GMF Municipal Energy Roadmap

A guide to help Canadian municipalities prioritize and tackle deep greenhouse gas emissions reductions in municipal and community buildings.
Acknowledgements

The Federation of Canadian Municipalities (FCM) acknowledges the expertise and professionalism provided by Dunsky Energy Consulting in leading the development of this guide.

FCM thanks the project advisory panel, which consisted of senior representatives from C40, QUEST, The Natural Step and Urban Equation, along with representatives from the Government of Canada and Ontario’s Independent Electricity System Operator (IESO), for their peer review of the solution and strategy factsheets.

This guide was made possible through FCM’s Green Municipal Fund (GMF), which supports initiatives that advance innovative solutions to environmental challenges. These projects improve air, water and land quality, reduce greenhouse gas emissions, and generate economic and social benefits for local communities. Through GMF, municipalities share lessons learned and successful new models for advancing sustainability in communities of all sizes in all regions across Canada. GMF is a $1 billion program, delivered by the Federation of Canadian Municipalities and funded by the Government of Canada.

© 2020 Federation of Canadian Municipalities. All rights reserved.
24 Clarence Street
Ottawa, Ontario K1N 5P3
www.fcm.ca
Executive summary

The energy sector challenge and opportunity

The way energy is produced, distributed and used is critical to the economic, social and environmental well-being of our communities. We depend on a safe, reliable and affordable supply of energy to power our homes and businesses and to get around. However, energy costs can account for a significant portion of municipal and community-wide spending, reducing funds for other municipal services and putting pressure on residents and business owners who can least afford it.

Energy also accounts for a significant percentage of Canada’s greenhouse gas (GHG) emissions. Energy use in municipal, residential and commercial buildings alone represents 17% of Canada’s GHG emissions. With climate change placing new, complex pressures on our communities, local governments are seeking cost-effective ways to reduce GHG emissions and mitigate the impacts of climate change, while also ensuring a good quality of life for current and future residents.

Fortunately, addressing these challenges represents a tremendous opportunity to advance a number of community priorities and support long-term economic development. Municipalities have significant control or influence over how energy is used in buildings and can create or support local opportunities to produce renewable energy. By working with residents, businesses and other stakeholders, municipalities can harness these local energy opportunities to create jobs, lead economic recovery, and significantly improve the affordability and attractiveness of their communities and the quality of life for residents, while also improving their environmental footprint and tackling climate change.

But identifying the right energy and climate change solutions for communities can be challenging. This roadmap is the first in a series of municipal sector reports that aims to help Canadian municipalities identify the most promising sustainability solutions for their local context. It helps municipalities move toward a clean energy future, serves as a decision support tool, and helps municipalities access the necessary guidance and resources along the path to implementation. Through this roadmap, FCM aims to provide guidance to municipalities on where to invest precious time and resources to achieve the biggest benefits for their communities.

Solutions and strategies

This roadmap dives into eight solutions for clean energy and energy efficiency in municipal, commercial and residential buildings (new and existing), and two solutions for community clean energy generation. It also explores five strategies, or policy and program options, to drive these solutions forward.
The solutions and strategies covered in this roadmap represent a menu of options that Canadian municipalities can start implementing right away to have the biggest possible impact on reducing GHG emissions over the next decade. They were selected based on the current state of energy infrastructure and technologies across Canada, as well as the key levers municipalities can use to implement or enable energy efficiency and low-carbon energy sources. To support municipal decision-making, the roadmap includes high-level estimates of the GHG and financial impacts that could be achieved from implementing these solutions at the building scale under current market conditions\(^1\). Importantly, the environmental impact and the cost-effectiveness of each solution will vary locally based on a number of factors, including local climate, the types of heating fuels used, local energy prices and existing incentive programs. Each municipality should take these local factors into account and conduct specific feasibility studies when assessing whether a given solution is right for its community.

\(^1\) The GHG and financial impacts were estimated using data accessed in March 2019.
Key solutions by grid type

This roadmap provides information on the impacts and benefits of building-level solutions based on the carbon intensity of the electricity grid.² Broadly speaking, the carbon intensity of the grid in different provinces and territories can be categorized as follows:

- Low-carbon grid (BC, MB, ON, QC, NL, YT)³
- Moderate-carbon grid (NB, NT, PE)⁴
- High-carbon grid (AB, NS, NU, SK)⁵

Depending on the grid type, certain solutions may be more or less impactful in reducing GHG emissions than others:

**Energy efficiency:** Measures that improve energy efficiency offer a promising approach to reducing emissions across all grid types. The potential impact of energy efficiency is especially high in municipal indoor ice rinks in all provinces and territories. The large amounts of energy used by these facilities can be reduced through energy-efficiency improvements that can be made while doing required upgrades.

**Renewable energy generation:** Generating electricity from renewable sources, such as rooftop solar panels, has the greatest potential to reduce emissions in areas with moderate- and high-carbon grids, with the greatest impact in areas with high-carbon grids.

**Electrification:** Switching from fossil fuels to electricity for space and water heating has the greatest potential to reduce emissions in areas with moderate- and low-carbon grids, with the greatest impact in areas with low-carbon grids. On the other hand, electrifying heating will generally increase GHG emissions in provinces and territories with high-carbon grids, under current conditions. The long-term impact of electrification will depend on how large-scale electricity generation changes over the coming decade and whether more low-carbon energy sources are added to the grid.

---

² Carbon intensity is based on how much CO₂e is produced per kilowatt hour of electricity consumed.
³ A low-carbon grid emits less than 80 gCO₂e/kWh, which is roughly equivalent to less than 10 percent of electricity generation coming from fossil fuels.
⁴ A moderate-carbon grid emits 80-420 gCO₂e/kWh, which is roughly equivalent to 10-50 percent of electricity generation coming from fossil fuels.
⁵ A high-carbon grid emits more than 420 gCO₂e/kWh, which is roughly equivalent to more than 50 percent of electricity generation coming from fossil fuels.
Why is grid carbon intensity important?

The carbon intensity of electricity is a measure of how much CO₂e is produced per kilowatt hour of electricity consumed. It currently differs significantly by province or territory because of the different sources used to generate electricity. The carbon intensity of the electricity grid is the key driving factor when it comes to choosing technology solutions for reducing greenhouse gas emissions in buildings, for two main reasons:

1. **It determines the impact of electrification on GHG emissions.**
   In areas with very low-carbon grids, electrification (i.e. switching from fossil fuels to electricity) can virtually eliminate GHG emissions, whereas in areas with high-carbon grids, electrification can actually increase GHG emissions because the carbon intensity of electricity in these areas is greater than the carbon intensity of oil and gas.

2. **It determines which end uses produce significant GHG emissions and, therefore, which end uses are worth focusing on.**
   End uses that only use electricity (such as plug loads, lighting, auxiliary motors and space cooling) are important contributors to emissions in areas with high-carbon grids but hardly contribute to emissions in areas with low-carbon grids.

---

6 Current provincial/territorial figures reflect 2017 grid intensities, which may undergo significant change over the coming years (e.g. as there is an increasing shift to non-emitting sources of electricity).
Low-carbon grid
(BC, MB, ON, QC, NL, YT)
A municipality falls into this group if 90 percent or more of its electricity is generated using low-carbon sources, namely renewables or nuclear. For this grid type, space heating generally represents the vast majority of emissions from residential and commercial buildings, followed by water heating. For both space heating and water heating end uses, natural gas and heating oil are the main energy sources contributing to emissions.

Municipalities in areas with low-carbon grids should focus on reducing fossil fuel consumption in buildings, primarily through electrification (i.e. switching from fossil fuels to electricity) and, to a lesser extent, energy efficiency when using oil or gas for space and water heating.

Relevant solutions include:
- High-efficiency indoor ice rinks
- Heat pumps replacing gas or oil
- Building envelope upgrades
- Improved HVAC controls
- Low-carbon water heating

Significant GHG reductions may also be realized through community-level solutions—namely, district energy systems—in municipalities where heating systems are reliant on fossil fuels. Community wind and solar energy generation is not a priority from a GHG perspective in areas with low-carbon grids, but this solution may be important for reducing demand on the grid (which will be critical as these municipalities move toward increased electrification). It can also lead to other key co-benefits, such as keeping energy dollars in the community, increasing economic development, and enhancing climate resilience.

Moderate-carbon grid
(NB, NT, PE)
A municipality falls into this group if 50–90 percent of its electricity is generated using low-carbon sources, namely renewables or nuclear. In commercial buildings, space heating, plug loads, lighting, and space cooling generally account for the majority of GHG emissions, while in the residential sector, space heating, plug loads and water heating are the primary emissions contributors. For both space heating and water heating end uses, electricity and oil are the main energy sources contributing to emissions in areas with this grid type, with natural gas hardly used (and not even available in many municipalities).

Municipalities in areas with moderate-carbon grids should focus on heat pumps, energy efficiency in space and water heating, high-efficiency lighting, and rooftop solar PV.

Relevant solutions include:
- High-efficiency indoor ice rinks
- Heat pumps replacing gas or oil
- Heat pumps replacing electric resistance
- Building envelope upgrades
- Improved HVAC controls
- Low-carbon water heating
- High-efficiency lighting and reduced plug loads
- Rooftop solar PV

Significant GHG reductions, as well as other important co-benefits, may also be realized through community-level solutions—namely, district energy systems and wind and solar energy generation.
**High-carbon grid (AB, NS, NU, SK)**

A municipality falls into this group if less than 50 percent of its electricity is generated using low-carbon sources, namely renewables or nuclear. Across all buildings, space heating and plug loads generally account for the majority of emissions. Lighting is another major contributor in the commercial sector, as is water heating in the residential sector.

Municipalities in areas with high-carbon grids should focus on energy efficiency and rooftop solar PV. Energy-efficiency solutions that reduce electricity consumption will have a particularly high impact. The carbon intensity of electricity in this grid type is significantly higher than that of gas or oil, so electrification options will typically increase GHG emissions—except where electricity-based technologies are exceptionally efficient.

**Relevant solutions include:**

- High-efficiency indoor ice rinks
- Heat pumps replacing gas or oil
- Heat pumps replacing electric resistance
- Building envelope upgrades
- Improved HVAC controls
- High-efficiency lighting and reduced plug loads
- Rooftop solar PV

Significant GHG reductions may also be realized by municipalities in areas with this grid type through community-level solutions—namely, district energy systems and wind and solar energy generation.

---

7 Oil has a carbon intensity of about 250 gCO₂e/kWh, while gas has a carbon intensity of about 180 gCO₂e/kWh. This compares to electricity carbon intensities of between 710 and 800 gCO₂e/kWh across provinces/territories in this grid category.

---

**Strategies to drive solutions forward**

Municipalities can leverage a range of policies and programs to help encourage adoption of high-impact solutions to reduce energy use and GHG emissions across municipal, residential and commercial buildings, and even improve social equity. Because municipalities have control over their own buildings and operations, making improvements in municipal buildings is a logical first step, but will not alone lead to GHG emissions reductions at scale. Five key strategies are considered in this roadmap:

1. **Lead by example:** Municipalities can lead by implementing policies and demonstrating the practices they want to encourage. Specific actions include adopting building energy performance standards, policies and practices in buildings they own or lease, benchmarking the energy performance of municipal buildings and showcasing innovative clean energy and energy-efficiency projects.

2. **Incentive programs:** Incentive programs offer support (financial and non-financial) to reduce costs for participants and improve the business case for energy-efficiency or clean energy solutions. Municipalities can offer various types of incentives, including discounts and rebates, tax credits, training and other services.

3. **Financing options:** Financing options support the adoption of efficient, clean energy technologies by addressing market barriers and increasing access to low-cost, long-term capital. For improvements in buildings within the community, municipalities can use several tools to offer financing, such as Property Assessed Clean Energy (PACE) and on-bill financing, or support third-party
financing. They can also access third-party financing for improvements in their own buildings.

4. **Home/building energy rating and disclosure (HERD/BERD):** These strategies help transform the market over the long term by providing energy performance information to home and building owners, managers, buyers and renters. Municipalities can enact voluntary or mandatory HERD/BERD policies or support provincial/territorial or federal programs.

5. **Local development policies and bylaws:** Municipalities can use policies and bylaws to promote or require improved design and construction or to expand the use of clean energy and efficient technologies in homes and buildings within their communities.

There is no one-size-fits-all approach for selecting or sequencing policies and strategies across municipalities. For example, some municipalities may offer rebate programs to incentivize the adoption of certain technologies, while others may use their tax collection system to de-risk loans for home energy improvements—and others may do both simultaneously. For some, these solutions may be impractical, and their communities may be more open to bylaws that tie local permits for new construction or major retrofits to recognized buildings standards.

**Moving forward**

This roadmap provides the foundations for municipal action on clean and efficient energy—but it is only the first step. Each municipality will need to undertake further analysis to determine whether a given solution or strategy is right for its community, based on local ambition to tackle climate change, financial feasibility and other community priorities. FCM offers funding, as well as tools and resources, to help municipalities validate and implement the right solutions for their communities.

- Learn more about FCM’s funding opportunities
- Learn more about resources for municipalities

Additionally, technology solutions in the energy sector are constantly evolving. New innovations, along with changes to the economic context and the energy and climate change policies adopted by other orders of government, will affect which solutions municipalities should prioritize in the future. FCM will endeavour to update the roadmap over time to reflect this changing landscape.

While energy is no doubt one of the most critical areas for addressing emissions and sustainability, it is not the only one. This roadmap will be followed by other municipal sector roadmaps—addressing transportation, land use, water and waste—that will similarly support municipalities across Canada in identifying the most promising options for clean, sustainable, healthy and vibrant communities.

---

8 FCM offers grants and loans to help plan, refine and scale-up innovative financing programs for residential retrofits. Learn more about how FCM can support municipal financing programs.
# Table of contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive summary</td>
<td>iii</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Developing this roadmap</td>
<td>2</td>
</tr>
<tr>
<td>Limitations</td>
<td>2</td>
</tr>
<tr>
<td>PART 1</td>
<td></td>
</tr>
<tr>
<td>Why use this roadmap?</td>
<td>4</td>
</tr>
<tr>
<td>The need for this roadmap</td>
<td>5</td>
</tr>
<tr>
<td>The energy sector challenge and opportunity</td>
<td>5</td>
</tr>
<tr>
<td>What municipalities are doing</td>
<td>7</td>
</tr>
<tr>
<td>Use this roadmap to start where you are</td>
<td>8</td>
</tr>
<tr>
<td>How this roadmap can help</td>
<td>9</td>
</tr>
<tr>
<td>Energy solutions and key strategies to drive them forward</td>
<td>9</td>
</tr>
<tr>
<td>What’s covered in this roadmap?</td>
<td>9</td>
</tr>
<tr>
<td>PART 2</td>
<td></td>
</tr>
<tr>
<td>Prioritize your solutions</td>
<td>16</td>
</tr>
<tr>
<td>How to use this roadmap</td>
<td>17</td>
</tr>
<tr>
<td>Key solutions for reducing building emissions</td>
<td>18</td>
</tr>
<tr>
<td>How to find solutions for your municipality</td>
<td>18</td>
</tr>
<tr>
<td>Key building-level solutions:</td>
<td></td>
</tr>
<tr>
<td>Low-carbon grids:</td>
<td></td>
</tr>
<tr>
<td>(BC, MB, ON, QC, NL, YT)</td>
<td>20</td>
</tr>
<tr>
<td>Key building-level solutions:</td>
<td></td>
</tr>
<tr>
<td>Moderate-carbon grids:</td>
<td></td>
</tr>
<tr>
<td>(NB, NT, PE)</td>
<td>26</td>
</tr>
<tr>
<td>Key building-level solutions:</td>
<td></td>
</tr>
<tr>
<td>High-carbon grids:</td>
<td></td>
</tr>
<tr>
<td>(AB, NS, NU, SK)</td>
<td>32</td>
</tr>
<tr>
<td>Key solutions for community energy generation</td>
<td>39</td>
</tr>
<tr>
<td>Strategies for driving solutions forward</td>
<td>42</td>
</tr>
<tr>
<td>PART 3</td>
<td></td>
</tr>
<tr>
<td>Factsheets for moving forward</td>
<td>50</td>
</tr>
<tr>
<td>BUILDING-LEVEL SOLUTION</td>
<td>51</td>
</tr>
<tr>
<td>Heat pumps replacing gas or oil</td>
<td>51</td>
</tr>
<tr>
<td>Heat pumps replacing electric resistance</td>
<td>68</td>
</tr>
<tr>
<td>Building envelope upgrades</td>
<td>83</td>
</tr>
<tr>
<td>Improved HVAC controls</td>
<td>100</td>
</tr>
<tr>
<td>Low-carbon water heating</td>
<td>115</td>
</tr>
<tr>
<td>High-efficiency lighting and reduced plug loads</td>
<td>134</td>
</tr>
<tr>
<td>Rooftop solar PV</td>
<td>147</td>
</tr>
<tr>
<td>High-efficiency indoor ice rinks</td>
<td>161</td>
</tr>
<tr>
<td>COMMUNITY-LEVEL SOLUTION</td>
<td>174</td>
</tr>
<tr>
<td>District energy systems</td>
<td>174</td>
</tr>
<tr>
<td>Wind and solar energy generation.............................................</td>
<td>189</td>
</tr>
<tr>
<td>STRATEGY</td>
<td>202</td>
</tr>
<tr>
<td>Lead by example</td>
<td>202</td>
</tr>
<tr>
<td>Incentive programs</td>
<td>216</td>
</tr>
<tr>
<td>Financing options</td>
<td>228</td>
</tr>
<tr>
<td>Home/building energy rating and disclosure</td>
<td>242</td>
</tr>
<tr>
<td>Local development policies and bylaws</td>
<td>259</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>270</td>
</tr>
<tr>
<td>Appendix A: Building-level analytics</td>
<td>271</td>
</tr>
<tr>
<td>Appendix B: Provincial/territorial data inputs</td>
<td>276</td>
</tr>
<tr>
<td>Appendix C: Additional guides and resources for implementation</td>
<td>279</td>
</tr>
</tbody>
</table>
Introduction

This is the first in a series of municipal sector roadmaps that aims to help Canadian municipalities identify the most promising sustainability solutions for their local context.

It has several objectives:

• Help Canadian municipalities take action toward a clean energy future by reducing energy consumption and increasing energy efficiency in municipal, commercial and residential buildings, and by transitioning to clean energy sources.

• Serve as a decision support tool to help municipalities—particularly those that are most resource-constrained—prioritize critical and impactful activities between now and 2030 that are aligned with their broader corporate and community objectives.

• Help municipalities access the necessary guidance and resources along the path to implementation.

Recognizing the great diversity across Canadian municipalities—in terms of population, size, geography, growth projection, climate ambitions and other characteristics—this roadmap is designed to provide useful information and resources for all, to help municipalities prioritize actions and take the next steps. It is designed to meet municipalities where they are and help them get where they want to go.

The roadmap dives into eight clean energy solutions for municipal, commercial and residential buildings (new and existing), and two solutions for community clean energy generation. It also explores five strategies, or policy and program options, to spur adoption of these solutions and even drive social equity.

If you are in this group or want to learn more about your municipality’s options in the energy sector, you can use this roadmap as a practical tool to prioritize solutions and start on the path to planning and implementation. It is organized into three sections:

Part 1: Why use this roadmap?

• Review the high-level energy sector challenges and opportunities.

• Understand how this roadmap can help your municipality move toward a clean, sustainable energy future.

• Learn how this roadmap was developed, and its key limitations.

Part 2: Prioritize your solutions

• Building-level solutions:
  • Prioritize solutions for municipal, commercial and residential buildings in your municipality, based on GHG impact, financial impact, co-benefits, and municipal strategies to drive solutions forward.
• **Community-level solutions:**
  • Explore options for community energy generation, to understand when they are good solutions, what their key advantages and challenges are, and what the various pathways are for municipal intervention.

• **Strategies to drive solutions forward:**
  • Review the key advantages and challenges of different strategies for driving priority solutions forward, to identify which strategies may be right for your municipality.

---

**Part 3: Factsheets for moving forward**

• Once you’ve identified the solutions and strategies that are of interest to your municipality, consult the relevant factsheets to dive deeper. Each factsheet explains what the solution or strategy is and how it works, outlines key steps for implementation, assesses its GHG and financial impacts, lists the key co-benefits, and provides case studies and resources to help you learn more.

---

**Developing this roadmap**

In developing this roadmap, FCM made a significant effort to ensure that the end product would meet the needs of municipalities and offer information that is robust and technically accurate.

To this end, FCM conducted numerous stakeholder workshops to advise on and validate the scoping, framing, format and content of this roadmap. This included consultation with over 100 municipal representatives and other stakeholders across all regions of the country:

• More than 40 scoping consultations with diverse stakeholders in early 2018

• Three online stakeholder workshops, including more than 15 municipal representatives from across Canada, in December 2018

• One in-person workshop in Montreal, QC, including more than 20 participants from all orders of government, academia, NGOs and industry, in March 2019

• One online stakeholder workshop, including eight municipal representatives from across Canada, in April 2019

In addition, a project advisory panel, which consisted of senior representatives from C40, QUEST, The Natural Step and Urban Equation, provided valuable input throughout the process of developing the roadmap.

Finally, to ensure technical rigor and accuracy, representatives from the Government of Canada and Ontario’s Independent Electricity System Operator (IESO) peer-reviewed the solution and strategy factsheets.

---

**Limitations**

This roadmap provides the foundation for actions, but it should not be used on its own to identify and implement the most appropriate solutions. Additional analysis of key options (e.g. feasibility studies) will be needed by each municipality prior to implementation. Municipalities should consider the triple bottom line benefits and risks of implementing different solutions, including potential impacts on the cost of energy and the reliability of the energy supply for residents and businesses.
In addition, when using this roadmap, bear in mind the following important exclusions and limitations:

- This analysis focuses only on the most impactful building-level technology solutions within each end use from a GHG perspective, using a simplified analytical approach to quantify the GHG and financial impacts associated with each solution (see Appendix A for more details). Certain types of municipal facilities, particularly water and wastewater treatment plants, are important users of energy and represent opportunities for energy-efficiency improvements, but are not analyzed in this roadmap.

- The solutions covered in this roadmap are based on a point-in-time analysis and represent what municipalities can start doing now to have the biggest impact on reducing GHG emissions over the next decade. Because the technology landscape is constantly evolving, other high-impact solutions may arise in the future. The roadmap also does not account for any changes to the carbon intensity of electricity grids or fluctuations in energy prices, including the impact of future carbon pricing. FCM will endeavour to update the roadmap over time to reflect this changing landscape.

- Certain municipalities, such as northern and remote communities, may have unique challenges that should be considered in prioritizing solutions. These challenges may include the availability and cost of technologies or contractors and the resilience of the local electricity grid and are not covered explicitly in this roadmap.

- While the focus of this roadmap is on technology solutions, FCM recognizes that energy analysis, conservation and demand management are also crucial elements in reducing energy consumption, cost and GHG emissions. When planning energy-efficiency improvements, the most cost-effective and least complex approach is to first reduce energy use (through energy analysis, conservation and efficiency) before adding renewable energy to meet the remaining energy demand. Other factors that can affect building energy performance, like building design, site selection, building orientation, integrated design processes, and operations and maintenance, are also important to consider but are not addressed in depth in this roadmap.

- While municipalities have the opportunity to lead the way on energy solutions, they shouldn’t go at it alone. Municipalities are uniquely positioned to convene multiple stakeholders who play a role in advancing energy efficiency and renewable energy, such as building developers and contractors, energy utilities and service providers, and residents and businesses. Stakeholder engagement and awareness raising are key strategies that should accompany any municipal actions in order to achieve the best possible outcomes. Such strategies are noted across the various factsheets, with further resources provided in Appendix C, but they are not covered in depth as stand-alone factsheets.

- Recognizing that funding for municipal projects will be a key consideration in deciding which projects to pursue, the factsheets encourage municipalities to explore potential GMF funding opportunities where relevant; but federal, provincial/territorial and other funding sources are not summarized here given the quickly changing landscape.
PART 1
Why use this roadmap?
The need for this roadmap

The energy sector challenge and opportunity

Energy provides the foundation for our modern lives. It powers the municipal facilities and fleets that deliver the services residents depend on. It lights up, heats and cools homes and businesses and helps us get around efficiently. But unless there’s a major interruption in service, we often don’t consider how energy is produced, used and distributed within our communities. Yet these considerations are critical to our communities’ economic, social and environmental well-being.

How so? Consider this:

- **Energy is an economic issue, as it accounts for a significant amount of municipal and community-wide resources.** Municipal corporate expenditures on energy can range from $700,000 to $24.5 million per year, while community-wide annual expenditures on energy can be multiple billions of dollars (see the table, “Average annual local government energy expenditures”). Saving energy will reduce these expenditures, while increasing the amount of energy generated locally will ensure that energy dollars stay within the community.

- **Energy is a social equity issue, with some of the highest energy costs borne by those who can least afford it.** More than 80 percent of homes in Canada were built in or before 2005. These typical Canadian homes consume about 20 percent more energy than energy-efficient homes built today—costing residents on average as much as $300 per year more on their utility bills. This additional cost is particularly burdensome for the roughly 20 percent of Canadian households that are “energy poor” (i.e. approximately 2.8 million households), who are often forced to compromise their home comfort, health and basic dignity as a result.

### Average annual local government energy expenditures

<table>
<thead>
<tr>
<th>Population</th>
<th>Municipal corporate energy expenditures ($)</th>
<th>Community-wide energy expenditures ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–9,999</td>
<td>700,000</td>
<td>12 million</td>
</tr>
<tr>
<td>10,000–49,999</td>
<td>1.6 million</td>
<td>71 million</td>
</tr>
<tr>
<td>50,000–99,999</td>
<td>2.3 million</td>
<td>243 million</td>
</tr>
<tr>
<td>100,000–299,999</td>
<td>12 million</td>
<td>780 million</td>
</tr>
<tr>
<td>300,000+</td>
<td>24.5 million</td>
<td>2.7 billion</td>
</tr>
</tbody>
</table>

Source: Partners for Climate Protection (PCP), *National Measures Report 2015*

---

9 Natural Resources Canada, Comprehensive Energy Use Database, Residential Sector, Canada, Table 9.
10 For new homes built to the latest standard for an ENERGY STAR® certified home. See Natural Resources Canada’s web page, ENERGY STAR® Certified Homes.
11 “Energy poverty” is defined here as spending 10 percent or more of one’s gross income on energy costs, including energy used within the home as well as gasoline (based on 2013 data from the Fraser Institute’s 2016 study, Energy Costs and Canadian Households: How Much Are We Spending?).
• **Energy is a climate issue, as it accounts for over 80 percent of Canada’s national greenhouse gas (GHG) emissions.** Even with renewable energy generation increasing across the country, fossil fuels made up 76 percent of Canada’s total primary energy supply in 2017. Energy emissions from buildings alone—including municipal, residential and commercial buildings, over which municipalities have direct control or influence either through ownership or through policies and programs—account for 17 percent of national emissions.

• **Energy is a resilience issue, as our buildings and entire energy systems are impacted by climate change.** Airtight buildings can maintain more comfortable conditions during extended blackouts (when no heating or cooling is functional)—which are becoming more frequent due to extreme weather events. Climate change is also affecting energy consumption and supply. For example, more intense heat waves are increasingly forcing us to rely on air conditioners, while extreme weather events are increasingly interrupting our energy supply. Renewable energy generation systems, such as solar PV and wind, can improve community resiliency by providing power to critical infrastructure during grid interruptions. This can be achieved by implementing systems with energy storage and designing a microgrid that can be disconnected from the grid during outages.

• **Energy is a health issue, as our use of fossil fuels compromises local air quality.** The burning of fossil fuels doesn’t only release greenhouse gases that contribute to climate change; it also releases particulates, sulfur dioxide gas, and other compounds that can be harmful to human health.

---

**The climate imperative**

As climate change places new, complex pressures on communities, it will challenge the ability of local governments to ensure a good quality of life for current and future residents. From increases in extreme weather events, to heavier precipitation and flooding, more damaging wildfire seasons, and more destructive storms—these impacts will continue to intensify and grow ever more costly for municipal, provincial, and national governments.

The Paris Agreement aims to limit the most severe, unmanageable impacts of climate change by quickly capping the escalation of global CO₂ emissions and reducing them to net-zero by mid-century. Under this agreement, Canada has committed to reducing its GHG emissions by 30 percent below 2005 levels by 2030, and has adopted the Pan-Canadian Framework on Clean Growth and Climate Change to achieve this target. Beyond 2030, the federal government has committed to set Canada on a course to net-zero GHG emissions by 2050, with legislation that will establish interim GHG reduction targets every five years along the way. But while the effectiveness of these actions has already been demonstrated through significant GHG emissions reductions, we are currently projected to fall about 10 percent below our 2030 target.

To improve this trajectory, energy efficiency alone will not be enough. Our energy supply must be decarbonized by increasing the proportion of electricity generated from renewable energy sources and switching to cleaner heating fuels. To get us there, deeper, more concerted action is needed by all orders of government—including municipalities.

---

14 For more information on the Paris Agreement commitments, see the 2018 blog post by the World Resources Institute, [“8 Things You Need to Know About the IPCC 1.5°C Report”](https://www.wri.org/blog/2018/04/8-things-you-need-know-about-ipcc-15c-report).
Fortunately, addressing these challenges represents a tremendous opportunity. Municipalities can target energy sector solutions to drive a wide range of local development objectives. For example:

- A well-built or retrofitted home will reduce energy costs for owners and tenants and keep residents more comfortable throughout the year.
- A program to retrofit older homes will increase business for the local construction industry, generating jobs and keeping dollars circulating in the local economy.
- Renewable energy projects can improve air quality and increase local revenue generation, while also providing backup power during outages.
- Well-designed community energy-efficiency and clean energy programs can support the most vulnerable members of the community and improve social equity.
- An upgraded arena with improved lighting and maintenance is more enjoyable for municipal residents and costs less to run on an annual basis.
- Energy cost savings realized through energy-efficiency improvements in municipal buildings can help to alleviate budget constraints and can be redirected toward other municipal priorities.

By harnessing these local energy opportunities, municipalities can significantly improve the affordability and attractiveness of their communities and the quality of life for residents, while also improving their environmental footprint and tackling climate change.

What municipalities are doing

Already, Canadian municipalities of all shapes and sizes have begun to leverage these opportunities, with many accessing funding and capacity building from FCM’s Green Municipal Fund to study, pilot and implement energy projects. More than 450 municipalities have joined FCM’s and ICLEI Canada’s Partners for Climate Protection (PCP) program and are leading the way toward a clean energy transition. Here are some shining examples:

- The Town of Bridgewater, NS (population ~8,500), is leading a community-wide initiative to achieve a clean and affordable energy economy. The town’s Community Energy Investment Plan identifies a $374M investment opportunity to achieve an energy shift by 2050, which will save the community over $2B in energy costs between 2018 and 2050, create 3,700 person-years of employment, and reduce GHG emissions by 80 percent by 2050 compared to 2011 levels. For Bridgewater, the energy shift is seen as a local economic development strategy and an opportunity to reduce energy poverty.15,16

- The City of Victoria, BC (population ~92,000), developed its Climate Leadership Plan outlining the city’s path to transition to 100 percent renewable energy and reduce GHG emissions by 80 percent compared to 2007 levels by 2050.17 The plan targets community-wide buildings and municipal operations (among other sectors) and seeks to maximize the city’s resilience by enhancing infrastructure and ecosystems. In addition, it is expected to deliver financial, environmental and social benefits across the community—like better air quality, less noise, reduced traffic congestion, increased building comfort, healthier and more active lifestyles, new jobs, and more independent and affordable energy choices.

---

15 For more information, see the Energize Bridgewater website.
16 Federation of Canadian Municipalities, "Case study: Helping Bridgewater, NS, take the lead on sustainability."
17 City of Victoria, City of Victoria Climate Leadership Plan, 2018.
• The City of Toronto, ON (population ~2.93 million), developed a climate action plan aiming to reduce building emissions by 80 percent compared to 1990 levels by 2050—including measures to ease strain on its energy infrastructure, improve resilience to power outages, and increase job creation and investment in the local economy.18 With more than 20 years of experience reducing energy consumption and GHGs in municipal operations, the city continues to raise the bar on environmental action, having achieved its 2020 GHG reduction target ahead of schedule. It’s due, in part, to successful community programs like the Better Buildings Partnership—a program that provides building owners, managers and developers in Toronto with the expertise, resources and financial assistance to retrofit existing buildings and make new buildings more energy-efficient. Likewise, The Atmospheric Fund’s TowerWise program is successfully accelerating deep energy and emissions retrofits across the multi-unit residential building sector, achieving 20–30 percent energy and carbon savings, while substantially improving comfort and air quality for building residents and creating employment opportunities.

Use this roadmap to start where you are

Identifying the right energy and climate change solutions can be challenging. Limited financial and human resources, competing political priorities, lack of technical knowledge on how to achieve targets, and low confidence in policy support from provincial/territorial and federal governments can impede municipal efforts.

Through consulting with municipal representatives, FCM has heard that municipalities are seeking guidance on where to invest precious time and resources to achieve the biggest benefits for their communities. This roadmap can help.

Great care was taken to develop this roadmap such that it meets municipalities where they are and helps get them where they want to go. This roadmap recognizes the diversity across Canadian municipalities—in terms of factors like population, size, geography and climate ambitions—and aims to provide useful information and resources to help all municipalities prioritize actions and take the next steps.

18 City of Toronto, TransformTO.
How this roadmap can help

Energy solutions and key strategies to drive them forward

This roadmap can help municipalities identify where to target their efforts in the energy sector, by distilling the most impactful solutions for achieving GHG reductions across the commercial and residential sectors and in municipal buildings. The analysis focuses on the technologies that will matter most for municipalities across key end uses—including space heating, water heating, lighting, plug loads and space cooling in both new and existing buildings. For each solution, the roadmap reveals where further opportunities lie to strengthen climate resilience and secure other community benefits, and how those benefits can impact which solutions are prioritized.

To help municipalities drive the most impactful solutions forward, this roadmap outlines key strategies such as incentives, financing, bylaws and disclosure requirements. These policy and program levers can help move the needle on adoption, and can even improve social equity.

What’s covered in this roadmap?

Time frame
Due to the long life of buildings, heating and cooling equipment, and power generation assets, the decisions made today will determine our ability to meet both short- and long-term GHG targets. This roadmap focuses on achieving deep GHG emissions reductions and maximizing local development priorities between now and 2030, to get us on path to achieving net-zero emissions by 2050.

2020 → 2030 → 2050

Scope
This municipal energy roadmap looks at how municipalities can manage their own operations and influence their communities to reduce GHG emissions and maximize local benefits. In particular, it looks at measures for municipalities to enhance energy efficiency in new and existing buildings (municipal, commercial and residential) and use low-carbon electricity in place of other energy sources. Opportunities for climate protection and enhanced sustainability through other sectors—transportation, land use, water and waste—are beyond the scope of this roadmap.

Figure 1: Roadmap scope
Solutions and strategies
This roadmap dives deep into eight solutions targeting buildings (new and existing) and two solutions targeting community clean energy generation. To drive these solutions forward, the roadmap also explores five strategies (policy and program options), as shown in Figure 2.

Each of the building-level and community-level solutions has the potential to reduce energy consumption, reduce the carbon intensity of the energy source (by switching to an alternative fuel that produces fewer GHG emissions), or both—as depicted in Figure 3. Importantly, not all measures that reduce energy consumption will also result in significant GHG emissions reductions. This will depend on the type of energy source used. The costs associated with each solution will vary locally based on a number of factors, including local energy prices.

Figure 2: Solutions and strategies covered in this roadmap

<table>
<thead>
<tr>
<th>Solutions</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Building-level</strong></td>
<td>1. Lead by example</td>
</tr>
<tr>
<td>1. Heat pumps replacing gas or oil</td>
<td>2. Incentive programs</td>
</tr>
<tr>
<td>2. Heat pumps replacing electric resistance</td>
<td>3. Financing options</td>
</tr>
<tr>
<td>3. Building envelope upgrades</td>
<td>4. Energy rating and disclosure</td>
</tr>
<tr>
<td>4. Improved HVAC controls</td>
<td>5. Local policies and bylaws</td>
</tr>
<tr>
<td>5. Low-carbon water heating</td>
<td></td>
</tr>
<tr>
<td>6. High-efficiency lighting and reduced plug loads</td>
<td></td>
</tr>
<tr>
<td>7. Rooftop solar PV</td>
<td></td>
</tr>
<tr>
<td>8. High-efficiency indoor ice rinks</td>
<td></td>
</tr>
<tr>
<td><strong>Community-level</strong></td>
<td></td>
</tr>
<tr>
<td>1. District energy systems</td>
<td></td>
</tr>
<tr>
<td>2. Wind and solar energy generation</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3: Solutions to reduce energy consumption and carbon intensity

Each of these solutions, as well as key strategies for driving them forward, are defined below. This roadmap includes factsheets for each of the solutions and strategies, to help municipalities identify whether the solution or strategy is right for them and how to get started.
Building-level solutions

- **Heat pumps**: Heat pumps provide efficient heating by drawing heat from outside air, the ground, or a water body, and transferring that heat into a building. They provide efficient cooling by performing the opposite process. This roadmap discusses the use of heat pumps in two distinct ways: in place of gas or oil-based heating systems (a process referred to as “electrification” because it involves switching from fossil fuels to electricity); and in place of electric resistance heating (i.e. baseboards, electric furnaces and electric boilers). Heat pumps can be implemented in parallel with other solutions that address space heating, such as building envelope upgrades and improved HVAC controls.

- **Building envelope upgrades**: Building envelope upgrades improve the building shell so that it better controls the flow of heat, air and moisture in and out of the building. Examples include adding insulation, sealing air leaks and installing high-quality windows and curtain walls. These upgrades can be implemented in parallel with other space heating solutions, such as improved HVAC controls or heat pumps.

- **Improved HVAC controls**: Heating, ventilation and air conditioning (HVAC) systems keep buildings at a comfortable temperature and maintain air quality. These systems account for a large proportion of a building’s energy use, so controlling them with intelligent technology can deliver substantial energy savings while also improving thermal comfort and reducing maintenance requirements. Improving HVAC controls can involve a range of technologies, from smart thermostats to building energy management systems (BEMS), all of which reduce unnecessary running of HVAC systems. Further, improved HVAC controls can enable equipment to reduce energy use during periods of peak demand (i.e. as part of a utility demand response program).

- **Low-carbon water heating**: GHG emissions from water heating can be reduced by improving the efficiency of water heating or by switching to a lower-carbon energy source. This roadmap focuses on three technologies in the residential sector with the greatest potential for GHG reductions: electrification (switching from gas or oil to electricity); grey water heat recovery; and solar water heaters.

- **High-efficiency lighting**: Energy consumption from lighting can be reduced by switching to energy-efficient light bulbs, improving lighting controls, and using natural light as a source of illumination. In particular, light-emitting diode (LED) light bulbs use much less electricity to produce the same amount of light as old light bulb technologies, such as fluorescent and incandescent lighting, and have a longer life span. Changes to national energy-efficiency codes are soon expected to restrict the use of inefficient light bulbs in residential buildings. Therefore, this roadmap only focuses on municipal actions to improve lighting efficiency in commercial and municipal buildings.

- **Reduced plug loads**: Plug loads are the energy used by equipment that is plugged into a power outlet, including appliances (such as refrigerators, dishwashers and clothes dryers) and electronic devices (such as computers, network equipment, photocopiers and televisions). Replacing these appliances and devices with efficient models or installing equipment that regulates their energy use (e.g. smart power strips) saves electricity.
- **Rooftop solar PV:** A rooftop solar photovoltaic (PV) system consists of electricity-generating solar panels mounted on the rooftop of a residential, commercial or municipal building or structure. Declining PV costs and rising utility rates have increased the attractiveness of building-sited rooftop solar systems across all sectors. Solar PV systems are primarily used to reduce utility bills by offsetting the building’s own electricity consumption. These systems can also be paired with battery storage to provide a number of additional benefits.

- **High-efficiency indoor ice rinks:** Indoor ice rinks use large amounts of energy for heating, refrigeration, lighting, pumping and hot water. Capital and operational measures can improve the energy efficiency of these processes. Significant GHG reductions may also be achievable by replacing certain refrigerants, though such benefits are not quantified in this roadmap. Additional building-level solutions described above can also be employed in indoor ice rinks to reduce energy use and GHG emissions (e.g. heat pumps, envelope upgrades and solar PV).

---

**Community-level solutions**

- **District energy systems:** District energy systems, also referred to as thermal grids, supply heating and, in some cases, cooling, to multiple buildings. They take heat from a centralized source, or from several different but interconnected sources, and distribute that heat to the buildings through a system of buried insulated pipes. These systems can also be used for cooling, in which case they remove heat from buildings and transfer it to a heat sink such as a borehole or lake. Combined heat and power (CHP) systems also supply electricity via a microgrid.

- **Wind and solar energy generation:** Community renewable energy generation projects are owned by local residents, businesses or municipalities and provide electricity to multiple buildings within the community. Project sizes can vary significantly—from small rooftop systems (as small as a few kilowatts (kW)) to large multi-megawatt (MW) installations sited on larger municipal buildings or ground-mounted. This roadmap focuses on wind and solar energy, but projects may also be developed for micro-hydro, geothermal, biomass or other sources of renewable energy.
Strategies

- **Lead by example:** Municipalities can lead by implementing policies and demonstrating the practices they want to encourage within the community to reduce GHG emissions. Specifically, municipalities can use three main strategies in relation to buildings they own or those in which they lease significant space: (1) adopt high-performance building policies and practices such as stringent building codes, targets, energy efficiency standards for procurement, and operational practices (2) implement or require benchmarking of building energy performance and public disclosure of that information; and (3) showcase and promote corporate or community-wide clean energy or energy-efficiency innovations through pilots and demonstration projects.

- **Incentive programs:** Incentive programs offer support (financial and non-financial) to reduce costs for participants and improve the business case for energy-efficiency and clean energy solutions, thus removing barriers and increasing uptake of those technologies. Because financing programs are addressed separately (in the *Financing Options* factsheet), the discussion of incentive programs focuses primarily on discounts and rebates, with some attention given to tax credits, technical services, education and training, and other services.

- **Financing options:** Financing options have become an increasingly popular tool to support the adoption of efficient, clean energy technologies by addressing market barriers and increasing access to low-cost, long-term capital. This roadmap discusses several innovative financing models that municipalities can use to support energy-efficiency and clean energy improvements in local homes and businesses, municipal buildings, and community-scale initiatives.

- **Home/building energy rating and disclosure:** Home and building energy rating and disclosure (HERD/BERD) policies are strategies for transforming the market over the long term. Energy ratings and disclosures provide information to owners, managers, buyers and renters about the energy performance of homes and buildings, and cost-effective ways to improve it. This helps consumers become more educated and demand energy-efficient buildings. This roadmap discusses how municipalities can enact voluntary or mandatory HERD/BERD policies, as well as how they can support provincial/territorial or federal HERD/BERD policies.

- **Local development policies and bylaws:** Although Canadian municipalities generally do not have the legal authority to adopt their own building or energy code requirements, they can create local development policies and bylaws that exceed or complement the provincial code. In addition, because municipalities implement building and energy codes adopted by their province or territory, they are uniquely positioned to prepare their staff and communities for upcoming code changes. This roadmap explores several options for using local development policies and bylaws and for preparing municipal staff and local markets for anticipated model building code changes. It also considers specific actions for municipalities in British Columbia, which may adopt various levels of the voluntary, locally mandated stretch code (the BC Energy Step Code) which is aimed at achieving higher energy savings than base code.
A deeper dive into building-level solutions

Because community-level solutions for energy generation, such as district energy and wind or solar energy projects, can take so many different shapes and sizes, their GHG and financial impacts are difficult to assess quantitatively across Canadian municipalities in a meaningful way. Conversely, the quantitative impacts of building-level solutions are more generalizable across municipalities.

Estimates of GHG and financial impacts

Each of the factsheets for the building-level solutions includes a quantitative assessment of the solution’s GHG and financial impacts by province/territory. These estimates are based on the carbon intensity of municipalities’ electricity grids and their average energy prices.19 (For an explanation of why carbon intensity is a key driver behind GHG solutions, see the text box, “Why is grid carbon intensity important?”)

Other factors are also important in determining the total GHG reduction potential and financial impact of various measures, such as local climate and mix of heating fuels, and are addressed quantitatively in the analytics.

Estimates of the GHG and financial impacts associated with each building-level solution—bybaseline fuel or energy source—are presented on a per-building basis.20 FCM used several metrics to assess these impacts:

- Annual GHG reductions
- Annualized return on investment
- Cost per tonne of CO₂ e abated

Costs assessed are those of the solution itself, excluding any incentives or other program and administrative costs that may be incurred by a municipality. The savings are the savings realized by the building owner (or in some cases, the occupant). Measures are assessed for an average home or office building (as relevant), with the exception of the “high-efficiency indoor ice rinks” solution, which is assessed for an average municipal arena. Assumptions about average homes and office buildings are presented in each factsheet, along with the definitions of the measures being assessed.

Several important caveats should be considered when reviewing the analytics around the building-level solutions:

- The analysis focuses on the most impactful building technology solutions for each end use, from a GHG perspective.
- Technology solutions are evaluated on a per-building basis, based on a simplified analytical approach.
- Each building technology is evaluated in isolation of other measures.
- The financial impacts assessed are applicable to the building owner, not the municipality.

For each building-level solution, the factsheets also include assessments of the following potential co-benefits, on a scale of 0 to 4 (none, low, moderate, high and very high):

- **Jobs:** new jobs in construction/installation, maintenance and management
- **Resilience:** enhanced resilience to climate change impacts; enhanced energy security
- **Health and comfort:** improved health from reduced air pollution; increased health and comfort of building occupants

These co-benefits are assessed only qualitatively, given that their realization will depend on local conditions. The factsheets also consider other environmental and economic benefits.

Appendix A provides more information on how the analytics were conducted for building-level solutions.

---

19 The carbon intensity of electricity is a measure of how much CO₂ e is produced per kilowatt hour of electricity consumed. It differs by province or territory, based on the sources used to generate electricity. See Appendix B for more specific information by province/territory.

20 Note that the estimates in the roadmap are indicative, meaning they are ballpark numbers based on a number of assumptions and point-in-time energy prices. They indicate what benefits one can expect, but should not be taken at face value.
Why is grid carbon intensity important?

The carbon intensity of electricity is a measure of how much CO$_2$e is produced per kilowatt hour of electricity consumed. It currently differs by province by a factor of 500, based on the sources used to generate electricity.\(^{21}\) The carbon intensity of the electricity grid is the key factor to consider when choosing technology solutions for decarbonizing buildings, for two main reasons:

1. **It determines the impact of electrification on GHG emissions.** In areas with very low-carbon grids, electrification can virtually eliminate GHG emissions, whereas in areas with high-carbon grids, electrification can actually increase GHG emissions because, as shown in the figure below, the carbon intensity of electricity in these areas is greater than the carbon intensity of oil and gas.

![Figure 4: Comparison of electricity carbon intensity across grid types and with fossil fuel carbon intensity (2017)](image)

2. **It determines which end uses produce significant GHG emissions and, therefore, which end uses are worth focusing on.** As shown in the figure below, end uses that only use electricity (such as plug loads, lighting, auxiliary motors and space cooling) are important contributors to emissions in areas with high-carbon grids but hardly contribute to emissions in areas with low-carbon grids.

