2020

Development of Discourse and Criteria in Green Building

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Senior Thesis by Ben Bronstein

In partial fulfillment of a Bachelor of Arts Degree in
Environmental Analysis

December 2019
Pitzer College
Claremont, CA

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ABSTRACT

The development of sustainable design rating systems and forward-thinking case studies create an increasingly holistic approach to green building that reflects and drives broader changes in sustainability discourse. Introduction of LEED by the U.S. Green Building Council alongside the Adam Joseph Lewis Center at Oberlin College transformed loosely defined notions of environmentally responsible and sustainable architecture into a tangible, comprehensive definition of green building. New rating systems in the late 2000s, Living Building Challenge and SITES, expanded green building to strengthen quantitative benchmarks, introduce qualitative standards such as biophilic design, and provide increased focus on site sustainability. Case studies at the time, such as Kroon Hall at Yale University, draw influence from new rating systems and illustrate a full-scale model of sustainable design. Living Building Challenge and other International Living Future Institute certifications shifted the conversation around green building toward decarbonization and influenced newer projects such as the Robert Redford Conservancy at Pitzer College to create buildings that will be responsive to a changing climate. Analysis of recent updates to certification systems and modern green building projects indicates a future of green buildings primarily based in decarbonization and resilience, as a reaction to uncertain yet inevitable effects of climate change in the future.

ACKNOWLEDGEMENTS

I would like to thank: Dr. Susan Phillips for unending support and guidance, and pushing me at every stage of the thesis process; my readers, Professor Lance Neckar and Professor Walker Wells, for challenging me and giving insightful feedback; Kevin Krumdieck, Bev Lloyd and Andrew Reilman for providing additional data and information for the Robert Redford Conservancy project; Vincent Bataoel, Jason Lorcher, James Wiener and John Zinner for their professional insight into the development of green building; members of my Senior Thesis course; and my family and friends for their endless support.

INTRODUCTION

An ongoing energy crisis beginning in the 1970s, increased recognition of anthropogenic resource degradation and early attention on environmentally responsible architecture led to the inception of a more defined green building field in the 1990s and early 2000s. Significant green building projects and introduction of green rating systems popularized the field and created accessible models for effective green building. Introduction of the Leadership in Energy and Environmental Design (LEED) rating system initiates a monumental shift in green building discourse, as the U.S. Green Building Council (USGBC) has transformed loose notions of environmentally responsible and sustainable architecture to a defined field with comprehensive, quantitative benchmarks for energy and performance. Living Building Challenge later became the world's most stringent green building rating system. It introduced qualitative measures of beauty, biophilia, happiness and equity that have altered sustainable design thinking.

Discussion here of three case studies, all in academia, in the context of green building rating systems presents a clear framework for exploring the development of the field and indications of where the field is headed. The Adam Joseph Lewis Center for Environmental Studies at Oberlin College (Oberlin, OH), Kroon Hall at Yale University (New Haven, CT) and the Robert Redford Conservancy for Southern California Sustainability at Pitzer College (Claremont, CA) form narratives that frame the development of analytic discourse around green building. Highlighted buildings serve the primary purpose of supporting environmental education on college campuses known for emphasizing environmental sustainability at the forefront of their core values and institutional goals. The development of sustainable design rating systems alongside these successful, forward-thinking case studies have created an increasingly holistic approach to green building over time. The green building field begins with a major focus on energy, broadens quantitatively and adds qualitative standards, and more recently shifts to a primary focus on decarbonization. The development of green building reflects changes in broader sustainability discourse, shifting from an approach that hopes to stem climate change to one that focuses on protection from climate change.

The Adam Joseph Center was built in 2000 to house the College's Environmental Studies Program. The project holds major significance in the green building field for its early innovation preceding LEED and ability to create a building that exists as a part of Oberlin's Environmental Studies curriculum. Kroon Hall was built in 2009 to house the Yale School of Forestry & Environmental Studies. The building presents a model of sustainable design that achieves the highest level of LEED certification and incorporates influence from new green building rating systems introduced in the mid to late 2000s. The Robert Redford Conservancy was built in 2018 to create a space for interdisciplinary environmental education and research. The Redford Conservancy holds value as a successful transformation of an over 80-year-old structure into a LEED Platinum and Zero Energy certified building. Each featured project has impacted green building discourse. Every project provides unique contributions to sustainable design thinking that reflects locality, project type and year built.

Significance of Green Building

The building and construction sectors account for a combined 36 percent of global final energy consumption and nearly 40 percent of total carbon dioxide emissions (IEA 2019). The Environmental Protection Agency (EPA) finds that heating and cooling accounts for about 43 percent of all energy use in the U.S., contributing to greenhouse gas emissions and air pollution (USGBC). Green buildings confront the massive environmental degradation caused by the construction of conventional buildings by addressing people, planet and profit through the triple bottom line approach.

Green buildings originally came about to reduce environmental degradation and issues associated with climate change (USGBC, WGBC). Green buildings work to reduce carbon, energy, water and waste and create a positive impact on the environment (USGBC, WGBC). The building sector has the largest potential for significantly reducing greenhouse gases of major emitting industries at the global level (WGBC). It can make energy savings of 50 percent or more in 2050 in support of limiting global temperature rises to 2°C (WGBC). At the building level, LEED certified buildings consume 25 percent less energy and 11 percent less water than conventional buildings (WGBC).

The green building field has contributed hundreds of billions of dollars to the U.S. economy and has created millions of jobs (USGBC). Cost savings on household utility bills, lower maintenance costs, shorter payback periods and increased property value make green buildings economically feasible and favorable for consumers (USGBC, WGBC). Building owners report that green buildings receive a seven percent increase in asset value as compared to traditionally constructed buildings (WGBC). Rise in asset value largely stems from marketability of green building certifications (WGBC 2013). An overall trend exists toward the reduction of costs in green building design and construction as building codes around the world become stricter and supply chains for green materials and technologies become more prominent (WGBC 2013).

Social benefits in green buildings aid the health and well-being of people living and working in green offices or homes (WGBC). The green building field combats poor air quality of indoor spaces, which is important as Americans spend around 90 percent of their time indoors

(USGBC). Green buildings use natural ventilation, materials, daylighting and other strategies to promote positive public health and healthy indoor spaces (LEED v4.1, USGBC). Employees in LEED buildings report feeling happier, healthier and more productive (USGBC). Studies back these reports by showing a 101 percent increase in cognitive brain functioning in green buildings (WGBC).

History of Green Building

Invention of air conditioning, reflective glass and structural steel support popularized enclosed glass and steel buildings that dominate the commercial architecture of American cities (Nature Stone Institute). These buildings use massive heating, ventilation and air conditioning (HVAC) systems that consume huge amounts of fossil fuels (Natural Stone Institute). A forward-thinking group of architects, environmentalists and ecologists in the 1970s were inspired by the growing environmental movement and higher energy costs associated with powering fossil fuel dependent HVAC and energy systems (Natural Stone Institute). Americans began to question its national dependency on fossil fuels for energy (Natural Stone Institute). Researchers in American universities began to examine energy efficient processes including more effective solar panels, prefabricated efficient wall systems, water-reclamation systems, and daylighting (Natural Stone Institute).

Clean energy entered political history in the United States when President Jimmy Carter spent three years fighting for installation of solar panels on the White House rooftop (Wihbey 2008). Introduction of solar plans symbolized a future of energy that moved away from the country's dependence on foreign oil. Eventually, President Carter succeeded, and the White House installed 32 solar panels (Wihbey 2008). The 1979 panels survived seven years until

President Ronald Reagan removed the solar panels, deeming government the problem, not the solution, to the energy crisis (Wihbey 2008). In 1993, as a part of his Earth Day Address, President Bill Clinton announced a plan to transform the White House into a model for energy efficiency and waste reduction that improved indoor air quality and building comfort (Natural Stone Institute, Browning et al.). Greening of the White House builds on a long tradition of installing advanced technologies into the White House (Browning et al.). Greening methods include tightening the building envelope, installing energy-saving light bulbs and maximizing natural light, initiating a recycling program and reducing unnecessary water and pesticide use in landscaping (Natural Stone Institute). The greening process demonstrates a pivotal moment in American environmentalism and government support for sustainability and green building.

Sustainable design increased in popularity throughout the 1990s. However, distinct guidelines for what constitutes ‘excellence’ or ‘best practices’ in green building performance remained unknown until LEED’s introduction (Cordero 2001, 25). City, state and county governments began many initial green building initiatives and guidelines. Sustainability efforts in the built environment, such as initiatives in the White House, primarily addressed energy efficiency, as environmental concern in the U.S. surrounded the ongoing energy crisis. Green building initiatives, Built Green in Denver, CO, Green Building Program in Scottsdale, AZ and Green Building Design Guidelines in Santa Monica, CA are examples of city-wide green building initiatives enacted before 2000 (Cordero 2001, 26). Green building programs began to take a broader approach to sustainable design, while the focus remained primarily on energy. Minnesota’s Sustainable Design Guide and Rating System and Pennsylvania’s Guidelines for Creating High Performance Green Buildings are early state-wide green building programs formed before 2000 (Cordero 2001, 27). Such programs develop checklists covering energy, site sustainability, water, materials, waste and more (Cordero 2001, 25).

The U.S. Green Building Council formed LEED to streamline green building and promote environmentally responsible architecture, healthy living and working spaces, and economically profitable building practices (Natural Stone Institute, USGBC). The USGBC published the first publicly available version of LEED, v2.0, in 2000 after testing the program's pilot program, LEED v1.0, beginning in 1998 (USGBC). Projects can earn LEED Certified, Silver, Gold and Platinum certifications based on adherence to prerequisites and credits across nine measurements of building excellence (USGBC). LEED v2.0 categories include Sustainable Sites (SS), Water Efficiency (WE), Energy & Atmosphere (EA), Materials & Resources (MR), Indoor Environmental Quality (EQ), and Innovation & Design Process (ID) (LEED v2.0). The USGBC added Location and Transportation (LT), Integrative Process (IP) and Regional Priority (RP) categories to LEED since publishing the original version (LEED v4.1). The USGBC divides LEED rating systems into LEED for Building Design and Construction (BD+C), LEED for Interior Design and Construction (ID+C), LEED for Operations and Maintenance (O+M), LEED for Neighborhood Development (ND), LEED for Homes, and LEED for Cities and Communities to provides flexible frameworks that any project type can use (USGBC). LEED has grown to become the most used green building rating system in the U.S. with nearly 80,000 projects participating in LEED across 162 countries, as of 2016 (Tufts 2016).

LEED project registrations experienced slow and steady growth after the USGBC introduced the rating system for new construction in 2000 (Tufts 2016). The USGBC had certified about 2,200 commercial projects under LEED v2.0 by 2009 (Tufts 2016). The green building movement began to expand rapidly by the concluding years of the decade, almost doubling the number of LEED Accredited Professionals (LEED AP) from the end of 2007 to the end of 2008 (Tufts 2016). Commercial real estate growth had hit its peak around the same time and began to decline afterwards as value of construction dropped between 2008 and 2010 (Tufts 2016). LEED began to grow despite the state of the market (Tufts 2016). Growth of LEED APs and introduction of LEED v4 in 2016 have supported growth in the green building movement (Tufts 2016).

Over twenty years of development in LEED and a broad array of LEED rating systems makes the system accessible to any type of project, from homes to schools to commercial office buildings. Living Building Challenge and the Sustainable Sites Initiative (SITES) came out in 2006 and 2009, respectively, to establish a more expansive and holistic approach to sustainable design. Living Building Challenge forms a distinct shift in discourse around green building in its introduction of qualitative standards, namely equity, happiness and beauty. SITES works hand-in-hand with LEED and adds emphasis to landscapes and site sustainability with and without buildings. Development of green building rating systems guide the green building market and discourse and introduce broader approaches to sustainable design over time.

Literature Review

The green building field has been developing for decades to address the environmental impact of urbanization and construction. In this literature review I will discuss the literature on green building and related topics in order to set the stage for my analytical discourse study of academic and educational green buildings in the United States. Many scholars have studied green building. Most of the related literature comes from the architecture, urban planning, and the environmental field and considers the interconnections between sustainability and the built environment.

