Ontario Architects' Perspectives on Sustainability

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Foreword:

The area of concentration of my Plan of Study (POS) is Applications of Renewable Energy and Sustainable Architecture with three components:

1. Renewable Energy
2. Sustainable Architecture
3. Sustainable Business

This major paper is primarily related to the second component but reflects aspects of each of the first and second components as well. The paper reports the results of a survey of Ontario architects on their perspectives of sustainable architecture, of which renewable energy is a key component, and which itself can be considered a form of sustainable business. Through several other learning strategies, I developed an understanding of the challenges of transitioning to an energy system based on renewable energy technologies. Foremost among these challenges are the inefficient use of energy at the point of consumption and an incompatibility between the types of energy generated and that which is required. The strategy of employing a questionnaire to survey architects was developed based on their role as key stakeholders in the building sector, which accounts for a large share of energy consumption and is the focus of significant policy intervention.

The MRP required the achievement of several learning objectives in order to develop the core primary research component. The research also helped to achieve several other learning objectives and provide a more complete understanding of the practical challenges associated with increasing the use of sustainable architecture and renewable energy generation in facing the environmental crisis.

Perhaps the most important outcome of this research, as it relates to my learning objectives, was its influence on my comprehension of the policy instruments being employed in Ontario, and elsewhere, to enable the transition from a fossil fuel-based energy system to a one based on renewable energy generation. A working knowledge of these policies was acquired through other learning strategies and developed through the completion of this major paper. Deeper understanding of these policies was developed through the process of review and analysis in the course of completing the research.

This major paper also helped to develop an understanding of the challenges faced by sustainable businesses in bringing to market environmentally sensitive products, in this case, buildings.

Abstract: The transition to a carbon free energy system requires a transformation of the way that energy is employed across all sectors. The building sector in Ontario accounts for approximately 20% of total emissions. Architects are key stakeholders in the design process of the building sector and their decisions will impact the built environment for significant period of time. Despite the broad suite of tools available to increase the ability of architects to design buildings that achieve sustainability and climate related targets, green buildings represent less than half of new construction in the province. This paper reports the results of a survey designed to capture the experiences of architects in regard to sustainable architecture and green building policies in order to better understand the related drivers, barriers and policy outcomes. High level takeaways include a preference toward performance standards over prescriptive standards, the importance of government regulation in leveling the playing field for energy efficiency and environmental performance, an acknowledgement that client priorities overrule personal conviction in selecting building design elements, and that high capital cost is the most important barrier to further implementation of elements of sustainable architecture that align with provincial climate goals.

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1. Introduction

Climate change adaptation and mitigation requires the implementation of policies across all sectors. In Ontario, great gains have been made in the energy sector through the adoption of policies which promoted the implementation of renewable energy technologies, increased energy efficiency and conservation, and led to the closure of coal-fired power plants. Through these policies, significant spill-over effects have contributed to progress in other sectors as well. The building sector in particular has benefitted from these energy-related policies, though it still accounts for 34.8 megatonnes (Mt) of emissions as of 2014.[1] Since 1990, emissions from the buildings sector has increased 28%.[2] Across Canada, building sector emissions are projected to increase by 14Mt CO_2e by 2020.[3]

To fulfill its role in achieving the greenhouse gas (GHG) emission reductions required to meet Canada's targets and uphold international agreements, Ontario needs to reduce GHGs a further 15Mt by 2020. The Province claims to have met its 2014 target of 6% below 1990 levels.[4] By 2050, Ontario is committed to reducing emissions to 80% of 1990 levels to 36 Mt CO2e.[5]

Strategies to achieve these cuts include changes to the building code,[6] support programs to fund energy-efficient equipment and building components in public buildings,[7] incentives for apartment building retrofits,[8] and rebates for low-carbon technologies installed in homes or the

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[1] ECO. *Facing Climate Change; Greenhouse Gas Progress Report 2016.* Toronto, ON: Environmental Commissioner of Ontario (2016), 41.
[2] Ibid., 44.
[3] Environment Canada. *Canada's Emissions Trends.* (Gatineau, Quebec, 2014), 22.
[4] Ontario. *Climate Change Action Plan 2016-2020.* (Toronto, ON: Queen's Printer for Ontario, 2016), 12.
[5] ECO, *Facing Climate Change*, 39.
[6] Ontario. Ministry of Municipal Affairs. *Potential Changes to Ontario's Building Code: Fall 2016 Consultation.* (Queens Printer for Ontario, 2016).
Ontario. *Climate Change Action Plan*, 25, 27.
[7] Ontario. *Climate Change Action Plan*, 12, 26.
[8] Ibid., 26.

purchase of new near net-zero homes.[9] Additional measures will be taken to empower municipalities to expand their ability to set green development standards.[10]

The result of these policy changes is to impose significant change upon stakeholders within the building sector. Architects, engineers, construction firms, owners/developers and tenants will all experience changes in the way that buildings are designed, built and used.

This report represents an attempt to understand the impact of climate change policy from the perspective of one set of actors in a sector of significance to the goal of minimizing the environmental impact of human activities.

Architects fulfill an important role in the decision-making process within the building sector, which contributes to the consumption of vast resources and the emission of a significant share of greenhouse gases in addition to more localized pollutants. Buildings are often built to last 50 years or more and therefore the design process represents a key point of intervention in the lifetime of a building.[11] While the environmental performance of the building sector is often presented in terms of GHG emissions alone, the impact of buildings is not limited to this metric. Buildings, throughout their construction and operation, disturb wildlife habitat,[12] contribute to water pollution,[13] interrupt drainage and water flow,[14] and create light and noise pollution[15] among other impacts.

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[9] Ibid., 27.
[10] Ibid., 32.
[11] Mohamad M. Khasreen, et al. “Life-Cycle Assessment and the Environmental Impact of Buildings: A Review.” *Sustainability* 1:3 (2009), 676.
[12] David M. Theobald, James R. Miller, and N. Thompson Hobbs. “Estimating the Cumulative Effects of Development on Wildlife Habitat.” *Landscape and Urban Planning* 39 (1) (1997), 25–36.
[13] R.L. Wilby. “A Review of Climate Change Impacts on the Built Environment.” *Built Environment* 33 (1) (2007), 35.
[14] Ibid., 38, 39.
[15] Hans Slabbekoorn, and E. Ripmeester. “Birdsong and anthropogenic noise: implications and applications for conservation. *Molecular Biology* 17 (2008), 73.

Buildings also represent a large volume of embodied energy, concentrated through the processes of natural resource extraction, transportation, construction, operation and destruction.[16] Life-cycle assessment (LCA) is used to determine the total cost of building construction, operation and demolition and is particularly specialized in part because of the inherent complexity of buildings and also because of their long lifecycle, often more than fifty years.[17] These studies show that, on average, the operational phase of a building accounts for 85-90% of energy consumption and associated emissions.[18] LCA can provide insight to the true cost of construction materials and, as Bhochhibhoya et al. note, "interest in documenting the environmental impact of building materials and processes is increasing in developed countries, aiming to reduce their energy consumption, but information in this field is still scanty."[19]

To address these environmental impacts and provide alternatives to reduce negative externalities, or at least effectively measure and compare the myriad options available, a broad selection of green building standards, tools, modeling systems, and metrics have been developed. From building materials and components to design decisions such as site orientation and building shape, these systems make clear the environmental impacts of elements of building design to maximize the potential for designers to achieve high-performance, low-impact buildings. Given the broad set of tools available, it is easier than ever for building designers to understand the environmental cost of each decision and component in the design of a building.

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[16] UNEP SBCI. *Buildings and Climate Change, Summary for Decision-Makers.* United Nations Environment Programme Sustainable Buildings & Climate Initiative (2009), 10.
[17] Mohamad M. Khasreen, et al. 2009. "Life-Cycle Assessment and the Environmental Impact of Buildings: A Review." *Sustainability* 1:3, 676, 677.
[18] Aashish Sharma, et al. "Life cycle assessment of buildings: A review." *Renewable and Sustainable Energy Reviews* 15 (2011), 875.
[19] Silu Bhochhibhoya, et al. "The Global Warming Potential of Building Materials: An Application of Life Cycle Analysis in Nepal." *Mountain Research and Development* 37 (1) (2017), 48.

From a governance perspective, reducing the building sector's emission reduction targets to achieve goals of international agreements on climate change may require merely legislating adherence to one or another green building standard, as numerous municipalities in North America have done with LEED.[20] Alternatively, by adopting a performance standard, such as the Passive House Standard's 15kWh/m^2 annual energy consumption limit,[21] and allowing the use of any means to meet this requirement, cities (or states, or countries) can achieve similar results while allowing more creativity on the part of designers. However, as noted, GHG emissions are only part of the problem and green building methods are being used to address the interrelated issues of urban development.

As environmental awareness grows, and the effects of climate change begin to be experienced, numerous jurisdictions are adopting green building standards to address local environmental impacts and, often, minimize the impact of property development on public infrastructure. The Toronto Green Standard (TGS), for example, requires storm-water retention and diversions at the building-scale to reduce pollution through overspill of combined sewage and storm-water holding systems, minimizing infrastructure spending while simultaneously improving environmental performance.[22]

One method of accomplishing this is the use of green roofs, which hold water in soils and plant matter while providing habitat for displaced local fauna while reducing airborne contaminants such as carbon monoxide, nitrous oxide, and sulphur dioxide.[23] Additionally, the

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[20] Eugene Choi. "The Effects of Municipal Policy on Green Building Designations in the United States." *The Korean Journal of Policy Studies*, 25:2 (2010), 44.

[21] Paola Sassi. *Strategies for Sustainable Architecture.* (Abingdon, Oxon, US: Taylor & Francis, 2006), 205.

[22] Toronto. City Planning. *Toronto Green Standard 2014 Update Version 2.0 Highlights*. (2015), 16. Toronto. *TGS – Checklist For New Low-Rise*, 9; *TGS – Checklist For New Mid to High Rise*, 5.

[23] Ryerson University. *Report on the Environmental Benefits and Costs of Green Roof Technology for the City of Toronto*. (Toronto, ON: Ryerson University), 57.

TGS requires bird-friendly window design to minimize deaths from collisions with building as a result of light pollution. [24]

Many of these green building standards, guidelines and tools have been developed at the trans/international level while some are national and regional in scope. As governments seek to strengthen the rules on building sector environmental performance it is important to understand the benefits and drawbacks of the numerous approaches in order to properly inform the policy-making process.

This research represents an attempt to explore the perspectives of architects–key actors in the building sector–regarding the role that green building standards, tools, methods, and expectations have in their professional practice.

1.2. Global Trends

The Intergovernmental Panel on Climate Change (IPCC) reports that the share of global emissions directly attributable to the building sector is 6.4% with a further 12% of indirect emissions coming from electricity and heat production.[25] Total direct and indirect building sector emissions in 2010 amounted to 9.18 giga-tonnes of carbon dioxide equivalent (Gt CO_2e).[26] Furthermore, 32% of total global energy use in 2010 is attributed to the building sector; 24% to residential buildings and 8% to commercial buildings.[27] Some research estimates that as much as

[24] Toronto. *Toronto Green Standard for New Mid to High-Rise Residential and All Non-Residential Development, Version 2*: (2015), 13.
[25] IPCC. *Climate Change 2014: Synthesis Report*. *Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. (Geneva, Switzerland: IPCC, 2014), 47.
[26] O. Lucon, et al. "Buildings." *Climate Change 2014: Mitigation of Climate Change Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* (Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2014), 678.
[27] Ibid., 678.

40% of both emissions and energy use globally can be traced to the building sector if pre-production and demolition are considered.[28]

In response to this knowledge, the adoption of sustainable building practices is growing. Research done at the international level on the impact and growth of green building practices suggests that green building now accounts for more than a third of all construction.[29] The share varies between countries, with South Africa (41%) and Singapore (39%) at the forefront and Saudi Arabia (24%), Colombia, India and the UK (all with 27%) following.[30]

Dodge Data & Analytics reports that in 2015, commercial and institutional construction made up a significant share of green building construction and activity in both sectors is expected to grow rapidly over the next three years.[31] In part, this is attributed to the adoption of green building standards by governments and corporations. For example, in the United States there is a high expectation of institutional green projects in the near future, "…due to certification requirements for many public buildings on a federal and state level, and schools on a municipal level."[32]

1.3. National Trends

Environment Canada reports that emissions of 86 $MtCO_2e$ were attributable to the building sector in 2015, approximately 12% of total emissions.[33] To achieve its national targets,

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[28] M. Zaid, et al. "The Need for Energy Efficiency Legislation in the Malaysian Building Sector." *The 3rd International Building Control Conference 2013* (2013), 1.
[29] Dodge Data & Analytics. *World Green Building Trends 2016: Developing Markets Accelerate Green Growth.* (Bedford, MA, 2016), 9.
[30] Ibid., 9.
[31] Ibid., 11.
[32] Ibid., 11.
[33] Environment Canada. *Greenhouse gas sources and sinks: Executive Summary.* (Environment and Climate Change Canada. ES.4., 2017), 4

Canada's building sector will need to reduce emissions to the 1990 level of 70 MtCO_2e.[34] The government notes that since 2005, building sector emissions have remained relatively stable at 12% of total emissions in part due to aggressive action on building retrofits, through which 40% of building floor space has been made more energy efficient.[35] However, emissions from the sector are growing and expected to reach 95 MtCO_2e by 2020.[36] This growth is anticipated to be focused primarily in the commercial sector (48 MtCO_2e by 2020) as the economy continues to grow while the residential sector (47 MtCO_2e by 2020) benefits from mandatory energy efficiency increases and targeted rebates for homeowners.[37]

This is supported by research done on the share of green building in Canada which found that "a much higher percentage of firms expect to do residential green projects in the next three years (25% low-rise and 31% mid-/high-rise) than the U.S."[38] However, the same study found that green building is estimated to account for between 35% and 50% of non-residential construction.[39] The Canadian Green Building Council states that commercial and institutional buildings reported as having the highest level of activity in part because of established sustainability goals for owners and tenants of these types of buildings. Furthermore, these firms may be a factor in the growth of green building practices within the construction industry. McGraw Hill Construction reports that there appears to be a small differential between those with high and low levels of green building activity in these sectors, "suggest[ing] that many

[34] Environment Canada. *Canada's Emissions Trends.* (Environment Canada, 2013), 15.
[35] Ibid., 17.
[36] Ibid., 21.
[37] Ibid., 31,32.
[38] McGraw-Hill Construction. *Canada Green Building Trends: Benefits Driving the New and Retrofit Market.* (Ottawa, ON: Canada Green Building Council, 2014), 9.
[39] Ibid., 8.

firms are introduced to doing green on their institutional projects, especially given that many institutions have well-published sustainable goals."[40]

One important factor in the reduction of emissions from the building sector is the cost of energy. McGraw Hill notes that "…the low cost of energy in Canada dampens the potential of green building investments. The ability to also provide a financial benefit for GHG emission reduction could help offset this issue."[41] This has been addressed through the federal carbon pricing benchmark outlined in the Pan-Canadian Framework on Clean Growth and Climate Change. All jurisdictions are directed to have adopted a carbon pricing scheme by 2018 with a starting price of at least $10 per tonne rising $10 per year.[42] Several Provinces have already implemented a carbon pricing scheme–cap and trade in Ontario and Quebec, carbon tax in British Columbia, carbon levy in Alberta–of which the impacts on the building sector are yet to be proven.[43]

1.4. Provincial Trends

1.4.1. Emissions

The building sector in Ontario accounted for 34.8 Mega tonnes (Mt) of emissions in 2014; 21.8Mt from residential buildings and 13Mt from commercial and industrial buildings.[44] The majority of these emissions are attributed to the use of fossil fuels for space heating and water heating. According to the Environmental Commissioner of Ontario (ECO), this has increased 28% since 1990, the baseline for emissions reductions.[45]

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[40] Ibid., 13.
[41] Ibid., 17.
[42] Canada. *Pan-Canadian Framework on Clean Growth and Climate Change*. (2016), 49.
[43] Ibid., 49.
[44] ECO. *Facing Climate Change*, 44.
[45] Ibid., 44.

