Pathway Study on New Residential Buildings in Ottawa

Presented to:
The City of Ottawa
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In relation to:
The City of Ottawa's Energy Evolution Strategy (Phase 2)

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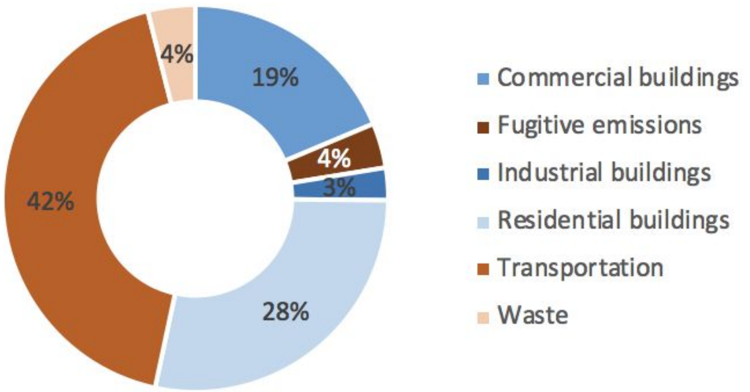
Contents

Executive Summary

This pathway profiles new residential buildings in the City of Ottawa and details relevant strategies to reduce their energy use and emissions in order to meet the goals and objectives of the City's Energy Evolution Strategy. As Ottawa grows, there will be a continued demand for new homes and buildings. New growth can take the form of new single detached housing that may be built outside of the greenbelt area, or intensification of existing areas within the greenbelt with increased rowhouses or low-rise buildings. Whether it is greenfield or infill development, the analysis undertaken in this Pathway Study indicates/suggests that achieving the City's long-term GHG reduction target will require efforts to improve the energy performance of new small buildings built in Ottawa.

Put into context, buildings represent the largest source of community GHG emissions, generating approximately 2.4 million tonnes of CO2e emissions annually and accounting for roughly 50% of the city's total emissions in 2016 (see Figure 1). Without significant intervention, it is anticipated that emissions from the building stock will continue to grow in a linear fashion, with residential buildings leading emissions growth due to the large proportion of floor space that they occupy within the city.

Figure 1. Emissions by sector, Ottawa 2016.



Using detailed data on Ottawa's current (2016) built form and energy consumption patterns, this Pathway Study models future energy scenarios associated with new small buildings based on four general approaches or input parameters: energy efficiency improvements, uptake or adoption of net-zero requirements, variations in the anticipated mix of housing form, and variations in the size of future dwellings. The boundaries specifically discuss strategies for a low-carbon pathway that will include zoning practices for a diversity of housing types, decreasing house size, the implementation of green standards for new builds including passive house, and the use of low carbon and renewable energy.

The pathway boundaries inform modelling procedures in three scenarios: conservative, moderate, and aggressive. The conservative scenario parallels a Business-as-Planned outlook, the moderate reflects a slow pathway to net zero new construction, and the aggressive scenario expedites the introduction of net zero residential buildings.

Section 1: Present Assessment of Residential Buildings

Pathway Description

In 2016, buildings accounted for 50 percent of Ottawa's total community-wide greenhouse gas (GHG) emissions.[1] Space and water heating are the largest end uses of energy, which are primarily provided through natural gas combustion in the Ottawa region—a significant source of greenhouse gas emissions. More rural areas may use propane or heating-oil for heating purposes. Electricity is also used in Ottawa buildings for heating and plug loads, but the GHG emissions intensity of electricity is low in Ontario. Electricity use for heating has historically been costly, but the Fair Hydro Plan (2017) is an action to lower the associated costs.

Most buildings are constructed following minimum efficiency requirements set out by the Ontario Building Code. While ongoing updates to the Ontario Building Code have improved building energy performance over the past decades, homes built to Code still contribute sustantially to Ottawa's emissions production.

This pathway explores technological, construction, and policy options available to improve the energy performance of new residential buildings in Ottawa. Buildings constructed today lock in future energy consumption and patterns of GHG emissions. The City estimates that there will be an additional 113,000 homes built between 2011 and 2031.[2] The initial construction of a building represents a critical moment in a building's life for maximizing energy performance. Every new home constructed to net zero emissions is one fewer building that will need a complex and disruptive future retrofit to achieve deep emissions reductions.

This pathway assesses the mainstreaming of net zero building principles into current design and construction practice for residential buildings, including passive design, inclusion of renewable energy generation on site, minimizing building size and encouraging more efficient residential building types.

Pathway Boundaries

The analysis and energy modelling undertaken for this Pathway Study categorizes strategies for achieving energy reductions and transitions in new small buildings into four broad boundaries or input parameters. These boundaries are:

1. Energy performance
2. Net zero homes
3. Dwelling mix
4. Dwelling size

These strategies are examined in relation to the current pathways for building development, including an overview of building energy systems, relevant policy, followed by potential tools for uptake such as incentives and awareness.

This paper will focus most heavily on new residential buildings. Low density single-detached neighbourhoods are very common in Ottawa and strategies to make them more energy efficient and to reduce their respective emissions are a key component to achieving the City's 2050 emissions reduction target. Larger non-residential buildings with institutional, commercial, or industrial uses are examined in the non-residential building pathway papers.

[1] City of Ottawa. (2014). Air Quality and Climate Change Action Summary. Appendix A GHG inventory Summary.
[2] City of Ottawa. Official Plan. Section 2: Strategic Directions.

Background Information

Building Type and Location

Different forms of low-rise residential buildings have different energy requirements (Table 1). The weighted average of household energy use in Ottawa was 104 GJ in 2016. Generally, detached housing has greater energy requirements than non-detached because it is exposed on all sides, and has higher surface area to volume ratios, which increases energy loss.[3] Detached homes also tend to be larger than non-detached, requiring more energy for space heating. Shared walls and stacked units reduce heat loss in a building.

