GREEN BUILDING CONSTRUCTION PRACTICES: REVIEW OF ENVIRONMENTAL MANAGEMENT FROM THE CONTRACTOR PERSPECTIVE IN THE CANADIAN INDUSTRY

by

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Abstract

Green building is a practice applied to the whole life cycle of a building, which means its environmental performance is not only defined by design, but also by the management processes in the construction, operation, and maintenance of a building. Over the past 10 years, research in green buildings has been increasing, mostly focusing on the design and energy efficiency. Contractors now represent a critical role in sustainability, but they have received less support and attention than the design community. This thesis aims to conduct research in environmental sustainability by focusing on three main areas: environmental practices, project management, and organizational perspective. While contractors in Canada are focusing on the implementation of green practices mainly established by LEED; a main problem is that the concept of "green" remains unclear and ambiguous in construction practices. This research started with the identification of green building construction practices categories applicable to contractors by reviewing and comparing green building standards and literature review. Next, this research considered the management perspective by conducting semi-structured interviews in four construction organizations in order to document how LEED is integrated into project management and what issues companies are facing in the implementation of green construction practices. In addition, this thesis identified best practices in how these companies are supporting the reduction of environmental impacts during the construction phase. Overall, this thesis collected several green categories that can serve as a guidance for Canadian contractors to develop specific practices within these categories and advance their environmental sustainability, along with four case studies to document LEED construction management and an overview of the organizational tools used by companies for their environmental management.

Lay Summary

There has been a growth in the green building movement in Canada over the last years in order to reduce climate change impacts. Sustainability in buildings is being considered in the design, construction and operation with the use of standards and rating systems. The main goal of this thesis was to conduct research in environmental categories related to the construction phase to help contractors identify the main areas where they can advance their practices and to examine project management, and organizational practices from four construction companies that work in the construction of green building projects.

Preface

For this thesis, the author was solely responsible for identifying the research gap, designing the research program and performing all the parts of the research. The author received continuous support and feedback from her supervisor Dr. Thomas Froese.

An ethics approval was required to conduct this research. The ethics approval was by the Behavioral Research Ethics Board at the University of British Columbia. The UBC BREB number is H17-00271.

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List of Abbreviations

AIA	American Institute of Architects
ASQ	American Society for Quality
BREEAM	Building Research Establishment's Environmental Assessment Method
BOMA	Building Owners and Managers Association
CAGBC	Canada Green Building Council
GBCI	Green Business Certification Inc.
CGBC	Cascadia Green Building Council
CII	Construction Industry Institute
CSA	Canadian Standards Association
CSC	Construction Sector Council
EMS	Environmental Management System
EPA	Environmental Protection Agency
EPD	Environmental Product Declarations
ESC	Erosion and sediment control
ILFI	International Living Future Institute
IAQ	Indoor Air Quality
ISO	International Organization for Standardization
IWBI	International WELL Building Institute
LCA	Life Cycle Assessment
LEED	Leadership in Energy and Environmental Design
NRCan	Natural Resources Canada
PMI	Project Management Institute
UBC	University of British Columbia
USGBC	United States Green Building Council
VOC	Volatile organic compound
WCED	World Commission on Environment and Development

Acknowledgements

I would like to thank Dr. Thomas Froese, my research supervisor, for giving me the opportunity to perform my research under his guidance. He provided me support to pursue a research topic that was of high interest for me. His constant questioning of my research ideas helped me define the scope and methodology of my thesis. He encouraged me to search and contact different construction companies in order to use them as case studies for my research, which provided me with valuable connections in the construction industry. He gave me feedback about the interview approach and presentation of results and finally, advice in how to frame my thesis, how to structure the chapters and the content in each chapter.

I would also want to express my sincere gratitude to the construction organizations participating in this research project. I would like to thank Bouygues Building Canada, PCL Constructors Westcoast, Urban One Builders and Ventana Construction Corporation for providing me an opportunity to learn about their current management practices, for devoting their time to meet with me for interviews and for their contribution to my research project.

I offer my enduring gratitude to my fellow colleagues and friends at UBC, who motivated me to continue with my research throughout my stay here at UBC. I owe particular thanks to Suzana Espindola, for providing me useful feedback and helping me define the scope of my research project. I also thank Diana Lopez for her patience when listening and questioning my ideas, which provided me guidance in my research final output.

Special thanks are owed to my parents, who supported me throughout my years of education.

I am thankful for the financial support received throughout my stay here at UBC. The Sustainable Building Science Program at UBC for providing my funding for this research, through the NSERC grant, and for providing office space to conduct my research. Finally, thanks to CONACYT- Consejo Nacional De Ciencia y Tecnologia for being my sponsor for my second year at UBC through the CONACYT-ALIANZA FiiDEM 2016 scholarship.

Dedication

To my family.

To my dad and mom, who have provided me support throughout this journey and encouraged me to always challenge myself and step out of my comfort zone.

To my sister and brother, who I will always admire and who encouraged me to take this opportunity.

Chapter 1 Introduction

1.1. Introduction

The construction industry is one of the largest sectors of Canada's economy, contributing approximately seven percent to the Gross National Product annually, with the scale of resource use similarly large. As the importance of sustainable development has been increasingly recognized, the awareness of the environmental impacts of the construction industry has grown.

According to the World Commission on Environment and Development, sustainable development refers to "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Sustainable development has become a goal in many countries around the world and Canada is a clear example. The City of Vancouver has the goal to become the greenest city in the world by 2020 in order to create a better life for future generations. One of its goals is "to lead the world in green building design and construction" (City of Vancouver, 2012) and in order to achieve this, more research in sustainability management should be conducted.

Sustainability should be considered in the whole life cycle of a building, from design to construction and operation. Standards, certifications, and other materials that help capture and codify sustainable practices in buildings are becoming increasingly common. One of the most popular standards used in Canada is LEED. However, LEED and other stardards mainly address design practices, while contractors also require guidance in green building construction practices.

"Contractors play an essential role in green buildings but have received less attention and support for these efforts than the design community in general" (Rosenberg, Merson, & Funkhouser, 2003). Due to the increasing changes of standards and policies, contractors are adopting new management activities in order to comply with certification and organization requirements. Contractors now represent a critical role in sustainability and they can add value through a better management process and through the implementation of additional green construction practices.

This thesis aims to establish a broad understanding of the green construction practices categories through a comparison of green buildings standards and literature review, and to explore best practices in project and organization management that support the implementation of green construction practices in Canada from the contractor perspective through a series of case studies.

1.2. Motivation

The motivation for this research started from my own personal background. I had two years of experience working for contractors, so doing research from their perspective provided a starting point. In addition, earning the LEED Green Associate certification gave me an insight of how LEED is mainly focused on the design phase. This lead to several questions such as: What other additional construction green practices can contractors apply? Also, I noticed the increasing amount and changes of standards, certifications, self-assessments, and regulations that companies need to follow during construction. Different questions arose from this idea such as: How are contractors adapting to those changes? How are contractors managing green building standards during construction? Are these processes well documented?

I decided to focus my research in this area. I wanted to explore, in a holistic way, the technical and management aspects of the environmental side of sustainability from the contractors' perspective. I chose case study interviews a central part of my methodology as it provides the best way to get an insight of Canadian industry practitioners. I used this idea as a motivation for my research and driver for defining my objectives and scope of my research work.

1.3. Objectives

This thesis has three primary objectives:

1. To identify the green building construction practices categories established in current green building standards that particularly impact the construction phase.
2. To document the integration of LEED construction practices in the project management areas established by the Project Management Institute.
3. To document the organizational approach from contractors for the implementation of green building construction practices.

1.4. Scope of Work

This thesis is based on the combination of information from three sources:

1. Existing research published in papers, books, reports, thesis/dissertations and organizations' websites (reviewed in **¡Error! No se encuentra el origen de la referencia.**) to understand the current trends in Canadian green building practices.
2. A comparison of green building rating systems and practices implemented in the construction phase (detailed in **¡Error! No se encuentra el origen de la referencia.**). This comparison examined four green building rating systems that are applied in the Canadian Industry and

one that is applied mainly in the UK in order to obtain a general overview of the differences in construction-related credits.

3. Case study information from four construction organizations. The main focus was on LEED management in green buildings, mostly considering pre-construction and construction phases, which fall under the project management team. Information about organizational support and tools for the management of green building site practices was also gathered through the interviews. The details of the data collection process and synthesis of information obtained from each organization are described in Chapter 4.

1.5. Research Challenges

There were a number of challenges regarding this research. The data collection was from different construction companies. Some of them didn't provide all the documentation required. Access to these missing components could have provided an opportunity for more detailed analysis of the documented processes.

The data collection consisted in 1.5 hour interviews. Clear understanding of the practices could be improved by direct observation in the daily activities and more involvement in the organization.

The final challenge was my limited knowledge of sustainability certifications before this research commenced. My background is in Civil Engineering and not specifically in sustainability or environmental management. I decided to take the LEED Green Associate certification and a Sustainability Management Certification from the University of Minnesota to become more familiar with green building standards and organizational sustainability.

1.6. Research Methodology

This research includes a literature review and a six-step methodology, 'DP4C: Define, Plan, Collect, Classify, Check, Communicate'. The idea for naming and following this methodology was obtained from similar methodologies such as the 'PDCA: Plan, Do, Check, Act' model followed by ISO Standards (ISO, 2013) and the 'DMAIC: Define, Measure, Analyze, Improve, Control' followed in the Six Sigma method by the American Society for Quality to review processes (ASQ, 2017). The overall methodology for this thesis was as follows:

1. **Conduct a literature review:** the review included journal and conference papers, reports, whitepapers, books and official organizations' reports related to the following themes:
    - overview of sustainability in terms of sustainable development and the triple bottom line,

- green building standards and Canadian industry trends in green building practices,
- previous research in environmental management from a contractor's perspective, and
- overview of the aspects to consider in each one of the layers of environmental management: green practices, project management and organization.

2. **Define:** define the level of impact of LEED 2009 credits in the construction phase and define green building construction practices categories applicable to contractors from literature and from 'credits' established in green building standards.
3. **Plan:** plan and design the interview.
4. **Collect:** collect the data through interviews in four construction organizations. Semi-structured interviews were conducted and project documentation was gathered if permitted by the company. All the interviews were recorded.
5. **Classify:** classify and synthesize the information obtained through the interviews and documentation. The information was classified in the two following perspectives:
   - Project Perspective
   - Organizational Perspective
6. **Check:** the accuracy of the information was reviewed in the two perspectives considered in this research.
   - *Project Perspective:* The results from the previous step were verified for any discrepancies among the case studies.
   - *Organizational Perspective:* The results from the previous step were reviewed with information about the approach to sustainability displayed on the top 40 contractors' websites in Canada. The list of these contractors was obtained from a report presented in "On-Site: Canada's Construction Magazine" (2017).
7. **Communicate:** communicate the final results and contributions of the research in this thesis.

The methodology from step 2 to step 7 is represented by the flowchart shown in Figure 1.1Figure 1.1 Research Methodology for illustration purposes:

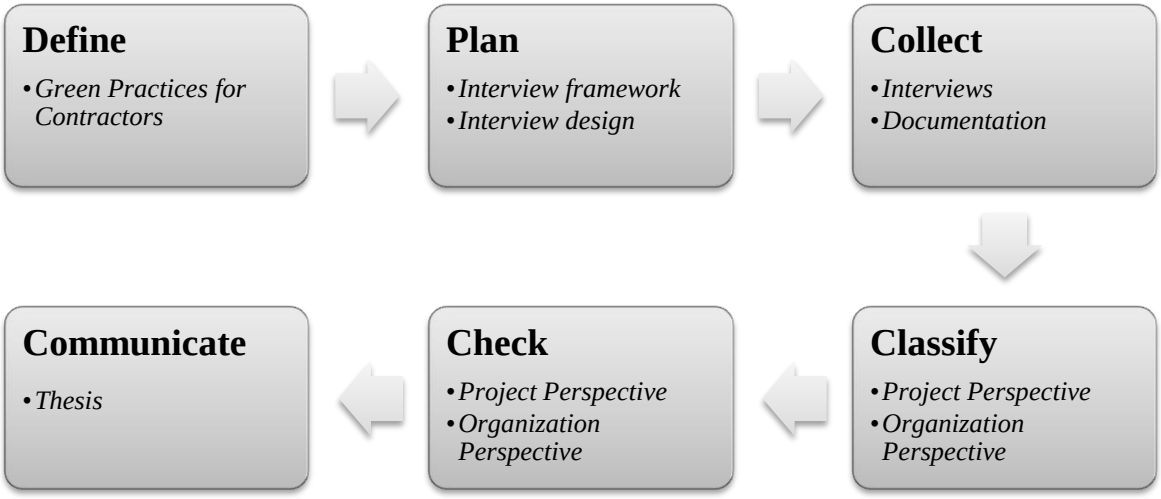


Figure 1.1 Research Methodology

1.7. Research Framework

The methodology previously mentioned are the steps followed in this research. However, this research follows a framework method for the management of qualitative data. The framework method is used for the management of qualitative data, where the information is organized into categories to help summarize and synthesize the data (Gale et al., 2013). The framework consists of three layers—the green practices layer, the project management layer, and the organizational layer—corresponding to the three objectives listed in Section 1.3. The reason to use this framework is that each layer is fundamental to achieve the best outcome of environmental sustainability in projects. A more detailed description about the framework and information related to each layer is provided in Chapter 3.

This thesis approaches the first layer, green practices, by:

1. Evaluating each one of LEED 2009 credits and determining the level of impact to the construction phase.

2. Collecting practices categories by exploring the credits found in GREEN Globes and LEED, which are popular standards used in Canada, REAP, which is the UBC green building standard, BREEAM, which is a recognized international standard, and a review of two journal papers. One of journal papers developed a list of 54 construction phase sustainability actions (O'Connor et al., 2016) while the other consisted of an evaluation of on-site environmental performance indicators to enhance a green construction operation (Zou & Sungwoo, 2013).

This thesis approaches the second layer, project management, by:

1. Conducting semi-structured interviews to determine how LEED is integrated in project management and classifying the information in the knowledge areas established by Project Management Institute.
2. Conducting semi-structured interviews to determine specific LEED credit issues and classifying the information in the knowledge areas established by Project Management Institute.

This thesis approaches the third layer, organizational implementation, by:

1. Conducting semi-structured interviews to determine how companies are supporting the implementation of green building construction practices and identifying best practices.

The information is summarized in Figure 3.2

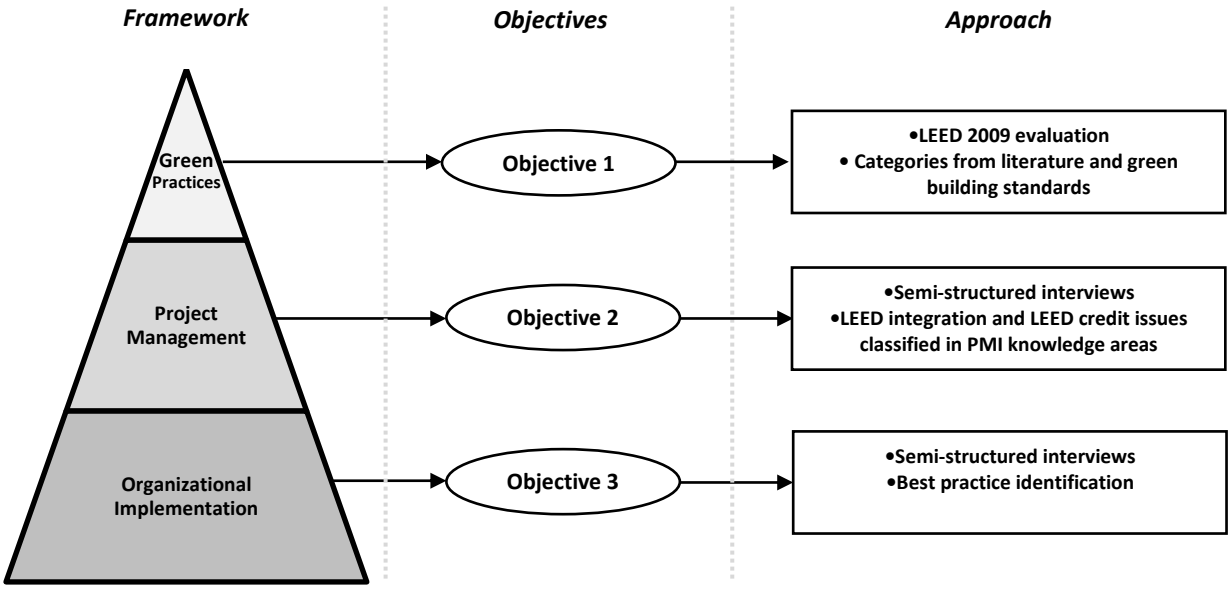


Figure 1. 2 Research Approach to Environmental Management Framework

1.8. Organization of Thesis

A brief overview of each chapter is presented below:

Chapter 2 sets up a knowledge platform for the rest of the thesis and acts as a point of departure. This chapter starts with a general overview of sustainability and how the construction building industry has defined it with standards and rating systems. This is followed by the literature related to the Canadian industry trends in green building practices and relevant information to the contractor's view in the implementation of these practices to set up the context

of this research. An overview of the factors impacting green building performance outcome is also included in this chapter.

Chapter 3 introduces the framework followed in this research, explaining the importance of each one of the layers and providing a detailed description of each layer is related to this research. This chapter also talks about the data collection process. It discusses the design of the interview, the selection of case studies, a brief introduction to each case, and an overview of the companies' contribution to this thesis.

Chapter 4 is related to objective 1 mentioned in Section 1.3 and presents the level of impact that the credits from LEED 2009 have on contractors (the case studies involved in this research all worked with the 2009 version of LEED). A list of building construction practices categories for improving environmental performance generated from LEED 2009, LEED v4, GREEN GLOBES, BREEAM and various research sources is provided in this chapter. The list of categories provide a reference, not only to technical practices, but also to some management aspects.

Chapter 5 reviews the project management perspective from the case studies evaluated. This section makes reference to the second objective established in Section 1.3. The information is first presented in terms of the 3P's—people, process and planning—according to the information from the interviews and the documentation gathered from the four construction organizations. Finally, the information from the interviews about LEED integration and issues related to green construction credits is synthesized and classified in the project management areas established by the Project Management Institute.

Chapter 6 corresponds to the organizational perspective and relates to the third objective established in Section 1.3. It gives a general overview of best practices and how companies can enhance their implementation towards environmental management in the construction phase. This section also involves a review of the websites of the top 40 contractors in Canada listed in On-Site Magazine in June 2017 which supported the information found in the case studies.

Chapter 7 summarizes the entire thesis while highlighting the research contributions. The limitations in this research and scope for future work are also mentioned in this chapter.

Chapter 2 Literature Review

2.1. Introduction

This chapter provides a general background for the research, starting with an overview of sustainability and green buildings and following with reviewing the Canadian perspective of the level of activity, triggers, benefits, and barriers to the implementation of green buildings. This background is continued with a review of current research done from a contractor's perspective. The final section discusses research related to the impact of project delivery and integration on building performance and critical project management success factors identified in several papers.

2.2. Sustainability Overview

Literature such as journal papers, conference papers, reports, whitepapers, and books are replete of definitions, frameworks, and models to define and implement sustainability. Most of them start addressing sustainability from one of the most popular definitions for sustainable development mentioned in 1987 by the U.N World Commission on Environment and Development (WCED) in the Brundtland Report. According to the definition established, sustainable development refers to "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". (WCED, 1987)

Sustainability is also generally described in terms of the triple bottom line. The triple bottom line goal as represented in Figure 2.1 was first established by John Elkington in his 1998 book, “Cannibals with Forks: the Triple Bottom Line of 21st Century Business” (USGBC, 2014), incorporating:

- social perspective (people): costs and benefits related to all people influenced directly or indirectly by a project;
- environment perspective (planet): costs and benefits related to the natural environment, locally or globally influenced by a project; and
- economic perspective (profit): economic costs and benefits of a project for all the stakeholders.

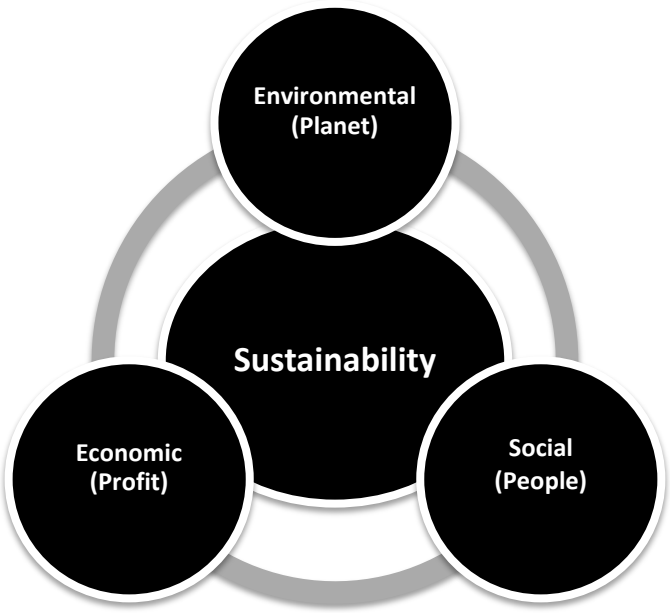


Figure 2.1 Triple Bottom Line

The definition of sustainable development and the triple bottom line seems to be applicable to every field from global development policies to the building industry. The building industry has a significant effect on the environment and human health as they consume more than one-half of the world's physical resources and account for 30% to 40% of the world's energy use. (CSC, 2011). Just in Vancouver, buildings account for 55% of GHG emissions (City of Vancouver, 2012). In this context, sustainability means creating places environmentally responsible, healthful and profitable (USGBC, 2014) and in order to achieve this, the building industry has been shifting the traditional practices to green practices.

2.3. Green Buildings

Green building has been defined by many organizations. The U.S. Office of the Federal Environmental Executive described it as "the practice of 1) increasing the efficiency with which buildings and their sites use energy, water and materials, and 2) reducing building impacts on human health and the environment, through better siting, design, construction, operation, maintenance and removal throughout the complete lifecycle" (CSC, 2011). The US EPA defines it 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, 2016). CAGBC defines it as the "method and practice for addressing climate, minimizing energy and resource demands, and for building more resilient and healthy communities". (CAGBC, 2016). Essentially, green

building is defined as the practice, method or even process of continual improvement (USGBC, 2014) applied to the whole life cycle of a building to increase efficiency and reduce its impacts, but not as the end product.

2.3.1. Green Building Standards and Assessment

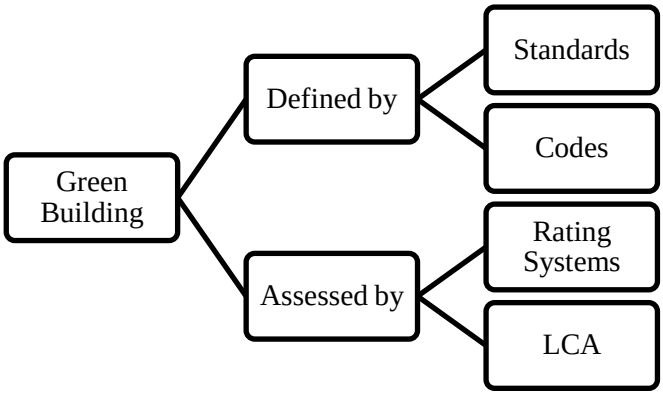


Figure 2.2 Green Building Practices Definition and Assessment

There is now a growth in the development of codes, standards, rating, and certification programs to help guide, demonstrate, and document efforts to deliver sustainable buildings. (Vierra, 2016). As shown in Figure 2.2, green building is defined by standards and codes and mainly assessed by rating systems and LCA methodology.

A standard is defined by ISO as: "a document, established by consensus, approved by a recognized body that provides for common and repeated use as rules, guidelines, or characteristics for activities or their results" (ISO, 2004) and they mainly serve as incentives for improved performance. Standards and codes can be prescriptive-based, where the methods of achievement are identified by quantifiable values or performance-based standards, and where only the expected end results are identified. (Vierra, 2016). Codes are intended to be mandatory and they represent the minimum standard (Cheong, 2017). Relevant codes provide minimum requirements for increasing the environmental and health performance of buildings (US EPA, 2017). A recognized international standard is the American Society of Heating, Refrigeration, and Air-Conditioning Engineers Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings, 2011 edition, ANSI/ASHRAE/USGBC/IES Standard 189.1-2011, (ASHRAE 189.1), and a recognized model code is the International Code Council's 2012 International Green Construction Code (IgCC) (US EPA, 2017); however, neither are used directly in Canada (Cheong, 2017).

There are two main approaches for assessing buildings' impacts: LCA (Life Cycle Assessment) and building rating systems (or a combination of both, Bernardi et al., 2017). Rating systems are a type of building certification system that rates the levels of compliance or performance with specific environmental goals and requirements (Vierra, 2016). The green building movement has involved the creation and modification of multiple green building standards and rating systems in order to change the design, planning, construction and operation of buildings to create sustainable and ultimately, regenerative built environments (USGBC, 2014). There are many rating systems used and created in different countries around the world, but most of them include the following criteria (Bernardi et al., 2017):

- Categories: specific sets of items considered during the assessment,
- Scoring System: a performance measurement system that represents the points or credits that can be earned by achieving a certain level of performance in several aspects,
- Weighting System: a level of relevance assigned to each specific category within the overall scoring system, and
- Output: the results of the performance obtained during the scoring phase.

The first sustainability standard for buildings was founded in 1990 in the United Kingdom by the Building Research Establishment Global Ltd., known as BREEAM, followed by a rapid growth in the creation of other similar standards, as represented in Figure 2.3, which highlights the increasing phenomenon from 1990 to 2014. After 2012, however, the rate of growth started to stabilize (Bernardi et al., 2017).

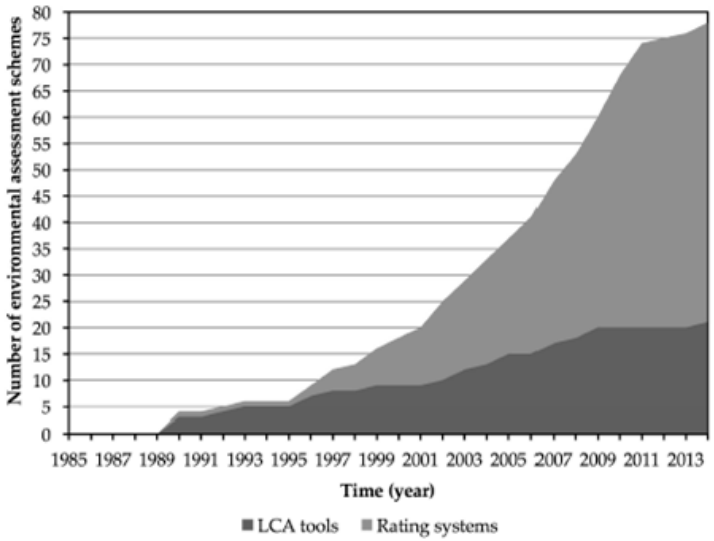


Figure 2.3 Growth in Building Assessment Tools. Source from (Bernardi et al., 2017)

2.3.2. Green Building Standards and Rating Systems in Canada

Green building standards in Canada began to appear shortly after the development of BREEAM, the first green building standard from the UK in 1990. The regional initiatives for green buildings started with BREEAM-Canada in 1996, an environmental performance assessment standard released by the Canadian Standards Association as CSA Plus 1132. Next, Green Globes for Existing Building was developed in 2000 by ECD Energy and Environmental Canada, followed by Green Globes for New Buildings Canada with the support of the Canadian Department of National Defense and Public Works and Government Services (ECD Energy and Environmental Canada, 2013). Green Globes for existing buildings is now administered by the Building Owners and Managers Association (BOMA Canada) and has been rebranded as BOMA BESt (Building Environmental Standards). Around the same years, after the release of BREEAM-Canada, the first LEED rating system was adapted for Canada and the LEED Canada for New Construction and Major Renovations version 1.0 was launched in December 2004 (CAGBC, 2010). More stringent standards started appearing in Canada, such as the Living Building Challenge, the first version of which was presented and launched in 2006 by the International Living Future Institute (ILFI), an organization created by Cascadia Green Building Council (CGBC), a chapter of USGBC and CAGBC. The Living Building Challenge was endorsed by both the US Green Building Council and the Canada Green Building Council in 2006 to promote their goals (ILFI, 2017). In 2011, the International Living Future Institute

created their Net Zero Energy Building Certification (NZEB) to verify net-zero energy building performance. NZEB is one of three certification paths under the Living Building Challenge (ILFI, 2017). Figure 2.4 represents the spectrum of increasing levels of "green" from typical building codes to restorative buildings and emphasizes the high level of stringency in the Living Building Challenge as it is close to reaching restorative buildings.

