

Case study of a Living Building Challenge project

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Living Building Challenge (LBC) is proven to be one of the most stringent sustainable building standards. LBC compares its principles to a flower, indicating that the buildings should function in harmony with nature like a flower. Currently in its version 3.1, Full LBC certification requires the fulfillment of 7 categories (or petals) consisting a total of 20 imperatives. In 2016, there were 331 registered LBC projects across the world. This paper is a case study describing the planning and design phase of an LBC project under construction at the Georgia Institute of Technology (Georgia Tech), a leading research university in North America. The Living Building Challenge standard published by the International Living Future Institute (ILFI) states and explains the imperatives for achieving the LBC certificate. However, not many studies have been published on the strategies adopted to practically meet those imperatives. In the absence of such studies, it would be difficult for the stakeholders interested in constructing Living Buildings, to successfully plan and design their projects. This paper explains the planning and designing strategies used by the project team for the Georgia Tech LBC project, to achieve the LBC imperatives. The strategies used by some of the projects which have already been certified in the past have also been summarized in this paper.

Keywords: Living Building Challenge, Sustainability, Net positive energy building, Case study

Introduction

The LBC is a program pioneered by the International Living Future Institute (ILFI) for green building certification. LBC being a young concept, few studies have been conducted on LBC, leading to limited available literature. Not many research studies have been published on the processes adopted for planning and designing LBC projects. This paper aims to explain the LBC concept and present a case study that discusses the programming, planning and designing strategies implemented for an LBC project. A living building has the potential of generating all of its energy, capturing and treating the required amount of water without a man-made water-supply source, and operating efficiently in harmony with the nature (International Living Future Institute, 2016). Living buildings are expected to achieve the performance requirements of seven 'Petals' or categories: Place, Water, Energy, Health & Happiness, Materials, Equity, and Beauty. These petals have in all 20 imperatives which a fully certified living building is expected to meet (International Living Future Institute, 2016). The goal of LBC is not only to ensure that the buildings cause less harm to the environment, but to make the buildings regenerative, pushing the sustainability envelope to the positive side. This paper is one of the first case studies that briefly explains the 20 imperatives, and highlights the strategies used in the programming, planning and designing of an LBC project.

The LBC project at Georgia Tech has been designed to be the most environmentally advanced research and education facility in the southeastern part of the United States (News Center, 2015). The project is a partnership between Georgia Tech and the Kendeda Fund, a private grantmaking foundation based in Atlanta, Georgia which has committed to provide a grant of $ 30 million for the project. The LBC project at Georgia Tech is named as 'Kendeda Building' to honor the generous donation of the funding organization. The grant of $ 30 million provides one hundred percent of the funding for the design and construction cost of the project ($ 25 million), plus $ 5 million funding for the programming activities (News Center, 2015). The selection of the architects for this project was done by ideas competition. Seventeen firms had submitted their entries for the competition out of which 3 teams were invited for the final design presentations. Lord Aeck Sargent and The Miller Hull Partnership team were announced as the winner of the competition and were awarded the design contract for the project. The delivery method of the project is Construction Management at Risk (CM at Risk) with a Guaranteed Maximum Price. Skanska, USA was selected as the Construction Management firm for the project (Jones and Jelin, 2018).

The main purpose of this paper is to help the stakeholders in the construction industry aiming for LBC certification understand the processes involved to achieve the imperatives for the LBC certification. This will enable them to develop a plan to program, design and construct LBC projects in future. This paper would be beneficial to the designers, contractors, builders, students or general audience interested in the sustainability aspects of the built environment. It would also serve as an educational tool to help students learn about the latest developments in the sustainability field.

