Living Building Challenge

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TABLE OF CONTENTS

I. Acknowledgements

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II. Abstract

The green building business is a rapidly growing industry. Currently, popular green building rating systems such as BREEAM and LEED are simply not stringent enough. The Living Building Challenge, a relatively new rating system has raised the standards of sustainable buildings. The Living Building Challenge provides incentives and knowledge for the construction of Net Zero Water and Energy Buildings. The LBC has a list of 20 imperatives that the building has to meet, and certification is only given 1 year after occupancy. This paper also discusses the Omega Center located in Rhinebeck, New York, which is one of the buildings that has achieved LBC and LEED platinum certification. This building acts as an educational center and wastewater treatment center for the entire OCHL campus. Although LBC is an improvement to BREEAM and LEED, it is also a work in progress. It is a rating system that is hard to scale up, and hard to apply to buildings in cities. As it is improved on and rewritten every couple of years, its improvements may lead to a necessary change in the green building industry.

III. Introduction

The world we live in today has seen unprecedented growth. We are a global economy of seven billion people and counting. The average life span has almost doubled, extreme poverty is decreasing, and technology is vastly changing the way people live. We are heading into uncharted waters. Global temperatures continue to rise, climate change causes severe weather fluctuations, and every major ecological system is in decline. In the United States, the building sector is responsible for almost half (44.6%) of our CO2 emissions. To dramatically reduce this figure we, as architects and designers, need "to transform how we think about every single act of design and construction as an opportunity to positively impact the greater community of life and the cultural fabric of our human communities (Living Building Challenge 3.0)." The Living Building Challenge (LBC) is a building certification system that takes the notion of a "green" building to another dimension. LBC creates a framework for a building to not only do less harm to the environment, but allows a building to be truly regenerative and self-supporting.

IV. Background

The Living Building Challenge is a strict green building guideline that buildings can strive to achieve. It was established in 2006 by the International Living Future Institute, a nonprofit based in Portland, Oregon. The program was created by Jason F. McLennan, the current CEO with Amanda Sturgeon and Bob Berkebile from BNIM Architects. The challenge was originally a program launched by the Cascadia Green Building Council, which is part of the USGBC and CGBC. (living-future.org) LEED is also owned by USGBC. In comparison to other green building assessments, LBC is far less widely known. Nonetheless, there are almost 300

projects that have been registered with LBC, and 25 have been certified[1]. BREEAM and LEED are the most popular green building assessments used today. BREEAM is the earliest standard for green building and was launched in 1990 by the Building Research Establishment, which was formerly part of the United Kingdom's government. (BREEAM, 2016) BREEAM has issued over 540,000 certificates in 73 countries around the world. 2,233,484 buildings have been registered with breeam. LEED was established in 1994 in the United States, and has nearly 69,000 commercial buildings certified under its system. (Long, 2016) Both programs are significantly older than LBC, but have a lot to learn from LBC. Green buildings receive significantly large amounts of benefits. "Roughly 170 cities give LEED builders tax breaks, grants, expedited permitting or waivers allowing them to construct larger buildings than local law allows" (Orr, 2). LEED and BREEAM have created a foundation for green building, and this has allowed LBC to have a solid foundation.

BREEAM and LEED standards are constantly being rewritten and improved. On April 3rd of 2015, the U.S. Green Building Council allowed the LBC's requirements for energy and water to be recognized within LEED's program. Rather than becoming programs that compete with each other, Scott Horst said "What matters is that people are doing good environmental work. We want to focus on them and create harmonization between systems." He also believed

[1] Registered LBC projects are in the process of being approved. Certified projects have been approved by the LBC team.

that “The Challenge plays an important role on the green building performance curve and is a complement to LEED.” (Long, 1) When BREEAM began, it was government funded, whereas both LEED and LBC were established by non-profits. BREEAM’s key advantage is for buildings constructed in the UK. BREEAM uses legislation and standards already established by the government, which makes it the preferable rating system in the UK. LEED is tailored to the US American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) standards. LBC is a very flexible standard that has a rating system that changes according to where the building is being constructed. This allows the design of the building to be more reactive to the environment.

V. Certification

Living Building Challenge has three different certification options, the living building certification, the petal certification, and the net-zero certification. LEED’s certification is built on four categories, from certified to platinum. BREEAM has 6 standards, from Unclassified to Outstanding. Of BREEAM and LEED, BREEAM is more stringent in its regulations. BREEAM requires energy standards to meet a certain amount whereas LEED allows the building to rely on a reduction of energy usage based on percentages. The difference in the rating systems is seen in buildings that have been certified by both BREEAM and LEED. The University of Cyprus campus building, achieved a Gold rating for LEED, but only a Very Good for BREEAM. “The results of the energy efficiency evaluation process according to iSBEM-cy, classified the building in the energy class "C" indicating an annual consumption of 341 KWh / m2 per year.” (Polychronidou, 1) BREEAM’s rating system is classified with percentages, whereas LEED uses points to determine the category of the building. The problem with LEED as well as

BREEAM is that the rating system is unweighted, which allows for the designer and client to "play the system" and choose options that are not the most effective, but the cheapest. LBC doesn't allow this. For a Living Building Certification, all the categories must be met.