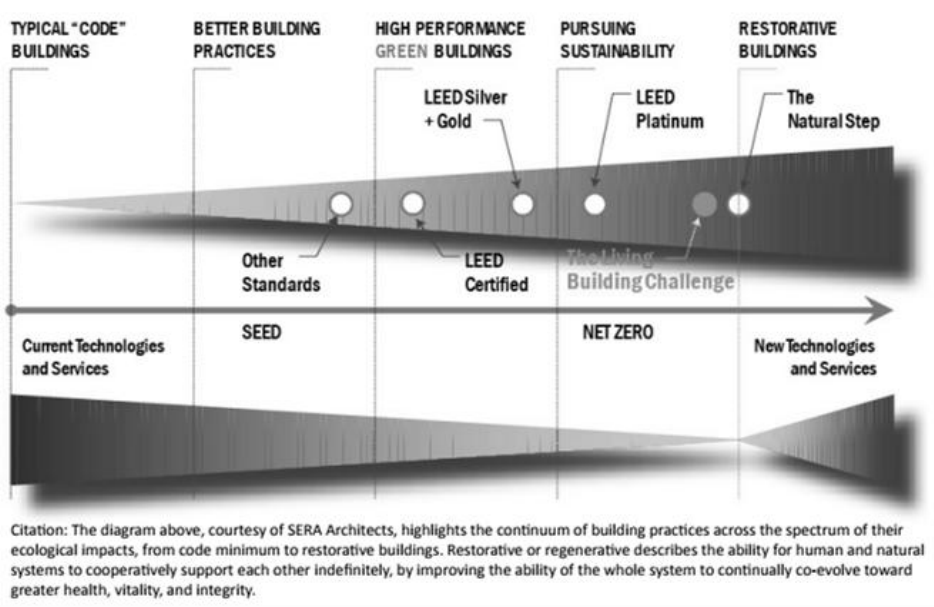


Figure 2.4 Shades of Green. Source from (Eisenberg et al., 2009)

Table 2.1 Popular Standards Used in Canada describes the top selected green building standards for new buildings.

Table 2.1 Popular Standards Used in Canada (1/2 Pages)

Building Rating or Certification System	Development	Details in Canada	Purpose	Description	Levels	Areas of Focus
Leadership in Energy and Environmental Design (LEED)	**Organization** USGBC **Year** 1998 **Country** U.S	•Administered in Canada by CAGBC •Latest Versions used: LEED 2009 LEED v4	Promote resource efficient buildings to create healthier environments and reduce impact to environment by using less water, energy and GHG while lowering operating costs	Internationally recognized third-party certification program	•Certified: 40-49 points •Silver: 50-59 points •Gold: 60-79 points •Platinum 80 points and above	•Sustainable Sites •Location and Transportation •Water Efficiency •Energy and Atmosphere •Material and Resources •Indoor Environmental Quality
Green Building Assessment Protocol for Commercial Buildings (Green Globes)	**Organization** ECD Energy and Environment Canada **Year** 2000 (for Existing Buildings) **Country** Canada	•Administered in Canada by BOMA BESt for existing buildings and ECD Energy and Environment Canada Ltd for New Buildings. •Latest Version: Green Globes Canada - Design for New Construction and Major Retrofits v.2 2014	Encourage improved environmental and health performance for wide range of commercial, institutional and multi residential building types.	An online assessment protocol, rating system, and guidance for green building design, operation and management. Can provide market recognition of a building's environmental attributes through third-party verification.	•1 globes •2 globes •3 globes •4 globes	•Project Management •Site •Energy •Water •Materials and Resources •Emissions •Indoor Environment

Table 2.1 (continued) Popular Standards Used in Canada (2/2 Pages)

Building Rating or Certification System	Development	Details in Canada	Purpose	Description	Levels	Areas of Focus
Living Building Challenge	**Organization** International Living Future Institute **Year** 2006 **Country** US/Canada	•ILFI was created by CGBC (Cascadia Green Building Council), a chapter of USGBC and CAGBC •Living Building Challenge v3.0 •Living Building Challenge v3.1 (As of Dec 31, 2016, all projects will need to register this one)	Promotes a healthy and sustainable future by creating resilient and sel-sufficient buildings. It uses a flower as a metaphor because the ideal built environment should function as cleanly and efficiently as a flower.	Philosophy, advocacy platform and certification program to define priorities and core values to direct the building industry rather than just providing information on the technical level. Green building certification program and sustainable design framework to create regenerative, self-sufficient, healthy and beautiful buildings. Includes performance goals rather than best practices to empower the creation of design solutions.	•Living Building Certification: All imperatives to the project typology •Petal certification: -3/7 Petals -One should be Water, Energy or Materials -Imperative 01:Limits to Growth + Imperative 20: Inspiration + Education are required •Zero Energy Certification: Generate all energy on site without combustion	• Place •Water •Energy •Health + Happiness • Materials •Equity • Beauty

***Data sourced from (Green Building Canada, 2016) (USGBC, 2017) (USGBC, 2013) (ECD Energy and Environmental Canada, 2013) (ILFI, 2017)**

The latest addition to the trend of green building standards is found in the Zero Carbon Building Standard initiative created by CAGBC in 2016 to assess carbon emissions in commercial, institutional and multifamily buildings (CAGBC, 2017). Another standard with increasing popularity is the WELL Building Standard, the first version of which was released in 2014 by the international WELL Building Institute (IWBI). Certification can be obtained by the Green Business Certification Inc. (GBCI), just as with LEED, and the purpose is to focus exclusively on enhancing people's health and well-being through the built environment. WELL and LEED complement each other in the optimization of healthy and high-performance environments as WELL mainly promotes human health and LEED mainly focused in enhancing environmental sustainability (IWBI, 2015). There are other popular certifications used in Canada focused on both green building and home building, such as BuiltGreen (a national certification program) and Passive House (a certification system focusing on home building envelope optimization) (Green Building Canada, 2016).

2.3.3. Green Building Standards in BC

Updates to green building codes, standards, rating, and certification have occurred in BC since 2007. There is a current focus on GHG emissions, carbon neutrality, and renewable energy. There has been more adaptation to the green building movement, which will be discussed in section 2.4.

The City of Vancouver's target is to reduce community-based GHG by 33% from 2007 by 2020, achieve zero emissions new buildings by 2030, and be 100% renewable by 2050. The City of Vancouver's 2011 Green Rezoning Policy references LEED NC Gold and Built Green Gold as tools to achieve their green building goals. Since January 2011, all rezoning projects are required to achieve LEED Gold with a minimum of 63 points and a minimum of 6 Optimize Energy Performance points, 20% Water Use Reduction (prerequisite), and 1 Storm Water point. Alternatively, projects may achieve a minimum of LEED Multifamiy Midrise, Built Green Multi-Storey and Residential Tower Gold (MS&RT) with a minimum of 35% better than MNECB (Model National Energy Code for Building), or Built Green for Homes Gold or LEED for Homes Gold, and a score of EnerGuide 82. (Sawatzky, 2011)

2.4. Canadian Green Building Movement

Canada's vision is to be one of the greenest countries in the world and to continue improving quality of life. Canada's view on sustainable development goes beyond conserving the environment for future generations, and strives for "achieving low-carbon, environmentally responsible economic growth, maintaining and restoring our ecosystems, and ensuring Canadians can flourish in clean and healthy environments" (Government of Canada, 2016). The Government of Canada is taking actions to reduce GHG emissions as mentioned in the previous section. In addition, companies across Canada are developing processes to reduce their environmental footprint.

Green building is an actionable solution that will help to achieve Canada's climate change commitments as buildings generate over 30% of Canada's GHG emissions from heating, cooling and lighting. In addition, 10-15% are embodied in building materials and products (CAGBC, 2017). There has been a transformation in the construction industry by the Canadian green building movement, and while Canada is still becoming more green, it has advanced its green market, ranking 24th globally on the 2014 Environmental Performance Index (a project between the Yale Center for Environmental Law and Policy and the Center for International Earth Science Information Network at Columbia University, in collaboration with the World Economic Forum) (CAGBC, 2014). The following sections provide a general view of three main aspects of this green building movement: level of green activity; triggers and reasons that increase green building activity; and benefits and barriers of green building rating systems from a Canadian perspective.

2.4.1. Level of Green Activity

Green building growth in Canada has been promoted by building owners, institutional investors, corporate sustainability policies and building code/by-law requirements; but voluntary adoption has played a major role in the increase of green buildings. McGraw Hill Construction along with the Canada Green Building Council conducted a study of the Canadian green building movement. This study involved 200 participants from Canada including architects, contractors, building owners/developers and consultants/engineers. For the purposes of the study, they considered a green building project as one that was LEED certified, or that used another recognized green building standard, or that was energy and water efficient and addressed improved indoor air quality and/or material resource conservation. The findings show how the

green building movement is growing (Figure 2.4) and it is expected to become even more common every year. In 2011, only 27% of the participants reported that more than 60% of their projects were green. This number increased by 6% in 2014 and it was expected to have another 17% increase by 2017 (CAGBC, 2014).

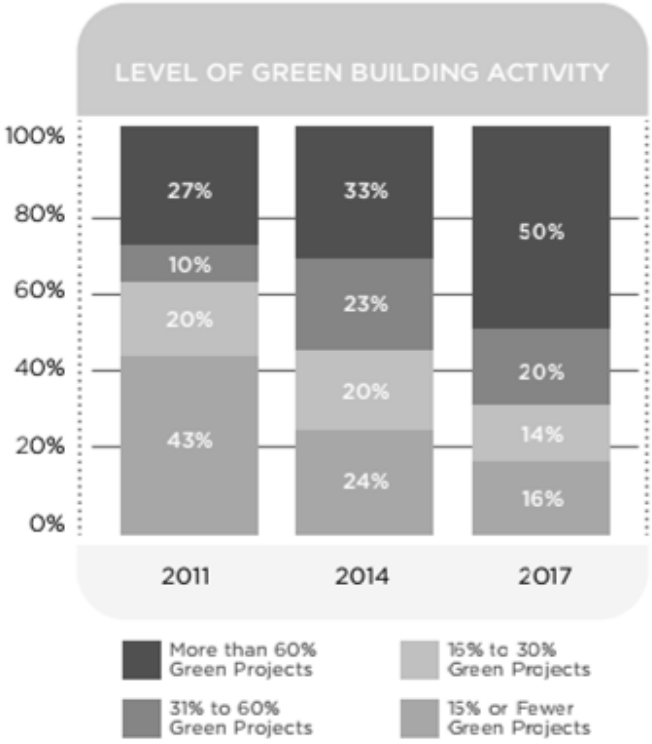


Figure 2.5 Level of Green Building Activity. Source from (CAGBC, 2014)

The use of green building certification or rating systems varies by building sector. The institutional and commercial sectors seek the most certifications, with 79% and 67% (respectively) of the projects in Canada being certified, while only 49% of new mid and high-rise residential projects seek certification (CAGBC, 2014). The use of rating systems also varies through the different regions of Canada (Figure 2.6), with Ontario reaching the highest level of green building activity, followed by Quebec and British Columbia.

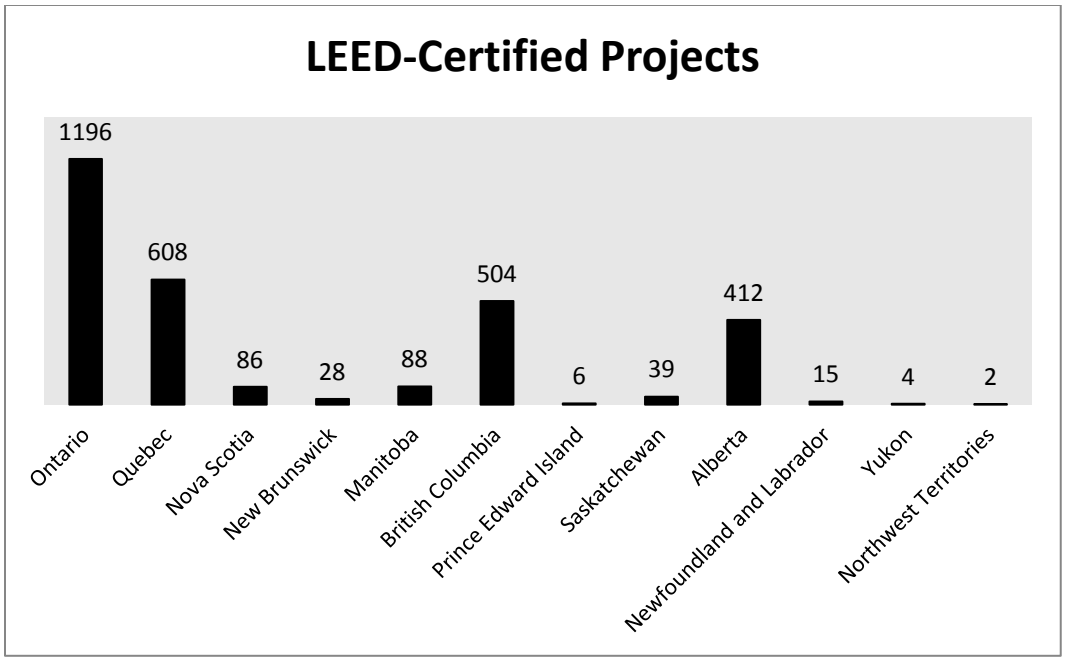


Figure 2.6 LEED-Certified Projects in Canada. Data obtained from (CAGBC, 2017)

2.4.2. Triggers for Green Buildings

A belief that it is the right thing to do and client demand are the main reasons for the increase in green building activity in the Canadian Industry. Other reasons, in order of importance, include: municipal and federal green building policies, lower operating costs, corporate social responsibility commitment, higher building values, market transformation, environmental/ public relations and higher return of investment, as represented in Figure 2.7. The desire to do the right thing demonstrates how strongly green building practices are promoted and valued in the Canadian industry because globally, this reason is not a main trigger for increasing green activity (client demand and environmental/public relations were found to be the most important world-wide, Figure 2.8). Lowering Operating Costs was an important factor in both Canada and globally; however, it is expected that the importance of this driver will begin to decline as energy efficiency becomes more widespread (CAGBC, 2014).

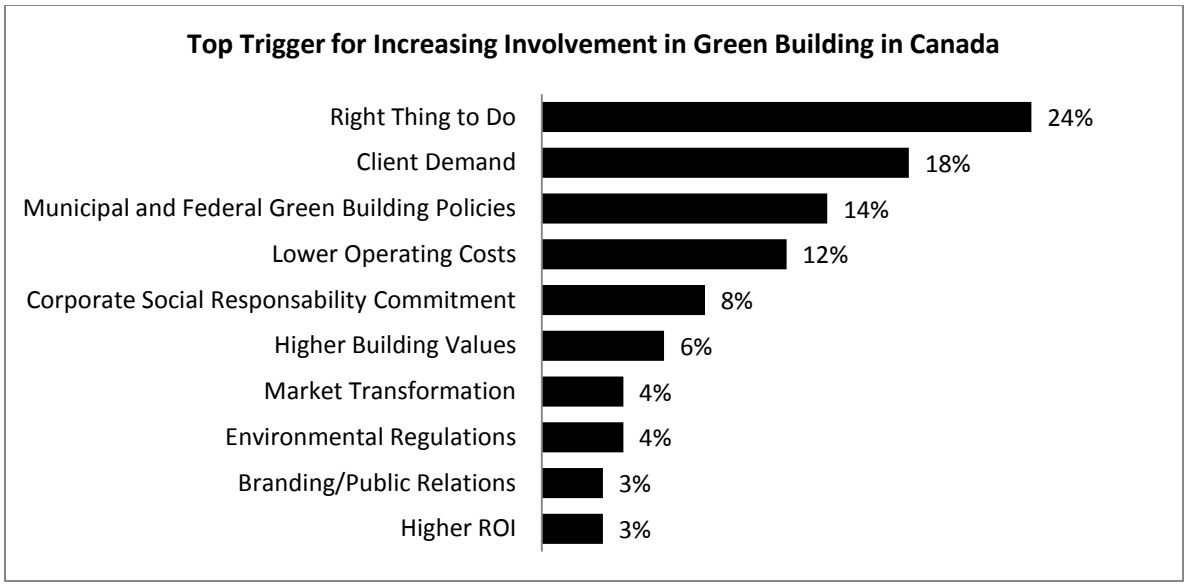
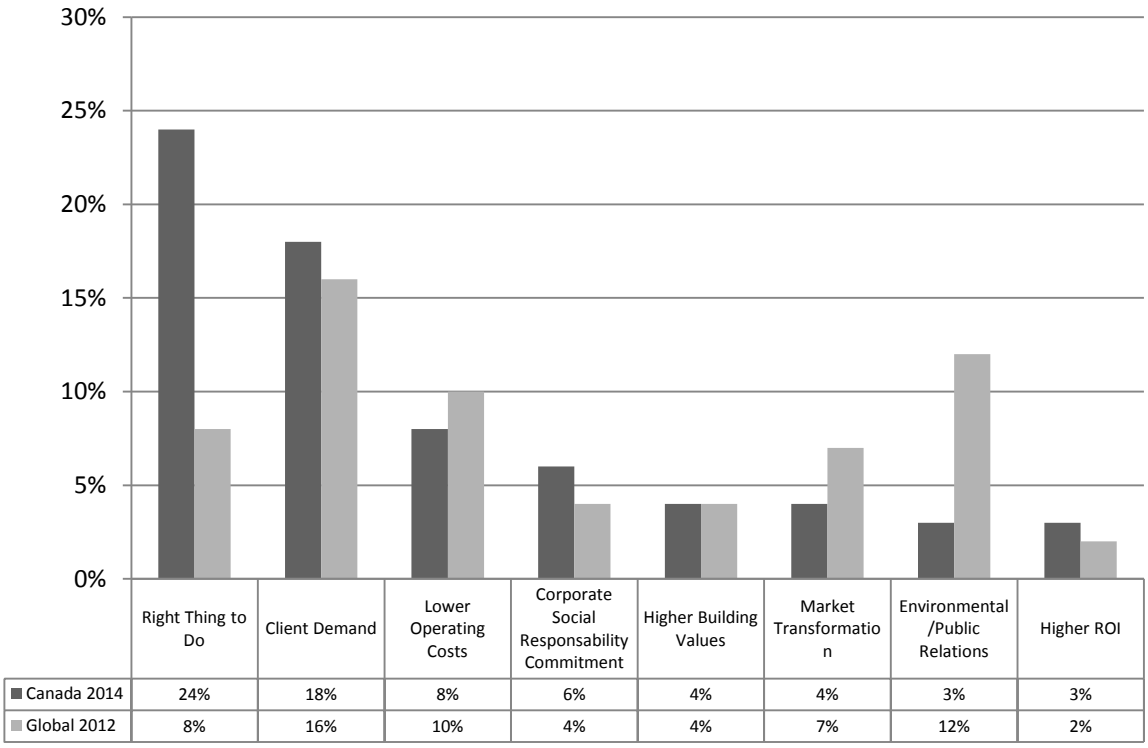


Figure 2.7 Top Trigger for Increasing Green Involvement in Canada. Adapted from (CAGBC, 2014)



	Right Thing to Do	Client Demand	Lower Operating Costs	Corporate Social Responsability Commitment	Higher Building Values	Market Transformation	Environmental /Public Relations	Higher ROI
Canada 2014	24%	18%	8%	6%	4%	4%	3%	3%
Global 2012	8%	16%	10%	4%	4%	7%	12%	2%

Figure 2.8 Triggers for Increasing Green Involvement in Canada. Adapted from (CAGBC, 2014)

Government mandates have made a large impact on companies. Policies can help drive the Canadian market to be a leader in sustainability and encourage green building activity.

2.4.3. Benefits and Barriers for Building Green

There are several barriers to the growth of green buildings such as higher first costs, lack of market demand, lack of political support, lack of government or utility incentives, affordability, lack of public awareness and time constraints (CAGBC, 2014). Other challenges include: a tendency to maintain current practices, limited sustainability knowledge and understanding from subcontractors, recovery of long-term savings not reflected in service fee structure, and high cost for sustainable materials and products (Kang et al., 2014).

However, clear evidence of the benefits of green building is shown by the Canada Green Building Council, a not-for-profit national organization that holds the license for the LEED green building rating system. As of 2015, LEED buildings have eliminated 1,261,016 CO^2e tons of GHG emissions, diverted over 1.5 million tonnes of waste from landfill, and saved 12.8 billion liters of water per year in Canada (CAGBC, 2017). Table 2.4 show a list of benefits of green buildings.

Table 2.2 Benefits of Green Buildings. Data obtained from (CAGBC, 2014)

Environmental	Social	Economic
Average: 82% decrease in energy consumption	Promote greater health and well-being	Decreased operating costs: For new buildings: 17% over years. For retrofit/renovation projects: 11% over 5 years
Lower greenhouse gas	Encourage sustainable business practices	Public demonstration of corporate sustainability
Improve indoor air quality	Increase employee productivity	Future proofing assets
Protect natural resources	Encourage sense of community	Reasonable payback periods: 7-8 years. Higher overall return of investment
Average: 68% decrease in water consumption	Support domestic economy	Increased building values: increased value of 4%
	Make aesthetically pleasing	Higher rental rates

2.5. Understanding the Current Situation from the Contractor's Perspective

Contractors play an important role in promoting sustainable development by taking responsibility to reduce the negative impacts on environment, society and maximize their economic contribution. Green building practices have evolved quickly, challenging the construction industry for a quick adaptation in their business practices and field operations (Tan et al., 2011). Contractors are participating and representing a crucial role in the success of green buildings as the implementation and documentation of some credits depend exclusively on them. (Rosenberg et al., 2003). For this reason, contractor's are taking not just the responsibility in achieving sustainability requirements but also developing strategies to streamline the processes.

Frank Ross, President of AECON, one of the top contractors in Canada mentioned "people are beginning to take a greater interest in how we manage our work, and how we manage the environment. And we've been getting a lot of support from our employees and clients. It's now central to just about every project that we're doing today." (AECON). This is one of the main reasons that contractors are choosing to be more "green". Figure 2.9 illustrate all the triggers that make contractors choose green building practices, showing not only client demand matters, but also because it is the right thing to do and for branding/public relations purpose, which means that being "green" can differentiate their business from other contractors. This is an interesting thing to see as only 14% of architects voted that they will do it for branding/public relations and not surprisingly, lowering operating costs was a main reason for owners. The Canadian industry is going to an increasing level of "green" in their practices but it is important to evaluate the differences in the reasons they are considering for their involvement in this movement as it is a way to know what are the impacts for them. It can be inferred that contractors will start developing strategies not only in their project management to achieve client requirements in the project but also in their organization. According to a research, the main challenges presented in contractors' organizations towards sustainability are perceived high cost, client requirements, knowledge or skills of employees, procurement process. support from company board, contract requirements, time constraints and diverse business services. (Opoku & Vian, 2014)

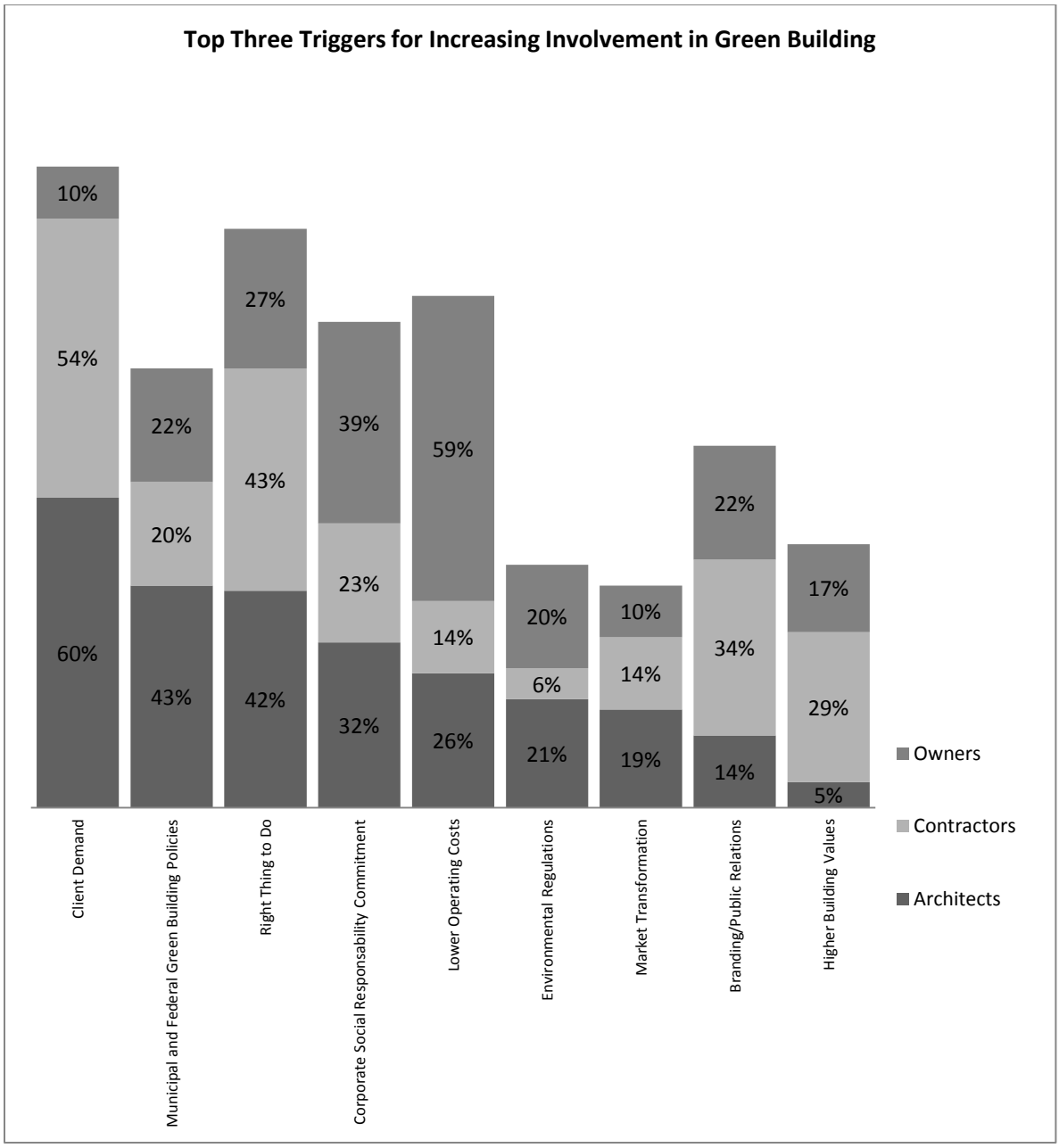


Figure 2.9 Top Three Triggers for Increasing Involvement in Green Building. Adapted from (CAGBC, 2014)

2.6. Factors Impacting Green Buildings Performance Outcomes

Sustainable high-performance buildings require superior planning, design and construction processes in order to achieve the goals within realistic financial time constraints. (Korkmaz et. al, 2010). Several studies have been conducted on the project delivery of green buildings and project management factors from the perspective of architectural, engineering and construction firms to improve the environmental performance outcome of building projects.

