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Capstone Project

Cracking the cleantech adoption barrier for cities & communities

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Executive Summary

This report examines the strategies that cities and cleantech companies can jointly implement in order to overcome barriers to cleantech adoption in the buildings sector, raise consumer awareness, and catalyze uptake in the short term. Based on a literature review, a series of case studies, and several interviews with industry experts, several key conclusions are identified. On the one hand, barriers to rapid municipal adoption of buildings cleantech include a lack of collaboration between stakeholders; inadequate regulatory frameworks; and low awareness of how to implement buildings cleantech solutions in a cost-effective way. On the other hand, there are significant opportunities when it comes to collaboration, policy alignment, and education. Based on these conclusions, 10 recommendations are outlined in the areas of more collaborative sectoral partnerships; enhanced enforcement of regulatory standards and provision of financial incentives; and increased education and awareness.

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1. Introduction

The construction and maintenance of buildings is responsible for 13% of greenhouse gas (GHG) emissions in Canada and for 39% of carbon emissions globally.[1] In fact, in order for Canada to meet its climate commitments as laid out under the Paris Agreement, the adoption of buildings clean technology solutions within municipalities is critical, particularly as cities account for over 70% of global carbon emissions.[2] Increasingly, cleantech solutions are becoming an important part of Toronto's efforts to increase energy efficiency and decrease the emissions of its existing and new buildings. Canada's building cleantech sector is growing rapidly, with the potential to significantly reduce the emissions of buildings. According to MaRS, this includes companies who are "focused on the creation of intellectual property, new products and services that protect and/or increase efficient utilization of land, energy, water or natural resources."[3] Today, Canada is home to 12 of the best 100 cleantech companies in the world, including MaRS-sponsored Ecobee, CarbonCure Technologies and Opus One Solutions.[4] However, large-scale adoption of cleantech solutions to reduce emissions from the building sector has yet to materialize. In effect, there remain significant barriers to rapid adoption and implementation of buildings cleantech solutions in Toronto.

Thus, this report focuses on the following research question: what strategies can cities and cleantech companies jointly implement to overcome barriers to cleantech adoption in the buildings sector, raise consumer awareness, and catalyze uptake in the short term? The report summarizes findings from the research and discussion of a Munk School Capstone project, in support of MaRS Discovery District's work to assist and advocate for cleantech companies. It begins with a review of the relevant literature, key findings from interviews, and an analysis of four case studies. Then, the report presents conclusions on current barriers and opportunities for rapid adoption of buildings cleantech in Toronto. Finally, it offers 10 recommendations for government, industry, and partners like MaRS to facilitate rapid municipal adoption of buildings cleantech solutions. Ultimately, the report concludes that increased collaboration, stronger regulatory frameworks, and enhanced education of key actors are needed in overcoming barriers and leveraging opportunities to catalyze rapid adoption of buildings cleantech in Toronto.

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[1] Barry Chong, "Building the future: How simple solutions can tackle climate change," *MaRS,* October 8, 2020, https://www.marsdd.com/news/building-the-future-how-simple-solutions-can-tackle-climate-change/.

[2] "Why Cities? Cities have the power to change the world," *C40 Cities*, accessed April 10, 2021, https://www.c40.org/why_cities.

[3] Joe Greenwood and Farooq Qaiser, "Innovation in Cleantech: How Canada can become a global leader," *MaRS Discovery District*, March 2017: 5, https://www.marsdd.com/wp-content/uploads/2017/03/Innovation-in-Cleantech-MaRS-Report-2017-1.

[4] According to the Cleantech Group's global rankings; see: MaRS Discovery District, "12 Canadian Cleantech Companies Recognized Among World's Top 100," *Cision,* January 16, 2020, https://www.newswire.ca/news-releases/12-canadian-cleantech-companies-recognized-among-world-s-top-100-855222872.html.

2. Methodology

The first component of this project consisted of a literature review of government websites and policy documents, academic papers, journal and newspaper articles, and consulting reports. The objective was to understand the key challenges that governments, cleantech companies, consumers and other industry stakeholders face in the cleantech sphere. This literature review was conducted in order to extrapolate best practices and opportunities that were used to craft the final recommendations. Main themes and findings will be outlined in the next section.

Secondly, we conducted four interviews with green building industry experts from the public, private and academic sectors. The interviewees were: Rob McMonagle, senior advisor from the city of Toronto's economic development office, who offered important insights on green sector growth, cluster formation, and sustainable procurement; Paul Dowsett, principal architect at Sustainable, who shared his perspective on the importance of retrofits, low technologies, passive design and consumers' paradigm shifts; Alastair Moore, co-founder of Greenworks Building Supply, who shared his knowledge on the interaction between government and industry actors, as well as the ability to transfer best practices from other municipalities to Toronto; and John Paul Morgan, president and chief technology officer of Morgan Solar, who offered critical insights on the barriers that private cleantech companies face as a result of government inaction.

Thirdly, we performed a global scan of successful examples of rapid cleantech adoption in municipalities that mirror the City of Toronto's size, geographical climate, sustainability outlook or a combination of the three. The cities that were selected are Vancouver, Copenhagen, New York and Singapore. These offer important insights with regards to pilot projects, regulatory frameworks, retrofit mechanisms, stakeholder engagement, public-private collaboration and other low-emission buildings initiatives that will be explored in greater detail in the case-study section of this paper.

3. Literature Review: Key Findings

Efficient buildings can achieve the triple-bottom line of environmental, social and economic benefits. In fact, not only can retrofits and other green building projects spur economic development and job creation, but sustainable buildings can also improve cities' resilience during extreme weather events (which have been rising in Toronto). Moreover, it is important to note that indoor air quality will be extremely important in a post-pandemic world, and sustainable buildings have the potential to be more financially competitive as well as more attractive in the market.[5]

[5] Eric Mackress et al., "Accelerating building efficiency. Eight actions for urban leaders," *World Resources Institute,* accessed March 10, 2021: 3-16, https://publications.wri.org/buildingefficiency/.

A review of the academic and grey literature on the topic of cleantech adoption in the buildings sector revealed several key findings related to barriers, opportunities, success factors, and recommendations. Some differences emerged between retrofits and new buildings; residential and commercial buildings; and private and public buildings. However, given that adoption of buildings cleantech will be required in every single one of these areas in order to meet emissions targets, this literature review examined relevant findings for each. The findings are laid out in this section.

3.1. Barriers

Common themes on the topic of barriers to rapid adoption of buildings cleantech consistently emerge in the literature. These themes include the beliefs of the homeowners and lack of information, the perception of the cost of the project, the homeowner's relationships, institutional barriers, landlord, tenant and housing associations, personal behaviour patterns, and the makeup of the property itself. According to the literature, these barriers often fall under three categories: cultural/behavioural; structural/operational; and regulatory/legislative.[6]

The category of cultural and behavioural barriers includes themes such as beliefs and lack of information. Homeowners are not aware of the cost-saving benefits of energy efficiency, and they are not aware of where to go to initiate retrofits.[7] In addition, they may not be inclined to carry out retrofits for a variety of reasons, including personal preferences, among other factors.[8] For those in the industry, such as builders and developers, there is a lack of skills and certifications needed to implement the technology.[9] Lack of information can also be influenced by demographic. For example, demographic characteristics, such as education level or a partner's

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[6] Sarah Burch, "In Pursuit of Resilient, Low Carbon Communities: An Examination of Barriers to Action in Three Canadian Cities," *Energy Policy* 38, no. 12 (2010): pp. 7575-7585, https://doi.org/10.1016/j.enpol.2009.06.070, 7576.

[7] Samuel Faye Gamtessa, "An Explanation of Residential Energy-Efficiency Retrofit Behavior in Canada," *Energy and Buildings* 57 (2013): pp. 155-164, https://doi.org/10.1016/j.enbuild.2012.11.006, 156.

[8] Marcos J. Pelenur and Heather J. Cruickshank, "Closing the Energy Efficiency Gap: A Study Linking Demographics with Barriers to Adopting Energy Efficiency Measures in the Home," *Energy* 47, no. 1 (2012): pp. 348-357, https://doi.org/10.1016/j.energy.2012.09.058, 350.

[9] Louise Crabtree and Dominique Hes, "Sustainability Uptake in Housing in Metropolitan Australia: An Institutional Problem, Not a Technological One," *Housing Studies* 24, no. 2 (2009): pp. 203-224, https://doi.org/10.1080/02673030802704337, 212;
Philip J. Vergragt and Halina Szejnwald Brown, "The Challenge of Energy Retrofitting the Residential Housing Stock: Grassroots Innovations and Socio-Technical System Change in Worcester, MA," *Technology Analysis & Strategic Management* 24, no. 4 (2012): pp. 407-420, https://doi.org/10.1080/09537325.2012.663964, 411.

lack of knowledge and/or disinterest, are seen as important barriers to retrofits being carried out.[10]

The second category revolves around structural and operational barriers, and this includes themes such as the cost of retrofit projects. The upfront cost of technologies can be a barrier, although the long-term savings are considered to be beneficial.[11] Included in this is the perception of the cost of the project. Although retrofits might be eligible for financial incentives, homeowners are often not aware of this and perceive the cost to be much higher.[12] This is particularly a challenge for landlords, tenants, and housing associations. Landlords and owners of residences are often disincentivized to carry out retrofits due to the high cost, and tenants are unwilling or unable to front the cost.[13] Given the number of large multi-family complexes, particularly in cities such as Toronto, it is very important to address this challenge. Another structural barrier would include the nature of the property. It may not be possible to carry out retrofits due to the physical makeup and structure of the building.[14] This is often the case in buildings that are very old and have complex structures and electrical wiring.[15]

Finally, the third category of regulatory and legislative barriers includes institutional barriers, particularly in government regulations, including high levels of red tape for adoption of new technologies in multiple jurisdictions.[16] In addition, there is a lack of cooperation among municipalities and at different levels of government.[17] There is also a significant problem with government inertia; when governments fail to act, path dependency is created that limits the

[10] Pelenur and Cruickshank, "Closing the Energy Efficiency Gap," 350.

