GREEN BUILDING IN CANADA

Assessing the Market Impacts & Opportunities

CANADA GREEN BUILDING COUNCIL • CONSEIL DU BÂTIMENT DURABLE DU CANADA

DelphiGroup
Environmental Strategies. Business Solutions.

Toronto and Region Conservation for The Living City

Canada Green Building Council
Every Building Greener

Conseil du bâtiment durable du Canada
Verdir tous les bâtiments

Canada Green Building Council
202-47 Clarence Street
Ottawa, ON K1N 9K1
Tel.: +1 (613) 241-1184
Fax: +1 (613) 241-4782
Toll-free: +1 (866) 941-1184
www.cagbc.org

Direct Contact:
Sarah Burns
+1 (613) 288-8097
sburns@cagbc.org

DelphiGroup
Environmental Strategies. Business Solutions.

Delphi Group
428 Gilmour Street
Ottawa, ON K2P 0R8
Canada
Tel.: +1 (613) 562-2005
Fax: +1 (613) 562-2008
www.delphi.ca

Direct Contact:
Paul Shorthouse
+1 (604) 338-9941
pshorthouse@delphi.ca

Project Sponsor

The Canada Green Building Council (CaGBC) is a not-for-profit, national organization that has been working since 2002 to advance green building and sustainable community development practices in Canada. Through its leading programs that include the Leadership in Energy and Environmental Design (LEED®) and in collaboration for its membership of over 1,200 industry organizations involved in designing, building, and operating buildings, homes, and communities, CaGBC has made excellent inroads toward achieving its mission of reducing the environmental impact of the built environment in Canada

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Toronto and Region Conservation (TRCA) works with its partners to ensure The Living City is built on a natural foundation of healthy rivers and shorelines, greenspace and biodiversity, sustainable communities, and green infrastructure projects.

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About the Researcher

As a pioneer in sustainability, environmental strategies, and business solutions, the Delphi Group has more than 25 years of experience helping some of Canada's best-known organizations improve their sustainability – as well as the local and global communities in which they operate. The Delphi Group brings a unique combination of policy expertise, strategic thinking, and technical know-how to every project, which has allowed it to work with a wide range of organizations, including 32 of the top 100 companies. The Delphi Group also works with some of Canada's largest and leading real estate and construction companies as clients.

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US GREEN BUILDING COUNCIL

WINDMILL DEVELOPMENT GROUP

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PREFACE

This project assesses the market and employment impacts, as well as the core strengths and capabilities, of Canada's green building industry. Based on considerable secondary research and literature review, 35 industry stakeholder interviews, and a detailed, data-driven economic impact assessment, this project:

- Developed an overview of the current status of activities in Canada's green building sector, including an update on trends impacting the industry and a list of policy, program, and financial drivers;
- Quantified the size and scope of the green building sector in Canada (for both LEED® activities and the broader industry), including an estimation of the latest economic activity (in terms of GDP, employment, and market penetration); and
- Identified national green building industry capabilities, including the range of products and services, innovation, and core competencies of industry leaders.

This report is designed to:

- Capture the exponential growth of the industry and the measurable impact that the sector is having on the economic, social, and environmental fabric of Canada;
- Inform policy-makers by demonstrating the impact of the sector on jobs and regional / community benefits;
- Provide an overview of the evolution of the sector, current trends and market opportunities, costs, risks, and barriers to growth;
- Showcase the strengths and capabilities of Canada's green building industry in line with potential export opportunities and global markets; and
- Provide an overview of the current state of innovation and the potential for new and emerging technologies, materials, and practices / processes in line with regional, national, and global trends.

While covering a broader scope and range of activities than those under the direct mandate of the Canada Green Building Council (CaGBC), the research and information contained within this report is intended to support the accelerated market transformation to high-performing, healthy green buildings, homes, and communities across Canada.

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EXECUTIVE SUMMARY

Green building is recognized globally as a method and practice for addressing climate change, minimizing energy and resource demands, and for building more resilient and healthy communities. Green building is driving innovation in service delivery and processes, product and technology design and manufacturing, and material and resource use.

This report provides an overview of the economic contributions of the green building sector in Canada. It profiles some of the leading trends and industry drivers, and showcases the impressive market transformation that is underway across the country. While research to date has largely focused on the environmental benefits of green buildings, less analysis has been dedicated to the sector's contribution to the broader Canadian economy. This study quantifies the economic value creation from green building in Canada, as well as the economic and market impact of the Canada Green Building Council's Leadership in Energy and Environmental Design (LEED®) program in terms of gross domestic product (GDP), jobs, and gross output.

Figure ES-1: National Green Building Economic Impact

NATIONAL GREEN BUILDING ECONOMIC IMPACT

In 2014, Canada's green building industry:

GENERATED

$23.45

BILLION IN GDP

SUPPORTED

297,890

DIRECT JOBS

The portfolio of LEED® buildings in Canada certified between 2005 – 2015 will:

GENERATE

$62.3

BILLION IN TOTAL GDP

over their lifetime
(direct, indirect, and induced)

CREATE

701,700

JOBS

over their lifetime
(direct, indirect, and induced)

PROVIDE

$128.0

BILLION IN GROSS OUTPUT

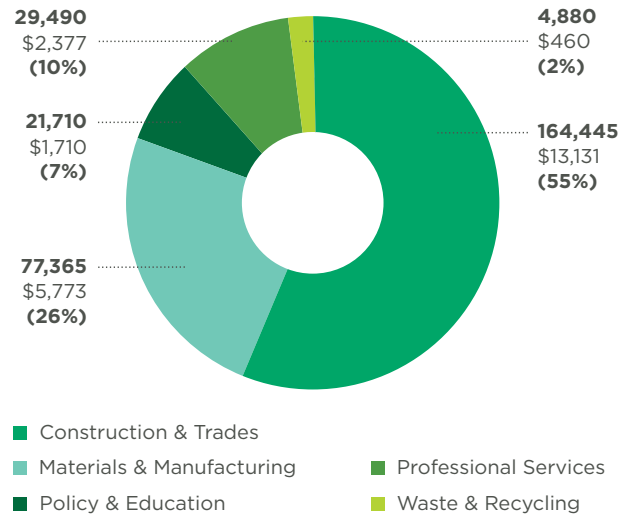
(direct, indirect, and induced)

Economic Impact of Canada's Green Building Industry

Green building growth in the commercial sector has been driven by building owners, institutional investors, and corporate sustainability policies; and by policy and building code / bylaw requirements in the institutional sector. Voluntary adoption played a major role in market uptake. This adoption was driven by a business case that demonstrated positive return on investment (ROI) over the life of green buildings. Findings from this study show that through direct and indirect benefits, green buildings are having a positive impact on new investments, job creation, and revenues for companies across the extensive value chain and full lifecycle of buildings.

In 2014, the green building industry was estimated to have employed 297,890 direct full-time workers in Canada and generated approximately $23.45 billion in GDP (see figure ES-1). For comparison, this represents more jobs than Canada's oil and gas extraction, mining, and forestry industries combined, which collectively employed approximately 270,450 workers in 2014.[1] Ontario and British Columbia generated more green building jobs as a percent of their total labour force in 2014 – equal to 2.1 percent and 1.6 percent respectively, due in part to greater market leadership, progressive building code requirements and green building policies.

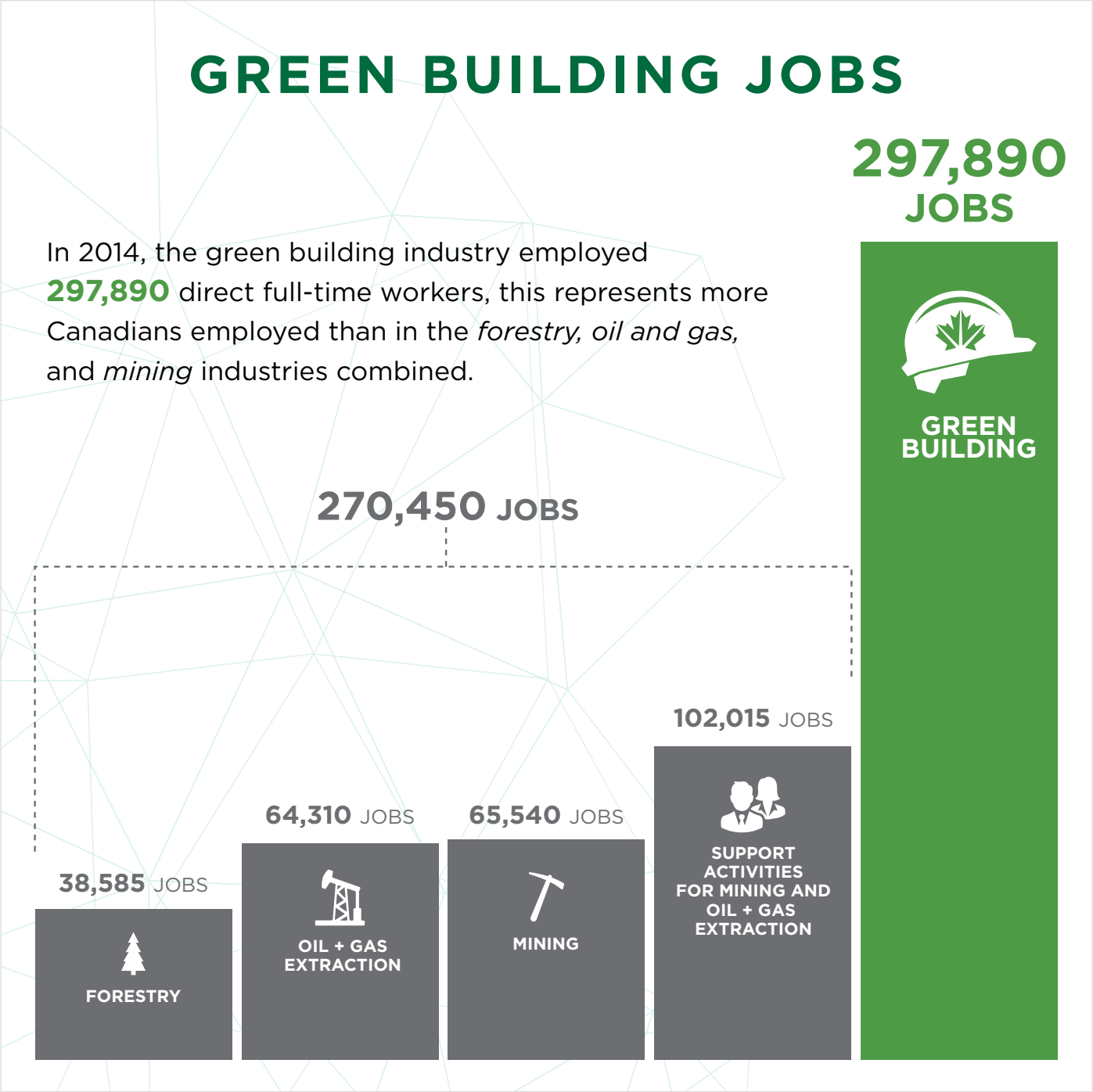
Figure ES-2: Green building jobs and GDP (millions of chained 2007$) by sector in Canada, 2014



Companies active in the Construction and Trades segment accounted for the largest percentage (55 percent) of green building employment and GDP in Canada, equal to approximately 164,445 jobs (approximately 13 percent of Canada's total construction work force) and $13.13 billion dollars in GDP (see figure ES-2). Jobs in this segment include contractors and trades engaged in the construction of residential and non-residential buildings certified under a recognized green building standard / certification or an energy efficient residential (Part 9) building based on building energy code requirements (equal to EnerGuide 80).

[1] Employment estimates for oil and gas, mining, and forestry industries come from Statistics Canada's Employment and Earnings Survey for 2014 (CANSIM table 281-0024). The estimate does not include jobs in processing or related value-add product sectors.

Figure ES-3: Green Building Jobs



Green Building Industry Growth

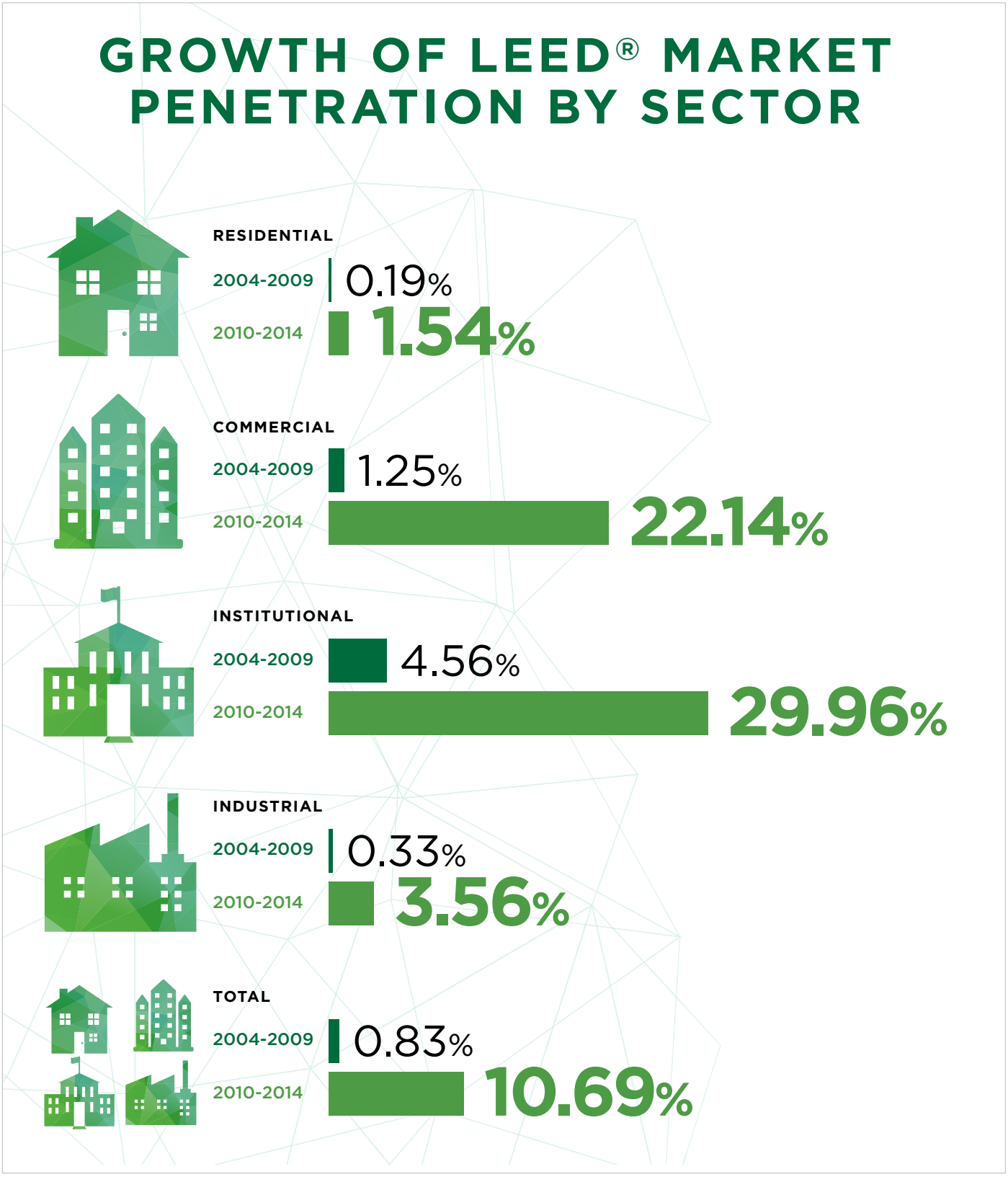
Green buildings are closely tied to standardized metrics defined by leading rating systems and certification programs such as LEED®, which has experienced rapid growth in Canada over the last decade. For example, from 31 certified buildings in 2005 to a cumulative total of 2,576 in 2015, LEED has seen enormous uptake across the country.

Furthermore, LEED certified building market penetration rates (as a percent of gross new construction floor space) have been growing over the last decade, reaching 22 percent penetration of all new commercial buildings and approximately 30 percent penetration of all new institutional buildings constructed in Canada in 2014 (see figure ES-4).

Across all asset classes, the market penetration of LEED certified buildings in Canada has increased from 0.8 percent for the period 2004 – 2009, to a present rate of 10.7 percent for all new construction floor space in 2014.

Following the introduction and successful market adoption of LEED, the first comprehensive green building rating system in 2002, other green building rating systems and third-party certification programs have been introduced in Canada for both the residential and non-residential segments. These include BOMA BESt, ENERGY STAR, Built Green, and Passive House. In Ontario, approximately 32 percent of all eligible Part 9 new homes were certified ENERGY STAR in 2014 with more than 62,000 homes having been labelled and over 80,000 enrolled.

Figure ES-4: Growth of LEED® Market Penetration by Sector



Economic Impact of LEED Building in Canada

Applying a lifecycle cost analysis (LCCA) methodology to LEED certified building projects in Canada, the overall economic contribution of the program since its inception was estimated in terms of jobs and GDP. Net lifecycle savings for LEED certified buildings were estimated based on a detailed review of 52 LEED project case studies in Canada. These case studies were selected in order to provide a representative sample of the portfolio of LEED certified buildings in Canada across all building types, certification levels, and provinces / territories.

In terms of the overall economic impact, it is estimated that LEED certified projects to date will generate approximately $59.1 billion in direct dollar gross output[2], $25.44 billion in GDP (in constant 2007 dollars[3]), and will create 329,912 direct jobs over the economic life time of these buildings, assumed to be 33 years (see table ES-1). When indirect and induced contributions are included, the overall economic impact from LEED projects to date over their lifetime will include $128.0 billion in gross output, $62.3 billion in total GDP, and will create 701,680 jobs.[4 5]

Table ES-1: Direct economic impacts generated from the LEED projects in Canada that have been certified in 2015 over their economic lifetime

	Residential	Commercial	Institutional	Industrial	Total
Direct Gross Output ($000, 2007$)	$3,732,418	$31,751,152	$22,575,694	$1,099,658	$59,158,923
Direct GDP ($000, 2007$)	$1,542,104	$13,689,746	$9,733,678	$474,126	$25,439,654
Direct Labour Income ($000, 2007$)	$1,198,371	$11,096,760	$7,890,015	$384,321	$20,569,466
Direct Jobs	19,366	177,897	126,488	6,161	329,912

[2] Gross output is a measure of an industry's sales, which can include sales to final users in the economy (GDP) and sales to other industries (intermediate inputs). Gross output can also be measured as the sum of an industry's value added and intermediate inputs.

[3] Construction costs were expressed in constant dollars in order to remove impacts from inflation. The constant dollar value (2007) is based on residential and non-residential construction deflators published in Statistics Canada Table 380-0102 Gross Domestic Product indexes, annual (2007=100).

[4] Direct impacts are related to the specific industry (in this case, green building), while indirect impacts relate to activities that support or supply the industry. Induced impacts are those that are a result of direct / indirect spending in the local economy outside of the green building industry (i.e. the economic as a whole). In general terms, industries with higher multipliers are more desirable.

[5] Note these are gross jobs; not net jobs. Net jobs reflect incremental jobs after shifts in the economy such as people moving from other construction activities are netted out.

Green Building Trends & Market Drivers in Canada

The green building movement in Canada over the last two decades has seen a significant shift from being primarily driven by market and policy leaders to greater synergies now emerging between regulation and industry practices. Leading trends and key industry drivers at the forefront of the green building market transformation in Canada are outlined in the table below.

Key Trends & Industry Drivers	Description
Growth of Reporting, Benchmarking & Energy Labelling	Real estate owners and property managers are increasingly taking a portfolio view to their building assets from a risk management perspective. They also compare the performance of buildings next to one another and to those of their competitors in order to attract and retain tenants and investors. As these practices become more standard across Canada, they will allow for better comparisons and a deeper understanding of building performance. This will allow a focus on designing more effective programs and related efforts to reduce environmental impacts and save on operational costs.
Growing Focus on Existing Buildings & Retro-Commissioning	Existing buildings comprise the majority of building stock and present significant opportunities for improvements. Recommissioning and retro-commissioning existing buildings will reduce energy consumption and GHG emissions, creating healthier indoor building environments, and attracting and retaining tenants.
Shift toward Community-focused Design Supporting Health & Wellbeing	Municipal planning is shifting toward urbanization, densification, better land-use policy, and a desire for more walkable, livable cities. This is causing a shift in design thinking from the individual building scale to more community-focused design. The benefits of community development are also becoming increasingly important to investors.
Movement toward Net Zero Energy Buildings	In designing to reduce energy usage and GHG emissions, buildings are dramatically changing in shape and form. This is underpinned by a greater focus on passive design features and building envelopes. Improvements in performance and decreasing costs for solar photovoltaics (PV) technology in the last several years has taken net zero that much closer to reality. The intersections evolving between solar PV, home energy storage (batteries), and plug-in electric vehicles are of interest to consumers, who are increasingly able to rely on low-carbon energy on the path to net zero.
Focus on Lowering Construction Costs & Improving Affordability	One of the biggest challenges and concerns within the building industry is the growing costs of construction. In addition to the rising costs of land, materials, and labour, increasing fees and taxes are resulting in a need to innovate and streamline processes. In collaboration with government and other stakeholders, industry has been working to improve energy performance, reduce construction and operational costs, and make homes and buildings more affordable for Canadians. Processes and technologies that are likely to be used more prominently in future include integrated design process (IDP), integrated project delivery (IPD), building information modelling (BIM), pre-fabrication, 3-D printing, and Lean Construction.

Canada's Green Building Strengths & Core Competencies

With a background in cold-climate science and construction expertise, Canada's green building industry has developed strengths in areas that include related engineering and design, quality home construction, and a range of energy-efficient / sustainable technologies and materials.

Canada is recognized for its design and related professional services (engineering, architecture, planning, and community infrastructure). Expertise in developing world-class building projects, as well as archetype buildings, has led to a better understanding of holistic, systems-based design in order to optimize performance. Leading Canadian firms have developed strengths in air-tightness, building envelope design, and building science. At the same time, while there are many small and mid-sized firms responsible for some of the most leading edge designs at a provincial level, there are still very few companies that operate at a national or global scale.

Historically, Canada has been an exporter of commodity-based natural resources (e.g. convention lumber products) rather than value-added products and technologies. Over the last decade, there has been a holistic and strategic approach from all levels of government and industry to enable Canadian companies to become leaders in engineered wood products (e.g. cross-laminated timber) and related building design / engineering. Canada also has growing expertise in building pre-fabrication and related components and processes.

Many Canadian companies are now developing advanced green building materials and energy efficient technologies that are being exported internationally. These include heating technologies (such as heat exchangers and heat / energy recovery ventilation systems, heat pumps, high-efficiency boilers, and drain water heat recovery), renewable energy systems (including geothermal and solar), energy management and building controls, and high-performance windows and building envelope technologies.

Global Competitiveness of Canada's Green Building Industry

On the strength of certain niche technologies, innovative standards, and leading-edge research, Canada has seen international success in the green building space in the face of stiff competition from Europe, Asia, and the US.

Low domestic market adoption within certain building asset classes and in some provinces is still an issue, in part because the policies and regulations in those provinces do not adequately support green building. The diversity of different policies across the country means that while some provinces are adopting green building faster than others, there is a disincentive for firms to expand outside their local area. As such, few Canadian green building firms compete internationally. In addition, the lack of federal supporting policies and programs (including investment in R&D) imposes barriers to domestic growth. Nominal investment in R&D and innovative technology and product development has resulted in Canada ranking only slightly above the global average in terms of its green building industry's competitive positioning.

While expertise in energy efficiency practices and technologies have developed in Canada, the relatively inexpensive cost for energy and electricity has somewhat lowered the impetus for action and consumer demand. This is unlike Europe and other jurisdictions where higher energy prices are driving market demand and industry development. As a result, Canadian companies tend not to export their energy-saving technologies and green building services to market leading countries in Europe but focus on markets where they have a competitive advantage. These include the United States, certain countries in Asia, and Latin America.

Accelerating Industry Growth & Maximizing the Economic Opportunities

In order to accelerate the growth of Canada's green building industry and maximize the economic and employment benefits, there is a need to address existing challenges and capitalize on the opportunity areas outlined below.

Opportunity Areas	Summary
Investing in Research & Innovation	The construction sector in Canada ranks at the bottom of all industries in terms of its expenditures in research and development (R&D). Consequently, due to a lack of innovation, productivity levels have suffered over time. Wood-related technologies (e.g. windows, insulation) and some value-added construction products show particular promise. On the materials side, circular economy, cradle-to-cradle, and biomimicry concepts indicate a potential for being integrated into practice in order to optimize resources and minimize waste. Greater federal and provincial government support for green building on the research and innovation agenda would help, with specific focus on both economic and export development.
Addressing the Gap between Design & Performance	The building performance gap is partly a design and modeling issue, as well as an operational issue as disconnects often exist between the two groups. The gap also presents a growing problem for builders with contracts that increasingly include penalties for not meeting performance requirements.[6] The Integrated Design Process (IDP) is helping here to some degree but there is room for improvement. In order to go further, design will have to fundamentally focus on the building envelope and the entire building-as-a-system approach. Greater standardization of energy modelling in Canada, as well as investment in supportive training for modelers would stimulate a focus on the building envelope and building-as-a-system approach, allowing design teams achieve greater end-use performance. On the operational side, there is a necessity for a more consistent approach to benchmarking of performance, post-occupancy evaluations and for taking an evidence-based approach to green building that has a focus on energy and data analytics to help move from information to intelligence. This also includes improved training for building operators.
Focusing on Asset Planning	A significant requirement exists for better building maintenance across Canada's existing building portfolio. North American construction as a general practice favours buildings with a limited life span and a focus on single usage – which is a very wasteful practice. Developing and upgrading buildings for greater durability, adaptability and flexibility will provide greater advantages to investors.

