LEED v Living Building Challenge: Critical Evaluation

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Abstract
LEED is entrenched in North America as one of the most prominent green building certification standard. LEED is not without flaws. It is developing to address some of its shortcomings, namely related to the building performance over building's life span. New emerging green building rating systems such as Living Building Challenge (LBC) are much stricter and go beyond the building itself. LBC does not only consider actual building performance rather than the predicted one but it addresses its context. It encompasses humane scale, universal access, social justice, health and urban agriculture. It is much closer to the concept of net zero energy and it is thriving for net zero environmental impact.
LEED Gold and Platinum buildings are reaching high environmental standards and number of certified b buildings is increasing exponentially. In this paper, four case studies of the top rated LEED office buildings in Southern Ontario are investigated. Common categories of LEED points scored by these building are described and their comparison matrix is presented. The summary of the case studies is used to define a typical LEED building. This building is then evaluated for compliance with LBC and imperatives not met are investigated in order to determine what strategies would need to be adopted to improve the LEED design. The projects which are candidates for LCB designation are studies to assist with identification of differences. Paper concludes with the findings of this comparison and discussion on their implication. It intends to address environmental, economic and social issues.

Introduction
The construction industry represents an economically dominant sector of the market as it creates jobs and significantly contributes to the economy with a share of just over 7% of Canada's Gross Domestic Product (1) in 2008. Currently the industry is on decline and it is predicted that it will stay that 1% will occur over each of next two years (CCA, 2007). The industry employs 6.9% of the total workforce (Staristics Canada, 2010). In 2009 it employed 1.16 millions of people.
However in the process of economic success it has a significant impact on the environment, both raw materials and energy. In Canada it consumes more than 50% of natural resources, including energy. Water too is very important, with its 17% share of extraction. This relates only to the production of materials. The impact does not stop with the completion of the construction project but it goes on. During their life, buildings consume energy and pollute the environment, and at the end of their useful life, they create waste. It is estimated that in Canada 35-40% of energy is spent during building's operational life (worldwide this figure is higher, around 62%).
In addition to global warming, other environmental concerns affecting the construction industry involve the rapidly depleting reserves of mineral resources, and the creation of waste material that needs disposal. Approximately 40% of Canada's annual national resource expenditure is consumed by the construction industry (CaGBC, 2004). The proportion is even larger for non-energy non-renewable minerals. As a result of ever-expanding economies and populations, the world's demand for materials is putting enormous pressure on natural resources. In today's global economic climate, competitive advantage realised through efficient resource use is likely to generate increasing strategic benefits. The continually escalating costs of oil demonstrate that scarcity of resources can cause incredible increases in costs for commodities that were once taken for granted.
Canada ranks second only to the USA in per capita generation of solid waste per year and land filling is becoming more expensive. Currently, construction and demolition (C&D) waste equals about 35% of the

total waste stream in Canada (CCA, 2001), representing 11mega tonnes in weight. In Europe, partly driven by new European Union directives, C&D waste has been identified as a primary waste stream and is targeted for reduction. The shift to resource scarcity in the future will make recycling and reusing existing resources particularly important.
Since 1998 The Leadership in Energy and Environmental Design (LEED) Green Building Rating System has been the most widely used system to rate the construction of current and new buildings, by providing a guideline for achieving an environmentally friendly building. This rating is divided into 6 topics: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation in design. The focus of LEED is predominately to promote a design which exceeds current energy codes, as well as provide the user with benchmark guidelines in the improvement of issues such as renewable resource utilization, user comfort, and durability.
The next tier towards achieving a rating system which creates a truly sustainable building is a guideline titled the Living Building Challenge. It was introduced by the Cascadia Chapter of the USGBC in 2006. As opposed to the credit based system used by LEED, the LBC uses a system of imperatives which must all be met before a building can be considered as having completed the challenge. A report submitted to the LBC certifying council outlining proof of the building's energy and water performance over a one year post-occupancy period is also required during the certification process. The predominate focus of this guideline is to design a building which causes no negative impact to the environment, is capable of producing 100% of its energy demands onsite through renewable energy, and is 100% independent of municipal water infrastructure.

