sustainable building efforts, as shown in Table 4. One private higher education institution located in California was the first among this study's sample institutions to design and construct a building that met the standards of the LEED rating system, in 2007. At the end of 2008, private universities and colleges were in the lead with eight LEED-certified buildings on their campus compared to zero LEED-certified buildings on public campuses. The highest density of buildings (n = 12) awarded LEED certification on private campuses occurred in 2010 and 2012. In 2007 and 2017, the least number of LEED certifications (n = 1) were awarded to private institutions. When sorted by geography, the state of New York consisted of the largest density of LEED-certified buildings (n = 15) on private higher education campuses, over the past decade (between 2007 and 2017). California, North Carolina, and Washington, D.C. each possessed six LEED-certified buildings on private higher education campuses during this time scale. Colorado, Florida, Iowa, Michigan, Missouri, New Hampshire, Rhode Island, South Carolina, Texas, and Washington each had at least one LEED certified building on a private higher education campus.

Public universities and colleges started earning third-party green ratings for new capital construction later than private institutions, but showed a greater number of buildings (n = 121) earning the LEED certification than private institutions (n = 74) between 2007 and 2017. LEED certification was first awarded to public institutions in 2009, with 10 building on the campuses of eight public institutions. The highest density of buildings awarded LEED certification on public campuses occurred in the following consecutive years: 2010 (n = 22), 2011 (n = 19), and 2012 (n = 19). The least number of buildings awarded LEED certification occurred in 2007 (n = 0), followed by 2017 (n = 7) and nine buildings awarded LEED certification in 2015. When the public institutions were arranged geographically, 24 states were found to have a public university or college with a LEED-certified building. California (n = 23), Arizona (n = 21), and Florida (n = 13) hosted public institutions with the highest density of LEED-certified buildings. The collective density of LEED-certified buildings on public campuses within these three states accounted for 29% of the entire sample's building population. Indiana, New Hampshire, New Mexico, New York, North Dakota, Pennsylvania, Utah, and Vermont each possessed at least one LEED-certified building on a private higher education campus between 2007 and 2017 (See Table 4).

Table 4

Frequency of LEED Buildings on Private and Public Campuses between 2007 and 2017

Year of Certification	**Private Universities and Colleges**		**Public Universities and Colleges**	
	State	**Frequency**	**State**	**Frequency**
2007	California	1		
2008	Massachusetts	1		
	Michigan	1		
	Missouri	1		
	New York	2		
	North Carolina	1		
	Pennsylvania	1		
2009	Georgia	1	Arizona	3
	Iowa	1	California	1
	Maine	2	Florida	1
	New York	1	Georgia	1
	North Carolina	1	Maryland	1
	Texas	1	Minnesota	1
	Virginia	1	South Carolina	1
			Virginia	1
2010	California	1	Arizona	4
	Illinois	1	California	4
	Indiana	1	Colorado	1
	Maine	1	Florida	4
	Maryland	1	Maryland	1
	Minnesota	1	New Hampshire	1
	New Jersey	2	Oregon	1
	Ohio	1	South Carolina	3
	Pennsylvania	1	Texas	1
	South Carolina	1	Virginia	2
	Virginia	1		
2011	California	2	California	4
	Georgia	1	Colorado	3
	New York	1	Florida	5
	North Carolina	1	Iowa	2
	Pennsylvania	1	New York	1
	Washington, D.C.	1	Oregon	1
			Texas	1
			Virginia	1
			Washington	1

Table 4 Continued

Year of Certification	Private Universities and Colleges		Public Universities and Colleges	
	State	Frequency	State	Frequency
2012	Colorado	1	Arizona	1
	Massachusetts	1	California	5
	New Hampshire	1	Colorado	1
	New York	6	Florida	2
	Pennsylvania	1	Georgia	1
	Washington, D.C.	2	Maryland	3
			South Carolina	1
			Texas	1
			Vermont	1
			Virginia	2
			Washington	1
2013	California	1	Arizona	1
	Georgia	1	California	1
	Louisiana	1	Florida	1
	Maryland	1	Indiana	1
	Massachusetts	1	Massachusetts	1
	Washington, D.C.	1	North Carolina	2
			North Dakota	1
			South Carolina	2
			Texas	1
			Utah	1
			Washington	1
2014	Illinois	1	Arizona	6
	Maine	1	California	1
	New York	2	Iowa	2
	North Carolina	1	Minnesota	1
	Rhode Island	1	New Mexico	1
			Texas	1
2015	California	1	Arizona	1
	Indiana	2	California	3
	Louisiana	1	Georgia	1
	New York	1	Maryland	1
	North Carolina	2	Pennsylvania	1
	Ohio	1	South Carolina	1
	Pennsylvania	1	Washington	1
	Washington	1		

Table 4 Continued

Year of Certification	Private Universities and Colleges		Public Universities and Colleges	
	State	Frequency	State	Frequency
2016	Florida	1	Arizona	4
	New York	1	California	2
	Washington, D.C	1	Colorado	1
			Georgia	1
			Oregon	1
			Washington	1
2017	Washington, D.C.	1	Arizona	1
			California	2
			Maryland	2
			Massachusetts	2

Description of buildings by LEED version. The study sample of 195 campus buildings was aggregated and described by LEED version, year of building certification, and level of certification. When the data were sorted by LEED versions, 11 buildings were rated under BD+C: New Construction v2 - LEED 2.1; 122 buildings were rated under BD+C: New Construction v2 - LEED 2.2; and 62 buildings were rated under BD+C: New Construction v3 - LEED 2009. BD+C: New Construction v2 - LEED 2.1 was the only LEED version used between 2007 and 2009 (See Table 5). Most buildings (n = 5) rated under this LEED version earned Gold level certification. BD+C: New Construction v2 - LEED 2.2 was used between 2008 and 2017 with the most buildings certified in 2010. The greatest density of buildings (n = 80) rated under BD+C: New Construction v2 - LEED 2.2 earned Gold level certification and 64% (n = 79) of campus buildings under this version of LEED are located on public higher education campuses. The state of California had the highest number of buildings (n = 17) rated under BD+C: New Construction v2 - LEED 2.2, as seen in Table 5. The third LEED version used by the study's sample institutions was BD+C: New Construction v3 - LEED 2009. This

LEED version was applied between 2012 and 2017 with the most buildings certified in 2015. The greatest density of buildings (n = 40) rated under BD+C: New Construction v3 - LEED 2009 earned Gold level certification and approximately 60% (n = 37) of campus buildings under this version of LEED are also located on public higher education campuses. Campus buildings in the states of Arizona (n = 11) and California (n = 10) were the most represented within LEED version, BD+C: New Construction v3 - LEED 2009.

Table 5

LEED-certified Buildings Classified by LEED Versions between 2007 and 2017

LEED Version	**Year Certified**		**Level of Certification**		**State**		**Institutional Funding Type**	
	Year	**Frequency**	**Level**	**Frequency**	**State**	**Frequency**	**Funding Type**	**Frequency**
BD+C: New Construction v2 - LEED 2.1 (n = 11)	2007	1	Gold	5	Arizona	2	Private	6
	2008	4	Silver	4	California	2	Public	5
	2009	4	Certified	2	Georgia	1		
	2010	2			Illinois	1		
					Michigan	1		
					New York	2		
					Pennsylvania	1		
					South Carolina	1		

Table 5 Continued

LEEED Version	Year Certified		Level of Certification		State		Institutional Funding Type	
	Year	Frequency	Level	Frequency	State	Frequency	Funding Type	Frequency
BD+C: New Construction v2 - LEED 2.2 (n = 122)	2008	4	Platinum	13	Arizona	8	Private	43
	2009	14	Gold	80	California	17	Public	79
	2010	32	Silver	22	Colorado	6		
	2011	26	Certified	7	Florida	14		
	2012	25			Georgia	4		
	2013	10			Indiana	1		
	2014	6			Iowa	3		
	2015	3			Maine	4		
	2016	1			Maryland	8		
	2017	1			Massachusetts	2		
					Minnesota	3		
					Missouri	1		
					New Hampshire	2		
					New Jersey	2		
					New Mexico	1		
					New York	9		
					North Carolina	5		
					Ohio	1		
					Oregon	2		
					Pennsylvania	3		
					South Carolina	6		
					Texas	5		
					Vermont	1		
					Virginia	8		
					Washington	4		
					Washington, D.C.	2		

Table 5 Continued

LEED Version	Year Certified		Level of Certification		State		Institutional Funding Type	
	Year	**Frequency**	**Level**	**Frequency**	**State**	**Frequency**	**Funding Type**	**Frequency**
BD+C: New Construction v3 - LEED 2009 (n = 62)	2012	6	Platinum	10	Arizona	11	Private	25
	2013	9	Gold	40	California	10	Public	37
	2014	12	Silver	11	Colorado	1		
	2015	16	Certified	1	Georgia	2		
	2016	12			Illinois	1		
	2017	7			Indiana	3		
					Iowa	2		
					Louisiana	2		
					Maryland	2		
					Massachusetts	4		
					New York	5		
					North Carolina	3		
					North Dakota	1		
					Ohio	1		
					Oregon	1		
					Pennsylvania	2		
					Rhode Island	1		
					South Carolina	2		
					Texas	1		
					Utah	1		
					Washington	2		
					Washington, D.C.	4		

Description of buildings by year awarded LEED certification. The study's sample of buildings received their LEED certification between 2007 and 2017 (See Table 6). The highest number of LEED-certified buildings constructed on university and college campuses occurred in 2010 with 34 buildings; where, 22 buildings were found on public campuses and 12 buildings were found on private campuses. The year with the second highest density of LEED-certified buildings occurred in 2012, with 19 building on located on public campuses and 12 building on private campuses. The least number of LEED-certified buildings constructed on a higher education campus was in 2007 with just one building. The second lowest number of LEED-certified buildings (n = 8) constructed on a university or college campus occurred almost a decade later, in 2017. The highest number of Platinum level certified buildings (n = 6) were awarded in 2011. The highest number of Gold level certified buildings (n = 24) were awarded in 2012. The highest number of Silver level certified buildings (n = 8) were awarded in 2010. The highest number of Certified level certified buildings (n = 9) were awarded in 2009.

Table 6

LEED-certified Buildings Catalogued by Year (2007-2017) the Buildings were awarded the LEED Certification

Year of Certification	Level of Certification		State		Institutional Funding Type	
	Level	**Frequency**	**State**	**Frequency**	**Funding Type**	**Frequency**
2007	Platinum	0	California	1	Private	1
(n = 1)	Gold	1			Public	0
	Silver	0				
	Certified	0				
2008	Platinum	0	Massachusetts	1	Private	8
(n = 8)	Gold	5	Michigan	1	Public	0
	Silver	2	Missouri	1		
	Certified	1	New York	3		
			North Carolina	1		
			Pennsylvania	1		
2009	Platinum	1	Arizona	3	Private	8
(n = 18)	Gold	6	California	1	Public	10
	Silver	7	Florida	1		
	Certified	4	Georgia	2		
			Iowa	1		
			Maine	2		
			Maryland	1		
			Minnesota	1		
			New York	1		
			South Carolina	2		
			Texas	1		
			Virginia	2		

Table 6 Continued

Year of Certification	Level of Certification		State		Institutional Funding Type	
	Level	**Frequency**	**State**	**Frequency**	**Funding Type**	**Frequency**
2010	Platinum	2	Arizona	4	Private	12
(n = 34)	Gold	22	California	5	Public	22
	Silver	8	Colorado	1		
	Certified	2	Florida	4		
			Illinois	1		
			Indiana	1		
			Maine	1		
			Maryland	2		
			Minnesota	1		
			New Hampshire	1		
			New Jersey	2		
			Ohio	1		
			Oregon	1		
			Pennsylvania	1		
			South Carolina	4		
			Texas	1		
			Virginia	3		

Table 6 Continued

Year of Certification	Level of Certification		State		Institutional Funding Type	
	Level	**Frequency**	**State**	**Frequency**	**Funding Type**	**Frequency**
2011	Platinum	6	California	6	Private	7
(n = 26)	Gold	18	Colorado	3	Public	19
	Silver	2	Florida	5		
	Certified	0	Georgia	1		
			Iowa	2		
			New York	2		
			North Carolina	1		
			Oregon	1		
			Pennsylvania	1		
			Texas	1		
			Virginia	1		
			Washington	1		
			Washington, D.C.	1		

Table 6 Continued

Year of Certification	Level of Certification		State		Institutional Funding Type	
	Level	**Frequency**	**State**	**Frequency**	**Funding Type**	**Frequency**
2012	Platinum	3	Arizona	1	Private	12
(n =31)	Gold	24	California	5	Public	19
	Silver	3	Colorado	2		
	Certified	1	Florida	2		
			Georgia	1		
			Maryland	3		
			Massachusetts	1		
			New Hampshire	1		
			New York	6		
			Pennsylvania	1		
			South Carolina	1		
			Texas	1		
			Vermont	1		
			Virginia	2		
			Washington	1		
			Washington, D.C.	2		

Table 6 Continued

Year of Certification	Level of Certification		State		Institutional Funding Type	
	Level	**Frequency**	**State**	**Frequency**	**Funding Type**	**Frequency**
2013	Platinum	2	Arizona	1	Private	6
(n = 19)	Gold	13	California	2	Public	13
	Silver	3	Florida	1		
	Certified	1	Georgia	1		
			Indiana	1		
			Louisiana	1		
			Maryland	1		
			Massachusetts	2		
			North Carolina	2		
			North Dakota	1		
			South Carolina	2		
			Texas	1		
			Utah	1		
			Washington	1		
			Washington, D.C.	1		

Table 6 Continued

Year of Certification	Level of Certification		State		Institutional Funding Type	
	Level	**Frequency**	**State**	**Frequency**	**Funding Type**	**Frequency**
2014	Platinum	3	Arizona	6	Private	6
(n = 18)	Gold	10	California	1	Public	12
	Silver	5	Illinois	1		
	Certified	0	Iowa	2		
			Maine	1		
			Minnesota	1		
			New Mexico	1		
			New York	2		
			North Carolina	1		
			Rhode Island	1		
			Texas	1		
2015	Platinum	0	Arizona	1	Private	10
(n = 19)	Gold	14	California	4	Public	9
	Silver	4	Georgia	1		
	Certified	1	Indiana	2		
			Louisiana	1		
			Maryland	1		
			New York	1		
			North Carolina	2		
			Ohio	1		
			Pennsylvania	2		
			South Carolina	1		
			Washington	2		

Table 6 Continued

Year of Certification	Level of Certification		State		Institutional Funding Type	
	Level	**Frequency**	**State**	**Frequency**	**Funding Type**	**Frequency**
2016	Platinum	4	Arizona	4	Private	3
(n = 13)	Gold	6	California	2	Public	10
	Silver	3	Colorado	1		
	Certified	0	Florida	1		
			Georgia	1		
			New York	1		
			Oregon	1		
			Washington	1		
			Washington, D.C.	1		
2017	Platinum	2	Arizona	1	Private	1
(n = 8)	Gold	6	California	2	Public	7
	Silver	0	Maryland	2		
	Certified	0	Massachusetts	2		
			Washington, D.C.	1		

Description of buildings by LEED levels of certification. When the sample's 195 buildings were organized by levels of certification, study results indicate 23 buildings were certified Platinum, 125 buildings were certified Gold, 37 buildings were certified Silver, and 10 buildings were certified under the Certified level as seen in Table 7. The state with the highest density of Platinum certified campus buildings was California (n = 7), followed by Arizona (n = 4). Eight-two percent of Platinum certified buildings were located on public campuses. The greatest density of Gold certified campus buildings were found in California (n = 17), New York (n = 12), and Arizona (n = 11). Public campuses were shown to possess 60.8%, the greatest number, of Gold certified buildings. Silver certified buildings were most numerous in the states of Arizona (n = 6) and California (n = 5). Approximately, 56.8% of Silver certified buildings were found to occur on public campuses. The state of Florida (n = 3) possessed the highest number of Certified buildings and an equal number of Certified buildings were found on private (n = 5) and public campuses (n = 5).

Table 7

LEED-certified Buildings Catalogued by the LEED Level of Certification Awarded to the Buildings between 2007 and 2017

Level of Certification	State		Institutional Funding Type	
	State	Frequency	Funding Type	Frequency
Platinum	Arizona	4	Private	4
(n = 23)	California	7	Public	19
	Colorado	2		
	Florida	1		
	New Hampshire	1		
	New York	2		
	North Dakota	1		
	Oregon	3		
	Texas	1		
	Virginia	1		

Table 7 Continued

Level of Certification	State		Institutional Funding Type	
	State	**Frequency**	**Funding Type**	**Frequency**
Gold	Arizona	11	Private	49
(n = 125)	California	17	Public	76
	Colorado	5		
	Florida	7		
	Georgia	5		
	Illinois	2		
	Indiana	3		
	Iowa	4		
	Louisiana	1		
	Maine	1		
	Maryland	9		
	Massachusetts	4		
	Minnesota	2		
	Missouri	1		
	New Hampshire	1		
	New York	12		
	North Carolina	5		
	Ohio	2		
	Pennsylvania	5		
	Rhode Island	1		
	South Carolina	6		
	Texas	4		
	Utah	1		
	Vermont	1		
	Virginia	5		
	Washington	5		
	Washington, D.C.	5		

Table 7 Continued

Level of Certification	State		Institutional Funding Type	
	State	**Frequency**	**Funding Type**	**Frequency**
Silver	Arizona	6	Private	16
(n = 37)	California	5	Public	21
	Florida	3		
	Georgia	1		
	Iowa	1		
	Louisiana	1		
	Maine	2		
	Maryland	1		
	Massachusetts	2		
	Michigan	1		
	Minnesota	1		
	New Jersey	2		
	New Mexico	1		
	New York	1		
	North Carolina	3		
	Pennsylvania	1		
	South Carolina	2		
	Texas	1		
	Washington	1		
	Washington, D.C.	1		

Table 7 Continued

Level of Certification	State		Institutional Funding Type	
	State	**Frequency**	**Funding Type**	**Frequency**
Certified	Florida	3	Private	5
(n = 10)	Georgia	1	Public	5
	Indiana	1		
	Maine	1		
	New York	1		
	South Carolina	1		
	Virginia	2		

Economic Principle

A total of 682 individual green-building features items were identified based on a review of the study's archival documents with the intended purpose of reducing the buildings' operations and maintenance costs. These sustainable features were incorporated into the design and construction of 183 buildings on the campuses of 104 universities and colleges. This cohort of buildings earned the LEED certification between 2007 and 2017. LEED version BD+C: New Construction v2 - LEED 2.2 was most used to rate 114 buildings (62.3%), BD+C: New Construction v3 - LEED 2009 were the second most used LEED rating version with 60 buildings (32.8%), and the BD+C: New Construction v2 - LEED 2.1 was the least used rating version with 9 buildings (4.9%). Most of the buildings were Gold certified (65%), as seen in Table 8. Green-building features were not identified for 12 buildings.

Table 8

Description of LEED-certified Buildings that Incorporated Green-building Features Intended to Reduce Operations and Maintenance Costs between 2007 and 2017

LEED-certified Buildings Characteristics (n = 183)		**Frequency**	**Percent (%)**
LEED Version:	BD+C: New Construction v2 - LEED 2.1	9	4.9
	BD+C: New Construction v2 - LEED 2.2	114	62.3
	BD+C: New Construction v3 - LEED 2009	60	32.8
Year of Certification	2007	1	0.5
	2008	7	3.8
	2009	15	8.2
	2010	32	17.5
	2011	25	13.7
	2012	28	15.3
	2013	19	10.4
	2014	18	9.8
	2015	17	9.3
	2016	13	7.1
	2017	8	4.4
LEED Level of Certification	Platinum	23	12.6
	Gold	119	65.0
	Silver	36	19.7
	Certified	5	2.7

Building features intended to reduce operations and maintenance costs. When the green-building features incorporated for the intended purpose of reducing operational and maintenance costs were sorted by credit category, the Energy & Atmosphere category consisted of the highest percentage of green-building features (47.8%) incorporated to impact operational and maintenance costs, followed by the Indoor Environmental Quality category (25.9%), the Water Efficiency category (12.3%), and the Sustainable Sites category (12.2%). The Material & Resources category (1.8%) consisted of the least number of green-building features identified from the buildings' archival data. No green-building features were identified under the Innovation credit category, as seen in Table 9.

