Pathway Study on Existing Residential Buildings in Ottawa

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

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Executive Summary

Existing residential buildings contribute to greenhouse gas emissions in the City of Ottawa. This is because most residential buildings rely on natural gas for space and water heating needs, a portion of which is wasted because of inefficient building design. Due to low rate of building stock turnover, most small buildings that exist today will remain standing by 2050, which makes reducing the energy used by existing buildings important for decarbonization as well as gaining the economic and social benefits associated with deep retrofits.

Retrofits and fuel switching are the primary tool to reduce energy use and emissions reductions from the existing building stock. Retrofits upgrade building components to reduce energy use, while fuel switching replaces fossil fuel energy systems with renewable or low carbon sources of energy. Audits can provide property owners with information on building energy use, which can lead to up uptake of retrofits or fuel switching.

Uptake of energy efficiency upgrades is currently the direct responsibility of individual property owners. Municipalities and higher levels of government encourage uptake of energy efficiency upgrades by providing awareness of retrofit benefits or by providing financial incentives. Energy benchmarking and disclosure of energy data empowers property owners to undertake retrofits through real energy cost data. Currently, utilities deliver a suite of incentive programs for audits, high efficiency building components and retrofit activities. Local improvement charges (LIC) can also be used to provide upfront capital to property owners to undergo retrofits.

This chapter examines low carbon pathways for existing residential buildings in the City of Ottawa. This pathway models three scenarios: conservative, moderate, and aggressive. The conservative scenario is a Business-as-Planned outlook with a small proportion of retrofits, the moderate reflects increased retrofit penetration with moderate energy savings, while the aggressive scenario involves retrofitting nearly all of the pre-2016 building stock by 2050, including fuel switching to electricity for heating and solar PV for renewable energy generation; the latter two pathways are also addressed in the other building papers.

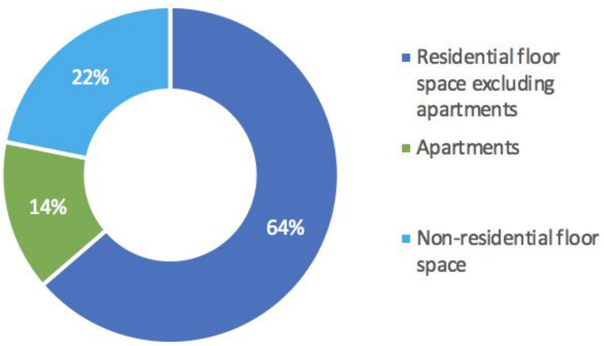
The conservative scenario reduces cumulative emissions (2018-2015) by 3.017kt CO2e. The moderate scenario sees cumulative emissions reductions of 3,356 kt CO2e. Finally, the aggressive scenarios is related to cumulative emissions reductions of 7,345 kt CO2e.

Section 1: Present Assessment of Existing Small Buildings

Pathway Description

The existing building stock accounts for approximately half of the GHG emissions in Ottawa; the residential building stock accounts for a third of the total GHG emissions. Identifying the emissions contributions of both residential and non-residential small buildings is challenging, but one approach is to segregate residential buildings that are not apartments. This approach understates the total contribution of small buildings because it doesn't include small buildings that are non-residential nor apartments that are less than five storeys. Under this approach, small buildings account for a least 64% of the total floor area of buildings in the City of Ottawa (Figure 1).

Figure 1. Floor area of small residential buildings versus other categories, 2016.



The existing small building stock is inefficient. Older buildings are often leaky, meaning energy is wasted as heat escapes beyond the building. Older appliances also have lower operational efficiency. Ottawa has a considerable portion of older residential buildings. Sixty-four percent of all residential dwellings in the City were built prior to 1990, and nearly 75% of all dwellings were built in or before the year 2000.[1]

In Ontario, new buildings are considerably more efficient. A building constructed in 2017 is approximately 35% more efficient than a building built in 1997.[2] Although new buildings are more efficient, the existing building stock will remain standing for many years to come. Estimates expect that it could take approximately 65 years to replace the existing building stock in Canada, with 66% of buildings remaining in the year 2050.[3]

Addressing GHG emissions and energy consumption of the existing residential building stock will be critical to deep emissions reductions for the City. This component is challenging because the GHG emissions are decentralized in ownership and geography. The hundreds of thousands of individual owners are typically capital constrained and do not have sophisticated energy management knowledge or tools.

Retrofits of existing buildings are effective at reducing emissions because they can minimize energy loss and reduce overall energy used for space conditioning. Conventional retrofit approaches are insufficient for a deep GHG emissions reductions pathway; whole system approaches are required. Fuel switching is also important to reduce emissions associated with fossil fuel combustion for heat. A key strategy will be integrating energy retrofits into the background cycle of renovations. Many older buildings require ongoing improvements for livability, which presents a critical opportunity for

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[1] Statistics Canada. (2017). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa.
[2] Environmental Commissioner of Ontario. (2017). Conservation: Let's Get Serious. Chapter 5: Codes and Standards.
[3] Now House. (2013). Net Zero Energy Home Retrofits. Sustainable Building/Renovating Housing Forum 2013 Kamloops Convention Centre. https://www.chbaci.ca/docs/evening_speaker_-_gauthier_kamloops.pdf

inclusion of efficiency retrofits. Of dwellings built prior to 2000 in Ottawa, 35% require minor repairs, while an additional 9% require extensive repairs for livability.[4]

Improvements to the existing residential building stock can also provide economic benefits to individuals and to local economies through reduced household spending on energy, as well as economic stimulus to the local construction sector. Reducing energy use in residential buildings can reduce demand burdens on electricity and natural gas providers, reducing the need for investments in new energy distribution infrastructure. Retrofits can also improve household living conditions, improving indoor air quality and comfort.

Pathway Boundaries

This paper describes low carbon pathways for existing residential buildings in Ottawa. Mixed-Use buildings that feature residential dwellings along with commercial or other non-residential uses are included in the non-residential building pathway papers. This pathway outlines background information related to the existing building stock and the key strategies for pathway advancement.

Section 2 of this pathway paper includes modelling method and parameters. Three uptake scenarios for existing small buildings are modelled: conservative, moderate and aggressive.

Opportunities for emissions reductions from the existing residential building stock will ultimately rely on aggressive uptake of deep whole building retrofits that include fuel switching and deployment of renewable energy and energy storage. While the whole systems approach includes fuel switching, solar PV and energy storage, these strategies are addressed in more detail in separate papers and this paper focuses on retrofits.

[4] CMHC. (2014). Dwelling condition by tenure and period of construction, Ottawa, 2011.

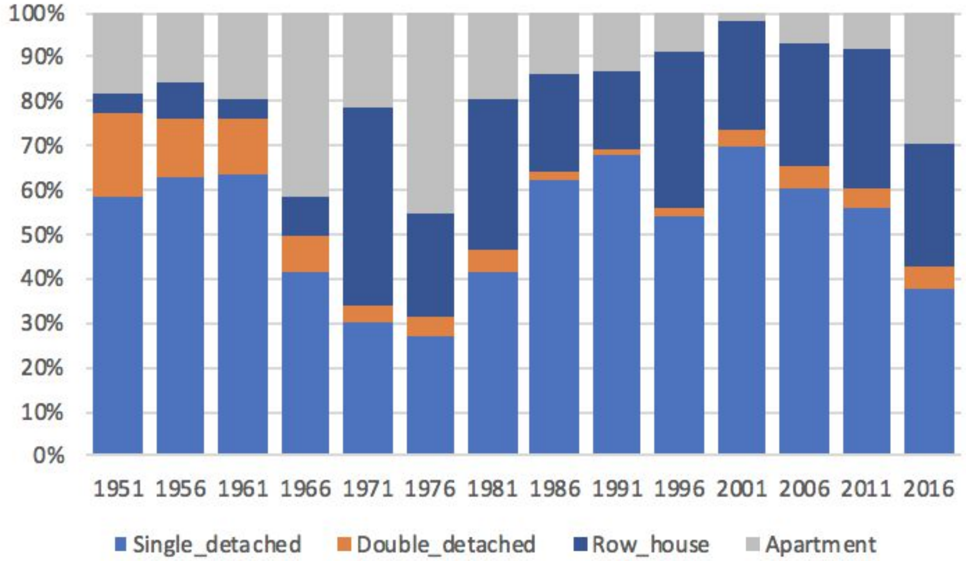
Background Information

Ottawa's Building Stock

There are approximately 104,000 units in apartment buildings in Ottawa. There are 327,000 units of of single detached homes, row houses, and duplexes. Figure 2 shows new dwellings according to the five-year increments during which they were constructed. The dwellings counted are inclusive of the cities that existed prior to amalgamation and represent the current Ottawa boundary. Note that all units constructed prior to 1951 are included in the 1951 data.