Methodology
Four LEED gold certified office buildings were identified in southern Ontario as case studies for this project. These buildings were visited and documented. Their LEED scores were analyzed. LBC version 2 Guidelines were studied and compared to LEED. Major differences between the two rating systems were identified and possible actions to bring these building to the LBC level were identified. The results will be discussed and conclusions made.

Results
LEED NC version 1 and Living Building Challenge 2.0 were used. The information about the case studies was obtained from CaGBC web site, LEED Consultants fact sheets, site visits and interviews of media department staff and operation manager and communication with architect s. The information collected is summarized in Tables 1 and 2.
Tables 1and 2 summarize features of four case studies projects. Table 3 gives LEED scores for four case studies. Table 4 compares LBC prerequisites with LEED credits.

Discussion
Common to all case studies is the office occupancy and LEED Gold certification. Three buildings are of similar size. There is quite a variation in construction costs. All buildings are designed with human comfort in mind, providing ample daylighting, views, operable windows and effective ventilation. The energy efficiency is achieved by well performing building envelope, natural lighting, effective ventilation combined with passive features and efficient mechanical system. Energy performance is 38% to 47% better than a regular code compliant building. Neither of the case studies uses renewable energy and two are purchasing green power. All buildings are using water efficient fixtures and three are collecting rain water and using for toilet flushing. All projects adopted management of construction waste and achieved significant waste diversion, used regional materials and materials with recycled content.
LBC is taking much broader view of each project which encompasses social, societal and cultural issues and more holistic approach to the environment based on zero ecological footprint. LBC consists of 20

prerequsites. It does not give designers option which credits to select; each project must satisfy all criteria. It recognizes that any construction has an environmental impact and it requires a part replacement of embodied carbon footprint through one-time offset, restoration of the natural habitat and contribution to local food production. One very significant difference between LEED and LBC is in the verification of performance of a constructed project. LEED relies on simulation of building energy performance while the LBC on actual energy use and production and measured indoor environment. LBC comprises of seven petals, site, water, energy, health, materials, equity and beauty. First five petals are corresponding to LEED categories.

How do LEED Gold buildings stand up to LBC? The most challenging is net zero energy. The case study projects are less than 50% better energy performers than regular buildings. There is no capacity on roofs of these building to generate sufficient energy from photovoltaic panels for the current needs. All buildings adopted efficient mechanical system, heat recovery, some passive features, natural lighting and individual controls. The steps which would have to be taken are further reductions in regulated loads by improvement of building envelope, incorporation of further passive features such as earth tube and shading. Also the plug loads would need to be reviewed. Other renewable energy sources especially those which can be integrated should be investigated. It was noted that only one project used the solar water heaters.

Other issue which would need to be addressed is the closed loop water system. This may require larger cisterns for storage of rainwater and collection and treatment of all grey. Currently only portion of potential rainwater is collected; it appears that the cisterns are collecting less than 5% of one-day rain. Water savings for indoor use is in the order of 43 to 70%. Only one project is using municipal water for landscaping. The significant improvement in indoor water is needed. The use of grey water recycling and increase rain water collection should improve the water savings. Another significant change requirement of treatment of all storm water on the property would need to be addressed as LEED deals with this issue only partly. It deals with the storm water management while LBC not only requires keeping of all storm water on site but it does not allow for any building water discharge. This means that the building sewage must be treated on site. This is costly and in some cases it can contravene with the local by-laws. It should be noted that only one project had a water retention pool on site. It should be noted that this site is more rural site.

Habitat exchange is not adequately address by all projects. LEED promotes reduction in site and habitat disturbance but does not go far enough.

While the initial cost of LEED Gold certified buildings has a premium between 7.8 to 10% (Matthiessen, 2004) , the initial cost of net zero energy and water is significantly higher due to the application of new technologies. In order to evaluate the true benefit it is necessary to consider the full life cycle cost including predicted cost escalation for energy and water.

The cost of purchase of one-time carbon offset is difficult to determine. Other issues which were left from the discussion are equity and beauty does not need to increase cost significantly if the integrated approach is adopted from the beginning. The development of educational component will add some cost. The benefit is not only for the general public but also for the occupants. Lot of resource conservation strategies are related either to technology which consumes energy and/ or occupant’s willingness to engage in the process. The development of onsite agriculture or participation in offsite initiatives requires additional funds.