Additionally, a large share of emissions from the electricity sector emissions, 6.2Mt total in 2014,[46] are attributable to buildings which utilize electricity for heating, cooling, lighting, and mechanical systems. Significant progress has been made in decreasing the emissions from electricity in Ontario with the closure of coal-fired power generating facilities and increased focus on efficiency and conservation programs. Since 1990, electricity emissions have been reduced 76 per cent.[47]

Furthermore, the waste sector, which includes solid waste disposal and wastewater treatment, contributed 9.4Mt CO_2e in 2014, an increase of 19% from 1990.[48] The decomposition of wood waste, a byproduct of construction, in landfills is implicated the release of methane from landfills.[49] For example, research on the decomposition of forest products in landfills found that construction waste in the US represented 28% of total landfill waste, with wood products accounting for 8.4%, approximately 17 million tonnes annually.[50] The authors found that this waste resulted in an estimated release of 209,000 tonnes of methane in 1993.[51]

Industry accounts for 51MtCO_2e, a reduction of 20% from 1990.[52] Some of this reduction is attributed to the increased use of recycled scrap steel instead of raw pig iron, much of which is used in the construction of buildings.[53] Much of the energy consumed and emissions released by the industrial sector is in the service of manufacturing building products such as steel, concrete, glass, and insulation. Research on the embodied energy of building materials

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[46] Ibid., 42.
[47] Ibid., 42.
[48] Ibid., 44.
[49] Environment Canada. *National Inventory Report 1990-2013. Part 3.* (Gatineau, QC: Environment Canada, 2015), 16.
[50] J. A. Micales & K. E. Skog. "The Decomposition of Forest Products in Landfills." *International Biodeterioration & Biodegradation* 39 (2-3) (1996), 146.
[51] Ibid., 152.
[52] ECO. *Facing Climate Change,* 43.
[53] Ibid., 48.

suggests that as a share of total lifetime energy use, materials represent a range of 2% - 38% for conventional buildings and from 9% - 46% for low energy buildings.[54] The manufacture and transport of just two products are responsible for nearly half of the emissions from building materials; steel (18.7%) and concrete (30.3%).[55]

Transportation contributed 58.7MtCO_2e in 2014, an increase of 28% since 1990.[56] ECO states that over 80% of these emissions are from on-road passenger and freight vehicles. In a study of one high-rise building in Hong Kong Yan et al. found that 6.4-8.6% of embodied energy could be attributed to the transport of building materials.[57] Addressing the role of passenger vehicles in carbon emissions, several Provincial policies[58] are directed at imposing changes on the building sector that will encourage the adoption of less carbon-intensive modes of transport, such as EV charging stations.[59]

1.4.2. Policy Measures

Ontario's *Climate Change Action Plan* describes measures to reduce emissions in the building sector which are implemented in Bill 172, *Climate Change Mitigation and Low-carbon Economy Act*. Bill 172 provides legislative support for government initiatives intended to reduce greenhouse gas emissions, several of which can be directed toward the building sector; supporting installation of alternative energy systems to reduce energy peak demand (which is often met with natural gas-based generation), R&D funding for technologies that eliminate or

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[54] Ignacio Z. Bribian, et al. "Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential." *Building and Environment* 46 (2011), 1134.
[55] Ibid., 1134.
[56] ECO. *Facing Climate Change*, 42.
[57] Hui Yan, et al. "Greenhouse gas emissions in building construction: A cast study of One Peking in Hong Kong." *Building and Environment* 45 (2010), 955.
[58] Ontario. Bill 172.
Ontario. Ministry of Municipal Affairs. *Potential Changes to Ontario's Building Code*.
[59] Ontario. *Climate Change Action Plan*, 32.

reduce fossil fuel consumption, installation support for geothermal or increased insulation, support for increasing consumer demand for near-net zero and net zero buildings, and initiatives related to reducing space and water heating and cooling through design, construction and retrofit.[60]

Funding from these initiatives will be delivered through a green bank, established and maintained with funds from the proceeds of Ontario's cap and trade system.[61] The *Action Plan* also details plans to retrofit social housing apartments, provide incentives for apartment building retrofits, and support schools, hospitals, and post-secondary institutions in retrofitting their buildings and energy systems.[62] Other measures will be directed at heritage buildings, helping residential homeowners install low-carbon technologies and high-efficiency wood stoves, and giving rebates for the purchase of net-zero and near-net-zero homes.[63]

Among the most important systemic changes included in the *Action Plan* are land-use planning changes and an update to the Ontario Building Code that includes long-term energy efficiency targets, electric vehicle infrastructure requirements, ground water protection and possible environmental protection changes.[64] Proposed changes to land-use planning processes include amending the Municipal Act to allow municipalities to pass bylaws related to green standards and require EV charging stations on surface parking lots, and amending the Provincial *Planning Act* to make climate change a mandatory consideration in planning decisions in both provincial and municipal official plans.[65]

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[60] Ontario. Bill 172.
Ontario. Ministry of Municipal Affairs. *Potential Changes to Ontario's Building Code*, 61.
[61] Ontario. *Climate Change Action Plan*, 15-17.
[62] Ibid., 26.
[63] Ibid., 27.
[64] Ibid., 27.
Ontario. *Potential Changes to Ontario's Building Code*, 26.
[65] Ontario. *Climate Change Action Plan 2016-2020*, 32.

Another set of measures that may have significant impacts on the building sector is the proposal to fund community energy mapping and planning, both of which enable municipalities to understand the various ways that energy is employed by their communities and respond through comprehensive planning with infrastructure such as district heating.[66]

1.5. The Role of Architecture

Decisions made in the architectural design process have impacts on the greenhouse gas emissions of all sectors. Material selections and sourcing, mechanical, heating and electrical system design, thermal efficiency and building alignment, and water system design represent decision points which influence the environmental performance of a building. While government policy can help direct these decisions, there are a wide variety of policy instruments that can be employed and determining the effect of those policies can be difficult.[67]

One method of inquiry to test the effectiveness of a set of policies is to survey the stakeholders upon whom the policy is imposed. As William Dunn states, "User surveys are central to the conduct of evaluability assessments and other forms of decision-theoretic evaluation."[68]

Architects play an important role in the design and development of the build environment, particularly in highly urbanized regions with a high share of commercial, industrial and multi-unit residential buildings. In addition to being creative professionals who present clients with individualized design solutions, architects act as intermediaries between the

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[66] Ibid., 33

[67] Louis- Gaëtan Giraudet, et al. "Comparing and Combining Energy Saving Policies: Will Proposed Residential Sector Policies Meet French Official Targets?" *The Energy Journal* 32:213 (2011), 42.
Grant D. Jacobsen and Matthew J. Kotchen. "Are Building Codes Effective at Saving Energy? Evidence from Residential Billing Data in Florida." *The Review of Economics and Statistics* 95 (1) (2011), 34–49.

[68] William Dunn. *Public Policy Analysis.* (New York: Routledge, 2015), 331.

owner/developer of a parcel of real estate and the systems of governance regarding building safety and construction.

In recent years, numerous sustainable building standards and techniques have been introduced at various scales to guide architects in reducing the environmental impact of the building sector.[69] These tools range from local to international in scope and vary in implementation method with some acting as mandatory supplements to building codes enforced by government agencies and others as voluntary certification systems overseen by non-profit organizations. In most cases, architects oversee and communicate with a variety of actors throughout the construction process including general contractors, civil and mechanical engineers, and city planners.

From the beginning of the global sustainability movement, ostensibly traced to the Brundtland Report[70], there has been a contingent of architects focused on developing sustainable buildings and transforming the market, increasing the share of green buildings. This takes numerous forms; highly technical, deeply ecological, socially-focused and health oriented to name a few. In Canada, this contingent is represented by advocacy groups such as the Canada Green Building Council (CaGBC) and Sustainable Buildings Canada (SBC).

Increasingly, the goals and strategies of this contingent are being adopted by institutional actors to achieve greenhouse gas emission reduction targets and as part of their climate change adaptation and mitigation plans. One example of this is the growth of the Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system, under which 91,700 buildings have been certified around the world as of 2017.[71]

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[69] Fowler and Rauch (2006) list 26 unique sustainable building rating systems and several subsidiary systems.
[70] Gro Harlem Brundtland. *Our Common Future.* (Oxford University Press, 1987).
[71] USGBC. "LEED." United States Green Building Council. (2017).

Discussions with members of SBC and CaGBC revealed an initiative on the part of this subgroup of architects to include sustainable design as a core requirement of professional certification in the Province of Ontario through the Ontario Association of Architects (OAA). However, not all architects agree with the need for the professional body to impose further requirements beyond the existing and proposed Provincial policies, codes and standards. Under this pretext, this research was undertaken to assess the predominance of sustainable architecture as philosophy and practice within the architectural community of Ontario.

1.6. Objectives

The purpose of this research was to analyze the implementation of sustainability and climate policy in the Province of Ontario as it relates to the building sector through a survey of a group of stakeholders in the sector and characterize the perspectives of those stakeholders. Based on the view that sustainable building has reached a moderate level of systemic adoption within Ontario, an online survey was developed to gather knowledge regarding the use, drivers, and governance of sustainable building practices and tools among architects in the province.

1.7. Research Scope

The research consisted of a literature review in two parts, the first defining the terms and concepts within the field of sustainable architecture and the second reviewing surveys of stakeholders within the building sector, and a survey of architects registered to practice in the Province of Ontario.

2. Methodology

2.1. Literature Review

An initial literature review was conducted to develop a conceptual understanding of sustainable architecture using a range of keywords including sustainable architecture, green building, ecological design, environmentally sensitive design, LEED, net-zero, and alternative architecture. Books and articles on sustainable architecture were selected based on popularity within the architectural community, number of citations, and perceived relevance.

A search for survey research reports was conducted with a focus on peer reviewed articles published in journals. Searches were conducted in journal collections including JSTOR, Science Direct as well as in journals with a focus on sustainability and the built environment (Journal of Cleaner Production, Energy and Buildings, Building and Environment). Keywords included: survey, questionnaire, perspectives, opinions, architects, sustainable architecture, sustainable design, green building, green design, sustainable construction. Various combinations of keywords were employed in each source and no preference was given to date of publication.

A total of 60 articles were selected in the initial search phase. These articles were reviewed for relevance to sustainability and organized into three categories; perspectives of architects, perspectives of other actors within the building industry, and perspectives of building users and inhabitants.

Priority was given to perspectives of architects and construction-related actors within the building industry. Articles that met these criteria were reviewed and those that did not contain survey results were eliminated. A total of 16 articles were selected that report on the findings of surveys conducted among architects and other actors in the building industry on various aspects of sustainable design and construction.

2.2. Survey Design

The questionnaire was informed by the literature review above and best practices described in two survey design texts; *Asking Questions: the definitive guide to questionnaire* *design*[72] and *Handbook of Survey Research*.[73] Based on these sources, a mix of questions were designed to examine respondents' professional experience with building-related sustainability technologies/techniques and draw out opinions on the goals of sustainable development. Additional questions sought to understand the importance that environmental concerns are given in the design process, whether pressure comes from within the company or from clients, and how energy issues are prioritized in the building design process.

The survey was organized in four sections; basic information, sustainable building standards, energy, and broader sustainability. Each section consisted of several question types including modified Likert scale, multiple selection, open-ended and yes/no questions.

Section 1 collected information about how long respondents have been practicing architecture, their professional specialization, and where their designs have been constructed. Section 2 asked about their experience with and preferences toward sustainable building standards. Section 3 included questions about how respondents consider energy performance/efficiency in their design process and their experience with related tools, how they and their clients prioritize energy issues, and their experience with building integrated renewable energy. Section 4 was a more detailed inquiry into notions of sustainability and contained questions about respondents' opinions of climate change, sustainable design, the frequency with which clients raise the topic, and reasons given for discarding sustainable design features.

2.2.1. Questions & Rationale

The first group of questions was directed at establishing a background profile of the respondent by asking the length of time they have been registered as an architect, which school

[72] Norman M. Bradburn. "Asking Questions: the definitive guide to questionnaire design – for market research, political polls, and social and health questionnaires." (San Francisco, CA, USA: John Wiley & Sons, 2004).
[73] P. V. Marsden & J.D. Wright. "Handbook of survey research (2nd ed.)." (Bingley, UK: Emerald, 2010).

they attended, their professional specialty, the number of projects they have completed throughout their career, and where these projects have been built. The intention of these questions is to provide the capacity to cross reference this background information with responses later in the survey and draw out relationships between professional experience and experience with particular components of energy and sustainability.

The second group of questions was directed toward respondents' experience with sustainable/green building tools, codes, and rating systems. It asked respondents to identify which rating/certification systems they have used and whether they have a preference. The intention here was to understand whether and why one system may be more popular than others. Respondents were asked if they consider environmental impact when selecting materials and to identify if they have used rating systems (such as FSC) to select materials. The remainder of this section pertained to local environmental factors and whether clients have identified these issues when commissioning a building with the goal of understanding the role that clients play in the prioritization of local environmental factors.

The third group of questions focused on energy; first, energy efficiency, by asking what priority it is given within the firm and by clients. Second, questions on the role of energy modelling in building design, whether it is handled in-house or by outside experts and what source of data is used in modelling. Third, questions about respondents' experience with building-integrated energy generation (e.g., solar PV or wind turbines) and the impact these technologies have on the design process. Last, the role of client requests and priorities was questioned regarding energy generation.

The final section was focused on sustainability as a concept; whether it is a priority for respondents, how it is integrated into their practice, and if clients raise the topic. Respondents were asked to rank 7 components of sustainable design in order of importance and then write in the top three priorities of their average client. Two final questions asked whether climate change influences respondents' architectural practice and if they believe architects should be required use their practice to respond to climate change. The intention of these questions was to gauge practitioners' attitudes toward climate goals at a provincial scale and to cross reference previous answers against the beliefs held by respondents.

2.2.2. Response Rate

From a total of 3,842 architects registered to practice in the Province of Ontario,[74] 31 complete responses were received, short of the target of 63, at which results would be considered statistically relevant.

2.2.3. Calculating Statistical Relevance

Sample size required for statistical relevance was calculated using the following equation:

$$n = \sqrt{N} + 1$$
$$n = \sqrt{3,842} + 1$$
$$n = 63$$

2.3. Methodological Issues

2.3.1. Design

The complex design of the survey was intended to capture an in-depth and varied understanding of the perspectives of respondents, recognizing that sustainability is a term that carries with it complex and varied conceptual and practical ideas.

The survey may have been too long and in depth for uninterested parties to complete which contributed to a significant bias toward respondents who favour sustainable design. A different approach, such as a three-step process consisting of one or two questions embedded in

[74] OAA. "What We Do." *The OAA.* Ontario Association of Architects. (January 23, 2017).

the initial email with an invitation to participate in a more in-depth questionnaire followed by interviews with interested respondents, may have yielded a higher rate of response. This approach may have better captured the opinions of those with little to no interest in the topic while enabling those with greater interest to answer more questions.

2.3.2. Distribution

The survey was distributed through the biweekly OAA email newsletter in two consecutive editions using an advertisement which drew attention to the subject of climate policy and its impacts on architecture. This may have contributed to the selection bias by attracting participants for whom this topic was already considered important. To address this, and to augment the newsletter distribution, invitations to participate were sent to architects selected at random from the OAA directory. Additionally, architects in the researcher's professional network were invited to participate. Due to the nature of these connections, many having been made at sustainability-focused events, these architects may have had a general bias toward sustainable architecture and green building.

3. Literature review

Sustainable architecture is a term that captures a wide variety of views on the role of building design and the application of environmental thought to a profession that can be highly technical in nature. Architects do not all agree on the need to respond to climate change, and those who do use their professional practice to address environmental issues do not necessarily agree on the best way to do so. Guy and Farmer suggest that a single definition of sustainable architecture may not be possible, in part because the very nature of sustainability is different in each place and social/cultural group. The authors state that, "it is vital that we learn to recognize and listen to the number of voices striving to frame the debate and the visions they express of alternative environmental places."[75]

Contributing to this goal of framing the debate, Guy and Farmer have organized the various approaches to sustainable architecture into six categories based on the logic that underlies the approaches. These six competing logics of green building include Eco-technic, Eco-centric, Eco-aesthetic, Eco-cultural, Eco-medical and Eco-social. The categories are an effective tool for understanding the differences between approaches to sustainable architecture. There is overlap between categories and complementary notions of beneficial outcomes but the description of these logics, as with the broader discussion of sustainability, reveals some disagreement about what it means to be sustainable.

Approaching sustainability from modernist viewpoint, both eco-technic and eco-medical logics primarily focus on the minimization of harms from the built environment utilizing existing institutional logic. Eco-technic logic "is based on a technorational, policy-oriented discourse,"[76] and captures such approaches as ecological modernization and a globalization viewpoint.

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[75] Simon Guy and Graham Farmer. "Reinterpreting Sustainable Architecture: The Place of Technology." *Journal of Architectural Education*, 54 (3) (2001), 146.
[76] Ibid., 141.

Industrial solutions and a focus on efficiency are common in this category. Eco-medical logic has a focus on public health and the negative impacts of the built environment. Healing "sick buildings" and responding to the "risk society" through the choice of materials which are natural and the use of traditional building methods.[77]

Others focus on notions of structural change, coming from what could be described as radical viewpoints with a focus on the human-nature nexus. Eco-centric logic has a focus on the need for a "radical reconfiguration of values" and the negative impacts of human activities on the environment.[78] Holistic approaches to building using natural, renewable, recycled and reused materials are captured by this label. Eco-aesthetic logic is compared to New Ageism in that it embodies a theory of social change with an idealist vision of ecological awareness. This category is typified by organic forms and unconventional notions of space.