Table 1. Average annual energy use per household in Ontario in 2015, by building type.[4]

Building Type	Description	Average annual energy use per household (GJ/yr)
Single Detached	Free-standing structure	122.6
Semi-detached	Two homes sharing a wall	102.2
Duplex	Two homes sharing a ceiling/floor	89.9
Row	>2 homes joined side-by-side	84.2
Low-rise multi-unit residential building (MURB)	Multiple homes arranged besides and above one another	53.7

Emissions from new residential buildings can be reduced by changing the building type mix. This includes encouraging higher residential density and mixed-use neighbourhoods to accommodate the growing population. The acceptance of home downsizing is generally becoming more common, but social barriers to living in smaller dwellings still exist.[5]

In addition to greater housing density, encouraging heterogenous neighbourhoods can also reduce emissions associated with new residential buildings. Mixed-use neighbourhoods combine various land uses to form 'complete' communities. These neighbourhoods are generally dense in population per hectare and support a range of services and amenities. Increased accessibility to services can make dense neighbourhoods more attractive, which can motivate a switch away from less dense, energy-intensive suburban lifestyles. In addition to reducing energy demand, mixed-use neighbourhoods also reduce vehicle kilometres traveled, as services can be accessed by active transportation. If a vehicle is required, the distances to services are short. Heterogeneous building mixes concentrate people closer to municipal service infrastructure as well, reducing the demand on, and costs of, services such as road maintenance and utility infrastructure.[6]

Achieving Low Carbon Homes Through Building Design Certification Standards

Current best practices in new building emissions reduction focus on net-zero energy and energy/carbon positive design. Net-zero energy homes produce as much energy as they use, including energy used for space heating, hot water, ventilation, air conditioning, appliances, lighting, and all other household electrical consumption. The emergence of electric vehicles and their charging requirements may require an increase in on-site energy produced to meet the net-zero threshold. Energy and carbon positive homes produce more energy than they consume and reduce

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[3] City of Vancouver. 2016. Zero Emissions Building Plan.
[4] Statistics Canada. Statistics Canada. Table 25-10-0061-01 Household energy consumption, by type of dwelling, Canada and provinces. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2510006101
[5] Huebner, G., Shipworth, D. (2017). All about size? – The potential of downsizing in reducing energy demand. Applied Energy, 186, 226-233.
[6] Murphy, R., Boyd, K., Jaccard, M. (2016). Evaluation of actions and policies to reduce urban GHG emissions using multiple criteria: a contribution towards energy efficiency in British Columbia's Built Environment. Simon Fraser University.

their GHG emissions beyond zero, typically by exporting renewable energy produced on site. In its most recent climate action plan, the Ontario Government identified net zero energy homes as a target for the 2030 building code. The federal government has committed to a "net-zero energy ready" model building code for 2030 through the Pan Canadian Framework.[7]

The most effective approach to achieving net zero is to maximize energy efficiency in order to limit energy demand. Passive solar building design is considered a best practice in this respect, as passive thermal gain can provide most or all of a home's heating needs, as well as much of the lighting required during the day. Heating requirements are minimized through the sun-orientation of the building, as well as glazing choice, shading design, enhanced airtightness, reduced thermal bridging, extensive use of thermal insulation, well designed ventilation design with heat recovery, and high R-value windows and doors.[8] Passive solar design can achieve heating and cooling energy reductions of up to 90%, with an average of 50% total energy savings.[9] Passive House is one example of a green building standard that is performance-based certification (meaning that certification reflects actual post construction performance that meet a set standard) and exemplifies this design approach.

Table 2. Passive House Canada Standards.[10]

Criteria	Yearly performance standard
Heating	Space heating demand maximum of 15 kWh/m2 OR Heating Load Max of 10 W/m2 (also applies to space cooling)
Airtightness	50 Pa max results in 0.6 ACH
Energy Demand	Total primary energy demand maximum of 120 kWh/m2

The Passive House standard has typically been applied to detached residences, as their size and simple shape, as well as the relative ease of sourcing high efficiency building components for them, enables ease of energy modelling and building design. In recent years, Passive House certification has also been applied to low-rise multi-unit residential buildings, office buildings, and high-rises.

Building to a Passive House standard currently costs more than conventional building due to the added cost of high performance building components and soft costs incurred from greater design efforts. Passive House Canada estimates that the incremental cost of building to Passive Standard is approximately 10% over building a conventional structure, with an annual reduction in heating and cooling energy consumption of 80-90%.[11] Gaining Passive House certification costs $3,000-$5,000, in addition to the 10% building costs.[12]In one Ottawa example, a Passive House single detached home was built for $337,130, with annual energy savings of 30,685 kwh/yr. over a similar-sized home built to the Ontario Building Code.[13] Another Ottawa example estimates a payback period of 15-30 years, with annual savings of $1,000, with an upfront additional cost of $15,000-$30,000.[14] Payback periods of building to Passive House is dependent on a variety of factors over the building's life, including building components used and energy costs over time, and are therefore case specific.

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[7] Natural Resources Canada (2017). Build Smart: Canada's Building Strategy. Retrieved from: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/emmc/pdf/Building_Smart_en.pdf
[8] Passive House Institute. Passive House Requirements. Retrieved from: https://passiv.de/en/02_informations/02_passive-house-requirements/02_passive-house-requirements.htm
[9] Passive House. A Developer's Guide to Passive House Buildings. Retrieved from: http://www.passivehousecanada.com/downloads/PHC-developers-guide.pdf
[10] Passive House Canada. Building Certification. Retrieved from: http://www.passivehousecanada.com/passive-house-building-certification
[11] Passive House Canada. Frequently Asked Questions.
[12] Passive House Canada. Building Certification. Retrieved from: http://www.passivehousecanada.com/passive-house-building-certification
[13] https://ekobuilt.com/ekobuilts-services/ottawa-passive-house/cost-analysis-for-building-an-eko-passive-house
[14] Local Impact Design. The Business Case for Passive House. Retrieved from: http://localimpactdesign.ca/wp-content/uploads/2016/04/The-Business-Case-for-Passive-House.pdf?189db0

The incremental cost of a net zero home can vary considerably. A recent study from the Rocky Mountain Institute (RMI) found incremental costs ranging from US$2,000 to US$6,000, in part because of additional efforts to drive down energy consumption in order to reduce the requirements for solar PV systems.[15] While not required for Passive House certification, inclusion of on-site renewable energy generation helps buildings achieve net-zero energy and emission levels. Roof-top solar PV or solar thermal systems combined with air or ground source heat pumps are common strategies to achieve net-zero standards.

Near-zero buildings are becoming more feasible as more buildings are built to Passive House certifications; greater local building expertise is developed; common issues are resolved, and components become more widely available. In the Ottawa region, Passive House certified buildings are becoming more common, with seven currently certified.[16] In order to successfully achieve significant GHG emissions reductions, the portion of new builds that are built to Passive House, or similar standards, needs to be scaled up.