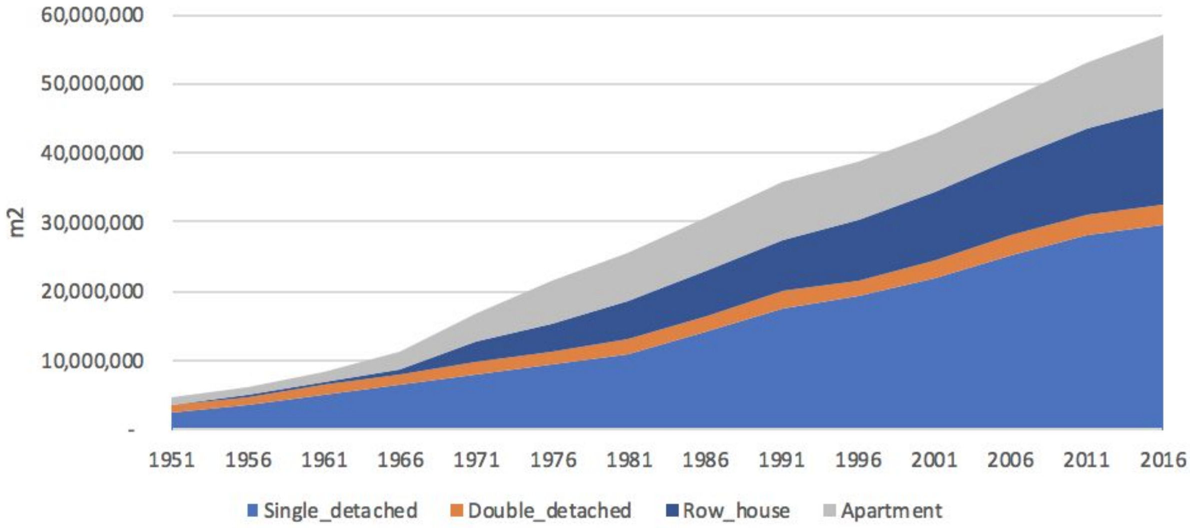
The share of different types of dwellings has gone up and down over the period, with a pronounced emphasis on small buildings from 1986 to 2011, followed by an increase in the construction of apartments over other forms in the last five years.

Figure 2. Proportion of new dwellings by type in five year increments, City of Ottawa.



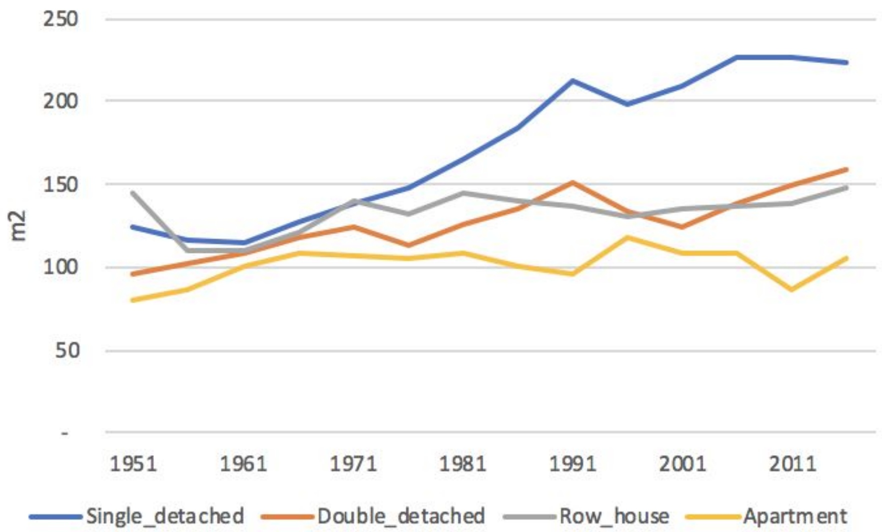
Overall, residential floor space has grown rapidly since 1951, increasing from just under 5 million m² to 60 million m² by 2016. While the overall share of apartments has gained over the period, the majority (81%) of the residential building stock in 2016 fits clearly within the small buildings category, as illustrated in Figure 3. Just over half (52%) of the dwellings were single family in 2016.

Figure 3. Cumulative floor space by dwelling type.



The size of new dwellings increases over time in all housing categories except for apartments. The trend is most pronounced in single family dwellings, whose size has increased by nearly 200%. In 1956, the average single-family home was 116 m^2; in 2016 the average house is 264 m^2.

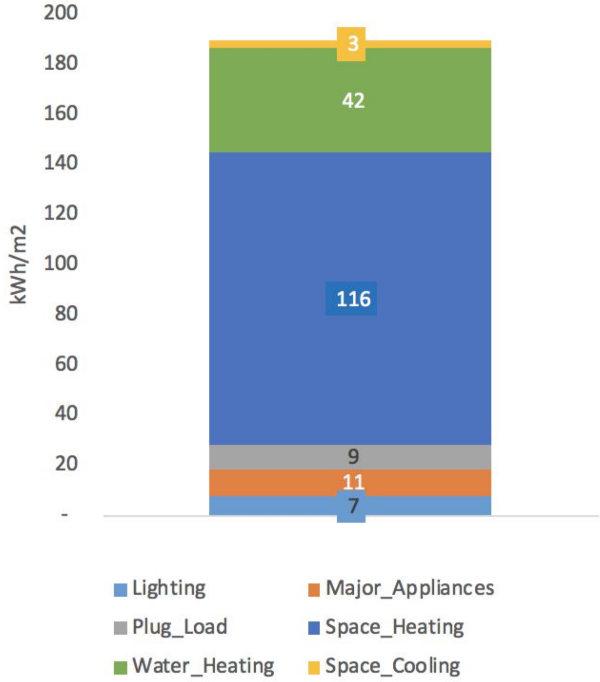
Figure 4. Average floor area by unit type.



Energy Consumption

The average residential dwelling (including apartments) in Ottawa has an energy use intensity of 190 kWh/m². Space heating represents 60% of energy use intensity, while water heating represents 22%.

Figure 5. Average energy intensity by end-use for residential dwellings in the City of Ottawa, 2016[5]

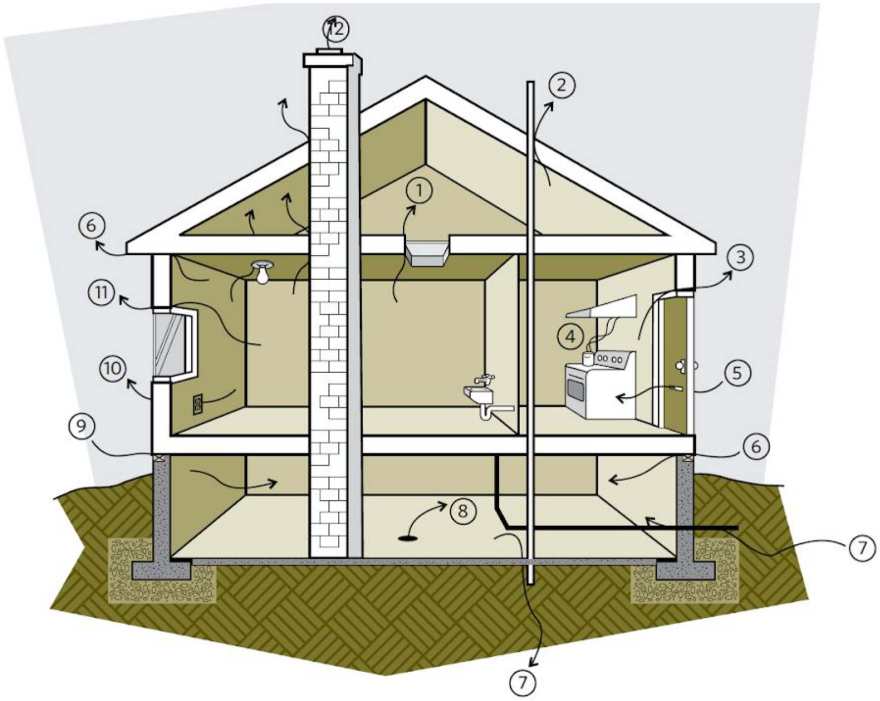


Space heating is influenced by the rate of heat loss. Buildings lose heat as it is transferred through the air, water and materials of the building, due to a temperature difference from the inside to the outside of the structure. Heat can be lost through direct contact from one object to another (conduction); through the movement of air (convection); and, through the radiation of heat from occupants to the exterior (radiation). Most heat loss occurs through convection, as air travels through the building and escapes through leakage points in the building envelope.