BREEAM	**LEED**	**LBC**
Unclassified < 30%	Certified 40 – 49	Net Zero Energy (Energy Requirements - at 100%)
Pass ≥ 30%	Silver 50 – 59	Petal Certification
Good ≥ 45%	Gold 60 – 79	Living Building Certification - All 20 Imperatives
Very good ≥ 55%	Platinum ≥ 80	
Excellent ≥ 70%		
Outstanding ≥ 85%		

For the Living Building Challenge, each project that registers for certification is required to follow seven areas of performance or "petals": Site, Water, Energy, Health, Materials, Equity and Beauty. Rather than going through a checklist - like LEED or BREEAM, LBC instead allows the architect and designers to innovate to best meet each category. Each building has sustainability catered to the project rather than following a checklist. LBC focuses more on the end performance of the building than the process. Unlike LEED and BREEAM, LBC's

guidelines don't provide a list of steps to become "green", because not all steps can be used for certain buildings. The designers have to make the project function correctly. This allows LBC to be more flexible than LEED and BREEAM, and the guidelines can be applied to a wide variety of building and infrastructure construction including; renovations, new buildings, communities, infrastructure and cities.

BREEAM	**LEED**	**LBC**
Energy	Energy and Atmosphere	Energy
Materials	Materials and Resources	Materials
Innovation	Innovation & Design	Beauty
Waste		
Pollution		Equity
Health & well being	Indoor Environment Quality	Health
Water	Water Efficiency	Water
Transport	Regional Priority	
Management		
Land Use and Ecology	Sustainable Sites	Site

The seven "petals" of the Living Building Challenge are sub-divided into twenty Imperatives. These twenty categories can be applied to almost every form of building construction, new or existing, landscape or infrastructure and of any scale and climate. One very

important distinction for LBC from other certification systems is that it is based on actual performance. Each imperative is mandatory for the Living Building Certification, while some categories for LEED and BREEAM are optional. The problem with LEED is that with the points system, and the lack of a sufficient amount of prerequisites, it is possible to have a low performance LEED certified building. Unlike LEED and BREEAM, which rely on the designer for projected energy and performance standards, LBC does an evaluation of the physical building and takes real world measurements of the buildings performance. LBC will only start these building evaluations no earlier than 12 months after it has been occupied and operational. Only after this evaluation is the building certified. Living Building Challenge does this for two reasons. The first is to ensure that the real world performance of the building is the same as the architect's projected performance. The second is to ensure that the building is well built and can stand the test of time without any hindrance to its performance.

In comparison, LEED and BREEAM design buildings with theoretical energy savings. There is no penalization for a building that doesn't meet the projected energy efficiency, an improvement that is greatly needed in each of these assessments (williams.edu). A national post-occupancy assessment, done by the GSA (General Services Administration) Public Buildings Service, found that buildings that were certified with a green organization: used less energy, had lower maintenance, costs, had higher occupant satisfaction, and had lower carbon emissions. (Assessing Building Performance). Unfortunately, this is only one assessment. In a study by Scofield, he examines over 7,000 LEED buildings to examine reductions in water and energy usage. He finds that, " the average energy consumption by LEED certified buildings is actually higher than the corresponding average for the US commercial building stock." (Orr, 3).

In other cases, although the building was more efficient than similar buildings, the constructed buildings did not perform to projected efficiencies, and many showed an increase of use of energy as each year passed. According to Alborza, "The average water consumption of LEED halls was 60% higher when compared to their LEED PDCs. The data showed yearly decreases in savings, rendering LEED halls less sustainable every year." [2] (Alborza, 3) In another study, a man named Henry Gifford investigated a LEED certified building's energy performance. "He was shocked by the small sampling of built projects (121 buildings volunteered by their owners) to support the claim and by lack of rigor used in calculations. When Gifford analyzed the same sampling, and applied appropriate rigor, results indicated that the same buildings actually used "29% more energy than the most similar buildings in the dataset that the study authors chose to use as a comparison" (Orr, 1). This data shows the problems associated with LEED certification, and using percentages instead of set amounts of allowable energy usage. A post occupancy study is essential to discover mistakes in design, and assess possible renovations to create a more efficient building.