[11] Gamtessa, "An Explanation of Residential Energy-Efficiency Retrofit Behavior in Canada," 156.

[12] *Ibid.*

[13] Pelenur and Cruickshank, "Closing the Energy Efficiency Gap," 350.

[14] Mark Dowson et al., "Domestic UK Retrofit Challenge: Barriers, Incentives and Current Performance Leading into the Green Deal," *Energy Policy* 50 (2012): pp. 294-305, https://doi.org/10.1016/j.enpol.2012.07.019, 297; Pelenur and Cruickshank, "Closing the Energy Efficiency Gap," 350.

[15] Dowson et al., "Domestic UK Retrofit Challenge: Barriers, Incentives and Current Performance Leading into the Green Deal," 297.

[16] Burch, "In Pursuit of Resilient, Low Carbon Communities," 7580.

[17] Sarah Burch, "Transforming Barriers into Enablers of Action on Climate Change: Insights from Three Municipal Case Studies in British Columbia, Canada," *Global Environmental Change* 20, no. 2 (2010): pp. 287-297, https://doi.org/10.1016/j.gloenvcha.2009.11.009, 288.

adoption of more novel or innovative ideas.[18] Moreover, policymakers are often slow to act to develop new policies enabling cleantech adoption such as financial incentives.[19]

It is important to note that all of these barriers are intrinsically connected and reinforce one another. Moreover, these barriers serve to create path dependencies, which make them resistant to radical changes.[20] Consequently, they need to be addressed in a holistic way.

3.2. Opportunities

Despite the large number of barriers that are preventing a rapid uptake of cleantech in buildings, there are some significant emerging opportunities. A common theme is the fact that small-scale experiments and pilot projects are useful and even necessary in facilitating collective learning. They can also encourage a transition in the socio-technical system of residential housing stock as well as in regulatory frameworks and building standards.[21] These projects are more successful if they are implemented in high traffic areas, as shown by a case study in Lochiel Park Green Village in Australia.[22] Being able to witness the development and process of the project increases awareness and educates citizens on the retrofit process.

One article encouraged greater involvement of the cleantech sector in public procurement.[23] According to research from the Innovation Economy Council "on a group of 259 cleantech high-growth startups, total federal procurement between 2009 and 2020 represented just 3.6 percent of these companies' overall 2019 revenues and just 4.4 percent of their 2019 exports."[24] It is clear from these statistics that cleantech companies are not getting much support

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[18] Burch, "Transforming Barriers into Enablers of Action on Climate Change," 288.

[19] Stephen Berry, Kathryn Davidson, and Wasim Saman, "The Impact of Niche Green Developments in Transforming the Building Sector: The Case Study of Lochiel Park," *Energy Policy* 62 (2013): pp. 646-655, https://doi.org/10.1016/j.enpol.2013.07.067, 651.

[20] Jochen Monstadt and Annika Wolff, "Energy Transition or Incremental Change? Green Policy Agendas and the Adaptability of the Urban Energy Regime in Los Angeles," *Energy Policy* 78 (2015): pp. 213-224, https://doi.org/10.1016/j.enpol.2014.10.022, 213.
Burch, "In Pursuit of Resilient, Low Carbon Communities," 7580.

[21] Joanna Williams, "Can Low Carbon City Experiments Transform the Development Regime?," *Futures* 77 (2016): pp. 80-96, https://doi.org/10.1016/j.futures.2016.02.003, 81;
Vergragt and Brown, "The Challenge of Energy Retrofitting the Residential Housing Stock," 409.

[22] Berry, Davidson, and Saman, "The Impact of Niche Green Developments in Transforming the Building Sector: The Case Study of Lochiel Park," 653.

[23] Joe Greenwood and Farooq Qaiser, "Innovation in Cleantech - MaRS Discovery District," 23.

[24] Shawn McCarthy, "Cleantech Can Drive Growth. We Need to Buy In," *MaRS Discovery District*, October 8, 2020, https://www.marsdd.com/news/cleantech-can-drive-growth-we-need-to-buy-in/.

from the Canadian government, and in fact, most companies see more profit outside of Canada than within it.[25] The question then becomes how to create and sustain these new engagement pathways. Another article proposed a vertically-focused and industry-supported cleantech acceleration model to build a pipeline of new innovation opportunities and help position industries in sustainability as world leaders.[26] Again, there remain challenges to how to initiate these new models and then incorporating them into existing public procurement frameworks. It is also clear that more knowledge and technology training is needed for builders and developers, in a more easily accessible manner.[27] Given the volume and complexity of information needed to educate all the actors, there is also a need for the design, chunking, and simplification of information on pathways to public procurement for cleantech companies.

Some authors found that key factors that affect adoption and use of energy technologies in the home include price of the technology, usefulness, interconnectedness with other technologies or services and symbolism.[28] In addition, financial incentives also play an important role in the probability and intensity of retrofits.[29] The larger the expected energy cost savings and government rebates are, the more likely it is that retrofit investments will be undertaken.[30] Convenience is also key here as well, as building owners need to be aware of the incentives and will be more likely to apply for them if the process is clear and easy to follow.

Furthermore, there is an important role for building construction and retrofit intermediaries in enabling rapid adoption of buildings cleantech solutions. According to the literature, intermediaries "play an important role in connecting actors in situations in which direct interaction is challenging because of high transaction costs, communication challenges and information asymmetries."[31] Because of this, the education of intermediaries is a major opportunity for the work of organizations like MaRS to promote buildings cleantech solutions.

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[25] McCarthy, "Cleantech Can Drive Growth. We Need to Buy In."

[26] "Accelerating Canada's Clean Growth Economy," *DeepCentre*, September 2016: 14, http://deepcentre.com/wordpress/wp-content/uploads/2016/11/DEEP_Centre_Clean_Growth_Economy.pdf.

[27] Mark Dowson et al., "Domestic UK Retrofit Challenge: Barriers, Incentives and Current Performance Leading into the Green Deal," 297.

[28] A. Owen, G. Mitchell, and A. Gouldson, "Unseen Influence—The Role of Low Carbon Retrofit Advisers and Installers in the Adoption and Use of Domestic Energy Technology," *Energy Policy* 73 (2014): pp. 169-179, https://doi.org/10.1016/j.enpol.2014.06.013, 169-170.

[29] Gamtessa, "An Explanation of Residential Energy-Efficiency Retrofit Behavior in Canada," 159.

[30] *Ibid.*

[31] Heini Vihemäki, Anne Toppinen, and Ritva Toivonen, "Intermediaries to Accelerate the Diffusion of Wooden Multi-Storey Construction in Finland," *Environmental Innovation and Societal Transitions* 36 (2020): pp. 433-448, https://doi.org/10.1016/j.eist.2020.04.002, 433.

Finally, energy audits are significant in the world of retrofits. They provide an important mechanism for informing homeowners about their current energy usage and waste, as well as available energy savings options.[32] This is vital for helping homeowners to decide to undertake retrofits. On a larger scale, this could lead to benchmarking of energy efficiency improvements through retrofits in a city or province. These strategies leverage a "show, don't tell" model of interaction that improves consumer engagement, trust, and credibility.

Key findings from report on "Accelerating Building Efficiency"[33]

Criteria that define the success of a project enhancing energy efficiency through adoption of buildings cleantech include:

- Job creation
- Well-designed building efficiency codes and standards
- Clear energy efficiency improvement targets, in government-owned buildings, voluntary targets for private sector
- Performance information and certifications
- Incentives and finance
- Government leadership by example (sharing of best practices)
- Engaging building owners, managers, occupants
- Engaging technical and financial service providers
- Working with utilities

3.2.1. Public-Private Partnerships

In addition, pilot projects and retrofits can be implemented through public-private partnerships (PPPs) between the municipal government and cleantech companies. Throughout this process, the government could act both as a leader and a facilitator that identifies industry champions and accelerates market acceptance at the same time. In fact, this is a win-win scenario where the public sector leverages its experience in long-term and low-risk projects while the private sector exploits its comparative advantage in project management and design. However, the government often faces budget constraints, and it cannot afford to take risks, innovate, or fail. Consequently, it is crucial that the local government engages more with citizens to hear their concerns and input on which clean technologies or projects should be prioritized. Therefore, for a

[32] Gamtessa, "An Explanation of Residential Energy-Efficiency Retrofit Behavior in Canada," 161.