Project delivery is a process that starts with the owner decision to construct a building and involves preconstruction, design, construction and commissioning activities. Five processes identified by Lapisnki et al. (2006) contributing to the project delivery of green buildings are: decision to evaluate and adopt sustainable objectives early in the process, alignment of sustainable objectives to the project business case, identification and pursuit of building features that align with sustainability, early selection of experienced design and construction team, and investing time to align individual team member goals with project goals. A research paper by Korkmaz et al. (2010) explored several attributes leading to better building project performance outcomes. They defined owner commitment, project delivery system, project team procurement contract conditions, design integration, project team characteristics, and construction process as independent variables and schedule, cost, quality and sustainable high performance as dependent variables. The study concluded that timing of the contractor's involvement and owner type strongly affect performance outcomes. A similar study was performed by Cheng (2015) exploring three case studies with a specific framework considering project context variables and key factors such as commercial strategies that include project-delivery type and contract type, leadership strategies in terms of collaboration and how teams are built, and logistical/process strategies for information management. The study identified that there is a strong link between the high-performance outcome with integrated decisions made during the design and construction processes. An integrated design process and integrated teams was recognized as the main factor in the creation of high-performance green buildings.

Different project delivery methods such as design-bid-build (DBB), construction manager at risk (CMR), and design-build provide different levels of integration between project teams. Molenaar et al. (2009) investigated the impacts of these main delivery methods for achieving sustainable high-performance building projects and concluded that the use of more integrated project delivery methods such as the design-build provides a more optimal performance, in addition, they also highlighted the importance of the early contractor involvement in meeting sustainable objectives.

There is also another project delivery method used in recent years that has taken design-build method to another level. Integrated Project Delivery (IPD) is defined by the American Institute of Architects as "project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all

participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction" (AIA, 2007). It is proposed that IPD can bring benefits to owners, designers and contractors. Contractors are allowed to contribute in the design process leading to improvements in the project quality and financial performance during the construction phase. It is suggested that strong pre-construction planning involving design-related issues, construction sequencing and budget management will increase the likelihood that project goals and sustainability are achieved. There are several principles that need to be followed in this type of project delivery as it is a collaboration process. Among them, early goal definition, early involvement of key participants, collaborative innovation, intensified planning, open communication, organization, and leadership are fundamental factors to achieve better outcomes. Beginning from the conceptualization phase, contractors can contribute with cost information, cost options, constructability issues, initial procurement and construction schedule. Later in the process, they can help with validation of cost and schedule, and assessment of compatibility between the design and the work of trades. (AIA, 2007).

Critical project management factors in green buildings have been also recently researched. A study by Yuan Li et al. (2011) explored five major project management components: human resources-oriented factors, technical and innovation-oriented factors, support from designers and senior management, project manager's competence, and coordination of designers and contractors. The study identified that coordination of designers and contractors, and technical and innovation-oriented factors such as innovative management approach, innovative financing method, and effective software applications are the most critical success factors. Similar research was performed by Pheng Low et. al (2014) highlighting that the top ten critical success factors for green buildings are: management support, effective project planning and control, building owner's involvement, cost management, responsiveness of building owner, legislation, clear project scope and priorities of stakeholders, competence of project manager, quality management, and space management.

2.7. Conclusion

This chapter started with an overview of sustainability and ended with an explanation of the environmental management framework used in this research. Hundreds of journal papers, books and articles are replete with definitions of sustainability, but they generally derive from the

definition of sustainable development established by UN WCED in 1987 as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" and the triple bottom-line approach to sustainability that takes into account the environmental, economic and social perspectives. These two approaches have been applied to many industries, including the building industry with the creation of green buildings. This chapter discussed the importance of considering green buildings as a method, practice or process of continual improvement—rather than as the end product—because the best practices of today will become the norms of tomorrow.

This chapter also gave a general overview of the Canadian context, explaining the high commitment that has taken the Government of Canada towards sustainability and towards the growth in green building activity. It also provided information about the green building movement, finding that the two main reasons for contractors to participate in green building projects are because it is the right thing to do and for branding/public relations purposes.

Finally, this chapter discussed factors impacting green building performance outcomes. An integrated design process and integrated teams were recognized as main factors in the creation of high-performance green buildings.

Chapter 3 Framework for Environmental Management

3.1. Introduction

This chapter introduces the three layers of environmental management—the green practices layer, the project management layer, and the organizational layer—corresponding to the three objectives listed in Section 1.3. This chapter provides an explanation of each one the layers and sets the background knowledge needed to understand the thesis approach mentioned in section 1.7.

The data collection process involved interviews and documentation review from four different case studies. The four companies were general contractors that worked on the construction of green buildings. This chapter also discusses the design of the interview, the selection of case studies, a brief introduction to each case, and a quick overview of the companies' contribution to this thesis. The same interview was applied to all the companies; however, the information obtained from each one varied slightly as summarized in the last section of this chapter.

3.2. Framework Description

The framework used in this research is shown in Figure 3.1, which includes green practices, project management, and organizational strategy. Each layer is connected to the corresponding objective mentioned in Section 1.3.

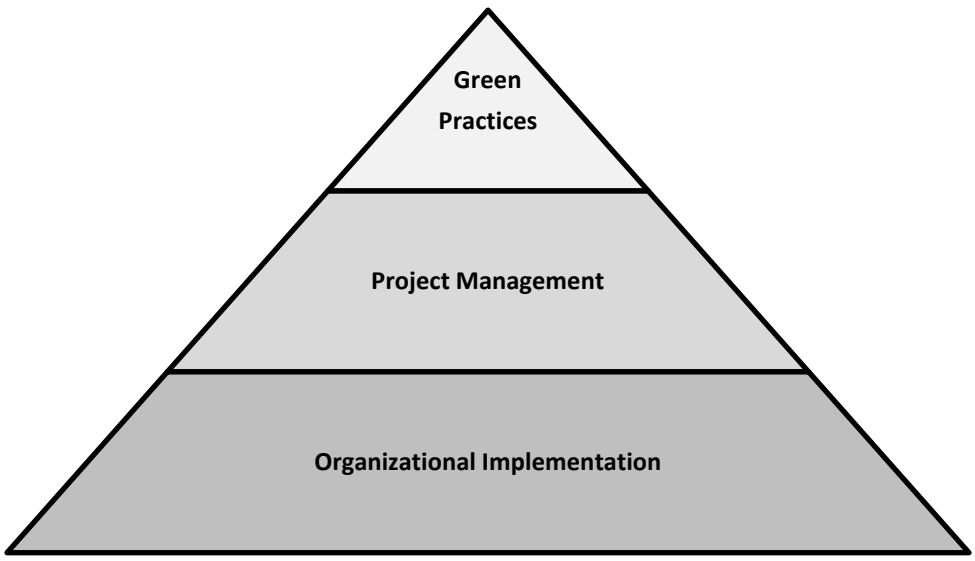


Figure 3. 1Environmental Management Framework

Srdic et al. (2013) took a similar approach in a study of environmental management in project-oriented companies within the construction. However, the three layers that the authors considered were building level (related to integrated quality and specific sustainability assessment), process/project level (concerned with both the project and organization perspective for the establishment of quality and environmental management systems), and construction product level (referring to the requirements that have to be met for the structure to ensure the quality of the structure).

The reason to use this framework is that each layer is fundamental to achieve the best outcome of environmental sustainability in projects. The first layer refers to the green practices categories that are more linked to the technical aspects managed in the construction phase. However, the nontechnical aspect is equally important for successful implementation of green building. Management is believed to be the factor that most often determines the success or failure of a project (Imada 2002), (ISO, 2013), so this was included in the next two layers. Project management is "the application of the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements" (PMI, 2013). A study suggested that project management factors such as human-resources oriented factors, technical and innovation-oriented factors, support from designers and senior management, project manager's competence, and coordination of designers and contractors are essential for the success of green building projects (Yuan Li et al., 2011).

The third layer arises because the construction industry is a project-based organization, creating "temporary systems" for carrying out their work. Project management activities should be aligned with top-level business direction and organizational strategy (PMI, 2013). Organizational strategy also relates to how environmental performance can be managed and controlled, including standards, organization policy and implementation systems (Poser et al., 2012). According to ISO 14031, management performance and indicators related to policies, people, planning, activities, practices, documentation, and procedures at all levels of the organization, including actions related to the environmental aspects will directly affect the performance in the organization's operations, influencing the environmental performance.

3.3. Green Construction Practices Categories

As mentioned in section 1.7, this thesis approaches the first layer, green practices, by:

1. Evaluating each one of LEED 2009 credits and determining the level of impact to the construction phase.
2. Collecting practices categories by exploring the credits found in GREEN Globes and LEED, which are popular standards used in Canada, REAP, which is the UBC green building standard, BREEAM, which is a recognized international standard, and a review of two journal papers. One of journal papers developed a list of 54 construction phase sustainability actions (O'Connor et al., 2016) while the other consisted of an evaluation of on-site environmental performance indicators to enhance a green construction operation (Zou & Sungwoo, 2013).

At present, sustainability in the construction industry often means applying LEED. LEED Canada NC-1.0 was introduced in 2004 and, since then, the number if certified building has grown rapidly from 31 certified buildings in 2005 to 2,576 buildings in 2015 (CAGBC, 2016). The Government of Canada established that LEED Canada has transformed the way that built environments are designed, constructed and operated—not only buildings but also homes, neighborhoods, and communities (Government of Canada, 2015). LEED will continue to be used to promote sustainability as building operators and corporate executives considered it to be a key way to communicate sustainability to stakeholders and to support corporate sustainability efforts (Long, 2015).

In a recent life cycle assessment study made for a 4000 m^2 office building, the construction phase represented between approximately 3% to 9% of the life cycle impact of the building (Delem et al., 2013). However, while LEED is widely implemented, it offers more specific recommendations in the planning and design phases of projects (O'Connor et al., 2015). This is problematic, as the environmental performance of a building is not only defined by the design features of a building, but also by the management processes for the construction, operation, and maintenance of a building (ISO, 2010).

According to a survey conducted by Construction Sector Council in the Canadian construction industry, the implementation of green practices extending beyond design are not a high priority—efforts to adopt efficient structural design and building science already poses enough challenges for the industry—yet efforts by contractors to become more "green" on-site are being seen within the Canadian industry (CSC, 2011). The main problem is that the concept of "green" remains unclear and ambiguous as sustainable construction practices are a relatively recent trend in the construction industry. This creates a confusion in how to transform "green"

into construction practices. The industry is currently in a transitional phase in which environmental approaches are becoming more common; however, they are not yet standardized in a cohesive manner. Certain approaches and aspects of green buildings—such as energy efficiency—are becoming more standardized, but there is still a lack of common understanding in terms of site management (CSC, 2011). Also, research has focused on design and energy efficiency, as highlighted in Figure 3.2, which shows that only 4% of the research is relates to on-site practices (as reported in a study of the state of knowledge of green buildings, evaluating 218 papers and published in the International Journal of Construction Engineering and Management) (Owens by-Conte & Yepes, 2012).

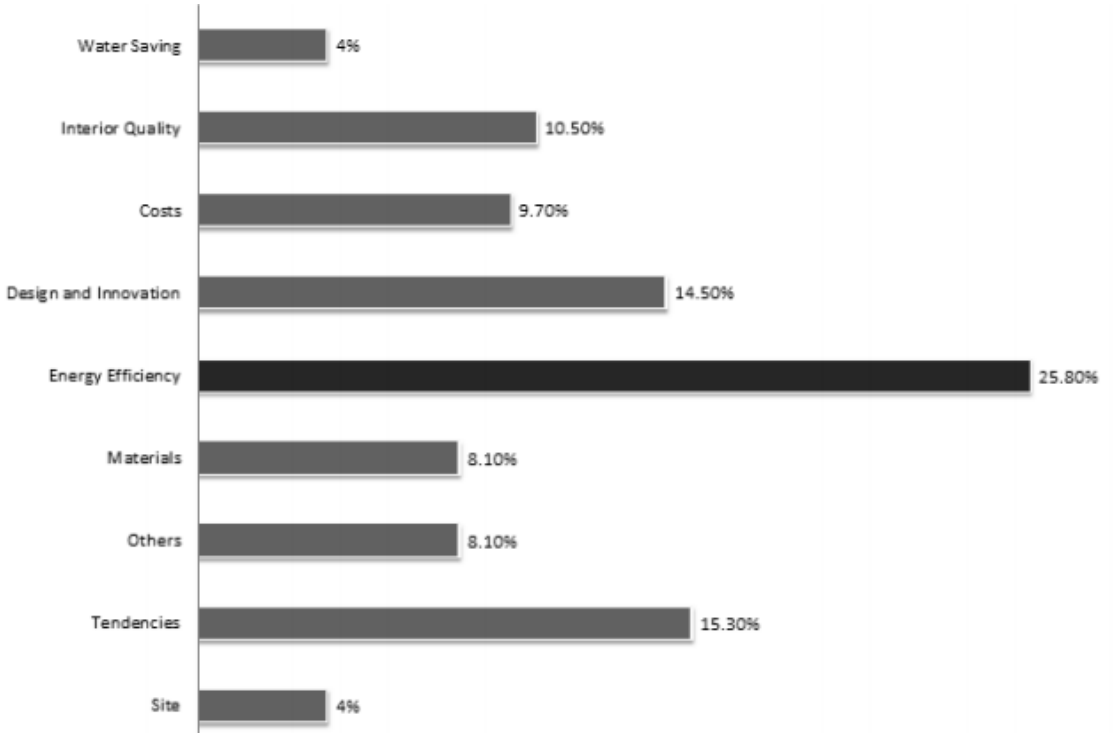


Figure 3. 2 Papers Related with Green Building Aspects . Source from (Owens by-Conte & Yepes, 2012)

Similar priorities are also seen in Vancouver's Greenest City 2020 Action Plan, which focuses mainly on updating the Vancouver Building Bylaw to improve energy efficiency and to reduce greenhouse gas emissions in both new and existing buildings, developing and promoting tools that enable energy efficiency, and using price signals in permit fees for new construction and in renovations to existing buildings to reward energy efficiency and greenhouse gas reductions (City of Vancouver, 2012).

Public and private owners, along with designers, are taking the lead in pursuing sustainable design and construction practices. The designers have taken the leading role in the green building movement since the beginning because they are the creators of the initial idea for the built environment (Riley et al. 2003). However, because both the designer and the owner are readily adopting sustainable design practices, it becomes essential for the contractor to become an active team member in successfully implementing green building projects (Syal et al. 2007).

3.4. Project Management Perspective

As mentioned in section 1.7, this thesis approaches the second layer, project management, by:

1. Conducting semi-structured interviews to determine how LEED is integrated in project management and classifying the information in the knowledge areas established by Project Management Institute.
2. Conducting semi-structured interviews to determine specific LEED credit issues and classifying the information in the knowledge areas established by Project Management Institute.

Management practices must be modified in order to incorporate sustainable practices into design and construction processes (Syal et al., 2011). There are a number of project management frameworks in existence for a variety of purposes. The ones chosen as foundations for this thesis were based on the book "LEED-New Project Management" (Yellamraju, 2010) and the fifth edition of the Project Management Body of Knowledge (PMI, 2013). These frameworks were used to design the interview and in Chapter 5 to classify the final results obtained from the interview.

The project processes performed by the project team generally fall into two categories (PMI, 2013):

- Product-oriented processes: these processes specify and create the project's product. In the case of this research, the "product" is considered to be the LEED practices carried out during the construction phase, so product-oriented processes correspond to the contractor's activities to manage the LEED certification efforts. These processes are classified using the 3P'S: People, Process, and Planning, as described in Section 2.6.2.1
- Project-management processes: these are the management processes that ensure the effective flow of the project through all phases. The description of these processes in Section 2.6.2.2 classifies how LEED is integrated into the project management areas.

Previous related research suggests that the six major project management functions impacted by LEED are: cost estimating, scheduling, project documentation, contracts and agreements, coordination with other team members, subcontractor coordination, and field operations. These impacts were assessed based on their design, material specification, field installation and LEED documentation requirements (Syal et al., 2011)(Syal et al., 2007).

3.4.1.1. LEED - New Project Management

LEED is a performance-based rating system that provides a framework for design, construction, and operation of buildings. LEED 2009, which is the version used on the case studies described in Chapter 4, evaluates performance in seven key areas (Yellamraju, 2010) (CAGBC, 2010):

- Sustainable Sites: selection, design, and management of project sites.
- Water Efficiency: water reduction strategies.
- Energy and Atmosphere: energy efficiency of buildings and energy consumption.
- Materials and Resources: waste reduction and selection of sustainable materials.
- Indoor Environmental Quality: the improvement of the overall indoor air quality of buildings.
- Innovation in Design: innovative strategies not addressed by the other credit areas or exemplary performance, which means going beyond the normal requirements for LEED credits.
- Regional Priority: credits that have been identified to be important priorities for a particular region.

In addition to the achievable credits, there are certain prerequisites under each category that the project must meet. The number of points will determine the level of certification. The levels that can be achieved are as follows:

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

LEED projects should be managed differently than non-LEED projects. Three major components that are critical for the management of a project are the 3P's: Process, People, and Planning. (Yellamraju, 2010)

- Process: refers to the streamlined series of steps to obtain LEED certification.
- People: involves the project team model, roles and responsibilities, and skills and characteristics of project team members.
- Planning: refers to the plan for the execution of LEED processes.

This classification was used for the interview design process described in Chapter 4.

3.4.1.2. Project Management Body of Knowledge

The Guide to the Project Management Body of Knowledge, known as the PMBOK Guide, was developed by the Project Management Institute to provide guidelines for managing individual projects, define project management related concepts, and describe project life cycle and related processes (PMI, 2013). The PMBOK Guide describes 47 project management processes within 5 project management process groups and 10 knowledge areas. This thesis will only use the knowledge areas, which are mainly defined as "set of concepts, terms, and activities that make up a professional field or area of specialization". The knowledge areas are described as follows:

1. **Integration management**: processes to identify, define, combine, unify, and coordinate the various processes.
2. **Scope management:** processes required to guarantee that the project includes all the work required, and only the work required, to complete the project successfully.
3. **Time management:** processes required to manage the timely completion of the project.
4. **Cost management:** processes involved in planning, estimating, budgeting, financing, funding, managing, and controlling costs.
5. **Quality management**: processes that determines quality policies, objectives, and responsibilities so that the project will satisfy the needs and requirements established.
6. **Human resources management:** processes that organize, manage, and lead the project team.
7. **Communications management:** processes that are required for the appropriate planning, collection, creation, distribution, storage, retrieval, management, control, monitoring, and final disposition of project information.
8. **Risk management:** processes of conducting risk management planning, identification, analysis, response planning, and controlling risk on the project.

9. **Procurement management:** processes necessary to purchase or acquire products, services, or results needed from outside the project team. Includes contract management and change control processes.
10. **Stakeholder management:** processes required to identify the people, groups, or organizations that could impact or be impacted by the project.

3.5. Organizational Perspective

As mentioned in section1.7, this thesis approaches the third layer, organizational implementation, by:

1. Conducting semi-structured interviews to determine how companies are supporting the implementation of green building construction practices and identifying best practices.

McGraw-Hill conducted a study demonstrating that only 9% of construction companies actually transformed sustainability into their organization and daily practices (McGraw Hill Construction, 2012). Therefore, it is important to develop organizational transformation strategies that allow companies to successfully adopt and implement sustainability (Kang Hee, Ahn, Jeon, & Suh, 2014).

A study performed by Ofori-Boadu et al. (2012) investigated best practices from six successful green building contractors and classified them using the six Malcolm Baldrige National Quality Award criteria of leadership, strategic planning, customer focus, measurement, analysis and knowledge management, workforce focus, and operation focus. In terms of leadership, each organization stated that they encouraged employee commitment to LEED, reward employees committed to LEED goals, and maintain membership with USGBC. In terms of strategic planning, the most significant factors were the incorporation of LEED goals in the organizational strategic planning, showcase on websites, green building department within the company, dedicated budget allocation for promoting LEED goals, advertisement of LEED credentials in the company, and partner with LEED contractors. In terms of knowledge management, performance metrics and performance database were the practices mentioned by the contractors. In terms of workforce, training resources, employee training, reward systems, LEED-AP prerequisites were the priority issues. And in terms of operations focus, promoting familiarity with LEED documents since the beginning of the projects was an important factor for the construction companies.

This research is intended to identify best practices relating to the organization perspective. Best practice research relies on the idea of communicating and transfering practices that seem to work well somewhere else. Best practice research—also referred to as "good practice" and "smart practice"—has been described as being practical and useful (Veselý, 2011). Table 3.1 provides different definitions considered for best practice research.

Table 3. 1 Definitions of BPR. Adapted from (Veselý, 2011)

Definition	Source
Best practice refers to the most efficient way of doing something. Almost every industry has adopted best practices in some aspect of its processes. One of those industries that has successfully and publicly adapted best practices is project management.	(Encyclopedia of Management , 2009)
Best practice arise from the management tool known as "benchmarking". Management processes are uniform enough so that a "best practice" can be identified and then adopted by another entity.	(Encyclopedia of Small Business, 2007)
Best practice is the selective observation of a set of exemplars across different contexts in order to derive more generalizable principles and theories.	(Overman & Boyd, 1994)

Best practices can emphasized the functionality, processes and/or innovativeness and transformability of a practice (Veselý, 2011):

- Functionality: emphasizes general ideas, where a set of functions can generate learning and be transferred.
- Processes: focuses on the identification of best or optimal process for attaining the highest profit.
- Innovativeness and transformability: focuses on the implementation of practices related to successful projects and the introduction of new approaches.

This research emphasizes innovativeness and transformability, striving to understand the tools that companies are applying to implement green building construction practices.

3.6. Data Collection Process

3.6.1. Design of the Interview

The author conducted semi-structured interviews, which are use for gathering qualitative information. Semi-structured interviews are organized around a set of predetermined open-ended questions, and throughout the interview, other questions can emerge from the dialogue between the interviewer and interviewee. The interview can take from between 30 minutes to several

hours to complete (DiCicco-Bloom & Crabtree, 2006). Interviews were between one hour to one hour and a half. The interview questions followed the framework presented in Table 4.1. For the project management perspective, the interview questions were to understand how LEED was integrated in project management and to document LEED credits issues from projects. The questions were not directly asked according to the knowledge management areas established in PMI due to time limits. The questions were made according to the interview framework presented in Table 3.2 and later classified in the knowledge areas. For the organization perspective, an open-ended question was made to know how they support green building practices implement and then the answer was discussed in the interview. The complete set of interview questions can be found in Appendix A.

Table 3. 2 Interview Framework

Framework for Interviews	
Practices	Material Selection
	Site Disturbance
	Waste Management
	Indoor Air Quality
People	Team Members
	Roles and Responsabilities
	Experience and Knowledge
Planning	Pre-construction activities
	Documentation
Process	Construction activities
	Documentation
Project Man.	Project Management Impact
General	Organizational Perspective

3.6.2. Selection of Case Studies

Four case studies were studied along with existing literature to develop this research. The selection of case studies was based on the willingness of construction companies to share information about their company, projects, and experiences. The four construction organizations were selected for this study because they manage LEED projects. They were all managing LEED version 2009 projects, which is not the most recent version. General information from the case studies is presented in Table 3.3

Table 3. 3 Case Studies Information

Case Study 1	Case Study 2	Case Study 3	Case Study 4
Company: •General contractor Intenational company with a Canadian subsidiary •Operate in all provinces in Canada -Offices in Toronto, Ontario and BC ***Project:*** •Design-build project •School project under LEED 2009 •LEED Gold •Upgrade project •Located BC	***Company:*** •General contractor & construction manager •Operates in BC •Focus is on multi-unit residential, commercial, light industrial, recreational, institutional and municipal construction projects •Services range from development management, general contracting, construction management, and other project delivery methods. **Project:** No specific project	***Company:*** •International company •Operates in all provinces in Canada -Focus on large commercial, institutional and civil construction projects ***Project:*** •Construction Management •New construction and renovation project under LEED 2009 •LEED Silver •Located in BC	***Company:*** •Services range from preconstruction, construction, virtual construction and work with several project delivery methods •Operate in BC and Alberta •Focus on commercial, residential and institutional buildings ***Project:*** •Design –bid-build •Residential building with community centre, park and plaza -LEED 2009 Gold -Located in BC

3.6.3. Data Collection Synthesis

The data collection synthesis is presented in Table 3.4, showing the person interviewed, documentation gathered, and collaboration from each. Semi-structured interviews were conducted and in some cases, the person focused on certain areas more than others and the collaboration varies slightly. However, all of them were very useful for developing the information provided in Chapter 5 and 6. The only case study that is not part of Chapter 6, which provides an overview of the organization perspective, is Case Study 4, since the project coordinator had a general idea but did not have deep knowledge of how the company supports green building construction practices implementation.

Table 3. 4 Data Collection Synthesis

	Case Study 1	Case Study 2	Case Study 3	Case Study 4
Number of Interviews	3	1	1	1
Interview	• Project Manager •LEED Project Coordinator •Safety Officer	Senior Project Manager	Project Manager	Project Coordinator
Documentation	Yes	No	Yes	Y (Documentation overview)
Documentation Provided	•LEED Scorecard •Waste and IAQ plans •LEED requirements •Organization policies towards sustainability •Inspection report	N/A	•Partial EMS •Environmental inspection report	•Material Tracking •Waste Tracking
Documentation Perspective	Project + Organization	N/A	Organization	N/A
Collaboration	•Define PM Changes •Define Practices Implementation •Define Practices Implementation •Additional Environmental Practices •Organizational Situation	•Define PM Changes •Define Practices Implementation •Define Practices Implementation •Organizational Situation	• Documentation Overview •Define Practices Implementation: Waste + Material Only •Define Practices Implementation •Organizational Situation	• General Input Project Management •Documentation Overview •Organizational Structure

3.7. Conclusion

A research framework was introduced in this chapter that serves as the basis for the development of this thesis. The framework considers green practices, project management, and organizational perspective. Each layer of this framework is important to reach the best outcome of environmental sustainability.

The data collection process was also discussed, showing the topics of the interview questions and the data collection synthesis. Semi-structured interviews were conducted and in some cases, the person interviewed focused on certain areas more than others and the collaboration varies slightly. However, all of them were very useful for developing the information provided in Chapter 5 and 6.