The Living Building Challenge provides three different pathways to certification. This allows LBC to accommodate a wider variety of budgets and other real world building restraints. For net zero energy certification, one hundred percent of building's energy reliance needs to be provided by on site renewable energy. No combustion energy processes are allowed. This is based on Imperative 06, Net Positive Energy, however it is reduced from 100 and 50 percent (respectively required for petal and living) to hundred percent. The other three required imperatives are 01, Limits to Growth, 19, Beauty + Spirit, and 20 Inspiration + Education. The

[2] According to a post occupancy study of residence halls for universities, LEED rating systems tend to overestimate energy and water savings, and occupant behaviors are poorly considered in the rating system

next level is LBC's mid-range certification, Petal. Petal Certification requires that at least three out of the seven petals must be completed. One of these three must include either the Water, Energy, or Materials Petal. Imperatives 01, Limits to Growth and 20, Inspiration and Education are also mandatory. Lastly is the Living Certification, the crown jewel of sustainable architecture. LBC sees this as the ultimate destination for a truly regenerative building and encourages all designers to achieve Living Certification. The requirement for this certification is all twenty of the Living Building Challenge's Imperatives. In contrast, LEED and BREEAM have 43 and 76 criteria. These criteria are much more specific and less rigorous than the imperatives followed by LBC, and of these criteria only 27 are mandatory for BREEAM and 28 for LEED. Some of these criteria for LEED include: Amount of insulation, High efficiency windows, Moisture Control, Surface water management, and non-toxic pest control.[3] This rather prescriptive set of steps confine the designer to think a certain way: to use low flow water fixtures, to put in fluorescent lights rather thinking about how to recycle water or maximize the light coming into the building.

VI. Living Building Challenge Imperatives

The Living Building Challenge loves to use the follow phrase in its literature, "If you can imagine it then it can likely be a Living Building with the right application of strategies, technologies and imagination." This is LBC's way of saying that any building can be a Living Building. Finished projects and projects currently pursuing certification include: single family, Multi-family, Government, Educational, Religious, Commercial, Healthcare, and Historic. LBC

[3] These categories have a point value allocated to each category. The larger categories i.e. Sustainable sites require a certain amount of points to be achieved.

is not only versatile in what type of building can be built but also where a building can be constructed. LBC projects can be built in any climate zone around the world. There are currently projects underway on four different continents. Because LBC's criteria is performance based, "the guiding principles and performance metrics apply well regardless of where in the world the project is located (Living Building Challenge 3.0)." When comparing a certified building in Alaska and a certified building in India, their heating and cooling strategies will be completely different as well as the building skin and infrastructure. However, in the end, the building performance must cohere with the universal standards of the Living Building Challenge. The flexibility of LBC is where LEED and BREEAM fall short.

In order to design the best strategy for building, LBC has divided the site settings into 6 categories. Based on density, these categories allow the architect to more accurately design for the building's surroundings. These categories make up The Living Transect and are applied to a few of the Imperatives of LBC. The goal of The Living Transect is to "promote the transition of suburban zones either to grow into new urban areas with greater density, or to be dismantled and repurposed as new rural zones for food production, habitat and ecosystem services." Acknowledging the site, and trying to change and develop what the site is rather than just placing requirements for what they can and cannot do on the site, as is seen with LEED and BREEAM brings a new measure of growth and future for the site.

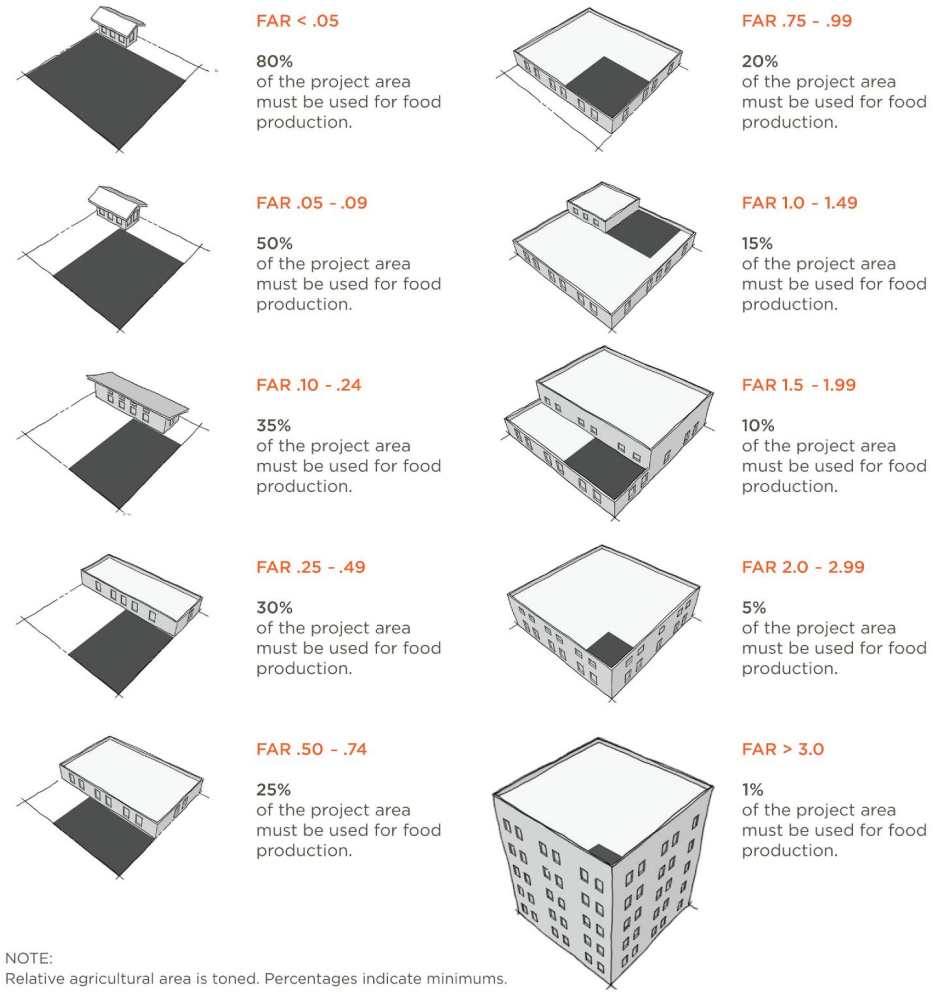
The first zone is L1, the Natural Habitat Preserve. This is the most rural zone, and is "comprised of land that is set aside as a nature preserve or is defined as sensitive habitat." Land in this zone may not be developed except in circumstances pertaining to the preservation of the natural landscape. The second zone, L2, is the Rural Agriculture Zone which is categorized as