[6] As one example, the developer of the Dockside Green development in Victoria, B.C. committed to pay the City of Victoria one dollar per buildable square foot as a penalty for all buildings that fail to achieve the LEED certification detailed in the MDA. Source: "Public Interest, Private Property: Law and Planning Policy in Canada" Anneke Smit, Marcia Valiante

Adoption of Sustainable Materials	The consideration of full life-cycle of products and materials that are being used in buildings will enable designers to inform material choices as opposed to being a compliance task at the end of the building certification process. While tools and methodologies for life-cycle assessments (LCAs) exist, the design community needs support to incorporate these early and quickly in the design stage.
Supporting Industry Training & Ongoing Education	Green building requires professional expertise and a better trained workforce as codes become increasingly complex, technology advances, and roles become more interdisciplinary because of the more systems-based focus. The increased need for education and training is running against demographic realities and skilled labour shortages. What is currently lacking is a multi-pronged approach to training that supports all of the different programs to help the construction industry understand, design, and build greener buildings. More investment in this space is required to support structured and modernized internship, mentorship, or apprenticeship programs, as well as recognized credentials for professions such as building operators. Investing in education and training, as well as the policy, regulatory, and incentive frameworks to support uptake of skills development and ongoing learning will be essential to success going forward.
Developing Supportive Policy & Incentives	Closing the gap between market leaders who have embraced green building and the bulk of the building industry will require a policy-driven carrot-and-stick approach to be most effective. The multi-unit residential segment is a particular area that requires greater attention across Canada. Legislation, changes to building codes, and a range of incentive and financing options are needed to construct and retrofit better buildings and homes. On the regulatory side, strengthening the building code is often the best tool available. Embedding performance targets into codes could help to drive improvements and level the current playing field. On the incentives side, a range of tools and program options exist – including tax breaks, grants, and rebates. The key is longevity in program design and delivery in order to achieve market transformation.

IN SUMMARY

Canada's green building industry has grown quickly and accomplished a great deal in a short period of time despite a range of barriers and challenges. However in order to accelerate market transition, a national, cross-sector strategy led by industry and supported by all levels of government is needed. This strategy will enable full realization of the benefits across the value chain and spectrum of opportunities for Canadian businesses, governments, and Canadian consumers and residents more broadly.

Appropriate support in the areas indicated above, including increased investment in research, development and deployment (RD&D), as well as education and training, could help to maximize the economic and employment opportunities that come with being a global leader while benefiting from the environmental, health, and societal contributions provided by the sector.

1. INTRODUCTION

The green building movement in Canada has evolved over the last two decades as a response to policy changes, market demand and environmental concerns.

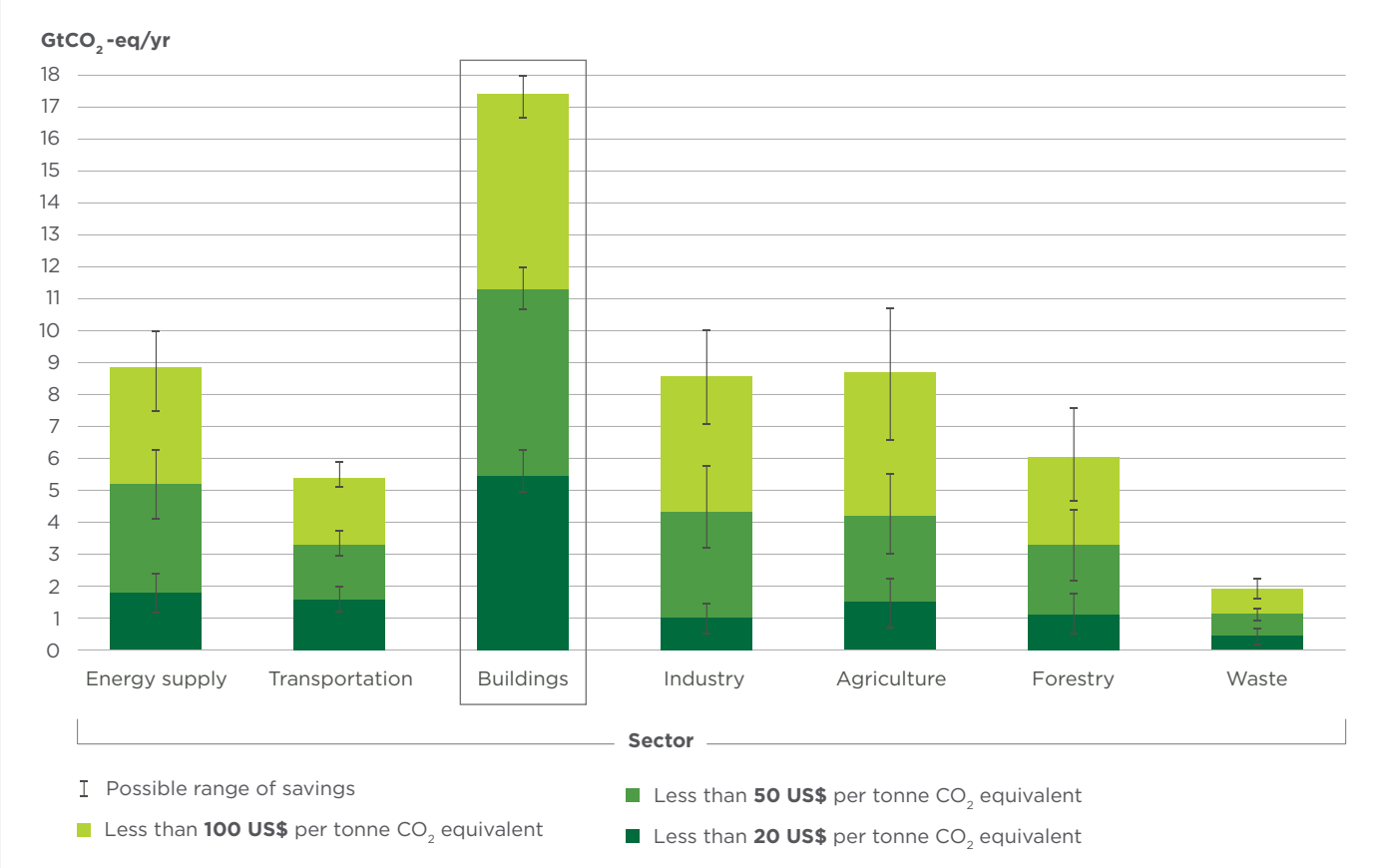
Globally, buildings are a major consumer of natural resources and energy, including one-sixth of the world's freshwater withdrawals, 25 percent of the world's wood harvest, and 40 percent of its raw materials. Buildings have a significant environmental impact, producing 30 percent of the world's solid waste and a third of global greenhouse gas (GHG) emissions.

Buildings offer some of the greatest potential for achieving significant energy and GHG emission reductions, and at the least cost (see figure 1). In urban centres, roughly half of GHG emissions are associated with the energy used to heat, cool, and operate buildings. Furthermore, buildings are generally regulated locally and not subject to complex cross-border regulations. Making large structures – condominiums, office towers, institutions, and apartment buildings – more energy efficient is one of the most impactful and cost effective means of addressing climate change.

In Canada, green building activities are already having a measurable impact on energy and GHG emission reductions. Despite a growing population and increased building stock, energy efficiency and other improvements to Canada's commercial and residential buildings have allowed GHG emissions to drop by 4 Mt between 2005 and 2012, with more than 40 percent of the floor space receiving some level of energy retrofit since 2005.[7]

Today, the definition of green building is holistic in nature and largely tied to standardized metrics defined by the leading rating systems and certification programs such as Leadership in Energy and Environmental Design (LEED®). In Canada, energy performance is benchmarked against the National Energy Code for Buildings (NECB)[8] or ASHRAE standards[9].

Figure 1: Potential CO2 reductions by sector and by cost (world totals in GtCo2 equivalent / year)



Source: United Nations Environment Programme

[7] Canada's Emissions Trends Report (2014). Available at: https://ec.gc.ca/ges-ghg/E0533893-A985-4640-B3A2-008D8083D17D/ETR_E%202014.pdf

[8] http://www.nrc-cnrc.gc.ca/eng/publications/codes_centre/2011_national_energy_code_buildings.html

[9] ASHRAE stands for "American Society of Heating, Refrigeration, and Air-Conditioning Engineers". See website: https://www.ashrae.org/

Working Definition of Green Building in Canada

Green buildings are holistic buildings that are designed, constructed, and operated to achieve clearly defined environmental, economic, and social performance objectives that are measurably above and beyond the norm. With respect to this study, projects in Canada are included in this definition if they have achieved one or more of the following criteria:

- A rating system certification with documented and verified increased performance level (e.g. LEED, BOMA BESt, Built Green, and Novoclimat);
- An energy rating standard (e.g. ASHRAE 90.1-2010, Passive House, EnerGuide 80, ENERGY STAR, R-2000); and/or
- Evidence of exemplary equivalent performance by other means in the areas of energy efficiency, water efficiency, material / resource efficiency, responsible site management, indoor air quality, and health.

Note: The outcomes from the different rating systems vary greatly depending on level of certification, required performance thresholds of each system and the rigour of certification.

The degree of focus on performance however, relies largely on where the line that denotes "green" is set, which varies across the country by province and territory, and is a constantly moving target. In the residential sector for example, NRCan's long-standing goal from its original R-2000 residential program was to have all new homes in Canada meeting the EnerGuide 80 standard.[10] The leading program has shifted the market over time so that now, Ontario and City of Vancouver have adopted this as part of their building codes and other jurisdictions are achieving close to this level of performance for new residential construction with support from various incentive programs.

Energy codes are now in place across Canada that set minimum performance for buildings. Ontario and the City of Vancouver have adopted EnerGuide 80 into their building codes as the minimum standard for new residential construction and other jurisdictions are also providing incentives to move in that direction.

Motivations for embracing green buildings have expanded beyond their original energy and environmental focus which were driven primarily by policy and regulation. Now economic drivers are increasingly advancing market transformation. This shift is also encompassing aspects of social sustainability, with health and wellness benefits a key focus. As such, green building is helping to create more resilient and healthy communities using business models that provide win-wins for all involved.

[10] EnerGuide is the official Government of Canada mark associated with the labelling and energy evaluation of a home. See: http://ener-guide80.com/

Figure 2: Environmental Benefits of LEED Certified Buildings from 2004 - 2014

Over the past decade LEED buildings have benefitted Canadians by:

Energy savings

Energy savings of **4,230,206** eMWh which is enough to power **143,533** homes in Canada for a full year.

Water Savings

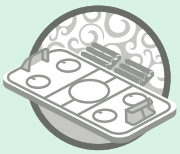
Water savings totalling over **8.7 billion** litres, the equivalent of **3,505** Olympic-sized swimming pools.

Reduction in Greenhouse Gases

A **822,731** CO_2e tonne reduction in greenhouse gas emissions which equates to taking **155,526** cars off the road for a year.

Recycling Garbage

Recycling over **1.1 million** tonnes of construction/demolition waste which represents **348,691** garbage truck loads.



Reducing urban heat

Installing **157,309** sq metres of green roofs, or an area the size of **104** NHL hockey rinks, to reduce the urban heat island effect and mitigate storm water flows in urban areas.

2004 – 2014 LEED certified buildings

At the same time, the green building industry in Canada today has become fiercely competitive, which is raising the bar on performance. Leading companies involved with design, construction, and the operation of buildings, as well as the full value chain to support these efforts, are actively pursuing green building as a standard of practice (see figure 3). Green buildings are pushing new solutions and driving innovation in service delivery and processes, product and technology design, manufacturing, and material and resource use.

Designers, product developers, businesses, and entrepreneurs are undertaking continuous improvements in environmental and economic performance using a more holistic approach to building design and development. This approach embraces systems-based thinking and is bringing people together in new ways to address challenges. Processes such as the integrated design process (IDP) and integrated project delivery (IPD), supported by technology-based tools such as building information modelling (BIM), are but a few examples of the innovation at the heart of the green building movement in Canada.

The proliferation and demand for expertise in the design, development, construction and operation of green building has led to the creation of new jobs. These jobs are found in areas such as energy modeling, green roof design and construction, and sustainability consulting. In addition, jobs within traditional realms including construction trades, equipment manufacturers, architects and engineers, and property managers are increasingly incorporating a focus on energy and resource efficiency among other environmental sustainability attributes.

This report provides an overview of the economic contributions of the green building sector in Canada, some of the leading trends and industry drivers, and showcases the impressive market transformation that is underway across the country (albeit at different rates depending on the province / region). It also highlights Canadian strengths in related products and services, as well as areas where Canada could improve, with the intention of developing a national, cross-sector strategy led by industry and supported by all levels of government. This strategy could help to accelerate the market transition and more fully realize the benefits across the spectrum of opportunities for Canadian businesses, governments, and Canadian consumers and residents more broadly.

"Building as a System"

"Building-as-a-system" is an enhanced building modelling approach that advances beyond performance-based building modelling simulations used for improving energy efficiency performance.

This approach incorporates five defined areas that more accurately simulate building performance by requiring the "view of *buildings as a system*" which is made up of:

1. Building itself (load bearing structure)

2. Service systems (installations)

3. Functional units
(work places, activity spaces, etc.)

4. Users (organization)

5. Control system
(building hardware and software controls)

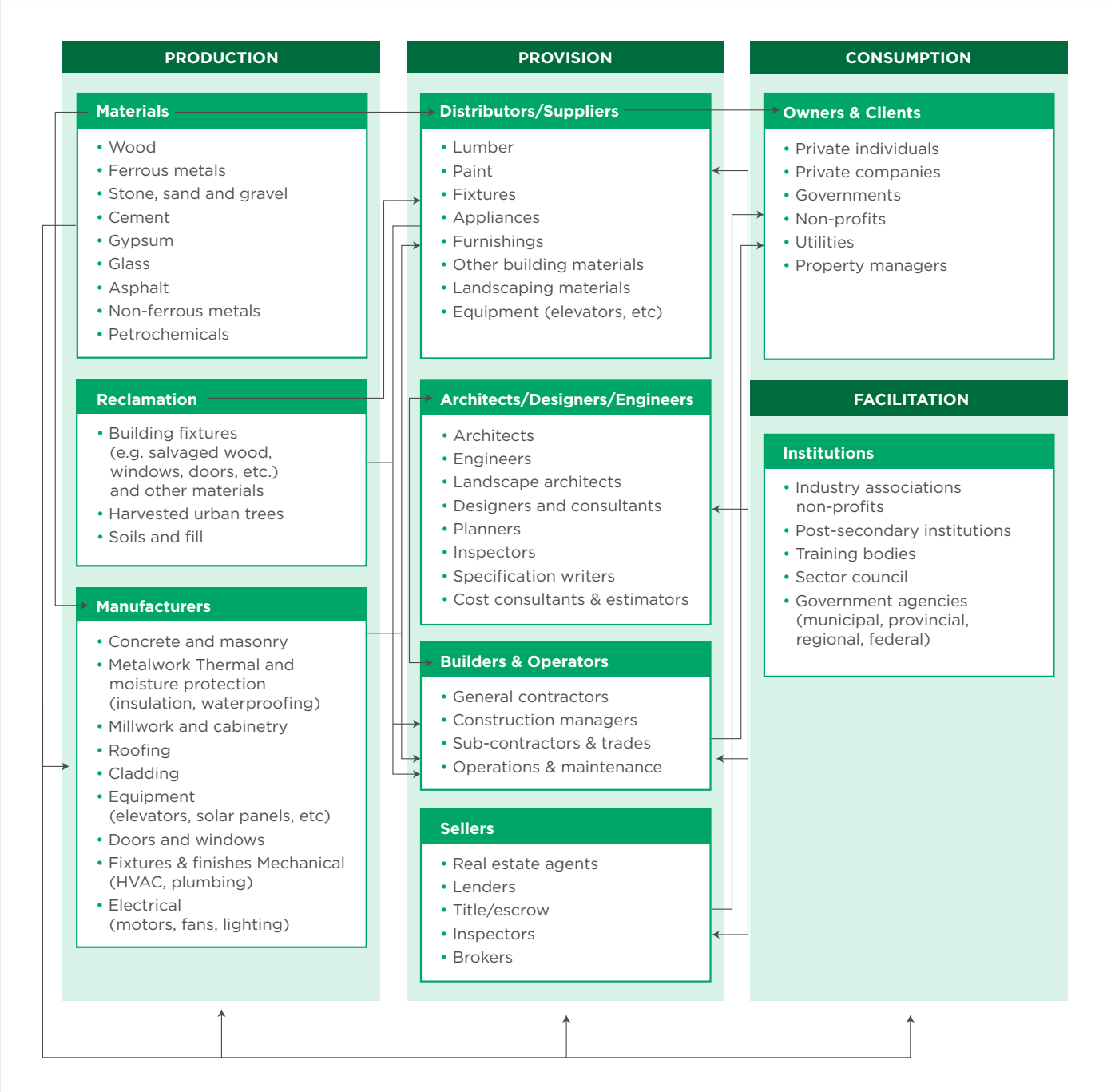
These areas present additional categories included into the calculation of heat flow, gains and losses into the building performance simulation typical in the performance-based approach.

Additionally, buildings-as-a-system aims to measure, validate and verify energy performance relying on the functional requirements that compose the integrated building system model.

Source: Zimmerman, G. (2003). "Modeling the Building as a System" in *Building Simulation 2003: Eighth International IBPSA Conference.* Eindhoven, Netherlands: 11-14 August 2003. pp 1483-1490.

Available at: http://www.ibpsa.org/proceedings/bs2003/bs03_1483_1490.pdf

Figure 3: The comprehensive value chain that operates within Canada's green building sectors



Source: Adapted from Light House Sustainable Building Centre

2. INDUSTRY GROWTH & ECONOMIC IMPACT

Green buildings are an engine of economic growth in Canada. Through both direct and indirect benefits, green buildings are having a positive impact on new investments, job creation, and revenues for companies of all sizes across the extensive value chain and full lifecycle of projects. This section details the growth of Canada's green building industry and profiles its estimated contributions to Canada's economy in terms of jobs and gross domestic product (GDP).

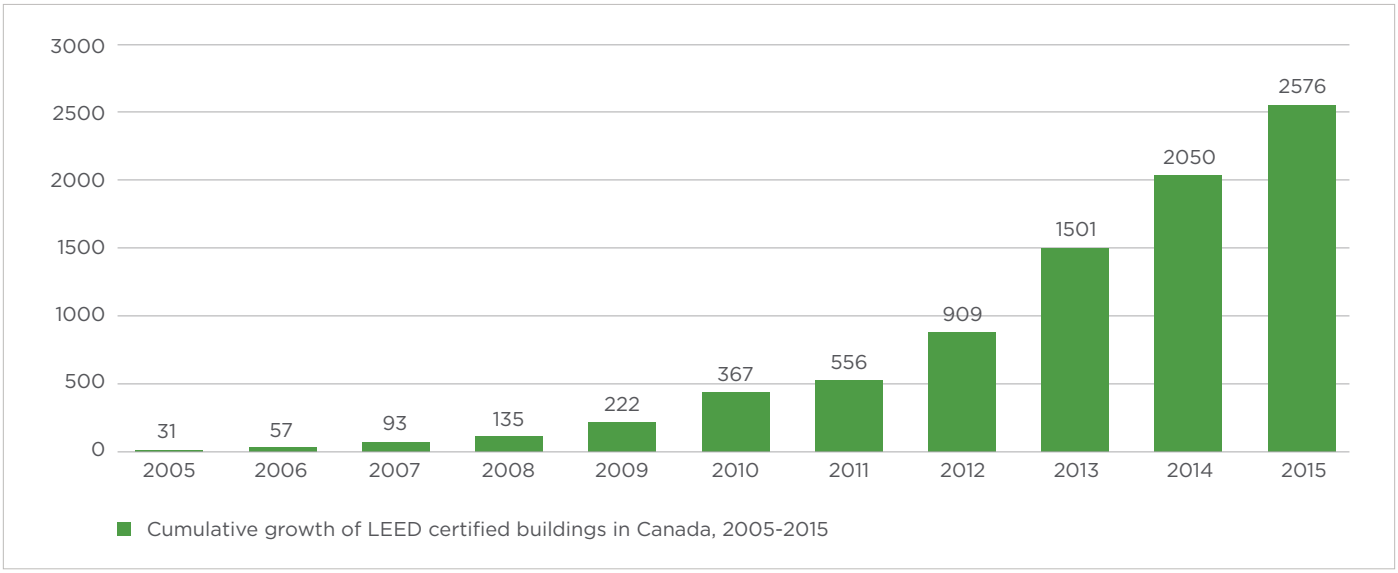
2.1 Green Building Sector Growth in Canada

The green building sector's growth in Canada has been rapid over the last decade, measured by the increase in the number of certified green buildings.

In 2002, the LEED® program was launched in Canada by the Canada Green Building Council (CaGBC), building on a successful and growing third-party rating system out of the United States and adapting it to the local market. From 31 buildings certified by the end of 2005 to 2,576 by the end of 2015, LEED has seen enormous uptake in Canada (see figure 4).

Today, LEED has more than 5,000 certified and registered projects across the country. As of June 2015, there were approximately 2,275 LEED certified buildings, with the dominant certification at the LEED Gold level (see figure 5). The bulk of LEED certifications in Canada are found in Ontario (41 percent), followed by Quebec, British Columbia, and Alberta (see figure 6).

Figure 4: Cumulative growth of LEED certified buildings in Canada, 2005-2015



Source: CaGBC

Figure 5: LEED certified buildings in Canada by level as of June 2015

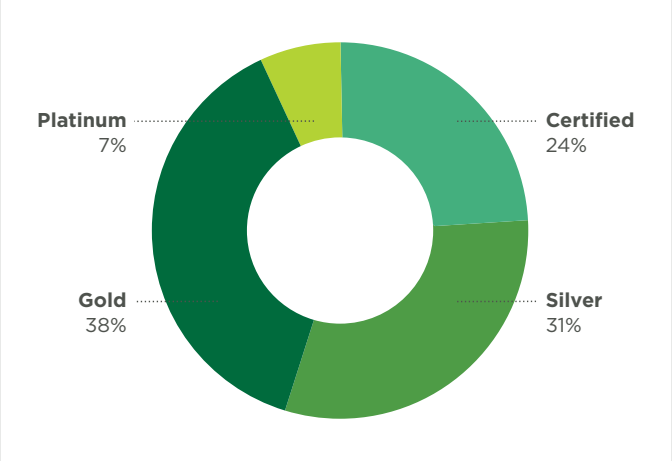
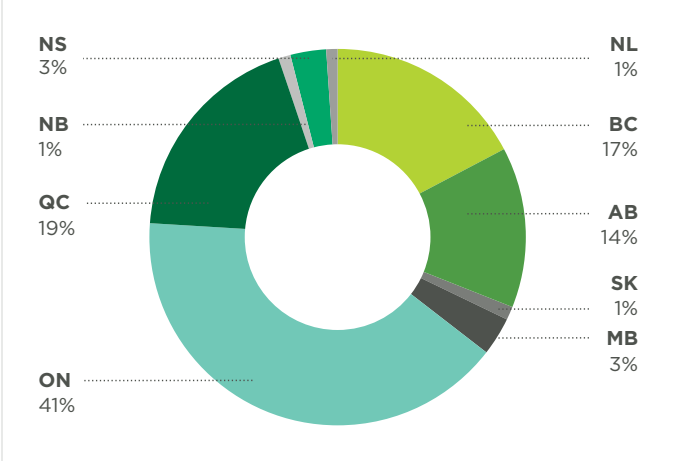


Figure 6: LEED certified buildings in Canada by province as of June 2015



On a per capita basis however, British Columbia ranks first, followed by Yukon, Nova Scotia, and Alberta in 2015 (see table 1).

Table 1: LEED certified buildings in Canada by province/territory on a per capita basis[10]

Rank	Province / Territory	LEED certified projects (end of Q1 2015)	Total population (x100,000)	Projects per 100,000 people
1	BC	395	46.310	8.5
2	YT	3	0.365	8.2
3	NS	72	9.427	7.6
4	AB	311	41.217	7.5
5	ON	928	136.787	6.8
6	MB	71	12.820	5.5
7	QC	426	82.147	5.2
8	PEI	5	1.463	3.4
9	NB	20	7.539	2.7
10	SK	29	11.254	2.6
11	NL	10	5.270	1.9
12	NWT	2	4.360	0.5

Market penetration rates (as a percent of gross new construction floor space) for LEED certified buildings in Canada have also been growing over the last decade (see table 2). The institutional sector has seen the greatest increase in market penetration of LEED since program inception, with approximately one in three (30 percent) new buildings constructed in 2014 certified as LEED, representing a 25 percent growth over the past five years.

[11] There is no data available for Nunavut.

Table 2: Market penetration of LEED certified projects as a percent of new floor space in Canada

Canada (includes territories)	2004-09 Floorspace	2004 to 2009 LEED Certification	Percent	2010-14 Floorspace	2010 to 2014 LEED Certification	Percent
Residential	125,262,304	235,521	0.19%	102,771,953	1,581,331	1.54%
Industrial	22,210,251	72,908	0.33%	18,604,400	661,785	3.56%
Commercial	70,241,755	878,085	1.25%	66,499,798	14,721,796	22.14%
Institutional	16,336,306	744,889	4.56%	16,165,185	4,845,882	29.96%
Total	234,050,616	1,931,403	0.83%	204,041,335	21,810,794	10.69%

Table 3 provides an estimate of the market penetration for LEED certified floor space by province and the territories for new construction over two time periods: 2004-2009 and 2010-2014 based on five-year moving averages.