Table 9

Frequency Distribution of Green-Building Features Incorporated for the Intended Purpose of Reducing Operational and Maintenance Costs

LEED Credit Categories (n = 682)	**Numerical First Digit Code**	**Frequency**	**Percent (%)**
Sustainable Sites	1	83	12.2
Water Efficiency	2	84	12.3
Energy & Atmosphere	3	326	47.8
Material & Resources	4	12	1.8
Indoor Environmental Quality	5	177	25.9
Innovation	6	00	0.0

Sustainable site. Eighty-three green-building features were sorted within the Sustainable Site category. Forty-eight of these features were incorporated in buildings on public campuses and 35 of the green-building features were incorporated in buildings on private campuses. The highest density of green-building features were implemented in 2010 (19.3%) and 2012 (18.1%). Gold level certified buildings incorporated the greatest number of green-building features. Table 10 highlights the frequency distribution of green-building features incorporated with the intended purpose of reducing maintenance and operation costs within the Sustainable Site category by institutional and building characteristics.

Ten Sustainable Site feature subgroups were identified, as seen in Figure 3. Green roofs (39.8%) and light/white reflective roofs (39.8%) were the most incorporated building features classified under the Sustainable Site category to effectuate reductions in maintenance and operations cost.

Table 10

Frequency Distribution of Green-Building Features Incorporated for the Intended Purpose of Reducing Operational and Maintenance Costs by Sustainable Site Credit Category

LEED Credit Category: Sustainable Site (n = 83)		**Frequency**	**Percent (%)**
Institutional Funding Type	Private	35	42.2
	Public	48	57.8
Year of Certification	2007	1	1.2
	2008	3	3.6
	2009	7	8.4
	2010	16	19.3
	2011	7	8.4
	2012	15	18.1
	2013	9	10.8
	2014	7	8.4
	2015	8	9.6
	2016	5	6.0
	2017	5	6.0
LEED Level of Certification	Platinum	11	13.3
	Gold	53	63.9
	Silver	16	19.3
	Certified	3	3.6

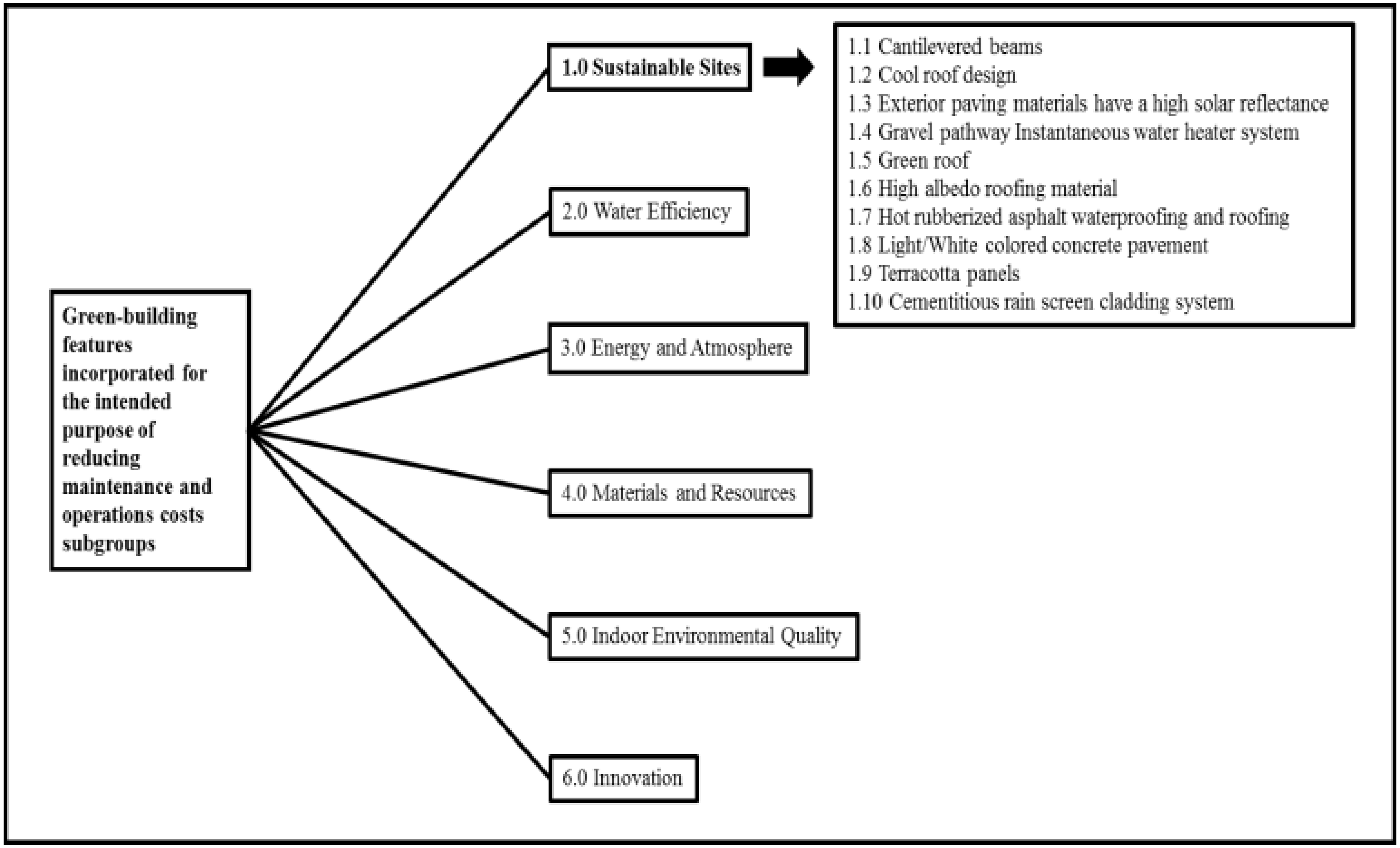


Figure 4. Green-building feature subgroups incorporated to reduce maintenance and operations costs classified within the Sustainable Site credit category.

Water efficiency. Eighty-four green-building feature items were classified within the Water Efficiency category. Forty-nine green-building features were incorporated in public campus buildings, while 35 green-building features were incorporated in private campus buildings. The greatest number of green-building features were implemented in 2010 (23.8%). Gold level certified buildings incorporated the greatest number of green-building features, as seen in Table 11.

Only two green-building feature subgroups were identified, as seen in Figure 4. Low/No flow-water fixtures (98.8%) were the most utilized feature to address Water Efficiency category strategies. The second sustainable feature identified was time-metered faucets.

Table 11

Frequency Distribution of Green-Building Features Incorporated for the Intended Purpose of Reducing Operational and Maintenance Costs by Water Efficiency Credit Category

LEED Credit Category: Water Efficiency (n = 84)		**Frequency**	**Percent (%)**
Institutional Funding Type	Private	35	41.7
	Public	49	58.3
Year of Certification	2007	1	1.2
	2008	3	3.6
	2009	8	9.5
	2010	20	23.8
	2011	12	14.3
	2012	7	8.3
	2013	10	11.9
	2014	4	4.8
	2015	7	8.3
	2016	7	8.3
	2017	5	6.0
LEED Level of Certification	Platinum	8	9.5
	Gold	57	67.9
	Silver	18	21.4
	Certified	1	1.2

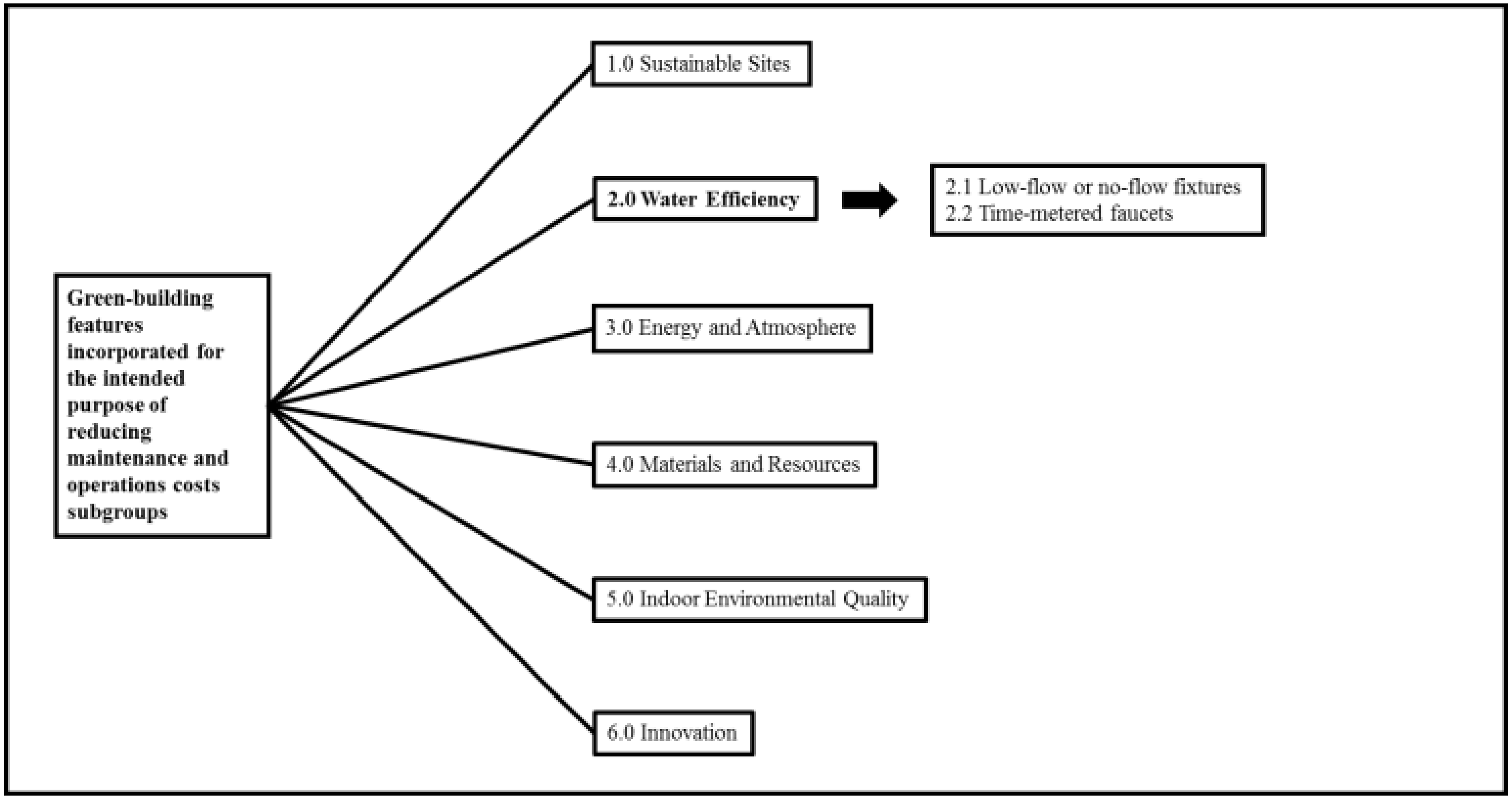


Figure 5. Green-building feature subgroups incorporated to reduce maintenance and operations costs classified within the Water Efficiency credit category.

Energy and atmosphere. Three hundred and twenty-six green-building feature items were classified within the Energy and Atmosphere category. Two hundred and one features were incorporated in public campus buildings on, while 125 features were incorporated in private campus buildings. The greatest number of green-building features were implemented in 2010 (15.0%). Gold level certified buildings incorporated the greatest number of green-building features, as seen in Table 12.

Green-building features were arranged and classified into 44 Energy and Atmosphere subgroups, as seen in Figure 5. The top five subgroups included occupancy sensors (13.5%), high efficiency HVAC systems (11.3%), solar photovoltaic panels (9.2%), efficient lighting fixtures (6.4%), and energy recovery wheel (6.1%). It was found that 39% of the Energy and Atmosphere subgroups consisted of a singular specific green-building feature which was identified only once.

Table 12

Frequency Distribution of Green-Building Features Incorporated for the Intended Purpose of Reducing Operational and Maintenance Costs by Energy and Atmosphere Credit Category

LEED Credit Category: Energy and Atmosphere (n = 326)		**Frequency**	**Percent (%)**
Institutional Funding Type	Private	125	38.3
	Public	201	61.7
Year of Certification	2007	1	0.3
	2008	6	1.8
	2009	29	8.9
	2010	49	15.0
	2011	42	12.9
	2012	44	13.5
	2013	37	11.3
	2014	29	8.9
	2015	32	9.8
	2016	36	11.0
	2017	21	6.4
LEED Level of Certification	Platinum	51	15.6
	Gold	224	68.7
	Silver	46	14.1
	Certified	5	1.5

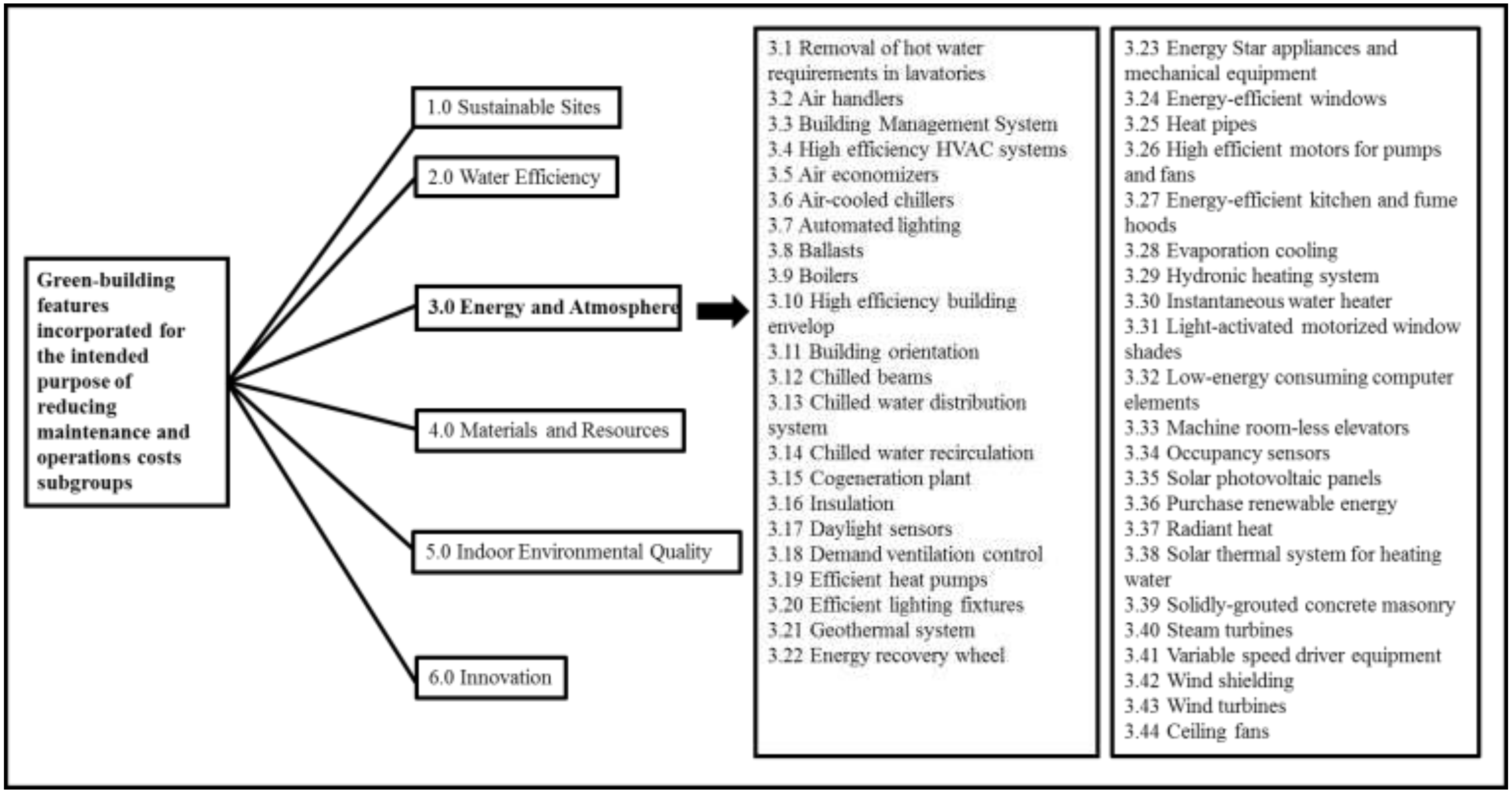


Figure 6. Green-building feature subgroups incorporated to reduce maintenance and operations costs classified within the Energy and Atmosphere credit category.

Materials and resources. Twelve green-building feature items were classified within the Materials and Resources category. Two features were incorporated in public campus buildings on, while 10 features were incorporated in private campus buildings. The greatest number of green-building features were implemented equally in 2009 (25.0%) and in 2011 (25.0%). No green-building features were identified for the following three years: 2007, 2015, and 2016. Gold level certified buildings incorporated the greatest number of green-building features, as seen in Table 13. No green-building features were identified for Certified level certified buildings in this credit category.

Once the features were organized and classified into 5 subgroups, as seen in Figure 6. Metal frame and roof was the most numerous green features and the only feature in this category to be incorporated multiple times, exactly eight buildings, within the sample. Specific, metals used to construction the frame and roof of the buildings included, steel and zinc.

Table 13

Frequency Distribution of Green-Building Features Incorporated for the Intended Purpose of Reducing Operational and Maintenance Costs by Materials and Energy Credit Category

LEED Credit Category: Materials and Energy (n = 12)		**Frequency (f)**	**Percent (%)**
Institutional Funding Type	Private	2	16.7
	Public	10	83.3
Year of Certification	2008	1	8.3
	2009	3	25.0
	2010	2	16.7
	2011	3	25.0
	2012	1	8.3
	2013	1	8.3
	2017	1	8.3
LEED Level of Certification	Platinum	3	25.0
	Gold	6	50.0
	Silver	3	25.0
	Certified	0	0.0

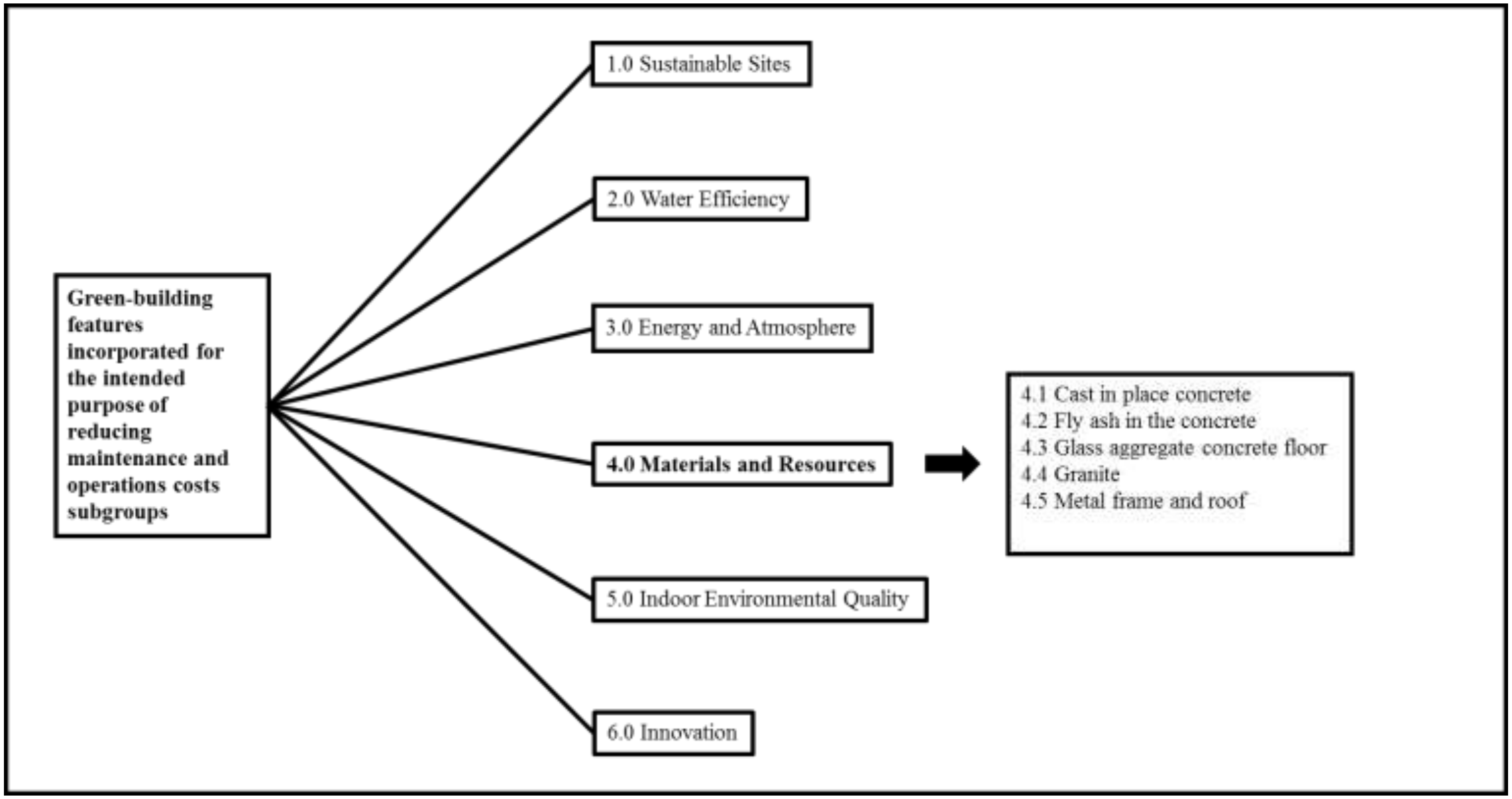


Figure 7. Green-building feature subgroups incorporated to reduce maintenance and operations costs classified within the Material and Resources credit category.