land primarily used for agriculture and other food production services. The last four zones are all mixed-use zones and are divided by their appropriate density. L3, Village or campus zone is for low density and is used for rural towns. L4, General Urban Zone is categorized as light to medium density found in small towns and the outskirts of larger cities. L5, Urban Center Zone is comprised of medium to high density found in small to mid-sized cities or in the "first ring" of large city. The Last Transect is L6, Urban Core Zone which can be found in high to very high density areas in metropolitan areas.

Buildings that have been certified by the Living Building Challenge live "off the grid." These projects must generate their own electricity and dispose of their waste. This self-sufficiency plays a key role in LBC's goal. However, LBC acknowledges that in certain cases that the efficiency of infrastructure is greater at a larger scale. The efficiency of green infrastructure depends on a variety of factors, including technology, environmental impact, first cost, and operating costs. As response, LBC allows what they call Scale Jumping. This permits "multiple buildings or projects to operate in a cooperative state—sharing green infrastructure as appropriate and allowing for Renovation or Building status to be achieved as elegantly and efficiently as possible." (Living Building Challenge 3.0)

The first Petal of the Living Building Challenge is titled 'Place.' Under this section there are four separate Imperatives titled: Limits to Growth, Urban Agriculture, Habitat Exchange, and Human Power Living. The objective of this Petal is to safely assimilate the built environment with the natural environment. Modern humans are always looking to expand their territory. We "value the untouched site more than the secondhand site." Instead we must design for healthy levels of density, connected communities, and a walkable future.

The first Imperative, Limits to Growth clearly articulates where new development is permitted, or how to restore a place that has already been developed. This sections aims to slow the suburban sprawl that keeps increasing its footprint into sensitive ecological zones. Projects may only be built on previously developed sites such as greyfields and brownfields. Buildings that wish to meet the criteria of this Imperative also cannot be built near any of the following ecological zones: Wetlands, primary dunes, old-growth forest, and virgin prairie. The LBC also restricts building on prime farmland or any land that is within the 100-year floodplain. The second Imperative is called Urban Agriculture and its intent is to reinforce the link between humans and our food supply.



There is no place in a sustainable society for globally sourced food. Local agriculture is key to a sustainable society. Every project must provide opportunities for agriculture production based on

scale and density, using Floor Area Ratio (FAR).An example would be a project with a .10 - .24 FAR needs to provide at least 35% of that area to accommodate agriculture.

The third Imperative is Habitat Exchange. This imperative is done in collaboration with the Living Habitat Exchange Program. The goal of this section is to "expand existing thriving wilderness areas and protect them from destruction caused by development and building material extraction." The requirements are simply put that for each hectare of development the same amount of land must be set aside in accordance with the Living Habitat Exchange Program or an approved Land Trust organization.

The fourth and last imperative under the Place Petal is titled Human Powered Living and is arguably the most important category. "A truly walkable, pedestrian-oriented community is the most democratic and socially just, allowing people of all ages access to the services they require, whether they can drive or not." - Jason F. McClennan The goal of Human Powered Living is to reduce our transportation linked carbon footprint by empowering compact and connected communities that enable residents to lead a happy and healthy lifestyle without the need for a car. Each new Living Building should aim towards the creation of pedestrian friendly communities and should not at all limit human mobility. Existing building may not lower the density from the previous building. All projects, except single family homes, should provide secure storage for 'human powered vehicles' (bicycles, longboards, etc.) Projects need to take into consideration the usability of their pedestrian routes and provide weather protection in front of buildings. On the interior of the building, layouts should be designed to promote the use of stairs over elevators. In addition, projects that are located in Transects L4-L6 (medium – very high density) must provide a transit subsidy to all of its building occupants. The subsidy can

either be human powered or public transit. The project must also include showers and changing rooms and one electric vehicle charging station. These amenities must be open to everyone. For single family homes, there needs to be a plan for how residents can reduce their carbon footprint by either car sharing, public transit, electric vehicles or human powered transportation. Finally all buildings regardless of location or use must provide a mobility plan that outlines "how the project will continue to support human-powered living through occupancy." (Place Petal Handbook) BREEAM also has high standards for access to public transportation or biking and walking but LEED does not, mainly because the rating system is more catered to suburban development. Connection to public transportation is extremely important, it allows people to have a choice between a more sustainable mode of transportation and car transport.