[33] Jennifer Layke et al., "Accelerating Building Efficiency," *World Resources Institute*, September 26, 2018, https://www.wri.org/publication/accelerating-building-efficiency-actions-city-leaders.

successful PPP, efficient communication; a clearly outlined cost-benefit analysis; and clearly defined roles, responsibilities and accountability are essential.[34]

4. Interview Results

Interviews with relevant stakeholders from the public, private, and academic sectors enabled a more in-depth analysis of some of the practical challenges associated with municipal cleantech adoption, specifically in Toronto. Interviewees came from a variety of different backgrounds, including from the municipal government, a sustainable architecture firm, a solar technologies company, and academia. However, they all shared one thing in common: the recognition of the need for a more collaborative approach to municipal cleantech adoption. Key themes from the interviews are highlighted in the following table; see Appendix 1 for a more detailed analysis.

Key Interview Themes	**Barriers**	**Opportunities**
Collaboration	Clear lack of collaboration between different levels of government, the private sector, the nonprofit sector, and academia	"The solutions are not purely technological, behavioural, or policy – they are all of the above"
Role of Municipal Government	Bureaucratic hurdles and complexities of municipal procurement (see below)	Municipalities can be effective at "providing a testbed for some of these ideas" through pilot buildings cleantech projects
Procurement	Stringent requirements for transparency and cost effectiveness	Potential to support small pilot projects
Municipal Building Codes	Changes to municipal building codes would be helpful but fall under provincial jurisdiction	Opportunity to follow the model of other sectors (transportation) and jurisdictions (Vancouver)
Retrofits	Cleantech solutions for retrofits are seen as less urgent than for new buildings, which have a longer lifespan	But retrofits are also more important, given that significantly more buildings will be retrofitted than built from scratch

[34] UN-Energy. "Strengthening Public-Private Partnerships to Accelerate Global Electricity Technology Deployment – Recommendations from the Global Sustainable Electricity Partnership Survey," 2012: 4-14, https://www.globalelectricity.org/content/uploads/2nd_edition_strengthening_ppps_-_joint_report_gsep-un-energy_20123.pdf.

Awareness of feasibility of cleantech solutions	Need / opportunity to create more awareness among: - Consumers - Government bodies and civil servants - Industry intermediaries, including construction workers	
Impact of COVID-19	Pandemic was devastating for many cleantech companies, as well as the City of Toronto's budget and capacity	People are more concerned about indoor air quality and natural materials
Miscellaneous	- Government inertia and unwillingness to underwrite risk - Inconsistent government subsidies for cleantech - Challenges in accessing bank loans for buildings cleantech - Lack of NAICS classifications for cleantech products - Perception of high costs	- Need for locally-driven cleantech clusters - Many existing certifications and standards for cleantech companies (e.g. LEED) - Enormous opportunity for growth in Toronto, a driver of Canada's wealth with significant "strength in diversity"

5. Case Studies

In addition to interviews, case studies provided a snapshot of successful strategies for rapid municipal adoption of buildings cleantech in Canada and around the world. Based on initial research, four cities were identified – Vancouver, New York, Copenhagen, and Singapore – that have demonstrated successful municipal adoption of buildings cleantech. This section will outline the preliminary lessons learned from the investigation of the abovementioned municipalities' environmental policies, cluster development, and green projects. These lessons contributed to the development of the recommendations on how to enhance rapid cleantech adoption in Toronto.

5.1. Case Study 1: Copenhagen's Nordhavn Energy Lab

Copenhagen is a global leader in cleantech adoption. It has recently announced the ambitious goal of becoming carbon neutral by 2025, and it is home to some of the most sustainable buildings in the world, such as the UN city, Copenhill, Green Light House, and many more. Public-private partnerships and multi-stakeholder engagement are essential for the success of Copenhagen's innovative ecosystem, as demonstrated by CLEAN, Denmark's biggest green

cluster organization, which can count on the expertise of over 170 members both from the private and public sector.[35]

EnergyLab Nordhavn – New Urban Energy Infrastructure is a product of these partnerships. Nordhavn is a harbour area in the district of Østerbro, Copenhagen, and it is currently the largest urban development in Northern Europe. The project started in 2015 after a total of 12 partners, including local government agencies, academia, and tech companies, decided to use Nordhavn's urban living lab to demonstrate how "electricity and heating, energy-efficient buildings and electric transport can be integrated into an intelligent, flexible and optimized energy system."[36]

In Nordhavn and Norrebro, another Copenhagen district, a new business model based on peer-to-peer energy exchange was implemented, and residents following this prosumer (proactive consumer) model were able to cut their utility bills by an average of 9%.[37] Moreover, during the 2017/2018 season, it was demonstrated that buildings' sensible heat storage is a powerful alternative to using economically and environmentally costly peak-load boilers. In fact, due to this simple but effective process, buildings' walls, floors and ceilings are charged with heat during normal heating supply, and later release this heat in order to maintain indoor temperature during peak-load periods, when heat demand is under pressure.[38] This time-of-use energy management maneuver was carried forward by HOFOR, a Danish utility company, which installed temperature sensors in 23 apartments, cut their energy supply during peak demand by five degrees and up to four hours, and achieved a 12% peak load reduction in 23 buildings.[39]

Therefore, the success of this program is due to data collection, district energy, customer flexibility, stakeholders' engagement, and knowledge dissemination. For instance, an EnergyHub was created in order to facilitate cooperation among the 12 partners. The EnergyLab showroom, which was specifically designed to promulgate the project results and incentivize peer-to-peer lending and prosumer behaviours, attracted over ten thousand visitors as well as 187 delegations

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[35] "Environmental cluster Denmark," *Clean*, accessed February 5, 2021, https://www.cleancluster.dk/en/.

[36] "A smart city energy lab," *Energy Lab Nordhavn*, accessed January 20, 2021, http://www.energylabnordhavn.com/index.html.

[37] "Results from an urban living lab," *Energy Lab Nordhavn*, 2020, 35, http://www.energylabnordhavn.com/uploads/3/9/5/5/39555879/energylab_nordhavn_final_report_2020.pdf.

[38] Christine Sandersen, and Kristian Honoré, "District heating flexibility – short term heat storage in buildings," *HOFOR,* 2018, 5-9, http://www.energylabnordhavn.com/uploads/3/9/5/5/39555879/d5.2c_and_5.2d_short_term_heat_storage_in_buildings.pdf.

[39] "Results from an urban living lab," *Energy Lab Nordhavn*, March 3, 2020: 26-27, https://stateofgreen.com/en/partners/energylab-nordhavn/news/energylab-nordhavn-results-from-an-urban-living-lab/.

from 46 countries, including Canada, in just four years.[40] Finally, this is a program that can be replicated in cities such as Toronto, which has announced its intention to expand its district energy systems, and whose diversified building stock offers great potential for thermal exploitation. In the meantime, it will be crucial to build consumer awareness with regards to the economic and environmental benefits of energy flexibility.

5.2. Case Study 2: Vancouver's Building Codes and ZEBx Collaboration Hub

Among Canadian cities, Vancouver is a leader in buildings clean technologies. As part of its Climate Emergency Action Plan, the City aims to ensure carbon pollution from buildings in 2030 is half what it was in 2007, and that new buildings and construction projects have 40% less embodied emissions compared to 2018.[41] In order to achieve this, Vancouver plans on transitioning to zero emissions buildings in all new construction by 2030 through a combination of bylaw requirements and other initiatives like the Zero Emissions Building Exchange.[42] While ambitious, this approach builds on the success of existing pilot green building projects. These include buildings at the University of British Columbia and at the 2010 Olympic Village which meet LEED Gold and Platinum standards.[43] To achieve this success, the City of Vancouver has had to better facilitate the effective use of existing resources in order to overcome path dependency.[44] Although Vancouver has a unique "culture of sustainable innovation," it remains a model for green building standards and initiatives in other cities like Toronto.

Part of Vancouver's success in promoting sustainable buildings retrofits and construction comes from its unique power over building codes and regulations. Indeed, the City of Vancouver was granted its own local government Charter by the province, giving it increased power over taxation and building codes.[45] Because of this, Vancouver has been able to develop more ambitious regulatory requirements in order to achieve its zero emissions building targets. By-law energy requirements, rezoning conditions, and certifications for passive houses and LEED

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[40] *Ibid.,* 36-7.

[41] City of Vancouver, "How we build and renovate," *City of Vancouver Climate Emergency Action Plan*, 2021, https://vancouver.ca/green-vancouver/how-we-build-and-renovate.aspx.

[42] City of Vancouver, "Zero Emissions Buildings," *Green Vancouver,* 2021, https://vancouver.ca/green-vancouver/zero-emissions-buildings.aspx.

[43] Interview with Alastair Moore; see also University of British Columbia and City of Vancouver Olympic Village websites.

[44] Sarah Burch,"Transforming barriers into enablers of action on climate change: Insights from three municipal case studies in British Columbia, Canada," *Global Environmental Change* 20, no. 2 (2010): 288.

[45] *Ibid.*, 290.

buildings all contribute to the City's high performance building standards.[46] Currently, Vancouver buildings are regulated by the 2019 municipal Building By-Law, but the City's approach has in turn inspired the development of a more ambitious British Columbia Energy Step Code. This Code, developed in 2017, is an optional compliance path in British Columbia's Building Code that allows local governments to incentivize or regulate energy efficiency in new construction.[47] Although Toronto does not have the same degree of independence over building regulations as Vancouver, the municipal building requirements and the provincial Energy Step Code may nonetheless serve as a model for a more ambitious approach to Toronto's own green building requirements (see Appendix 2 for a more detailed comparison).