![Figure 5: Proportion of residential and commercial GHG emissions from each end use (2017)](image)

---

\(^{21}\) In other words, the amount of carbon generated per kWh of electricity is about 500 times as much for provinces/territories with high-carbon grids, compared to those with low-carbon grids. Current provincial figures reflect 2017 grid intensities, which may undergo significant change over the coming years (e.g. as there is an increasing shift to non-emitting sources of electricity).
PART 2
Prioritize your solutions
How to use this roadmap

This roadmap will guide you through four steps that can help you identify appropriate solutions for reducing GHG emissions in your municipality and develop strategies for driving those solutions forward.

**Step 1: Review and prioritize top building-level solutions based on your electricity grid.**

In “Key solutions for reducing building emissions” below, you will find a quantitative assessment of top building-level GHG reduction options for three categories of electricity grid carbon intensity (low, moderate and high). You can begin to prioritize these options based on their GHG impact, financial impact, co-benefits and the municipal strategies to drive solutions forward.

**Step 2: Consider community-level solutions for energy generation.**

The “Key solutions for community energy generation” section provides a qualitative assessment of two community-level solutions for driving the clean energy transition—district energy systems, and wind and solar energy generation—and addresses the following questions:

- When is this a good solution?
- What are the key advantages and challenges?
- What are the options for municipal intervention?

**Step 3: Identify strategies for driving solutions forward.**

The section, “Strategies for driving solutions forward,” outlines five types of strategy involving municipal policies and programs that can help move the needle on technology adoption, and addresses the following questions:

- When is this a good strategy?
- What are the key advantages and challenges?

**Step 4: Dive deeper into your priority solutions and strategies.**

Once you have identified which solutions and strategies are of interest to your municipality, you can dive deeper into each one by reviewing the factsheets provided in Part 3. For each solution and strategy, the factsheets answer critical questions faced by municipal decision-makers:

- What is this solution/strategy?
- How does this solution/strategy work and why is it important?
- Is this solution/strategy right for my municipality?
- What does it take to implement?

- What are the GHG and financial impacts?
- What are the potential co-benefits? (building-level solutions only)
- What is the current and projected state of the market? (building-level solutions only)
- What have municipalities done?
- What resources can support next steps?

Appendix C provides a list of additional resources to support you, including resources that focus on stakeholder engagement, equitable clean energy and other ways to support implementation.
Key solutions for reducing building emissions

How to find solutions for your municipality

To help you navigate the solutions for residential, commercial and municipal buildings, this roadmap calculates the GHG and financial impacts of each solution and groups them into three categories based on the carbon intensity of the provincial/territorial electricity grid (i.e. based on how much CO₂e is produced per kilowatt hour of electricity consumed):

- **Low-carbon grid**
  British Columbia, Manitoba, Ontario, Quebec, Newfoundland and Labrador, Yukon

- **Moderate-carbon grid**
  New Brunswick, Northwest Territories, Prince Edward Island

- **High-carbon grid**
  Alberta, Nova Scotia, Nunavut, Saskatchewan

---

22 A low-carbon grid emits less than 80 gCO₂e/kWh, which is roughly equivalent to less than 10 percent of electricity generation coming from fossil fuels.

23 A moderate-carbon grid emits 80–420 gCO₂e/kWh, which is roughly equivalent to 10 to 50 percent of electricity generation coming from fossil fuels.

24 A high-carbon grid emits more than 420 gCO₂e/kWh, which is roughly equivalent to more than 50 percent of electricity generation coming from fossil fuels.
The average grid carbon intensities shown above by province/territory are based on the most current data (2017). It should be noted that grids may undergo significant change over the coming years. For example, an increasing shift to non-emitting sources of electricity will reduce the carbon intensity of certain grids. If your municipality is off-grid and generates its own electricity, you should review the results for the level of carbon intensity that most closely resembles that of your municipality’s grid. If your municipality generates some or all of its own electricity but you are connected to the provincial/territorial grid, you should still review the results for your province’s or territory’s grid carbon intensity category.

Once you have identified your municipality’s grid category, consult the relevant pages in this section for your grid type to find information on key technical solutions, challenges and opportunities.

For each grid category, only the most impactful solutions for reducing GHG emissions from municipal, commercial and residential buildings are presented, as well as the key value propositions associated with each solution. This section is designed to help you select the most appropriate options to explore further. You can then take the next steps to better understand the potential impacts of those options in your municipality—for example, through feasibility studies.

Because heating fuel mix is also important in determining the GHG reduction potential (and cost) of specific measures, results are further disaggregated within each grid type according to baseline fuel.
Key building-level solutions: Low-carbon grids
(BC, MB, ON, QC, NL, YT)

**About these municipalities**
Municipalities fall into this group if they have a grid carbon intensity of 80 gCO₂e/kWh or less. In this category, 90 percent or more of a municipality’s electricity is generated using low-carbon sources, namely renewables or nuclear. Generally, municipalities in the following provinces and one territory are included in this group (based on provincial/territorial average data from 2017):
- British Columbia (9.7 gCO₂e/kWh)
- Manitoba (2.1 gCO₂e/kWh)
- Ontario (20 gCO₂e/kWh)
- Quebec (1.5 gCO₂e/kWh)
- Newfoundland and Labrador (40 gCO₂e/kWh)
- Yukon (57 gCO₂e/kWh)

Municipalities in other provinces and territories may also fall into this group if their electricity is provided by a local utility with similar grid carbon intensity.

Figure 6 presents the GHG emissions by each end use from commercial and residential buildings across provinces and territories in the low-carbon grid category. As shown, space heating represents the vast majority of emissions in both the residential and commercial sectors, followed by water heating.

**Figure 6: Average GHG emissions by end use for provinces and territories with low-carbon grids**

<table>
<thead>
<tr>
<th>End Use</th>
<th>Residential</th>
<th>Commercial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxiliary motors*</td>
<td>0.5%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Space Cooling</td>
<td>0.5%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Lighting</td>
<td>2.6%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Plug Loads</td>
<td>13.0%</td>
<td>3.8%</td>
</tr>
<tr>
<td>Water Heating</td>
<td>25.0%</td>
<td>79.7%</td>
</tr>
<tr>
<td>Space Heating</td>
<td>71.5%</td>
<td></td>
</tr>
</tbody>
</table>

* Auxiliary motors are devices used to transform electric power into mechanical energy, such as pumps, ventilators, compressors and conveyors.

---

25 These figures represent GHG emissions across the provinces and territory that have low-carbon grids (i.e. BC, MB, ON, QC, NL and YT) based on data from Natural Resources Canada’s Comprehensive Energy Use Database and Canada’s Official Greenhouse Gas Inventory.
For both space heating and water heating end uses, natural gas and heating oil are the main energy sources contributing to emissions. The low carbon intensity of electricity in these provinces and this territory means that space and water heating with electricity, as well as end uses that only use electricity, account for an insignificant portion of GHG emissions. See Appendix B for the proportion of heating energy provided by electricity, gas and oil, by province/territory.

**Key opportunities for reducing GHG emissions**

Municipalities in areas with low-carbon grids should focus on reducing fossil fuel consumption, primarily through electrification (i.e. switching from fossil fuels to electricity) and, to a lesser extent, energy efficiency in space and water heating fueled by oil or gas. Overall, the technologies needed to implement these solutions are mature and widely available across the country (though some exceptions apply), and offer great potential for a range of community co-benefits.

Options that generate both GHG benefits and positive annual rates of return include electrification and heating energy-efficiency measures implemented in buildings with oil-fired space heating or water heating—namely, heat pumps, HVAC controls, building envelopes, and select water heating solutions. These solutions can also be win-win options in buildings with gas-fired space heating or water heating, in cases where gas prices are relatively high. Improving the efficiency of ice rinks also represents an opportunity to reduce GHG emissions at positive annual rates of return.

Although electricity energy-efficiency measures and rooftop solar PV projects will only yield minimal GHG reductions in areas with low-carbon grids, these solutions may be important in ensuring there is enough clean electricity supply to electrify heating and transportation.

**Key challenges**

The low price of gas relative to electricity means that replacing gas with electricity is often not cost-effective based on energy savings alone. This issue is most severe in the residential sector in Ontario and British Columbia, where one unit of energy in gas costs less than one-third of a unit of energy in electricity. In Manitoba, that ratio is one-half, and in Quebec, it is almost one-to-one. But while switching from gas to electricity brings low or negative financial returns, it may still be a compelling option for municipalities based on the GHG reductions and co-benefits alone. Moreover, the economics will become more favorable over time as the price on carbon rises. Until then, municipal programs and policies, such as incentives and financing, can be vital in increasing adoption of these high-impact solutions.

Beyond cost barriers, several other market barriers are at play. Cold climate heat pump models can be harder to source, for example, and much of the contractor workforce is not familiar with how to size, install and maintain heat pumps—which can negatively impact heat pump performance.

**High-impact solutions**

The table below presents the key building-level solutions for reducing GHG emissions, for municipalities with low-carbon grids. The estimates of GHG reductions and annualized return on investment are presented on a per-building basis, and assume that solutions are implemented in existing buildings (though they may also be implemented in new buildings). The figures are intended to be indicative only, as actual estimates will vary by municipality based on a host of factors (such as climate, building profiles and baseline conditions, and specifics around the selected solution). Summary information on each solution is presented below.
### Summary findings

#### Municipal and commercial buildings

<table>
<thead>
<tr>
<th>Solution</th>
<th>Baseline fuel</th>
<th>GHG impact (per building)</th>
<th>Annualized return on investment (per building)</th>
<th>Co-benefits</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>BC</td>
<td>MB</td>
<td>ON</td>
</tr>
<tr>
<td>Heat pumps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td></td>
<td>High</td>
<td>Med</td>
<td>Med</td>
<td>High</td>
</tr>
<tr>
<td>Gas</td>
<td></td>
<td>Neg</td>
<td>Neg</td>
<td>Neg</td>
<td>Neg</td>
</tr>
<tr>
<td>High-efficiency indoor ice rinks</td>
<td>Oil or gas</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Med</td>
</tr>
<tr>
<td>Improved HVAC controls</td>
<td></td>
<td></td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Oil</td>
<td></td>
<td>High</td>
<td>Med</td>
<td>Med</td>
<td>High</td>
</tr>
<tr>
<td>Gas</td>
<td></td>
<td>Low</td>
<td>Med</td>
<td>Med</td>
<td>Med</td>
</tr>
<tr>
<td>Building envelope upgrades</td>
<td></td>
<td></td>
<td>Low</td>
<td>Med</td>
<td>Med</td>
</tr>
<tr>
<td>Oil</td>
<td></td>
<td>Low</td>
<td>Med</td>
<td>Med</td>
<td>Med</td>
</tr>
<tr>
<td>Gas</td>
<td></td>
<td>Neg</td>
<td>Neg</td>
<td>Neg</td>
<td>Neg</td>
</tr>
</tbody>
</table>

**GHG reduction (kgCO₂e/m²/year)**
- 🕰️ = <1
- ⏰️ = 1 to <5
- 🕰️ = 5 to <10
- 🕰️ = 10 to <20
- 🕰️ = 20 to <30
- 🕰️ = 30

**Annualized return on investment**
- Negative: <0
- Low: ≥0% to <4%
- Medium: ≥4% to <8%
- High: ≥8%
- n/a = not applicable, as the baseline fuel is not in use in the specified province or territory

**Co-benefits**
- None
- Low
- Moderate
- High
- Very high

**Strategies**
- Lead by example
- Incentive programs
- Financing options
- Energy rating and disclosure
- Local policies and bylaws

#### Other energy savings opportunities in municipal and commercial buildings

Although not highly impactful from a GHG perspective, the following options yield medium or high financial returns and reduce energy consumption in all provinces and territories with low-carbon grids:

- Improved HVAC controls in electrically heated buildings
- High-efficiency lighting
- Reduced plug loads

Note: In addition to the solutions discussed in this section, there are other building-level technologies that have limited impact on emissions in areas with low-carbon grids, yet can yield small but positive financial returns in most provinces and territories with this grid type. These energy-saving options will likely have increasingly positive returns over time as energy prices increase. They include building envelope upgrades in buildings with electric heating, heat pumps replacing electric resistance, and rooftop solar PV. Consult the factsheets in Part 3 to determine if these solutions are right for your community.

---

26 These values do not account for any federal, provincial/territorial, utility or other incentives that may be available. Such incentives can significantly change the business case. Municipalities should investigate further before finalizing their understanding of the economic value of any given option.
## Residential buildings

<table>
<thead>
<tr>
<th>Solution</th>
<th>Baseline fuel</th>
<th>GHG impact (per building)</th>
<th>Annualized return on investment (per building)</th>
<th>Co-benefits</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>BC MB ON QC NL YT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat pumps</td>
<td>Oil</td>
<td>High High High High High High</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>Neg Low Neg High n/a n/a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>Neg Low Low Low Low Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-carbon water heating:</td>
<td>Oil</td>
<td>* * * * * * * *</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>electrification</td>
<td>Gas</td>
<td>* * * * * * * *</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-carbon water heating:</td>
<td>Oil</td>
<td>Neg Low Low Low Low Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>solar water heaters</td>
<td>Gas</td>
<td>Neg Neg Neg Neg n/a n/a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>grey water heat recovery</td>
<td>Gas</td>
<td>Neg Neg Neg Low n/a n/a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved HVAC controls</td>
<td>Oil</td>
<td>High High High High High High</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>Neg High High High n/a n/a</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Annualized ROI cannot be calculated for electrification of water heating because there is no incremental capital investment required for this technology (as electric storage water heaters are cheaper than their oil or gas counterparts); however, annual energy bills may increase or decrease, depending on local energy costs. For an indication of the financial impact, a net present value (NPV) has been calculated instead, with positive NPV reflected in green shading and negative NPV reflected in red shading.

**GHG reduction (kgCO₂e/m²/year)**

- ○ ○ ○ ○ ○ ○ ○ = <1
- ○ ○ ○ ○ ○ = 1 to <5
- ○ ○ ○ ○ = 5 to <10
- ○ ○ ○ = 10 to <20
- ○ ○ = 20 to <30
- ○ = ≥30

**Annualized return on investment**

- Negative: <0
- Low: ≥0 to <4%
- Medium: ≥4% to <8%
- High: ≥8%
- n/a = not applicable, as the baseline fuel is not in use in the specified province or territory

**Co-benefits**

- None
- Low
- Moderate
- High
- Very high

---

### Other energy savings opportunities in residential buildings

Although not highly impactful from a GHG perspective, the following options yield medium or high financial returns and reduce energy consumption in most provinces and territories with low-carbon grids:

- Improved HVAC controls in electrically heated buildings
- Reduced plug loads
- Heat pumps replacing electric resistance

Note: In addition to the solutions discussed in this section, there are other building-level technologies that have limited impact on emissions in areas with low-carbon grids, yet can yield small but positive financial returns in most provinces and territories with this grid type. These energy-saving options will likely have increasingly positive returns over time as energy prices increase. They include building envelope upgrades and low-carbon water heating (grey water heat recovery) in buildings with electric heating. Consult the fact-sheets in Part 3 to determine if these solutions are right for your community.

---

27 These values do not account for any federal, provincial/territorial, utility or other incentives that may be available. Such incentives can significantly change the business case. Municipalities should investigate further before finalizing their understanding of the economic value of any given option.
Heat pumps replacing oil and gas—municipal, commercial and residential buildings

Heat pumps not only provide heating more efficiently than any other heating system; when replacing oil or gas heating systems, they also switch the source of energy from fossil fuels to electricity. Further, heat pumps provide air conditioning in addition to heat, increasing occupant comfort and enhancing a building’s resilience to extreme heat events. Today, this option is a cost-effective replacement for oil-fired heating but an expensive replacement for gas-fired heating. The economics will become more favorable over time as the price on carbon rises. For existing buildings, the best time to install heat pumps is when replacing or installing HVAC systems. Learn more about this solution.

High-efficiency indoor ice rinks

Nearly 30 percent of Canadian ice arenas are in poor or very poor physical condition. There is great opportunity to make energy-efficiency improvements while doing required maintenance upgrades, to further improve the look and feel of the arena and provide significant cost savings each year. Learn more about this solution.

Building envelope upgrades—municipal, commercial and residential buildings

Building envelope upgrades bring a host of benefits to the building occupant and the greater community—including annual energy savings, enhanced resilience, improved occupant health and comfort, and local jobs. Building envelope upgrades are typically more cost-effective in residential buildings than in commercial or municipal buildings (since residential buildings typically have higher surface-area-to-volume ratios, resulting in a greater proportion of heat being lost through the envelope). These upgrades lead to greater GHG reductions and are more cost-effective in buildings heated with oil than in those heated with gas. The benefits to the building occupant persist over the lifetime of the building and the upgrades require little or no maintenance. The costs of envelope upgrades can be reduced significantly by combining such upgrades with other renovations, so planned renovations present a key opportunity to improve the building envelope. Learn more about this solution.

Improved HVAC controls—municipal, commercial and residential buildings

Improving HVAC controls can involve a range of technologies, from smart thermostats to building energy management systems (BEMS), all of which reduce unnecessary running of HVAC systems. These systems can be very sophisticated and provide additional functionality, such as early detection of building system faults. This solution yields high returns on investment in commercial and municipal buildings. Learn more about this solution.

Low-carbon water heating—residential buildings

Electrification from gas or oil

In areas with low-carbon grids, electric water heaters are more efficient, have fewer GHG emissions than their gas or oil counterparts, and have lower upfront costs. They are widely in use already in places where gas prices are comparable to electricity rates. In provinces with low gas prices (British Columbia, Manitoba and Ontario), this option will increase annual energy bills but will also lead to the greatest GHG emissions reductions per building, compared to the other water heating solutions considered in this analysis (grey water heat recovery and solar water heaters). The economics will become more favorable over time as the price on carbon rises.
Grey water heat recovery

Grey water heat recovery systems capture heat from hot water flowing down the drain and use it to pre-heat cold water entering the water heater. This technology is easy and very cost-effective to install in new buildings because it can be situated in a way that is optimal for energy savings and it can be installed without cutting any pipes (a step that is necessary in existing buildings, even if the installation is done during other renovations). Grey water heat recovery has a lower GHG impact per home than electrification of water heating, but can lead to higher cost savings.

Solar water heaters

Solar water heaters can cover 40–50 percent of the hot water requirement of an average home. Solar water heaters are more expensive than the electrification option and, for municipalities with low-carbon grids, they have less of an impact on GHG emissions per building—but they may be of interest in areas with grid capacity issues. Solar water heating has a greater GHG impact per building than grey water heat recovery, but a lower return on investment.

Learn more about these solutions.

Additional options

Significant GHG reductions may also be realized by municipalities with low-carbon grids through community-level solutions—namely, district energy systems. From a GHG perspective, community wind and solar energy generation is not a priority for municipalities in this category because electricity is already low-carbon. Nonetheless, other benefits may still be realized through community renewable energy projects, such as keeping energy dollars in the community, increasing economic development and enhancing resilience. Moreover, community renewable energy and district energy systems may both contribute to reducing electricity demand from the grid, which will be critical as these municipalities move towards increased electrification.

To learn more about these solutions, please see “Key solutions for community energy generation.”
Key building-level solutions: Moderate-carbon grids
(NB, NT, PE)

About these municipalities
Municipalities fall into this group if they have a grid carbon intensity of between 80 gCO₂e/kWh and 420 gCO₂e/kWh or less—or where 50–90 percent of their electricity is generated using low-carbon sources, namely renewables or nuclear. Generally, municipalities in the following provinces and one territory will be included in this group (based on provincial/territorial average data from 2017):²⁸
- New Brunswick (330 gCO₂e/kWh)
- Prince Edward Island (200 gCO₂e/kWh)
- Northwest Territories (180 gCO₂e/kWh)

Municipalities in other provinces and territories may also fall into this group if their electricity is provided by a local utility with a similar grid carbon intensity.

Figure 7 presents the GHG emissions by end use from commercial and residential buildings across provinces and territories in the moderate-carbon grid category. In commercial buildings, space heating, plug loads, lighting, and space cooling account for the majority of GHG emissions. In the residential sector, space heating, plug loads and water heating are the primary emissions contributors.

Figure 7: Average GHG emissions by end use for provinces and territories with moderate-carbon grids²⁹

<table>
<thead>
<tr>
<th>End Use</th>
<th>Residential</th>
<th>Commercial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxiliary motors*</td>
<td>16%</td>
<td>4%</td>
</tr>
<tr>
<td>Space Cooling</td>
<td>5%</td>
<td>9%</td>
</tr>
<tr>
<td>Lighting</td>
<td>14%</td>
<td>10%</td>
</tr>
<tr>
<td>Plug Loads</td>
<td>22%</td>
<td>1%</td>
</tr>
<tr>
<td>Water Heating</td>
<td>40%</td>
<td>61%</td>
</tr>
<tr>
<td>Space Heating</td>
<td>18%</td>
<td>9%</td>
</tr>
</tbody>
</table>

* Auxiliary motors are devices used to transform electric power into mechanical energy, such as pumps, ventilators, compressors and conveyors.

²⁸ These categories reflect current grid intensities, which may undergo significant change over the coming years (e.g. as there is an increasing shift to non-emitting sources of electricity).
²⁹ These figures represent GHG emissions across the provinces and territory that have moderate-carbon grids (NB, PEI, NT) based on data from Natural Resources Canada’s Comprehensive Energy Use Database and Canada’s Official Greenhouse Gas Inventory.
For both space heating and water heating end uses, electricity and oil are the main energy sources contributing to emissions, with natural gas hardly used (and not even available in many municipalities). See Appendix B for the proportion of heating energy provided by electricity, gas and oil, by province/territory.

Key opportunities for reducing GHG emissions
Municipalities in areas with moderate-carbon grids should focus on heat pumps and other energy-efficiency measures in space heating, as well as low-carbon water heating solutions, high-efficiency lighting, and rooftop solar PV. Overall, the technologies needed to implement these solutions are mature and widely available across the country (though some exceptions apply).

Energy rates in provinces and territories that fall into this grid type are typically very high. As a result, almost all the GHG solutions considered will generate positive annual returns on investment. Additionally, some of the most impactful GHG solutions for this grid type—such as heat pumps, building envelope upgrades and rooftop solar—bring important benefits in addition to GHG reductions, such as increased jobs, occupant comfort and climate resilience. Improving the efficiency of ice rinks also represents an opportunity to reduce GHG emissions at a positive return on investment.

Key challenges
A number of barriers are at play for the most impactful GHG solutions in areas with moderate-carbon grids, which are limiting adoption. In the case of heat pumps, for example, cold climate heat pump models can be hard to source and much of the contractor workforce is not familiar with how to size, install and maintain heat pumps. This can compromise heat pump performance. Likewise, rooftop solar PV and solar water heaters are only marginally cost-effective, based on current energy prices. This will change as prices for rooftop solar continue to fall. Until then, municipal programs and policies, such as incentives and financing, can be vital in increasing adoption of these high-impact solutions.

High-impact solutions
The table below presents the key building-level solutions for reducing GHG emissions, for municipalities with moderate-carbon grids. The estimates of GHG reductions and annualized return on investment are presented on a per-building basis, and assume that solutions are implemented in existing buildings (though they may also be implemented in new buildings). The figures are intended to be indicative only, as actual estimates will vary by municipality based on a host of factors (such as climate, building profiles and baseline conditions, and specifics around the selected solution). Summary information on each solution is presented below.
## Summary findings

### Municipal and commercial buildings

<table>
<thead>
<tr>
<th>Solution</th>
<th>Baseline fuel</th>
<th>GHG impact (per building)</th>
<th>Annualized return on investment (per building)</th>
<th>Co-benefits</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>NB</td>
<td>PE</td>
<td>NT</td>
</tr>
<tr>
<td>High-efficiency indoor ice rinks</td>
<td>Oil or gas</td>
<td>⬤⬤⬤⬤⬤</td>
<td>Med</td>
<td>Med</td>
<td>Med</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>⬤⬤⬤⬤⬤</td>
<td>Med</td>
<td>Low</td>
<td>Neg</td>
</tr>
<tr>
<td></td>
<td>Electricity</td>
<td>⬤⬤⬤⬤⬤</td>
<td>Low</td>
<td>n/a</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>⬤⬤⬤⬤⬤</td>
<td>High</td>
<td>n/a</td>
<td>High</td>
</tr>
<tr>
<td>Heat pumps</td>
<td></td>
<td></td>
<td>NB</td>
<td>PE</td>
<td>NT</td>
</tr>
<tr>
<td>Improved HVAC controls</td>
<td>Electricity</td>
<td>⬤⬤⬤⬤</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>⬤⬤⬤⬤</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>⬤⬤⬤⬤</td>
<td>High</td>
<td>n/a</td>
<td>High</td>
</tr>
<tr>
<td>Rooftop solar PV</td>
<td>Electricity</td>
<td>⬤⬤⬤⬤</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Building envelope upgrades</td>
<td>Oil</td>
<td>⬤⬤⬤⬤</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Electricity</td>
<td>⬤⬤⬤⬤</td>
<td>Low</td>
<td>Med</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>⬤⬤⬤⬤</td>
<td>Low</td>
<td>n/a</td>
<td>High</td>
</tr>
<tr>
<td>High-efficiency lighting</td>
<td>Electricity</td>
<td>⬤⬤⬤⬤</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

GHG reduction (kgCO₂e/m²/year):
- ⬤⬤⬤⬤⬤⬤ = <1
- ⬤⬤⬤⬤⬤ = 1 to <5
- ⬤⬤⬤⬤ = 5 to <10
- ⬤⬤⬤ = 10 to <20
- ⬤ = 20 to <30
- ⬤⬤ = 30

Annualized return on investment:
- Negative: <0
- Low: 0% to <4%
- Medium: 4% to <8%
- High: ≥8%

Co-benefits:
- None
- Low
- Moderate
- High
- Very high

### Other energy savings opportunities in municipal and commercial buildings

Although not highly impactful from a GHG perspective, the following options yield medium or high returns and reduce energy consumption in all provinces and territories with moderate-carbon grids:
- Reduced plug loads

---

30 These values do not account for any federal, provincial/territorial, utility or other incentives that may be available. Such incentives can significantly change the business case. Municipalities should investigate further before finalizing their understanding of the economic value of any given option.
## Residential buildings

<table>
<thead>
<tr>
<th>Solution</th>
<th>Baseline fuel</th>
<th>GHG impact (per building)</th>
<th>Annualized return on investment (per building)</th>
<th>Co-benefits</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat pumps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>High</td>
<td>High</td>
<td>Med</td>
<td>☑️ incentive programs</td>
</tr>
<tr>
<td></td>
<td>Electricity</td>
<td>Med</td>
<td>High</td>
<td>High</td>
<td>☑️ Financing options</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>High</td>
<td>n/a</td>
<td>High</td>
<td>☑️ Energy rating and disclosure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>☑️ Local policies and bylaws</td>
</tr>
<tr>
<td>Building envelope upgrades</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>High</td>
<td>Med</td>
<td>High</td>
<td>☑️ incentive programs</td>
</tr>
<tr>
<td></td>
<td>Electricity</td>
<td>Med</td>
<td>Med</td>
<td>High</td>
<td>☑️ Financing options</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>High</td>
<td>n/a</td>
<td>High</td>
<td>☑️ Energy rating and disclosure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>☑️ Local policies and bylaws</td>
</tr>
<tr>
<td>Rooftop solar PV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electricity</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>☑️ incentive programs</td>
</tr>
<tr>
<td>Low-carbon water heating: solar water heaters</td>
<td>Oil</td>
<td>Low</td>
<td>Neg</td>
<td>Neg</td>
<td>☑️ Financing options</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>Neg</td>
<td>n/a</td>
<td>n/a</td>
<td>☑️ Local policies and bylaws</td>
</tr>
<tr>
<td>Improved HVAC controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>☑️ incentive programs</td>
</tr>
<tr>
<td></td>
<td>Electricity</td>
<td>Med</td>
<td>High</td>
<td>High</td>
<td>☑️ Financing options</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>High</td>
<td>n/a</td>
<td>High</td>
<td>☑️ Energy rating and disclosure</td>
</tr>
<tr>
<td>Low-carbon water heating: grey water heat recovery</td>
<td>Oil</td>
<td>Med</td>
<td>Low</td>
<td>Med</td>
<td>☑️ Local policies and bylaws</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>Low</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Low-carbon water heating: electrification</td>
<td>Oil</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>☑️ incentive programs</td>
</tr>
</tbody>
</table>

* Annualized ROI cannot be calculated for electrification of water heating because there is no incremental capital investment required for this technology (as electric storage water heaters are cheaper than their oil or gas counterparts); however, annual energy bills may increase or decrease, depending on local energy costs. For an indication of the financial impact, a net present value (NPV) has been calculated instead, with positive NPV reflected in green shading and negative NPV reflected in red shading.

### Other energy savings opportunities in residential buildings

Although not highly impactful from a GHG perspective, the following options yield medium or high returns and reduce energy consumption in all provinces and territories with moderate-carbon grids:

- Reduced plug loads

---

31 These values do not account for any federal, provincial/territorial, utility or other incentives that may be available. Such incentives can significantly change the business case. Municipalities should investigate further before finalizing their understanding of the economic value of any given option.
High-efficiency indoor ice rinks
Nearly 30 percent of Canadian ice arenas are in poor or very poor physical condition. There is great opportunity make energy-efficiency improvements while doing required maintenance upgrades, to further improve the look and feel of the arena and provide significant cost savings each year. Learn more about this solution.

Heat pumps—municipal, commercial and residential buildings
Heat pumps provide heating more efficiently than any other heating system and also provide air conditioning, which increases occupant comfort and enhances a building’s resilience to extreme heat events. For municipalities with moderate-carbon grids, heat pumps can reduce GHG emissions roughly the same amount whether fuel switching is involved or not, since the carbon intensity of electricity is similar to that of fossil fuels.32

This option can be highly cost-effective, especially in residential buildings. Residential buildings tend to be heated with forced air (unlike commercial and municipal buildings), which in turn leads to higher heat pump efficiency. For buildings heated with oil or gas, the economics of heat pumps will become increasingly favorable over time as the price on carbon rises. For existing buildings, the best time to install heat pumps is when replacing or installing HVAC systems. Learn more about heat pumps replacing oil and gas or electric resistance.

Building envelope upgrades—municipal, commercial and residential buildings
Building envelope upgrades bring a host of benefits to the building occupant and the greater community—including annual energy savings, enhanced resilience, improved occupant health and comfort, and local jobs.

Building envelope upgrades are typically more cost-effective in residential buildings than in commercial or municipal buildings (since residential buildings typically have higher surface-area-to-volume ratios, resulting in a greater proportion of heat being lost through the envelope). These upgrades lead to greater GHG reductions and more cost effectiveness in buildings heated with oil or electricity than in those heated with gas. The benefits to the building occupant persist over the lifetime of the building and the upgrades require little or no maintenance. The costs of envelope upgrades can be significantly reduced by combining such upgrades with other renovations, so planned renovations present a key opportunity to improve the building envelope. Learn more about this solution.

Rooftop solar PV—municipal, commercial and residential buildings
Rooftop solar photovoltaic (PV) systems reduce utility bills by offsetting the building’s own electricity consumption with the renewable energy generated through the installed system. This solution yields significant GHG reductions in areas with moderate-carbon grids, but only yields small or negative returns. However, returns are likely to increase over the next 5–10 years, as solar PV prices continue to fall and electricity prices rise. This solution offers opportunities for local job creation and can increase resiliency when paired with battery storage. Learn more about this solution.

Improved HVAC controls—municipal, commercial and residential buildings
Improved HVAC controls involve a range of technologies, from smart thermostats to building energy management systems (BEMS), all of which reduce unnecessary running of HVAC systems. These

32 Oil has a carbon intensity of about 250 gCO2e/kWh and gas has a carbon intensity of 180 gCO2e/kWh. By comparison, electricity carbon intensities of provinces and territories with moderate-carbon grids range from 180 to 330 gCO2e/kWh.
systems can be very sophisticated and provide additional functionality, such as early detection of building system faults. This solution yields high returns on investment in commercial and municipal buildings. Learn more about this solution.

**Low-carbon water heating—residential buildings**

**Solar water heaters**

Solar water heaters can cover 40–50 percent of the hot water requirement of an average home. For municipalities with moderate-carbon grids, solar water heaters have the greatest potential to reduce GHG emissions from water heating, but they have a lower return on investment than grey water heat recovery.

**Grey water heat recovery**

Grey water heat recovery systems capture heat from hot water flowing down the drain and use it to pre-heat cold water entering the water heater. This technology is easy and very cost-effective to install in new buildings because it can be situated in a way that is optimal for energy savings and installed without cutting any pipes (a step that is necessary in existing buildings, even if the installation is done during other renovations). Grey water heat recovery has a lower GHG impact per home than solar water heaters but yields higher rates of return.

**Electrification from gas or oil**

In areas with moderate-carbon grids, electric water heaters are slightly more efficient than their gas or oil counterparts and have lower upfront costs. Replacing oil water heaters with electric water heaters yields GHG reductions across all provinces and territories with moderate-carbon grids, whereas replacing gas water heaters could increase or decrease GHG emissions, depending on the carbon intensity of the electricity grid. In both cases, the GHG impacts will improve as the carbon intensity of the electricity grid drops. The economics will also become increasingly favorable over time as the price on carbon rises. Learn more about these solutions.

**High-efficiency lighting—municipal and commercial buildings**

Energy consumption from lighting can be reduced by switching to energy-efficient light bulbs, improving lighting controls, and using natural light as a source of illumination. In particular, light-emitting diode (LED) light bulbs use much less electricity to produce the same amount of light as old light bulb technologies, such as fluorescent and incandescent lighting, and have a longer lifespan. Installing high-efficiency light bulbs in commercial and municipal buildings only results in modest GHG reductions in areas with moderate-carbon grids, but is highly cost-effective. This solution can be packaged with other, more impactful GHG reduction solutions to create a portfolio that delivers substantial GHG impacts while remaining cost-effective. Learn more about this solution.

**Additional options**

Significant GHG reductions may also be realized by municipalities with moderate-carbon grids through community-level solutions—namely, district energy systems and wind and solar energy generation. To learn more, please see “**Key solutions for community energy generation**.”
Key building-level solutions: High-carbon grids
(AB, NS, NU, SK)

About these municipalities
Municipalities fall into this group if they have a grid carbon intensity greater than 420 gCO₂e/kWh, where less than 50 percent of their electricity is generated using low-carbon sources, namely renewables or nuclear. Generally, municipalities in the following provinces and one territory will be included in this group (based on provincial/territorial average data from 2017):33

- Alberta (800 gCO₂e/kWh)
- Saskatchewan (710 gCO₂e/kWh)
- Nova Scotia (720 gCO₂e/kWh)
- Nunavut (790 gCO₂e/kWh)

Municipalities in other provinces and territories may also fall into this group if their electricity is provided by a local utility with a similar grid carbon intensity.

Figure 8 presents the GHG emissions by end use from commercial and residential buildings across provinces and territories in the high-carbon grid category. Across all buildings, space heating and plug loads account for the majority of emissions, with lighting being another major contributor in the commercial sector, and water heating being a significant contributor in the residential sector.

Figure 8: Average GHG emissions by end use for provinces and territories with high-carbon grids34

* Auxiliary motors are devices used to transform electric power into mechanical energy, such as pumps, ventilators, compressors and conveyors.

33 These categories reflect current grid intensities, which may undergo significant change over the coming years (e.g. as there is an increasing shift to non-emitting sources of electricity).
34 These figures represent GHG emissions across the provinces and territory that have high-carbon grids (AB, SK, NS, NU) based on data from Natural Resources Canada’s Comprehensive Energy Use Database and Canada’s Official Greenhouse Gas Inventory.
Natural gas, electricity and oil all contribute significantly to space heating and water heating emissions. The high carbon intensity of electricity means that electricity accounts for a much larger portion of total emissions than it does of energy use. See Appendix B for the proportion of heating energy provided by electricity, gas and oil, by province/territory.

**Key opportunities for reducing GHG emissions**

Municipalities in areas with high-carbon grids should focus on energy efficiency and on rooftop solar PV. Energy efficiency solutions that reduce electricity consumption will have a particularly high impact. The carbon intensity of electricity in this grid type is significantly higher than that of gas and oil, so electrification options will typically increase GHG emissions—except where electricity-based technologies are exceptionally efficient. Overall, the technologies needed to implement these solutions are mature and widely available across the country (though some exceptions apply), and offer great potential for a range of community co-benefits.

Almost all solutions that yield GHG benefits in areas with high-carbon grids also give positive returns in most provinces and territories. Solutions that offer the highest GHG impact with the highest returns are HVAC controls and high-efficiency lighting in commercial and municipal buildings, and heat pumps replacing electric resistance in residential buildings. Improving the efficiency of ice rinks also represents an opportunity to reduce GHG emissions at a positive annual return on investment.

**Key challenges**

Based on current prices, solar water heaters are generally not cost-effective based on energy savings alone and rooftop solar PV only gives low returns. This may change as prices for rooftop solar continue to fall. The low price of natural gas means that building envelope upgrades and grey water heat recovery are not generally cost-effective based on energy savings alone when implemented in buildings heated with gas. Municipal programs and policies, such as incentives and financing, will therefore be vital in increasing adoption of these high-impact solutions.

Beyond cost barriers, several other market barriers are at play. In the case of heat pumps, for example, cold climate heat pump models can be hard to source and much of the contractor workforce is not familiar with how to size, install and maintain heat pumps—which can negatively impact heat pump performance.

**High-impact solutions**

The table below presents the key building-level solutions for reducing GHG emissions, for municipalities with high-carbon grids. The estimates of GHG reductions and annualized return on investment are presented on a per-building basis, and assume that solutions are implemented in existing buildings (though they may also be implemented in new buildings). The figures are intended to be indicative only, as actual estimates will vary by municipality based on a host of factors (such as climate, building profiles and baseline conditions, and specifics around the selected solution). Summary information on each solution is presented below.

---

35 Oil has a carbon intensity of about 250 gCO₂e/kWh, and gas has a carbon intensity of about 180 gCO₂e/kWh. This compares to electricity carbon intensities of between 710–800 gCO₂e/kWh across provinces/territories with high-carbon grids.
### Summary findings

#### Municipal and commercial buildings

<table>
<thead>
<tr>
<th>Solution</th>
<th>Baseline fuel</th>
<th>GHG impact (per building)</th>
<th>Annualized return on investment (per building)</th>
<th>Co-benefits</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>AB</td>
<td>SK</td>
<td>NS</td>
</tr>
<tr>
<td>High-efficiency indoor ice rinks</td>
<td>Gas or oil</td>
<td>●●●●●</td>
<td>Low</td>
<td>Low</td>
<td>Med</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat pumps</td>
<td>Electricity</td>
<td>●●●●●</td>
<td>Low</td>
<td>Low</td>
<td>Med</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rooftop solar PV</td>
<td>Electricity</td>
<td>●●●●</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved HVAC controls</td>
<td>Electricity</td>
<td>●●●●●</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>●●●●●</td>
<td>n/a</td>
<td>Med</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>●●●●●</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-efficiency lighting</td>
<td>Electricity</td>
<td>●●●●●</td>
<td>High</td>
<td>Med</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>●●●●●</td>
<td>n/a</td>
<td>Med</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>●●●●●</td>
<td>Neg</td>
<td>Neg</td>
<td>Neg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced plug loads</td>
<td>Electricity</td>
<td>●●●●●</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GHG reduction (kgCO₂e/m²/year)**
- ●●●●● = ≥30 to <50
- ●●●●● = ≥20 to <30
- ●●●● = ≥10 to <20
- ●●● = ≥5 to <10
- ●● = ≥1 to <5
- ● = >0 to <1
- n/a = not applicable, as the baseline fuel is not in use in the specified province or territory

**Annualized return on investment**
- Negative: <0
- Low: 0% to <4%
- Medium: 4% to <8%
- High: ≥8%

**Co-benefits**
- None
- Low
- Moderate
- High
- Very high

---

36 These values do not account for any federal, provincial/territorial, utility or other incentives that may be available. Such incentives can significantly change the business case. Municipalities should investigate further before finalizing their understanding of the economic value of any given option.
## Residential buildings

<table>
<thead>
<tr>
<th>Solution</th>
<th>Baseline fuel</th>
<th>GHG impact (per building)</th>
<th>Annualized return on investment (per building)</th>
<th>Co-benefits</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>AB</td>
<td>SK</td>
<td>NS</td>
</tr>
</tbody>
</table>
| Roof top solar PV                | Electricity   | ●●●●●                      | Low   | Low   | Low   | Low   | -    | -    | -            | ✓ Incentive programs ≤ 1%  
|                                  |               |                           |       |       |       |       | -    | -    | ✓ Financing options ≤ 1%  
|                                  |               |                           |       |       |       |       | -    | -    | ✓ Local policies and bylaws ≤ 1%  |
| Building envelope upgrades       | Electricity   | ●●●●●                      | Med   | Med   | Med   | n/a   | -    | -    | -            | ✓ Incentive programs ≤ 1%  
|                                  |               |                           |       |       |       |       | -    | -    | ✓ Financing options ≤ 1%  
|                                  | Oil           | ●●●●●                      | n/a   | Med   | Low   | Med   | -    | -    | -            | ✓ Energy rating and disclosure ≤ 1%  
|                                  |               |                           |       |       |       |       | -    | -    | ✓ Local policies and bylaws ≤ 1%  |
|                                  | Gas           | ●●●●●                      | Neg   | Low   | Low   | n/a   | -    | -    | -            | ✓ Local policies and bylaws ≤ 1%  |
| Heat pumps                       | Electricity   | ●●●●●                      | Med   | High  | Med   | n/a   | -    | -    | -            | ✓ Incentive programs ≤ 1%  
|                                  |               |                           |       |       |       |       | -    | -    | ✓ Financing options ≤ 1%  
|                                  | Oil           | ●●●●●                      | n/a   | High  | High  | Med   | -    | -    | -            | ✓ Energy rating and disclosure ≤ 1%  
|                                  |               |                           |       |       |       |       | -    | -    | ✓ Local policies and bylaws ≤ 1%  |
| Low-carbon water heating: solar water heaters | Electricity | ●●●●●                      | Neg   | Low   | Neg   | Low   | -    | -    | -            | ✓ Incentive programs ≤ 1%  
|                                  |               |                           |       |       |       |       | -    | -    | ✓ Financing options ≤ 1%  
|                                  | Oil           | ●●●●●                      | n/a   | Low   | Neg   | Neg   | -    | -    | -            | ✓ Local policies and bylaws ≤ 1%  |
|                                  | Gas           | ●●●●●                      | Neg   | Neg   | n/a   | n/a   | -    | -    | -            | ✓ Local policies and bylaws ≤ 1%  |
| Improved HVAC controls           | Electricity   | ●●●●●                      | Med   | High  | High  | n/a   | -    | -    | -            | ✓ Incentive programs ≤ 1%  
|                                  |               |                           |       |       |       |       | -    | -    | ✓ Financing options ≤ 1%  
|                                  | Oil           | ●●●●●                      | n/a   | High  | High  | High  | -    | -    | -            | ✓ Local policies and bylaws ≤ 1%  |
|                                  | Gas           | ●●●●●                      | Low   | Med   | High  | n/a   | -    | -    | -            | ✓ Local policies and bylaws ≤ 1%  |
| Low-carbon water heating: grey water heat recovery | Electricity | ●●●●●                      | Low   | Med   | Med   | Med   | -    | -    | -            | ✓ Incentive programs ≤ 1%  
|                                  |               |                           |       |       |       |       | -    | -    | ✓ Financing options ≤ 1%  
|                                  | Oil           | ●●●●●                      | n/a   | Med   | Med   | Med   | -    | -    | -            | ✓ Local policies and bylaws ≤ 1%  |
|                                  | Gas           | ●●●●●                      | Neg   | Neg   | n/a   | n/a   | -    | -    | -            | ✓ Local policies and bylaws ≤ 1%  |
| Reduced plug loads               | Electricity   | ●●●●●                      | High  | High  | High  | High  | -    | -    | -            | ✓ Incentive programs ≤ 1%  

### GHG reduction (kgCO₂e/m²/year)

- ○○○○○ = <1
- ○○○○○ = 1 to <5
- ○○○○○ = 5 to <10
- ○○○○○ = 10 to <20
- ○○○○○ = 20 to <30
- ○○○○○ = 30 to <50
- ○○○○○ = 50 to <100
- ○○○○○ = 100 to <200
- ○○○○○ = 200 to <300
- ○○○○○ = ≥300

### Annualized return on investment

- Negative: <0
- Low: ≥0% to <4%
- Medium: ≥4% to <8%
- High: ≥8%
- n/a = not applicable, as the baseline fuel is not in use in the specified province or territory

### Co-benefits

- None
- Low
- Moderate
- High
- Very high

---

37 These values do not account for any federal, provincial/territorial, utility or other incentives that may be available. Such incentives can significantly change the business case. Municipalities should investigate further before finalizing their understanding of the economic value of any given option.
High-efficiency indoor ice rinks
Nearly 30 percent of Canadian ice arenas are in poor or very poor physical condition. There is great opportunity to make energy-efficiency improvements while doing required maintenance upgrades, to further improve the look and feel of the arena and provide significant cost savings each year. Learn more about this solution.

Rooftop solar PV—municipal, commercial and residential buildings
Rooftop solar photovoltaic (PV) systems reduce utility bills by offsetting the building’s own electricity consumption with the renewable energy generated through the installed system. This solution yields very significant GHG reductions in areas with high-carbon grids, but only yields small returns. However, returns are likely to increase over the next 5–10 years, as solar PV prices continue to fall and electricity prices rise. This solution offers opportunities for local job creation and can increase resiliency when paired with battery storage. Learn more about this solution.

Building envelope upgrades—municipal, commercial and residential buildings
Building envelope upgrades bring a host of benefits to the building occupant and the greater community—including annual energy savings, enhanced resilience, improved occupant health and comfort, and local jobs. Building envelope upgrades are typically more cost-effective in residential buildings than in commercial and municipal buildings (since residential buildings typically have higher surface area to volume ratios, resulting in a greater proportion of heat being lost through the envelope). These upgrades also lead to greater GHG reductions and more cost-effectiveness in buildings heated with oil or electricity than in those heated with gas. The benefits to the building occupant persist over the lifetime of the building and the upgrades require little or no maintenance. The costs of envelope upgrades can be significantly reduced by combining such upgrades with other renovations, so planned renovations present a key opportunity to improve the building envelope. Learn more about this solution.

Heat pumps replacing electric resistance—municipal, commercial and residential buildings
Heat pumps provide heating more efficiently than electric resistance heating. In areas with high-carbon grids, electric resistance heating is very carbon-intensive, so replacing electric resistance heating with a heat pump produces substantial GHG reductions. This solution is very cost-effective in residential buildings and sometimes cost-effective in commercial and municipal buildings. In addition to heat, heat pumps provide air conditioning, increasing occupant comfort and enhancing a building’s resilience to extreme heat events. This is a key solution in municipalities with widespread use of electric resistance heating, because of the high GHG impact, cost-effectiveness and host of co-benefits. For existing buildings, the best time to install heat pumps is when replacing or installing HVAC systems. Learn more about this solution.

Improved HVAC controls—municipal, commercial and residential buildings
Improved HVAC controls can involve a range of technologies, from smart thermostats to building energy management systems (BEMS), all of which reduce unnecessary running of
HVAC systems. These systems can be very sophisticated and provide additional functionality, such as early detection of building system faults. This solution yields high returns on investment in commercial and municipal buildings. Learn more about this solution.