Urban Sustainability

With the global population exponentially rising, the challenge confronting humanity is not whether to urbanize, but how to do so sustainably and with less environmental impact (Decker et al. 2000, 686; Seto et al. 2010, 183). Today, the majority of the world's population lives in urban areas, and this is expected to rise as an increasing amount of the world's economic activities exist in cities (McGranahan et al. 2003, 244). The resulting expansion of the built environment has contributed to a loss of biodiversity and an abuse of Earth's natural resources through linear consumption and production processes, through which humans consume rapidly and dispose of items as waste after use (Opoku 2019, 1). The idea of urban sustainability looks at the role of cities in supporting biodiversity and the environment, as well as connecting urban populations to nature (Opoku 2019, 2).

Environmental literature of the 1960s throughout the 1980s predominantly viewed urbanization as a detriment to the environment, but research since the early 2000s shows a more complex relationship between cities and the environment, in which both can benefit each other (Seto et al. 2010). Scholars focus on studying these interactions and identifying solutions to adopt a circular model of production, consumption and waste as a replacement to the linear one that typically exists in today's cities (Girardet 1999, 158; Seto et al. 2010). Construction is widely recognized as one of the least sustainable industries globally as its processes consume substantial amounts of Earth's resources and result in high amounts of waste (Opoku 2019, 1). Given the inevitability of urban expansion, urban sustainability is studied as a means to reframe the city from a place that drives habitat loss, releases emissions into the atmosphere, intensifies climate change and disrupts other natural processes (Decker et al. 2000, 703; Seto et al. 2010, 183). Scholars use a more systemic view of the city that integrates the built environment into our ecosystem, a place that supports the environment and promotes biodiversity (Seto et al. 2010, 169).

Green Building

Real estate developers have traditionally made decisions based exclusively on profit and met building code requirements for energy and water efficiencies at their bare minimums (Steinberg 2015, 39). Global consumption of Earth's non-renewable resources and growing concerns about energy and the environment led to heightened emphasis on sustainability and ultimately the development of the green building field (Sinha 2009, 91; Opoku 2019, 1). The 'sick building syndrome' scare in the 1970s also played a role in the green building movement's evolution (Del Percio 2004, 151). The syndrome describes symptoms of health and discomfort that building occupants experience from exposure to indoor air pollutants (Del Percio 2004, 151). Issues of the last 50 years have led to a focus on environment degradation, energy consumption and indoor environmental quality in architecture and construction. (Del Percio 2004; Sinha 2009, 93-94; Opoku 2019).

Green building is built upon the conceptual foundation that humans must live in synchronization with nature and the environment to survive (Sinha 2009, 92). Living in proximity to green spaces, spending time in nature, or having views of the outdoors has a positive influence on mental health and well-being (Russell et al. 2013, 479). The built environment can promote biodiversity and connect people with nature by creating green spaces and using biophilic and sustainable design practices (Opoku 2019). Green buildings reduce the impact of the built environment on human health and the natural environment by using water and energy efficiently, protecting occupant health, and reducing waste, pollution, and environmental degradation (Khashe et al. 2015).

Leadership in Energy and Environmental Design (LEED)

The term “green” was first used in architectural terms in the *Architecture* magazine in the 1990s when architects began experimenting with green building projects (Del Percio 2004, 127). Once the first two green buildings earned LEED certification in early 2000, the idea spread quickly (Steinberg 2015, 42). LEED successfully altered social rules around building and construction by demonstrating the feasibility and benefits of green building (Steinberg 2015, 42). LEED brings uniformity to the green building movement by standardizing green building elements, promoting integrative design practices, and transforming the architecture and building markets (Del Percio 2004, 120).

The first decade of LEED brought about skepticism within architecture as sustainable design can steer the attention of architects away from design innovation and excellence (Mostafavi et al. 2010, 13). Green building projects in the last decade show focuses on both biophilic and beautiful design and sustainability, attributed to the introduction of qualitative green building standards in Living Building Challenge. Economic and design conflicts have constrained architects from using sustainable design practices as well (Del Percio 2004, Mostafavi et al. 2010). Scholarly literature comments on the debate around economic feasibility of green building, showing that higher short-term costs exist with each increasing level of LEED

(Del Percio 2004). Long-term costs decrease substantially, levelling out the economic viability of sustainable design practices (Del Percio 2004).

Sustainable design practices have begun to enter mainstream of the industry since the introduction of LEED (Mostafavi et al. 2010, 13). The U.S. Green Building Council produced a discourse through LEED that alters the way the building industry functions worldwide (Cidell 2009). Literature shows that LEED certifications encourages pro-environmental behavior in order to maximize building efficiencies (Khashe et al. 2015, 477). Heating controls, window shades, waste reduction strategies, and other sustainable design solutions are controlled by occupants and are only effective when used correctly (Khashe et al. 2015, 478).

The modern city's rising population, increasing demand for food, and overconsumption of energy and natural resources pose the challenge of urban sustainability. Scholars study urban sustainability to understand the complex interactions that take place between the natural and built environments (Seto et al. 2010, 168). Such analysis can help scholars form a more sustainable, ecological built environment. Implementation of green building practices and LEED certification helps urban dwellers adopt pro-environmental behaviors, form sustainable mindsets and connect with nature (Russell et al. 2013, 474; Khashe et al. 2015, 477). Scholars view urban sustainability, green building and LEED as interrelated concepts that work to transform the city into a living, breathing place, one that supports biodiversity, human health and green spaces (Russell et al. 2013; Khashe et al. 2015; Opoku 2019, 2). The development of scholarly discourse in the green building field influences ways that people design and operate buildings and approach sustainability in the built environment more broadly.

EARLY GREEN BUILDING

> "If we are to build a better world—one that can be sustained ecologically and one that sustains us spiritually—we must transcend the disorder and fragmentation of the industrial age."
>
> *– David Orr, 2002*

Pre-LEED Green Building

Pre-LEED Discourse Analysis

Early efforts toward ecological design were inspired by the arts and crafts movement in Britain, especially works of William Morris and John Ruskin (Orr 2006, 34). Frank Lloyd Wright, for example, attempted to define "organic architecture" with resonance of these works (Orr 2006, 34). David Orr has suggested that Wright helped pioneer ecological design in the U.S. through his attempt to harmonize building and ecology, setting a precedent for those involved in the green building movement (Orr 2006, 34).

Notions of environmentally responsible, restorative and sustainable architecture preceded the more standardized green building field formed with the introduction of LEED. Motivation to build sustainably was driven by similar reasons that inspired LEED, including industrial deterioration, land degradation, ozone depletion, reduction of biodiversity, rising world population and an ongoing energy crisis (Probert 1995, 72; Lechner 2000, 2). Environmentally responsible architecture stemmed from the idea that human's ability to design in environmentally degrading ways insinuates human's potential to repair it (Probert 1995; Magnoli et al. 2002, 212).

Elizabeth Cordero's 2001 text on sustainable architecture provides definitions of sustainable architecture by prominent architects and related organizations of the time (Cordero

2001, 17-20). The American Institute of Architects (AIA) and architects, William McDonough, Bruce Coldham, Fred Harris and John Norton define sustainable architecture using ideas present in LEED and green building today such as regeneration, integrative design, material recyclability and renewability, and triple bottom line thinking (Cordero 2001, 17-20). William McDonough, architect of the Adam Joseph Lewis Center, emphasizes an awareness of short and long-term consequences of environmental transformation. McDonough's sustainable design philosophy is evident in the Adam Joseph Lewis Center's material selection and its regenerative and integrative systems approach. Early definitions of sustainable architecture mimic ideas prevalent in modern green building and current versions of rating systems. LEED standards become more stringent and expansive with each version to address a broad array of concerns, but the core values of 1990s sustainable architecture remain a crucial part of LEED and Living Building Challenge's most current versions.

LEED is often recognized as the original green building rating system. However, several sustainable design guidelines began to appear in the decade preceding LEED's introduction. Popular early systems include the Building Research Establishment Environmental Assessment Method (BREEAM), introduced in 1990, British Columbia University (BC University), introduced in 1995, and Hellmuth, Obata & Kassabaum (HOK), introduced in 1998 (Cordero 2001, 31). 1990s green building guidelines sometimes differ in approach or structure from LEED, but address similar sustainability elements that later make up LEED categories (Figure 1). LEED transformed the marketplace and has expanded green building widely, making people recognize the rating system as integral to the field's existence. However, environmental criteria of early green building rating systems in the below figure suggests that LEED may not have released the innovative, revolutionary system that people make it out to be.

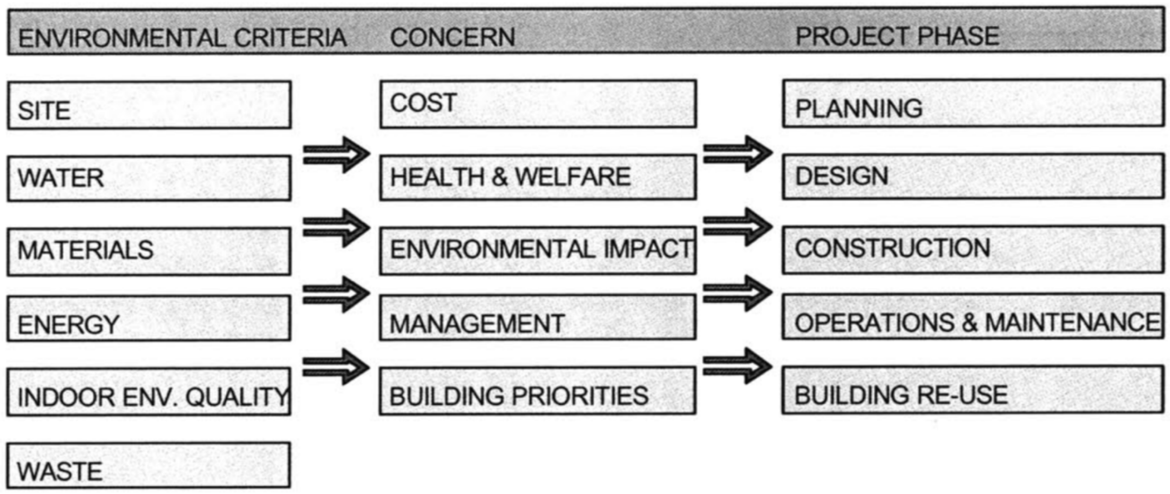

Figure 1. Diagram of sustainable design emphases in early green building.

The derivation of LEED from prior rating systems shows a lack of originality, but positive marketability and accessibility to a wide range of project types allows LEED to create a shift in sustainable architecture that continues to define the field. It has become the most popular green building rating system in the world and continues to drive discourse around the world.

Early Green Building Movement on College Campuses

Following this idea of precedent, the Adam Joseph Lewis Center became the first substantially green building in higher education (Orr 2011). Oberlin College was instantly celebrated as the anchor institution to create a building with economic resilience, clean energy, and holistic sustainability (Orr 2011). This project guided standardization in the green building field and introduction of LEED certification.

Conventional construction is based in the assumption that price and supply of energy derived from fossil fuels and nuclear power is relatively permanent (Orr 2006, 125). Architects who work under this model do not consider energy efficiency or use of renewable energy, resulting in the compromise of ecological health and climate stability around the world (Orr 2006, 125). Paul Steinberg states that a transformation toward green buildings requires changing rules that guide conventional decisions (Steinberg 2015). The Adam Joseph Lewis Center tested such rules and led people to reconsider construction and design processes. Rejection of economically driven decision making opened the door for environmental and social ways of thinking about architecture.

S.D. Probert's 1995 text on environmentally and energy responsible universities identifies the function of universities to demonstrate ways that a sustainable society can be achieved (Probert 1995). Universities at the time began to devise environmental policy statements and sustainability action plans (Probert 1995, 74). Common commitments and areas of focus included integrating sustainable energy use and environmental management policies and practices into all aspects of the campus, reducing fossil fuel consumption through improved energy effectiveness, conserving resources and minimizing waste, and using natural materials (Probert 1995, 75). Elements of sustainability in environmental policy statements and action plans mirror emphasized aspects of sustainable design in LEED and pre-LEED rating systems. New policies and plans symbolize a transition toward more streamlined sustainability and the beginning of a movement that emphasizes environmental thinking on college campuses worldwide.

As world leaders in research, innovation and education, universities are critical places to address environmental issues like climate change (Finlay et al. 2012, 150). College campuses are ideal platforms for environmental advocacy as centers of discourse and vehicles of social change (Finlay et al. 2012, 150). Students from environmentally oriented universities are more likely to bring environmental ideals into their work, homes and communities and thereby help form a substantial collective effect (Rappaport 2008, 7).