In addition to enforcement of building bylaws, Vancouver is very reliant on other "building catalyst tools" in order to enable its zero emissions buildings targets. For example, incentives like additional floor space for buildings meeting certain standards provide an additional incentive to building developers and designers.[48] Meanwhile, in order to support further growth of the buildings cleantech sector in Vancouver, a new collaborative platform – the Zero Emissions Building Exchange, or ZEBx – has been developed to facilitate knowledge exchange in the sector. ZEBx is an industry hub, hosted by the Vancouver Regional Construction Association in partnership with the City of Vancouver, Passive House Canada, and the Open Green Building Supply.[49] While still fairly young, this initiative provides a model of how a neutral organization can bring together public and private actors to support capacities for Zero Emissions Buildings in Vancouver and British Columbia. As a result of these initiatives – as well as high achievement of globally-recognized green certification standards – many of Vancouver's planners, architects, contractors and engineers are in high demand worldwide.[50] Although the Toronto context is very different from that of Vancouver, it is clear that it could benefit from a similar approach of more ambitious regulatory mechanisms, increased incentivization of Zero Emissions Buildings, and development of new collaborative spaces for industry partnership.

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[46] City of Vancouver, "High performance building standards," *Green Vancouver*, 2021, https://vancouver.ca/green-vancouver/build-a-passive-house.aspx.

[47] Government of British Columbia, "Background," *Energy Step Code: Building Beyond the Standard*, 2021, https://energystepcode.ca/.

[48] City of Vancouver, "Zero emissions building tools," *Green Vancouver*, 2021, https://vancouver.ca/green-vancouver/zero-emissions-buildings-tools.aspx.

[49] "What is ZEBx," *ZEBx*, 2021, https://www.zebx.org/about/.

[50] Vancouver Economic Commission, "Clean Tech," 2021, https://www.vancouvereconomic.com/clean-tech/.

5.3. Case Study 3: New York City's Local Law 97

Meanwhile, in New York City (NYC), efforts to ramp up retrofitting of existing buildings with clean technologies have increased significantly in the past few years, imposing some of the most stringent regulations on buildings in a major city. In 2019, the City Council passed Local Law 97, which places carbon caps on most buildings larger than 25,000 square feet.[51] This accounts for roughly 50,000 properties across the city, or 60% of the city's building area. The caps are expected to start in 2024 and will increase over time, and by 2050 it is expected that emissions from buildings will be reduced by 80%.[52] However, affordable housing is given an exception, and buildings that fall into this category will be exempted from emission limits so long as the owners implement low-cost saving measures. To monitor progress and oversee implementation of the regulation, City Council established the Office of Building Energy and Emissions Performance at the Department of Buildings.[53] The new regulations recognize that there is a significant need to transform NYC's buildings, which consume 95% of electricity, emit 70% of carbon and use 80% of water in the city.[54]

In order to finance this, City Council also passed Local Law 96, which establishes the Property Assessed Clean Energy (PACE) Program.[55] PACE is a financing program that offers lower-cost loans for sustainability projects, such as HVAC upgrades and rooftop solar. Commercial PACE (C-PACE) provides loans for commercial, multifamily, and industrial properties. With C-PACE loans, "owners pay little or no upfront costs and have low interest rates and repayment terms as long as the useful life of the project - often up to 20 or 30 years."[56] Notably, annual payments are generally less than projected annual savings. PACE loans are funded by private lenders and are structured in a similar way to mortgages. However, unlike mortgages, they do not immediately become due when a borrower is in default. Rather, payments that are past due become liens against the property. The nature of the structure requires states and municipalities to legislate the program, designate rules, and approve lenders. For that reason, the program has not yet launched but is expected to launch soon. It is important to note that

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[51] "NYC Building Emissions Law Summary - Local Law 97," *Urban Green Building Council*, July 2020, https://www.urbangreencouncil.org/sites/default/files/urban_green_building_emissions_law_summary_2020.02.19.pdf.

[52] "All About Local Law 97," *Urban Green Council*, April 7, 2021, https://www.urbangreencouncil.org/content/projects/all-about-local-law-97.

[53] "The Climate Mobilization Act Overview," *Building Energy Exchange*, June 30, 2020, https://be-exchange.org/insight/the-climate-mobilization-act-int-1253/.

[54] "About Us," *Urban Green Council*, March 18, 2021, https://www.urbangreencouncil.org/aboutus.

[55] "Picking Up the PACE: NYC LL96 Final Rules Expected Soon," *Urban Green Council*, March 10, 2021, https://www.urbangreencouncil.org/content/news/picking-pace-nyc-ll96-final-rules-expected-soon.

[56] "Picking Up the PACE: NYC LL96 Final Rules Expected Soon."

Toronto's Home Energy Loan Program (HELP) is also a PACE program and similar to the New York model, but HELP targets homeowners whereas NYC's model focuses on commercial and industrial properties.

To date, almost all building retrofits have been initiated by the building owners, and were carried out through a series of partnerships. Some of these partners include the New York City Energy Efficiency Corporation (NYCEEC), the Urban Green Council, and the Building Energy Exchange. The NYCEEC is the first local green bank in the United States, which provides loans for energy efficiency and clean energy projects in NYC, with a particular focus on buildings.[57] NYCEEC partners with financial institutions and affordable housing agencies in order to build green financing markets that can break down barriers and scale up investments. To date, NYCEEC has mobilized $237 million of capital and upgraded 321 buildings, with 73% of those projects taking place in lower-middle income communities.[58] The bank is also partnering with New York City to reduce carbon emissions. On the other hand, Urban Green Council is a non-profit organization that focuses on broadening stakeholder consensus through the use of data and education, and to create actionable solutions for bringing the retrofit market to scale.[59] Urban Green Council develops reports and briefs educating stakeholders on regulations being implemented by the City and the resulting opportunities. Finally, the Building Energy Exchange is a centre of excellence that connects NYC's real estate and design communities to energy efficient solutions through education, exhibitions, technology demonstrations and research.[60] These two organizations offer resources to cleantech companies, building owners, and the government to find the most effective path forward for building retrofits.

Pulling all of these entities together, the New York State Energy Research & Development Authority (NYSERDA) is currently developing the Empire Building Challenge, which will leverage $50 million in State funds to create a cluster of key stakeholders in the building sector while drawing on low-carbon retrofit approaches that can be replicated in multiple buildings.[61] As illustrated above, there is a strong presence of organizations that are working to educate stakeholders on the retrofit process and create actionable plans to bring it to scale. The success NYC has seen so far in retrofits can be attributed to the collaboration between these organizations and stakeholders and the regulatory environment, which incentivises the retrofits. NYSERDA's establishment as the authority should help to formally establish a cluster

[57] "NYCEEC," *NYCEEC*, March 17, 2021, https://www.nyceec.com/.

[58] "Our Impact," *NYCEEC*, March 19, 2021, https://nyceec.com/our-impact/.

[59] "About Us," *Urban Green Council*, March 18, 2021, https://www.urbangreencouncil.org/aboutus.

[60] "Home," *Building Energy Exchange*, April 8, 2021, https://be-exchange.org/.

[61] "Empire Building Challenge," *NYSERDA*, accessed April 11, 2021, https://www.nyserda.ny.gov/All-Programs/Programs/Empire-Building-Challenge.

in NYC and bring together all the relevant stakeholders and organizations to foster collaboration and facilitate retrofit processes.

The cluster model and carbon caps offer lessons for Toronto. At the same time, it should be recognized that New York City is much larger in scale compared to Toronto and also has significantly more power than the City of Toronto does. While there are budget and capacity constraints at the municipal level for an authority that could lead Toronto's green building cluster, New York's model nonetheless offers a model for strong collaboration between many different actors, and for how private financing can be leveraged to incentivize retrofits, particularly in large apartment complexes. In addition, Toronto, like New York City, has a multitude of relevant stakeholders such as the Canada Green Building Council and The Atmospheric Fund, as well as other industry and academic organizations. Therefore, New York City's model of collaboration is extremely relevant for Toronto.

5.4. Case Study 4: Singapore's BCA Green Mark Scheme

The city state of Singapore sits at the intersection of unique constraints, with a small geographic footprint, limited natural resources, high population density, and high energy consumption. The metropolis manages these constraints though highly effective, efficient, and stratified urban planning. The physical development of modern Singapore has been bolstered by significant shifts towards innovative green building projects. Singapore is home to structures such as Gardens by the Bay, Parkroyal on Pickering by WOHA, CapitaGreen, and National Gallery Singapore, a mixture of public and private spaces which have used innovative technology in building science to create highly efficient green spaces.

The building sector in Singapore consumes up to half of the nation's total energy consumption.[62] Up to 80% of Singaporeans live in public residential developments provided by the national Housing & Development Board.[63] Because of this, standards for buildings are able to change swiftly and unilaterally. This model is unique due to the country's size, density, and government oversight. Singapore is looking to radically transform the building industry by targeting 80% of all buildings to be green-certified by 2030.

The Singaporean government has created, through the Housing Development board, comprehensive outlines for green buildings through the Building and Construction Authority (BCA) Green Mark scheme. Launched in 2005, the BCA Green Mark scheme is updated almost

[62] Vidushini Siva, Thomas Thomas, and Mansi Jain, "Green Buildings in Singapore; Analyzing a Frontrunner's Sectoral Innovation System," *Sustainability* 9, no. 6 (2017): 919, https://doi.org/10.3390/su9060919.