**High-efficiency lighting—municipal and commercial buildings**

Energy consumption from lighting can be reduced by switching to energy-efficient light bulbs, improving lighting controls, and using natural light as a source of illumination. In particular, light-emitting diode (LED) light bulbs use much less electricity to produce the same amount of light as old light bulb technologies, such as fluorescent and incandescent lighting, and have a longer life span. Installing high-efficiency light bulbs in commercial and municipal buildings results in significant GHG reductions in areas with high-carbon grids and is highly cost-effective. This solution can be packaged with other less cost-effective GHG reduction solutions to create a portfolio that delivers substantial GHG impacts while remaining cost-effective. Learn more about this solution.

**Heat pumps replacing oil—residential buildings**

For municipalities in areas with high-carbon grids, the carbon intensity of electricity is much higher than that of gas or oil, so generally electrification will increase GHG emissions. In this case, the efficiency of the heat pump is paramount to determining whether fuel switching is beneficial from a GHG perspective. In other words, it will depend on the efficiency of the specific heat pump technology and the quality of the installation. In the sample measures analyzed here, heat pumps were found to be beneficial in residential buildings when replacing oil (but not gas), but not in commercial and municipal buildings (when replacing gas or oil). As the carbon intensity of the electricity grid drops, this solution will result in greater GHG reductions. Municipalities may choose to implement this solution now in the expectation that it will result in GHG reductions over its lifetime. In addition to heat, heat pumps provide air conditioning, increasing occupant comfort and enhancing a building’s resilience to extreme heat events. For existing buildings, the best time to install heat pumps is when replacing or installing HVAC systems. Learn more about this solution.

**Reduced plug loads—municipal, commercial and residential buildings**

Plug loads are the energy used by both appliances and electronic devices. Replacing these appliances and devices with efficient models or installing equipment that regulates their energy use saves electricity. This solution only results in limited GHG reductions, but it is highly cost-effective. It can be packaged with less cost-effective but higher-impact solutions, to create a portfolio that delivers substantial GHG impacts while remaining cost-effective. Learn more about this solution.

**Low-carbon water heating—residential buildings**

Solar water heaters

Solar water heaters can cover 40-50 percent of the hot water requirement of an average home. For municipalities in areas with high-carbon grids, solar water heaters have the greatest potential to reduce GHG emissions from water heating, but they have a lower return on investment than grey water heat recovery.
Grey water heat recovery

Grey water heat recovery systems capture heat from hot water flowing down the drain and use it to pre-heat cold water entering the water heater. This technology is easy and very cost-effective to install in new buildings because it can be situated in a way that is optimal for energy savings and installed without cutting any pipes (a step that is necessary in existing buildings, even if the installation is done during other renovations). Grey water heat recovery has a lower GHG impact per home than solar water heaters but yields higher rates of return.

Learn more about these solutions.

Additional options

Significant GHG reductions may also be realized by municipalities with high-carbon grids through community-level solutions—namely, district energy systems and wind and solar energy generation.

To learn more, please see “Key solutions for community energy generation.”
Key solutions for community energy generation

The solutions

In addition to pursuing building-level solutions to achieve your sustainability objectives in the energy sector, your municipality may also consider community energy generation projects. Such projects can offer significant GHG reductions (depending on the baseline energy sources being used) while keeping energy dollars in the community, creating local jobs, spurring economic development and enhancing climate resilience—among other potential benefits.

This roadmap explores two community energy generation options:

- **District energy systems**: District energy systems, also referred to as thermal grids, supply heating and, in some cases, cooling, to multiple buildings. They take heat from a centralized source, or from several different but interconnected sources, and distribute that heat to the buildings through a system of buried insulated pipes. These systems can also be used for cooling, in which case they remove heat from buildings and transfer it to a heat sink such as a borehole or lake. Combined heat and power (CHP) systems also supply electricity via a microgrid. A wide range of energy sources and technologies may be used for these systems, including: biomass, geoxchange, waste heat recovery, municipal waste, solar thermal, excess wind and solar electricity, thermal storage, and backup boilers.

- **Wind and solar energy generation**: Community renewable energy generation projects are owned by local residents, businesses or municipalities and provide electricity to multiple buildings within the community. Project sizes can vary significantly—from small rooftop systems (as small as a few kilowatts (kW)) to large multi-megawatt (MW) installations sited on larger municipal buildings or ground mounted. This roadmap focuses on wind and solar energy, but projects may also be developed for micro-hydro, geothermal, biomass or other sources of renewable energy.

Because these projects can take so many different forms, their GHG and financial impacts are only addressed qualitatively in this roadmap. For municipalities with high-carbon heating/cooling or electricity, these types of energy generation projects are critical to significantly reducing GHG emissions. For municipalities with low-carbon heating/cooling or electricity, these options will not result in significant GHG reductions but may contribute to reducing electricity demand from the grid, which will be important as these municipalities move toward increased electrification.
Key considerations

Table 1 provides an overview of each of these solutions, to help you assess which options are right for driving the clean energy transition in your community. More details on each solution, including brief case studies and additional resources, can be found in Part 3.

Table 1: Community energy generation—key considerations

<table>
<thead>
<tr>
<th>Solution</th>
<th>When is this a good solution?</th>
<th>Key advantages</th>
<th>Key challenges</th>
<th>Options for municipal intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>District energy systems</td>
<td>• Existing heating system is high-carbon (i.e. oil, gas or high-carbon electricity) &lt;br&gt; • Municipality is experiencing rapid growth &lt;br&gt; • Construction of new developments &lt;br&gt; • High building density, preferably including large buildings with a high demand for heating and cooling &lt;br&gt; • Availability of waste heat sources such as industrial waste heat or municipal waste that can be incinerated</td>
<td>• Can yield very significant GHG emissions reductions &lt;br&gt; • Keeps energy dollars in the community &lt;br&gt; • Potential to create value from waste products such as municipal waste &lt;br&gt; • Can double as backup electricity source when heat is provided by a combined heat and power plant &lt;br&gt; • Spurs local economic development by creating jobs and supporting non-energy spending</td>
<td>• Systems must be designed specifically for the conditions of the municipality &lt;br&gt; • High capital expenditures will require financing &lt;br&gt; • Lack of municipal awareness and technical/management expertise around district energy projects &lt;br&gt; • Must engage complex array of stakeholders</td>
<td>• Own through a municipal utility &lt;br&gt; • Participate as an anchor tenant &lt;br&gt; • Develop targets, land use policies and connection policies &lt;br&gt; • Incentivize/finance projects with low-cost loans, loan guarantees, or early-stage grants &lt;br&gt; • Raise awareness and support projects through stakeholder engagement, facilitation and capacity building</td>
</tr>
<tr>
<td>Solution</td>
<td>When is this a good solution?</td>
<td>Key advantages</td>
<td>Key challenges</td>
<td>Options for municipal intervention</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------</td>
<td>----------------</td>
<td>----------------</td>
<td>------------------------------------</td>
</tr>
</tbody>
</table>
| Wind and solar energy generation | • Current electricity is supplied by carbon-intensive fossil fuel sources  
• Municipal infrastructure/land offers strong wind or solar resource potential  
• High coincidence between solar and wind production and a municipality’s peak electricity demand  
• Need to ensure adequate clean electricity supply to meet future electrification demands (from heating and transportation)  
• Enabling policies in place from local energy regulator, utility or provincial/territorial government (e.g. net-metering, feed-in-tariffs, etc.) | • Keeps energy dollars in the community  
• Lowers costs of community renewable projects  
• Spurs local economic development by creating jobs and supporting non-energy spending  
• Can improve community resiliency at the local level  
• Can reduce GHG emissions and potentially improve air quality  
• Expands availability of renewable energy to non-traditional customer segments such as renters and apartment dwellers | • Complex management structures  
• Lack of municipal awareness/expertise around energy projects, regulations and related actions  
• Need for early engagement with the local utility  
• Local regulations may result in provincial/territorial taxation of project revenues (from energy sales)  
• Provincial/territorial regulations and utility operations may pose a barrier | • Offer wind and solar energy generation directly by owning or leading the development of the systems in the community  
• Offer shares in the system to local residents and businesses  
• Offer financial, administrative or educational support for others to establish their own community energy systems that provide renewable energy services to local customers |

**Next steps**

For more information on these technologies, please see the following factsheets:

- [District energy systems](#)
- [Wind and solar energy generation](#)
Strategies for driving solutions forward

The strategies

To drive adoption of high-impact GHG solutions, municipalities need to consider their sphere of control or influence within their jurisdictions. Because municipalities have control over their own buildings and operations, making improvements in municipal buildings is a logical first step, but will not alone lead to GHG emissions reductions at scale.

There is no one-size-fits-all approach to selecting or sequencing policies and strategies across municipalities. Therefore, this roadmap guides municipalities on how to lead by example, as well as how to leverage other strategies to help residents and businesses participate in these solutions. This roadmap considers the conditions needed for each strategy to work, the benefits they may bring, and the challenges that must be overcome. This information can help you identify the mix of programs and policies that will best achieve your municipality’s unique objectives within its unique context.

Specifically, this roadmap looks at five types of strategies (i.e. policies and programs) to promote the uptake of building-level and community-level solutions:

- **Lead by example**: Municipalities can lead by implementing policies and demonstrating the practices they want to encourage within the community to reduce GHG emissions. Specifically, municipalities can use three main strategies in relation to buildings they own or those in which they lease significant space:
  - Adopt high-performance building policies and practices such as stringent building codes, targets, energy-efficiency standards for procurement, and operational practices.
  - Implement or require benchmarking of building energy performance and public disclosure of that information.
  - Showcase and promote corporate or community-wide clean energy or energy-efficiency innovations through pilots and demonstration projects.

- **Incentive programs**: Incentive programs offer support (financial and non-financial) to reduce costs for participants and improve the business case for energy-efficiency and clean energy solutions, thus removing barriers and increasing uptake of those technologies. In addition to the financing programs addressed separately in the Financing Options factsheet, municipalities can use incentives in several ways:
  - Offer discounts and rebates that stand alone or that serve as top-ups to any existing incentives in place.
  - Provide tax credits for improvements such as energy-efficiency retrofits.
  - Offer technical services, like home energy audits.
  - Offer or fund education and training, including third-party training for municipal building operators.
  - Provide other services, like no-cost installation of energy-efficiency measures.
• **Financing options:** Financing options have become an increasingly popular tool to support the adoption of efficient, clean energy technologies by addressing market barriers and increasing access to low-cost, long-term capital. Municipalities can use innovative financing models to support energy efficiency and clean energy improvements in local homes and businesses, municipal buildings, and community-scale initiatives. They can do this in several ways:
  • Support third-party financing programs.
  • Deliver financing programs for local households and businesses. This can include Property Assessed Clean Energy (PACE) programs or local improvement charges, on-bill financing, and credit enhancements.
  • Access financing for municipal building retrofits. This can be done through utility on-bill financing, equipment leases, or energy service agreements (ESAs).

• **Home/building energy rating and disclosure:** Home and building energy rating and disclosure (HERD/BERD) policies are strategies for transforming the market over the long term. Energy ratings and disclosures provide information to owners, managers, buyers and renters about the energy performance of homes and buildings, and cost-effective ways to improve it. This helps consumers become more educated and demand energy-efficient buildings. Municipalities can use HERD/BERD strategies in three ways:
  • Enact voluntary HERD/BERD policies.
  • Enact mandatory HERD/BERD policies.
  • Support provincial/territorial or federal HERD/BERD policies.

• **Local development policies and bylaws:** Municipalities can use policies and bylaws to promote or require energy-efficient design and construction, or expanded use of clean energy technologies, in the homes and buildings within their communities. They can also prepare staff and the local community for upcoming provincial/territorial and federal building and energy code changes. Municipalities have several options:
  • Adopt local development policies and bylaws related to building construction/renovation (e.g. building requirements that exceed or complement provincial or territorial codes, or institute permit-related incentives).
  • Ready municipal staff and local markets for model building code changes.
  • For municipalities in British Columbia: adopt various levels of the voluntary, locally mandated stretch code (the BC Energy Step Code), which is aimed at achieving higher energy savings than base code.

**Key considerations**

Table 2 provides an overview of each of the five strategies, to help municipalities assess which are right for helping drive one or more of the solutions outlined in this roadmap. See the [Strategy](#) factsheets in Part 3 for more details on each strategy.
### Table 2: Strategies for driving solutions forward—key considerations

<table>
<thead>
<tr>
<th>Strategy</th>
<th>When is this a good strategy?</th>
<th>Key advantages</th>
<th>Key challenges</th>
</tr>
</thead>
</table>
| Lead by example   | • Targeting municipally controlled assets through lead-by-example policies is a logical starting place for municipalities to tackle emissions reductions. | • Makes municipal buildings more climate-resilient  
• Strengthens asset management practices  
• Improves building stock and reduces operational costs  
• Encourages local economic development and trains the local workforce  
• Supports monitoring progress toward energy/GHG goals  
• Pilots and promotes green technologies and practices while showcasing municipal leadership  
• Educates the community through case studies  
• Safeguards the health and productivity of building occupants  
• Supports broader policy/program objectives | • Competing municipal priorities require resources.  
• Human and financial resources are needed.  
• Municipal accounting rules may need to be reviewed/modified.  
• Senior leadership is required.  
• Smaller municipalities may lack capacity or internal expertise. |
| Incentive programs| • Incentive programs can take a variety of forms, but will only have a meaningful impact if they are properly targeted to overcome key market barriers at play.  
• Rebate programs can bring down first costs and increase market adoption, especially if dovetailed with existing provincial/territorial or utility programs. | • Tried-and-tested approach for accelerating the adoption of clean/efficient technologies  
• Can be less complex to administer than other programs designed to reduce cost barriers  
• Brings cost savings to local residents and businesses  
• Dovetailing with existing provincial/territorial or utility programs can maximize impact and reduce strain on municipal funds | • Significant monetary resources may be required from municipalities, especially if no federal or provincial/territorial grants can be leveraged.  
• Administration costs as a percentage of program costs can be high for municipalities that aren’t able to achieve economies of scale. Some municipalities may need to pool resources with neighbouring communities.  
• Dovetailing with existing provincial/territorial or utility programs can introduce challenges around coordination and savings attribution.  
• There is risk of free-ridership, in which participants accept the incentive even though they would have installed the energy-efficient measure without the incentive. |
<table>
<thead>
<tr>
<th>Strategy</th>
<th>When is this a good strategy?</th>
<th>Key advantages</th>
<th>Key challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financing options</td>
<td>• Municipalities looking to access financing for efficiency or renewable energy projects in their own buildings can leverage utility on-bill financing (OBF), equipment leases, and energy service agreements (ESAs). • Municipalities can also provide financing to increase access to capital for investments in the greater community. A wide range of innovative financing options exists, but some require enabling provincial or territorial legislation or have other pre-conditions.</td>
<td>Financing of municipal facilities: • Can help reduce key barriers associated with high upfront costs and extended lifetimes and paybacks • Can be tied to local municipal priorities (community energy plans, jobs, water conservation, improving building stock, etc.) • Certain financing models may allow borrowers to transfer improvement project costs from their capital budgets to their operating budgets, thereby streamlining decision-making and budgeting Municipal financing programs offered to the community: • Can be tied to local municipal priorities (community energy plans, jobs, water conservation, improving building stock, etc.) • Can encourage uptake in hard-to-reach market segments • Helps overcome the “split incentive” barrier if financing is attached to the property rather than an individual (i.e. circumstances where the party incurring the costs of clean energy or efficient technology is different than the party that receives the associated benefits) • Certain financing models allow for municipalities to recover costs on a user-basis, negating the need for support from the property-tax base</td>
<td>Financing of municipal facilities: • Project costs may increase because of increased interest expenses. • Internal capacity may be required (e.g. to establish revolving funds, green bonds, etc.). Municipal financing programs offered to the community: • Municipal investment may be required or it may be necessary to raise program capital from non-traditional and private sources. • Complex financing structures may be difficult or costly for smaller municipalities to deliver. • There may be negative perceptions about the potential impacts on municipal credit ratings and debt limits. • Priority lien of PACE/LIC relative to mortgages may be a concern for mortgage lenders and insurers. • Debt burden on local households can increase. • Provisions may be needed to de-risk municipally- or municipally sponsored financing programs.</td>
</tr>
<tr>
<td>Strategy</td>
<td>When is this a good strategy?</td>
<td>Key advantages</td>
<td>Key challenges</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Home/building energy rating and disclosure   | • Municipalities seeking to lead in long-term market transformation should consider mandatory or voluntary HERD/BERD policies, which ultimately aim to increase awareness of and demand for energy-efficient buildings.  
• For mandatory HERD/BERD policies, your municipality must have the authority to regulate.                                                                                                                                                                                                                                                                                                                                 | • Provides municipalities with valuable information on the building stock to support new policies and program development, enforce regulations, and monitor progress toward energy/GHG goals  
• Targets worst performers with tailored interventions  
• Increases knowledge and awareness of building owners around energy performance and opportunities for improvement  
• Improved buildings command higher premiums when sold or rented and make cities more desirable  
• Unlocks demand for energy-efficient products and skilled workers, creating economic growth and jobs | • A mandatory program may be challenged by industry if the benefits are not well-understood or if industry is not consulted in the policy design process.  
• If not mandatory, participation may be limited to those who are already leading in high-performance buildings/homes.  
• Lack of understanding and trust in the ratings can limit HERD/BERD impact.  
• Energy savings and GHG reductions may be limited unless enabling HERD/BERD policies are part of an energy-efficiency ecosystem, including incentives, financing or building codes, or a combination of these elements.  
• Higher premiums for energy-efficient home/building sales and rentals can negatively impact lower-income households. |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Local development policies and bylaws        | • If the province/territory has signalled what new building codes it will adopt and when, municipal efforts can focus on enabling them.  
• If the province/territory has not signalled what new building codes it will adopt or when, municipalities can encourage or require improved building performance by enacting new policies or bylaws—as long as they are not in conflict with provincial/territorial law. Slow-growing municipalities should prioritize efforts on existing buildings, while fast-growing municipalities should prioritize new construction. | Local development policies:  
• Reduce energy use and GHG emissions from community building stock  
• Fulfill other sustainability/development objectives (e.g. more compact, livable cities)  
Readying for new building codes:  
• Readies local construction industry  
• Demonstrates leadership on energy efficiency and emissions reductions | Local development policies:  
• Municipal capacity to implement or enforce new policies and bylaws may be limited.  
• Changes may be met with resistance from the development community.  
• Requirements may increase costs of construction (but reduce operating costs over the life of the building and insulate the owner from escalating utility costs).  
Readying for new codes:  
• Training and other enabling activities may not lead to direct GHG reductions.  
• Studies are needed to define costs, benefits and approaches. |
Designing for equity

Designing for equity is about considering the diversity of the community when designing municipal policies and programs to ensure the full inclusion and participation of residents and businesses. Designing for equity is critical in the context of energy efficiency and clean energy generation programs in Canada for two key reasons:

1. **Those at risk of exclusion are most in need of energy-efficiency upgrades.**

   Most of Canada’s social housing, lower-income owned and renter-occupied housing is older and less efficient than typical housing. In many cases, these households spend a larger portion of their earnings on energy costs than average Canadians. Their homes are the ones that can most benefit from efficiency upgrades to reduce greenhouse gas emissions and improve occupant comfort. Similarly, small businesses typically occupy older buildings that could most benefit from energy-efficiency upgrades.

2. **Those at risk of exclusion face the greatest barriers to participation.**

   Energy-efficiency programs and clean energy generation programs have real and perceived barriers, which are exacerbated among populations at risk of exclusion. For example, in the multi-family housing sector, where a large proportion of low- and moderate-income households reside, barriers include:
   - Limited capacity (time and expertise) on the part of building owners to develop and implement new projects
   - Competing capital interests for building owners, with general building maintenance and repairs taking precedence over energy-efficiency upgrades
   - Lack of capital for the upfront costs of building upgrades
   - Potential need for health and safety repairs before efficiency improvements can be made, which are often not eligible to receive program funding
   - Split incentives are another common barrier for multi-family housing, where building ownership and utility metering can impact the adoption of energy-efficiency solutions (i.e. circumstances where the party incurring the costs of clean energy or efficient technology is different than the party that receives the associated benefits).

   Likewise, small businesses tend to be more focused on daily survival and have more limited capital to invest in building upgrades than larger businesses that typically occupy newer buildings. They may also make investment decisions based on shorter time horizons (with the day-to-day in mind) and are less likely to have adequate asset management planning, knowledge and capacity to pursue efficiency upgrades.

This section summarizes the inherent challenges and opportunities associated with the strategies addressed in this roadmap related to community equity, focusing mainly on low- and moderate-income residents and small businesses. Please see Appendix C for additional guides and resources to promote equitable clean energy, including the City of Ottawa’s *Equity and Inclusion Lens Handbook*, which provides a more fulsome description of those at risk of exclusion.

**Incentive programs**

**Challenges**

Additional incentives may be offered for programs aimed at low- to moderate-income households in recognition of the social benefits resulting from efficient, clean energy technologies.
Opportunities
Municipal programs may cover 100 percent of the incremental cost of the measures for qualifying homes or businesses rather than the portion of such costs offered to other participants.
Examples include direct install programs, which generally provide low-cost efficiency upgrades at no cost to customers (e.g., lights, faucet aerators, power strips), or fully subsidized energy assessments and building envelope improvements.
Direct install programs are highly effective at eliminating many barriers (e.g., split incentives, upfront costs, access to capital, program complexity, etc.) that prevent these sectors from making energy-efficiency upgrades. Programs can directly target customers or landlords and property owners.

Financing options
Challenges
Attention should be paid to the impact that financing can have on the debt burdens and risk exposure of low- to moderate-income (LMI) residents and the small business sector. Financing programs that expand access to capital for non-creditworthy customers may make retrofits more affordable, but also run the risk of increasing debt burdens on vulnerable households and businesses.

Opportunities
Financing programs can promote equity in several ways, such as by being directed to LMI households and small businesses. Doing so requires sound analysis to identify gaps in measures, strategies and markets.
Typically, these disadvantaged segments include a high portion of rental properties, so financing programs can be aimed at helping landlords overcome the “split incentive” barrier. Financing tools that tie repayment to the property (PACE/LIC) or meter (OBF) rather than the customer can help reduce repayment and performance risk to LMI and small business borrowers and lenders. This can lead to lower financing costs, and expanded access to capital for these segments.
Financing should align closely with other social initiatives and borrowing strategies—such as direct install programs, which offer efficiency upgrades at no cost—to reduce participation barriers.
Financing programs can also promote equity by targeting other socially disadvantaged groups, as well as non-profit housing providers and private rental operators offering affordable housing.

Home/building energy rating and disclosure
Challenges
While many jurisdictions are regulated to have low-income programs that offer free energy-efficiency installations for qualifying low-income households, the cost of an energy evaluation can be a significant barrier to disadvantaged population segments where this is not the case. Disclosure also favours more efficient housing, which can lead to increased purchase and rental costs for higher-performing properties.
Raising the prices for more efficient properties can further push low- or moderate-income households and small businesses toward inefficient homes/buildings.

Opportunities
Municipalities must carefully consider the cost and complexity of the energy rating system, and whether exemptions or incentives should be offered to alleviate potential negative impacts on these markets.
Applying a social equity lens can help in evaluating the impacts, needs and costs for those most vulnerable and identify solutions.
Local development policies and bylaws

Challenges
Green building requirements may lead to higher construction costs, which are expected to be passed on to home/building buyers or renters. Without policy interventions, this may have the effect of pushing low- to moderate-income households and businesses into less efficient buildings, leading to higher monthly bill payments for these already-vulnerable segments.

Opportunities
Offsetting green building premiums through incentive programs for low- or moderate-income participants can be an effective way to ensure equity of access to high-performance construction.

See Appendix C for a list of key resources on equitable clean energy.

Next steps
For more information on these strategies, please see the following factsheets:

- Lead by example
- Incentive programs
- Financing options
- Home/building energy rating and disclosure
- Local development policies and bylaws
PART 3
Factsheets for moving forward
Building-level solution

Heat pumps replacing gas or oil

What are heat pumps?

Heat pumps provide efficient heating by drawing heat from outside air, the ground, or a water body, and transferring that heat into a building. They provide efficient cooling by performing the opposite process. This factsheet addresses the use of electric-powered heat pumps in place of gas or oil-based heating systems. The process of replacing other energy sources with electricity is often referred to as “electrification.” To learn more about using heat pumps in place of electric resistance heating (i.e. baseboards, electric furnaces and electric boilers), please see the factsheet, *Heat Pumps Replacing Electric Resistance*.

This solution can be implemented in parallel with other solutions that address space heating—such as building envelope upgrades and HVAC controls—but because of the interactive effects, the greenhouse gas (GHG) impacts may not be additive. In other words, if more than one of these solutions is implemented in the same building, the GHG impacts may be less than the sum of the GHG impacts of each individual solution.

<table>
<thead>
<tr>
<th>Carbon intensity of electricity grid</th>
<th>Fuel</th>
<th>Residential</th>
<th>Commercial and municipal</th>
<th>Co-benefits*</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>GHG impact (per building)</td>
<td>Annualized return on investment (per building) (range across provinces/territories)</td>
<td>GHG impact (per building)</td>
<td>Annualized return on investment (per building) (range across provinces/territories)</td>
</tr>
<tr>
<td>Low</td>
<td>Gas</td>
<td>Negative to high</td>
<td>Negative to low</td>
<td>Gas: Negative to low</td>
<td>Oil: Negative to high</td>
</tr>
<tr>
<td>Oil</td>
<td>Gas</td>
<td>Negative to high</td>
<td>Negative to low</td>
<td>Negative to low</td>
<td>Oil: Negative to high</td>
</tr>
<tr>
<td>Moderate</td>
<td>Gas</td>
<td>Medium to high</td>
<td>Negative to low</td>
<td>Gas: Negative to low</td>
<td>Oil: Negative to high</td>
</tr>
<tr>
<td>Oil</td>
<td>Gas</td>
<td>Negative to high</td>
<td>Negative to low</td>
<td>Negative to low</td>
<td>Oil: Negative to high</td>
</tr>
<tr>
<td>High</td>
<td>Gas</td>
<td>Negative to high</td>
<td>Negative to low</td>
<td>Negative to low</td>
<td>Oil: Negative to high</td>
</tr>
<tr>
<td>Oil</td>
<td>Gas</td>
<td>Negative to high</td>
<td>Negative to low</td>
<td>Negative to low</td>
<td>Oil: Negative to high</td>
</tr>
</tbody>
</table>

*Other environmental benefits may also result, depending on local circumstances, such as the use and location of fossil fuel power plants and their impact on air quality. Equity considerations will depend on program design but can lead to further co-benefits.
How does this solution work and why is it important?

This solution involves replacing natural gas, propane or oil heating—partly or fully—with air-source or ground-source electric heat pumps. Natural gas, propane or oil furnaces achieve efficiencies of up to 98 percent. In other words, as little as two percent of the energy put into the system is lost and the rest is generated as heat. Yet heat pumps improve upon this—they can provide heat at efficiencies of 150–400 percent. They use electricity to extract heat from air, water or the ground, increase pressure to concentrate the heat and increase the temperature, and then transfer that heat into a building. In cooling mode, that process works in reverse, with heat being collected from indoor air and rejected outside.

In areas with low-carbon grids, GHG emissions from electricity generation are a fraction of those created by burning gas or oil. Replacing natural gas, propane or oil heating systems with heat pumps powered with clean electricity can dramatically reduce emissions—by both using less energy and using a lower-carbon form of energy.

Switching to electricity does increase electricity demand, especially when the electric system completely replaces the fossil fuel system. In areas where electricity demand is a concern, municipalities may also want to promote energy-efficiency measures targeting electricity use to offset this increased demand (e.g. heat pumps that replace electric resistance heating, and insulation and airtightness retrofits). Another option is to encourage homeowners and building owners to keep their old fossil fuel systems in place to provide backup on the coldest days. Municipalities may also partner with their local utility to promote demand response technologies (i.e. technologies that help adjust the demand for power, such as smart meters) if heat pumps are increasing peak demand.

Because space heating with gas or oil accounts for 39 percent of all GHG emissions from residential buildings and 52 percent of all emissions from commercial buildings across Canada, replacing gas or oil heating with heat pumps offers an enormous opportunity for GHG reductions.

---

**Need funding for your energy project? Contact FCM!**

Access grants and loans for energy-efficiency and clean energy solutions that support service delivery in your community.

- Improve efficiency and reduce GHG emissions in municipal and community buildings
- Integrate renewable energy generation solutions
- Plan, refine and scale-up innovative financing programs for residential retrofits

[Learn more!](#)
Is this solution right for my municipality?

To determine the potential GHG impact and economic feasibility of replacing gas or oil heating with heat pumps in buildings within your municipality, consider the following questions:

- **What is the carbon intensity of electricity?**
  Based on the typical performance of heat pumps today, switching from natural gas to electricity will not yield GHG emissions reductions in areas where coal and oil are still major sources of electricity generation—as is the case in Alberta, Saskatchewan, Nova Scotia and Nunavut. However, this solution may yield GHG emissions reductions in the future, as the carbon intensity of electricity generation in these provinces and territories is expected to decrease.

- **How expensive is electricity compared to gas/oil?**
  Given the current costs of oil and natural gas in Canada, switching to an electric heat pump from oil will be cost-competitive throughout Canada (apart from the territories where electricity is very expensive), but completely switching from natural gas will only currently be cost-competitive in a few provinces. As heat pump performance improves, the switch from gas to electricity will become more cost-effective. For more details, see the section below, “What are the GHG and financial impacts?”

- **Are there existing incentive programs?**
  Several provincial and territorial governments and utilities offer incentives for heat pump installation. These incentives can have a significant impact on the cost-effectiveness of this measure for building owners.

- **Will heat pumps work well in your municipality’s climate?**
  Air-source heat pump performance deteriorates as ambient air temperatures decrease, but heat pumps specifically designed for cold climates can still achieve efficiencies of greater than 100 percent down to -25°C (though they cost more). Ground-source heat pumps perform better in cold climates than cold climate air-source heat pumps but are significantly more expensive.

What does it take to implement?

If this solution is appropriate for your municipality, you will need to develop an effective strategy to drive adoption. Here are some key actions and considerations:

- **Understand your options for promoting the replacement of oil or gas heating with heat pumps.** You can provide financing or incentive programs to reduce the upfront costs to residents and businesses of buying high-efficiency heat pumps. Energy rating and disclosure programs can ensure that the value of these high-efficiency heating systems is reflected in the value of a property. You can pursue other innovative approaches through local development bylaws (e.g. banning the use of heating oil for certain building types or banning the sale of mini-split air conditioners in favor of mini-split ductless heat pumps). Further, you can lead by example by replacing oil and gas heating systems with heat pumps in your own facilities. For more detail, please see the factsheets, *Home/Building Energy Rating and Disclosure, Local Development Policies and Bylaws*, and *Lead by Example*. 
- **Decide whether to focus on commercial or residential buildings (or both).**
  - Overall heating and cooling costs are higher in commercial and multi-residential buildings than they are in single-family residential buildings. Ground-source heat pumps, which yield larger annual cost savings than air-source heat pumps but have much higher upfront costs, may therefore be a cost-effective option in these buildings.\textsuperscript{i,k}
  - Municipalities in areas with low-carbon grids where residential heating is already largely electric will typically still have commercial buildings that are heated with fossil fuels. If this is the situation in your municipality, you could address both the residential and the commercial sectors by promoting heat pumps that replace electric resistance and those that replace gas and oil, in the same program.
  \(\Rightarrow\) In Atlantic Canada and the territories, most commercial buildings are heated with fuel oil,\textsuperscript{x} which means that switching to heat pumps in those buildings should be cost-competitive.
  \(\Rightarrow\) Elsewhere in Canada, most commercial buildings are heated with natural gas,\textsuperscript{x} so cost-competitiveness will depend on local energy prices.
  - If your municipality is in an area with a low-carbon grid where both residential and commercial buildings use fossil fuels for heating, you could target both sectors.
  - Off-the-shelf cold climate heat pumps are available for residential buildings. Systems for commercial buildings will tend to be more customized. You should design municipal programs to account for this difference.

- **Target buildings that are replacing or installing air conditioners.** Heat pumps can provide cooling as well as heating, so adding a heat pump to a building removes the need for a dedicated air conditioning unit. In areas where heating is predominantly gas and where gas prices are low (such as Ontario), replacing air conditioners with heat pumps but keeping the gas heating as a backup may be much more affordable than fully replacing the heating system with a heat pump. This option can still yield significant GHG emissions reductions.

- **Implement building envelope upgrades before installing heat pumps, to achieve deeper energy savings.** To achieve deeper energy savings in a given building, it is necessary to implement multiple measures. In buildings where you are targeting deep energy savings, it makes sense to perform building envelope upgrades before installing a heat pump because the envelope upgrades reduce the heating demands of the building, allowing a smaller heat pump to be installed.

- **Understand how heat pumps should be sized.** Heat pumps need not be sized to cover the whole heating load of a building (whether the building is new or existing). They can cover the full heating load in the spring and autumn, and work in parallel with a backup heating system in the winter. While this approach requires reliance on fossil fuels during the coldest days of the year, it offers a more economical option for achieving energy savings that are still significant (since smaller units are cheaper and can satisfy a large portion of the heating load). Pay close attention to how heat pumps are controlled when they are sized in this way, however. The heat pump must keep running in parallel.
Heat pumps replacing gas or oil

with the backup system, rather than turning off once the backup is required; otherwise, savings will be much lower than expected.

- **Ensure high-quality installation.** Installation quality has a big effect on the performance of heat pumps. Poorly installed heat pumps will not deliver the promised savings. Poorly trained, “fly-by-night” installers can kill the market. Your municipality can provide, require or promote contractor training and certification programs—as well as on-site audits to ensure quality installation. For example, for heat pumps to be eligible for incentives through the provincial energy-efficiency programs in Nova Scotia and New Brunswick, they must be installed by a certified technician. It can be useful to track the system’s ongoing operation for some time following installation, to ensure that the system is performing as designed and is delivering the promised savings. With air source heat pumps in particular, sizing is critical to achieving as-designed performance. Contractors and HVAC designers can use Natural Resources Canada’s *Air Source Heat Pump Sizing and Selection Guide*, to be published in 2020, to ensure that the right heat pump is selected and sized for the application being considered. New performance ratings such as the CSA EXP07 (*Load-based and Climate-Specific Testing and Rating Procedures for Heat Pumps and Air Conditioners*) more accurately capture the as-installed performance of air-source heat pumps. Future programs should encourage the use of equipment that meets the requirements for these performance ratings.

- **Leverage existing incentive programs.** If your provincial/territorial government or local utility offers an incentive for heat pump installation, your municipality could consider offering additional incentives to further move the market. Incentives are usually in the form of a rebate to cover a portion of upfront system costs. For example, Efficiency Nova Scotia provides an incentive of $300 per ton for ductless mini-split heat pumps and $500 per ton for central air-source heat pumps.

**What are the GHG and financial impacts?**

The GHG reductions, costs and cost savings associated with installing a heat pump to supply part of a building’s heating load are highly dependent on many factors, including: grid carbon intensity, local energy rates, building heating requirements, climatic conditions, the sizing approach used to select the heat pump, and the existing heat distribution system in the building.

This section calculates the GHG and financial impacts associated with installing an air-source heat pump to provide part of the heating load in a building otherwise heated with natural gas or oil. The impacts are calculated for a typical office building and a typical house. The calculations are based on average data for each province and territory, only consider existing buildings, and do not account for any incentives offered by provincial/territorial governments or local utilities.
Commercial and municipal buildings\textsuperscript{xvi}
This section explores the impacts of installing heat pumps to cover part of the load handled by electric resistance heating in a “typical” office building—assumed to have four floors and a total floor area of about 2,900 m\textsuperscript{2} (31,200 ft\textsuperscript{2}).

The analysis assumes that cold climate air-to-water heat pumps are installed to cover a portion of the heating load and have an expected useful life of 15 years.\textsuperscript{xvii} The required capacity of these heat pumps, the proportion of the heating load they cover, and their efficiency, vary from location to location depending on the climate. All these factors have been considered in this analysis.\textsuperscript{xviii} Based on modelling, these heat pumps will cover between 35 and 85 percent of the annual heating requirement, depending on the province or territory, while the existing boiler will cover the remainder.\textsuperscript{xx} This hybrid system is estimated to achieve an overall system efficiency of between 90 and 180 percent.\textsuperscript{xx} Based on current prices, this heat pump system is estimated to have an upfront cost (including installation) of between $65,000 and $240,000, depending on the amount of heating power installed,\textsuperscript{xxi, xxii} with an annual maintenance cost of $500.\textsuperscript{xxiii}

This upgrade results in a heating energy savings of between 20 and 60 percent compared to heating only with the existing gas or oil boiler. Table 1 presents the different impacts by province/territory, as well as the proportion of commercial space heating provided by gas and oil in each province and territory. It should be noted that heating fuel mix may vary significantly across municipalities within a province or territory, especially between rural and urban areas.

\textbf{Table 1:} GHG and financial impacts of installing cold climate air-to-water heat pumps in a typical office building\textsuperscript{a, b}

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of commercial space heating provided by specified fuel</th>
<th>GHG reductions (for a typical office) (tCO\textsubscript{2}e/year)</th>
<th>Annualized return on investment (for building owner)\textsuperscript{c}</th>
<th>$/tCO\textsubscript{2}e (for a typical office)\textsuperscript{d}</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Gas</td>
<td>80%</td>
<td>40</td>
<td>No return</td>
<td>230</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>4%</td>
<td>55</td>
<td>9%</td>
<td>-202</td>
</tr>
<tr>
<td>AB</td>
<td>Gas</td>
<td>92%</td>
<td>-59</td>
<td>No return</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>SK</td>
<td>Gas</td>
<td>92%</td>
<td>-55</td>
<td>No return</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
## Heat pumps replacing gas or oil

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of commercial space heating provided by specified fuel</th>
<th>GHG reductions (for a typical office) (tCO₂e/year)</th>
<th>Annualized return on investment (for building owner)</th>
<th>$/tCO₂e (for a typical office)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MB</td>
<td>Gas</td>
<td>82%</td>
<td>71</td>
<td>No return</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>1%</td>
<td>98</td>
<td>6%</td>
<td>-130</td>
</tr>
<tr>
<td>ON</td>
<td>Gas</td>
<td>81%</td>
<td>62</td>
<td>No return</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>1%</td>
<td>87</td>
<td>9%</td>
<td>-210</td>
</tr>
<tr>
<td>QC</td>
<td>Gas</td>
<td>78%</td>
<td>69</td>
<td>-11%</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>4%</td>
<td>95</td>
<td>7%</td>
<td>-150</td>
</tr>
<tr>
<td>NB</td>
<td>Gas</td>
<td>10%</td>
<td>19</td>
<td>1%</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>10%</td>
<td>48</td>
<td>6%</td>
<td>-240</td>
</tr>
<tr>
<td>PE</td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>49%</td>
<td>70</td>
<td>0%</td>
<td>27</td>
</tr>
<tr>
<td>NS</td>
<td>Gas</td>
<td>22%</td>
<td>-42</td>
<td>-10%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>49%</td>
<td>-15</td>
<td>5%</td>
<td>-</td>
</tr>
<tr>
<td>NL</td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>15%</td>
<td>110</td>
<td>9%</td>
<td>-150</td>
</tr>
<tr>
<td>YT</td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>63%</td>
<td>120</td>
<td>6%</td>
<td>-150</td>
</tr>
<tr>
<td>NT</td>
<td>Gas</td>
<td>11%</td>
<td>41</td>
<td>-2%</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>77%</td>
<td>69</td>
<td>-6%</td>
<td>200</td>
</tr>
</tbody>
</table>
Table 1 shows the extent to which grid carbon intensity affects the capacity for achieving GHG reductions by switching from gas or oil to an electrically powered heat pump. In Quebec, switching from gas furnaces to air-source heat pumps virtually eliminates GHG emissions from space heating, because the province relies on low-carbon hydro for its electricity. Conversely, in Alberta, where electricity generation is primarily coal-fired, the carbon intensity of electricity is so high that, despite the efficiency improvement when switching from a gas furnace to an air-source heat pump, the change will significantly increase emissions from commercial space heating.

In terms of financial impacts, switching from an oil-based system to the heat pump system described in this example will yield positive returns everywhere except in the Northwest Territories and Nunavut, where electricity prices are extremely high. But switching from a gas-based system will only yield a positive return on investment in New Brunswick, where gas prices are very high. These negative financial returns but high GHG impacts point to the need for incentives for heat pumps. As heat pumps improve and prices drop, they could become cost-competitive in more areas and situations. Increases in the price of gas and oil due to carbon taxes will also increase the cost-competitiveness of heat pumps.
Residential buildings

This section explores the impacts of installing a heat pump to cover part of the heating load in a “typical” home—assumed to have two floors and a total floor area of about 140 m² (1,500 ft²). This analysis assumes only partial replacement of the gas or oil heating system with a heat pump, as this solution is typically the most cost-effective and so will achieve the widest adoption.xxiv

This analysis assumes that a small, central, cold climate air-source heat pump is installed instead of a new efficient central air conditioner, and that the heat pump has an expected useful life of 15 years.xxv The efficiency of the system and the proportion of the heating load that it covers vary from location to location, depending on the climate.xxvi Modelling suggests that the heat pump will cover between 60 and 100 percent of the annual heating requirement, depending on the province/territory, while the existing furnace will cover the remainder.xxvii This hybrid system is estimated to achieve an overall system efficiency of between 130 and 360 percent.xxviii Based on current prices, this heat pump is estimated to cost about $3,000 more to install than the central air conditioner,xxix while requiring the same annual spending on maintenance.xxx

This upgrade results in heating energy savings of between 40 and 80 percent compared to heating only with the existing gas or oil furnace. Table 2 shows the GHG reductions and financial impacts resulting from this upgrade. This measure has no impact on cooling energy use as the heat pump is assumed to have the same cooling efficiency as the central air conditioning unit that would otherwise have been installed. Table 2 shows the proportion of residential space heating provided by gas or oil in each province/territory, as a rough indication of the likely GHG reductions and financial impacts that may result in different areas. Note that the proportion of homes heated with each fuel may vary significantly across municipalities within a province or territory, especially between rural and urban areas.

### Table 2: GHG and financial impacts of installing a central heat pump in place of a central air conditioner in a typical gas- or oil-heated homea, b

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of residential space heating provided by specified fuel</th>
<th>GHG reductions (for a typical home) (tCO₂e/year)</th>
<th>Annualized return on investment (for home owner)c</th>
<th>$/tCO₂e (for a typical home)d</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Gas</td>
<td>52%</td>
<td>1.8</td>
<td>-6%</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0.4%</td>
<td>2.6</td>
<td>11%</td>
<td>-260</td>
</tr>
<tr>
<td>AB</td>
<td>Gas</td>
<td>88%</td>
<td>-1.1</td>
<td>-13%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0.0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
# FACTSHEET

Heat pumps replacing gas or oil

<table>
<thead>
<tr>
<th>Province/taxonomy</th>
<th>Heating fuel</th>
<th>Percentage of residential space heating provided by specified fuel</th>
<th>GHG reductions (for a typical home) ($CO_2e/year)</th>
<th>Annualized return on investment (for home owner)c</th>
<th>$/tCO_2e (for a typical home)d</th>
</tr>
</thead>
<tbody>
<tr>
<td>SK</td>
<td>Gas</td>
<td>82%</td>
<td>-1.2</td>
<td>No return</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>1.1%</td>
<td>0.7</td>
<td>14%</td>
<td>-1600</td>
</tr>
<tr>
<td>MB</td>
<td>Gas</td>
<td>47%</td>
<td>3.9</td>
<td>2%</td>
<td>-10</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0.3%</td>
<td>5.7</td>
<td>16%</td>
<td>-295</td>
</tr>
<tr>
<td>ON</td>
<td>Gas</td>
<td>68%</td>
<td>2.8</td>
<td>No return</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>3%</td>
<td>4.2</td>
<td>15%</td>
<td>-330</td>
</tr>
<tr>
<td>QC</td>
<td>Gas</td>
<td>7%</td>
<td>3.3</td>
<td>10%</td>
<td>-170</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>9%</td>
<td>4.8</td>
<td>15%</td>
<td>-320</td>
</tr>
<tr>
<td>NB</td>
<td>Gas</td>
<td>2%</td>
<td>1.6</td>
<td>9%</td>
<td>-290</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>28%</td>
<td>3.2</td>
<td>14%</td>
<td>-410</td>
</tr>
<tr>
<td>PE</td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>49%</td>
<td>4.0</td>
<td>11%</td>
<td>-190</td>
</tr>
<tr>
<td>NS</td>
<td>Gas</td>
<td>1%</td>
<td>-0.4</td>
<td>6%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>37%</td>
<td>1.1</td>
<td>12%</td>
<td>-800</td>
</tr>
<tr>
<td>NL</td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>18%</td>
<td>5.2</td>
<td>14%</td>
<td>-250</td>
</tr>
<tr>
<td>YT</td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>69%</td>
<td>6.4</td>
<td>17%</td>
<td>-320</td>
</tr>
</tbody>
</table>
### Heat pumps replacing gas or oil

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of residential space heating provided by specified fuel</th>
<th>GHG reductions (for a typical home) (tCO₂e/year)</th>
<th>Annualized return on investment (for home owner)</th>
<th>$/tCO₂e (for a typical home)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NT</td>
<td>Gas</td>
<td>11%</td>
<td>3.2</td>
<td>9%</td>
<td>-150</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>77%</td>
<td>5.5</td>
<td>7%</td>
<td>-50</td>
</tr>
<tr>
<td>NU</td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>94%</td>
<td>-0.3</td>
<td>7%</td>
<td>-</td>
</tr>
</tbody>
</table>

**Notes:**

- See Appendix A for more information on return on investment and dollar-per-tonne values.
- This analysis assumes an identical building with identical heating equipment across all provinces and territories; actual GHG impacts and returns on investment will vary by municipality. Likewise, return on investment and $/tCO₂e figures will be more favourable if incentives are offered by provincial/territorial governments or utilities in the jurisdiction.
- Returns are based on 2019 prices but may be much more favourable over the subsequent 5–10 years, as heat pump costs are projected to fall by as much as 20 percent (National Renewable Energy Laboratory (NREL) 2017). Fields labelled “no return” indicate that annual energy costs are actually greater after the measure has been implemented than before.
- "Cost per tonne of CO₂e abated ($/tCO₂e)" indicates the carbon price required to make a given measure cost-effective. A negative cost-per-tonne value indicates that the measure saves money while also reducing emissions. Note that a more negative cost-per-tonne value isn’t necessarily more cost-effective. A blank cell (-) indicates that impacts were not calculated because the measure yields insignificant GHG reductions in this province/territory.
- n/a = not applicable, as specified fuel source is not present in baseline

Partially replacing gas or oil heating with a heat pump yields significant GHG reductions in provinces and territories with low- and moderate-carbon grids. Compared to commercial and municipal buildings, greater energy savings for residential buildings means greater GHG reductions per unit area and a higher return on investment. Replacing oil heating has high returns in almost all provinces and territories, and replacing gas heating has positive returns in Quebec, Manitoba, New Brunswick, Nova Scotia and Yukon. The negative returns but high GHG impacts for installing heat pumps in gas-heated buildings in Ontario and BC point to the need for incentives. It should be noted that in BC, a heat pump that is not designated as “cold climate” may be more cost-effective, as it will still give reasonable performance in BC’s moderate climate and will be significantly less expensive.
What are the potential co-benefits?