Chapter 4 Objective 1, Green Construction Practices Categories

4.1. Introduction

Section 2.6.1 described how the environmental performance of a building is defined not only by its design quality, but also by the management processes for its construction, operation, and maintenance (ISO, 2010). Since current Canadian construction sustainability practices focus mainly on LEED, this chapter examines the level of impact that LEED 2009 credits have on contractors. The impact in the different phases was evaluated according to the management activities related to each credit referenced in the book "LEED-New Project Management" (Yellamraju, 2010). The impact of each credit was classified as high, medium and low.

LEED was used to set the first green categories. After that, LEED v4, REAP and Green Globes were explored, developing a table with the specific credits contained in each one of these standards applicable specifically to contractors. This was useful for the categories classification and to understand the main green areas upon which the current industry is focusing.

A list of categories where practices can be advanced to improve environmental performance is generated, collecting practices categories from credits found in: LEED 2009, LEED v4, REAP, GREEN GLOBES, BREEAM, and research in order to provide guidance to contractors to focus and advance their environmental construction practices within these categories. The list of categories provide a reference to not only technical practices, but also to practices suggested by green building standards for managing the construction phase.

4.2. LEED in Contractors

Several studies have analyzed the impact of LEED requirements on the construction management practices as general contractors. Different studies suggest that contractors should develop techniques and strategies for erosion and sedimentation control requirements, construction IAQ management, coordination with the commissioning agent, management of performance-based materials credits, and data tracking (Rosenberg et al.,2003) (Syal et al., 2007) (Syal et al., 2011), suggesting that these are the main practices impacting the construction phase of a project. However, they do not provide insight of how LEED impacts a project as a whole. In order to understand this, the author conducted an evaluation in each credit of LEED 2009 and how it impacts the different phases of a project. The phases considered were as follows (Yellamraju, 2010):

- Pre-design: pre-schematic design

- Design: schematic design, design development, and construction documents
- Construction: building construction

The impact of each credit was classified as high, medium and low as in described in Table 4.1.

Table 4. 1 Description of Credit Impact Levels

Impact	Number	Description
High	4	Main activity /Implementation /High level of coordination
Medium	3	Reviews /Low level of coordination
Low	2	Recommended activities
N/A	1	No specific activities were recommended for the credit

***Note: Impact levels defined by author**

The impact in the different phases was evaluated according to the management activities related to each credit referenced in the book "LEED-New Project Management" (Yellamraju, 2010). Results are illustrated in Figure 4.1, highlighting that the LEED 2009 standard is mainly focused on attributes managed during the early project phases (pre-design and design) and is limited to aspects related to the structural building itself such as energy efficiency, water, and interior systems.

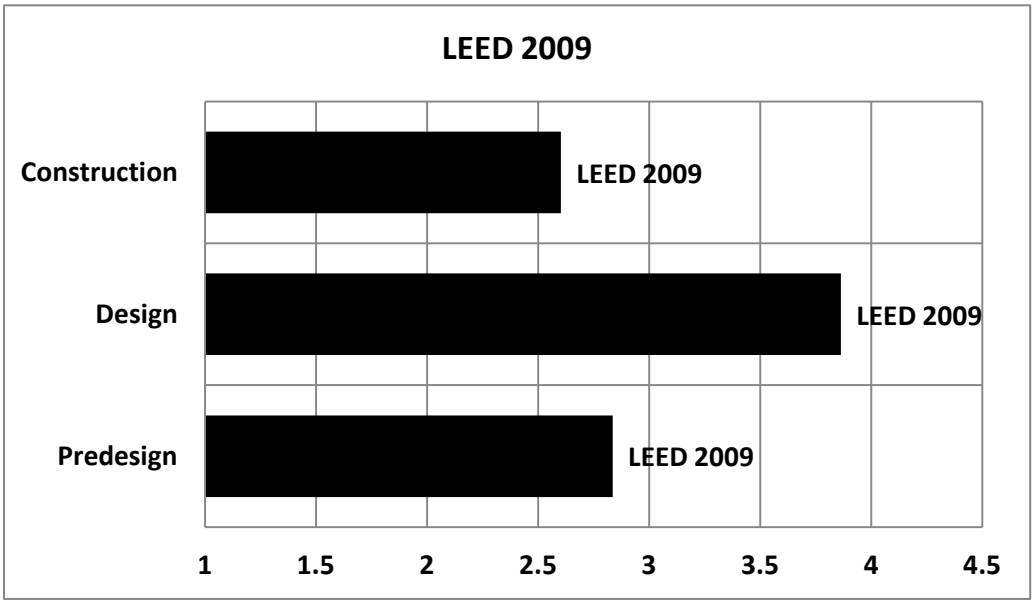


Figure 4. 1 LEED 2009 Impact in Project Phases

The complete table showing the impacts related to each credit in the different phases is included in Appendix D. However, as the objective of this thesis is to evaluate the construction

phase. The table of the impacts of each credit is presented in Table 4.2. This was done in order to obtain the practices to be included in the data collection process, which were as follows:

- Site disturbance: includes the prevention of pollution arising from construction activities and habitat protection and restoration.
- Waste management: includes planning and implementation.
- Indoor air quality: includes indoor air quality during construction, before occupancy and low-emitting materials.
- Materials coordination: includes materials reuse, recycled content, regional materials, rapidly renewable materials and certified wood.

Table 4. 2 LEED 2009 Credit Impact in Contractors, in terms of High, Medium, Low Impact (1/2 Pages)

L E E D 2009		Impact			
		H	M	L	N/A
Sustainable Sites					
Prereq 1	Construction Activity Pollution Prevention	●			
Credit 1	Site Selection				●
Credit 2	Development Density and Community Connectivity				●
Credit 3	Brownfield Redevelopment		●		
Credit 4.1	Alternative Transportation: Public Transportation Access				●
Credit 4.2	Alternative Transportation: Bicycle Storage & Changing Rooms				●
Credit 4.3	Alternative Transportation: Low-Emitting & Fuel-Efficient Vehicles				●
Credit 4.4	Alternative Transportation: Parking Capacity				●
Credit 5.1	Site Development: Protect and Restore habitat	●			
Credit 5.2	Site Development: Maximize Open Space				●
Credit 6.1	Stormwater Design: Quantity Control			●	
Credit 6.2	Stormwater Design: Quality Control			●	
Credit 7.1	Heat Island Effect: Non-Roof			●	
Credit 7.2	Heat Island Effect: Roof			●	
Credit 8	Light Pollution Reduction		●		
Water Efficiency					
Prereq 1	Water Use Reduction		●		
Credit 1	Water Efficient Landscaping				●
Credit 2	Innovative Wastewater Technologies		●		
Credit 3	Water Use Reduction		●		
Energy & Atmosphere					
Prereq 1	Fundamental Commissioning of Building Energy Systems		●		
Prereq 2	Minimum Energy Performance				●
Prereq 3	Fundamental Refrigerant Management				●
Credit 1	Optimize Energy Performance				●
Credit 2	On-Site Renewable Energy		●		
Credit 3	Enhanced Commissioning		●		
Credit 4	Enhanced Refrigerant Management				●
Credit 5	Measurement and Verification		●		
Credit 6	Green Power				●
Materials & Resources					
Prereq 1	Storage and Collection of Recyclables				●
Credit 1.1	Building Reuse: Maintain Existing Walls, Floors, and Roof		●		
Credit 1.2	Building Reuse: Maintain Interior Non-Structural Elements		●		
Credit 2	Construction Waste Management	●			
Credit 3	Materials Reuse	●			
Credit 4	Recycled Content	●			
Credit 5	Regional Materials	●			
Credit 6	Rapidly Renewable Materials	●			
Credit 7	Certified Wood	●			

Table 4.2 LEED 2009 Credit Impact in Contractors, in terms of High, Medium, Low Impact (2/2 Pages)

LEED 2009		Impact			
		H	M	L	N/A
Indoor Environmental Quality					
Prereq 1	Minimum Indoor Air Quality Performance				•
Prereq 2	Environmental Tobacco Smoke (ETS) Control			•	
Credit 1	Outdoor Air Delivery Monitoring			•	
Credit 2	Increased Ventilation				•
Credit 3.1	Construction IAQ Management Plan: During Construction	•			
Credit 3.2	Construction IAQ Management Plan: Before Occupancy	•			
Credit 4.1	Low-Emitting Materials: Adhesives and Sealants	•			
Credit 4.2	Low-Emitting Materials: Paints and Coatings	•			
Credit 4.3	Low-Emitting Materials: Flooring Systems	•			
Credit 4.4	Low-Emitting Materials: Composite Wood and Agrifibre Products	•			
Credit 5	Indoor Chemical and Pollutant Source Control		•		
Credit 6.1	Controllability of System: Lighting			•	
Credit 6.2	Controllability of System: Thermal Comfort			•	
Credit 7.1	Thermal Comfort: Design				•
Credit 7.2	Thermal Comfort: Verification				•
Credit 8.1	Daylight and Views: Daylight				•
Credit 8.2	Daylight and Views: Views				•

***Note: Credits sourced from LEED 2009, activities related to each credit were considered from (Yellamraju, 2010), impact level determined by author**

4.3. Advancing Environmental Practices in the Construction Phase

As mentioned in the previous section, the LEED 2009 practices that most impact the contractor are as follows:

- site disturbance,
- material tracking,
- waste management, and
- indoor air quality.

Table 4.3 demonstrates how LEED's focus on the design phase is increasing. This table shows the number of credits that can be submitted in design and the number of credits that can be submitted in construction. Appendix C and D contain the complete list of credits with the design and construction classifications. A new category was added in LEED v4 "Location and Transportation" which mainly impacts the design phase as well. Some credits such as low-emitting materials were combined into one credit in LEED v4, causing the points concerning the construction phase to decrease. In LEED v4, 75% of the credits can be submitted once the design phase is completed in comparison with 61% in LEED 2009.

Table 4. 3 LEED 2009 and v4 Credits - Recommended Submission

LEED 2009			LEED v4		
Design	33 credits	61%	Design	39 credits	75%
Construction	21 credits	39%	Construction	13 credits	25%

**Excludes Innovation and Regional Priority Credits*
**Based on Split Review Suggestions in LEED Reference Guides*
**Based on LEED for New Construction Reference Guides*

Table 4.4 shows the specific credits related to green construction practices. The green building standards considered were LEED 2009, LEED v4, Green Globes and the Residential Environmental Assessment Program (REAP, UBC's own green building standard). The complete evaluation of these standards is shown in Appendix B. The complete evaluation was done in order to ensure that Table 3.5 included all the criteria of green practices; therefore, the intent, requirement and evaluation of each credit is documented in Appendix B.

Table 4. 4 Credit Comparison LEED 2009, LEED v4, REAP, Green Globes (1/3 Pages)

Name		LEED 2009	LEED V4	REAP	GREEN GLOBES
Category	Subcategory				
Site Disturbance	Erosion and Sediment Control	Sustainable Sites > Prereq 1> **Construction Activity Pollution Prevention**	Sustainable Sites>. Prereq. **Construction Activity Pollution Prevention**	Construction > CON Mandatory > M5 - **Erosion and Sediment Control**	B. Site > B.2. Ecological Impacts > **Site Disturbance and Erosion**
	Site Protection	Sustainable Sites > Credit 5.1 **Site development: Protect and Restore Habitat**	Sustainable Sites > Credit. **Site Development: Protect and Restore Habitat**	Construction > CON Mandatory > M1 - **Staging and Construction**	B. Site > B.2. Ecological Impacts > **Site Disturbance and Erosion**
				Construction > CON Mandatory > M2 - **Vegetation Safeguards and Land-Clearing Debris**	B. Site > B.2. Ecological Impacts > **Tree Preservation**
Coordination for Material Tracking	Coordination for Material Tracking	Materials and Resources > Credit 3 **Materials Reuse**	Materials and Resources >.Credit. **Building Product Disclosure and Optimization - Environmental Product Declarations**	Materials and Resources>MR 1- Recycled Content and Reused Materials >MR 1.1 & 1.2 **Reused Building Materials**	E. Materials and Resources >E.2 **Interior Fit-Out (Including Finishes and Furnishings)**
		Materials and Resources >Credit 4. **Recycled Content**	Materials and Resources >. Credit. **Building Product Disclosure and Optimization - Sourcing of Raw Materials**	Materials and Resources>MR 1- Recycled Content and Reused Materials >MR 1.3 **Recycled Content Materials**	
		Materials and Resources > Credit 5. **Regional Material**	Materials and Resources >. Credit **Building Product Disclosure and Optimization - Material Ingredients**	Materials and Resources>MR 2- Regional Materials >MR 2.1 & 2.2 **Regionally Manufactured Building Materials**	
		Materials and Resources > Credit 6**. Rapidly Renewable Materials**		Materials and Resources>MR 3- Certified and Non-Endangered Forest Products >MR 3.1 **Dimensional Lumber and Plywood**	
		Materials and Resources >Credit 7. **Certified Wood**		Materials and Resources>MR 3- Certified and Non-Endangered Forest Products >MR 3.2 **Hardwood Floors**	
				Materials and Resources>MR 4- Building Product-Ingredients>MR 4.1 **Transparency of Ingredients**	
				Materials and Resources>MR 4- Building Product-Ingredients>MR 4.2 **Optimization of Ingredients**	

Table 4.4 Credit Comparison LEED 2009, LEED v4, REAP, Green Globes (2/3 Pages)

Name		LEED 2009	LEED V4	REAP	GREEN GLOBES
Category	Subcategory				
Indoor Air Quality	Low Emitting Materials	Indoor Environmental Quality >**Low-Emitting Materials: Adhesives and Sealants** > Credit 4.1	Indoor Environmental Quality > Credit. **Low-Emitting Materials**	Indoor Environmental Quality >IEQ Mandatory > IEQ M1-**Adhesives and Sealants**	G. Indoor Environment > G.1 Ventilation >**Source Control and Measurement of Indoor Pollutants**
		Indoor Environmental Quality >**Low-Emitting Materials: Paints and Coatings** > Credit 4.2		Indoor Environmental Quality >IEQ Mandatory > IEQ M2-**Paints and Coatings**	
		Indoor Environmental Quality >**Low-Emitting Materials: Flooring Systems** > Credit 4.3		Indoor Environmental Quality >IEQ Mandatory > IEQ M3-**Carpet**	
		Indoor Environmental Quality >**Low-Emitting Materials: Composite Wood and Agrifibre Products** > Credit 4.4		Indoor Environmental Quality >IEQ 1 -Low Emitting Materials> IEQ 1.1 **Low VOC Paints and Coatings**	
				Indoor Environmental Quality >IEQ 1 -Low Emitting Materials> IEQ 1.2 **Low Emitting Composite Wood Producs**	
				Indoor Environmental Quality >IEQ 1 -Low Emitting Materials> IEQ 1.3 **Low Emitting Insulation**	
				Indoor Environmental Quality >IEQ 1 -Low Emitting Materials> IEQ 1.4 **Low Emitting Cabinetry**	
	Construction Indoor Air Quality	Indoor Environmental Quality > Credit 3.1 **Construction Indoor Air Quality Management Plan: During Construction**	Indoor Environmental Quality >Credit. **Construction Indoor Air Quality Management Plan: During Construction**	Construction > CON 1 -Construction Indoor Air Quality Management Plan> CON1.1 -**Indoor Air Quality Management Plan**	A-Project Management A.2 Environmental Management During Construction > **IAQ During Construction**
		Indoor Environmental Quality > Credit 3.2. **Construction Indoor Air Quality Management Plan: Before Occupancy**	Indoor Environmental Quality >Credit. **Indoor Air Quality Assessment**	Construction > CON 1 -Construction Indoor Air Quality Management Plan> CON1.2 **Flushout/ IAQ Test**	G. Indoor Environment > G.1 Ventilation > **Air Handling Equipment**
Commissioning	-	Energy & Atmosphere > Prereq 1. **Fundamental Commissioning of Building Energy Systems**	Energy & Atmosphere > Prereq. **Fundamental Commissioning of Building Energy Systems**	Energy and Atmosphere > EA 3-Commissioning > EA 3.1 -**Commissioning**	A-Project Management>A.3 Commissioning > **Whole Building Comissioning**
		Energy & Atmosphere > Credit 3. **Enhanced Commissioning**	Energy & Atmosphere > Credit. **Enhanced Commissioning**		

Table 4.4 Credit Comparison LEED 2009, LEED v4, REAP, Green Globes (3/3 Pages)

Name		LEED 2009	LEED V4	REAP	GREEN GLOBES
Category	Subcategory				
Waste Management	-	Materials and Resources > Credit 2 **Construction Waste Management**	Materials and Resources> Prereq. **Construction and Demolition Waste Management Planning**	Construction > CON Mandatory > M6 - **Waste Management Plan**	Materials and Resources > Waste > **Construction Waste**
			Materials and Resources> Credit. **Construction and Demolition Waste Management**		
Equipment and Material Related Practices	-			Construction > CON Mandatory > M3 - **Truck Management Plan**	A-Project Management A.2 Environmental Management During Construction > **Clean Diesel Practices**
				Construction > CON Mandatory > M4 - **Wheel Wash**	A-Project Management A.2 Environmental Management During Construction > **Mould Mitigation During Construction**
Management Related Practices	Green Building Professional	Innovation in Design > Credit 2. **LEED Accredited Professional**	Innovation in Design > Credit. **LEED Accredited Professional**	Innovation and Design Process (ID) >ID 2 - Integrative and Universal Design > ID 2.1 **Green Building Specialist**	
	Environmental Management Tools				A-Project Management A.2 Environmental Management During Construction > **Environmental Management System**

As mentioned in Section 2.6.1, there is no clear consensus among contractors about what "green" means in the construction phase. This can be observed in Table 4.4 as LEED 2009, LEED v4, REAP and Green Globes have different name and classification of credits applicable to contractors. In order to solve this, Table 3.5 was created to show a complete list of environmental technical and management practices categories in which contractors can advance their practices to improve their green performance. Table 3.5 also makes a comparison between LEED 2009, LEED v4 and BREEAM. Practices that are not marked in any of the green building standards were obtained from REAP or from two journal papers (O'Connor et al., 2016) (Zou & Sungwoo, 2013). BREEAM practices were explored, excluding the practices that were already acknowledged to impact contractors in the previous section. The commissioning-related practices were explored in general detail as they only represent a moderate impact to contractors and are mainly managed by an external company. The list provides 76 practices categories and LEED v4 only includes 34 of these practices categories.

Table 4. 5 Full List of Environmental Building Construction Practices Categories (1/4 Pages)

CONTEXT			CANADA			UK
NAME			LEED 2009	LEED V4	GREEN GLOBES	BREEAM
CATEGORY	SUBCATEGORY 1	SUBCATEGORY 2				
Site Disturbance	Erosion and Sediment Control	ESC plan	•	•	•	
		Soil erosion control	•	•	•	
		Waterway sedimentation control	•	•	•	
		Airbone dust generation control	•	•	•	
	Site Protection	Site disturbances limit	•	•	•	
		Site vegetation protection and restoration	•	•		
		Tree preservation plan			•	
		Staging and construction plan				
Resources	Materials	Materials reuse	•	•	•	
		Materials with recycled content	•	•	•	
		Regional materials	•	•	•	
		Rapidly renewable materials	•	•	•	
		Certified wood	•	•	•	
		Materials with EPD		•	•	
		Sourcing of Raw Materials		•		
		Materials ingredients		•		
	Waste Management	Construction waste management plan	•	•	•	
		Waste monitoring	•	•	•	
		Waste final calculation	•	•	•	
		Minimum values for % of waste diversion	•	•	•	
		Minumum # of material streams diverted		•		
		Source reduction strategies		•		

Table 4.5 Full List of Environmental Building Construction Practices Categories (2/4 Pages)

CONTEXT			CANADA			UK
NAME			LEED 2009	LEED V4	GREEN GLOBES	BREEAM
CATEGORY	SUBCATEGORY 1	SUBCATEGORY 2				
Indoor Air Quality	Low Emitting Materials	Adhesives and sealants	•	•	•	
		Paints and coating	•	•	•	
		Flooring systems	•	•	•	
		Wood products	•	•		
		Insulation		•		
		Furniture		•		
	During Construcion	IAQ plan	•	•	•	
		HVAC protection	•	•	•	
		Pathway interruption	•	•	•	
		Housekeeping	•	•	•	
		Scheduling	•	•	•	
		Moisture protection	•	•	•	
	Before Occupancy	Policy for non-smoking			•	
		Air-handlers filtration media	•	•	•	
		Flush-out	•	•	•	
		IAQ testing report	•	•	•	
Commissioning	-	CxA authority	•	•	•	
		Systems commissioning	•	•	•	
		Commissioning final report	•	•	•	
Equipment Related Practices	-	Equipment energy efficiency				
		Selection and replacement of equipment				
		Reduction in idling of equipment				
		Truck management plan				
		Wheel wash /Tire-cleaning				
		Clean diesel practices			•	•
		Inspection and maintenance of equipment				

Table 4.5 Full List of Environmental Building Construction Practices Categories (3/4 Pages)

CONTEXT			CANADA			UK
NAME			LEED 2009	LEED V4	GREEN GLOBES	BREEAM
CATEGORY	SUBCATEGORY 1	SUBCATEGORY 2				
Construction Site Impacts	On-Site Energy Use	Energy Use Reduction				
		Energy Monitoring				•
	On-site water Consumption	Water Use Reduction				
		Water Monitoring				•
	Transportation Data	Monitor Transport Data Materials				•
		Monitor Transport Data Waste				•
	Noise	Assessment under local legislation				
		Noise Managament Plan				
		Noise - Mitigation measures				•
		On-site monitoring measures				•
	Vibration	Assessment under local legislation				
		Equipment selection				
		On-site reduction measures				•
		On-site monitoring measures				
	Other	Light Pollution				
		Sustainable Temporary Facilities				•

Table 4.5 Full List of Environmental Building Construction Practices Categories (4/4 Pages)

CONTEXT			CANADA			UK
NAME			LEED 2009	LEED V4	GREEN GLOBES	BREEAM
CATEGORY	SUBCATEGORY 1	SUBCATEGORY 2				
Management Related Practices	Green Building Professional	Green Building Professional	•	•	•	•
	Green Building Professional Specific to Construction	Green Building Professional Specific to Construction				•
	Environmental Management Tools	Environmental Management Tools			•	•
		Environmental Policy			•	•
		Regulatory Compliance and Training			•	•
		Environmental Risk Assessment			•	•
		Environmental Risk Management Strategies			•	•
		Environmental Management Roles, Responsabilities and Reporting Structutre			•	•
		Site and Work Instructions for site personnel			•	•
		Environmental Inspection Checklists			•	•
		Records of Compliance			•	•
		Train Workers for Emergency Response				•

The construction phase of a building typically represents 3-9% of the life cycle impact of the building. The complete impacts are shown in Figure 4.2. The transport of materials accounts for 80% of the impact of transport, but trucks evacuating soil were half the recorded trucks used on site. The following high impact is caused by the materials wasted on site, representing more than a third of the impact. The remaining impact of the construction phase is caused by the electricity used on - site and the use of the hydraulic excavators, mainly used for groundwork. The impact of the electricity used on-site came mainly from site offices, with 35% of the impact. The impact of trucks waiting on site also represented a significant impact in the construction phase. It was concluded that the major impact came from the transport of materials on site, construction waste, electricity use and groundwork (Delem et at., 2013). In addition, construction equipment, materials transportation, and on-site traveling are major contributors to GHG emissions (O'Connor et al., 2016).

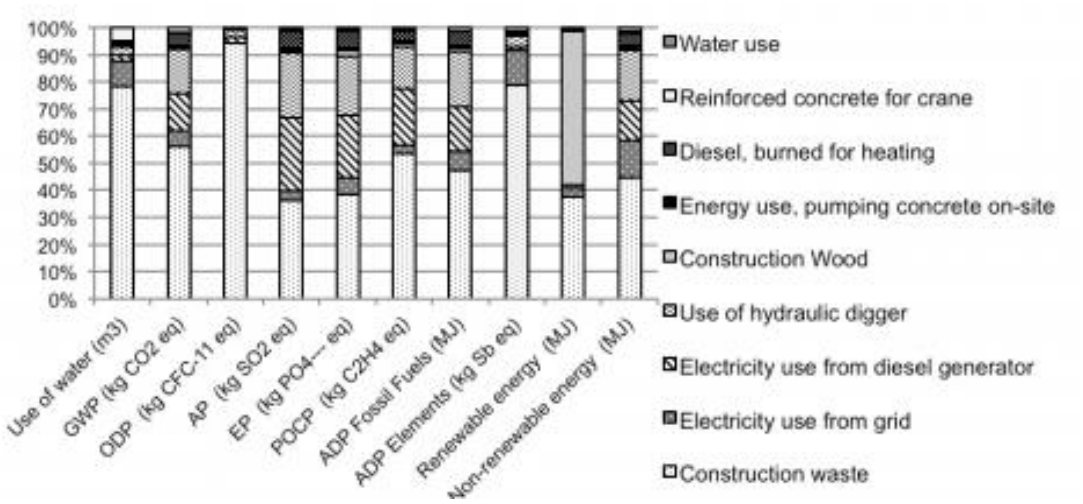


Figure 4. 2 Environmental Impacts in the Construction Phase. Source from (Delem et al., 2013)

Noise is also an important issue from building construction as it can affect the community and the workers. Humans can be adversely affected by both single events of loud noise and the long duration of noises. There are two types of negative effects created by noise: physical impact such as hearing loss, and psychological effects such as annoyance and disturbance of activities (Stein, 2000).

The most frequently implemented green site practices by Canadian contractors are shown in Figure 4.3. The top three most prevalent practices were: reuse of buildings materials, recycling, and site protection, which are already established by LEED. On-site energy conservation was the

next most prevalent, which can increase profit margins, improve resource efficiency, and reduce environmental impacts (Gottsche et al., 2016) However, it does not include energy monitoring which is one of the credits established by BREEAM.

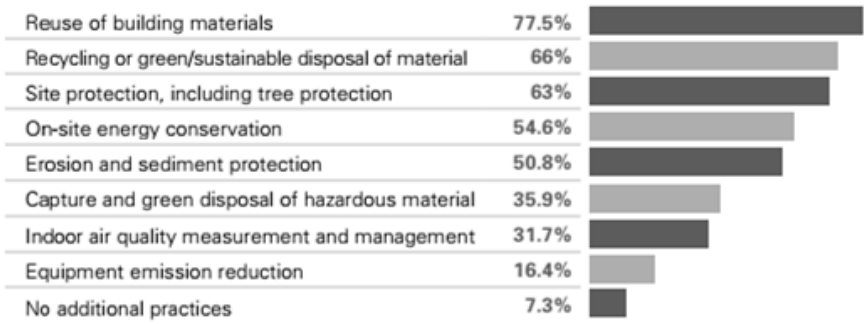


Figure 4. 3 Prevalence of Green On-Site Practices in Canadian Contractors. Source from (CSC, 2011)

LEED does not cover important impacts such as noise or electricity use during the construction phase. Relevant practices categories that contractors can focus from Table 3.5 are:

- Monitoring Energy Consumption**:** related to equipment and site.
- Monitoring Water Consumption: related to equipment and site.
- Monitoring of Transportation Data: not only from materials, but also from the evacuation of soils and waste, which means monitoring the truck from the construction gate to waste disposal.
- Equipment Related Practices: reduction of idle times, clean diesel practices, selection and maintenance of equipment, tire-cleaning and a truck management plan.
- Environmental Management System: includes environmental policy, environmental inspection checklists, records of compliance, management strategies, reporting structure, and more. Commonly environmental management systems are based on ISO 14001.