[63] Cheong Yi Wei, "The Missing Piece in Singapore's Green Building Puzzle," *Eco-Business*, August 7, 2019, https://www.eco-business.com/news/the-missing-piece-in-singapores-green-building-puzzle/.

yearly to incorporate residential and nonresidential buildings. Due to geographical constraints, the Singaporean government has adopted green, sustainable lifestyles into the social fabric. The Singaporean authorities regulate all buildings energy by mandating building owners to submit energy consumption data to the BCA. In 2014, it became mandatory for building owners to conduct periodic energy audits, and achieve the minimum Green Mark certification when updating or retrofitting their cooling system.[64] Over the years, more than 3200 buildings have been evaluated and have met the BCA Green Mark Standards. This accounts for about one-third of Singaporean buildings.

The assessment system of the Green Mark scheme awards points for energy efficient and pro-environmental practices. Based on scores, buildings are marked as BCA Green Mark Platinum standard, the GoldPlus, Gold standard, or the standard Certified rating.[65] Highly certified buildings are given publicity by the government and are open to the public for tours, which in turn generates additional revenues for the buildings themselves. Bodies in the government are also working on integrating energy efficiency in the assessment and appreciation of buildings so energy efficient buildings accrue higher market value over time.[66]

Apart from assessment systems, BCA also has initiatives to incentivize financing new projects and retrofitting existing projects. For example, the Green Mark Incentive Scheme for Existing Building and Premises (GMIS-EBP) "co-funds up to 50% of the retrofitting cost of energy improvements."[67] Another initiative, The Building Retrofit Energy Efficiency Financing (BREEF), helps to counter high costs of investing in new retrofits technology by underwriting the risk of loan defaults from financiers.[68] The program was created to reduce risk aversion among investors and project developers and coax more risk averse financial institutions towards green building investments.[69]

The Government of Singapore further supports the uptake of green technology through grant schemes promoted by the Green Building Innovation Cluster (GBIC). "GBIC is an

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[64] *Ibid*.

[65] Building and Construction Authority, "Green Mark Certification Scheme," accessed April 11, 2021, https://www1.bca.gov.sg/buildsg/sustainability/green-mark-certification-scheme.

[66] Vidushini Siva, Thomas Thomas, and Mansi Jain, "Green Buildings in Singapore; Analyzing a Frontrunner's Sectoral Innovation System."

[67] Building and Construction Authority, "Green Mark Incentive Scheme for Existing Buildings," accessed April 11, 2021, https://www1.bca.gov.sg/.

[68] Building and Construction Authority. "Green Mark Building Retrofit Energy Efficiency Financing (BREEF) Scheme," accessed April 11, 2021, https://www1.bca.gov.sg/.

[69] Cheong Yi Wei, "The Missing Piece in Singapore's Green Building Puzzle."

integrated research, development and demonstration hub.[70]" The GBIC gives funding for experimentation, exhibition, and exchange of prospective new energy efficiency solutions among industry stakeholders.[71] In addition to funding, the government also facilitates more communication between clusters, the Singapore Green Building Council (SGBC), the annual SGBC Leadership Conversations networking forum and the International Green Building Conference are monthly seminars to connect all facets of the industry together.

Thus, the BCA and Green Mark scheme truly represent an ecosystem of policy and innovation to induce more growth in the green buildings sector. Unlike Toronto, Singapore is an island nation with specific energy and space constraints, with unilateral oversight. Singapore uses an aggressive top-down approach in its push towards highly efficient buildings. A power Toronto, as a part of a larger providence, does not possess. However, Toronto as a major metropolitan city, can take lessons from the BCA's model of total support of the green buildings sector. The political will to make impactful change is a defining feature of the Green Mark scheme. Toronto has the capacity to leverage its size and innovation sectors to progress towards change in this sector. Given enough political support, both governments have the business environment and the enforcement capacity to reach their 2030 goals.[72]

These case studies highlight some innovations made in jurisdictions around the world. This selection of projects and schemes summarizes a few of the vast regulatory bodies in existence. Examples of other successful assessment schemes have been developed around the world include, LEED (US), BREEAM (UK), GBCA (Australia), DGNB (Germany), CASBEE (Japan), and Pearl Rating System (Abu Dhabi). Each offers different potential lessons as the City of Toronto continues to work towards the achievement of its green building targets.

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[70] Building and Construction Authority. "Green Mark Cluster GBIC Program," accessed April 11, 2021, https://www1.bca.gov.sg/.

[71] Vidushini Siva, Thomas Thomas, and Mansi Jain, "Green Buildings in Singapore; Analyzing a Frontrunner's Sectoral Innovation System."

[72] Cheong Yi Wei, "The Missing Piece in Singapore's Green Building Puzzle."

6. Conclusions

From the literature review, case studies, and interviews, several key themes have been emphasized. These are aligned under several core barriers and opportunities.

6.1. Barriers

Overall, three core barriers emerged from the literature review, the interviews, and the case studies: the limited sectoral collaboration between stakeholders; the flawed design of regulatory frameworks; and the lack of awareness of buildings cleantech solutions.

1. Collaboration between different levels of government, industry partners, and other relevant buildings cleantech actors (including academia) remains limited.
    a. There are a large number of actors in the sector (see Appendix 3 for full stakeholder analysis) and efforts at collaboration exist, but there remains a lack of communication between actors on successful integration of buildings cleantech options.
    b. Greater coordination between actors at the local level (and not just through a federal industry association) is needed. The question becomes *how* to usher in this new age of collaboration. It will require breaking old habits, building and sustaining new habits, and instilling trust across the various actors toward positive outcomes and rapid momentum.[73]

2. Regulatory frameworks at the municipal and provincial level hinder rapid adoption of buildings cleantech. Moreover, there is an inherent inertia or path dependency of municipal government processes that inhibits rapid clean-tech adoption. This includes when it comes to:
    a. Requirements for transparency and cost-effectiveness as part of municipal procurement processes;
    b. The modernization of building codes and green building standards;
    c. Strict building standards rather than performance-based standards that limit the flexibility of sustainable building designers and architects, and;
    d. Contradictions between policies and regulations of different levels of government and different municipalities.

3. Lack of awareness of different buildings cleantech solutions and their feasibility remains a challenge for various actors. Increasing awareness is a core element of changing

[73] "Behavioral Design: User Guide," *Deloitte*, 2017, https://static1.squarespace.com/static/5b9eceb5c3c16a3124d15970/t/5bd5ca11e2c483508805e2b6/1540737554188/Doblin-BehavioralDesign-UserGuide.pdf.

behaviour when it comes to the critical uptake of innovative buildings cleantech ideas. It is important to note that this behaviour may also be affected by factors like income and personal beliefs. Key challenges in this area include:

a. Policy makers may be unaware of the benefits of cleantech retrofits;
b. Public servants responsible for approving buildings and retrofits may be unaware of their effectiveness;
c. Industry members, from construction workers to intermediaries, may lack knowledge of available cleantech options and their feasibility;
d. Consumers may lack an understanding of the benefits and low costs of certain cleantech options, while maintaining the perception that cleantech is "fringe" or "special interest" and therefore not a priority for them.

6.2. Opportunities

Based on the research, there are also significant opportunities to scale cleantech adoption in the building sector, related to greater government support, awareness building, and enhanced collaboration among stakeholders.

1. There can be greater collaboration between sectors and institutions, both at the public and private level. For example:
    a. Public-private partnerships and corporation partnerships could be incentivized;
    b. Green clusters are present in the GTA,[74] but most actors still operate independently there is no overarching authority that can manage them and encourage cooperation, and;.
    c. "Barriers can be transformed into enablers of action" if a culture of collaboration and innovation is encouraged;[75] and
    d. Coordination of competitiveness and regulatory policies can be utilized to enact technical change at different levels in the production process. The challenge consists of helping policy makers to overcome paralysis and persevere through large systems change.

2. The City of Toronto could implement consistent regulations and financial incentives that are aligned with their economic and environmental priorities. For example, they could:
    a. Offer financial incentives and/or rebates for retrofits. Although buildings represent a more urgent need since every new unsustainable building that is built

[74] Rob McMonagle, "Developing Growth Roadmaps for Toronto's Green Industries," City of Toronto, September 19, 2019, https://ontario-sea.org/resources/Documents/Toronto%20Green%20Industries%20Growth%20Roadmap.pdf, 17-19.

[75] Sarah Burch, "In pursuit of resilient, low carbon communities: An examination of barriers to action in three Canadian cities," *Energy Policy* 38, no. 12 (2010): 7575.

will have a negative environmental impact for 50 years, retrofits are more important because most of the buildings that exist today will still be there in 30 years. As such, yet to be retrofitted buildings offer incredible long-term savings and carbon emission reduction opportunities;

b. Develop innovative mechanisms to attract investors, scale up a retrofit economy, and normalize sustainable building practices that offer both economic and environmental benefits, and;
c. Update or enhance current regulations such as the Toronto Green Building standards and the Energy & Water reporting and benchmark.

3. The cleantech market could grow at a faster rate if consumers and other relevant stakeholders were better educated about the economic and environmental benefits of cleantech solutions in their homes. Mechanisms for this might include:
    a. Intermediaries and social norms, which are important drivers of the cleantech transition;
    b. Consumers, who can benefit from tangible experiments and cost-benefit analyses tailored to what their needs could be, and;
    c. Pilot projects and expositions, which are great to demonstrate technological feasibility and to promote user desirability.