In addition to GHG emissions reductions and energy bill savings, the use of heat pumps in place of gas or oil systems has the potential for a number of co-benefits.

- **Jobs**
  - New skilled jobs are created installing and maintaining heat pumps. Investment in heating energy-efficiency programs creates an estimated seven to nine times more jobs per million dollars invested than investment in existing electricity infrastructure (generation, transmission and distribution).

- **Environment**
  - Local air quality will improve.

- **Resilience**
  - Heat pumps provide cooling as well as heating. The addition of cooling reduces the negative health impacts associated with heat waves, which are expected to become increasingly frequent.

- **Health and comfort**
  - In cases where air conditioning is not installed, the use of heat pumps adds cooling to the building, which improves occupant comfort and reduces health risks.
  - Reliance on low-carbon electricity in lieu of gas or oil (in cases where no backup heating system is used) eliminates the risk of oil spills and gas explosions.

- **Other**
  - Variability in energy bills is reduced when heating oil is replaced with heat pumps (in whole or in part), because electricity prices are generally more stable than heating oil prices.
  - Maintenance and insurance costs are reduced if a heat pump fully replaces an oil furnace.

What is the current and projected state of the market?

**Current state of the market**

- Heat pumps are already used to heat approximately five percent of homes in Canada. The number of heat pumps in Canada has increased steadily since 2000.
- A number of key market barriers will need to be addressed to enable widespread adoption of heat pumps instead of gas or oil systems: affordability, contractor qualifications and acceptance.

**Affordability:**

- The high upfront cost of heat pumps is a barrier to adoption. Financing and incentive programs can help address this (see the factsheets, Financing Options and Incentive Programs). Lower-cost heat pumps not specifically designed for cold climates are also available and will perform well in milder conditions. These systems will give smaller savings but may offer higher rates of return and be less of a burden in terms of upfront costs.
Heat pumps replacing gas or oil

• **Contractor qualifications:**
  ➔ Many contractors are not familiar with air-source heat pump technologies, how to properly size and select the model for the application, or even where to source them—let alone how to install and maintain them. This is particularly important because the performance of heat pumps is very dependent on the sizing decision and the quality of the installation.xxxvi Use of Natural Resources Canada’s Air Source Heat Pump Sizing and Selection Guide and Tool, to be published in 2020, will help ensure that the system is properly sized and selected for the application. Training and certification programs can improve contractor knowledge and signal to homeowners which contractors are adequately qualified.

• **Acceptance:**
  ➔ Lack of accurate performance information, improper system sizing, poor-quality installation, and improper maintenance by inadequately trained contractors have resulted in heat pumps not always performing as advertised (in terms of both comfort and the lifetime of the system). This has created skepticism in the building industry about their reliability and performance. More accurate performance information is becoming available, but the skepticism may well linger.xxxvii

**Projections for the future**

• **Adoption:** Market penetration is expected to increase significantly in the future. Analyses by the National Energy Board assume that heat pumps will represent 10–20 percent of new heating systems by 2030, and 40–70 percent by 2040.xxxviii

• **Affordability:** U.S. projections suggest that heat pump costs could fall 10–20 percent by 2025–2030 and 20–30 percent by 2040.xxxix

• **Research and development:**
  • **Cold climate heat pumps:** Much investment is currently being focused on the research, development and deployment of improved cold climate heat pumps.xl This investment will increase their efficiency at low temperatures, and hence their cost-effectiveness. The Canadian government has set targets for improving the performance of cold climate heat pumps. The aim is for all air-source heat pumps available in Canada to have seasonal efficiencies of 250 percent by 2025, and for residential models with seasonal efficiencies of 275 percent to be available and cost-effective by 2030.xli

• **Multi-function heat pumps:** Work is being done to develop heat pumps that provide space heating and cooling as well as water heating, but limited data is available on their cost and performance.xlii
Heat pumps replacing gas or oil

- **Heat pumps that work with natural gas rather than electricity as a fuel:**
  This type of heat pump exists but is not yet widely used in Canada. Natural Resources Canada has set a target that, by 2030, a residential natural gas heat pump with a seasonal efficiency of more than 120 percent can be manufactured and installed cost-effectively. This technology could be interesting in areas where the carbon intensity of the grid remains high.

What have municipalities done?

**Municipalities leading by example**

**Town of Richmond Hill: Centre for the Performing Arts ground-source heat pump**
The Town of Richmond Hill, ON, installed a ground-source heat pump to provide heating and cooling for part of its Centre for the Performing Arts. The system reduced annual GHG emissions by approximately 16 tonnes and provided annual electricity savings of approximately $15,000.

**Incentive programs**

**British Columbia: Municipal top-up rebates**
Many municipalities in BC offer a top-up rebate for residents who switch from a fossil fuel heating system to an electric air-source heat pump. This rebate is in addition to a provincial rebate. BC municipalities offering this kind of top-up include:

- City of North Vancouver
- Regional District of Comox Valley
- Resort Municipality of Whistler
- City of Victoria
- District of Saanich
- City of Vancouver
- City of Campbell River

**City of Sacramento: Go-Electric Bonus Package**
Through its municipally owned utility, the Sacramento Municipal Utility District (SMUD), the City of Sacramento, CA, offers rebates for heat pumps replacing gas furnaces as part of the utility's “Go-Electric Bonus Package.”

**Financing programs**

**City of Toronto: Home Energy Loan Program**
The Home Energy Loan Program run by the City of Toronto, ON, is a Property Assessed Clean Energy (PACE) financing program for energy-efficiency retrofits to single-family homes. Eligible retrofits include heat pumps.

**Building codes and bylaws**

**City of Montreal: Heating oil ban**
The City of Montreal, QC, has announced that it will ban the use of heating oil for industrial and commercial buildings by 2025, and for residential buildings by 2030. It is likely that some of the buildings currently using heating oil will replace those systems with heat pumps.
What resources can support next steps?

This guide explains how heat pumps work and the different heat pump options available for different types of buildings. It also provides cost estimates for the various equipment options and guidance to ensure successful installation.

**Cold Climate Air Source Heat Pump specification and product list**, Northeast Energy Efficiency Partnerships (NEEP), 2019
This online database of cold climate heat pumps includes performance data. It may be useful when choosing a model for installation in a municipal building or when compiling a list of eligible products for a program.

**An Examination of the Opportunity for Residential Heat Pumps in Ontario**, Independent Electricity Systems Operator (IESO), 2017
This report prepared for the Ontario Ministry of Energy provides recommendations for programs to encourage the adoption of heat pumps. While it is focused on Ontario, many of its recommendations can be applied across the country.

**Future of Home Heating**, MaRS Advanced Energy Centre and Enbridge Gas Distribution Inc., 2018
This paper is a detailed assessment of the opportunity to use heat pumps for residential heating in Ontario. It outlines the scenario considered here for fully replacing gas or oil heating systems with electric heating, but also assesses scenarios where a gas or oil backup system remains in place.
Endnotes

i See the factsheet, *Heat Pumps Replacing Electric Resistance*, for more information on the basics of heat pump technologies.

ii The terms COP (coefficient of performance) and HSPF (heating seasonal performance factor) are more typically used to describe heat pump efficiency. All expressions of heat pump efficiency describe the relationship between the useful energy you get out of the system and the amount of electricity you put in. COP is the useful energy output divided by the electricity input. In this factsheet, an efficiency of 300 percent is equivalent to a COP of 3. HSPF is the useful energy output over the heating season in kBtu divided by the electricity input in kWh. An average COP of 3 is equivalent to an HSPF of 10.2.


iv Natural Resources Canada, *Comprehensive Energy Use Database, Residential Sector, Canada*, tables 2 and 7 (2016 data).


vi Replacing an efficient gas furnace with a cold climate heat pump that has an efficiency of 230 percent will not yield GHG reductions in areas where the grid carbon intensity is above 425 gCO$_2$e/kWh. As heat pump performance improves, this number will increase.

vii Cold climate models may not be necessary in southern BC, where winter temperatures are much milder.

viii Data is scarce on the performance of heat pumps in the territories. A 2013 study prepared for Yukon’s Energy, Mines and Resources Department suggested that cold climate air-source heat pumps could provide energy savings of around 40 percent in the Yukon (see *An Evaluation of Air Source Heat Pump Technology in Yukon*, Energy Solutions Centre, 2013).


x Natural Resources Canada, *Comprehensive Energy Use Database, Commercial/Institutional Sector, Atlantic*.

xi Natural Resources Canada, *Comprehensive Energy Use Database*.


xiv A ton (also known as a refrigerant ton) is a unit of power used to describe the heating/cooling power of air conditioners and heat pumps. It is equivalent to 3.5 kW.


xvi For the purposes of this analysis, a “typical” office building includes both municipal and commercial office buildings.

xvii This analysis assumes that heat pumps are sized to provide at least 35 percent of the peak heating power in all provinces and territories.

xviii This analysis uses hourly temperatures from a typical year in the most populous city in each province and territory.

xix The existing boiler is assumed to have an efficiency of 75 percent.

xx Modelling based on the above assumptions suggests that the heat pumps provide between 35 percent (NT) and 85 percent (BC) of the building’s net heating energy requirement with an efficiency of between 170 percent (NT) and 230 percent (BC), resulting in an overall system efficiency of between 90 percent (NT) and 180 percent (BC).

xxi A heat pump is assumed to cost $70,000 per 45 kW nominal capacity. This assumes that existing air handlers and plumbing remain in place and that the existing boiler remains in place as a backup.

xxii Note that the analysis does not account for higher costs and lower equipment availability in some parts of the country, such as the territories.


xxv Assumes a two-ton, cold climate system is installed in all provinces and territories.
Heat pumps replacing gas or oil

xxvi This analysis uses hourly temperatures from a typical year in the most populous city in each province and territory.

xxvii Existing gas furnaces are assumed to have an efficiency of 85 percent and existing oil furnaces are assumed to have an efficiency of 80 percent.

xxviii Modeling based on these assumptions suggests that the heat pumps provide between 60 percent (NT) and 100 percent (BC) of the building’s net heating energy requirement with an efficiency of between 240 percent (NT) and 360 percent (BC), resulting in an overall system efficiency of between 130 percent (NT) and 360 percent (BC).


xxs Pembina Institute, Job Growth in Clean Energy: Employment in Alberta’s emerging renewables and energy efficiency sectors, 2016. This includes direct and indirect jobs, and takes into account the decrease in jobs due to reduced demand for electricity.


xxxiv Natural Resources Canada, Comprehensive Energy Use Database, Residential Sector, Canada, Table 27 (2016 data).


xxxvii Energy and Mines Ministers’ Conference, Paving the Road to 2030 and Beyond: Market transformation road map for energy efficient equipment in the building sector, 2018.

xxxviii Canada Energy Regulator (formerly the National Energy Board), Canada’s Energy Future 2018, Chapter 4 (Technology Case Results).


xl Ibid.

xli Energy and Mines Ministers’ Conference, Paving the Road to 2030 and Beyond: Market transformation road map for energy efficient equipment in the building sector, 2018.


xliv Energy and Mines Ministers’ Conference, Paving the Road to 2030 and Beyond: Market transformation road map for energy efficient equipment in the building sector, 2018.
Building-level solution
Heat pumps replacing electric resistance

What are heat pumps?

Heat pumps provide efficient heating by drawing heat from outside air, the ground or a water body, and transferring that heat into a building. They provide efficient cooling by performing the opposite process. This factsheet addresses the use of electric-powered heat pumps in place of electric resistance heating (i.e. baseboards, electric furnaces and electric boilers). To learn more about using heat pumps in place of gas or oil-based heating systems, please see the factsheet, Heat Pumps Replacing Gas or Oil.

This solution can be implemented in parallel with other solutions that address space heating—such as building envelope upgrades and HVAC controls—but because of the interactive effects, the greenhouse gas (GHG) impacts may not be additive. In other words, if more than one of these solutions is implemented in the same building, the GHG impacts may be less than the sum of the GHG impacts of each individual solution.

<table>
<thead>
<tr>
<th>Carbon intensity of electricity grid</th>
<th>Fuel</th>
<th>Residential GHG impact (per building)</th>
<th>Annualized return on investment (per building) (range across provinces/territories)</th>
<th>Commercial and municipal GHG impact (per building)</th>
<th>Annualized return on investment (per building) (range across provinces/territories)</th>
<th>Co-benefitsa</th>
<th>Jobs</th>
<th>Resilience</th>
<th>Healthy/Comfort</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Electricity</td>
<td>⬜⬜⬜⬜⬜</td>
<td>Low to high</td>
<td>⬜⬜⬜⬜⬜</td>
<td>Low to high</td>
<td>⬜⬜⬜⬜⬜</td>
<td>Low</td>
<td>Resilience</td>
<td>Healthy/Comfort</td>
<td>-</td>
</tr>
<tr>
<td>Moderate</td>
<td>Electricity</td>
<td>⬜⬜⬜⬜</td>
<td>Negative to high</td>
<td>⬜⬜⬜⬜</td>
<td>Negative to high</td>
<td>⬜⬜⬜⬜</td>
<td>Moderate</td>
<td>Resilience</td>
<td>Healthy/Comfort</td>
<td>-</td>
</tr>
<tr>
<td>High</td>
<td>Electricity</td>
<td>⬜⬜⬜⬜⬜</td>
<td>High</td>
<td>⬜⬜⬜⬜⬜</td>
<td>High</td>
<td>⬜⬜⬜⬜⬜</td>
<td>High</td>
<td>Resilience</td>
<td>Healthy/Comfort</td>
<td>-</td>
</tr>
</tbody>
</table>

GHG reduction (kgCO₂e/m²/year)

- ⬜⬜⬜⬜⬜ = <1
- ⬜⬜⬜⬜ = 1 to <5
- ⬜⬜⬜⬜ = 5 to <10
- ⬜⬜⬜ = 10 to <20
- ⬜⬜ = 20 to <30
- ⬜ = ≥30

Annualized return on investment

- Negative: <0
- Low: ≥0% to <4%
- Medium: ≥4% to <8%
- High: ≥8%

Co-benefits

- None
- Low
- Moderate
- High
- Very high

- Lead by example
- Incentive programs
- Financing options
- Energy rating and disclosure
- Local policies and bylaws

Other environmental benefits may also result, depending on local circumstances, such as the use and location of fossil fuel power plants and their impact on air quality. Equity considerations will depend on program design but can lead to further co-benefits.
How does this solution work and why is it important?

Electric resistance heating is 100 percent efficient. In other words, the amount of energy generated by the system is the same as the amount put into the system. Yet heat pumps improve upon this—they can provide heat at efficiencies of 150–400 percent. They use electricity to extract heat from air, water or the ground, increase pressure to concentrate the heat and increase the temperature, and then transfer that heat into a building. In cooling mode, that process works in reverse, with heat being collected from indoor air and rejected outside.

Various types of heat pumps are currently available:

- **Air-source heat pumps** collect heat from the air and deliver that heat to the building during the heating season. For cooling, they collect heat from the building and reject that heat into the outside air. Cold climate heat pumps are now available that can maintain efficiencies greater than 100 percent in ambient temperatures as low as -25°C. There are two main types of air-source heat pumps:
  - **Central air-source heat pumps** provide heating for the whole building through a central heating system. These systems are good for buildings that already have, or will have, ducts. Central heat pumps for residences in cold climates achieve seasonal heating efficiencies of 230 percent and above in climates like that of Ottawa, ON—and even higher efficiencies in milder climates.
  - **Ductless mini-split heat pumps** provide heating for a room or a few rooms via in-room units. These systems don’t require ducts, so they are easy to retrofit in buildings that are currently heated with baseboards. The systems can have one head, or multiple heads to cover multiple zones (referred to as a “multi-split”). Residential, ductless “cold climate heat pumps,” which are specifically designed to perform well in cold climates, can achieve seasonal heating efficiencies of 250 percent in climates like Ottawa, ON, and even higher in milder climates.

- **Ground-source heat pumps** work in much the same way as air-source heat pumps, except that they use a ground loop heat exchanger to collect/reject heat, rather than an air heat exchanger. These systems achieve higher seasonal heating efficiencies in colder climates compared to air-source heat pumps, achieving overall efficiencies of up to 320 percent in southern Canada. They also provide a steadier supply of heat at low temperatures, which...
Heat pumps replacing electric resistance helps reduce peak demand. Ground-source heat pumps are significantly more expensive to install than air-source heat pumps, largely due to the costs associated with the installation of the ground heat collection system, but they offer larger annual energy savings. They are therefore most suitable for buildings with large heating bills, such as commercial and institutional buildings or large residential buildings. Many options are available for the ground loop heat exchanger—each has its own advantages and disadvantages. More information is available in the “Ground-Source Systems” section of the CEA Technologies Inc. Heat Pump Energy Efficiency Reference Guide.

Because space heating with electric resistance accounts for 11 percent of GHG emissions from residential buildings and five percent of GHG emissions from commercial buildings across Canada, replacing electric resistance with heat pumps represents an important opportunity for GHG reductions. In addition to the potential GHG impacts, heat pumps that replace electric resistance may help to reduce electricity use in areas where electricity demand is at risk of exceeding generation capacity.

Is this solution right for my municipality?
To determine the potential GHG impact and economic feasibility of replacing electric resistance heating with heat pumps in buildings within your municipality, consider the following questions:

- **What is the carbon intensity of electricity?**
  Switching from electric resistance heating to heat pumps will yield the greatest emissions reductions in areas with high-carbon grids. In provinces or territories with low-carbon grids, electric resistance heating produces very low GHG emissions already, so reducing electricity use has only a small GHG impact. Conversely, in provinces or territories with high-carbon grids, electric resistance heating results in high GHG emissions, so switching to a more efficient technology leads to significant GHG impacts. While switching to
heat pumps in buildings that are already electrically heated will not have a big impact on GHG emissions in provinces or territories with low-carbon grids, heat pumps can reduce electricity demand, which will be critical as these municipalities move toward the electrification of transportation and heating.\textsuperscript{viii}

- **What proportion of buildings use electric resistance heating?** Heat pumps replacing electric resistance heating will only have a big impact on GHG emissions in municipalities where electric resistance heating is quite widely used. For example, very few buildings in Alberta and the territories are currently heated with electric resistance heating.\textsuperscript{ix} While heat pumps won’t have a large impact on GHGs in municipalities with a low penetration of electric heating, they may still be cost-effective to include in a program aimed at reducing emissions, especially if heat pumps that replace electric resistance are promoted in the same program as those that replace gas or oil systems. See the factsheet, *Heat Pumps*.

\textbf{What does it take to implement?}

If this solution is appropriate for your municipality, you will need to develop an effective strategy to drive adoption. Here are some key actions and considerations:

- **Understand your options for promoting the replacement of electric resistance heating with heat pumps.** You can provide financing or incentive programs to reduce the upfront costs to residents and businesses of buying high-efficiency heat pumps. Energy rating and disclosure programs can ensure that the value of these high-efficiency heating systems is reflected in the value of a property. Further, you can lead by example by replacing electric heating with heat pumps in your own facilities. For more detail, please see the factsheets, *Home/Building Energy Rating and Disclosure* and *Lead by Example*.
• **Decide whether to focus on commercial or residential buildings (or both).**
  - Overall heating and cooling costs are higher in commercial and multi-residential buildings than they are in single-family residential buildings. Ground-source heat pumps, which yield larger annual cost savings than air-source heat pumps but have much higher upfront costs, may therefore be a more cost-effective option in these buildings.
  - Electric resistance heating tends to be more prevalent in residential buildings than in commercial buildings, so the market for heat pumps may be larger in the residential sector. Despite the smaller market in the commercial sector, it may be worth promoting heat pumps through a joint program for both the residential and commercial sectors, whether the heat pumps are replacing gas, oil or electric resistance systems.
  - Off-the-shelf cold climate heat pumps are available for residential buildings. Systems for commercial buildings will tend to be more customized. You should design municipal programs to account for this difference.
  - **Target buildings that are replacing or installing air conditioners.** Heat pumps can provide cooling as well as heating, so adding a heat pump to a building removes the need for a dedicated air conditioning unit. Installing an air-source heat pump when an air conditioner is due for replacement or is being installed is a good option. The added cost of the heat pump over a new air conditioner is small, and the heat pump will reduce electricity use in the heating season while providing efficient cooling in the cooling season.

• **Implement building envelope upgrades before installing heat pumps, to achieve deeper energy savings.** To achieve deeper energy savings in a given building, it is necessary to implement multiple measures. In buildings where you are targeting deep energy savings, it makes sense to perform building envelope upgrades before installing a heat pump because the envelope upgrades reduce the heating demands of the building, allowing a smaller heat pump to be installed.

• **Understand how heat pumps should be sized.** Heat pumps need not be sized to cover the whole heating load of a building (whether the building is new or existing). They can cover the full heating load in the spring and autumn, and work in parallel with a backup heating system in the winter. While this approach requires reliance on inefficient electric resistance heating during the coldest days of the year, it offers a more economical option for achieving energy savings that are still significant (since smaller units are cheaper and can satisfy a large portion of the heating load). Pay close attention to how heat pumps are controlled when they are sized in this way, however. The heat pump must keep running in parallel with the backup system, rather than turning off once the backup is required; otherwise, savings will be much lower than expected.
• **Ensure high-quality installation.**
  Installation quality has a big effect on the performance of heat pumps. Poorly installed heat pumps will not deliver the promised savings. Poorly trained, “fly-by-night” installers can kill the market. Your municipality can provide, require or promote contractor training and certification programs—as well as on-site audits to ensure quality installation. For example, for heat pumps to be eligible for incentives through the provincial energy-efficiency programs in Nova Scotia and New Brunswick, they must be installed by a certified technician. It can be useful to track the system's ongoing operation for some time following installation, to ensure that the system is performing as designed and is delivering the promised savings. With air-source heat pumps in particular, sizing is critical to achieving as-designed performance. Contractors and HVAC designers can use Natural Resources Canada's *Air Source Heat Pump Sizing and Selection Guide*, to be published in 2020, to ensure that the right heat pump is selected and sized for the application being considered. New performance ratings such as the CSA EXP07 (*Load-based and Climate-Specific Testing and Rating Procedures for Heat Pumps and Air Conditioners*) more accurately capture the as-installed performance of air-source heat pumps. Future programs should encourage the use of equipment that meets the requirements for these performance ratings.

• **Leverage existing incentive programs.**
  If your provincial/territorial government or local utility offers an incentive for heat pump installation, your municipality could consider offering additional incentives to further move the market. Incentives are usually in the form of a rebate to cover a portion of upfront system costs. For example, Efficiency Nova Scotia provides an incentive of $300 per ton for ductless mini-split heat pumps and $500 per ton for central air-source heat pumps. The impacts are calculated for a typical office building and a typical house. The calculations are based on average data for each province and territory, only consider existing buildings, and do not account for any incentives offered by provincial/territorial governments or local utilities.

What are the GHG and financial impacts?

The GHG reductions, costs and cost savings associated with installing a heat pump to supply part of a building’s heating load are highly dependent on a variety of factors, including: grid carbon intensity, local energy rates, building heating requirements, climatic conditions, the sizing approach used to select the heat pump, and the existing heat distribution system in the building.

This section calculates the GHG and financial impacts associated with installing an air-source heat pump to provide part of the heating load in a building otherwise heated with electric resistance heating. The impacts are calculated for a typical office building and a typical house. The calculations are based on average data for each province and territory, only consider existing buildings, and do not account for any incentives offered by provincial/territorial governments or local utilities.

**Commercial and municipal buildings**

This section explores the impacts of installing heat pumps to cover part of the load handled by electric resistance heating in a “typical” office building—assumed to have four floors and a total floor area of about 2,900 m² (31,200 ft²).

The analysis assumes that cold climate air-to-water heat pumps are installed to cover a portion of the heating load, and have...
an expected useful life of 15 years.\textsuperscript{xvii} The required capacity of these heat pumps, the proportion of the heating load they cover, and their efficiency, vary from location to location depending on the climate. All these factors have been considered in this analysis.\textsuperscript{xviii} Based on modelling, these heat pumps will cover between 35 and 85 percent of the annual heating requirement, depending on the province or territory, while the existing electric boiler will cover the remainder.\textsuperscript{xix} This hybrid system is estimated to achieve an overall system efficiency of between 115 and 190 percent.\textsuperscript{xx} Based on current prices, this heat pump system is estimated to have an upfront cost (including installation) of between $65,000 and $240,000, depending on the amount of heating power installed,\textsuperscript{xxi, xxii} with an annual maintenance cost of $500.\textsuperscript{xxiii}

This upgrade results in a heating energy savings of between 15 and 50 percent compared to heating only with electric boilers. Table 1 presents the different impacts by province/territory, as well as the proportion of commercial space heating provided by electricity in each province and territory. It should be noted that heating fuel mix may vary significantly across municipalities within a province or territory, especially between rural and urban areas.

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of commercial space heating provided by electricity</th>
<th>GHG reductions (for a typical office) (tCO\textsubscript{2}e/year)</th>
<th>Annualized return on investment (for building owner)\textsuperscript{c}</th>
<th>$/tCO\textsubscript{2}e (for a typical office)\textsuperscript{d}</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Electricity</td>
<td>14%</td>
<td>&lt;1.0</td>
<td>6%</td>
<td>-</td>
</tr>
<tr>
<td>AB</td>
<td>Electricity</td>
<td>1.3%</td>
<td>120</td>
<td>3%</td>
<td>-25</td>
</tr>
<tr>
<td>SK</td>
<td>Electricity</td>
<td>6.7%</td>
<td>100</td>
<td>3%</td>
<td>-39</td>
</tr>
<tr>
<td>MB</td>
<td>Electricity</td>
<td>15%</td>
<td>&lt;1.0</td>
<td>-1%</td>
<td>-</td>
</tr>
<tr>
<td>ON</td>
<td>Electricity</td>
<td>11%</td>
<td>2.6</td>
<td>4%</td>
<td>-</td>
</tr>
<tr>
<td>QC</td>
<td>Electricity</td>
<td>12%</td>
<td>&lt;1.0</td>
<td>2%</td>
<td>-</td>
</tr>
<tr>
<td>NB</td>
<td>Electricity</td>
<td>66%</td>
<td>49</td>
<td>5%</td>
<td>-150</td>
</tr>
<tr>
<td>PE</td>
<td>Electricity</td>
<td>4.0%</td>
<td>31</td>
<td>7%</td>
<td>-480</td>
</tr>
</tbody>
</table>
Heat pumps replacing electric resistance

Replacing electric resistance heating with heat pumps in commercial and municipal office buildings yields significant GHG emissions reductions in provinces and territories with high-carbon grids. While this solution is not a key GHG-reducing opportunity in areas with low-carbon grids, it can reduce demand for clean electricity, which will be important as the load may grow rapidly in the future, with communities moving toward the electrification of heating and transportation.

In terms of financial impacts, this measure yields positive returns in all provinces and territories—apart from Manitoba, where electricity prices are very low. The cost-effectiveness of this upgrade may improve significantly over the next 5–10 years, as heat pump prices are expected to fall by as much as 20 percent. xxiv
Residential buildings
This section explores the impacts of installing a heat pump to cover part of the heating load in a “typical” home—assumed to have two floors and a total floor area of about 140 m² (1,500 ft²). This analysis assumes only partial replacement of the electric resistance heating load with a heat pump, as this solution is typically the most cost-effective and so will achieve the widest adoption.\textsuperscript{xv}

This analysis assumes that a cold climate ductless multi-split heat pump is installed instead of an equivalent ductless mini-split air conditioning system in a home that is initially heated with electric resistance baseboards, and has an expected useful life of 15 years.\textsuperscript{xxvi} The proportion of heating covered by the heat pump will depend on the layout of the house. The heat pump will be able to cover a bigger proportion of the heating in houses with a more open floor plan. This analysis assumes that the heat pump can cover up to 50 percent of the annual heating requirement while the existing baseboards cover the remaining heating load.\textsuperscript{xxvii} The efficiency of the system depends on climate, which was considered in this analysis.\textsuperscript{xxviii} This system is estimated to achieve an overall system efficiency of between 135 percent and 155 percent.\textsuperscript{xxix} Based on current prices, this heat pump is estimated to cost about $4,000 more to install than two mini-split air conditioners, with the same annual maintenance costs.\textsuperscript{xxx}

This upgrade results in heating energy savings of between 25 and 35 percent compared to heating only with baseboards. Table 2 shows the GHG reductions and financial impacts resulting from this upgrade. This measure has no impact on cooling energy use as the heat pump is assumed to have the same cooling efficiency as the air conditioning unit that would otherwise have been installed.

Table 2 shows the proportion of residential space heating provided by electricity in each province and territory, as an indication of the likely GHG and financial impacts that may result in different areas. Note that the proportion of homes heated with each fuel may vary significantly across municipalities within a province or territory, especially between rural and urban areas.

Table 2: GHG and financial impacts of installing a ductless multi-split heat pump in place of an air conditioner in a typical electrically heated home.\textsuperscript{a,b}

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of residential space heating provided by electricity</th>
<th>GHG reductions (for a typical home) (tCO(_2)e/year)</th>
<th>Annualized return on investment (for homeowner)\textsuperscript{c}</th>
<th>$/tCO(_2)e (for a typical home)\textsuperscript{d}</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Electricity</td>
<td>31%</td>
<td>0.03</td>
<td>2%</td>
<td>–</td>
</tr>
<tr>
<td>AB</td>
<td>Electricity</td>
<td>5%</td>
<td>4.9</td>
<td>6%</td>
<td>-69</td>
</tr>
<tr>
<td>SK</td>
<td>Electricity</td>
<td>10%</td>
<td>5.1</td>
<td>10%</td>
<td>-170</td>
</tr>
</tbody>
</table>
## Heat pumps replacing electric resistance

### Factsheet

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of residential space heating provided by electricity</th>
<th>GHG reductions (for a typical home) (tCO$_2$e/year)</th>
<th>Annualized return on investment (for homeowner)$^c$</th>
<th>$$/tCO_2e$$ (for a typical home)$^d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MB</td>
<td>Electricity</td>
<td>43%</td>
<td>0.01</td>
<td>6%</td>
<td>–</td>
</tr>
<tr>
<td>ON</td>
<td>Electricity</td>
<td>14%</td>
<td>0.09</td>
<td>5%</td>
<td>–</td>
</tr>
<tr>
<td>QC</td>
<td>Electricity</td>
<td>50%</td>
<td>&lt;0.01</td>
<td>2%</td>
<td>–</td>
</tr>
<tr>
<td>NB</td>
<td>Electricity</td>
<td>41%</td>
<td>1.9</td>
<td>7%</td>
<td>-210</td>
</tr>
<tr>
<td>PE</td>
<td>Electricity</td>
<td>4%</td>
<td>1.1</td>
<td>9%</td>
<td>-530</td>
</tr>
<tr>
<td>NS</td>
<td>Electricity</td>
<td>21%</td>
<td>3.7</td>
<td>8%</td>
<td>-140</td>
</tr>
<tr>
<td>NL</td>
<td>Electricity</td>
<td>68%</td>
<td>0.23</td>
<td>7%</td>
<td>-1,600</td>
</tr>
<tr>
<td>YT</td>
<td>Electricity</td>
<td>23%</td>
<td>0.47</td>
<td>9%</td>
<td>-1,400</td>
</tr>
<tr>
<td>NT</td>
<td>Electricity</td>
<td>0.8%</td>
<td>1.8</td>
<td>17%</td>
<td>-1,500</td>
</tr>
<tr>
<td>NU</td>
<td>Electricity</td>
<td>0.0%</td>
<td>9.8</td>
<td>20%</td>
<td>n/a</td>
</tr>
</tbody>
</table>

$^a$ See Appendix A for more information on return on investment and dollar-per-tonne values.

$^b$ This analysis assumes an identical home with identical heating equipment across all the provinces and territories; actual GHG impacts and returns on investment will vary by municipality. Likewise, return on investment and $$/tCO_2e$$ figures will be more favourable if incentives are offered by provincial/territorial governments or utilities in the jurisdiction.

$^c$ Returns are based on 2019 prices but may be much more favourable over the subsequent 5–10 years, as heat pump costs are projected to fall by as much as 20 percent (National Renewable Energy Laboratory (NREL) 2017).

$^d$ “Cost per tonne of CO$_2$e abated ($$/tCO_2e$$)” indicates the carbon price required to make a given measure cost-effective. A negative cost-per-tonne value indicates that the measure saves money while also reducing emissions. Note that a more negative cost-per-tonne value isn’t necessarily more cost-effective. A blank cell (–) indicates that impacts were not calculated because the measure yields insignificant GHG reductions in this province/territory.

n/a = not applicable, as specified fuel source is not present in baseline.
Replacing resistance heating with heat pumps in residential buildings yields significant GHG emissions reductions in provinces and territories with high- and moderate-carbon grids. As with commercial and municipal buildings, although the GHG impacts in areas with low-carbon grids are not as significant, the electricity saved means there is reduced demand for clean electricity, which will be important as municipalities move toward the electrification of heating and transportation.

This measure yields a positive return on investment in all provinces and territories. The highest returns are in provinces and territories with high residential electricity prices. As heat pump prices decline over the coming years, the economics will become more favourable across the country.

In short, the greatest opportunity for benefits from this solution is in areas where electric resistance heating is widely used and where the grid carbon intensity is relatively high, such as Nova Scotia and New Brunswick. The savings per building are also very high in Alberta and Saskatchewan, so this measure is promising for municipalities in those provinces, although it is not as broadly applicable (since electricity powers only 5–10 percent of heating in those provinces).

What are the potential co-benefits?

In addition to GHG emissions reductions and energy bill savings, the use of heat pumps in place of resistance heating has the potential for a number of co-benefits.

- **Jobs**
  - New skilled jobs are created installing and maintaining heat pumps. Investment in heating energy-efficiency programs creates an estimated seven to nine times more jobs per million dollars invested than investment in existing electricity infrastructure (generation, transmission and distribution).xxx, xxxii

- **Environment**
  - Local air quality will improve in areas with high-carbon grids, downwind from power plants that burn fossil fuels.

- **Resilience**
  - Heat pumps provide cooling as well as heating. The addition of cooling reduces the negative health impacts associated with heat waves, which are expected to become increasingly frequent.xxxiii

- **Health and comfort**
  - In cases where air conditioning is not installed, the use of heat pumps adds cooling to the building, which improves occupant comfort and reduces health risks.
What is the current and projected state of the market?

**Current state of the market**
- Heat pumps are already used to heat approximately five percent of homes in Canada. The number of heat pumps in Canada has increased steadily since 2000.
- A number of key market barriers will need to be addressed to enable widespread adoption of heat pumps instead of electric resistance.

**Affordability:**
- The high upfront cost of heat pumps is a barrier to adoption. Financing and incentive programs can help address this (see the factsheets, Financing Options and Incentive Programs). Lower-cost heat pumps not specifically designed for cold climates are also available and will perform well in milder conditions. These systems will give smaller savings but may offer higher rates of return and be less of a burden in terms of upfront costs.
- A lack of recognized value in the marketplace means that developers will often install baseboards in new buildings due to their low installation cost and because the value of installing a higher-efficiency system will not be reflected adequately in the building price. Energy rating and disclosure programs can alleviate this barrier by allowing improvements made to the building to be reflected in the building’s value (see the factsheet, Home/Building Energy Rating and Disclosure).

**Contractor qualifications:**
- Many contractors are not familiar with air-source heat pump technologies, how to properly size and select the model for the application, or even where to source them—let alone how to install and maintain them. This is particularly important because the performance of heat pumps is very dependent on the sizing decision and the quality of the installation. Use of Natural Resources Canada’s Air Source Heat Pump Sizing and Selection Guide and Tool, to be published in 2020, will help ensure that the system is properly sized and selected for the application. Training and certification programs can improve contractor knowledge and signal to homeowners which contractors are adequately qualified.

**Acceptance:**
- Lack of accurate performance information, improper system sizing, poor-quality installation, and improper maintenance by inadequately trained contractors have resulted in heat pumps not always performing as advertised. This has created skepticism in the building industry about their reliability and performance. More accurate performance information is becoming available, but the skepticism may well linger.
**Projections for the future**

- **Adoption:** Market penetration is expected to increase significantly in future. Analyses by the National Energy Board assume that heat pumps will represent 10–20 percent of new heating systems by 2030, and 40–70 percent by 2040.xxxviii

- **Affordability:** U.S. projections suggest that heat pump costs could fall 10–20 percent by 2025–2030 and 20–30 percent by 2040.xxxix

- **Research and development:**
  - **Cold climate heat pumps:** Much investment is currently being focused on the research, development and deployment of improved cold climate heat pumps.xli This investment will increase their efficiency at low temperatures, and hence their cost-effectiveness. The Canadian government has set targets for improving the performance of cold climate heat pumps. The aim is for residential air-source heat pump models with seasonal efficiencies of 275 percent to be available and cost-effective by 2030.xlii
  - **Multi-function heat pumps:** Work is being done to develop heat pumps that provide space heating and cooling as well as water heating, but limited data is available on their cost and performance.xliii

**What have municipalities done?**

There are no known municipal examples of policies or programs in place to promote heat pumps without fuel switching. However, utility programs do exist to this end.

- **New Brunswick Power: Rebates on ductless mini-split heat pumps**
  To be eligible for incentives, all heat pumps must be installed by certified technicians.

- **Efficiency Nova Scotia: Heating System Rebates program**
  To be eligible for incentives, all heat pumps must be installed by certified technicians.

**What resources can support next steps?**

  This guide explains how heat pumps work and the different heat pump options available for different types of buildings. It also provides cost estimates for the various equipment options and guidance to ensure successful installation.

- **Cold Climate Air Source Heat Pump specification and product list,** Northeast Energy Efficiency Partnerships (NEEP), 2019
  This online database of cold climate heat pumps includes performance data. It may be useful when choosing a model for installation in a municipal building or when compiling a list of eligible products for a program.

- **An Examination of the Opportunity for Residential Heat Pumps in Ontario,** Independent Electricity Systems Operator (IESO), 2017
  This report provides recommendations for programs to encourage the adoption of heat pumps. While it is focused on Ontario, many of its recommendations can be applied across the country.
Heat pumps replacing electric resistance

Endnotes

i COP (coefficient of performance) and HSPF (heating seasonal performance factor) are the terms typically used to describe heat pump efficiency. All expressions of heat pump efficiency describe the relationship between the useful energy you get out of the system and the amount of electricity you put in. COP is the useful energy output divided by the electricity input. In this factsheet, an efficiency of 300 percent is equivalent to a COP of 3. HSPF is the useful energy output over the heating season in kBtu divided by the electricity input in kWh. An average COP of 3 is equivalent to an HSPF of 10.2.


iii The Cold Climate Air-Source Heat Pump Specification (Version 3.0) by Northeast Energy Efficiency Partnerships (NEEP) requires a minimum HSPF of 7.8 for central air-source heat pumps in climates like that of Ottawa’s. An HSPF of 7.8 translates to a seasonal efficiency of 230 percent.

iv The Northeast Energy Efficiency Partnership’s Cold Climate Air-Source Heat Pump Specification (Version 3.0) requires a minimum HSPF of 8.7 for ductless air-source heat pumps in climates like Ottawa’s. An HSPF of 8.7 translates to a seasonal efficiency of 250 percent.

v Closed-loop systems in southern Canada will have an HSPF of between 9.2 and 11. An HSPF of 11 translates to a seasonal efficiency of 320 percent. See Ground-Source Heat Pumps (Earth-Energy Systems), Section 5—Heating and Cooling with a Heat Pump, Natural Resources Canada, 2017.

vi Natural Resources Canada, Comprehensive Energy Use Database, Residential Sector, tables 2 and 11 (2016 data.)


viii The impact on peak electricity demand of replacing resistance heating with heat pumps will depend on local conditions and on the heat pumps installed. Municipalities hoping to reduce electricity demand should conduct local studies to better understand what to expect.

ix Natural Resources Canada, Comprehensive Energy Use Database, Commercial/Institutional Sector, Table 24; and Residential Sector, Table 5 (2016 data).

x Cold climate models may not be necessary in southern BC, where winter temperatures are much milder.


xiv A ton (also known as a refrigerant ton) is a unit of power used to describe the heating/cooling power of air conditioners and heat pumps. It is equivalent to 3.5 kW.


xvi For the purposes of this analysis, a “typical” office building includes both municipal and commercial office buildings.

xvii This analysis assumes that heat pumps are sized to provide at least 35 percent of the peak heating power in all provinces and territories.

xviii This analysis uses hourly temperatures from a typical year in the most populous city in each province and territory.

xix The existing electric boiler is assumed to have an efficiency of 98 percent.

xx Modeling based on the above assumptions suggests that heat pumps provide between 35 percent (NT) and 85 percent (BC) of a building’s net heating energy requirement, with an efficiency of between 170 percent (NT) and 230 percent (BC), resulting in an overall system efficiency of between 115 percent (NT) and 190 percent (BC).
For this analysis, a heat pump is assumed to cost $70,000 for every 45 kW of nominal capacity. The analysis assumes that existing air handlers and plumbing remain in place and that the existing boiler remains in place as a backup.

Note that the analysis does not account for higher costs and lower equipment availability in some parts of the country, such as the territories.


Assumes a 1.5-ton, two-zone, multi-split, cold climate system is installed in all provinces and territories.

Baseboards are assumed to have an efficiency of 100 percent.

This analysis uses hourly temperatures from a typical year in the most populous city in each province and territory.

Modeling based on these assumptions suggests that the heat pump achieves an efficiency of between 215 percent (NT) and 355 percent (BC), resulting in an overall system efficiency of between 135 percent (NT) and 155 percent (BC) when combined with the baseboards.


Pembina Institute, *Job Growth in Clean Energy: Employment in Alberta’s emerging renewables and energy efficiency sectors*, 2016. This includes direct and indirect jobs, and takes into account the decrease in jobs due to reduced demand for electricity.


Natural Resources Canada, *Comprehensive Energy Use Database, Residential Sector, Canada, Table 27* (2016 data).


Energy and Mines Ministers’ Conference, *Paving the Road to 2030 and Beyond: Market transformation road map for energy efficient equipment in the building sector*, 2018.

Canada Energy Regulator (formerly the National Energy Board), *Canada’s Energy Future 2018*, Chapter 4 (Technology Case Results).


Ibid.

Energy and Mines Ministers’ Conference, *Paving the Road to 2030 and Beyond: Market transformation road map for energy efficient equipment in the building sector*, 2018.

Building-level solution

Building envelope upgrades

What are building envelope upgrades?

Building envelope upgrades improve the building shell so that it better controls the flow of heat, air and moisture in and out of the building. Examples include adding insulation, sealing air leaks and installing high-quality windows and curtain walls.

These solutions can be implemented in parallel with other space heating solutions—such as improved HVAC controls and heat pumps—but because of the interactive effects, the greenhouse gas (GHG) impacts may not be additive. In other words, if more than one of these solutions is implemented in the same building, the GHG impacts may be less than the sum of the GHG impacts of each individual solution.

<table>
<thead>
<tr>
<th>Carbon intensity of electricity grid</th>
<th>Fuel</th>
<th>Residential</th>
<th>Commercial and municipal</th>
<th>Co-benefits</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>GHG impact</td>
<td>Annualized return on investment (per building)</td>
<td>GHG impact</td>
<td>Annualized return on investment (per building)</td>
</tr>
<tr>
<td>Low</td>
<td>Electricity</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
</tr>
<tr>
<td>Gas</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
</tr>
<tr>
<td>Oil</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
</tr>
<tr>
<td>Moderate</td>
<td>Electricity</td>
<td>Low to medium</td>
<td>Low to medium</td>
<td>Low to high</td>
<td>Low to high</td>
</tr>
<tr>
<td>Gas</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
</tr>
<tr>
<td>Oil</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
</tr>
<tr>
<td>High</td>
<td>Electricity</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
</tr>
<tr>
<td>Gas</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
</tr>
<tr>
<td>Oil</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
<td>Low to high</td>
</tr>
</tbody>
</table>

a Other environmental benefits may also result, depending on local circumstances, such as the use and location of fossil fuel power plants and their impact on air quality. Equity considerations will depend on program design but can lead to further co-benefits.
How does this solution work and why is it important?

The building envelope is the shell of the building. It consists of the basement or crawl space floor and walls, above-grade walls, windows and doors, and attic/roof. Building envelope upgrades reduce heating energy use by reducing the rate of heat loss through these components. The benefits of building envelope retrofits can last for the lifetime of the building, and these upgrades require little or no maintenance.

Possible building envelope upgrades include:

- adding insulation to the walls, roof or floors
- sealing air leaks in the building or adding air barriers to reduce infiltration
- installing low-conductivity windows and doors

The impact of envelope upgrades depends largely on the quality of the materials and the completeness of the work. Key aspects are the insulating value of the insulation (i.e. the nominal R-value), the extent of insulation coverage (i.e. the extent to which the insulation offers continuous coverage of the surface), and whether various joints are air-sealed and openings sealed. To save more heating energy, additional steps can be taken alongside building envelope upgrades, wherever different building systems interact—such as replacing heating and cooling systems and upgrading building controls. For example, if the building envelope is upgraded at the same time that the heating system is changed, heating equipment can be installed that is lower-capacity (hence lower-cost) and high-efficiency. Such projects, commonly referred to as “deep energy retrofits,” can deliver energy savings of up to 50 percent.

Because space heating accounts for about 60 percent of building-related GHG emissions in the commercial and residential sectors nationally, building envelope upgrades offer an important opportunity for GHG reductions. Aggressive envelope upgrades are critical to achieving buildings with net-zero energy consumption—those that don’t consume any more energy than they produce on an annual basis.

Need funding for your energy project? Contact FCM!

Access grants and loans for energy-efficiency and clean energy solutions that support service delivery in your community.

- Improve efficiency and reduce GHG emissions in municipal and community buildings
- Integrate renewable energy generation solutions
- Plan, refine and scale-up innovative financing programs for residential retrofits

Learn more!
Is this solution right for my municipality?

To determine the potential GHG impact and economic feasibility of building envelope upgrades for buildings within your municipality, consider the following questions:

- **What is the carbon intensity of the heating fuel being used?** Building envelope upgrades will only deliver significant GHG emissions reductions when implemented in buildings heated with high-carbon energy (e.g. natural gas, oil, propane or electricity from high-carbon grids).

- **What is the quality of the existing building envelopes?** The potential for achieving energy savings through building envelope upgrades is highly dependent on the energy efficiency of the existing building envelope. Building envelope standards have gradually improved over time, so newer buildings tend to be better insulated and are constructed with fewer thermal bridges (heat loss points) than older buildings. Upgrades will yield greater GHG emissions reductions and be more cost-effective in older buildings. This factsheet includes a quantitative analysis of buildings built in the 1970s. Newer buildings may still benefit from upgrades, but the impacts will be smaller.

- **Is (peak) electricity demand a concern?** If your municipality is working to encourage the adoption of electric heating technology, building envelope upgrades can help reduce the impact on electricity demand by reducing overall heating demand.

High-performance building certifications

A high-performance building certification is given to structures that meet a set of material specifications or performance requirements, or both. Many certifications are available, including Passive House, R-2000 (including R-2000 NZE and NZER), LEED® (Leadership in Energy and Environmental Design) and ENERGY STAR® Certified Homes. These standards typically include requirements for the building envelope as well as for the building’s heating and cooling system. The Passive House standard places a particular focus on the building envelope.