The second Petal is titled Water and has only one Imperative: Net Positive Water. The scarcity of clean water is has been increasing slowly over the past decade. As our global population grows the need for more potable waters grows with it. As storm water runoff and sewage mix with our rivers and fresh water supply, we need to look to new technologies and innovations to ensure our future has a safe and abundant supply of water. "The Living Building Challenge envisions a future whereby all developments are configured based on the carrying capacity of the site: harvesting sufficient water to meet the needs of a given population while respecting the natural hydrology of the land." (Living Building Challenge 3.0)

The fifth imperative, Net Positive Water, dictates all the requirements for a closed loop water system. One hundred percent of the water supplied to the building must come from rain water of from nearby natural water source. This water must be captured and purified without the use of chemicals. All of the storm, grey, and black water that accumulates on site must be treated

on site. This water will then go back into the building reserves, completing the closed loop system. Any excess storm water can be flushed from site under the right conditions.

The third Petal is the Energy petal. It also has only one Imperative: Net Positive Energy. The need for a transition to renewable forms of energy is more evident than ever in today's society. Sadly, the reason for this newly found public awareness stems from the impacts of climate change and pollution. Most of our needs today are met by highly polluting sources such as coal, gas, and oil. The Living Building Challenge calls climate change, "the most worrisome major global trend attributed to human activity." (Living Building Challenge 3.0) The goal of this Petal is to design an extremely efficient building that relies on safe, renewable forms of energy, with zero negative externalities. LBC admits that the limited technology of renewable energy is the biggest challenge in reaching their goals. The sixth Imperative, Net Positive Energy, requires that one hundred and five percent of the building energy's need are met through the use of on-site renewable energy. This extra five percent is used to power a back-up generator for emergency purposes.

The fourth Petal is titled Health and Happiness. The average human spends 90% of their lives inside buildings. A majority of buildings today provide substandard indoor environmental conditions. If these buildings are not living up to their fullest potential, how can the people inside be expected to perform well? Indoor pollutants can inhibit growth and cause health problems. Indoor spaces should be designed to enhance our wellbeing both physically and psychologically. Well-designed spaces should have natural light and air, and no indoor pollutants. The intent of this Petal is to provide the designer with the criteria and obligation to "create robust, healthy spaces."

The seventh Imperative is called Civilized Environment. It has only one requirement. All regularly occupied space must provide operable windows. This ensures that the building and its inhabitants are given access to light and air. The next Imperative is called Healthy Interior Environment. This section is basically a checklist for providing a clean living environment. Buildings must comply with the current version of ASHRAE Standard 62[4], and there is to be no smoking allowed within the boundary. Kitchens, bathrooms, and janitorial areas need to have their own exhaust systems, and building products need to comply with CDPH Standard Method v1.1-2010[5]. The entrance to the building must provide a proven way to reduce unwanted particles that are tracked in by foot. Lastly there needs to be cleaning protocol for the entire building that complies with the EPA's Design for the Environment[6]. The Last Imperative under Health and Happiness is called Biophilic Environment. The design of an LBC building must include elements that "nurture the innate human/nature connection." The design team must provide a plan that outlines how the building will incorporate nature through lighting space, and natural forms. The project must also reflect its location through the use of place-based relationships.

The next Petal is called Materials and deals with the Red List for LBC buildings as well as waste and carbon footprint. Many materials used in buildings today are responsible for environmental issues and personal illness. Some of high embodied energy to produce or come from halfway around the world. These issues are gaining more and more public attention. Many

[4] ASHRAE Standard 62 is the section with The Standards For Ventilation And Indoor Air Quality.
[5] This is the California Department of Public Health's Standards for healthy indoor building products, such as paint and cleaning products.
[6] The Environmental Protection Agency's Design for the Environment developed several different programs and tools to help organizations evaluate human health and environmental attributes of chemicals in products.

manufacturers are starting to become more transparent and aiming to remove harmful chemicals that are in their products. The goal of this petal is to ensure that our buildings are constructed from only non-toxic materials that are regenerative, transparent, and socially equitable. LEED and BREEAM allow use of any material in the construction or renovation of a building, and give points for the use of sustainable and locally sourced materials. Having a red list of materials and adhering to a limited materials standard instead of having a couple materials be "sustainable" is a large improvement to the system. It also brings attention to harmful effects of these Red List materials.

The first Imperative of the Materials Petal is the Red List of Materials. This is a list of materials that are under no circumstance allowed inside the building before or after occupancy. Some of the materials on this list include: Asbestos, Cadmium, Formaldehyde, Lead, Mercury, Polyvinyl Chloride, and Volatile, Organic Compounds. The next Imperative, Embodied Carbon Footprint, is similar to the Habitat Exchange Imperative. Since the building is Net Zero Energy the only carbon footprint is from the construction of the building. This carbon footprint must be documented throughout the entire construction process and then offset through a donation to the Living Future Carbon Exchange.