CONCLUSION

LEED Gold buildings although significantly better than the standard code building are still far from the concept of net zero impact which is promoted by LBC. LEED buildings are better building but simply not enough. The LBC User’s Guide is not yet available and therefore it is difficult to estimate the impact of the intent of the newly added petals. It should be noted that the energy intensity for four case study buildings vary by 64.7% (comparing the highest intensity to the lowest) while energy savings are ranging between 40 to 49% and the area per employee are comparable. This is based on theoretical prediction of energy intensity. It is obvious that it is important that we develop the feedback loop into the energy simulation software and better understanding of simulation. With the net zero energy there is a very little room for errors. The Living Building Challenges is forcing designers to approach any environmental impact holistically, including social, cultural and environmental issues. Some site issues and dealing with water, waste water and stormwater can be achieved more easily on the rural site or the implementation may be necessary while car free living is difficult to achieve there. Adoption of net zero energy and water is very costly for small projects especially if high technology is adopted because of high initial cost. In some cases these small projects can be very successful if low technology is adopted. It should be noted that the first two buildings which applied for LBC certification were relatively small with low permanent occupancy and perhaps more relaxed concerns about the indoor environment. Further advantage of small buildings can be in the commitment of occupants to conserve resources. The interface between the occupant and its environment is very important. It can positively impact building performance and save resources. The education is very importance to the success of net zero environmental impacts. One question which can be posed is if the concept of the net environmental impact of each individual project is in fact achieving its intent. It may be better to create communities and combine the efforts and create net zero energy and water initiatives which are more effective because of the volume and diversity. Although the Living Building Challenge has yet to certify a project, over 60 submissions have already been made over the relatively short lifespan of the LBC guideline. It is therefore important to point out that a shift in the construction industry is happening; slowly, the awareness of the need to build healthier and more environmentally friendly buildings is growing.

One very important issue which is life cycle cost related is the ownership of the building. If the building is developed for profit with the intention to sell then the incentive of building green or above green is not there due to higher initial cost. If the owner intends to own and operate the building, then return on investments incurred initially can be recovered and benefits of higher productivity can be included.

REFERENCES

CCA, 5-Year Construction Trends, Dec 2007. Retrieved from http://www.cca-acc.com/news/stats/industry_stats_e.pdf

Statistics Canada, Employment by Industry, 2010. Retrieved from http://www40.statcan.gc.ca/l01/cst01/econ40-eng.htm

Matthiessen L.F., Morris, P., Costing Green: A Comprehensive Cost Database and Budgeting Methodology, 2004. Retrieved from http://www.davislangdon.com/upload/images/publications/USA/2004 Costing Green Comprehensive Cost Database.pdf

ILBCI, The Living Building Financial Study, 2009. Retrieved from http://ilbi.org/community/living-building-financial-study

ILBCI, Living Building ChallengeTM 2.0, 2009. Retrieved from http://ilbi.org/the-standard/version-2-0

LEED Canada-NC, Dec. 2004

	Cambridge City Hall	CUPE Stan Little Building	ETFO Waterloo Office	Grey Bruce Health Unit
Location	Cambridge -downtown	Ottawa, Cryvilla Industrial Park area	Kitchener Trillium Industrial Park area	Owen Sound, close to residential area
Size	7,558 m²	5,871 m²	645 m²	5,575 m²
Construction Price	$30 Million	$14 Million		
Occupancy	Office	Office	Office	Office
Capacity	200 full time workers, capable to hold 1000 people	160 full time workers, capable to hold 366 people in all offices, meeting areas, and conference rooms	6 full time workers, meeting rooms to hold 20, conference room for 125 (not serviced by HVAC)	155 part-time workers, most work onsite when reporting and paper work (service the Owen Sound and surrounding area)
Layout	4 storey building. **Atrium** on south side of rectangular shaped layout with **operable skylights**. All office spaces are **around perimeter;** mix of open concept with closed offices. Meeting areas: natural light from exterior and interior.	5 storey builidng plus 1 level basement. **Atrium** in centre of rectangular shaped layout with **non-operable skylights**. All office space are **located around perimeter**. All meeting areas and class rooms located around the elevator core.	Single storey square lfloorplate building. All officies **located on perimetre** of south side, service space in centre of building, meeting room and conference room located on west and north sides.	3 storey building. **Atrium** in centre of 'A' shaped layout with **automated skylights**, open concept layout with daylight and views from exterior as well as from interior atrium space.
Interesting design features	Floating staircase , multistorey living wall, extensive green roof, stack ventilation, daylighting design	Artist decorated emergency staircase, with windows promotes use of stair; gymnasium and staff room	Officies face south view into green space, two overhang areas have extensive green roofs, parking lot runoff to storm pond	'A' shape of building is directed to deflect prevailing winds from Georgian Bay; brownfield site