4.4. Conclusion

As project teams seek to lessen the environmental impacts of their construction activities, they increasingly recognize the importance of construction sustainability techniques. Contractors are looking for guidance and resources for conducting sustainable construction activities to improve their sustainability performance (CII, 2014a) (CII, 2014b). The first main contribution of this chapter was the evaluation LEED 2009 practices and the impact of each credit on the contractor, concluding that the practices categories that most impact the contractor are as follows:

- Site disturbance
- Material Tracking
- Waste Management
- Indoor Air Quality

As mentioned in Section 2.6.1, there is no clear consensus among contractors about what "green" means in the construction phase. This lead to the second contribution of this chapter, which was a table with credits from LEED 2009, LEED v4, REAP and Green Globes applicable to contractors in order to understand this confusion in contractors. It was observed that they have different names and classification of credits.

In order to solve this, a general table with all the green construction practices categories was created. The final contribution of this chapter and objective 1 of this thesis is presented in Table 3.5, identified practices categories from LEED 2009, LEED v4, REAP, BREEAM and research. It was concluded that contractors can support environmental sustainability by monitoring energy and water consumption on site, in addition to just reduction techniques. Additional practices can be monitoring of transportation data, equipment related practices and management techniques such as an EMS (Environmental Management System).

Chapter 5 Objective 2, Project Management Perspective

5.1. Introduction

This chapter reviews the project management perspective from the case studies evaluated. This section makes reference to the second objective established in Section 1.3 in this document. The information answers two questions: “How is LEED integrated into the construction project management?” and "What are the main issues related to LEED Credits?"

For the first question, the information is first presented in terms of the 3P's—People, Process and Planning—according to the interview answers and the documentation gathered. The information about LEED integration are finally synthesized and classified in the project management areas established by the Project Management Institute.

For the second question, an impact matrix is first created to give the credit issues a classification in terms of severity and occurrence. The information is synthesized and classified in the project management areas established by the Project Management Institute.

An explanation of the 3P's and the project management areas was provided in Section 2.6.1 and 2.6.2 of this document.

5.2. 3P's: Planning, Process, People

Table 5.1 explains the usual requirements for contractors to comply with LEED. This information was gathered from a combination of the documentation provided by Case Study #1 and literature review. This list is intended to provide an general understanding of the LEED requirements for contractors in terms of planning and process activities, as well as the documentation required. This information was useful for developing section 5.3.1.

Table 5.1 LEED Construction Management Requirements for Contractors (1/2 Pages)

Practice	Activities	Output Required by Contractors	Source
SSp1: Pollution Prevention Plan	•Implement ESC control plan •Monitor and repair measures as required	•Monthly inspection logs •Minimun 2 date-stamped photos per measure	Project #1
SSc3: Brownfield Redevelopment	•Incorporate remediation activities into construction schedule if the site has not already remediated when development begins	N/A	LR
SSc5.1: Site Development: Protect and Restore habitat	•Implement site disturbance plan, by clearly identifying construction entrances, inspecting boundaries and fences, and ensuring protected areas are not encroached upon •Document measures by photos •Update civil drawings	•Site plans/drawings and specs highlighting limit of construction activities •Photos of disturbed areas characterizing the limitation of construction activities	LR
SSc6.1/6.2 Stormwater Design	•Implement stormwater design strategies identified in design	N/A	LR
SSc7.1:Heat Island Effect: Non-Roof	•Execute site plan according to construction drawings	N/A	LR
SSc7.2: Heat Island Effect: Roof	•Procure roof materials as specified and/or install vegetated roof according to installation drawings	N/A	LR
SSc8: Light Pollution Reduction	•Commission lighting systems according to commissioning plan	N/A	LR
WEp1/WEc3: Water Use Reduction WEc2: Innovative Wastewater Technologies	•Procure fixtures according to specified flow/flush rates •Provide cutsheets and/or shop drawings for flush/flow rate approval prior to ordering fixtures	•Final approved cutsheets and/or shop drawing once ordered if changes have been made from original design specification	Project #1 /LR
EAp1/EAc3: Fundamental & Enhanced Commissioning	•Attend commissioning meeting on-site to review roles & respo, constructionand testing/training schedules	•Operations and maintenance (O&M) manuals, record(s) of operator training and as-built drawings.	Project #1
MRc1.1/MRc1.2: Building Reuse	Implement measures to preserve and reuse existing building components identified in construction drawings and specs	N/A	LR
MRc2: Construction Waste Management	• Submit Construction Waste Management Plan • Monitor waste bins to minimize food and moisture contamination. • Monitor monthly diversion rate to ensure it is at the minimum required. •If diversion rate falls below required, take corrective action.	•List of receiving facilities for all anticipated waste types prior to construction commencement. • Waste Management Plan. • Monthly Waste Reports from each waste hauler. • Monthly waste waybills from each waste hauler. • At construction completion, complete and sign the LEED Letter Template	Project #1
MRc3: Material Reuse MRc4: Recycled Content MRc5: Regional Materials MRc6: Rapidly Renewable Materials MRc7: Certified Wood	• Procure materials according for specs and drawings	• Completed Green Building Product Information Submittal Forms for all applicable materials and products. (See Appendix). • Cutsheets, product literature or other manufacturer documentation •Material costs, excluding labor and equipment • At construction completion, complete and sign LEED Letter Template,	Project #1 /LR

Table 5.1 LEED Construction Management Requirements for Contractors (2/2 Pages)

Practice	Activities	Output Required by Contractors	Source
EQ Credit 3.1: Construction IAQ Management Plan, During Construction	• IAQ plan • Monitor Plan adherence on-site. If Sub-Contractor activities are not compliant, take corrective actions.	• IAQ Management Plan. • Monthly IAQ inspections and a minimum of 2 date-stamped photographs of each measure. • At construction completion, fill out and sign LEED Letter Template, and submit to LEED Project Manager.	Project #1 /LR
EQ Credit 3.2: Construction IAQ Management Plan, Before Occupancy	Comply with IAQ Management Plan to reduce indoor sources of contaminant on-site.	•Construction IAQ plan •Op1. : Recordings of dates, occupancy, outdoor air delivery rates, internal temp and huumidity •Op2: Copy of testing report and verify that all required contaminants are accounted for and reported in the correct unit of measure	Project #1 /LR
EQ Credit 4.1-4.4: Low-emitting Materials:	• Review and pre-approve the use of compliant adhesives and sealants on-site. • Monitor Sub-Contractors to ensure non-compliant products are not used. If non-compliant products are discovered on-site, take corrective actions.	• Green Building Product Information Submittal Form • MSDS for all products. • At construction completion, complete and sign LEED Letter Template, and submit to LEED Project Manager.	Project #1
EQc5: Indoor Chemical & Pollutant Source Control	Install MERV 13 filters in air intakes and re-circulation after construction completion, prior to occupancy.	• Photographs of all permanent entryway systems (mats/grills/grates). • Product cutsheets for MERV 13 filters.	Project #1
RPc1: Durable Building	• Coordinate selection and installation of durable envelope assemblies such as structural elements, cladding, glazing and roofing with the Envelope Specialist. Review and comment on Durability Plan.	• Provide cutsheets and warranty information, if requested, to the Envelope Specialist. • Comply with all Envelope Specialist request for testing, site review and quality management.	Project #1

In terms of people, the organizational diagrams (only including LEED-related people) are shown in Figure 5.1 through 5.4. In the four cases, the main responsibility for LEED rested with the Project Manager. However, the LEED coordination varied between case studies. Two of the cases had a specific LEED coordinator on site, while the other two integrated the LEED responsibilities within the traditional project team members: the project manager in one case and the project coordinator in the other. This responsibility of reviewing LEED documentation was assigned to the LEED consultant, with the exception of Company #2, which had a Sustainability Manager in house who coordinated all the LEED projects and helped with the evaluation of LEED documentation. For the inspections on site, the main responsibility rested with the site superintendent with the exception of Company #3, which had their own environmental on site

supervisor (in addition to the site superintendent) to ensure that the inspections were done correctly.

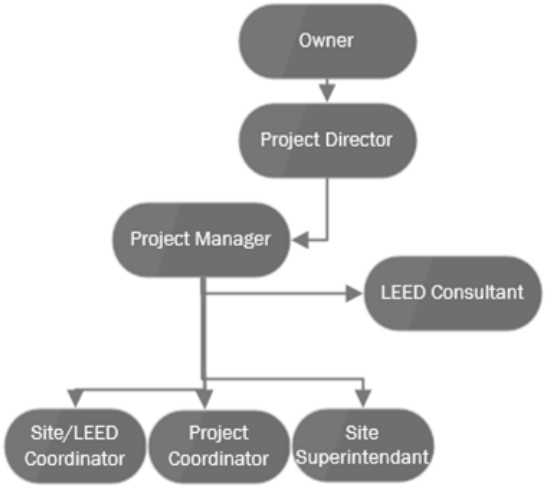


Figure 5.1 People-Case Study 1

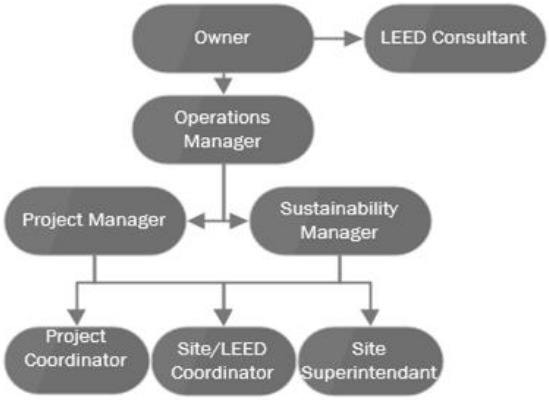


Figure 5.2 People-Case Study 2

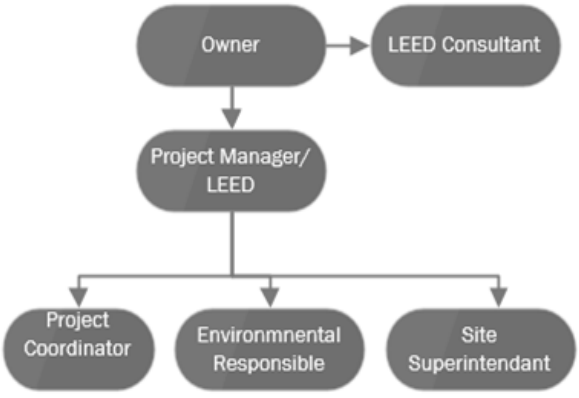


Figure 5.3 Case Study 3

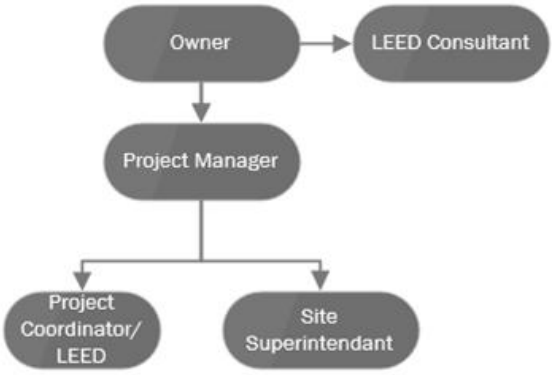


Figure 5.4 People- Case Study 4

5.3. LEED Project Management

5.3.1. LEED Integration in the Project Management Knowledge Areas

After conducting the interviews for the four case studies, a general finding is that the participants did not view LEED as having "an impact on project management", but rather and something that has been integrated into their construction project management. Aspects of LEED have been incorporated into each one of the project management areas established by the Project Management Institute as follows:

1. **Integration**: this knowledge area refers to the coordination and unification of several processes. LEED plays an important role as it is highly related to the design phase. The case study participants reported that it LEED requires more design reviews during the construction phase and more attention to change orders. Contractors mentioned that LEED is an integrated process that comes from the design phase, so in some cases (depending on the type of contract) the contractor can provide suggestions for materials or waste management strategies that can be integrated into the design.
2. **Scope management:** this knowledge area refers to the processes required to ensure that the project includes all the work required to complete the project successfully. Three out of the four cases commented that this area is one that is most impacted by LEED. They mentioned that even if it not difficult to manage, it adds more effort and work to the project. The main work load arises from the paperwork. As mentioned, contractors are already adopting LEED practices in all the construction sites—however, LEED adds an specific indicator to each one of the practices to verify performance such as, percentage of waste diverted, total value of regional materials, total value of re-used materials, etc. In addition, although the LEED

documentation is submitted to GBCI for review after the construction is complete, the review process can take around 6 to 8 months and usually, a person has to modify or explain certain documentation, even when the construction has finalized.

3. **Time:** this knowledge area refers to the processes required to manage the timely completion of the project. Company #2 remarked that LEED involves integration with the construction schedule. The meetings and the inspections should be integrated with the master schedule, as well as document submission deadlines. They considered that LEED does not add additional duration time; however, it is included in the scheduling of the activities because the sequence might be affected by certain credits such as waste management.
4. **Cost:** this knowledge area refers to the processes related to costs so that the project can be completed within the approved budget. Three out of the four cases mentioned this area was impacted by LEED. It can change the total project cost, especially because it adds administrative work and, therefore, the paperwork requirements and the LEED coordinator should be considered in the budget. It also adds material cost since sustainable materials are often more costly. In design-build project, the cost of the LEED consultant should also be considered.
5. **Quality**: this knowledge area refers to the processes and activities for achieving the quality requirements of the project. Case study #2 considered LEED to affects this area since additional inspections are required for some credits. Credits such as indoor air quality might require that photos from the site are taken daily during certain phases. Inspections should be documented in a more specific way so that more quality is asked from the trades and from the site superintendent.
6. **Human resources:** this knowledge area refers to the processes related to project teams. None of the companies considered this to have major impact from LEED. However, many of the issues related to green practices discussed in the section 5.3.2 correspond to human resources management. LEED requires additional training for subcontractors and trades for the documentation related to materials and for green procedures related to waste management, indoor air quality and site disturbance. LEED, depending on the project and company, might require an additional person specialized in LEED coordination. Additional responsibilities are added to the team members, especially to the site superintendent, subcontractors and

project manager. Some level of knowledge or experience is also expected from some team members for better LEED coordination.

7. **Communications:** this knowledge area refers to the processes related to project information. This area was emphasized by Company #4, which stated that everything is based on the communication and coordination with the LEED consultant. Company #1 and #3 mentioned that LEED was a part in the client monthly report as well, as well as in regular meetings. Company #2 emphasized the importance of regular meetings for achieving the best environmental outcome, and therefore they have weekly and monthly meetings to review and inspect the procedures. At the beginning of the project, there is also a pre-kickoff meeting to explain the green requirements to the subcontractors and trades and another internal meeting, including the project manager, the site superintendent and the LEED coordinator. At the end of the project, there is also the post-mortem meeting to discuss lessons learned—green practices issues are discussed and documented in this meeting.
8. **Risk:** this knowledge area refers to the processes related to managing and controlling the risks of the project. Company #1 considered LEED to add risk to the project because contracts usually stipulate a penalty if the target LEED certification is not achieved. This penalty is approximately 1% of the total project cost. There are also risks related to project delays. For example, if the documentation from the subcontractors is delayed, then the project may be delayed since there must be proof that the materials comply with the specifications. Also, the project might be delayed for not having the initial measures related to erosion and sediment control. Some additional emergency response strategies should be considered for the achievement of this credit as well.
9. **Procurement:** this knowledge area refers to the processes necessary to purchase or acquire products, services, or results needed from outside the project team. There are several material credits and all of them impact the contracts and agreements. Specified requirements should be written in the contracts or an additional appendix should be included to detail the specifications. Most of the contracts are prescriptive, which means that specific requirements are already established in the contract. However, project teams still should ensure the availability of materials. Some contracts can be performance-based: project teams must achieve the certification but they have the freedom to choose the materials. This last case occurs in design-build projects.

10. **Stakeholder:** this knowledge area refers to the processes required to identify the people, groups, or organizations that could impact or be impacted by the project. This is an area with less impact as it is addressed extensively during the design while establishing the location and features of the project. In construction, however, LEED only creates minimal additional involvement from the client. There are some credits, such as Green Power, that the client can require at the end of the project.

LEED integration is summarized in Table 5.2. The numbers inside the brackets represent the number of the case study that considered the area to be of top impact.

Table 5.2 LEED Integration in Project Management

Knowledge Area	Integration	Scope [1,3,4]	Time [2]	Cost [1,2,3]	Quality [2]
LEED Integration	•More Diligency with Change Orders •More Design Reviews	•Overall Project Administration •LEED Plans •LEED Calculations •LEED Implementation Documentation •Response for GBCI after months	•Meetings integration with master schedule •Inspections Integration with master schedule •Document submission deadlines •Follow up time for certification •Scheduling of activities	•Total Project Cost •Cost Estimations Presentation •Administrative costs: Paperwork + LEED Coordinator	•Additional inspections on site •Quality of trades •LEED review progress

Knowledge Area	Human Resources	Communication [4]	Risk [1]	Procurement [3,4]	Stakeholder
LEED Integration	•Additional training for Subcontractors •Additional team member •Additional team responsabilities •Green knowledge/ experience	•Client reporting •LEED Consultant •Weekly /monthly meetings •Pre-kick off meeting	•Penalty for compliance •Risk considerations for delays for doc. •Risk considerations for delays for measures •Emergency response strategies	•Specs in Contracts and Agreements •Availability for materials	•More client engagement to the project

5.3.2. LEED Practices in the Project Management Knowledge Areas

The previous section determined LEED integration in the project management areas established by the Project Management Institute. This section seeks to put the practice-related issues in the same framework. In order to do this, the interviews asked participants to provide common issues concerning green construction practices implementation, including: material tracking, waste management, site disturbance and indoor air quality. The severity and impact of each issue were also asked about, and the results were classified and presented in Table 5.3. The impact and severity considered are shown in Figure 5.5 Impact and Severity Matrix, were HS stands for high severity, HO for high occurrence, LS for low occurrence and LO for low occurrence. The table also presents several abbreviations to better display the information: W stands for waste management, SD for site disturbance, IAQ for indoor air quality and M for materials. The number displayed in brackets represents the number of the corresponding case study that specifically emphasized that issue.

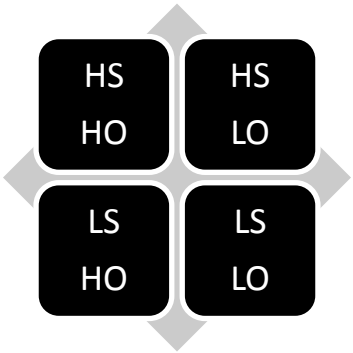


Figure 5.5 Impact and Severity Matrix

Table 5.3 Practices Issues in Project Management Knowledge Areas

Knowledge Area	Integration	Scope	Time	Cost	Quality
Practices Issues	M: Design Change [HS,HO][2]	SD: Site specific details not considered early in the process [HS,LO] W: Wrong estimates of waste [HS,LO][1] W:Poor diversion strategies [HS,LO][1]	W: Poor construction scheduling [LS,HO] IAQ: Occupancy required before flush-out [LS,HO] W:Site Layout since the beginning of project [HS,LO] [3]	N/A	SD: LEED Consultant experience about constructability issues [LS,HO] W: Collaboration of Site Workers [LS,HO][2] W: Knowledge of Measures [HS,LO] IAQ: Trades knowledge of measures [LS,LO]

Knowledge Area	Human Resources	Communication	Risk	Procurement	Stakeholder
Practices Issues	SD: Poor record keeping procedures [HS,LO] W:Poor record keeping procedures [HO,LO][2]	N/A	M: Delays for incomplete documentation [HS,LO] SD: Delays for not measures in place [HS,LO]	M:Wrong spec. For materials in contract doc. [HS,LO] W:Wrong documentation from subs [HO,LO][2,1]	N/A

In general, the issues that are classified as high severity and low occurrence often represented issues that had occurred frequently in the past, when LEED was a new practice on projects. For material tracking, the most relevant issue came from design changes. Case study 2 mentioned more diligence has to be done and some change orders (even when required by the owner) have to be rejected. A major issue is that a large percentage of all projects are now required to be LEED due to Vancouver's regulations, so design changes does not only adds a risk of achieving the certification but also a compliance risk with the regulations, causing delays in the project until ensuring the certification will be achieved. Another important and recurrent issue is incorrect documentation coming from subcontractors. One case study reported that the documentation is wrong 60% of the time, while another one reported having this problem 80% of the time. This presents a major problem because, if they do not present the documentation with the material compliance according to the project requirements on time, the work can't proceed. Three of the companies said they had a pre-construction kick-off meeting with subcontractors and one of the topics was materials documentation. However, subcontractors still have problems provide the correct documentation. More training should be done and specific green experience should be required. None of the contractors required this kind of experience from subcontractors and often they are selected according to project experience. However, they also mentioned that sometimes the LEED coordinator will not have enough experience, causing them to make mistakes while reviewing the documentation and to send incomplete information to the LEED consultant. This creates a minor problem, since the LEED consultant will identify the issue but it adds time to the process. In order to solve this, LEED certifications can be required from the person responsible for managing LEED in the project. This requirement is not currently applied by any of the four companies, even though they mentioned that it would be good if they had certification. A high severity issue that occurred in the past when LEED was new was incorrect or incomplete specifications in the contracts. One company solved this problem by using LEED consultants and an in-house sustainability manager. Another company solved it by hiring a specification writer to add the detailed requirements into the contracts in addition to the contract review made by the LEED consultant.

In terms of waste management, incorrect estimates of waste and poor diversion strategies are issues that come from the design phase but are essential for achieving the percentage of waste targeted. In Company #1, although they mentioned that it is not often an issue, it has occurred on

their project as they did not take into account the large volume of waste arising from the demolition. They were at risk of losing the points related to waste management credits and their lesson learned was that, in case of demolition, this waste credit is a difficult credit to achieve and better estimates and diversion strategies are required. Company #3 emphasized the importance of site layout from the beginning of the project with respect to waste management—site workers need to be engaged with waste management and, without the proper layout, no coordination can be done. Poor construction scheduling is another issue that is often related to waste management; waste bins are frequently removed before they are full due to constructability circumstances. For this situation, techniques such as more detailed planning or lean construction prtactices can be helpful to solve this problem. A minor issue was the collaboration of site workers as often they do not exhibit required sustainable behavior such as putting waste in the correct bins. However, this is usually solved with regular supervision and cooperation from the site superintendent. The first case study mentioned that more companies are looking to increase their percentage of waste diversion, even without LEED—however, they would usually not calculate the volume diverted. One reason for this is poor record keeping procedures from waste subcontractors. Usually, waste subcontractors only send required information in monthly or weekly reports. One of the companies solved this problem by selecting a subcontractor that gives daily reports online so that the LEED coordinator can check at any time to verify if the project is on track with the waste percentage established for the project.

In terms of site disturbance, it was reported that the LEED consultant often will not have experience in constructability issues, or that both the LEED consultant and the civil engineer will not be familiar with some local site requirements. To address this, the project manager have become more involved in reviewing the erosion and sediment control plan. One company said that the in-house sustainability manager was also involved in this process to make sure that all the required measures were included in the plan. An important practice is to establish all of the required site disturbance measures early in the planning to avoid project delays. Record keeping procedures are essential for achieving the certification, however, site superintendents are not always familiar with the detailed LEED requirements for complete inspections. Again, a suggestion to address this is to require green experience from the team members during the qualification process.

Indoor air quality contributed to fewer issues. One issue that arose frequently was that owners required occupancy before completion of system flush-out. However, this could be resolved with additional coordination and communication with the client to explain the correct procedures. Trades often have limited detailed knowledge of the measures established in the indoor air quality plan, but any problems can be solved through supervision from the site superintendent or LEED responsible consultant. One company mentioned that all the indoor air quality practices required by LEED—such as HVAC protection, source control, and housekeeping—are good practices that should be done with or without LEED certification.

5.4. Validation

The information displayed in tables 5.2 and 5.3 was validated with one of the case studies. The final results were explained and discussed with the project coordinator from Company #1, first case study conducted for this project, in order to make sure that the information gathered in the other three companies was consistent.

To provide a degree of verification of the results, additional literature research was conducted to seek independent results by others that supported the results obtained from the case studies. In the previous section, it was suggested that subcontractor training and worker collaboration are essential for achieving green construction practices. This was also found in other research conducted to investigate LEED practices where subcontractors' education and life cycle costing were suggested as beneficial to project participants (Syal et al., 2007). Kang et al. (2014) also emphasized the importance of subcontractor management, education and training to achieve sustainability. Looking in more detail at education and worker collaboration, a survey conducted of Canadian contractors found that approximately 50% of the workers did not have the appropriate technical skills and knowledge base and a similar portion (approximately 50%) indicated that there were not sufficient training, education and certification opportunities in place to support green building. These results are shown in Figure 5.6. Survey respondents reported that the workforce members are not adequately trained or educated in green site management techniques and that more training is needed. They expressed the belief that the workforce has the skills and tools in place but that more information and support is needed to implement green site practices (CSC, 2011). The same survey asked construction companies to describe specific skills or knowledge gaps with respect to green building; some indicated a lack of information available on courses, poor quality of courses, lack of leadership/direction/initiative, lack of

knowledge/experience, and lack of understanding of technical aspects. These two last aspects relate to the finding from this research project regarding the lack of knowledge that LEED consultants have about constructability issues.

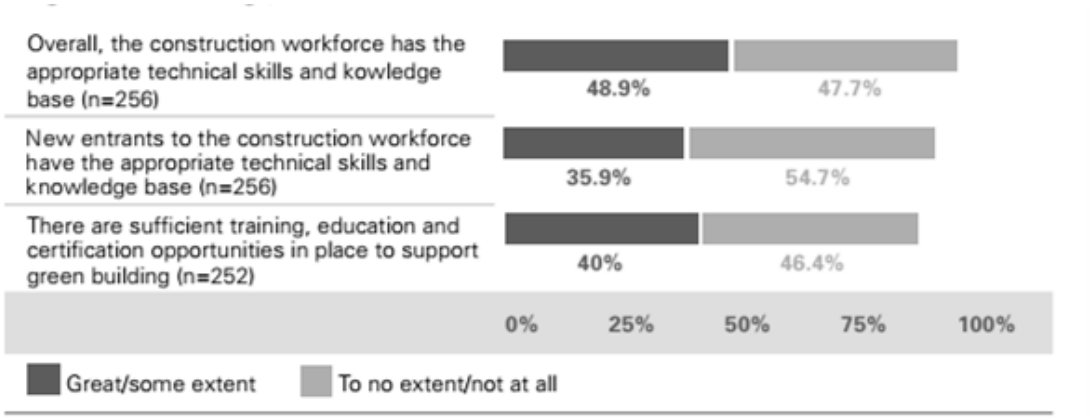


Figure 5.6 Knowledge, Education and Skills of Workforce. Source from (CSC, 2011)

5.5. Conclusion

This chapter reviewed the project management perspective from the case studies evaluated. The general conclusion is that LEED is highly integrated into project management practices and—even though it is not considered as an "impact"—the companies still identified that LEED mainly affects the PM areas of scope and cost management. Other issues related to green practices are related to materials coordination, waste management, indoor air quality and site disturbance.

The most serious issue was related to human resources management. A lack of collaboration and knowledge of subcontractors and the workforce are reported to be the main cause of issues in material coordination, indoor air quality measures, site disturbance inspections and waste management procedures. General training on green buildings for subcontractors and field supervisors is considered as the most effective strategies to mitigate these problems.