Air leakage can occur at multiple places in the building envelope. Walls can account for 20% of heat loss in a building, while windows and doors can be up to 25% of heat loss.[6] Common locations of air leaks are displayed in Figure 6, such as cracks near windows and in the roof. It can also occur through thermal bridging, where building components that conduct heat provide a pathway to the exterior. Thermal bridging often occurs at wall studs and balconies.

[5] This average includes apartments.
[6] Natural Resources Canada (2017). Keeping the Heat in. Retrieved from: https://www.nrcan.gc.ca/energy/efficiency/housing/home-improvements/keeping-the-heat-in/how-your-house-works/15630

Figure 6. Common air leakage points in a detached home.[7]



Where to look

Key locations to check for leaks

1. attic hatch
2. ceiling penetrations into the attic
3. door
4. exhaust vent
5. mail slot
6. sill and header
7. service entry
8. floor drain
9. foundation crack
10. electrical outlet
11. window
12. chimney

Air leakage is minimized in efficient buildings by ensuring there is an air barrier to block airflow through the building envelope, sealing cracks, using efficient windows and doors, and through insulation in the walls and roof. The extent of airflow movement is often referred to as the tightness of the building. The efficiency of building components is described by its R-value, referring to its resistance to thermal transmittance. Older homes were not frequently built to reduce thermal loss or have lost thermal resistance over time through a lack of maintenance or through changing building use.

Efficiency can also be integrated into structural design. Passive buildings are constructed in relation to the surrounding environments to minimize energy required to reach thermal comfort. For example, heat in the winter is maximized using south-facing windows, while shade cover from trees block solar insolation from those same windows in the summer.

Older electrical appliances, which account for just 6% of the average dwelling's energy consumption, are generally less efficient than modern appliances. Plug loads and lighting together account for 9% of total energy. More efficient lighting and plug loads decrease the waste heat produced in a dwelling and can result in increased GHG emissions if that waste heat is replaced with heat produced by natural gas.

[7] Natural Resources Canada (2017). Keeping the Heat In.

The Effect of Climate

Ottawa’s climate impacts building heat loss, and the insulation required to minimize loss. Ottawa’s climate is considered humid continental, relating to Koppen Dfb climate index, experiencing large seasonal temperature fluctuations, with cold winters and hot summers. This translates to high heating requirements in the winter, and greater air conditioning loads in the summer.

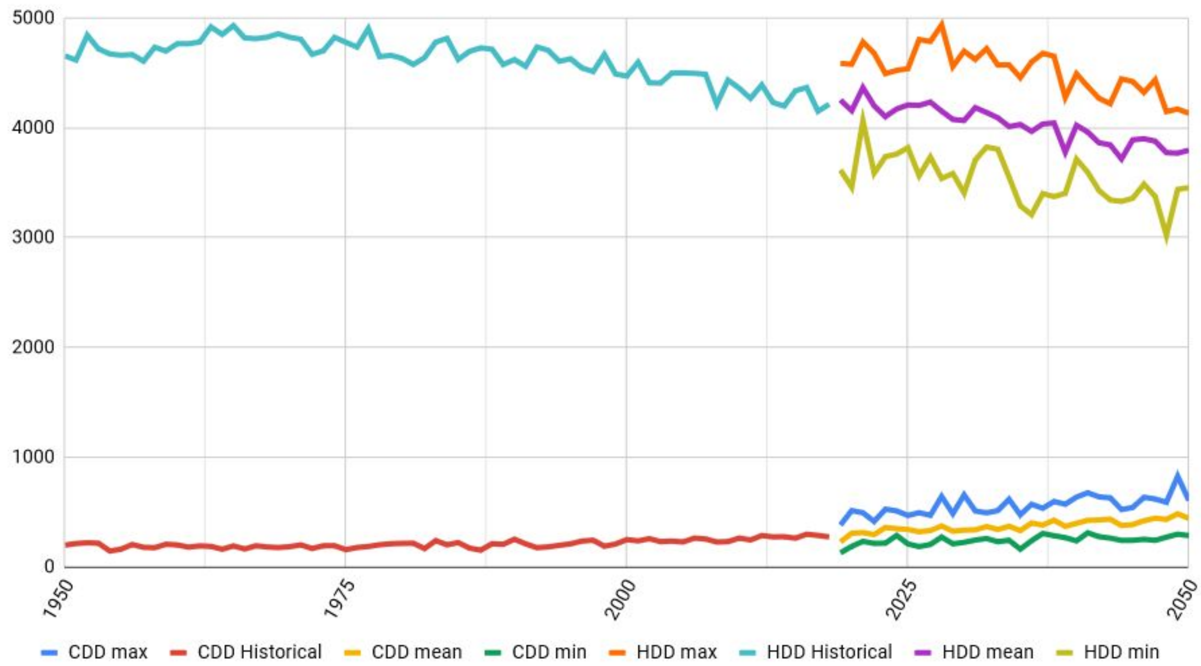
In the winter, wider temperature gradients between the interior and the exterior of a building will cause greater heat loss. In order to reach optimal thermal comfort in a leaky building, more thermal energy will be required. This generally results in higher demands for natural gas in colder temperatures causing seasonal winter peaks in gas usage. In areas outside of the gas grid, there may be increased use of heating-oil, propane or wood/pellet stoves. In an efficient building, greater insulation retains heat within the structure and minimizes peak demand for heating fuel at colder temperatures.

In the summer, air conditioning is frequently used for space cooling. There is a thermal gradient between the warm exterior of the building and the cold interior, which cause warm air to enter the building without proper insulation, ultimately requiring further space cooling demand. Building design can reduce space cooling needs through effective building design that minimizes sunlight, maximizes airflow, and by using insulation in the building exterior to keep cooler air in the building. Air conditioning contributes to critical annual peaks in electricity demand in Ontario. Because critical electrical demand peaks are often met with natural gas fired generation, high air conditioning loads in the summer can cause disproportionately higher emissions.

A heating degree day is the number of degrees that a day's average temperature is below 18°C, indicative of the amount of energy needed to heat buildings to operating temperatures in that day. For example, a day with an average temperature of 4°C will have a Heating Degree Day of 14°C. Similarly, a cooling degree day provides a measure of energy needed to cool buildings, noted by the number of degrees that a day's average temperature is above 18°C.

In Ottawa, heating degree days are projected to decline by 10% by 2050 over 2018, with cooling degree days increasing by 60% over the same period (Figure 7). Under a BAP scenario, space heating will go down, but air conditioning use is expected to increase.

Figure 7. HDD and CDD projections for the City of Ottawa.[8]



Evaluation of the Current Pathway

Energy Auditing

Energy audits are an inspection of an existing building, surveying energy use and flows in the structure. Audits often include an analysis of energy bills, inspection of building components during site visits, and some energy modelling of building components. Auditing can point to specific areas of concern with regards to energy loss within a building, describing techniques for energy and cost saving measures for property owners, often focusing on lighting, heating, cooling, ventilation and water heating.

Audits are often the first step towards building upgrades, providing initial information on building energy use. Energy audits typically cost under $1000, with actual costs varying by service provider, scope of services and the size of the building. For example, as a part of its Home Energy Conservation Program, Enbridge charges $600 for an energy audit.[9]

Energy auditing is a low-cost solution for improving existing building efficiency, as it can target simple technological and behavioural improvements to the structure and encourage building owners to perform building upgrades through real cost and energy information. Energy audits need to focus on the whole system and the steps required to achieve deep GHG emissions reductions. Natural Resources Canada has recently invested in a clean net zero pilot program in Nova Scotia to explore the design requirements to achieve net zero retrofits.[10]

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[8] Prairie Climate Centre (2018). The Climate Atlas. https://climateatlas.ca/data/city/459/hdd_2060_85
[9] Enbridge, Inc. Home energy Conservation. Retrieved from: https://enbridgesmartsavings.com/home-energy-conservation/pre-energy-audit#advisors
[10] See Clean Nova Scotia's website at: http://clean.ns.ca/clean-net-zero

Retrofits

Retrofits further expand on commissioning techniques by updating system design and building components to maximize building energy efficiency. Retrofits minimize energy loss in buildings by reducing air leakage in the building envelope, reducing heat loss through walls, installing high R-value windows and doors, using energy efficient heating systems and appliances, and installing energy management systems. Retrofit activities seek to include high efficiency components into existing buildings, to provide similar levels of comfort using less energy. Retrofit activities range in their depth: simple retrofit activities are often cheap, with little effect, while deeper but more intrusive options are expensive yet more effective at reducing emissions. A comparison of retrofits is described in Table 1.

