Spatial Analysis of LEED Certified Buildings in Canada

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Abstract: *The Building and Construction industry has the highest impact on the environment, ahead of transportation and industrial sectors. 30-40% of energy and material consumption, 35% of landfilled waste generation, and 35% of greenhouse gas emissions are associated with buildings. Many building rating systems have been developed over the past three decades but Leadership in Energy and Environmental Design (LEED) is the most widely used rating system in Canada.*

Canada presents a wide geographical variation from Atlantic to Pacific Ocean. In this paper, spatial analysis for LEED certified buildings across Canada is performed to investigate and study the relationship of regional characteristics to LEED strategies (points). Results show that only 1% of LEED certified projects are located in Far East provinces. Also, only 2% of LEED certified projects use onsite renewable energy despite the fact that most of regions in Canada have a high photovoltaic potential for solar energy use. The result of this paper can assist in choosing appropriate LEED strategies based on regional characteristics in Canada.

Keywords, Spatial analysis, green building, LEED, Canada

Introduction and Background

The world population is growing and development is a driving force of nations to stay competitive in the modern world. Both population growth and economic development need infrastructure and building support. This led to more construction globally specially in the past decades. It took a while until society became aware of drastic impacts of building and construction industry on environment, society and economy. Studies show that building sector generates biggest amount of CO_2 emission that is more than the emissions produced by other major sectors such as transportation and industry (Energy information administration, 2006). Buildings consume 30-40% of the limited natural reserves on the planet (Roodman and Lenssen, 1995) and are responsible for 40% of global energy consumption (WBCSD, 2007). More than half of landfilled generated waste comes from construction and building activities. (USGBC 2007).

Building sector has a considerable economic footprint in both developed and developing countries. Canadian construction industry contributes has grown more than 40% in the last decade (Statistics Canada, 2011). This economic impact is even higher in developing countries, due to higher demand for building and infrastructures. Statistical data shows that building sector share in GDP is even in developing countries, such as Armenia (19%), Tajikistan (11%), Spain (10%) and Romania (10%) are considerable (UNECE, 2010).

People are in direct interaction with buildings during construction (i.e. construction workers) and operation (i.e. building occupants). This exposure leads to direct impact of indoor environmental quality (both during and after construction) on health, comfort and well-being of building users.

In the past three decades many studies, researches and experiments have been conducted to understand and evaluate the environmental impacts of buildings such as global warming, resource depletion and waste generation and highlighted the need to move toward “green buildings”. There are various definitions for green buildings (also referred to as ”sustainable buildings”), but a widely accepted definition of green building is provided by the United States Environmental Protection Agency (US EPA) as “the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction”. (US EPA, 2010).

The current research on green building can be categorized into three groups (Zue and Zhao, 2014):

1. Studies that investigate the benefits of green building and try to answer: why green buildings?
2. Studies that define the boundary for green building and try to answer: what is a green building?
3. Studies that provide metric on how to measure green buildings?

Leadership in Energy and Environmental Design (LEED) is the most widely used rating system in North America, and Canada Green Building Council (CaGBC) has adopted LEED to develop LEED Canada.

LEED is a point-based building rating system developed by the United States Green Building Council (USGBC) in 2000. LEED covers various types of buildings, including, LEED for new construction and major renovation (NC), existing buildings (EB), commercial interior (CI), core and shell (CS), homes (H) and neighborhood development (ND).

LEED-NC (USGBC, 2009) has total of 110 points consist of 100 base points, 6 possible points for innovation in Design and 4 regional priority points. A building may receive different level of certification based on its point scores. The certification levels are:

- Certified 40–49 points
- Silver 50–59 points
- Gold 60–79 points
- Platinum 80 points and above

Buildings are assessed in five main categories for certification, namely:

- Sustainable Sites (SS)

- Water Efficiency (WE)
- Energy and Atmosphere (EA)
- Materials and Resources (MR)
- Indoor Environmental Quality (IEQ)

Design, construction and operation of buildings are under a big influence by their surrounding climate, availability of buildings materials, technology and behavior of people in that region. Despite the significance of regional characteristics, spatial consideration in green buildings lacks largely in the literature (Cidell and Beata, 2009). It is a major drawback to ignore the role of geography in green buildings evaluation considering the variations of environmental conditions around the world and their influence on energy demands and cultural norms (Eliasson, 2000).