Dramatic growth on college campuses driven by expanding libraries and residence halls, influx of computers and new laboratories, and increasing global environmental concern led to new campus green programs in the 1990s (Rappaport 2008, 8). Early efforts focused on increased recycling, more efficient lighting, water conservation, and waste reduction (Rappaport 2008, 7). As an effort to reduce emissions associated with energy, colleges and universities took action to increase use of green power or renewable energy and reduce demand through changed behavior and expectations (Rappaport 2008, 8). The conversation around energy in late 20th and early 21st centuries indicates concerns of energy efficiency and consumption related to economic, environmental and health concerns (UNDP 2000, 3). Understanding of the connection between greenhouse gas emissions and climate change influences early leaders in green building and environmental activists to address energy as a means of stemming climate change. Discussion of energy in 2000 emphasizes sustainable energy as fundamental to sustainable development (UNDP 2000, 26). Green building programs integrate energy into the center of their missions to address environmental concerns and sustainable development goals of the time.

A concern existed in the early green building movement that sustainability efforts on college campuses would cost too much and divert funds away from teaching and research (Sharp 2009, 2). Institutions began to realize that sustainable design practices can be implemented at either no added cost or within a reasonable payback period (Sharp 2009, 2). As campus sustainability became standard across campuses and prospective students began to pursue environmentally focused universities, college campuses began to adopt sustainability into their social action agendas (Rappaport 2008, 8; Dougherty 2010, 6). Environmental efforts on college campuses began to increase marketability of institutions, making campus greening an economically beneficial decision.

Adam Joseph Lewis Center

Figure 2. Adam Joseph Lewis Center, Oberlin College. Photo by Dale Preston ‘83.

Background

A conventional idea exists that building and landscape design have no relationship to the process of learning that occurs in a particular place (Orr 2002, 127). The Adam Joseph Lewis Center at Oberlin College combats this notion as the building itself acts as critical part of the Environmental Studies curriculum (Figure 2). It stands with Professor David Orr’s idea that curriculum embedded in a building instructs as powerfully as a course taught in it (Orr 2002). Emphasis on sustainable design innovation, systems integration and energy efficiency made the Adam Joseph Lewis Center an early model of green building that influenced the creation of sustainable design rating systems and expansion of the green building field. The Lewis Center remains a prominent case of green building nearly twenty years after opening in 2000.

The Lewis Center's integrative design approach began with stakeholder meetings. Initially 25 students and a dozen architects met over two semesters to develop project goals and ideas (Orr 2002, 129). The project moved forward after receiving an endorsement from Oberlin College's president in the fall of 1995 (Orr 2002, 129). William McDonough & Partners was selected from 26 architectural firms that applied for the position (Orr 2002, 130). Two recent Oberlin alumni helped coordinate the project design and engaged students, faculty and the community throughout the process (Orr 2002, 129). Architect John Lyle helped facilitated 13 charrettes that involved 250 students, faculty and community members (Orr 2002, 130).

Le Corbusier's idea of a house as a "machine for living" inspired William McDonough to question whether he could create a building that acted like a tree (Macaulay 2011). McDonough aspired to optimize student, faculty, and community participation, encourage mindfulness of materials and energy, promote ecology, and form an integrative design approach by examining upstream and downstream impact of design choices and performance (Macaulay 2011).

Members of the design team devised a building that modeled principles of ecological design and focused on key sustainability features such as water conservation, recycled materials, energy efficiency, daylighting, and individual lighting and window controls (Petersen 2007). The Lewis Center is recognized for the Living Machine, a wastewater system that treats and recycles water within the building (NREL 2002). Water cleaned by the Living Machine is reused in the building's toilets and landscape (NREL 2002).

The building relies on the sun for daylight, passive heating and power. Photovoltaic (PV) panels (4,000 square feet) supply over half the building's electricity (NREL 2002). The grid-interconnected photovoltaic system exports energy back to the grid when the PV system produces more than the building uses, and it imports energy when the PV system does not produce enough to meet the building's needs (NREL 2002). Daylighting from expansive south-facing windows reduces electricity needed for the atrium and classrooms (NREL 2002). Motion sensitive lighting and efficient fixtures, dimmers and sensors reduce energy as well (NREL 2002). The Lewis Center's HVAC system uses a closed-loop groundwater heat pump system, which uses the Earth's temperature to heat and cool the building (NREL 2002). Treated glass panes with low-emissivity coating trap heat in the winter (NREL 2002). Strategic placement of overhanging eaves shade south windows from sun, and a trellis shades the atrium from the sun on the east side (NREL 2002).

The Adam Joseph Lewis Center has earned national acclaim as a model of green building through its innovative design and integration into the Environmental Studies program and the Oberlin community. Flows of energy and cycling of materials are monitored and displayed by a Building Dashboard that presents real-time data, engaging its occupants and ensuring that the building is performing at its highest potential (Oberlin College). The unique relationship between the building and its occupants resulted in an early fascination with green building and exposed people to the wide range of benefits associated with sustainable design.

LEED Analysis

Connections between the Lewis Center and LEED v2.0 are evident in credits under LEED's Energy and Atmosphere (EA), Water Efficiency (WE) and Materials and Resources (MR) categories. The Lewis Center project team planned and designed the building at roughly the same period as the USGBC formulated LEED v2.0. The opening of the Lewis Center and the release of LEED v2.0 coincided as well. Uniformity in both projects and parallels between LEED credits and the Lewis Center's sustainable design elements illustrate the building's influence on LEED's establishment and development.

The integrative design team considered sustainability in each component of the design process. The Lewis Center's full-spectrum sustainability signals a turning point in ecological design marked by proliferation of green building projects and the creation and development of LEED. The Lewis Center provides an innovative model of sustainability that seamlessly integrates all sustainability systems and tracks their performances to prove high quality functioning over time. The Lewis Center provided the USGBC with an opportunity to analyze building's stellar optimization of systems and standardize them through LEED.

The Lewis Center's Living Machine wastewater system is consistent with the Innovative Wastewater Technologies under the WE category. The credit requires reduction of municipally provided potable water or on-site treatment of wastewater for fulfilment (LEED v2.1). The Lewis Center lays the foundation for a later trend in reuse and regeneration in green building through its wastewater system, responsible material selection and renewable energy generation.

The Lewis Center improved energy efficiency through daylighting, efficient lighting and on-site grid-interconnected photovoltaic (PV) production. The building's sustainable energy features are consistent with the Optimize Energy Performance and Renewable Energy credits in LEED's first publicly available major version. These credits require energy cost reduction and renewable energy production, respectively (LEED v2.1). Installation of metering systems comply with the Measurement and Verification credit which requires continuous metering equipment for several end uses (LEED v2.1). The Lewis Center brings innovation to green building through several sustainability systems including the Living Machine, even though the experimental wastewater technology is not fully integrated across water efficiency systems. The Lewis Center creates an example of comprehensive sustainable design at the time, but the integrative energy systems remain the most notable sustainability elements on the site.

The Lewis Center was built using local and recycled materials when possible. The Lewis Center's ideology behind materials abides by Resource Reuse and Regional Materials credits under LEED's MR category which intend to salvage and reuse materials in the building process and use materials and products manufactured within close proximity to the site (LEED v2.1). Although the Regional Materials credit exists under the MR category, Regional Materials mainly aims to reduce energy consumption associated with transportation. The Lewis Center approaches energy efficiency holistically and inspires future projects to adopt similar passive design techniques and renewable energy production. Focus on energy is consistent with green building in the pre-LEED and early LEED years that aim to stem climate change through sustainable energy systems and processes that reduce greenhouse gas emissions.

Strong correlations exist between LEED's vision of green building and the Lewis Center's ideologies that predate LEED. The Lewis Center's success in integrative design through all-stakeholder charrettes and interconnected sustainability systems influenced its peers to adopt similar design frameworks and led to its inclusion in LEED certification. Project leaders installed 150 environmental sensors to ensure that sustainability features perform as designed (Petersen 2007, 2). Sensors continue to monitor energy production by solar arrays, energy consumption by major end uses within the building, weather conditions, soil temperature and moisture, on-site rainwater storage, water flows within the on-site wetland-wastewater treatment system, as well as other variables (Petersen 2007, 2). Oberlin's decision to monitor building performance demonstrates a forward-thinking approach to sustainable design that does not enter the field until the release of Living Building Challenge, which requires projects to undergo a 12-month performance period before receiving certification (ILFI).

UCSB Bren Hall

Figure 3. Bren Hall, University of California, Santa Barbara. Photo by UCSB.

Background

University of California (UC) campuses have individually adopted minimum LEED Silver certifications for New Construction (NC). Scholars recognize UCSB as an early adopter of green building for Bren Hall which opened in 2002. Bren Hall houses UCSB's Environmental Studies department and the Donald Bren School of Environmental Science & Management (Figure 3) (UCSB Bren School 1999, 1).

The building advisory committee began planning for Bren Hall in 1992. The State of California approved to construct the building but was initially unwilling to fund an experimental building in environmental sensitivity (UCSB Bren School 1999, 1). The project intended to begin construction in 1995, but the failure of a statewide bond issue delayed funding until a bond issue passed in 1998 (UCSB Bren School 1999, 1). The unorthodox nature of sustainable design at the time slowed the process but also provided an outstanding model of green building that helped jumpstart the green building movement.

This 26 million dollar, 85,000 square foot building opened in April 2002 and was instantly recognized as the greenest laboratory facility in the U.S. (Fried 2002, UCSB Bren School 2017). Bren Hall later became the first building to earn two LEED Platinum certifications when it was re-certified at the highest level of LEED for Operations & Maintenance (O&M) in August 2009 (UCSB Bren School 2017). Bren Hall became the first triple LEED Platinum certified building when it achieved a second Platinum certification under LEED O&M in 2017 with the highest LEED score in the country that year (UCSB Bren School). Bren Hall's triple LEED certification represents strong commitment to sustainability by monitoring building systems and ensuring that they are operating at their highest peak of sustainability. Bren Hall's constant improvement of building performance influences the field by demonstrating that successful green building transcends initial design.

Bren Hall has set a new standard for sustainable design by combining advanced technology with environmentally sound principles and products (UCSB Bren School 2017). Consistent with the period of planning, design and construction, 1992-2002, project leaders emphasized energy consumption as the root of sustainable design. The building surpasses California energy code, Title 24, by 32-40 percent through its 47-kilowatt rooftop photovoltaic system and natural heating, cooling and lighting (Fried 2002). 240 on-site solar panels generate 7 to 10 percent of the building's total power (UCSB Bren School). Operable windows and daylighting through expansive windows reduce energy typically used in lighting or HVAC systems (Fried 2002). The building uses energy-efficient lighting and motion sensors to further reduce energy consumption.

Notable sustainable design elements include Bren Hall's water efficiency and waste reducing systems. Project leaders took steps to address water consumption and efficiency in bathroom fixtures, cooling and landscaping. Waterless urinals are installed in bathrooms, and first-floor toilets use reclaimed ground water (Fried 2002). Bren Hall is connected to a shared multi-building chilled water loop that saves as much as 85 percent run time on the chiller (UCSB Bren School). The project used sustainable landscaping by preserving the existing landscape and habitats and planting drought-tolerant native plants to limit water consumption (Fried 2002). Bren Hall maximizes water efficiency through its circularity and integration in water systems.

The project uses waste reducing strategies in their deliberate material selection. 100 percent of demolition waste and 92 percent of construction waste was recycled (UCSB Bren School 2017). Materials were shipped from within a 350-mile radius to reduce the carbon footprint associated with construction. Structural steel of the building has 80 percent recycled content (Fried 2002). Carpets, flooring, fabrics, tiles, furniture, and insulation are all made with high recycled content as well (UCSB Bren School 2017).

LEED Analysis

Bren Hall has earned three LEED Platinum certifications under three major versions of LEED. Analysis of Bren Hall's second and third LEED Platinum certifications allows for deeper understanding of the project's commitment to consistently meeting the highest standards of green building. Bren Hall's three certifications under different LEED versions shows progression in green building toward a more holistic approach to energy efficiency and a higher prioritization of local environmental issues.