Imperative number twelve, Responsible Industry, requires that the project must support the use of third-party certification for sustainable resource extraction and fair labor. Materials included in this section are stone, rock, metal, minerals, and timber. All timber used must be certified by the Forest Stewardship Council. For every 500 m^2 of gross building area, one Declared product must be used. Living Economy Sourcing, Imperative thirteen, requires that the project must contribute to the local economy by sourcing materials from nearby. 20% of

materials must come from within 500km of the site. 30% of materials must come from 1000km from the site. 25% of the materials must come from 5000km from site. The outstanding materials can come from any location. The last Imperative in Materials is called Net Positive Waste. For every 500 m^2 of gross building area one of the materials needs to be of either a salvaged material or reused from an existing structure. There also needs to be a Material Conservation Management Plan for every phase of construction. In comparison Material and Resources plan for LEED only has three prerequisites. These include the storage and collection of recyclables, waste management for the construction and demolition of the building, and a mere reduction of Mercury, rather than completely outlawing the material.

[7]

[7] Declare is an organization also run by the Living Future Institute. Many products do not require labels that tell the consumer what is actually in the product, or how it was made. Declare is a product label that requires a very informative list of information of what a product contains, if it has toxins, and its source and life expectancy

The sixth Petal of the Living Building Challenge is titled Equity. This imperative addresses political and cultural issues that do not appear in BREEAM or LEED. In recent decades there has been an increase in the privatization of developments and infrastructure. This privatization excludes people of certain economic or cultural backgrounds from participating fully in the life of the community. Included in this trend is the notion that people can own access to nature. Some organizations cut off the access to certain natural location such as waterways and beaches that should be law be a public service. “We need to prioritize the concept of “citizen” above that of “consumer.” Equity implies the creation of communities that provide universal access to people with disabilities, and allow people who can’t afford expensive forms of transportation to fully participate in the major elements of society.” The intent of this petal is to design developments that nurture a sense of community regardless of an individual’s background, age, class, race, gender, or sexual orientation.

Imperative number fifteen, Human Scale and Humane Places, expands upon the Human Powered Living Imperative. Project must be designed at human scale not automobile scale, in order to promote human interaction. This section gets very technical and gives different dimensions for and square footages for the six different transects of LBC. These are then applied to Pervious vs. Impervious areas, street and intersection widths, signage, proportions, and building scale. Impetrative sixteen, Universal Access to Nature and Place, deals with the public’s ability to access beauty of the projects creation. This is aided by the use of street furniture, public art, gardens and benches. Also the project itself may not restrict access to the following: fresh air, sunlight, or natural waterways. Equitable investment, Imperative seventeen, requires that for every dollar spent of the total project cost, the developer or owner must donate a half a cent to a

charity of their choosing. The last Imperative of the Equity Petal is title Just Organizations. This intent here is to "create a more just, equitable society through the transparent disclosure of the business practices of the major organizations involved." JUST is an organization that provides labels for a company to shed light on the public of their business practices. One of the parties involved in the development of the project must have a JUST label associated with their business.

The seventh and final Petal of the Living building Challenge is Beauty. The goal of this petal is "celebrate design that uplifts the human spirit." LBC sees beauty as a precursor to caring about the nature. If we do not care for the built environment why should we care about the natural environment? This Petal is not meant to foster criticism, but rather ensure every square foot of space clearly articulated and thought through. The first Imperative of this section is called beauty and Spirit. The only requirements here are that: "The project must contain design features Intended solely for human delight and the celebration of culture, spirit and place appropriate to its function and meaningfully integrate public art." The 20th and final Imperative, Inspiration and Education, exists to ensure that the building remains friendly, healthy, and educational for years to come. There must be a day open to the public to allow tours of the building. The Project must have a brochure and website to describe all the design and environmental features. Lastly there needs to be an Operations and Maintenance Manual on site at all times. Both LEED and BREEAM do not require "beauty" as an assessment, although each achieves points and percentages for innovation. A problem with green building is also that it takes more knowledge to operate than a regular building. Sometimes this knowledge is lost, and all the efforts put into