Shallow Retrofits are aimed at simple upgrades to buildings. This includes replacing low efficiency lighting for higher efficiency LED lighting, as well as some upgrades to higher efficiency appliances, such as refrigerators and ovens. Shallow retrofits can sometimes include light weatherization, targeting caulking and sealing open gaps where heat can escape the building. It can also include installing automated thermostats to allow building owners to see energy use, energy prices and control thermostat temperatures remotely.

Shallow retrofits are often lower cost than other deeper retrofits, with average costs at less than $5,000 for a detached home, and less than $2,000 per unit in a multi-unit residential building, but do not provide the same energy savings. One estimate places energy savings at approximately 10-20% through shallow retrofits.[11]

Moderate retrofits include similar techniques as in shallow retrofits but can also target upgrades to heating systems and insulation. This includes upgrading to a greater efficiency boiler or furnace for the building or replacing with a heat pump. Medium retrofits can also include improving roofing insulation.

Moderate retrofits are more expensive per unit than shallow retrofits as more building components have been modified or upgraded. Average costs can be from $5,000-$50,000 for a detached house, and $2,000-$6,000 per unit in a MURB. Although more expensive, energy savings are estimated to be closer to the 30-50% range.

Deep building retrofits target all aspects of heat loss in a building, and often require structural upgrades to the building. Deep retrofits can include replacement of window and doors with higher R-values, re-insulation of foundation and walls, envelope replacement, and changes to home heating system. Energy savings can be higher, from 40-80%, although deep retrofits are considerably more expensive. Estimates place deep retrofits at over $100,000 for a detached home, and $10,000-$60,000 per unit in a MURB.

[11] Frappe-Seneclauze, T., Heerema D., Wu, K. (2017). Deep emissions reduction in the existing building stock. The Pembina Institute.

Table 1. Comparison of retrofit depths.[12]

	Shallow Retrofit	Moderate Retrofit	Deep Retrofit
Typical energy conservation measures	• Lighting • Smart controls • HVAC motors and fans Caulking and sealing Optimization	• Boiler, furnace, or AHU replacement • Steam to hot/low-temp water • Heat pumps • Drain/waste heat recovery • Heat recovery ventilation Roof/cavity insulation	• Window replacement • Wall and foundation reinsulating Shading • Envelope replacement • Conversion to renewable district energy
Energy savings range	10-20%	30-50%	40-80%
Typical payback period and costs	1-3-year payback MURB: <$2,000 / unit Home: <$5,000	3-6-year payback MURB: $2,000-$6,000/unit Home: $5,000-$50,000	6+ year payback MURB: $10,000-$60,000/unit Home: $100,000-$150,000
Advantages	• Short payback Cost-effective • Incentivized by current program and policy structure	• Attractive balance of energy savings and payback • Can be performed with minimal disruption to tenants	• Holistic approach optimizes components • Large and lasting energy and emissions reductions
Disadvantages	• Small energy savings Weakens business case for deeper retrofits in the future • Missed synergies between building components • GHG reductions can be small when focusing on electrical savings only	• Higher energy reductions difficult to achieve without envelope upgrade • May result in oversized mechanical systems compared with a deep envelope retrofit	• Complex • Longer payback period • Disruption to tenants/owners

[12] Frappe-Seneclauze, T., Heerema D., Wu, K. (2017). Deep emissions reduction in the existing building stock. The Pembina Institute.

Payback periods for building retrofits are a major part of building a business case for any level of retrofit. Payback periods can vary greatly depending on levels of expertise, the retrofit path chosen, and the depth level of the retrofit. Other economic dimensions such as incentives offered or carbon pricing can greatly speed up payback periods, and the lack of of these items can make payback periods lengthy and thereby less attractive to undertake.

Case studies on larger apartment building retrofits by The Toronto Atmospheric Fund (TAF) show that reasonable paybacks (4-6 years) can be achieved on older and less efficient buildings in Ontario. The TAF helped to finance and provide grants for a portion of these retrofit programs.

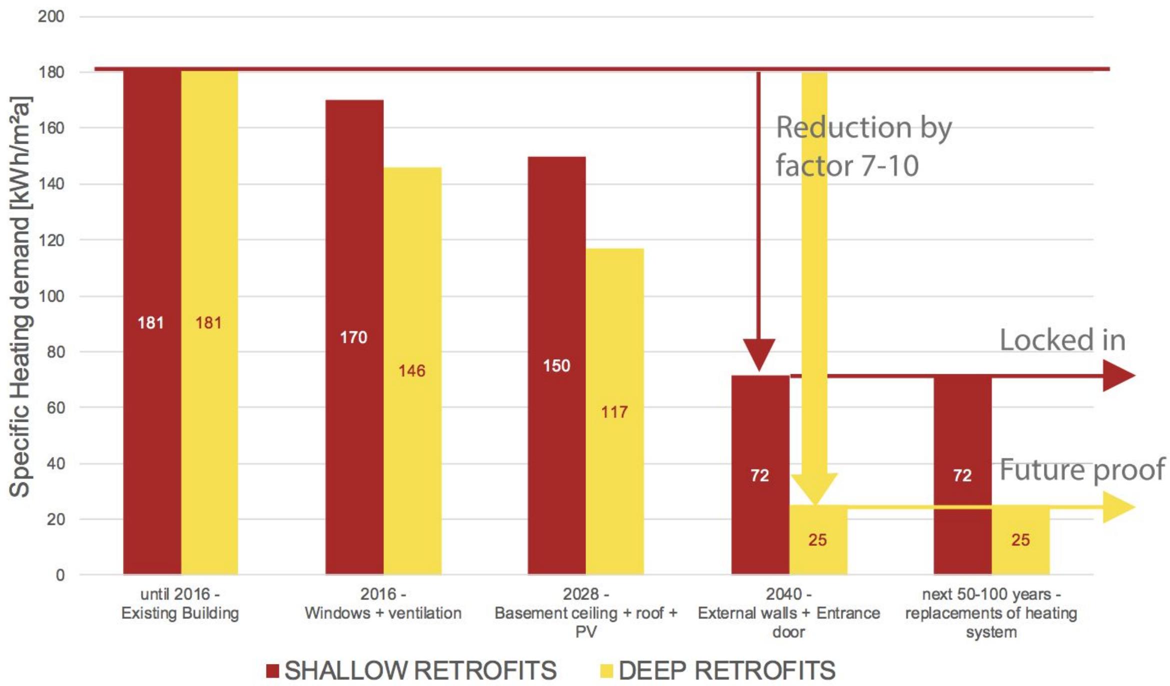
Table 3: Retrofit case studies and payback periods.

Project Description	Retrofits	Energy, Utility, and water savings	Payback Period
45-year old multi-family building in Burlington, Ontario[13] 210 units over 18 storeys	• Boiler replacement • Toilet replacement • Chiller replacement	• 20% natural Gas reduction • 29% water reduction • 50% electricity demand reduction • 300 tonnes GHG reduction	4.4 Years
20-year old social housing apartment building, Toronto Ontario[14] 13-storeys high with with 125 1-3 bedroom units	• Boiler replacement • Make-up air/HVAC upgrade • Lighting system upgrade to LED • Toilet, shower, aerator replacements	• 11% electricity reduction • 31% natural gas reduction • 33% water reduction • 166 tonnes GHG reduction	6.2 Years
30-year old social housing building in Toronto Ontario[15] 8-storey building combined with 4-storey section, 102 1-3 bedroom units	• Programmable electric baseboard heating system installed • Boiler upgrade • Make-up air/HVAC upgrade • Centralized control for building systems added • Domestic cold water booster pump system installed • Lighting system retrofit to LED • Toilet, Showerheads, and Aerators replacement • Exterior door and lobby air conditioner replacement	• 22% Electricity reduction • 29% Natural gas reduction • 47% Water reduction • 82 tonnes GHG reduction	4 Years

[13] "15 Kensington Road." 2011. Case Study. Towerwise. Toronto, ON: Toronto Atmospheric Fund. http://taf.ca/wp-content/uploads/2018/02/TAF_TowerWise_Case_Study_Kensington_Road_2011-01-21.pdf.
[14] Finn, Derrick. 2016. "Development of Three Multi-Unit Residential Building Energy Efficiency Retrofit Case Studies." Case Study. Housing Research Report. Ottawa, ON: CMHC. ftp://ftp.cmhc-schl.gc.ca/chic-ccdh/Research_Reports-Rapports_de_recherche/2017/RR_Three_Multi_Unit_Retrofit_Case_Studies_Jun2.pdf
[15] Ibid.