**Passive House** takes an “envelope-first” approach, to create buildings that are comfortable, durable and highly energy-efficient. This performance-based standard places a stringent limit on annual space heating demand, regardless of the heating system used. The building envelope must be extremely well-designed, well-sealed and well-insulated. This ensures that the building will continue to use very little energy for the duration of its life, even if the mechanical equipment changes. The performance-based standard also leaves room for innovation in terms of how the targets outlined in that standard are met, meaning that the solutions can adapt to regional factors, such as climate and the availability of materials or skilled trades. The original Passive House standard is for new construction, but a retrofit standard called EnerPHit also exists.
What does it take to implement?

If building envelope upgrades are appropriate for your municipality, you will need an effective strategy to drive adoption. Consider the following actions:

- **Promote the implementation of building envelope upgrades.** You can use a number of strategies to encourage local residents and businesses to install building envelope upgrades:
  - Enact voluntary or mandatory home/building energy rating and disclosure (HERD/BERD) policies or support provincial/territorial or federal HERD/BERD policies.
  - Provide financing or incentive programs to reduce the upfront costs of building envelope upgrades.
  - Promote energy audits to help identify which building envelope upgrades will yield the largest energy savings for a particular building.
  - Pursue other innovative approaches through local development bylaws and building codes (e.g. performance-based standards for new or existing buildings).
  - Lead by example, by upgrading the building envelopes of municipal facilities.

- **Decide whether to focus on new or existing buildings, or target both.** It is much easier to install high-quality insulation and air barriers, and avoid creating thermal bridges, when a building is being built than to retrofit it later. Thus, there is an opportunity cost to not installing high-quality building envelopes in new buildings. If your population is growing rapidly, you may want to focus first on new buildings. However, because buildings have a typical life span of 40–120 years, most buildings that will be standing in 2050 have already been built—so retrofits of existing buildings are vital, especially for older buildings, which tend to have the worst performance.

- **Combine upgrades with planned renovations, to leverage efficiencies.** The cost of building envelope upgrades depends largely on whether the upgrades are conducted at the same time as other renovations. In particular, wall insulation, roof insulation and air sealing are best undertaken as part of larger renovation projects. When considering upgrades to municipal buildings, consider coordinating work so that the building envelope upgrades are combined with other work. For buildings in the community, you can encourage or mandate building owners to undertake building envelope upgrades at the same time as planned renovations.

- **Once you’ve started doing the job, do it right.** Building envelope measures can require significant time and resources, so maximize the impact of this effort by doing the job right. For municipal projects, once you open the walls, you might as well install as much of the best insulation as is feasible (possibly more than doubling the existing insulating value). The volume and quality of insulation used does not significantly impact the cost.
• Design programs that encourage multiple, high-impact measures—but don’t make smaller projects ineligible. For example, incentive programs can be structured so that the incentive is greater if multiple retrofits are carried out in a single project. You can tie more complex measures (such as envelope upgrades) to simpler measures (such as heating equipment changes) to motivate owners to do more.

• Consider promoting the health and resiliency co-benefits that come with a higher-performance building envelope. Building envelope upgrades have many benefits besides energy cost savings and GHG emissions reductions (for details, see the section, “What are the potential co-benefits?”). You can promote these additional benefits as part of your programs.

What are the GHG and financial impacts?

The GHG reductions, costs and cost savings associated with a building envelope upgrade are highly dependent on many factors, including local energy rates, the state of the existing building envelope, and the heating fuel used in the building. This section calculates the impact of a sample set of retrofits on a typical office building and a typical house. The calculations are based on averages for each province/territory, only consider existing buildings, and don’t include any incentives offered by provincial/territorial governments or local utilities.

Commercial and municipal buildings

This section explores the impacts of a selection of building envelope upgrades in a “typical” office building—assumed to have four floors and a total floor area of about 2,900 m² (31,200 ft²). While average building size and building envelope quality vary across provinces and territories, this analysis considers an identical building across all jurisdictions. The different GHG and financial impacts shown are due to differences in climate, heating fuel mix, grid carbon intensity and energy rates. The analysis assumes the following building envelope upgrades:

- Add insulation to the roof to roughly double the insulating value.
- Add insulation to the walls to roughly double the insulating value.
- Perform air sealing to reduce air leakage by 10–15 percent.

These upgrades are assumed to occur when the walls are being opened anyway (for other renovations), so the cost of closing and finishing the wall work is not included in the calculations. The cost of these upgrades is assumed to be $50,000. The expected useful life of the air sealing is 15 years, while that of the insulation is 20 years.

Together, these upgrades result in heating energy savings of about 15 percent. The cost savings and GHG reductions vary, depending on the heating fuel used in the building (electricity, gas or oil). Table 1 outlines the different impacts by province/territory, as well as the proportion of commercial building heating provided by each fuel in each province and territory. It should be noted that heating fuel mix may vary significantly across municipalities within a province or territory, especially between rural and urban areas.
### Table 1: GHG and financial impacts of select envelope upgrades in a typical office building\(^a,b\)

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of commercial space heating provided by specified fuel(^c)</th>
<th>GHG reductions (for a typical office) (tCO(_2)e/year)</th>
<th>Annualized return on investment (for building owner)</th>
<th>$/tCO(_2)e (for a typical office)(^d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Electricity</td>
<td>14%</td>
<td>&lt;1</td>
<td>0%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>80%</td>
<td>7.4</td>
<td>-9%</td>
<td>650</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>4%</td>
<td>11</td>
<td>1%</td>
<td>10</td>
</tr>
<tr>
<td>AB</td>
<td>Electricity</td>
<td>1%</td>
<td>49</td>
<td>3%</td>
<td>-36</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>92%</td>
<td>13</td>
<td>-7%</td>
<td>340</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>SK</td>
<td>Electricity</td>
<td>7%</td>
<td>50</td>
<td>6%</td>
<td>-110</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>92%</td>
<td>15</td>
<td>-6%</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>MB</td>
<td>Electricity</td>
<td>15%</td>
<td>&lt;1</td>
<td>3%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>82%</td>
<td>15</td>
<td>-2%</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>1%</td>
<td>22</td>
<td>6%</td>
<td>-250</td>
</tr>
<tr>
<td>ON</td>
<td>Electricity</td>
<td>11%</td>
<td>&lt;1</td>
<td>2%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>81%</td>
<td>10</td>
<td>-6%</td>
<td>430</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>1%</td>
<td>14</td>
<td>4%</td>
<td>-180</td>
</tr>
<tr>
<td>QC</td>
<td>Electricity</td>
<td>12%</td>
<td>&lt;1</td>
<td>2%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>78%</td>
<td>11</td>
<td>-2%</td>
<td>290</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>4%</td>
<td>16</td>
<td>4%</td>
<td>-160</td>
</tr>
</tbody>
</table>
## Building Envelope Upgrades

### Factsheet

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of commercial space heating provided by specified fuel (for a typical office)</th>
<th>GHG reductions (for a typical office) (tCO₂e/year)</th>
<th>Annualized return on investment (for building owner)</th>
<th>$/tCO₂e (for a typical office)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB</td>
<td>Electricity</td>
<td>66%</td>
<td>16</td>
<td>3%</td>
<td>-110</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>10%</td>
<td>10</td>
<td>1%</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>10%</td>
<td>15</td>
<td>4%</td>
<td>-140</td>
</tr>
<tr>
<td>PE</td>
<td>Electricity</td>
<td>4%</td>
<td>11</td>
<td>6%</td>
<td>-460</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>49%</td>
<td>17</td>
<td>3%</td>
<td>-90</td>
</tr>
<tr>
<td>NS</td>
<td>Electricity</td>
<td>25%</td>
<td>33</td>
<td>4%</td>
<td>-68</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>22%</td>
<td>10</td>
<td>-1%</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>49%</td>
<td>14</td>
<td>3%</td>
<td>-70</td>
</tr>
<tr>
<td>NL</td>
<td>Electricity</td>
<td>73%</td>
<td>2.3</td>
<td>3%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>15%</td>
<td>18</td>
<td>4%</td>
<td>-140</td>
</tr>
<tr>
<td>YT</td>
<td>Electricity</td>
<td>4%</td>
<td>4.7</td>
<td>6%</td>
<td>-1,200</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>63%</td>
<td>26</td>
<td>8%</td>
<td>-330</td>
</tr>
<tr>
<td>NT</td>
<td>Electricity</td>
<td>1%</td>
<td>18</td>
<td>12%</td>
<td>-1,100</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>11%</td>
<td>21</td>
<td>9%</td>
<td>-560</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>77%</td>
<td>31</td>
<td>9%</td>
<td>-360</td>
</tr>
</tbody>
</table>
## Building envelope upgrades

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of commercial space heating provided by specified fuel&lt;sup&gt;c&lt;/sup&gt;</th>
<th>GHG reductions (for a typical office) (&lt;sup&gt;tCO₂e&lt;/sup&gt;/year)</th>
<th>Annualized return on investment (for building owner)</th>
<th>$/tCO₂e (for a typical office)&lt;sup&gt;d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>NU</td>
<td>Electricity</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>94%</td>
<td>37</td>
<td>10%</td>
<td>-390</td>
</tr>
</tbody>
</table>

<sup>a</sup> See Appendix A for more information on return on investment and dollar-per-tonne values.

<sup>b</sup> This analysis assumes an identical building with identical envelope upgrades across all provinces and territories; actual GHG impacts and returns on investment will vary by municipality. Likewise, return on investment and $/tCO₂e figures will be more favourable if incentives are offered by provincial/territorial governments or utilities in the jurisdiction.

<sup>c</sup> Numbers do not add up to 100 percent because wood and propane heating fuels are not shown here.

<sup>d</sup> “Cost per tonne of CO₂e abated ($/tCO₂e)” indicates the carbon price required to make a given measure cost-effective. A negative cost-per-tonne value indicates that the measure saves money while also reducing emissions. Note that a more negative cost-per-tonne value isn’t necessarily more cost-effective. A blank cell (–) indicates that impacts were not calculated because the measure yields insignificant GHG reductions in this province/territory.

n/a = not applicable, as specified fuel source is not present in baseline.

As shown, commercial or municipal building envelope upgrades yield significant GHG emissions reductions in buildings heated with oil, gas and—in provinces and territories with high-carbon grids—electricity. Building envelope upgrades are typically most cost-effective in commercial and municipal office buildings heated with oil and—in provinces and territories with high electricity rates—those heated with electricity. Building envelope upgrades give a much lower return on investment in gas-heated buildings, because of low gas prices. The variation in results between provinces/territories for a given heating fuel is due to differences in climate, grid carbon intensity and energy rates. Negative dollar-per-tonne values indicate that the upgrades save money while also reducing carbon.

### Residential buildings

This section explores the impacts of building envelope upgrades in a “typical” home—assumed to have two floors, a total floor area of about 140 m² (1,500 ft²), and a building envelope typical for a home built in the 1960s or 1970s. While home size and building envelope quality vary across provinces and territories, this analysis considers an identical home across all jurisdictions. The different GHG and financial impacts are due to differences in climate, heating fuel...
Building envelope upgrades

- Add more attic and wall insulation to upgrade from levels typical in a home built in the 1970s to levels required for a home to be rated ENERGY STAR®.
- Add insulation to the walls of a basement that is not already insulated.
- Upgrade from double pane windows to windows that meet ENERGY STAR® 2020 requirements.
- Perform air sealing to reduce leakage by 10–15 percent.

These upgrades are assumed to occur when the walls are being opened anyway (for other renovations), so the cost of closing and finishing the wall work is not included in the calculations. The cost of these upgrades is assumed to be $7,000. The expected useful life of the air sealing is 15 years, while that of the windows and insulation is 20–25 years.

Together, these upgrades result in **heating energy savings of about 30 percent**. The GHG and cost savings vary, depending on the heating fuel used in the building. Table 2 outlines the different impacts by province/territory, as well as the proportion of home heating provided by each fuel in each province and territory. It should be noted that heating fuel mix may vary significantly across municipalities within a province or territory, especially between rural and urban areas.

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of residential space heating provided by specified fuel</th>
<th>GHG reductions (for a typical home) (tCO₂e/year)</th>
<th>Annualized return on investment (for homeowner)</th>
<th>$/tCO₂e (for a typical home)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Electricity</td>
<td>31%</td>
<td>&lt;0.01</td>
<td>2%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>52%</td>
<td>0.83</td>
<td>-3%</td>
<td>370</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0.4%</td>
<td>1.2</td>
<td>3%</td>
<td>-160</td>
</tr>
<tr>
<td>AB</td>
<td>Electricity</td>
<td>5%</td>
<td>5.5</td>
<td>4%</td>
<td>-81</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>88%</td>
<td>1.5</td>
<td>0%</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Province/territory</td>
<td>Heating fuel</td>
<td>Percentage of residential space heating provided by specified fuel$^c$</td>
<td>GHG reductions (for a typical home) (tCO₂ e/year)</td>
<td>Annualized return on investment (for homeowner)</td>
<td>$/tCO₂ e (for a typical home)$^d</td>
</tr>
<tr>
<td>--------------------</td>
<td>--------------</td>
<td>-------------------------------------------------</td>
<td>---------------------------------</td>
<td>-----------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>SK</td>
<td>Electricity</td>
<td>10%</td>
<td>5.6</td>
<td>7%</td>
<td>-200</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>82%</td>
<td>1.6</td>
<td>0%</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>1%</td>
<td>2.4</td>
<td>6%</td>
<td>-350</td>
</tr>
<tr>
<td>MB</td>
<td>Electricity</td>
<td>43%</td>
<td>&lt;0.01</td>
<td>4%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>47%</td>
<td>1.6</td>
<td>1%</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0.3%</td>
<td>2.4</td>
<td>6%</td>
<td>-360</td>
</tr>
<tr>
<td>ON</td>
<td>Electricity</td>
<td>14%</td>
<td>0.02</td>
<td>3%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>68%</td>
<td>1.1</td>
<td>-2%</td>
<td>230</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>3%</td>
<td>1.6</td>
<td>5%</td>
<td>-330</td>
</tr>
<tr>
<td>QC</td>
<td>Electricity</td>
<td>50%</td>
<td>&lt;0.01</td>
<td>1%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>7%</td>
<td>1.2</td>
<td>2%</td>
<td>-49</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>9%</td>
<td>1.8</td>
<td>5%</td>
<td>-290</td>
</tr>
<tr>
<td>NB</td>
<td>Electricity</td>
<td>41%</td>
<td>1.8</td>
<td>4%</td>
<td>-210</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>2%</td>
<td>1.2</td>
<td>2%</td>
<td>-91</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>28%</td>
<td>1.7</td>
<td>4%</td>
<td>-280</td>
</tr>
<tr>
<td>PE</td>
<td>Electricity</td>
<td>4%</td>
<td>1.3</td>
<td>6%</td>
<td>-630</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>49%</td>
<td>1.9</td>
<td>4%</td>
<td>-210</td>
</tr>
</tbody>
</table>
### Building envelope upgrades

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of residential space heating provided by specified fuel $^c$</th>
<th>GHG reductions (for a typical home) (tCO$_2$e/year)</th>
<th>Annualized return on investment (for homeowner)</th>
<th>$$/tCO_2e$ (for a typical home) $^d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>Electricity</td>
<td>21%</td>
<td>3.7</td>
<td>5%</td>
<td>-150</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>1%</td>
<td>1.1</td>
<td>2%</td>
<td>-55</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>37%</td>
<td>1.6</td>
<td>4%</td>
<td>-210</td>
</tr>
<tr>
<td>NL</td>
<td>Electricity</td>
<td>68%</td>
<td>0.26</td>
<td>4%</td>
<td>-1,800</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>18%</td>
<td>2.0</td>
<td>5%</td>
<td>-260</td>
</tr>
<tr>
<td>YT</td>
<td>Electricity</td>
<td>23%</td>
<td>0.5</td>
<td>6%</td>
<td>-1,700</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>69%</td>
<td>2.9</td>
<td>7%</td>
<td>-430</td>
</tr>
<tr>
<td>NT</td>
<td>Electricity</td>
<td>1%</td>
<td>2.0</td>
<td>11%</td>
<td>-1,800</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>11%</td>
<td>2.3</td>
<td>8%</td>
<td>-70</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>77%</td>
<td>3.5</td>
<td>8%</td>
<td>-450</td>
</tr>
<tr>
<td>NU</td>
<td>Electricity</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>94%</td>
<td>4.2</td>
<td>9%</td>
<td>-480</td>
</tr>
</tbody>
</table>

---

*a* Appendix A for more information on return on investment and dollar-per-tonne values.

*b* This analysis assumes an identical home with identical envelope upgrades across all provinces and territories; actual GHG impacts and returns on investment will vary by municipality. Likewise, return on investment and $$/tCO_2e$ figures will be more favourable if incentives are offered by provincial/territorial governments or utilities in the jurisdiction.

*c* Numbers do not add up to 100 percent because wood and propane heating fuels are not shown here.

*d* “Cost per tonne of CO$_2$e abated ($$/tCO_2e$)” indicates the carbon price required to make a given measure cost-effective. A negative cost-per-tonne value indicates that the measure saves money while also reducing emissions. Note that a more negative cost-per-tonne value isn’t necessarily more cost-effective. A blank cell (–) indicates that impacts were not calculated because the measure yields insignificant GHG reductions in this province/territory.

n/a = not applicable, as specified fuel source is not present in baseline.
This comparison shows that building envelope upgrades result in greater energy savings for homes than for office buildings, and therefore slightly greater reduction in GHGs and return on investment. Residential building envelope upgrades are typically most cost-effective in buildings heated with oil and—in provinces and territories with high electricity rates—those heated with electricity. Building envelope upgrades give a much lower return on investment in gas-heated buildings, because of low gas prices. As with commercial and municipal buildings, the variation in results between provinces/territories for a given heating fuel is due to differences in climate, grid carbon intensity and energy rates. Negative dollar-per-tonne values indicate that the upgrades save money while also reducing carbon.

**What are the potential co-benefits?**

In addition to GHG emissions reductions and energy bill savings, building envelope upgrades have the potential for a number of co-benefits.

- **Jobs**
  - New skilled jobs are created designing and building or retrofitting high-quality building envelopes.
  - Energy-efficiency programs create more jobs (an estimated seven to nine times more jobs per $1 million invested) than investment in existing electricity infrastructure (generation, transmission and distribution).\(^{xiii, xiv}\)

- **Environment**
  - Local air quality improves in areas that have high-carbon grids and are located downwind from power plants run on fossil fuel.
  - Local air quality improves where oil heating is prevalent.

- **Resilience**
  - Leak-tight buildings can better withstand floods and storms.
  - Building temperatures stay more comfortable during extended blackouts (when no heating or cooling is functional).

- **Health and comfort**
  - High-quality retrofits reduce mold occurrences and significantly improve indoor air quality; however, moisture and mold can result if no energy recovery ventilator (ERV) is installed in cases where extensive envelope upgrades are made to significantly improve air-tightness.
  - Improved air sealing reduces drafts.
  - Insulation upgrades and the installation of high-quality windows and doors reduce noise.

- **Other**
  - Increased home values lead to an increase in the municipal tax base.
  - Improved envelope quality can improve tenant retention.
What is the current and projected state of the market?

Current state of the market

- Building envelope requirements for new construction have drastically improved over the last 60 years (see the factsheet, *Local Development Policies and Bylaws*, for more information). Buildings built between 2011 and 2015 use almost three times less heating energy per unit area than those built between 1946 and 1960. Across all provinces and territories, buildings constructed between 1960 and 1979 represent the age class with the largest opportunity for total carbon emissions reductions.

- A number of key market barriers need to be addressed to enable widespread adoption of building envelope upgrades. These include affordability, awareness and availability.

  • **Affordability:**
    -> Building envelope upgrades last a long time, but the high upfront cost to implement them means that it takes a long time for the investment to pay back. Financing and incentive programs can help to reduce this barrier.
    
    -> Split incentives come into play when changing from one property owner to the next because the party that incurred the expense for the upgrades will no longer benefit from the return on investment. Property Assessed Clean Energy (PACE) financing programs can alleviate this barrier by tying the loan to the building rather than the building owner, allowing transferability of payments and benefits (see the factsheet, *Financing Options*, for more information).

  • **Awareness:**
    -> It can be difficult for homeowners and small business owners to identify qualified contractors—certification programs can help with this. For insulation upgrades, building owners will also need to find an architect to design the insulation layout so that condensation inside the wall does not create a problem.
    
    -> Home and building owners may have difficulty assessing the return on investment of building envelope upgrades, which are complex and offer many options. For example, building owners often do not realize that they can save money by upgrading the building envelope when they are doing other maintenance work.

  • **Availability:**
    -> Delivering building envelope upgrades requires professional expertise and a trained workforce. More education and training is needed to develop a larger pool of qualified contractors. Similarly,
the market for building envelope upgrades is fragmented, with contractors and service providers typically specializing in one area. Few contractors can provide whole-home upgrades for optimal deep retrofit solutions (although they are growing in number).

• Other:
  → Building upgrades come with their fair share of customer hassle. Getting quotes for retrofits can take a lot of time and effort, and getting the work done can be disruptive.

Projections for the future
  • The building industry is moving toward net-zero energy buildings in new construction. Canada’s Buildings Strategy includes a goal to develop and adopt increasingly stringent model building codes, starting in 2020. The strategy includes a goal to develop a model energy code for existing buildings by 2022, and for provinces and territories to adopt a net-zero energy ready model building code for new buildings by 2030.²⁷ (See the factsheet, Local Development Policies and Bylaws, for more information.)
  • Experience with prefabricated energy retrofits is increasing worldwide and offers great promise to improve performance and significantly reduce costs. Alberta and BC are trying this approach, using the successful Energiesprong initiatives in Europe as a model. In Alberta, a demonstration project, supported by Natural Resources Canada, is being run through the Sundance Housing Cooperative; and in British Columbia, the Pembina Institute is working in partnership with BC Housing, the BC Non-Profit Housing Association, and the City of Vancouver.²⁸,²⁹ Likewise, Natural Resources Canada’s Prefabricated Exterior Energy Retrofit (PEER) project seeks to develop technologies and processes for applying prefabricated components to retrofit existing homes and buildings from the exterior. This would enable the Canadian manufacturing and renovation industries to commercialize new prefabricated façade retrofit technology.³⁰

What have municipalities done?

Municipalities leading by example

Region of Waterloo: LEED® Silver standard
The Region of Waterloo, ON, has a policy that all new occupied facilities over a certain size must be built to a minimum standard of LEED® Silver. By the end of 2015, 11 regional buildings were certified Silver or Gold. Energy-efficient building envelope design is an important component in LEED® certification.

City of Varennes: Net-zero library
The City of Varennes, QC, built a net-zero library which opened in 2014. The library was the first net-zero institutional building in Canada. High-efficiency insulation and windows with superior energy performance contribute to the building’s very low energy consumption.

City of Airdrie: Arena upgrades
The City of Airdrie, AB, upgraded the siding and insulation on its arena in 2017. The upgrades increased the arena’s insulation level from R-2 to R-20.
Incentive programs

**Brazeau County: Brazeau County Municipal Energy Efficiency Rebate Program**
Brazeau County, AB, offered rebates of up to $1,500 on ENERGY STAR® certified windows and rebates of up to $3,500 on attic, wall, basement or floor insulation as part of a pilot program from April 2018 to April 2019.

**City of Medicine Hat: Air sealing rebate program**
Medicine Hat, AB, offered performance-based rebates of $500–700 on air sealing. These incentives were in addition to provincial incentives.

Financing programs

**City of Toronto: Home Energy Loan Program**
The City of Toronto, ON, runs a Property Assessed Clean Energy (PACE) financing program for energy-efficiency retrofits to single family homes. Eligible retrofits include basement, attic and exterior wall insulation, air sealing, and window and door replacements. HVAC control measures are eligible for the program.

**City of Guelph: Guelph Energy Efficiency Retrofit Strategy**
The City of Guelph, ON, developed the Guelph Energy Efficiency Retrofit Strategy (GEERS) to encourage and support energy-efficiency upgrades to residential buildings through a local improvement charge (LIC) mechanism. The goal is for 80 percent of existing residential buildings to be upgraded by 2031.

Building codes and bylaws

**BC Energy Step Code**
As of April 2019, 21 municipalities in BC, including the City of Richmond, the Township of Langley, the City of Campbell River and the District of Squamish, have adopted the BC Energy Step Code into their policies, programs or bylaws. Improving insulation values and increasing airtightness are key aspects of the Step Code.

**City of Toronto: Toronto Green Standard**
The Toronto Green Standard was initially introduced in 2006 as a voluntary standard for new development. Over time, it has evolved to include multiple tiers for energy and emissions performance. In 2018, Version 3 of the standard was released. It is now mandatory, and includes four tiers of performance targets that approach zero emissions for all new buildings by 2030. Profiles of buildings constructed to tiers 2, 3 and 4 can be found on the City of Toronto website. The information includes project energy savings and details on the specific energy-efficient measures used.

Energy rating and disclosure

**City of Edmonton: Building Energy Benchmarking Program**
The City of Edmonton, AB, has a voluntary building energy benchmarking program for buildings over 20,000 square feet. In 2016, participating buildings accounted for 12 percent of all GHG emissions from commercial and institutional buildings within the city.
What resources can support next steps?

**Major Energy Retrofit Guidelines for Commercial and Institutional Buildings: Principles, Natural Resources Canada, 2016**

These guidelines discuss how to assess opportunities, plan and implement energy-efficiency retrofits, and maintain performance. This resource will be useful for projects in municipal buildings as well as for programs targeting commercial buildings in the broader community.

**Keeping the Heat In, Natural Resources Canada, 2017**

This is a guide to energy retrofits that includes detailed information on selecting and implementing envelope upgrades in residential buildings. The resource is targeted at homeowners but provides technical detail that may be useful in designing programs.

**Guide to Building the Case for Deep Energy Retrofits, Rocky Mountain Institute, 2012**

This guide provides guidance on quantifying the value of deep energy retrofits and building the business case.

**Challenges and Opportunities in Deep Envelope Retrofitting, Paul Bertram**

This case study of deep energy retrofits in affordable housing in Boston demonstrates how significant energy savings can be achieved even in buildings that are traditionally hard to address. It includes detailed cost and savings data for the project.

**Resilient Design for a Changing World, The C3 Living Design Project**

This website describes a tool called RELi, which acts as a reference guide and certification system for resilient design of neighbourhoods, buildings, homes and infrastructure. Many resources are available on the website, including a list of actions that communities can take to improve resilience and an approach to planning for resilience.
Endnotes

i Improvements to envelope air sealing can result in the need to add some form of mechanical ventilation (via a heat recovery ventilator or an energy recovery ventilator) to ensure that air quality and indoor moisture levels are maintained at healthy levels.

ii Solar gains through windows have an impact on building space heating and space cooling loads. When upgrading windows, building owners should not only consider the thermal performance of the windows, but also their solar performance.

iii Natural Resources Canada, Comprehensive Energy Use Database, Residential Sector (Table 2), Commercial/Institutional Sector (Table 4).

iv For more details on these strategies, please see the following factsheets: Home/Building Energy Rating and Disclosure; Financing Options; and Local Development Policies and Bylaws.

v Word Resources Institute, Accelerating Building Efficiency: Eight Actions for Urban Leaders.

vi Canada Green Building Council and Delphi Group, Green Building in Canada: Assessing the Market Impacts & Opportunities.

vii For the purposes of this analysis, a “typical” office building includes both municipal and commercial office buildings.

viii Roofs are assumed to go from an R-value of 13.5 to 30 (°F ft² hr/ BTU) / RSI 2.4 to 5.3 (°C m²/W).

ix Walls are assumed to increase in R-value from 13 to 25 (°F ft² hr/ BTU) / RSI 2.3 to 4.5 (°C m²/W). Note that the amount of insulation that can be added to a wall will depend on the thickness and construction of the wall cavity.

x Walls are assumed to increase in R-value from 12 to 21 (°F ft² hr/ BTU); attics are assumed to increase in R-value from 26 to 49.

xi Basement walls are assumed to increase in R-value from 3 to 12 on half of the total wall area.

xii Windows are assumed to increase in U-Factor from 2.0 to 1.22 (W/m²K).


xiv Pembina Institute, Job Growth in Clean Energy: Employment in Alberta’s emerging renewables and energy efficiency sectors, 2016. This includes direct and indirect jobs, and takes into account the decrease in jobs due to reduced demand for electricity.

xv Canada Green Building Council and Delphi Group, Green Building in Canada: Assessing the Market Impacts & Opportunities.

xvi A split incentive involves circumstances in which the party paying for energy-efficiency or renewable energy technologies is different than the party that receives the associated benefits—as is common for rental properties (with tenant–landlord relationships) and investment properties (where return-on-investment exceeds typical investment horizons).


xviii Northern Alberta Cooperative Housing Association, “National Resources Canada Invests in Energy Efficiency with Sundance.”


xx Natural Resources Canada, PEER—Prefabricated Exterior Energy Retrofit.

xxi City of Toronto, Tier 2, 3, and 4 Project Profiles, 2019.
Building-level solution

Improved HVAC controls

What are improved HVAC controls?

Heating, ventilation and air conditioning (HVAC) systems keep buildings at a comfortable temperature and maintain air quality. These systems account for a large proportion of a building’s energy use, so controlling them with intelligent technology can deliver substantial energy savings and greenhouse gas (GHG) reductions while also improving thermal comfort and reducing maintenance requirements. Improving HVAC controls can involve a range of technologies, from smart thermostats to building energy management systems (BEMS), all of which reduce unnecessary running of HVAC systems. Further, improved HVAC controls can enable equipment to reduce energy use during peak demand periods (i.e. as part of a utility demand response program).

<table>
<thead>
<tr>
<th>Carbon intensity of electricity grid</th>
<th>Fuel</th>
<th>Residential</th>
<th>Commercial and municipal</th>
<th>Co-benefits(^a)</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Electricity</td>
<td>Low to high</td>
<td>High</td>
<td>Electricity: Low to high</td>
<td>Gas: High</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>Low to high</td>
<td>Moderate: Low to high</td>
<td>Gas: Low to high</td>
<td>Moderate: Low to high</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>Low to high</td>
<td>Moderate: Low to high</td>
<td>Oil: High</td>
<td>Moderate: High</td>
</tr>
<tr>
<td>Moderate</td>
<td>Electricity</td>
<td>High</td>
<td>Low to high</td>
<td>Electricity: Low to high</td>
<td>Gas: High</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>High</td>
<td>Low to high</td>
<td>Gas: Low to high</td>
<td>Low to high</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>High</td>
<td>Moderate: High</td>
<td>Oil: High</td>
<td>Moderate: High</td>
</tr>
<tr>
<td>High</td>
<td>Electricity</td>
<td>High</td>
<td>High</td>
<td>Electricity: High</td>
<td>Gas: High</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>High</td>
<td>Moderate: High</td>
<td>Gas: Low to high</td>
<td>Moderate: High</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>High</td>
<td>High</td>
<td>Oil: High</td>
<td>Very high</td>
</tr>
</tbody>
</table>

GHG reduction (kgCO₂e/m²/year)

<table>
<thead>
<tr>
<th>Levels</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt;1</td>
</tr>
<tr>
<td>1</td>
<td>1 to &lt;5</td>
</tr>
<tr>
<td>2</td>
<td>5 to &lt;10</td>
</tr>
<tr>
<td>3</td>
<td>≥10 to &lt;20</td>
</tr>
<tr>
<td>4</td>
<td>≥20 to &lt;30</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
</tr>
</tbody>
</table>

Annualized return on investment

<table>
<thead>
<tr>
<th>Levels</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Negative: &lt;0</td>
</tr>
<tr>
<td>1</td>
<td>Low: ≥0% to &lt;4%</td>
</tr>
<tr>
<td>2</td>
<td>Medium: ≥4% to &lt;8%</td>
</tr>
<tr>
<td>3</td>
<td>High: ≥8%</td>
</tr>
</tbody>
</table>

Co-benefits

- None
- Low
- Moderate
- High
- Very high

\(a\) Other environmental benefits may also result, depending on local circumstances, such as the use and location of fossil fuel power plants and their impact on air quality. Equity considerations will depend on program design but can lead to further co-benefits.
Improved HVAC controls

This solution can be implemented in parallel with other solutions that address space heating—such as building envelope upgrades and heat pumps—but because of the interactive effects, the greenhouse gas (GHG) impacts may not be additive. In other words, if more than one of these solutions is implemented in the same building, the GHG impacts may be less than the sum of the GHG impacts of each individual solution.

How does this solution work and why is it important?

Improvements to HVAC controls can be made in commercial, municipal and residential buildings. The specific types of HVAC control technologies relevant to each building type are listed below.

**Commercial and municipal buildings**

**Building energy management systems (BEMS)** monitor and control building systems to minimize energy use and maintain comfort across one or more buildings. They gather data from energy-using equipment (i.e. HVAC equipment, pumps and fans), building sensors (e.g. indoor and outdoor thermometers, occupancy sensors and CO₂ sensors) and energy meters and sub-meters (e.g. electricity and natural gas meters). BEMS use that data with various levels of sophistication, with a number of possible functionalities:

- **Equipment can be intelligently controlled in real time based on input data** (e.g. adjusting the temperature or ventilation rate in rooms based on information from occupancy sensors, which indicate whether there are people in the rooms). In order to vary the functioning of different HVAC systems according to actual demand, BEMS often include the following two subsystems:
  - Demand-controlled ventilation (DCV) adjusts the ventilation rate based on room occupancy levels. These systems are especially useful in places with high occupancy variability, such as theatres and lecture halls.
  - Variable frequency drives (VFDs) adjust the speed of fans and pumps so that they only work at the rate necessary to fulfill heating, cooling and indoor air quality requirements.
- **Faulty operation of the building system can be detected and diagnosed based on input data** (e.g. the system can generate a warning if building energy consumption is higher than it should be, based on the weather and time of day).
- **BEMS can provide an interface (web-based or otherwise) that allows building managers to visualize and analyze input data, to understand ongoing problems and observe the building’s energy use over the longer term.**
- **The system enables predictive analysis, which can help to reduce overall energy use and cost and improve comfort—specifically, by reducing demand during peak hours, varying electricity demand to increase the use of local renewables, and optimizing the use of available energy storage devices.**
- **The system can be used to control other building functions, such as lighting and security.**
• System data can predict faults in building operation, helping to improve maintenance of the building systems and potentially decrease the associated costs.

**Residential buildings**

**Connected/smart thermostats** make it easy for households to adjust temperatures during the night or when the house is vacant. These devices can have varying levels of sophistication, with the range of functionalities including:

- monitoring and making changes to thermostat settings remotely from a connected device
- tracking the performance of HVAC systems in the home
- using data on local weather to inform HVAC system control
- giving the utility control to adjust or turn off equipment and systems during peak periods

**Programmable thermostats** also allow households to program a variable temperature schedule but are less user-friendly than smart thermostats. Research suggests that many users do not actually program them. Because of this, they typically result in lower energy savings than smart thermostats, which are easier to program (and therefore, more likely to be programmed).

Space heating and air conditioning account for roughly 65 percent of building-related GHG emissions (of which air conditioning accounts for only two percent of residential building emissions and only five percent of commercial building emissions). Because improvements to HVAC controls can be very cost-effective, these measures offer a low-cost opportunity to achieve GHG reductions.

**Is this solution right for my municipality?**

To determine the potential GHG impacts and economic feasibility of improving HVAC controls in buildings within your municipality, consider the following questions:

- **What is the carbon intensity of heating, ventilation and air conditioning?** Improving HVAC controls will only deliver significant GHG emissions reductions when implemented in buildings heated with fossil fuels or in areas where high-carbon-intensity electricity is used for heating, ventilation or air conditioning. In provinces and territories with low-carbon grids, improving HVAC controls in electrically heated buildings will not have a big impact on GHG emissions but can help reduce electricity demand, which will be critical as these municipalities move toward the electrification of transportation and heating.

- **How high are local energy prices?** Bill savings from improved HVAC controls will depend on the cost of the energy used to heat, cool and ventilate the building. Improvements to HVAC controls will deliver the greatest savings in buildings with high heating, cooling and ventilation costs.
What does it take to implement?

If this solution is appropriate for your municipality, you will need to develop an effective strategy to drive adoption. Here are some key actions and considerations:

- **Identify ways to promote the installation of improved HVAC controls.** To encourage the uptake of this solution, you can provide financing or incentive programs to reduce the additional upfront costs for residents and businesses. You can pursue other innovative approaches through local development bylaws (e.g., performance-based standards for new or existing buildings). You can also lead by example, by upgrading HVAC controls in your municipality’s facilities. Please see the relevant “Strategy” factsheets for more details.

- **Decide whether to focus on commercial or residential buildings, or both.** To understand where best to target interventions, consider the split of residential versus commercial buildings in your community, and the type of fuel they use. It is important to note that the per-building GHG emissions reductions and cost savings associated with improved HVAC controls likely will be greater in commercial buildings, given their higher energy usage and more complex HVAC system designs. These complex system designs provide greater opportunity for optimizing controls.

- **Understand how sophisticated HVAC control systems need to be for the type and size of buildings you are focusing on.** The level of sophistication required in a building energy management system will depend on building size and HVAC complexity. While small buildings may not require sophisticated control systems, it may be worth investing in advanced features for larger buildings (e.g., continuous optimization and predictive controls). These considerations will be important if you are considering installing improved HVAC controls in municipal facilities, and when designing incentive or financing programs.

- **Understand the energy savings that can be achieved in the existing building stock.** The savings that can be achieved by installing a new HVAC control system will depend on the performance of the existing control system, and the efficiency of the existing HVAC systems and building envelopes. Buildings that have separate control systems for each piece of equipment will see greater savings than buildings that already have some level of centralized HVAC control.
What are the GHG and financial impacts?

The GHG reductions, costs and cost savings associated with improved HVAC controls are dependent on various factors, including local energy rates, the efficiency of the existing system, the heating fuel used in the building and the specifics of the new system to be installed. This section calculates the impact of select retrofits on a typical office building and a typical house. The calculations are based on provincial and territorial average data, only consider upgrades to existing buildings, and do not account for any incentives offered by provincial/territorial governments or local utilities.

**Commercial and municipal buildings**

This section explores the impacts of an example upgrade to HVAC controls in a “typical” office building—assumed to have four floors and a total floor area of about 2,900 m² (31,200 ft²). A simple BEMS, or building automation system (BAS), is assumed to be installed in a building that previously only had basic HVAC controls. The BAS intelligently controls equipment but does not have more advanced functionality, such as detection and diagnostics of faulty operation or predictive analysis.

This upgrade is estimated to cost about $30,000 to install (including commissioning) and results in annual building energy savings of about 15 percent (12 percent heating and three percent electricity). Annual maintenance costs are not quantified here, though some incremental costs would be incurred for regular calibration throughout the equipment life. The measure has an expected useful life of 10 years. Table 1 presents the different impacts by province/territory, as well as the proportion of commercial space heating provided by each fuel in each province/territory. It should be noted that heating fuel mix may vary significantly across municipalities within a province or territory, especially between rural and urban areas. This upgrade will also reduce cooling energy use in buildings that have air conditioning, which will yield additional GHG reductions and cost savings beyond those shown below. Because cooling represents a small proportion of HVAC energy use in commercial buildings in Canada (about five percent), these savings will be much smaller than those associated with heating.

Table 1: GHG and financial impacts of select upgrades to HVAC controls in a typical office building.

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of commercial space heating provided by specified fuel</th>
<th>GHG reductions (for a typical office) (tCO₂e/year)</th>
<th>Annualized return on investment (for building owner)</th>
<th>$/tCO₂e (for a typical office)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Electricity</td>
<td>14%</td>
<td>&lt; 1.0</td>
<td>11%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>80%</td>
<td>11</td>
<td>3%</td>
<td>-63</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>4%</td>
<td>16</td>
<td>13%</td>
<td>-440</td>
</tr>
</tbody>
</table>
### FACTSHEET

**Improved HVAC controls**

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of commercial space heating provided by specified fuel</th>
<th>GHG reductions (for a typical office) (tCO₂e/year)</th>
<th>Annualized return on investment (for building owner)</th>
<th>$/tCO₂e (for a typical office)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>Electricity</td>
<td>1%</td>
<td>91</td>
<td>15%</td>
<td>-100</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>92%</td>
<td>39</td>
<td>4%</td>
<td>-25</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>SK</td>
<td>Electricity</td>
<td>7%</td>
<td>89</td>
<td>19%</td>
<td>-170</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>92%</td>
<td>39</td>
<td>6%</td>
<td>-59</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0%</td>
<td>49</td>
<td>19%</td>
<td>-310</td>
</tr>
<tr>
<td>MB</td>
<td>Electricity</td>
<td>15%</td>
<td>&lt; 1.0</td>
<td>14%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>82%</td>
<td>21</td>
<td>8%</td>
<td>-140</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>1%</td>
<td>32</td>
<td>18%</td>
<td>-440</td>
</tr>
<tr>
<td>ON</td>
<td>Electricity</td>
<td>11%</td>
<td>1.8</td>
<td>13%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>81%</td>
<td>15</td>
<td>5%</td>
<td>-100</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>1%</td>
<td>22</td>
<td>16%</td>
<td>-510</td>
</tr>
<tr>
<td>QC</td>
<td>Electricity</td>
<td>12%</td>
<td>&lt; 1.0</td>
<td>12%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>78%</td>
<td>16</td>
<td>8%</td>
<td>-200</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>4%</td>
<td>24</td>
<td>16%</td>
<td>-440</td>
</tr>
<tr>
<td>NB</td>
<td>Electricity</td>
<td>66%</td>
<td>32</td>
<td>15%</td>
<td>-320</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>10%</td>
<td>23</td>
<td>13%</td>
<td>-310</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>10%</td>
<td>31</td>
<td>16%</td>
<td>-350</td>
</tr>
<tr>
<td>Province/ territory</td>
<td>Heating fuel</td>
<td>Percentage of commercial space heating provided by specified fuel</td>
<td>GHG reductions (for a typical office) (tCO₂e/year)</td>
<td>Annualized return on investment (for building owner)</td>
<td>$/tCO₂e (for a typical office)</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------</td>
<td>-------------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td><strong>PE</strong></td>
<td>Electricity</td>
<td>4%</td>
<td>21</td>
<td>19%</td>
<td>-750</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>49%</td>
<td>30</td>
<td>16%</td>
<td>-370</td>
</tr>
<tr>
<td><strong>NS</strong></td>
<td>Electricity</td>
<td>25%</td>
<td>66</td>
<td>16%</td>
<td>-170</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>22%</td>
<td>32</td>
<td>11%</td>
<td>-180</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>49%</td>
<td>39</td>
<td>15%</td>
<td>-250</td>
</tr>
<tr>
<td><strong>NL</strong></td>
<td>Electricity</td>
<td>73%</td>
<td>4.4</td>
<td>14%</td>
<td>-2,100</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>15%</td>
<td>27</td>
<td>16%</td>
<td>-390</td>
</tr>
<tr>
<td><strong>YT</strong></td>
<td>Electricity</td>
<td>4%</td>
<td>8.2</td>
<td>19%</td>
<td>-1,900</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>63%</td>
<td>39</td>
<td>21%</td>
<td>-490</td>
</tr>
<tr>
<td><strong>NT</strong></td>
<td>Electricity</td>
<td>1%</td>
<td>30</td>
<td>29%</td>
<td>-1,300</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>11%</td>
<td>35</td>
<td>24%</td>
<td>-770</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>77%</td>
<td>49</td>
<td>24%</td>
<td>-520</td>
</tr>
</tbody>
</table>
Improved HVAC controls

Improvements to HVAC controls in commercial and municipal office buildings yield significant GHG emissions reductions in buildings heated with gas and oil, and in buildings heated with electricity in provinces and territories with high-carbon grids. While this solution does not represent a key GHG reduction opportunity for electrically heated buildings in provinces and territories with low-carbon grids, it can be a cost-effective way to reduce demand for clean electricity, which will be important as communities move to the electrification of heating and transportation (which will increase the load on the grid).

These select upgrades yield positive returns in all cases considered here. They are highly cost-effective measures, and can be packaged with other, less cost-effective measures to achieve deeper emissions reductions (e.g. building envelope upgrades and heat pumps).

**Residential buildings**

This section explores the impacts of replacing a manual thermostat with a smart thermostat in a “typical” home—assumed to have two floors and a total floor area of about 140 m² (1,500 ft²). This measure is estimated to result in annual heating energy savings of about six percent. The estimated cost is about $270 in a home with central heating and $550 in a home heated with baseboards. The technology has an expected useful life of eight years. Table 2 presents the different impacts by province/territory.

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of commercial space heating provided by specified fuel</th>
<th>GHG reductions (for a typical office) (tCO₂e/year)</th>
<th>Annualized return on investment (for building owner)</th>
<th>$/tCO₂e (for a typical office)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NU</td>
<td>Electricity</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>94%</td>
<td>73</td>
<td>27%</td>
<td>-450</td>
</tr>
</tbody>
</table>

*a* See Appendix A for more information on return on investment and dollar-per-tonne values.

*b* This analysis assumes an identical building with identical heating equipment across all provinces and territories; actual GHG impacts and returns on investment will vary by municipality. Likewise, return on investment and $/tCO₂e figures will be more favourable if incentives are offered by provincial/territorial governments or utilities in the jurisdiction.

*c* Numbers do not add up to 100 percent because wood and propane heating fuels are not shown here.

*d* “Cost per tonne of CO₂e abated ($/tCO₂e)” indicates the carbon price required to make a given measure cost-effective. A negative cost-per-tonne value indicates that the measure saves money while also reducing emissions. Note that a more negative cost-per-tonne value isn’t necessarily more cost-effective. A blank cell (–) indicates that impacts were not calculated because the measure yields insignificant GHG reductions in this province/territory.

*n/a = not applicable, as the specified fuel source is not present in baseline.*
 territory, as well as the proportion of residential space heating provided by each fuel in each province/territory. It should be noted that heating fuel mix may vary significantly across municipalities within a province or territory, especially between rural and urban areas. This measure will also reduce cooling energy use in homes that have air conditioning, which will yield additional GHG reductions and cost savings beyond those shown below. Because cooling represents a small proportion of HVAC energy use in residential buildings in Canada (less than five percent), these savings will be much smaller than those associated with heating.

Table 2: GHG and financial impacts of installing a smart thermostat in a typical existing home.