Indoor environmental quality. One hundred and seventy-seven green-building feature items were classified within the Indoor Environmental Quality category. One hundred and twenty-five features were incorporated in public campus buildings on, while 52 features were incorporated in private campus buildings. The greatest number of green-building features were implemented in 2012 (15.3%). No green-building features were identified for only 2007. Gold level certified buildings incorporated the greatest number of green-building features, as seen in Table 14. No green-building features were identified for Certified level certified buildings in the Indoor Environmental Quality credit category.

The green-building features were organized and then classified into 11 subgroups, as seen in Figure 7.

Table 14

Frequency Distribution of Green-Building Features Incorporated for the Intended Purpose of Reducing Operational and Maintenance Costs by Indoor Environmental Quality Credit Category

LEED Credit Category: Indoor Environmental Quality (n = 177)		**Frequency**	**Percent (%)**
Institutional Funding Type	Private	52	29.4
	Public	125	70.6
Year of Certification	2008	7	4.0
	2009	11	6.2
	2010	22	12.4
	2011	23	13.0
	2012	27	15.3
	2013	23	13.0
	2014	19	10.7
	2015	21	11.9
	2016	17	9.6
	2017	7	4.0
LEED Level of Certification	Platinum	31	17.5
	Gold	108	61.0
	Silver	38	21.5
	Certified	0	0.0

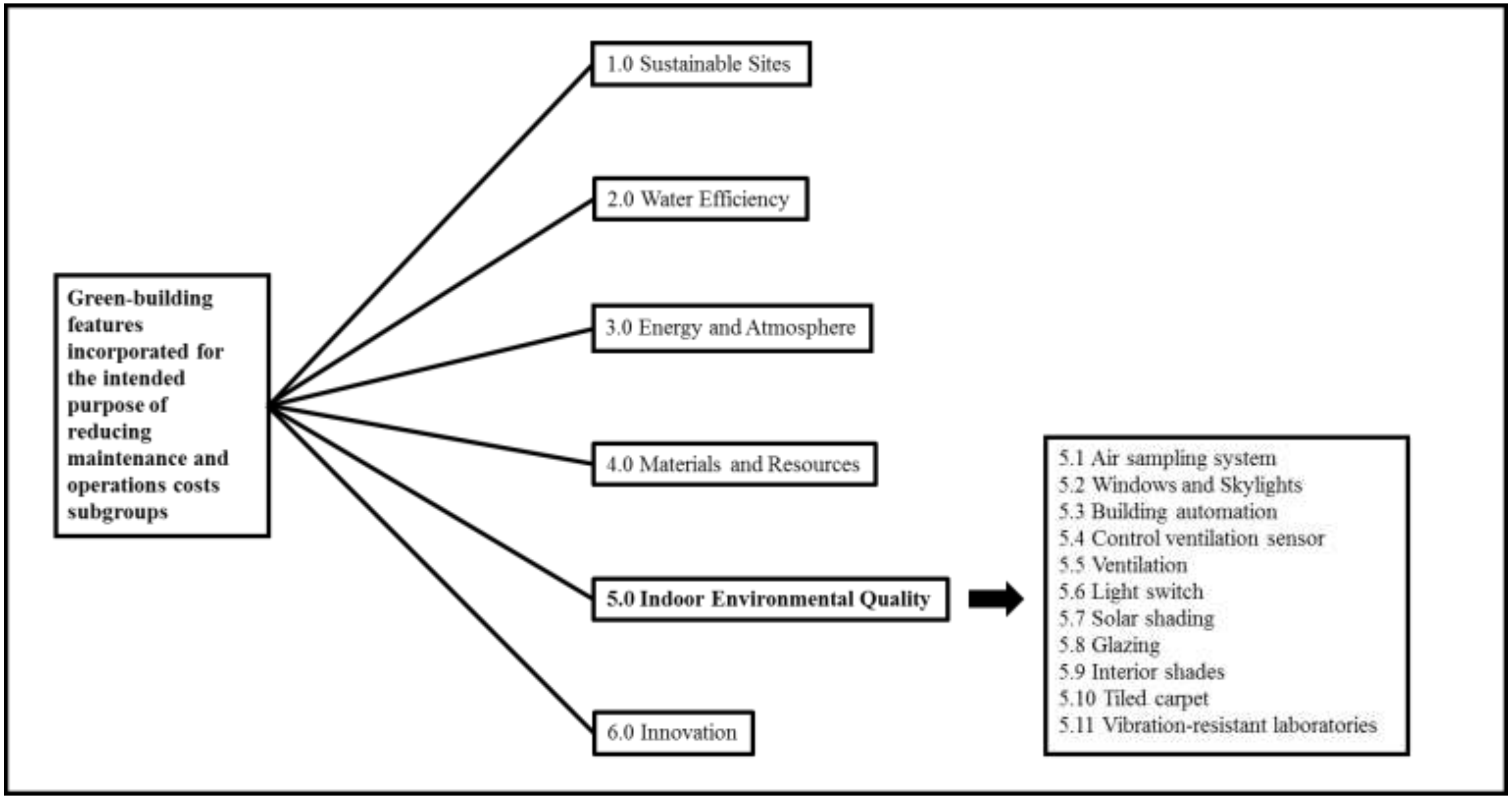


Figure 8. Green-building feature subgroups incorporated to reduce maintenance and operations costs classified within the Indoor Environmental Quality credit category.

Economic Inferential Analyses

To look for evidence of differences of green-building features incorporated to generate operational and maintenance performance cost savings between institutional funding groups and LEED levels of certification groups from 2007 to 2017, green-building features were classified into one of six LEED credit category subgroups and examined. The results are presented by LEED credit category.

Sustainable sites. The mean Private institutions group was 5.571 (SD = 1.441) and the mean Public institutions group was 5.438 (SD = 1.486). According to the *t* test, there was not enough evidence to suggest a significant difference between the green-building features subgroups of the two groups of higher education institutions, $t(81) = .411$, $p = .682$. When LEED levels of certification groups were analyzed there were no significant differences between the levels of certification groups in the mean number of Sustainable Site feature subgroups $F(3, 79) = 1.355$, $p = .269$.

Table 15

Sustainable Site Category: Group Means and Standard Deviations by LEED Levels of Certification

Levels of Certification	**N**	***M***	**SD**
Platinum	11	6.091	1.758
Gold	53	5.64	1.483
Silver	16	5.813	1.167
Certified	3	5.667	0.577

Water efficiency. The mean Private institutions group was 2.000 (SD < 0.001) and the mean Public institutions group was 1.980 (SD = 0.143). According to the *t* test, there was not enough evidence to suggest a significant difference between the green-building features subgroups of the two groups of higher education institutions, $t(82) = .844$, $p = .401$. When LEED levels of certification groups were analyzed there were no significant differences between the levels of certification groups in the mean number of Water Efficiency feature subgroups $F(3, 80) = .153$, $p = .927$.

Table 16

Water Efficiency Category: Group Means and Standard Deviations by LEED Levels of Certification

Levels of Certification	N	*M*	SD
Platinum	8	2.000	<.001
Gold	57	1.983	.134
Silver	18	2.000	<.001
Certified	1	2.000	

Energy and atmosphere. The mean Private institutions group was 23.016 (SD = 11.825) and the mean Public institutions group was 21.433 (SD = 12.203). According to the *t* test, there was not enough evidence to suggest a significant difference between the green-building features subgroups of the two groups of higher education institutions, $t(324) = 1.152$, $p = .250$. When LEED levels of certification groups were analyzed there were no significant differences between the levels of certification groups in the mean number of Energy and Atmosphere feature subgroups $F(3, 322) = 1.221$, $p = .302$.

Table 17

Energy and Atmosphere: Group Means and Standard Deviations by LEED Levels of Certification

Levels of Certification	**N**	***M***	**SD**
Platinum	51	24.745	12.011
Gold	224	21.406	12.113
Silver	46	22.500	11.897
Certified	5	18.600	10.945

Materials and resources. The mean Private institutions group was 4.500 (SD = .707) and the mean Public institutions group was 4.100 (SD = 1.524). According to the *t* test, there was not enough evidence to suggest a significant difference between the green-building features subgroups of the two groups of higher education institutions, $t(10) = .535$, $p = .196$. When LEED levels of certification groups were analyzed there were no significant differences between the levels of certification groups in the mean number of Materials and Resources feature subgroups $F(2, 9) = .335$, $p = .724$.

Table 18

Materials and Resources: Group Means and Standard Deviations by LEED Levels of Certification

Levels of Certification	**N**	***M***	**SD**
Platinum	3	3.667	2.309
Gold	6	4.167	1.329
Silver	3	4.667	.577
Certified			

Indoor environmental quality. The mean Private institutions group was 3.654 (SD = 2.465) and the mean Public institutions group was 4.224 (SD = 2.664). According to the *t* test, there was not enough evidence to suggest a significant difference between the green-building features subgroups of the two groups of higher education institutions, *t*(175) = 1.325, *p* = .060. When LEED levels of certification groups were analyzed there were no significant differences between the levels of certification groups in the mean number of Indoor Environmental Quality feature subgroups *F*(2, 174) = .295, *p* = .745.

Table 19

Indoor Environmental Quality: Group Means and Standard Deviations by LEED Levels of Certification

Levels of Certification	N	*M*	SD
Platinum	31	4.032	2.639
Gold	108	3.963	2.572
Silver	38	4.342	2.754
Certified			

Social Principle

A total of 355 individual green-building feature items were identified from the archival documents for the intended purpose of improving indoor wellbeing. These green features were incorporated into the design and construction of a total of 161 buildings on the campuses of 93 universities and colleges. Public university and college campuses incorporated green-features intended to improve the indoor environment in approximately 61% more buildings when compared to private institutions. This cohort of buildings earned their LEED certification between 2008 and 2017. LEED version BD+C: New Construction v2 - LEED 2.2 was most used with 105 buildings (65.2%), followed by BD+C: New Construction v3 - LEED 2009 with 49 buildings (30.4%), and the BD+C: New Construction v2 - LEED 2.1 was used to rate 7 buildings (4.3%). Most of the buildings were Gold certified (64.0%), as seen in Table 20. Green-building features were not identified for 34 buildings.

Table 20

Description of LEED-certified Buildings that Incorporated Green-building Features Intended to Improve Occupant Indoor Wellbeing

LEED-certified Buildings Characteristics (n = 161)		**Frequency**	**Percent (%)**
LEED Version:	BD+C: New Construction v2 - LEED 2.1	7	4.3
	BD+C: New Construction v2 - LEED 2.2	105	65.2
	BD+C: New Construction v3 - LEED 2009	49	30.4
Year of Certification	2008	4	2.5
	2009	17	10.6
	2010	29	18.0
	2011	23	14.3
	2012	25	15.5
	2013	16	9.9
	2014	15	9.3
	2015	13	8.1
	2016	12	7.5
	2017	7	4.3
LEED Level of Certification	Platinum	21	13.0
	Gold	103	64.0
	Silver	32	19.9
	Certified	5	3.1

Building features intended to improve indoor wellbeing. Green-building features incorporated in campus buildings for the intended purpose of improving occupant indoor wellbeing were shown to occur 50% more often on public campuses than on private campuses. These green-building features were most implemented into buildings rated under LEED BD+C: New Construction v2 - LEED 2.2 (n=208) more than the other two versions, BD+C: New Construction v3 - LEED 2009 (n = 128) and BD+C:

New Construction v2 - LEED 2.1 (n = 19). Gold level certified buildings were found to incorporate the highest density of green-building features incorporated for the intended purpose of improving occupant indoor wellbeing, as seen in Table 21. Green-building features incorporated for the intended purpose of improving occupant indoor wellbeing were incorporated most often in 2010 (n = 55).

The 355 green-building feature items were sorted and organized within only three LEED credit categories, which included Sustainable Sites, Materials and Resources, and Indoor Environmental Quality, as seen in Figures 8, 9, and 10. Approximately, 94% of all green-building features incorporated for the intended purpose of improving occupant indoor wellbeing were classified into one of 23 subgroups within the LEED credit category, Indoor Environmental Quality. Thirteen green-building feature items did not satisfy any of LEED version 2's strategies and, therefore, were not identified within any of the six LEED credit categories. The thirteen items included:

- Bottle refill station (n = 1),
- Campus sustainability tours (n = 2),
- Building design reflect the institution's historic signature features, or institution's academic programs, or the regional features (n = 4),
- Allows occupants to full view of the heating system (n = 1),
- Organic garden (n = 1),
- Building preserve campus views (of historical or meaningful buildings or statues) (n = 1),
- Promote health by encouraging residents to use the stairs (n = 1),
- Residential programs including green education events (n = 1), and

- Students worked with the design team on the building (n = 1).

Mix-use/Multi-use Facilities (22%), Classroom Facilities (19.4%), and Residential Faculties (15.8%) were the building usage, by occupancy categories, with the highest number of features intended to improve indoor wellbeing.

Table 21

Description of Green-building Features that were Incorporated for the Intended Purpose of Improving Indoor Wellbeing

Green-building Features (n = 355)		**Frequency**	**Percent (%)**
LEED Version	BD+C: New Construction v2 - LEED 2.1	19	5.4
	BD+C: New Construction v2 - LEED 2.2	208	58.6
	BD+C: New Construction v3 – LEED 2009	128	36.1
Year of Certification	2007	1	0.3
	2008	8	2.3
	2009	39	11.0
	2010	55	15.5
	2011	52	14.6
	2012	45	12.7
	2013	35	9.9
	2014	29	8.2
	2015	28	7.9
	2016	30	8.5
	2017	33	9.3
LEED Level of Certification	Platinum	6	1.7
	Gold	3	0.8
	Silver	333	93.8
	Certified	13	3.7
Institutional Funding Type	Private	133	37.5
	Public	222	62.5
Building Use By Occupancy	Classroom Facilities	69	19.4
	General Use Facilities	47	13.2
	Healthcare Faculties	4	1.1
	Laboratory Facilities	38	10.7
	Mix-use/Multi-use Facilities	78	22.0
	Office/Administration Facilities	16	4.5
	Residential Facilities	56	15.8
	Special Use Facilities	32	9.0
	Study/Library Facilities	8	2.3
	Supporting Facilities	7	2.0

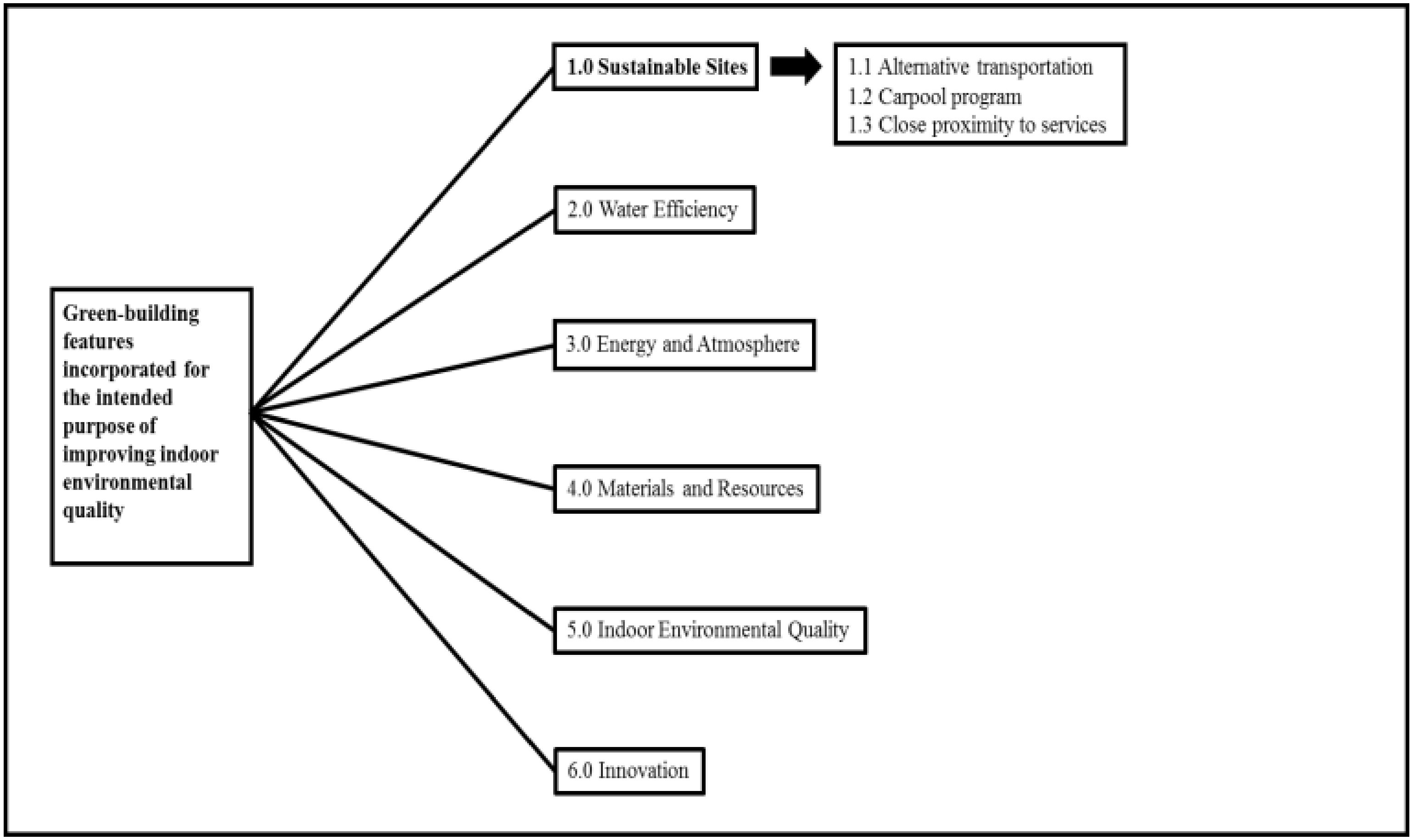


Figure 9. Green-building feature subgroups incorporated to improve indoor wellbeing classified within Sustainable Site credit category.