In the past decade over 1000 LEED buildings have been certified in Canada, the second highest number in the world. Canada presents a wide geographical variation from Atlantic Ocean to Pacific Ocean. In this paper spatial analysis for LEED certified buildings across Canada is performed to investigate and study the relationship of regional characteristics to LEED strategies (points).

Methodology

This paper considers 100 LEED building across Canada that received certification under one of LEED version 2009 rating systems, including LEED for New Construction and Major Renovations, LEED for Core and Shell Development and LEED for Retail. The building and certification data were collected from CaGBC project profile database (2014) and USGBC LEED project directory (2014) in May 2014. Complete set of data used for this paper is included in Appendix A. ArcGIS (2014) is used for analyzing and presentation of data. Figure 1 shows location of these LEED certified buildings on a map. All of the maps created for this paper are accessible online through: http://bit.ly/1gXAqlE

Results and Discussion

Spatial patterns of four categories are studies in this paper and discussed in the following sections:

A. Level of LEED certification and number of green buildings across Canada

Figure 1 shows level of certification of each project across Canada. The area of circle represents the number of points, and the color represents level of certification. Ontario (ON) with 45% of projects has the highest number of LEED certified projects in Canada. Quebec (QC) with 20%, British Columbia (BC) with 15% and Alberta (AB) with 14% are after ON. It is interesting to point out that eastern provinces (Newfoundland and Labrador, New Brunswick, Nova Scotia and Prince Edward Island) account for only 1% of LEED certified projects in Canada.

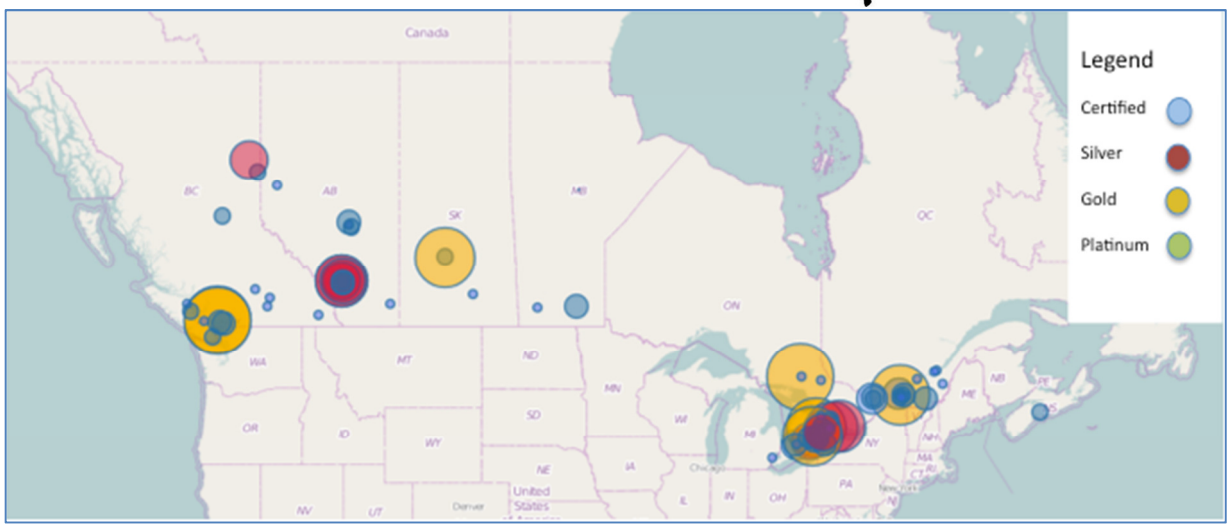

Figure 1. Level of LEED certification across Canada

Majority of the LEED projects are only Certified, 12% of the buildings are Silver (mainly in the ON and QC), 13% are Gold certified and there is no Platinum certified building. In recent years, provincial and federal governments have adopted green building policies. As a result, 60% of Gold certified buildings are owned by university, college, government or the public sector. As it can be seen, the projects that are outside of major cities (lower population, and less income level) and have lower environmental concerns targeted only LEED Certified. Examples are projects in interior BC, AB, Saskatchewan (SK) and Manitoba (MB).