Other voluntary standards and efficiency labelling programs also encourage awareness of efficient building design. In addition to Passive House Certification other standards and labelling schemes include:

- *EnerGuide:* This is the Government of Canada's official labelling program to display energy efficiency of appliances, vehicles and homes. Previously, EnerGuide rating used a rating scale of 0-100, where 100 is full energy efficiency, and 0 is complete energy loss. EnerGuide is now transitioning to demonstrate total energy use in GJ/year. Energuide labels are displayed on consumer products to show average energy use and associated energy costs, compared to the relative efficiency of other products in its class. If a property owner is purchasing new appliances as a part of a retrofit, EnerGuide can encourage energy efficient purchasing decisions.

- *Energy Star*: Developed by the US EPA, Energy Star is a marking system that labels energy efficient appliances, homes and vehicles. Energy Star Canada works in concert with EnerGuide.

- *R-2000:* Natural Resources Canada's internally developed standard for highly efficient home building, encouraging efficiency best practices in construction. Buildings must be built by R-2000 certified contractors to achieve this certification.

- *LEED:* Leadership in Energy and Environmental Design (LEED) is a rating system to describe positive environmental attributes. LEED is a pioneering program which continues to help transition the design and construction industry to advance low carbon, energy efficient buildings. LEED uses a point system, where various building attributes such as energy systems, efficiency features, building location, and efficient water devices are allocated points.

- Canada Green Building Council (CaGBC) Zero Carbon Building Program: Launched in 2017, the CaGBC developed a system to make carbon emissions as the driver for better building performance. This practice will advance the goals of the LEED program which will target energy reductions and not necessarily carbon emissions. The key components of this system include offsetting GHG emissions by building operations, increasing efficiency and driving down thermal energy demand, the use of on-site renewable energy, and building materials that are low-carbon.[17]

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[15] Peterson, A., Gartman, M., & Corvidae, J. (2018). The economics of zero energy homes. Rocky Mountain Institute.
[16] Passive House Canada. Project Maps. Retrieved from:
http://www.passivehousecanada.com/projects/?keyword=Ottawa&province=Province&building_type=Building+Type&search=Search
[17] "Zero Carbon Building Standard." 2017. Canada: Canada Green Building Council.
https://www.cagbc.org/cagbcdocs/zerocarbon/CaGBC_Zero_Carbon_Building_Standard_EN.pdf

District energy connection

Phase 1 of the Energy Transition Strategy featured a pathway on District Energy and its use can have energy and emissions impacts on new residential buildings. If there is sufficient housing density, implementing a district energy connection can present and opportunity to provide new residential buildings access to low carbon heat sources. For example, Drake Landing Solar Community in Alberta represents a best-practice model for solar thermal storage district energy systems in new developments. This system connects 52 single detached homes to an underground solar thermal energy storage battery, storing most of the thermal energy during the summer for use in winter months. The system provides 90% of the total thermal energy used in the subdivision.[18]

While connection to a district energy system for new houses represents one option for low carbon thermal systems, other low carbon, energy efficient housing approaches may be superior, such as passive design and distributed energy resources. Vancouver now requires new buildings to design and implement low-carbon energy systems, which do not necessarily use district energy systems, providing greater flexibility to developers. The experience of the City of Vancouver has been that district energy systems are only as useful as buildings are energy inefficient.

The use of District Energy may apply in contexts where Ottawa is considering new mixed-use districts or subdivisions with a variety of housing density meeting the needs for a variety of stakeholders and residents.

'District-Energy Ready' guidelines in new subdivisions ensure that a building can easily connect to a district energy system in the future, should such connections become available. District energy ready features include:[19]

- The ability to supply thermal energy from the ground level, including adequate space for an energy transfer station;
- Easement between the mechanical room and the property line for thermal piping;
- Two-way pipes placed in the building to carry the thermal energy from the district energy network to the potential location of the energy transfer station;
- A low temperature hydronic heating system that is compatible with a district energy system; and
- Thermal energy metering capabilities.

[18] Drake Landing Solar Community. About DLSC. Retrieved from: https://www.dlsc.ca/about.htm
[19] City of Toronto. (2016). Guidelines for District Energy Ready Buildings.

Current Pathway Assessment

The make-up of residential buildings in Ottawa is dominated by detached single housing, which represents the largest portion of floor area in new development applications to the City. In 2017, single detached units represented 51% of all area of new development applications.[20] However, the total number of detached units constructed in Ottawa has declined since 2001. There were 3,497 single detached units completed in 2001, whereas single detached completions were 1,745 units in 2017.[21] The portion of single units in relation to another low rise residential is displayed in Figure 2 and Figure 3.

Figure 2. Residential completions by building type in Ottawa from 2001-2017.[22]

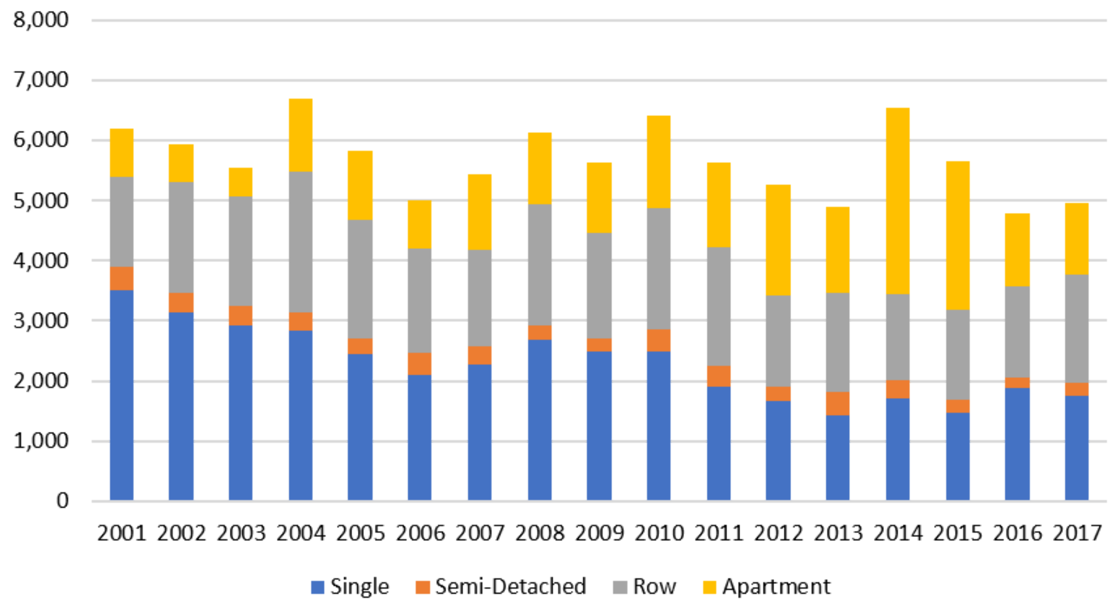
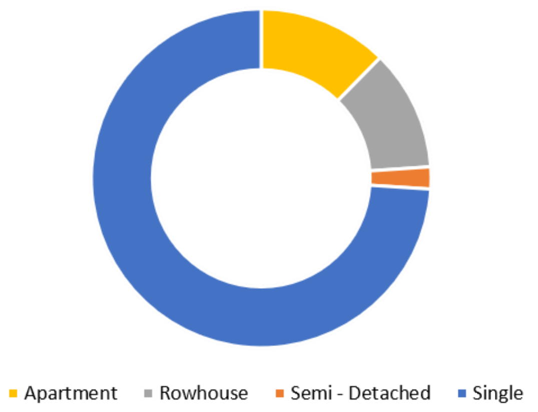