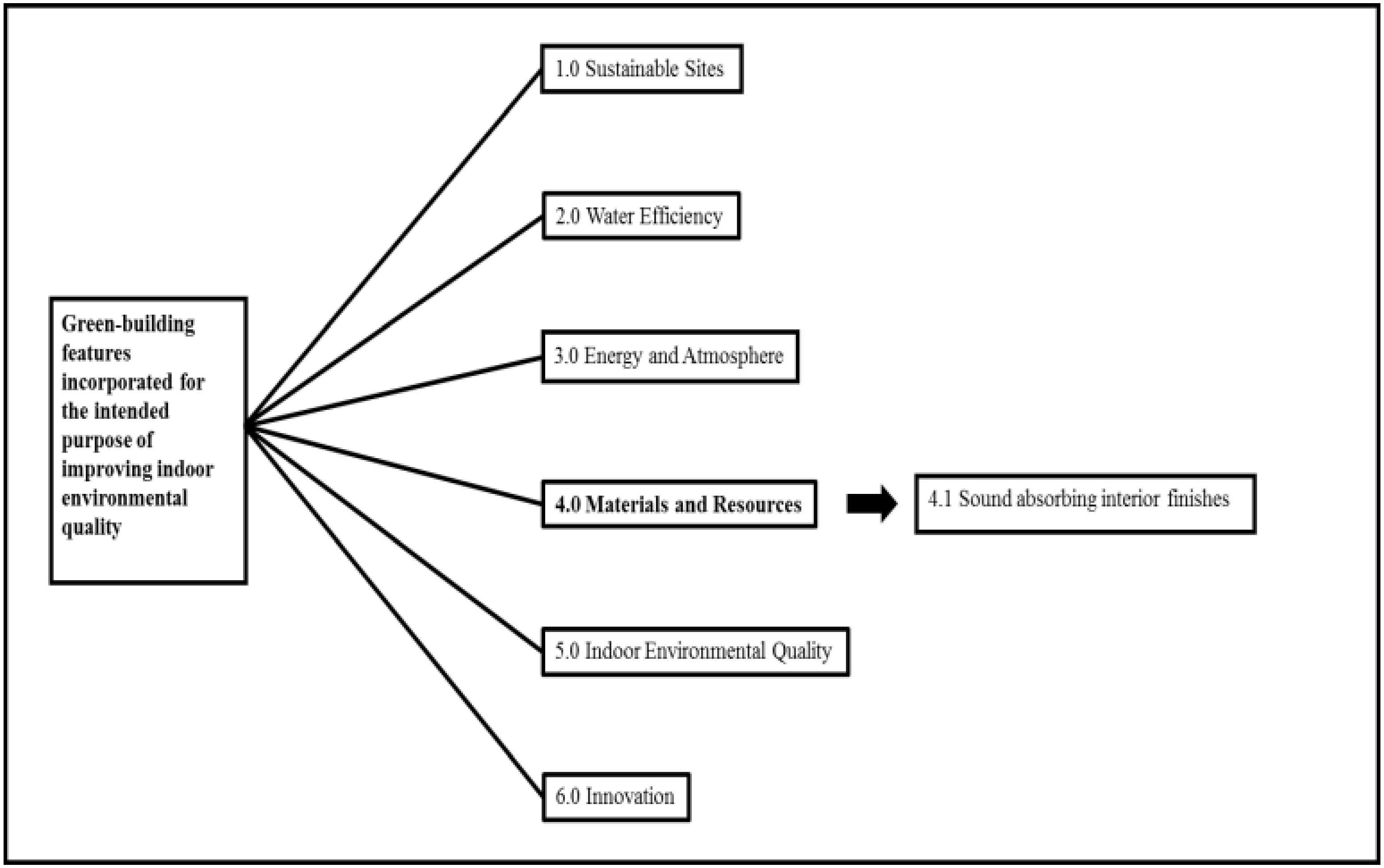


Figure 10. Green-building feature subgroup incorporated to improve indoor wellbeing classified within Materials and Resources credit category.

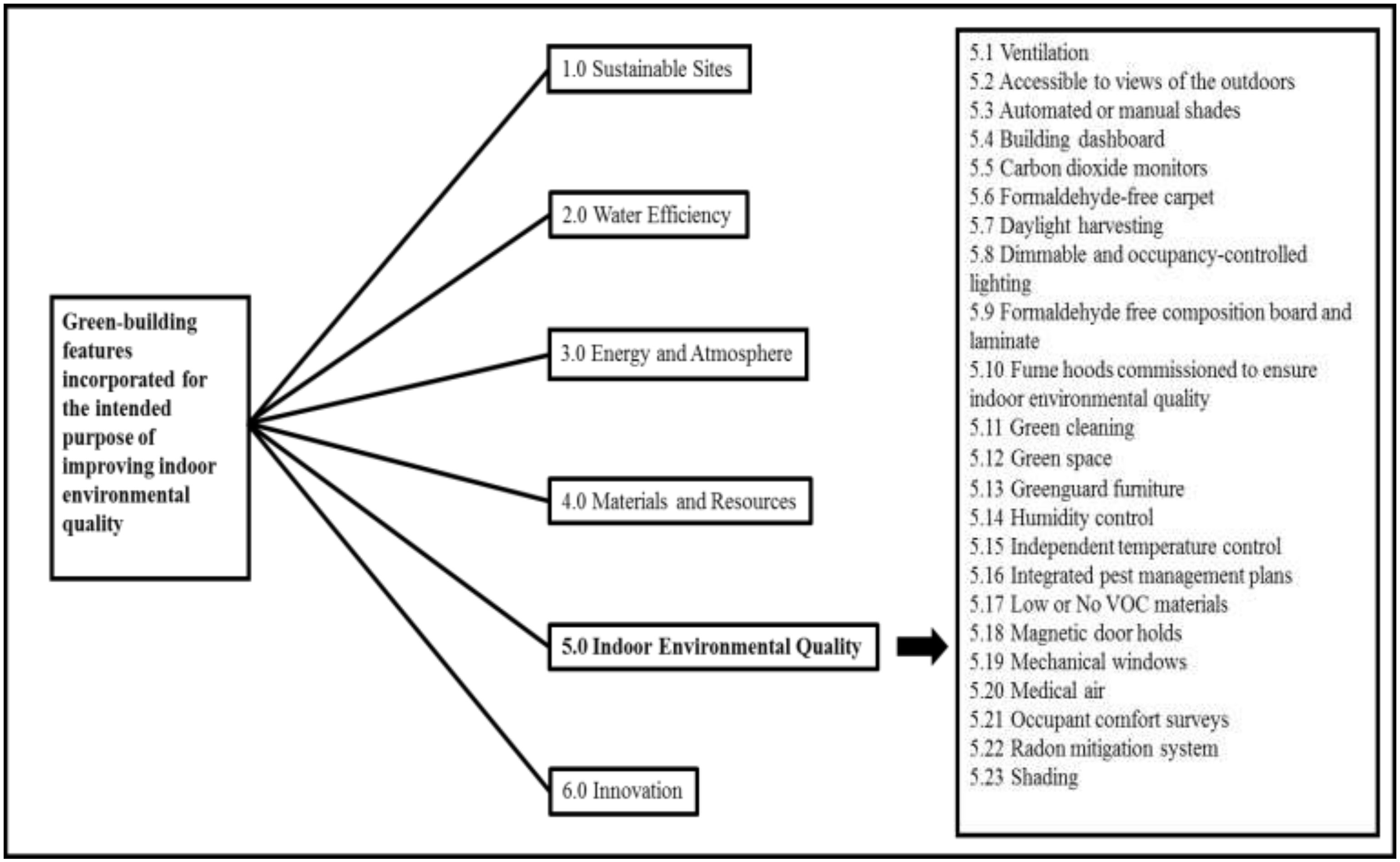


Figure 11. Green-building feature subgroup incorporated to improve indoor wellbeing classified within Indoor Environmental Quality credit category.

Social Inferential Analyses

For evidence of differences of green-building features incorporated to generate improved indoor wellbeing between building, institutional, and LEED characteristic groups from 2007 to 2017; green-building features classified into LEED credit category: Indoor Environmental Quality subgroups were examined as approximately 94% of all green features were classified within this category. In addition, LEED Indoor Environmental Quality scores for the cohort of buildings with green-building features incorporated for the intended purpose of improving occupant indoor wellbeing identified from the archival data were used to investigate differences between LEED characteristics.

Indoor environmental quality subgroups. The mean Private institutions group was 10.37 (SD = 5.873) and the mean Public institutions group was 9.64 (SD = 5.882). According to the *t* test, there was not enough evidence to suggest a significant difference between Indoor Environmental Quality credit category subgroups of the two groups of higher education institutions, $t(331) = 1.100$, $p = .272$. ANOVA results showed no significant differences of Indoor Environmental Quality subgroups between LEED versions groups $F(2, 330) = .078$, $p = .925$. When LEED levels of certification groups were analyzed, there were significant differences between the LEED levels of certification groups in the mean number of Indoor Environmental Quality credit category subgroups $F(3, 329) = 4.011$, $p = .008$. Tukey post hoc test was used to determine where the differences occurred. When the group mean differences were compared Silver and Certified group means were significantly different from Platinum group means for green-building features incorporated for the intended purpose of improving occupant indoor wellbeing classified within the Indoor Environmental Quality credit category (Table 22).

Table 22

Pair-wise Comparison between LEED Levels of Certification by Indoor Environmental Quality Subgroups

LEED Levels of Certification	High Confidence Limits	Low Confidence Limits	Mean Difference	Significantly different Level of Certification
Platinum	0.45	6.24	3.346	Silver
Platinum	0.08	10.52	5.298	Certified

Note. 95% Confidence Limits were used to compare Platinum group means to Silver and Certified group means for green-building features incorporated for the intended purpose of improving occupant indoor wellbeing classified within the Indoor Environmental Quality credit category.

Indoor environmental quality credit scores. Since the green-building features are directly related to the buildings' earning credit points toward the LEED certification, the LEED credit category scores were used to determine difference between LEED characteristics. The mean Private institutions group was 10.14 (SD = 2.004) and the mean Public institutions group was 10.64 (SD = 1.991). According to the *t* test, there was no significant difference between the Indoor Environmental Quality credit category scores of private and public higher education institutions, $t(159) = -1.500$, $p = .136$. ANOVA results showed significant differences were not found between LEED versions groups $F(2, 158) = 1.388$, $p = .253$. When LEED levels of certification groups were analyzed, there were significant differences in the mean number of Indoor Environmental Quality credit category scores between LEED levels of certification groups $F(3, 157) = 25.518$, $p = < .001$. Tukey post hoc test was used to determine where the differences occurred. When the group mean differences were compared all levels of certification groups were significantly different from each other (Table 23).

Table 23

Pair-wise Comparison between LEED Levels of Certification by Indoor Environmental Quality Credit Category Scores

LEED Levels of Certification	High Confidence Limits	Low Confidence Limits	Mean Difference	Significantly different Level of Certification
Platinum	2.74	1.37	2.056	Gold
	4.35	2.70	3.526	Silver
	6.12	3.21	4.662	Certified
Gold	2.08	.86	1.470	Silver
	3.95	1.26	2.606	Certified
Silver	2.56	-.28	1.136	Certified

Note. 95% Confidence Limits were used to compare LEED Level of Certification group means for the buildings' Indoor Environmental Quality credit category score.

Buildings by occupant usage. ANOVA results showed no significant differences in Indoor Environmental Quality green-building feature subgroups between building by occupancy use groups $F(9,323) = .494$, $p = .879$. When building by occupancy use groups were analyzed, there were no significant differences in the mean number of Indoor Environmental Quality credit category scores between building by occupancy use groups $F(9, 151) = 1.353$, $p = .215$.

Environmental Principle

A total of 628 individual green-building features items were identified from the archival documents for the intended purpose of improve environmental stewardship.

These green features were incorporated into the design and construction of a total 174 buildings on the campuses of 101 universities and colleges. Public university and college campuses implemented green-features intended to improve environmental stewardship in approximately 41% more buildings when compared to private institutions. This cohort of buildings earned their LEED certification between 2007 and 2017. LEED version BD+C: New Construction v2 - LEED 2.2 was most used with 114 buildings (65.5%), followed by BD+C: New Construction v3 - LEED 2009 with 49 buildings (28.2%), and the BD+C: New Construction v2 - LEED 2.1 was used to rate 11 buildings (6.3%). Most of the buildings were Gold certified (63.8%), as seen in Table 24. Green-building features were not identified for 21 buildings located on the campuses of 18 higher education campuses.

Table 24

Description of LEED-certified Buildings that Incorporated Green-building Features Intended to Increase Environmental Stewardship

LEED-certified Buildings Characteristics (n = 161)		**Frequency**	**Percent (%)**
LEED Version:	BD+C: New Construction v2 - LEED 2.1	11	6.3
	BD+C: New Construction v2 - LEED 2.2	114	65.5
	BD+C: New Construction v3 - LEED 2009	49	28.2
Year of Certification	2007	1	0.6
	2008	8	4.6
	2009	18	10.3
	2010	33	19.0
	2011	22	12.6
	2012	29	16.7
	2013	17	9.8
	2014	13	7.5
	2015	16	9.2
	2016	11	6.3
	2017	6	3.4
LEED Level of Certification	Platinum	20	11.5
	Gold	111	63.8
	Silver	34	19.5
	Certified	9	5.2

Building features intended to increase environmental stewardship. Green-building features incorporated in campus buildings for the intended purpose of increasing environmental stewardship were shown to occur approximately 30% more often on public campuses than on private campuses. These green-building features were most implemented into buildings rated under LEED BD+C: New Construction v2 - LEED 2.2 (n = 428) more than the other two versions, BD+C: New Construction v3 - LEED 2009 (n = 165) and BD+C: New Construction v2 - LEED 2.1 (n = 35). Gold level certified buildings were found to incorporate the highest density of green-building features incorporated for the intended purpose of improving occupant indoor wellbeing, as seen in Table 25. Green-building features incorporated for the intended purpose of increasing environmental stewardship were incorporated most often in 2010 (n = 119). The greatest density of green-building feature subgroups were classified within Sustainable Site credit category (38.5%) and Materials and Resources credit categories (34.1%).

Table 25

Description of Green-building Features that were Incorporated for the Intended Purpose of Increasing Environmental Stewardship

Green-building Features (n = 628)		**Frequency**	**Percent (%)**
LEED Version	BD+C: New Construction v2 - LEED 2.1	35	5.6
	BD+C: New Construction v2 - LEED 2.2	428	68.2
	BD+C: New Construction v3 - LEED 2009	165	26.3
Year of Certification	2007	6	1.0
	2008	29	4.6
	2009	76	12.1
	2010	119	18.9
	2011	95	15.1
	2012	73	11.6
	2013	54	8.6
	2014	50	8.0
	2015	58	9.2
	2016	28	4.5
	2017	40	6.4
LEED Level of Certification	Platinum	73	11.6
	Gold	421	67.0
	Silver	99	15.8
	Certified	35	5.6
Institutional Funding Type	Private	267	42.5
	Public	361	57.5

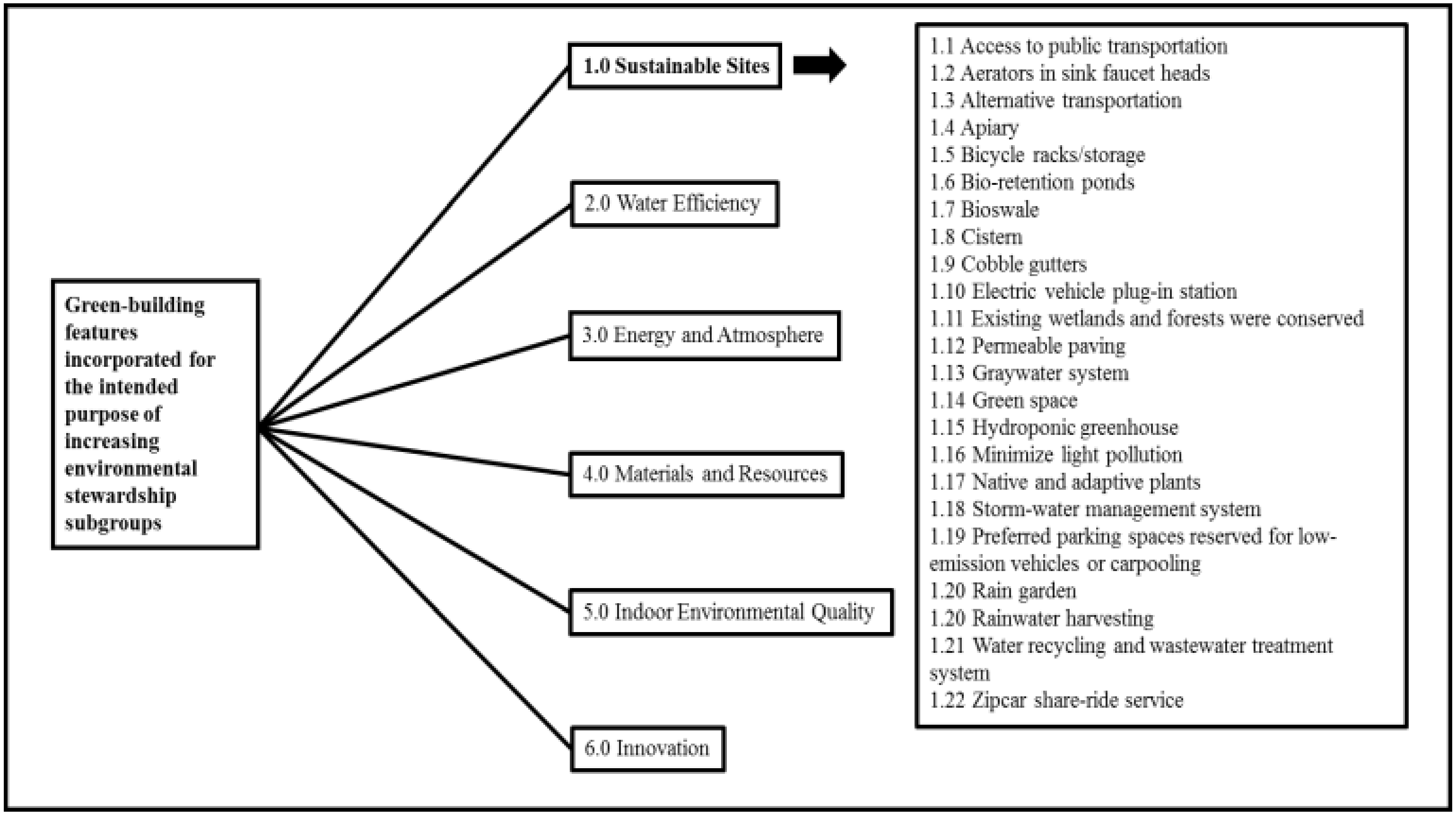


Figure 12. Green-building feature subgroups incorporated to increase environmental stewardship classified within Sustainable Site credit category.

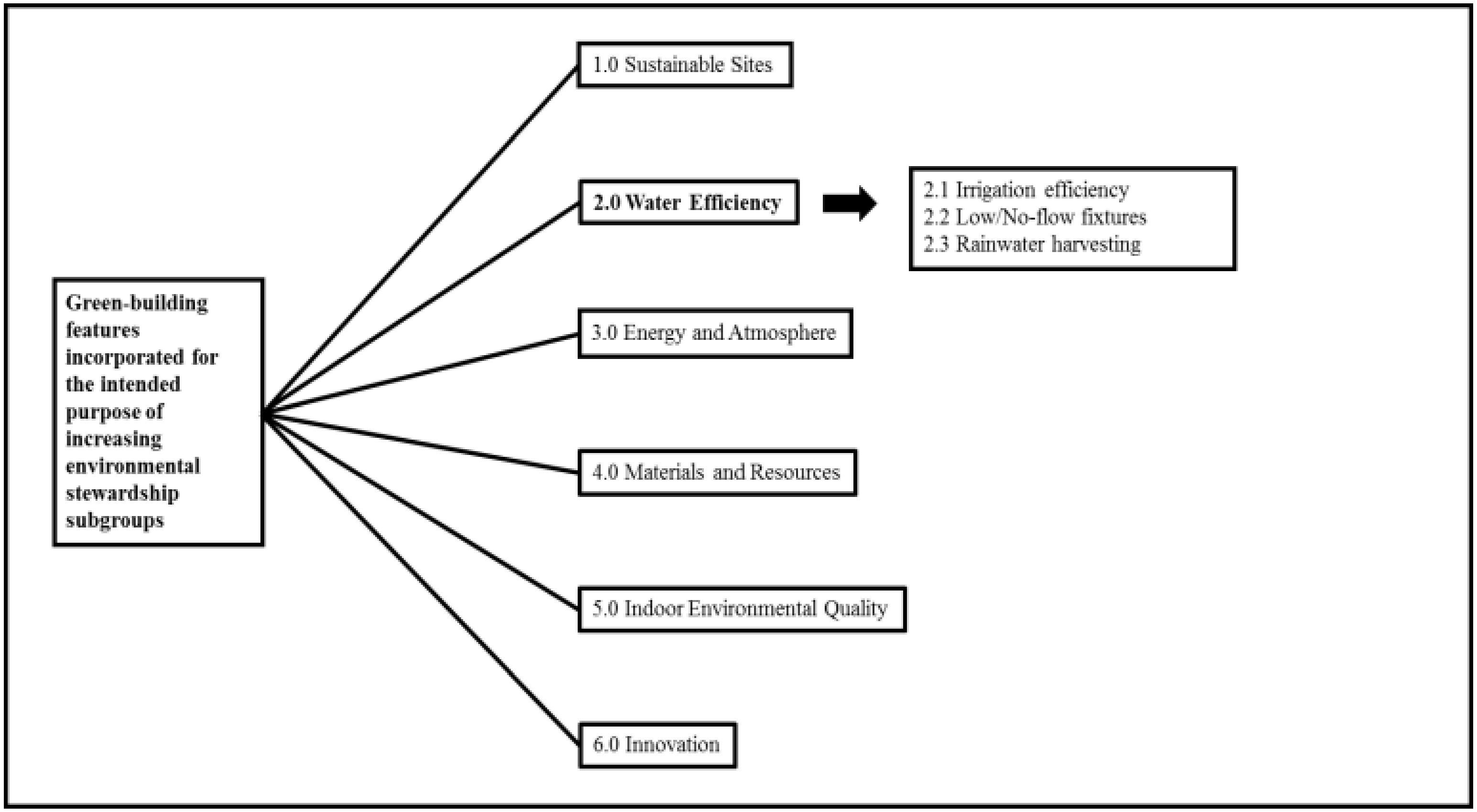


Figure 13. Green-building feature subgroups incorporated to increase environmental stewardship classified within Water Efficiency credit category.