7. Recommendations

Based on this analysis, 10 recommendations were developed for overcoming barriers to municipal cleantech adoption in the buildings sector in the short term. These recommendations are intended not just for MaRS, or the City of Toronto, or cleantech companies themselves; instead, they require the participation and collaboration of all actors in the sector. Fundamentally, they consist of "design principles" on what needs to be done in order to enhance the capacity of cleantech companies to reduce emissions from buildings in Toronto.[76] The 10 recommendations fall under three overarching themes: facilitating collaboration through sectoral partnerships; enhancing regulatory frameworks and financial incentivization; and increasing awareness and education.

7.1. Facilitating Collaboration Through Sectoral Partnerships

1) **Create an independent advisory group chaired by MaRS that can operate as an authority for the cleantech industry and other key actors in the retrofit process. The advisory group could carry out the following functions:**
    a) Communicate to members of the cleantech industry about regulatory changes within the green buildings sector and how this affects the ways that companies can operate within the industry;
    b) Facilitate public-private partnerships to collaborate on low-carbon retrofit approaches that can be replicated across existing buildings;
    c) Hold annual meetings in Toronto to bring together stakeholders and ensure everyone has the same level of knowledge and awareness of legal regulations as well as existing opportunities, and;
    d) Work to overcome distrust among key stakeholders and establish Toronto as a hub for successful retrofits that creates jobs and local economic development while reducing greenhouse gas emissions.
    e) The Advisory Group would include the following key stakeholders:
        i) Buildings Associations;
        ii) Government;
        iii) Academia, and;
        iv) Cleantech Companies.

2) **Create a partnerships framework to connect green building materials and services sectors with corporate clients and building owners.**

[76] While some of these recommendations attempt to integrate design principles and behavioural thinking, further work must be done to enhance the capacity of these solutions to result in significant behaviour change. For more on behavioural design, see "Behavioral Design: User Guide."

a) Connect large corporations and building owners with small businesses within the green building sector:
    i) this includes green insulation businesses, materials contractors, and building framing companies, as well as high tech and low tech startups with proven pilots;
b) MaRS, possessing a network of startups in the MaRS ecosystem and willing private and crown corporate clients, could facilitate network introductions and help partners work together to find and create building contracts for new green buildings and energy efficient retrofits;
c) The framework would give simple choices in building contractors and green suppliers. Large businesses can easily integrate sustainability into their ecosystem, with an added benefit of maintaining green social image.

3) Develop investments (private and public) to target and subsidize major retrofits programs in the city.

a) Rather than implementing a singular private retrofit project at a time, the City of Toronto and private financiers should pool and invest in building retrofit projects. MaRS (or any facilitating body) in cooperation with the Toronto government and private corporations could create an investment pooling framework for retrofitting commercial buildings.
b) Under this scheme, funding is pooled from the public and private sector to subsidize retrofits for buildings with high energy, water, or waste footprints and high potential for footprint reductions. Once chosen, performance-based contracts would be created, linked to how well retrofits meet energy, water, waste, material finishes, and insulation performance standards.
c) The buildings pay over time for retrofits and services though the energy savings to investors. Investors' returns come from cost savings. Investors also have the opportunity to add lower risk green investments to their domestic portfolio.
d) This is not a framework to create an energy service company, but pools investments from stakeholders towards major retrofit projects. The accumulated risk and returns are split between stakeholders. (See Appendix 4 for more details on energy service companies).

7.2. Enhancing Regulatory Frameworks and Financial Incentivization

4) Enhance enforcement of Toronto Green Building Standards to promote further performance-based increases to building sustainability and energy efficiency.

a) Provincially, the Building Code could be modernized to reflect enhanced minimum requirements of the Toronto Green Building Standards while encouraging further performance-based improvements. The provincial building

code could be adapted to allow for separate minimum material-based and performance-based requirements for City of Toronto buildings.

b) Following the model of the B.C. Step Code, municipalities – Toronto in particular – should provide increased incentives to builders and their clients, like additional floor plan space, for achieving voluntary tiers of the Standards.

c) Additionally, the City should enhance its monitoring and enforcement of penalties for not meeting minimum required levels of the Toronto Green Building Standards. These standards should be enforced to the same extent as the provincial Building Code in order to motivate the formation of new habits in buildings cleantech integration.

5) **Develop a financing program under the City of Toronto similar to the Home Energy Loan Program (HELP)[77] that could offer low-cost loans to property owners of commercial, multi-family, and industrial buildings.[78]**

a. Owners would pay little or no upfront costs and have low interest rates and repayment terms as long as the useful life of the project (usually up to 20 or 30 years). Annual payments would typically be less than annual savings.

b. Compared to regular loans, PACE loans would have lower interest rates and loan maturities which would allow for smaller payments.

c. Loans would be financed by private lenders, but repaid along with property tax payments making it a very convenient option. PACE debt would not accelerate and repayments would remain with the building upon transfer.

d. Eligibility would be based on the equity value of the subject building, making it easier to qualify for than other loans.

6) **Provide an intermediary service that could assist homeowners, commercial building owners, or cleantech companies in applying for financial incentives for which they are eligible, and minimizing bureaucratic barriers that are preventing higher uptake.[79] Incentives could include (additional details in Appendix 5):**

a) National Level

i) Canada Mortgage and Housing Corporation Green Home Initiative

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[77] This would be similar to the City of Toronto's HELP, but it focuses on incentivizing owners of commercial buildings instead of homeowners. See https://www.toronto.ca/services-payments/water-environment/environmental-grants-incentives/home-energy-loan-program-help/.

[78] This recommendation is modelled off of New York City's Property Assessed Clean Energy (PACE) Program. See https://www.urbangreencouncil.org/content/news/picking-pace-nyc-ll96-final-rules-expected-soon and https://www.nyceec.com/nyc-c-pace-administration/.

[79] This could be done using the model of the Nova Scotia Clearing House. See https://nssc.novascotia.ca/before-you-invest/question-week-%E2%80%93-what-clearing-house.

ii) Sagen Energy Efficient Housing Program
iii) RBC Energy Saver Loan
iv) Federal Government's Greener Homes Initiative
v) Federal Tax Incentive for Clean Energy Equipment

b) City of Toronto
i) Eco-Roof Incentive Program
ii) Energy Retrofit Loan
iii) Home Energy Loan Program

c) Utility Providers
i) Enbridge Home Efficiency Rebate
ii) Smart Thermostat Rebate
iii) Home Winterproofing Program

d) MaRS
i) Embark Funding

7.3. Increasing Awareness and Education

7) **Facilitate the provision of relevant information to all stakeholders involved in retrofitting and procurement processes to update them on existing resources available.[80] Methods of disseminating information could include:**
   a) Holding yearly expositions which would allow the cleantech industry to showcase new technologies and network with other stakeholders in the industry and the general public;
   b) Promoting existing websites such as EnergyHub.org and BetterHomesTO, which outline all the financial incentives homeowners and cleantech companies can apply for, allow homeowners to evaluate retrofit costs and savings, and provide relevant information on legal requirements for retrofits;
   c) Hosting workshops and consultations to involve citizens in the retrofit process and to increase public awareness of retrofits and the opportunities available to them, and;
   d) Informing citizens of the city's green initiatives through social media, emails, flyers, websites, and other forms of public communication. These would be designed in a way that prioritizes a usable interface for consumers, rather than the content itself.

8) **Provide a training and certification program for construction and retrofit intermediaries in order to enable them to educate clients and adopt buildings clean technologies in their projects.**

[80] This could be done in a manner that follows the Vancouver Greenest City Action Plan's public engagement mode; see https://vancouver.ca/files/cov/Greenest-city-action-plan.pdf.

a) Intermediaries between cleantech firms and potential clients (including architects, designers, construction workers, and others) have significant influence over what sort of building materials and cleantech solutions are adopted, but lack awareness of different options and their feasibility. They also may distrust certain innovative cleantech solutions.
b) MaRS could hold a virtual workshop series on accelerating green buildings in Toronto with a target audience of construction workers and buildings intermediaries. This could be modelled on the format of the Virtual Workshop Series on Smart Grid Adoption.[81] The main objective of these workshops would be to exhibit examples as evidence of successful buildings cleantech projects.
c) A certification program would allow intermediaries to increase their own awareness of cleantech solutions following these workshops, demonstrate proof of knowledge of these solutions to clients, and further integrate innovations from MaRS' cleantech ventures in their buildings and building retrofits.
d) This program could also include regular seminars and workshops on recent trends in sustainable buildings, in order to update the knowledge of intermediaries and allow them to better present their clients with different options for integrating cleantech in their new buildings and retrofits.

9) **Broaden support for non-traditional buildings cleantech firms, including those working on nature-based solutions, passive houses, and Indigenous designs, through:**
    a) Integration of non-traditional cleantech firms into programs like Mission to MaRS;
    b) Increased subsidies and other financial incentives offered to non-traditional buildings cleantech firms and to consumers purchasing these solutions, for example through Recommendation 5;
    c) Enhanced awareness of non-traditional buildings cleantech solutions, including as part of expositions and workshops outlined in Recommendation 7, and;
    d) Development of public-private partnership projects using nature-based and other non-traditional buildings cleantech solutions at the municipal level.