Bren Hall's LEED O&M certifications under versions 2.0 and 4 represent constant improvement in building performance. Project leaders made strides in improving Indoor Environmental Quality (EQ) in Bren Hall's third certification, earning 14/17 points (82%), an increase from its 12/22 points (55%) in its second certification (Bren Hall LEED v2.0 scorecard, Bren Hall LEED v4 scorecard). Bren Hall updated indoor environmental quality performance to address growing concerns for indoor environmental quality in the field. Green building considered human health from its beginning, attributed to the 'sick building syndrome' scare in the 1960s and 1970s (Del Percio 2004, 151). LEED develops IEQ criteria over time to better address occupant health and productivity, which is especially important as an academic building. Bren Hall improved its total amount of earned credits from 64/85 (75%) in 2009 to 93/110 (85%) in 2017 (Bren Hall LEED v2.0 scorecard, Bren Hall LEED v4 scorecard). Bren Hall's ability to achieve a higher LEED Platinum score in a version with higher standards indicates its commitment to maintaining the highest level of sustainable design over time. Scholars recognize Bren Hall as an early model of green building, but the project's LEED O&M certification in LEED v4 makes it an applicable modern example of green building as well.

Categorical differences between LEED v2.0 and LEED v4 show a stronger emphasis of local environmental issues in modern green building. The Innovation in Design (ID) category no longer exists in LEED v4, and Regional Priority (RP) and Location and Transportation (LT) categories are present in the most current major version (Bren Hall LEED v2.0 scorecard, Bren Hall LEED v4 scorecard). Regional Priority requires a deeper allegiance to site locality and encourages buildings to perform in accordance with local environmental issues. This site-specific credit category advances sustainable design thinking beyond streamlined green building standards and leads architects to consider their project in terms of its local siting. LEED v2.0 includes four credits for alternative transportation within Sustainable Sites: “public transportation access,” “bicycle storage & changing rooms,” “alternative fuel vehicles,” and “car pooling and telecommuting” (Bren Hall LEED v2.0 scorecard). Bren Hall earned three out of four credits for alternative transportation (Bren Hall LEED v2.0 scorecard). Version 4 includes 15 points for “Alternative transportation” under Location & Transportation, all of which the building earned (Bren Hall LEED v4 scorecard). Alternative transportation accounts for 14 percent of possible points in version 4 (15/110), an increase from version 2.0 in which it accounted for just five percent of total points (4/85) (Bren Hall LEED v2.0 scorecard, Bren Hall LEED v4 scorecard). Increased emphasis in alternative transportation reflects higher prioritization of reducing carbon emissions. Bren Hall achieves Alternative Transportation credits to demonstrate its commitment to reducing carbon emissions and the highest, most current standards of sustainable design.

Adam Joseph Lewis Center and Bren Hall: Influence and Legacy

The Adam Joseph Lewis Center and Bren Hall inspired innovation in early green building. Both projects began planning in 1992, during a decade when people began to recognize the extent of the damage humans inflict on the environment (UCSB Bren School 1999, 1). Project leaders envisioned buildings that promote environmental stewardship and provide students with spaces to learn in and from, reflecting Orr’s vision to create buildings that teach the curriculum as strongly as the professors and students within them (UCSB Bren School 1999, 4; Orr 2002). Orr’s thought-provoking reflections and ideas behind the Adam Joseph Lewis Center catalyzed early green building (Rappaport 2008, 14). Building design complements its curriculum and adds an interdisciplinary approach to learning, collaborative research and learning (UCSB Bren School 1999, 4).

Early projects at Oberlin College and UCSB focused on mitigating emissions of fossil fuels and reducing energy consumption using the sun for solar energy generation and passive heating and cooling (UCSB Bren School 1999, 66). Adam Joseph Lewis Center 's opening in the same year as LEED's introduction presented a tangible example of comprehensive sustainable design and performance. Bren Hall's opening two years later represented another monumental moment in green building as it became one of the first buildings to achieve LEED Platinum certification as well as the first LEED Platinum certified laboratory.

The Adam Joseph Lewis Center's influence stems from its intelligent design process. Project leaders focused on integrative ecological design and beyond that, considered economic resilience and ways that humans interact with the building. Green building was primarily focused on environmental issues at its beginning, namely energy, and the Lewis Center pushed the envelope of conformity by addressing broader sustainability and social and economic factors. Disconformities led to a proliferation of green buildings in the early 2000s, such as Bren Hall, and the building's recognition as the most remarkable of a new generation of college buildings by the New York Times (William McDonough + Partners).

Both projects adopted integrated sustainability systems from their inceptions using the triple bottom line approach. Project leaders used this model to consider ecology, equity and economic factors to make intelligent decisions and optimize sustainable design (UCSB Bren School 1999, 6). The Adam Joseph Lewis Center and Bren Hall became early implementers of this holistic design approach and countered simple and profit-driven traditional construction. Adoption of this framework supports each building's Environmental Studies department, representing the interdisciplinary nature of the field and illustrating the importance of viewing environmental issues from several perspectives. Both buildings were instantly recognized as models of innovative sustainable design and continue to steer scholarly discourse in the field.

MID-LATE 2000s GREEN BUILDING

> "As a society we are often surrounded by ugly and inhumane physical environments. If we do not care for our homes, streets and offices then why should we extend care outward to our farms, forests and fields?"

– Living Building Challenge 1.3, 2008

Sustainability at Yale University

Yale University's focus on sustainable design can be traced back to 1932 with the opening of the campus's first green building (Yale Scientific 2008). Payne Whitney Gym is an example of sustainable design common in buildings preceding World War II (Yale Scientific 2008). Architects designed the building with comprehensive daylighting, natural ventilation, and a combination of natural and mechanical ventilation in some places, a strategy now called hybrid ventilation (Yale Scientific 2008). The Yale Student Environmental Coalition regenerated interest in sustainable design with the 1998 "Yale Green Plan" (Yale Scientific 2008). The plan called for the University to reduce energy consumption and to introduce sustainable construction practices (Yale Scientific 2008). In 2005, President Richard Levin promised that Yale would reduce greenhouse gas emissions by 10 percent below 1990 levels by 2020 (Yale Scientific 2008). Yale University established the Office of Sustainability and a Student Taskforce for Environmental Partnership to inform its faculty, staff and students of the benefits of environmentally conscious behavior (Yale Scientific 2008).

Kroon Hall Background

Figure 4. Kroon Hall, Yale University. Photo by Barry A. Hyman, 2012.

Yale School of Forestry and Environmental Studies began in 1901 as the first professional forestry program in the U.S. The school has since developed into a leading institution for the study of the environment (Yale University). Kroon Hall opened in 2009 and currently houses the graduate school (Figure 4) (Yale University). Hopkins Architects designed the building in partnership with Centerbrook Architects and Planners (Yale University). Yale chose Centerbrook for its prior experience working in New Haven, CT and knowledge of local sustainability (Rappaport 2009, 19). The 58,000 square-foot building has aided the program's recognition as a school that practices superior sustainable design.

Kroon Hall achieved LEED Platinum certification in 2010 for its significant energy use reduction and on-site energy production, innovative water-saving and water-reusing features, and environmentally responsible material use. The building is also carbon neutral (Rappaport 2009). Architects designed the building to have a low environmental impact and foster relationships between humans and the natural world using biophilic design features (Falloon 2010). Kroon Hall accommodates faculty offices, classrooms, a library and study center, and flexible space to host exhibitions and other events (Architizer).

Kroon Hall achieves stellar energy efficiency through optimized lighting, on-site photovoltaic energy production and a solar hot water (Solaripedia). The project addresses energy through use of building commissioning, reducing its use of refrigerants, on-site renewable energy production, a geothermal system, building energy performance, and measurement and verification (Yale News 2010). Kroon Hall uses 58 percent less energy than a typical, comparably sized building as a result (Kuang 2010). The project faced challenges associated with creating a zero-carbon building, especially generating sufficient electrical energy (Rappaport 2009, 19). The design team achieved carbon neutrality by devising a rooftop photovoltaic array that provides more than 20 percent of the building's electricity despite New Haven's often grey weather (Yale University, Kuang 2010).

Natural ventilation, passive design and optimized lighting reduce energy demand. Kroon Hall's east-west orientation takes advantage of natural ventilation and daylighting (Yale News 2010). Architects and engineers devised a highly insulated building envelope with technologies that naturally cool the building in the summer and heat it in the winter (Yale News 2010). Kroon Hall addresses indoor environmental quality by using high-efficiency filtration for ventilation and maximizing daylight and views to the outdoors (Solaripedia). Such features contribute to greater productivity and satisfaction as well as reduced health-related absences by building users (Yale News 2010).

Kroon Hall draws heating and cooling energy from four 1,500 foot deep open-loop standing column wells. The heat recovery system warms the air using available energy from occupants, lights and appliances then uses supplementary energy from the geothermal system (Solaripedia). The geothermal system is one of Kroon Hall's primary strategies to cut energy demand and produce its own energy and heat.

Intelligent water-reusing and water-saving systems like solar hot water production allow the building to use 81 percent less water than a conventional building of the same size (Kuang 2010). A constructed wetland naturally filters water from the rainwater system, which allows Kroon Hall to reuse water from non-potable water needs such as toilet flushing and irrigation (Yale University). Low-flow plumbing and sustainable irrigation systems also contribute to low water consumption by reducing the demand for water (Yale University).

Kroon Hall addresses materials and resources by using recycled, local and sustainable materials. Project leaders purchased 16 percent of materials with recycled content and 34 percent from regional sources (Yale News 2010). Nearly 80 percent of timber purchased for the project is Forest Stewardship Council (FSC) Certified, designating wood as sustainably harvested (Yale News 2010). The project chose site materials that combat the urban island effect, such as light-colored "thermally inactive" concrete and a green roof over the courtyard (Solaripedia).

Yale University has a long history of environmentalism. The University's current sustainability plan places especial emphasis on green building and sustainability in the built environment. Kroon Hall is recognized as the flagship building in achieving Yale's pledge to reduce greenhouse gas emissions by 43 percent from 2005-2020 (Yale University 2013, 5; Cross 2011).

LEED Analysis

Kroon Hall achieved LEED Platinum for new construction under LEED v2.2 (Kroon Hall LEED scorecard). The project earned all points under the Water Efficiency, Energy and Atmosphere and Indoor Environmental Quality categories, and the majority of points in remaining categories to earn 59 out of 69 available points (Kroon Hall LEED scorecard). Its carbon neutral design required major reductions in energy consumption and intelligent passive design that significantly lowers energy demand. It also increases climate resiliency by reducing Yale's reliability on grid power and reducing greenhouse gas emissions.

Energy and Atmosphere

Kroon Hall achieved all 17 EA credits for its interconnected and natural energy systems (Kroon Hall LEED scorecard). This is attributed to the project's successful on-site renewable energy production, focus on energy efficiency, passive design approach, and ongoing commissioning. Use of photovoltaic arrays and a geothermal system indicates successful interaction between different forms of renewable energy. The project's focus on maximizing energy efficiency stems from Yale's campus-wide efforts to reduce greenhouse gas emissions and foreshadows a more recent movement toward decarbonization in green building. Kroon Hall's carbon neutral design serves as a stepping stone in Yale's goal to achieve campus-wide carbon neutrality by 2050 (Yale University 2016).

Kroon Hall's design team strategically oriented the building to reduce energy demand and maximize passive heating and cooling. Kroon Hall takes inspiration for its passive heating and cooling technologies from the Adam Joseph Lewis Center. The Oberlin project took advantage of daylighting through expansive south-facing windows and used a closed-loop groundwater heat pump system to heat and cool the building (NREL 2002). Intelligent passive design thinking changed the way green building projects approached factors of energy. Kroon Hall indicates the feasible scalability of the Lewis Center's energy systems to accommodate a similarly fluctuating climate in Connecticut.

Kroon Hall gained inspiration for its geothermal heating and cooling system from the Lewis Center, which has 24 boreholes that supply 100 percent of the building's heating and cooling needs (Cross 2011, 38). The geothermal system proved successful at Oberlin and influenced Kroon Hall to implement a design that is similarly effective for heating in winter and cooling in the summer (Figure 5). Kroon Hall's concrete walls and exposed concrete ceilings help maintain a tight building envelope, retaining heat in winter and helping to cool in the summer (Cross 2011).