Table 3: Market penetration of LEED certified projects as a percent of new floor space by province/territories

Province	2004-09 Floorspace	2004 to 2009 LEED Certification	Percent	2010-14 Floorspace	2010 to 2014 LEED Certification	Percent
ON	86,769,668	730,649	0.84%	72,745,118	11,114,195	15.28%
NS	4,243,210	11,795	0.30%	3,407,290	364,473	10.74%
QC	43,658,543	524,062	1.22%	37,532,185	3,777,026	10.06%
SK	5,382,522	49,814	0.93%	7,509,164	729,384	9.71%
BC	36,044,219	341,143	0.95%	28,124,528	2,500,676	8.89%
AB	45,411,689	224,488	0.49%	41,603,889	2,888,685	6.94%
PEI	724,157	0	n/a	574,102	30,957	5.39%
MB	5,305,253	8,663	0.16%	5,947,352	227,725	3.83%
NB	3,353,138	33,529	1.12%	2,427,432	73,934	3.05%
NL	2,249,182	0	n/a	3,300,252	92,099	2.79%
Territories	909,022	7,260	0.80%	854,156	11,640	1.36%
All Provinces / Territories	234,050,616	1,931,403	0.83%	204,041,335	21,810,794	10.69%

Based on the success of LEED, there has been a proliferation of other green building rating systems and third-party certification schemes in Canada for both the residential and non-residential segments.

A second widely-adopted certification program for non-residential (existing) buildings is the BOMA BESt program. Since program inception, the total number of BOMA BESt certified buildings has grown, with more than 4,125 having achieved certification and/or recertification in Canada as of 2014, equal to approximately 125.8 million registered square feet. More than half (55 percent) of all the 562 certifications in 2014 were found in Ontario and Quebec, most notably in Toronto, Ottawa, and Quebec, largely linked to the amount of commercial real estate that exists.

In the residential sector, (particularly with respect to new construction), ENERGY STAR, Novoclimat, and Built Green are the currently the dominant programs.

- **ENERGY STAR** is gaining traction across several Canadian provinces, particularly in Ontario and increasingly in Saskatchewan and British Columbia. In Ontario for example, approximately 32 percent of all eligible Part 9 new homes were certified ENERGY STAR in 2014. More than 62,000 homes have received an ENERGY STAR label and over 80,000 enrolled.
- In its first iteration from 1999 to 2013, over 21,000 residential dwellings were built according to the Province of Quebec's **Novoclimat** program standards. Since then, 2,000 homes a year are built to this standard. In 2013 the Quebec government launched Novoclimat 2.0, which scales up the program to achieve 15 percent market penetration of new buildings.
- **Built Green**, initiated in 2003, has grown its representation to include Alberta, British Columbia, Manitoba, Saskatchewan, and Ontario, having enrolled and completed over 24,000 Built Green certified homes in Canada.[12]

It should be noted that not all green building rating systems are equal in terms of the aspects and criteria they cover. Programs such as ENERGY STAR and Passive House are focused only on energy criteria whereas LEED consists of a number of prerequisites and optional credits that provide a comprehensive framework of criteria considering energy use, water, waste, health, and other key sustainability factors. LEED is internationally recognized for its rigorous standards and more holistic approach, which has led it to be adopted by building developers and owners in the non-residential sector in more than 200 countries worldwide.

Most provinces require that provincially-funded projects pursue LEED certification for new construction and major renovations of public institutional buildings, including office buildings, community centres, hospitals, universities, and schools (see table 4 for LEED requirements for public buildings by province). The resulting growth in market penetration for institutional buildings in Canada is largely attributed to public sector policies across all levels of government and institutions to build to LEED standards.

Table 4: Provincial LEED requirements for public building construction in Canada (by province)

Province	Provincial LEED Requirements for Public Buildings
BC	LEED Gold
AB	LEED Silver
MB	LEED Silver
ON	LEED Silver
NL	LEED Silver
NS	LEED Silver
NB	LEED Silver
QC	LEED Certified
SK	No requirement
PEI	No requirement

Source: LEED in Motion in Canada 2015

[12] See: http://www.builtgreencanada.ca/

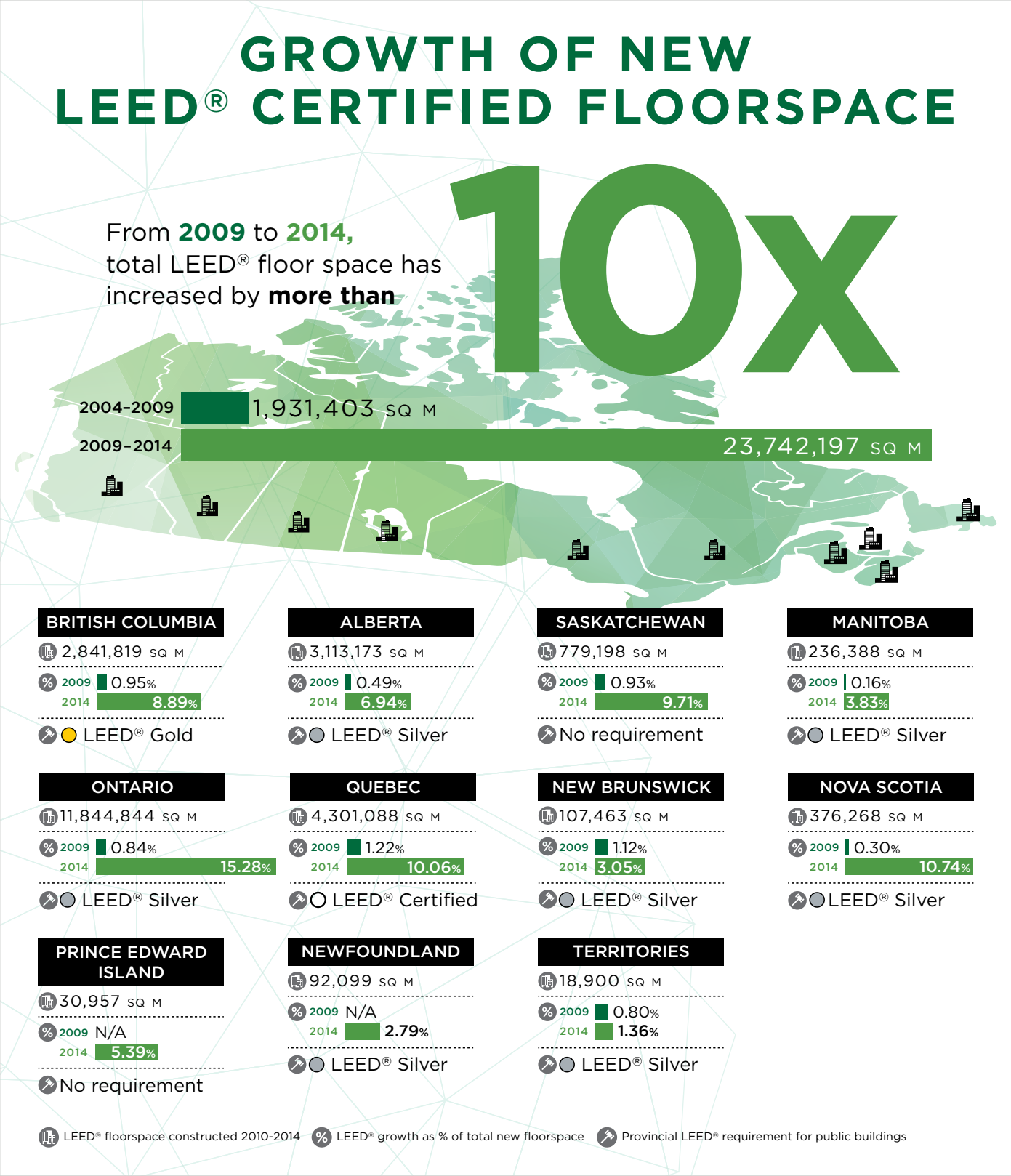
Green building requirements for federal buildings are administered through the department of Public Works and Government Services Canada (PWGSC) Real Property Branch, which commits to achieving LEED Gold for its new construction and build-to-lease projects and LEED Silver for major renovations.

At a municipal level, the cities of Calgary, Montreal, Vancouver, Kitchener, Richmond, New Westminster, North Vancouver, and the Regional Municipality of Wood Buffalo (Fort McMurray) require that all city-owned and/or funded projects must be LEED Gold. Several Ontario municipalities have also collaborated on the grading of a regional sustainability checklist, and LEED has become a part of the included metrics.

This "policy push" has had a positive effect resulting in a gradual market transformation, growing industry knowledge of LEED certification programs, as well as awareness for green building practices more broadly with the general public. It has also created investments and jobs in the green building sector across the entire value chain as a result.

Over the last decade, private building owners and property managers, particularly in the commercial office real estate sector, have been developing growing interest in LEED for new construction as well as for existing buildings through LEED Existing Buildings Operations and Maintenance (EB:O&M) program. Leading property managers and building owners are now adopting LEED Gold certification for buildings in their portfolios as a standard of practice in order to attract and retain both tenants and institutional investors. This trend is further accelerating the pace of green building market transformation in Canada.

Figure 7: Cumulative growth of LEED certified buildings in Canada, 2005-2015



2.2 Jobs & GDP

Industry leadership, the growth of green building certification programs, public sector policies, building code advancements and institutional sector capital have resulted in significant job creation, investments, and economic activity across the extensive construction value chain in Canada.

In 2014, the green building industry was estimated to have employed 297,890 direct full-time workers in Canada and generated approximately $23.45 billion in gross domestic product (GDP).[13] For comparison, this represents more jobs than Canada's oil and gas extraction, mining, and forestry industries combined, which collectively employed approximately 270,450 workers in 2014.[14]

Companies active in the **Construction and Trades** segment accounted for the largest percentage (55 percent) of green building employment and GDP in Canada, equal to approximately 164,445 jobs (approximately 13 percent of Canada's total construction work force) and $13.13 billion dollars in GDP. Jobs in this segment include contractors and trades engaged in the construction of non-residential and residential buildings certified under a recognized green building standard / certification or an energy efficient building based on mandatory energy code requirements.

The **Materials and Manufacturing** segment, which includes firms that produce green construction materials, wood-based products, and energy-efficient building equipment and technologies (tied to market penetration of ENERGY STAR building equipment and lighting), accounted for 26 percent of all green building employment and GDP in Canada, equal to approximately 77,365 jobs and $5.77 billion in GDP in 2014.

The **Professional Services** segment, including firms active in green building design, architecture, engineering, property management, and related scientific and technical services, are estimated to have generated approximately 29,490 jobs and $2.38 billion in GDP in 2014.

The **Policy and Education** segment employed approximately 21,710 people related to green building activities in Canada. This includes jobs in universities, colleges and technical trade schools, industry associations and non-profit organizations, and government agencies at all levels.

The **Waste Management and Recycling** segment employed approximately 4,880 green building related workers in Canada in 2014, includes those involved with the collection and treatment of construction waste and recyclable materials.

[13] For the full methodology and calculations related to estimating green building jobs and GDP in Canada, refer to Appendix A.

[14] Employment estimates for oil and gas, mining, and forestry industries come from Statistics Canada's Employment and Earnings Survey for 2014 (CANSIM table 281-0024). The estimate does not include jobs in processing or related value-add product sectors.

Figure 8: Green building jobs and GDP (millions of chained 2007$) by sector in Canada, 2014

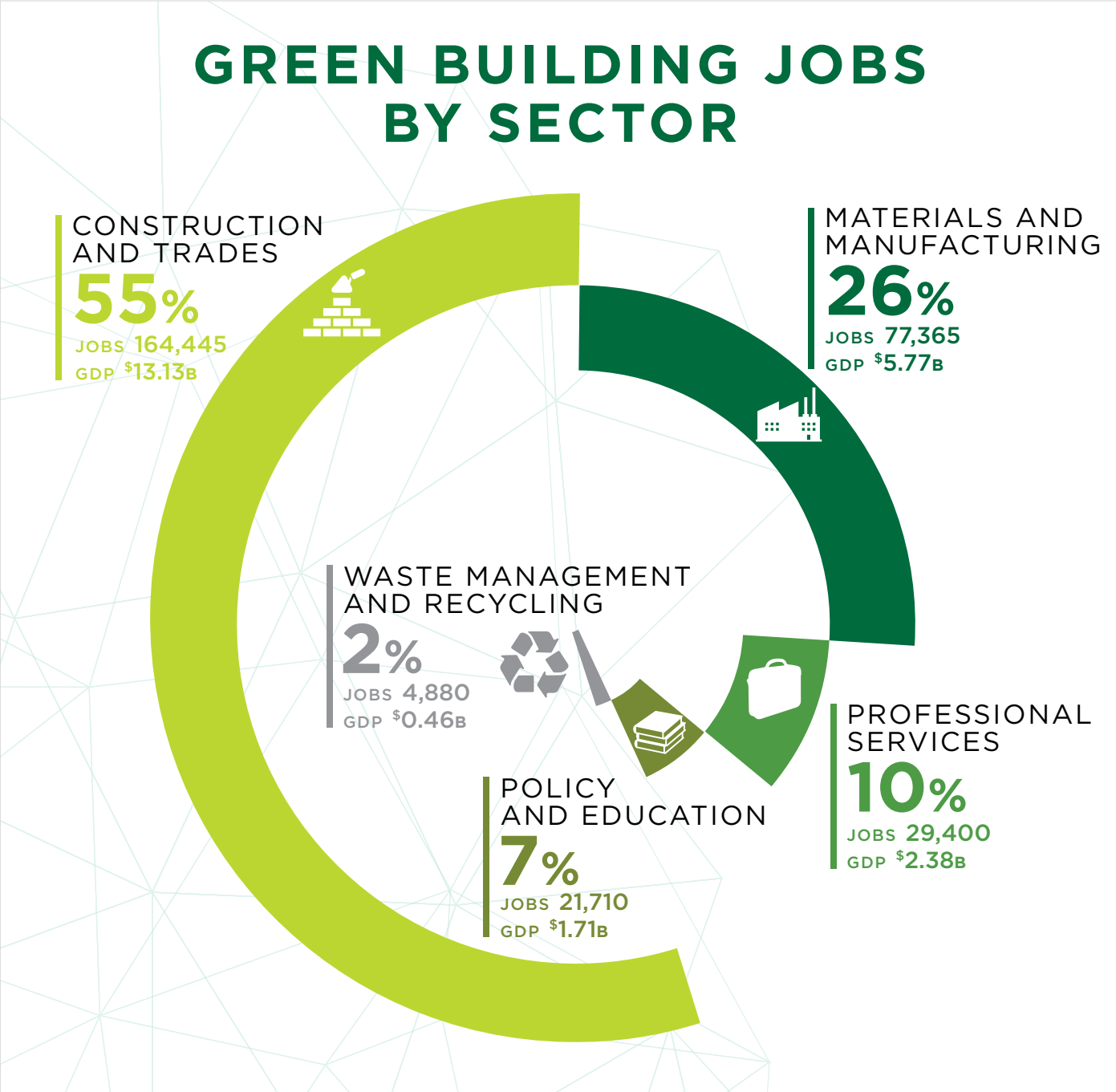


Table 5 shows a breakout of green building related GDP and employment by province, including jobs as a percentage of total provincial labour force. Ontario and British Columbia show the greatest percentage of green building jobs as a percentage of total workers across the economy (all industries).

Variations in green building economic activity between provinces can be attributed to the amount of investment and green building certification activity (particularly LEED and BOMA BESt for non-residential buildings) as a percent of total construction activity in those jurisdictions. Within the residential segment, building codes and incentive programs were also factored into the estimates and tied to the amount of green building investment and jobs. Jurisdictions where EnerGuide 80 is a requirement for new construction for example (i.e. Ontario and the City of Vancouver) also show a higher overall level of green building due to the more progressive building code and municipal bylaws.

Table 5: Green building GDP (millions of chained 2007$) and jobs by province in Canada, 2014

By Province	2014 Green Building GDP	2014 Green Building Jobs	Labour Force (July 2015)	Jobs as % of Labour Force	Green Jobs by Province
ON	$ 11,989.9	153,690	7,425,100	2.1%	51.8%
QC	$ 4,149.7	48,710	4,438,500	1.1%	16.4%
BC	$ 2,915.1	38,824	2,452,300	1.6%	13.1%
AB	$ 2,469.6	30,914	2,446,100	1.3%	10.4%
SK	$ 525.5	6,844	599,600	1.1%	2.3%
MB	$ 438.8	5,578	669,700	0.8%	1.9%
NS	$ 369.3	4,750	489,300	1.0%	1.6%
NB	$ 321.6	4,380	390,400	1.1%	1.5%
NL	$ 162.6	2,162	268,300	0.8%	0.7%
PEI	$ 46.3	873	81,700	1.1%	0.3%

Figure 9: Distribution of Green Building Jobs by Province

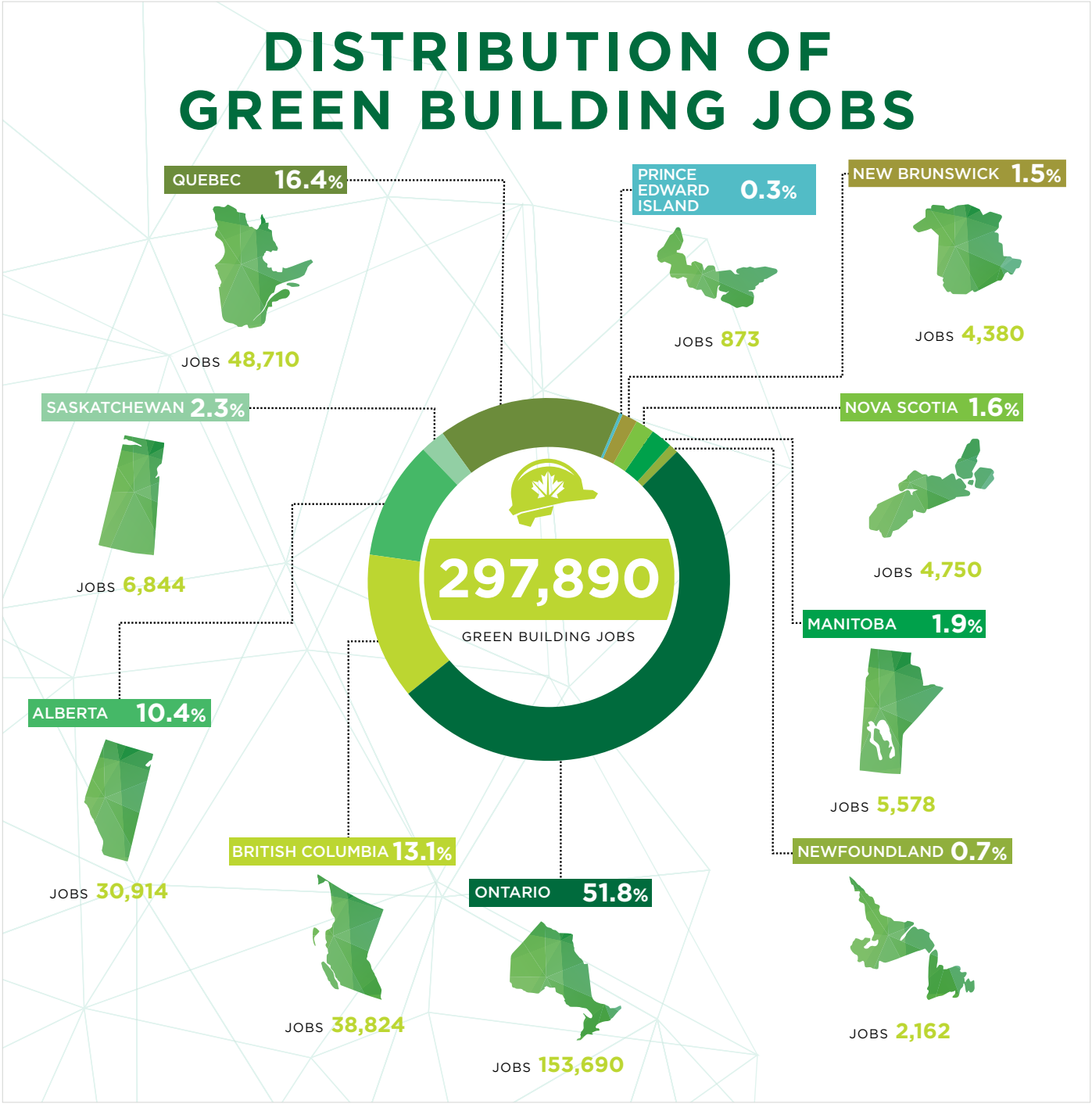
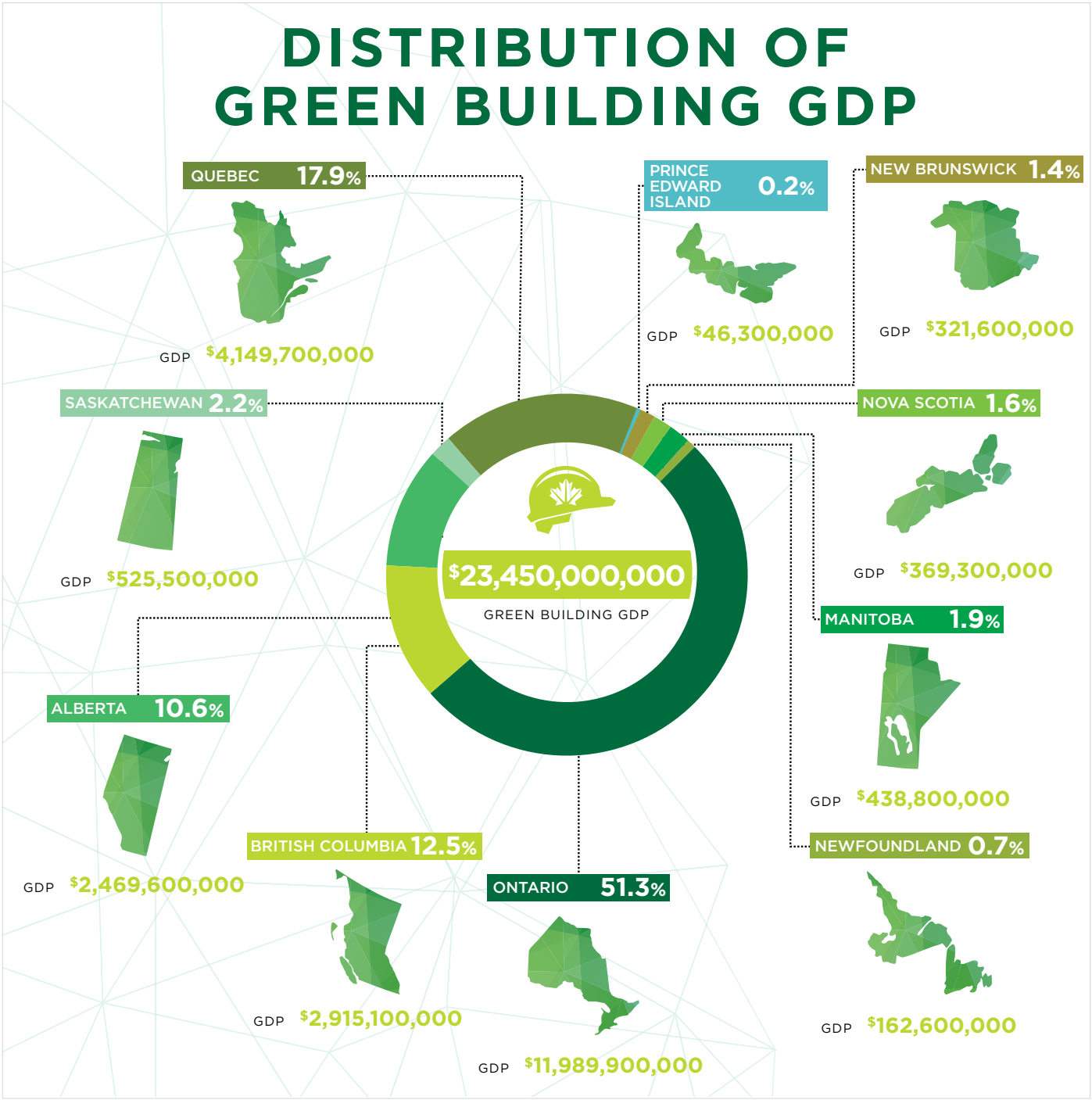


Figure 10: Distribution of Green Building GDP by Province



2.3 Economic Impact of LEED® Building in Canada

By applying a lifecycle cost analysis (LCCA) to LEED certified building projects in Canada, it is possible to estimate the overall economic impact of the program in terms of jobs and GDP since inception. To calculate this impact, the average project costs per gross square meter of LEED certified projects for residential, commercial, and industrial buildings was estimated using 5 percent for the approximate above average cost of construction between 2005 and 2015. For institutional buildings a 4 percent margin was used to determine economic impacts as well as the average savings from energy, water, waste, and operations and maintenance (O&M) from LEED certified projects in Canada.

The estimated overall annualized lifecycle savings for all LEED certified projects in Canada (as of June 2015) are shown in table 6.

On average, the LEED energy, water, waste disposal, and O&M savings provide an overall net savings of approximately $294.31 per square meter (see figure 11) over the estimated 33 year economic life of the building.

In terms of the overall economic impact, it is estimated that LEED certified projects to date will generate approximately $59.1 billion in direct dollar gross output[15], $25.4 billion in GDP (in constant 2007 dollars), and 329,912 direct jobs over their economic lifetime (see table 7). When indirect and induced contributions are included, the overall economic impact generated by LEED projects since program inception is $128.0 billion gross output, $62.3 billion in total GDP, and 701,740 jobs created[16] [17]

[15] Gross output is a measure of an industry's sales, which can include sales to final users in the economy (GDP) and sales to other industries (intermediate inputs). Gross output can also be measured as the sum of an industry's value added and intermediate inputs.