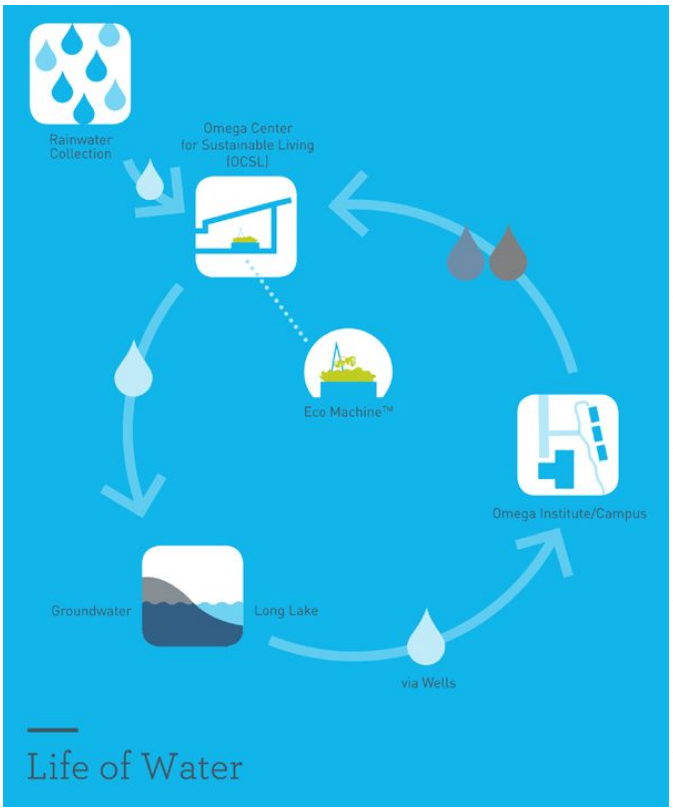
making the system green fails when there is no education about how to properly manage the building.

VII. Omega Center for Sustainable Living

As a Case Study we decided to research the Omega Center for Sustainable Living located in Rhinebeck, NY. The Omega Center for Sustainable Living is part of the Omega Institute for Holistic Studies, which is a non-profit retreat center. The Omega Institute's mission statement is to "provide hope and healing for individuals and society through innovative educational experiences that awaken the best in the human spirit". The Omega Center was completed in May, 2009 and is the first building in the United States to receive LEED Platinum certification as well as the Living Building Certification. This building totals 6,250 square feet, and cost $4.1 million to construct. This price includes construction of the wetlands as well as the wastewater treatment systems.

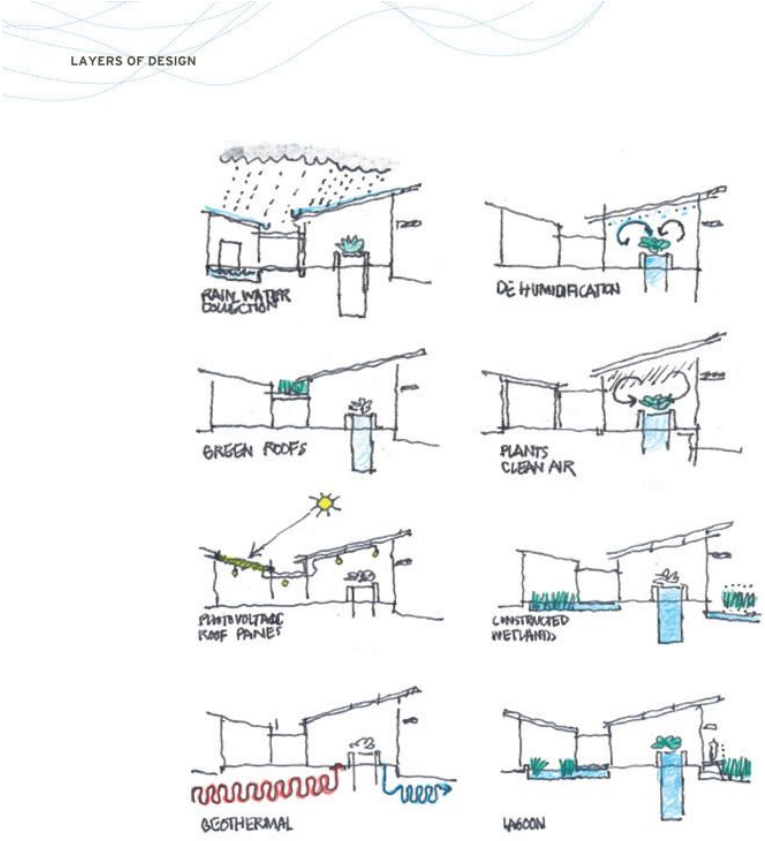
The primary use of this building is as Wastewater treatment facility for the Omega Center campus, which has more than 100 buildings. (Lesniewski, 1) CEO Skip Backus wanted to create a closed loop water cycle for a campus that was environmentally conscience. Backus realized that the Omega Center was degrading natural environment, especially causing agricultural runoff, and chemicals to run into Long Lake, which is connected to the Hudson River. Backus decided to clean up the former site, and ensure that the building would no longer harm the natural systems around it, and instead reclaim the water and clean it for the campus' purposes.

Skip enlisted the help of one of the early pioneers of ecological design, John Todd, to design a nature-influenced water treatment system. The result is the heart of the Omega Center for Sustainable Living, the Eco Machine. An Eco Machine is a "water reclamation system that cleans water by mimicking the processes of the natural world." (Omega, 1) This machine is showcased in the main building to educate visitors about the importance of the water treatment. It was designed in collaboration with Biohabitats, BNIM Architects, and The Chazen Companies. The treated water is used in a grey water recovery, and used for irrigation. The facility can process over 52,000 gallons of water a day. To minimize use of water, there are low flow plumbing fixtures and waterless urinals. All the excess grey and black water is sent through the Eco Machine.