The final logic categories, eco-cultural and eco-social, place a priority on the integration of environmental degradation and social issues. Eco-cultural logic embodies the idea that humans are a part of nature and therefore places focus on place as a counterpoint to the "deficiencies of abstract modernist space."[79] This category has an emphasis on building techniques that utilize local materials and culturally sustainable solutions. Eco-social logic attempts to address the larger social factors at the root of the ecological crisis. Social structures lead to environmental degradation based on the patterns of domination within them and a response is possible through buildings that have a positive influence on the "social and ecological community."[80]

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[77] Ibid., 145.
[78] Ibid., 142.
[79] Ibid., 144.
[80] Ibid., 146.

3.1. Niches

Segmenting the various approaches to sustainable architecture implies that these categories are niches within the architectural profession in which proponents become specialized, leading to groups of practitioners who are separated from the larger profession. In response to this notion, Bennetts, et al. suggest that sustainable architecture need not be considered a separate form of architecture but instead, "a revised conceptualization of architecture in response to a myriad of contemporary concerns about the effects of human activity."[81] The authors note that architects have always designed buildings to address the needs and concerns of the time and place in which they work. In this view, sustainability becomes the context rather than the goal.

These authors point out that sustainability is a fuzzy term and each individual or group may have their own definition. As an example, the authors describe the difficulty with a commonly used acronym, ESD, which is often used to mean Environmentally Sustainable Design. However, things become unclear very quickly. The 'E' can mean environmentally, ecologically or economically; the 'S' most often represents sustainable but can also mean sensitive; and finally, the 'D' has been used to mean alternately design and development.[82]

Sustainable architecture, the authors state, "carries with it the imprecise and contested meanings embedded in ESD, and denotes broader ideas than any of the individual understandings of ESD, in particular, the notion of 'sustainable architecture' includes questions of a buildings suitability for its sociocultural as well as environmental context."[83] Merely changing materials or increasing the energy efficiency of a building, while reducing the environmental impact of architecture, may not be sufficient to fit within the context of

[81] Helen Bennetts, et al. *Understanding Sustainable Architecture* (1). (Abingdon, Oxon, US: Taylor & Francis, 2003), i.
[82] Ibid., 4.
[83] Ibid., 4.

sustainability. From this viewpoint, the competing logics described by Guy and Farmer may be better described as complementary logics – each significant components of a complex conceptual shift.

Bennetts, et al. even state that sustainability includes “both local and global concerns and has a political dimension, embracing issues of resource control and the inequalities that exist between developed and developing nations.”[84] Without this conceptual complexity, sustainability may become a technical exercise situated within existing institutional structures that serves to reinforce these inequalities. This may be best represented by Guy and Farmer’s eco-technic logic, the category of thought that is primarily concerned with science and technology as sources of environmental solutions and top-down policy implementation as a path toward sustainability.

Bennetts, et al. also express the somewhat cynical suggestion that this globalist approach to sustainability often employs fear-based arguments in favour of sustainability to overwhelm opposing viewpoints. One outcome of this tactic of framing the discussion is that sustainability can be viewed as a political machination used to support existing power structures. Here the authors quote noted satirist H.L. Mencken in stating, “The whole aim of practical politics is to keep the populace alarmed – and hence clamorous to be led to safety – by menacing it with an endless series of hobgoblins, all of them imaginary.”[85] It is these “hobgoblins” of climate change that some alternative perspectives, those Guy and Farmer refer to as eco-aesthetic, eco-social and eco-cultural logics,[86] are opposing when they focus on the environmental and human benefits of sustainable architecture rather than allowing technocratic systems to dominate the design process.

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[84] Ibid., 5.
[85] Ibid., 17.
[86] Guy and Farmer. “Reinterpreting Sustainable Architecture” 143 & 144.

3.2. Dominant Systems

Technocratic systems have nonetheless come to dominate the institutional discussion of sustainable architecture. Paola Sassi describes the development of databases, rating schemes, calculators, and other methods of understanding building materials and their characteristics over the last thirty years which, the author states, has increased the visibility of indirect impacts associated with those materials.[87] The acknowledgement by architects that design decisions, such as the selection of materials, have wide reaching direct and indirect environmental and social impacts has led, to some extent, to the development of these tools. This systemic approach to sustainability, not changing the system but presenting transparency as a fundamental feature, enabled the development of tools to make it easier for architects to select materials based on their environmental and social impact. Once architects were able to more easily see the natural resource depletion, natural habitat destruction, global warming and public health impacts of their design choices, they began to select materials with fewer negative impacts.[88]

Sassi suggests that the development of the wide range of tools now available to architects pushed sustainability forward faster than perhaps a less technocratic approach would have because they enable architects to "design in sympathy with the environment, but also to provide a building that can accommodate changes of use."[89] While some architects, using logic Guy and Farmer refer to as eco-centric,[90] focus on radical reconfiguration of modern life, Sassi's description of sustainable architecture falls squarely into the eco-technic logic. The author states that "The aim of sustainable building in respect of energy is to enable the occupants of a building

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[87] Sassi, *Strategies for Sustainable Architecture*, 144.
[88] Ibid., 144.
[89] Ibid., 149.
[90] Guy and Farmer. "Reinterpreting Sustainable Architecture" 142.

to maintain and, if possible, improve their quality of life, while producing the least possible amount of CO_2 emissions."[91]

This seemingly straightforward approach, minimizing CO_2 emissions, has led to surprisingly impactful building guidelines. One of these is the Passivhaus Standard, often rendered into English as Passive House Standard (PHS), which has been adopted in Denmark as a component of the country's carbon emissions reduction plan.[92] In German, where the standard was developed, several cities have mandated PHS as the minimum for residential homes and the country may soon adopt it as a national standard.[93] The major aim of PHS is to ensure a comfortable living space with passive heating.[94] The standard requires a maximum heating consumption of 15kWh/m^2 annually by mandating minimum U- and R-value ratings for windows and insulation, design prescriptions for mechanical systems that specify preheating and heat recovery, and orientation recommendations.[95] The PHS is a possibility only because of the vast amount of data, large number of modelling tools and myriad technical systems available to modern architects in the pursuit of reduced energy consumption. Using these tools, architects can adapt the performance standards to fit in any number of locales, enabling the design of buildings that fit in any building tradition.[96]

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[91] Sassi, *Strategies for Sustainable Architecture,* 204.
[92] IEA. *Energy Policies of IEA Countries: Denmark 2011 Review.* (OECD/IEA, 2011), 58.
[93] Craig Morris and Martin Pehnt. *Energy Transition, The German Energiewende.* (Heinrich Boll Foundation, 2012), 50.
[94] Sassi, *Strategies for Sustainable Architecture,* 205.
[95] Ibid., 205.
[96] Marcel Elswijk and Henk Kaan. *European Embedding of Passive Houses.* (European Commission, Intelligent Energy Europe Programme, 2008.), 9.

3.3. Green Building Standards

More complex standards and rating systems have been developed that provide guidance through the entire building process from design through construction and continuing into operation and maintenance. Mao et al. compare six sustainable building tools – LEED, BREEAM, SBTool, CASBEE, BCA-GM, and ESGB – and find that they share three guiding purposes and three "pillars of sustainability."[97] The three purposes shared by all tools are assessing the performance of the building process, guiding the process of building and accelerating the transformation of the construction industry.[98] The three pillars of sustainability, according to the authors, are environmental protection and ecological balance, economic growth, and social progress and equity.[99]

A common theme in many rating systems is the professional accreditation of adherents as both a method of ensuring quality projects and promoting the tools themselves within the industry. The great number of tools increases the options for designers but may have the effect of further segmenting and isolating architects who pursue sustainable methods into subgroups based on the specific tool they employ. However, Mao et al. trace all green building tools to BREEAM, the Building Research Establishment Environmental Assessment Method. Considered the first green building tool, BREEAM was first published in 1990 and most others are based on or influenced by this system.[100] The importance of energy and water efficiency, materials and resources, and indoor environmental quality is included in all standards.

The authors note a difference in market penetration of tools based on their origins. Those developed by third-party organizations and operated as non-profit organizations are found to

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[97] Xiaoping Mao, et al. "A Comparison Study of Mainstream Sustainable/Green Building Rating Tools in the World." *IEEE (*2009), 5.
[98] Ibid., 1.
[99] Ibid., 5.
[100] Ibid., 2.

have higher market penetration, in part because they are intended to be flexible enough to be applied in as many contexts as possible (eg, LEED). Government-created standards (eg, ESGB from China) are found to be less favoured by the market because they are applied as top-down, prescriptive policies developed without input from industry stakeholders.[101]

3.4. Surveys of Architects

The discipline of architecture is not monolithic and the approaches to sustainable architecture are diverse, with many different perspectives competing against and complementing one another to generate a vibrant field of practice. Against this background, numerous surveys have been conducted among professionals to gather their opinions on a wide array of topics including environmental responsibility and commitment, design processes, materials, and the importance of various components of sustainable building.

In a survey of Australian architects, Sabine Wittman found that less than a third consider energy efficient/ecological architecture to be among the top three most important factors of building design.[102] Building on this survey, Demirbilek et al. found that less than half of responding Australian architects believed themselves to be solely responsible for designing in response to the environment, while the remainder agreed that it requires a team of experts.[103] The complexity of the processes of sustainable building design may require more knowledge and expertise than an individual is capable of possessing.

Similarly, in Italy, Annunziata et al. found that the large number of green building certification systems was a significant barrier to adoption of sustainable design practices amongst

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[101] Ibid., 5.
[102] Sabine Wittmann. “Architects’ Commitment Regarding Energy Efficient/Ecological Architecture.” *Architectural Science Review* 41 (2) (1998), 90.
[103] Nur Demirbilek and Amanda L. Cheetham. Achieving Sustainability in Architecture: The Approach of Architects to Climate Responsive Building Design Practice in South-East Queensland. In Proceedings ANZASCA2002 36th Annual Conference of the Australian and New Zealand Architectural Science Association. (Victoria, Australia: Deakin University, 2002), 121.

building designers.[104] The findings show that designers, including architects, express support for 'eco-design' but this does not lead to sustainable buildings without support from all parties involved in the design and construction process including developers, engineers and materials manufacturers. Pedrini and Szokolay delved into the decision-making process to understand how architects conceive of design solutions and why energy tools are not popular among architects, finding that respondents placed the greatest importance on intuition.[105] Following intuition, respondents identified 3-D thinking, the meaning of the building, impact of the design, and lateral thinking as important aspects of their design process, suggesting that there is a preference for simple, straight-forward methods among architects.[106] The complexity of tools extends to many aspects of design, Kanters et al. found that architects who use computer-based tools for solar design, to design low-energy passive solar buildings, consider the complexity, cost, and lack of integration with other tools to be the biggest barriers to broader use.[107] Respondents noted that they may have to learn several different tools for each component and stage of the design of a building, adding cost and time to the process.[108]

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[104] Eleanora Annunziata, et al. "Environmental Responsibility in Building Design: An Italian Regional Study." *Journal of Cleaner Production* 112, Part 1 (January, 2016), 647.
[105] Aldomar Pedrini and Steven Szokolay. "The Architects Approach to the Project of Energy Efficient Office Buildings in Warm Climate and the Importance of Design Methods." *Ninth Annual IBSPA Conference* (2005), 940.
[106] Pedrini and Szokolay. "The Architects Approach" 940.
[107] Jouri Kanters, et al. "Tools and methods used by architects for solar design." *Energy and Buildings* 68 (2014), 725.
[108] Ibid., 728.

3.5. The Role of Clients

In addition to the complexity of the green building tools landscape, several surveys indicate that architectural clients are a barrier to sustainable building (Annunziata 2016; Reinhart and Fitz 2006; Alrashed and Asif 2014; Vatalis et al. 2013). The lack of client knowledge of and interest in the benefits of sustainable design and thus unwillingness to pay are identified by Reinhart and Fitz (2006) as a reason given by architects for not using daylight simulations in the design process.[109] Alrashed and Asif (2014) found that respondents' clients were least interested in sustainable design solutions, except energy efficiency, and were focused on cost, 'modernity' and development time.[110] The authors suggest that the Saudi building industry has not yet realized the significance of sustainability and is preoccupied with high-energy systems and materials.[111] Vatalis et al. (2013) surveyed industry actors and clients, finding that respondents placed a higher value on sustainability components that provide either a direct financial return or reduced indirect costs for inhabitants.[112] Respondents placed energy efficiency, toxics, and indoor air quality as the three most important factors of sustainable design with other, more expensive components such as waste reduction, environmentally sensitive materials, and life cycle assessment near the bottom.[113]

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[109] Christoph Reinhart and Annegret Fitz. "Findings from a Survey on the Current Use of Daylight Simulations in Building Design." *Special Issue on Daylighting Buildings* 38 (7) (2006), 826.
[110] Farajallah Alrashed and Muhammad Asif. "Saudi Building Industry's Views on Sustainability in Buildings: Questionnaire Survey." *Energy Procedia*, 6th International Conference on Sustainability in Energy and Buildings, SEB-14, 62 (January, 2014), 387.
[111] Reinhart and Fitz. "Findings from a Survey" 829.
[112] K. I. Vatalis, et al. "Sustainability Components Affecting Decisions for Green Building Projects." *Procedia Economics and Finance*, International Conference On Applied Economics (ICOAE) 2013, 5 (January, 2013), 748.
[113] Vatalis, et al., "Sustainability Components" 748.

3.6. Elements of Sustainability

This trend also appears when architects were asked by Hepner and Boser (2006) what they believed were the most important of LEED's six checklist areas.[114] The top three, in order of importance, were Energy and Atmosphere, Indoor Environmental Quality, and Materials and Resources.[115] Energy efficiency provides a direct payback to building owners through reduced expenditures while indoor environmental quality is linked to higher productivity among employees. The same study found that architects consider daylighting to 75% of spaces to have the most impact on employee productivity, therefore making it a worthwhile cost for building owners.[116] Materials however, may have the largest environmental impact because of their extraction, processing, manufacturing and transportation, all of which requires energy and generally produces pollution and greenhouse gases.[117]

Several studies discuss building materials (Annunziata 2016; Demirbilek et al. 2002; Vatalis et al. 2013) and find that they are an important consideration in sustainable building but fall below other components when rated by architects, designers and clients. Chick and Micklewaite (2004) focused on recycled materials, finding that of approximately 700 UK architects and designer, 91% specified recycled materials never or less than one quarter of the time.[118] The most commonly cited barrier preventing respondents from selecting recycled materials was the added complication for other parties within the supply chain and building

[114] Christina M. Hepner and Richard A. Boser. "Architects' Perceptions of LEED Indoor Environmental Quality Checklist Items on Employee Productivity." *International Journal of Construction Education and Research* 2 (3) (2006), 193–208.
[115] Hepner and Boser. "Architects' Perceptions of LEED" 202.
[116] Ibid., 204.
[117] Sassi, *Strategies for Sustainable Architecture*, 146.
[118] Anne Chick and Paul Micklethwaite. "Specifying Recycled: Understanding UK Architects' and Designers' Practices and Experience." *Design Studies* 25 (3) (2004), 256.

process, though the authors note that BRE (Building Research Establishment) launched an initiative to certify recycled materials for buildings.[119]

In another example of material selection as the basis for sustainable design, Hemstrom, et al. discuss the replacement of concrete and steel in multi-story buildings with wood. Their study found that despite promotion of sustainable forestry products as suitable materials for multi-story construction by government and industry, architects consider the environmental aspects to be less important the project cost, fire safety, stability and sound insulation.[120] Despite the fact that respondents had a favourable attitude toward the use of wood, they perceived concrete to be the most suitable frame material for this type of building.[121] These studies show that while material selection has a large impact on the environmental impact of a building, there are various factors that influence the decision to utilize a specific material including the opinions of numerous actors, supply chain issues, and client knowledge.

3.7. Discussion

Architectural approaches to sustainability are broad in scope and, while they can be described in discrete categories based on their underlying logic, contain many overlapping notions of what it means to build sustainably. It is apparent that the technocratic systems that have developed within the architectural profession surrounding materials, energy efficiency, and modelling have enabled architects to realize sustainability goals based on the ever-increasing amount of data available to them.

Without these tools and systems, it is unlikely that the sub-discipline or specialization of sustainable architecture would have developed to its current level of adoption globally. Because

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[119] Chick and Micklethwaite. "Specifying Recycled" 271.
[120] Kerstin Hemströ, et al. "Perceptions, Attitudes and Interest of Swedish Architects towards the Use of Wood Frames in Multi-Storey Buildings." *Resources, Conservation and Recycling* 55 (11) (2011), 1016.
[121] Hemströ, et al. "Perceptions, Attitudes and Interest of Swedish Architects" 1018.