[16] Direct impacts are related to the specific industry (in this case, green building), while indirect impacts relate to activities that support or supply the industry. Induced impacts are those that are a result of direct / indirect spending in the local economy outside of the green building industry (i.e. the economic as a whole). In general terms, industries with higher multipliers are more desirable.

[17] Note these are gross jobs, not net jobs. Net jobs reflect incremental jobs after shifts in the economy such as people moving from other construction activities are netted out.

Table 6: Overall annualized life cycle savings from energy, water, waste, and O&M for LEED projects in Canada since program inception

	Residential	Commercial	Institutional	Industrial	Total
Total LEED sq. meters	1,816,852	15,599,881	5,590,771	734,693	23,742,197
Commercial $ Cost per sq. meter (2007 $) *	$1,957	$1,938	$3,883	$1,425	$2,382
Total "normal costs"($000, 2007$)	$3,554,684	$30,239,193	$21,707,398	$1,047,293	$56,548,568
Green building surcharge (5%, 4% institutional) ($000, 2007$)	$177,734	$1,511,960	$868,296	$52,365	$2,610,354
Total Construction Costs ($000, 2007)	$3,732,418	$31,751,152	$22,575,694	$1,099,658	$59,158,923
Annual Savings ($000, 2007$)					
Energy Savings	$39,502	$339,173	$121,555	$15,974	$516,204
Water Savings	$830	$7,124	$2,553	$336	$10,843
Waste Savings	$723	$6,207	$2,235	$292	$9,447
O&M Savings	$3,438	$29,520	$10,580	$1,390	$44,928
Total Savings	$44,493	$382,025	$136,912	$17,992	$581,422
33 year PV of Savings ($000, 2007$)	$711,999	$6,113,379	$2,484,636	$287,916	$9,597,930
Net Savings ($000, 2007$)**	$534,265	$4,601,419	$1,616,340	$235,551	$6,987,576
Net Savings per sq. meter	$294.06	$294.96	$289.11	$320.61	$294.31
Net Savings as percent of total costs per year	9.1%	9.2%	5.6%	13.6%	8.1%

Assumptions

1. The Present Value of the annual net savings were based on a 5 percent discount rate and taken over 33 years, which is considered to be the economic life for buildings.

2. The average green building incremental cost for LEED certified buildings is estimated to be 5 percent of "normal" building costs (4 percent for institutional buildings), which are shown in the second line of the table.

* Average costs for construction were estimate based on Informetrica data and information from several appraisal firms.

** Net savings are the difference between the 33 year present value of savings and the green building surcharge.

Figure 11: Net lifecycle savings per square meter for LEED certified buildings in Canada

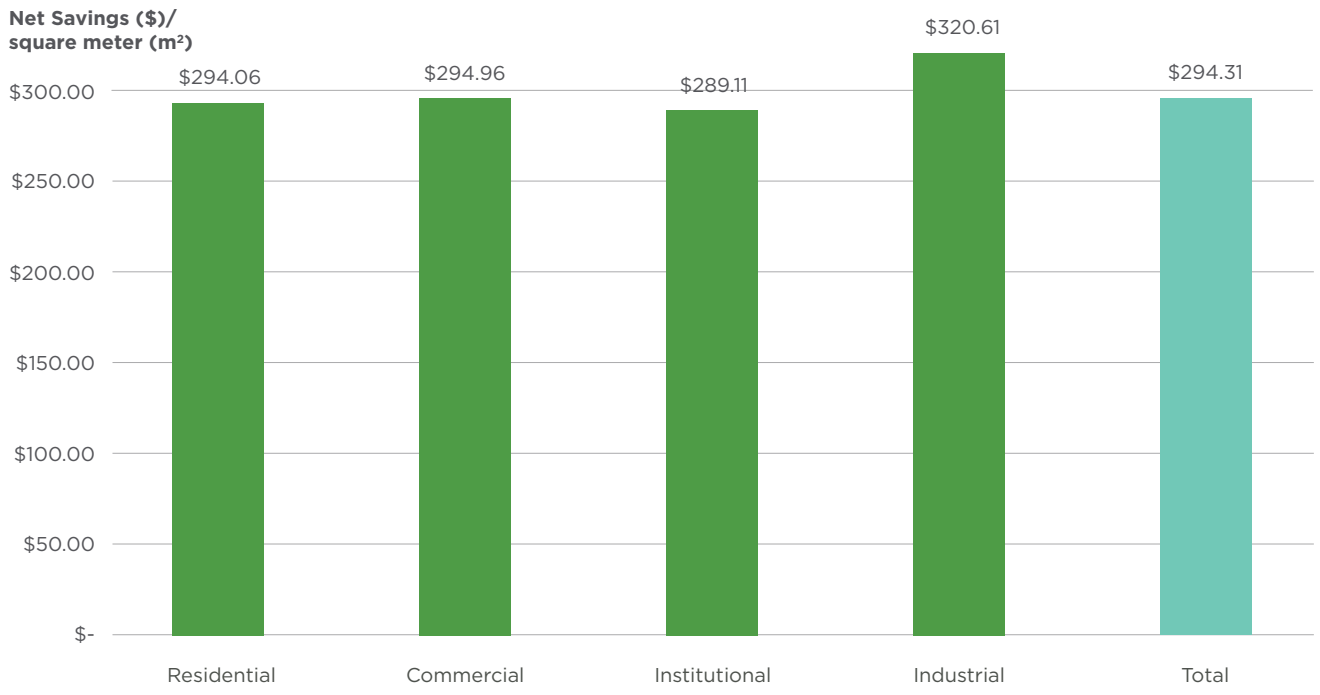


Table 7: Direct economic impacts generated from the LEED projects in Canada that have been certified up to 2015 over their economic lifetime

	Residential	Commercial	Institutional	Industrial	Total
Direct Gross Output ($000, 2007$)	$3,732,418	$31,751,152	$22,575,694	$1,099,658	$59,158,923
Direct GDP ($000, 2007$)	$1,542,104	$13,689,746	$9,733,679	$474,126	$25,439,654
Direct Labour Income ($000, 2007$)	$1,198,371	$11,096,760	$7,890,015	$384,321	$20,569,466
Direct Jobs	19,366	177,897	126,488	6,161	329,912

Figure 12: Annualized lifecycle savings from LEED certified buildings

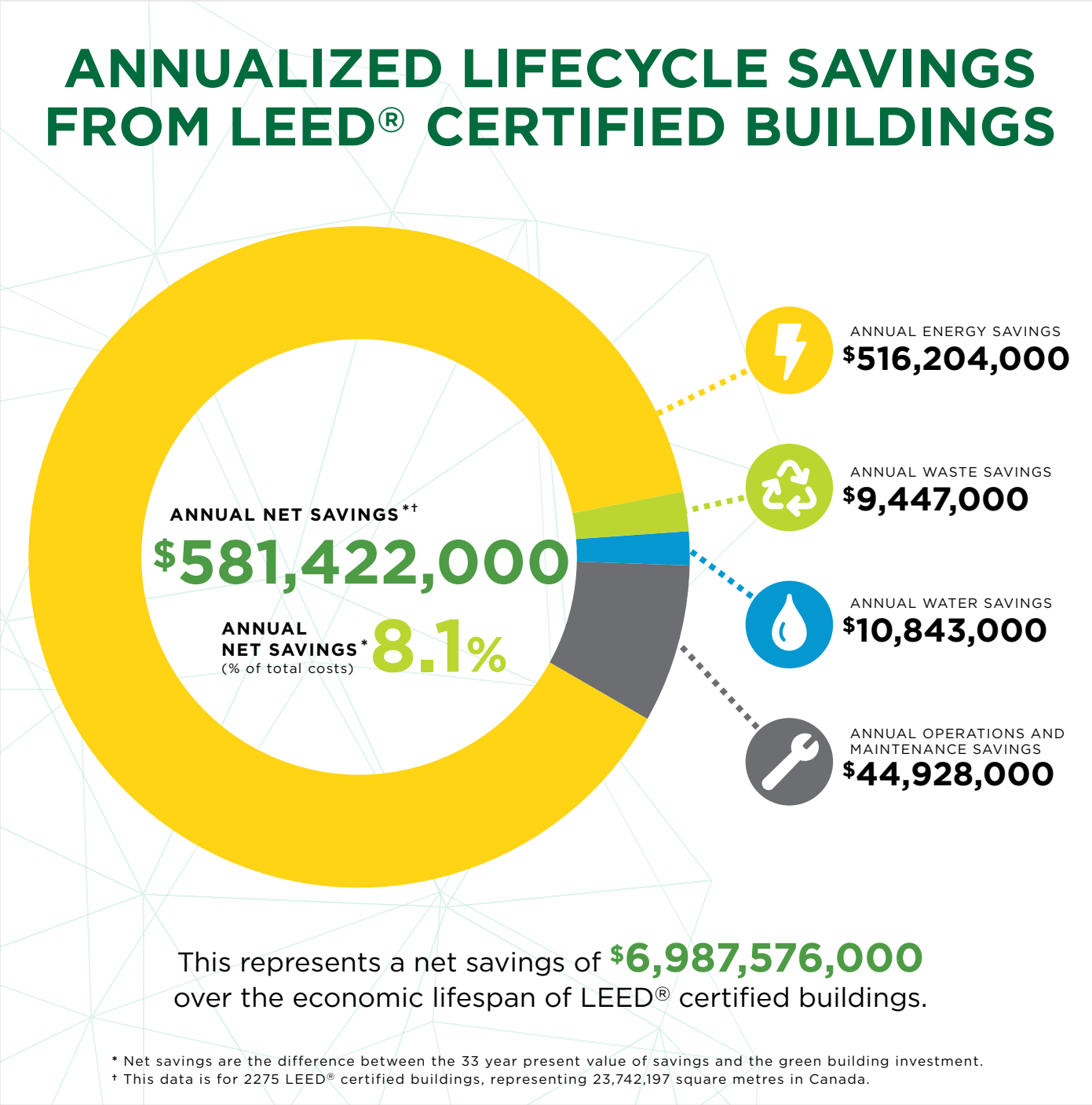


Figure 13: Net savings for LEED® certified projects by sector

NET SAVINGS FOR LEED® CERTIFIED PROJECTS BY SECTOR

RESIDENTIAL

TOTAL LEED® SQUARE METERS
1,816,852

TOTAL CONSTRUCTION COSTS
$3,554,684,000

SAVINGS	
ENERGY	$39,502,000
WATER	$830,000
WASTE	$723,000
O&M	$3,438,000

NET SAVINGS (% of total costs)
9.1%

COMMERCIAL

TOTAL LEED® SQUARE METERS
15,599,881

TOTAL CONSTRUCTION COSTS
$30,239,193,000

SAVINGS	
ENERGY	$339,173,000
WATER	$7,124,000
WASTE	$6,207,000
O&M	$29,520,000

NET SAVINGS (% of total costs)
9.2%

INSTITUTIONAL

TOTAL LEED® SQUARE METERS
5,590,771

TOTAL CONSTRUCTION COSTS
$21,707,398,000

SAVINGS	
ENERGY	$121,555,000
WATER	$2,553,000
WASTE	$2,235,000
O&M	$10,580,000

NET SAVINGS (% of total costs)
5.6%

INDUSTRIAL

TOTAL LEED® SQUARE METERS
734,693

TOTAL CONSTRUCTION COSTS
$1,047,293,000

SAVINGS	
ENERGY	$15,974,000
WATER	$336,000
WASTE	$292,000
O&M	$1,390,000

NET SAVINGS (% of total costs)
13.6%

2.4 Additional Economic Benefits

Over the last several years, a strong business case for green building has been revealed through research on the market value of green buildings for industry, owners, and occupants. A comprehensive global study undertaken by the World Green Building Council demonstrates how adopting green building best practices contributes to reducing overall design and construction costs, increasing asset valuations and reducing operating costs. These practices also contribute to improving workplace productivity and health, and can increase resiliency against short and long term economic and environmental risks.[18] These additional economic and performance measures are elaborated below, captured by the breadth of research on green building and their positive benefits.

Green building is becoming more affordable with increasing return on investments. Although the cost of design and construction varies based on project size, complexity, location, equipment, technology and materials, the premium on green buildings has been declining.[19]

Typically, the most significant cost is the system (mechanical / electrical equipment and building envelope) installed for improving the overall energy performance. However, according to a Trends Report on Canada's Green Building sector, over 70 percent of owners and architects involved in green building construction estimate the payback of their investments to be returned within 10 years (see figure 14).[20] Additionally, building owners found that green retrofit and renovation efforts contribute to increased building values, with a median increased value of 4 percent.[21]

Investments in building envelope and energy efficiency reduce operational and maintenance costs, protecting asset value over the long-term. As industry becomes familiar with new business processes and technologies, this has the effect of raising the knowledge and skills involved in green building design, construction and operation. Industry is also realizing the benefits of economies of scale which are driving price reductions for certain products and services. The additional cost now for obtaining LEED® Silver certification in many urban areas in Canada can be close to zero.

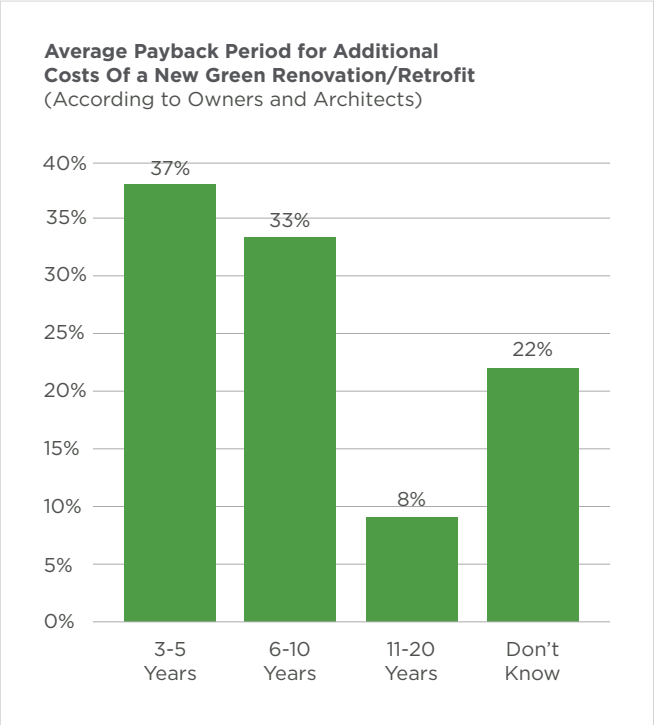
[18] The World Green Building Council's 2013 report on "The Business Case for Green Building" provides many excellent examples. Download: http://www.worldgbc.org/files/1513/6608/0674/Business_Case_For_Green_Building_Report_WEB_2013-04-11.pdf

[19] These additional costs range on average from zero to six percent of a LEED certified building project in Canada.

[20] Trends Report on Canada's Green Building sector by McGraw Hill (developed for CaGBC)

[21] See: http://www.cagbc.org/cagbcdocs/resources/CaGBC%20McGraw%20Hill%20Cdn%20Market%20Study.pdf

Figure 14: Average payback period for green improvements according to owners and architects



Source: Canada Green Building Trends Report, McGraw Hill Construction[22]

Green building significantly benefits the local economy. The findings of a 2014 study by the Acadia Center showed that efficiency programs have a multiplier effect, driving significant economic growth across all sectors of the Canadian economy.[23] Due to the domestic nature of work in the green building sector, investments into efficiency programs and improvements recirculate revenues into the local economy. The efficiency stimulus also results in a net increase in employment from the indirect increase of household disposable income that becomes available from avoided energy costs. In other words, the greater the household disposable income, the greater the average increase in spending – driving job creation not only in the green building sector, but other industries as well.

Green buildings are in greater demand and value over conventional buildings. Perhaps the most compelling reasons to build green are the combined effects of increase asset valuation, lease renewals, and greater economic and environmental resiliency. A 2015 report by TD Bank on Toronto's 'green' condo market shows that LEED-silver certified buildings sold at 5.7 percent to 6.2 percent more than non-certified building units and 12.2 percent to 14.9 percent more in LEED-gold certified buildings.[24]

Recently, a joint study undertaken by researchers from the University of Guelph and University of Maastricht found that green certified buildings provide "significantly higher levels of tenant satisfaction, increased probability of lease renewals, and decreased tenant rent concessions."[25] Data collected, from 12,667 leases of nearly 300 commercial office buildings across North America for the period 2004 – 2013 shows that, in Canada:

- *Net Effective Rents* are 3.7 percent higher in LEED certified properties
- *Rent concessions* are 4 percent lower on average in green certified buildings than non-certified buildings
- *Lease Renewals* are 5.6 percent higher in green certified buildings
- *Occupancy rates* are 18.7 percent higher for buildings with both LEED and BOMA BESt certification
- *Tenant satisfaction* scores are 7 percent higher in green certified buildings
- *Utility consumption* of LEED buildings is 28 percent less energy consumed than non-certified buildings
- *Building HVAC performance* in LEED certified buildings out-performed in tenant satisfaction surveys across all 6 categories[26];

[22] See: http://www.cagbc.org/cagbcdocs/resources/CaGBC%20McGraw%20Hill%20Cdn%20Market%20Study.pdf

[23] Acadia Center (2014), Energy Efficiency Engine of Economic Growth in Canada. Download report: http://acadiacenter.org/wp-content/uploads/2014/11/ENEAcadiaCenter_EnergyEfficiencyEngineofEconomicGrowthinCanada_EN_FINAL_2014_1114.pdf

[24] TD Economics (May 12, 2015), The Market Benefits of 'Green' Condos in Toronto. Download: http://www.td.com/document/PDF/economics/special/GreenCondos.pdf

[25] Devine, Avis and Nils Kok. "Green Certification and Building Performance: Implications for Tangibles and Intangibles". Journal of Portfolio Management – Special Real Estate Issue 2015. See: http://www.iinews.com/site/pdfs/JPM_RE_2015_Kok.pdf.

[26] These are: heating, air circulation, air conditioning, HVAC performance outside business hours, summer humidity, and winter humidity, respectively. See: http://www.iinews.com/site/pdfs/JPM_RE_2015_Kok.pdf.

Analyzing tenant satisfaction surveys with rents and renewal rates is a strong indicator of the economic viability of green buildings. Beyond the immediate financial outlook of investing in green building however, new research has uncovered deeper returns on green buildings arising from a previously unconsidered source – the people occupying these spaces.

Green buildings boost the health, wellbeing, and productivity of occupants. Improved organizational productivity is an emerging value proposition for green building that is gaining significant attention. Considering people spend approximately 90 percent of their lives indoors, the ability of the indoor built environment to impact human health requires greater understanding.

Organizational productivity is defined as the ratio of the cost of inputs to output. Staff salaries and benefits typically account for approximately 90 percent of operating costs, leaving rent and utilities to comprise of only 10 percent of operating budgets.[27] Figure 15 illustrates how even marginal improvements to productivity can yield greater gains in business operations. As stated by the World Green Building Council's study on health, wellbeing and productivity: "modest improvements in employee health or productivity can have huge financial implication for employers – one that is many times larger than any other financial savings associated with an efficiently designed and operated building."[28]

Figure 15: The 10 percent variation rule on business operating costs

Source: Health, Wellbeing, & Productivity in Offices, World Green Building Council[29]

[27] *Ibid*

[28] See: http://www.worldgbc.org/files/6314/1152/0821/WorldGBC__Health_Wellbeing__productivity_Full_Report.pdf

[29] See: http://www.cagbc.org/cagbcdocs/resources/CaGBC%20McGraw%20Hill%20Cdn%20Market%20Study.pdf

This recommendation is corroborated by the joint research initiative undertaken by Harvard University's T.H Chan School of Public Health partnering with United Technologies Corporation, Syracuse University, and SUNY Upstate Medical University, who recently released empirical research on the cognitive function scores for occupants in 'green' buildings against conventional buildings. Controlling for volatile-organic-compounds (VOCs), carbon dioxide (CO2), and ventilation (air exchange rates), the study found that cognitive function scores of participants were significantly improved when working in green environments compared with conventional office spaces.[30] The findings reveal that overall performance was higher in all categories for day(s) spent in green buildings versus conventional buildings:

- **1 Day in Green Building vs. Conventional Building Conditions**
  - Cognitive Function: 61 percent higher on average in the green building;
  - Crisis Response: 97 percent higher scores in green building;
  - Information Usage: 172 percent higher scores in green building over conventional conditions
- **2+ Days in Green Building vs. Conventional Building Conditions**
  - Cognitive Function: 101 percent higher on average in the green building;
  - Crisis Response: 131 percent higher scores in green building;
  - Information Usage: 299 percent higher scores in green building over conventional conditions

This evidence demonstrates that a green building can contribute to improving worker health, mental wellbeing, energy levels, and overall productivity (see sidebar on Manitoba Hydro office building). While these studies have linked improved productivity levels to green buildings, more work is required to monetize the connection and quantify the impacts. Nevertheless, it is becoming clear to commercial property owners and managers that green building certification is a proven way to attract investors and tenants, as well as improve the environmental performance of their properties and occupant health.

[30] Allen, J.G., MacNaughton, P., Satish., et al. (2015). "Green buildings and cognitive functions," in *Environmental Health Perspectives*. National Institute of Environmental Health Sciences. Harvard T.H. Chan School of Public Health: Boston. (26 Oct 2015). http://ehp.niehs.nih.gov/wp-content/uploads/advpub/2015/10/ehp.1510037.acco.pdf.

Manitoba Hydro: A healthy and productive workplace

As a leader in energy efficiency and sustainability, Manitoba Hydro set out to design the most energy efficient and sustainable office tower in North America. Manitoba Hydro delivers one of the most successful demand management programs in North America – Power Smart – where customers are encouraged to maximize the utilization of energy efficient sustainable products while optimizing their quality of indoor comfort. Due to this, they felt it was critical that they demonstrate their commitment to energy efficiency and sustainability to their customers.

Manitoba Hydro Place was the first climatically-responsive office tower designed in Canada, with all aspects of the form and building components created with this as a key objective. Unique sustainable aspects include: one of the world's first double walls, with double glazing on the external wall of the system; the first indoor winter gardens in North America; podium green roofs that reduce air conditioning requirements by 25 percent; and a geothermal system consisting of 280 wells that taps natural energy stored in the earth to heat and cool the building.

Manitoba Hydro's 2,000 employees who work in the building have provided positive feedback on the natural light, excellent air quality and overall feelings of better health. On average there has been a significant drop in absenteeism of the employees in Manitoba Hydro Place as compared to other Manitoba Hydro facilities.

In terms of energy efficiency, Manitoba Hydro Place surpassed performance targets and is 70 percent more energy efficient than a typical office tower at an average energy intensity of 85kWh/m^2 (7.9kWh/ft^2). These energy savings equate to an annual savings of over $750,000.

Read more at: www.cagbc.org/manitobahydrospotlight

3. MARKET TRENDS & DRIVERS

The green building movement in Canada over the last two decades has seen a significant shift from being driven primarily by policy and regulation to more industry-driven market transformation. For example, in the commercial property sector, tenant demand and brand recognition are key drivers for LEED® building certification which in turn, results in economic benefits that include greater occupancy, higher rents, and lower operating costs. This section provides an overview of some of the leading trends and key industry drivers at the forefront of the green building market transformation in Canada.

3.1 Growth of Reporting, Benchmarking & Energy Labelling Initiatives

There has been growing demand from commercial building owners and private sector tenants with large portfolios (both on the demand and supply sides), for increased reporting of building performance data and related sustainability metrics – as well as benchmarking across building types for comparative purposes. Energy and greenhouse gas (GHG) emissions are measured and reported by many building owners, which has helped drive further performance improvements.

In the commercial sectors, some of the demand comes from real estate owners with investors to satisfy (e.g. pension funds), or to meet corporate social responsibility commitments. As LEED® expands outside North America as a global standard, this increasingly drives demand for measurement from multi-national companies who have to report sustainability efforts to their stakeholders and investors.

Real estate owners and property managers moreover, now take a portfolio view of their building assets from a risk management perspective in order to compare the performance of buildings next to one another, and to those of their competitors. GRESB, a global real estate sustainability benchmark provider, offers institutional investors a portfolio analysis of their financial investments in sustainability performance by evaluating the market position benefits of improving the environmental, social, and governance of their assets. GRESB's 2015 benchmark reports that Canada significantly outperforms the global and U.S. average in all categories based on participating portfolios which include 2,059 assets representing 39 million square meters of property valued at $96 billion USD.[31] With a total of 6,207 third-party green building certifications, Canadian GRESB participants hold an 11-point lead with an average score of 67 over the global average score of 56.[32] Despite these optimistic results however, the report found total energy consumption continues to grow in absolute terms with the building sector contributing 12 percent of Canada's overall GHG emissions even with a 25 percent improvement in economy-wide energy efficiency over the last two decades.[33]

The connection between building performance, energy use, GHG emissions and climate change policy is invoking greater transparency for energy reporting and benchmarking, which is slowly being integrated into policy.

Energy Benchmarking: Why is it important?

Energy benchmarking is the ongoing review of building energy consumption to determine if energy performance of a building is getting better or worse over time in comparison to other similar buildings in a portfolio and/or compared to peers and competitors. Benchmarking is essential to understanding building performance and is setting the stage for owners to strategically invest in improvements in operations, maintenance and/or retrofits. Normalized building performance data also provides consistent, transparent information on overall building performance assisting utilities and government to target programs, incentives and policies. Quality energy performance data can also assist in improving building energy models and designs, and hence over building performance.