Table 1 – Case Studies Summary

	Cambridge City Hall	CUPE Stan Little Building	ETFO Waterloo Office	Grey Bruce Health Unit
Water Efficiency techniques	Low-flow faucets, dual-flush toilets, waterless urinals, 10m^3 rainwater **cistern** for toilet flushing	Dual-flush toilets, low-flow urinals, low-flow water fixtures, drought resistant native/naturalized plants	Low-flow plumbing fixtures, drough resistant landscaping species, rainwater collection cistern	Dual-flush toilets, low-flow plumbing fixtures, rainwater cistern
Water Demand	59% savings indoor	Approx. 456,000 litres/year; 43%reduction indoor	70% savings indoor	1.26 million litres saved 60% reduction indoor
Energy Efficiency Techniques	Energy efficient windows, radiant heating panels, high-efficiency modulating gas boiler, condensing water heater, energy-efficient chiller with free cooling mode, stack ventilation from atrium , heat recovery on exhaust air, occupancy sensors, daylighting sensors, indirect lighting with fluorescent fixtures	Occupancy light sensors, CO_2 sensors, heat recovery for exhaust air, high-efficiency mechanical equipment and office appliances, six solar hot water panels (60% of H_2O demand)	Ground source heat pump, demand-controlled ventilation linked to CO_2 monitoring	Well-insludated building envelope, high performance windows, occupancy sensors, daylighting sensors, energy recovery ventilators, 93% energy-efficient condensing boilers, variable speed drives on mechanical equipments
Energy Demand	684MWh/year (estimated 100% of regulated load) purchased from greenpower power 244 ekWh/m^2 (59% saving)	176 ekWh/m^2 (47% savings)	182ekWh/m^2 (49% savings)9% reduction in demand	24,887m^3/year of gas, 9.376 MWh/ year of hydro 149 ekWh/m^2 (39% savings)
Types of materials used	16% recycled content, 38% regional material	17% recycled content, 70% of wood used was FSC certified, 31% regional materials	15% recycled content, 20% regional material, 89% of construction waste was diverted	16% recycled content, 34% regional material
Annual/ Day Total Precipitation (mm)	890 (113)	900 (86)	925 (119)	1075 (119)
Number of Degree Days	4150	4600	4250	4250

Table 2 – LEED Features of Case Studies

	Cambridge City Hall	CUPE Stan Little Building	ETFO Waterloo Office	Grey Bruce Health Unit
Summary of LEED Credits	41 of 70 Total Points,	39 of 70 Total Points,	39 of 70 Total Points,	39 of 70 Total Points,
Sustainable Sites	5 of 14	6 of 14	10 of 14	7 of 14
Water Efficiency techniques	5 of 5	4 of 5	5 of 5	3 of 5
Energy Atmosphere	7 of 17	9 of 17	7 of 17	7 of 17
Materials Resources	7 of 14	5 of 14	6 of 14	6 of 14
IEQ	12 of 15	10 of 15	6 of 15	11 of 15
Innovation Design	5 of 5	5 of 5	5 of 5	5 of 5