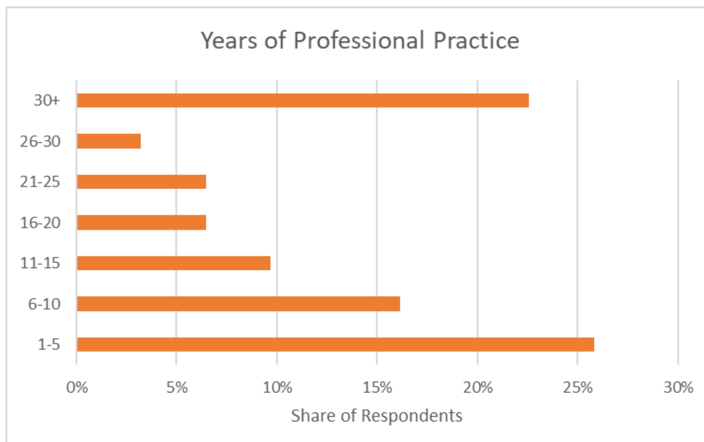
of the complexity of modern architectural requirements, practitioners are expected to be experts in the science of designing safe, comfortable and aesthetically pleasing buildings. Simultaneously, they are expected to possess in-depth knowledge of the life cycle costs and chemical properties of each material used, energy efficient design, solar and daylighting design, and waste reduction.

Architects are not the only actors within the building industry and, as several surveys reveal (Dimirbilek et al. 2002; Hemstrom et al. 2011), many do not believe themselves to be solely responsible for sustainable design. However, they are key actors in the goal of a sustainable built environment and their involvement is integral to the achievement of Canada's emissions reductions targets.

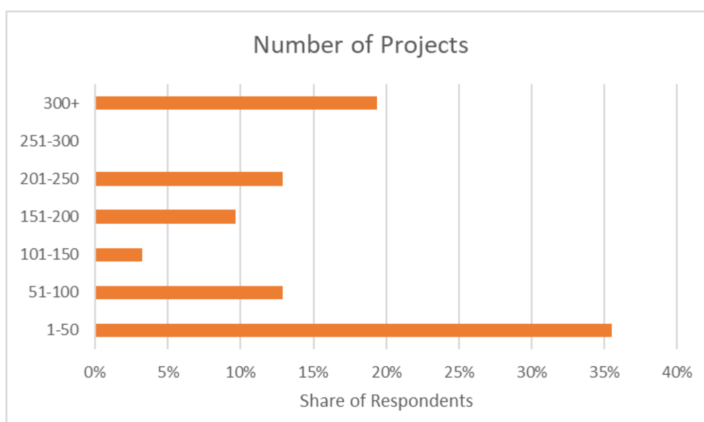
4. Survey Results

4.1. General information about respondents

Respondents represented a breadth of experience with the largest number of participants having between one and five years' experience (26%) followed by those with more than thirty years' experience (23%). Respondents with 6-10 years' experience made up 16% and those with 11-15 years' experience accounted for 10%. Two groups, 16-20 years and 21-25 years, made up 6% of respondents each with the final group, 26-30 years, making up 3% of the total.

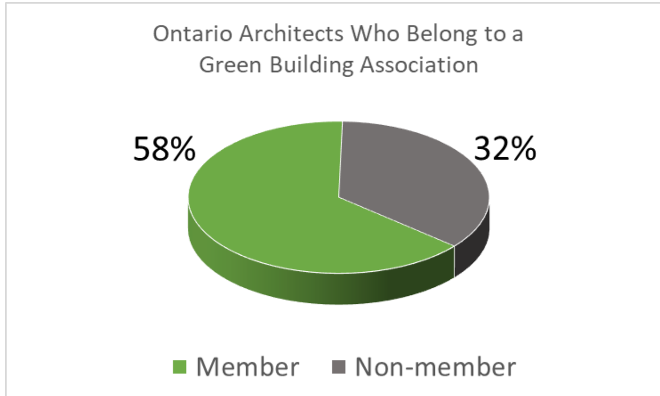


Respondents' experience represents thousands of completed buildings. The number of completed projects was grouped into blocks of 50 up to 300 with one group for more than 300. The largest number of respondents have completed between one and fifty projects (35%) followed by those who have completed more than 300 projects (19%).

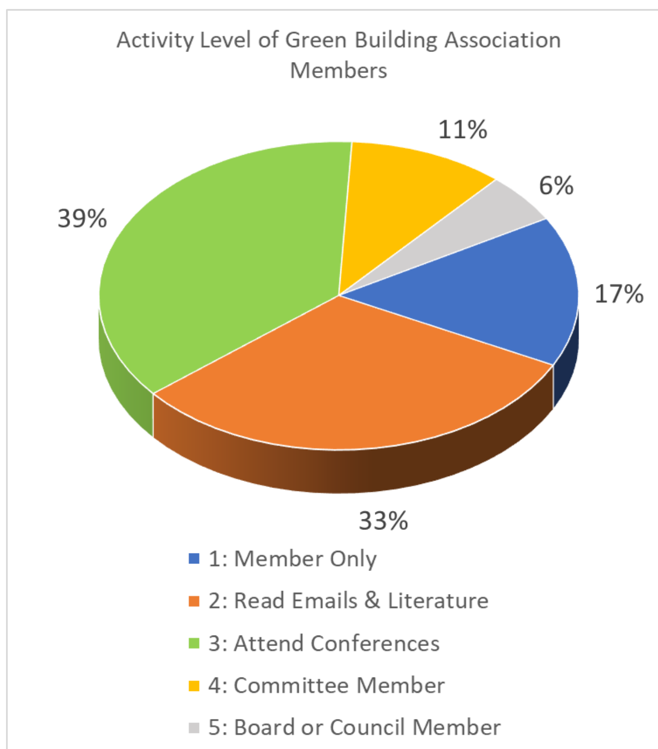


Survey participants were educated in a wide variety of architectural schools, predominantly based in Ontario with several U.S. and international school represented.

4.1.1. Participation in sustainability related professional organizations



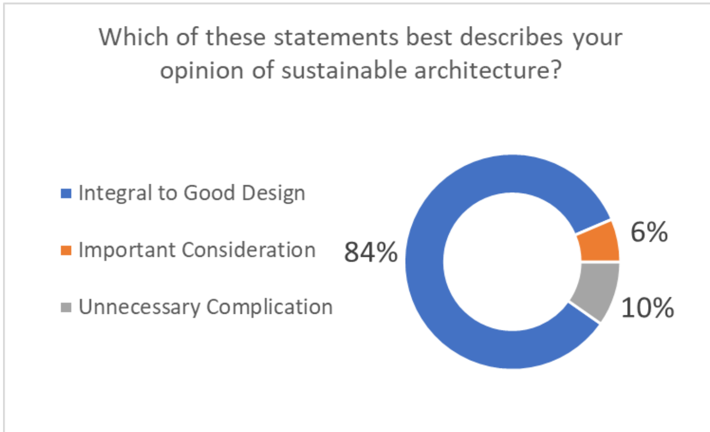
Survey participants were asked to describe their level of activity in the green building community; if they belong to a green building association, such as the Canadian Green Building Council or Sustainable Buildings Canada, and, if so, how active they were within that organization. More than half of respondents, fifty-eight percent, identified themselves as belonging to a green building association. Activity level within the organization was rated on a five-point scale with 1 being the least active and 5 being the most active.



The majority of respondents who are members of a green building association are moderately active; reading emails and literature (33%) and attending conferences (39%). Only 6% stated that they sit on the council of board of directors, the highest level of activity, with an additional 11% who are part of a committee, the second highest level of activity. A small share (17%) of respondents belong to the least active group of members, simply belonging to an association.

4.1.2. Perspectives on sustainability

Survey participants were asked which of three statements best described their opinion of sustainable architecture. More than two-thirds of respondents (84%) agreed with the statement that sustainable architecture is "Integral to Good Design." Only 6% agreed that sustainable architecture is an "Important Consideration," and 10% considered it to be an "Unnecessary Complication."



This aligns with the statement of Bennetts, et al. that architects have always worked to address the needs and concerns of the time and place in which they work.[122] Regardless of the individual opinions of those in the building sector, contextual pressures are beginning to place sustainable design at the forefront of the needs and concerns of contemporary society.

Personal conviction appears to be an important factor leading to the inclusion of climate change concerns and environmental issues in the building design process, corroborating findings reported by McGraw Hill Construction.[123] However, as Annunziata, et al. report, this does not necessarily translate to increased adoption of sustainability tools.[124] This personal conviction

[122] Bennetts, et al. *Understanding Sustainable Architecture*, i.
[123] McGraw Hill Construction report that 42% of respondents placed "Right Thing To Do" as a top three trigger for increasing involvement in green building in Canada. (*Canada Green Building Trends*, 23.)
[124] Annunziata, et al. "Environmental Responsibility in Building Design" 642, 644.

may be more important in the way it influences the broader market transformation and influences the architectural profession.[125]

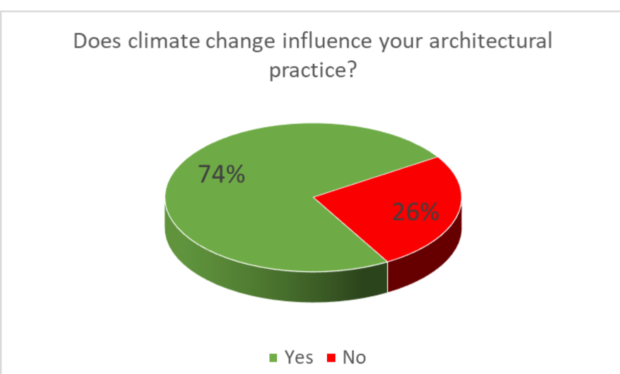
As some respondents' comments reveal, a client's priorities often supersede the personal convictions of the architect, as "Clients will only pay for the minimum requirements," and "if the client can't afford it then there won't be a project."

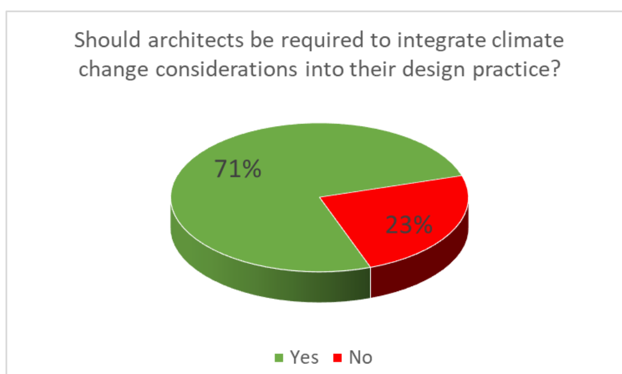
4.1.3. Influence of Climate Change

Discussions with architects in Ontario revealed some debate regarding whether there should exist a professional responsibility regarding climate change and whether registered architects should be required to considered climate change as part of their membership in the professional association.

The following questions were designed to understand the influence of personal belief on the application of and experience with the concepts and tools of sustainable architecture and whether this personal belief extended to a professional responsibility or requirement.

When asked if climate change influences their architectural practice 74% percent of participants responded positively. A slightly lower number (71%) agreed that architects should be required to integrate climate change considerations into their design practice. This slight





[125] Dodge Data & Analytics state "doing the right thing" is associated with "the goal of achieving transforming the market [which] tends to be more important to early adopters…" (*World Green Building Trends 2016*, 14.)

decrease may reflect the results reported by Annunziata et al., in which the stated preference toward green building did not necessarily translate to those practices being employed.[126]

This notion is reflected in the comments given in response to the question of how climate change influences respondents' architectural practice. A range of responses were received highlighting the importance of using architecture to respond to the pressures of climate change, some addressing the global problem:

> "…trying more and more to create efficient and sustainable buildings that won't have a negative impact on climate change."
>
> "…with all project choices we consider the carbon footprint associated."
>
> "We look at GHG potential in product selection… We encourage clients to build less, but build it better."

Other responses considered the related environmental changes at a more regional scale:

> "…storm water management as storm volumes seem to be increasing…"
>
> "Consideration of materials and methods that might be able to deal with extreme weather and the fallout from the change…"
>
> "Changing weather conditions, increased potential for flooding in some locations, unpredictable seasons…"

Some respondents stated that climate change did not influence their practice and expressed a reticence toward the concept. One particular comment captures this sentiment; "Climate changes all the time... the climate change industry is the biggest fraud in history and huge resources wasted. It does not influence my work." This comment reflects a hostility toward

[126] Annunziata, et al. "Environmental Responsibility in Building Design" 642, 644.

the notion that climate change is a challenge worth facing and that an individual architect has any responsibility in adapting his or her practice to incorporate the principles of sustainability.

However, architects are increasingly obligated to incorporate these principles into their practice as governments of all scales adopt climate-related policies and some commented that stronger building codes should be imposed to increase adoption of such considerations. Several comments support the notion that architects should be required to incorporate climate change adaptation and the principles of sustainability into their design practice:

> "Buildings contribute a huge amount of greenhouse gases to the atmosphere - part of this can be addressed in design and architects should have a responsibility to address this."
>
> "…this is already being achieved to a certain extent through changing legislation for building requirements. Clients will only pay for the minimum requirements therefore the base level requirements must increase to make all buildings more responsible towards the environment."
>
> "It is akin to asking should we integrate sound structural design into our practice. It would be incompetent to not do so."

Some expressed dismay at the notion that a legal or professional obligation should be placed upon architects:

> "Mandated? No. But we should, as an industry, see it as good design."
>
> "It is a personal decision to be made by the client and not another reason to expand government or create another certification industry or twist it into another revenue tool."

This second comment seems to reflect a response to what Guy and Farmer term eco-technic logic, which has come to dominate the conversation of sustainable architecture, just as the technocratic paradigm has come to dominate sustainability policy. In this paradigm, architects are merely tools of a greater system which seeks to maximize efficiency and minimize harm. As Guy and Farmer describe, there is a reticence for those who have adopted other conceptual framings of sustainable architecture to accept the imposition of a technocratic framework of sustainability.[127]

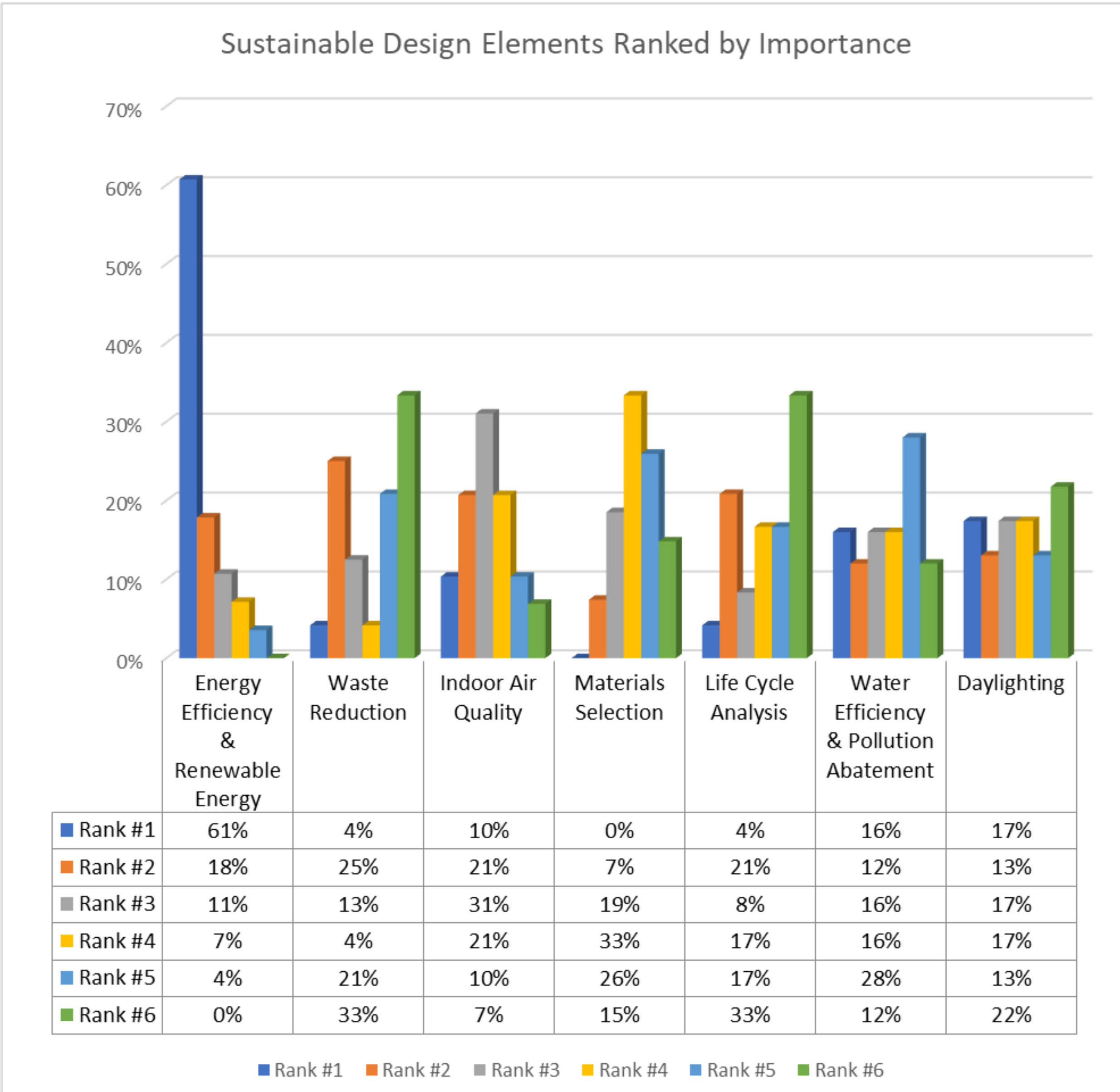
4.2. Elements of Sustainability

Sustainable architectural design is often described in terms of several elements. For the purposes of this survey, these elements were organized into seven categories; Energy Efficiency & Renewable Energy, Waste Reduction, Indoor Air Quality, Materials Selection, Life Cycle Analysis, Water Efficiency & Pollution Abatement, and Daylighting.