[31] https://gresb-public.s3.amazonaws.com/content/Canada_Snapshot_2015.pdf

[32] *Ibid.*

[33] *Ibid.*

Since its launch in 2013, Natural Resources Canada's (NRCan) ENERGY STAR Portfolio Manager program is growing in popularity and is presently used to benchmark more than 13,000 buildings and 160 million square meters of existing floor space across Canada, equal to 25 percent of total applicable floor space for buildings that qualify to use the tool (see figure 16). ENERGY STAR Portfolio Manager has been expanding rapidly in Canada and globally, and is now being extended into the areas of water consumption and waste management. In the residential sector, the emergence of home energy labeling (tied to NRCan's EnerGuide label), is being used to help raise the profile of the value of energy efficient homes through greater consumer and industry awareness.

The CaGBC also has a longstanding interest and commitment to energy benchmarking. Between 2007 – 2013, the CaGBC's GREEN UP program was the first to pilot and advance energy assessment and benchmarking in Canada.Energy benchmarking is a key requirement of LEED EB:O&M, and energy reporting is a prerequisite for certified projects under LEED v4. While a growing proportion of building owners are beginning to track energy consumption, the ability to compare performance with similar buildings to determine the impact of investments remains a challenge.

Quality energy performance data can assist in improving building energy models and designs, and hence overall building performance. Proposed legislation to require commercial buildings to disclose their energy consumption data is emerging in Ontario and British Columbia, however, consistency across reporting regulations will require alignment. In response to this need, the CaGBC convened a working group of key industry associations and officials in 2015, to contribute to a national framework on energy benchmarking, reporting, and disclosure.[34]

Figure 16: Total buildings in NRCan's Portfolio Manager, December 2015

Source: Natural Resources Canada

[34] Please see: CaGBC National Energy Benchmarking Framework Working Group Summary Report, January 2016

Life-cycle assessment (LCA) approaches applied to products, assemblies and even whole buildings are gaining traction, and being adopted into assessment tools used by the industry. There is a significant amount of work underway to create inventories of lifecycle data for construction materials and products in the form of Environmental Product Declarations (EPDs). In Canada, industry sectors that export products to the EU (e.g. wood) have invested the most heavily in producing a range of EPDs. These industries also support organizations such as the Athena Sustainable Materials Institute as the repository of lifecycle information for Canada. LCA is making its way into North American green building rating systems, with the next version of LEED (version 4) incentivizing the use of products with EPDs and reduced environmental impacts.

Historically, LCA has not been top of mind for policy makers and designers because the operational impacts of buildings have vastly outweighed the embodied impacts of construction materials. However, as operational performance improves, embodied energy, GHG emissions, and other impacts become increasingly pronounced and require attention to reduce the environmental footprint of products and materials. As these efforts become more standard practice across Canada, they will allow for better comparisons and a deeper understanding for how buildings are performing to allow a focus on designing more effective programs and related efforts to reduce environmental impacts and save on operational costs.

3.2 Focus on Existing Buildings & Retro-Commissioning

While new construction is important, the biggest challenge and opportunity exists in the retrofit market, by making improvements to the existing building stock. As such, there has been a growing focus on the recommissioning and retro-commissioning of buildings as significant opportunities for reducing energy consumption and GHG emissions, creating healthier indoor building environments, and attracting and retaining tenants (see sidebar on WaterPark Place). Programs such as LEED EB:O&M and BOMA BESt are helping to drive activities in this space, particularly in the commercial office segment.

Some leading property owners have undertaken whole-building energy retrofits for their major commercial real estate in Canada. While the business case for large scale retrofits can present challenges given Canada's low-cost of energy, the economics are becoming easier to justify with rising electricity prices.

In addition, provincial building codes, municipal bylaws, and various incentive programs are emphasizing the retrofit opportunity for existing buildings. For example, the Toronto Atmospheric Fund's green loan program has helped to encourage energy efficiency retrofits in Ontario which has saved upwards of $20 million (over $2.7 million annually) in cumulative energy and maintenance costs.[35] Demand-side management programs and product / equipment rebates through provincial utilities has further improved market uptake.

Real estate owners and large property management companies are also focusing on building operations through engagement programs, helping to drive performance as a mechanism to add value and benefits for tenants. Leading property management firms promote sustainability and customer (tenant) engagement by developing internal green teams, providing better information sharing as well as financial and other incentives, and initiating collaboration with community stakeholders in order to get the right information into the hands of the right people. Many buildings already have programs in place where tenants can view real-time energy use, enabling them to make better informed decisions to reduce energy consumption bills.

[35] See: http://www.c40.org/case_studies/toronto%E2%80%99s-atmospheric-fund-makes-sustainability-affordable


Photo courtesy of Oxford Properties

Oxford Properties' WaterPark Place

In 2014 WaterPark Place became the first project in Canada to earn LEED® Platinum recertification, after first earning LEED Gold for Existing Buildings in 2012, and then LEED Platinum for Core & Shell Development in 2014. The goal was to re-establish WaterPark Place as a premiere commercial real estate destination in the downtown core of Canada's largest city, Toronto. Oxford Property Group's sustainability strategy involves using integrated building systems to manage energy savings and occupant comfort on a daily basis, while constantly revisiting their policies and execution in order to ensure that day-to-day operations match sustainability goals.

When considering recertification, Oxford felt that it made sense to continue to transform their green policies and operations, just as the physical buildings were about to be transformed as well. This also made financial sense for their customers– the plan to achieve new credits and earn recertification was projected to have a simple payback (in utility savings) of 1.5 to 2.5 years. The resulting LEED recertification was both environmentally and fiscally beneficial to Oxford Property and its tenants.

Read more at: www.cagbc.org/waterparkplacespotlight

3.3 Community-focused Design Supporting Health & Wellbeing

Trends toward urbanization, densification, better land-use policy, and a desire for more walkable, livable cities, are causing a shift in design thinking from the individual building scale to more community-focused design.

Land use planning and regulations are limiting the expansion of green field developments, resulting in greater intensification of existing developments. Higher density housing (multi-unit, duplexes, and row housing) has become the fastest growing segment of Canada's housing stock.

Many provincial governments have revised their building codes to allow for wood frame construction up to six-storeys, which has encouraged more mid-rise development in certain locations in Ontario, Quebec, and British Columbia. Mid-rise developments have been linked to supporting healthier lifestyles and local economies as it increases walkability and puts more people close to transit while supporting local businesses.[36] This trend is supported by a report by the Pembina Institute and the Royal Bank of Canada (RBC), which found that homebuyers are favouring walkable communities and more livable neighborhoods.[37]

Additionally, a study on health in urban centers showed that increased access to green spaces can have both cognitive and psychological benefits. The study found that having ten more trees on a city block, on average, improves health perceptions comparable to an increase in annual personal income of $10,000 or being seven years younger.[38]

[36] Ontario Home Builders' Association & Pembina Institute (2015): *Make Way for Mid-Rise* report. Download: https://www.pembina.org/reports/make-way-for-mid-rise.pdf

[37] http://www.pembina.org/reports/location-matters.pdf

[38] Source: http://www.washingtonpost.com/news/energy-environment/wp/2015/07/09/scientists-have-discovered-that-living-near-trees-is-good-for-your-health/

Photo courtesy of University of Toronto / City of Toronto

The Toronto Pan Am Sports Centre

Co-owned by the University of Toronto and the City of Toronto, the Toronto Pan Am Sports Centre is a hub of activity and collaboration for University of Toronto students, members of the community, and high performance athletes, underpinned by the shared value of a healthy, active lifestyle. As a legacy venue, the facility hosted a number of events during the Toronto 2015 Pan Am/Parapan Games.

Among its many sustainability features, the facility was designed and built to optimize energy performance, achieving a 40 per cent reduction in design energy cost over the reference building of the Model National Energy Code for Buildings (MNECB). The project also achieved a 37 percent water use reduction over baseline fixture performance requirements, and 100 percent of the facility's property irrigation demand is met using non-potable rainwater harvested by underground cisterns buried in various locations.

The building provides a brighter and healthier indoor environment for community members, as well as reduced maintenance requirements, which will allow the facility to remain high-performing well into the future.

Read more at:
www.cagbc.org/panamsportscentrespotlight

The benefits of community development are becoming increasingly important to investors. A recent study out of California found that "the mortgage default risk of buildings within a quarter mile of fixed-rail transit stations is reduced by 30 percent compared to other locations; properties with a Walk Score of 77 (out of 100) have a 13.5 percent lower default risk than properties with a Walk Score of 45; and Energy Star properties are 20 percent less likely to default than others".[39]

With these insights, it is not surprising that a growing number of certification and third-party standards tie community-scale initiatives and social wellbeing to green buildings, such as LEED Neighbourhood Development (ND), the WELL Standard, and the Living Building Challenge Petal certifications that have emerged in Canada.

WELL Building Standard

The WELL Building Standard is a new performance-based system for measuring, certifying and monitoring features that impact human health and wellbeing, through air, water, nourishment, light, fitness, comfort and mind. It complements other green building rating systems such as LEED. The Green Business Certification Inc. (GBCI) and the CaGBC have come together to promote and advance WELL in Canada.

Grounded on a body of medical research that explores the connection between buildings, where we spend more than 90 percent of our time, and the health and wellness of people in them – WELL measures attributes of the built environment by looking at seven concepts and over 100 features addressing behavior, design, and operations.

More information: http://www.wellcertified.com/

[39] http://capla.arizona.edu/sites/default/files/faculty_papers/Default%20Risk%20of%20Securitized%20Commercial%20Mortgages%20and%20Sustainability%20Features%2C%202015.pdf

3.4 Movement toward Net Zero Energy Buildings

According the US Department of Energy, a Zero Energy Ready Home, or "net zero" building, is a high performance building that has reached peak energy efficiency, allowing a renewable energy system to offset all or most of its annual energy consumption. Provinces including Alberta, British Columbia, and Saskatchewan have been leading the net zero energy push in Canada.

The Canadian market can anticipate greater opportunities for investing in net zero design and technology, as provincial climate change policies such as Ontario's recent climate change strategy, include net zero energy buildings as a goal. In designing with the goal of net zero, buildings are dramatically changing in shape and form underpinned by a greater focus on passive design features and building envelopes (including increased insulation, reduced glazing surfaces, and triple-paned glass).

What is Passive House?

Passive House is a voluntary building standard developed by the Passive House Institute (PHI) in Germany, and is composed of several strict performance requirements for operational, space heating and cooling energy demand and airtightness of building envelope.

The Passive House design strategy first looks to minimize the heating and cooling loads as much as possible through passive measures such as orientation, massing, insulation, heat recovery, passive use of solar energy, solar shading, elimination of thermal bridges, and incidental internal heat sources. Passive House certified buildings performance typically results in approximately 90 percent reduction in heating and cooling energy usage and up to a 75 percent reduction in primary energy usage from existing buildings.

Source:
http://nypassivehouse.org/what-is-passive-house/

The interest in Passive House certification[40] across the country is a good example. The Passive House program has trained over 500 Canadian builders, architects, engineers, tradespeople, planners, and homeowners in Passive House design and construction since 2010. Starting with single-family homes, the standard is now being applied to mid-rise residential and institutional projects in Canada.

Decreasing costs and improvements in the performance of solar photovoltaics (PV) technology over the last several years have taken net zero that much closer to reality. The intersection evolving between solar PV, home energy storage (batteries), and plug-in electric vehicles is one to watch as consumers are increasingly able to seek sustainable energy options along the pathway to net zero.

In Canada, building design and construction best practices are approaching the point where achieving net zero energy and/or carbon for new homes is technically viable, although the upfront extra costs (in the range of $40,000-$50,000) for the required features and technologies remain the greatest barrier to widespread market adoption.

In the context of emerging federal and provincial climate change policy and carbon pricing, net zero is a necessary target to reduce greenhouse gas emissions from the building sector. However, applied to larger or multiple buildings, the business case for net zero without connectivity to a carbon neutral district energy system can become challenging, given the need to build in redundancy to meet peak demands. While many high-performance buildings exist in Canada and the technology to achieve net zero has been initiated, achieving this target on a broader scale is still a few years away. It should also be noted that net zero energy and carbon targets need to be balanced with reducing other environmental impacts (e.g. water, waste) along with health and wellbeing of building occupants.

[40] Passive House is a design standard that originated in Europe and focuses on deep energy efficiency in the order of 90 percent more efficient than building code in some jurisdictions.

3.5 Lowering Construction Costs & Improving Affordability

One of the biggest challenges within the building industry is the growing cost of construction. In addition to the rising costs of land, materials, and labour - increasing fees and taxes affect the affordability of green home purchases and retrofits. Builders and developers, particularly in the residential sector, are stretched with capital costs and struggle to pass on the rising price of construction and/or added costs of better performance features to their customers. These challenges have placed lowering costs and improving affordability on par with the goal of building better homes that are equivalent to, or less than, the cost of conventional buildings. Working closer with government and stakeholders, leaders in the development industry are collaborating to improve energy performance, reduce construction and operational costs, and make homes more affordable for Canadians.

Some builders in Canada have started adopting new productivity-enhancing methods of construction, such as pre-fabrication and pre-assembly. These methods can expedite the construction process, deliver superior projects reliably, and reduce waste throughout the supply chain. Using computational design and assembly line labour and equipment, Canadian companies are beginning to shift activities to the factory floor. Modular homes and related building components that include roofing panels, wall assemblies, and floor systems, are now becoming commonplace. Processes and technologies that are likely to be used more prominently in the future include building information modelling (BIM), 3-D printing, and Lean Construction (see sidebar on CCA's Lean Centre of Innovation).

For the Canadian Construction Association (CCA) and leading construction firms in the non-residential sector, priority areas of focus are on improved processes, better use of resources and materials, and innovative technologies that can drive down both the upfront and the longer-term life cycle costs. The integrated design process (IDP) is gaining momentum as a streamlined approach to planning, design and construction phases. This process identifies creative solutions across architecture, engineering and construction, which has generated positive results in terms of advancing green building practices and delivering cost savings. Most recently, efforts at advancing the integrated project delivery (IPD) model in Canada are having growing success, as an efficient way to deliver a project at least cost.

CCA's Lean Centre of Innovation

The Canadian Construction Association (CCA) announced in June 2015, the establishment of its recently formed Lean Construction Institute – Canada (LCI-Canada) as a special committee of the CCA. LCI-Canada is committed to transforming the built environment through the development and application of lean tools and techniques throughout the building industry supply chain. This commitment begins with conversations and collaboration that includes all members of the industry – owners, designers, contractors, trades, and allied services within the complete supply chain.

LCI-Canada believes that the building industry needs to improve value delivered by capital projects while reducing waste. Deep application of lean principles throughout the industry including the definition of needs, design, construction, and operation of capital facilities will continuously improve industry value.

Read more: http://www.cca-acc.com/en/?option=com_content&view=article&id=984&Itemid=157&catid=187

4. CANADIAN STRENGTHS & COMPETITIVENESS

Canada's diverse geographic regions and relatively harsh climate has fostered expertise in developing well-constructed and durable buildings. Strengths exist in engineering and design, home construction, wood products and associated wood engineering design, and a range of energy-efficient / sustainable technologies and materials, highlighted in this section.

4.1 Areas of Canadian Strength, Capabilities and Competitiveness

Engineering, Architecture & Urban Design

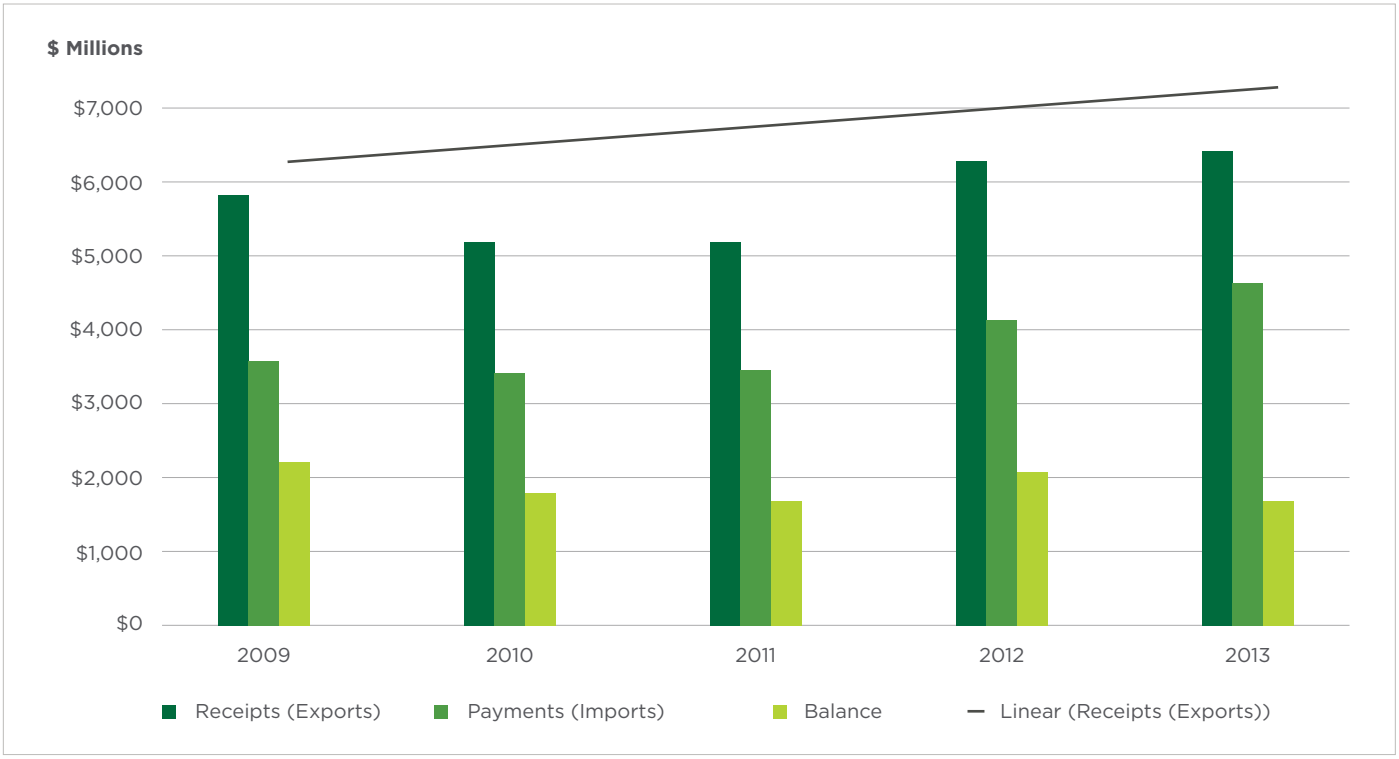
Canada is recognized for having a strong design and related professional services industry (engineering, architecture, planning, and community infrastructure). Yet, while there are many firms creating leading edge design at a provincial level, there are very few that have the capacity to operate at a national or international scale.

Canadian certified green building projects, such as TD Centre Tower, Manitoba Hydro, and Vancouver's Centre for Interactive Research on Sustainability (see sidebar), are globally renowned and attract international delegations who come to learn about specific systems, innovative materials and applications, and unique design features developed by Canadian designers, architects, and engineers.

International trade in architecture, engineering, and other technical services has shown a healthy trade balance and a growth in overall export receipts between 2009 and 2013 (see figure 17). Some Canadian leaders in sustainable building and community design are successfully exporting their knowledge and consulting expertise to other jurisdictions such as the United States, Asia, Europe, and Latin America.

Expertise in developing world-class building projects, as well as archetype buildings, has led to a better understanding of systems-based design in order to optimize performance. Canadian firms have expertise in air-tightness, building envelope design, and building science, due in part to the harsher climate. Canada's mechanical and electrical design community has made great strides in the effectiveness of how it specifies systems in order to improve and achieve performance of design.

Figure 17: International receipts and payments for architectural, engineering, and other technical services in Canada, 2009-2013



Source: Statistics Canada


Photo courtesy of the University of British Columbia

UBC's Centre for Interactive Research on Sustainability (CIRS)

The Centre for Interactive Research on Sustainability (CIRS) at the University of British Columbia was developed in response to the challenge of creating a more sustainable society. The building acts as a "living laboratory" where students, researchers and partners test and demonstrate designs and technologies to advance knowledge of sustainable building and community practices. CIRS was designed to be the most innovative and high performance building in North America at the time of its construction. Integrated building systems, comprehensively monitored and centrally controlled, are designed to meet four net-positive goals in energy, embodied carbon emissions, operational carbon emissions and water consumption.

Designed to promote research and innovation in sustainability, CIRS reduces UBC's carbon emissions, utilizes waste heat from a neighboring building, treats wastewater on-site and harvests rainwater for re-use in the building. Made primarily from wood, the building sequesters over 904 tonnes of carbon. The building envelope includes integrated renewable energy systems for electricity and hot water generation, and natural ventilation provides a means for cooling. The building massing and geometry allows for access to daylight and views in all occupied areas. The site and landscaping includes a rain garden, bioswales and green roof designed to address rain and stormwater runoff as part of the closed loop water strategy.

Read more at: www.cagbc.org/CIRSspotlight

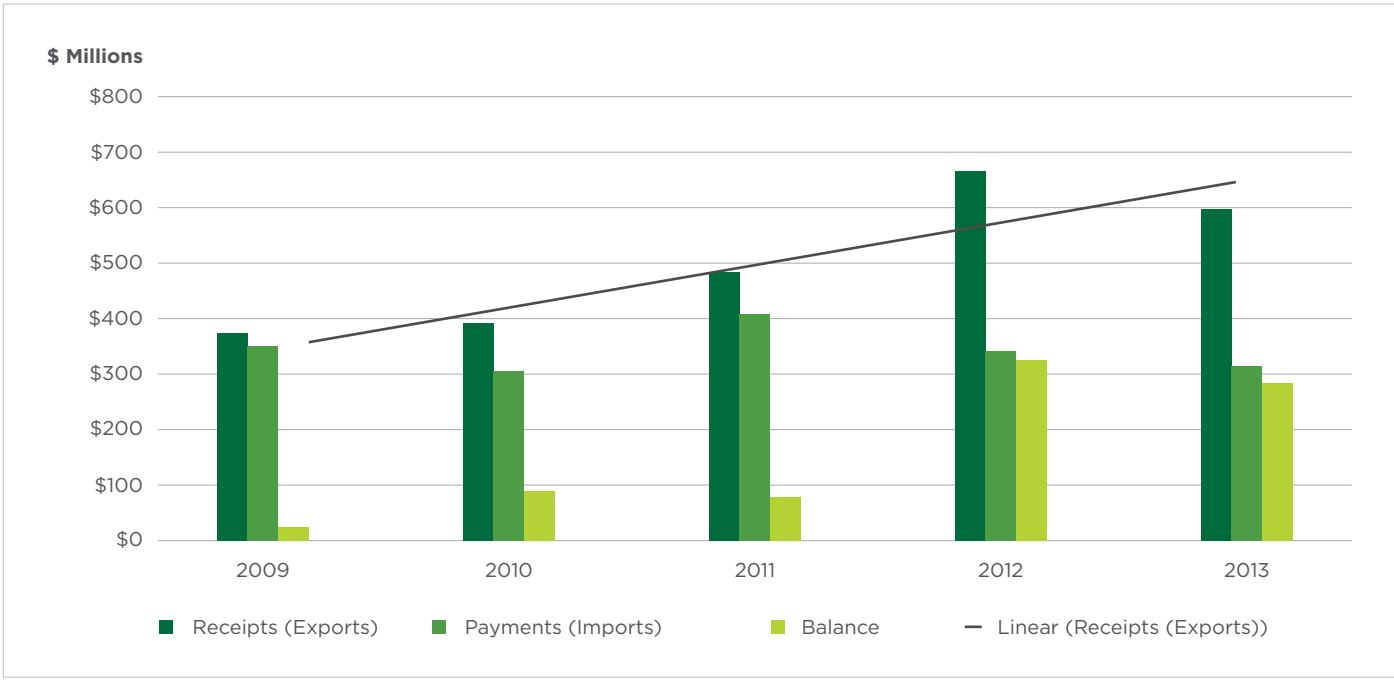
Canadians have demonstrated expertise in designing lighting, heating, ventilation and air conditioning (HVAC) systems that are as efficient as possible within the constraints of the building requirements. With respect to the building envelope, there is a strong knowledge of how to specify high-performance glazing, optimize insulation levels, and eliminate thermal-bridging (although these activities are not always put into practice based on current market demands).

Canada's expertise and knowledge in green building and planning has largely focused on new construction in cities as part of green field developments, with designers and planners working in locations such as Shanghai and Abu Dhabi. Further opportunities may exist to work on existing building projects and with city landscapes in places like Beijing and Mexico City.

Durable Home Construction

Trade in construction services has shown strong growth from 2009 to 2012, although it dipped marginally in 2013. Overall, this segment has shown a healthy and growing trade balance over that five-year period (see figure 18).

Figure 18: International receipts and payments for construction services in Canada, 2009-2013



Source: Statistics Canada

In the residential space, Canada is considered a North American leader in terms of durable home design and construction expertise. Similar to Northern Europe, Canada's harsher climate requires quality home construction as a necessity, and as such, houses tend to be much better built than in places with milder climates (e.g. the southern United States). Builders in the United States in particular, have looked at Canada as a leading model for home construction.

The R-2000 program, developed by Natural Resources Canada (NRCan) in partnership with the Canadian Home Builders' Association (CHBA), captured existing state-of-the-art cold-climate building science turning it into a voluntary standard with protocols that looked to exceed building code requirements for energy efficiency, indoor air quality, and environmental responsibility. Canadian companies have been successful in the past at exporting pre-fabricated R-2000 homes to countries that include the United Kingdom and Japan.

Home performance and house-as-a-system construction best practices are becoming more common among leading builders in Canada. These efforts are supported by industry organizations such as the Canadian Home Builders' Association (CHBA), which represents more than 8,500 small and medium-sized businesses in nine provinces across Canada, as well as the similar organization in Quebec, the Association des professionnels de la construction et de l'habitation du Quebec (APCHQ).