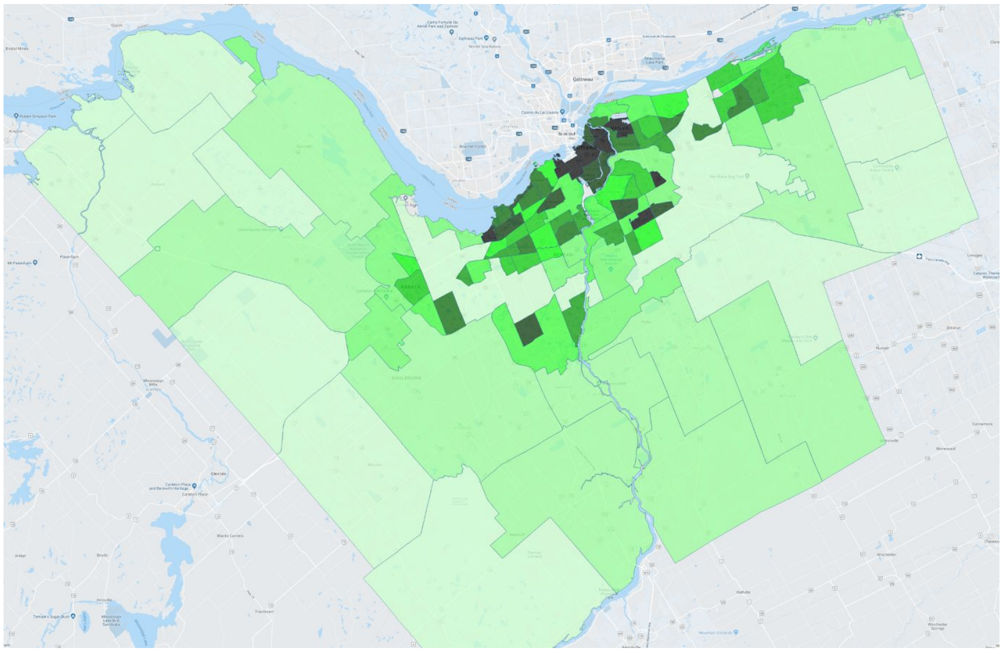
Figure 3. Floor area (m2) of approved residential permits in Ottawa in 2017.[23]



[20] City of Ottawa. (2018). Issues Permit Statistics for the Period of 2017-Jan-01 to 2017-Dec-31.
[21] CMHC. 2018. Housing Starts and Completion Survey. Retrieved from: https://www03.cmhc-schl.gc.ca/hmip-pimh/en#Profile/3506008/4/Ottawa%20(CV)%20(Ontario)
[22] Ibid.
[23] City of Ottawa. (2018). Issues Permit Statistics for the Period of 2017-Jan-01 to 2017-Dec-31.

Large rural areas and predominantly single-family housing residential neighbourhoods make Ottawa's population density low compared to other Canadian cities.[24] There is higher population density in Ottawa's downtown neighbourhoods; both Lowertown and Centretown have a population density above 7000 persons/km2.[25] Residential density in Ottawa is depicted in Figure 4.

Figure 4. Population density by neighbourhood (persons/km2). Darker green represents higher density.[26]



Ottawa's population is expected to grow over the coming decades. Population and housing change estimates from the Official Plan are included in Table 3.

Table 3. Population and housing estimates.[27]

Area	Totals by 2021		Totals by 2031	
	population	homes	population	homes
Inside Greenbelt	562,000	258,000	591,000	278,000
Outside Greenbelt, urban	367,000	140,000	432,000	168,000
Rural	102,000	38,000	113,000	43,000
Total	1,031,000	436,000	1,136,000	489,000

[24] Statistics Canada. Population and Dwelling Counts, Highlight Tables, 2016 Census.
[25] Ottawa Neighbourhood Study. Retrieved from: https://www.neighbourhoodstudy.ca/maps-2
[26] Ibid.
[27] City of Ottawa. Official Plan. Section 2: Strategic Directions.

The location of new dwellings is important because greenfield or suburban development is associated with greater energy consumption due to the buildings form and size as well as increased vehicular transportation (see Transportation Pathway). Intensification, in contrast is associated with smaller dwellings that have lower energy consumption because of shared walls. Residential intensification and mixed-use neighbourhood development in urban areas are objectives in the Official Plan. The City is planning to accommodate approximately 90% of new population growth within its urban boundaries, with a focus on mixed-use and transit-oriented sites.[28]

Based on the Official Plan, most growth from 2021-2031 will be in the areas outside the Greenbelt, which are further away from the city centre. Furthermore, greenfield development still occurs in Ottawa, where new development - predominantly single detached housing - occurs in previously undeveloped areas. While this largely occurs in rural areas and neighbourhoods peripheral to the city, it further contributes to urban sprawl, and establishes long term development of neighbourhoods that feature detached and less-dense housing forms.