The lock-in impacts of retrofits should be considered. Many building components last 20 or more years, or even 40-60 years for the building shell. If shallow retrofits are undertaken, no additional improvements in the equipment installed can be expected over the course of its lifetime without considerable additional expense. In this way, lower levels of energy reductions can be locked in for a long period. In one example, a house that undergoes shallow retrofit measures has an energy demand three times as high as that with deep retrofit measures, over the buildings lifetime (Figure 8).

Figure 8. The lock-in effect of shallow retrofits.[16]



The Passive House Institute has developed Energy Retrofits with Passive House Components (EnerPHit), a certification program for existing buildings. EnerPHit is a retrofit plan that may include multiple steps using Passive House standard components such as insulation, opaque building envelope, high-R windows, which can ensure the building does not exceed a prescribed maximum heating demand.[17]

Reaching a net-zero retrofit is also possible, and generally includes rooftop solar PV, ground source heat pumps, solar thermal and highly efficient building design to reduce overall energy needs.

Reaching Passive House or net-zero performance levels in a deep retrofit is possible, but existing buildings present some difficulties. For example, Passive House standards are harder to achieve in retrofitted buildings, often because of the difficulty in retrofitting basements, the orientation of the building relative to sun exposure, and high area to volume ratios.[18] Ottawa's climate presents further challenges, as the high heating and cool requirements will require considerable airtightness.

Over time, a building's structure and operational performance degrade, especially with little maintenance and upkeep. In some instances, it may be more advantageous—both economically and from an emissions perspective—to replace an existing building. Replacement is most effective if it

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[16] Passive House Institute. (2016). Implementing deep energy step-by-step retrofits. Retrieved from https://europhit.eu/sites/europhit.eu/files/EuroPHit_brochure_final_PHI.pdf
[17] Passive House Institute. (2016). Criteria for the Passive House, EnerPHit and PHI Low Energy Building Standard. Retrieved from: https://passiv.de/downloads/03_building_criteria_en.pdf
[18] Passive House Canada. Passive House FAQs. Retrieved from: http://www.passivehousecanada.com/passive-house-faqs/

targets the worst-performing buildings. Retrofit-or-replace decisions are building-specific, and largely depend on property owner decision-making.

Retrofit Information

Industry knowledge is an important tool in effective retrofit programs uptake, as it can instill trust in homeowners and provide superior retrofit outcomes.[19] Improved energy retrofit information can encourage building owners to invest in retrofits. Despite availability of energy efficiency information—including energy models available to homeowners—it is often perceived as difficult to navigate, and potentially unreliable when taken with local policy and climate context.[20] There are multiple actors, certification schemes, contractors, and financing options to consider. Energy efficiency awareness is also an important tool to encourage local knowledge, a role that local governments and utilities take on through task forces, training offerings, local events and publicly available information.

Encouraging local one-stop-shops for retrofit services is seen as an important driver for uptake.[21] This has been encouraged in Alberta with the development of the Energy Efficiency Alberta Agency, a public facing entity that encourages retrofits and energy savings.[22] In Ontario, Peterborough Utilities and other community organizations have developed a local hub for information on energy efficiency.[23]

Retrofit Funding / Financing Programs

<u>Local Improvement Charges</u>

Local Improvement Charges (LIC) are an important tool for encouraging uptake of energy efficiency upgrades. Homeowners receive a loan from municipalities, which is repaid alongside local taxes, called a local improvement charge. This financing structure is often referred to as Property Assessed Clean Energy (PACE). *Ontario Regulation 586/06 Local Improvement Charge* allows municipalities to undertake works that provide local benefits and recover the costs from benefitting properties.[24] Regulation 322/12 allowed such projects to be used for a wider range of uses, including home retrofits. The City of Toronto and City of Guelph have both developed PACE/LIC programs.

Local improvement charges reduce the upfront costs of retrofit activities, a considerable barrier for retrofit activities. The LIC charge is also tied to the property, which can be transferred to new owners in the event of property sale, addressing the split incentive issue so that those who benefit from the investment pay for the investment. While this can be a positive benefit, it may also have the unintended consequence of discouraging the purchase of homes that have a pre-existing loan attached to the property.[25] In Canadian examples of LIC programs, interest rates are 2%-3.5% on loan repayment, which is considered low cost capital.[26] LIC programs require startup funding for loans and to cover administration costs, which can be a barrier to uptake for municipalities.[27]

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[19] Wolfe, A., Hendrick, T. (2012). Homeowner decision making and behavior relating to deep home retrofits. Oak Ridge National Laboratory.
[20] Bardhan, A., Jafee, D., Kroll, C., Wallace, N. (2014). Energy efficiency retrofits for US Housing: Removing the bottlenecks. Regional Science an urban Economics, 47, 45-60.
[21] Frappe-Seneclauze, T., Heerema D., Wu, K. (2017). Deep emissions reduction in the existing building stock. The Pembina Institute.
[22] Energy Efficiency Alberta. Retrieved from: https://www.efficiencyalberta.ca
[23] GreenUp. (2016, April 8). Green Business Program will provide One-Stop-Shopping for Energy Efficiency. Retrieved from: https://www.greenup.on.ca/green-business-program-will-provide-one-stop-shopping-energy-efficiency
[24] O. Reg. 586/06: LOCAL IMPROVEMENT CHARGES - PRIORITY LIEN STATUS. https://www.ontario.ca/laws/regulation/060586
[25] City of Ottawa. (2014). Air Quality and Climate Change Action Plan, Appendix F.
[26] City of Toronto. Home energy Loan Program. Retrieved from: https://www.toronto.ca/services-payments/water-environment/environmental-grants-incentives-2/home-energy-loan-program-help
[27] City of Ottawa. (2014). Air Quality and Climate Change Action Plan, Appendix F.

On-bill Financing

On-bill financing programs for retrofits have a similar repayment schedule as LIC structures, except repayment occurs through monthly utility bills. On-bill financing ties retrofit activity to actual energy and cost reductions. In theory, on-bill financing aims to reach bill neutrality, where monthly costs are equal to the savings achieved through retrofits and there are little incurred costs to customers; in practice, bill neutrality is far from guaranteed.[28] Loans are transferable if the unit is sold. On-bill financing can better target rental units because the retrofit costs can be passed to the tenant through the utility bill if renters directly pay the utility, which is not always the case. Utilities need to provide upfront capital for project administration and initial loan funding.

There has been multiple successful on-bill financing for retrofit programs in Canada. Manitoba Hydro has provided $317M in loan support to 75,000 customers. A similar program has been used by Nova Scotia Power. Some jurisdictions have not found the same success, and have transitioned to third-party financing, including SaskPower and the City of Vancouver (provided through BC Hydro).[29]

Third-party financing

Both on-bill financing and local improvement charges present an alternative to loans from a traditional lending institution. In some cases, third-party financing can be advantageous, especially if an institution can provide low interest and long-term loans or bundle energy efficiency measures within a mortgage.[30] Third party loans are seen as a lower risk to utilities and local governments, both of which are institutions that are not traditionally designed to provide loans. Unfortunately, third-party lending may screen out applicants that are perceived unable to repay loans, which may overlap with properties that may benefit the most from a retrofit program. Furthermore, the disconnect between energy savings and loan costs may make it difficult for home owners to see the value and immediate savings.

Third-party financing program examples include VanCity Credit Union's Home Energy Loan, which provides a prime+1% loan to be repaid over 15 years.[31] The program is associated with BC Hydro's Home Energy Rebate Offer, presenting an interesting hybrid between commercial and utility-led lending. An example of a program currently available in Ottawa is Desjardins' Energy Efficiency Loan for businesses.[32]

Incentive Programs

Incentives are also frequently used to encourage efficiency upgrades. Incentives provide building owners non-repayable sums of money (directly or as a rebate) to purchase efficient appliances and products or to perform energy audits or recommissioning.

For the most part, the Government of Ontario has provided upfront capital to fund incentives through SaveOnEnergy, the IESO's energy conservation initiatives. Local utilities are responsible for administering IESO funding at a local scale. Table 2 describes available funding incentives in Ottawa. Many of the incentives targeted to businesses can be applied to both small and large buildings.