Canada is growing expertise in building pre-fabrication and related components and processes. Leading companies in this area are supported by industry organizations such as the Canadian Manufactured Housing Institute. The Northern Housing initiative by NRCan's CanmetEnergy Research Centre for example, is working on an experimental, potentially game-changing energy-efficient modular housing design. This design can be transported to more remote locations and northern communities in order to reduce the energy demand for homes and subsequently, the costs associated with importing expensive diesel fuel for heating.[41]

[41] See: http://www.nrcan.gc.ca/science/video/17167

While Canadian-built homes by leaders in the industry are durable and relatively energy efficient by North American standards, it should be noted that from an energy perspective, European home construction is generally considered to be further ahead in terms of passive design features and based on absolute energy consumption measures. This represents an opportunity for Canadian companies with expertise in green home construction and design to strengthen performance further, and in turn, develop exports of both products and expertise.

Wood Products & Engineering

Wood is considered a green building material due to its renewable nature and ability to sequester carbon, allowing it to score positively from a life cycle assessment (LCA) perspective. Canada is a global leader in conventional lumber products and construction, as well as in engineered wood products (e.g. cross-laminated timber) and related building.

Cross-laminated timber and other mass timber products are allowing designers to create a broader range of lower-impact structures. Recently for example, Canada set up design details to open up the multi-residential construction market in South Korea. There is also an uptake of innovative wood solutions across Europe, Asia, and the United States, including tall wood structures, innovative framed housing projects, and passive house projects.

Domestically, BC's forest industry accounts for 68 percent of GDP and 57 percent employment in the province, which has resulted in greater use of wood in buildings and is leading to the development of some of the most innovative structural wood design expertise in Canada amongst architects and structural engineers.[42]

Since 2009, when BC adopted its Wood First policy and six-storey building code allowance, more than 250 new mid-rise projects have been built across the province. Most notably, the University of British Columbia has proposed an 18-storey wooden tower with a minimum LEED Gold certification, making it the tallest of its kind in the world.[43]

An example of Canadian expertise is the recognition for excellence in wood design recently achieved by the Wood Innovation and Design Centre located on the University of Northern British Columbia's campus, which won the 2015 Wood Design Award (see figure 19).[44]

Figure 19: Wood Innovation and Design Centre at UNBC

Source: http://www.unbc.ca/engineering-graduate-program/wood-innovation-and-design-centre

Through its strategic investments in market diversification, the federal government and industry organizations such as Forest Products Association of Canada (FPAC), FP Innovations, and the Canadian Wood Council, have helped Canada's wood products sector export to a wider array of end markets and market segments.[45] Canada's expertise in wood-based construction has also in part, been driven by policies as well as building code changes, such as the six-storey wood frame code for multi-unit residential buildings (MURBs) now in place in several provinces across the country. Most recently, Quebec launched its 12-storey wood building construction guide. These investments have helped to enhance the overall competitiveness of Canada's wood and forest sector.[46]

[42] http://www.cofi.org/wp-content/uploads/2015/01/bc_industry_impact_01-2015.pdf

[43] See: http://www.bcbusiness.ca/natural-resources/can-bc-lead-the-world-in-building-tall-wood-towers and http://www.woodskyscrapers.com/blog/ubc-brock-commons-18-story-reciprocal-framed-hex-grid-v3

[44] See: http://www.unbc.ca/engineering-graduate-program/wood-innovation-and-design-centre

[45] See: http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/35173.pdf

[46] See: https://www.rbq.gouv.qc.ca/batiment/les-mesures-differentes-et-equivalentes/guide-du-bois.html

Cement & Concrete Technologies

In the past five years, the Canadian cement and concrete industry has begun introducing new products that aim to reduce the amount of GHG emissions associated with production, specifically to target green building certification programs such as LEED. These products are used mostly in Canada's major urban centres in Ontario, Quebec, British Columbia, and Alberta, where the majority of green building activity is occurring.

In 2011, a new category of cement called Portland-limestone cement (PLC) was launched in Canada. PLC has a lower carbon footprint and similar performance characteristics as compared to conventional Portland cement. It is now approved for use by the Canadian Standards Association (CSA), the National Building Code of Canada (NBCC), and the Ontario, Quebec, and BC building codes. Other examples of "green cement" include Nova Scotia-based CarbonCure Technologies which retrofits concrete plants with a technology that sequesters carbon dioxide to make a greener concrete product; and Contempra which reduces greenhouse gas emissions by 10 percent by substituting up to 15 percent limestone for regular clinker (the main ingredient in cement).

The proportion of "green" cement ranges from approximately 5-10 percent of total volumes sold in Canada. In urban centres such as BC's Lower Mainland, it can be as high as 60 percent, which is the highest in the country. The proportion of green ready-mix products (e.g. high fly-ash concrete) can be as much as 25 percent in urban centres, but low to non-existent outside these regions.

Research and innovative work in Canada continues in areas such as the development of recycled ("dis-aggregated") concrete and recyclable aggregates. The Canadian cement industry is also close to commercializing a new product called "Solidia" which offers a different chemical mechanism for making a concrete-like substance that can reduce the CO_2 emissions associated with production by 60 to 70 percent.

Energy & Other Green Building Technologies

Several Canadian companies are developing and exporting advanced green building and energy efficient technologies. Natural Resources Canada has been working closely and have partnered with international players, including the United States, in order to develop standards for sustainable technology systems that can be used in a broad range of climates and locales. These include heating technologies, renewable energy systems, energy management and building controls, and high-performance windows and building envelope technologies.

Heating Technologies

Due to Canada's cold-weather climate, expertise has been developed with respect to heating technologies. Buildings are increasingly integrating high-efficiency boilers, heat exchangers / heat and energy recovery ventilation systems (HRVs and ERVs), and variable refrigerant flow (VRF) systems (heat pumps), in some cases replacing their gas-fired rooftop units.

Canada also has specific expertise in the areas of:

- Drain-water heat recovery
- Combined space and water heating systems
- Cold-climate heat pumps
- Vaccuum insulated panels
- HRVs / ERVs and related components
- High-efficiency boilers

Drain Water Heat Recovery (DWHR) is a proven energy-saving technology, which typically reduces water heating energy consumption by 20 to 35 percent and total building energy usage by up to 10 percent.[47] Ontario is a market leader in manufacturing and supplying DWHR technology throughout the world, with tens of thousands of systems manufactured and installed to date and growing on an annual basis.

[47] See: http://www.chba.ca/uploads/TRC/May%202013/Cold%20Climate%20Air%20Source%20Heat%20Pumps%20Presentation%20-%20May%202013.pdf

A current project in Ontario involves the development and demonstration of cold climate air-source heat pumps in a number of Canadian climate regions. A leading company (Ecologix) and its industry partners are taking technologies developed for commercial applications and applying them at the residential scale. One phase of the project will also test the technology using natural refrigerants and explore the integration of solar energy. Successful demonstration of air-source heat pumps at the residential scale has the potential to be transformative within the heating, ventilation, and air conditioning (HVAC) industry.

Renewable Energy Technologies

Canada is developing expertise in renewable energy technologies and systems as they relate to green building, in particular solar PV, micro wind turbines, and geothermal / geo-exchange. Research in this space through groups such as CanmetEnergy and the Toronto and Region Conservation Authority (TRCA) is helping further Canadian expertise. The TRCA's partnership with the Building Industry and Land Development Association (BILD) to develop an Archetype Sustainable House at The Living Campus just north of Toronto is helping to demonstrate viable, sustainable housing solutions and is serving as a showcase for a range of green building technologies and materials.[48] In Ontario, the Feed-In-Tariff (FIT) program for example has had a largely positive effect on growth of key technology sectors in the renewable energy, energy storage, and smart grid space, particularly tied to solar PV.[49]

Energy Management & Building Controls

Despite the highly-competitive nature of the international market, some Canadian companies have been highly successful developing energy management related technologies, including building automation controls and ICT / software-based solutions. One example is Delta Controls that has gained approximately 25 percent of the North American market share.

High-performance Windows & Building Envelope

Canada has developed building envelope expertise that also translates into certain related technologies, including windows, doors, and insulated concrete forms (ICFs). While Canada generally lags behind European manufacturers of high-performance and Passive House certified windows and curtain wall, there are companies making highly-efficient fiber glass window and door frames which are being exported into the United States.

[48] See: http://www.sustainablehouse.ca/

[49] See: http://fit.powerauthority.on.ca/

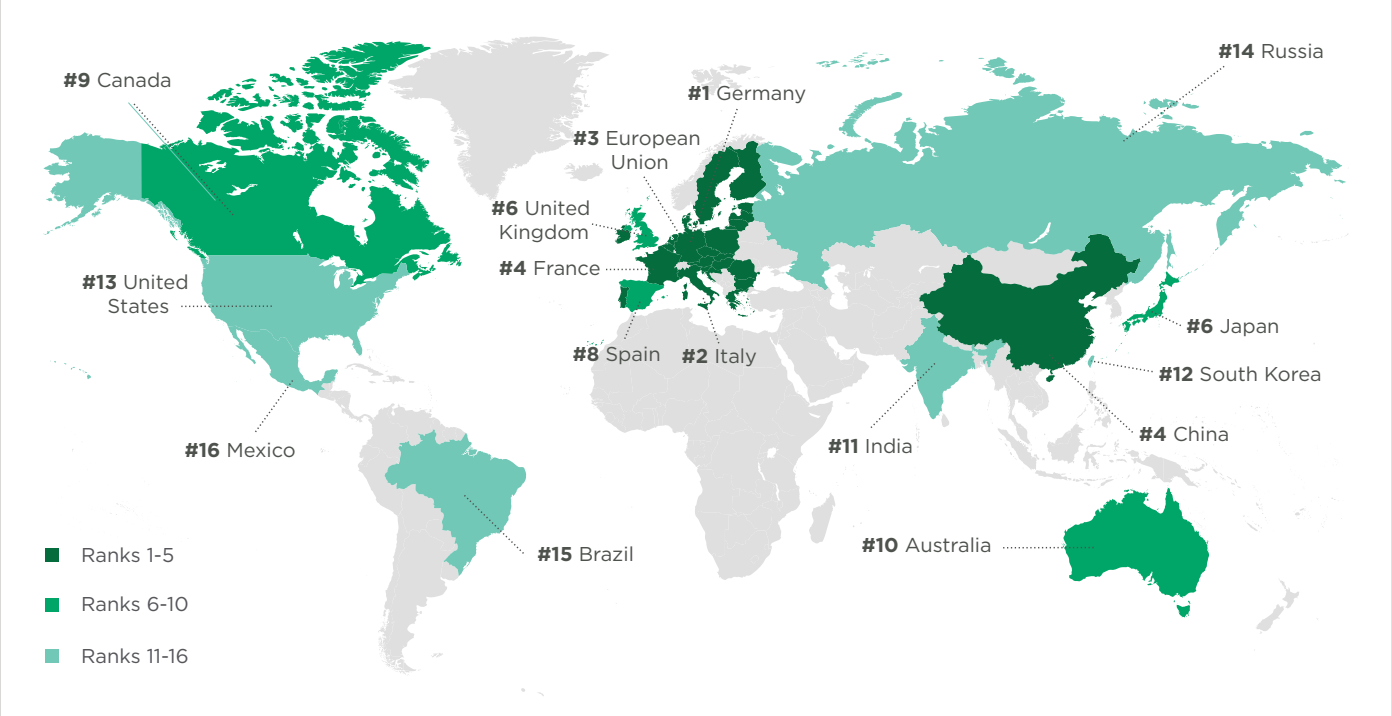
4.2 Global Competitiveness

The global green and sustainable building industry is forecast to grow at an annual rate of 23 percent between 2014 and 2017.[50] Many countries around the world are actively supporting and investing in their green building sectors, knowing that developing domestic leadership can help to position them for greater economic development, job creation, and for capitalizing on the export market growth opportunities.

On the strength of certain niche technologies, innovative standards, and leading-edge research, Canada has had some success in the green building space despite stiff competition from Europe, Asia, and the United States. Canada is already a global leader with respect to the LEED green building certification programs, having placed first (not including the United States) for the last two years on the U.S. Green Building Council's Top 10 Country ranking in terms of the total gross square meters of LEED certified commercial and institutional space.[51]

At the same time, Canada ranks ninth out of 16 countries on the American Council for Energy-Efficient Economy's (ACEEE) International Energy Efficiency Scorecard[52], suggesting it could be doing better (see figure 20). The scorecard is based on measuring the national, building, industry and transportation sector policies and programs focused on improving energy efficiency. Canada's rank diminishes from poor scores in industry and transportation, where manufacturing research to improve energy efficiency is low, and the number of vehicle miles traveled per capita is in the top two for countries analyzed.

Figure 20: Canada's ranking on ACEEE's 2014 International Energy Efficiency Scorecard



Source: ACEEE http://aceee.org/portal/national-policy/international-scorecard [52]

[50] Dodge SmartMarket Report. See: http://construction.com/about-us/press/world-green-building-trends-smartmarket-report.asp

[51] See: https://www.cagbc.org/News/EN/2015/20150722_News_Release.aspx

[52] The *International Energy Efficiency Scorecard* ranks the world's 16 largest economies on their energy efficiency policies and programs in four different categories, including buildings, industry, transportation, and national policies. Thirty-one different energy efficiency indicators have been analyzed for each economy ranked in the report.

[53] http://aceee.org/portal/national-policy/international-scorecard

More specifically as it relates to buildings, Canada trails China, Germany, France, and the EU, but ranks comparatively to Australia and Spain (see figure 21).

Europe is further ahead in terms of using passive design in common practice and is moving towards incorporating the Passive House standard into EU building regulations starting in 2016. Germany and Switzerland are aggressive in terms of the amount of money invested in research programs to support green building innovation, technologies, and processes. On account of a history of equipment-focused incentive programs, Canada tends to focus more on HVAC equipment and mechanical systems rather than designing the most energy efficient building envelope.

While expertise in energy efficiency practices and technologies related to the colder-climate challenge has developed in Canada, the relatively inexpensive cost for energy and electricity has somewhat lowered the impetus for action and consumer demand. This is compared to Europe and other jurisdictions where energy prices are relatively higher driving market demand and industry development. As a result, Canadian companies tend not to export their energy-saving technologies and green building services to Europe but focus on markets where they have a competitive advantage. These include the United States, certain countries in Asia, and Latin America.

Figure 21: Building sector scores by country

	Total buildings score	Energy intensity in residential buildings	Energy intensity in commercial buildings	Residential building codes	Commercial building codes	Building labeling	Appliance and equipment standards	Appliance and equipment labeling	Building retrofit policy
China	14	4	4	2	2	1	4	2	0
Germany	17	1	2	3	3	2	2	2	2
EU	16	1	2	3	3	2	2	2	1
France	16	1	1	3	3	2	2	2	2
Australia	15	2	0	3	3	2	2	2	1
Canada	15	2	2	2	2	0	5	1	1
Spain	15	2	0	3	3	2	2	2	1
UK	14	0	2	3	3	2	2	2	0
USA	14	2	1	2	2	0	5	1	1
Italy	13	1	0	3	2	2	2	2	1
Japan	13	2	0	2	3	1	2	2	1
Mexico	13	4	4	0	1	0	3	1	0
India	12	3	4	0	2	0	0	2	1
South Korea	12	0	1	3	3	0	3	2	0
Brazil	10	4	3	0	0	0	1	2	0
Russia	6	0	1	1	1	1	0	1	1

Source: ACEEE, 2014 International Energy Efficiency Scorecard

Canada has historically been an exporter of commodity-based natural resources rather than value-added products, technologies, and services – although this has been shifting in recent years, with the development of the domestic engineered wood product industry (particularly in BC and Quebec) and an assortment of advanced technology firms as examples.

Low domestic market adoption within certain building asset classes and in some provinces is still an issue, in part because the policies and regulations in those provinces do not adequately support green building. The diversity of different policies across the country can also mean that while some provinces are adopting green building faster than others, there is disincentive for firms to expand outside their local area. As such, few Canadian green building firms compete internationally. Furthermore, due to the highly competitive and increasingly consolidated nature of the global green building industry - where large, multi-national firms tend to dominate, it is becoming more difficult for Canadian companies across sectors to compete.

In addition, a lack of federal supporting policies and programs (including investment in R&D) impose barriers to domestic growth. Nominal investment in R&D and innovative technology and product development, means that from a competitiveness and export perspective, Canada ranks only slightly above the global average in terms of its green building industry's competitive positioning.

While programs such as LEED v4 encourage local products, there is a shortage of availability for certain products within Canada. Buyers for building technology and services are looking for the best in the world, not necessarily those aligning with domestic strengths representing the best in Canada. Building construction however, remains a largely local endeavor and as such, the opportunity to foster and leverage Canada's domestic capabilities comes from within. Investment within Canadian expertise in turn, will allow for innovation that can then be exported at the international level.

Although many of these challenges are perhaps the consequences of a lack of leadership on climate change, this trend may be shifting with the introduction of new climate policies from the provinces and the federal outcomes of the COP 21 climate change summit in Paris.

Canada has an enormous opportunity to further grow its green building sector, enhance its reputation as an international leader, grow its global market share, and further seize the strategic investment, job creation, and export opportunities available particularly in areas of existing strength. At present, industry is largely focused on internal competition whereas the sector must think opportunistically and collaboratively in order to compete internationally. In addition, an overarching federal government strategy, supported by industry and across all levels of government that involves investing in R&D, innovation, supportive policy frameworks, and industry development would substantially leverage Canadian products and expertise on the international arena.

5. OPPORTUNITIES FOR ACCELERATING INDUSTRY GROWTH

As underscored in this report, improving the environmental performance of Canada's building stock through green building best practices has considerable benefits for growing the economy and creating jobs, while also raising Canada's global leadership position. Accelerating the market transition in order to realize the full benefits will require addressing existing gaps and pursuing key opportunities. Some of the gaps and opportunity areas identified as part of the research for this study are outlined here.

5.1 Supporting Research & Innovation

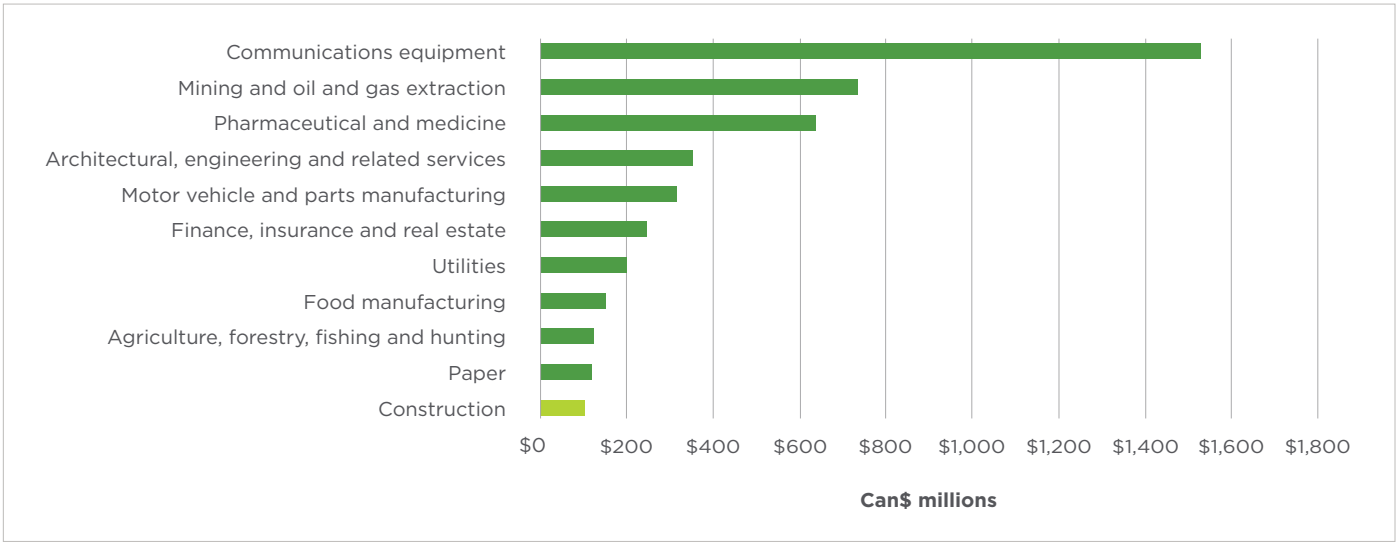
As referenced in the previous section, Canada has developed strengths in the research, development, and deployment (RD&D) of innovative products, processes, and standards that are evident in the leading edge green buildings and communities throughout Canada. However, the challenge has often come from the lack of impetus to scale up and sustain these innovations into the broader market and capitalize on the opportunities.

The construction sector in general (particularly in North America), has a poor record for investing in research and development (R&D). In Canada, construction ranks at the bottom of all industries in terms of its R&D expenditures (see figure 22). Productivity levels have also suffered due to the lack of innovation over time. Not only does construction lag behind other sectors in Canada, but when compared against international competitors, Canada ranks quite low and the amount of R&D investment in construction has been stagnant since 2001.

In the United Kingdom for example, the construction industry has rallied around innovation and developed its Construction 2025 Strategy and related action plan for improving performance within the industry at a national level.[54] Industry in Canada is beginning to recognize the issues stemming from a lack of investment in innovation as it relates to productivity, profitability, competitiveness, and workforce recruitment and skill development. As such, initiatives are underway to address some of the challenges. Efforts by the Canadian Construction Association through Canadian Construction Innovations (CCI)[55] and activities at the provincial level are now underway to instill innovation into construction practices.

At present, innovation in Canada is driven primarily by leading architects, engineers, designers, builders, and technology developers, as well as a number of academics and researchers, who are rethinking the processes used to build buildings. The advancement of green building programs such as Living Building Challenge and LEED continue to push the innovation agenda. These programs are driving the conversation beyond simply energy and water efficiency towards the full suite of long-term life cycle impacts of products, assemblies, and whole buildings, many of which are still largely ignored outside.

Figure 22: Canadian industrial intramural R&D expenditures - manufacturing industries (2012 estimates)



Source: Statistics Canada

[54] See: https://www.gov.uk/government/publications/construction-2025-strategy

[55] See: http://www.ccinnovations.ca/about-us/

Governments play an important role supporting green building technologies and approaches. While some support does exist from federal agencies, such as the National Research Council (NRC) and Natural Resources Canada (NRCan), as well as various municipal governments (see sidebar on the BRE Innovation Park as an example) - the potential exists for greater federal and provincial support for green building on research and innovation agendas that focuses on economic and export development.

For example, at times internal conflicts arise between green building and municipal departments due to differing priorities, As such, there can be contradictory or competing bylaws, policy that is not streamlined or cohesive, and a lack of knowledge and skills to understand and support changes on the ground.

The opportunity to introduce pilot projects in the green building sector provides a productive ground for municipal governments to pursue innovation. For example, the City of Vancouver's Green and Digital Demonstration Program allows selected participants in the program to gain temporary access to City-owned assets (e.g. buildings, streets, and vehicles) for technology demonstrations and proof-of-concept trials.[56] To celebrate success, Vancouver has also launched an Urban Design award to recognize "projects that demonstrate visionary thinking and support design excellence in Vancouver".[57]

The challenge of integrating innovation into industry is compounded by approvals required for advanced technologies, as well as overcoming industry and government aversion to risk. Reforming regulations in certain areas that are stifling innovation is important to encourage market transformation. For example, the only way to effectively get to net zero energy is to integrate onsite renewables with high-performance building design, which requires utilities allowing for this to occur. Opportunities to establish green building commercialization centres and innovation networks exist which can be leveraged to pilot innovative policies and partnerships such as the Toronto and Region Conservation Authority's proposed BRE Innovation Park, the Living City Campus.

There is potential to integrate practices such as circular economy, cradle-to-cradle, and biomimicry concepts to optimize resources and minimize waste. Designing policies and/or incentives that support industry players (i.e. developers, designers, builders) when they are introducing new processes or developing low-impact products would help to provide the innovation safety net needed for universities and organizations with a mandate to experiment. Since the private sector is not currently primed for innovation due to the difficulties to reconcile failures with respect to their investments in real estate. It is especially important for government at all levels to support local businesses in advancing technology, innovative processes and the adoption of domestic technologies, to contribute to growing expertise in Canada.

[56] See: http://www.vancouvereconomic.com/gddp/

[57] See: http://vancouver.ca/home-property-development/urban-design-awards.aspx


Source: Toronto and Region Conservation Authority (TRCA)

BRE Innovation Park

Part of the Toronto and Region Conservation Authority's Living City Campus, the primary aim of the proposed BRE Innovation Park is to provide a platform for the construction industry to demonstrate innovative solutions to achieve low carbon buildings and sustainable neighbourhood development, as well as to provide government and industry with data on capital costs, skills gaps, and carbon savings.

Canada has the resources and ideas but the platform to showcase these in many cases is missing; the BRE Innovation Park is designed to help bridge the gaps. Members will be able to showcase their most innovative products on site, with an added benefit of testing, monitoring, and even certifying products and technologies for the market.

The Innovation Park will assist in fostering the Canadian sustainable building supply chain, and connects to the global network of Innovation Parks. Supply chains refer not only to the manufacturing of products and technologies, but also the related services, including designers / architects, engineers, real estate agents, financial services, and certification provides who are all involved in the construction industry.

The BRE Innovation Park in Ontario facilitates partnerships between Canadian organizations on new innovation, enabling developers, manufacturers, architects, and pioneering ideas to charge the future proof of the Canadian built environment. Many universities from across Ontario are conducting research in the Innovation Park, but the goal is to invite other universities and institutions from across Canada to participate and transform it into an international showcase.