B. Trend of energy saving in buildings across Canada

In discussions around green buildings, energy saving is the first and most important parameter. Similarly, energy conservation has the highest number of points in LEED rating system. Figure 2 shows number of points awarded by each building for LEED credit EAc1 Optimized Energy Performance.

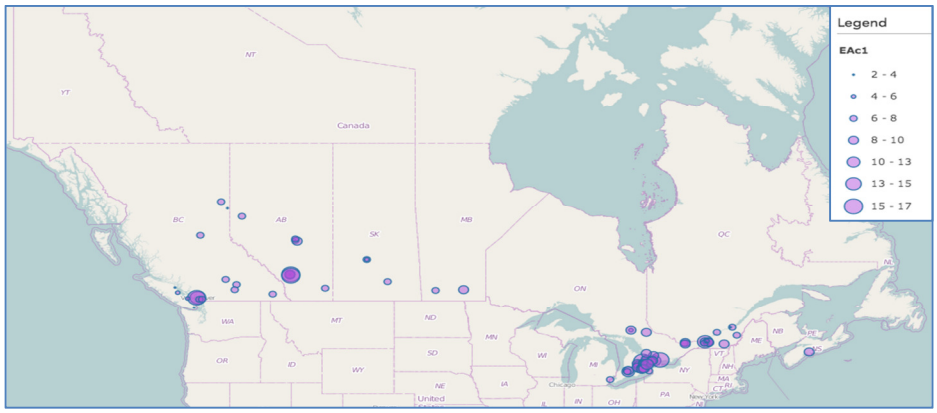

Figure 2. Energy saving in green buildings: LEED EAc1 points

The points are based on energy savings compared to the base building defined by ASHRAE 90.1 (2007) standard, as shown in Table 1.

Table 1. LEED Points for EAc1

Points	Energy Savings	Points	Energy Savings
1	12%	11	32%
2	14%	12	34%
3	16%	13	36%
4	18%	14	38%
5	20%	15	40%
6	22%	16	42%
7	24%	17	44%
8	26%	18	46%
9	28%	19	48%
10	30%		

On average, projects in Alberta and Ontario with 28% have the highest energy savings in Canada. Average project in BC saves 24% and in QC saves 22% energy. Two projects, one in Toronto and one in Calgary, have 44% energy savings. The spatial analysis shows that project in suburban and rural areas have less energy savings compared to projects in developed urban areas. This might be due to use of less effective building insulation materials and energy efficient technologies.

Use of onsite renewable energy (LEED credit EAc2) and investment in green power generation off-site (LEED credit EAc6) are among key strategies to reduce the environmental impacts of buildings that rely on grid sources for their energy supply (mainly from non-renewable resources). Figure 3 illustrates these two LEED credits across Canada.