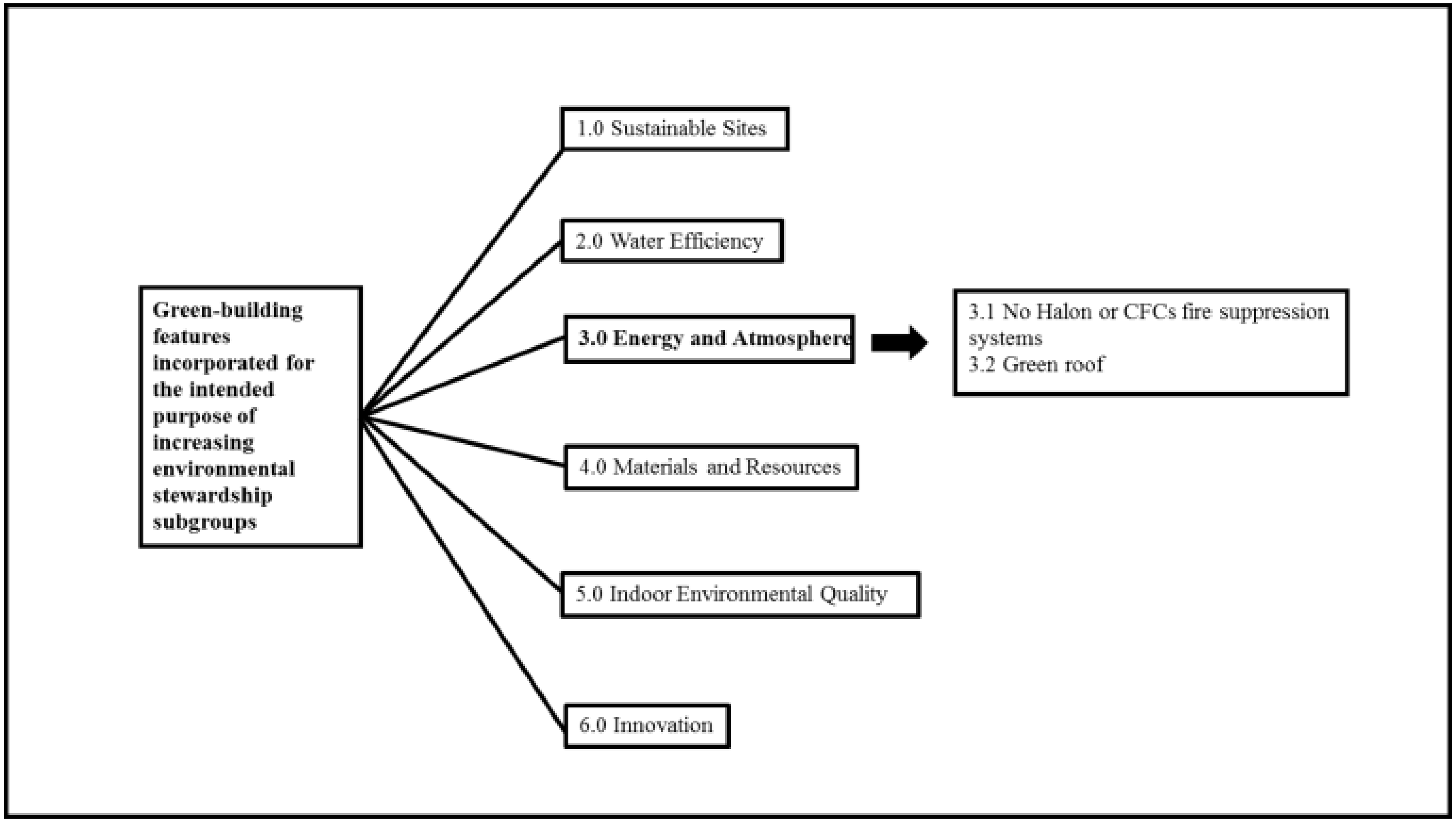


Figure 14. Green-building feature subgroups incorporated to increase environmental stewardship classified within Energy and Atmosphere credit category.

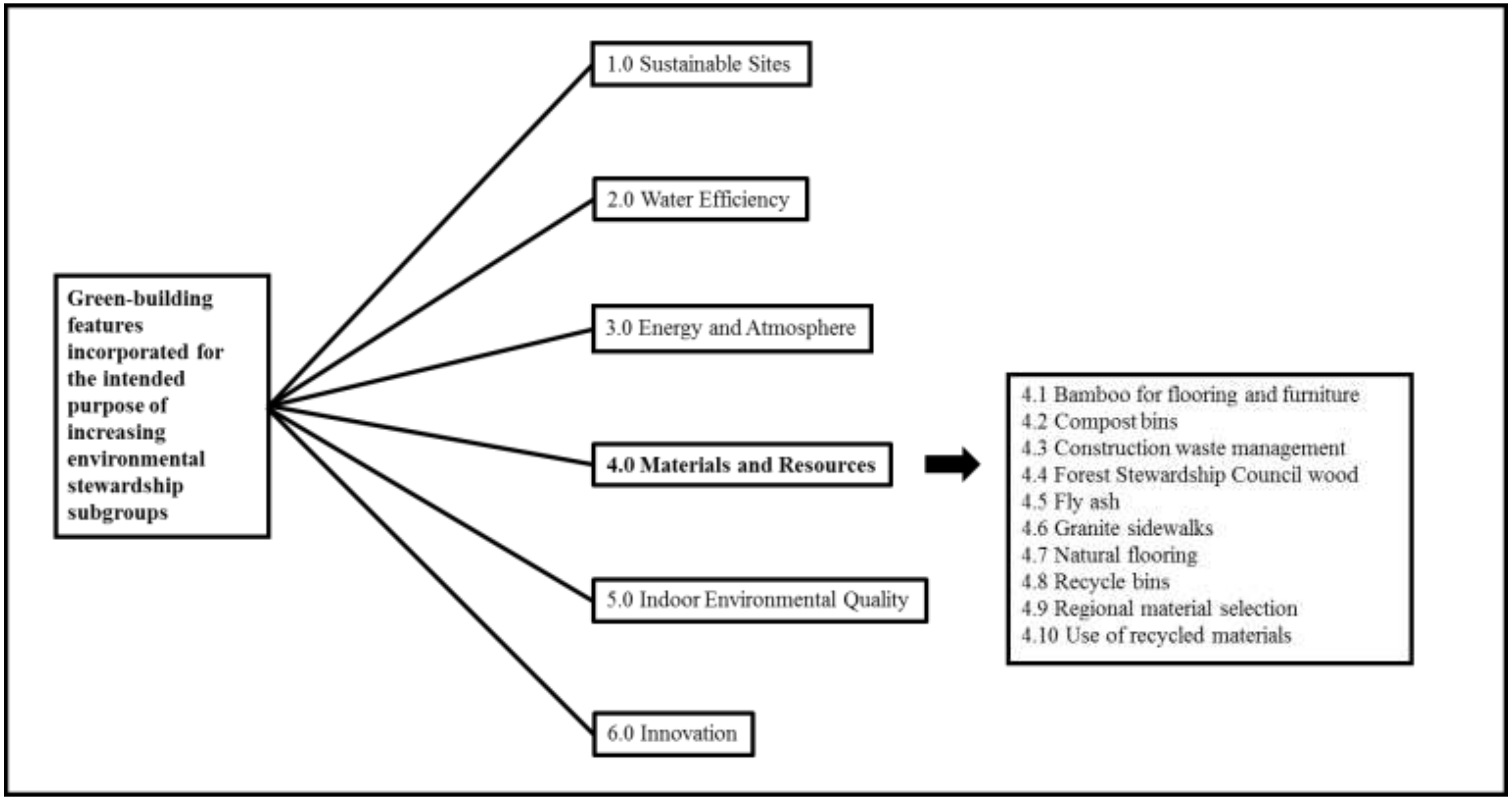


Figure 15. Green-building feature subgroups incorporated to increase environmental stewardship classified within the Material and Resources credit category.

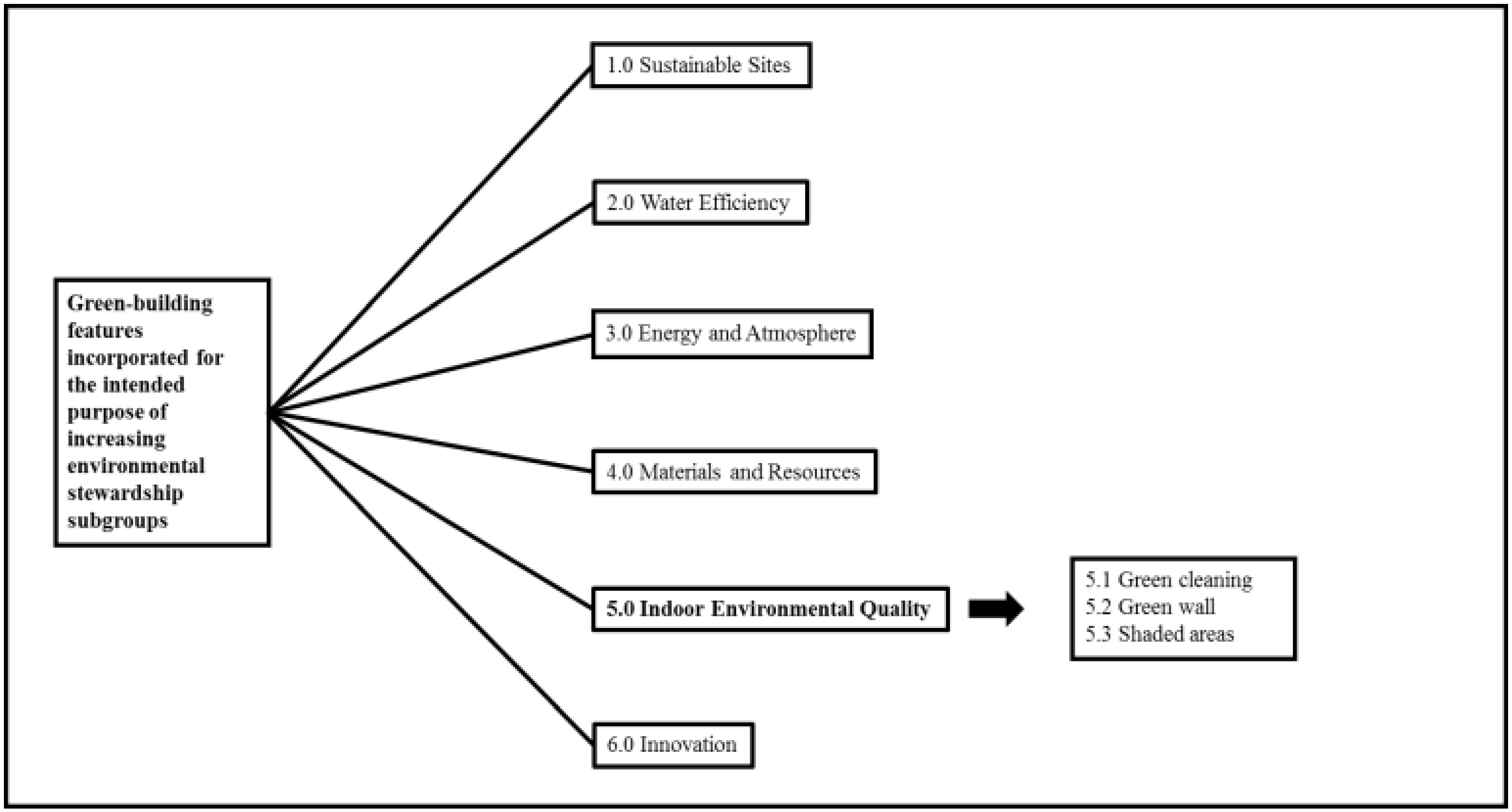


Figure 16. Green-building feature subgroups incorporated to increase environmental stewardship classified within the Indoor Environmental Quality credit category.

Environmental Inferential Analyses

For evidence of differences between building, institutional, and LEED characteristic groups from 2007 to 2017; the building size, by square foot, were examined. The mean Private institutions group was 76065.64 (SD = 65929.930) and the mean Public institutions group was 110879.64 (SD = 118321.738). According to the *t* test, there was enough evidence to suggest a significant difference between LEED-certified campus building sizes of the two groups of higher education institutions, $t(626) = -4.335$, $p = <.001$. ANOVA results showed significant differences of campus building sizes between LEED versions groups $F(2, 625) = .7.957$, $p = <.001$. Tukey post hoc test was used to determine where the differences occurred. When the group mean differences were compared BD+C: New Construction v2 - LEED 2.2 and BD+C: New Construction v3 - LEED 2009 group means were significantly different from BD+C: New Construction v2 - LEED 2.1 group means for building size (Table 26).

When LEED levels of certification groups were analyzed, there were no significant differences between the LEED levels of certification groups in the mean number of Indoor Environmental Quality credit category subgroups $F(3, 624) = 2.599$, $p = .051$.

Table 26

Pair-wise Comparison between LEED Rating Versions Groups by Building Size

LEED Rating Versions	High Confidence Limits	Low Confidence Limits	Mean Difference	Significantly different Level of Certification
BD+C: New Construction v2 - LEED 2.1	107190.14	24758.89	65974.515	BD+C: New Construction v2 - LEED 2.2
	116662.10	29405.90	73034.003	BD+C: New Construction v3 - LEED 2009

V. DISCUSSION

Leaders of new campus construction projects are seeking to reduce natural resource consumption and waste production, while simultaneously creating a healthy indoor environment for campus citizens (Fischbach, 2007; Shriberg, 2000). Fundamental to understanding how green buildings perform during their operations and maintenance stage is the necessity to discern what building features were incorporated during the design and construction phases. Considering these building features collectively allows the entire building to earn its green certification. Archival documents from three sources allowed for the creation of an in-depth green-feature database, which informed on a number of levels, common patterns and trends among green-building features. Relationships between institutional and LEED characteristics groups relative to green-building features were also revealed. Implications of the study's results are discussed in this chapter. The study's results are organized within the three sustainable development principles, economic, social, and environmental.

Institutional Trends

A determined effort by higher education in the United States to reduce their use of natural resources, while improving the quality of work and life for the campus community, has led to a conscious shift to third-party, green certification for all new capital construction. Green-building features implemented during the design and construction phases allowed buildings to earn their green rating. A major thread that seems to exist within this study is the void of two-year college representation.

Public universities and colleges were found to host a greater number of green buildings when compared to private institutions. States, like Ohio, have been mandating, since 2007, that public intuitions new construction be LEED certified (Swearingen, 2014). LEED certification for Ohio public schools equated to an added $131 million and was funded through state tax dollars (Swearingen, 2014). Campus location may explain why private institutions do not possess as many newly constructed green buildings. That is some private universities and colleges such as Harvard and Princeton, are located in urban cities where there is no room to expand. Therefore, many of Harvard University's green buildings are renovations (Melton, 2011).

However, private institutions were the first to certify campus building. A private higher education institution located in California was the first among this study's sample institutions to design and construct a building that met the standards of the LEED rating system, in 2007. At the end of 2008, private universities and colleges were in the lead with eight LEED-certified buildings on their campus when compared to public campuses' zero buildings. Private institutions in the United States have extensive history of environmental stewardship ethics. According to Meffe, Carroll, and Contributors (1997), "the Judeo-Christian Stewardship Environmental Ethic makes human being directly accountable to God for conserving biodiversity...As God cares for humanity, so we who are created in the image of God must care for the earth" (p. 41).

Building Trends

More buildings were rated under the LEED v2.2 followed by LEED v3. LEED v2.2 was introduced in 2005 and four years later the third revision, LEED 3.0, was introduced to the green building industry (Cidell, 2009; Hart, 2009).

Institutions are stating their commitments to achieve campus sustainability in their missions and campus policies requiring that new and/or renovated buildings be built according to LEED standards. This may explain why Gold certified buildings were the most numerous. Few buildings were certified under the lowest level of certification. This may be as due to institutions requiring a minimum of Silver or Gold LEED certification for all new construction.

The least number of buildings were found in 2007 and 2017. To rationalize why the study found fewer LEED-certified buildings in 2007 may be due to a lack of specialized knowledge pertaining to innovative green technology and equipment, which often creates reluctance to apply LEED and impedes LEED certification (Cortese, 2003; Levy & Dilwali, 2000). The study's data collection ended in spring 2017 and did not take into account buildings certified after spring 2017. This may explain why the study's building density for 2017 was lower than previous years.

Public Arizona institutions, and public and private California institutions were found to incorporate the most green-building features. This could be due to these institutions having more open space to construction new buildings. The state of Florida had the most certified buildings.

Economic Principle

The Energy & Atmosphere category consisted of the highest percentage of green-building features incorporated to impact operational and maintenance costs. Lower energy is the main reason to building green. Universities and colleges in the United States spend almost $2 billion on energy costs annually (Rappaport, 2008). The U.S. EPA has stated buildings in the United States accounted for 72% of total U.S. electricity consumption in 2006 and this number is expected to increase 75% by 2025 (U.S. Environmental Protection Agency, 2009).

Many LEED professionals are highly concentrated in urban settings to accommodate their geographically broad client base. As a result of this spatial disparity, the versatility of LEED professional consultants to respond to a diversity of environmental risk is restricted (Cidell, 2009). Additionally, LEED consultants further add to the initial investment cost of a capital project (Cupido et al., 2010). A case study reported LEED consulting and associated costs were at around 2.78 % of the total soft costs, and approximately 0.3% of the total construction costs (Cupido et al., 2010). So it behooves an institution to select consultants with knowledge of the local environmental conditions and selective pressures.

Social Principle

Ventilation and daylight harvesting were the most abundant green-building features incorporated to improve indoor wellbeing.

The quality of campus facilities can translate into to attracting and retaining employees (Eichholtz et al., 2010; Gottfried & Malik, 2009). However, in an interview centered on the Miami University built-campus environment, James Garland, the former president of Miami University, acknowledged that while beautifying the campus attracted more students; the issue of financial burden is still a constant especially if all other industry competitors are applying the same tactic to attract students (Wang, 2013).

The study's results revealed that windows and skylights can be used to take advantage of daylight harvesting. This is noteworthy because it has been found that lighting design can influence academic achievement through the simultaneous use of daylight and artificial lighting (Weis Van Mil, Iversen, & Strømann, 2016).

Environmental Principle

Green-building features incorporated in campus buildings for the intended purpose of increasing environmental stewardship were shown to occur more often on public campuses than on private campuses.

With the use of native plants means less water and an opportunity to save local pollinators. The habitability of the planet is being determined by the expansion of the anthropocentric-built environment, through continual conversion of natural capital into man-made products (Cortese, 2003).

When the group mean differences were compared BD+C: New Construction v2 - LEED 2.2 and BD+C: New Construction v3 - LEED 2009, group means were significantly different from BD+C: New Construction v2 - LEED 2.1 group means for building size. The results showed that the more current rating version the larger the building size. According to Janda (2011), not all buildings are the same size, nor are they used in the same manner.

Research Implication

The implication for future research includes the need to examine what sustainable efforts are occurring on community college green campuses, explore the policies that lead to green construction, and greater post-occupant performance assessments of green-building features are needed.

Conclusion

The presence of LEED-certified buildings on higher education campuses are a reflection of institutional support for sustainable building initiatives (Cupido et al., 2010). According to Naik (2013), the higher education green building market is considered a "mature green market" (para. 18). However, research focusing on green construction in higher education are single cast studies and more research remain to be done. Most LEED post-occupancy performance research are situated within the boundaries of the commercial industry. Further, many studies remain isolated in focus and rarely addressed the three principles of sustainable development simultaneously as have been done in this study.

At the same time, the construction, maintenance, and operations of the built environment, including the built campus environment, have contributed to the decline of natural resources and degradation of natural processes (Rappaport, 2008; Riddell et al., 2009; Savanick et al., 2008). Buildings in particular consume energy and natural resources at each of their life cycle stages from the design and construction of the building through operation and maintenance to finally demolition (Akadiri et al., 2012).