Background Studies on LBC

As discussed above, LBC outlines 7 petals or categories and 20 imperatives for achieving the Full certification. The first petal is ‘Place’, and as the name suggests, this petal dictates the location for the LBC projects, and the way the site should be developed. According to this petal, the project should be developed on a previously developed site (greyfield or brownfield) which is not classified or adjacent to ecologically sensitive areas such as wetlands, primary dunes, old-growth forest, virgin prairie, prime farmland or within the 100-year flood plain. The philosophy behind this petal is to ensure that the built environment does not cause any further harm to the nature. Thus, the land which was already disturbed from its natural state in the past should only be used for constructing new buildings. Within the project boundaries, agricultural opportunities commensurate to the scale and density of the project should be planned. However, no pesticides or petrochemical fertilizers should be used for maintaining the landscape on the site. Pesticides and petrochemical fertilizers may accumulate in the soil, leading to degradation of the soil and land. Also, the project overall should encourage the community to use human-powered transportation and should encourage the users to rely less on machine-driven vehicles. Besides, “For each hectare of development, an equal amount of land away from the project site must be set aside in perpetuity through the Institute’s Living Future Habitat Exchange Program or an approved Land Trust organization.” (International Living Future Institute, 2016)

The next two most important petals are water and energy. To achieve the water petal, 100% of the building’s water needs must be met by capturing the rain water or other natural closed-loop water system, and/or by recycling used water. The water must be purified according to the needs without using chemicals. All the storm water and water discharge, including grey and black water must be treated on the site and managed through reuse, a closed loop system, or infiltration. Black water is the waste water from toilets, while the waste water from everywhere else in the building is called as grey water. The energy petal requires105% of the project’s energy needs (on annual basis) to be met through on-site renewable energy, without using on-site combustion. Also, the project must provide on-site energy storage for resiliency (International Living Future Institute, 2016).

The Bullitt Center project in Seattle, Washington had made use of composting toilets to save water in flushing. Besides, the rainwater gets collected on the building’s roof membrane and is diverted into the cistern in the basement of the building. The potable water is supplied through the utilities, to comply with the regulatory requirements. Similar strategy is also being used for the Phipps Center project for sustainable landscapes, a certified LBC project in Pittsburgh, Pennsylvania; The building captures rainwater for uses other than drinking, while the drinking water comes from the Municipal sources, with temporary exceptions due to local health regulations (International Living Future Institute, n.d.-b). The Chesapeake Bay Brock Environmental Center in Virginia (another LBC certified project) uses several water-saving plumbing fixtures such as low-flow lavatories, low-flow kitchen sinks, low-flow shower and composting toilets. This project harvests rainwater too by capturing it through the metal roofs installed on the building. For this project, rainwater was allowed for potable use (International Living Future Institute, 2018 - c). For achieving the imperative of Net Positive Energy, many of the previously LBC certified projects like Bullitt Center and Phipps Center had also made use of and are currently using photovoltaic array for using Solar energy, showing good results in terms of energy efficiency. The Phipps Center project has a large glass atrium, light shelves and an interior daylight ceiling ‘cloud’. Light shelves are horizontal surfaces which cause the sunlight to reflect deep into a building, reducing the need for artificial lighting. Daylight ceiling cloud is a transparent opening in the ceiling of the building which allows entry of sunlight into the building. These features helps in reduction in the energy consumption of the building as a good amount of daylight penetration is facilitated inside the building (Kure, 2012).

The fourth petal of LBC is health and happiness. The requirements of this petal are that the building must provide access to fresh air and daylight to the occupants, by having operable windows at every occupied regular space. Also, the project must create a healthy interior environment plan, promoting good indoor air quality and thermal comfort for the occupants. The project must follow the current version of ASHRAE (The American Society of Heating, Refrigerating and Air-Conditioning Engineers) 62, or an international equivalent. "The project must be designed to include elements that nurture innate human/nature connection" (International Living Future Institute, 2016). For achieving this petal, the Bullitt Center had made use of low Volatile Organic Compounds (VOC) and zero VOC finishes in the building, while the Phipps Center has an Aircuity system and uses a rooftop energy recovery unit (International Living Future Institute, n.d.-b). The Aircuity system collects air particles remotely and sends it to the sensors to assess the indoor air quality. Based on the assessment, the system then optimizes the air quality and energy efficiency. The energy recovery unit helps in energy exchange which an exhausted building or air space contains and is used for preconditioning the outdoor ventilation air which is about to enter the Heating Ventilation and Air-conditioning (HVAC) system.