The primary mechanism for urban intensification available to the City is zoning by-laws. The City can allow rezoning to encourage or require denser building types, and meet goals to ensure that commercial and institutional land uses are also nearby. Establishing land for duplexes, townhomes and multi-unit residential buildings, and reducing zoning for single detached housing can encourage higher population density in residential neighbourhoods. One strategy, which may or may not be applicable to Ottawa, is the application of a differentiated development levy to incentivize intensification over greenfield projects.[29]

Municipal Influence on Building Design

The Ontario Building Code (OBC) governs technical and administrative requirements for building development and construction in the province. The Code includes requirements to encourage fire prevention, hazard reduction and energy efficiency in buildings. OBC is updated every five to seven years, with each cycle bringing improvements in building design and efficiency. The next Code update is slated for 2019. OBC incorporates national model codes, such as the Model National Energy Code for Buildings, and considers input through a consultation process.

OBC has both prescriptive and performance compliance pathways. Prescriptive compliance includes specific design criteria to guide builders, such as minimum requirements for insulation and passage of heat (RSI-values). In contrast, performance-based compliance relies on actual building performance. In the OBC, this currently relates to a reference building against which the buildings' modelled energy use is compared. Although not yet a part of the OBC, absolute energy targets are considered to be more effective in evaluating energy use and greenhouse gas emissions because it provides a value for total energy use intensity. Natural Resources Canada's EnerGuide program is moving away from its relative energy rating scale towards a total energy use value (GJ/year). Because of this shift, the Building Code is no longer associated with an EnerGuide rating.

As of 2017, two supplementary energy efficiency standards came into effect in the Ontario Building Code. SB-10 includes efficiency requirements for Part 9 commercial and Part 3 buildings. SB-12 is a supplementary standard for houses that includes both prescriptive and performance-based compliance paths. Prescriptive requirements include using drain water heat recovery and heat recovery ventilators, as well as various requirements for windows, insulation and other components to have a minimum RSI-value. Compliance through performance requires builders to meet various performance metrics for airtightness, wall-window ratios and others.[30] SB-12 also allows an alternative compliance through achieving Energy Star or R-2000 certification.

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[28] Ibid.
[29] Stikeman Elliott (2016). City of Calgary passes new off-site levies bylaw. Retrieved from: https://www.stikeman.com/en-ca/kh/real-estate-municipal/city-of-calgary-passes-new-off-site-levies-bylaw
[30] Ministry of Municipal Affairs. (2016). MMA Supplementary Standard SB-12 Energy Efficiency for Housing. Retrieved from: http://www.mah.gov.on.ca/AssetFactory.aspx?did=15947

The province recently completed consultations for the next phase of energy efficiency improvements, for implementation in the 2019 OBC, with some measures to be implemented in 2022. Possible requirements in the Building Code include mandatory airtightness testing before occupancy and improved envelope performance, ultimately resulting in 60% improvements in energy efficiency over a home built in 2005.[31] Implementation of Phase 2 components is now under the decision of the new provincial government.

Although OBC is provincially designated, it is the responsibility of municipalities to enforce the Building Code. Municipalities can control the administration of the building code through municipal by-laws. Municipalities do not have the jurisdiction to enforce any building requirements other than the OBC. In practice, this means that the City of Ottawa cannot mandate better-than-code efficiency requirements for buildings.

Municipalities in Ontario can not Site Plan Control to influence features on the interior of a building, and as such, cannot influence heating system components and design. Single-unit dwellings are exempt from Site Plan Controls, which further limits the influence the City has on single detached units.[32]In Ottawa, the City has designated the entire area within territorial limits as within Site Plan Control Area, where the city can require developers to provide elements or facilities as a condition for approval, so long as such conditions are required in the City's Official Plan. Conditions put forward by the City can only relate to the exterior of the building, including parking, driveways, walkways, trees, fences, and other exterior features. This mechanism can be used to encourage sustainable design features, including orienting buildings for passive solar, measures to reduce urban heat island effects, permeable paving surfaces, and other features.[33]

There are also provisions within the Planning Act that allow municipalities to impose conditions on rezoning applications. However, because such conditional zoning is not currently referenced within Ottawa's Official Plan, this opportunity would require a change to the Official Plan.[34]

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[31] Ministry of Municipal Affairs. (2017). Potential changes to Ontario's Building Code: Summer and Fall 2017 Consultation. Retrieved from: http://www.mah.gov.on.ca/AssetFactory.aspx?did=19606
[32] Ibid.
[33] City of Ottawa. (2013). 2012 Green Buildings Promotion Program.
[34] Ibid.

GHG and Energy Intensity Targets

GHG and energy intensity targets can encourage emissions reductions in new residential buildings. Absolute performance targets can better describe how buildings contribute to local GHG emissions. GHG and energy intensity targets are related to building performance rather than prescriptive building requirements, which provide flexibility for builders and designers. Compliance with performance targets requires modelling building energy use, which can cause discrepancy between modelled and actual energy and GHG intensity of a given building.

GHG and energy use intensity targets can gradually 'step', to require greater reductions in overall GHG and energy use in the building stock. Vancouver and Toronto use GHG and energy targets that step up until the year 2030. Both cities use three metrics for GHG and energy use intensity limits, described in Table 4.

Table 4. Common performance-based yearly targets for buildings.

Metric (yearly)	Description
GHG Intensity (GHGI, kg CO2e/m2)	Total amount of energy supplied to the building by type, multiplied by the energy's carbon intensity, divided by the building area in m2.
Thermal Energy Demand (TEDI, kWh/m2)	The annual heating energy demand for space conditioning and conditioning of ventilation air
Total Energy Use Intensity (TEUI, kWh/m2)	Total amount of externally provided thermal energy to a building per unit of floor area.

Vancouver Zero Emissions Building Plan

Vancouver uses rezoning applications to require increasingly stringent energy and GHG targets. The City has established a timeline for reductions in GHGI and TEDI metrics for new buildings, for major building types. Vancouver's Green Building Policy for Rezoning currently requires buildings to meet Passive House requirements or GHGI, TEDI and TEUI targets. These same targets are then included in Vancouver's Building Bylaw five years later. In doing so, builders and developers that apply for rezoning push forward innovation in efficient design, help establish local demand for efficient products and become the 'first-movers' in efficient buildings to make it more feasible for widespread uptake years later. Low-rise multi-unit residential building GHG and TEDI targets are displayed in Table 5.

Table 5. Vancouver's time-stepped GHG and TEDI requirements for Low-rise MURBS.[35]

Current Bylaw		Current Rezoning		2016 Bylaw Updates		2016 Rezoning Update		2020 Rezoning Update		2025 Bylaw Requirement	
GHGI	TEDI	GHGI	TEDI	GHGI	TEDI	GHGI	TEDI	GHGI	TEDI	GHGI	TEDI
12.5	50	10.5	42	5.5	35	5	25	4.5	15	0	15

Detached homes are also subject to a GHG and energy use intensity limit (Table 6). However, there is no rezoning policy in place for detached homes in Vancouver, and these buildings are therefore not included within the 'step' framework.