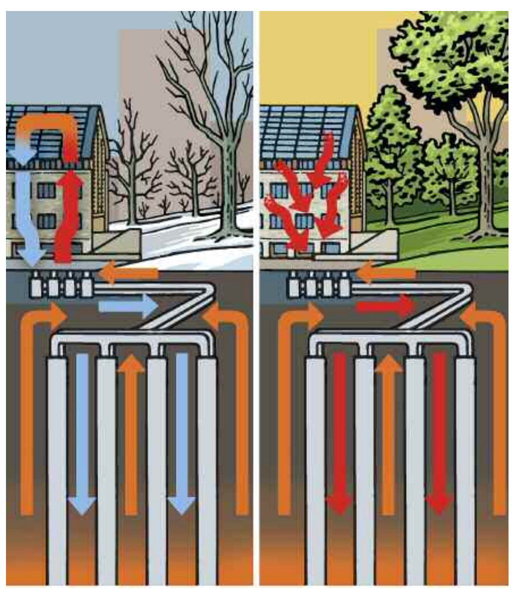

Figure 5. Diagram of Kroon Hall's open loop wells in winter (left) and summer (right), Illustration by Gregory Nemec.

Water Efficiency

Kroon Hall achieved all five WE credits toward LEED certification as well as Innovation in Design (ID) credits for exemplary performance in potable water savings (Kroon Hall LEED scorecard). The project intended for the rainwater harvesting system alone to satisfy at least six WE credits, including two points for stormwater management and four points for water efficiency (Solaripedia). Kroon Hall achieved the highest level of water efficiency through its water efficient landscaping and innovative wastewater technologies (Kroon Hall LEED scorecard).

Kroon Hall builds upon the Lewis Center's approach to water reduction and efficiency by incorporating water-saving and water-reusing features. Project leaders installed an on-site constructed wetland that serves a similar purpose to the Living Machine at the Lewis Center. Kroon Hall implemented a rainwater harvesting system to save approximately 500,000 gallons of potable water annually (Solaripedia). The closed-loop water system reuses collected rainwater from a water catchment system (Yale News 2010). Native plants in the constructed wetland help remove sediment and contaminants from collected rainwater (Yale University). Kroon Hall reuses filtered stormwater for toilet flushing and irrigation (Yale News 2010). Wastewater from sinks and showers fulfills non-potable needs as well (Yale News 2010). The rainwater harvesting system adds an essential element of water efficiency lacking in the Lewis Center's design. The water systems at Kroon Hall are more advanced and integrative, thereby presenting a more updated model of water efficiency.

Living Building Challenge

Background

New green building rating systems came out in the mid to late 2000s to complement LEED. Systems brought about expansive sustainable design thinking that influenced the design of Kroon Hall and other notable green building projects at the time. The Cascadia Green Building Council released Living Building Challenge in 2006, setting more stringent standards of sustainable design and introducing a the first qualitative standards of green building. Living Building Challenge continues to push green building projects forward and advance the field. Other sustainable design certifications under the International Living Future Institute, which now controls Living Building Challenge, include Petal certification for certification of specific Living Building Challenge categories, Zero Energy certification and Zero Carbon certification (ILFI).

The Cascadia Green Building Council founded Living Building Council on the basis that LEED Platinum does not fulfill the highest level of sustainable buildings (LBC 1.3). Living Building Challenge expands discourse around green building through its emphasis on biophilia, beauty, human health and well-being, and equity, areas not covered in LEED. Living Building Challenge uses the metaphor of a flower to symbolize an ideal built environment that functions as cleanly and efficiently as a flower (ILFI). Living Building Challenge requires achievement of imperatives under seven petals: Place, Water, Energy, Health + Happiness, Materials, Equity, and Beauty (LBC 4.0). It pushes sustainable design thinking beyond issues of climate and environment and raises concern for social issues, looking more critically at how humanity connects with its urban environment.

The Place petal re-envisions LEED's Sustainable Sites category to better realign the way people understand and relate to the natural environment, encouraging urban density, reduction of transportation impacts, and transit dependent on “people power” (LBC 4.0). The difference between Sustainable Sites in LEED and the Place petal in Living Building Challenge is the more stringent ecological standards and an emphasis on urban agriculture under Place (LBC 4.0). Living Building Challenge differs from LEED in its requirement of all imperatives for certification, whereas LEED awards different levels of sustainability through certification levels. Place therefore requires fulfillment of the field’s highest level of site sustainability for Living Building Challenge or Place petal certifications.

Water and Energy petals require fulfilment of highly stringent imperatives such as net positive water and net zero energy, respectively. The Materials petal rethinks LEED’s Materials and Resources category to help create a materials economy that is non-toxic, ecologically restorative, transparent, and socially equitable (ILFI). It also uncovers the carbon footpring associated with materials. The Embodied Carbon Footprint Imperative sets the Materials petal apart from LEED’s Materials and Resources category in its consideration of carbon associated with material reuse and selection. LEED lacks credits directly related to embodied carbon but introduced credits that encourage embodied carbon in the rating system’s fourth major version.

Health + Happiness, Equity and Beauty petals promote connection between people and buildings. The Health + Happiness petal considers ways to create physically and psychologically healthy spaces (LBC 4.0). The Health + Happiness petal expands LEED’s Indoor Environmental Quality category that solely considers mitigating pollutants and other factors that can compromise indoor environmental quality. The Healthy Interior Environment Imperative requires a technical approach to indoor environmental quality, and the Biophilic Environment Imperative complements the first Health + Happiness imperative with a requirement to include design elements that nurture the innate connection between humans and nature (LBC 4.0). The

Equity petal raises environmental justice concerns in sustainable design. Imperatives require projects to promote business practices of organizations that support an equitable future (LBC 4.0). The Beauty petal aims to help people recognize beauty as a precursor to preservation and conservation through requiring biophilic design and public art installation (LBC 4.0).

Discourse Analysis

The International Living Future Institute defines living buildings as regenerative buildings that connect occupants to light, air, food, nature, and community, and self-sufficient buildings that remain within resource limits of their site (ILFI). Living buildings create a positive impact on human and natural systems that interact with them (ILFI). Living Building Challenge remains a highly technical system, but considers green building from a strikingly different, more holistic perspective than LEED. Projects achieve LEED certification by earning credits set by the market's benchmarks for efficiencies and standards, while Living Building Challenge broadens this to ensure a strong connection between the building and its occupants. Addition of self-sufficiency to the conversation around green building sets forth the challenge of designing buildings that depend on available on-site resources for water, energy, and more. Net zero energy, water and carbon programs enter green building as a result. Living Building Challenge also alters the way green building professionals consider energy and carbon related issues through changes to its Energy and Materials petals.

Living Building Challenge borrows its Petals from LEED categories and other rating systems but creates a shift in discourse in the field by introducing the first qualitative measures of green building design. Living Building Challenge's Health + Happiness, Equity and Beauty petals expands green building by implementing social factors into sustainable design thinking.

An approximately equal number of imperatives exist under all petals, showing that Living Building Challenge recognizes Health + Happiness, Equity and Beauty with the same level of importance as other petals such as Water or Energy.

Living Building Challenge renamed the Site petal to Place in the system's third version to better reflect Living Building Challenge's values and the unique qualities of communities and places (LBC 3.0). The system aims to create highly sustainable, living buildings that become an integral part of the place rather than buildings on a site intended for development. The Site Petal Intent under Living Building Challenge 2.0 outlines technical requirements for acceptable sites for development and dangers of urban sprawl (LBC 2.0). The Place Petal Intent under the third version adds emphasis to human connection with the natural environment, unique stories and qualities of each unique place, and importance of ecological protection (LBC 3.0). Living Building Challenge updates the first Place petal imperative from the third to the fourth version to better address local ecological features (LBC 3.0, LBC 4.0). Living Building Challenge renames the Limits to Growth imperative to Ecology of Place (LBC 3.0, LBC 4.0). The newer imperative intends to protect and positively contribute to local ecology in addition to previous requirements that solely prohibited development on prime farmland, greenfield or wilderness (LBC 3.0, LBC 4.0). Living Building Challenge emphasizes local environmental issues in the fourth version and influences green building projects to consider local ecology, whether or not a project is pursuing certification. The Robert Redford Conservancy presents an example of a project that adopts concepts of Living Building Challenge through its remarkable attention to local ecology and environmental issues in its design process.

Change in the Energy petal from Living Building Challenge's third to fourth major versions represents a shift in green building discourse. Living Building Challenge included only one imperative under energy, Net Positive Energy, until the ILFI published Living Building Challenge 4.0 in 2019 (LBC 3.0, LBC 4.0). Net Positive Energy solely required that projects produce 105 percent of the projects energy needs using on-site renewable energy production (LBC 3.0). Living Building Challenge shifted the intent of its Energy Petal in the fourth version to further emphasize carbon reduction. The fourth major version replaces Net Positive Energy with two new imperatives, Energy + Carbon Reduction and Net Positive Carbon (LBC 4.0). Net Positive Carbon builds upon Net Positive Energy and includes the same energy production requirement (LBC 4.0). The new imperative also requires that all projects sub-meter major energy end uses and account for total embodied carbon emissions from construction through using carbon-sequestering materials and carbon offsets (LBC 4.0). Energy + Carbon Reduction intends to minimize energy-related carbon emissions that contribute to climate change by reducing energy consumption by a designated percentage from an equivalent building baseline (LBC 4.0).

A change in the Energy petal from third to fourth major version of Living Building Challenge represents a shift in green building discourse. Living Building Challenge begins to focus more closely on carbon in the fourth version. The Materials petal considers embodied carbon as well through its updated materials red list (LBC 4.0). The keyword “carbon” arises 15 times in the second version of Living Building Challenge, 14 times in the third version, and 39 times in the fourth version, showing an increase in the prevalence of carbon in the sustainable design thinking (LBC 2.0, LBC 3.0, LBC 4.0). More projects begin to consider carbon emissions and embodied carbon to view energy efficiency and consumption more holistically and address rising concerns of climate change. LEED simultaneously made changes to EA and MR categories in LEED v4.1 to better address carbon related issues. The Robert Redford

Conservancy and other recent projects at Colorado College and Dartmouth College consider embodied carbon through renovating existing buildings.

Living Building Challenge initiates changes in green building discourse that reflect alterations in the broader sustainability discourse, which shows movement from climate change mitigation to climate resilience. Introduction and development of the certification system influences green building projects to include both climate change mitigation and adaptation strategies to help create a built environment that is both responsive and resilient to uncertain climate extremes in the future (Larsen et al. 2011, 5). Living Building Challenge addresses regional sustainability through the Place petal to incorporate adaptation strategies in the site design that are resilient to the future impacts of climate change.

Influence on Kroon Hall

The Omega Center for Sustainable Living became the first Certified Living building three years after the Cascadia Green Building Council published Living Building Challenge in 2006 (ILFI). Green building professionals did not initially recognize Living Building Challenge as feasible, but rather as a model to implement design ideas into their projects. Kroon Hall adopts concepts of biophilia, human well-being and productivity, and water reusing systems from Living Building Challenge imperatives.

Kroon Hall draws inspiration from the requirements of biophilic and beautiful design. The Beauty & Inspiration petal in version 1.3, published in 2008 one year before Kroon Hall was built, aims to alter inhumane physical environments surrounding human society (LBC 1.3). Kroon Hall implements such values through its biophilic design. Construction from natural materials and use of natural lighting and ventilation connect occupants to the building and its surrounding environment. Kroon Hall's wooden building structure and interior furniture form a tree-like structure that nurtures a connection between humans and nature. Operable, expansive windows and skylights enhance the building's natural ventilation and biophilic design by providing occupants with a view of the outdoors. Natural ventilation and indoor environmental quality design elements optimize human health and productivity. Kroon Hall draws inspiration from the Indoor Quality petal under Living Building Challenge Version 1.3 to form ideal spaces for productivity.

Kroon Hall earned all LEED WE credits and looks to optimize sustainable design by adopting concepts from the Water petal under Living Building Challenge Version 1.3. Net Zero Water requires 100 percent of occupants' water use to come from captured rainwater or closed loop water systems. (LBC 1.3). The second Water imperative, Sustainable Water Discharge, requires 100 percent stormwater and building water discharge to be managed on-site and integrated into water system (LBC 1.3). Kroon Hall may not satisfy Water imperatives in full, but the building uses a rainwater catchment system that is filtered on-site through constructed wetland and later enters a closed-loop water system that gets reused for non-potable water needs.

Kroon Hall serves as a model for the ILFI's Zero Carbon certification, which the organization published in 2018, as well as a recent trend toward decarbonization in green building and sustainability (Liljequist 2018). The ILFI Zero Carbon certification responds to the Zero Carbon concept released by Architecture 2030, the Rocky Mountain Institute, and the World Green Building Council issued in 2017 (Liljequist 2018). Zero Carbon certification acts as a first step toward Living Building Challenge certification (Figure 6). Kroon Hall's carbon neutral design indicates success in pushing beyond LEED toward a fossil fuel free, decarbonized future.