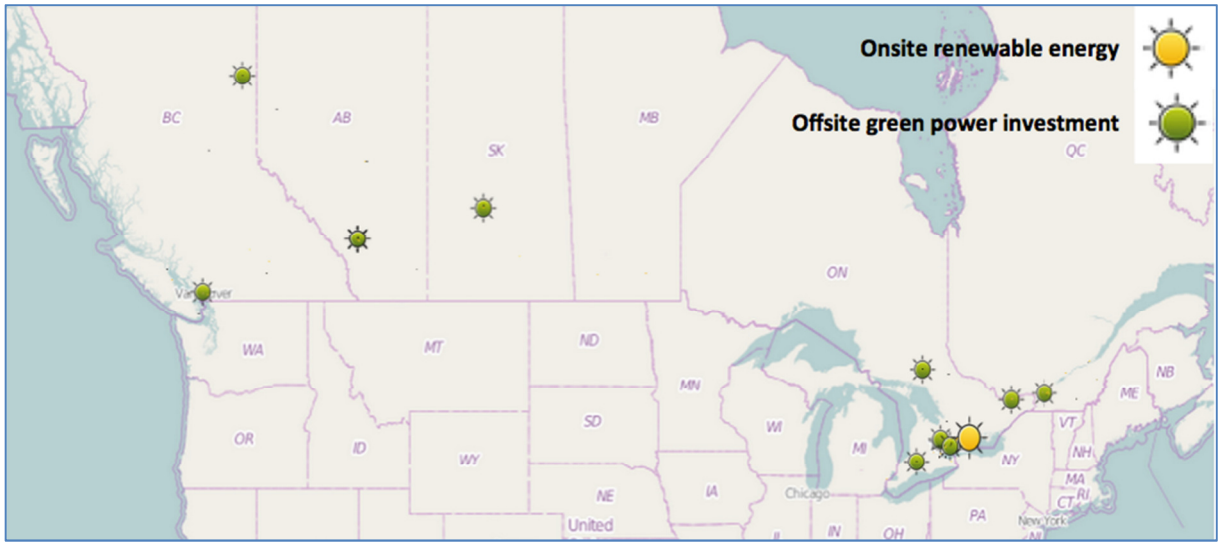

Figure 3. Onsite renewable energy (EAc2) and offsite green power investments (EAc6)

Even though most of regions of Canada have a high photovoltaic potential (kWh/kW) of 1000 to 1400 (NRC, 2014), only 2% of LEED certified projects uses onsite renewable energy. Moreover, only 15% of green building projects across Canada (mainly in metro Toronto region) invest in offsite renewable power generation from wind and solar.

C. Water use reduction across Canada

Water is a precious resource that is used and wasted in buildings. In this section, water use reduction of LEED certified building is studied. The water savings due to efficient landscaping (LEED credit WEc1), innovative wastewater technologies (LEED credit WEc2) and less use in buildings (LEED credit WEc3) are shown in Figure 4.

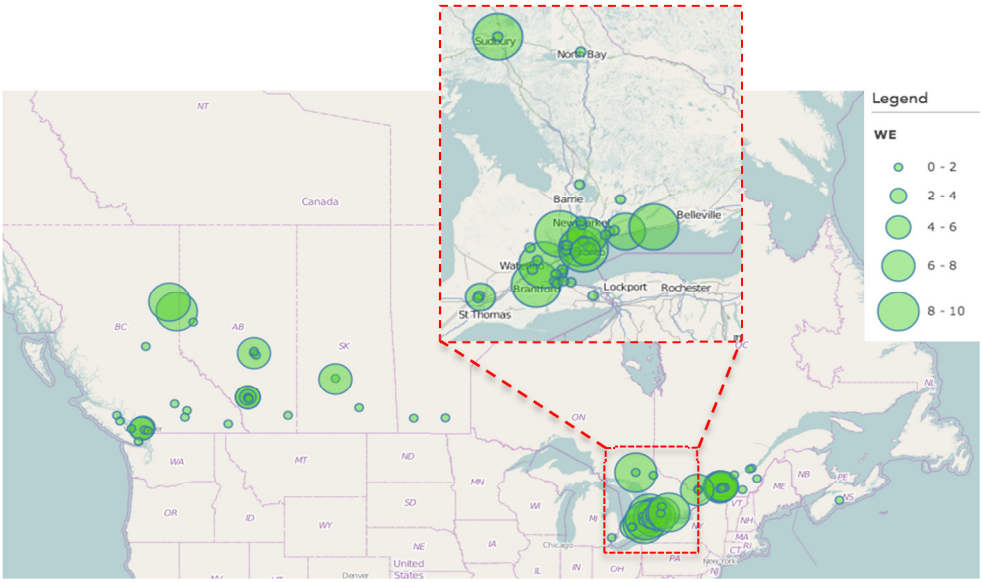

Figure 4. Water use reduction

Analysis of this study shows that on average LEED certified building in Canada have 30% water savings compared to conventional buildings. Interior regions of BC, AB, MB and SK with 100-200 mm of mean annual precipitation have the lowest amount of precipitation in Canada and water conservation should be more stringent in these regions. However, the spatial analysis shows that LEED certified projects in these regions have least amount of water savings. The highest amount of water saving in buildings occurs in southern Ontario, which also receives one of the highest amounts of precipitation in Canada (800-1200mm) (Atlas of Canada, 2009).