Table 6. Vancouver's time stepped GHG and TEDI limits for detached homes.[36]

2007 Baseline		Current Bylaw		2020 bylaw		2025 Bylaw	
GHGI	TEDI	GHGI	TEDI	GHGI	TEDI	GHGI	TEDI
23	113	12	84	7	55	0	30

[35] City of Vancouver. (2016). Zero Emissions Building Plan.
[36] Ibid.

Toronto Green Standard

The City of Toronto also uses a stepped energy efficiency performance tool to transition new building construction to be near-zero emission by 2030. The Toronto Green Standard is a tiered set of measures for building performance, that includes both performance target and prescriptive requirements for common building types:

- *Performance Targets*: total energy use, thermal energy demand and GHG intensity targets for each tier.
- *Prescriptive*: renewable energy generation, district energy connection, air tightness testing, building commissioning, submetering, building labelling, disclosure requirements for each tier.

Tier 1 is mandatory for all new planning applications, including zoning bylaw amendments, site plan approvals and subdivision plans, which does not typically include small buildings. Tiers 2, 3 and 4 have increasingly stringent efficiency and sustainability elements but are voluntary. Higher tiers are incentivized through reduced development charges for developers. Voluntary steps are intended to drive innovation, establish local supply chains and develop ideal outcomes for buildings. Over time, the voluntary tiers step-up: Tiers 2, 3 and 4 will eventually become mandatory through Green Standard updates. For example, Tier 2 of TGS version 2 is now Tier 1 of version 3. The schedule for TGS updates is displayed in Figure 5. The stepped format prepares the building industry for future mandatory requirements.

Figure 5. TGS stepped schedule.[37]

2018	2022	2026	2030
V3 Tier 1	--	--	--
V3 Tier 2	V4 Tier 1	--	--
V3 Tier 3	V4 Tier 2	V5 Tier 1	--
V3 Tier 4	V4 Tier 3	V5 Tier 2	V6 Tier 1

Off-site renewable energy procurement = Zero Emission Buildings

Version 3 of the TGS was required in May 2018. Figure 6 displays the GHG and energy intensity targets set out for low-rise residential buildings with more than five units. The City also intends to provide support to developers that aim to build in the upper tiers through awareness, energy modelling resources, and financial support.

[37] City of Toronto. (2018). Toronto Green Standard v3.

Figure 6. TGS targets for low-rise MURBs.[38]

Tier	New TGS Targets			Overall % Change in Construction Costs*
	EUI (kWh/m²)	TEDI (kWh/m²)	GHGI (kgCO2e/m²)	
TGS v2 T1 (SB 10 2017)	198	97	28	N/A
TGS v2 T2	165	65	20	0.4%
TGS v3 T1	165	65	20	0.5%
TGS v3 T2	130	40	15	2.1%
TGS v3 T3	100	25	10	5.1%
TGS v3 T4	70	15	5	4.9%

Although Toronto and Vancouver provide a compelling model, Ottawa has less jurisdictional power than either of these two cities.

Both Vancouver and Toronto programs capture low-rise MURBs, but target larger buildings more effectively. In Vancouver and Toronto there are fewer policy levers applied to detached homes. Furthermore, Ontario municipalities are not provided the same jurisdiction under Ontario's Planning Act. The exemption of detached housing is a critical gap that needs to be addressed in Ontario's programming to allow Ottawa to make a more meaningful impact in this sector.

A Green Standard could also include a requirement for connections to district energy systems. Toronto's Green Standard includes provisions for district energy connection at Tier 2 for large MURBs.

Financial incentives

Ultimately, the primary barrier for high efficiency buildings is the increased upfront costs, which will need to be addressed if high efficiency buildings are to reach wide scale deployment.

The Independent Electricity System Operator (IESO) provides funding for new builds that are efficient, through the SaveOnEnergy High Performance New Construction Program.[39] Enbridge also offers its Savings by Design Program, which provides design support and funding incentives for efficient building components.[40] While these programs are a positive start, their impact so far is miniscule. The New Construction Program reached 130 homes for overall energy savings of 2 GWh in 2016.[41]

A key factor in driving forward the Toronto Green Standard is the reduced Development Charges for developers. Because financial incentives are built into to the upper tiers of the Green Standard, financial incentives are widely available to developers and under the terms of the City. Other financial incentives that were considered by the City of Toronto are a 'feebate' structure for under-performing buildings, financial support for building modelling and financial support for information and training.[42] In the development of a Green Standard for Ottawa, reduced Development Charges are considered a core component of program design, as well as additional financial supports for encouraging industry capacity.

[38] Ibid.
[39] https://saveonenergy.ca/en/For-Business-and-Industry/Programs-and-incentives/High-Performance-New-Construction
[40] http://residential.savingsbydesign.ca/incentives.php
[41] IESO. (2017). 2016 Conservation Results Report.
[42] City of Toronto. (2017). Zero Emissions Building Framework.

Section 2: Growth Projections for New Residential Buildings

The following assumptions are applied to the residential building stock in three different scenarios, representing conservation, moderate and aggressive pathway uptake.

Table 7. Low carbon pathway action parameters.

Action	Conservative scenario	Moderate scenario	Aggressive scenario
Improve energy performance of new construction	Apply a 5% increase in energy performance every ten years to reflect revisions to the building code.	Scale up the performance of residential buildings so that 100% of new buildings achieve Passive House levels of performance by 2050.	Scale up the performance of residential buildings so that 100% of new buildings achieve Passive House levels of performance by 2030.
Net zero homes	Increase the percent of new construction which is net zero energy from 0% in 2030 to 50% in 2050.	Increase the percent of new construction which is net zero energy from 50% by 2030 and 100% by 2050.	Increase the percent of new construction which is net zero energy buildings to 100% by 2030.
Dwelling mix	Maintain existing shares of dwellings types consistent with 2016.	Decrease the share of single-family homes to 10% by 2050.	Decrease the share of single-family homes to 10% by 2030.
Dwelling size	Maintain 2016 sizes of dwellings.	Decrease the average dwelling size by 10% by 2050.	Decrease the average dwelling size by 16% by 2050.