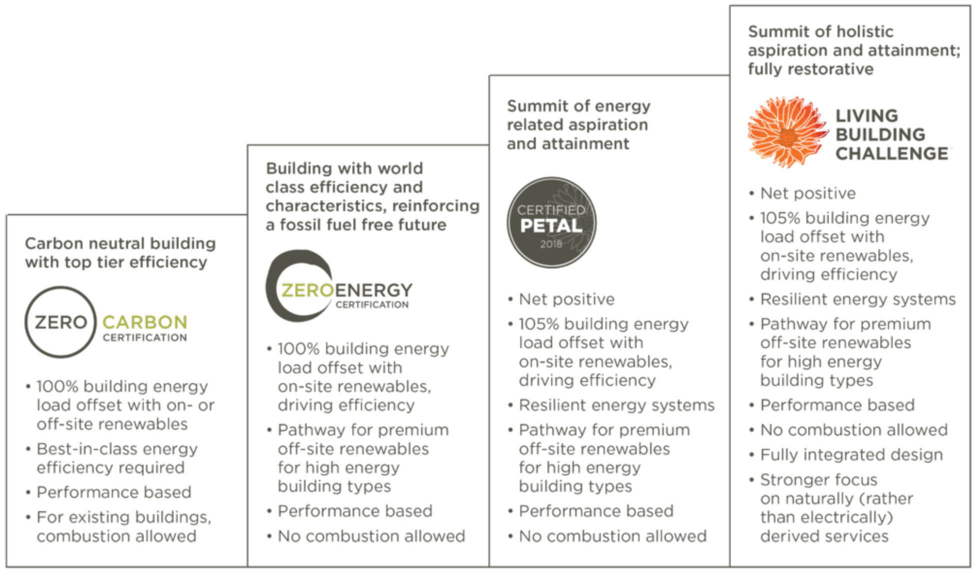

Figure 6. Hierarchy and associated attributes of the ILFI's energy certification levels. Image by Living Building Challenge, 2018.

The Sustainable Sites Initiative (SITES)

Background

The Sustainable Sites Initiative put forth the first version of SITES in November 2009, ten months after Kroon Hall opened its doors. SITES complements LEED with its site-specific approach to sustainable design for the design, construction and maintenance of sustainable sites, with or without a building (SITES v2). SITES-certified landscapes help decrease water demand, filter and reduce stormwater runoff, provide wildlife habitat, reduce energy consumption, improve air quality, and increase outdoor recreation opportunities (SITES).

Architects, landscape architects, designers, engineers, planners, ecologists and others use SITES to align land development and management with innovative sustainable design (SITES). Stakeholders modeled SITES after LEED with same structure of prerequisites and credits, with 48 credits amounting to 200 potential points (Philbin 2014, SITES v2). The system was developed to work with LEED to meaningfully integrate natural and built systems (Pieranunzi 2018).

Synergies exist between SITES and LEED and allow projects to earn corresponding points across rating systems (GBCI 2016, 2). Select SS, ID and MR credits under LEED v2009 earn equivalent SITES v2 credits, and some SITES credits earn SS, WE and ID credits (GBCI 2016). A long list of SITES credits account for an ID credit (GBCI 2016, 7-8). Connection between LEED and SITES strengthens integration and allows project leaders to efficiently address sustainable design of buildings and surrounding landscapes.

Living Building Challenge creates a greater emphasis on site sustainability in green building. Broader sustainability discourse shifts its focus toward regional sustainability as a means to address the local effects of climate change. Green building adopts this notion by encouraging designs that are responsive to a changing climate, specific to the region. A comprehensive site sustainability program results as a holistic design tool for sustainable landscapes. SITES provides guidelines to address site sustainability in ways that take into account landscape design and stormwater management within the context of the site, and thereby create sustainable landscapes that are responsive to suspected changes in precipitation, temperature patterns and more.

Influence on Kroon Hall

Kroon Hall's earned SS credits account for 20 percent of its total points achieved for LEED certification (Kroon Hall LEED scorecard). Kroon Hall transforms the fossil fuel-burning Pierson-Sage Power Plant that previously occupied the site into a LEED certified environmental education building, symbolizing a shift into a sustainable future and successful brownfield remediation.

Kroon Hall complies with requirements of several credits under SITES Site Context and Construction categories. The project's environmentally responsible material use and closed-loop water system contribute to site sustainability and consider relevant concepts of Site Design – Water and Site Design – Materials categories. Kroon Hall earned all LEED credits that substitute for SITES credits except MR credit three, Materials Reuse (GBCI 2016, Kroon Hall LEED scorecard).

Innovative sustainable design elements in Kroon Hall become integrated into the institutional identity of Yale through the University's Sustainability Plan, which came out in 2016 and sets goals for 2025. (Yale University 2016). The Plan focuses on environmental issues present in green building and the built environment, and implements ideas from Living Building Challenge and SITES. The University draws concepts of health and well-being, sustainable transportation, and responsible materials from sustainable design present in Kroon Hall (Yale University 2016). The building sets a legacy of sustainable design on Yale's campus, which plays into wider goals of sustainability and resilience on campus, ideas that play significant roles in recent green building and sustainability discourse.

New certification systems advance the field toward net zero energy building, carbon neutrality, and amplified standards for landscaping, water efficiency, materials, and other sustainable design factors. Such topics pervade green building and become increasingly evident in projects as they seek certification and adopt ILFI and SITES design concepts. The Robert Redford Conservancy for Southern California Sustainability and other modern green building projects display the highest levels of sustainable design as a result of new certification systems.

MODERN GREEN BUILDING

> "If there is one thing we know, it's that the future is going to have plenty of shocks. Living nonextractively does not mean that extraction does not happen... But it does mean the end of the extractivist mindset—of taking without caretaking, of treating land and people as resources to deplete rather than as complex entities with rights to a dignified existence based on renewal and regeneration."
>
> *– Naomi Klein, 2014*

Robert Redford Conservancy Background

Figure 7. Robert Redford Conservancy for Southern California Sustainability, Pitzer College. Photo by Pitzer College.

Conception of the Conservancy

Pitzer College established the Robert Redford Conservancy in 2012 with a commitment to connect Claremont Colleges students with faculty, alumni, scientists, policy-makers, artists, and other members of the local community (Figure 7) (Pitzer College 2015, 1). This collaborative space helps advance the longevity of Southern California's natural environment and facilitates action on Pitzer's commitment to sustainability (Pitzer College). The Conservancy facilitates an interdisciplinary and collaborative environmental education by creating a space for field-based natural science and Environmental Analysis courses, public outreach, and collaborations with Indigenous communities (Pitzer College). Project leaders focus on reenergizing and restoring the land, building and culture, as well as embracing low-impact design that works in harmony with nature (Pitzer College, Carrier Johnson + Culture 2016).

Pasadena architects Marston and Maybury originally designed the Conservancy's main building as an infirmary for Claremont Colleges students and opened its doors in 1931 (PR News Wire). The Claremont Colleges originally used the building as a 20-bed hospital until the 1960s when it was shut down due to establishment of more restrictive seismic code requirements for hospitals (Pitzer College). The building was firebombed in the 1970s as a part of a student protest (Pitzer College). The city and fire department declared the building unusable as a result, but the building's historic nature permitted it from demolition, leaving it boarded up from the late 1990s until renovation began (Pitzer College).

Discussion of a strengthened environmental studies program began in 2007 when the Claremont University Consortium (CUC) committee on new ventures was formed (Sarathy 2015). The committee decided establish an intercollegiate environmental studies program (Sarathy 2015). Pitzer College and Pomona College secured funding between 2009 and 2011 for a cooperative Environmental Analysis Program (Sarathy 2015). Pitzer College President Laura Trombley saw an opportunity to purchase and protect a portion of the north campus land (Sarathy 2015). She considered the idea to renovate the old Claremont Colleges infirmary as a site for the newly expanded Environmental Analysis curriculum given the site's proximity to the Bernard Field Station (BFS) (Sarathy 2015). Trombley presented a draft concept paper on the Redford Conservancy in 2010, which was endorsed by Student Senate and the board of trustees, and later approved by College Council (Sarathy 2015).

Planning and Design

The Conservancy's team design approach began in 2014 when Professor Lance Neckar, founding director of the Redford Conservancy, organized and facilitated two charrette sessions that involved 30 stakeholders (Sarathy 2015). The next Director of the Conservancy, Professor Brinda Sarathy, co-hosted a faculty forum with Director of the BFS Wallace Meyer in 2015 (Sarathy 2015). 22 stakeholders, who currently used the BFS or planned to do so in the future, considered ways to enhance the educational experiences of students in the space and methods to minimize the impact on the site's natural ecosystems (Sarathy 2015). Early charrettes and forums provided opportunities for Pitzer faculty and students and community members to provide feedback and create a space that served the needs of all its users.

Architects and engineers began working at the programming phase to implement smart, simple and cost-effective design decisions to achieve Zero Energy (ZE) and LEED Platinum goals (LBC). Integral Group was chosen to taken on roles of Project Manager, Mechanical, Electrical and Plumbing (MEP) Engineer, Lighting Design and Energy Modeling (ILFI). Carrier Johnson + Culture was selected as the project architect (ILFI). The Conservancy relies on the sun for its photovoltaic system, daylighting, natural ventilation and passive heating and cooling. The photovoltaic system mounted on the rooftop of outdoor classrooms generates on-site renewable energy (Pitzer College 2015, 43). Strategic window orientation and LED fixtures, occupancy sensors, and photo-cells are used to reduce power demands for electrical lighting (LBC). The Conservancy uses a passive heating and cooling system that operates using cross-ventilation, thermal chimneys and night-time air flushing, which results in a more efficient HVAC system and a decrease in the necessary size of the PV system (LBC).

Stakeholders aspired for a design that honors its locality and creates a sense of place. The project aims to promote longevity of Southern California's natural environment and establish a place that fosters connection with the land, the people, and with culture (Pitzer College, Pitzer College 2015, 1). Sustainable landscaping reduces water use, improves filtration, and promotes healthy waterways (Pitzer College 2015, 46). Restoration of natural vegetation and native plants reflects the site's natural character (Pitzer College, Carrier Johnson + Culture 2016). Outdoor educational spaces connect students and faculty to their natural environments, and biophilic design connects occupants to history, culture and geology of the place. The Redford Conservancy was renovated from Fall 2016 to Fall 2017, and the space opened for programming in Spring 2018 (Pitzer College). It earned LEED and Zero Energy certifications.

Precedent

Pitzer College, Carrier Johnson + Culture, Integral Group, and other stakeholders examined the most current green building projects on college campuses to design a building that adhered to the most advanced strategies in sustainable design. Managing Principal of Integral Group in Los Angeles, Andrew Reilman used his experience from previous work at the University of California, Berkeley to aid the Conservancy's energy efficiency. Prior experience allowed Integral Group to achieve their vision to naturally ventilate the Conservancy (Conversation with Andrew Reilman, Integral Group). Eshelman Hall's south side is entirely naturally ventilated with no cooling and uses heating from a campus-wide system (Conversation with Andrew Reilman, Integral Group). It uses operable windows and chimneys that release air from the building to reduce energy demand (Conversation with Andrew Reilman, Integral

Group). Prior experience inspired Integral Group to use similar strategies for passive design and natural cooling in the Conservancy.

The Charles L. Tutt Library serves as another precedent for the Redford Conservancy as a successful example of renovation in green building (Figure 8). Tutt Library opened in 2017 and has become quickly recognized as the nation's largest carbon neutral, net zero energy academic library (Mosher 2019). The Redford Conservancy adopts Tutt Library's vision to transform an existing building into a net zero, highly sustainable structure.

Figure 8. Charles L. Tutt Library, Colorado College, Photo by Colorado College, 2018.

Walter Netsch originally designed Tutt Library at Colorado College in 1961 (Pfeiffer Partners). In 2015, Colorado College commissioned Pfeiffer Partners to expand and renovate Tutt Library to reflect the changing values of the College and its signature academic program, the Block Plan, in which students take on class at a time intensively for three and a half weeks

(Pfeiffer Partners, Mosher 2019). Designers added nearly 38,000 square feet to the structure to create a 94,000 square foot library (Pfeiffer Partners).