APPENDICES

Appendix A: LEED for New Construction and Major Renovations (v2.0) version 2.1 and 2.2 scorecard sample

LEED for New Construction and Major Renovations (v2.0)

SUSTAINABLE SITES		POSSIBLE: 14
SSc1	Site selection	1
SSc2	Urban redevelopment	1
SSc3	Brownfield redevelopment	1
SSc4.1	Alternative transportation - public transportation access	1
SSc4.2	Alternative transportation - bicycle storage and changing rooms	1
SSc4.3	Alternative transportation - alternative fuel vehicles	1
SSc4.4	Alternative transportation - parking capacity	1
SSc5.1	Reduced site disturbance - protect or restore open space	1
SSc5.2	Reduced site disturbance - development footprint	1
SSc6.1	Stormwater management - rate and quantity	1
SSc6.2	Stormwater management - treatment	1
SSc7.1	Landscape and exterior design to reduce heat islands - non roof	1
SSc7.2	Landscape and exterior design to reduce heat islands - roof	1
SSc8	Light pollution reduction	1

WATER EFFICIENCY		POSSIBLE: 5
WEc1.1	Water efficient landscaping - reduce by 50%	1
WEc1.2	Water efficient landscaping - no potable water use or no irrigation	1
WEc2	Innovative wastewater technologies	1
WEc3.1-3.2	Water use reduction	2

ENERGY & ATMOSPHERE		POSSIBLE: 17
EAp1	Fundamental building systems commissioning	REQUIRED
EAp2	Minimum energy performance	REQUIRED
EAp3	CFC reduction in HVAC&R equipment	REQUIRED
EAc1.1-1.5	Optimize energy performance	10
EAc2.1-2.3	Renewable energy	3
EAc3	Additional commissioning	1
EAc4	Ozone depletion	1
EAc5	Measurement and verification	1
EAc6	Green power	1

MATERIAL & RESOURCES		POSSIBLE: 13
MRp1	Storage and collection of recyclables	REQUIRED
MRc1.1	Building reuse - maintain 75% of existing walls, floors and roof	1
MRc1.2	Building reuse - maintain 100% of existing walls, floors and roof	1
MRc1.3	Building reuse - maintain 100% of shell/structure and 50% of non-shell/non-structure	1
MRc2.1-2.2	Construction waste management	2
MRc3.1-3.2	Resource reuse	2

MATERIAL & RESOURCES		CONTINUED
MRc4.1-4.2	Recycled content	2
MRc5.1	Local/regional materials - 20% manufactured regionally	1
MRc5.2	Local/regional materials - 50% extracted regionally	1
MRc6	Rapidly renewable materials	1
MRc7	Certified wood	1

INDOOR ENVIRONMENTAL QUALITY		POSSIBLE: 15
EQp1	Minimum IAQ performance	REQUIRED
EQp2	Environmental Tobacco Smoke (ETS) control	REQUIRED
EQc1	Carbon dioxide (CO2) monitoring	1
EQc2	Increase ventilation effectiveness	1
EQc3.1	Construction IAQ management plan - during construction	1
EQc3.2	Construction IAQ management plan - after construction	1
EQc4.1	Low-emitting materials - adhesives and sealants	1
EQc4.2	Low-emitting materials - paints and coatings	1
EQc4.3	Low-emitting materials - carpet systems	1
EQc4.4	Low-emitting materials - composite wood	1
EQc5	Indoor chemical and pollutant source control	1
EQc6.1	Controllability of systems - perimeter spaces	1
EQc6.2	Controllability of systems - non-perimeter spaces	1
EQc7.1	Thermal comfort - compliance with ASHRAE 55-1992	1
EQc7.2	Thermal comfort - permanent monitoring system	1
EQc8.1	Daylight and views - daylight 75% of spaces	1
EQc8.2	Daylight and views - views for 90% of spaces	1

INNOVATION		POSSIBLE: 5
IDc1	Innovation in design	4
IDc2	LEED Accredited Professional	1

TOTAL	69

LEED for New Construction and Major Renovations (v2009) version 3 scorecard sample.

LEED for New Construction and Major Renovations (v2009)

SUSTAINABLE SITES		POSSIBLE: 26
SSp1	Construction activity pollution prevention	REQUIRED
SSc1	Site selection	1
SSc2	Development density and community connectivity	5
SSc3	Brownfield redevelopment	1
SSc4.1	Alternative transportation - public transportation access	6
SSc4.2	Alternative transportation - bicycle storage and changing rooms	1
SSc4.3	Alternative transportation - low-emitting and fuel-efficient vehicles	3
SSc4.4	Alternative transportation - parking capacity	2
SSc5.1	Site development - protect or restore habitat	1
SSc5.2	Site development - maximize open space	1
SSc6.1	Stormwater design - quantity control	1
SSc6.2	Stormwater design - quality control	1
SSc7.1	Heat island effect - non-roof	1
SSc7.2	Heat island effect - roof	1
SSc8	Light pollution reduction	1

WATER EFFICIENCY		POSSIBLE: 10
WEp1	Water use reduction	REQUIRED
WEc1	Water efficient landscaping	4
WEc2	Innovative wastewater technologies	2
WEc3	Water use reduction	4

ENERGY & ATMOSPHERE		POSSIBLE: 35
EAp1	Fundamental commissioning of building energy systems	REQUIRED
EAp2	Minimum energy performance	REQUIRED
EAp3	Fundamental refrigerant management	REQUIRED
EAc1	Optimize energy performance	19
EAc2	On-site renewable energy	7
EAc3	Enhanced commissioning	2
EAc4	Enhanced refrigerant management	2
EAc5	Measurement and verification	3
EAc6	Green power	2

MATERIAL & RESOURCES		POSSIBLE: 14
MRp1	Storage and collection of recyclables	REQUIRED
MRc1.1	Building reuse - maintain existing walls, floors and roof	3
MRc1.2	Building reuse - maintain interior nonstructural elements	1
MRc2	Construction waste management	2
MRc3	Materials reuse	2
MRc4	Recycled content	2

MATERIAL & RESOURCES		CONTINUED
MRc5	Regional materials	2
MRc6	Rapidly renewable materials	1
MRc7	Certified wood	1

INDOOR ENVIRONMENTAL QUALITY		POSSIBLE: 15
EQp1	Minimum IAQ performance	REQUIRED
EQp2	Environmental Tobacco Smoke (ETS) control	REQUIRED
EQc1	Outdoor air delivery monitoring	1
EQc2	Increased ventilation	1
EQc3.1	Construction IAQ management plan - during construction	1
EQc3.2	Construction IAQ management plan - before occupancy	1
EQc4.1	Low-emitting materials - adhesives and sealants	1
EQc4.2	Low-emitting materials - paints and coatings	1
EQc4.3	Low-emitting materials - flooring systems	1
EQc4.4	Low-emitting materials - composite wood and agrifiber products	1
EQc5	Indoor chemical and pollutant source control	1
EQc6.1	Controllability of systems - lighting	1
EQc6.2	Controllability of systems - thermal comfort	1
EQc7.1	Thermal comfort - design	1
EQc7.2	Thermal comfort - verification	1
EQc8.1	Daylight and views - daylight	1
EQc8.2	Daylight and views - views	1

INNOVATION		POSSIBLE: 6
IDc1	Innovation in design	5
IDc2	LEED Accredited Professional	1

REGIONAL PRIORITY		POSSIBLE: 4
RPc1	Regional priority	4

TOTAL		110

40-49 Points	50-59 Points	60-79 Points	80+ Points
CERTIFIED	SILVER	GOLD	PLATINUM

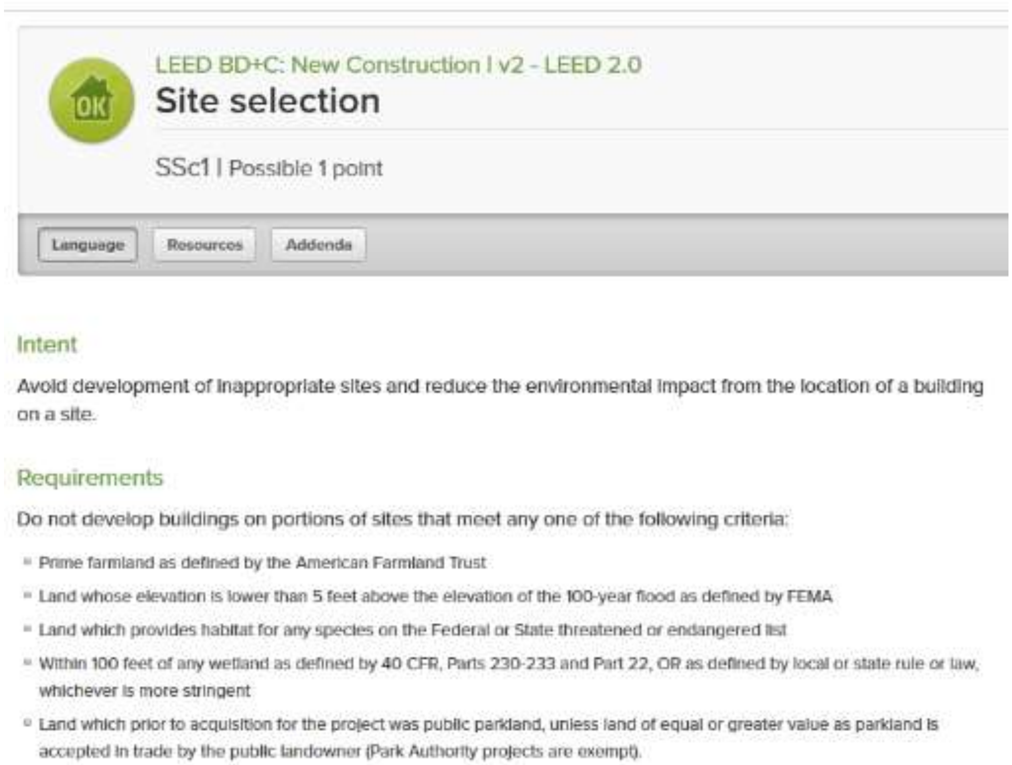
A comparison of LEED for New Construction and Major Renovations version 2.1 and 2.2 scorecards scores and version 3.0 by credit category.

	LEED-NC v2.0, v2.1, and v2.2 (Scale 1 - 69)		**LEED-NC v3.0 (Scale 1 - 100)**	
Credit Category	Number of Strategies and sub-strategies	Possible number of points	Number of Strategies and sub-strategies	Possible number of points
Sustainable Site	8 strategies/ 10 sub-strategies	14	8 strategies/ 10 sub-strategies/	26
Water Efficiency	5 credit strategies/ 4 sub-strategies	5	3 strategies	10
Energy and Atmosphere	6 credit strategies/ 8 sub-strategies	17	6 strategies	35
Material and Resources	7 credit strategies/ 11 sub-strategies	13	7 strategies/ 2 sub-strategies	14
Indoor Environmental Quality	8 credit strategies/ 12 sub-strategies	15	8 strategies/ 12 sub-strategies	15
Innovation in Design	2 credit strategies	5	2 strategies	6
Regional Priority			1 strategy	4

Appendix B: LEED BD+C: New Construction (v2), LEED 2.0 credit category strategies

According to LEED (n.d.),

> The **Sustainable Sites (SS)** category rewards decisions about the environment surrounding the building, with credits that emphasize the vital relationships among buildings, ecosystems, and ecosystem services. It focuses on restoring project site elements, integrating the site with local and regional ecosystems, and preserving the biodiversity that natural systems rely on (para. 1)



LEED BD+C: New Construction | v2 - LEED 2.0

Site selection

SSc1 | Possible 1 point

Language Resources Addenda

Intent

Avoid development of inappropriate sites and reduce the environmental impact from the location of a building on a site.

Requirements

Do not develop buildings on portions of sites that meet any one of the following criteria:

- Prime farmland as defined by the American Farmland Trust
- Land whose elevation is lower than 5 feet above the elevation of the 100-year flood as defined by FEMA
- Land which provides habitat for any species on the Federal or State threatened or endangered list
- Within 100 feet of any wetland as defined by 40 CFR, Parts 230-233 and Part 22, OR as defined by local or state rule or law, whichever is more stringent
- Land which prior to acquisition for the project was public parkland, unless land of equal or greater value as parkland is accepted in trade by the public landowner (Park Authority projects are exempt).

LEED BD+C: New Construction | v2 - LEED 2.0

Urban redevelopment

SSc2 | Possible 1 point

Language Resources Addenda

Intent

Channel development to urban areas with existing infrastructure, protect greenfields and preserve habitat and natural resources.

Requirements

Increase localized density to conform to existing or desired density goals by utilizing sites that are located within an existing minimum development density of 60,000 square feet per acre (two story downtown development).

LEED BD+C: New Construction | v2 - LEED 2.0

Brownfield redevelopment

SSc3 | Possible 1 point

Language Resources Addenda

Intent

Rehabilitate damaged sites where development is complicated by real or perceived environmental contamination, reducing pressure on undeveloped land.

Requirements

Develop on a site classified as a Brownfield and provide remediation as required by EPA's Sustainable Redevelopment of Brownfields Program requirements.

LEED BD+C: New Construction | v2 - LEED 2.0

Alternative transportation - public transportation access

SSc4.1 | Possible 1 point

Language | Resources | Addenda | All credits

Intent

Reduce pollution and land development impacts from automobile use.

Requirements

Locate building within ½ mile of a commuter rail, light rail or subway station or ¼ mile of 2 or more bus lines.

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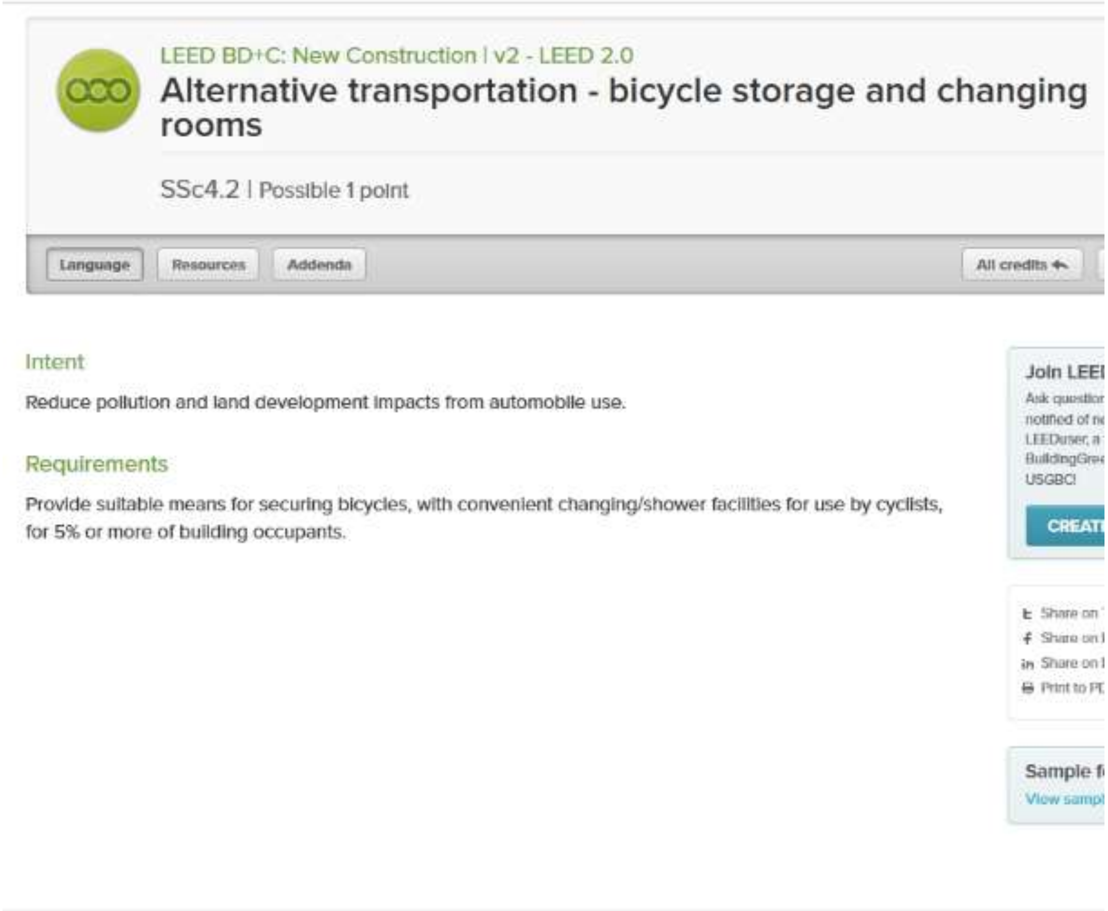

LEED BD+C: New Construction | v2 - LEED 2.0

Alternative transportation - bicycle storage and changing rooms

SSc4.2 | Possible 1 point

Language | Resources | Addenda | All credits

Intent

Reduce pollution and land development impacts from automobile use.

Requirements

Provide suitable means for securing bicycles, with convenient changing/shower facilities for use by cyclists, for 5% or more of building occupants.

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LEED BD+C: New Construction | v2 - LEED 2.0

Alternative transportation - alternative fuel vehicles

SSc4.3 | Possible 1 point

Language Resources Addenda All cre

ntent

Reduce pollution and land development impacts from automobile use.

Requirements

nstall alternative-fuel refueling station(s) for 3% of the total vehicle parking capacity of the site. Liquid or gaseous fueling facilities must be separately ventilated or located outdoors.

LEED BD+C: New Construction | v2 - LEED 2.0

Alternative transportation - parking capacity

SSc4.4 | Possible 1 point

Language Resources Addenda All

Intent

Reduce pollution and land development impacts from single occupancy vehicle use.

Requirements

Size parking capacity not to exceed minimum local zoning requirements AND provide preferred parking for carpools or van pools capable of serving 5% of the building occupants, OR, add no new parking for rehabilitation projects AND provide preferred parking for carpools or van pools capable of serving 5% of the building occupants.

LEED BD+C: New Construction | v2 - LEED 2.0

Reduced site disturbance - protect or restore open space

SSc5.1 | Possible 1 point

Language Resources Addenda All credits

Intent

Conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

Requirements

On greenfield sites, limit site disturbance including earthwork and clearing of vegetation to 40 feet beyond the building perimeter, 5 feet beyond primary roadway curbs, walkways, and main utility branch trenches, and 25 feet beyond pervious paving areas that require additional staging areas in order to limit compaction in the paved area; OR, on previously developed sites, restore a minimum of 50% of the remaining open area by planting native or adapted vegetation.

LEED BD+C: New Construction I v2 - LEED 2.0

Reduced site disturbance - development footprint

SSc5.2 I Possible 1 point

Language Resources Addenda All cre

Intent

Conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

Requirements

Reduce the development footprint (including building, access roads and parking) to exceed the local zoning's open space requirement for the site by 25%.

LEED BD+C: New Construction | v2 - LEED 2.0

Stormwater management - rate and quantity

SSc6.1 | Possible 1 point

Language Resources Addenda

Intent

Limit disruption of natural water flows by minimizing stormwater runoff, increasing on-site infiltration and reducing contaminants.

Requirements

Implement a stormwater management plan that results in: No net increase in the rate and quantity of stormwater runoff from existing to developed conditions; OR, if existing imperviousness is greater than 50%, implement a stormwater management plan that results in a 25% decrease in the rate and quantity of stormwater runoff.

LEED BD+C: New Construction | v2 - LEED 2.0

Stormwater management - treatment

SSc6.2 | Possible 1 point

Language Resources Addenda All

Intent

Limit disruption of natural water flows by minimizing stormwater runoff, increasing on-site infiltration and reducing contaminants.

Requirements

Implement a stormwater management plan that results in: Treatment systems designed to remove 80% of the average annual post development total suspended solids (TSS), and 40% of the average annual post development total phosphorous (TP), by implementing Best Management Practices (BMPs) outlined in EPA's Guidance Specifying Management Measures for Sources of Non-point Pollution in Coastal Waters (EPA 840-B-92-002 1/93).

LEED BD+C: New Construction | v2 - LEED 2.0

Landscape and exterior design to reduce heat islands - non-roof

SSc7.1 | Possible 1 point

Language Resources Addenda All credits Prev

Intent

Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat.

Requirements

Provide shade (within 5 years) on at least 30% of non-roof impervious surface on the site, including parking lots, walkways, plazas, etc., OR, use light-colored/high-albedo materials (reflectance of at least 0.3) for 30% of the site's non-roof impervious surfaces, OR place a minimum of 50% of parking space underground OR use open-grid pavement system (net impervious area of LESS than 50%) for a minimum of 50% of the parking lot area.

LEED BD+C: New Construction | v2 - LEED 2.0

Landscape and exterior design to reduce heat islands - roof

SSc7.2 | Possible 1 point

Language Resources Addenda All credits Prev

Intent

Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat.