Chapter 6 Objective 3, Organizational Perspective

6.1. Introduction

This chapter corresponds to the organization perspective and relates to the third objective established in Section 1.3 of this document. This chapter mainly answers the question, "how are organizations supporting the implementation of green building construction practices?" It gives an overview of best practices and of how companies can enhance their implementation towards environmental management. This chapter also involves the review of the websites of the top 40 contractors in Canada listed in On-Site Magazine (June 2017) in order to support the information found in the case studies.

6.2. Case Studies: Companies' Contribution

As mentioned in Section 2.5, one of the main reasons for which contractors are increasing their level of green activity is to improve their branding/public relations; therefore, they will try to incorporate green construction strategies in their differentiate their businesses from others. These strategies are supporting the current green building standards. During the interviews, different clue words indicating active support of various green-related issues were detected and are presented in Figure 6.1. An open-ended question was made to the person about the impact of green building standard and practices in the organization. The people interviewed mentioned different topics in this question, so before classifying the information in Table 6.1, it was useful to create a general map with the topics mentioned to have an understanding of what organizational support meant to them.

Table 6.1 shows this information in greater detail, including information from the websites of the top 40 contractors listed in On-Site Magazine in June 2017 that were reviewed in order to obtain additional information to support and validate the case study observations. Out of the 40 companies, only 29 were taken into consideration. Some of them were discarded as they did not provide buildings construction services or did not have enough information on their websites.

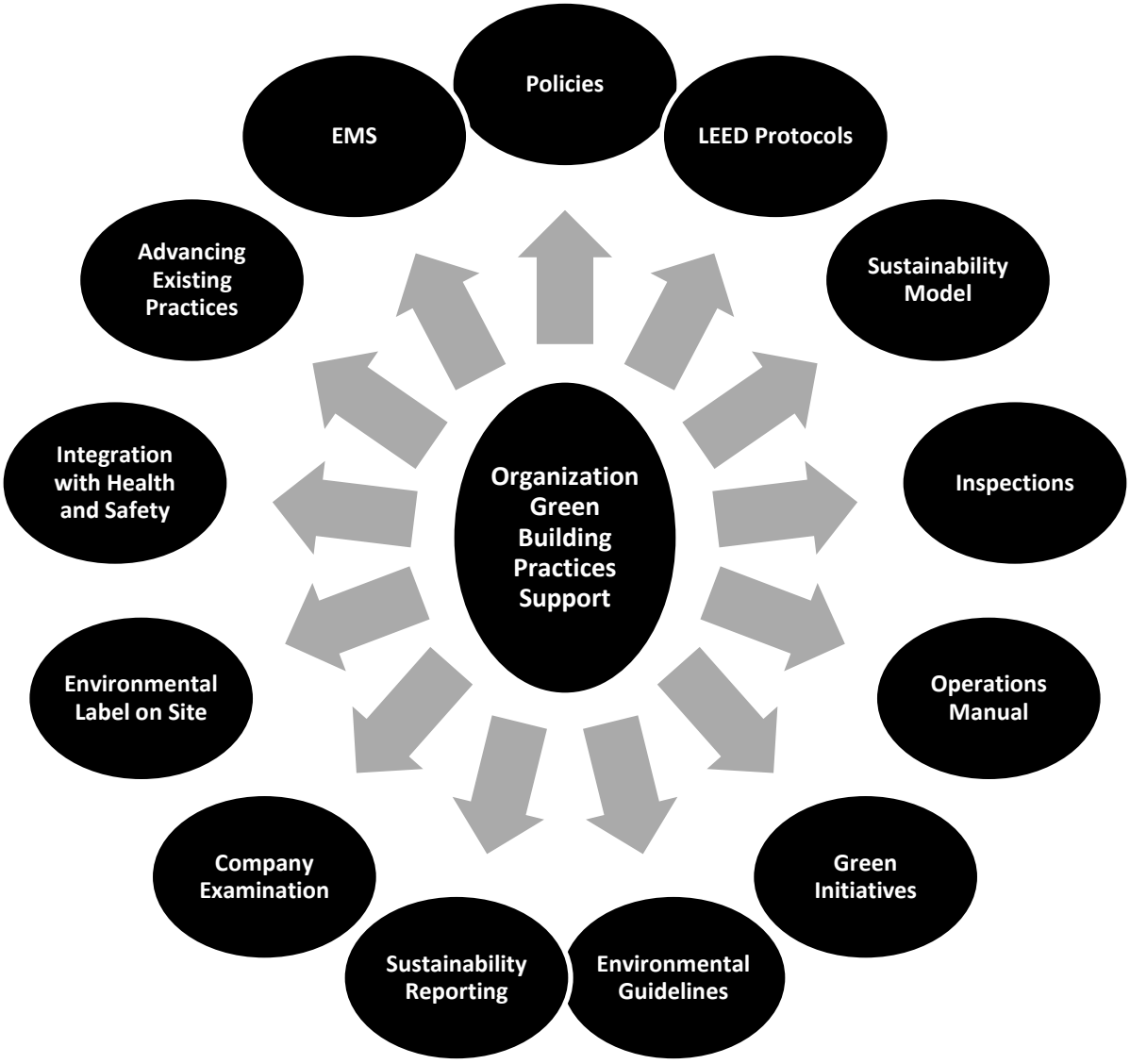


Figure 6.1 Clue Words from Case Studies in the Organization Perspective

Table 6.1 Organization Tools for Green Building Practices Implementation

Area	Company 1	Company 2	Company 3	Top 29/40
Commitment	Yes *Specific Sustainability Model	Yes	Yes *Specific Sustainability Model	20/29
Guidance for On-Site Practices	•In- house ***Environmental Label:*** Based on ISO + Environmental Stds (BREEAM + LEED) from Parent Organization *CANADA: **LEED Protocols** •Integrated Health and Safety Policy	•Operations Manual /Guidelines •***LEED Protocols***	***EMS*:** based on ISO •Integrated Health + Safety Policy **•LEED Protocols**	*Only 1 with In-house environmental label for worksites *EMS *Integration with Health and Safety Policy ***LEED Protocols**
Measurement Framework (Additional to LEED)	•Environmental Inspection Report **(Performance Indicators)**	•Inspection report **(Performance Indicators related to LEED)**	•Environmental Inspection Report **(Performance Indicators)**	N/A
Sustainability Reporting	Y	N	N	3/29
Initatives	*Promote solution for reducing carbon footprint *LCA for promotion of new construction methods and low carbon materials *Calculate carbon footprint	*Site-specific green building initiatives *In house consultants (commissioning) *Provide in house administrative requirements for certifications	*Office space guidelines *Company evaluation /reporting	N/A

A recent study suggested that, in order to apply sustainability at a corporate level, aspects such as sustainability goals and commitment, sustainability measurement frameworks, sustainability reporting, sustainability teams, knowledge management and training, and community engagement should be evaluated (Kang et al., 2014). Some of these aspects were mentioned by the companies.

Starting with goals and commitment, the three companies showed a high level of commitment to sustainability. The company that had the most stringent tool for managing on-site practices was Company #1, followed by Company #3 and then Company #2. Company #1, which can be defined as exhibiting the best practice as mentioned in section 2.6.3.1, commented they had an in-house environmental label for worksites. They adopted a general site initiative in order to improve the environmental performance of sites, mobilize teams around clear environmental objectives and enhance environmental initiatives internally and externally. This initiative has three primary tools:

- Site environmental standard guide: this standard provides recommendations related to maintaining a clean environment and it presents best practices to be implemented on site that take the surrounding environment into consideration. This standard was created based on LEED, BREEAM and ISO 14001—including practices from each one—creating a unified standard.
- Evaluation grid/scorecard: this scorecard provides an evaluation of implemented practices (similar to a LEED scorecard) in order to check the implementation of actions recommended in the standard guide.
- Site environmental label: analogous to a project receiving a label of "LEED Certified/Silver/Gold/Platinum", a result is awarded according to the scorecard, guaranteeing to their clients that they respect the environment while executing the construction. In order to obtain the label, compliance with all of the indispensable criteria must be met and a score equal or higher to the average of the entire criteria must be achieved.

Some of the practices established in the standard are mandatory while others may vary according to the location and specifications of the project. The audit to obtain the label is conducted using the scorecard. This audit is performed by the company's Quality, Safety, and Environmental Department, which is independent of the site team. In addition, follow-up audits are made throughout the construction phase to ensure that the criteria is being met. At the end, the site is awarded a flag in the presence of the client, company management, the production team, and partners, symbolizing the commitment and motivation of the teams. This environmental label considers 11 areas: the project's environmental risks, waste, hazardous products, noise nuisances, air, aquatic environment, biodiversity, energy consumption, cleanliness and storage, communication and emergency situations. These areas are detailed in 60

different actions or criteria, including management and technical aspects and can be graded according to three levels of performance.

The inspection report or audit includes an evaluation of the best practices implemented and the points to improve, and if there are any insufficient actions, then corrective actions and the person responsible for them are documented. The tool has mainly been used for international projects, whereas in Canada, the company usually follows only LEED protocols alone.

A similar initiative was seen in the review of the top contractors in Canada. One of the companies created a designation to indicate that a jobsite has taken specific measurable steps to improve health and working conditions for the workers and to reduce the environmental impact of the operations: actions ranging from using green cleaning products and recycled paper goods to taking public transportation and automatically turning out lights at the end of the day. The designation covers 12 prerequisites and 50 credits in five categories: well-being and environmental quality, recycling and waste, energy and atmosphere, and innovation and design. In order to get the designation, a jobsite must achieve at least 12 prerequisites and five additional credits.

An additional supporting tool for sustainability within Company #1 is their own specific model of sustainability (as does Company #3), establishing clear and detailed objectives in a specific framework to reflect their sustainability mission. Company #1 uses three main resources to evaluate their sustainable development policy:

- Performance summary: key indicators are evaluated with respect to each sustainability commitment.
- Annual non-financial reporting: covers all structures, with approximately 50 indicators relating to all sustainable development challenges.
- Annual self-assessment: performed by every operating unit against certain benchmarks that translate the commitments into practical initiatives.

Company #1 also has innovative initiatives towards green buildings such as promoting solutions for reducing carbon footprint in buildings, performing LCA for the promotion of new construction methods and low carbon materials, and calculating carbon footprint. Company #1 also makes their sustainability reporting available to the public. According to the Global Reporting Initiative, the purpose of sustainability reporting is to be accountable to "internal and external stakeholders for organizational performance towards the goal of sustainable

development" (GRI, 2006). Sustainability reporting includes disclosing the organization's commitments and achievements towards all aspects of sustainability, from both internal and external stakeholders' perspectives. Common approaches to sustainability policy include online disclosure, a dedicated section on sustainability issues in the annual report, and a stand-alone sustainability report (Zuo et al., 2012). According to Maclaren, the absence of a clearly articulated methodology of sustainability reporting presents a significant barrier to achieve the goal of sustainable development (Maclaren, 1996). Based on the review of 29 companies' web sites, most have a section related to sustainability to show their commitment. However, only 3 out of the 29 companies provide sustainability reporting with specific environmental indicators.

Company #2 was very committed to sustainability. It did not have any specific sustainability model, but they used the following mechanisms in order to achieve environmental sustainability on site:

- Policy procedures: environmental policy and guidelines documented in their operations manual.
- Protocols: requirements for each individual project.

They have their own guidelines for the implementation of green construction practices. The top three practices followed are as follows:

- Waste management and pollution control: which include higher percentages or performance levels than LEED requirements.
- ESC and water control systems: in this area, actions such as keeping the site clean and controlling dust are also considered. In addition, they have their own tree management policy.
- Quality commissioning program: a green building initiative is implemented that shows commitment towards achieving high energy efficiency in buildings.

Company #2's approach is to start with the requirements of the project and then try to advance them; they start from the requirements of a green building standard such as LEED, Built Green or another standard (depending on the requirements of the district) and then they start adding to those practices. For example, in the waste management credit, LEED can ask for either 50% or 75% of waste diversion, but Company #2 usually tries to achieve 85% in their projects. Many other Canadian construction companies follow a similar approach, as most of the reviewed websites indicated that the companies mainly follow LEED protocols. Projects that follow LEED

without registering are called "LEED shadow"; contractors are using this term to follow LEED guidelines, often at a minimum of LEED Silver level (Gager, 2016).

Company #2 mentioned that they do monthly and weekly meetings to review the ESC system, water control system, waste management system, and pollution control procedures; and they keep track of these in order to ensure compliance with the project requirements and company policies. They do not have any public sustainability reporting concerning indicators, but they demonstrated their commitment through sustainability initiatives such as site-specific green building initiatives towards the reduction of on-site energy consumption, the commissioning program, and the provision of in-house administrative requirements for certifications. This last initiative can be considered as a best practice—they mentioned that it provides great improvements in the LEED process. This avoids some problems related to LEED consultants of failing to provide appropriate information or of being unaware of local constructability requirements.

Company #3, one of the top contractors in Canada, is committed to sustainability and has their own sustainability model. They have an EMS (Environmental Management System) in place and their environmental policy is aligned with their health and safety programs. For achieving the best environmental outcomes on site, they employ the following:

- A Health, Safety and Environment (HSE) & Sustainability Operations Guide
- An EMS based on ISO 14001
- LEED Certification Procedures: documented as part of the Environmental Management System but dependent to the requirement of every project.

An EMS is defined by ISO as "part of the management system used to manage environmental aspects, fulfill compliance obligations and address risks and opportunities" (ISO, 2015) and it can help organizations achieve their environmental policy and objectives. Many organizations use "reviews" or "audits" to assess their environmental performance but, in some cases, this is not enough to provide assurance that the performance is meeting legal and policy requirements. An EMS provides a structured documented management system integrated with the organization (ISO, 2004) using the following methodology:

- Plan: establish objectives and processes to deliver results according to the environmental policy.
- Do: implement the processes.

- Check: monitor and measure processes against policy, objectives, targets, legal and other requirements, and report the results.
- Act: take actions to achieve continual improvement in the performance of the EMS.

The EMS includes organizational structure, planning activities, responsibilities, practices, procedures, processes, and resources for developing, implementing, achieving, reviewing and maintaining an environmental policy. The environmental inspection report is also established in their EMS. Company #3 does not have any public reporting of environmental indicators. However, they have their own system that tracks several indicators internally for all the projects that they are managing. They also have internal initiatives such as office space guidelines to reduce on-site office environmental impacts and they have regular company evaluations in order to find new strategies that they can implement to reduce their environmental impact and to improve their environmental indicators.

6.3. Conclusion

This chapter provided a general overview of the companies' approaches to environmental management. The level of commitment, tools for on-site practices guidance, sustainability initiatives, and sustainability reporting were discussed. The best practices identified from Table 6.1 were as follows:

1. Follow LEED guidelines on projects, even if the formal certification process is not pursued.
2. Go above the minimum standards by advancing the level of performance called for in LEED practices.
3. Use an EMS to assess environmental performance and to manage environmental policy.
4. Create an environmental label or designation specific to the worksite based on a combination of management and technical aspects from LEED, BREEAM, ISO 14001, and others.

Chapter 7 Conclusion

7.1. Contribution

Canada's green building industry has grown quickly, but more training and support is needed to help the construction industry to understand, design and build buildings that achieve high environmental, economic and social asperations (CAGBC, 2016). As a general contribution, this research provides a review of green building construction practices categories and environmental management in the Canadian industry from the contractor's perspective.

This research can be used as a guideline for contractors that are trying to improve or incorporate more green construction practices in their operations. Chapter 4 details a number of practices categories beyond LEED that will help reduce the environmental impact of the construction activities. These categories were determined by reviewing different green building standards, complemented with the review of several journal papers so it can serve as a guidance for contractors. They can advance their environmental practices in those areas.

In addition, this thesis reviewed the project management perspective by conducting semi-structured interviews in four construction organizations. This contribution is presented in Chapter 5 by showing how LEED is integrated into construction project management and by identifying the issues related to material tracking, waste management, indoor air quality and site disturbance facing Canadian contractors.

Finally, this research determined several best practices in organization tools that can support the implementation and management of green construction practices. This contribution is presented in Chapter 6 and it can be useful for contractors that are trying to improve the management of their environmental policy.

7.2. Future Research

1. **Green Construction Practices Categories:** this research focused on investigating categories established in green building standards and research, but it can be extended by including more social and economic categories that specifically impact the construction phase to provide broader guidance on sustainability management from a contractor's perspective.
2. **Project Perspective:** this research was focused on LEED 2009 case studies. The same approach can be taken for projects under different certification systems such as LEED v4 or Living Building Challenge.

3. **Organization Perspective:** this research focused on an overview of the organizational approach to environmental management. However, it could be extended to a more detailed case study evaluating the details of organizational structure, sustainability indicators and reporting systems.

7.3. Limitations of Work

Limitations of this research included the following:

1. **Data Collection:** the primary source of data collection for the project management and organization perspective was through interviews with the project manager, project coordinator or LEED coordinator. Since these actors were generally proponents of the sustainability practices within their companies, this created an inevitable bias in the responses. Efforts were made to minimize bias through the design of the questionnaire. However, the degree of bias in the results is unknown.
2. **Organization Perspective:** the information provided in Chapter 6 was developed based on the information provided in the interviews and on the review of the top 40 contractors in Canada listed in On-Site Magazine of June 2017. However, the information could besought at a more detailed level if the construction organizations shared their documentation in terms of environmental management systems, environmental policy, inspection reports and environmental guidelines. However, the companies were generally concerned about confidential issues and it was not possible to gather all of the desirable documentation for this research.

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Appendices

Appendix A: Interview Questions

Area: General - Sustainable Practices in Place (Company)

1. Certifications this company works with?
2. Can you mention other sustainable practices than the ones mentioned below that cause the major impact in the construction process?

   *Waste management

   *Material procurement

   *Indoor air quality,

   *Site disturbance,

   *Commissioning
3. Please mention the impacts of Green Building Standards in the Organization. Example: Company created its own environmental label, inspection reports, environmental management system, sustainability department, etc.?
4. From the practices mentioned before, please mention which ones are part of Company Policies as well as any additional one.
5. Does the green sustainable policies from the company interact/support green building standards implementation? Explain
6. Does the company follows these guidelines regardless of the client requirements?
7. Are all the sustainable practices documented and communicated in an EMS? Describe the core elements
8. Is the LEED management process is documented within the company? Describe the core elements

Area: Project Life Cycle (Planning and Process)

9. In the planning phase. Did a pre-construction kick off meeting happened in this project for discussing sustainable practices?
10. In the executing phase. Does the EMS and Certification reviewed periodically against its goals?
11. In the closing phase. Are lessons learned captured for better sustainable management practices?

Area: Project (People)

12. In LEED projects, who is the main responsible in the project for managing the LEED process and ensuring LEED compliance?
13. Is the same person responsible for managing other sustainable practices applied by the organization during construction?
14. Are there any specific requirements for the selection of construction team members in terms of green building experience/education for this project?
15. Are there any requirements for the selection of subcontractors in terms of green building experience/education for this project?
16. Did the General Contractor participate in the Design Process? How do you consider is the collaboration between design and contractor team?

Area: Project Management Knowledge Areas

17. From a project perspective, please rank the level of impact of including sustainable practices during the construction phase

Project Management Areas	No impact	Low Impact	Moderate Impact	Significant Impact	High Impact
Integration	1	2	3	4	5
Scope	1	2	3	4	5
Time	1	2	3	4	5
Cost	1	2	3	4	5
Quality	1	2	3	4	5
HR	1	2	3	4	5
Communications	1	2	3	4	5
Risk	1	2	3	4	5
Procurement	1	2	3	4	5
Stakeholder	1	2	3	4	5

18. Explain the major impacts and provide examples

Area: Practices

Subarea: Material Coordination

19. Who is responsible for the following activities?

*Participate in availability/ pricing of materials in design phase

*Verify which materials have to be tracked

*Ensure proper installation

*Request Documentation from Subcontractors

*Review Documentation

20. When is the documentation required from subcontractors?
21. Average time subcontractors take to send information
22. % of time documentation from subcontractors was wrong
23. % of time documentation sent by LEED coordinator to LEED consultant was wrong
24. Type of training provided for subcontractors
25. Mention some possible issues related to this practice and rate the level of severity and occurrence

Examples: Wrong green specifications for materials in contract documents, Team members not having familiarity with material tracking, poor knowledge of subcontractors about green specifications, not providing subcontractor training, design changes

1- Low severity	1- Low occurence (1-25%)
2-Normal/ Minor Impact	2-Normal ocurrence (26-50%)
3- Significant Impact	3- Significant Ocurrence (51-75%)
4- Critical Impact	4- High Ocurrence (75-100%)

26. What have you done differently?
27. Are you satisfied in how the process is performed in this project. What factors do you consider are most important for its successful implementation?

Subarea: Site Disturbance

28. Who is responsible for the following activities?

*Develop Erosion and Sediment Control Plan

*Review Erosion and Sediment Control Plan

*Inspections

*Document measures with photographs

29. Do you elaborate a tree protection plan/ site protection plan?
30. Who elaborates this plan and who ensures it is implemented?
31. Mention some possible issues related to this practice and rate the level of severity and occurrence

Examples: Scheduling of land-disturbing activities, poor knowledge of control measures. site-specific details not considered early in the process, not having the right contingency plans, wrong site evaluation, mitigation measures installed incorrectly, inspections framework, poor record-keeping procedures

1- Low severity	1- Low occurence (1-25%)
2-Normal/ Minor Impact	2-Normal ocurrence (26-50%)
3- Significant Impact	3- Significant Ocurrence (51-75%)
4- Critical Impact	4- High Ocurrence (75-100%)

32. Are you satisfied in how the process is performed in the projects. What factors do you consider are most important for its successful implementation?
33. What have you done differently?

Subarea: Waste Management

34. Who is responsible for the following activities?

*Establish diversion goals and estimate of waste for the project

*Elaborate CWM Plan

*Communicate Plan with subcontractors and site workers

*Retain receipts and estimate weight or volume for materials

*Calculate Diversion Rate periodically

*Prepare CWM Report

*Ensure waste management plan is being applied/inspections

35. Mention some possible issues related to this practice and rate the level of severity and occurrence

Examples: Wrong estimates of waste at the beginning of the project, poor diversion strategies/ specific measures, poor education to team members, site workers and subcontractors, esign changes, errors and incomplete contract documents, not participating in the design process (source reduction strategies), activity sequencing/ construction scheduling, site layout, poor recordkeeping/ follow up process, management of materials- not effective, poor collaboration/ communication from site workers and subcontractors, poor knowledge of roles and responsibilities

1- Low severity	1- Low occurence (1-25%)
2-Normal/ Minor Impact	2-Normal ocurrence (26-50%)

3- Significant Impact	3- Significant Ocurrence (51-75%)
4- Critical Impact	4- High Ocurrence (75-100%)

36. What have you done differently?
37. Are you satisfied in how the process is performed in the projects. What factors do you consider are most important for its successful implementation?

Subarea: Indoor Air Quality

38. Who is responsible for the following activities?

*Determine IAQ practices

*Elaborate IAQ plan

*Educate/communicate plan with subcontractors/site workers

*Prepate IAQ Report

*Ensure IAQ plan is being applied/inspections

39. Mention some possible issues related to this practice and rate the level of severity and occurrence

Examples: Poor knowledge /application of IAQ management strategies and control measures, activity sequencing/ construction scheduling, errors and incomplete contract documents

Not participating in the design process, poor education and orientation to workers/subcontractors, poor follow up/process, poor collaboration/ communication from site workers and subcontractors, poor knowledge of roles and responsibilities

1- Low severity	1- Low occurence (1-25%)
2-Normal/ Minor Impact	2-Normal ocurrence (26-50%)
3- Significant Impact	3- Significant Ocurrence (51-75%)
4- Critical Impact	4- High Ocurrence (75-100%)

40. What have you done differently?
41. Are you satisfied in how the process is performed in the projects. What factors do you consider are most important for its successful implementation?

Subarea: General- Conclusion

42. In general, what do you consider are the most important factors for achieving sustainability in the construction process?

43. In general, what other practices do you suggest can be implemented during the construction process that are regularly not found in green building standards. Examples, noise, energy consumption during construction, etc.

Appendix B:Comparison between LEED 2009, LEED v4, REAP and Green Globes

NAME & VERSION		LEED 2009				
COMPLETE NAME		LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS 2009				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Site Disturbance	Construction Activity Pollution (Erosion and Sediment Control)	Sustainable Sites > Prereq 1> **Construction Activity Pollution Prevention**	Reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airbone dust generation	•ESC Plan + Implementation •Conform with 2003 U.S. EPA or local codes/stds, whichever is more stringent	Required	•Narrative and comparative with std/ code selection and compliance •E&S control drawings and plan/ spectifications •Implementation activities: Periodic inspection or photos or narrative
	Disturbance limits and vegetation preservation	Sustainable Sites > Credit 5.1 **Site development: Protect and Restore Habitat**	Conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity	1. Greenfield Sites: Limit site disturbance to certain parameters 2. Previously Developed Areas or Graded Sites: Restore or protect 50% of site area or 20% of total site area (whichever is greater) with native or adapted vegetation *Exemplary Performance: Restoring or protecting a min. of 75% of site or 30% of total site including building footprint (whichever is greater)	1/110	For greenfield sites: •Site plans/drawings and specs highlighting limit of construction activities •Photos of disturbed areas characterizing the limitation of construction activities For previously developed or graded sites: •Site plans highlighting protected or restored sie area •List of native and adapted plant species •Short narrative describing species selection and maintenance

NAME & VERSION		LEED v4				
COMPLETE NAME		LEED v4 FOR BUILDING DESIGN AND CONSTRUCTION: NEW CONSTRUCTION AND MAJOR RENOVATION				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Site Disturbance	Construction Activity Pollution (Erosion and Sediment Control)	Sustainable Sites>. Prereq. **Construction Activity Pollution Prevention**	Reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airbone dust generation	•ESC Plan + Implementation •Conform with 2012 U.S. EPA or local codes/stds, whichever is more stringent	Required	•Narrative with std/ code selection and compliance •E&S control drawings and plan/ spectifications •Implementation activities: Periodic inspection or photos or narrative
	Disturbance limits and vegetation preservation	Sustainable Sites > Credit. **Site Development: Protect and Restore Habitat**	Conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity	*Preserve and protect all development and construction activity 40% of the greenfield area on the site + Op1. On-Site Restoration : Previously Developed: Restore 30% of total site area. Opt2. Financial Support: at least $4 US dll/ m2 for the total site area to a conservation organization (for 100% greenfield sites) *Exemplary Performance: Not available	2/110	•Greenfield area calculations •Description of greenfield area protection Option1: •Native or adaptive vegetation calculations •Site plan •Description of disturbed or compacted soils to be revegetated •Reference soil characteristics and soil test results •Provide FAR Option2: •Financial support calculations •Agreement with land trust or conservation org • Verification of organization being recognized, qualifications and mission

NAME & VERSION		REAP 3.0				
COMPLETE NAME		RESIDENTIAL ENVIRONMENTAL ASSESSMENT PROGRAM 3.0				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Site Disturbance	Construction Activity Pollution (Erosion and Sediment Control)	Construction > CON Mandatory > M5 -**Erosion and Sediment Control**	To control on-site erosion to reduce negative impacts on water and air quality	•ESC Plan + Implementation •Conforms to Best Management Practices Guide for Stormwater: Appendix H – Construction Site Erosion and Sediment Control Guide (GVS&DD, October 1999).	Required	•Letter signed by the Civil Engineer or responsible party declaring that the requirements have been met •Copy of the Erosion and Sedimentation Control Plan.
	Disturbance limits and vegetation preservation	Construction > CON Mandatory > M2 -**Vegetation Safeguards and Land-Clearing Debris**	To protect the ecology and natural features of the site such as topography, watercourses, flora and fauna from damage during the construction process.	•Site plan showing the sizes and locations of vegetation to be removed, retained and salvaged, including plants located on adjacent public rights-of-way and develop a plan to effectively handle debris from land clearing and divert it from landfill disposal.	Required	•Letter signed by Developer declaring that the requirements have been met. •Copy of vegetation site plan. • Copy of debris and land clearing management plan.
	Other	Construction > CON Mandatory > M1 -**Staging and Construction**	To protect the ecology and natural features of the site such as topography, watercourses, flora and fauna from damage during the construction process.	Prepare and implement a Staging and Construction Plan, including alternate detour information and signage for pedestrians and cyclists.	Required	•Letter signed by Developer declaring that the requirements have been met. •Copy of staging and construction plan.