Read more: https://www.thelivingcitycampus.com/bre-innovation-park

5.2 Design versus Performance

While performance of green buildings in Canada has improved over the past several years, there often remains a tradeoff between market demand related to building aesthetics and form versus function and performance. The traditional segregation of the design, engineering and construction of buildings tends to relegate operation as an afterthought, especially since this does not typically fall into the area of expertise or responsibility of project development. Outsourcing the inclusion of "green" components in project design, is an approach taken by well-meaning architects that often misses the opportunity for considering the building as a more holistic operating system through the integrated design process, which is followed by green building rating systems like LEED.

Research has shown that, on average, LEED certified buildings use 25 percent less energy than conventional counterparts.[58] Yet, many certified green buildings are not meeting energy performance expectations. This performance gap is both a building design and modeling issue, as well as an operational problem as there is a disconnection between the two groups.

Energy modelling is typically used to demonstrate code compliance by determining how a building would perform in comparison to a minimally code compliant building. An effective energy modelling process is iterative, in that it uses compliance modelling as a step towards informing design options and decisions. Predicting the end performance of occupancy and including this into the model improves the level of accuracy of energy models. However, when energy modelling is not used with the intention to consider design options and building occupancy, the results may not accurately predict building performance. Ensuring the accuracy between predicted and actual energy performance is a growing concern for builders with contracts increasingly including penalties for not meeting performance requirements.

A shift in standards such as LEED v4 to require the reporting of operational data for longer periods post-certification on the energy side, as well as the inclusion of passive design features and standards such as Passive House, which are having positive impacts on overall performance. Standardization of energy modeling in Canada, as well as the supportive training for modelers however, is also required upfront.

At the same time, the operational aspect of meeting performance requirements means that building operators must know how to manage increasingly complex technologies and building automation systems. This requires training operators to properly understand these new systems (more on training later in this chapter), as well as commission and ongoing / retro-commissioning to properly achieve performance targets.

Results from consultations conducted for this report suggest that the traditional approach of measure-driven energy efficiency is limited in its ability to deliver deep energy savings in buildings. Increasingly, a focus on data-driven analytics allows for greater insights and intelligent decisions to be made based on energy metrics. Building owners and managers are then able to use a range of products, software solutions, and suppliers to find the savings through data-driven analysis and set specific targets.

[58] Based on a post-occupancy of evaluation of 100 LEED certified green buildings in Canada by the NRC in 2012.

5.3 Asset Planning & Adoption of Sustainable Materials

There exists a need for improvement in building maintenance across Canada's existing building portfolio. A great deal of energy savings can be achieved for little to no capital cost based on changing the operation of fans, temperature set-points, and undertaking other low-cost initiatives. Regular preventative maintenance on equipment, filter changes, sensor calibrations, and re-commissioning can also help in this regard. Making good decisions in a strategic, proactive fashion can help lower overall costs and avoid issues with repairs and equipment failures.

Ensuring effective long-term asset planning requires considering the full life cycle of products and materials that are being used in buildings. This involves greater consideration toward using more durable and sustainable materials in construction. However, whole building LCAs requires significant data and involves more work from designers. While tools and methodologies exist, the design community lacks motivation (from policies or owners) to incorporate LCAs early enough in the design stage and quickly enough that they actually inform material choices, as opposed to this being a compliance task at the end of the design process. Developing supportive policy to enable and facilitate the incorporation of LCA early on in the design stage will help accelerate the transition to more sustainable materials use in Canada.[59]

Canada needs to invest in developing more durable buildings in order to continue reaping the advantages from investments and the resources they represent. Focusing on ensuring a durable building envelope that can be easily maintained and replaced for example, must ensure adaptability to allow for changes over time. Buildings should be able to accommodate multiple usages and must be able to adapt to new, more efficient technology.

There is also room for greater conversations around materials, resource efficiency, and the circular economy. This includes a growing need to codify and measure restorative projects (including embodied footprint of buildings and capturing the value of stored carbon in products as examples). There are multiple impacts (eutrophication, smog, acid rain, etc.) that are measured and tracked by Environmental Product Declarations (EPDs) and used for life cycle assessment (LCA) calculations, which are expected to become increasingly important considerations as part of the design process.

LEED v4 is helping to move the market in this direction, by incorporating LCA and EPDs further into its system. Providing grants to Canadian product manufacturers to support the required documentation process related to emerging certification standards and EPDs, for example, could assist them compete more effectively with international players.

[59] For example, the Flemish government is plotting a Materials Awareness Policy and the "Environmental Performance of Materials used in Building Elements" method. Source: www.ovam.be/sites/default/files/2014-DEF-Milieuverantwoord-milieugebruik-bouw-3luik-LR.pdf

5.4 Industry Training & Ongoing Education

Continued green building growth requires professional expertise and a better trained workforce. As the building process has evolved to become more collaborative and the boundaries between traditional disciplines in design and construction begin to blur, there is an increasing demand for more inter-disciplinary, systems-based expertise. The constant evolution of practice, advancement of technology, and policy and code changes also result in the need for continuous education and training.

Research in 2012 by the BC Institute of Technology (BCIT), British Columbia's largest educational institution for construction trades training, identified approximately 20 learning outcomes related to green building that are currently missing from the training curricula of most construction trades in Canada. For some trades such as plumbing and electricians, the number of missing learning outcomes added up to more than 50. What is currently lacking is a multi-pronged approach to training that supports all of the different programs to help the construction industry understand, design, and build greener buildings. While it is often difficult to influence the broader public demand for green buildings, targeting industry with effective training in order to make green building common practice may be a solution.

Educational needs extend beyond practitioners to regulators including building officials and inspectors. Energy efficiency and building performance is typically beyond the realm of building inspectors who are often more focused on health and safety issues. Building code interpretations can be challenging for building inspectors who will usually only allow the explicit technologies and solutions described in the building code and may not be knowledgeable on newly developed or higher performing solutions as they relate to green buildings.

Simultaneously, the need for education and training is running up against demographic realities and skilled labour shortages. According to BuildForce Canada, the residential construction industry alone will need more than 129,000 new skilled workers over the next decade.[60] The constant balance of labour demand versus supply may create significant challenges within the workforce for delivering better performing, green buildings. That being said, the need to replace the aging Canadian work force with new recruits is an ideal opportunity to infuse innovation and emerging concepts into new and existing educational and training programs, consider new formats for curriculum delivery, and integrate stronger requirements and standards for training.

This requires effective training programs, incentives and regulatory frameworks to drive industry demand for training, as well as education, business support and resources around the value of green building processes and technologies. Also needed is training to effectively communicate and demonstrate to customers the benefits between conventional building and green building best practices (i.e., the educational sales process). Support through structured internship, mentorship, or apprenticeship programs for building operators presents some opportunities. Property management companies have taken initiatives to develop their own "apprenticeship" programs for young technical staff as opposed to trying to re-educate traditional operators who have advanced from managing janitorial services. Investing in education and training, as well as the policy, regulatory, and incentive frameworks to support uptake of skills development and ongoing learning will be essential to success moving forward.

[60] BuildForce Canada press release (April 27, 2015): http://www.buildforce.ca/en/media/press-release/new-residential-report-shows-need-more-129000-skilled-workers

An additional challenge in this area is the lack of affiliation to established organizations (e.g. industry associations, utility programs, etc.). This somewhat unreachable segment in Canada's construction industry is often satisfied with the status quo. The challenges are further compounded from the lack of incentives to pursue training and ongoing professional development, as well as existing requirements for industry to undertake compulsory training within the vast majority of construction trades in Canada. In some cases, the comprehensive training programs and recognized credentials for occupations that include building operators and home performance contractors simply do not exist.

In the case of building operators, the evolution of "smart" and connected buildings means that they are essentially becoming sophisticated computers. Currently, there is a lack of qualified building operators possessing a hybrid skillset which includes experience on mechanical and operational building maintenance, as well as the ability to manage emerging building ICT and software systems. Consequently, there is often disconnects between ideas and practice, as well as design and performance. Although BOMA has been working with a number of organizations to address the training challenge for operators, a key issue is that no nationally recognized credential exists in this realm, which means that the quality and number of skilled and available operators can vary considerably by province.

5.5 Supportive Policy & Incentives

Green building remains very much a top tier practice and is not reaching market penetration throughout the mid-lower asset classes. At present, financial incentives are not strong enough to drive the mass market transformation. The multi-unit residential segment is a particular area that requires greater attention across Canada through legislation, changes to building codes, and a range of incentive and financing options.

Presently, codes and policies are too prescriptive with respect to technologies. Instead, introducing performance targets may be more effective as they allow for optimal solutions to be found for individual projects. However, opportunities to recognize builders and developers that go beyond code and standards may benefit from financial (e.g. rebates) and non-financial incentives (e.g., an accelerated permitting process).

On the incentives side, a range of tools and program options exist – including tax breaks, grants, and rebates. Incentive programs, when designed effectively, are important for encouraging the early adoption of green building related initiatives, as well as for long-term market transformation. Traditional financial incentives seek to lower upfront costs and shorten the payback periods for energy efficiency upgrades. These programs typically deal with the existing stock of products / services in a building, yet few incentives have taken holistic views of the building fabric and how products / services fit in. There is also lack of financial incentives to support entrepreneurs and businesses in taking on the added costs and risks of developing new technologies and products.

Long-term thinking is the key to achieving market transformation. The ebb and flow of incentive programs can create industry instability when financial support dries up unexpectedly. This was the case in Canada's home energy efficiency retrofit market in several provinces following the termination of the federal ecoENERGY program and various provincial rebate programs. The Green Municipal Fund administered by the Federation of Canadian Municipalities is a successful example of how the federal government is supporting green municipal infrastructure development by establishing funds and programs administered by a third-party over longer periods of time.

On the regulatory side, strengthening the building code is often the best tool available. Many cities and provinces in Canada are already following this path, as outlined in previous sections of this report. There are some jurisdictions outside of Canada that are moving very aggressively with their code changes, including California and Massachusetts. At an international level, the European Union issued a Directive in 2012 mandating all buildings built in EU countries after December 31, 2012, to be "near-zero" energy.

Additional code considerations might include requiring retrofitting and/or energy audits for renovations, as well as mandatory labelling, which could help to drive market transformation. It is important that the building codes advance in a way that the market and industry can achieve upcoming requirements that evolve over time.

Carbon pricing is another policy mechanism that may help to influence market behavior from large portfolio holders in the institutional and commercial sectors. For businesses, a consistent price on carbon through a cap-and-trade system and/or a carbon tax can provide the policy direction to drive investment toward energy efficient operations and renewable energy and energy efficient technology, further enhancing building performance.

Closing the gap between the market leaders who have embraced green building and the bulk of the building industry will require new approaches to achieve success. The Canada Green Building Council and other industry associations recognize that market transformation relies on working collaboratively with stakeholders and policy makers to develop recommendations that support industry innovation and adoption of green building practices and policies.

Emerging energy benchmarking and reporting legislation in the provinces of Ontario and British Columbia is a good example of leadership in this space. Consistent energy benchmarking is critical to improving building performance as it helps to establish a set of reliable data on by type, region, age, and other factors which can help to move the market forward. However, a piecemeal approach to policy would ultimately make it more difficult for industry to meet jurisdictional requirements and diminish the likelihood of collecting meaningful data. In response to a need to optimize effective policy, the CaGBC convened a working group in 2015 with industry and government representatives to develop sound recommendations for a national energy benchmarking framework which will be published in a white paper in 2016.

6. CONCLUSIONS

As this report highlights, green buildings in Canada are not only a pathway to lowering environmental impacts but are also an engine of economic growth. Findings from this study show that the green building industry in Canada has experienced tremendous growth over the last decade, employing more than 297,890 direct full-time workers and generating over $23.45 billion in GDP.

The green building industry in Canada over the last two decades has seen a significant shift from being driven primarily by policy and regulation to more industry-driven market transformation. Certification programs continue to grow in terms of their market penetration as the business case for green building becomes more widely understood and accepted.

In the commercial property sector for example, economic benefits that are key drivers for LEED building certification include greater occupancy, higher rents, and lower operating costs. Analysis for this study shows how LEED certified buildings in Canada, on average, provide net savings of approximately $294.31 per square meter over their economic life time for building owners / occupants, based on the average energy, water, waste disposal, and operational (O&M) savings.

In addition, leading companies across the value chain are seizing business opportunities, both domestically and internationally, where Canada has developed strengths in sectors that include engineering, design, and architecture, home construction, engineered wood products, and energy efficient technologies.

Despite strong market uptake of LEED and a handful of other green building certification programs in Canada across certain asset classes, a large percentage of buildings continue to be constructed without using green building practices or third-party certification. For example, the market penetration for LEED certified floor space in the commercial sector was an estimated 22 percent of the total new commercial floor space added in 2014. Building codes and municipal bylaws in provinces such as Ontario that support the residential sector, have introduced EnerGuide 80 as the standard for new construction and the ENERGY STAR program which has achieved certification of 32 percent of all eligible homes in 2014. Despite these improvements, Canada could be doing better.

The existing building and housing market remains the greatest untapped opportunity for economic development and job creation. BOMA BESt, for example, certified less than 2 percent of eligible existing floor space in Canada in 2014. The residential sector, both the multi-unit segment (condos and rentals) as well as Part 9 (single-family homes, duplexes, and townhouses), is particularly challenged by its fragmented nature and numerous small players. Builders stress the importance of consumer demand for green homes, but to move this market Canada will need a combination of incentives, financing and regulatory approaches.

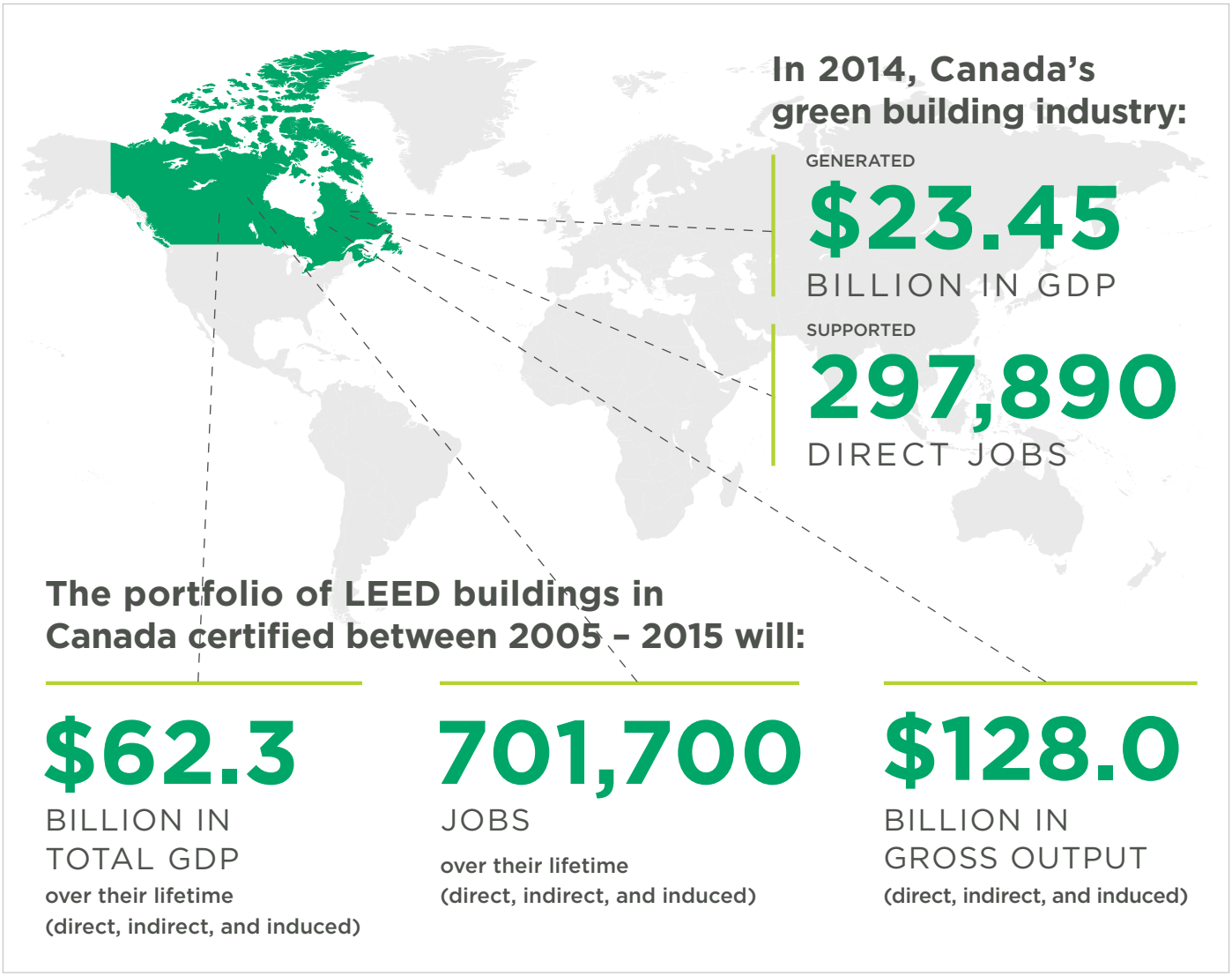
Financial barriers must also be addressed. Presently, financing projects is primarily based on the upfront valuation of the asset, whereas the economic benefit of green building occurs over the life cycle. This represents a significant challenge with respect to how the market values building assets. Innovative financing methods and mechanisms, as well as well-structured incentives, will be required to address these issues, as will improved metrics for asset valuation that recognizes life cycle financing.

From an international green building policy and performance perspective, Canada is sitting somewhere in the middle. Climate change and the related business opportunities that come from embracing the transition to a low-carbon economy is catalyzing action in many countries around the world, including China and the United States, Canada's two largest trading partners.

According to the Climate Change Index Report, Canada barely misses last spot in terms of global climate performance rankings, placing 58th out of a possible 61 slots.[61] Given that 30 percent of Canada's GHG emissions come from the built environment, the opportunity for making cost-effective measures to building improvements through the adoption of green building best practices is considerable.

Whereas Canada previously lacked an overarching vision and clear direction from the federal government supporting growth of the green building industry, the recent national and provincial focus on climate change promises to introduce sector-based approaches to achieve emission reduction targets through cap-and-trade, carbon taxes, investment in renewables, energy benchmarking policies, for example, noting that harmonization across standards is critical to success.[62]

Figure 23: Summary of economic impacts of green building in Canada



[61] GermanWatch & CAN Europe (2014): Climate Change Index Report. Link: http://treealerts.org/region/canada/2014/12/canada-barely-misses-last-place-in-latest-global-climate-performance-rankings/

[62] See Ontario's Climate Change Strategy, British Columbia's Climate Leadership Team Recommendations, and Manitoba's Climate Change and Green Economy Action Plan.

IN CONCLUSION

Canada's green building industry has accomplished significant growth in a short period of time despite facing a range of barriers and challenges. Support in the right areas however can help to catapult Canadian companies into a more competitive position and accelerate the market transformation. A proactive approach to embracing opportunities offered by green building through the contribution of an overarching strategy and policy framework at the national level will allow Canada to seize both the domestic and export opportunities and transition the nation to becoming a global leader in green building.

APPENDIX A: METHODOLOGY

The information below provides an overview of the methodology applied for measuring both the economic impact of Canada's green building industry (in terms of jobs and gross domestic product), as well as the more specific life cycle impacts and market penetration of LEED certified buildings in Canada.

A1. Estimating the Economic Impact of Green Building in Canada

Following refinement of a working definition for the green building sector in Canada (see box below), a statistical framework was developed that best defines activities in Canada's green building sector in order to define the scope of the sector and act as a guideline for the collection of statistical data. The framework was based on relevant North American Industry Classification System (NAICS) codes (including architecture, design, engineering, residential and ICI construction, building suppliers / materials / technology, operations, and related supporting organizations) at the 4-digit level.

Using this NAICS code framework, total GDP and employment in 2014 was determined for each industry by province using the following methods and sources:

- Employment – Statistics Canada Employment and Earnings Survey (2014) and the National Household Survey (2011) for those industries where data was suppressed due to confidentiality reasons.
- GDP – Both Statistics Canada's National Accounts and Input-Output multipliers were used to convert employment to current dollar GDP, which was then adjusted to constant (chained) 2007 dollars.

The estimated percentage of green building activity within each industry NAICS code that make up Canada's full green building sector value chain was then estimated (for jobs and GDP by province) through the development of "intensity ratios" that were applied to each industry code. This work involved a detailed analysis of each relevant NAICS codes; an effort that builds on considerable work that has already been done on developing intensity ratios for the green building industry in some jurisdictions, including work by the United States Bureau of Labor Statistics (US BLS)[63], GLOBE Advisors[64], and others.

Working Definition of Green Building in Canada

Green buildings are holistic buildings that are designed, constructed, and operated to achieve clearly defined environmental, economic, and social performance objectives that are measurably above and beyond the norm. With respect to this study, projects in Canada are included in this definition if they have achieved one or more of the following criteria:

- A rating system certification with documented and verified increased performance level (e.g., LEED, BOMA BESt, Built Green, Novoclimat, and Green Globes);
- An energy rating standard (e.g., ASHRAE 90.1-2010, Passive House, EnerGuide 80, *ENERGY STAR, R-2000); and/or
- Evidence of exemplary equivalent performance by other means in the areas of energy efficiency, water efficiency, material / resource efficiency, responsible site management, indoor air quality, and health.

*ENERGY STAR certified homes perform approximately 20 percent more efficiently than homes built to code.

Source: http://www.nrcan.gc.ca/energy/efficiency/housing/new-homes/5057

[63] See: http://www.bls.gov/green/home.htm

[64] See Clean Economy market study methodology: http://globeadvisors.ca/media/4489/globe_bcce_methodology(sept.2012).pdf

For example, an intensity ratio of 0.38 (or 38 percent) was applied to total employment and GDP in Ontario's Part 9 residential construction industry (NAICS code 2361 Residential Building Construction). This was estimated by taking a weighted average of the percentages of 'green' related construction activities in new construction (tied to Ontario's provincial building code that requires EnerGuide 80 for all new construction and programs such as ENERGY STAR), combine with green building and energy efficiency retrofit activities in the existing residential building space. For some industries where green building is a very small percentage of the overall activities in that industry (such as NAICS code 6113 Universities; 5416 Management, Scientific, and Technical Consulting Services; and 5622 Waste Treatment and Disposal), intensity ratios were estimated based on results from secondary research findings and industry consultation, both as part of this study and from the work done by other organizations in the past.[65]

The intensity ratios developed by GLOBE Advisors in 2012 for BC's green building sector were used as a starting point and refined and validated through both secondary research and industry consultation. This included an analysis of the energy efficiency components of provincial building codes for new residential construction (which qualified homes built to EnerGuide 80 or higher in 2014 as 'green'), examining the market penetration of various green building certification programs and rating systems (for both new and existing residential and non-residential construction), and extensive industry consultation (including 35 key informant interviews) as part of this study. Certification programs that were part of this analysis include LEED, Built Green, Novoclimat, ENERGY STAR, and BOMA BESt.

Part of the research and analysis to refine and validate intensity ratios and determine the economic impact of Canada's broader green building industry included:

- Estimating the total square footage by building type in Canada by province using the Informetrica National Model and other relevant data sources (e.g. CMHC);
- Estimating the "business as usual" (BAU) expenditures (proportional and absolute) for residential and non-residential (ICI) buildings for energy, water, and waste management savings based on Statistics Canada Households Expenditure Survey and related energy, water, and waste components;
- Tabulating BAU and 10-year trends for energy usage and GHG emissions for residential and ICI buildings by type of structure and province based on data published by NRCan, Environment Canada, and Statistics Canada;
- Tabulating 10-year trends to date for residential and non-residential (ICI) building construction by type by province using Statistics Canada data; and
- Tabulating LEED trends by type of structure, province, and year based on available data from CaGBC (by province).

Intensity ratios were then adjusted for each industry (i.e. for each NAICS code) by province based on the gathered data and information. Intensity ratios for the relevant building industry NAICS codes that were estimated for the United States by the US BLS were also reviewed for comparison purposes, particularly for US states with similar building codes and climates to specific Canadian regions and/or provinces.

The results of this provincial-based analysis on Canada's green building sector are shown in the tables on the following pages, rolled up at the national level. Note that the territories were not included in this analysis due to data suppression issues by Statistics Canada for confidentiality purposes. The estimated total for Canada's green building jobs and GDP does not include the territories and, as such, can be considered under reported.

[65] For the full set of intensity ratios applied to each industry by province, please contact the Delphi Group.