4.2.1. Relative Importance of Elements

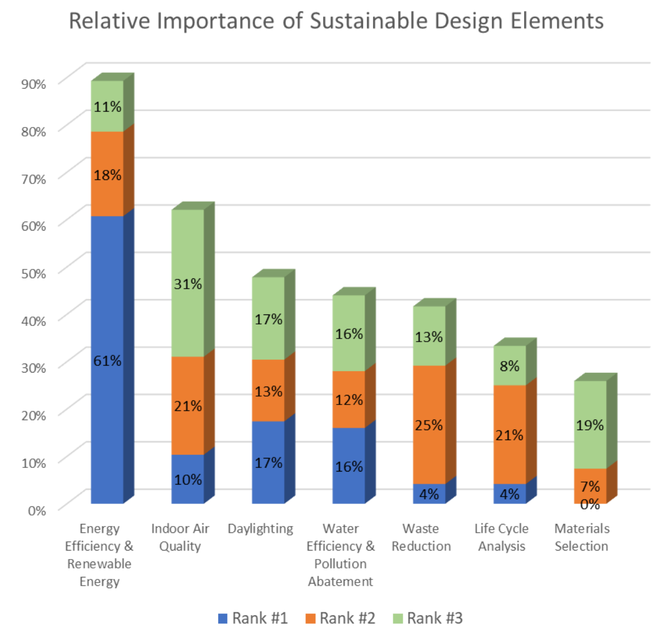
Respondents were asked to rank each element by importance. More than half of respondents (61%) ranked Energy Efficiency & Renewable Energy first, with the next highest first-ranked elements being Daylighting (17%) and Water Efficiency & Pollution Abatement (16%). Waste Reduction was identified by 25% of respondents as the second most important element, followed closely by Indoor Air Quality (21%) and Life Cycle Analysis (21%). Indoor Air Quality was selected by 31% of respondents as the third-rank element followed by Materials Selection (19%) and Daylighting (17%). Full results below.

[127] Guy and Farmer. "Reinterpreting Sustainable Architecture" 143.



	Energy Efficiency & Renewable Energy	Waste Reduction	Indoor Air Quality	Materials Selection	Life Cycle Analysis	Water Efficiency & Pollution Abatement	Daylighting
Rank #1	61%	4%	10%	0%	4%	16%	17%
Rank #2	18%	25%	21%	7%	21%	12%	13%
Rank #3	11%	13%	31%	19%	8%	16%	17%
Rank #4	7%	4%	21%	33%	17%	16%	17%
Rank #5	4%	21%	10%	26%	17%	28%	13%
Rank #6	0%	33%	7%	15%	33%	12%	22%

Put another way, the elements of sustainable architecture in order of importance as determined by the share of responses which placed them in the top three ranks are as follows: Energy Efficiency and Renewable Energy (90%), Indoor Air Quality (62%), Daylighting (48%), Water Efficiency & Pollution Abatement (44%), Waste Reduction (42%), Life Cycle Analysis (33%), and Materials Selection (26%).



These findings align with research at the global scale on green building trends, undertaken by Dodge Data & Analytics, which reported that reducing energy consumption was identified by 66% of respondents as the most important reason for employing green building techniques.[128] Also given as important reasons were protecting natural resources (37%), reducing water consumption (31%), lower GHG emissions (24%), and improving indoor air quality (17%).[129]

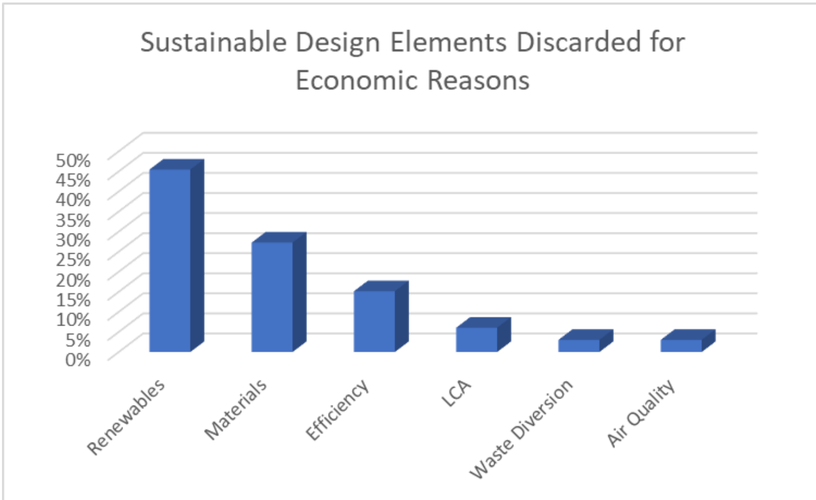
4.2.2. Economic Determinants

While each of these seven elements of sustainable architecture are important to achieving the goals of minimizing the environmental impact of buildings, several are associated with increased costs that may be beyond the financial capacity of building owners and developers. As

[128] Dodge Data & Analytics. *World Green Building Trends*, 17.
[129] Ibid., 17.

shown above, architects must be sensitive to the financial capabilities of their clients. Having ranked the elements of sustainable architecture from their own perspective, respondents were then asked which elements were most often discarded for economic reasons. In order to allow specificity on the part of respondents, this question was an open answer rather than multiple-choice and the responses were categorized afterward.

Renewable energy was identified by 45% of respondents as the most common element to be discarded for economic reasons followed by materials (27%) and energy efficiency (15%). The final three elements were each identified by fewer than 10% of respondents; Life Cycle Assessment (6%), Waste Diversion (3%), and Air Quality (3%).



The high cost of renewables sets it significantly above other elements in regard to cost concerns and several comments reflected this, for example: “Renewable energy will take hold when the capital cost comes down,” and “Costs of BIPV and other technologies need to be further reduced to make them enticing for clients.” While some comments expressed support for the application of building integrated renewable energy, for example; “All buildings should be net energy positive,” the high cost dissuades building owners from pursuing such an approach.

4.2.3. Discussion

Ontario's Climate Change Action Plan and subsequent policy implementations have begun to address the concerns expressed by respondents. Four significant actions may drive changes in the building sector which encourage faster adoption of sustainable building practices in the province; the cap-and-trade program, building code changes, rebates for renewable energy and energy efficiency, and support for public institutions. Each of these policies increases the necessity for architects to consider the impacts of climate change in their design process through either mandate or by changing the economics in such a way as to alter client priorities.

A concern cited by several respondents was that energy is inexpensive enough that clients may not be willing to invest in energy efficiency retrofits and high-efficiency new builds. This is reiterated by McGraw Hill Construction, as quoted above.[130] Ontario's commitment to join the Western Climate Initiative cap-and-trade program will ensure that energy is priced at a level that internalizes the cost of GHG emissions, potentially driving increased numbers of energy efficiency retrofits and higher expectations for new building performance. The Province has, at the time of writing, held three stand-alone auctions of GHG allowances with the price having reached approximately $18 per tonne.[131] This exceeds the minimum price of $10/tonne recommended in the Pan-Canadian Framework by more than 80%. However, this policy is somewhat undermined by the decision to subsidize electricity prices with approximately $1 billion of these proceeds, as described by the Environmental Commissioner,[132] thereby reducing the incentive for electricity consumers to invest in energy efficiency. For the cap-and-trade

[130] McGraw Hill Construction. *Canada Green Building Trends*, 17.
[131] Ontario. MOECC. *Ontario Post-Auction Public Proceeds Report.* Ministry of Environment and Climate Change: 2.
[132] ECO. *Facing Climate Change,* 11, 118.

program to be effective at driving down emissions in the building sector it must incentivize allocation of funds toward efficiency upgrades rather than support the continuation of the status quo.

Changes to the Ontario Building Code ensure that all buildings of similar purpose and size are held to similar, and higher, standards of energy efficiency. Several respondents supported the use of building codes as a tool to increase adoption of sustainable building practices. As of January 2017, increased energy efficiency requirements are in place which mandate a 50% increase in energy efficiency for small buildings and 65% increase for large buildings.[133] These standards are intended to increase through 2030 with the intention of mandating net-zero carbon emission standards for small buildings.[134] Additional changes impose a requirement for buildings to be designed with EV charging infrastructure in anticipation of future growth in adoption of this type of vehicle, removing the decision to pursue such installation from the building owner.[135] These Code changes even the playing field for efficiency standards and technological adoption in the province, changing the dynamics of building owner priorities and addressing the concern that these elements of sustainable architecture will be adopted only if the client is so inclined.

Rebates funded with proceeds of the cap-and-trade program, directed through the Green Bank, increase the ability of some architectural clients to afford elements of sustainable architecture such as renewable energy which would otherwise be eliminated from a project based on cost. In particular, those building residential buildings will be supported with rebates for the construction of net-zero or near net-zero carbon homes, reducing the number of people who

[133] Ontario. *Potential Changes to Ontario's Building Code*, 17, 18.
[134] Ibid., 18.
[135] Ibid., 27.

would otherwise discard these elements due to high up-front costs.[136] The Action Plan also describes programs directed at supporting green retrofits of existing buildings to increase energy efficiency and install low-carbon energy technologies in residential buildings.[137] While these programs will help reduce the up-front costs of system replacements, they also suffer from the subsidization of electricity prices which reduces the pressure to reduce consumption.

The final policy instrument focused on addressing the issues raised above by architects in Ontario is the commitment to support schools, hospitals, colleges and universities in retrofitting existing buildings. This is primarily a financial solution to provide a large group of architectural clients, public sector building owners, a source for funding retrofit projects to increase energy efficiency and install renewable energy technologies. The other effect of this policy is to require architects working on these buildings to take climate change into account in the design process as these institutions are planning for effects such as, "higher than average temperatures that are unevenly distributed, and more damaging and more unpleasant extremes."[138] Public institutions tend to have mandates that ascribe to a conception of sustainability more in line with what Mao et al. describe as the three pillars of sustainability; environmental protection and ecological balance, economic growth, and social progress and equity.[139] Whereas private sector actors in the building sector are primarily motivated by financial concerns and, perhaps the marketability of green buildings, public institutions are often guided by the broader concerns of the public and communities in which they are sited.

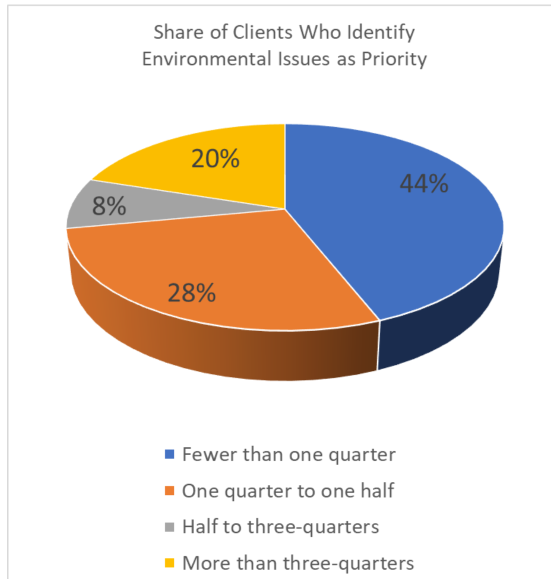
4.3. Role of Clients

[136] Ontario. *Climate Change Action Plan*, 27.
[137] Ibid., 27.
[138] ECO. *Facing Climate Change*, 27, 29.
[139] Mao, et al. "A Comparison Study" 5.

This series of questions was directed at understanding the role of the client in prioritizing environmental issues in the architectural design processes. From the perspective of design and utility of buildings, clients generally make the final decision on what will be built.

4.3.1. Environmental Issues as Priority

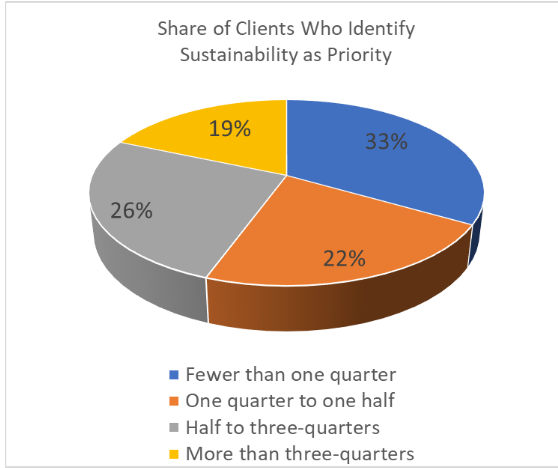
Survey participants were asked what share of their clients identify environmental issues in the client brief, a document which lays out the client's priorities for a building at the first stages of the design process. In this document a property owner defines the requirements and purpose of the building in order to provide architects with an understanding of the practical and design considerations of a particular project.



The results suggest that clients are not necessarily driving the green building trend, with a majority (72%) of respondents stating that fewer than one-half of their clients have identified environmental issues in the client brief. Of those respondents for whom a majority of clients identify environmental issues in the client brief, 8% had between half and three-quarters doing so and 20% had more than three-quarters. This supports the notion that architects specializing in green building design are sought out by clients with a focus on environmental issues and sustainable architecture.[140]

[140] Bennetts, et al. *Understanding Sustainable Architecture*, 4.

4.3.2 Sustainability as Priority

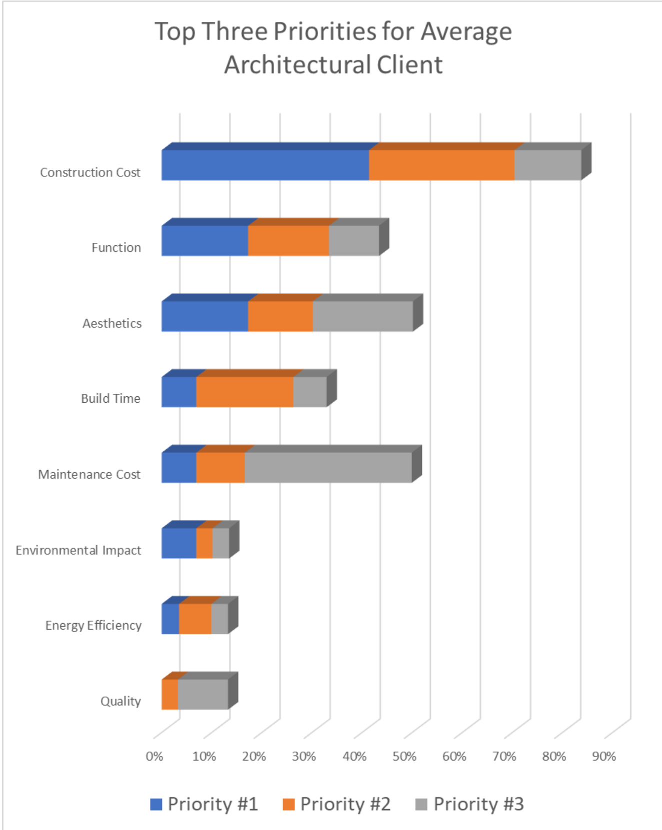


Sustainability and environmental issues are not necessarily synonymous, especially under a technocratic paradigm in which sustainability is considered to be a corporate or governmental requirement. In an attempt to understand whether this potentially subtle difference could be discerned, survey participants were asked what share of their clients prioritize sustainability when describing their architectural requirements. Again, a majority of respondents (55%) stated that fewer than half of their clients prioritized sustainability however, this share dropped almost twenty percent compared to the question of environmental issues in the client brief.