[28] Bardhan, A., Jafee, D., Kroll, C., Wallace, N. (2014). Energy efficiency retrofits for US Housing: Removing the bottlenecks. Regional Science and Urban Economics, 47, 45-60.
[29] Natural Resources Canada. (2016). Financing Energy Efficiency Retrofits in the Built Environment. Energy and Mines Ministers' Conference.
[30] Ibid.
[31] VanCity. Home Energy Loan. Retrieved from: https://www.vancity.com/Loans/TypesOfLoans/HomeEnergyLoan
[32] Desjardins. Energy Efficiency Loan. Retrieved from: https://www.desjardins.com/ca/business/financing-credit/long-term-financing/energy-efficiency-loan/index.jsp

Table 2. Available incentives in the province for existing small buildings.

Program Name	Target	Provider	Description
Affordability Fund	Residential	Government of Ontario	Free installations of energy saving devices for low-income households.
Home Assistance Program	Residential	IESO, utilities and GreenSaver	Free energy assessment and upgrades to low-income households and tenants.
Home Winter Proofing Program	Residential	Enbridge, Inc	Attic insulation, programmable thermostat and draft proofing provided to customers under a specified income level or on federal assistance programs.
Home Energy Conservation Program	Residential	Enbridge, Inc with Union Gas	Up to $5,000 in rebates for efficiency upgrades including heat pumps, lighting and ventilation. Requires an energy audit.
Heating and Cooling Incentive Program	Residential	IESO via SaveonEnergy	Up to $850 for furnace and air conditioning upgrades; up to $4000 for installation of a heat pump.
Business Refrigeration Incentive	Business	IESO via SaveonEnergy	Up to $2,500 for refrigeration incentives.
Small Business Lighting Incentive Program	Business	IESO via SaveOnEnergy	Up to $2,000 for efficient lighting upgrades.
Retrofit program	Business	IESO via SaveOnEnergy	Range of funding options for retrofit activities.
Ontario Energy Audit Funding	Business	IESO via SaveOnEnergy	50% of the cost of an energy audit.
Existing Building Commissioning	Business	IESO via SaveOnEnergy	Funding for chilled water systems. Generally geared towards larger buildings, but could be applied to smaller buildings.
CMHC Green Home	Residential	CMHC	Rebate of up to 25% of CMHC mortgage for homeowners who intend to retrofit new home.

Incentives are often targeted to low-income households, including the Affordability Fund and the Home Assistance Program. These programs work directly to target energy poverty, with a focus on reducing energy bills for low income households.

Retrofit incentive programs increase uptake of efficiency measures. For example, In British Columbia, the Federal ecoENERGY Retrofit Program combined with the LiveSmart BC residential incentive program reach 1% of BC homes per year, with average emissions reductions of 26% per unit.[33] In Ontario, IESO programs corresponded to energy reductions of 2,810 GWh from 2015-2016.[34] Table 3 demonstrates participation from IESO SaveOnEnergy programming in 2016.

[33] Frappe-Seneclauze, T., Heerema D., Wu, K. (2017). Deep emissions reduction in the existing building stock. The Pembina Institute.

[34] IESO. (2016). Conservation Results Report.

Table 3. IESO Save on Energy program participation relevant to existing small buildings and energy savings in 2016.

	Energy Savings (GWh)	Program Costs ($M)	Incentive Costs ($M)	Participation
Residential Sector				
Coupons	428	10	31	17,053,287 products
Heating and Cooling Incentive	76	5	33	136,617 HVAC measures
Home Assistance	8	3	7	5,066 homes
peaksaver PLUS	150 MW DR	3	6	320,158 devices
Business Sector				
Audit Funding	3	2	1	213 projects
Retrofit	567	38	102	11,190 projects
Small Business Lighting	11	3	3	2,421 projects
Existing Building Commissioning	0	1	0	0 projects
Process and System Upgrades	12	5	17	5 projects
Energy Managers	13	1	3	69 projects

While program uptake shows positive momentum, current programs have not yet reached a scale that can meaningfully contribute to emissions reductions in the existing small buildings sector. The 76 GWh of energy savings through the Heating and Cooling Incentive, displayed in Table 3, corresponds to 0.23 PJ of energy savings. In comparison, the residential sector in Ontario used 281 PJ of energy for space heating in 2015.[35]

Some see the wide range of incentive programs as a potential barrier. Although considerable funding is provided, it is spread across various jurisdictions and targets different end uses, which can lead to piecemeal uptake of retrofits.[36]

[35] Office of Energy Efficiency. (2016). Table 2: Secondary Energy Use and GHG Emissions by End use. http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=on&rn=2&page=0

[36] Sustainable Buildings Canada. (2016). Energiesprong Summary Report. Retrieved from: https://sbcanada.org/wp-content/uploads/2017/09/Energiesprong-Summary-Report.pdf

Aggregated Retrofit Programming

Scaling retrofits provides an opportunity to reach economies of scale by targeting multiple similar buildings in one retrofit.

Retrofit aggregation programs that follow the Energiesprong model are increasingly being pursued in Canada. The program was originally developed in the Netherlands and aggregates sufficient demand for retrofits to create a market demand for contractors, which can be quickly deployed using prefabricated components.

Natural Resources Canada is currently developing its Prefabricated Exterior Energy Retrofit (PEER) program. The goal of the program is to develop prefabricated building components for the residential building exteriors that can be easily installed on similar buildings. This often includes exterior cladding, switching the HVAC and other mechanical components, as well as the addition of rooftop solar. Prefabricated components reduce the cost and complexity of retrofits and can improve aesthetics.[37] Because the retrofits are externally applied, there is limited disruption to residents.

The PEER program is currently working to advance commercialization and examine costs of building components and program administration. Building associations, advocacy groups and housing associations have also showed interest in the program, including Sustainable Buildings Canada, which is spearheading the initiative in Canadian cities, including Ottawa.[38]

According to analysis by Sustainable Buildings Canada, aggregated retrofits could reduce total energy use by 50% using wall applications, with further energy reductions possible through switching HVAC systems.[39] Despite the potential benefits, aggregated retrofits are still cost prohibitive, with costs reaching approximately $144,000 per unit.[40] However, it is expected that costs will decrease as program uptake continues.

Aggregated retrofit models using pre-fabricated components are also currently targeting social and low-income housing, reducing energy spending and improving living conditions for residents.[41] Such programs work directly to tackle housing inequality and reduce energy poverty.

Retrofit requirements

In the United States, energy efficiency upgrades have been mandated through local government ordinances. For example, Boulder, Colorado's SmartRegs Ordinance requires that all rental properties meet a specified level of energy efficiency by the year 2019.[42] Although not geared to efficiency, upgrades to at-risk residential properties for seismic upgrades has been mandated in the City of Los Angeles and other cities in California. Mandatory programming can be politically risky but can influence uptake of efficiency upgrades. In Ontario, municipalities cannot pass by-laws that counteract or exceed the Ontario Building Code. However, the province is considering provisions for energy efficiency upgrades during renovations in the Ontario Building Code.[43] A key lever for encouraging retrofits in Ottawa would be through tiered building requirements similar to Toronto's Green Standard or BC's Step Code. Buildings that undergo renovations could be subject to mandatory requirements for energy efficiency and sustainable building design.