Methodology

The modelling approach for new residential buildings is as follows:

1. Identifying future population projections: Future population projections will be generated out until 2050, in alignment with the City of Ottawa's projections.
2. Assigning the population to dwellings, some of which will be apartments: Population will be assigned to dwellings based on historical people per dwelling ratios, which are carried forward into the future. This calculation will determine the number of dwellings that will be projected.
3. Assigning the population to employment types: The working age population will be allocated to employment sectors according to the historical mix of employment types. If an employment projection is available, the mix of allocations to sectors will align with this projection.
4. Translating the employment into buildings: The ratio of jobs per floor area for each sector will be calculated based on the calibrated year.
5. Reflecting trends of declining office space per employee and an increased mix of dwelling types: The 2016 ratio for employees per year and people per household will be adjusted according to historical or projected trends. The mix of dwelling types can also be adjusted, either to align with the mix in the zone where they will be allocated or according to trends or projections.

6. Specifying the location of the buildings, as determined by current land-use plans: The new buildings that result from the population and employment projections allocated to zones according to the Official Plan policies or another projection in five-year increments.
7. Setting targets for new buildings that achieve net zero energy.
8. Adjusting the building design and end uses to meet the energy performance targets. The performance of equipment and thermal envelope for new construction will be adjusted to achieve the energy performance targets.
9. Adjust the energy system of the buildings: Those buildings which are located in areas with sufficient energy density will be connected to district energy. Geothermal or heat pumps will be incorporated to the remaining buildings. Finally, solar PV will be added to the roofs of new construction according to a predetermined schedule.

Constraints

From a technological perspective, high efficiency building design has been shown to be feasible in multiple examples in the Ottawa region and there are notable technological and logistical barriers. Attachment to district energy is physically constrained in many locations, based on proximity to existing systems, and most district energy systems are not yet zero emissions. Ongoing developments in supply chain and process design will be important to lower upfront costs for Passive House standard or net-zero buildings. For MURBs, financial incentives for Green Standard will be important to incentivize higher efficiency projects. A final strategy is to use local improvement charges or a Property Assessed Clean Energy (PACE) program to distribute the upfront costs over the lifetime of the building in alignment with avoided energy costs.

There are some limitations to urban intensification that need to be mitigated to effectively pursue urban intensification. This includes local opposition, which can significantly slow development on a case-by-case basis. Local opposition makes low-rise multi-unit residential an attractive option in relation to high-rise MURBs. Development charges by unit can also disincentivize higher density building projects.[43]

The primary constraint to influencing a low carbon pathway for new residential buildings is that Ottawa does not have legal jurisdiction to require better-than-code efficiency standards. Although Ottawa can rely on mechanisms relating to Site Control and conditions on new planning applications for larger buildings or larger development projects, an ability to require better than code outcomes could help maximize efficient building design in a timely manner. There is uncertainty as to how future updates to the Building Code will be rolled out, decisions which rest with the Provincial Government. Furthermore, the City has limited control over detached single unit homes making Passive House standards difficult to reach. Site Plan Control and other rezoning controls can influence low-rise MURBs and new subdivisions, but not individual small detached units.

Finally, industry capacity is also an important barrier to large scale uptake of high efficiency design in new residential buildings.[44] Home construction is generally performed by smaller companies, which adds a layer of complexity in the transfer of information on building practices required to achieve high efficiency as they may have limited capacity to learn and employ new construction techniques. Certification and standards provide a strong foundation for industry awareness and uptake of principles of efficient design by providing certainty in the direction of the industry. LEED certification still remains one of the most important industry certifications, as it is widely known and recognized. Similarly, Natural Resources Canada's R-2000 standard also seeks to increase industry standards by requiring that contractors be R-2000 certified to build. The City of Ottawa currently uses certification

[43] Graham, K. (n.d.). How can the development permit system be used to achieve residential intensification outcomes in the suburbs?
[44] Wolfe, A., Hendrick, T. (2012). Homeowner decision making and behavior relating to deep home retrofits. Oak Ridge National Laboratory.

schemes to encourage new efficient building construction. Under the 2012 Green Building Promotion Program, Ottawa has taken multiple steps to increase capacity for efficient buildings, including LEED training and revision of permits. Certification schemes provide indirect support to encouraging near-zero buildings but are not a standalone solution.

Uptake projections

The following tables detail the energy use and emissions reductions based on the actions and assumptions described in this pathway paper.

Conservative

Figure 7. Number of new dwellings that meet Passive House standard in five year increments in the conservative scenario.

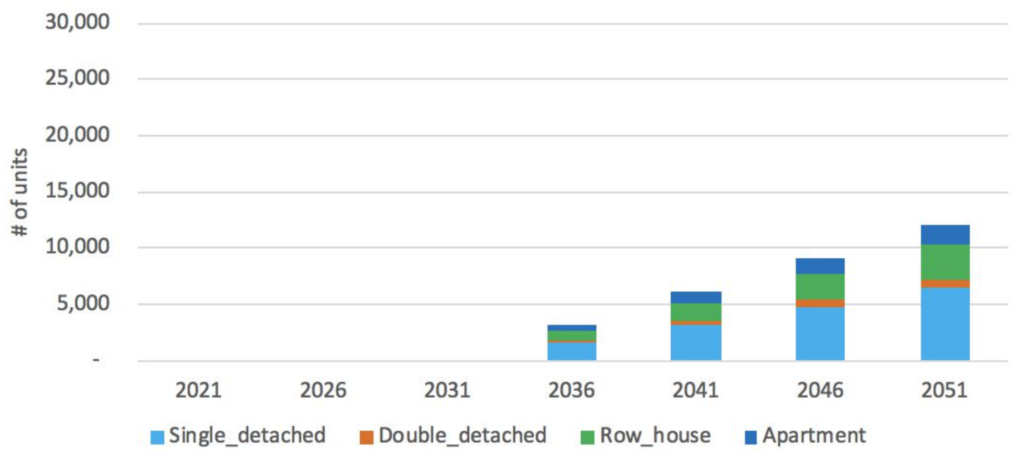

Table 5. Energy and GHG emissions results of the conservative existing buildings pathway.

Action	Description	Cumulative emissions reductions 2018-2050 (kt CO2eq)	Emissions reductions 2050 (kt CO2eq)	Cumulative energy reductions 2018-2050 (TJ)	Energy reductions 2050 (TJ)
Efficiency of new homes	Apply a 5% increase in energy performance every ten years	-725	-53	-17,376	-1,298
Net zero homes	Increase the percent of new construction which is net zero energy from 0% in 2030 to 50% in 2050	308	36	1,938	234
Dwelling Mix	Maintain existing shares of dwelling types consistent with 2016	No change	No change	No change	No change
Size of new homes	Maintain 2016 size of dwellings	No change	No change	No change	No change

Moderate

Figure 8. Number of new dwellings that meet Passive House standard in five year increments in the moderate scenario.