Table 3 – LEED Score for Case Studies

	Living Building Challenge Version 2	Corresponding LEED Credits LEED Canada – NC ver. 1	Differences	Similarities	Related LEED Credit
SITE	P1 – Limits to Growth	SS 1 – Site Selection SS 3 – Redevelopment of Contaminated Sites SS 2 – Development Density	Minor, LBC more specific in defining the sensitive land	Inclusion of ecologically sensitive areas, floodplains; intent to reduce pressure on undeveloped land	SS 4.1- Alternate Transportation: Public access
	P2 – Urban Agriculture (All projects must integrate opportunities for agriculture)				
	P3 – Habitat Exchange	SS 5.1 – Protect or Restore Open Space SS 5.2 – Development Footprint	LBC more specific in provisions of natural habitat	Aim to minimize the footprint and create green space	SS Preq.- Erosion & Sediment Control SS 7.1 – Heat Island; Non-roof SS 8 – Light Pollution Reduction
	P4 – Car Free Living	SS 4.2, 4.3, 4.4- Alternate Transportation		Aim to introduce mix of transportation (pedestrians, bicycles, cars)	
WATER	P5 – Net Zero Water	WE 1.1, 1.2- Efficient Landscaping WE 2 – Innovative Wastewater Technologies WE 3.1, 3.2 Water Use Reduction	LEED promotes municipal water reduction while LBC aims for zero use (closed loop system)	Decrease dependency on municipal water	
	P6 – Ecological Water Flow	SS Credit 6–Stormwater Management	LBC requires management of all stormwater on site	Management of stormwater	
ENERGY	P7 – Net Zero Energy	EA Credit 1 – Optimize Energy Performance EA Credit 2 – Renewable Energy EA Credit 3 – Best Practice Commissioning EA Credit 5 – Measurement & Verification EA 6 – Green Power	LEED is aiming for reduction in energy demand, LBC generates all energy on site	Energy reduction, generation of energy on site	EA Preq. 1- Fundamental Bldg. System Commissioning EA Preq. 2 – Minimum Energy Performance
HEALTH	P8 – Civilized Environment	EQ Credit 6 – Controllability of System EQ Credit 8 – Daylight and View		Provide connection to outdoors	
	P9 – Healthy Air	EQ 1 –CO_2 Monitoring EQ 2- Ventilation Effectiveness EQ Credit 3- Construction IAQ Management Plan EQ Credit 4 – Low-emitting Materials EQ 5 – Indoor Chemical & Pollutant Source Control EQ 7 – Thermal Comfort	LEED is more detailed; it refers to effectiveness and deals with impact of construction on IAQ LBC has entryway dirt tracks	Provide healthy indoor environment	EQ Preq. 1- Minimum IAQ EQ Preq. 2 – Environmental Tobacco Smoke Control

	Living Building Challenge Version 2	Corresponding LEED Credits LEED Canada – NC ver. 1	Differences	Similarities	Related LEED Credit
HEALTH	P10 – Biophilia (elements that nurture the innate human attraction to natural system and processes)		Does not exist in LEED		
MATERIALS	P11 – Materials: Red List	EA Preq.3 – CFC Reduction in HVAC &R Equipment and Elimination of Halons EA 4 – Ozone Protection	LBC prohibits materials beyond CFC and Halons		
MATERIALS	P12 – Embodied Carbon Footprint		LBC requires a one-time carbon offset	Responsible management of resources	MR Credit 1 – Building Reuse MR Credit 3 – Resource Reuse MR 8 – Durable Building
MATERIALS	P13 – Responsible Industry	MR 7 – Certified Wood	LBC covers stone, rock, metal and timber. LBC requires all wood to be FSC, salvage or site clearing	Use local materials and support local economy.	MR 6 – Rapidly renewable Materials
MATERIALS	P14- Appropriate Sourcing	MR Credit 5 – Regional Materials	LBC more detailed on materials/ services.		
MATERIALS	P15 – Conservation + Reuse	MR 8 – Durable Building MR Credit 2 – Construction Waste Management MR Preq.1 – Storage & Collection of Recyclables	LBC includes adaptable reuse and deconstruction	Reduce waste during the life of a project	
EQUITY	P16 – Human Scale + Humane Places				
EQUITY	P17 – Democracy + Social Justice				
EQUITY	P18 – Rights to Nature				
BEAUTY	P19 – Beauty + Spirit				
BEAUTY	P20 – Inspiration + Education				

Table 4 – Comparison of LBC and LEED