D. Sustainable materials and construction waste reduction across Canada

Considering that buildings consume 30-40% of the limited natural reserves on the planet (Roodman and Lenssen, 1995), using sustainable materials and construction waste reduction is of key importance in green buildings. Figure 5 shows number of points awarded by LEED projects in Materials and Resources (MR) category.

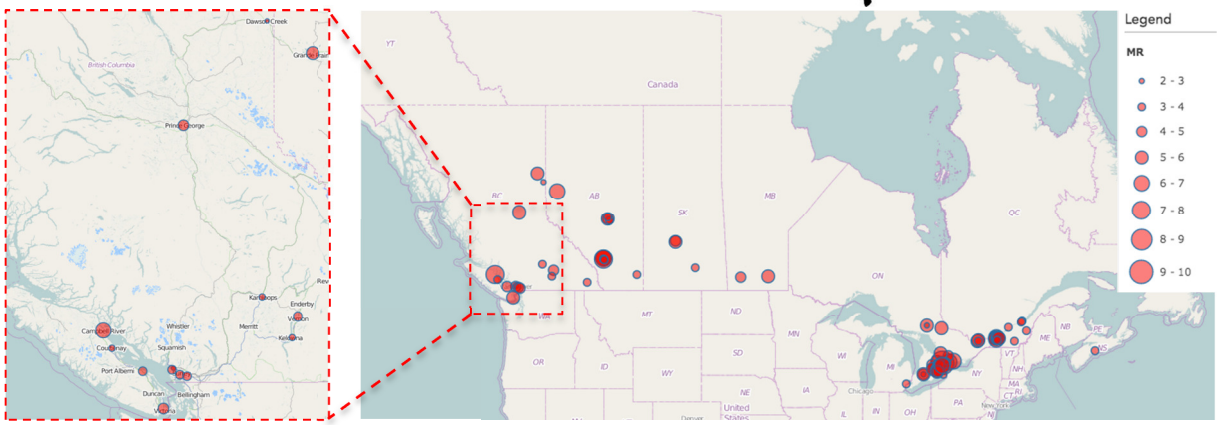

Figure 5. Sustainable materials and construction waste reduction

On average, LEED buildings received 5 points for this category. Buildings in BC have more than 50% diversion rate for construction waste. It is an important achievement noting that more than half of land-filled generated waste comes from construction and building activities. (USGBC 2007). This is due to proper construction waste management programs promoted by Metro Vancouver, City of Vancouver and other local governments in BC.

Conclusion

This paper studied spatial analysis for 100 LEED certified buildings across Canada to investigate the relationship of regional characteristics to LEED strategies (points). The building and certification data were collected from CaGBC project profile database (2014) and USGBC LEED project directory (2014) in May 2014.

Results show that only 1% of LEED certified projects in Canada are located in eastern provinces of Newfoundland and Labrador, New Brunswick, Nova Scotia and Prince Edward. Also, only 2% of LEED certified projects use onsite renewable energy despite the fact that most of regions of Canada have a high photovoltaic potential for solar energy use. Moreover, only 15% of green building projects across Canada (mainly in metro Toronto region) invest in offsite renewable power generation from wind and solar. In addition, Interior regions of BC, AB, MB and SK with the lowest amount of precipitation in Canada have the least amount of water savings.

Result of the spatial analysis in this study shows that Canada has a high geographical potential that can be used strategically to reduce the impacts of buildings. However, LEED certified buildings do not fully take advantage of these resources, and are not designed based on the needs of their region. The result of this paper can assist in choosing appropriate LEED strategies based on regional characteristics in Canada.

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