10) **Modernize the "Energy & Water Reporting and Benchmarking (EWRB) – Large Buildings" data disclosure by making it visually engaging as well as easy to understand and to compare.**
    a) Data on water and energy intensity is disclosed annually on the Ontario Open Data Website. Figure 1 demonstrates a sample of this data. It is recommended that

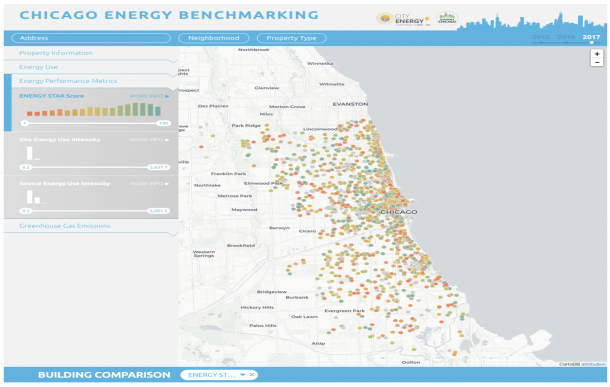
[81] MaRS, "Summary of the Virtual Workshop Series: Accelerating Smart Grid Adoption Across Canada," accessed April 10, 2021, https://www.marsdd.com/wp-content/uploads/2019/03/Summary-Virtual-Workshop-Series-Accelerating-Adoption-Across-Canada-MaRS-2020-1.pdf.

the City of Toronto uses a format similar to the Chicago energy benchmarking map (Figure 2).

Figure 1: Extract from EWRB dataset

WN_Site_EUI1	WN_Site_EUI2	WN_Source_EUI1	WN_Source_EUI2	GHG_Emiss_Int1	GHG_Emiss_Int2
0.96	24.76	1.22	31.51	36.60	3.40
Not Available	Not Available	Not Available	Not Available	26.91	2.50
Not Available	Not Available	Not Available	Not Available	34.44	3.20
Not Available	Not Available	Not Available	Not Available	Not Available	Not Available
0.99	25.53	1.31	33.70	35.52	3.30
1.26	32.62	1.54	39.74	51.67	4.80
0.73	18.84	0.89	23.01	30.14	2.80
1.31	33.88	2.01	51.79	34.44	3.20
0.78	20.19	0.98	25.38	32.29	3.00
0.66	16.97	0.88	22.83	22.60	2.10
1.14	29.54	1.51	39.01	43.06	4.00
0.98	25.18	1.49	38.51	29.06	2.70
0.30	7.71	0.54	13.83	4.31	0.40
0.82	21.25	1.15	29.57	29.06	2.70
Not Available	Not Available	Not Available	Not Available	73.19	6.80
0.66	16.97	0.87	22.39	24.76	2.30
1.36	34.99	1.80	46.34	49.51	4.60
1.04	26.93	1.76	45.54	19.38	1.80
2.71	69.93	3.82	98.53	86.11	8.00
1.83	47.19	2.94	75.94	47.36	4.40
2.65	68.43	3.82	98.62	87.19	8.10
1.47	37.98	2.01	51.93	49.51	4.60
0.43	11.11	0.68	17.50	10.76	1.00
2.16	55.63	3.42	88.16	49.51	4.60

Figure 2: Chicago Energy Benchmarking



b) This map-based visualization is being used by cities such as Chicago, New York, Philadelphia, Boston and many others. Toronto should follow their example and allow building owners/managers to:
   i) Better identify best practices and energy saving opportunities, and;
   ii) Simplify the comparison of buildings' performances.
c) This could be part of an overarching website design project where the city could integrate an evaluation of the other recommendations. Some examples include:
   i) Green incentives application growth;
   ii) Green cluster consolidation, and;
   iii) Pilot projects and expos mapping.

8. Limitations and Next Steps

This report was completed over the course of three months and while we hope it offers useful recommendations and advice for MaRS, governments, and industry stakeholders, this is by no means the final word on the subject. Our global scan consisted only of four cities, all of which made clear that there are many different mechanisms for breaking down barriers to cleantech adoption in buildings. A larger scan might reveal more barriers and opportunities that we were not able to consider. Data also still remains incomplete, given that many governments have only recently started implementing regulations related to improving energy efficiency in buildings. This includes the City of Toronto itself, which for example only updated the Toronto Green Building Standards in 2018. As a result, it is difficult to measure what the effect of regulations has been on curbing carbon emissions in buildings, and whether more stringent regulations will be needed to achieve the goals each of the cities have set out. With regard to retrofits, they have not been widely implemented on a large scale, and while the barriers to

cleantech adoption are well-known, there may be more barriers and opportunities that will become apparent as cities try to scale-up retrofits. We also recognize that there are significant political limitations for the City of Toronto, particularly given that many regulations are controlled at the provincial level, which has not made sustainable buildings a priority. These constraints are not present in many of the cities we looked at.

Looking forward to next steps, it is clear that further research on the effect of current regulations recently implemented to scale-up retrofits is needed. It will be necessary to keep informed about emerging barriers and opportunities as more cities seek to implement widespread retrofits. In the immediate future, MaRS can take the lead on implementing some of these recommendations, such as developing workshops and expositions, facilitating meetings with the buildings cleantech sector, and indicating support for non-traditional buildings cleantech firms. In the longer term, MaRS could act as an important intermediary between the cleantech sector and the City of Toronto to facilitate the other recommendations for the scale-up of retrofits.

It is clear that the issue of how to enhance rapid adoption of municipal buildings cleantech is becoming of increasing importance, especially as the City works towards implementing and achieving the TransformTO targets. Indeed, many of the conclusions reflect MaRS' previous work on the topic, including as part of a 2017 report on cleantech innovation.[82] As an emerging player in support of cleantech firms through the Mission to MaRS initiative, there is significant potential for MaRS to further advocate for some of these recommendations, in collaboration with other industry stakeholders.

[82] Joe Greenwood and Farooq Qaiser, "Innovation in Cleantech: How Canada can become a global leader."

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Appendix 1: Detailed Analysis of Interview Results

Interviews were conducted with Rob McMonagle, Economic Development, City of Toronto; Paul Dowsett, Principal Architect, Sustainable; Alastair Moore, Greenworks Building Supply; and John Paul Morgan, President and Chief Technology Officer, Morgan Solar.

Although the interviewees discussed different approaches to buildings cleantech – from passive houses to rooftop solar solutions – a common theme was the need for greater collaboration between different levels of government, the private sector, and the nonprofit sector. As one interviewee put it: "The solutions are not purely technological, behavioural, or policy – they are all of the above." Consequently, the actors involved in each of these elements of cleantech adoption need to be implicated in adopting it. Moreover, as one interviewee described, many cleantech innovations that could improve the energy efficiency of buildings already exist. The issue is that these solutions often face financing or regulatory barriers, and struggle to scale. Thus, there is an important need for more collaboration between different actors in order to implement these solutions at scale.

While this need for greater collaboration was evident, interviews uncovered differences in the perceived capacity of municipal governments to support adoption of cleantech, particularly in Toronto. On the one hand, municipalities can be key actors in encouraging experimentation and financing cleantech pilot projects. One interviewee described how the Vancouver Olympics represented an example of how municipalities can be good at "providing a testbed for some of these ideas." On the other hand, there appear to be many bureaucratic hurdles for the adoption of buildings cleantech by municipalities themselves, not least of which is conflicting priorities between federal, provincial, and municipal levels of government. In some ways, the interviews illustrated the gap between private sector perceptions of what municipalities are capable of doing and actual bureaucratic hurdles for civil servants to accomplish this.

A clear example of how this bureaucracy can limit the adoption of buildings cleantech is in municipal procurement. All interviewees highlighted the complexities of government procurement within the Toronto context. Procurement may be capable of supporting small pilot projects, like in Vancouver, but it has a small impact and is heavily regulated. For instance, there are strong requirements for transparency and cost effectiveness in Toronto that make it complex and less feasible for the City of Toronto to purchase more sustainable building solutions. As one interviewee described, the federal government is increasingly likely to make purchases from Canadian cleantech companies, but municipalities are not yet able to catch up.

Similarly, changes to the ways in which municipal building codes are implemented have the potential to enhance municipal adoption of buildings cleantech, but not before significant bureaucratic hurdles are overcome. Here, interviewees suggested looking at other sectors and

jurisdictions as models. For example, progress in transportation cleantech has been a result of aggressive government regulation on vehicles. Similar regulations for buildings could enhance the capacity of cleantech companies to offer their products and services at the municipal level. Once again, Vancouver is an example of a jurisdiction that has done this well. Having untied their building code from that of the province, which eventually inspired the modernized British Columbia Step Code, they have been able to lead the way in this kind of regulation for more energy efficient buildings. While there are existing standards like LEED for Ontario buildings cleantech companies, more needs to be done from a regulatory standpoint to encourage the adoption of their products.

Unfortunately, there remain several other practical barriers to municipal adoption of buildings cleantech in Toronto. Some of the barriers raised during interviews include government inertia and unwillingness to underwrite risk; issues around cleantech subsidies and lending from banks; and even the way cleantech companies are classified by the NAICS system. Moreover, as several interviewees highlighted, COVID-19 has been devastating for many cleantech companies, as well as for the City of Toronto's budget and capacity. At the same time, it may have increased awareness of the need for prioritizing health and environmental concerns in buildings, though there needs to be more done to raise awareness of potential cleantech solutions to these concerns.