NAME & VERSION		Green Globes v.2				
COMPLETE NAME		GREEN GLOBES CANADA DESIGN FOR NEW CONSTRUCTION AND MAJOR RETROFITS V.2 2014				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Site Disturbance	Construction Activity Pollution (Erosion and Sediment Control)	B. Site > B.2. Ecological Impacts > **Site Disturbance and Erosion**	To avoid the negative effects of erosion on air and water quality and maintain the ecological integrity of the site	•ESC Plan + Implementation •signed and stamped by a Professional Engineer OR require that the General Contractor implement best-practices for erosion control, with measures such as silt fencing, placing gravel pads at all site entrances and riprap around all storm sewer drains, using control mats or mulching to correct disturbed soils, and control dust by wetting soil •Conforms to EPA	5/1000	•ESC plan
	Disturbance limits and vegetation preservation	B. Site > B.2. Ecological Impacts > **Site Disturbance and Erosion**	To avoid the negative effects of erosion on air and water quality and maintain the ecological integrity of the site	Construction activities will be located in such a way to limit disturbance to the site. Construction activity should not extend beyond 12.2 m (40 ft.) of the building footprint; and not beyond 1.5 m (5 ft.) of parking lots, roadways, sidewalks, and utility right-of-ways. E	2/1000	Reference to the Specification (e.g. Section 31 14 13 Soil Stripping and Stockpiling) or to the Erosion and Sedimentation Control Plan.
	Other	B. Site > B.2. Ecological Impacts > **Tree Preservation**	To maintain the ecological integrity of the site	Develop a Tree Preservation Plan for existing trees on the site, or take measures to ensure existing trees are sufficiently protected and integrated into the development plan. •Tree protection barriers will enclose a minimum Tree Protection Zone (TPZ) •Root protection will be installed to protect tree roots from compaction •Sediment control barriers will be provided where some fill or excavate will be temporarily located near a TPZ	4/1000	•Tree protection plan •Photos

NAME & VERSION		LEED 2009				
COMPLETE NAME		LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS 2009				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Materials	N/A	Materials and Resources > Credit 3 **Materials Reuse**	To reuse building materials and products in order to reduce demand for virgin materials and reduce waste, thereby lessening impacts associated with the extraction and processing of virgin resources	*Use salvaged, refurbished or reused materials Op1. Sum constitutes 5% based on cost Op2. Sum constitutes 10% based on cost *Exemplary Performance: 15% or more of the total materials cost	2/110	•List of reused and salvaged materials •Manufacturer datasheets or letters / photos if applicable •List of actual material costs, excluding labour and equipment
		Materials and Resources >Credit 4. **Recycled Content**	To increase demand for building products that incorporate recycled content materials, thereby reducing impacts resulting from extraction and processing of virgin materials	*Use materials with recycled content such that the sum of post-consumer recycled content plus 1/2 of the pre-consumer content consitutes: Op1. 10% based on cost Op2. 20% based on cost *Exemplary Performance: 30% or more of the total materials cost	2/110	•List of recycled materials : Product names, manufacturer's name, costs, % post-consumer content, % pre-consumer content •Manufacturer datasheets or letters / photos if applicable •List of actual material costs, excluding labour and equipment
		Materials and Resources > Credit 5. **Regional Material**	To increase demand for building products extracted, processed and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmnetal impacts resulting from transportation	*Use materials that have been extracted, harvested, recovered and processed within 800 km (2,400 km if shipped by rail or water) of the final manufacturing site Op1. 20% based on cost Op2. 30% based on cost *Fractions of products count *Exemplary Performance: 40% or more of the total materials cost	2/110	•List of product purchases manufactured, extracted, harvested, recovered, and processed regionally •List of materials : Product names, manufacturer's name, costs, distances between manufacturer and the extraction, harvesting, recovery and processing site(s). Include mode of travel (road or rail/water) •Cutsheets that document material as regional •List of actual material costs, excluding labour and equipment

NAME & VERSION		LEED 2009				
COMPLETE NAME		LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS 2009				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Materials	N/A	Materials and Resources > Credit 6**. Rapidly Renewable Materials**	To reduce the use and depletion of finite raw materials and long-cycle renewable materials by replacing them with rapidly renewable materials	*Use rapidly renewable building materias and producs for 2.5% of total value of all building materials and products used in the project, based on cost *Rapidly renewable building materials are made from plants that are typically harvested within a 10-year cycle or shorter *Exemplary Performance: content of 5% or more	1/ 110	•List of product purchases manufactured, extracted, harvested, recovered, and processed regionally •List of materials : Product names, manufacturer's name, costs, distances between manufacturer and the extraction, harvesting, recovery and processing site(s). Include mode of travel (road or rail/water) •Cutsheets that document material as regional •List of actual material costs, excluding labour and equipment
		Materials and Resources >Credit 7. **Certified Wood**	To encourage environmentally responsible forest management	*Use a min. of 50% (based on cost) of wood-based materials and products that are certified with FSC for building components. *Exemplary Performance: FSC certified wood content of 95% or more of the project's total new wood	1/110	•Track certified wood purchases and retain associated COC documentation •Copies of vendor invoices for each certified wood product •List that identifies the % of certified wood in each purchase

NAME & VERSION		LEED 2009				
COMPLETE NAME		LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS 2009				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Materials	N/A	Materials and Resources > Credit 6**. Rapidly Renewable Materials**	To reduce the use and depletion of finite raw materials and long-cycle renewable materials by replacing them with rapidly renewable materials	*Use rapidly renewable building materias and producs for 2.5% of total value of all building materials and products used in the project, based on cost *Rapidly renewable building materials are made from plants that are typically harvested within a 10-year cycle or shorter *Exemplary Performance: content of 5% or more	1/ 110	•List of product purchases manufactured, extracted, harvested, recovered, and processed regionally •List of materials : Product names, manufacturer's name, costs, distances between manufacturer and the extraction, harvesting, recovery and processing site(s). Include mode of travel (road or rail/water) •Cutsheets that document material as regional •List of actual material costs, excluding labour and equipment
		Materials and Resources >Credit 7. **Certified Wood**	To encourage environmentally responsible forest management	*Use a min. of 50% (based on cost) of wood-based materials and products that are certified with FSC for building components. *Exemplary Performance: FSC certified wood content of 95% or more of the project's total new wood	1/110	•Track certified wood purchases and retain associated COC documentation •Copies of vendor invoices for each certified wood product •List that identifies the % of certified wood in each purchase

NAME & VERSION		LEED v4				
COMPLETE NAME		LEED v4 FOR BUILDING DESIGN AND CONSTRUCTION: NEW CONSTRUCTION AND MAJOR RENOVATION				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Materials	N/A	Materials and Resources >.Credit. **Building Product Disclosure and Optimization - Environmental Product Declarations**	To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products from manufacturers who have verified improved environmental life-cycle impacts	Op1. Environmental Product Declarations: At least 20 different products from 5 different manufacturers: •Product -specified declaration conforming ISO 14044 with at least cradle to gate scope as 1/4 of a product •EPD declaration conforming ISO 14025, 14040, 14044, EN 15804 or ISO 21930 and at least a cradle to gate scope (Industry wide - generic EPD valued as 1/2 of a product /Product specific Type III EPD valued as a whole product) • USGBC approved program Op2. Multi-attribute optimization: For 50% by cost of the total value of permanently installed products in the project: • Third party certified products with impact below industry average in these 3 categories. (Products will be valued 100% of their cost) -GHG, depletion of stratospheric ozone layer, acidification of land and water sources, eutrophication, formation of tropospheric ozone • USGBC approved program *Products sourced within 100 miles (160 km) of project site will be valued 20% of their base contributing cost *Structure and enclosure materials may not constitute more than 30% of the value Exemplary performance: Op1. Source at least 40 qualifying products from 4 manufacturers Op2. Purchase 75% by cost that meet required attributes	2/110	•MR building product disclosure and optimization calculator or tracking tool • EPD and LCA reports or compliant summary doc for 100% products contributing to credit • Documentation of compliance with USGBC - approved program

NAME & VERSION		LEED v4				
COMPLETE NAME		LEED v4 FOR BUILDING DESIGN AND CONSTRUCTION: NEW CONSTRUCTION AND MAJOR RENOVATION				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Materials	N/A	Materials and Resources >. Credit. **Building Product Disclosure and Optimization - Sourcing of Raw Materials**	To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products verified to have been extracted or sourced in a responsible manner	Op1. Raw Materials Source and Extraction Reporting: At least 20 different permantently installed products from at least 5 dif. Manufacturers Op2. Leadership Extraction Practices. At least 25% by cost of the total value of permanently installed building products. •Extended producer responsability •Bio-based materials •Wood products •Materials reuse •Recycled contect •USGBC approved program *Products sourced within 100 miles (160 km) are valued 200% of their base contributing cost *Structure and enclosure materials may not constitute more than 30% of the value of compliant building products Exemplary performance: Op1. Source at least 40 products from 5 manufacturers Op2. Purchase 50% by cost	2/110	•MR building product disclosure and optimization calculator or tracking tool • Corporate sustainability reports for 100% of products contributing toward credit •Documentation of product claims for credit requirements or other USGBC approved program

NAME & VERSION		LEED v4				
COMPLETE NAME		LEED v4 FOR BUILDING DESIGN AND CONSTRUCTION: NEW CONSTRUCTION AND MAJOR RENOVATION				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Materials	N/A	Materials and Resources >. Credit **Building Product Disclosure and Optimization - Material Ingredients**	To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products for which the chemical ingredients in the product are inventoried using an accepted methodology and for selecting products verified to minimize the use and generation of harmful substances. To reward raw material manufacturers who produce products verified to have improved life-cycle impacts.	Op1. Material Ingredient Optimization : At least 20 dif permantently installed products from at least 5 different manufacturers to demonstrate the chemical inventory of the product to at least 0.1% using: •Manufacturer Inventory: Publicly inventory of all ingredients by name and CASRN or role, amooung and GreenScreen benchmark in GreenScreen v1.2 •Health Product Declaration • Cradle to Cradle: certified at the Cradle to Cradle v2 Basic level or Cradle to Cradle v3 Bronze Level •USGBC approved program Op2. Material Ingredient Optimization: At least 25% by cost of: •GreenScreen v1.2 Benchmarl •Cradle to Cradle Certified •International Alternative Compliance Path-REACH Optimization •USGBC approved program Op3. Product Manufacturer Supply Chain Optimization: At least 25% by cost *Products sourced within 100 miles (160 km) are valued 200% of their base contributing cost *Structure and enclosure materials may not constitute more than 30% of the value of compliant building products Exemplary performance: Op1. Purchase at least 40% of permanently installed building products Op2. Purchase at least 50% by cost	2/110	•MR building product disclosure and optimization calculator or tracking tool • Op1. Documentation of chemical inventory through HPD, Cradle to Cradle certification labels, manufacturer's lists of ingredients with GreenScreen assessment reports for confidential ingredients or USGBC approved programs (if applicable •Op2. Verification of ingredient optimization through Cradle to Cradle certification labels, manufacturers's lists of ingredients with GreenScreen benchmarks listed for all ingredients, or manufacturers' declaration (for REACH) or USGBC approved programs (if applicable) •Op3. Documentation of supply chain optimization

NAME & VERSION		REAP 3.0				
COMPLETE NAME		RESIDENTIAL ENVIRONMENTAL ASSESSMENT PROGRAM 3.0				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Materials	N/A	Materials and Resources>MR 1-Recycled Content and Reused Materials >MR 1.1 **Reused Building Materials**	To reduce the environmental impacts associated with manufacturing new building materials by reusing salvaged building materials.	Use salvaged, refurbished or reused materials for at least 5% of the total cost of building materials	2/134	•Letter signed by Architect declaring that the requirements have been met. •Total value of construction materials and total value of re-used building materials.
		Materials and Resources>MR 1-Recycled Content and Reused Materials >MR 1.2 **Reused Building Materials**	To reduce the environmental impacts associated with manufacturing new building materials by reusing salvaged building materials.	Use salvaged, refurbished or reused materials for at least 10% of the total cost of building materials	2/134	•Letter signed by Architect declaring that the requirements have been met. •Total value of construction materials and total value of re-used building materials.
		Materials and Resources>MR 1-Recycled Content and Reused Materials >MR 1.3 **Recycled Content Materials**	To reduce the environmental impacts associated with manufacturing new building materials by using products with recycled content.	Specify and use building materials with the following recycled content levels: 1. Common area carpet with minimum 25% recycled content 2. Drywall with minimum 15% recycled content 3. Batt insulation with minimum 40% recycled content 4. Doors contain minimum 15% recycled material 5. Concrete with minimum 20% fly ash content, excluding suspended slabs 6. Concrete with minimum 40% fly ash content, excluding suspended slabs 7. Cabinetry with minimum 20% recycled content 8. MDF products with minimum 50% recycled content Op1.Minimum four recycled content items on list above Op2. All eight recycled content items on list above	2/134	•Letter signed by Architect declaring that the requirements have been met. •Manufacturer's cut sheet for each material selected indicating recycled content

NAME & VERSION		REAP 3.0				
COMPLETE NAME		RESIDENTIAL ENVIRONMENTAL ASSESSMENT PROGRAM 3.0				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Materials	N/A	Materials and Resources>MR 2-Regional Materials >MR 2.1 **Regionally Manufactured Building Materials**	To foster sustainable regional economic development by increasing demand for building materials that are manufactured locally, and to reduce the environmental impacts associated with transporting materials over long distances.	Use a minimum of 20% (by value) of building materials and products that are assembled or manufactured within a radius of 800 km (500 miles).	1/134	•Letter signed by Architect declaring that the requirements have been met. •Total value of building materials and total value of regionally manufactured materials.
		Materials and Resources>MR 2-Regional Materials >MR 2.2 **Regionally Sourced Building Materials**	To foster sustainable regional economic development by increasing demand for building materials that are extracted and manufactured locally, and to reduce the environmental impacts associated with transporting materials over long distances.	Of the materials from Credit MR 2.1, use a minimum of 50% (by value) of building materials and products that are extracted, harvested or recovered (as well as assembled or manufactured) within a radius of 800 km (500 miles).	1/134	• Letter signed by Architect declaring that the requirements have been met. •Total value of regionally manufactured materials and total value of those materials that are also regionally extracted, harvested, or recovered.
		Materials and Resources>MR 3-Certified and Non-Endangered Forest Products >MR 3.1 **Dimensional Lumber and Plywood**	To support environmentally responsible, socially beneficial, and financially viable forest stewardship.	Demonstrate that a minimum of 50% of the total value of dimensional lumber and plywood is certified in accordance with either: CSA Z809 – 2 Points Or Forest Stewardship Council (FSC) – 3 Points	2/134	•Letter signed by Architect declaring that the requirements have been met. •Total value of lumber and plywood • Total value of certified lumber and plywood used in the project and for FSC provide CoC documentation for each product.

NAME & VERSION		REAP 3.0				
COMPLETE NAME		RESIDENTIAL ENVIRONMENTAL ASSESSMENT PROGRAM 3.0				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Materials	N/A	Materials and Resources>MR 3-Certified and Non-Endangered Forest Products >MR 3.2 **Hardwood Floors**	To support environmentally responsible, socially beneficial, and financially viable forest stewardship as well as the use of rapidly renewable flooring materials.	Specify and install hardwood or bamboo flooring that is certified in accordance with the Forest Stewardship Council or CSA Z809. If floors are offered only as an option, specify and offer only bamboo or renewable products with third-party certification. CSA Z809 – 2 Points Or Forest Stewardship Council (FSC) – 3 Points	3/134	• Letter signed by Architect declaring that the requirements have been met. •Manufacturer's cut sheet for each material selected indicating certification standard and for FSC provide CoC documentation for each product.
		Materials and Resources>MR 4-Building Product-Ingredients>MR 4.1 **Transparency of Ingredients**	To encourage transparency in the market place by requesting ingredients for building products. By encouraging early adopters the intent is to start moving towards building products that contain less potentially harmful chemicals	nstall ten different building products from three different manufacturers that demonstrate the chemical inventory of the product to and accuracy of 0.1% for each product. For each product selected provide either: • Health Product Declaration (HPD) • Manufacturers Inventory of all ingredients by CAS number, or • Declare Label (Living Building Institute)	2/134	• Letter signed by Architect declaring that the requirements have been met, including a list of the chosen products. • Documentation for each product.
		Materials and Resources>MR 4-Building Product-Ingredients>MR 4.2 **Optimization of Ingredients**	Encourage the selection of building products that minimize the use or generation of harmful substances	Demonstrate that a minimum of 10% (by value) of building materials are optimized for ingredient content by demonstrating optimization in one of the following ways: • GreenScreen v1.2 benchmark 4 minimum • Red List free • Free of ingredients listed on REACH Authorization and Candidate List	2/134	• Letter signed by Architect declaring that the requirements have been met. • Documentation of optimized ingredient content for each product chosen. • Total value of building materials and the total value of building materials optimized for ingredient content.

NAME & VERSION		Green Globes v.2				
COMPLETE NAME		GREEN GLOBES CANADA DESIGN FOR NEW CONSTRUCTION AND MAJOR RETROFITS V.2 2014				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Materials	N/A	E. Materials and Resources >E.2 **Interior Fit-Out (Including Finishes and Furnishings)**	To increase demand for fit-up products that incorporate recycled content materials, thereby reducing impacts resulting from extraction and processing of virgin materials; and building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation	Products with either of: •Industry Wide (Generic) EPD •Product Specific Declaration •Third-party certifications •Third-party certified life cycle product assessment based upon ISO 14040 and 14044, and minimally covers cradle-to-gate scope *EPDs must conform to ISO standards 14040, 14044, 14025, and 21930 or EN 15840 (Type III: EPDs). Based on cost: •> 40% (10 points) •25 - 39% (8 points) • 10 - 24% (6 points) •1 - 9%	10/1000	•EPDscontaining: -Description of the manufacturer -Description of the product / material -Components / materials of the product - Additional information (optional) -Life Cycle Assessment -Statement of EPD review •LCA documentation •Chart of comparable products that meet the functional needs with specifications, including third-party certifications and environmental product declarations

NAME & VERSION		LEED 2009				
COMPLETE NAME		LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS 2009				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
IAQ	Low-Emitting Materials	Indoor Environmental Quality >**Low-Emitting Materials: Adhesives and Sealants** > Credit 4.1	To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants	• Adhesives, Sealants and Sealant Primers: VOC limits established in LEED Canada Reference Guide according to SCAQMD Rule #1168 • Aerosol Adhesives comply with Green Seal Std for Commercial Adhesives GS-36	1/110	•Manufacturer data sheet or MSDS •List of products with manufacturer name, product name, specific VOC data and allowable VOC from referenced std •Narrative if VOC budget approach is taken and justification
		Indoor Environmental Quality >**Low-Emitting Materials: Paints and Coatings** > Credit 4.2	To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants	•Architectural paints and coatings applied to interior walls and ceilings : Green Seal Std GS-11 -1993 •Anti-corrosive and anti rust paints : Green Seal Std GC-03-1997 •Clear wood finishes, floor coatings, stains, primers, and shellacs: SCAQMD Rule 1113 - 2004	1/110	•Manufacturer data sheet or MSDS •List of each indoor paint and coating product used, Manufacturer's name, product name, VOC data and allowable VOC from Std. •Narrative if VOC budget approach is taken and justification
		Indoor Environmental Quality >**Low-Emitting Materials: Flooring Systems** > Credit 4.3	To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants	Op1. Non compliant flooring -not exceed 5% of floor area + all carpet according to Carpet and Rug Institute's Green Label Plus Program + Carpet Adhesives limit 50 g/L + Hard surface flooring certified by FloorScore Std + Components of hardsurface flooring system must comply with C 4.1 + Floor finishes according to SCAQMD Rule 1113 -2004 + Tile setting adhesives and grout according to SCAQMD Rule 1168 -2005 Op2. Non compliant flooring -not exceed 5% of floor area + All flooring products installed must meet testing and product requirements of the California Department of Public Health Std Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmnetal Chambers, including 2004 Addenda	1/110	•Manufacturer data sheet or MSDS •List of carpet, carpet cushion, carpet adhesive installed and VOC content • List of hard surface flooring product, tile setting adhesive, finishes, and grout installed and VOC content

NAME & VERSION		LEED 2009				
COMPLETE NAME		LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS 2009				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
IAQ	Low-Emitting Materials	Indoor Environmental Quality >**Low-Emitting Materials: Composite Wood and Agrifibre Products** > Credit 4.4	To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants	•Composite woord and agrifibre products shall contain no addded-urea formaldehyde resins. •Laminated adhesives used to fabricate on-site and shop-applied composite wood and agrifibre assemblies must not contain added-urea formaldehyde resins. •FF&E excluded	1/110	•Manufacturer data sheet or MSDS •List of each composite wood and agrifibre product installed in the building interior
	During Construction	Indoor Environmental Quality > Credit 3.1 **Construction Indoor Air Quality Management Plan: During Construction**	To reduce IAQ problems resulting from the construction or renovation to promote the comfort and well-being of construction workers and building occupants	•IAQ plan + Implementation •Control measures SMACNA IAQ Guidelines 2007. (HVAC protection, source control, pathway interruption, housekeeping and scheduling) •Protect stored on-site and installed absorptive materials from moisture damage •If permanently installed air handlers, filtration media with a minimun efficiency reporting value (MERV) of 8 must be used. Replace filtration media prior to occupancy	1/110	•IAQ plan during demolition and construction •Photo log of plan practices followed during construction
	Before Occupancy	Indoor Environmental Quality > Credit 3.2. **Construction Indoor Air Quality Management Plan: Before Occupancy**	To reduce IAQ problems resulting from the construction or renovation to promote the comfort and well-being of construction workers and building occupants	Develop an IAQ plan and implement after all finishes have been installed and building has been completely cleaned before occupancy. Op1. 1 Flush- out : Install new filtration media and flush-out with 4,300 m3 of outdoor air/ m2 (14000 ft3/ft2) , internal temp of 16 °C and humidity no higher than 60% Op1. 2: Flush out: 1,075 m3 of outdoor air/m2 (3500 ft3/ft2) if space ocuppied with 1.54 L/s/m2 ventilation or design rate of Prereq IEQ1 until 4,300 m3 of outdoor air/ m2 delivered. Op2. Air testing: Conduct baseline IAQ testing using testing protocols consistent with US EPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air and do not exceed concentrations detailed in LEED Canada Reference Guide	1/110	•Construction IAQ plan •Op1. : Recordings of dates, occupancy, outdoor air delivery rates, internal temp and huumidity •Op2: Copy of testing report and verify that all required contaminants are accounted for and reported in the correct unit of measure

NAME & VERSION		LEED v4				
COMPLETE NAME		LEED v4 FOR BUILDING DESIGN AND CONSTRUCTION: NEW CONSTRUCTION AND MAJOR RENOVATION				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
IAQ	Low-Emitting Materials	Indoor Environmental Quality > Credit. **Low-Emitting Materials**	To reduce concentrations of chemical contaminants that can damage air quality, human health, productivity and the environment	Includes VOC emissions into indoor air and VOC content of materials, as well as the testing methods by which indoor VOC emissions are determined. Op1. Product Category Calculations for: •Interior paints and coatings applied on site •Interior adhesives and sealants applied on site (including flooring adhesive) •Flooring •Composite Wood •Ceilings, walls, thermal and acoustic insulation •Furniture *Most of them 90% by vol. for emissions and 100% VOC content Op2.Budget Calculation Method: 1. 50% to 70% 2. 70% to 90 % 3. above 90% Includes: flooring, ceilings, walls, thermal and acoustic insulation, furniture	3/110	•USGBC low -emitting materials calculator •Product information (MSDS, certifications, testing reports)
	During Construction	Indoor Environmental Quality >Credit. **Construction Indoor Air Quality Management Plan: During Construction**	To promote the well-being of construction workers and building occupants by minimizing indoor air quality problems associated with construction and renovation	•IAQ plan + Implementation •Control measures SMACNA IAQ Guidelines 2007. (HVAC protection, source control, pathway interruption, housekeeping and scheduling) •Protect stored on-site and installed absorptive materials from moisture damage •If permanently installed air handlers, filtration media with a minimun efficiency reporting value (MERV) of 8 must be used. Replace filtration media prior to occupancy •Prohibit the use of tobacco products inside the building and within 25 ft (7.5 m) from building entrance during construction	1/110	•IAQ management plan or detailed checklist, highlightinh nonsmoking policy •Narrative describing protection measures for absorbent materials •Annotated photographs or indoor air and environmental quality measures •Record of filtration media

NAME & VERSION		LEED v4				
COMPLETE NAME		LEED v4 FOR BUILDING DESIGN AND CONSTRUCTION: NEW CONSTRUCTION AND MAJOR RENOVATION				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
IAQ	Before Occupancy	Indoor Environmental Quality >Credit. **Indoor Air Quality Assessment**	To establish better quality indoor air in the building after construction and during occupancy	Op1. 1 Flush- out : Install new filtration media and flush-out with 4,300 m3 of outdoor air/ m2 (14000 ft3/ft2) , internal temp of 15 °C and humidity no higher than 80% Op1. 2: Flush out: 1,075 m3 of outdoor air/m2 (3500 ft3/ft2) at 15°c Aand humidity no higher than 80% if space ocuppied with 1.54 L/s/m2 ventilation or design rate of Prereq IEQ1 unti1 4000 ft3/ft2 Op2. Air testing: Conduct baseline IAQ testing using testing protocols consistent with ASTM standard, EPA compendium method, or ISO methods.	2/110	•Op1. Flush-out report •Op2. IAQ testing report

NAME & VERSION		REAP 3.0				
COMPLETE NAME		RESIDENTIAL ENVIRONMENTAL ASSESSMENT PROGRAM 3.0				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
IAQ	Low-Emitting Materials	Indoor Environmental Quality >IEQ Mandatory > IEQ M1- **Adhesives and Sealants**	To reduce the quantity of indoor air contaminants that are odorous or potentially irritating or harmful to the comfort and health of installers and occupants.	Specify and use adhesives, sealants and sealant primers that do not exceed the VOC limits of the Canadian Environmental Choice/EcoLogo program or do not exceed the VOC limits specified in the State of California's South Coast Air Management District Rule #1168.	Required	• Letter signed by Architect declaring that the requirements have been met. • Manufacturer's cut sheet indicating VOC content of all adhesives, sealants and sealant primers used in the project.
		Indoor Environmental Quality >IEQ Mandatory > IEQ M2- **Paints and Coatings**	To reduce the quantity of indoor air contaminants that are odorous or potentially irritating or harmful to the comfort and health of installers and occupants.	Specify and use paints and coatings that carry an EcoLogo label or those rated at a minimum GPI-1 by the Master Painter's Institute on the interior of the building.	Required	•Letter signed by Architect declaring that the requirements have been met. •Manufacturer's cut sheet indicating VOC content of all paints and coatings used on the interior of the building.
		Indoor Environmental Quality >IEQ Mandatory > IEQ M3- **Carpet**	To reduce the quantity of indoor air contaminants that are odorous or potentially irritating or harmful to the comfort and health of installers and occupants.	Specify and install carpet and carpet cushion that carry the following certifications: Carpet and Rug Institute Green Label Plus or the Ecologo.	Required	•Letter signed by Architect declaring that the requirements have been met. •Certification documentation for products selected.
		Indoor Environmental Quality >IEQ 1 - Low Emitting Materials> IEQ 1.1 **Low VOC Paints and Coatings**	To reduce the quantity of indoor air contaminants that are odorous or potentially irritating or harmful to the comfort and health of installers and occupants.	Specify and use paints and coatings rated at a minimum GPS-2 by the Master Painter's Institute on the interior of the building.	2/134	•Letter signed by Architect declaring that the requirements have been met. •Manufacturer's cut sheet indicating VOC content of all paints and coatings used on the interior o the building.