The new building adds a more welcoming, locally inspired design to the original structure that reflected the dominant contemporary brutalist, introverted architectural style of the 1960s. The brick-colored cladding, which covers the ground floor and west façade, references geologic formations of the nearby Garden of the Gods (Mosher 2019). Addition of terraces and a fourth floor connect provides occupants with outdoor areas and sweeping views of Pike's Peak and the Rocky Mountains (Mosher 2019). Architects draw inspiration from Living Building Challenge's Place petal in its design that reflects the local Colorado landscape.

Pfeiffer Partners designed Tutt Library to establish a model of regenerative design, achieve net zero energy and adhere to the College's commitment to achieving carbon neutrality by 2020, making it the nation's largest (94,000 sf) carbon neutral, net zero 24/7 academic library (Caulfield 2018, Mosher 2019, Pitzer College 2019). Tutt Library is powered by a geothermal energy field on neighboring Armstrong Quad, a 115-kilowatt rooftop solar array, a 400-kilowatt offsite solar array, and a 130-kilowatt combined heat and power system (Alvarez 2017). Colorado College staff managed mechanical design of the geothermal walls and created a system that adopted sustainable design beyond LEED energy standards (Kelley 2017). The College claims that the building uses more efficient energy than any other library in the U.S. (Kelley 2017). Its carbon neutral plan goes beyond Barack Obama's Better Buildings Challenge, a plan to make commercial buildings 20 percent more energy efficient by 2020 (Alvarez 2017).

Tutt Library presents an example of successful renovation in green building. It follows the same model of net zero energy as the Redford Conservancy, except Tutt Library bypasses LEED and ZE certifications to avoid cost and implement project-specific sustainable design targets. Tutt Library's superior sustainable design sets the building apart from typical green buildings and uplifts it to a model in higher education and otherwise.

LEED and Zero Energy Analysis

The Robert Redford Conservancy achieved Platinum certification under LEED v2009 in May 2018 (Redford Conservancy LEED scorecard). Project leaders chose to certify the Conservancy under LEED's new construction given the project's major renovation. The Conservancy primarily considers elements of sustainable design that address climate resilience and decarbonization. The project takes a holistic approach to green building, but focuses on local environmental issues, responsible materials and energy consumption to achieve Zero Energy certification and mitigate greenhouse gas emissions.

Regional Priority Analysis

The most significant difference in LEED v2009 from the previous major version is the introduction of the Regional Priority category (LEED v2009). The addition of RP illustrates higher emphasis on local environmental issues in green building. It represents a transition toward climate resilience, in which green buildings pay closer attention to local sustainability as a means of preparing for anticipated effects of climate change in a given region.

The Conservancy aimed to address environmental issues of Southern California and well-being of its people since its inception. The project achieved three out of the four possible RP credits as a result. Project leaders took advantage of the local abundance of sunshine to produce solar energy on-site by installing PV systems on rooftops of outdoor classrooms, which supplies energy to the main structure of the Conservancy. Monitoring of PV system between January and

October 2018 displays consistently higher energy production than needed in the building (Pitzer College, Carrier Johnson + Culture). The Conservancy's siting in Southern California maximizes solar energy production and has allowed the building to receive the "On-site renewable energy" RP credit. The design team also optimized natural daylighting to reduce indoor lighting energy and costs. Operable windows allow for natural ventilation and lighting. The Conservancy earned "Daylight and views – Daylight RP" credit as a result. The green landscaping and natural gravel ground surfaces allowed the project to earn the "Heat island effect – nonroof" RP credit.

The Redford Conservancy was planned, designed and built with an emphasis in locality, both environmentally and socially. Its principles coincide with Pitzer's core values of social responsibility and environmental sustainability. Project leaders foresaw a re-energized landscape and a cultural restoration in which the land reflected Indigenous influence in academic courses and resource management collaborations (Pitzer College, Carrier Johnson + Culture 2016).

Materials and Resources Analysis

The Conservancy design team maintained the exterior structure to preserve its historical value, reduce demolition waste and maintain embodied carbon. Integral Group's Andrew Reilman sees the Conservancy's ability to sustain embodied carbon as one of the project's main successes, since green building professionals only began to consider embodied carbon and energy related to materials and resources in recent years (Conversation with Andrew Reilman, Integral Group). LEED v4.1 adds credits under the MR category to reward preservation of embodied carbon, including five new possible points from the rating system's previous version, LEED v4 (LEED v4, LEED v4.1). The MR category now accounts for 18 out of 110 possible points (16 percent) from 13 out of 110 (12 percent) in LEED v4 (LEED v4, LEED v4.1).

Addition of MR points results in fewer points under SS, WE and EA from the last version (LEED v4, LEED v4.1). The USGBC's vision for MR comprises three strategies: reduce embodied carbon, protect human and ecological health, and advance the circular economy (Hughes 2019). The MR category works to both mitigate and adapt to climate change by better addressing carbon emissions and protecting building occupants from the effects of climate change.

The USGBC revised Building Life-Cycle Impact Reduction and Building Product Disclosure and Optimization (BPDO) credits in LEED v4.1 to increase accessibility of carbon mitigation techniques for different project types and scopes (LEED v4.1). The Building Life-Cycle Impact Reduction credit was revised in the newest version of LEED to strengthen credit requirements for embodied carbon reductions (LEED v4.1, Hughes 2019). The USGBC edited Option 3, Building and Material Reuse, to include two paths for project teams to reuse and salvage building materials (Hughes 2019, LEED v4.1). Project teams can either maintain a combination of structural and non-structural elements to gain two to four credits, or can maintain certain percentages of existing walls, floor and roofs to earn one to three points (LEED v4.1). The USGBC restructured the fourth option, Whole-Building Life-Cycle Assessment to include four pathways to achieve credits.

The USGBC updated the Building Product Disclosure and Optimization (BPDO) credits in LEED v4.1 to increase accessibility for diverse project types while continuing to reward selection of building products with reductions in global warming potential and embodied carbon (Hughes 2019). Option two under BPDO, Multi-Attribute Optimization, was revised under LEED v4.1 to expand criteria of adherent products and materials (LEED v4.1). The USGBC broadened compliance options to include Life Cycle Impact Reduction Action Plan, which provides an action plan to mitigate or reduce life cycle impacts, and Life Cycle Impact Reduction in Embodied Carbon, products that demonstrate environmental impact reductions in global warming potential and embodied carbon (LEED v4.1).

LEED v4.1 emphasizes embodied carbon reductions through building reuse, salvage, whole building life cycle assessments and Environmental Product Declarations (EPD) (LEED v4.1). Addition of multiple pathways under MR credits provide project teams with more accessible pathways to make sustainable material and product choices. LEED v4.1 draws a stronger connection between materials and energy by placing increased focus on embodied carbon and rewarding products with low global warming potential. The USGBC reallocated points from EA to MR to broaden the scope of energy consumption and efficiency. Changes in LEED v4.1 provide diverse ways to achieve credits and a wider lens of sustainability that matches developing standards in green building.

The Conservancy is a stellar model of sustainable design that pushes the field forward through its efforts in addressing local environmental issues in Southern California and demonstrating the feasibility and benefits of renovation in green building. Carbon sequestration and responsible material use lowers the project's carbon footprint and demonstrates efforts toward a decarbonized future.

Energy and Atmosphere and Zero Energy Analysis

The Redford Conservancy's focus on energy led the project to earn 33 out of 35 possible points for EA and ZE certification from the ILFI (Redford Conservancy LEED scorecard, ILFI). The design team implemented the most advanced and strategic energy systems to reenergize a formerly abandoned and decrepit building into a ZE building. Passive cooling, daylighting and natural ventilation reduce energy consumption, allowing rooftop photovoltaic arrays on outdoor classroom rooftops to produce all building needs.

Project leaders installed skylights as the primary source of lighting. Two skylights are placed on rooftops of the central hall, immediately through the doors of the building's front entrance (Integral Group 2018). Operable, sloped north facing skylights exist on rooftops of the Art Classroom and Science Classroom (Integral Group 2018). Daylighting modelling shows significant differences when comparing the central hall with two skylights and without skylights (Figure 9) (Integral Group 2018). Without skylights, modelling displays illumination levels between 10 and 40 foot-candles, whereas the model with two skylights shows levels up to 200 foot-candles (Integral Group 2018). Integral Group created models in September during clear sunny skies, and in December with overcast skies (Integral Group 2018). Differences in weather most likely impacted the results, however, high variances in illumination levels suggest the value of skylights and natural daylighting in replacing electric lighting.

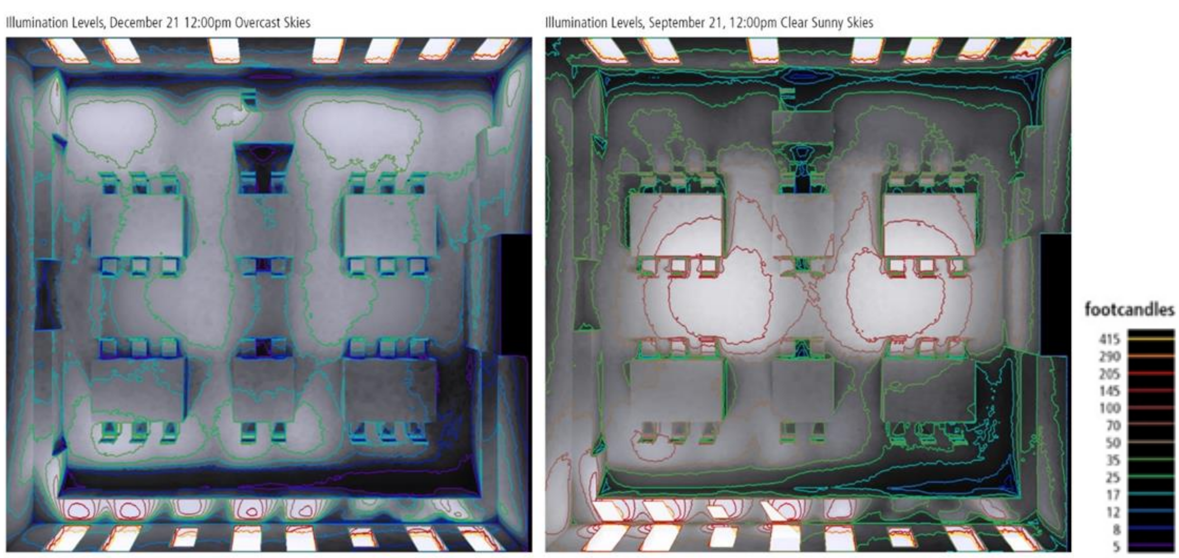

Figure 9. Daylight illumination levels without skylights (left) and with skylights (right). Models by Integral Group, 2018.

LEED baseline projects have annual energy use intensities amounting to nearly 35 kBtu/sf, while the Conservancy has an annual energy use intensity of just over 25 kBtu/sf (Pitzer College, Carrier Johnson + Culture). PV arrays consistently generate net positive production. In 2018, the PV system generated 83,000 kWh and provided over 62,000 kWh to the grid (Pitzer College, Carrier Johnson + Culture). Project leaders made concerted efforts to design a place that addressed local environmental issues and took advantage of regional factors such as solar abundance.

Pitzer College presented Integral Group with the challenge of renovating a building that had been boarded up since the late 1990s into a living, net zero energy building. At the time of certification, the Conservancy became the first ZE Certified higher education building in California, the fourth ZE Certified higher education building in the world, and the fifteenth ZE Certified project in California (Pitzer College 2019). This project creates a new standard of energy in green building that goes beyond LEED and demonstrates feasibility of building a net zero energy structure. It helped initiate a recent movement in the green building field that emphasizes decarbonization at the forefront of sustainable design. The project serves as inspiration for other colleges and universities to push their idea of green building forward and create buildings that further enhance productivity and collaboration of their students.

Legacy and Influence

Pitzer College's transformation of an 80-year-old building demonstrates the possibility of driving the same or higher sustainability results through renovation rather than new construction. The Conservancy also spearheads a movement toward net zero energy in institutions of higher education. Dana Hall at Dartmouth College seeks to achieve net zero energy certification as a key component of its building design and sustainability efforts. University of California, Merced broadens the limits of net zero energy through its Triple Zero Commitment, an all-campus pledge to consume zero net energy, and produce zero waste, and generate zero net greenhouse gas emissions by 2020 (UC Merced). Case study projects illustrate the most advanced modern forms of green building on college campuses, and the University of California's Environmental Sustainability plan presents strategies to make similar sustainability efforts on a wider scale.