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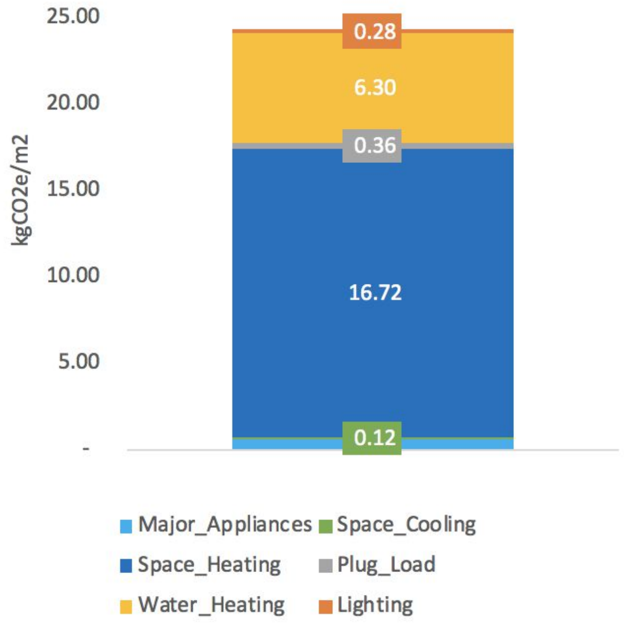
[37] Natural Resources Canada (2017). PEER Prefabricated Exterior Energy Retrofit.
[38] Ibid.
[39] Ibid.
[40] Ibid.
[41] The Pembina Institute. (2017). Affordable Housing Renewal: Retrofits at Scale.
[42] City of Boulder (2018). SmartRegs requires all licensed rental housing to meet a basic energy efficiency standard by Dec. 31, 2018. Retrieved from: https://bouldercolorado.gov/plan-develop/smartregs
[43] Government of Ontario (2017). Potential changes to Ontario's Building Code. http://cleanairpartnership.org/cac/wp-content/uploads/2017/09/MMA-Proposed-Building-Code-Energy-Efficiency-Requirements-for-Renovations.pdf

Fuel Switching

Deeper retrofits often target fuel switching to avoid energy use produced from emitting fuels such as natural gas, which is a critical component for emissions reductions in Ottawa. Propane and heating-oil are also emitting fuels in Ottawa but to a lesser extent. Natural gas is predominately used for space and water heating, which account for 94% of the GHG emissions from residential dwellings in Ottawa, as illustrated in Figure 9.

Figure 9. Average dwelling unit GHG intensity, by end use, 2016.[44]



A whole system retrofit aims to reduce the need for space and water heating through conservation measures aligned with the EnerPHit standard, but also to switch away from fossil fuel-based sources of energy. A typical pathway is to electrify heating using heat pumps, either ground source or air source to maximize the efficiency.

Policy Options for Existing Residential Buildings

Policy options are typically focused on increasing awareness and offer funding to encourage building owners to pursue energy efficiency upgrades. Such policies typically include incentives for low-flow toilets, renewable energy systems, heat pumps, building envelope upgrades, light bulb modernization, appliance upgrades, window upgrades, energy assessments, etc.

Energy Benchmarking

Energy Benchmarking refers to systematically tracking building energy use over time. This allows tracking energy reduction progress and enables comparisons between similar buildings. Greater awareness of a building's energy use, especially in relation to other buildings, can encourage property owners to take on energy efficiency and conservation work.

Generally, energy benchmarking programs are geared to large commercial, institutional or industrial buildings, although energy benchmarking principles can be applied to small residential buildings as well. Disclosure of energy use at the time of property sale is the primary benchmarking tool for

[44] Note that emissions from major appliances are hidden behind space cooling.

smaller buildings.[45] Energy disclosure provides incentive for buyers to purchase energy efficient homes or buildings by explicitly revealing operational costs of low efficiency systems. This can increase the market value of energy efficient homes, with one study estimating that energy disclosure of efficient buildings can increase the sale price by 3%.[46]

Energy benchmarking and disclosure programs can also improve the data available on energy use. Required disclosure of energy data can be analyzed in relation to retrofit activities, providing greater accuracy for property owners on the potential outcomes of retrofit activities.

Disclosure programs can include a required home energy rating system, disclosure of utility bills and disclosure of results from an energy audit.[47] Multiple cities in the United States have energy disclosure programs for residential buildings.[48] In Austin, Texas, the Energy Conservation Audit and Disclosure Ordinance requires that residential buildings older than ten years are audited with information disclosed prior to home sale, with non-compliance subject to a fine.[49] The City of Toronto and the City of Vancouver have energy benchmarking programs for large buildings, but there are no energy benchmarking programs for small buildings yet in Canada.

Announced under the Climate Change Action Plan, a residential energy disclosure program was considered in Ontario. Ontario's Home Energy Rating and Disclosure Program intended to make energy audit information mandatory during home sale and would provide funding for individuals to perform energy audits. The program has since been postponed.

Under Ontario's 2017 Long Term Energy Plan, a Green Button Program Regulation was moved forward. The proposed program would require utilities to provide customers with access to their individual energy use data by 2020.[50] Hydro Ottawa already provides Home Energy Reports, detailing monthly use summaries, a comparison of homes in the neighbourhood and tips to reduce energy.[51]

[45] Frappe-Seneclauze, T., Heerema D., Wu, K. (2017). Deep emissions reduction in the existing building stock. The Pembina Institute.
[46] Naima Canada. (2017, November 2). Home Energy Rating and disclosure Guide. Retrieved from: http://www.naimacanada.ca/home-energy-rating-disclosure-guide
[47] ACEE. (2014). Residential Energy use disclosure: a guide for policymakers. https://aceee.org/files/pdf/toolkit/residential-energy-use-disclosure.pdf
[48] Ibid.
[49]Austin Energy. energy Conservation Audit and disclosure Ordinance. Retrieved from: https://austinenergy.com/ae/energy-efficiency/ecad-ordinance/energy-conservation-audit-and-disclosure-ordinance
[50] Loewen, E. (2018, May 27). introducing the Green Button: Empowering consumers through energy data. The Atmospheric Fund. http://taf.ca/introducing-green-button-empowering-consumers-energy-data
[51] Hydro Ottawa. Home Energy Reports. Retrieved from: https://hydroottawa.com/save-energy/monitor-consumption/home-energy-reports

Section 2: Growth Projections for Existing Residential Buildings

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

Table 4. Low carbon pathway action parameters.

Action	Conservative scenario	Moderate scenario	Aggressive scenario
Retrofit older homes (pre-1980).	1% of the existing building stock is voluntarily retrofitted to a performance level in compliance with the current building code.	Achieve thermal savings of 40%; electrical savings of 25%: scale up rate of retrofits exponentially between 2020 and 2050 to 68% of the dwellings by 2050.	Achieve thermal savings of 60%; electrical savings of 50%: scale up rate of retrofits exponentially between 2020 and 2050 to 98% of the dwellings by 2050.
Retrofit newer homes (post 1980).	1% of the building stock is retrofit each year in compliance with the current building code.	Achieve thermal savings of 30%; electrical savings of 20%: scale up rate of retrofits exponentially between 2020 and 2050 to 68% of the dwellings by 2050.	Achieve thermal savings of 50%; electrical savings of 40%: scale up rate of retrofits exponentially between 2020 and 2050 to 98% of the dwellings by 2050.
Retrofits for small commercial and office buildings	1% of the existing building stock is voluntarily retrofitted to a performance level in compliance with the current building code.	Achieve thermal savings of 30%; electrical savings of 20%: scale up rate of retrofits exponentially between 2020 and 2050 to 68% of the dwellings by 2050.	Achieve thermal savings of 50%; electrical savings of 40%: scale up rate of retrofits exponentially between 2020 and 2050 to 98% of the dwellings by 2050.
Fuel Switching	10% of buildings switch from natural gas, heating-oil, and propane to air source heat pumps by 2050; 2% of buildings switch to ground source heat pumps by 2050.	30% of buildings switch from natural gas, heating-oil, and propane to air source heat pumps by 2050; 10% of buildings switch to ground source heat pumps by 2050.	60% of buildings switch from natural gas, heating-oil, and propane to air source heat pumps by 2050; 30% of buildings switch to ground source heat pumps by 2050.

Methodology

The methodology for all of the building pathways (large existing, small existing, new large, new small) follows a similar modelling methodology. A summary is shown is below.

Energy and GHG emissions are derived from a series of connected stock and flow models, evolving on the basis of current and future geographic and technology decisions/assumptions. The model accounts for physical flows such as energy use as determined by stocks such as buildings and heating equipment.

CityInSight incorporates and adapts concepts from the system dynamics approach to complex systems analysis. For any given year within its time horizon, CityInSight traces the flows and transformations of energy from sources through energy carriers such as gasoline, electricity, and hydrogen to end uses such as personal vehicle use and space heating to energy costs and to GHG emissions. An energy balance is achieved by accounting for efficiencies, conservation rates, and trade and losses at each stage in the journey from source to end use.

Residential buildings are allocated to a CityInSight zone based on its parcel location. Each building is classified by archetype, using a detailed set of 30+ building archetypes capturing footprint, height and type (single, double, row, high rise apartment, low rise apartment), in addition to year of construction. This enables a "box" model of buildings and the estimation of surface area. With this "box" model methodology, CityInSight models residential buildings as rectangular boxes with fixed aspect ratios without individual components such as doors, windows, crawl spaces, or foundations. CityInSight applies an average thermal envelope performance (thermal transmittance or U-value) to the building surface area and degree-days to calculate space conditioning energy demand independent of any particular space heating or cooling technology and fuel.