Requirements

Use ENERGY STAR Roof-compliant, high-reflectance AND high emissivity roofing (initial reflectance of at least 0.65 and three-year-aged reflectance of at least 0.5 when tested in accordance with ASTM E903 and emissivity of at least 0.9 when tested in accordance with ASTM 408) for a minimum of 75% of the roof surface; OR, install a "green" (vegetated) roof for at least 50% of the roof area.

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LEED BD+C: New Construction | v2 - LEED 2.0

Light pollution reduction

SSc8 | Possible 1 point

Language | Resources | Addenda

Intent

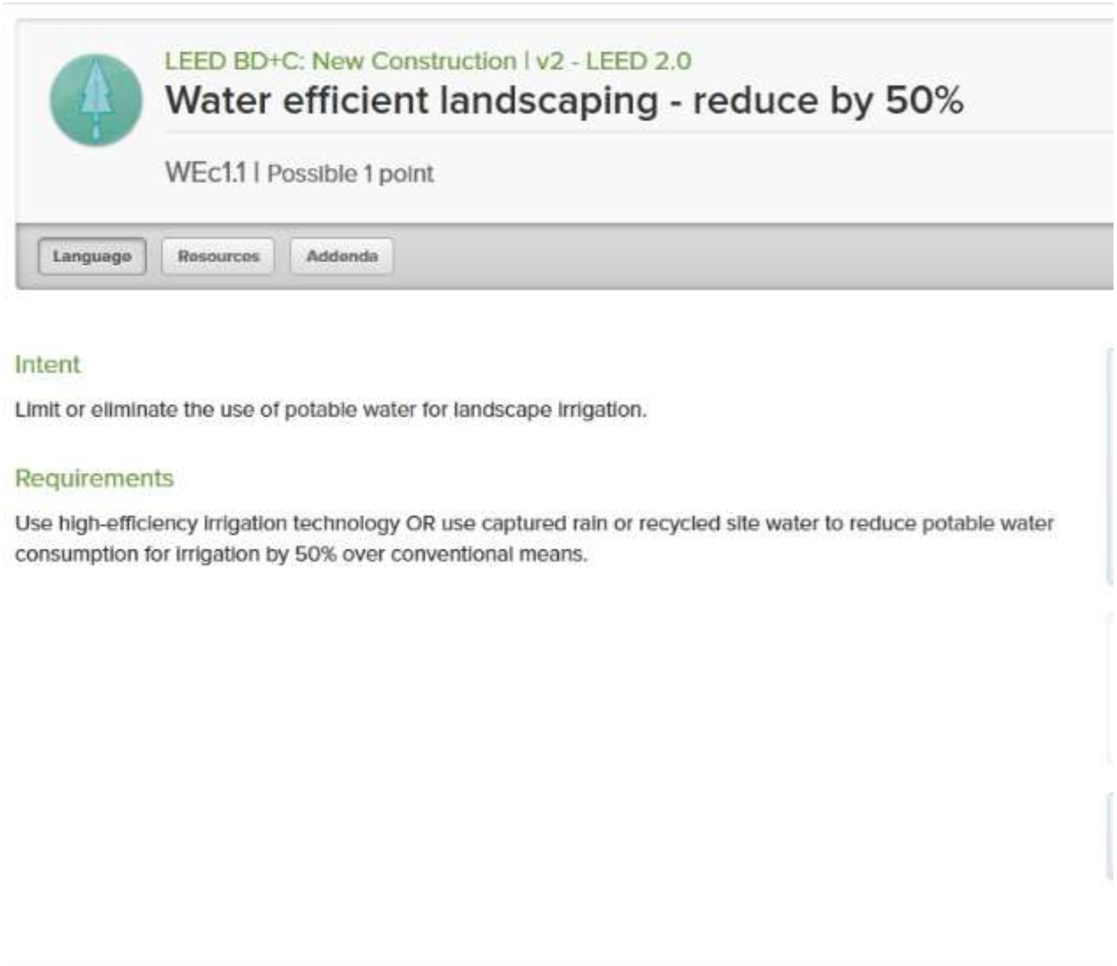
Eliminate light trespass from the building and site, improve night sky access and reduce development impact on nocturnal environments.

Requirements

Do not exceed Illuminating Engineering Society of North America (IESNA) footcandle level requirements as stated in the Recommended Practice Manual: Lighting for Exterior Environments, AND design interior and exterior lighting such that zero direct-beam illumination leaves the building site.

According to LEED (n.d.),

> The **Water Efficiency** (WE) section addresses water holistically, looking at indoor use, outdoor use, specialized uses, and metering. The section is based on an “efficiency first” approach to water conservation. As a result, each prerequisite looks at water efficiency and reductions in potable water use alone. Then, the WE credits additionally recognize the use of nonpotable and alternative sources of water. (para. 1)



LEED BD+C: New Construction | v2 - LEED 2.0

Water efficient landscaping - no potable water use or no irrigation

WEc1.2 | Possible 1 point

Language | Resources | Addenda

Intent

Limit or eliminate the use of potable water for landscape irrigation.

Requirements

Use only captured rain or recycled site water for an additional 50% reduction (100% total reduction) of potable water for site irrigation needs, OR, do not install permanent landscape irrigation systems.

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LEED BD+C: New Construction | v2 - LEED 2.0

Innovative wastewater technologies

WEc2 | Possible 1 point

Language Resources Addenda

Intent

Reduce the generation of wastewater and potable water demand, while increasing the local aquifer recharge.

Requirements

Reduce the use of municipally provided potable water for building sewage conveyance by a minimum of 50%, OR treat 100% of wastewater on site to tertiary standards.

LEED BD+C: New Construction | v2 - LEED 2.0

Water use reduction

WEc3.1-3.2 | Possible 2 points

Language Resources Addenda

Intent

Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

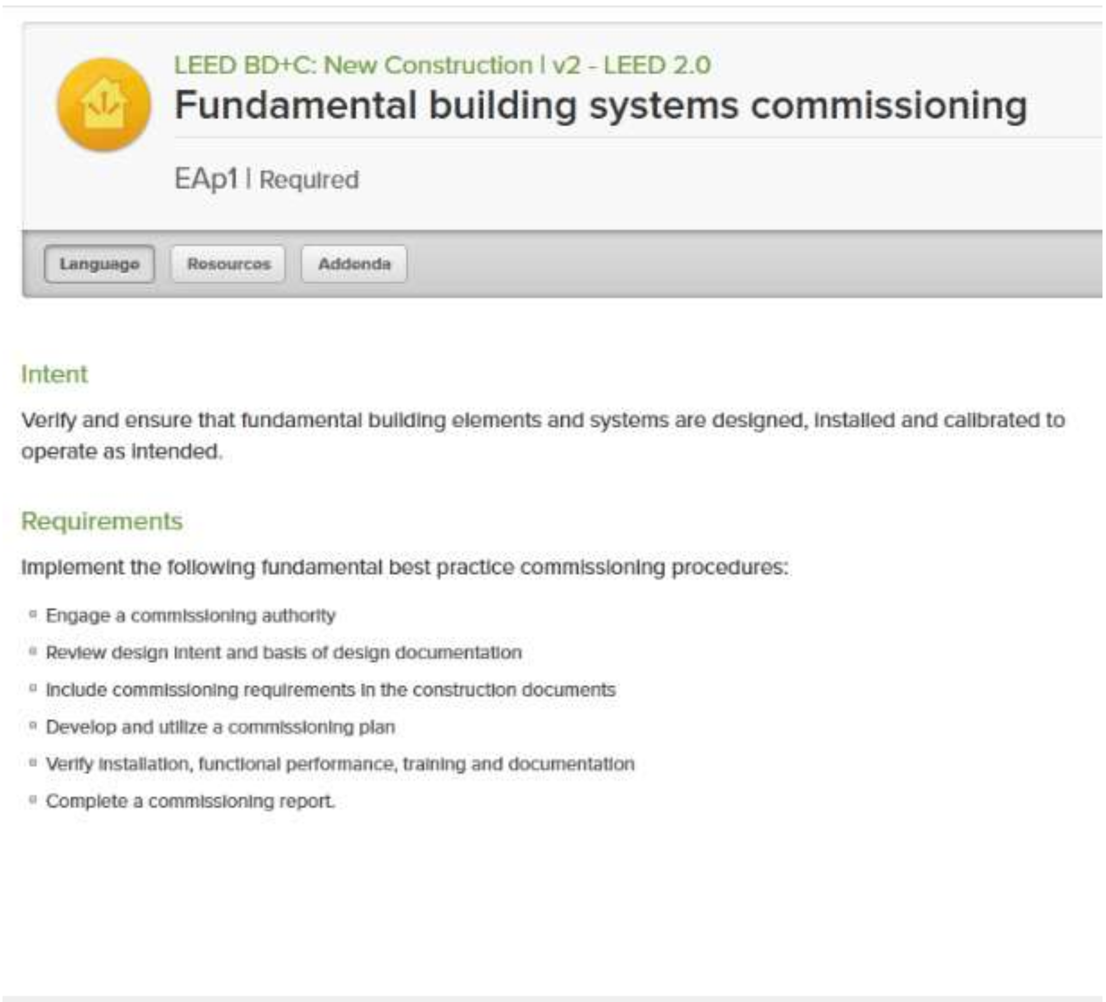
Requirements

Credit 3.1 (1 point) Employ strategies that in aggregate use 20% less water than the water use baseline calculated for the building (not including irrigation) after meeting Energy Policy Act of 1992 fixture performance requirements.

Credit 3.2 (1 point) Exceed the potable water use reduction by an additional 10% (30% total efficiency increase).

According to LEED (n.d.),

> The **Energy and Atmosphere (EA)** category approaches energy from a holistic perspective, addressing energy use reduction, energy-efficient design strategies, and renewable energy sources. (para. 1)



LEED BD+C: New Construction | v2 - LEED 2.0

Fundamental building systems commissioning

EAp1 | Required

Language Resources Addenda

Intent

Verify and ensure that fundamental building elements and systems are designed, installed and calibrated to operate as intended.

Requirements

Implement the following fundamental best practice commissioning procedures:

- Engage a commissioning authority
- Review design intent and basis of design documentation
- Include commissioning requirements in the construction documents
- Develop and utilize a commissioning plan
- Verify installation, functional performance, training and documentation
- Complete a commissioning report.

LEED BD+C: New Construction | v2 - LEED 2.0

Minimum energy performance

EAp2 | Required

Language Resources Addenda All c

Intent

Establish the minimum level of energy efficiency for the base building and systems.

Requirements

Design to meet building energy efficiency and performance as required by ASHRAE/IESNA 90.1-1999 or the local energy code, whichever is the more stringent.

LEED BD+C: New Construction | v2 - LEED 2.0

CFC reduction in HVAC/R equipment

EAp3 | Required

Language Resources Addenda All c

Intent

Reduce ozone depletion.

Requirements

Zero use of CFC-based refrigerants in new building HVAC&R base building systems. When reusing existing base building HVAC equipment, complete a comprehensive CFC phaseout conversion.

LEED BD+C: New Construction | v2 - LEED 2.0

Optimize energy performance

EAc1.1-1.5 | Possible 10 points

Language Resources Addenda

Intent

Achieve increasing levels of energy performance above the prerequisite standard to reduce environmental impacts associated with excessive energy use.

Requirements

Reduce design energy cost compared to the energy cost budget for regulated energy components described in the requirements of ASHRAE/IESNA Standard 90.1-1999, as demonstrated by a whole building simulation using the Energy Cost Budget Method described in Section 11:
[INSERT TABLE HERE]

Regulated energy components include HVAC systems, building envelope, service hot water systems, lighting and other regulated systems as defined by ASHRAE.

Credit 1.1 (2 points) Reduce design energy cost by 20% / 10%.
Credit 1.2 (4 points) Reduce design energy cost by 30% / 20%.
Credit 1.3 (6 points) Reduce design energy cost by 40% / 30%.
Credit 1.4 (8 points) Reduce design energy cost by 50% / 40%.
Credit 1.5 (10 points) Reduce design energy cost by 60% / 50%.

LEED BD+C: New Construction | v2 - LEED 2.0

Renewable energy

EAc2.1-2.3 | Possible 3 points

Language Resources Addenda

Intent

Encourage and recognize increasing levels of self-supply through renewable technologies to reduce environmental impacts associated with fossil fuel energy use.

Requirements

Supply a net fraction of the building's total energy use (as expressed as a fraction of annual energy cost) through the use of on-site renewable energy systems.
[INSERT TABLE HERE]

Credit 2.1 (1 points) Renewable energy, 5% contribution
Credit 2.2 (2 points) Renewable energy, 10% contribution
Credit 2.3 (3 points) Renewable energy, 20% contribution

LEED BD+C: New Construction | v2 - LEED 2.0

Additional commissioning

EAc3 | Possible 1 point

Language | Resources | Addenda | All

Intent

Verify and ensure that the entire building is designed, constructed and calibrated to operate as intended.

Requirements

In addition to the Fundamental Building Commissioning prerequisite, implement the following additional commissioning tasks:

1. Conduct a focused review of the design prior to the construction documents phase.
2. Conduct a focused review of the Construction Documents when close to completion.
3. Conduct a selective review of contractor submittals of commissioned equipment. (The above three reviews must be performed by a firm other than the designer.)
4. Develop a recommissioning management manual.
5. Have a contract in place for a near-warranty end or post occupancy review.

LEED BD+C: New Construction | v2 - LEED 2.0

Ozone depletion

EAc4 | Possible 1 point

Language Resources Addenda All

Intent

Reduce ozone depletion and support early compliance with the Montreal Protocol.

Requirements

Install base building level HVAC and refrigeration equipment and fire suppression systems that do not contain HCFCs or Halons.

LEED BD+C: New Construction | v2 - LEED 2.0

Measurement and verification

EAc5 | Possible 1 point

Language | Resources | Addenda

Intent

Provide for the ongoing accountability and optimization of building energy and water consumption performance over time.

Requirements

Comply with the long term continuous measurement of performance as stated in Option B: Methods by Technology of the US DOE's International Performance Measurement and Verification Protocol (IPMVP) for the following:

- Lighting systems and controls
- Constant and variable motor loads
- Variable frequency drive (VFD) operation
- Chiller efficiency at variable loads (kW/ton)
- Cooling load
- Air and water economizer and heat recovery cycles
- Air distribution static pressures and ventilation air volumes
- Boiler efficiencies
- Building specific process energy efficiency systems and equipment
- ndoor water risers and outdoor irrigation systems.

LEED BD+C: New Construction | v2 - LEED 2.0

Green power

EAc6 | Possible 1 point

Language Resources Addenda

Intent

Encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis.

Requirements

Engage in a two year contract to purchase power generated from renewable sources that meet the Center for Resource Solutions (CRS) Green-e products certification requirements.

According to LEED (n.d.),

> The **Materials and Resources (MR)** credit category focuses on minimizing the embodied energy and other impacts associated with the extraction, processing, transport, maintenance, and disposal of building materials. The requirements are designed to support a life-cycle approach that improves performance and promotes resource efficiency. Each requirement identifies a specific action that fits into the larger context of a life-cycle approach to embodied impact reduction. (para. 1)

LEED BD+C: New Construction | v2 - LEED 2.0

Building reuse - maintain 75% of existing walls, floors and roof

MRc1.1 | Possible 1 point

Intent

Extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport.

Requirements

Reuse large portions of existing structures during renovation or redevelopment projects. Maintain at least 75% of existing building structure and shell (exterior skin and framing excluding window assemblies).

LEED BD+C: New Construction | v2 - LEED 2.0

Building reuse - maintain 100% of existing walls, floors and roof

MRc1.2 | Possible 1 point

Language Resources Addenda All credits Prev

Intent

Extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport.

Requirements

Reuse large portions of existing structures during renovation or redevelopment projects. Maintain an additional 25% (100% total) of existing building structure and shell (exterior skin and framing excluding window assemblies).

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LEED BD+C: New Construction | v2 - LEED 2.0

Building reuse - maintain 100% of shell/structure and 50% of non-shell/non-structure

MRc1.3 | Possible 1 point

Language | Resources | Addenda | All credits | Previou

Intent

Extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport.

Requirements

Reuse large portions of existing structures during renovation or redevelopment projects. Maintain 100% of existing building structure and shell AND 50% non-shell (walls, floor coverings, and ceiling systems).

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LEED BD+C: New Construction | v2 - LEED 2.0

Construction waste management

MRc2.1-2.2 | Possible 2 points

Language Resources Addenda All

Intent

Divert construction, demolition, and land clearing debris from landfill disposal. Redirect recyclable material back to the manufacturing process.

Requirements

Develop and implement a waste management plan, quantifying material diversion by weight. (Remember that salvage may include the donation of materials to charitable organizations such as Habitat for Humanity.)

Credit 2.1 (1 point) Recycle and/or salvage at least 50% (by weight) of construction, demolition, and land clearing waste

Credit 2.2 (1 point) Recycle and/or salvage an additional 25% (75% total by weight) of the construction, demolition, and land clearing debris

LEED BD+C: New Construction | v2 - LEED 2.0

Resource reuse

MRc3.1-3.2 | Possible 2 points

Language Resources Addenda All cr

Intent

Extend the life cycle of targeted building materials by reducing environmental impacts related to materials manufacturing and transport.

Requirements

Credit 3.1 (1 point) Specify salvaged or refurbished materials for 5% of building materials

Credit 3.2 (1 point) Specify salvaged or refurbished materials for 10% of building materials

LEED BD+C: New Construction | v2 - LEED 2.0

Recycled content

MRc4.1-4.2 | Possible 2 points

Language Resources Addenda All cre

Intent

Increase demand for building products that have incorporated recycled content materials, therefore reducing the impacts resulting from the extraction of new materials.

Requirements

Credit 4.1 (1 point) Specify a minimum of 25% of building materials that contain in aggregate, a minimum weighted average of 20% post-consumer recycled content material, OR, a minimum weighted average 40% post-industrial recycled content material.

Credit 4.2 (1 point) Specify an additional 25% (50% total) of building materials that contain in aggregate, a minimum weighted average of 20% post-consumer recycled content material, OR, a minimum weighted average of 40% post-industrial recycled content material.

LEED BD+C: New Construction | v2 - LEED 2.0

Local/regional materials - 20% manufactured regionally

MRc5.1 | Possible 1 point

Language Resources Addenda All credits

Intent

Increase demand for building products that are manufactured locally, thereby reducing the environmental impacts resulting from their transportation and supporting the local economy.

Requirements

Specify a minimum of 20% of building materials that are manufactured* regionally within a radius of 500 miles.

*Manufacturing refers to the final assembly of components into the building product that is furnished and installed by the tradesmen. For example, if the hardware comes from Dallas, Texas, the lumber from Vancouver, British Columbia and the joist is assembled in Kent, Washington; then the location of the final assembly is Kent, Washington

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LEED BD+C: New Construction | v2 - LEED 2.0

Local/regional materials - 50% extracted regionally

MRc5.2 | Possible 1 point

Language Resources Addenda All cr

Intent

Increase demand for building products that are manufactured locally, thereby reducing the environmental impacts resulting from their transportation and supporting the local economy.

Requirements

Specify a minimum of building materials that are manufactured* regionally within a radius of 500 miles (MR 5.1). Of these regionally manufactured materials, specify a minimum of 50% that are extracted, harvested, or recovered within 500 miles.

*Manufacturing refers to the final assembly of components into the building product that is furnished and installed by the tradesmen. For example, if the hardware comes from Dallas, Texas, the lumber from Vancouver, British Columbia and the joist is assembled in Kent, Washington; then the location of the final assembly is Kent, Washington

LEED BD+C: New Construction | v2 - LEED 2.0

Rapidly renewable materials

MRc6 | Possible 1 point

Language Resources Addenda All

Intent

Reduce the use and depletion of finite raw, and long-cycle renewable materials by replacing them with rapidly renewable materials.

Requirements

Specify rapidly renewable building materials for 5% of total building materials.