The fifth Petal of LBC is materials which includes a total of 5 imperatives. The petal describes a 'Red List' of materials and chemicals which cannot be used in the LBC project (Keegan, 2011). ILFI defines 'Red List' as 'the worst in class materials prevalent in the building industry'(International Living Future Institute, 2019). According to ILFI, "The project must account for the total embodied carbon (tCO2e) impact from its construction through a one-time carbon offset from an approved carbon offset provider" (International Living Future Institute, 2016). Carbon offset means reducing the harmful impacts of carbon dioxide and other greenhouse gas emissions by doing things which can compensate the effects by removing the carbon dioxide from air, like planting trees. Also, the project team must work towards reducing and eliminating the production of waste during design, construction, operation and end of life of the building in order to conserve the natural resources (International Living Future Institute, 2016).

The last two Petals of LBC are equity and beauty. According to these petals, the project must be designed in such a way that it creates human-scaled places instead of automobile-scaled places, and everyone irrespective of background, age, socio-economic class, should have equal access to all primary transportation, roads and non-building infrastructure around the developed project which are considered externally focused. Also, for every dollar spent of the total project cost, at least half a cent must be set aside and donated to a charity or should be contributed to the Equity Exchange program of International Living Future Institute. Moreover, at least one of the key stakeholders involved in the project must have a JUST label for their organization. An organization which has a JUST label is socially just, treats its employees well and contributes towards the welfare of the community. To make the project look beautiful, public art must be meaningfully integrated into the project. Lastly, the operational and performance characteristics of the project must be shared with the public in the form of educational materials, motivating others to make a positive change (International Living Future Institute, 2016).

Methodology

The research deploys case study methodology to present the design and planning processes involved in delivery of the LBC project at Georgia Tech. One of the important goals of the Project teams constructing living buildings is to inspire and educate others in the green building community and beyond (Mirel, 2014), and so, information about the Georgia Tech LBC project has been published online by several organization and individuals. Some of these online sources were referred. Additionally, interviews were conducted with various project stakeholders, for getting first-hand information about the project. For developing and implementing the case study research, the book titled "Case study Research – Design and Methods, 2nd Edition, by Robert k. Yin" was referred. The Case study method questions 'How?' and 'Why?' focusing on contemporary events. The case study method of research does not require control over behavioral events, and it is important to record them in their natural state (Yin, 2018).

To get a general idea about the project, a preliminary face-to-face interview was conducted with Scott Jones (Assistant Vice President, Facilities Design & Construction at Georgia Tech)) and Gary Jelin (Associate Director of Design Services, Georgia Tech). The interview was a structured interview, with pre-written questions which lasted for around 30 minutes. Questions related to the selection process of the project teams, project delivery method, methods of cost reimbursement of the architects and the contractors, project timeline, etc., were asked and their verbal responses were written down during the interview.

To get in-depth details about the design and planning strategies of the project, a questionnaire was sent through E-mail to John DuConge (Senior Project Manager, Georgia Tech Facilities Management). Initially, an interview was requested with John DuConge, but he asked to send over the questions by e-mail first. The questionnaire was structured with 20 questions related to the imperatives mentioned in the LBC standard version 3.1. The questionnaire was returned in two weeks, with the responses to 17 questions. Out of the remaining three responses, response for one question was the same as the response for a question already answered among the 17 responses, and so it was directed to that questions. For the remaining two questions, the information was not yet available. Information from all the 17 responses have been used in this paper, to explain the project team's plan of action for achieving the LBC certificate. Since most of the information was received through the response to the questionnaire, there was no further need to conduct an in-person interview.