The Eco Machine processes the water through several stages. During the first stage, natural microbial organisms digest substances such as nitrogen, potassium, phosphorus. The water during this stage is stored in two 5,000 gallon anoxic tanks which are located beneath the building. After this process, the water then filters to the wetlands behind the buildings. These four wetlands use plants such as cattails and bulrushes to remove odor, and harvest nutrients to feed the plants and microorganisms in the wetland. According to Tackett, there is "a 75 percent

increase in the water's clarity and a 90 percent reduction in the water's odor" (Tackett, 1) simply from the first two steps. During the third step, the water is pumped into two aerated lagoons. These lagoons are 10 feet deep, and the plants, snails, algae and other microorganisms convert toxins and ammonia into elements that are safe to drink. The plants actually require no soil to live, and grow on metal racks lifted above the water in the lagoons. These tropical plants flourish, and the clients are actually considering selling the excess plants as an outside source of income for the wastewater treatment plant. After being processed through the lagoons, the water moves through the sand filter behind the building, and then the water returns to nature as clean groundwater. What was taken from the earth returns back to the earth.



Another vital part of the building is the amount of energy it uses. The building maximizes the use of renewable energy through passive heating and cooling, as well as using daylight to its greatest advantage. By using natural ventilation and stack ventilation, the building is able to cool itself during the summer. This use of natural air is not only energy efficient, but also comfortable

to the occupant. The interior of the building is comfortable not only for people, but ideal for the indoor plants in the aerated lagoon. The amount of solar energy needed for these plants is very precise. The building uses its thermal mass as well as the thermal mass of the water surrounding it to regulate the building's temperature. The building also has photovoltaic panels to generate the extra energy that the building uses. The excess energy from these panels is sent to local electricity utility. The diagrams below show the many ways the architects utilized passive systems to allow the building to function efficiently.

Besides being an extremely efficient, natural water treatment facility, the building is also an educational center. Backus realized that education about sustainable living and improving the environment is an important part of saving the environment. The Omega Institute has hosted many programs, such as "Ecology by Design," "Grow Food Everywhere". The building is also regularly available for tours and educational trips. This educational aspect allows visitors to learn more about the state of environment, and how to improve and make changes to help lower each individual's ecological footprint.

VIII. Critique of LBC

The Living Building Challenge tries to solve all sustainability problems within one building, when in fact the majority of buildings are connected to a larger system. Sometimes it is not possible to have a building that is net zero, it is hard for buildings in cities to be net zero, because they can't gain energy from solar panels. Living Building Challenge buildings also rely heavily on solar panels. Solar panels have a lot of problems, and may not always function as desired. The Living Building Challenge can't be applied to high rise buildings because with

current technologies, these buildings simply cannot be net zero energy and net zero water. Living building challenge does not allow for the building's energy to come from outside renewable energy sources. The building itself has to provide its own energy. Sometimes the issue can be resolved through the "scale jumping" aspect of the program, which allows multiple buildings or projects to operate together, and share infrastructure. To scale up, the living building challenge should consider net zero energy cities, and possibly just allowing for energy to come from other outside renewable energy sources.

Having net zero water for a building in a city makes little sense, and is very difficult. A high rise building uses a lot of water, but can't capture enough water for it's own use. Having water for each building monitored by the building owner doesn't totally make sense, some part of it should be monitored as carefully as possible, but not all water treating should have to be from the building itself. Our cities already have ways to treat water, although they may not be the most sustainable of systems, it's the larger system that needs to be changed rather than for each individual buildings. The agricultural garden required for each building is also a somewhat daunting task for clients. The garden is an extra expense that has to be maintained daily and workers have to be hired to maintain the garden. Instead of every building having a food garden, just having locations in a city where food is grown is a more manageable and economical way of running a city.

IX. Conclusion

BREEAM and LEED were established to make buildings less harmful. Each of these systems have also started to give green design credibility. LEED especially has achieved major

success in branding and making itself a recognizable, marketable tool. Both rating systems, while still difficult to achieve have made green development a solid business investment, and made green design less daunting to clients. Both systems recognize that there are many improvements necessary to become truly sustainable, and each year the LEED and BREEAM are becoming more rigorous. The length of time that LEED and BREEAM have been has also created support from the government and other organizations. With time, LBC would be able develop more support as well.

LBC is an incredible resource for improvement in green design, and allows for other certification systems to learn from its guidelines. It is also not a perfect rating system, and with each revision, its improvements help make the certification more comprehensive. Living Building Challenge can also learn from LEED and BREEAM. LEED has done an incredible job marketing and branding itself, and has made LBC's success possible. Buildings like the Omega center have been able to achieve both LBC certification and LEED platinum. The Omega center and other buildings certified by LBC have proved that a self-supporting building is possible, that a truly sustainable building is not totally out of our reach. As Living Building Challenge gains in popularity, we'll see more and more buildings that are able to be self-supporting, regenerative, and perhaps in the future we'll see a significant impact of the way the building industry constructs future buildings.

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