That being said, a key barrier remains the lack of awareness about the feasibility of cleantech solutions. Part of this is the perception of cleantech costs being an important barrier for many consumers, if not the price itself. Meanwhile, there is a lack of knowledge from some government bodies on the capacity of green building sector innovations to be effective. For instance, many regulators are unaware of the fact that low-tech cleantech can work well. Additionally, there remains skepticism from industry itself, including for example construction workers. In order to overcome some of these barriers, more may need to be done to promote information sharing between actors.

Still, there remain opportunities for cleantech in Toronto. One of these is in retrofits, which are incredibly important given the lifespan of buildings. Incentives from the government are also important. Finally, as several interviewees brought up, initiatives like locally-driven cleantech clusters could provide roadmaps for developing green industry so suppliers, builders, and other industry groups operate symbiotically. While industry associations typically operate on a national scale, more locally-driven cluster management organizations could support better linkages between clean-tech companies and policymakers in Toronto.

Appendix 2: Comparison of Toronto and Vancouver Building Standards

Disclaimer: This is a brief overview of existing information available on the Vancouver Building Code and the Toronto Green Building Standards. The scope of this table is limited due to time constraints, as well as the main project focus on enhancing adoption of buildings cleantech (and not on meeting municipal green buildings objectives). For more information on how to increase efficacy of the Toronto Green Building Standards, additional research is needed, including through potential interviews with City of Toronto and City of Vancouver officials.

City	**Vancouver**	**Toronto**
Current Framework	2019 Municipal Building By-Law (closely aligned with British Columbia Energy Step Code)	Ontario Building Code and Toronto Green Standard Version 3
Jurisdiction	Vancouver is able to design its building code independently from the province (as permitted under the Vancouver Charter)	Toronto buildings must follow the Ontario Building Code's requirements, though the City has developed additional municipal Standards
Tiers	Similar to that of B.C. Energy Step Code, which has 3-5 levels depending on type of building with performance-based requirements[83]	"Tier 1 of the Toronto Green Standard is required through the planning approval process. Tiers 2 to 4 are higher level voluntary standards associated with financial incentives and verified post construction"[84]
Incentivization	Various incentives, including possibility to increase floor space and support for those working on buildings cleantech[85]	Development Charge Refund program which offers incentives and refunds to projects that demonstrate higher levels of sustainable design beyond Tier 1[86]

[83] Andrew Pape-Salmon and Toby Lau, "Net-Zero Ready Building Codes," University of Victoria, October 16, 2020, https://www.uvic.ca/engineering/civil/assets/docs/profiles/andrewps/net-zero-ready-building-codes.pdf.
[84] City of Toronto, "Toronto Green Standard: Overview," City of Toronto, August 28, 2018, https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/toronto-green-standard-overview/.
[85] City of Vancouver, "Zero Emissions Building Tools," Green Vancouver, accessed April 11, 2021, https://vancouver.ca/green-vancouver/zero-emissions-buildings-tools.aspx; see also other incentives: https://betterhomesbc.ca/all-incentives/page/4/
[86] "The City of Toronto Zero Emissions Buildings Framework," City of Toronto, March 2017, https://www.toronto.ca/wp-content/uploads/2017/11/9875-Zero-Emissions-Buildings-Framework-Report.pdf.

Enforcement	Performance-based requirements for both new buildings and retrofits to existing buildings for them to be approved by the City[87]	Tier 1 of the Toronto Green Standard is required through the planning approval process; voluntary standards verified through a third party review post construction[88]
Updates / Evaluation	Most recent version of the Building Code updated in 2019; provincial Energy Step Code Council meets quarterly to monitor how local governments are implementing the standard[89]	Updated Version 3 of the Standards includes four tiers that reflect the need to update building performance targets every four years to reach the zero emissions target[90]
Strengths	5-step Code will enable all buildings to be net-zero energy ready by 2032	Performance-based standards have the potential to allow for flexibility, by providing firms with market incentives and institutional frameworks to innovate[91]
Remaining Opportunities / Barriers	British Columbia has formulated a "Lessons Learned" document, noting the importance of elements like "Simple, Clear, and Accessible Materials" and encouraging collective ownership[92]	Lack of uptake: only about 30 certified Tier 2 projects according to City of Toronto website;[93] according to interviews, enforcement (especially of the Voluntary standards) is the next major challenge

[87] City of Vancouver, "Zero Emissions Buildings," City of Vancouver, accessed April 11, 2021, https://vancouver.ca/green-vancouver/zero-emissions-buildings.aspx.
[88] City of Toronto, "Toronto Green Standard: Overview," City of Toronto, August 28, 2018, https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/toronto-green-standard-overview/.
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[90] "Sustainable Design: Understanding the Toronto Green Standard: UrbanToronto," Urban Toronto, accessed April 11, 2021, https://urbantoronto.ca/news/2018/06/sustainable-design-understanding-toronto-green-standard.
[91] David M. Gann, Yusi Wang, and Richard Hawkins, "Do Regulations Encourage Innovation? - the Case of Energy Efficiency in Housing," *Building Research & Information* 26, no. 5 (1998): pp. 280-296, https://doi.org/10.1080/096132198369760.
[92] Government of British Columbia, "Lessons from the BC Energy Step Code."
[93] City of Toronto, "Tier 2, 3 and 4 Project Profiles," City of Toronto, February 18, 2021, https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/tier-2-project-profiles/.

Appendix 3: Stakeholder Mapping

Buildings Cleantech Actors in Toronto	High Influence	Low Influence
High Interest	- City of Toronto - Buildings Cleantech Companies - Industry Associations (Canada Green Building Council)	- Government of Canada - MaRS Discovery District
Low Interest	- Province of Ontario - Architects / Designers / Engineers - Other Construction Intermediaries - Consumers	- Indigenous Governments - Universities / Academia - Utilities Providers

Appendix 4: Energy Service Companies

The objective of this appendix is to give context to the use of ESCOs, referenced in recommendation 3. One way municipalities are attempting to curb energy use in their jurisdictions is through the employment of energy service companies (ESCOs). "ESCOS are sector instruments that offer energy or emission-improvement."[94] They guarantee energy improvements to their clients by financing or assist in financing energy saving schemes. ESCOs are remunerated through energy savings costs. They are intrinsically incentivized to apply their expertise to ensure that the conversion process from fuel to energy service is achieved as efficiently as possible.[95] ESCOs are not always privately owned. They can be owned by a government body, partnership between a government body and private firm or community owned and run. Different ESCO frameworks have different risks and rewards for stakeholders involved. What impedes ESCOs are political will, community uptake, and financial risk. The risk associated with creating as ESCOs comes from operating and maintaining the scheme. If not adequately calculated, returns may not be high enough or within an adequate time frame for stakeholders to engage with. However, ESCOs can give incentives for buildings to consider investing in energy savings if paired with risk mitigation strategies.

[94] Nesrin Okay and Ugur Akman, "Analysis of ESCO Activities Using Country Indicators," *Renewable and Sustainable Energy Reviews* 14, no. 9 (2010): pp. 2760-2771, https://doi.org/10.1016/j.rser.2010.07.013.
[95] Matthew J. Hannon and Ronan Bolton, "UK Local Authority Engagement with the Energy Service Company (ESCo) Model: Key Characteristics, Benefits, Limitations and Considerations," *Energy Policy* 78 (2015): pp. 198-212, https://doi.org/10.1016/j.enpol.2014.11.016.

Appendix 5: Financial Incentives

This table outlines the financial incentives that are available to homeowners, commercial building owners, and cleantech companies in Ontario.

Financial Incentive	**Offered By**	**Description of Incentive**
Green Home Initiative	Canada Mortgage and Housing Corporation	Partial refund of up to 25% of mortgage insurance premium for borrowers purchasing an energy efficient home or making energy-saving renovations
Energy Efficiency Housing Program	Sagen	Partial refund of up to 25% of mortgage insurance premium for borrowers purchasing an energy efficient home or making energy-saving renovations
Energy Saver Loan	RBC	Borrowers receive 1% off the loan interest rate or a $100 rebate on a home energy audit on a fixed rate instalment loan over $5,000
Greener Homes Initiative	Federal Government	Provides grants of up to $5,000 to help homeowners make energy-efficient retrofits
Federal Tax Incentive for Clean Energy Equipment	Federal Government	Businesses can fully expense clean energy generation and energy efficiency equipment in the first year, with a capital cost allowance rate of 100%
Eco-Roof Incentive Program	City of Toronto	Green Roof: Provides $100/m2 for green roof installed and up to $1,000 for a structural assessment Cool Roof: Provides $5/m2 for cool roof with a new membrane, or $2/m2 for cool

		roof coating over an existing roof
Energy Retrofit Loan	City of Toronto	Low-interest loans for up to 100% of energy efficiency project costs, at a rate equal to the City's cost of borrowing, with repayment terms up to 20 years
Home Energy Loan Program	City of Toronto	Low-interest loans for up to $75,000 to cover the cost of home energy improvements, with repayment terms up to 20 years
Home Efficiency Rebate	Enbridge	Provides up to $5,000 in rebates for insulation, air sealing, windows, doors, water heaters, boilers, furnaces and home energy assessments
Smart Thermostat Rebate	Enbridge	Offers a discount for $75 for purchase of a smart thermostat
Home Winterproofing Program	Enbridge	Provides low-income households with free services to winterproof their houses, including insulation, draft proofing, and a smart thermostat
Embark Funding	MaRS Discovery District	Provides up to $20,000 to help place a young professional in an Ontario-based technology venture to accomplish specific goals. Recipients are required to contribute $2,500 in cash over the program's six month period