An interview was conducted with Ramana Koti, a Building Performance Analyst at Lord Aeck Sargent (LAS), who is one of the key design team members of the project. The interview was conducted in the Atlanta office of LAS and lasted for 30 minutes. The questions asked were related to the design strategies used for meeting the LBC imperatives for the Kendeda building project. The interview was a semi-structured interview, with open ended questions related to the design implementations adopted for achieving the LBC certificate. The interview was audio recorded with the permission of the interviewee. The important and required information from the audio recording was later transcribed by listening to the audio. The information gained through this interview has been used in several parts of the paper.
A phone interview was conducted with Jimmy Mitchell, Business Development Manager of Skanska, USA (the Contractor for the Kendeda Building Project). The interview was a structured interview consisting of 12 questions, involving a blend of open-ended questions (e.g. the importance of collaboration in delivering LBC projects) and definite questions (e.g. strategy used for meeting the imperative of 'Net Positive Waste'). The phone interview lasted for about 30 minutes. The key words and important information from the interviewee's response were written down in front of the respective questions. The information collected through this interview has been used in different sections of the paper.

Kendeda Building: A Living Building Challenge Case study

Collaboration among the key stakeholders is key to achieve the LBC certification. The programing and conceptual planning phase included a 2-day programming and process charrette organized for the Living Building Challenge (LBC) Project at Georgia Tech. The charrette was attended by the owners, designers, contractors and key community and faculty members. In total, 57 professionals representing 16 organizations attended the charrette.The goal of organizing the programming charrette was to discuss the status of the project, the big questions and big ideas and the immediate action items (Programming Charrette, 2016). Through careful planning and programming, the project team for the Kendeda Building project at Georgia Tech came up with strategies to achieve each of the 20 imperatives, to get the Living Building Challenge certificate for the project.

Figure 1. Artistic view of Kendeda building (Lau, 2017)

Figure 2. Interior rendering of Kendeda building (Edelstein, 2017)

Place (4 imperatives):

Limits to growth. The site selected for the project was used as a surface-parking lot and was asphalted. Thus, the site can be classified as a brownfield site and the 'Limits to growth' imperative can be achieved.

Urban agriculture. The Floor Area Ratio (Ratio of the total floor area of the building to that of the plot) of the project is 0.63 (DuConge'2018). Thus, according to the LBC standard 3.1, at least 20% of the project area must be reserved for agriculture. During the programming charrette, extensive discussions had taken place for the urban agriculture imperative. It has been planned to grow plants, fruit trees etc. within the site boundary to meet this imperative. Foraging gardens have been planned in the project's boundary which will have fruits and nut bearing trees and bushes that will benefit humans and other life forms (Koti, 2018).

Habitat exchange. This has not been done yet but will be done. (DuConge'2018)

Human-powered Living. The project has been designed to have covered bike storage at the basement level. Also, bike racks will be constructed at the south and west sides of the building. To promote human-powered transportation, the bike masterplan was studied by the project team during the design phase of the project. There will be no vehicle parking within the project boundaries. (DuConge'2018). The contractor Skanska was involved in estimating the costs for the bike parking facilities, during the design and planning stage. (Mitchell, 2018).

Water (1 Imperative):

Net positive water. It's necessary to put the water into 3 categories of use: potable water, landscape irrigation, and ground absorption (to recharge underground aquifers). For the Kendeda Building, rainwater will be used to serve potable water needs. Rainwater will be captured from the photovoltaic array and channeled through a gutter system to a cistern and filtration system. The design consultants reviewed historical records for rainfall in Atlanta and compared that to the anticipated consumption based on the expected building occupancy. The consultants found that the average annual rainfall amounts in Atlanta significantly exceeds the anticipated consumption. Condensate (water captured from the building's mechanical systems) is relatively clean water and will be piped to a tank, filtered, and pumped to the landscape when needed. Water from showers, sinks, floor drains and the site will be run through a primary treatment tank, then pumped through an underground pipe to a "constructed wetland" (an above-ground basin near the south entrance of the building. It has plants that will help clean the water near for further treatment and polishing) before being released to above ground wales that will direct the water through the site for absorption into the ground. Since compostable toilets are designed, very small amount of water will be used to create foam as a primer for toilet use, and no black water will be generated within the building. The waste from toilets will be collected in bins, composted, and carted off. (DuConge'2018)