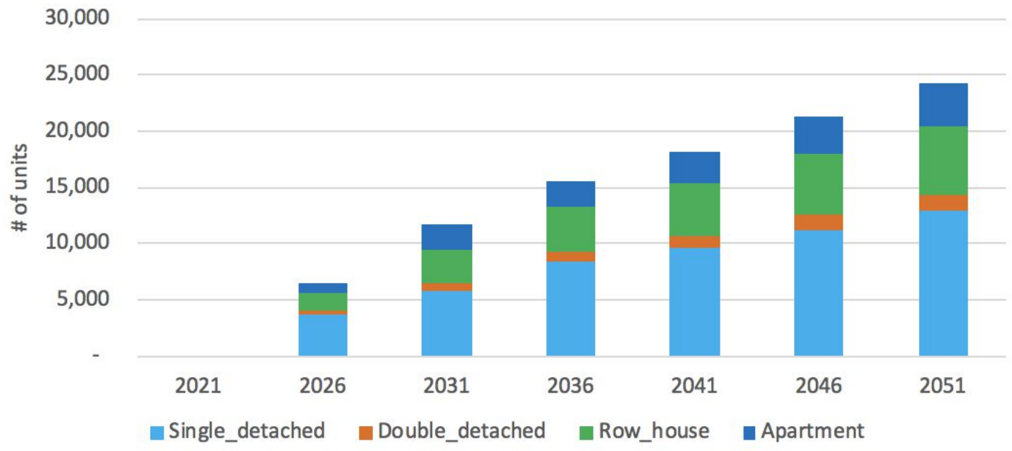

Table 6. Energy and GHG emissions results of the moderate existing buildings pathway.

Action	Description	Cumulative emissions reductions 2018-2050 (kt CO2eq)	Emissions reductions 2050 (kt CO2eq)	Cumulative energy reductions 2018-2050 (TJ)	Energy reductions 2050 (TJ)
Efficiency of new homes	100% of new buildings are Passive House compliant by 2050	128	17	2,586	344
Net zero homes	Increase the percent of new construction which is net zero energy from 50% in 2030 to 100% in 2050	1,207	89	11,746	889
Dwelling Mix	Decrease the share of new single family homes to 10% by 2050	1	1	27	14
Size of new homes	Decrease the average dwelling size by 10% by 2050	501	23	9,977	470

Aggressive

Figure 8. Number of new dwellings that meet Passive House standard in five year increments in the aggressive scenario.

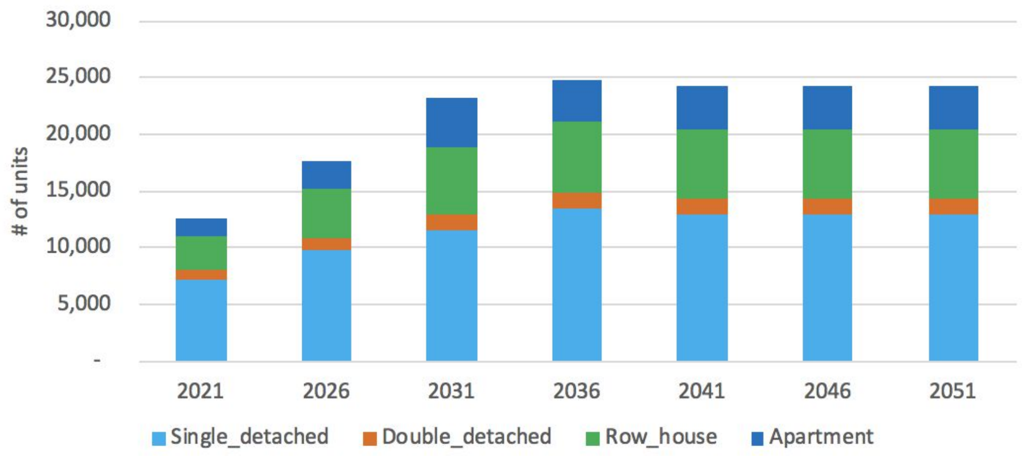

Table 6. Energy and GHG emissions results of the aggressive existing buildings pathway.

Action	Description	Cumulative emissions reductions 2018-2050 (kt CO2eq)	Emissions reductions 2050 (kt CO2eq)	Cumulative energy reductions 2018-2050 (TJ)	Energy reductions 2050 (TJ)
Efficiency of new homes	100% of new buildings are Passive House compliant by 2030	1,038	63	22,636	1,405
Net zero homes	Increase the percent of new construction which is net zero energy from 100% in 2030	1,967	114	22,636	1,405
Dwelling Mix	Decrease the share of new single family homes to 10% by 2030	43	3	1,191	96
Size of new homes	Decrease the average dwelling size by 16% by 2050	836	39	16,627	785

Ways to Advance this Pathway

The following are ways in which this pathway can be encouraged:

- Green standard: A green standard can be used to require net zero buildings by 2030. This could influence multi-unit residential buildings.

- Financial Incentives: Provide a range of financial incentives to support efficient buildings, including cash incentives in coordination with utilities, expedited permitting process, reduced or eliminated permitting fees, discounted service or utility fees, and reduced property taxes.

- Density / Floor Space: Permit increased floor space, or waive a proportion of floor space if builders choose to pursue a green building standard. For example, a waiver in basement floor space can help builders maximize floor area but meet green building requirements. With this incentive, an examination of increased thermal energy compared to additional floor space granted needs to be completed. Floor space waivers may be more effective for duplexes or small row houses which have floor area ratio maximums.

- Education: Invest in training and education programs to increase the literacy of the development and construction industries and the uptake by homeowners. In this vein, the City of Vancouver has published a guidebook on passive house design to support home buildings in the City.[45] Workshops and training for builders and other tradespersons who are involved in the construction industry can also increase construction industry capacity

- Advocacy to Province: Continue to identify gaps in decision making ability in the context of detached housing, and ask for similar powers to Toronto to regulate the sector.

[45] City of Vancouver. (2009). Passive design toolkit. Retrieved from https://vancouver.ca/files/cov/passive-home-design.pdf

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