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of residential space heating provided by specified fuel</th>
<th>GHG reductions (for a typical home) (tCO₂e/year)</th>
<th>Annualized return on investment (for home owner)</th>
<th>$/tCO₂e (for a typical home)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Electricity</td>
<td>31%</td>
<td>&lt;0.01</td>
<td>1%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>52%</td>
<td>0.13</td>
<td>-3%</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>&lt;1%</td>
<td>0.20</td>
<td>13%</td>
<td>-280</td>
</tr>
<tr>
<td>AB</td>
<td>Electricity</td>
<td>5%</td>
<td>0.90</td>
<td>8%</td>
<td>-55</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>88%</td>
<td>0.24</td>
<td>3%</td>
<td>-22</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>SK</td>
<td>Electricity</td>
<td>10%</td>
<td>0.90</td>
<td>15%</td>
<td>-160</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>82%</td>
<td>0.27</td>
<td>5%</td>
<td>-37</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>1%</td>
<td>0.40</td>
<td>23%</td>
<td>-370</td>
</tr>
<tr>
<td>MB</td>
<td>Electricity</td>
<td>43%</td>
<td>&lt;0.01</td>
<td>7%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>47%</td>
<td>0.27</td>
<td>8%</td>
<td>-100</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>&lt;1%</td>
<td>0.39</td>
<td>23%</td>
<td>-380</td>
</tr>
</tbody>
</table>
### Improved HVAC controls

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of residential space heating provided by specified fuel</th>
<th>GHG reductions (for a typical home) (tCO₂e/year)</th>
<th>Annualized return on investment (for home owner)</th>
<th>$/tCO₂e (for a typical home)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ON</strong></td>
<td>Electricity</td>
<td>14%</td>
<td>0.02</td>
<td>5%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>68%</td>
<td>0.18</td>
<td>0%</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>3%</td>
<td>0.26</td>
<td>19%</td>
<td>-390</td>
</tr>
<tr>
<td><strong>QC</strong></td>
<td>Electricity</td>
<td>50%</td>
<td>&lt;0.01</td>
<td>0%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>7%</td>
<td>0.20</td>
<td>10%</td>
<td>-180</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>9%</td>
<td>0.30</td>
<td>19%</td>
<td>-350</td>
</tr>
<tr>
<td><strong>NB</strong></td>
<td>Electricity</td>
<td>41%</td>
<td>0.30</td>
<td>7%</td>
<td>-130</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>2%</td>
<td>0.19</td>
<td>11%</td>
<td>-230</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>28%</td>
<td>0.28</td>
<td>18%</td>
<td>-340</td>
</tr>
<tr>
<td><strong>PE</strong></td>
<td>Electricity</td>
<td>4%</td>
<td>0.20</td>
<td>12%</td>
<td>-480</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>49%</td>
<td>0.31</td>
<td>17%</td>
<td>-270</td>
</tr>
<tr>
<td><strong>NS</strong></td>
<td>Electricity</td>
<td>21%</td>
<td>0.60</td>
<td>9%</td>
<td>-110</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>1%</td>
<td>0.18</td>
<td>10%</td>
<td>-210</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>37%</td>
<td>0.26</td>
<td>16%</td>
<td>-290</td>
</tr>
<tr>
<td><strong>NL</strong></td>
<td>Electricity</td>
<td>68%</td>
<td>0.04</td>
<td>8%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>18%</td>
<td>0.33</td>
<td>19%</td>
<td>-310</td>
</tr>
</tbody>
</table>
### FACTSHEET

#### Improved HVAC controls

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Heating fuel</th>
<th>Percentage of residential space heating provided by specified fuel</th>
<th>GHG reductions (for a typical home) (tCO₂e/year)</th>
<th>Annualized return on investment (for home owner)</th>
<th>$/tCO₂e (for a typical home)²</th>
</tr>
</thead>
<tbody>
<tr>
<td>YT</td>
<td>Electricity</td>
<td>23%</td>
<td>0.09</td>
<td>13%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>69%</td>
<td>0.46</td>
<td>26%</td>
<td>-430</td>
</tr>
<tr>
<td>NT</td>
<td>Electricity</td>
<td>1%</td>
<td>0.32</td>
<td>30%</td>
<td>-1500</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>11%</td>
<td>0.38</td>
<td>30%</td>
<td>-680</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>77%</td>
<td>0.56</td>
<td>29%</td>
<td>-440</td>
</tr>
<tr>
<td>NU</td>
<td>Electricity</td>
<td>0%</td>
<td>1.7</td>
<td>34%</td>
<td>-390</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>94%</td>
<td>0.67</td>
<td>32%</td>
<td>-450</td>
</tr>
</tbody>
</table>

---

**a** See Appendix A for more information on return on investment and dollar-per-tonne values.

**b** This analysis assumes an identical home with identical HVAC controls across all provinces and territories; actual GHG impacts and returns on investment will vary by municipality. Likewise, return on investment and $/tCO₂e figures will be more favourable if incentives are offered by provincial/territorial governments or utilities in the jurisdiction.

**c** Numbers do not add up to 100 percent because wood and propane heating fuels are not shown here.

**d** "Cost per tonne of CO₂e abated ($/tCO₂e)" indicates the carbon price required to make a given measure cost-effective. A negative cost-per-tonne value indicates that the measure saves money while also reducing emissions. Note that a more negative cost-per-tonne value isn't necessarily more cost-effective. A blank cell (–) indicates that impacts were not calculated because the measure yields insignificant GHG reductions in this province/territory.

n/a = not applicable, as specified fuel source is not present in baseline.
Improved HVAC controls

Improvements to HVAC controls in residential buildings only yield GHG emissions reductions in homes heated with gas and oil, and in homes heated with electricity in provinces and territories with high-carbon grids. Even then, the GHG impacts are somewhat limited for residential buildings compared to commercial and municipal buildings, because the energy savings associated with smart thermostats in residential buildings are smaller. These upgrades give positive returns in all but two cases: gas-heated homes in BC and Ontario, where gas prices are low and heating loads are also relatively low; and electrically heated homes in Quebec, where electricity prices are very low. As with the commercial measures, in areas with low-carbon grids, the electricity saved by making these improvements can be used to meet other needs, which will be important as municipalities move toward the electrification of heating and transportation, increasing the load on the grid.

What are the potential co-benefits?

In addition to GHG emissions reductions and energy bill savings, improved HVAC controls have the potential for a number of co-benefits.

- **Jobs**
  - New skilled jobs are created installing high-performance HVAC control systems, and in energy management.

- **Resilience**
  - Adding BEMS or smart thermostats to buildings makes it possible to reduce peak demand, which can reduce the probability of blackouts.

- **Health and comfort**
  - Improved HVAC controls allow for better control of the internal environment, which leads to greater occupant comfort.

- **Other**
  - Improved occupant comfort increases productivity and reduces employee turnover in commercial and institutional buildings.x
  - Sophisticated BEMS systems can reduce maintenance costs for commercial and institutional buildings by allowing building owners and managers to detect and fix problems quickly, before they escalate.
What is the current and projected state of the market?

**Current state of the market**
- Smart thermostats entered the residential market in 2009. Since then the market has grown by over 100 percent per year in the United States. In 2015, 40 percent of the thermostats sold in the U.S. were smart thermostats.xi In Canada, smart thermostats also face relatively low barriers to adoption, with low upfront costs and simple installation; but additional market information, greater awareness, and incentives to reduce customer upfront costs could expand market adoption.
- In the commercial sector, BEMS are becoming increasingly widespread as awareness grows regarding the value of data in commercial buildings.xii Market awareness and incentives can help expand adoption of these and other types of improved HVAC controls.

**Projections for the future**
- The adoption of smart thermostats is forecast to continue growing at a very fast rate. Smart thermostat manufacturers will likely continue to innovate and add features specific to HVAC control and energy management. This may open the door to real-time measurement and verification of energy-efficiency upgrades, performance monitoring and fault detection, and the addition of demand response capabilities.xiii
- The global BEMS market is forecast to grow very quickly over the next few years due to a combination of high demand charges, a drive toward sustainability, and increasingly tight energy-efficiency regulation.xiv

What have municipalities done?

**Municipalities leading by example**

**City of Kingston: Energy-efficiency improvements to municipal buildings**
The City of Kingston, ON, made a series of energy-efficiency improvements to municipal buildings which included improvements to the buildings’ energy management systems and the installation of a demand controlled ventilation system in the city’s Grand Theatre.

**Incentive programs**

**Municipality of Brazeau County: Municipal Energy Efficiency Rebate Program**
The municipality of Brazeau County, AB, offered residents a rebate of up to $100 on smart thermostats,xv as a top-off to an existing provincial incentive of $75.xvi
**Financing programs**

**City of Toronto: High-rise Retrofit Improvement Support (Hi-RIS)**
The City of Toronto, ON, runs a financing program for energy-efficiency retrofits in high-rise buildings. HVAC control measures are eligible for financing under the program as long as they are identified in an energy assessment report prepared by a qualified auditor.

**What resources can support next steps?**

**Major Energy Retrofit Guidelines for Commercial and Institutional Buildings, Natural Resources Canada, 2017**
This resource focuses on commercial buildings and provides guidelines for assessing opportunity, energy management planning, implementing energy retrofits to improve efficiency, and maintaining performance.

This technical guide to variable frequency drives (VFDs) includes a succinct summary of what VFDs are and how and where they can yield savings.

This short guide explains what demand control ventilation is and why it yields savings. It includes definitions for various key terms.
Endnotes


v Natural Resources Canada, Comprehensive Energy Use Database, *Residential Sector, Table 2: Commercial/Institutional Sector, Table 4*.

vi For the purposes of this analysis, a “typical” office building includes both municipal and commercial office buildings.

vii Heating energy use intensity data from Natural Resources Canada’s *Comprehensive Energy Use Database, Commercial/Institutional Sector, Table 2* (2016 data).


ix This analysis assumes that a baseboard-heated home has six thermostats whereas a centrally heated home has one. The models used in each case are different because baseboard thermostats are line voltage thermostats which are connected directly to the mains voltage, whereas central thermostats are low-voltage thermostats.


xv Brazeau County Municipal Energy Efficiency Rebate Program

xvi Energy Efficiency Alberta, “Smart-Thermostats.”
Building-level solution

Low-carbon water heating

What is low-carbon water heating?

Greenhouse gas (GHG) emissions from water heating can be reduced by improving the efficiency of water heating or by switching to a lower-carbon energy source. This factsheet focuses on three technologies in the residential sector with the greatest potential for GHG reductions:

- electrification (switching from gas or oil to electricity)
- grey water heat recovery
- solar water heaters

<table>
<thead>
<tr>
<th>Carbon intensity of electricity grid</th>
<th>Fuel</th>
<th>Electrification from gas or oil</th>
<th>Grey water heat recovery</th>
<th>Solar water heaters</th>
<th>Co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas</td>
<td>●●●●●</td>
<td></td>
<td>●●●●●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>●●●●●</td>
<td></td>
<td>●●●●●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>n/a</td>
<td>Not applicable (no upfront investment costs)</td>
<td>●●●●●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas</td>
<td>Negative</td>
<td></td>
<td>●●●●●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>●●●●●</td>
<td></td>
<td>●●●●●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>n/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas</td>
<td>Negative</td>
<td></td>
<td>●●●●●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>Negative</td>
<td></td>
<td>●●●●●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GHG reduction (kgCO₂e/m²/year)

- ●●●●● = <1
- ●●●● = ≥1 to <5
- ●●●● = ≥5 to <10
- ●●●● = ≥10 to <20
- ●●●● = ≥20 to <30
- ●●●● = ≥30

Annualized return on investment

- Negative: <0
- Low: ≥0% to <4%
- Medium: ≥4% to <8%
- High: ≥8%

Co-benefits

- None
- Low
- Moderate
- High
- Very high

Other environmental benefits may also result, depending on local circumstances, such as the use and location of fossil fuel power plants and their impact on air quality. Equity considerations will depend on program design but can lead to further co-benefits.

Electric water heaters are cheaper than their gas or oil counterparts; however, the annual energy costs or savings depend on local energy prices. See Table 1 for net present value (NPV) calculations specific to each province/territory, which can help indicate the lifetime value of the measure to homeowners.

Comfort/health co-benefits are only achieved with electrification from gas or oil.
While low-carbon water heating technologies can also reduce emissions in municipal and commercial buildings—particularly restaurants, pools, and gyms with shower facilities—these settings represent a proportionally smaller opportunity than the residential sector, since water heating accounts for a smaller share of sector emissions (less than 10 percent of commercial GHG emissions compared to 21 percent for the residential sector). As such, this factsheet places greater focus on the residential sector.

How does this solution work and why is it important?

Municipalities can use several technologies to reduce GHG emissions from water heating in buildings:

- **Electrification from gas or oil**: Switching from storage water heaters powered by gas or oil to electric storage water heaters can reduce GHG emissions in municipalities with low-carbon electricity grids. This change enhances energy efficiency (because electric storage water heaters are significantly more efficient than their gas or oil counterparts) and reduces the carbon intensity of the energy source (clean electricity is much less carbon-intensive than gas or oil). Switching to electric water heating will tend to increase peak electricity demand. Municipalities concerned about peak demand may partner with their local utility to promote demand response technologies.

- **Grey water heat recovery**: Grey water (or “drain water”) heat recovery systems capture heat from hot water flowing down the drain and use it to pre-heat cold water entering the water heater. These systems can reduce hot water energy use by 10–30 percent.

- **Solar water heaters**: In Canada, a solar water heating system can cover 40–50 percent of the hot water requirement of an average home. Solar water heating systems consist of solar thermal collectors that pre-heat the water and a conventional water heater that kicks in when required to ensure that the water temperature is high enough to prevent bacterial growth. In Canada, cold winter temperatures mean that freeze-protected solar water heaters are typically required if the system is to be used year-round. These systems use antifreeze in the collectors instead of water, enabling them to continue generating hot water even when outdoor temperatures are well below zero.

- **Heat pump water heaters**: Heat pump water heaters take heat from the surrounding air and transfer it to the stored hot water. During the cooling season, these systems provide “free cooling” to buildings by removing unwanted heat from air inside the building and transferring it to hot water. During the heating season, these systems simply take heat that has been provided by a heating system and transfer that heat to the stored hot water. This effectively means that space heating systems provide the heat for water heating—therefore, heat pump water heaters only generate significant energy savings if highly efficient space heating systems are installed, such as a heat pump.ii, iii
• **Condensing gas-fired water heaters:** Condensing gas-fired water heaters use a condensing heat exchanger to capture heat contained in moisture that would otherwise be lost out the flue. These water heaters can be storage tank systems or instantaneous systems. A condensing gas-fired water heater improves the performance of water storage tank systems by 70 to 90 percent. Due to their high cost, these systems are more common in commercial markets.

• **Instantaneous water heaters:** These systems don’t have a storage tank; rather, they heat water as it flows through a heater. These systems are more efficient than storage water heaters because there is no hot water sitting around losing heat. It should be noted, however, that electric instantaneous water heaters use significant amounts of power. This can be disadvantageous for municipal utilities struggling to meet peak electricity demand.

• **Energy-efficient faucet aerators and low-flow showerheads:** These fixtures reduce the flow rate of hot water from the shower or tap. They are cheap, easy to install, and offer reasonable energy savings—so they can be a good first step to reducing emissions from water heating.

Because water heating is responsible for 21 percent of residential GHG emissions nationally, low-carbon water heating technologies offer an important opportunity for GHG reductions. Conversely, in the commercial sector, water heating accounts for only nine percent of GHG emissions nationally, so opportunities for reducing emissions are more limited (with the greatest potential in restaurants, gyms and other commercial buildings that use high volumes of hot water).

The remainder of this factsheet focuses on the residential sector, looking at the three water heating technologies with the most promise in terms of feasibility and GHG reductions: electrification; grey water heat recovery; and solar water heaters. It should be noted that in cases where buildings are heated with heat pumps, a heat pump water heater may be the most promising option.

---

**Is this solution right for my municipality?**

To determine the potential GHG impact and economic feasibility of switching to low-carbon water heating technologies in residential buildings within your municipality, consider the following questions:

• **What is the carbon intensity of water heating?** You will only achieve significant GHG emissions reductions by addressing this end-use if the main water heating fuel is carbon-intensive—that is, if the main energy source for water heating is oil, gas or high-carbon electricity. If the main energy source for water heating is already low-carbon electricity, water heating measures will not achieve significant GHG reductions.
• **How high are water heating costs?** The cost effectiveness of improving the efficiency of water heating or switching to a different energy source will be heavily dependent on the current cost of water heating. These measures will be most cost-effective in municipalities where fuel prices and hot water consumption are high.

If water heating measures are right for your municipality, below are some key questions to help identify which technology option is most appropriate.

**Electrification from gas or oil**

• **What is the carbon intensity of the grid?** In areas with low-carbon grids, switching from oil or gas to electric heating will yield significant GHG emissions reductions. In areas with high-carbon grids, that switch may actually increase emissions.

• **How high are local electricity prices compared to oil and gas prices?** Bill savings from replacing oil or gas water heaters with electric water heaters will depend on the price of electricity compared to the price of the fuel replaced. Electrification will be most cost-competitive in municipalities where electricity prices are low and the existing fuel used for water heating is expensive.

**Grey water heat recovery**

• **Does most of the hot water run straight down the drain?** Grey water, or drain water, heat recovery is optimal with hot water uses where the hot water runs straight down the drain, such as with showers or dishwashers, but is less effective when water is collected for a time before it drains, such as with baths and clothes washers. This is because the heat recovery occurs when cold water is flowing into the hot water tank as hot water is flowing down the drain.

• **How accessible is the main drain?** Difficulty accessing the main drain, or lack of space around the main drain to install the technology, may make installation very costly.

• **How long is the main drain?** A drain approximately 5–6 feet in length is needed for the equipment to effectively transfer heat.

• **How close to the water heater is the main drain?** If the main drain is located far from the water heater, significant amounts of piping will be needed, which will reduce the efficiency and cost effectiveness of the measure. This tends to be an issue when the water tank is not located in the basement.

• **Is the building a new construction?** This technology is easier and more cost-effective to install in new buildings than existing buildings. In new construction, the technology can be situated in a way that is optimal for energy savings and installed without cutting any pipes.

**Solar water heaters**

• **How significant is your municipality’s solar potential?** Energy savings from switching to a solar water heater will depend on the intensity of sunlight in the region (as well as the suitability of the local building stock—as described in the next bullet). The map below shows approximate energy savings for an identically oriented solar water heater for various places in Canada, with savings ranging from about 20 percent to more than 50 percent.
Figure 1: Potential portion of water heating energy savings obtained by installing a solar water heater

- Is solar PV also a solution of interest in your municipality? Solar thermal systems may compete with solar PV systems for roof space. Solar hot water heaters convert solar energy to heat more efficiently than solar PV converts solar energy to electricity. This means that, when panels of an equivalent size are put on the same roof, solar thermal will typically save more energy than solar PV will produce. However, electricity is often more expensive per unit of energy than oil or gas, so the economic comparison will depend on local energy prices and on the fuel used for water heating. Of note, solar thermal requires more piping and has a different aesthetic than solar PV, which may deter people from installing both system types on the same roof.
• **Is the local building stock suitable?**
  Several factors determine a building’s suitability for solar thermal deployment, including: orientation and size of the building area that will be used to install the collectors; whether the collectors would be shaded by trees, parts of the building or surrounding buildings (partial shading is not considered a big problem); accessibility of the collectors for future inspection and maintenance; available space for the storage tank; and proximity of the collectors to the storage tank.

What does it take to implement?

If this solution is appropriate for your municipality, you will need an effective strategy to drive adoption. Consider the following actions:

• **Offer financing or incentive programs.** Such programs reduce the incremental upfront costs of low-carbon water heating technologies. Several jurisdictions across Canada offer financing or rebates for the installation of these technologies (e.g. Quebec’s Rénoclimat program and Manitoba Hydro’s Home Energy Efficiency Loan and PAYS Financing program). You can play an impactful role by topping up or promoting existing programs or launching new ones.

• **Mandate the installation of drain water heat recovery systems in new construction.** You can do this through bylaws, depending on what your municipal authority allows.

• **Introduce policies that reduce or eliminate the use of fossil fuel heating systems in new construction or existing buildings, or both.**

• **Provide training for contractors.** This type of training (e.g. training plumbers to install drain water heat recovery systems) can reduce barriers to installing this technology, increasing its uptake.

• **Promote or require energy rating and disclosure programs.** This can help to ensure that the value of low-carbon water heating systems is reflected in the value of a property.

What are the GHG and financial impacts?

The GHG reductions, costs and cost savings associated with installing low-carbon water heating technologies are highly dependent on a variety of factors, including grid carbon intensity, local energy rates, building water heating requirements and the existing water heating systems in a building.

This section explores the impacts of each measure (electrification of water heating, drain water heat recovery and solar water heating systems) in a typical house—assumed to have two floors and a total floor area of about 140 m² (1,500 ft²). The analysis is based on provincial and territorial average data, only considers existing buildings, and assumes that no incentives are in place. To understand the impact of each measure, the analysis applies each technology in isolation. If more than one of these
solutions is implemented in the same building, the GHG impacts may be less than the sum of the GHG impacts of each individual solution, because of the interactive effects.

**Electrification from gas or oil**

This analysis assumes that at the end of life of an old gas or oil water heater, a typical electric storage water heater is installed instead of a new ENERGY STAR® gas or oil storage water heater. The electric storage water heater is assumed to have a useful life of 10 years and cost about $1,100, compared to a gas system cost of $2,700 and an oil system cost about $3,400. The electric storage water heater costs less than its oil and gas counterparts, so this measure actually saves the building owner money upfront. Depending on local prices of electricity, gas and oil, this technology may lead to increases or decreases in annual energy bills. The fact that there is no incremental upfront cost relative to a new gas or oil water heater means that a return on investment cannot be calculated. Instead, we have calculated the net present value (NPV), which represents the current value to the homeowner of all the costs and savings associated with the measure over its lifetime. The greater the NPV, the greater the lifetime cost effectiveness of the measure.

The enhanced efficiency associated with the measure results in an annual water heating energy savings of 29 percent. Table 1 presents the impacts by province/territory, as well as the proportion of homes with water heating provided by each fuel type in each province and territory. It should be noted that water heating fuel mix may vary significantly across municipalities within a province or territory, especially between rural and urban areas.

**Table 1**: GHG and financial impacts of switching from gas or oil to electric storage water heaters in a typical homena,b

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Baseline water heating fuel</th>
<th>Percentage of homes with specified water heating fuel</th>
<th>GHG reductions (for a typical home) (tCO\textsubscript{2}e/year)</th>
<th>Net present value of installation ($) (for homeowner)d</th>
<th>$/tCO\textsubscript{2}e (for a typical home)c</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Gas</td>
<td>65%</td>
<td>1.1</td>
<td>-2,800</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>1.0%</td>
<td>1.5</td>
<td>4,600</td>
<td>-240</td>
</tr>
<tr>
<td>AB</td>
<td>Gas</td>
<td>90%</td>
<td>-2.5</td>
<td>-2,700</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0.0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>SK</td>
<td>Gas</td>
<td>84%</td>
<td>-2.1</td>
<td>-6,100</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0.55%</td>
<td>-1.6</td>
<td>1,100</td>
<td>–</td>
</tr>
<tr>
<td>Province/territory</td>
<td>Baseline water heating fuel</td>
<td>Percentage of homes with specified water heating fuel</td>
<td>GHG reductions (for a typical home) (tCO₂e/year)</td>
<td>Net present value of installation ($) (for homeowner)</td>
<td>$/tCO₂e (for a typical home)</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------------------------</td>
<td>----------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>MB</td>
<td>Gas</td>
<td>47%</td>
<td>1.1</td>
<td>-560</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0.36%</td>
<td>1.6</td>
<td>6,000</td>
<td>-300</td>
</tr>
<tr>
<td>ON</td>
<td>Gas</td>
<td>74%</td>
<td>1.1</td>
<td>-3,400</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>2.7%</td>
<td>1.5</td>
<td>5,400</td>
<td>-290</td>
</tr>
<tr>
<td>QC</td>
<td>Gas</td>
<td>4.4%</td>
<td>1.1</td>
<td>2,600</td>
<td>-180</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>2.4%</td>
<td>1.6</td>
<td>7,200</td>
<td>-370</td>
</tr>
<tr>
<td>NB</td>
<td>Gas</td>
<td>4.0%</td>
<td>-0.34</td>
<td>-200</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>2.1%</td>
<td>0.10</td>
<td>3,600</td>
<td>-</td>
</tr>
<tr>
<td>PE</td>
<td>Gas</td>
<td>0.0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>76%</td>
<td>0.67</td>
<td>-460</td>
<td>55</td>
</tr>
<tr>
<td>NS</td>
<td>Gas</td>
<td>0.0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>47%</td>
<td>-1.7</td>
<td>640</td>
<td>-</td>
</tr>
<tr>
<td>NL</td>
<td>Gas</td>
<td>0.0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>9.4%</td>
<td>1.4</td>
<td>3,100</td>
<td>-180</td>
</tr>
<tr>
<td>YT</td>
<td>Gas</td>
<td>0.0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>40%</td>
<td>1.3</td>
<td>4,700</td>
<td>-280</td>
</tr>
<tr>
<td>NT</td>
<td>Gas</td>
<td>0.0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>40%</td>
<td>0.78</td>
<td>-6,500</td>
<td>670</td>
</tr>
</tbody>
</table>
## Low-carbon water heating

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Baseline water heating fuel</th>
<th>Percentage of homes with specified water heating fuel</th>
<th>GHG reductions (for a typical home) (tCO₂e/year)</th>
<th>Net present value of installation ($) (for homeowner)</th>
<th>$/tCO₂e (for a typical home)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NU</td>
<td>Gas</td>
<td>0.0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>40%</td>
<td>-2.0</td>
<td>-7,700</td>
<td>–</td>
</tr>
</tbody>
</table>

---

**Drain water heat recovery**

Replacing oil or gas storage water heaters with an electric storage water heater yields significant GHG emissions reductions in areas with low-carbon grids but can increase GHG emissions in areas with moderate- and high-carbon grids. Switching from oil to electricity has a positive NPV in almost all provinces and territories, whereas switching from gas to electricity only has a positive NPV in Quebec (where electricity prices are low relative to gas prices). Nonetheless, even in areas where this measure results in costs to homeowners, it may be cost-effective from a GHG reduction perspective. For example, in Manitoba, switching from gas to electricity has an NPV of -$560, but results in a cost of just $40 per tonne of GHG emissions avoided. Negative NPVs associated with high GHG reductions point to the need for incentives to switch from gas and oil water heating to electric water heating.

### Drain water heat recovery

This analysis assumes that a drain water heat recovery unit 1.5m long is installed in a typical home. This technology is estimated to have an upfront cost of about $1,050, including installation, and an expected useful life of 30 years. This upgrade is assumed to result in an annual water heating energy savings of 16 percent. Table 2 presents the impacts by province/territory, as well as the proportion of homes with water heating provided by each fuel type in each province and territory. It should be noted that water heating fuel mix may vary significantly across municipalities within a province or territory, especially between rural and urban areas.
### Table 2: GHG and financial impacts of installing drain water heat recovery in a typical home\(^{a,b}\)

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Baseline water heating fuel</th>
<th>Percentage of homes with specified water heating fuel(^c)</th>
<th>GHG reductions tCO(_2)e/year (for a typical home)</th>
<th>Annualized return on investment (for homeowner)</th>
<th>$/tCO(_2)e (for a typical home)(^d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Electricity</td>
<td>33%</td>
<td>&lt;0.01</td>
<td>2%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>65%</td>
<td>0.20</td>
<td>-2%</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>1.0%</td>
<td>0.28</td>
<td>5%</td>
<td>-320</td>
</tr>
<tr>
<td>AB</td>
<td>Electricity</td>
<td>8%</td>
<td>0.57</td>
<td>2%</td>
<td>-40</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>90%</td>
<td>0.20</td>
<td>-2%</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0.0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>SK</td>
<td>Electricity</td>
<td>15%</td>
<td>0.50</td>
<td>4%</td>
<td>-150</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>84%</td>
<td>0.20</td>
<td>-2%</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0.55%</td>
<td>0.28</td>
<td>4%</td>
<td>-300</td>
</tr>
<tr>
<td>MB</td>
<td>Electricity</td>
<td>51%</td>
<td>&lt;0.01</td>
<td>1%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>47%</td>
<td>0.20</td>
<td>0%</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>0.36%</td>
<td>0.28</td>
<td>5%</td>
<td>-310</td>
</tr>
<tr>
<td>ON</td>
<td>Electricity</td>
<td>21%</td>
<td>0.0</td>
<td>3%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>74%</td>
<td>0.20</td>
<td>-2%</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>2.7%</td>
<td>0.28</td>
<td>5%</td>
<td>-390</td>
</tr>
<tr>
<td>QC</td>
<td>Electricity</td>
<td>93%</td>
<td>&lt;0.01</td>
<td>0%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>4.4%</td>
<td>0.20</td>
<td>2%</td>
<td>-70</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>2.7%</td>
<td>0.28</td>
<td>5%</td>
<td>-320</td>
</tr>
</tbody>
</table>
## Factsheet

### Low-carbon water heating

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Baseline water heating fuel</th>
<th>Percentage of homes with specified water heating fuel</th>
<th>GHG reductions tCO_2e/year (for a typical home)</th>
<th>Annualized return on investment (for homeowner)</th>
<th>$/tCO_2e (for a typical home)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB</td>
<td>Electricity</td>
<td>92%</td>
<td>0.23</td>
<td>3%</td>
<td>-170</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>4.0%</td>
<td>0.20</td>
<td>2%</td>
<td>-140</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>2.1%</td>
<td>0.28</td>
<td>5%</td>
<td>-320</td>
</tr>
<tr>
<td>PE</td>
<td>Electricity</td>
<td>21%</td>
<td>0.14</td>
<td>4%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0.0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>76%</td>
<td>0.28</td>
<td>4%</td>
<td>-210</td>
</tr>
<tr>
<td>NS</td>
<td>Electricity</td>
<td>50%</td>
<td>0.51</td>
<td>4%</td>
<td>-140</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0.0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>47%</td>
<td>0.28</td>
<td>4%</td>
<td>-260</td>
</tr>
<tr>
<td>NL</td>
<td>Electricity</td>
<td>90%</td>
<td>0.03</td>
<td>2%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>9.4%</td>
<td>0.28</td>
<td>4%</td>
<td>-250</td>
</tr>
<tr>
<td>YT</td>
<td>Electricity</td>
<td>60%</td>
<td>0.04</td>
<td>3%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0.0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>40%</td>
<td>0.28</td>
<td>5%</td>
<td>-360</td>
</tr>
<tr>
<td>NT</td>
<td>Electricity</td>
<td>60%</td>
<td>0.13</td>
<td>7%</td>
<td>-1,600</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0.0%</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>40%</td>
<td>0.28</td>
<td>5%</td>
<td>-350</td>
</tr>
</tbody>
</table>
Installing drain water heat recovery only yields GHG reductions in homes where the water heating fuel is gas, oil or high-carbon electricity, and even then, the reductions are somewhat limited. Returns on investment are generally positive, however (the exception being in provinces and territories where natural gas prices are very low), so this may be a cost-effective first step to reducing emissions in residential buildings. Even in the few cases where this measure isn’t cost-effective for the homeowner, it represents a low-cost option for reducing GHG emissions.

**Solar thermal water heating**

This analysis assumes that a 6 m² solar collector and associated storage tank is installed on the roof of a typical home, and that the existing heating system remains in place to provide top-up water heating.

This technology is estimated to have an upfront cost of about $7,000, including installation, and an expected useful life of 20 years.

This upgrade is assumed to result in an annual water heating energy savings of 25–49 percent, depending on the province/territory. Table 3 presents the impacts by province/territory, as well as the proportion of homes with water heating provided by each fuel type in each province and territory. It should be noted that water heating fuel mix may vary significantly across municipalities within a province or territory, especially between rural and urban areas.
Table 3: GHG and financial impacts of installing a solar thermal water heater in a typical home

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Baseline water heating fuel</th>
<th>Percentage of homes with specified water heating fuel</th>
<th>GHG reductions tCO₂e/year (for a typical home)</th>
<th>Annualized return on investment (for homeowner)</th>
<th>$/tCO₂e (for a typical home)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Electricity 33%</td>
<td>0.02</td>
<td>-2%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas 65%</td>
<td>0.53</td>
<td>-6%</td>
<td>830</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil 1.0%</td>
<td>0.75</td>
<td>0%</td>
<td>190</td>
<td></td>
</tr>
<tr>
<td>AB</td>
<td>Electricity 8%</td>
<td>1.7</td>
<td>-2%</td>
<td>160</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas 90%</td>
<td>0.59</td>
<td>-6%</td>
<td>720</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil 0.0%</td>
<td>0.84</td>
<td>0%</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>SK</td>
<td>Electricity 15%</td>
<td>1.5</td>
<td>0%</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas 84%</td>
<td>0.59</td>
<td>-6%</td>
<td>730</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil 0.55%</td>
<td>0.84</td>
<td>0%</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>MB</td>
<td>Electricity 51%</td>
<td>&lt;0.01</td>
<td>-3%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas 47%</td>
<td>0.57</td>
<td>-5%</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil 0.36%</td>
<td>0.81</td>
<td>0%</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>ON</td>
<td>Electricity 21%</td>
<td>0.04</td>
<td>-2%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas 74%</td>
<td>0.55</td>
<td>-6%</td>
<td>790</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil 2.7%</td>
<td>0.79</td>
<td>1%</td>
<td>90</td>
<td></td>
</tr>
</tbody>
</table>
## Factsheet

### Low-carbon water heating

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Baseline water heating fuel</th>
<th>Percentage of homes with specified water heating fuel</th>
<th>GHG reductions tCO₂e/year (for a typical home)</th>
<th>Annualized return on investment (for homeowner)</th>
<th>$/tCO₂e (for a typical home)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QC</td>
<td>Electricity</td>
<td>93%</td>
<td>&lt;0.01</td>
<td>-5%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>4.4%</td>
<td>0.54</td>
<td>-3%</td>
<td>590</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>2.7%</td>
<td>0.77</td>
<td>0%</td>
<td>170</td>
</tr>
<tr>
<td>NB</td>
<td>Electricity</td>
<td>92%</td>
<td>0.63</td>
<td>-2%</td>
<td>420</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>4.0%</td>
<td>0.53</td>
<td>-2%</td>
<td>550</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>2.1%</td>
<td>0.75</td>
<td>0%</td>
<td>190</td>
</tr>
<tr>
<td>PE</td>
<td>Electricity</td>
<td>21%</td>
<td>0.35</td>
<td>-1%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0.0%</td>
<td>0.48</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>76%</td>
<td>0.68</td>
<td>-1%</td>
<td>360</td>
</tr>
<tr>
<td>NS</td>
<td>Electricity</td>
<td>50%</td>
<td>1.3</td>
<td>-1%</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0.0%</td>
<td>0.50</td>
<td>-3%</td>
<td>610</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>47%</td>
<td>0.72</td>
<td>-1%</td>
<td>270</td>
</tr>
<tr>
<td>NL</td>
<td>Electricity</td>
<td>90%</td>
<td>0.05</td>
<td>-4%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0%</td>
<td>0.37</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>9.4%</td>
<td>0.53</td>
<td>-2%</td>
<td>570</td>
</tr>
<tr>
<td>YT</td>
<td>Electricity</td>
<td>60%</td>
<td>0.08</td>
<td>-4%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>0.0%</td>
<td>0.38</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>40%</td>
<td>0.54</td>
<td>-1%</td>
<td>450</td>
</tr>
</tbody>
</table>
## Low-carbon water heating

| Province/territory | Baseline water heating fuel | Percentage of homes with specified water heating fuel | GHG reductions $tCO_2e$/year (for a typical home) | Annualized return on investment (for homeowner) | $/tCO_2e (for a typical home)

### NT

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>60%</td>
<td>0.21</td>
<td>0%</td>
<td>680</td>
</tr>
<tr>
<td>Gas</td>
<td>0.0%</td>
<td>0.32</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Oil</td>
<td>40%</td>
<td>0.46</td>
<td>-2%</td>
<td>650</td>
</tr>
</tbody>
</table>

### NU

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>60%</td>
<td>0.88</td>
<td>0%</td>
<td>150</td>
</tr>
<tr>
<td>Gas</td>
<td>0.0%</td>
<td>0.31</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Oil</td>
<td>40%</td>
<td>0.44</td>
<td>-3%</td>
<td>700</td>
</tr>
</tbody>
</table>

---

**a** See Appendix A for more information on net present value and dollar-per-tonne values.

**b** For each province and territory, the portion of water heating energy savings obtained by installing a solar water heater is assumed to be that of the most populated city in that province (see Figure 1). The variation in energy savings between provinces/territories only accounts for differences in climate; it does not account for differences in net heating energy demand, baseline efficiency of water heaters or roof suitability. This analysis assumes an identical home with identical water heating equipment across all provinces and territories; actual GHG impacts and NPVs will vary by municipality. Likewise, NPV and $/tCO_2e$ figures will be more favourable if incentives are offered by provincial/territorial governments or utilities in the jurisdiction.

**c** Numbers do not add up to 100 percent because wood and propane heating fuels are not shown here.

**d** “Cost per tonne of CO$_2e$ abated ($/tCO_2e$)” indicates the carbon price required to make a given measure cost-effective. A negative cost-per-tonne value indicates that the measure saves money while also reducing emissions. Note that a more negative cost-per-tonne value isn’t necessarily more cost-effective. A blank cell (–) indicates that impacts were not calculated because the measure yields insignificant GHG reductions in this province/territory.

**e** Because data on average water heating fuel is not available by territory, an average value was used across all territories. n/a = not applicable, as specified fuel source is not present in baseline.

Installing solar thermal water heating yields moderate GHG reductions in homes where the water heating fuel is gas or oil, and relatively high GHG reductions in areas with high-carbon grids where the water heating fuel is electricity. Returns on investment are almost always negative, however, because of the high upfront cost of solar thermal.

In provinces and territories with low-carbon grids, electrification from gas or oil is a higher-impact and more cost-effective option than solar thermal. In provinces and territories with high-carbon grids, solar thermal yields the greatest GHG reductions of the three technologies considered, but those reductions come at a higher price than those available through drain water heat recovery.
What are the potential co-benefits?

In addition to GHG emissions reductions and potential energy bill savings, the use of low-carbon water heating technologies has the potential to offer a number of co-benefits. It should be noted, however, that electrification of water heating can actually reduce resilience to climate change by increasing vulnerability to electricity outages.

- **Jobs**
  - New skilled jobs are created for contractors to install new water heating systems. Investment in electricity energy-efficiency programs creates an estimated 7–12 times more jobs per million dollars invested than investment in existing electricity infrastructure (generation, transmission and distribution). xviii, xix

- **Environment**
  - Reduced use of oil or high-carbon electricity will improve local air quality in areas downwind from fossil fuel-fired power plants.
  - Faucet aerators and low-flow showerheads yield water savings.

- **Health and comfort**
  - Fuel switching from gas or oil to clean electricity reduces the risk of oil spills and gas explosions—and eliminates that risk in cases where a household’s entire HVAC system is electrified.

- **Other**
  - Replacement of heating oil with electricity can reduce variability in energy bills, since electricity prices are generally more stable than heating oil prices.

What is the current and projected state of the market?

**Current state of the market**

- Residential water heaters have been subject to energy performance standards under Canada’s Energy Efficiency Act since 1995, so the market is well-established for energy-efficient technologies. xx The market is less established in the commercial sector, where energy performance standards are just now being integrated into federal and provincial/territorial regulations. xxi, xxi

- The high-impact technologies discussed in this factsheet are at different stages of market uptake:
  - **Electric resistance water heaters** account for 44 percent of residential water heaters in Canada, but that proportion varies significantly across provinces and territories—from eight percent in Alberta to 93 percent in Quebec. Low gas prices in Ontario, British Columbia and Manitoba mean that a significant proportion of homes have gas water heating, despite the fact that electric water heating would produce significantly fewer GHG emissions in those provinces.
Low-carbon water heating

- **Drain water heat recovery systems** are a fairly well-developed technology that is becoming increasingly widespread in the Canadian market. Ontario and Manitoba recently made the installation of drain water heat recovery mandatory in new residential buildings under their building codes.xxiii

- **Solar thermal water heating** has a very small market share in Canada, with less than 500 new residential hot water systems estimated to have been installed in 2014.xxiv High upfront costs remain a key barrier for this technology.xxv

- Heat pump water heaters currently account for less than one percent of the residential and commercial markets for electric storage water heaters.xxvi

- Well-insulated water tanks are now the norm in most Canadian households, as are low-flow fixtures that can reduce water use by up to 20 percent.

**Projections for the future**

- The market for drain water heat recovery is expected to grow fast in Canada due to the code changes in Ontario and Manitoba, as well as the inclusion of this technology in the BC Step Code.xxvii

- The adoption of both electrified water heating and solar thermal water heating will depend heavily on national, provincial/territorial and local incentives and carbon prices.

- The Canadian government has set targets for the efficiency of water heating technologies, aiming for all fuel-burning water heating technologies for sale in Canada to perform at a minimum of 90 percent efficiency (through the use of condensing technology) by 2025. The target for 2035 is for all water heaters sold in Canada to perform at more than 100 percent efficiency, which effectively requires the use of heat pump water heaters or solar thermal water heaters.xxviii

- The 2018 report, *Paving the Road to 2030 and Beyond: Market Transformation Road Map for Energy Efficient Equipment in the Building Sector*, lays out priorities for research and development and deployment, for heat pump water heaters and other advanced technologies (e.g. solar thermal). Research and development priorities include establishing national cost estimates, establishing performance estimates for cold climate conditions, improving performance and reducing installation complexity. Deployment priorities include developing Canada-specific performance ratings, increasing contractor awareness, developing incentive programs, supporting the development of codes and standards, and developing high-performance specifications for heat pump water heaters.xxix
What have municipalities done?

Incentive programs

**Town of Banff: Residential Environmental Rebates**
The Town of Banff, AB, offers its residents a rebate of $650 for ENERGY STAR® certified solar hot water heaters.

**Municipality of Brazeau County: Municipal Energy Efficiency Rebate Program**
The Municipality of Brazeau County, AB, offered its residents rebates of up to $500 on drain water heat recovery and up to $1,000 on gas tankless water heaters.

Financing programs

**City of Toronto: Home Energy Loan Program**
The City of Toronto, ON, runs a Property Assessed Clean Energy (PACE) financing program for energy efficiency retrofits to single-family homes. Eligible retrofits include high-efficiency water heaters, drain-water heat recovery systems and solar hot water systems.

Building codes and bylaws

**City of Montreal: Heating oil ban**
The City of Montreal, QC, has announced that it will ban the use of heating oil for industrial and commercial buildings by 2025, and for residential buildings by 2030.

Provincial actions

**Province of Manitoba: Residential Earth Power Loan**
The Province of Manitoba offers a loan of up to $7,500 for the installation of solar hot water heaters through Manitoba Hydro’s Residential Earth Power Loan program.

**Province of Alberta: Drain Water Heat Recovery**
The Alberta Energy Efficiency Agency offered $500 for the installation of drain water heat recovery systems.

What resources can support next steps?

**Product information: Water heaters, Natural Resources Canada**
This web page on residential water heaters includes links to many useful resources, such as product finders and information on different types of water heating technologies.

This guide considers water heating among many other building end-uses. It includes information on typical water consumption and on the key water heating technologies.

**Water Heater Guide, Natural Resources Canada, 2012**
This guide provides an introduction to a broad range of water heating options and includes advice on the practicalities of switching water heating systems. It also offers non-equipment-related tips on reducing energy consumption from water heating.

**Drain Water Heat Recovery Calculator, CEATI**
This tool provides customized estimates of fuel and cost savings based on user-specified building parameters on water use, water heater technology and location.

This detailed guide on solar water heating systems helps municipalities assess the impact and suitability of this technology and find contractors for installation.
Endnotes


iv Energy and Mines Ministers’ Conference, *Paving the Road to 2030 and Beyond: Market transformation road map for energy efficient equipment in the building sector*, August 2018.

v Gas-fired instantaneous water heaters have an energy factor (EF) of 0.85, compared to gas-fired storage tank water heaters, which have an EF of 0.6 (source: Natural Resources Canada, *Water Heater Guide*, 2012).

vi Natural Resources Canada, *Comprehensive Energy Use Database, Residential Sector, Table 2* (2016 data).

vii Natural Resources Canada, *Comprehensive Energy Use Database, Commercial/Institutional Sector, Table 4* (2016 data).

viii This is based on a consideration of each water heating technology in isolation, and does not consider possible additive effects of other building-level solutions covered in this roadmap.


xi See Transition énergétique Québec, “Rénoclimat.”

xii See Manitoba Hydro, *Drain water heat recovery systems*.

xiii This analysis assumes a water heating energy requirement of 4,210 kWh across all provinces and territories. It also assumes the efficiency of existing water heating equipment is the same in all provinces and territories—namely, 95 percent for electric, 62 percent for gas and 60 percent for oil.

xiv This analysis assumes an electric storage water heater Uniform Energy Factor (UEF) of 0.93 and a gas/oil storage water heater UEF of 0.66.

xv U.S. Energy Information Administration, *Updated Buildings Sector Appliance and Equipment Costs and Efficiencies*, 2018. The costs are for a 50 gallon electric resistance electric storage water heater with a UEF of 0.93, a 40 gallon storage water heater with a UEF of 0.66, and a 32 gallon oil storage water heater with a UEF of 0.67.


xvii For each province and territory, the portion of water heating energy savings obtained by installing a solar water heater is assumed to be that of the most populated city in that province (see Figure 1). The variation in energy savings between provinces/territories only accounts for differences in climate; it does not account for differences in net heating energy demand, baseline efficiency of water heaters or roof suitability.


xix Pembina Institute, *Job Growth in Clean Energy: Employment in Alberta’s emerging renewables and energy efficiency sectors*, November 2016. This includes direct and indirect jobs, and takes into account the decrease in jobs due to reduced demand for electricity.


xxiii EcoInnovation website, accessed on July 31, 2019.


xxviii Energy and Mines Ministers’ Conference, *Paving the Road to 2030 and Beyond: Market transformation road map for energy efficient equipment in the building sector*, August 2018.

xxix Ibid.

**Building-level solution**

**High-efficiency lighting and reduced plug loads**

**What are high-efficiency lighting and reduced plug loads?**

Energy consumption from lighting can be reduced by switching to energy-efficient light bulbs, improving lighting controls, and using natural light as a source of illumination. In particular, light-emitting diode (LED) light bulbs use much less electricity to produce the same amount of light as old light bulb technologies, such as fluorescent and incandescent lighting.

Plug loads are the energy used by equipment that is plugged into a power outlet, including appliances (such as refrigerators, dishwashers and clothes dryers) and electronic devices (such as computers, network equipment, photocopiers and televisions). This energy use can be reduced by replacing appliances and devices with efficient models, and by installing equipment that regulates the energy use of these devices (e.g. smart power strips that reduce standby power consumption).

For residential buildings, changes to national energy-efficiency codes are soon expected to restrict the use of inefficient light bulbs. Therefore, this factsheet only focuses on municipal actions to improve lighting efficiency in commercial and municipal buildings.

<table>
<thead>
<tr>
<th>Carbon intensity of electricity grid</th>
<th>Fuel</th>
<th>Commercial and municipal</th>
<th>Co-benefits</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Electricity</td>
<td><img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /></td>
<td><img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /></td>
<td>Lead by example, Incentive programs</td>
</tr>
<tr>
<td>Moderate</td>
<td>Electricity</td>
<td><img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /></td>
<td><img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Electricity</td>
<td><img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /></td>
<td><img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /> <img src="#" alt="Circle" /></td>
<td></td>
</tr>
</tbody>
</table>
High-efficiency lighting and reduced plug loads

How does this solution work and why is it important?

Nationwide, lighting accounts for nine percent of commercial greenhouse gas (GHG) emissions and three percent of residential GHG emissions. Plug loads (energy demand from appliances such as clothes dryers, ranges, refrigerators, freezers, computers and photocopiers) account for 12 percent of building sector GHG emissions in both the commercial and residential sectors. Although these end uses only contribute a modest amount to building emissions, they are very cost-effective to address, making them a good target for a first step toward reducing GHG emissions.