Energy (1 Imperative):

Net positive energy. To achieve the imperative of net positive energy, the design team used an energy model to document certain assumptions about the project. These assumptions were the anticipated energy usage for the building based on the programmatic requirements and the hours of operation. The Photovoltaic array is sized to generate more than the 5% of the minimum electricity required by the building over the course of a year. Since the amount of available sunlight varies by season, it's important to note the amount of electricity generated by the array will generally be lower during winter months and higher during summer months, therefore it is necessary to plan for the anticipated consumption based on a full year cycle. Also, the Kendeda Building will provide resiliency for emergency lighting and refrigeration for one week in accordance with the LBC requirements. (DuConge' 2018). Ramana Koti from Lord Aeck Sargent was closely involved in designing the building as energy efficiently as possible. According to him, a 3-step process was followed for ensuring that the net positive energy imperative will be achieved. Firstly, the project team took the advantage of the passive features like orientation, shading, window placement, and daylight performance. Secondly, the emphasis was on using as energy-efficient equipment as possible. The first two steps basically involved setting reducing the loads and meeting the remaining loads with energy efficient equipment. The third step was to meet the reduced energy requirements with the use of renewable energy sources. It was very important to focus on the first two steps, because if good results are not achieved in the first two steps, then the amount of Photovoltaic array required on the building would be large and expensive, and it wouldn't be possible to achieve the imperative of Net positive energy (Koti, 2018).

Health and Happiness (3 imperatives):

Civilized environment. In the context of LBC, civilized environment means an environment which is well lit. The design team worked to ensure the balance of natural light versus glare, since it is critical to the success of the project. Automated window shades will be used on the east and west facades to allow natural light infiltration, while mitigating glare. The south façade will have fixed window shades and glazing on the north façade will not be subjected to direct sun/glare. Other strategies include the use of clerestory windows in the two-story lobby to increase the amount of natural light in the center of the building. The use of taller windows and no ceilings at perimeter spaces will also allow natural light to penetrate the building. (DuConge', 2018). According to Ramana Koti, the building is designed in response to the site and the windows have been arranged in a fashion which will ensure control of the entry of sunlight during the day. The windows have been designed based on their orientations within the buildings which is also one of the unique features of this project. Also, all occupant workstations are within 30' of an operable window (Koti, 2018).

Healthy interior environment. To reduce the particulates entering the building through the shoes of the users, floor mats will be used at the building entrances. For cleaning, the Facilities Custodial staff has been utilizing green cleaning for several years and they are reconfirming practices for this project. One of the key cleaning solutions is the use of ionized water. (DuConge', 2018)

Bio-philic environment. Bio-philic environment means an environment with a strong human and nature connection. There will be a foraging garden within the boundaries of the project. This garden will allow visitors to pick and eat edible fruits (e.g. blueberries) raw, thus helping nurture the human/nature connection. (DuConge', 2018). The site falls in Piedmont Forest Eco-region, and so the plan is to restore the site to the features of the Piedmont forest. This will ensure that the site will be in harmony with the context in terms of water flows and ecology. (Koti, 2018).

Materials (5 imperatives):

Red list. The project team is selecting "red list" free products where they are currently available in the market. However, the market has not yet caught up with the LBC requirement for many commonly-used materials. The project team is advocating for market change where LBC compliant products are not yet available. (DuConge', 2018). According to Jimmy Mitchell, in current market conditions, it is difficult to construct a project completely free from red materials, but still the project teams have tried to ensure the least possible use of such materials. The project teams have used very diligent approach in selecting the materials and have advocated the use of materials. They have also been making efforts to ensure transparency from the suppliers, in terms of the content of the products (Mitchell, 2018).

Embodied carbon footprint. The project will account for the total embodied carbon (tCO2e) impact from its construction through carbon offset from an approved carbon offset provider (Mitchell, 2018).