4.3.3. Client Priorities

Contrasting the prioritization of sustainability and environmental issues, participants were asked to rank their clients' top three priorities. This question was framed as open-answer, allowing respondents to use whatever language they preferred to describe these priorities. Answers were then categorized into eight elements based on commonalities.

In order of respondents' assignment of priority these elements are: construction cost, function, aesthetics, maintenance cost, build time, environmental impact, energy efficiency, and quality. The overwhelming majority of respondents stated that their clients' priority was Construction Cost, with 41% placing it first, 29% placing it second and 13% placing it third. A cumulative total of 84% respondents identified construction cost as being among the top three priorities for their clients.



Building Function received the next most first priority (17%) and second priority (16%) rankings. However, the total number of respondents who placed this in the top three priorities of their clients (43%) was less than both Aesthetics (50%) and Maintenance Cost (50%).

Aesthetics was the third highest rated building element for respondents' clients with 17% rating it as the first priority and 13% rating it second. The cumulative total was 50%.

The next two elements were ranked equally as a number one priority by 7% of respondents. However, as a number two priority, Build Time (19%) significantly out-ranked Maintenance Cost (10%). A third of respondents (33%) identified Maintenance Cost as their clients' number three priority while only 7% did so for Build Time.

The remaining elements, Environmental Impact, Energy Efficiency, and Quality each were prioritized as a top-three concern for a cumulative total of 13% of respondents. Of these, Environmental Impact received the highest share of first-rank prioritization with 7% while Quality was ranked not ranked first by any respondents. Energy Efficiency was placed first by 3% and second by 6% of respondents.

4.3.4. Discussion

These findings suggest that although architectural clients in Ontario are not the primary factor in pursuing green building they play an important role in driving market transformation. The formation of the questions was intended to distinguish between environmental impacts and the broader concept of sustainability as a client priority. The difference in prioritization may reflect the institutionalization and marketability of sustainability compared to the concept of environmental impact. Sustainability is a term that has been adopted and operationalized in corporate and government processes and includes economic metrics such as energy efficiency.

Findings from this section align with research done at the national level but conflict with the findings of international research. Nationally, McGraw Hill Construction found that only 18% of respondents placed client demand as the top trigger for green building with a further 24% placing it second.[141] Supporting the notion that sustainability has been adopted within economic and political system, the middle five triggers for green building (after right thing to do and client demand) were; municipal and federal green building policies, lower operating costs, corporate social responsibility commitment, and higher building value.[142] Environmental regulations were cited by only 4% of respondents as the top trigger.[143] Building owners operate in a context in which sustainability is becoming increasingly prevalent while environmental impact is only a single subordinate aspect. Internationally, research suggests a larger role for client demand. Dodge Data & Analytics found that client demand was the top trigger for green building globally for 40% of respondents in 2015 and 35% in 2012. [144]

[141] McGraw Hill Construction. *Canada Green Building Trends*, 23.
[142] Ibid., 23.
[143] Ibid., 23.
[144] Dodge Data & Analytics. *World Green Building Trends*, 14.

The second portion of this segment questioned architects on their clients' priorities in regard to building design and construction cost dominated with 84% of respondents identifying is as a top-three priority. The increased cost, or at least the perceived cost increase, associated with green building is a major factor preventing greater adoption of green building practices. Proposed increases to Ontario's building code will have a positive impact on this factor by increasing energy efficiency standards for the construction industry as a whole.[145] However, this will only mandate the increased expenditures rather than remove the problem of increased costs. The benefits will be experienced by building owners as reduced maintenance expenses, which was identified by 50% of respondents as a top-three client priority.

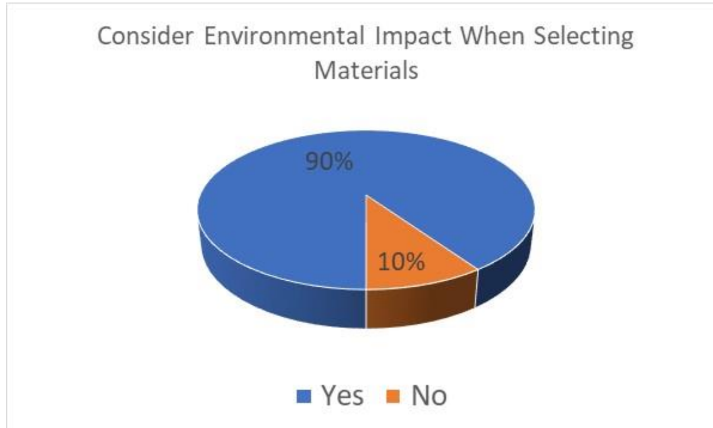
4.4. Materials Selection and Use

From the point of resource extraction through processing and manufacturing, packaging and transportation, the materials used in construction have significant environmental impacts. These impacts of these materials can be measured through life cycle analysis and, increasingly, governments and non-governmental organizations produce standards and maintain databases to ease the comparison of materials by those looking to employ these materials. In the design phase of a building, architects can use these standards and databases to select the material with the least environmental impact, if such action is prioritized, which enables the use of greater volumes of sustainable materials where feasible.

[145] Ontario. *Potential Changes to Ontario's Building Code*, 17, 18.

4.4.1. Environmental Impact

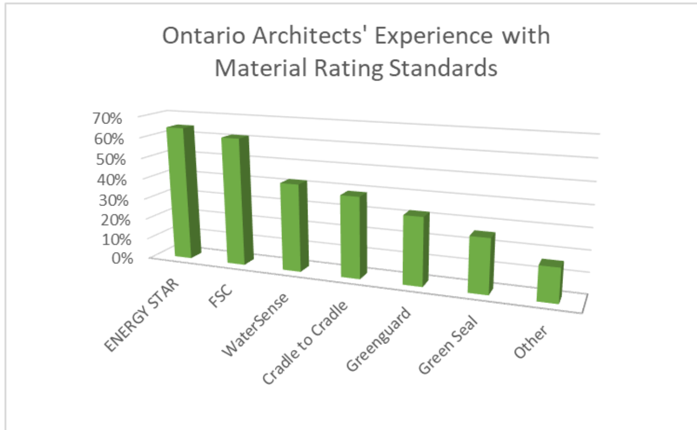
When asked if they consider environmental impact when selecting materials for a building, 90% of respondents replied in the affirmative. Comments reflected the problematic use of "non-renewable resources in construction," the impacts of toxic pollution in manufacturing and the importance of materials selection to indoor air quality. The carbon impacts of material selection were not explicitly referenced in any comments, however several respondents stated that they prioritize local materials in their practice.



4.4.2 Material Rating Systems

While there are a great number of governmental and non-governmental material rating standards and databases, respondents identified six such standards as commonly employed within their practice. These are: Cradle to Cradle, ENERGY STAR, Forestry Stewardship Council (FSC), Green Seal, Greenguard, and WaterSense. Each standard provides architects, and others, with third-party verification of sustainability metrics in the material supply chain. Some are government-run; ENERGY STAR and WaterSense for example, while most are non-profit organizations or corporations. The key benefit of using such certification standards is that the carbon footprint and environmental impact of materials and end-use products can be made clear, and verified by an independent body, which often aligns with the requirements of green building standards. For example, the use of FSC certified wood qualifies a building for a credit under LEED v4.[146]

A majority of respondents have experience using ENERGY STAR (65%) and Forestry Stewardship Council (FSC) (61%) rating standards in the selection of materials. Close to half of respondents have experience with two other material rating standards, WaterSense (42%) and Cradle to Cradle (39%). The remainder have been used by more than a quarter of respondents; GreenGuard (32%) and Green Seal (26%).



4.4.3. Discussion

Though "Materials Selection" was identified by respondents as the least important element of sustainable architecture in the previous set of responses, it has far-reaching environmental impacts. One comment summarizes this notion; "This industry requires of great amounts of transformed raw materials into the final forms, using tons of energy to accomplish that."

These indirect impacts fall under Scope 3 emissions in the commonly employed GHG Protocol overseen by the World Resources Institute, which categorizes emission as direct (Scope 1), electricity indirect (scope 2), or other indirect (Scope 3).[147] In a study of the US building

[146] FSC. "USGBC Members Approve LEED v4." *Market.* (Forestry Stewardship Council, 2013) https://us.fsc.org/en-us/market/green-building/leed-v4.
[147] WRI. *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard. Revised Edition.* (World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD): Geneva, Switzerland, 2015), 25.

sector, Onat, et al. found that Scope 3 emissions accounted for 32% of building emissions, with construction activities and material supply chain making up 6.2% overall.[148]

The low rating of the impacts of materials selection by respondents suggests that these are not considered to be as important as other elements of building design such as energy efficiency, indoor air quality or daylighting. However, the impact of materials selection is revealed by the number of respondents who have employed these product certification standards.

Proposed amendments to Ontario's Municipal Act may enable lower levels of government in the province to encourage greater use of recycled and local materials in construction in official plans as a method of climate change mitigation and adaptation.[149] As an example, for a low-rise building to qualify for development charge relief under the City of Toronto's green building standard at least 20% of materials must be locally harvested, extracted or processed (within 800km of site).[150] This increases to 30% for mid- and high-rise buildings.[151]

Updates to the Building Code will also have an impact on these Scope 3 emissions and the associated local environmental impacts. In particular, water conservation measures will increase the number of high efficiency fixtures and drain water heat recovery installed in the province, reducing the demands put upon ground water and municipal water systems while increasing efficiency of water heating systems.[152]

4.5 Green Building Standards & Tools

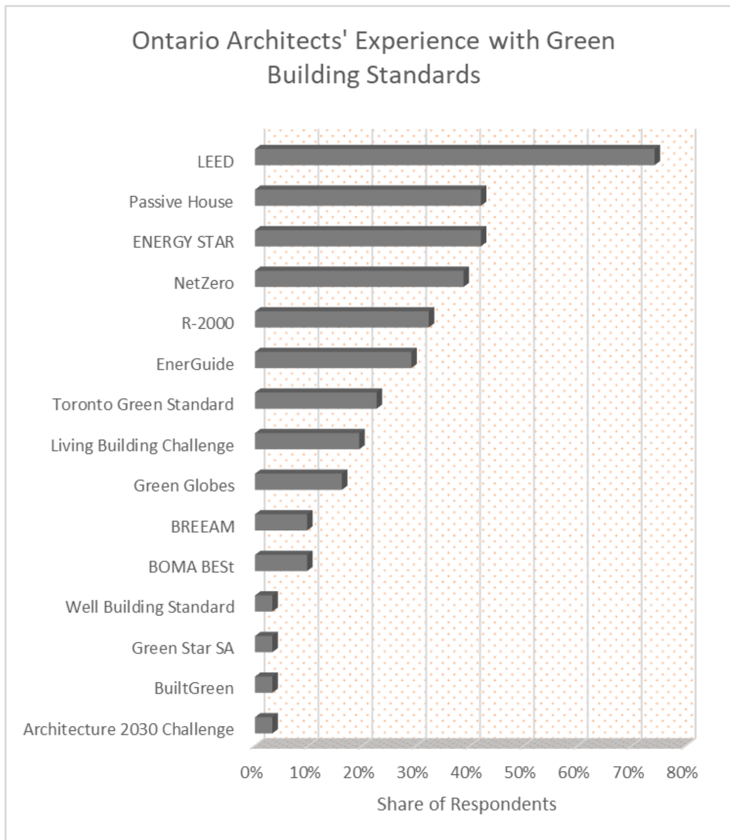
The number of green building standards and guidelines has increased dramatically in recent years as governments and non-governmental organizations (both for- and non-profit) seek

[148] Nuri Cihat Onat, et al. "Scope-based carbon footprint analysis of U.S. residential and commercial buildings: An input-output hybrid life cycle assessment approach." *Building and Environment* 72 (2013), 58.
[149] Ontario. *Climate Change Action Plan*, 32.
[150] Toronto. *TGS – Checklist For New Low-Rise,* 10.
[151] Toronto. *TGS – Checklist For New Mid to High Rise,* 14.
[152] Ontario. *Potential Changes to Ontario's Building Code,* 18.

to contribute to the goal of climate change mitigation and adaptation and address the local environmental impacts of the building sector.

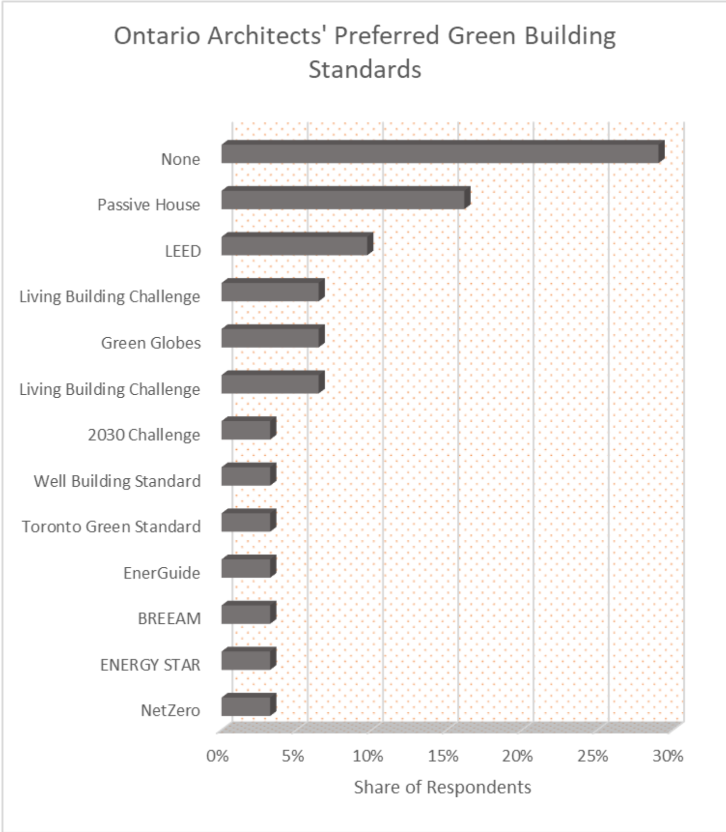
4.5.1 Experience with Green Building Standards

Survey participants were asked which of this growing list of standards they have had experience using. Respondents identified LEED as the most commonly used green building standard, 74% report having experience with this international checklist-style standard. The second-most used (42%) is Passive House, a performance-based standard that sets a maximum level of thermal and energy efficiency above which buildings cannot be certified but no minimum level of efficiency, encouraging designers to achieve ever higher levels of performance. The same number of respondents (42%) had experience with ENERGY STAR, a government standard which covers all manner of consumer products including buildings and building components. Next most commonly used (29%) was NetZero, a rating system which guides designers to produce buildings that produce as much energy as they consume by incorporating renewable energy generation with high levels of energy and thermal efficiency.



4.5.2 Green Building Standard Preferences

When asked which of these green building standards they preferred, almost a third of respondents (29%) stated that they had no preference or preferred to use none of them. Comments reveal a variety of reasons for this, some respondents commented that several standards are restrictive and often expensive because of bureaucratic processes, and others stated that they prefer to use more ecological notions of environmental performance while incorporating elements from all existing standards. Several respondents commented that the main reason to use a rating system is for the client's benefit and therefore they only use such a standard if requested. Others noted that prescriptive standards may discourage innovation and flexibility and that performance standards, such as Passive House, were preferred for this reason.



Passive House was identified second most with 16% of respondents citing it as their preferred standard. Comments suggest that this is because it is performance-based, "more holistic," has "clear guidelines on energy efficiency", and "improv[es] comfort and quality of the interior space."

The third-most preferred green building standard was LEED, with 10% of respondents stating a preference. Comments cite this standard's global reach, third-party verification, and rigor as support for this preference.

4.5.3. Discussion

These findings reflect the comments made by Guy and Farmer that eco-technic logic, "based on a technorational, policy-oriented discourse,"[153] dominates the conversation of sustainable architecture at the institutional level. While respondents demonstrate considerable experience with green building standards and tools, they prefer more ecological notions of sustainable architecture. As Guy states elsewhere, "one must fundamentally revise the focus and scope of the debate about sustainable architecture and reconnect issues of technological change with the social and cultural contexts within which change occurs."[154]

This suggests that for governments to achieve their climate mitigation and adaptation targets will require the standardization and operationalization of sustainable architecture which may be at odds with a large contingent of the community of architects who have developed and continue to practice sustainable architecture.