**Lighting**

New lighting technologies are far more efficient than old ones. Light-emitting diode (LED) bulbs use about 80 percent less electricity to provide the same amount of light as incandescent light bulbs. Compact fluorescent lights (CFLs) or halogen bulbs are more efficient than incandescent light bulbs, but not nearly as efficient as LED lights. LEDs also have a longer life span than other bulb types. Significant lighting energy savings can also be achieved by improving lighting controls (i.e. using timers, occupancy sensors and dimmers), and through carefully designed daylighting (making use of natural light as a source of illumination).

---

### Reduced plug loads

<table>
<thead>
<tr>
<th>Carbon intensity of electricity grid</th>
<th>Fuel</th>
<th>Residential</th>
<th>Commercial and municipal</th>
<th>Co-benefits&lt;sup&gt;a, b&lt;/sup&gt;</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>GHG impact (per building)</td>
<td>Annualized return on investment (per building) (range across provinces/territories)</td>
<td>GHG impact (per building)</td>
<td>Annualized return on investment (per building) (range across provinces/territories)</td>
</tr>
<tr>
<td>Low</td>
<td>Electricity</td>
<td>○○○○○○</td>
<td>○○○○○○</td>
<td>○○○○○○</td>
<td>○○○○○○</td>
</tr>
<tr>
<td>Moderate</td>
<td>Electricity</td>
<td>○○○○○○</td>
<td>Medium to high</td>
<td>Medium to high</td>
<td>○</td>
</tr>
<tr>
<td>High</td>
<td>Electricity</td>
<td>●●●●●●</td>
<td>●●●●●●</td>
<td>●●●●●●</td>
<td>●●●●●●</td>
</tr>
</tbody>
</table>

**GHG reduction (kgCO₂e/m²/year)**

- ○○○○○○ = <1
- ○○○○○ = 1 to <5
- ○○○○○ = 5 to <10
- ○○○○○ ○ = 10 to <20
- ○○○○● = ≥20 to <30
- ●●●●●● = ≥30

**Annualized return on investment**

- Negative: <0
- Low: ≥0% to <4%
- Medium: ≥4% to <8%
- High: ≥8%

**Co-benefits**

- ○ None
- ● Low
- ●● High
- ●●● Very high

<sup>a</sup> Other environmental benefits may also result, depending on local circumstances, such as the use and location of fossil fuel power plants and their impact on air quality. Equity considerations will depend on program design but can lead to further co-benefits.

<sup>b</sup> For residential plug loads involving dishwashers and clothes washers, water savings will also result.
Municipalities should be aware that more efficient lighting has indirect impacts on heating and cooling loads. Because inefficient bulbs produce more heat than efficient bulbs, changing to more efficient bulbs leads to increases in heating energy use in winter while also reducing cooling energy use in summer. In buildings with fossil fuel heating and low-carbon electricity, installing efficient bulbs can actually increase GHG emissions because the heating that was indirectly being provided by the light bulbs through low-carbon electricity is replaced by high-carbon gas or oil. In such cases, it still makes sense to implement this measure, but it is advisable to put the resulting cost savings toward other, more impactful GHG reduction measures, such as replacing gas or oil heating with heat pumps.

**Plug loads**

In residential buildings, the following measures can be taken to reduce plug load energy use:

- Appliances can be replaced with higher-efficiency versions, such as those certified by ENERGY STAR® (which must be 10 percent more efficient than the U.S. federal standard) or those that meet more stringent standards, such as the Consortium for Energy Efficiency (CEE) Tier 3 standard (which requires at least 20 percent better efficiency than the U.S. federal standard).vi

- Electronic devices can be replaced with more efficient ENERGY STAR® versions.vi

- Smart power strips can be used to automatically switch off unused electronic devices.

- Timers or motion sensors can be used to switch off unused lights.viii

In commercial and municipal buildings, the following measures can be taken to reduce plug load energy use:

- Timers or occupancy sensors can be installed to switch off unused devices outside of business hours.

- Smart power strips can be used to switch off unused equipment.ix

- Electronic devices such as computers, monitors and imaging equipment can be replaced by ENERGY STAR® certified versions.x

- Underused equipment, such as printers and photocopiers, can be replaced with multifunction equipment.xi
Is this solution right for my municipality?

To determine the potential GHG impact and economic feasibility of high-efficiency lighting and measures to reduce plug loads in buildings within your municipality, consider the following questions:

- **What is the carbon intensity of electricity?**
  GHG emissions reductions from improving lighting efficiency and reducing plug loads will depend on the carbon intensity of the grid. In municipalities with a low-carbon grid, lighting efficiency improvements in buildings heated with fossil fuels will actually lead to a slight increase in GHG emissions due to the interactive effects with heating systems. With cooler light bulbs, additional gas or oil is needed for heating, resulting in an increase in GHG emissions that outweighs the reductions achieved by reducing electricity use.

- **How high are electricity prices?**
  Improving lighting and plug load efficiency will be cost-effective throughout Canada, but electricity prices will determine just how cost-effective it is for the customer or business. Return on investment will be highest in municipalities where electricity prices are high.

What does it take to implement?

If this solution is appropriate for your municipality, you will need to develop an effective strategy to drive adoption. Here are some key actions and considerations:

- **Consider setting up incentive programs, or using existing ones.** You can provide incentive programs for residents and businesses, such as rebates (which can stand alone or top off those offered under existing programs), direct install programs, or energy savings kits for residential segments. The factsheet, *Incentive Programs*, provides more information on this strategy.

- **Lead by example by upgrading lighting and plug load efficiency within municipal facilities.** The factsheet, *Lead by Example*, offers more details on this strategy.

- **Increase community awareness and education.** While not explored in detail in this roadmap, you can increase community awareness and education by providing information about energy-efficient products. Your municipality can also play an environmental stewardship role by offering a safe disposal program for old, inefficient products that may otherwise pose environmental risks (e.g. fluorescent light bulbs that contain mercury, and old refrigerators that contain chlorofluorocarbons (CFCs) and polychlorinated biphenyl (PCBs)).
• Decide whether to focus on commercial or residential buildings, or both. At the national level, the commercial and residential sectors contribute equally to GHG emissions from plug loads. As a municipality, it’s best to focus efforts on whichever sector is most significant within your jurisdiction. As for lighting, federal regulation restricting the sale of residential incandescent and halogen light bulbs may come into play in Canada in the coming years. If this happens, homes will transition to using efficient light bulbs without the need for municipal (or other) action. However, an equivalent regulation has not been established or proposed for the types of bulbs that are generally used in commercial buildings, so there is a role for municipal action in improving commercial lighting efficiency. Improved lighting controls are also easier to implement in commercial buildings than in residential buildings.

• Determine how much stakeholder engagement is needed. Communication and user buy-in is a key driver of success for any plug load efficiency program. If homeowners and building users do not understand the importance of the program or don’t know how to use the new equipment, they may override controls or misuse the equipment and reduce the impact of the program.

What are the GHG and financial impacts?

The GHG reductions, costs and cost savings associated with improving lighting and plug load efficiency are dependent on many factors, including grid carbon intensity, local energy rates, and the amount of energy currently used on lighting and plug loads. This section calculates the impact of installing high-efficiency equipment in a typical office building and a typical house. The calculations are based on average data for each province and territory and do not include any incentives offered by provincial and territorial governments or utilities in the jurisdiction.

Commercial and municipal buildings

This section explores the impacts of improving lighting and plug load efficiency in a “typical” office building—assumed to have four floors with a total floor area of about 2,900 m² (31,200 ft²). The lighting analysis assumes that 830 fluorescent tubes in the office are replaced by LED tube bulbs, which have an expected useful life of 20 years. This is estimated to cost about $12,000 more than replacing burned out fluorescent tubes with new fluorescent tubes. LED tube bulbs last longer than fluorescent tubes, resulting in annual cost savings as the bulbs do not need to be changed as often (these savings are not quantified here).

The lighting upgrade results in annual reductions in lighting energy use of 54 percent, which corresponds to a 5.5 percent reduction in overall building energy use. However, the lighting upgrades lead to an increase in heating energy use in winter and a decrease in cooling requirements in summer. When these interactive effects are considered, the upgrade only results in a 4.5 percent reduction in overall building energy use. Table 1 shows the GHG reductions and cost savings associated with performing this upgrade in an electrically heated building.
Table 1: GHG and financial impacts of select lighting upgrades in a typical office building with electric heating.\textsuperscript{a, b}

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Fuel saved</th>
<th>GHG reductions (for a typical office) (tCO₂e/year)</th>
<th>Annualized return on investment (for building owner)</th>
<th>$/tCO₂e (for a typical office)\textsuperscript{c}</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Electricity</td>
<td>&lt;1.0</td>
<td>11%</td>
<td>–</td>
</tr>
<tr>
<td>AB</td>
<td>Electricity</td>
<td>31</td>
<td>10%</td>
<td>-135</td>
</tr>
<tr>
<td>SK</td>
<td>Electricity</td>
<td>28</td>
<td>12%</td>
<td>-210</td>
</tr>
<tr>
<td>MB</td>
<td>Electricity</td>
<td>&lt;1.0</td>
<td>9%</td>
<td>–</td>
</tr>
<tr>
<td>ON</td>
<td>Electricity</td>
<td>&lt;1.0</td>
<td>11%</td>
<td>–</td>
</tr>
<tr>
<td>QC</td>
<td>Electricity</td>
<td>&lt;1.0</td>
<td>10%</td>
<td>–</td>
</tr>
<tr>
<td>NB</td>
<td>Electricity</td>
<td>13</td>
<td>12%</td>
<td>-420</td>
</tr>
<tr>
<td>PE</td>
<td>Electricity</td>
<td>8.0</td>
<td>13%</td>
<td>-930</td>
</tr>
<tr>
<td>NS</td>
<td>Electricity</td>
<td>28</td>
<td>12%</td>
<td>-230</td>
</tr>
<tr>
<td>NL</td>
<td>Electricity</td>
<td>1.6</td>
<td>11%</td>
<td>–</td>
</tr>
<tr>
<td>YT</td>
<td>Electricity</td>
<td>2.2</td>
<td>11%</td>
<td>–</td>
</tr>
<tr>
<td>NT</td>
<td>Electricity</td>
<td>7.1</td>
<td>15%</td>
<td>-1,400</td>
</tr>
<tr>
<td>NU</td>
<td>Electricity</td>
<td>31</td>
<td>17%</td>
<td>-460</td>
</tr>
</tbody>
</table>

\textsuperscript{a} See Appendix A for more information on return on investment and dollar-per-tonne values.

\textsuperscript{b} The analysis assumes that 830 30W T8 fluorescent tubes are replaced with 12W LEDs rather than with new fluorescent tubes and that the original ballast is not changed. While lighting energy use may vary across provinces/territories, this analysis assumes an identical building with identical lighting needs across all provinces and territories.

\textsuperscript{c} “Cost per tonne of CO₂e abated (\$/tCO₂e)” indicates the carbon price required to make a given measure cost-effective. A negative cost-per-tonne value indicates that the measure saves money while also reducing emissions. Note that a more negative cost-per-tonne value isn’t necessarily more cost-effective. A blank cell (–) indicates that impacts were not calculated because the measure yields insignificant GHG reductions in this province/territory.
The plug load analysis assumes that a smart power strip is installed on 135 computers at a cost of roughly $6,000 and has an expected useful life of eight years. The selected upgrades result in annual reductions in plug load energy use of 10 percent. This corresponds to a 1.5 percent reduction in overall building energy use. Table 2 presents the GHG reductions and cost savings associated with these upgrades.

Table 2: GHG and financial impacts of select plug load upgrades in a typical office building\textsuperscript{a,b}

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Fuel saved</th>
<th>GHG reductions (for a typical office) (t\text{CO}_2\text{e/year})</th>
<th>Annualized return on investment (for building owner)</th>
<th>$/t\text{CO}_2\text{e} (for a typical office)\textsuperscript{c}</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Electricity</td>
<td>&lt;1.0</td>
<td>9%</td>
<td>–</td>
</tr>
<tr>
<td>AB</td>
<td>Electricity</td>
<td>9.9</td>
<td>8%</td>
<td>-57</td>
</tr>
<tr>
<td>SK</td>
<td>Electricity</td>
<td>8.7</td>
<td>12%</td>
<td>-110</td>
</tr>
<tr>
<td>MB</td>
<td>Electricity</td>
<td>&lt;1.0</td>
<td>6%</td>
<td>–</td>
</tr>
<tr>
<td>ON</td>
<td>Electricity</td>
<td>&lt;1.0</td>
<td>9%</td>
<td>–</td>
</tr>
<tr>
<td>QC</td>
<td>Electricity</td>
<td>&lt;1.0</td>
<td>7%</td>
<td>–</td>
</tr>
<tr>
<td>NB</td>
<td>Electricity</td>
<td>4.1</td>
<td>11%</td>
<td>-220</td>
</tr>
<tr>
<td>PE</td>
<td>Electricity</td>
<td>2.5</td>
<td>15%</td>
<td>–</td>
</tr>
<tr>
<td>NS</td>
<td>Electricity</td>
<td>8.9</td>
<td>13%</td>
<td>-130</td>
</tr>
<tr>
<td>NL</td>
<td>Electricity</td>
<td>&lt;1.0</td>
<td>9%</td>
<td>–</td>
</tr>
<tr>
<td>YT</td>
<td>Electricity</td>
<td>&lt;1.0</td>
<td>10%</td>
<td>–</td>
</tr>
<tr>
<td>NT</td>
<td>Electricity</td>
<td>2.2</td>
<td>19%</td>
<td>–</td>
</tr>
<tr>
<td>NU</td>
<td>Electricity</td>
<td>9.7</td>
<td>24%</td>
<td>-350</td>
</tr>
</tbody>
</table>

\textsuperscript{a} See Appendix A for more information on return on investment and dollar-per-tonne values.

\textsuperscript{b} The analysis assumes that a smart power strip is installed on 135 computers. While computer energy use in offices may vary across provinces/territories, this analysis assumes an identical building with identical plug load profiles across all provinces and territories.

\textsuperscript{c} “Cost per tonne of \(\text{CO}_2\text{e}\) abated (\$/t\text{CO}_2\text{e})” indicates the carbon price required to make a given measure cost-effective. A negative cost-per-tonne value indicates that the measure saves money while also reducing emissions. Note that a more negative cost-per-tonne value isn’t necessarily more cost-effective. A blank cell (–) indicates that impacts were not calculated because the measure yields insignificant GHG reductions in this province/territory.
Both types of measure—lighting efficiency upgrades and measures to reduce plug load energy use—will only yield significant GHG reductions in provinces and territories with high-carbon grids. Lighting efficiency upgrades actually increase GHG emissions in buildings heated with fossil fuels, in provinces and territories with low-carbon grids, due to the interactive effects with the heating systems.

These improvements are typically very cost-effective—as indicated by the negative dollar-per-tonne values, which signify that the upgrades save money while also reducing GHG emissions in locations that have carbon-intensive grids—so they represent an easy first step in a larger plan to reduce emissions in commercial and municipal office buildings.

Residential buildings
As described above, this factsheet does not assess the impacts of improving lighting efficiency in residential buildings, because federal regulations are expected soon that would restrict the use of less efficient lighting such as residential incandescent and halogen light bulbs. This section focuses on the impacts of improving plug load efficiency in a “typical” home—assumed to have two floors with a total floor area of about 140 m² (1,500 ft²) in which all the appliances, and the water heating system, are electric. The analysis assumes that the refrigerator, freezer, clothes dryer, clothes washer and dishwasher are upgraded to ENERGY STAR® certified models,xvi and that one advanced smart strip is installed. Altogether, installing a smart power strip and replacing all appliances with ENERGY STAR® certified models would cost about $150 more than just replacing all appliances with standard models.xvii, xviii

This measure has an expected useful life of 10–15 years.

These select efficiency improvements are estimated to result in an annual reduction of plug load energy use of nine per cent.xix Table 3 presents the associated GHG reductions and cost savings by province/territory.xx If more stringent standards (i.e. CEE Tier 3 rather than ENERGY STAR®) were used for the appliance replacements, realized energy savings would almost double, yielding greater GHG emissions reductions than those presented here—although the incremental cost of using a more stringent standard would also be higher. Additional energy savings could also be achieved by replacing electronic devices with ENERGY STAR® certified options.
Table 3: GHG and financial impacts of select plug load upgrades in a typical home$^{a, b}$

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Fuel saved</th>
<th>GHG reductions (for a typical home) (tCO$_2$e/year)</th>
<th>Annualized return on investment (for homeowner)</th>
<th>$/tCO$_2$e (for a typical home)$^c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Electricity</td>
<td>&lt;0.01</td>
<td>10%</td>
<td>–</td>
</tr>
<tr>
<td>AB</td>
<td>Electricity</td>
<td>0.27</td>
<td>10%</td>
<td>-88</td>
</tr>
<tr>
<td>SK</td>
<td>Electricity</td>
<td>0.24</td>
<td>14%</td>
<td>-180</td>
</tr>
<tr>
<td>MB</td>
<td>Electricity</td>
<td>&lt;0.01</td>
<td>8%</td>
<td>–</td>
</tr>
<tr>
<td>ON</td>
<td>Electricity</td>
<td>&lt;0.01</td>
<td>11%</td>
<td>–</td>
</tr>
<tr>
<td>QC</td>
<td>Electricity</td>
<td>&lt;0.01</td>
<td>6%</td>
<td>–</td>
</tr>
<tr>
<td>NB</td>
<td>Electricity</td>
<td>0.11</td>
<td>11%</td>
<td>–</td>
</tr>
<tr>
<td>PE</td>
<td>Electricity</td>
<td>0.07</td>
<td>14%</td>
<td>–</td>
</tr>
<tr>
<td>NS</td>
<td>Electricity</td>
<td>0.24</td>
<td>14%</td>
<td>-180</td>
</tr>
<tr>
<td>NL</td>
<td>Electricity</td>
<td>0.01</td>
<td>11%</td>
<td>–</td>
</tr>
<tr>
<td>YT</td>
<td>Electricity</td>
<td>0.02</td>
<td>11%</td>
<td>–</td>
</tr>
<tr>
<td>NT</td>
<td>Electricity</td>
<td>0.06</td>
<td>20%</td>
<td>–</td>
</tr>
<tr>
<td>NU</td>
<td>Electricity</td>
<td>0.26</td>
<td>21%</td>
<td>-380</td>
</tr>
</tbody>
</table>

$^a$ See Appendix A for more information on return on investment and dollar-per-tonne values.

$^b$ The analysis assumes that the clothes washer, clothes dryer, freezer, fridge and dishwasher are replaced with ENERGY STAR® certified appliances rather than standard appliances when old appliances reach their end of life, and that an advanced smart strip is installed on a computer or home entertainment system. While the energy use of appliances and electronic devices may vary across provinces/territories, this analysis assumes an identical home with identical appliances across all provinces and territories.

$^c$ “Cost per tonne of CO$_2$e abated ($/tCO$_2$e)” indicates the carbon price required to make a given measure cost-effective. A negative cost-per-tonne value indicates that the measure saves money while also reducing emissions. Note that a more negative cost-per-tonne value isn't necessarily more cost-effective. A blank cell (–) indicates that impacts were not calculated because the measure yields insignificant GHG reductions in this province/territory.
As with commercial and municipal buildings, the select upgrades in residential buildings only yield GHG reductions in provinces and territories with high-carbon grids, and even then, the emissions reductions are somewhat limited. Returns on investment are high for all provinces and territories, however, and barriers to adoption are low, so this may be an easy first step in a larger plan to reduce emissions in residential buildings. The electricity saved by these improvements in areas with low-carbon grids can be used to power other needs, which will be important as municipalities move toward the electrification of heating and transport.

To understand which upgrades contribute most to the estimated GHG emissions reductions presented in the example above, see Figure 1, which shows how much each appliance contributes.

**Figure 1:** Relative GHG reduction impact of select plug load measures in a typical home

<table>
<thead>
<tr>
<th>Appliance</th>
<th>GHG Reduction Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dishwasher</td>
<td>5%</td>
</tr>
<tr>
<td>Freezer</td>
<td>10%</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>18%</td>
</tr>
<tr>
<td>Clothes washer</td>
<td>29%</td>
</tr>
<tr>
<td>Clothes dryer</td>
<td>21%</td>
</tr>
<tr>
<td>Advanced power strip</td>
<td>17%</td>
</tr>
</tbody>
</table>

What are the potential co-benefits?

In addition to potential GHG reductions and cost savings, improving lighting and plug load efficiency has the potential for a number of co-benefits.

- **Environment**
  - Some appliance upgrades also yield water savings (i.e. clothes washers and dishwashers).
  - Using LED bulbs avoids the risk of mercury contamination, which is a concern for CFLs at their product end of life.

- **Health and comfort**
  - Lighting upgrades reduce cooling loads and building overheating by reducing heat emitted from inefficient lights, particularly if incandescent bulbs are replaced.
  - Increased user satisfaction results from LED instant-on technology (i.e. no lag time in reaching full brightness).
• Other
  • LED bulbs last two to four times longer than a CFL, and about 15 times longer than a standard incandescent bulb, resulting in cost savings.
  • Lighting upgrades can improve employee productivity.xxii

What is the current and projected state of the market?

Current state of the market
  • The market penetration of LEDs has grown very rapidly in recent years. Global penetration was estimated at one percent in 2011 and is expected to be 61 percent in 2020.xxiii In Ontario, 42 percent of light bulbs in single-family homes were estimated to be LEDs in 2018.xxiv
  • Home appliances have significantly improved in the last 25 years and there is a significant uptake of new efficient appliances. In 2016, 27 percent of electric clothes dryers, 63 percent of fridges, 65 percent of clothes washers and 96 percent of dishwashers that were shipped to Canada were ENERGY STAR® qualified.xxv

Projections for the future
  • National energy-efficiency codes are soon expected to restrict the use of inefficient light bulbs in the residential sector.xxvi
  • Commercial plug loads are forecast to become an increasingly large proportion of commercial building energy consumption, as the use of electronic devices and the need for computing power are growing rapidly. According to the U.S Department of Energy, by 2030, plug load energy consumption in U.S. commercial buildings will have grown at more than twice the rate of overall commercial building energy consumptionxxvii—with a similar trend likely in Canada. Ensuring plug load efficiency will therefore be an important part of limiting building energy consumption and GHG emissions.

What have municipalities done?

Municipalities leading by example

City of Mississauga: Lighting retrofits and conversion of streetlights to LEDs
The City of Mississauga, ON, carried out lighting retrofits at a variety of city-owned facilities, including tennis clubs, community centers and ice rinks. The city also converted its streetlights to LEDs. The interior lighting retrofits alone resulted in annual cost savings of about $189,000. Altogether, the retrofits reduced GHG emissions by about 130 tonnes.
High-efficiency lighting and reduced plug loads

Incentive programs

**Municipality of Banff: Residential Environmental Rebates**
The Municipality of Banff, AB, offers residents a rebate of $100 on ENERGY STAR® certified dishwashers. The municipality also offers residents a rebate of up to $100 on qualified energy-efficient refrigerators (which are at least 20 percent more efficient than the federal minimum efficiency standard and at least 10 percent more efficient than the ENERGY STAR® standard).

**Municipality of Brazeau County: Municipal Energy Efficiency Rebate Program**
The Municipality of Brazeau County, AB, offered a rebate of 25 percent off the purchase price of LED light bulbs as part of a pilot program from April 2018 to April 2019.

**City of Medicine Hat: ENERGY STAR® Clothes Dryer Incentive Program**
The City of Medicine Hat, AB, offers residents a rebate of $75 on ENERGY STAR® certified clothes dryers.

What resources can support next steps?

**Lighting**

“Light bulb guide: LED vs. CFL vs. Halogen,” tom’s guide, 2019
This web page provides a succinct explanation of different light bulb technologies, and includes information on product costs and life spans.

This technical guide on lighting energy efficiency provides background information on lighting technologies and includes sample projects with calculations of costs and savings.

**Plug loads**

This resource is designed to help building owners find the right strategy for reducing plug loads in their buildings. It includes specific guidance for buildings used in different sectors, including education, healthcare, office and public assembly buildings.

This “quick start guide” aims to help building owners and energy managers reduce plug and process load energy use in their facilities. It provides an overview of plug and process loads in office buildings and describes a step-by-step process and strategies for cost-effectively reducing the energy impact.

*Standby power: When “off” means on*, Natural Resources Canada, 2014
This guide explains the issue of standby power consumption and discusses ways to reduce standby power use in homes.
Endnotes

i Natural Resources Canada, Comprehensive Energy Use Database, Commercial/Institutional Sector, Table 4; Residential Sector, Table 2 (2016 data).

ii Ibid.

iii Natural Resources Canada, “Light bulbs or lamps.”


vi Natural Resources Canada, “Appliances for residential use.”

vii Natural Resources Canada, “Electronics,” 2019


ix New Buildings Institute, Managing Your Office Equipment Plug Load.


xii Natural Resources Canada, “Forward Regulatory Plan 2019–2021.”

xiii New Buildings Institute, Managing Your Office Equipment Plug Load.

xiv For the purposes of this analysis, a “typical” office building includes both municipal and commercial office buildings.

xv For buildings that are not electrically heated, GHG reductions will vary from those shown here. In low-carbon grid municipalities, this measure will actually increase GHG emissions if implemented in buildings heated with oil or gas; in high-carbon grid municipalities, this measure will lead to slightly greater GHG reductions than those shown in Table 1 if implemented in buildings heated with oil or gas.

xvi Note that this doesn’t include cooking appliances because there is no ENERGY STAR® specification for cooking appliances. Modern cooking appliances are about as energy efficient as current technology allows, and there is insufficient difference between available models to justify an ENERGY STAR® specification (Natural Resources Canada, 2019).

xvii ENERGY STAR® certified appliances tend to cost either the same as standard models or up to $75 more (according to Natural Resources Canada’s ENERGY STAR® Simple Savings Calculator).


xx In assessing the GHG emissions and costs associated with clothes washers, this analysis assumes that all baseline water heating is powered by electricity. For municipalities with low-carbon grids, where a large proportion of water heating is actually powered by gas or fuel oil, the GHG reductions in Table 3 are underestimates because the calculations assume electric water heating. For those that have a similar water heating profile and are located in areas with high-carbon grids, the GHG reductions shown here represent overestimates.

xxi Efficient clothes washers reduce energy use by spinning clothes faster to reduce drying requirements and by better controlling water levels and temperature. Efficient clothes dryers use less energy by shutting the dryer off as soon as clothes are dry and drying clothes for longer at a lower temperature. Efficient freezers and fridges are better insulated and have more efficient compressors, allowing them to consume less energy. Efficient dishwashers use sensors to assess how clean dishes are and to adjust the cycle accordingly. They also better filter out food soils from the wash water to allow efficient use of detergent and water, and they use more efficient jets to spray water over dishes.


xxiii Statista, “Estimated LED penetration of the global lighting market from 2010 to 2020.”


xxv Natural Resources Canada, National Energy Use Database, Energy Consumption of Major Households Appliances Shipped in Canada, 1990–2016—Data Tables, Table 1, 2016.


Building-level solution

Rooftop solar PV

What is rooftop solar PV?

A rooftop solar photovoltaic (PV) system consists of electricity-generating solar panels mounted on the rooftop of a residential or commercial building or structure. Declining PV costs and rising utility rates have increased the attractiveness of building-sited rooftop solar systems across all sectors (residential, commercial and municipal, as well as institutional, which includes universities, schools and hospitals). Solar PV systems are primarily used to reduce utility bills by offsetting the building’s own electricity consumption. These systems can also be paired with battery storage to provide a number of additional benefits.

It should be noted that, while solar PV systems do not represent a key greenhouse gas (GHG) reduction opportunity in provinces and territories with low-carbon electricity grids, they can serve an important role in addressing demand for clean electricity. This could be key to meeting rapidly growing demand for electricity in the future, as communities move to the electrification of transportation and heating.

<table>
<thead>
<tr>
<th>Carbon intensity of electricity grid</th>
<th>Fuel</th>
<th>Residential (= 5 kW)</th>
<th>Commercial and municipal (= 60 kW)</th>
<th>Co-benefits²</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Electricity</td>
<td>00000</td>
<td>00000</td>
<td>00000</td>
<td>✔️ Lead by example, ✔️ Incentive programs, ✔️ Financing options, ✔️ Local policies and bylaws</td>
</tr>
<tr>
<td>Moderate</td>
<td>Electricity</td>
<td>00000</td>
<td>00000</td>
<td>00000</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Electricity</td>
<td>00000</td>
<td>00000</td>
<td>00000</td>
<td></td>
</tr>
</tbody>
</table>

GHG reduction (kgCO₂e/m²/year)

- 0 = <1
- 1 = 1 to <5
- 2 = 5 to <10
- 3 = 10 to <20
- 4 = 20 to <30
- 5 = ≥30

Annualized return on investment

- Negative: <0
- Low: ≥0% to <4%
- Medium: ≥4% to <8%
- High: ≥8%

- None
- Low
- High
- Very high

Other environmental benefits may also result, depending on local circumstances, such as the use and location of fossil fuel power plants and their impact on air quality. Equity considerations will depend on program design but can lead to further co-benefits.
How does this solution work and why is it important?

Solar photovoltaic (PV) systems have emerged as an increasingly popular technology over the past two decades, mostly driven by significant cost reductions and technology advancements. Rooftop solar systems can be designed to operate as grid-tied assets or off-grid, and can be paired with battery storage for increased self-supply, resiliency and peak shaving (i.e. reducing energy consumption during peak demand). For more information on this, see the text box, “Storage-paired solar PV.” Since peak energy consumption and peak solar production do not always coincide, customers usually export excess energy to the grid and receive compensation for the produced energy through an enabling policy such as net energy metering (NEM).

This factsheet focuses on building-sited rooftop solar for residential, commercial and municipal buildings, with some consideration also given to institutional buildings. This form of local renewable electricity generation offers increased energy security (by reducing reliance on fuel and imported electricity), enhanced energy resilience (by providing an off-grid or backup energy solution), and opportunities for local job creation. Moreover, the technology is becoming increasingly competitive: capital costs have declined significantly and are projected to decline further over the coming years. In several jurisdictions and market sectors, solar PV is already cost-competitive with the grid.

Need funding for your energy project? Contact FCM!

Access grants and loans for energy-efficiency and clean energy solutions that support service delivery in your community.

- Improve efficiency and reduce GHG emissions in municipal and community buildings
- Integrate renewable energy generation solutions
- Plan, refine and scale-up innovative financing programs for residential retrofits

Learn more!
Storage-paired solar PV

With the increased penetration of renewable energy, significant technological improvements, and cost reductions over the past few years, battery storage technologies have emerged as critical components of a modern, secure, reliable and low-carbon grid. Batteries have several distinct features that make them a unique resource:

- **Scalability:** Battery systems can be as small or large as desired and can be sited behind the meter (i.e. customer-sited) or at the transmission and distribution levels.

- **Versatility:** Battery storage can provide a range of services to utilities, system operators and customers, such as reducing peak capacity requirements, allowing for energy arbitrage, providing grid ancillary services, reducing building energy demand during peak periods, reducing bills, and increasing resiliency during outages.

- **Stackable value:** Battery systems are designed to provide multiple, stacked services to optimize value and financial returns. For example, the primary service may be solar self-consumption, but secondary services may include time-of-use optimization and resource adequacy (i.e. adequate capacity to meet fluctuating grid demands).

Solar-plus-storage solutions can offer the following key benefits:

- enhanced resiliency during outages
- increased self-consumption of produced electricity and minimized exports to the grid
- reduced peak demand costs
- optimized electricity purchases and exports under time-of-use rates

Battery costs vary significantly based on technical characteristics (such as power output and energy capacity). The estimated cost is $1,500–2,500 per kW of power installed ($500–750 per kWh of energy consumed). It should be noted that the simultaneous installation of a new solar PV system and battery storage can result in a 10 percent cost savings compared to adding battery storage to existing rooftop systems, because everything can be installed more efficiently.

Recent surveys from the U.S. show that almost 75 percent of those shopping for solar PV systems are already interested in battery storage. Looking to the future, an increasing share of solar uptake is expected to be storage-paired, as customer interest in self-supply continues to increase, battery costs continue to decline, and more jurisdictions implement changes to their electricity compensation mechanisms or rate structures (e.g. adopting net-billing, time-of-use rates or demand charges).
Is this solution right for my municipality?

To determine the potential GHG impact and economic feasibility of rooftop solar PV for buildings within your municipality, consider the following questions:

- **What is the carbon intensity of the electricity grid?** The GHG emissions reductions achieved by using solar energy are dependent on the carbon intensity of the displaced electricity. In areas with low-carbon grids, switching to solar PV will reduce emissions less than in areas with high-carbon grids. Additionally, the coincidence between solar production and your municipality’s peak load could impact the associated GHG reductions, since utilities often rely on carbon-intensive power plants during peak load hours. This means that for “summer-peaking” municipalities, where the highest power demand occurs during the day when solar production is greatest, reliance on carbon-intensive power plants can be reduced if not eliminated.

- **Is there a need to ensure adequate clean electricity supply to support future electrification?** While switching to rooftop solar may not significantly reduce GHG emissions in municipalities with low-carbon electricity grids in the near term, these systems may play a critical role in ensuring adequate clean electricity supply as municipalities prepare to electrify heating and transportation. Moreover, rooftop solar allows clean electricity to be generated locally, keeping energy dollars in the community.

**Figure 1:** Solar potential across Canada ([energyhub.org](https://energyhub.org), 2019)
• **How significant is your municipality's solar potential?** Solar insolation varies significantly across Canada’s geography, with municipalities along the southern border in the Prairie region having the highest solar potential. An average solar system in Canada would produce about 1,150 kWh of electricity per kW of PV installed, with a range of 950-1,400 kWh per kW, depending on geography. Despite a lower solar potential having a negative impact on system economics, there may still be a business case for solar in jurisdictions with low insolation, depending on other technical and financial factors.

• **Is there a business case?** The business case for rooftop solar in your municipality will depend primarily on utility rates and system costs. The main drivers that make these systems economical are the avoided electricity purchases from the utility/grid and reduced operation and maintenance costs. The higher the electricity rates are in your jurisdiction, the greater the savings are when switching to solar. Utility rate structures, such as time-of-use pricing and demand charges—where customers are charged different rates for electricity consumption during defined peak and off-peak periods—can further tilt the scale in favour of solar. Of course, system costs must also be factored in. The cost of a solar PV system can vary by jurisdiction, based on market competitiveness and local soft costs (such as labour and permitting). System costs are often presented in “dollars per watt,” which captures the full installed unit cost of a system, including PV panels, auxiliary equipment, installation and other costs. Additional factors that influence the business case include the existence of incentives offered by government or utility players. For more information on the business case, see “What are the GHG and financial impacts?” below.

• **Are the right enabling policies in place?** A key enabling policy for rooftop solar, which also affects the technology’s cost-effectiveness, is the compensation mechanism by which grid exports are valued, as set by the local energy regulator, utility or provincial/territorial government. Compensation mechanisms include net-metering, net-billing and feed-in tariffs. Under a net-metering arrangement, customers usually get full retail credit for energy exported, whereas under net-billing, customers are only paid the energy portion of their retail rate (i.e. excluding transmission and distribution charges). Net-metering is the most popular mechanism used in Canada, with Alberta being the only province to have a net-billing arrangement. Feed-in tariffs provide a fixed value for every unit of energy provided to the grid (e.g. Ontario’s former micro-FIT and FIT programs).
• **Is the local building stock suitable?**

Several factors determine a building’s suitability for PV deployment, including roof area, tilt, azimuth, age, material and shading. Suitability criteria and ideal conditions differ by location. In general, however, flat or sloped shade-free roofs with access to south-facing orientation and at least 10 m² of appropriate space are suitable for PV deployment. PV systems with a tilt of less than 60 degrees are generally suitable. A detailed geospatial analysis is required to determine building suitability accurately—for which tools are increasingly becoming available. See, for example, [Nova Scotia’s SolarAssist tool](https://www.solarassist.ns.ca) and Google’s [Environmental Insights Explorer](https://directory.google.com). As a general rule of thumb, about 80 percent of buildings in a given jurisdiction are suitable for solar. It should be noted that there may be challenges with retrofitting older building stock with solar systems, due to roof conditions and required electrical and structural upgrades. Timing installation of PV systems shortly after roof replacement may help address some of these issues. Other factors to consider include insurance options, sizing of the system, and emergency shutdown procedures for large systems.

---

**Solar third-party ownership**

Third-party ownership (TPO) models have been a key tool in increasing the uptake of rooftop solar PV in the United States and increasingly in Canada. In the early years of solar uptake in the U.S., TPO models accounted for as much as 72 percent of residential systems installed. Under TPO models, homeowners and businesses gain the benefits of having a solar system installed on their roof, without purchasing or paying upfront for the system. TPO customers pay recurring monthly fees, through either a solar lease model (where the customer pays a pre-determined amount for the lease of the installed equipment) or a Power Purchase Agreement (where the customer pays a “dollar per kWh” rate for the electricity produced from the system). In both cases, the third party maintains ownership of the system for the duration of the lease agreement, while the customer benefits from the bill savings associated with the installed solar system.

You can explore the availability of TPO models in your area, and whether these can be leveraged to promote rooftop solar on municipal buildings or in the broader community. This financing option is unique to the solar rooftop market, so it is not addressed in the [Financing Options](https://www.greenmunicipalfund.org) factsheet.
What does it take to implement?

If this solution is appropriate for your municipality, you will need an effective strategy to drive adoption. Consider the following actions:

- **Decide which market segments to address.**
  - **Residential:** Most existing programs target single-family residential buildings as this is an easier segment to tackle compared to multi-unit residential buildings (MURBs). While MURBs also represent an opportunity for rooftop solar, they must be approached differently, since no single apartment dweller owns the rooftop. Solar PV systems in MURBs can either be designed to meet the energy demand of common areas owned by a co-op board or other similar entity, or they can be approached as a community energy project that is owned by multiple apartment dwellers and used to offset a portion of their own electricity consumption. In new construction, homes can be built “PV-ready” by following Natural Resources Canada’s Photovoltaic Ready Guidelines. These guidelines describe some simple, low-cost upgrades to make new homes ready for large-array PV systems (i.e. for net-zero energy ready homes). For smaller-array systems, builders can reference Natural Resources Canada’s Solar Ready Guidelines. Your municipality may consider requiring new homes to be built solar-ready or PV-ready. Several jurisdictions have already done this for solar hot water systems.

- **Commercial and institutional:** Large commercial and institutional customers that adopt solar may gain an additional benefit in the potential reduction in peak demand costs. Buildings with load profiles that correspond with solar production are more financially attractive for PV solutions. Generally, mainstream commercial customers require short paybacks (e.g. around five years) to consider solar adoption; however, payback periods are still longer in most jurisdictions. Conversely, municipalities and institutions generally accept much longer payback times and may be good initial targets for this technology. This is especially true for the education sector, where solar PV systems can provide excellent learning opportunities for students and the general public.

- **Identify existing incentive programs that could be leveraged.** Several provinces and territories across Canada offer incentives for solar installations in the residential, commercial, institutional or other sectors, including Alberta, Nova Scotia and Prince Edward Island. Incentives are usually in the form of a rebate to cover a portion of upfront system costs and are usually provided in dollars per watt of energy-generating capacity, along with a maximum dollar amount or percentage of costs. For example, Energy Efficiency Alberta provided homeowners with a $0.90/W rebate up to a maximum of $10,000 or 35 percent of system eligible costs. Municipalities can offer additional incentives to further move the market.
What are the GHG and financial impacts?

The GHG reductions, costs and cost savings associated with rooftop solar are highly dependent on many factors, including a municipality’s solar potential, grid carbon intensity and energy rates.

PV system costs have declined significantly over the past decade, primarily due to reduced manufacturing costs. In 2018, average system costs for distributed solar PV systems in Canada (1 kW – 1 MW installed capacity) ranged from roughly $2.00 to $3.50 per nominal watt installed. An average solar system for a single-family home usually has a capacity of around 7 kW ($14,000–24,500). For a small business, the average capacity of a solar system is around 15 kW ($30,000–52,500). As with most technologies, the larger a system, the lower the unit cost. System costs also vary by jurisdiction as a result of market competitiveness and local soft costs (such as labour and permitting). Compared to other energy generation technologies, solar PV has minimal operation and maintenance costs.

Two factors related to utility rates also impact solar economics: electricity costs and rate structures. Higher electricity costs mean that the avoided electricity purchases from the utility/grid yield greater savings—a better business case for solar. However, solar can only help customers avoid the variable portion of their bills (i.e. consumption-based charges, not transmission and distribution charges, which can vary widely). The second factor that influences solar economics is time-of-use pricing and demand charges, which make rooftop solar comparatively cost-effective. For example, some jurisdictions (e.g. Ontario) charge different rates for consumption during defined peak and off-peak hours. Depending on the exact timing and duration of peak hours, using solar during peak hours could allow customers to save money by avoiding energy from the grid.

The GHG and financial impacts associated with rooftop solar are illustrated in the example below. The benefits of a solar installation on a typical office building and a typical house are calculated based on provincial/territorial average data and do not assume any incentives are in place. A fixed rate for electricity is also assumed, regardless of time of day.

Commercial and municipal buildings

This section explores the impacts of a 60 kW rooftop solar system in a “typical” office building—assumed to have a roof space of 750 m² (8,000 ft²). Based on current prices, this system is estimated to cost between $120,000 and $210,000, with an annual maintenance cost of $1,200 and an expected useful life of 30 years. Table 1 presents the GHG and financial impacts associated with this system. The calculations assume an average price of $2.30/W and an average annual generation of 1,125 kWh per kW installed (though both price and annual energy generation are tailored by province/territory).
### Table 1: GHG and financial impacts of installing a 60 kW rooftop solar PV system on a typical office building\(^a,b\)

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Fuel saved</th>
<th>GHG reductions (for a typical office) (tCO(_2)e/year)</th>
<th>Annualized return on investment (for building owner)(^c)</th>
<th>$/tCO(_2)e (for a typical office)(^d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Electricity</td>
<td>&lt;1.0</td>
<td>1%</td>
<td>–</td>
</tr>
<tr>
<td>AB</td>
<td>Electricity</td>
<td>57</td>
<td>1%</td>
<td>7</td>
</tr>
<tr>
<td>SK</td>
<td>Electricity</td>
<td>53</td>
<td>2%</td>
<td>-43</td>
</tr>
<tr>
<td>MB</td>
<td>Electricity</td>
<td>&lt;1.0</td>
<td>0%</td>
<td>–</td>
</tr>
<tr>
<td>ON</td>
<td>Electricity</td>
<td>1.3</td>
<td>2%</td>
<td>-740</td>
</tr>
<tr>
<td>QC</td>
<td>Electricity</td>
<td>&lt;1.0</td>
<td>1%</td>
<td>–</td>
</tr>
<tr>
<td>NB</td>
<td>Electricity</td>
<td>21</td>
<td>1%</td>
<td>-20</td>
</tr>
<tr>
<td>PE</td>
<td>Electricity</td>
<td>13</td>
<td>3%</td>
<td>–</td>
</tr>
<tr>
<td>NS</td>
<td>Electricity</td>
<td>44</td>
<td>2%</td>
<td>-50</td>
</tr>
<tr>
<td>NL</td>
<td>Electricity</td>
<td>2.1</td>
<td>-1%</td>
<td>–</td>
</tr>
<tr>
<td>YT</td>
<td>Electricity</td>
<td>3.1</td>
<td>1%</td>
<td>–</td>
</tr>
<tr>
<td>NT</td>
<td>Electricity</td>
<td>11</td>
<td>4%</td>
<td>-800</td>
</tr>
<tr>
<td>NU</td>
<td>Electricity</td>
<td>48</td>
<td>4%</td>
<td>-270</td>
</tr>
</tbody>
</table>

\(^a\) See Appendix A for more information on return on investment and dollar-per-tonne values.

\(^b\) Actual GHG impacts and return on investment will vary based on the orientation and exposure of the roof and the electricity rate structure that is in place. Return on investment and $/tCO\(_2\)e figures will also be more favourable if incentives are offered by provincial/territorial governments, utilities or other entities.

\(^c\) Returns are based on current prices and 30 years of PV operation, but may become much more favourable as solar PV prices fall.

\(^d\) “Cost per tonne of CO\(_2\)e abated ($/tCO\(_2\)e)” that indicates the carbon price required to make a given measure cost-effective. A negative cost-per-tonne value indicates that the measure saves money while also reducing emissions. Note that a more negative cost-per-tonne value isn’t necessarily more cost-effective. A blank cell (–) indicates that impacts were not calculated because the measure yields insignificant GHG reductions in this province/territory.
Installing rooftop solar PV in commercial and municipal office buildings yields significant GHG emissions reductions in provinces and territories with high-carbon grids. While these measures do not reduce GHG emissions significantly in provinces with low-carbon grids, they can generate clean electricity, which may be needed to help satisfy a rapidly growing load in future, as communities move to the electrification of transportation and heating.

In terms of financial impacts, this measure only yields low or negative returns across Canada. That said, returns are likely to increase over the next 5–10 years, as solar PV prices fall and electricity prices rise. If incentives are in place, the economics will be much more favourable.

### Residential buildings

This section explores the impacts of a 5 kW rooftop solar system on a “typical” home—assumed to have panels covering a roof space of 100 m² (1,000 ft²). Based on current prices, this system is estimated to cost between $12,500 and $20,000 (depending on the province or territory), with an annual maintenance cost of $100. It has an expected useful life of 30 years. Table 2 presents the GHG and financial impacts of installing this system.

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>GHG reductions (for a typical home) (tCO₂e/year)</th>
<th>Annualized return on investment (for homeowner)</th>
<th>$/tCO₂e (for a typical home)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>0.05</td>
<td>0%</td>
<td>-</td>
</tr>
<tr>
<td>AB</td>
<td>4.7</td>
<td>0%</td>
<td>40</td>
</tr>
<tr>
<td>SK</td>
<td>4.4</td>
<td>2%</td>
<td>-48</td>
</tr>
<tr>
<td>MB</td>
<td>0.01</td>
<td>0%</td>
<td>-</td>
</tr>
<tr>
<td>ON</td>
<td>0.11</td>
<td>1%</td>
<td>610</td>
</tr>
<tr>
<td>QC</td>
<td>&lt;0.01</td>
<td>-1%</td>
<td>-</td>
</tr>
<tr>
<td>NB</td>
<td>1.8</td>
<td>0%</td>
<td>150</td>
</tr>
<tr>
<td>PE</td>
<td>1.0</td>
<td>1%</td>
<td>-</td>
</tr>
<tr>
<td>NS</td>
<td>3.6</td>
<td>1%</td>
<td>-18</td>
</tr>
</tbody>
</table>
Municipalities in Alberta and Saskatchewan have the greatest potential for GHG reductions from solar, because of the high solar potential and high carbon grid intensity. Municipalities with low solar potential and high-carbon grids, such as those in Nova Scotia and Nunavut, also have strong potential for GHG reductions from solar. Conversely, municipalities with moderate solar potential but low-carbon grids, such as those in Manitoba and Quebec, would realize minimal to no GHG reductions. Nonetheless, rooftop solar can increase renewable energy capacity to support the increased load associated with the electrification of heating systems and transport across Canada, which will be important for clean grid municipalities moving forward.

As noted above, there is general agreement that further cost reductions are expected over the next decade. With the declining costs of solar PV systems and increasing utility rates, the financial benefits of solar will increase significantly over the same time frame.
What are the potential co-benefits?

In addition to potential GHG benefits and energy bill savings, rooftop solar brings several co-benefits to its customers and communities.