Table A1-1: 2007 NAICS industry codes for 2014 green building jobs

Industry Code (2007 NAICS)	2014 Green Building Jobs	Segment
2361 Residential building construction	23,110	Construction & Trades
2362 Non-residential building construction	19,899	Construction & Trades
2371 Utility system construction	4,463	Construction & Trades
2379 Other heavy and civil engineering construction	776	Construction & Trades
2381 Foundation, structure, and building exterior contractors	24,735	Construction & Trades
2382 Building equipment contractors	53,442	Construction & Trades
2383 Building finishing contractors	18,531	Construction & Trades
2389 Other specialty trade contractors	19,490	Construction & Trades
Subtotal	**164,446**	**Construction & Trades**
3141 Textile furnishings mills	844	Materials & Manufacturing
3211 Sawmills and wood preservations	16,697	Materials & Manufacturing
3212 Veneer, plywood and engineered wood product manufacturing	8,337	Materials & Manufacturing
3219 Other wood product manufacturing	8,438	Materials & Manufacturing
3255 Paint, coating and adhesive manufacturing	1,765	Materials & Manufacturing
3271 Clay product and refractory manufacturing	557	Materials & Manufacturing
3273 Cement and concrete product manufacturing	6,633	Materials & Manufacturing
3274 Lime and gypsum product manufacturing	480	Materials & Manufacturing
3279 Other non-metallic mineral product manufacturing	2,039	Materials & Manufacturing
3323 Architectural and structural manufacturing	12,401	Materials & Manufacturing
3324 Boiler, tank and shipping container manufacturing	2,686	Materials & Manufacturing
3334 Ventilation, heating, air-conditioning and commercial refrigeration equipment manufacturing	4,553	Materials & Manufacturing
3342 Communications equipment manufacturing	860	Materials & Manufacturing
3344 Semiconductor and other electronic component manufacturing	654	Materials & Manufacturing
3345 Navigational, measuring, medical and control instruments manufacturing	1,098	Materials & Manufacturing
3351 Electric lighting equipment manufacturing	1,245	Materials & Manufacturing
3353 Electrical equipment manufacturing	777	Materials & Manufacturing
3359 Other electrical equipment and component manufacturing	593	Materials & Manufacturing
3372 Office furniture (including fixtures) manufacturing	5,772	Materials & Manufacturing
3379 Other furniture-related product manufacturing	937	Materials & Manufacturing
Subtotal	**77,366**	**Materials & Manufacturing**

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Industry Code (2007 NAICS)	2014 Green Building Jobs	Segment
6112 Community colleges and C.E.G.E.P.s	1,781	Policy & Education
6113 Universities	2,802	Policy & Education
6115 Technical and trade schools	467	Policy & Education
9112-9119 Other federal services	2,735	Policy & Education
9120 Provincial and territorial public administration (9121 to 9129)	5,494	Policy & Education
9130 Local, municipal and regional public administration (9131 to 9139)	8,429	Policy & Education
Subtotal	**21,708**	**Policy & Education**
2372 Land subdivision	620	Professional Services
5313 Activities related to real estate	284	-
5413 Architectural, engineering and related services	19,813	Professional Services
5414 Specialized design services	1,744	Professional Services
5415 Computer systems design and related services	1,801	Professional Services
5416 Management, scientific and technical consulting services	2,653	Professional Services
5417 Scientific research and development services	1,695	Professional Services
5617 Services to buildings and dwellings	884	Professional Services
Subtotal	**29,494**	**Professional Services**
4181 Recyclable material wholesaler-distributors	1,801	Waste & Recycling
5621 Waste collection	1,407	Waste & Recycling
5622 Waste treatment and disposal	1,672	Waste & Recycling
Subtotal	**4,881**	**Waste & Recycling**
Total GB Jobs	**297,894**	**All Segments**

Table A1-2: 2007 NAICS industry codes for 2014 green building GDP (millions, chained 2007$)

Industry Code (2007 NAICS)	"2014 Green Building GDP	Segment
(Millions of chained 2007$)"	Segment	Construction & Trades
2361 Residential building construction	1,631.4	Construction & Trades
2362 Non-residential building construction	1,649.1	Construction & Trades
2371 Utility system construction	631.5	Construction & Trades
2379 Other heavy and civil engineering construction	62.0	Construction & Trades
2381 Foundation, structure, and building exterior contractors	1,582.1	Construction & Trades
2382 Building equipment contractors	3,418.3	Construction & Trades
2383 Building finishing contractors	1,185.3	Construction & Trades
2389 Other specialty trade contractors	2,971.5	Construction & Trades
Subtotal	**13,131.2**	**Construction & Trades**
3141 Textile furnishings mills	45.3	Materials & Manufacturing
3211 Sawmills and wood preservations	261.9	Materials & Manufacturing
3212 Veneer, plywood and engineered wood product manufacturing	1,178.8	Materials & Manufacturing
3219 Other wood product manufacturing	181.5	Materials & Manufacturing
3255 Paint, coating and adhesive manufacturing	921.7	Materials & Manufacturing
3271 Clay product and refractory manufacturing	40.4	Materials & Manufacturing
3273 Cement and concrete product manufacturing	728.0	Materials & Manufacturing
3274 Lime and gypsum product manufacturing	34.8	Materials & Manufacturing
3279 Other non-metallic mineral product manufacturing	147.8	Materials & Manufacturing
3323 Architectural and structural manufacturing	788.8	Materials & Manufacturing
3324 Boiler, tank and shipping container manufacturing	222.8	Materials & Manufacturing
3334 Ventilation, heating, air-conditioning and commercial refrigeration equipment manufacturing	333.8	Materials & Manufacturing
3342 Communications equipment manufacturing	116.8	Materials & Manufacturing
3344 Semiconductor and other electronic component manufacturing	44.5	Materials & Manufacturing
3345 Navigational, measuring, medical and control instruments manufacturing	74.7	Materials & Manufacturing
3351 Electric lighting equipment manufacturing	116.7	Materials & Manufacturing

(Continued from previous page)

Industry Code (2007 NAICS)	"2014 Green Building GDP	Segment
3353 Electrical equipment manufacturing	71.7	Materials & Manufacturing
3359 Other electrical equipment and component manufacturing	49.9	Materials & Manufacturing
3372 Office furniture (including fixtures) manufacturing	360.1	Materials & Manufacturing
3379 Other furniture-related product manufacturing	52.8	Materials & Manufacturing
Subtotal	**5,773.2**	**Materials & Manufacturing**
6112 Community colleges and C.E.G.E.P.s	51.4	Policy & Education
6113 Universities	86.3	Policy & Education
6115 Technical and trade schools	12.5	Policy & Education
9112-9119 Other federal services	295.5	Policy & Education
9120 Provincial and territorial public administration (9121 to 9129)	537.1	Policy & Education
9130 Local, municipal and regional public administration (9131 to 9139)	726.8	Policy & Education
Subtotal	**1,709.5**	**Policy & Education**
2372 Land subdivision	49.6	Professional Services
5313 Activities related to real estate	25.1	Professional Services
5413 Architectural, engineering and related services	1,718.3	Professional Services
5414 Specialized design services	46.1	Professional Services
5415 Computer systems design and related services	153.6	Professional Services
5416 Management, scientific and technical consulting services	188.2	Professional Services
5417 Scientific research and development services	159.3	Professional Services
5617 Services to buildings and dwellings	36.9	Professional Services
Subtotal	**2,377.1**	**Professional Services**
4181 Recyclable material wholesaler-distributors	135.9	Waste & Recycling
5621 Waste collection	147.9	Waste & Recycling
5622 Waste treatment and disposal	175.7	Waste & Recycling
Subtotal	**459.5**	**Waste & Recycling**
Total GB GDP	**23,450.5**	**All Segments**

A2. Estimating the Market Penetration of LEED® Certified Buildings in Canada

Calculating the LEED market penetration rates by building type comes from comparing LEED certifications for new buildings in Canada to the estimated total new floor space of the same building type based on the total value of new building permits that were issued in a given year / time period.

Building permit values were converted to constant dollars (2007) based on the GDP deflators[66] for residential and non-residential building construction in Canada and then converted to estimates of floor space in square meters based on new construction costs per square meter for residential, commercial, industrial, and institutional / public sector buildings. Construction costs were derived from examining key appraisal directories including RS Means and the Altus Group, as well as from Informetrica's historical database on floor space and investment. As the investment data was based on constant 2007 dollars, the construction costs per square meter were also deflated to constant 2007dollars.

These new building cost estimates per square meter are shown in Table A2-1 below.

Table A2-1: Estimated building costs per square meter by building type (constant 2007$)

Building Type	Cost per Sq. Meter	Source
Residential	$1,956	Altus Group
Industrial	$1,425	RS Means
Commercial	$1,938	Informetrica Ltd.
Institutional	$3,883	Informetrica Ltd.

The square meter costs for institutional buildings derived from Informetrica's historical database were higher than the appraised costs of institutional buildings by both RS Means and Altus. The Altus institutional costs per square meter were $2,506 and RS Means was equal to $2,446. Informetrica's derived number was $3,883 per square meter. It is not unusual for appraisal costs derived from online databases to be significantly higher or lower than actual costs. It was decided to use the Informetrica square meter costs for this building category as its historical data was derived from actual figures. Informetrica did not provide either floor space or cost data for residential and industrial buildings; hence, the appraisal figures were applied for these building types.

New LEED certifications based on floor space (square meters) were tracked by year and by building type and then compared to the estimate of total new floor space for all buildings in the same category. The periods for this comparison were 2004 to 2007, 2008 to 2010, and 2011 to 2014. These broader periods were used for this comparison as on a year-to-year basis, LEED certifications and overall building investment may represent different time periods and hence are not directly comparable. This anomaly is less likely for these two- and three-year time frames.

In addition to showing LEED penetration rates for the above three periods, penetration rates were derived from 2007 to 2014 based on three-year moving averages for both the new building stock and LEED certifications. Both the three time period approach and the three-year moving average market penetration rate analysis showed continuous annual growth for LEED certified buildings as a percent of new building stock.

[66] GDP deflators are what Statistics Canada uses to convert current dollar GDP to constant dollar GDP.

A3. Estimating the Life Cycle Impacts of LEED® Certified Buildings in Canada

Life-cycle cost analysis (LCCA) is an economic method of project evaluation in which all costs arising from owning, operating, maintaining, and ultimately disposing of a project are tabulated. It is a technique designed to evaluate building cost alternatives where all costs including capital construction costs, repair, operating and maintenance, power, water and waste disposal are tabulated and discounted to present value.

In this regard, cost savings algorithms (based on square meters) were applied to first estimate annual savings for energy, water, waste disposal, and operations for the LEED building types including Residential, Industrial, Commercial, and Institutional / Government. These savings were calculated based on a representative sample of LEED certified buildings in Canada (by province / territory, building type, and certification level) over the last 10 years.

The data for this analysis came from detailed reviews of 52 LEED building case studies in Canada, the results of which are shown in Table A3-1. Cost savings shown are averages over the estimated 33 year economic life for buildings and assume that energy costs remain constant. However, it should be noted that the actual savings will vary based on the building type. For example, a recreation centre may have a higher potential for savings than a hospital that may be limited somewhat by regulatory restrictions or a condo tower that has a high glazing factor.

The approach taken for calculating cost savings was similar to one applied by Booze Allen Hamilton for the US Green Building Council's 2012 Green Jobs study.[67] The US reference is provided in Table 7 above by cost savings category.

It should be noted that the energy savings recorded in Canadian samples compared to the US was quite a bit higher, likely due to the fact that green building energy performance has been improving in recent years and the Canadian sample was more representative. For example, the Canadian data included the full spectrum of certified buildings from Certified to Platinum, with the appropriate percentages by certification (LEED Gold was the dominant certification level). It should also be noted that the case study samples did not have much data for the waste or O&M savings. As such, more work to quantify these impacts will be required in the future.

The calculated cost savings were subsequently discounted over 33 years, which is the estimate for the economic life of buildings in Canada. The net savings is based on subtracting the additional costs of building to the LEED standard.

There is a relatively wide range of incremental costs for building green, relating to the building type, the level of desired performance, and the approaches taken (e.g. materials, technologies, etc.). While the LEED standard can often be met at minimal additional cost,

Table A3-1: Average cost savings achieved from LEED certified buildings in Canada

Cost Savings	Number of Samples	Average $/m2	Average $/sq ft	Median $/m2	Median $/sq ft	US Reference
Energy Savings	50	21.74	2.02	20.43	1.90	0.52
Water Savings	6	0.46	0.04	0.31	0.03	0.02
Waste Savings	1	0.40	0.04	0.40	0.04	0.05
O&M Savings	2	1.89	0.18	1.89	0.18	0.32

[67] See: http://www.usgbc.org/Docs/Archive/General/Docs6435.pdf

this analysis used an estimate of 5 percent of "normal" costs as an average surcharge across all LEED certified residential, commercial, and industrial building types and 4 percent for institutional buildings over the entire project portfolio since program inception. The lower incremental rate for institutional buildings reflects that on average construction costs per square meter are significantly higher for institutional buildings than for commercial buildings, but these additional costs do not directly translate into an equivalent incremental investment requirement to make institutional buildings green. The tabular calculations are shown in Table A3-2 and Figure A3-1 illustrates the net savings per square meter.

Table A3-2: Overall lifecycle savings from energy, water, waste and O&M for LEED projects since program inception

	Residential	Commercial	Institutional	Industrial	Total
Total LEED sq. meters	1,816,852	15,599,881	5,590,771	734,693	23,742,197
Commercial $ Cost per sq. meter (2007 $) *	$1,957	$1,938	$3,883	$1,425	$2,382
Total "normal costs"($000, 2007$)	$3,554,684	$30,239,193	$21,707,398	$1,047,293	$56,548,568
Green building surcharge (5%, 4% institutional) ($000, 2007$)	$177,734	$1,511,960	$868,296	$52,365	$2,610,354
Total Construction Costs ($000, 2007)	$3,732,418	$31,751,152	$22,575,694	$1,099,658	$59,158,923
Annual Savings ($000, 2007$)					
Energy Savings	$39,502	$339,173	$121,555	$15,974	$516,204
Water Savings	$830	$7,124	$2,553	$336	$10,843
Waste Savings	$723	$6,207	$2,235	$292	$9,447
O&M Savings	$3,438	$29,520	$10,580	$1,390	$44,928
Total Savings	$44,493	$382,025	$136,912	$17,992	$581,422
33 year PV of Savings ($000, 2007$)	$711,999	$6,113,379	$2,484,636	$287,916	$9,597,930
Net Savings ($000, 2007$)**	$534,265	$4,601,419	$1,616,340	$235,551	$6,987,576
Net Savings per sq. meter	$294.06	$294.96	$289.11	$320.61	$294.31
Net Savings as percent of total costs per year	9.1%	9.2%	5.6%	13.6%	8.1%

Assumptions

3. The Present Value of the annual net savings were based on a 5 percent discount rate and taken over 33 years, which is considered to be the economic life for buildings.

4. The average green building incremental cost for LEED certified buildings is estimated to be 5 percent of "normal" building costs (4 percent for institutional buildings), which are shown in the second line of the table.

* Average costs for construction were estimate based on Informetrica data and information from several appraisal firms.

** Net savings are the difference between the 33 year present value of savings and the green building surcharge.

Figure A3-1: Net lifecycle savings per square meter

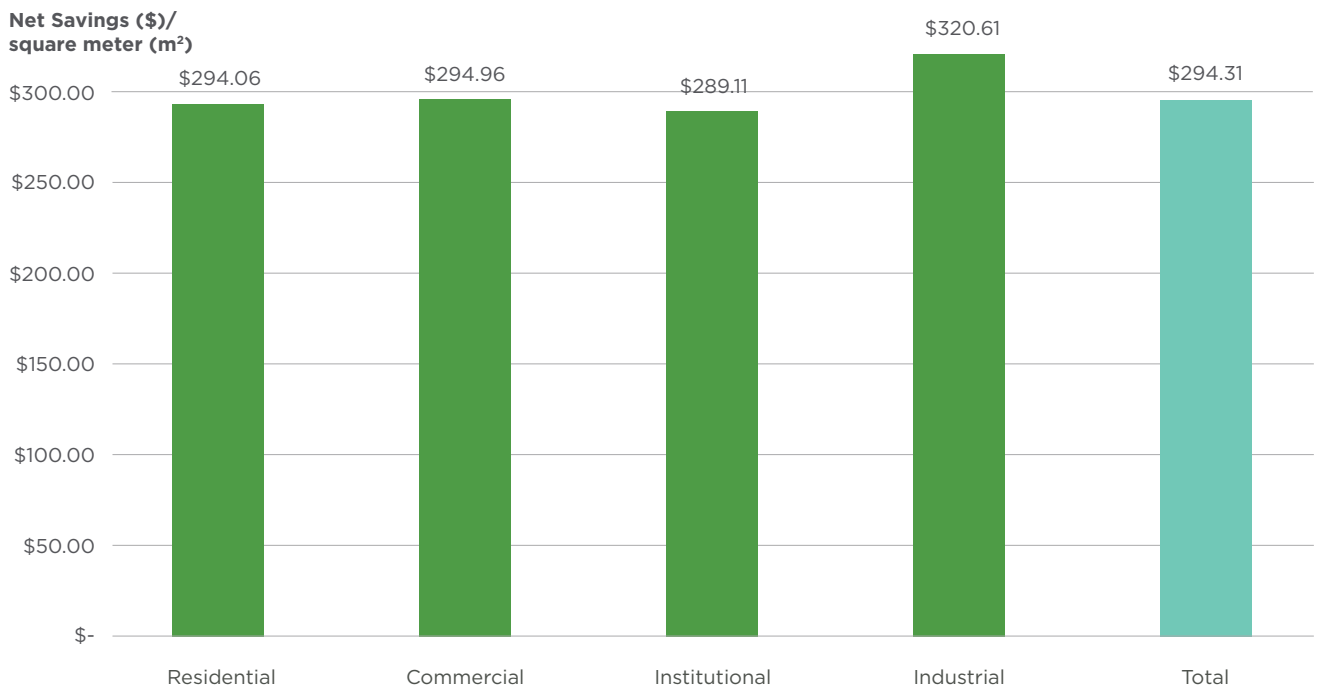
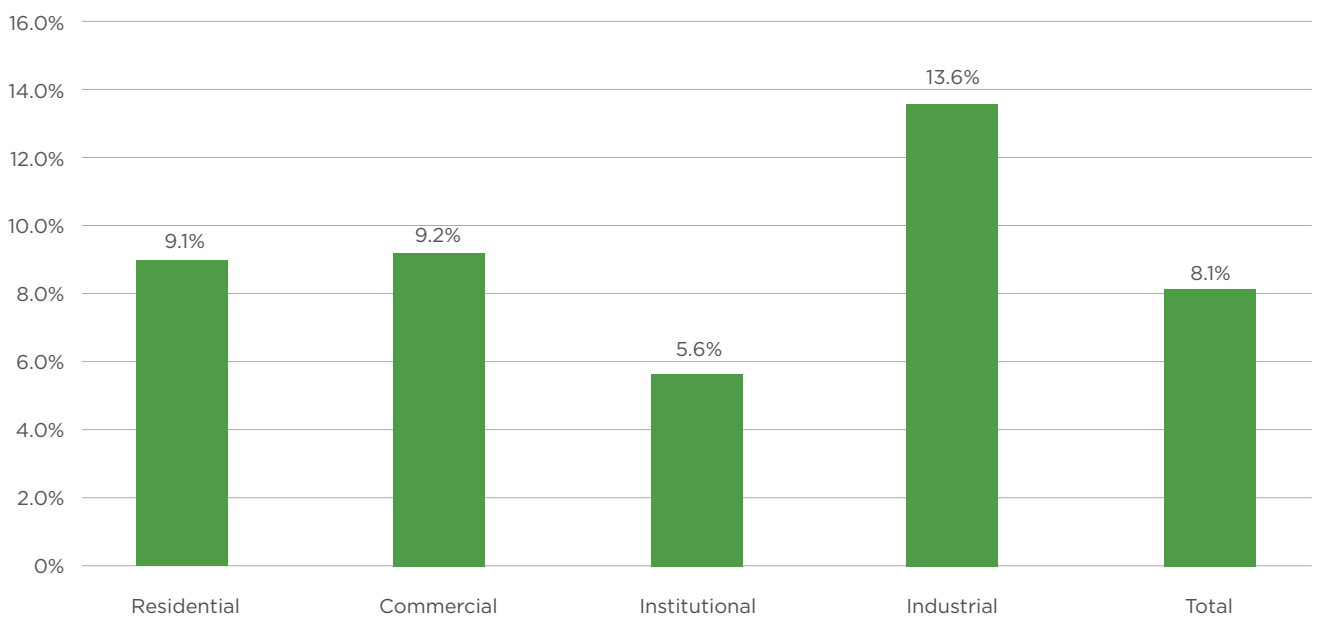


Figure A3-2 illustrates the annualized net savings as a percent of the green building surcharge, which is an estimate of Return on Investment (ROI).

Figure A3-2: Annualized net lifecycle savings as a percent of the green building surcharge



On average, the energy, water, waste disposal and O&M savings from LEED certified buildings provide a ROI of 8.1 percent. The respective ROI's were 9.1 percent for Residential, 9.2 percent for Commercial, 5.6 percent for Institutional / Government and 13.6 percent for Industrial. The smaller ROI for the Institutional class of LEED buildings are attributed to overall higher construction costs for these often highly-specialized, more expensive buildings.

Multiplier Impacts

The direct, indirect and induced impacts generated in this paper were derived from multipliers at the 4-digit NAICS code level, obtained from the National Accounts Division of Statistics Canada for the national economy based on its Input-Output model.

An Input Output model is a way of understanding and estimating how economic changes in one industry can affect other industries. The Input-Output model consists of tables that cover all economic activities conducted in the market economies of each province and territory, encompassing persons, businesses, government, and non-government organizations (NGOs), and entities outside its jurisdiction that give rise to imports or exports (inter-provincially or internationally).

The Input Output tables represent the most detailed accounting of the Canadian economy available and thus serve as benchmarks to the Canadian System of National Accounts. These tables are the most comprehensive and detailed statistics on transactions involving production activity, as well as intermediate and final consumption of goods and services in the economy.

Statistics Canada reports that "the input-output multipliers ... are used to assess the effects on the economy of an exogenous change in final demand for the output of a given industry. They provide a measure of the interdependence between an industry and the rest of the economy. The national multipliers show the direct, indirect, and induced effects on gross output, the detailed components of GDP, jobs, and imports."[68]

Multipliers show how industries use each other's inputs as well as the linkages between a change in output in one industry and its ripple effect on others.

In this analysis, Delphi worked with Revenue (Output) Multipliers, GDP Multipliers, and Job Multipliers. Each of these three multiplier groups included Direct Impacts, Indirect Impacts, and Induced Impacts:

- **Direct impacts** are those first-level impacts resulting from a shock or change in demand, to either industry output or final demand. They refer to the direct impact on those industries that must respond to satisfy the change in demand for commodities.
- **Indirect impacts** are secondary, and are generated from the linkages between industries. They refer to the impacts on industries that supply intermediate inputs to the industries directly impacted by the shock.
- **Induced impacts** capture the income effect of the shock. They measure the impact of additional consumption from spending the wages generated by the shock. For example, when there is an increase in final demand, industries have to increase production. They hire additional people, who receive wages. It is assumed that these households, after withdrawing a portion of their income for savings and taxes, spend the rest of their income on consumer goods and services. This creates an additional multiplier effect on the economy.

[68] http://www5.statcan.gc.ca/olc-cel/olc.action?ObjId=15F0046X2014000&ObjType=46&lang=en

Table A3-3: Direct economic impacts of LEED projects over the economic lifetime of these buildings

	Residential	Commercial	Institutional	Industrial	Total
Direct Gross Output ($000,2007$)	$3,732,418	$31,751,152	$22,575,694	$1,099,658	$59,158,923
Direct GDP ($000,2007$)	$1,542,104	$13,689,746	$9,733,679	$474,126	$25,439,654
Direct Labour Income ($000,2007$)	$1,198,371	$11,096,760	$7,890,015	$384,321	$20,569,466
Direct Jobs	19,366	177,897	126,488	6,161	329,912

Table A3-3 shows the direct impacts of the construction investments for the LEED projects in Canada based on the multipliers published by Statistics Canada. These include direct gross output[69], GDP, labour income, and jobs. LEED projects will generate $59.1 billion in direct gross output and $25.4 billion in constant dollar GDP.

Table A3-4: Direct, indirect, and induced impacts of LEED projects over the economic lifetime of these projects

	Residential	Commercial	Institutional	Industrial	Total
Direct, Indirect and Induced Gross Output ($000,2007$)	$8,277,018	$68,570,294	$48,754,828	$2,374,838	$127,976,979
Direct, Indirect and Induced GDP ($000,2007$)	$3,885,365	$33,489,478	$23,811,677	$1,159,862	$62,346,382
Direct and Indirect Labour Income ($000,2007$)	$2,561,090	$22,389,934	$15,919,683	$775,445	$41,646,152
Direct and Indirect Jobs	44,270	376,599	267,770	13,043	701,682

The overall GDP multiplier is 2.45 to 1. In other words, for every direct dollar of GDP created, another $1.45 in indirect and induced GDP results. The job multiplier is 2.13. For every direct job created, an additional 1.13 indirect and induced jobs are created.Table A3 4 shows the direct, indirect, and the induced impacts.[70] The overall direct, indirect, and induced gross output that will be generated by LEED projects to date over their economic lifetime will be $128.0 billion. Direct, indirect, and induced GDP impacts will be $62.3 billion and 701,700 total impact jobs will be created.[71]

[69] Gross output is a measure of an industry's sales, which can include sales to final users in the economy (GDP) and sales to other industries (intermediate inputs). Gross output can also be measured as the sum of an industry's value added and intermediate inputs.

[70] Direct impacts are related to the specific industry, while indirect impacts relate to activities that support or supply to the industry. Induced impacts are those that are a result of direct / indirect spending in the local economy outside of the industries that are directly or indirectly impacted.

[71] Note these are gross jobs rather than net jobs. Net jobs reflect incremental jobs after shifts in the economy such as people moving from other construction activities are netted out.

Canada Green Building Council
Every Building Greener

Conseil du bâtiment durable du Canada
Verdir tous les bâtiments

Canada Green Building Council
202-47 Clarence Street
Ottawa, ON K1N 9K1
Tel.: +1 (613) 241-1184
Fax: +1 (613) 241-4782
Toll-free: +1 (866) 941-1184
www.cagbc.org

Direct Contact:
Sarah Burns
+1 (613) 288-8097
sburns@cagbc.org

DelphiGroup
Environmental Strategies. Business Solutions.

Delphi Group
428 Gilmour Street
Ottawa, ON K2P 0R8
Canada
Tel.: +1 (613) 562-2005
Fax: +1 (613) 562-2008
www.delphi.ca

Direct Contact:
Paul Shorthouse
+1 (604) 338-9941
pshorthouse@delphi.ca