Research at the global scale found that the top three reasons given for using a green building rating system include the ability to create better performing buildings, a perceived marketing and competitive advantage, and the opportunity to learn more about specific green

[153] Guy and Farmer. "Reinterpreting Sustainable Architecture" 141.
[154] Simon Guy. "Cultures of architecture and sustainability." *Building Research & Information* 33:5 (2005), 471.

building elements.[155] Corroborating the views expressed by Ontario architects, Dodge Analytics describe several additional benefits of an international green building standard such as providing a common language for the industry, enabling governments to specify incentives and rebates for green buildings, and encouraging the use of an integrated design team.[156] The focus of these benefits is on systemic adaptation and accommodation – features that enable sustainable architecture to achieve higher levels of operationalization and standardization within existing institutional frameworks.

International research shows that similar experiences are reported globally. Drawbacks of using a green building standard are found to be additional costs in terms of both time and money, lack of regional specificity, and overly complex documentation processes.[157] Each of these elements grows as a concern in a manner that is inversely proportional to the level of standardization. As a green building standard becomes larger in scope and more readily applied across geographic zones, it becomes less sensitive to regional differences and/or more bureaucratically complex while the cost to administer grows.

Government policies directed at changing the building sector to achieve emissions reduction targets should acknowledge that a significant tradeoff of overly prescriptive green building standards may be the discouragement of innovation. Recent updates to the Ontario Building Code energy efficiency requirements provides a variety of paths for compliance including prescriptive and performance based options.[158] These paths are based on American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and National

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[155] Dodge Data & Analytics. *World Green Building Trends*, 20.
[156] Ibid., 20.
[157] Ibid., 20.
[158] OAA. *OBC SB-10 Energy Efficiency Requirements – Prescriptive Compliance*. (Ontario Association of Architects, 2017), 1.

Energy Code for Buildings (NECB) standards with the prescriptive paths requiring adherence to applicable standards.[159] Performance paths require at least 13% greater efficiency over relevant standards for large buildings and 15% for residential buildings.[160]

One proposed update to the Building Code that may not be as well received, because of its broad application, is the harmonization of Ontario's Building Code with the national construction codes and standards.[161] While the stated benefits, lowering cost of construction, removing technical barriers, and increasing cross-Canada code harmonization have systemic benefits there is a danger of becoming less sensitive to regional differences.

4.6. Perspectives on energy efficiency

Energy efficiency is a key component of green building and a significant focus of government policy. The Climate Change Action Plan lays out the government's intention to amend the Ontario building code to increase the minimum energy efficiency of residential buildings by 50% and commercial buildings by 65%, which has already begun with updates to the Ontario Building Code.[162] The implementation of the longer-term elements of this policy are proposed to increase the standard for small buildings to net-zero by 2030.[163]

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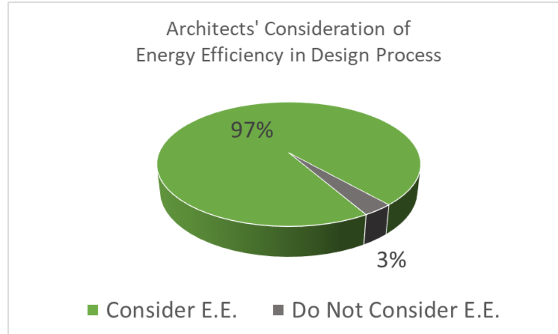
159 OAA. *OBC SB-10 Energy Efficiency*, 1.
160 Ontario. *Potential Changes to Ontario's Building Code*, 1.
161 Ibid., 14.
162 Ibid., 1.
163 Ontario. *Climate Change Action Plan,* 68.

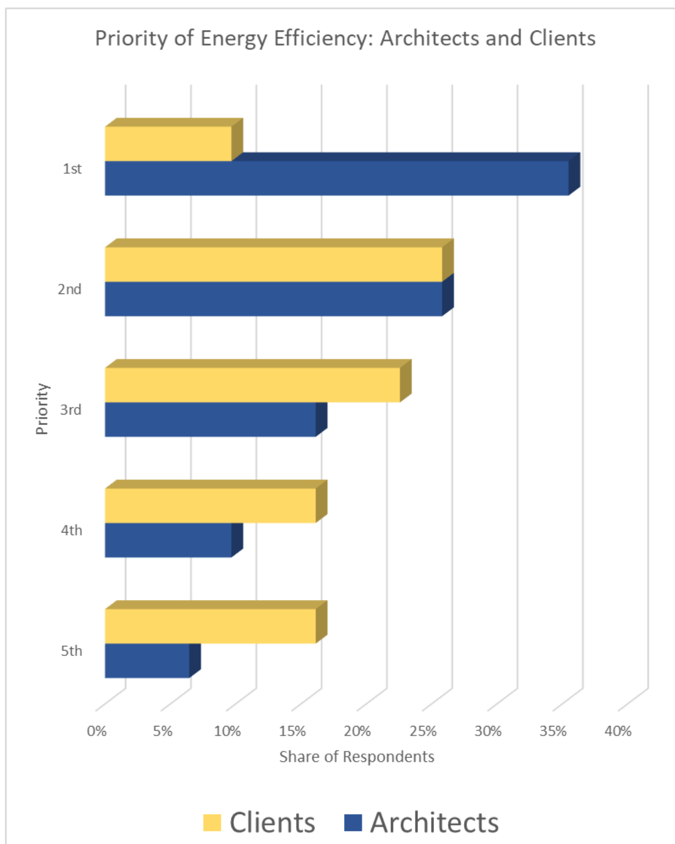
4.6.1. Energy Efficiency in Design

This set of questions was directed at understanding the priority given to energy efficiency, a key component of modern conceptions of sustainable architecture. Participants were asked whether energy efficiency is considered in the design stage of their practice, to which an overwhelming majority (97%) responded affirmatively. Comments reflected this, with several mentions of energy efficient components, envelope insulation values, low energy building design, daylighting, and passive solar home design.

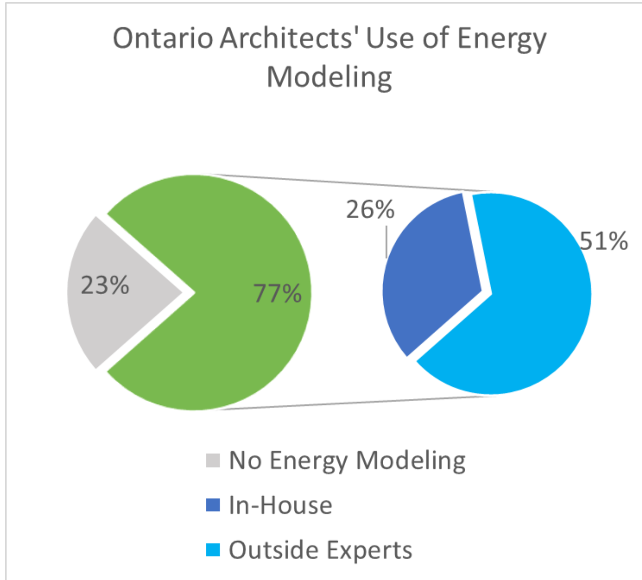


4.6.2. Priority of Energy Efficiency

Comparing the prioritization of energy efficiency on the part of architects themselves with the priority given by clients we see that more than one third (35%) of respondents place energy efficiency as their first priority in the design process while only 10% stated that their clients put it first. In both cases, more than half of all respondents believe that energy efficiency one of the top three priorities for both themselves and their clients (77% for architects, 59% for clients).



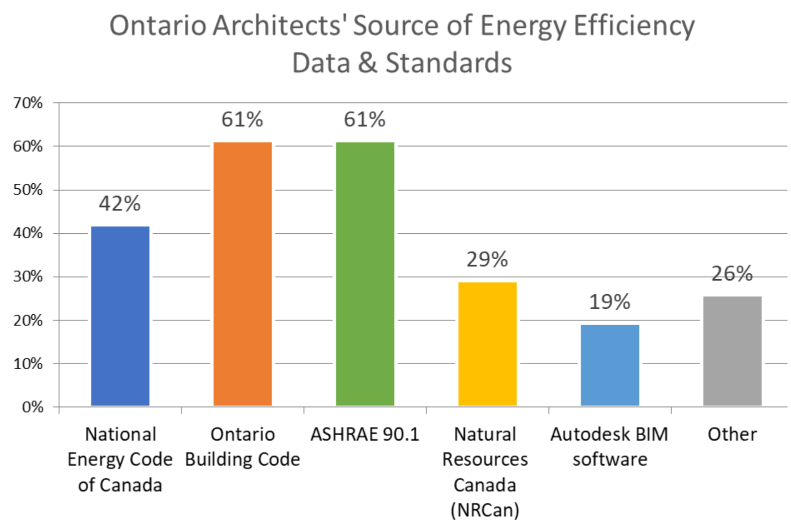
This may reflect the institutional focus on energy efficiency in architecture, requiring architects to prioritize energy efficiency early in the process to meet regulatory standards while clients prioritize other elements of the building first. As one comment made clear, architects have a "responsibility as professionals with impact on a major factor in energy use."



4.6.2. Use of Energy Modeling

The next question asked whether energy modeling was used to compare potential designs and if this was done in-house or by outside experts. More than two thirds (77%) of respondents stated that they use energy modeling in their design process. Of these respondents, more than half (61%) employ outside experts to conduct modeling on their behalf while the remainder conduct energy modeling in-house.

4.6.3. Sources of Climate Data



Respondents were asked which sources of energy efficiency data used and more than half identified both the Ontario Building Code (61%) and ASHRAE 90.1 (61%) as a source. The next most popular source of energy efficiency standards, with 42% of respondents identifying it as a source, was the National Energy Code of Canada. Other sources include Natural Resources Canada (29%) and AutoDesk Building Information Modeling (BIM) software (19%). Twenty-six percent of respondents also employ other sources of energy efficiency data including the Passive House Planning Package, and ArchiCAD and Vectorworks (both BIM software).

4.6.4. Discussion

Energy efficiency is clearly a priority for both architects and building owners/developers and government regulation, such as its inclusion in the building code, is responsible to a great degree. However, there is an additional cost associated with increased energy efficiency including the use of energy modeling. Several comments suggested that policy should be directed at reducing the cost of energy efficiency, in part because the benefits are felt at the provincial scale while the costs are borne by the individual building owner and these elements often have high capital costs and long payback periods.

The impact of energy modeling and selection of climate data for modeling is of particular concern to the lifetime performance of buildings and, as weather and climatic patterns change, energy modeling will grow in importance. Kegel and Tosh have drawn attention to the dramatic differences in modeled and actual building performance when incorrect, or inappropriate climate data is used in modeling.[164] The authors found that the use of historical weather data, Typical Meteorological Year (TMY) data, is no longer appropriate for modeling future building performance and propose that Extreme Meteorological Year (XMY) data should be included to account for increased extreme weather events.[165] Furthermore, results of this study suggest that the variance in energy use intensity (between the two modeling methods) is greatest colder climates.[166]

In response to the knowledge that future weather and climatic patterns are not likely to follow past trends, the Ontario Ministry of Housing Affairs in undertaking consultations including the question of whether the government should be “Updating the climatic data in the Building Code to reflect current weather conditions?”[167] The prevalence of OBC and ASHRAE (both employed by 61% of respondents), as sources of climate data suggests that pursuing this update would be beneficial. This action would be a rational policy change to address already changing weather patterns that will impact the performance of buildings and could be strengthened by including several future climate scenarios in order to test building models under various potential outcomes, as recommended by Kegel and Tosh.[168]

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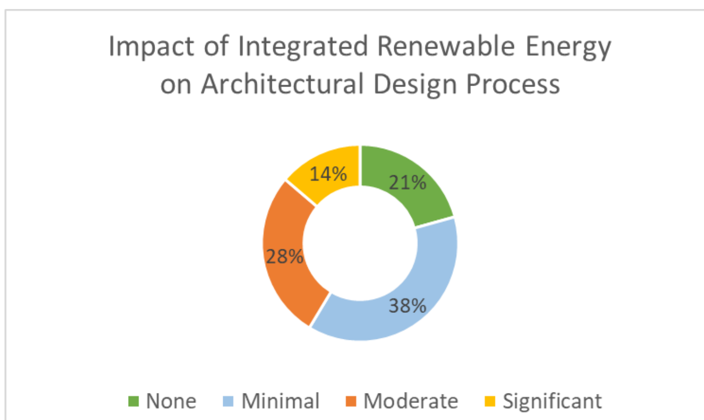
[164] N. Kegel and M. Tosh. “Climate Change and Building Energy Consumption: Design Considerations for an Uncertain Future.” Presented at *Sustainable Built Environment Conference of the Americas*, (19 September 2016).
[165] Ibid., 12.
[166] Ibid., 4-12.
[167] Ontario. *Potential Changes to Ontario’s Building Code*, 20.
[168] Kegel and Tosh. “Climate Change and Building Energy Consumption” 12.

4.7. Perspectives on renewable energy

A significant component of reducing the environmental impact of buildings is reducing the associated energy consumption. Ontario has made great progress in reducing the emissions profile of the electricity sector in recent years with the closure of coal-fired power plants. From 1990 to 2014, emissions from electricity generation dropped 76%; from 25.8Mt to 6.2 Mt.[169] The burning of natural gas is now responsible for almost all emissions in the electricity sector.[170] This electricity production combined with its use in space and water heating meant that natural gas was responsible for 37% of Ontario's emissions in 2014.[171] The integration of renewable energy technologies in buildings is a strategy to increase both the resilience of the building itself and the community in which it is sited, reducing the reliance on fossil-fuels incrementally as buildings are constructed and renovated.

4.7.1. Experience with Renewables

More than half (61%) of respondents have experience with building integrated renewables. When asked what they believe the impact of integrating renewables has or will have on their design process, only 14% stated that this impact was significant. Twenty-one percent stated that there was no impact on their design process while the majority of responses suggest integration of renewable has a minimal (38%) to moderate (28%)



[169] ECO. *Facing Climate Change*, 42.
[170] Ibid., 42.
[171] Ibid., 42.

impact on the architectural design process. Eighty-four percent (84%) of respondents agreed that building integrated energy generation is likely to become more common in the future and several comments suggested that all buildings should be net positive, producing more energy than they consume.

In an attempt to understand the drivers for the integration of renewable energy, participants were asked if any of their clients had requested building integrated energy generation and what reasons they gave for this request. A small majority of respondents (55%) stated that they have had such requests. Reasons given by clients include utility savings, self-sufficiency, government incentives, and environmental concerns. Further comments on the topic suggest that cost is the most important factor dissuading architectural clients from installing building integrated renewable energy systems, often leading them to consider increased conservation measures instead.

4.7.2. Discussion

Findings suggest that building integrated renewable energy generation does not have a large impact on the architectural design process and that a majority of Ontario architects have experience with these technologies. The key barrier to growth in this area is capital cost. The *Climate Change Action Plan* proposes future measures to support the installation of renewable energy generation on institutional and residential buildings, including social housing and apartment buildings, which will positively influence the number of net-zero buildings in the province.[172]

[172] Ontario. *Climate Change Action Plan,* 26, 27.

The *Action Plan* is not clear on specific funding methods but states that "government would establish a fund to help hospitals, universities and colleges retrofit their facilities…"[173] with funds from the cap-and-trade program directed through the green bank. Direct funding, also from the green bank, is likely to be employed for social housing, schools and heritage buildings, while incentive programs will be offered to apartment buildings and residential homes who install a range of renewable energy technologies.[174] One challenge with this approach, as compared to the feed-in-tariff approach, is ensuring that low-carbon technologies are installed and operating properly after the rebate has been collected.

For new construction, the province is proposing future changes to the Building Code which will mandate net zero buildings by 2030, supporting both increased energy efficiency and integrated generation.[175] As stated, the greatest barrier to achieving this goal is capital cost.

The findings of this survey suggest that evening the playing field by implementing regulations through the OBC that mandate all new buildings to be net-zero without specifying how this should be achieved will enable architects and the building sector at large to find innovative ways to reach this goal. However, as Code requirements become more stringent, the cost of homes will inevitably increase, and policy will may be required to address this conflict if home ownership is considered a social and political priority. Changes to the Land Transfer Tax for first-time homebuyers and the proposed Fair Housing Plan announced in the 2017 Provincial budget[176] may relieve some of this pressure but these policies cannot remain in place in perpetuity.

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[173] Ibid., 26.
[174] Ibid., 26, 27.
[175] Ibid., 68.
[176] Ontario. Ministry of Finance. *2017 Ontario Budget: Budget Papers.* (Toronto, ON: Queen's Printer for Ontario, 2017), 41.

5. Conclusions

The purpose of this research was to develop a more complete understanding of the perspectives of Ontario architects on sustainability in the building sector including drivers, barriers, and policy outcomes. High level takeaways include a preference toward performance standards over prescriptive standards, the importance of government regulation in leveling the playing field for energy efficiency and environmental performance, an acknowledgement that client priorities overrule personal conviction in selecting building design elements, and that high capital cost is the most important barrier to further implementation of elements of sustainable architecture that align with provincial climate goals.