The number of dwelling units drives stock levels of key energy service technologies such as heating systems, air conditioners and water heaters. These stocks are modelled with a stock-turnover approach capturing equipment age, retirements, and additions - exposing opportunities for efficiency gains and fuel switching, but also showing the limits to the rate of new technology adoption and the effects of lock in. The energy service stocks are allocated to the energy service demand.

Residential building archetypes are also characterized by number of contained dwelling units, allowing the model to capture the energy effects of shared walls but also the urban form and transportation implications of population density.

The model multiplies the residential building surface area by an estimated thermal transmittance (heat flow per unit surface area per degree day) and the number of degree days to derive the energy transferred out of the building during winter months and into the building during summer months. The energy transferred through the building envelope, the solar gain through the building windows, and the casual heat gains from equipment inside the building constitute the space conditioning load to be provided by the heat systems and the air conditioning. The initial thermal transmittance estimate is a provincial average by dwelling type from the Canadian Energy System Simulator (CanESS), a model of the Canadian energy system.

Starting values for output energy intensities and equipment efficiencies for other residential and non-residential end uses are also provincial averages from CanESS. All parameter estimates are further adjusted during the calibration process.

Using assumptions for thermal envelope performance for each building type, the model calculates total energy demand for all buildings, independent of any particular space heating or cooling technology and fuel. Space conditioning demand is allocated to different fuel types by specified fuel shares. Efficiency by fuel type is applied to derive input energy use for space conditioning.

Total buildings energy demand, derived from the buildings box model, is calibrated against observed utility data for electricity and natural gas, provided by utilities. In the calibration process, fuel shares are adjusted to meet the ratio of electricity to natural gas energy use in a given sector. The thermal transmittance for residential building space conditioning and output energy use intensities for non-residential buildings and non-space conditioning residential end uses are then adjusted until the model estimate of electricity and natural gas use matches the observed data.

Steps in developing the scenarios for existing small buildings are as follows:

1. Place existing buildings in space in the base year, disaggregated by geographic zone, year building and building type.
2. Simulate additions to and removals from the building stock over time, as required by the population and employment projections.
3. Derive energy use in buildings according to the thermal envelope profile, energy-using stocks (appliances, equipment).
4. Disaggregate energy use by end-use and fuel type as well as building categories.
5. Calibrate projected energy use with observed energy consumption as provided by the energy utilities.
6. Apply energy use intensity targets incrementally to the existing building stock, targeting specific criteria such as age, size, use and location of buildings to represent retrofits.
7. Analyse the cost of the retrofits that achieve the energy use intensity targets.

Constraints

Heritage building status presents a minor barrier to retrofit upgrades. Under the Ontario Heritage Act, the City of Ottawa has influence over the preservation of buildings of cultural, architectural and stylistic merit. There are approximately 900 properties on Ottawa's heritage register.[52] While there are no demolition restrictions on these properties, building owners must notify the City for negotiation of building demolition or upgrades. There are also concerns that retrofits can cause a loss of building character. Programs specifically geared to heritage buildings to maintain building heritage character is a possible solution, similar to the Vancouver Heritage Foundation's Heritage Energy Retrofit Grant.[53]

In order to provide retrofits at the scale that will yield energy reductions in the City, there must be a construction and retrofit industry available to do the work. Inconsistent introduction and removal of incentives provided by higher levels of government creates instability in market demand for retrofits, and therefore is seen as risky for a contracting business to pursue training in building efficiency.[54]

There is also a lack of understanding and practical examples about how to achieve deep GHG emissions reductions and energy savings through retrofits. Initial pilot projects and research is required to support the development of retrofit pathways that are aligned with the City of Ottawa's GHG reduction targets.

Uptake of retrofits is also limited in rental housing, as most funding structures do not align benefits to landlords, who are ultimately responsible for retrofit activities. For example, LIC and third-party loan structures reduce energy bill costs, but may increase property taxes. These retrofit programs are limited in rental housing, because energy bills are frequently paid by tenants, while property taxes are covered by the property owner; this provides less incentive for landlords to take up retrofit activities because benefits are ultimately experienced by tenants. On-bill financing theoretically reduces this issue as repayment is the responsibility of the utility ratepayer, however, there is still a disconnect between who is responsible for paying for retrofits. The City of Vancouver's Green Landlord Program has examined solutions to the disconnect between landlord/tenant benefits, by providing guidance and support to landlords, and leveraging potential utility incentives.[55]

There are also behavioural limitations to retrofit uptake. In the case of retrofits, despite being presented with potential cost savings, rebates and other policy encouragements, homeowners may still choose not to perform efficiency upgrades for various reasons, including upfront capital, a lack of interest or other competing priorities. Similarly, behavioural changes to everyday activities for energy conservation is also not straightforward. Policies to encourage energy efficiency are limited because of uncertainties on consumer energy use behaviour.[56] Greater availability of real-time energy data attempts to overcome behavioural barriers by providing individuals with data to make rational decisions related to energy use.

[52] City of Ottawa. Heritage Conservation Overview. Retrieved from: https://ottawa.ca/en/city-hall/planning-and-development/heritage-conservation#overview
[53] Vancouver Heritage Foundation. Heritage Energy Retrofit Grant. Retrieved from: http://www.vancouverheritagefoundation.org/get-a-grant/heritage-energy-retrofit-grant/
[54] Frappe-Seneclauze, T., Heerema D., Wu, K. (2017). Deep emissions reduction in the existing building stock. The Pembina Institute.
[55] City of Vancouver. (2016). Building Energy Retrofit Fund: Accelerating the Implementation of the Energy Retrofit Strategy for Existing Buildings. Administrative Report RR-1c.
[56] Bardhan, A., Jafee, D., Kroll, C., Wallace, N. (2014). Energy efficiency retrofits for US Housing: Removing the bottlenecks. Regional Science and Urban Economics, 47, 45-60.

Uptake projections

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

Conservative Scenario

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

Action		Cumulative emissions reductions 2018-2050 (kt CO2eq)	Emissions reductions 2050 (kt CO2eq)	Cumulative energy reductions 2018-2050 (TJ)	Energy reductions 2050 (TJ)
Retrofit older homes (pre-1980)	1% of the building stock is retrofit each year in compliance with the current building code	1,897	112	41,983	2,540
Retrofit newer homes (post-1980)	1% of the building stock is retrofitted each year in compliance with the current building code	1,120	72	25,240	1,712

Moderate Scenario

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

Action		Cumulative emissions reductions 2018-2050 (kt CO2eq)	Emissions reductions 2050 (kt CO2eq)	Cumulative energy reductions 2018-2050 (TJ)	Energy reductions 2050 (TJ)
Retrofit older homes (pre-1980)	Scale up rate of retrofits to 68% of all dwellings by 2050; achieve thermal savings of 40%; electrical savings of 25%	1,898	148	44266	3,442
Retrofit newer homes (post-1980)	Scale up rate of retrofits to 68% of all dwellings by 2050; achieve thermal savings of 30%; electrical savings of 20%	1,457	113	35,333	2,749

Aggressive Scenario

Table 7. Energy and GHG emissions results of the aggressive existing buildings pathway.

Action		Cumulative emissions reductions 2018-2050 (kt CO2eq)	Emissions reductions 2050 (kt CO2eq)	Cumulative energy reductions 2018-2050 (TJ)	Energy reductions 2050 (TJ)
Retrofit older homes (pre-1980)	Scale up rate of retrofits to 98% of all dwellings by 2050; achieve thermal savings of 60%; electrical savings of 50%	3,637	313	86,476	7,477
Retrofit newer homes (post-1980)	Scale up rate of retrofits to 98% of all dwellings by 2050; achieve thermal savings of 50%; electrical savings of 40%	3,708	317	91,974	7,921

Opportunities to advance this pathway

To move forward with reducing energy use and emissions from large existing buildings, the City of Ottawa and its partners may consider the following actions:

1. Undertake pilot projects on deep retrofits for small buildings in coordination with colleges, NRCan, universities and industry.
2. Develop a whole systems approach to a program for retrofits including audits, financing and implementation that can support building owners or homeowners in undertaking projects with minimal logistical considerations.
3. Develop a retrofitting strategy based on prioritizing of measures and the avoidance of lock-in
4. Ensure that non-energy related renovations oblige a property owner to undertake energy and emissions retrofits
5. Ensure retrofits integrate fuel switching to electricity and renewable energy installation.
6. Provide incentives for deep retrofits such as expedited building approvals or financial contributions in coordination with utilities.

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