NAME & VERSION		REAP 3.0				
COMPLETE NAME		RESIDENTIAL ENVIRONMENTAL ASSESSMENT PROGRAM 3.0				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
IAQ	Low-Emitting Materials	Indoor Environmental Quality >IEQ 1 -Low Emitting Materials> IEQ 1.2 **Low Emitting Composite Wood Producs**	To reduce the quantity of indoor air contaminants that are odorous or potentially irritating or harmful to the comfort and health of installers and occupants.	Specify and install interior composite wood products, such as flooring, doors, trim, etc., that have no added urea formaldehyde. Cabinetry is excluded from this credit.	2/134	• Letter signed by Architect declaring that the requirements have been met. • Manufacturer's cut sheet indicating each interior composite wood product contains no added urea formaldehyde.
		Indoor Environmental Quality >IEQ 1 -Low Emitting Materials> IEQ 1.3 **Low Emitting Insulation**	To reduce the quantity of indoor air contaminants that are odorous or potentially irritating or harmful to the comfort and health of installers and occupants.	Specify and install formaldehyde-free insulation on the interior of the building.	2/134	• Letter signed by Architect declaring that the requirements have been met. •Manufacturer's cut sheet indicating each product selected is urea-formaldehyde free.
		Indoor Environmental Quality >IEQ 1 -Low Emitting Materials> IEQ 1.4 **Low Emitting Cabinetry**	To reduce the quantity of indoor air contaminants that are odorous or potentially irritating or harmful to the comfort and health of installers and occupants.	Specify and install interior cabinetry (doors, boxes, counters and laminating adhesives) that contain no added urea formaldehyde.	2/134	•Letter signed by Architect declaring that the requirements have been met. •Manufacturer's cut sheet indicating each product selected contains no added urea formaldehyde.
	During Construction	Construction > CON 1 - Construction Indoor Air Quality Management Plan> CON1.1 -**Indoor Air Quality Management Plan**	To prevent indoor air contamination resulting from the construction process that is odorous or potentially irritating or harmful to the comfort and health of installers and occupants.	•Indoor Air Quality (IAQ) Management Plan + Implementation for the construction and pre-occupancy phases of the building.	2/134	•Letter signed by Contractor declaring that the requirements have been met. • Copy of Indoor Air Quality Management Plan.

NAME & VERSION		REAP 3.0				
COMPLETE NAME		RESIDENTIAL ENVIRONMENTAL ASSESSMENT PROGRAM 3.0				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
IAQ	Before Occupancy	Construction > CON 1 - Construction Indoor Air Quality Management Plan> CON1.2 **Flushout/ IAQ Test**	To reduce the concentration of indoor air contaminants produced during construction prior to occupancy.	After construction ends and prior to occupancy conduct a minimum two-week continuous building flushout with new filtration media at 100% outside air or conduct a Baseline Indoor Air Quality Test.	2/134	•Letter signed by Contractor declaring that the requirements have been met, including: •Copy of specifications showing requirement for flushout or results of IAQ testing.

NAME & VERSION		Green Globes v.2				
COMPLETE NAME		GREEN GLOBES CANADA DESIGN FOR NEW CONSTRUCTION AND MAJOR RETROFITS V.2 2014				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
IAQ	Low-Emitting Materials	G. Indoor Environment > G.1 Ventilation >**Source Control and Measurement of Indoor Pollutants**	To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants	•(2.5 points) Require that adhesives and sealants (not including carpet adhesives) comply with prescribed limits of VOCs as per the Green Globes for New Construction Technical Reference Manual and/or have third-party certifications showing compliance to predetermined indoor air quality standards • (2 points) Require that carpets and under-carpet adhesives comply with the Carpet and Rug Institute's (CRI) Green Label Plus certification program • (3 points) Require that paints comply with prescribed limits of VOCs as per the Green Globes for New Construction Technical Reference Manual, and/or have third-party certifications showing compliance to predetermined indoor air quality standards	7.5/1000	•Project Specifications
	During Construction	G. Indoor Environment > G.1 Ventilation >**Source Control and Measurement of Indoor Pollutants**	To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants	Provide a construction management policy that prohibits smoking in the building and within 7.6m (25 feet) from building entrances	1/1000	•Construction management policy
		A-Project Management A.2 Environmental Management During Construction > **IAQ During Construction**	To incorporate the best practices to maintain good indoor air quality	Where parts of the building will be occupied during construction, are one or more of the following five basic strategies specified per SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction" to control dust, odors, or irritants •HVAC protection • Source Control •Pathway Interruption •Housekeeping •Scheduling *Points given for each strategy	1.5/1000	•Specification IAQ Management •Indoor Air Quality Plan •Photos

NAME & VERSION		Green Globes v.2				
COMPLETE NAME		GREEN GLOBES CANADA DESIGN FOR NEW CONSTRUCTION AND MAJOR RETROFITS V.2 2014				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
IAQ	During Construction	A-Project Management A.2 Environmental Management During Construction > **IAQ During Construction**	To incorporate the best practices to maintain good indoor air quality	•Op1.Building flushed + filters changed: The area under construction is to be flushed with 100% outdoor air for 14 consecutive days prior to occupancy and filters changed before it is occupied •Op2 .IAQ Test yiedls results: Baseline Indoor Air Quality testing gives positive results as per Environmental Protection Agency (EPA) "Testing for Indoor Air Quality", Section 01 81 09 (December 2007). Check for: • Formaldehyde • Volatile organic compounds (VOCs) • Mount and mildew • Carbon monoxide • Other compounds	2/1000	•Specification IAQ Management •Indoor Air Quality/Indoor Environmental Quality Plan •Baseline Indoor Air Quality Test
	Before Occupancy	G. Indoor Environment > G.1 Ventilation > **Air Handling Equipment**	To establish indoor air quality (IAQ) performance, contributing to the comfort and well-being of the occupants with healthy indoor air	Provide air handling equipment that has air filters with a Minimum Efficiency Reporting Value (MERV) of 13 (or equivalent) or higher, OR terminal equipment with the highest filtration level available for the specific equipment under consideration	5	Reference to specification (e.g. Sections 23 41 00 Particulate Air Filtration)
	Other	A-Project Management A.2 Environmental Management During Construction > **Mould Mitigation During Construction**	To incorporate the best practices by protecting building materials and control mount	•Protecting building materials: Building materials made of organic material or those that could absorb moisture are protected in transit and at the construction site from contact with moisture and from collecting organic matter such as leaves, soil or insects •Weather-tight envelope: The building envelope will be weather-tight and permitted to dry before installation of interior walls, wood floors, ceilings, or HVAC systems	2/1000	• Environmental Management System •Specification Construction Facilities and Temporary Controls

NAME & VERSION		LEED 2009				
COMPLETE NAME		LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS 2009				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Waste Management	N/A	Materials and Resources > Credit 2 **Construction Waste Management**	To divert construction and demolition debris from disposal in landfills and incineration facilities. Redirect recycable recovered resources back to the manufacturing process and redirect reusable materials to appropiate sites	•CWM Plan + Implementation • Op1. Divert 50% (weight or volume) •Op 2. Divert 75% (weight or volume) *Exemplary Performance: Divert 95% or more (weight or volume)	2/110	•Spreadsheet Tracking (summary log of waste generated) •List of waste management firms or receivers with supporting letters on the end use of materials

NAME & VERSION		LEED v4				
COMPLETE NAME		LEED v4 FOR BUILDING DESIGN AND CONSTRUCTION: NEW CONSTRUCTION AND MAJOR RENOVATION				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Waste Management	N/A	Materials and Resources> Prereq. **Construction and Demolition Waste Management Planning**	To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing and recycling materials	•CWM plan •5 material streams and no min. %	Required	• CWM plan • Total construction waste
		Materials and Resources> Credit. **Construction and Demolition Waste Management**	To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing and recycling materials	•CWM Implementation •Op 1. 1. Divert 50% (weight or volume) and 3 Mat. Streams •Op 1.2. Divert 75% (weight or volume) and 4 Mat. Streams •Op 2.1. Reduction of Total Waste Material (no + than 2.5 lb/sqft of building's floor area)	2/110	*Option 1:* •CWM calculator, tracking total and diverted waste amounts and material streams •Documentation of recycling rates for commingled facilities (if applicable) • Justification narrative for use of waste-to-energy strategy (if applicable) • Documentation of waste-to-energy facilities adhering to relevant EN stds (if applicable) *Option 2:* •Total waste per area

NAME & VERSION		REAP 3.0				
COMPLETE NAME		**RESIDENTIAL ENVIRONMENTAL ASSESSMENT PROGRAM 3.0**				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Waste Management	N/A	Construction > CON Mandatory > M6 -**Waste Management Plan**	To divert constructin and demolition from landfill disposal, to redirect recyclable material back to the manufacturing process, and to reclaim reusable construction materials for future use.	•CWM Plan + Implementation •Divert 75% (by weight)	Required	•Letter signed by Contractor declaring that the requirements have been met • Copy of CWM plan • Hauling summary demonstrating 75% diversion
NAME & VERSION		**Green Globes v.2**				
COMPLETE NAME		**GREEN GLOBES CANADA DESIGN FOR NEW CONSTRUCTION AND MAJOR RETROFITS V.2 2014**				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Waste Management	N/A	Materials and Resources > Waste > **Construction Waste**	To divert construction and demolition debris from disposal in landfill and incineration facilities; redirect recycable recovered resources back to the manufacturing process and resuable materials to appropiate sites; and facilitate the reduction of waste generated by building occupants that is disposed of in landfillls.	•CWM Plan + Implementation •Divert 50% (weight) •Reuse existing on-site materials for site development or landscaping	6/1000	•Post Construction Questionnaire signed by Contractor or builder •Specific documentation requirements not mentioned: • Provide reference to Construction Specifications for waste management and indication of waste diverstion target and it will be verified (waste should be tracked) • Provide reference to Construction Specifications for site development (Verifier may request landscaping and site development plans)

NAME & VERSION		LEED 2009				
COMPLETE NAME		LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS 2009				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Commissioning	N/A	Energy & Atmosphere > Prereq 1. **Fundamental Commissioning of Building Energy Systems**	Verify project's energy related systems are installed, calibrated and perform according to the owner's project requirements, basis of design, and construction documents	*CxA designation authority *Documented OPRs *Commissioning plan + implementation *Commissioning report *Commissioning systems: • HVAC & R systems • Lighting and daylighting controls • Domestic hot water systems • Renewable energy sytems	Required	•Commissiong plan •Systems list •CXA documented experience and qualifications •Copies of OPRs, basis of design, commissioning specs, commissioning report and systems manual
		Energy & Atmosphere > Credit 3. **Enhanced Commissioning**	Begin commissioning process early during design process and execute additional activities after systems performance verification is complete	*Contract in place to implement additional activities Exemplary Performance: Envelope commissioning	2/110	•Commissiong plan •Systems list •CXA documented experience and qualifications •Copy of commissioning authority's design review •Copies of OPRs, basis of design, commissioning specs, commissioning report and systems manual

NAME & VERSION		LEED v4				
COMPLETE NAME		LEED v4 FOR BUILDING DESIGN AND CONSTRUCTION: NEW CONSTRUCTION AND MAJOR RENOVATION				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Commissioning	N/A	Energy & Atmosphere > Prereq. **Fundamental Commissioning of Building Energy Systems**	To support the design, construction and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmnetal quality and durability.	*Commissioning Process Scope: ASHRAE Guidelines + Develop OPR, BOD + commissioning plan + checklists and procedures *CxA autthority designation *Current facilities req and operations and maintenance plan *Commissioning systems: • HVAC & R systems •Pumbling, including domestic hot water systems, pumps and controls • Electrical, including service, distribution, lighting and controls • Renewable energy sytems	Required	•Commissiong plan •Systems list •CXA documented experience and qualifications •Confirmation of OPR and BOD contents •Verification of CxA activities and reviews •Documentation of testing and verification and Cx report •CFR, O&M plan
		Energy & Atmosphere > Credit. **Enhanced Commissioning**	To further support the design, construction and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmnetal quality and durability	*Additional requirements to CxA experience and qualifications + Op1. 1 Enhanced Systems Comissioning Op1.2 Enhanced and Monitoring Based Comissioning: Op1.1 + Monitioring based procedures of energy and water systems Op2: Envelope Commissioning	2/110	•List of all tasks completed as part of Cx activities •Training outline and participation list •Confirmation of systems manual delivery •Cx plan •Op1.2 Inclusion of monitoring and tracking in Cx Plan Op1. Verification of additional reviews Op2. Inclusion of envelope in Cx plan

NAME & VERSION		REAP 3.0				
COMPLETE NAME		RESIDENTIAL ENVIRONMENTAL ASSESSMENT PROGRAM 3.0				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Commissioning	N/A	Energy and Atmosphere > EA 3- Commissioning > EA 3.1 - **Commissioning**	To ensure that best practices in design are combined with best practices in construction.	•Contract a third party CxA •Commissioning plan + Implementation for all major building energy systems and verify they are installed, calibrated and perform according to design intent.	4/134	• Commissioning Plan • Final Commissioning Report, detailing the final approvals and the project commissioning process.
NAME & VERSION		Green Globes v.2				
COMPLETE NAME		GREEN GLOBES CANADA DESIGN FOR NEW CONSTRUCTION AND MAJOR RETROFITS V.2 2014				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Commissioning	N/A	A-Project Management>A.3 Commissioning > **Whole Building Comissioning**	To design, construct and calibrate building systems so they operate as intended	•CxA authority •Require that whole building commissioning be conducted and produce a Commissioning Plan in accordance with ASHRAE/NIBS Guideline 0-05 "The Commissioning Process: Article 5, 6 and 7" Including: •HVAC &R systems and controls •Building envelope •Structural systems •Fire protection system •Plumbing system •Electrical system •Lighting system and controls •Building automation system •Elevating and conveying systems •Communication systems *Points given for each system commissioned	17.5/1000	• •Commissioning Plan •Commissioning Final Report •Issue Logs

NAME & VERSION		REAP 3.0				
COMPLETE NAME		RESIDENTIAL ENVIRONMENTAL ASSESSMENT PROGRAM 3.0				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Additional Practices	N/A	Construction > CON Mandatory > M3 - **Truck Management Plan**	To manage truck traffic through residential neighbourhoods and control the frequency with which designated routes are used to reach the project site.	•Truck management plan + Implementation •Conforms to the UBC Strategic Transportation Plan and the Neighbourhood Plan Development Guidelines.	Required	• Letter signed by Developer declaring that the requirements have been met. • Copy of truck management plan.
		Construction > CON Mandatory > M4 - **Wheel Wash**	To reduce the amount of soil and other solids leaving the site during excavation and entering into the storm water system.	Provide a wheel wash for vehicles leaving the site or a street cleaning program and catch basin protection.	Required	•Letter signed by Developer declaring that the requirements have been met.

NAME & VERSION		Green Globes v.2				
COMPLETE NAME		GREEN GLOBES CANADA DESIGN FOR NEW CONSTRUCTION AND MAJOR RETROFITS V.2 2014				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Additional Practices	N/A	A-Project Management A.2 Environmental Management During Construction > **Clean Diesel Practices**	To incorporate the best practices and principles of an Environmental Management System (EMS) by implementing one or more of the following "clean diesel" strategies	•Vehicle "idling-reduction" directive (no more than 3 min) • Use of clean fuels (ex. ltra-low sulfur diesel (ULSD) fuel, biodiesel blends, liquid petroleum gas (LPG), compressed natural gas (CNG), and liquefied natural gas (LNG). •Engine upgrades that reduce emissions • Engine maintenance records	2/1000	• Environmental Regulatory Requirements •EMS (Site and Work Instructions)

NAME & VERSION		LEED 2009				
COMPLETE NAME		LEED CANADA FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS 2009				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Management	Green Building Specialist	Innovation in Design > Credit 2. **LEED Accredited Professional**	To support and encourage the design integration required by LEED to streamline the application and certification process	At least 1 principal participant of the project team must be LEED AP	1/110	•Copy of certificate
NAME & VERSION		**LEED v4**				
COMPLETE NAME		**LEED v4 FOR BUILDING DESIGN AND CONSTRUCTION: NEW CONSTRUCTION AND MAJOR RENOVATION**				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Management	Green Building Specialist	Innovation in Design > Credit. **LEED Accredited Professional**	To support and encourage the design integration required by LEED to streamline the application and certification process	At least 1 principal participant of the project team must be LEED AP	1/110	•Copy of certificate

NAME & VERSION		REAP 3.0				
COMPLETE NAME		RESIDENTIAL ENVIRONMENTAL ASSESSMENT PROGRAM 3.0				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Management	Green Building Specialist	Innovation and Design Process (ID) >ID 2 - Integrative and Universal Design > ID 2.1 **Green Building Specialist**	To support, encourage, and streamline the process of implementing green strategies into building projects.	Engage an expert in green buildings and sustainable construction practices to provide advice on effective green building strategies to the design team.	1/134	• Letter signed by Developer identifying an expert in green buildings and construction practices has been engaged for the project. • Explanation of expert's combination of experience and education that demonstrate ability to provide advice.
NAME & VERSION		**Green Globes v.2**				
COMPLETE NAME		**GREEN GLOBES CANADA DESIGN FOR NEW CONSTRUCTION AND MAJOR RETROFITS V.2 2014**				
CATEGORY	**SUBCATEGORY**	**Specific Credit**	**Intent**	**Objectives/ Requirements**	**Max. Value**	**Evaluation / Documentation**
Management	EMS	A-Project Management A.2 Environmental Management During Construction > **Environmental Management System**	To incorporate the best practices and principles of an Environmental Management System (EMS)	EMS with: • Environmental Policy • Regulatory Compliance and Training • Environmental Risk Assessment •Environmental Risk Management Strategies •Environmental Management Roles, Responsabilities and Reporting Structutre •Site and Work Instructions for site personnel •Environmental Inspection Checklists • Records of Compliance *Points are given for each point included in the EMS	4/1000	•EMS

Appendix C:LEED v4 Construction and Design Credits

L E E D v4 - New Construction			D/C
Credit	Integrative Process	1	D
Location and Transportation			
Credit	LEED for Neighborhood Development Location	16	D
Credit	Sensitive Land Protection	1	D
Credit	High Priority Site	2	D
Credit	Surrounding Density and Diverse Uses	5	D
Credit	Access to Quality Transit	5	D
Credit	Bicycle Facilities	1	D
Credit	Reduced Parking Footprint	1	D
Credit	Green Vehicles	1	D
Sustainable Sites			
Prereq	Construction Activity Pollution Prevention	Required	C
Credit	Site Assessment	1	D
Credit	Site Development - Protect or Restore Habitat	2	D
Credit	Open Space	1	D
Credit	Rainwater Management	3	D
Credit	Heat Island Reduction	2	D
Credit	Light Pollution Reduction	1	D
Water Efficiency			
Prereq	Outdoor Water Use Reduction	Required	D
Prereq	Indoor Water Use Reduction	Required	D
Prereq	Building-Level Water Metering	Required	D
Credit	Outdoor Water Use Reduction	2	D
Credit	Indoor Water Use Reduction	6	D
Credit	Cooling Tower Water Use	2	D
Credit	Water Metering	1	D
Energy and Atmosphere			
Prereq	Fundamental Commissioning and Verification	Required	C
Prereq	Minimum Energy Performance	Required	D
Prereq	Building-Level Energy Metering	Required	D
Prereq	Fundamental Refrigerant Management	Required	D
Credit	Enhanced Commissioning	6	C
Credit	Optimize Energy Performance	18	D
Credit	Advanced Energy Metering	1	D
Credit	Demand Response	2	C
Credit	Renewable Energy Production	3	D
Credit	Enhanced Refrigerant Management	1	D
Credit	Green Power and Carbon Offsets	2	C

L E E D v4 - New Construction			D/C
Materials and Resources			
Prereq	Storage and Collection of Recyclables	Required	D
Prereq	Construction and Demolition Waste Management Planning	Required	C
Credit	Building Life-Cycle Impact Reduction	5	D
Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2	C
Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2	C
Credit	Building Product Disclosure and Optimization - Material Ingredients	2	C
Credit	Construction and Demolition Waste Management	2	C
Indoor Environmental Quality			
Prereq	Minimum Indoor Air Quality Performance	Required	D
Prereq	Environmental Tobacco Smoke Control	Required	D
Credit	Enhanced Indoor Air Quality Strategies	2	D
Credit	Low-Emitting Materials	3	C
Credit	Construction Indoor Air Quality Management Plan	1	C
Credit	Indoor Air Quality Assessment	2	C
Credit	Thermal Comfort	1	D
Credit	Interior Lighting	2	D
Credit	Daylight	3	D
Credit	Quality Views	1	D
Credit	Acoustic Performance	1	D
Innovation			
Credit	Innovation	5	D/C
Credit	LEED Accredited Professional	1	D/C
Regional Priority			
Credit	Regional Priority: Specific Credit	1	D/C
Credit	Regional Priority: Specific Credit	1	D/C
Credit	Regional Priority: Specific Credit	1	D/C
Credit	Regional Priority: Specific Credit	1	D/C

Appendix D:LEED 2009 Impact Values in Project Phases

LEED 2009 Impact Values in Project Phases						
				P	D	C
LEED 2009			D/C	3	4	3
SS		**26 Points**		**3**	**4**	**2**
Prereq 1	Construction Activity Pollution Prevention	Required	C	1	3	4
Credit 1	Site Selection	1	D	4	4	1
Credit 2	Development Density and Community Connectivity	3, 5	D	4	4	1
Credit 3	Brownfield Redevelopment	1	D	4	3	3
Credit 4.1	Alternative Transportation: Public Transportation Access	3, 6	D	3	4	1
Credit 4.2	Alternative Transportation: Bicycle Storage & Changing Rooms	1	D	3	4	1
Credit 4.3	Alternative Transportation: Low-Emitting & Fuel-Efficient Vehicles	3	D	4	4	1
Credit 4.4	Alternative Transportation: Parking Capacity	2	D	3	4	1
Credit 5.1	Site Development: Protect and Restore habitat	1	C	3	4	4
Credit 5.2	Site Development: Maximize Open Space	1	D	3	4	1
Credit 6.1	Stormwater Design: Quantity Control	1	D	3	4	2
Credit 6.2	Stormwater Design: Quality Control	1	D	3	4	2
Credit 7.1	Heat Island Effect: Non-Roof	1	C	4	4	2
Credit 7.2	Heat Island Effect: Roof	1	D	4	4	2
Credit 8	Light Pollution Reduction	1	D	3	4	3
WE		**10 Points**		**4**	**4**	**2**
Prereq 1	Water Use Reduction	Required	D	3	4	3
Credit 1	Water Efficient Landscaping	2, 4	D	4	4	1
Credit 2	Innovative Wastewater Technologies	2	D	4	4	2
Credit 3	Water Use Reduction	2 - 4	D	3	4	2
EA		**35 Points**		**3**	**4**	**2**
Prereq 1	Fundamental Commissioning of Building Energy Systems	Required	C	3	3	3
Prereq 2	Minimum Energy Performance	Required	D	2	4	1
Prereq 3	Fundamental Refrigerant Management	Required	D	4	4	1
Credit 1	Optimize Energy Performance	1 - 19	D	2	4	1
Credit 2	On-Site Renewable Energy	1 - 7	D	3	4	3
Credit 3	Enhanced Commissioning	2	C	3	4	3
Credit 4	Enhanced Refrigerant Management	2	D	1	4	1
Credit 5	Measurement and Verification	3	C	3	3	3
Credit 6	Green Power	2	C	2	4	1

LEED 2009 Impact Values in Project Phases						
				P	D	C
LEED 2009			**D/C**	**3**	**4**	**3**
MR		**14 Points**		**2**	**4**	**3**
Prereq 1	Storage and Collection of Recyclables	Required	D	2	4	1
Credit 1.1	Building Reuse: Maintain Existing Walls, Floors, and Roof	1 - 3	C	4	4	3
Credit 1.2	Building Reuse: Maintain Interior Non-Structural Elements	1	C	3	4	3
Credit 2	Construction Waste Management	1 - 2	C	2	3	4
Credit 3	Materials Reuse	1 - 2	C	3	4	4
Credit 4	Recycled Content	1 - 2	C	1	4	4
Credit 5	Regional Materials	1 - 2	C	1	4	4
Credit 6	Rapidly Renewable Materials	1	C	1	4	4
Credit 7	Certified Wood	1	C	3	4	4
IEQ		**15 Points**		**1**	**4**	**2**
Prereq 1	Minimum Indoor Air Quality Performance	Required	D	2	4	1
Prereq 2	Environmental Tobacco Smoke (ETS) Control	Required	D	2	4	2
Credit 1	Outdoor Air Delivery Monitoring	1	D	2	4	2
Credit 2	Increased Ventilation	1	D	2	4	1
Credit 3.1	Construction IAQ Management Plan: During Construction	1	C	1	3	4
Credit 3.2	Construction IAQ Management Plan: Before Occupancy	1	C	1	3	4
Credit 4.1	Low-Emitting Materials: Adhesives and Sealants	1	C	1	3	4
Credit 4.2	Low-Emitting Materials: Paints and Coatings	1	C	1	3	4
Credit 4.3	Low-Emitting Materials: Flooring Systems	1	C	1	3	4
Credit 4.4	Low-Emitting Materials: Composite Wood and Agrifibre Products	1	C	1	3	4
Credit 5	Indoor Chemical and Pollutant Source Control	1	D	1	4	1
Credit 6.1	Controllability of System: Lighting	1	D	1	4	2
Credit 6.2	Controllability of System: Thermal Comfort	1	D	1	4	2
Credit 7.1	Thermal Comfort: Design	1	D	3	4	1
Credit 7.2	Thermal Comfort: Verification	1	D	1	4	1
Credit 8.1	Daylight and Views: Daylight	1	D	3	4	2
Credit 8.2	Daylight and Views: Views	1	D	1	4	1

**Impacts based on activities described (Yellamraju,2011)*