LEED BD+C: New Construction | v2 - LEED 2.0

Certified wood

MRc7 | Possible 1 point

Language | Resources | Addenda

Intent

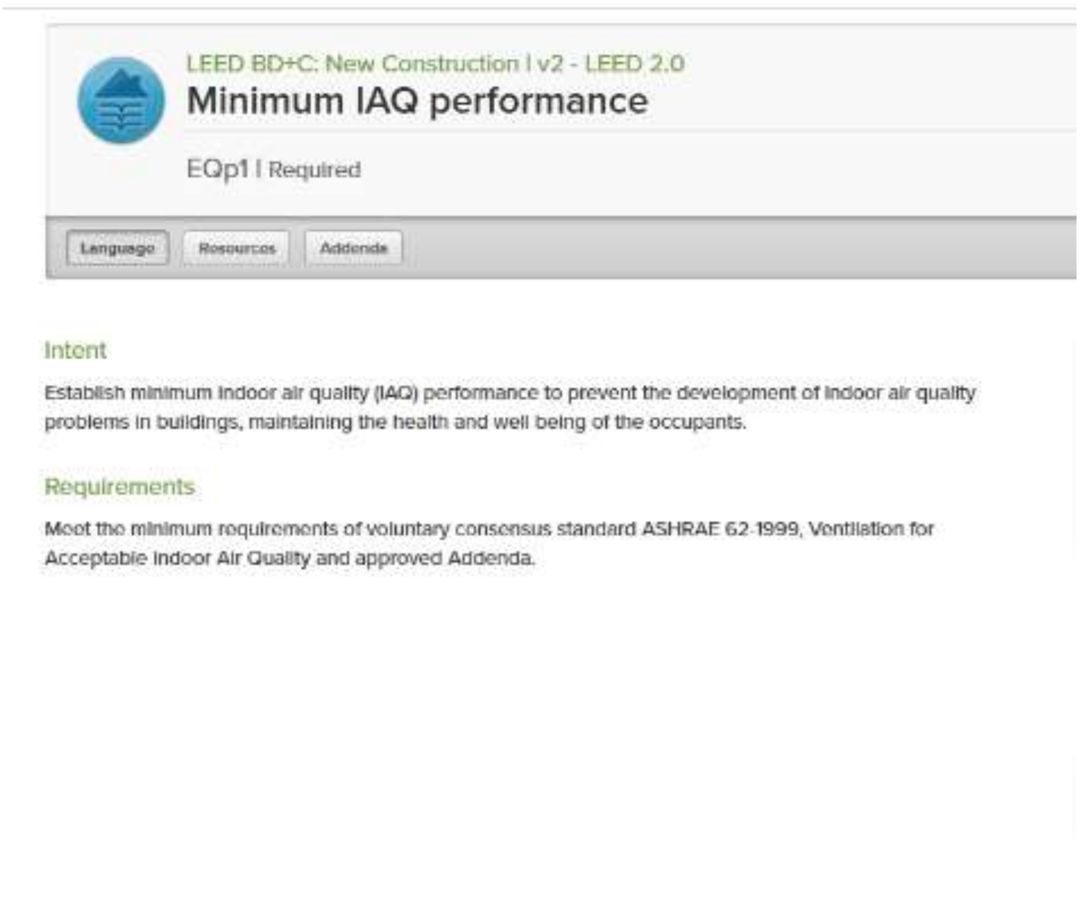
Encourage environmentally responsible forest management.

Requirements

Use a minimum of 50% of wood-based materials certified in accordance with the Forest Stewardship Council Guidelines for wood building components including but not limited to structural framing and general dimensional framing, flooring, finishes, furnishings, and non-rented temporary construction applications such as bracing, concrete form work and pedestrian barriers.

According to LEED (n.d.),

> The **Indoor Environmental Quality (EQ)** category rewards decisions made by project teams about indoor air quality and thermal, visual, and acoustic comfort. Green buildings with good indoor environmental quality protect the health and comfort of building occupants. High-quality indoor environments also enhance productivity, decrease absenteeism, improve the building's value, and reduce liability for building designers and owners1. This category addresses the myriad design strategies and environmental factors—air quality, lighting quality, acoustic design, control over one's surroundings—that influence the way people learn, work, and live. (para. 1)



LEED BD+C: New Construction | v2 - LEED 2.0

Environmental Tobacco Smoke (ETS) control

EQp2 | Required

Language Resources Addenda

Intent

Prevent exposure of building occupants and systems to Environmental Tobacco Smoke (ETS).

Requirements

Zero exposure of nonsmokers to ETS by prohibition of smoking in the building, OR, provide a designated smoking room designed to effectively contain, capture and remove ETS from the building. At a minimum, the smoking room shall be directly exhausted to the outdoors with no recirculation of ETS-containing air to the nonsmoking area of the building, enclosed with impermeable structural deck-to-deck partitions and operated at a negative pressure compared with the surrounding spaces of at least 7 Pa (0.03 inches of water gauge).

Performance of smoking rooms shall be verified using tracer gas testing methods as described in the ASHRAE Standard 129-1997. Acceptable exposure in nonsmoking areas is defined as less than 1% of the tracer gas concentration in the smoking room detectable in the adjoining nonsmoking areas. Smoking room testing as described in the ASHRAE Standard 129-1997 is required in the contract documents and critical smoking facility systems testing results must be included in the building commissioning plan and report or as a separate document.

LEED BD+C: New Construction | v2 - LEED 2.0

Carbon dioxide (CO_2) monitoring

EQc1 | Possible 1 point

Language Resources Addenda

Intent

Provide capacity for indoor air quality (IAQ) monitoring to sustain long-term occupant health and comfort.

LEED BD+C: New Construction | v2 - LEED 2.0

Increase ventilation effectiveness

EQc2 | Possible 1 point

Language | Resources | Addenda

Intent

Provide for the effective delivery and mixing of fresh air to support the health, safety, and comfort of building occupants.

Requirements

For mechanically ventilated buildings, design ventilation systems that result in an air change effectiveness (ε_{ac}) greater than or equal to 0.9 as determined by ASHRAE 129-1997. For naturally ventilated spaces demonstrate a distribution and laminar flow pattern that involves not less than 90% of the room or zone area in the direction of air flow for at least 95% of hours of occupancy.

LEED BD+C: New Construction | v2 - LEED 2.0

Construction IAQ management plan - during construction

EQc3.1 | Possible 1 point

Language | Resources | Addenda

Intent

Prevent indoor air quality problems resulting from the construction/renovation process, to sustain long-term installer and occupant health and comfort.

Requirements

Develop and implement an Indoor Air Quality (IAQ) Management Plan for the construction phase of the building as follows: During construction meet or exceed the minimum requirements of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction, 1995, AND protect stored on-site or installed absorptive materials from moisture damage, AND replace all filtration media immediately prior to occupancy. Filtration media shall have a Minimum Efficiency Reporting Value (MERV) of 13 as determined by ASHRAE 52.2-1999.

LEED BD+C: New Construction | v2 - LEED 2.0

Construction IAQ management plan - after construction

EQc3.2 | Possible 1 point

Language | Resources | Addenda

Intent

Prevent indoor air quality problems resulting from the construction/renovation process, to sustain long-term installer and occupant health and comfort.

Requirements

Develop and implement an Indoor Air Quality (IAQ) Management Plan for the preoccupancy phases of the building as follows: Conduct a minimum two-week building flush-out with new filtration media at 100% outside air after construction ends and prior to occupancy, OR conduct a baseline indoor air quality testing procedure consistent with current EPA Protocol for Environmental Requirements, Baseline IAQ and Materials, for the Research Triangle Park Campus, Section 01445.

LEED BD+C: New Construction | v2 - LEED 2.0

Low-emitting materials - adhesives and sealants

EQc4.1 | Possible 1 point

Language | Resources | Addenda

Intent

Reduce the quantity of indoor air contaminants that are odorous or potentially irritating to provide installer and occupant health and comfort.

Requirements

Adhesives must meet or exceed the VOC limits of South Coast Air Quality Management District Rule #1168 by, AND all sealants used as a filler must meet or exceed Bay Area Air Quality Management District Reg. 8, Rule 51.

LEED BD+C: New Construction | v2 - LEED 2.0

Low-emitting materials - paints and coatings

EQc4.2 | Possible 1 point

Language Resources Addenda

Intent

Reduce the quantity of indoor air contaminants that are odorous or potentially irritating to provide installer and occupant health and comfort.

Requirements

Paints and coatings must meet or exceed the VOC and chemical component limits of Green Seal requirements.

LEED BD+C: New Construction | v2 - LEED 2.0

Low-emitting materials - carpet systems

EQc4.3 | Possible 1 point

Language Resources Addenda

Intent

Reduce the quantity of indoor air contaminants that are odorous or potentially irritating to provide installer and occupant health and comfort.

Requirements

Carpet systems must meet or exceed the requirements of the Carpet and Rug Institute's Green Label Indoor Air Quality Test Program.

LEED BD+C: New Construction | v2 - LEED 2.0

Low-emitting materials - composite wood

EQc4.4 | Possible 1 point

Language Resources Addenda

Intent

Reduce the quantity of indoor air contaminants that are odorous or potentially irritating to provide installer and occupant health and comfort.

Requirements

Composite wood and agrifiber products must contain no added urea-formaldehyde resins.

LEED BD+C: New Construction | v2 - LEED 2.0

Indoor chemical and pollutant source control

EQc5 | Possible 1 point

Language Resources Addenda

Intent

Avoid exposure of building occupants to potentially hazardous chemicals that adversely impact air quality.

Requirements

Design to minimize cross-contamination of regularly occupied occupancy areas by chemical pollutants: Employ permanent entry way systems (grills, grates, etc.) to capture dirt, particulates, etc. from entering the building at all high volume entry ways, AND provide areas with structural deck to deck partitions with separate outside exhausting, no air recirculation and negative pressure where chemical use occurs (including housekeeping areas and copying/print rooms), AND provide drains plumbed for appropriate disposal of liquid waste in spaces where water and chemical concentrate mixing occurs.

LEED BD+C: New Construction | v2 - LEED 2.0

Controllability of systems - perimeter spaces

EQc6.1 | Possible 1 point

Language Resources Addenda

Intent

Provide a high level of individual occupant control of thermal, ventilation, and lighting systems to support optimum health, productivity, and comfort conditions.

Requirements

Provide a minimum of one operable window and one lighting control zone per 200 SF for all occupied areas within 15 feet of the perimeter wall.

LEED BD+C: New Construction | v2 - LEED 2.0

Controllability of systems - non-perimeter spaces

EQc6.2 | Possible 1 point

Language Resources Addenda

Intent

Provide a high level of individual occupant control of thermal, ventilation, and lighting systems to support optimum health, productivity, and comfort conditions.

Requirements

Provide controls for each individual for airflow, temperature and lighting for at least 50% of the occupants in non-perimeter, regularly occupied areas.

LEED BD+C: New Construction | v2 - LEED 2.0

Thermal comfort - compliance with ASHRAE 55-1992

EQc7.1 | Possible 1 point

Language Resources Addenda

Intent

Provide for a thermally comfortable environment that supports the productive and healthy performance of the building occupants.

Requirements

Comply with ASHRAE Standard 55-1992, Addenda 1995 for thermal comfort standards including humidity control within established ranges per climate zone.

LEED BD+C: New Construction | v2 - LEED 2.0

Thermal comfort - permanent monitoring system

EQc7.2 | Possible 1 point

Language Resources Addenda

Intent

Provide for a thermally comfortable environment that supports the productive and healthy performance of the building occupants.

Requirements

Install a permanent temperature and humidity monitoring system configured to provide operators control over thermal comfort performance and the effectiveness of humidification and/or dehumidification systems in the building.

LEED BD+C: New Construction I v2 - LEED 2.0

Daylight and views - daylight 75% of spaces

EQc8.1 | Possible 1 point

Language Resources Addenda

Intent

Provide a connection between indoor spaces and outdoor environments through the introduction of sunlight and views into the occupied areas of the building.

Requirements

Achieve a minimum Daylight Factor of 2% (excluding all direct sunlight penetration) in 75% of all space occupied for critical visual tasks, not including copy rooms, storage areas, mechanical, laundry, and other low occupancy support areas. Exceptions include those spaces where tasks would be hindered by the use of daylight or where accomplishing the specific tasks within a space would be enhanced by the direct penetration of sunlight.

LEED BD+C: New Construction | v2 - LEED 2.0

Daylight and views - views for 90% of spaces

EQc8.2 | Possible 1 point

Language | Resources | Addenda

Intent

Provide a connection between indoor spaces and outdoor environments through the introduction of sunlight and views into the occupied areas of the building.

Requirements

Direct line of sight to vision glazing from 90% of all regularly occupied spaces, not including copy rooms, storage areas, mechanical, laundry, and other low occupancy support areas.

According to LEED (n.d.),

> **Innovation (IN)** - Sustainable design strategies and measures are constantly evolving and improving. New technologies are continually introduced to the marketplace, and up-to-date scientific research influences building design strategies. The purpose of this LEED category is to recognize projects for innovative building features and sustainable building practices and strategies. (para. 1)

LEED BD+C: New Construction | v2 - LEED 2.0

Innovation in design

IDc1 | Possible 4 points

Language Resources Addenda

Intent

To provide design teams and projects the opportunity to be awarded points for exceptional performance above requirements set by the LEED Green Building Rating System™ and/or innovative performance in Green Building categories not specifically addressed by the LEED Green Building Rating System™.

Requirements

Credit 1.1 (1 point) In writing, using the LEED™ Credit Equivalence process, identify the intent of the proposed innovation credit, the proposed requirement for compliance, the proposed submittals to demonstrate compliance, and the design approach used to meet the required elements.

Credit 1.2 (1 point) Same as Credit 1.1.

Credit 1.3 (1 point) Same as Credit 1.1.

Credit 1.4 (1 point) Same as Credit 1.1.

LEED BD+C: New Construction | v2 - LEED 2.0

LEED Accredited Professional

IDc2 | Possible 1 point

Language | Resources | Addenda

Intent

To support and encourage the design integration required by a LEED green building project and to streamline the application and certification process.

Requirements

At least one principal participant of the project team that has successfully completed the LEED Accredited Professional exam

Appendix C: Romney's (1972) Higher Education Facilities Inventory and Classification Manual

Appendix 6.2: Room Data Definitions and Codes/
Standard Room Use Categories (Continued)

Discussion

ASSIGNABLE AREAS

100 CLASSROOM FACILITIES

110 Classroom

Definition: A room used by classes that do not require special-purpose equipment for student use.

Description: Included in this category are rooms generally used for scheduled instruction requiring no special equipment and referred to as lecture rooms, lecture-demonstration rooms, seminar rooms, and general purpose classrooms. A classroom may be equipped with tablet arm chairs (fixed to the floor, joined together in groups, or flexible in arrangement), tables and chairs (as in a seminar room), or similar types of seating. A classroom may be furnished with special equipment appropriate to a specific area of study if this equipment does not render the room unsuitable for use by classes in other areas of study.

Limitations: This category does not include conference rooms (350), meeting rooms (680), auditoriums (610), or class laboratories (210). Conference rooms and meeting rooms are distinguished from seminar rooms on the basis of primary use; rooms with tables and chairs that are used primarily for meetings (as opposed to classes) are conference rooms or meeting rooms. (See categories 350 and 680 for the distinction between conference rooms and meeting rooms.) Auditoriums are distinguished from lecture rooms on the basis of primary use; a large room with seating oriented toward some focal point which is used for dramatic or musical productions, or for general meetings is an assembly facility (i.e., an auditorium normally used for purposes other than scheduled classes). A class laboratory is distinguished from a classroom on the basis of equipment in the room and by its limited use. A room with specialized equipment such as laboratory benches, typewriters, desk calculators, drafting tables, musical equipment (instructional), shop equipment, etc., that is used for instructional purposes is a class laboratory, a special class laboratory, or an individual study laboratory.

... are separately categorized (560).

300 OFFICE FACILITIES

310 Office

Definition: A room used by faculty, staff, or students working at a desk (or table).

Description: An office typically is equipped with one or more desks, chairs, tables, bookcases, and/or filing cabinets. Included in this category are rooms generally referred to as faculty offices, administrative offices, clerical offices, graduate assistant offices, teaching assistant offices, student offices, etc. Included in this category is a studio (music, art, etc.) if that room also serves as the office of a staff member.

Limitations: Special note should be taken of rooms which are equipped both as office and "research laboratory." A room equipped with laboratory benches, specialized scientific equipment, and/or such utilities as gas, water, steam, air, etc., is classified as a non-class laboratory (250). Note that this distinction rests on equipment rather than function. It is recommended that those rooms that have office-type equipment and fixed laboratory-type equipment (primarily in the biological and physical sciences) within the same room be classified as non-class laboratories (250). Large rooms, such as glass shops, printing shops, reading rooms, research laboratories, etc., that incidentally contain a desk space for a technician or staff member are classified according to the primary purpose of the room, rather than as offices.

520 Athletic/Physical Education

Definition: A room (or area) used by students, staff, or the public for athletic/physical education activities.

Description: Included in this category are rooms generally referred to as gymnasiums, basketball courts, handball courts, squash courts, wrestling rooms, swimming pools, ice rinks, indoor tracks, indoor "fields," and fieldhouses.

Limitations: No distinction by room use category is made on the basis of instructional versus intramural or intercollegiate use of gymnasiums, swimming pools, etc. The program dimension of this classification structure provides the capability of making those distinctions.

Institutions that wish to study the utilization of such facilities will need to further subdivide this category. This category does not include classroom facilities (100), laboratory facilities (200), or office facilities (300), even though they may be located in an athletic building. This category does not include the spectator seating area associated with athletic facilities (523). It does not include outside fields, tennis courts, archery ranges, etc. This category does not include rooms used for recreational purposes (670) such as bowling alleys, billiards rooms, ping pong rooms, ballrooms, chess rooms, card playing rooms, or hobby rooms.

523 Athletic Facilities Spectator Seating

Definition: The seating area used by students, staff, or the public to watch athletic events.

Description: Included in this category are permanent seating areas in fieldhouses, gymnasiums, and natatoria.

Limitations: This category does not include temporary or moveable seating areas. Stadium seating by definition is structural area.

580 Greenhouse

Definition: A building or room, usually composed chiefly of glass or other light transmitting material, for the cultivation and/or protection of plants.

Description: Includes rooms generally referred to as greenhouses.

Limitations: Does not include greenhouses related to farm operations. (See 560.)

Appendix 6.2: Room Data Definitions and Codes/
Standard Room Use Categories (Continued)

620 Exhibition

Definition: A room used for exhibition of materials, works of art, artifacts, etc., and intended for general use by students and the public.

Description: This category includes museums, art galleries, and similar exhibition areas.

Limitations: Collections not primarily for general exhibition, such as departmental displays of anthropological, botanical, or geological specimens, should be classified under an appropriate laboratory category.

General Use Facilities

630 Food Facilities

Definition: A room used for eating food.

Description: This category includes dining halls, cafeterias, snack bars, restaurants, and similar eating areas, including such areas in residence halls, faculty clubs, etc. This category includes facilities which are open to the student body and/or the public at large. Areas intended primarily as food facilities, even though containing vending machines rather than serving counters, are included in this category. Rooms with vending machines other than for regular meal or snack service are classified as lounge facilities (650) or merchandising facilities (660).

Appendix 6.2: Room Data Definitions and Codes/
Standard Room Use Categories (Continued)

635 Food Facilities Service

Definition: A room that directly serves a food facility as an extension of the activities in that facility.

Description: This category includes such areas as kitchens, refrigeration rooms, freezers, dishwashing rooms, cafeteria serving, preparation, cleaning, etc., including such areas in residence halls.

670 Recreation

Definition: A room used by students, staff, and/or the public for recreational purposes.

Description: This category includes such rooms as bowling alleys, pool and billiards rooms, ping pong rooms, ballrooms, chess rooms, card-playing rooms, (noninstructional) music listening rooms, and hobby rooms.

Limitations: This category does not include gymnasiums, basketball courts, handball courts, squash courts, wrestling rooms, swimming pools, ice rinks, indoor tracks, indoor fields, or fieldhouses that should be classified as athletic/physical education facilities (520). It does not include outdoor facilities such as tennis courts, archery ranges, fields (football, hockey, etc.), or golf courses.

800 HEALTH CARE FACILITIES

Note: This category includes the room uses listed below that are located in student health facilities and in health professions clinics and in hospitals. The codes and definitions in this series (800) are designed to describe health care facilities for humans as well as animals requiring health care. This ategory does not include non-medical clinic facilities. Note also that offices that serve in health care activities are classified as offices (310). Therefore, a tabulation of all facilities dedicated to student health care may be obtained by summing all room use categories for program subcategories 5.5.7320, as in Figure 9, page 26.

Building Use Categories Codes

(1) Classroom Facilities

(2) General Use Facilities

- Exhibition/Museum Facilities
- Food/Dining Facilities
- Student Recreation Facilities

(3) Healthcare Faculties

(4) Laboratory Facilities

(5) Mix-use/Multi-use Facilities

(6) Office/Administration Facilities

(7) Residential Faculties

(8)Special Use Facilities

- Athletic Facilities
- Athletic Facilities Spectator Seating
- Animal quarters
- Greenhouse

(9) Study/Library Facilities

(10) Supporting Facilities

- Public Order/Safety
- Technology Support

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