Responsible industry. The project team has been doing rigorous advocacy for the use and availability of sustainable materials in the construction. The wood to be used in the Kendeda Building will be 100% FSC (Forest Stewardship Certified), in compliance with the LCB standard 3.1. The project team has also tried, wherever possible, to follow the similar guidelines for other materials like stone, rock, metals etc. (Mitchell, 2018).

Living economy sourcing. The LBC version 3.1 (to which the Kendeda Building is being designed) requires consultants to be within 2,500 km (1,550 mi) of the project location but allows specialty consultants and subcontractors to travel up to 5,000 km (3,100 mi). The lead for the design team is a local firm with a mix of local subconsultants paired with subconsultants from other areas of the country with LBC expertise - Miller Hull Partnership (architects) from Seattle, PAE (engineers) from Portland, OR and BioHabitats from Albequerque to name a few. The partnering of local consultants and consultants with LBC expertise guide the project and expand the local LBC knowledge base. (DuConge', 2018)

Net positive waste. Net positive waste means that the project team must not only work actively towards diverting materials from the waste stream but should also take out and salvage materials from the buildings which otherwise would be dumped as scrap. A materials conservation plan was also prepared, to ensure the optimum use of all the materials. The design itself ensured least wastage of materials, as it allowed implementation of strategies like cutting perfect corner concrete materials, floorings, etc. A very detailed waste management plan is being followed, ensuring the achievement of this imperative (Mitchell, 2018).

Equity (4 imperatives):

Human scale and humane places. As discussed earlier, the project is being designed to human scale, and there will not be any facilities for parking automobiles etc. in the campus, encouraging the users to walk and bike. Also, the gates of the building have been designed to the scale of humans, and all the other guidelines for achieving this imperative have been followed in the design (Koti, 2018).

Universal access to nature and place. The building will have an open access to people from all the sections of the society irrespective of age, gender, socio-economic background, etc., including the homeless. Also, the building has been designed and planned in such a way that there will be ample and controlled amount of sunlight and entry of fresh air indoors, creating a healthy interior environment (Koti, 2018).

Equitable investment. This imperative does not involve any design or construction strategy, and accounts only for donation of money. However, charitable organizations are exempted from this imperative (International Living Future Institute, 2016). Since Kendeda fund is a grantmaking organization, the project is eligible to get an exemption for this imperative.

Just organizations. The design architect Miller Hull partnership has a JUST certificate, ensuring the fulfillment of this imperative.

Beauty (2 imperatives):

Beauty + spirit. The project has been designed to the modern beauty standards, and will integrate the public art in the building, making the building aesthetically pleasing and appealing (Koti, 2018).

Inspiration + education. Case study of the entire project, design and construction features of the project, operations and maintenance manual etc. would be published publicly, once the project is completed. Information like the project timeline, project stories etc. is already being published by several individuals and organization.

Conclusion, Limitations and Future Scope

The case study of the LBC project at Georgia Tech clearly shows that LBC is a stringent sustainability standard. The process of designing and planning a project to the LBC standards is not an easy task and it requires a lot of efforts with attention to details. Conceptualizing the construction of an LBC building is in itself a challenge, as failure to meet even one imperative can jeopardize the chances of getting an LBC certificate. In addition, the building must meet the performance standards after at least 12 consecutive months of full occupation and operation. Even if a project achieves 19 imperatives and fails to meet just one imperative, the chances of getting the certificate might get affected. One major limitation of this paper is that the strategies described for the Kendeda Building cannot guarantee the achievement of the imperatives, as the project is still in the construction stage and the building may not function as expected.

The future scope of this study would be to see how the LBC buildings perform, once they are certified. The goal of constructing LBC projects is to ensure that the built environment causes minimum negative impact on the environment and in fact, function as a regenerative system. Even if the building achieves the LBC certificate after performing well for 12 months, it is crucial to check and monitor the performance throughout the operations and maintenance phase of the building and to study the lifecycle cost of LBC projects.

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