Dana Hall, Dartmouth College

Figure 10. Rendering of Dana Hall, Dartmouth College, Rendering by Leers Weinzapfel.

Dana Hall at Dartmouth College follows in the footsteps of Tutt Library and the Redford Conservancy through its major renovation into a sustainable net zero energy building (Figure 10). The college has decided to renovate the 33,000 square foot, 1960s building to provide a location for the Guarini School of Graduate & Advanced Studies, creating space for faculty offices and workspaces, teaching and conference spaces, a graduate student lounge, and a café with a seating area and outdoor terrace (Campus Services). Construction began in September 2018 for the building's expected opening for the 2020 Winter Term (Malone 2018).

Design plans call for Dana Hall to be completely gutted in order to replace all mechanical, electrical and plumbing systems (Boutwell 2017, Campus Services). The project took the same approach to renovation as the Conservancy, as it restructured the building interior and maintained much of the exterior structure and building façade. Dana Hall uses highly effective strategies to reduce the building footprint within a limited construction budget, illustrating the economic feasibility of building sustainable, net zero energy structures without increasing construction costs.

University of California Environmental Sustainability Plan

The University of California system has achieved LEED certifications in over 100 buildings across its campuses, and the University of California, Merced has become the only campus in the country to earn LEED certification in 100 percent of its buildings (University of California 2013, 11). The University of California is the nation's leading university for green building and has approached sustainability through setting goals for conservation, water efficiency, renewable energy and sustainable food. (University of California 2013, 5). The campuses have pledged to cut greenhouse gases to 1990 levels by 2020, a fifty percent reduction (University of California 2013, 5).

UC Merced pledges to be net zero in emissions, energy use and waste by 2020. The campus's zero net energy project has similar goals to the Redford Conservancy, Tutt Library and Dana Hall, but UC Merced aims to achieve that target on a much wider scale. The Chancellor's Advisory Committee on Sustainability (CACS) and the Department of Sustainability (DOS) at

UC Merced initiated a planning process to standardize sustainability initiatives on campus (Ortiz 2018). The group participated in several workshops to develop a consistent sustainability definition and identify the committee's vision and mission (Ortiz 2018). The new Sustainability Strategic Plan was developed from these workshops to provide an overview of campus sustainability goals through 2022 (Ortiz 2018).

The campus pledges to follow guidelines of a Triple Zero plan as a part of its sustainability goals, committing to consume zero net energy, and produce zero waste and zero net greenhouse gas emissions by 2020 (UC Merced). Implementations of the Triple Zero Plan include enhancement of the campus's solar array, more recycling and composting bins, and reduction of greenhouse gas emissions through landscaping, smart energy use, and transportation systems (UC Merced). Improving sustainability continuously improves student engagement and environmental stewardship as on-campus organizations and initiatives such as a Carbon Neutrality Initiative and Global Food Initiative which continue to grow and seek student members (UC Merced). The University's Sustainability Strategic Plan and Triple Zero Plan act as models for sustainability on college campuses and illustrate ways to reach results of the Redford Conservancy, Dana Hall and Tutt Library on a broader scale.

UC Merced's holistic campus-wide sustainability standards demonstrate increasing importance around decarbonization in sustainability, as goals for waste, energy and greenhouse gases all relate to reducing carbon emissions. Kroon Hall's carbon neutral design helped initiate a transition toward decarbonization, and the Redford Conservancy initiated a trend toward zero energy design, as well as addressing local environmental issues to protect occupants from expected climate change effects in Southern California. Shifts in green building discourse and criteria, and changes in discourse in sustainability more generally, demonstrate a future of green building grounded in decarbonization.

Future of Green Building

Case studies in green building and updated sustainable design rating systems show the field moving toward decarbonization, net zero programs, and generally, a more holistic approach to green building. The Georgia Institute of Technology is currently constructing the Kendeda Building, a highly sustainable model of green building that exemplifies trends currently gaining momentum in green building. Increasing popularity of Living Building Challenge and ILFI certifications continue to gain popularity and promote peak performance of sustainable design. Updates to LEED and introduction of LEED Zero play crucial roles in guiding green building into a decarbonized future and making concepts in Living Building Challenge more accessible to various project types.

The Kendeda Building

Colleges and universities nationwide continue to adopt sustainability into their institutional identities in the same way that Pitzer College defines itself in part by its core value of environmental sustainability. The Kendeda Building for Innovative Sustainable Design at the Georgia Institute of Technology advances the field as one of the first Living Building Challenge certified buildings in higher education (Figure 11). The Redford Conservancy serves as a precedent for the Kendeda Building as one of the original Zero Energy certified higher education buildings in the world.

Figure 11. Rendering of the Kendeda Building, Georgia Institute of Technology, Rendering by Miller Hull Partnership in collaboration with Lord Aeck Sargent, 2017.

The Kendeda Fund has committed to a 30 million dollar investment to fund construction of the Kendeda Building (Georgia Tech). The new building will support education and research and include classrooms, labs, maker space, offices and an auditorium (Draper et al. 2018). The university chose Lord Aeck Sargent and The Miller Hull Partnership to design the project and Skanska USA to build the approximately 47,000 square feet structure (Georgia Tech).

Georgia Tech expects the building to become the most environmentally advanced education and research building ever constructed in the Southeast, as well as one the first Living Building Challenge v3.1 building of its size and function in the region (Georgia Tech). Living Building Challenge certification supports Georgia Tech's educational missions, regenerative philosophy and its efforts in positive social impact (Draper et al. 2018). The Kendeda Building aims to publicly open and begin classes in January 2020 and gain certification in 2021 after 12 months of consecutive performance after full occupation. Upon successful certification, the Kendeda Building will inspire projects on college campuses to pursue more advanced green buildings, Living Building Challenge certification, and other ILFI certifications, thereby demonstrating feasibility of Living Building Challenge and advancing standard of green building at colleges and universities nationwide.

Future of LEED

The most updated version of LEED provides a look into the future of green building. The USGBC published LEED v4.1 as an update to LEED v4 in 2019 and a new certification program, LEED Zero, in 2018 (USGBC). LEED v4.1 and LEED Zero make updates that increase energy benchmarks in a holistic way and more strongly emphasize decarbonization.

LEED v4.1 makes changes under EA and LT categories to increase energy benchmarks and make energy credits more accessible to projects. LEED v4.1 adds pathways for the Renewable Energy credit to include broader options for energy procurement (LEED v4.1). LEED adds four options for off-site renewable energy generation to ensure clean energy is accessible to all projects, such as ones with no solar access and therefore no means of generating energy on site (LEED v4.1). The updated Electric Vehicles credit allows for installation of charging stations and adds an option for electric vehicle charging infrastructure (LEED v4.1).

LEED v4.1 updates MR credits to more holistically address carbon reduction and energy efficiency. LEED updates Building Life-Cycle Impact Reduction to encourage building reuse and renovation, which encourages maintenance of sequestered carbon (LEED v4.1). It adds pathways to each option to increase accessibility of reuse among all projects. LEED v4.1 adds Life Cycle Impact Reduction in Embodied Carbon to the Multi-Attribute Optimization option to encourage carbon sequestration, building and material reuse, and ensure carbon reduction is addressed whenever possible in LEED v4.1 (LEED v4.1). Notable modern green building projects take a holistic approach to reducing greenhouse gas emissions by responsibly selecting materials, installing green energy systems and encouraging building occupants to drive electric vehicles or use sustainable means of transportation.

The ILFI originally introduced net zero energy programs to reduce carbon emissions. Such programs exist in Living Building Challenge's Net Positive Carbon imperative and the Zero Energy certification (LBC 4.0). The USGBC recently established LEED Zero to create a rating system that takes LEED buildings to the next level by recognizing zero energy, carbon, water and waste (USGBC). LEED Zero complements LEED certification to expand building sustainability and debunks LEED Platinum as the program's most rigorous certification. The USGBC adopts Living Building Challenge's 12 month review period in LEED Zero, requiring project teams to present a year's worth of data providing zero impact before issuing certification (USGBC). LEED Zero reinforces Living Building Challenge's attempt to push the market toward net zero strategies. It will play an integral role in making net zero practices commonplace in green building.

CONCLUSION

Recognition of anthropogenic climate change, fears of peak oil, air pollution and other environmental concerns led to the beginning of an environmental movement in the 1960s (Sinha 2009, 91). Early attempts to design environmentally responsible buildings presented alternatives to traditional building techniques. New examples of sustainable architecture used a triple bottom line approach and addressed relevant environmental concerns primarily by implementing clean energy sources and increasing energy efficiency. Cities and states established green building standards in the 1990s to help promote sustainable design practices and create a definition for green building (Cordero 2001, 26-27).

Such attempts to systematize green building ultimately led to the creation of LEED. The comprehensive green building system has transformed loosely defined ideas of environmentally responsible and sustainable architecture into an established set of guidelines that determine a project's level of sustainability. LEED v2.0 successfully transformed the market and continues to define the green building field with each new major version. LEED drove the market on its own until certification systems, Living Building Challenge and SITES, launched to offer new perspectives. LEED, however, remains the most popular green building rating system in the world.

The ILFI introduced Living Building Challenge as an expansive system that raises quantitative benchmarks of green building and adds qualitative standards. Living Building Challenge alters sustainable design thinking through three concepts never before implemented into green building rating systems. The Health + Happiness, Beauty and Equity petals respond to oppositions between humans and the built environment. The ILFI intends to create a connection between living buildings and their occupants that encourages compassion for sustainability and the natural environment. The Beauty petal reacts to the industrial, bleak buildings present in our society by promoting building design that emphasizes a connection to place, climate, culture and community (LBC 4.0).

The Adam Joseph Lewis Center, Kroon Hall, and the Robert Redford Conservancy create models of biophilic design that serve to remedy tensions between humans and the built environment. Case study projects draw inspiration from the program's beautiful and biophilic design concepts. All three case projects implement biophilic design elements that not only increase human health and productivity, but also instill ideals of preservation and conservation into the minds of its occupants. ILFI sees beautiful and biophilic design as a precursor for these environmental ideologies (ILFI).

Living Building Challenge remains the most strict green building rating system in the world. Its stringent imperatives, high building costs and lack of accessibility keep the majority of green building projects from pursuing Living Building Challenge certification. Two founders of green building consulting firms based in Los Angeles, Vincent Bataoel and John Zinner, reaffirm that Living Building Challenge and other ILFI certifications lack the economic feasibility and scalability present in LEED (Conversation with John Zinner, Zinner Consultants; Conversation with Vincent Bataoel, Above Green). The ILFI introduced Petal certifications and net zero programs to allow projects to maximize sustainability in one or more areas of sustainable design. The popular Zero Energy certification faces issues of scalability, as smaller buildings such as the Redford Conservancy can adopt a zero energy design much more easily than a larger building can (Conversation with John Zinner, Zinner Consultants; ILFI). Living Building Challenge caters to green building projects aiming for peak performance, ruling out most of the market (Conversation with Vincent Bataoel, Above Green). The system, however, remains a major part of green building discourse as it continues to advance sustainable design thinking, introduce new perspectives to green building, and drive the market toward higher standards of sustainability.

The ILFI introduces Zero Energy and Zero Carbon certifications that encourage projects to consider energy and carbon more intently and address sustainable design beyond LEED certification. Early green buildings dealt with energy efficiency in reaction to an ongoing energy crisis and as a means to mitigate climate change. ILFI certification programs and modern green building projects such as the Redford Conservancy demonstrate a shift in green building discourse toward decarbonization, using a more holistic approach to energy consumption, material selection and other factors. Changing lexicon in green building is reactionary to an uncertain future of climate change. Zero energy and carbon neutral design help projects create long-lasting, self-sufficient, and climate resilient buildings that are responsive to the uncertain yet inevitable effects of climate change in the future.

Society will increasingly push for more resilient buildings and cities as the effects of climate change increasingly impact the lives of humans. LEED and Living Building Challenge will continue to make updates that holistically address decarbonization. Systems will likely analyze projected climate change effects in specific regions and make updates to the Regional Priority category in LEED and the Place petal in Living Building Challenge to best address resilience in varying climates. The green building field is likely to develop according to shifting sustainability discourse to react and adapt to the most pressing environmental issues, and will therefore continue to stress decarbonization and locality in rating systems and projects.

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