Policy interventions proposed in the Climate Change Action Plan and implemented through the Building Code, Municipal Act, cap-and-trade program and green bank appear to address the concerns identified in the survey by removing or minimizing barriers and supporting drivers of market transformation. One issue with this set of policies is the electricity subsidization policy, which counteracts market signals directing architectural clients to pursue energy efficiency and conservation measures or the installation of on-site renewable energy generation.

The survey results show that a large number of Ontario architects are concerned about climate change (74%) and would support a policy that mandates consideration of climate change in the design process (71%). The large majority (84%) of respondents agreed that sustainable architecture is integral to good design. However, because of the selection bias, these findings must be tempered by the acknowledgement that this reflects the perspectives of a group of architects who are active in the green building movement (58% are members of green building associations) and whose personal convictions drive their support for sustainable architecture.

Findings suggest that Ontario architects prefer performance standards to prescriptive standards. As such, Building Code changes to increase environmental performance of buildings should, where possible, be performance based to enable innovation and creativity in achieving emissions reductions. Where prescriptive standards are employed they should be sensitive to regional differences. Recent and potential changes to the OBC appear to have taken this into account and offer numerous pathways to achieving energy efficiency targets; prescriptive, performance and mixed.

The personal convictions of architects in regard to sustainability and climate change are found to be an important factor in driving green building but do not necessarily translate to the construction of the best possible buildings from an environmental and climate perspective. Client priorities, most prominently construction cost, function, aesthetics, and operational/maintenance cost, are a key determinant of the final form of any building. As such, this a key leverage point for government policy, discussed below. Architectural clients, building owners and developers, are particularly driven to pursue green building practices for operational savings and therefore changing weather patterns are among the greatest concerns shared by respondents.

Due to this focus on future changes in climate and weather patterns and the effect this will have on building performance, energy efficiency is a top concern for both architects and their clients. Renewable energy is closely tied to energy efficiency and, while it is considered to be one of the most important elements of sustainable architecture, it is often cost-prohibitive for clients and is among the first to be discarded for economic reasons. Despite this, findings suggest that the addition of building integrated renewable energy generation does not greatly impact the design process and the main barrier is capital cost.

The greatest leverage point to rapidly decrease emissions from the building sector appears to be in changing client priorities. In part this can be done through Building Code requirements which mandate increasingly stringent energy efficiency standards, as proposed in the Climate Change Action Plan. Additional measures should focus on reducing the barrier of capital cost for conservation and renewable energy.

This can be augmented by evening the playing field, requiring high energy efficiency standards for all buildings and providing funding or loan programs for renewable energy installation. Proposed policies in the Climate Change Action Plan appear to reflect this perspective with increased efficiency standards in the OBC and green bank funding directed toward rebates for net-zero carbon homes. Additional funding programs could be directed at relieving the cost-burden for commercial buildings as projections suggest they represent the greatest share of future growth.

The majority of architects in Ontario employ energy modeling in their design process (71%) and the main source of climate and weather pattern data is the Ontario Building Code (61%) and related sources such as ASHRAE (61%) and NECB (42%). While respondents suggested that energy modeling adds extra cost, comments support its use where appropriate as a method of justifying capital cost expenditures for operational savings.

The proliferation of green building standards and tools appears to benefit architectural clients most of all, requests from whom are cited as the most common reason for employing a GBS. A large share of architects has experience with more than one green building standard, with LEED (74%), Passive House (42%) and ENERGY STAR (42%) being most popular. However, the top preference identified by respondents was “none” (29%). Respondents cited added cost, in both time and money, overly prescriptive processes, and bureaucratic complexity as the foremost reasons for this response. The second-most preferred was Passive House (16%) followed by LEED (10%).

Scope 3 emissions, indirect emissions from non-electricity sources, can be addressed with policies to encourage the use of recycled and local materials in buildings. Future updates to the OBC could include provisions for recycled/local materials but this may be difficult to mandate. Another approach is for municipalities to employ tax or development charge rebates to encourage the use of these materials as has been done as part of the Toronto Green Standard.

The Building Code is the greatest source of climate and weather pattern data, which determines the projections upon which energy models for buildings are based. This data should at very least be updated to reflect rapidly changing weather patterns and increased extreme weather events and ideally, should include several climate change scenarios to enable the best possible buildings to be designed.

Findings suggest that the concept of sustainability has reached a high level of penetration within mainstream institutions and processes. Almost half (47%) of respondents stated that more than half of their clients identified sustainability in the architectural requirements while just over a quarter (28%) said the same of environmental issues. In part this may be because conceptions of sustainability are more holistic, including economic, efficiency, and social concerns while also carrying the benefits of increased marketability.

Bibliography

Ahn, Yong Han, and Annie R Pearce. “Green Construction: Contractor Experiences, Expectations, and Perceptions.” *Journal of Green Building* 2: 3 (2007): 106–122.

Alrashed, Farajallah, and Muhammad Asif. “Saudi Building Industry’s Views on Sustainability in Buildings: Questionnaire Survey.” *Energy Procedia*, 6th International Conference on Sustainability in Energy and Buildings, SEB-14, 62 (January, 2014): 382–90.

Annunziata, Eleonora, Francesco Testa, Fabio Iraldo, and Marco Frey. “Environmental Responsibility in Building Design: An Italian Regional Study.” *Journal of Cleaner Production* 112, Part 1 (January, 2016): 639–48.

Bennetts, Helen, Antony Radford and Terry Williamson. *Understanding Sustainable Architecture* (1) Abingdon, Oxon, US: Taylor & Francis, 2003.

Bhochhibhoya, Silu, Michela Zanetti, Francesca Pierobon, Paola Gatto, Ramesh Kumar Maskey, and Raffaele Cavalli. “The Global Warming Potential of Building Materials: An Application of Life Cycle Analysis in Nepal.” *Mountain Research and Development* 37: 1 (2017): 47–55.

Bradburn, Norman M. *Asking Questions: the definitive guide to questionnaire design – for market research, political polls, and social and health questionnaires*. San Francisco, CA, USA: John Wiley & Sons, 2004.

Bribian, Ignacio Z., A. Capilla, A. Uson. 2011. “Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential. *Building and Environment* 46: 1133-1140.

Brundtland, Gro Harlem. *Our Common Future.* Oxford University Press, 1987.

CaGBC. “Member Company List,” *Member Directory.* (Canada Green Building Council, 2016). http://www.cagbc.org/CAGBC/Membership/Member_Directory/CAGBC/MyCaGBC/Directory.aspx?hkey=51d851f0-0275-40fd-8a1f-ef6c72819abb.

Canada. Greenhouse Gas Emissions by Economic Sector 2016. *Environmental Indicators.* Environment and Climate Change Canada. Last Updated 14 April 2016. https://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=F60DB708-1

Canada. *Pan-Canadian Framework on Clean Growth and Climate Change*, 2016. https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html

Chick, Anne, and Paul Micklethwaite. “Specifying Recycled: Understanding UK Architects’ and Designers’ Practices and Experience.” *Design Studies* 25 (3) (2004): 251–73.

Choi, Eugene. “The Effects of Municipal Policy on Green Building Designations in the United States.” *The Korean Journal of Policy Studies*, Vol. 25, No. 2, (2010): 39-63.

Demirbilek, Nur and Cheetham, Amanda L. “Achieving Sustainability in Architecture: The Approach of Architects to Climate Responsive Building Design Practice in South-East Queensland.” In *Proceedings ANZASCA2002 36th Annual Conference of the Australian and New Zealand Architectural Science Association*, (Victoria, Australia: Deakin University, 2002): 117-124.

Dunn, William. *Public Policy Analysis.* New York: Routledge, 2015.

ECO. *Facing Climate Change; Greenhouse Gas Progress Report 2016.* Toronto, ON: Environmental Commissioner of Ontario, 2016, 1-146.

Elswijk, Marcel and Henk Kaan. *European Embedding of Passive Houses.* European Commission, Intelligent Energy Europe Programme, 2008.

Environment Canada. *Greenhouse gas sources and sinks: Executive Summary.* Environment and Climate Change Canada. 2017. https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/sources-sinks-executive-summary.html#es-4

Fowler, K.M and E.M. Rauch. *Sustainable Building Rating Systems Summary.* Pacific Northwest National Laboratory, 2006: 1-55.

FSC. “USGBC Members Approve LEED v4.” *Market.* Forestry Stewardship Council, 2008. https://us.fsc.org/en-us/market/green-building/leed-v4.

Guy, Simon “Cultures of architecture and sustainability.” *Building Research & Information* 33:5 (2005), 468-471.

Guy, Simon and Graham Farmer. “Reinterpreting Sustainable Architecture: The Place of Technology.” *Journal of Architectural Education,* 54 (3) (2001): 140-148.

Hemström, Kerstin, Krushna Mahapatra, and Leif Gustavsson. “Perceptions, Attitudes and Interest of Swedish Architects towards the Use of Wood Frames in Multi-Storey Buildings.” *Resources, Conservation and Recycling* 55 (11) (2011): 1013–21.

Hepner, Christina M., and Richard A. Boser. “Architects’ Perceptions of LEED Indoor Environmental Quality Checklist Items on Employee Productivity.” *International Journal of Construction Education and Research* 2 (3) (2006): 193–208.

Hui Yan, et al. “Greenhouse gas emissions in building construction: A cast study of One Peking in Hong Kong.” *Building and Environment* 45 (2010): 949-955.

IEA. *Building Energy Performance Metrics.* Paris, France: International Energy Agency (IEA)/Organisation for Economic Co-operation and Development (OECD), 2015: 1-110.

IEA. *Energy Policies of IEA Countries: Denmark 2011 Review.* Paris, France: International Energy Agency (IEA)/Organisation for Economic Co-operation and Development (OECD), 2011.

IPCC. *Climate Change 2014: Synthesis Report*. *Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. (Intergovernmental Panel on Climate Change (IPCC): Geneva, Switzerland, 2014), 1-151.

Kanters, Jouri, et al. "Tools and methods used by architects for solar design." *Energy and Buildings* 68 (2014), 721-731.

Kegel, N. and M. Tosh. "Climate Change and Building Energy Consumption: Design Considerations for an Uncertain Future." Presented at *Sustainable Built Environment Conference of the Americas*, 19 September 2016. http://sbcanada.org/wp-content/uploads/2016/04/Nathan_Kegel_Tosh-Climate-Change-and-Building-Energy-Consumption-Design-Considerations-for-an-Uncertain-Future.pdf?x41824

Lucon O., D. Urge-Vorsatz, A. Zain Ahmed, H. Akbari, P. Bertoldi, L. F. Cabeza, N. Eyre, A. Gadgil, L. D. D. Harvey, Y. Jiang, E. Liphoto, S. Mirasgedis, S. Murakami, J. Parikh, C. Pyke, and M. V. Vilarino: "Buildings." In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlomer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2014: 671-738.

Mao, Xiaoping, Huimin Lu, and Qiming Li. "A Comparison Study of Mainstream Sustainable/Green Building Rating Tools in the World." *IEEE*. (2009): 1–5.

Marsden, P. V., & Wright, J. D. "Handbook of survey research (2nd ed.)." Bingley, UK: Emerald, 2010.

Micales, J. A. & K. E. Skog. "The Decomposition of Forest Products in Landfills." *International Biodeterioration & Biodegradation* 39: 2-3 (1996): 145-158.

Mohamad M. Khasreen, et al. "Life-Cycle Assessment and the Environmental Impact of Buildings: A Review." *Sustainability* 1:3 (2009): 674-701.

Morris, Craig and Martin Pehnt. *Energy Transition, The German Energiewende.* Heinrich Boll Foundation, 2012.

NRCan. "Buildings" *Energy.* National Resources Canada. Last Updated 15 July 2016. http://www.nrcan.gc.ca/energy/efficiency/buildings/4261

OAA. "What We Do." *The OAA.* Ontario Association of Architects. January 23, 2017 http://www.oaa.on.ca/the oaa/about the oaa.

OAA. OBC SB-10 Energy Efficiency Requirements – Prescriptive Compliance. Ontario Association of Architects: 1-5 (2017). http://www.oaa.on.ca/oaamedia/documents/PT%2036.2- OBC SB-10 (V2) (July 6 2017) (Final) (Conway).pdf

Onat, Nuri Cihat, et al. "Scope-based carbon footprint analysis of U.S. residential and commercial buildings: An input-output hybrid life cycle assessment approach." *Building and Environment* 72 (2013): 53-62.

Ontario. *Climate Change Action Plan 2016-2020.* Toronto, ON: Queen's Printer for Ontario, 2016.

Ontario. Bill 172, *Climate Change Mitigation and Low-carbon Economy Act*, 1st Sess., 41st Legislature, 2016, SO 2016. http://www.ontla.on.ca/bills/bills-files/41_Parliament/Session1/b172ra.pdf

Ontario. MOECC. *Ontario Post-Auction Public Proceeds Report.* Ministry of Environment and Climate Change, 2017: 1-3. https://files.ontario.ca/post-auction_public_proceeds_report_en_2017-09-28.pdf

Ontario. Ministry of Finance. *2017 Ontario Budget: Budget Papers.* Toronto, ON: Queen's Printer for Ontario, 2017: 1-305.

Osmani, M., J. Glass, and A.D.F. Price. "Architects' Perspectives on Construction Waste Reduction by Design." *Waste Management* 28 (7) (2008): 1147–58.

Pedrini, Aldomar and Steven Szokolay. "The Architects Approach to the Project of Energy Efficient Office Buildings in Warm Climate and the Importance of Design Methods." *Ninth Annual IBSPA Conference.* 2005.

Reinhart, Christoph, and Annegret Fitz. "Findings from a Survey on the Current Use of Daylight Simulations in Building Design." *Special Issue on Daylighting Buildings* 38 (7) (2006): 824–35.

Sassi, Paola. *Strategies for Sustainable Architecture.* New York, NY: Taylor & Francis, 2006.

Sharma, Aashish, et al. "Life cycle assessment of buildings: A review." *Renewable and Sustainable Energy Reviews* 15 (2011): 871-875.

Slabbekoorn, Hans and E. Ripmeester. "Birdsong and anthropogenic noise: implications and applications for conservation. *Molecular Biology* 17 (2008): 72-83.

Sottile, G.M. “2004 Survey of United States Architects on the Subject of Switchable Glazings.” *SVC - Smart Materials Symposium* 119 (3) (2005): 240–45.

Tam, C. M, Vivian W. Y Tam, and W. S Tsui. “Green Construction Assessment for Environmental Management in the Construction Industry of Hong Kong.” *International Journal of Project Management* 22 (7) (2004): 563–71.

Theobald, David M., James R. Miller, and N. Thompson Hobbs. “Estimating the Cumulative Effects of Development on Wildlife Habitat.” *Landscape and Urban Planning* 39 (1) (1997):25–36.

Toronto. City Planning. *Toronto Green Standard 2014 Update Version 2.0 Highlights*. (2015): 1-26.

Toronto. Toronto Green Standard for New Low-Rise Residential Development, Version 2. (2015): 1-13.

Toronto. Toronto Green Standard for New Mid to High-Rise Residential and All Non-Residential Development, Version 2. (2015): 1-18.

Toronto. Toronto Green Standard Version 2.0 – Checklist For New Low-Rise Residential Development, (2014): 1-10.

Toronto. Toronto Green Standard Version 2.0 – Checklist For New Mid to High Rise Residential and all New Non-Residential Development, (2014): 1-14.

UNEP SBCI. *Buildings and Climate Change, Summary for Decision-Makers.* United Nations Environment Programme Sustainable Buildings & Climate Initiative (2009): 1-10.

USGBC. *LEED.* United States Green Building Council, 2017. https://new.usgbc.org/leed.

Vatalis, K. I., O. Manoliadis, G. Charalampides, S. Platias, and S. Savvidis. “Sustainability Components Affecting Decisions for Green Building Projects.” *Procedia Economics and Finance*, International Conference On Applied Economics (ICOAE), 5 (January, 2013): 747–56.

Wilby, R.L. “A Review of Climate Change Impacts on the Built Environment.” *Built Environment* 33 (1) (2007): 31–45.

Wittmann, Sabine. “Architects’ Commitment Regarding Energy Efficient/Ecological Architecture.” *Architectural Science Review* 41 (2) (1998): 89–92.

WRI. *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard. Revised Edition.* World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD). Geneva, Switzerland, 2015: 1-116.

Zaid, Suzaini M., Nik Eleyna Myeda, Nohayati Mahyuddin, Raha Sulaiman. "The Need for Energy Efficiency Legislation in the Malaysian Building Sector." *The 3rd International Building Control Conference 2013*: 1-9.