- **Jobs**
  - Jobs are created in the construction and operation and maintenance of solar systems. Studies estimate 15 and 20 full-time-equivalent jobs (FTEs) per MW installed for commercial and residential solar systems, respectively—compared to less than two FTEs per MW installed for natural gas plants.\(^\text{viii}\)

- **Resilience**
  - While the amount of electricity production from solar PV is variable, solar paired with storage can serve as a valuable backup resource that increases the resiliency of power systems by potentially islanding and operating independently from the grid during power outages and severe events.

- **Other**
  - **Grid assets:** Storage-paired solar systems and advanced power electronics can serve as unique resources to the utility and the grid, by providing grid ancillary services, reducing capacity requirements and offering multiple additional value-streams.
  - **Property value:** Studies from the U.S. have shown that solar panels are viewed as value-added upgrades. Homes with rooftop solar showed an average increase of $15,000 in home value.\(^\text{ix}\)

What is the current and projected state of the market?

**Current state of the market**

With about 3 GW installed, Canada has an established solar market. Program support and marketing efforts have increased customer awareness of the technology. While the majority of installed distributed solar capacity today is found in Ontario, policy support for solar in Alberta, Saskatchewan, Nova Scotia and other provinces and territories has resulted in a significant increase in uptake over the past few years. On the supply side, there is a strong industry presence in Ontario and Alberta and growing local industries in other emerging markets across the country.

However, high upfront costs and limited access to capital often restrict some segments from solar adoption, particularly low-income households. Additionally, low electricity rates in many provinces and territories across Canada mean there is limited economic incentive for adoption of solar.

**Projections for the future**

Significant cost reductions have been observed in solar hardware and soft costs\(^\text{x}\) over the past decades. System costs are expected to decrease by an additional 25–50 percent over the next decade as a result of technological advancement and increased solar deployment. However, there is uncertainty around future reductions in soft costs—which can be a key barrier in some markets, as they can account for over 50 percent of total system costs.\(^\text{x}\)
What have municipalities done?

Municipalities leading by example

City of Calgary: Rooftop solar energy
The City of Calgary, AB, has installed more than 20 solar systems on municipal buildings to offset energy consumption and reduce costs. The buildings include fire stations, recreation centres, water treatment plants and others.

Incentive programs

City of Edmonton: Change Homes for Climate—Solar Program
The City of Edmonton, AB, offers a $0.40/W rebate for residential properties in the city that install solar panels. This rebate serves as a top-up to an existing provincial incentive of $0.90/W.

Financing programs

Long-term municipal financing for solar power
The cities of Halifax, NS, and Toronto, ON, both offer access to low-cost and long-term financing for solar power, through Halifax’s Solar City program and Toronto’s Home Energy Loan Program (HELP).

New construction mandates

City of San Francisco: Ordinance requiring solar panel installation
The City of San Francisco, CA, passed an ordinance that requires all newly constructed buildings under 10 storeys to install solar panels. The state of California has since adopted a similar state-wide mandate for all newly constructed homes to have solar power starting in 2020.

What resources can support next steps?

Economics of Solar Power in Canada, Canada Energy Regulator (formerly the National Energy Board), 2018
This report outlines the financial viability of typical solar power projects (residential, commercial, community and utility-scale) in over 20,000 Canadian communities by estimating the amount and cost of electricity these projects might generate. It also compares these costs to local electricity prices to understand whether it makes financial sense to install solar power.

Canada’s GO SOLAR Guide and Directory, Canadian Solar Industries Association (CanSIA), 2018
This guide provides information on how to educate homeowners on the value of going solar and includes a “Municipal Corner” highlighting municipal actions to promote solar adoption in their communities.

This guide helps consumers in the residential and commercial sectors navigate various solar options and identify the right solutions for them. Specifically, it discusses terminology, ownership options, compensation for electricity generation, how to select a solar vendor, and additional resources.

Solar PV Basics: Technology, Installation & Cost, Municipal Climate Change Action Centre (MCCAC), 2017
Aimed to help municipalities that want to install solar PV technology on their own facilities, this document provides Alberta-specific information on solar PV and the permitting process, along with a review of project costs, options for financing and earnings from project investments.
Rooftop solar PV

Endnotes

i This is the practice of purchasing and storing electricity during off-peak times when prices are low, and then utilizing or selling that stored power during periods when electricity prices are the highest.

ii These are the services needed to help maintain reliable operation of the interconnected transmission and distribution system.


v For example, BC’s Solar Hot Water Ready Regulation.

vi For the purposes of this analysis, a “typical” office building includes both municipal and commercial office buildings.

vii Costs for most provinces are toward the low estimate of this range, while costs for remote and northern parts of the country are reflected by the upper bound.


ix Sandra Adomatis and Ben Hoen, Appraising into the Sun: Six-State Solar Home Paired-Sales Analysis, November 2015.

x Soft costs include permitting, financing, and installing solar power, as well as other non-hardware expenses that solar companies incur to acquire new customers, pay suppliers and cover their bottom line.

Building-level solution

High-efficiency indoor ice rinks

What are high-efficiency indoor ice rinks?

Indoor ice rinks use large amounts of energy for heating, refrigeration, lighting, pumping and hot water. Capital and operational measures can improve the energy efficiency of these processes. Significant greenhouse gas (GHG) reductions may also be achievable by replacing certain refrigerants, though such benefits are not quantified here.

Additional solutions addressed in the other “building-level solutions” factsheets can also be employed in indoor ice rinks to reduce energy use and GHG emissions, although they may not all bring additive savings, due to the interactive effects. In other words, if more than one solution is implemented in the same building, the GHG impacts may be less than the sum of the GHG impacts of each individual solution.

<table>
<thead>
<tr>
<th>Carbon intensity of electricity grid</th>
<th>Fuel</th>
<th>Municipal</th>
<th>Co-benefits</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Electricity &amp; natural gas or heating oil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>Electricity &amp; heating oil</td>
<td>Low to high</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Electricity &amp; natural gas or heating oil</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GHG reduction (kgCO2e/m²/year)

- $\bullet\bullet\bullet\bullet\bullet = <1$
- $\bullet\bullet\bullet\bullet\bullet = 1$ to $<5$
- $\bullet\bullet\bullet\bullet\bullet = 5$ to $<10$
- $\bullet\bullet\bullet\bullet\bullet = 10$ to $<20$
- $\bullet\bullet\bullet\bullet\bullet = 20$ to $<30$
- $\bullet\bullet\bullet\bullet\bullet = 30$

Annualized return on investment

- Negative: $<0$
- Low: $0\%$ to $<4\%$
- Medium: $4\%$ to $<8\%$
- High: $\geq 8\%$

Co-benefits

- None
- Low
- Moderate
- High
- Very high

Other environmental benefits may also result, depending on local circumstances, such as the use and location of fossil fuel power plants and their impact on air quality.
How does this solution work and why is it important?

Indoor ice rinks account for roughly 40 percent of municipal corporate GHG emissions from buildings. Within ice rinks, space heating and refrigeration account for the vast majority of energy use and related GHG emissions. Refrigeration systems also typically use refrigerants that are potent greenhouse gases. Other features with significant energy demands are lighting, pumps, and hot water for Zamboni machines and showers.

Canada has approximately 2,500 arenas with artificial ice rinks. Energy use in Canadian ice rinks varies significantly, depending on the efficiency of the equipment, the size of the arena, the ice area, the number of months of operation per year, and the local climate. The average Canadian single rink arena uses about one million equivalent kilowatt hours (ekWh) of energy per year, but energy use varies widely between arenas due to large differences in energy efficiency.

For example, the energy savings potential of community centres in Ontario varies, from as low as five percent to as high as 65 percent, depending on the condition of the arena. Efficiency upgrades made to the arena in the poorest condition were found to reduce annual GHG emissions by 730 tCO₂e, with associated cost savings of almost $300,000 annually.

Given that nearly 30 percent of Canadian ice arenas are in poor or very poor physical condition, there is a tremendous opportunity to improve their energy efficiency while doing required maintenance upgrades. Moreover, because municipalities already invest significant amounts of money in their ice rinks—spending an average of $53,000 annually on rehabilitation, reconstruction or replacement of infrastructure—the annual cost savings that can be generated through reduced energy consumption can be very compelling as a way to offset those expenses.

Many measures can reduce energy consumption and associated GHG emissions from arenas, including operational improvements and system upgrades to space heating, refrigeration, lighting, pumping and hot water systems. For example, the refrigeration systems in old arenas (built circa 1995) are not designed with heat recovery, and typically reject three times the amount of energy needed by the entire building for heating. Similarly, old refrigeration systems rely on refrigerants with high global warming potential (GWP)—such as hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs)—which contribute to climate change or the destruction of the stratospheric ozone layer, or both.

The table below provides further detail on the broad range of operational or system upgrade measures that can be implemented, along with assumed levels of complexity.
Table 1. Measures to reduce energy use and GHG emissions in indoor ice rinks, and associated levels of complexity

<table>
<thead>
<tr>
<th>Energy conservation and GHG reduction measures for ice rinks</th>
<th>Level of complexity&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td><strong>Operational measures</strong>&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Paint the floor of the ice rink white to reduce the amount of heat it absorbs</td>
<td>✅</td>
</tr>
<tr>
<td>Keep doors to arena closed and seal leaks in building enclosure</td>
<td>✅</td>
</tr>
<tr>
<td>Keep ice thin (increasing ice thickness from 1” to 2” increases refrigerant loads by 10%)</td>
<td>✅</td>
</tr>
<tr>
<td>Shave ice to remove impurities and ensure that the water used to make the ice is pure</td>
<td>✅</td>
</tr>
<tr>
<td>Place ice that has been shaved from the rink outside, to avoid cooling non-rink spaces</td>
<td>✅</td>
</tr>
<tr>
<td>Keep ice temperature as high as possible (hockey rinks run with brine at -9°C; figure skating ice runs with brine at -6 °C; recreational skating is somewhere in between)</td>
<td>✅</td>
</tr>
<tr>
<td>Maintain the concentration of the brine used to cool the ice (aim for a specific gravity of 1.20 to 1.22 for optimum energy use)</td>
<td>✅</td>
</tr>
<tr>
<td>Let air temperatures drop and ice temperatures increase overnight</td>
<td></td>
</tr>
<tr>
<td>Vary lighting levels with facility use by using lighting systems equipped with dimmers</td>
<td></td>
</tr>
<tr>
<td><strong>System upgrades: space heating</strong>&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Install occupancy sensors to control heating/ventilation/lighting</td>
<td>✅</td>
</tr>
<tr>
<td>Install condensing boilers and water heaters</td>
<td></td>
</tr>
<tr>
<td>Install radiant heating for stands not heavily in use and maintain lower air temperatures (control radiant heating using occupancy sensors)</td>
<td></td>
</tr>
<tr>
<td>Use electric desiccant dehumidifiers for year-round ice rinks</td>
<td></td>
</tr>
<tr>
<td>Use air source heat pumps for rooms that are too far from the refrigeration room to be able to use waste heat</td>
<td></td>
</tr>
<tr>
<td>Recover heat that has been produced by the refrigeration system and use it for space heating and sub-floor heating (this can be done directly or by using a water-source heat pump to achieve higher air temperatures)</td>
<td></td>
</tr>
</tbody>
</table>
# Energy conservation and GHG reduction measures for ice rinks

<table>
<thead>
<tr>
<th>System upgrades: refrigeration <strong>ab</strong></th>
<th>Level of complexity<strong>a</strong></th>
<th>Low</th>
<th>Med</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install a building automation system (BAS) to accurately control ice temperature</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install a low-emissivity ceiling sheet to reduce the amount of heat radiated onto the ice and reflect more light back down to the ice surface</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convert the brine distribution piping under the ice from a two-pass to a four-pass arrangement to reduce pumping power</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use floating head pressure control to be able to vary the pressure drop across the compressor, thereby improving compressor efficiency</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install a more efficient refrigeration system using a refrigerant with low global warming potential (GWP), such as CO₂, ammonia, HFO-1234yf, or other new-generation, low-GWP refrigerants (when refrigeration systems are replaced at equipment end-of-life, there is great opportunity to make other system upgrades, such as adding heat recovery)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>System upgrades: lighting, pumping, hot water <strong>bc</strong></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Install low-flow showerheads and faucet aerators to reduce hot water use</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vary the speed of the brine pump using a variable frequency drive (VFD) based on how much refrigeration is needed (VFDs can also be installed in cooling tower fans or condensate pumps)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install energy-efficient bulbs (high bay LEDs) to reduce both the heating of the ice by the lights and the energy use of the lighting itself</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recover heat that has been produced by the refrigeration system and use it to pre-heat water for the showers and for the Zamboni</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**a** Levels of complexity are assumed to be as follows: “low” means the measure can be performed by in-house staff or a maintenance contractor; “medium” refers to relatively standardized capital infrastructure projects; and “high” refers to more complex infrastructure projects that need a high level of engineering design input.


Is this solution right for my municipality?

To determine the potential GHG impact and economic feasibility of ice rink efficiency upgrades for your municipality, consider the following questions:

- **What is the carbon intensity of the grid?**
  If your municipality is in an area with low-carbon electricity, you should concentrate on replacing refrigerant systems that have high global warming potential, and on reducing processes reliant on natural gas or heating oil, such as space and water heating (see the text box, “The climate impact of refrigerants”). If your area uses high-carbon electricity, you should work on reducing electricity use by the refrigeration system, in addition to the above measures.

- **How high are local energy prices?**
  Savings from improving refrigeration efficiency will depend on electricity prices, while savings from improving space and water heating efficiency will depend on the price of the heating fuel used (most commonly, natural gas or heating oil). The higher the cost of electricity and heating fuel, the greater the cost savings from improving efficiency.

- **What is the current condition of your arena?** The cost and impact of upgrading an arena will depend on its current condition and on any plans for maintenance or replacement. If the refrigeration system is in need of replacement anyway, this presents a significant opportunity to add widespread heat recovery systems. If your arena currently needs reinvestment, the incremental cost of adding energy-efficiency improvements may be relatively small.

### The climate impact of refrigerants

Older refrigeration systems in Canadian ice rinks have traditionally used HCFC (R-22) refrigerant or ammonia (R-717), while newer systems often rely on HFC refrigerants. The HCFC and HFC refrigerants commonly used in ice rinks have high global warming potentials (GWPs) ranging from 1,430–4,000 (see table below). This means they trap thousands of times more heat in the atmosphere than the equivalent mass of CO₂.

<table>
<thead>
<tr>
<th>Common refrigerant in ice rinks</th>
<th>GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-717 (Ammonia)</td>
<td>0</td>
</tr>
<tr>
<td>R-744 (CO₂)</td>
<td>1</td>
</tr>
<tr>
<td>R-22 (HCFC)</td>
<td>1,810</td>
</tr>
<tr>
<td>R-134a (HFC)</td>
<td>1,430</td>
</tr>
<tr>
<td>R-404A (HFC)</td>
<td>3,900</td>
</tr>
<tr>
<td>R-507A (HFC)</td>
<td>4,000</td>
</tr>
</tbody>
</table>

While these gases are gradually being phased out under international agreements (the Montreal Protocol and the Kigali Amendment), they remain in ice rinks across Canada and produce significant GHG emissions—often outweighing the rink’s GHG emissions from energy consumption.

*Source: Natural Resources Canada, *Comparative Study of Refrigeration Systems for Ice Rinks*, 2013*
What does it take to implement?

If this solution is appropriate for your municipality, you will need to decide on an upgrade strategy. Here are some key actions and considerations:

- **Identify whether your municipality uses more energy for heating or for refrigeration.** Municipalities in colder climates will use more energy for space heating than for refrigeration. You may choose to tailor the focus of your efficiency improvements based on the balance of energy use between these two applications.

- **Determine the cost-effectiveness of refrigeration improvements based on the number of months of operation per year of your arena.** The cost-effectiveness and GHG emissions reductions resulting from improvements to the refrigeration system will vary significantly depending on the number of months of operation per year. This is because refrigeration systems use significant amounts of electricity in the summer months, so any efficiency improvements will yield particularly big savings during that period.

- **Identify financing options.** Major arena upgrades require significant capital investment. You may have access to utility and provincial/territorial incentives, as well as financing options through government or energy services companies (see the factsheet, Financing Options, for more information). Municipalities with limited resources may choose to focus on operational measures, and some of the simpler system upgrades, for relatively little cost.

- **Consider leveraging planned reinvestments to minimize cost and disruption.** Upgrades to your arena may require the arena to be closed for a period. You can combine efficiency upgrades with other planned renovations to minimize disruption and cost. To avoid technical or operational difficulties after equipment upgrades, ensure that commissioning support is available from contractors and that operators are trained on any new equipment.

What are the GHG and financial impacts?

In general, the GHG reductions, costs and cost savings associated with improving ice rink efficiency are highly dependent on many factors, including:

- the efficiency of existing equipment
- the size of the arena
- how many months of the year the arena is used
- the local climate
- local energy rates
- the carbon intensity of electricity
- the heating fuel used in the building

This section discusses the impact of an example set of retrofits on a non-efficient arena. The arena is assumed to have a single ice rink with an area equal to that...
of an NHL rink.\textsuperscript{xi} It is assumed to be in use eight months per year, with an annual energy consumption of 1.4 million ekWh (from a combination of electricity and a non-electric source like natural gas, propane or heating oil).\textsuperscript{xii} The analysis assumes the following upgrades:

- Add heat recovery to the existing refrigeration system and use the waste heat as follows:
  - Use waste heat for space heating.
  - Use high-temperature waste heat for domestic hot water and ice re-surfacing water.
  - Use low-temperature waste heat to meet subfloor heating requirements.
- Reduce brine pump energy use by changing brine distribution piping from a two-pass configuration to a four-pass configuration.
- Use low-emissivity ceiling sheets to reduce radiation of heat from the ceiling onto the ice.
- Replace metal halide bulbs with high-efficiency LED bulbs.

Together, these upgrades are assumed to have a capital cost of $360,000 and annual energy savings of about 43 percent (33 percent heating and 10 percent electricity). These measures have an expected useful life of 20–25 years. Not all measures contribute equally to reducing the energy consumption of ice rinks. Figure 1 below shows the estimated breakdown of reductions in energy use from each measure.

**Figure 1:** Relative contribution of each measure to the 43 percent overall energy savings achieved in an inefficient, single-rink arena
The associated GHG reductions and cost savings for each province and territory are presented in Table 2. The results are calculated based on the average energy rate for the province/territory, the carbon intensity of the electricity grid, and the typical heating fuel used, and may vary depending on each of these factors.

While the cost of these energy-efficiency measures will vary based on the existing state of the arena and on what other upgrades are being carried out at the same time, here are some rough estimates:

- Adding heat recovery to an existing refrigeration system: $300,000 (this type of system would provide space heating, water heating and subfloor heating using recovered heat)\textsuperscript{xiii}
- Changing the brine piping configuration: $20,000\textsuperscript{xiv}
- Installing a low-emissivity ceiling: $30,000\textsuperscript{xv}
- Installing LED lights: $400/luminaire\textsuperscript{xvi}

Table 2: GHG and financial impacts of select upgrades on a typical arena\textsuperscript{a, b}

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>Fuels saved</th>
<th>GHG reductions (for a typical ice rink) (tCO\textsubscript{2}e/year)</th>
<th>Annualized return on Investment (for building owner)</th>
<th>$/tCO\textsubscript{2}e (for a typical ice rink)\textsuperscript{c}</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Natural gas and electricity</td>
<td>73</td>
<td>3%</td>
<td>-240</td>
</tr>
<tr>
<td>AB</td>
<td>Natural gas and electricity</td>
<td>200</td>
<td>2%</td>
<td>-18</td>
</tr>
<tr>
<td>SK</td>
<td>Natural gas and electricity</td>
<td>190</td>
<td>3%</td>
<td>-73</td>
</tr>
<tr>
<td>MB</td>
<td>Natural gas and electricity</td>
<td>69</td>
<td>3%</td>
<td>-220</td>
</tr>
<tr>
<td>ON</td>
<td>Natural gas and electricity</td>
<td>76</td>
<td>3%</td>
<td>-220</td>
</tr>
<tr>
<td>QC</td>
<td>Natural gas and electricity</td>
<td>72</td>
<td>4%</td>
<td>-330</td>
</tr>
<tr>
<td>NB</td>
<td>Heating oil and electricity</td>
<td>160</td>
<td>6%</td>
<td>-390</td>
</tr>
<tr>
<td>PE</td>
<td>Heating oil and electricity</td>
<td>140</td>
<td>7%</td>
<td>-520</td>
</tr>
<tr>
<td>NS</td>
<td>Heating oil and electricity</td>
<td>210</td>
<td>7%</td>
<td>-300</td>
</tr>
<tr>
<td>NL</td>
<td>Heating oil and electricity</td>
<td>120</td>
<td>6%</td>
<td>-440</td>
</tr>
</tbody>
</table>
As shown, improvements to arena efficiency can yield significant GHG emissions reductions and positive returns on investment in all provinces and territories. GHG emissions reductions are greatest in areas with high-carbon grids. Returns on investment are highest in areas with high electricity and heating fuel prices. Negative values for dollar-per-tonne of CO₂e indicate that the upgrades save money while also reducing GHG emissions.

It should be noted that the above analysis doesn’t include the positive impact of some of these measures on maintenance costs. For example, increasing the temperature of the ice at night means the ice is soft for resurfacing the next morning. Consequently, wear and tear on equipment is lower than with colder ice. Moreover, the analysis doesn’t consider complete replacement of the refrigeration system, which could significantly increase GHG reductions for arenas relying on refrigerants with high global warming potential, especially for obsolete equipment using HCFC refrigerant (R-22).
What are the potential co-benefits?

In addition to GHG reductions and cost savings, a number of co-benefits may be realized through various types of ice rink upgrade.

- **Environment**
  - Reduced air pollution results from reduced burning of fossil fuels, which are typically used to heat arenas.
  - Lighting upgrades can improve light quality, output and durability, provide instant-on technology and reduce maintenance requirements.

- **Other**
  - Having the right ice firmness (which is affected by ice temperature), thickness and lighting will increase user performance, playability and satisfaction, which could also lead to increased ice rink rentals and usage.
  - Reduced air pollution results from satisfaction, which could also lead to reduced burning of fossil fuels, which increased ice rink rentals and usage.

There are also some marginal benefits associated with improved thermal comfort, lighting comfort and acoustics.

What is the current and projected state of the market?

**Current state of the market**

- Refrigeration heat recovery systems have only become widespread in the last decade. For example, a survey of arena and curling rink projects in Quebec between 2008 and 2013 showed that 80 percent of the ice rinks that carried out major renovations during that period added an energy recovery system. xvii
- The space heating measures mentioned in Table 1 (condensing boilers, radiant heat, and heat pumps) are mature technologies.
- Many refrigeration systems are nearing their end of life and require major renovations or replacement. Most of these older systems use HCFCs like R-22, or ammonia refrigerant. Because R-22 is being phased out under the Montreal Protocol, there are added costs when upgrading refrigeration systems to replace R-22 with climate-friendlier alternatives like ammonia and CO₂. xviii

**Projections for the future**

- Technological advancements are underway to improve refrigeration systems and heat recovery from such systems. Increasingly, climate-friendly refrigerant systems are being installed:
  - CO₂-based refrigerant systems are more efficient and cost-competitive, but they are relatively new to the market, so long commissioning times remain an issue. xx
  - Ammonia-based refrigeration technology is widely available, and installers are very familiar with it. It also offers reliable long-term performance but requires careful maintenance practices due to its toxicity.
  - New refrigerants—including HFOs like R-449A or R-513A—have been in commercial use for nearly a decade and are considered safe, climate-friendly options with competitive energy performance. xxi
What have municipalities done?

**Municipalities leading by example**

**Town of Aberdeen: Aberdeen Recreation Complex**

The recreation complex in the Town of Aberdeen, SK, uses a ground-source heat pump to provide refrigeration for two ice rinks. The system also recaptures waste heat from the ice plant and uses it to preheat water, melt snow, and generate space heating.

**City of Dorval: Dorval Arena and Westwood Sports Centre**

While retrofitting several municipal buildings, the City of Dorval, QC, installed a new carbon dioxide ice refrigeration system and integrated a number of energy-efficiency measures in its arena and sports centre that will reduce the buildings’ energy consumption by nearly 45 percent, their natural gas consumption by 35 percent, and their GHG emissions by more than 47 percent. The heat produced by the refrigeration systems is recovered, in part to heat certain ventilation systems, the water for the Zamboni, and the domestic water in the locker rooms. The new system is also expected to reduce the impact on human health and the environment by eliminating the use of ozone-depleting substances. The project cost $3.8 million and the expected payback period is 13 years.

**Township of Uxbridge: Uxbridge Arena and Swimming Pool retrofit**

The Township of Uxbridge, ON, retrofitted its ice rink and swimming pool to improve energy efficiency. The township installed energy-efficient lighting, replaced hot water tanks and furnaces with high-efficiency models, upgraded the ice temperature control system and upgraded the insulation in the roof. These upgrades reduced annual energy consumption at the arena by 544,000 kWh and annual GHG emissions by 94 tCO2e—resulting in annual cost savings of $67,000. The project cost $78,000, so the simple payback period was just 1.2 years.

**City of Halifax: BMO Centre**

The City of Halifax, NS, built a Leadership in Energy and Environmental Design (LEED®) Gold certified four-rink arena—the BMO Centre. Waste heat from the refrigeration system is used for space and water heating, saving about $175,000 in energy costs annually. This measure, combined with natural lighting, advanced lighting control, radiant heating and cold thermal energy storage for cooling, reduced annual GHG emissions by more than 500 tCO2e compared to a conventional facility.

**City of Port Hawkesbury: Port Hawkesbury Civic Centre**

The City of Port Hawkesbury, NS, built a new civic centre that uses a ground source heat pump for space heating and refrigeration, and also uses rejected heat from the refrigeration system for water heating.
What resources can support next steps?

**Comparative Study of Refrigeration Systems for Ice Rinks**, Natural Resources Canada, 2013
This study compares the upfront costs, running costs, environmental impacts and safety considerations of different refrigerants. It includes hard numbers on the different options. The information may be useful for municipalities preparing an initial business case for their own upgrades.

Laurier Nichols, P.E. “**Improving Efficiency in Ice Hockey Arenas**,” *ASHRAE Journal*, June 2009
This succinct, informative article discusses the different measures that can be taken to improve ice rink efficiency.

**Energy Efficiency Guide for Municipal Recreation Facilities**, Manitoba Hydro, 2018
This comprehensive guide explains how the different components of an arena can be made more efficient. It includes guidance on how to analyze the energy and financial implications of different options.

**ENERGY STAR® Score for Indoor Ice Rinks in Canada**, ENERGY STAR®, 2017
Municipalities can use this resource to benchmark the energy performance of their indoor ice rinks relative to others in Canada, taking into account climate, weather and the business activities at the property. The document explains how the ENERGY STAR® rating system works and provides an example calculation.
Endnotes


iii Natural Resources Canada, Comparative Study of Refrigeration Systems for Ice Rinks, 2013.


vi Toronto and Region Conservation for The Living City, 2016, Using Best Practice Targets to Achieve the Energy Conservation Potential in Community Centres, April 2016.

vii Ibid.

viii Natural Resources Canada, 2013, Comparative study of refrigeration systems for ice rinks, 2013.


x Global warming potential (GWP) is a measure of how much heat a greenhouse gas traps in the atmosphere over a specific time horizon (typically 100 years), relative to carbon dioxide (CO₂). The larger the GWP of a given gas, the more that gas warms the earth compared to CO₂ over that time period. Hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs), typically used as refrigerants in arenas, are considered high-GWP gases because their GWPs are in the thousands. (Source: “Understanding Global Warming Potentials,” United States Environmental Protection Agency)

xi Assumed rink dimensions: 3,200 m² (34,000 ft²) in total, with ice area of 1,500 m² (16,200 ft²).


xiii Dunskey Energy Consulting, professional judgement.

xiv Ibid.


xvi Dunskey Energy Consulting, professional judgement.

xvii Natural Resources Canada, Comparative Study of Refrigeration Systems for Ice Rinks, 2013.

xviii Ibid.

xix Ibid.

xx Ibid.


Community-level solution

District energy systems

What are district energy systems?

District energy systems, also referred to as thermal grids, supply heating and, in some cases, cooling, to multiple buildings. They take heat from a centralized source, or from several different but interconnected sources, and distribute that heat to the buildings through a system of buried insulated pipes. District energy system can also be used for cooling, in which case they remove heat from buildings and transfer it to a heat sink such as a borehole or lake. Combined heat and power (CHP) systems also supply electricity via a microgrid.

Municipalities can play a critical role in influencing the speed and success of district energy development within their communities, in several ways:

Direct involvement:
- Own a district energy system through a municipal utility.
- Participate by connecting municipal buildings to a district energy network.

Indirect involvement:
- Develop policies that consider district energy systems and that require or encourage the use of these systems.
- Offer incentives or financing.
- Educate and support others—for example, by engaging stakeholders, building capacity and raising awareness.

Advantages
- Systems can yield very significant greenhouse gas (GHG) emissions reductions if powered with a low-carbon energy source.
- Energy dollars stay in the community.
- Private investment is attracted and local economic development supported.
- Systems provide heating and cooling services with high reliability.
- Combined heat and power (CHP) plants can further improve community resiliency by providing local electricity generation during blackouts and balancing electricity supply and demand in places with capacity issues.
- Local air quality improves if the system displaces oil-fired heating.
- Value is created from waste products, such as municipal waste and industrial waste heat.
District energy systems can offer a wide range of benefits for communities. When they are powered with low-carbon energy sources that replace oil or gas-fired heating, they significantly reduce GHG emissions, keep energy dollars in the community, stabilize heating and cooling costs and reduce the risk of oil spills or gas explosions. By connecting many buildings together, district energy systems allow for the use of energy sources that cannot be used economically for a single building or would otherwise go unused (e.g. waste heat from industrial processes). For commercial and institutional buildings, district energy systems free up high-value commercial space by removing the need to have heating equipment on-site. They also reduce maintenance burdens on individual building owners. The existence of a district energy system can support local economic development by attracting industrial customers. Furthermore, when district energy systems are designed to include cooling, they improve resiliency to increasing summer temperatures.

Challenges

- Systems must be designed specifically for the conditions of the municipality.
- Large capital expenditures will require financing.
- Municipalities may lack expertise and awareness around district energy projects and related actions.
- A complex array of stakeholders must be engaged.
- Infrastructure on private land will require a statutory right of way.
- Municipalities that want some ownership of the district energy system will need to establish a public utility if they don’t already have one.

How does this solution work and why is it important?

Need funding for your energy project? Contact FCM!

Access grants and loans for energy-efficiency and clean energy solutions that support service delivery in your community.

- Improve efficiency and reduce GHG emissions in municipal and community buildings
- Integrate renewable energy generation solutions
- Plan, refine and scale-up innovative financing programs for residential retrofits

Learn more!
District energy systems range in size from institution-sized (e.g. in a university) to municipality-sized. These systems consist of a thermal energy plant (which generates or collects and stores the thermal energy) and a thermal distribution network (which distributes a heated or cooled fluid between buildings). Table 1 summarizes the range of low-GHG thermal energy sources available and their key attributes. It should be noted that thermal energy plants in Canada have traditionally been powered with natural gas or oil, but systems that use these fuels as a primary heat source are not addressed in this factsheet as they will not yield deep GHG emissions reductions.

In addition to a thermal energy plant and distribution network, in-building equipment is also needed to transfer heat to or from the buildings. Specifically, buildings must have HVAC equipment that is compatible with the system in order to connect to it. Buildings that have a mechanical design allowing them to connect to a future district energy system are referred to as district-energy-ready (DE-ready). DE-ready design elements can include adequate space at or below ground level to install heat transfer equipment, or an in-building heat distribution system that works with relatively low water temperatures. Ensuring that new buildings are DE-ready will make it easier to move forward with future district energy developments.

### Table 1: Low-GHG thermal energy sources for district energy systems and key attributes

<table>
<thead>
<tr>
<th>Energy source/technology</th>
<th>Description</th>
<th>Local requirements</th>
<th>Supply and demand considerations</th>
<th>Number of systems in Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined heat and power (CHP, or “co-gen”)</td>
<td>In a CHP plant, the heat left over from the electricity generation process is transferred into the district energy network. This heat would otherwise be wasted. Possible fuels include biomass, biogas, municipal waste, landfill gas and natural gas.</td>
<td>CHP is feasible in areas with biomass/biogas energy sources (e.g. wood chips or biogas from landfill) or in areas with a natural gas network. Waste heat can also be captured from existing electrical generation, such as from diesel, gas or nuclear generators.</td>
<td>CHP plants can be used to help balance electricity supply and demand locally. They can also be used as backup for key functions during blackouts.</td>
<td>29</td>
</tr>
</tbody>
</table>
### District energy systems

<table>
<thead>
<tr>
<th>Energy source/technology</th>
<th>Description</th>
<th>Local requirements</th>
<th>Supply and demand considerations</th>
<th>Number of systems in Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biomass</strong></td>
<td>Biomass (typically wood chips) or biogas can be burned in a boiler to generate heat or, in a CHP plant, heat and electricity.</td>
<td>A sustainable, continuous source of biomass feedstock is needed for biomass-powered district energy to be a good option.</td>
<td>Energy supply depends on the technology used to burn the biomass (CHP vs. backup boilers). Thermal energy storage can be used to store waste heat if biomass feedstock is intermittent.</td>
<td>biomass only: 13 combined with other energy sources: 24</td>
</tr>
<tr>
<td><strong>Geoexchange</strong></td>
<td>A heat pump extracts heat from the ground or from water bodies such as lakes. The heat pump can also provide cooling by rejecting heat into the ground or water.</td>
<td>Geoexchange requires adequate room to drill the wells for a borehole field or, alternatively, a nearby water body. It can be possible to take advantage of existing aquifers, such as flooded mineshafts, for thermal energy supply or sink/storage.</td>
<td>Ground-source heat pumps are good for supplying base energy demand.</td>
<td>geoexchange only: 14 combined with other energy sources: 10</td>
</tr>
<tr>
<td><strong>Waste heat recovery</strong></td>
<td>Waste heat from industrial processes or commercial operations (e.g. data centres, grocery store refrigeration), as well as low-temperature heat from sewage, can be captured and used in a district heating system. Note: putting a price on waste heat can be complex.</td>
<td>This is only feasible in areas with waste heat sources such as industrial or commercial facilities or sewage pumping stations.</td>
<td>Waste heat supply cannot normally be controlled to scale with demand. Thermal energy storage can be used to store waste heat when demand is low. Backup systems, such as boilers, are required to meet demand when waste heat output is low.</td>
<td>waste heat only: 2 combined with other energy sources: 2</td>
</tr>
<tr>
<td>Energy source/technology</td>
<td>Description</td>
<td>Local requirements</td>
<td>Supply and demand considerations</td>
<td>Number of systems in Canada</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------</td>
<td>--------------------</td>
<td>-----------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Municipal waste</td>
<td>Gasification of municipal waste produces heat at low cost and, compared to conventional incineration, limits the formation of dioxins, sulphur oxides and nitrogen oxides. The gas generated from gasification can either be used directly (for heating) or used to produce both electricity and heat in a CHP plant.</td>
<td>Gasification plants may need to be located outside of cities or treat the process gases to avoid creating local air pollution (e.g. particulates). The ash removed from the process gas must be disposed of somewhere, so proximity to landfill, a concrete plant, or other processes that can use the ash can be useful.</td>
<td>Because gasification of municipal waste can be used to power CHP plants, similar supply and demand considerations will apply.</td>
<td>waste incineration only: 1 combined with other energy sources: 2</td>
</tr>
<tr>
<td>Solar thermal</td>
<td>Solar thermal panels can provide heat for a district heating system—or for cooling/dehumidification via solar absorption chillers or desiccant cooling.</td>
<td>Adequate roof space (with appropriate angle, orientation, sun exposure, etc.) or land (for ground-mounted panels) is required.</td>
<td>Borehole or aquifer thermal energy storage may be used to store large quantities of solar heat collected in summer for use in winter. While thermal storage systems can be used to smooth out variations in solar power availability, a backup boiler will still likely be required to meet peak load requirements.</td>
<td>solar thermal only: 0 combined with other energy sources: 2</td>
</tr>
</tbody>
</table>
## District energy systems

<table>
<thead>
<tr>
<th>Energy source/technology</th>
<th>Description</th>
<th>Local requirements</th>
<th>Supply and demand considerations</th>
<th>Number of systems in Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excess wind or solar electricity</td>
<td>Excess renewable energy from wind or solar photovoltaic (PV) systems can be converted to heat and fed into a district energy system or thermal storage.</td>
<td>Wind or solar generation capacity is necessary.</td>
<td>If operating in parallel with CHP plants and thermal storage, the CHP plants can be used for electricity generation when renewable output power is low, and unwanted heat can be sent to thermal storage.</td>
<td>Unknown</td>
</tr>
<tr>
<td>Thermal storage</td>
<td>Borehole, pit or aquifer thermal storage can be used to store excess hot water, cold water or ice.</td>
<td>-</td>
<td>Thermal storage helps match supply and demand, reducing the use of backup boilers or backup refrigeration. The storage period can range from a few hours to a season, depending on the system requirements.</td>
<td>6</td>
</tr>
<tr>
<td>Backup boilers</td>
<td>Backup boilers are used to meet peak load heating requirements. Possible fuels include biomass, biogas, natural gas, heating oil and electricity.</td>
<td>Fuel choice will depend on what is locally available.</td>
<td>Backup boilers provide heat when demand exceeds the available supply from the main energy source.</td>
<td>Unknown: it is likely that most systems have a backup boiler</td>
</tr>
</tbody>
</table>
District energy is currently a small industry in Canada, despite the technology being very mature. In 2019, the Canadian Energy and Emissions Data Centre (CEEDC, formerly the Canadian Industrial Energy End-Use Data and Analysis Centre) identified 217 operating district energy systems across the country, serving a total of 3,203 buildings.

The technology is much more widely used in other countries. For example, district heating meets 12 percent of heat demand in Europe (and over 90 percent in many Nordic cities, such as those in Denmark, Finland and Sweden), 30 percent of heat demand in China, and 50 percent in Russia.

Is this solution right for my municipality?

To determine the GHG impact and economic feasibility of a district energy system for your municipality, consider the following questions:

- **What is the carbon intensity of heating/cooling?** Replacing existing thermal systems with a district energy system will only deliver GHG emissions reductions if your existing system has high GHG emissions. In provinces/territories with low-carbon electricity, replacing electric heating with a district energy system will not yield significant GHG impacts but may contribute to reducing electricity demand (which will be critical as these municipalities move towards increased electrification).

- **Is your municipality experiencing high growth?** It is much easier to install a district energy system when a site is developed than after it is built out. If your municipality is experiencing significant growth, you could consider promoting the installation of district energy systems in new developments.

- **Does your municipality have sufficient building density (demand) and adequate thermal energy (supply) to support district energy?**
  - **Density of demand:** District energy systems are more cost-effective in high-density areas with a high demand for heating and cooling. This is because the piping network is a significant part of the system cost, so the shorter the pipes can be per unit of energy delivered, the cheaper the system will be. This means that district energy is unlikely to be a good option in low-density areas.

- **Heat sources:** Identifying potential heat sources and sinks is important when installing a district energy system. Municipalities with waste heat streams can create value from these currently wasted resources.

- **Does your municipality have the right mix of building types and sizes to support district energy?** The connection between the network and individual buildings is a significant cost. Additionally, one of the biggest challenges (and design considerations) when
considering building types and mixes is the need for sufficient base heating load demand in the summer. As a result, it is more cost-effective to connect large buildings with big year-round heating loads (such as apartment buildings) than small buildings (such as single-family homes). It can be easier to match supply and demand in networks that connect to a mixture of types of buildings (institutional, commercial and residential) because these different building types need heat at different times of day, and this evens out the demands on the network. District energy systems can start with one large and stable base load and then expand to add other buildings.

What does it take to implement?

If district energy systems are appropriate for your municipality, you can take various actions to drive adoption, based on your municipality’s resources, objectives and appetite for risk. You can support district energy projects directly or indirectly, as described below.xii

Direct involvement

Ownership models

District energy systems can be municipally owned (through a municipal utility), owned through a public-private partnership, or privately owned. The fully public business model allows municipalities to have complete control of the project and to use the project to achieve broader social objectives. Hybrid public-private models allow municipalities to maintain some control while also attracting private sector investment. Fully private models occur where there is a high rate of return and little need for public sector support, such as in the case of small, standalone developments.

For more information on business models for district energy systems, see the 2015 UNEP report, District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy.

Own/develop

- Own a district energy system through a municipal utility. See the “Ownership models” text box more information.
- Consider best practices such as mapping, targets and policies, coordination with other utility upgrades, and waste heat tariffs.
  - Mapping: When considering implementing a district energy system, you can develop a detailed map of your community’s heating and cooling demand, as well as access to local energy supplies (e.g. excess waste heat, renewable heat sources) and distribution infrastructure. If resources are limited, this mapping exercise can focus on high-potential areas, such as the central business district, or areas of new development. Based on the results of your mapping exercise, you can decide where to develop district energy systems, and whether it is worth including cooling in those systems.
• **Targets and policies:** If your municipality owns its own utility, you can prescribe the use of low-carbon heat sources in district energy networks.

• **Coordination with other utility upgrades:** Installing a distribution network will be much cheaper if you do it at the same time as other similar redevelopment, such as upgrades to sewers and road infrastructure.

• **Waste heat tariffs:** District energy networks can use waste heat. Pricing that waste heat can be difficult, but you should ensure that tariffs account for the cost of connection to the waste heat source, the cost of having backup boilers for when the waste heat source doesn’t meet demand, and adequate incentive to encourage the waste heat provider to connect to the network.

**Participate**

• **Support or undertake demonstration projects.** Municipally supported demonstration projects illustrate the feasibility and benefits of district energy systems and build local capacity.

• **Support district energy by involving the municipality as a consumer.** It can be hard to get private investors to make the initial investments in district energy systems, but once a network exists, it is much easier to secure private sector finance to expand it. Municipal buildings can provide an initial customer base for planned district energy projects, therefore reducing the risk of the development.

**Indirect involvement**

**Develop policy**

• **Set targets for the future adoption of district energy systems.** The target may represent a portion of public buildings connected or an absolute number of buildings in the wider community.

• **Include energy planning considerations as part of land use planning.** District energy systems are most viable in high-density and mixed-use areas, so you can support the development of district energy by encouraging mixed-use zoning and compact land use in new developments.

• **Establish policies that mandate or encourage connection to district energy systems.** District energy projects require a large upfront capital investment before any buildings can be connected. This means that there is uncertainty for the developer about how many buildings will connect. You can reduce this risk by establishing policies that ensure a base level of adoption. For example:
  - Establish mandatory connection policies for new developments, public buildings or certain areas.
  - Encourage connections by waiving or reducing fees for access to rights-of-way.
  - Ensure access to public or institutional lands such as roads, parks and schoolyards, for borehole thermal energy storage or geoexchange wells.
  - Ban undesirable alternatives, such as fuel oil.
  - Provide credits toward green building requirements for buildings that connect.
**District energy systems**

**Incentivize/finance**

- **Offer financing and incentives.** The high capital cost of district energy systems is a key barrier to their development. You can use financing and incentives to reduce this barrier—for example, by providing low-cost loans, loan guarantees, or grants for early-stage feasibility assessments. You can also help developers secure national or international grants to fund local district energy projects.

**Educate/support**

- **Engage stakeholders.** Successfully implementing district energy projects requires attention to diverse stakeholder interests. Your municipality can play a role in this process even if the district energy system is not being developed by a municipal utility. It is critical to engage real estate developers and building owners and operators as early as possible.

- **Have a municipal unit dedicated to facilitating projects and building capacity.** The development of a district energy system is complex and involves many stakeholders. It’s not usually feasible for one stakeholder to provide the resources needed for coordination and capacity-building throughout the project. Having a municipal unit dedicated to facilitation, training, project structuring and multi-stakeholder engagement is key in implementing a district energy system. You can strengthen your municipality’s capacity for this role by partnering with the private sector to leverage expertise.

- **Raise awareness and do outreach.** You can play a critical role in promoting district energy systems by providing evidence to companies and consumers of the benefits. Start by gathering data on current and future demand for building energy, and on potential sources of energy. More broadly, it is vital to communicate with stakeholders—from customers to the broader public—on the benefits of district energy and the status of projects.

- **Advocate for supportive policies and regulations from other orders of government.** You can push other orders of government to adopt policies and regulations that will aid the adoption of district energy.

**What are the GHG and financial impacts?**

**GHG reductions**

Nationwide, space heating accounts for about 60 percent of both residential and commercial building GHG emissions. District energy systems can have a significant impact on those heating-related GHG emissions by using low-carbon energy sources in place of high-carbon sources like natural gas and heating oil. In addition, district energy systems can increase efficiency by transferring heat from buildings that need cooling (such as computer server rooms) to buildings that need heating.

Cooling, meanwhile, accounts for just five percent of commercial and two percent of residential building GHG emissions. In places with high cooling loads, providing cooling using a district energy system may reduce GHG emissions, but it is likely to have a smaller effect than providing heating.
The GHG emissions reductions achieved by district energy systems will depend on the energy source, and on the proportion of buildings connected. If district energy systems use no-carbon or low-carbon energy sources (such as waste heat, sustainable biomass or ground-source heat pumps powered by low-carbon electricity), they can nearly eliminate GHG emissions related to space heating. According to a 2019 survey by CEEDC, the use of renewable energy in Canada’s district energy systems avoided 5.5 percent of the GHG emissions from space heating that would otherwise have been emitted.xv

Canadian municipalities are demonstrating what is possible. The district energy system in Vancouver’s Southeast False Creek, which uses sewage heat recovery, has reduced heating-related GHG emissions by 60 percent for 395,000 m² of residential, commercial and institutional space.xvi This amounts to a GHG reduction of about 1,800 tCO₂e per year.xvii The City of Richmond, which is continuing to develop its ground-source and air-source heat pump-based district energy systems, estimates it will achieve GHG reductions of 70 to 80 percent once the system is fully built out.xviii

**Project costs and savings**

Costs will depend heavily on the fuel source used and on the local context. Typically, where natural gas grids exist, combined heat and power will be the most economical type of district energy system, but powering a CHP system with natural gas will yield smaller GHG reductions compared to other low-carbon energy sources. Elsewhere, waste heat and heat from municipal waste generation will be the cheapest sources of heat.xix Costs will be lower in places with a high density of energy demand (i.e. many buildings with high energy demand in a small area—such as a central business district, or a single large development), and in places with fewer individual connections (such as apartment buildings rather than single-family homes). Costs will also be lower if installation can be combined with other utility projects, such as sewer, water or transport projects.xx

In addition to energy savings, new building developments save the capital cost of installing their own heating equipment. In places with high land values, valuable space can also be saved inside buildings and on roofs. Operating and management costs are reduced because there is just one large system operated by one professional contracting firm, rather than multiple small systems supported by various contractors.xxi Large, energy-efficient systems also usually have sophisticated control systems, sensors, real-time monitoring tools, and knowledgeable control room operators that can achieve deeper energy savings and better upkeep relative to conventional HVAC equipment.

Cost savings or municipal utility profits can be distributed back to the community. As an example, the Southeast False Creek Neighbourhood Energy Utility in Vancouver, BC, provides a return on investment to city taxpayers, while also providing affordable rates to customers.xxii, xxiii
What have municipalities done?

**Waste heat recovery**

**City of Vancouver: Neighbourhood Energy Utility**
The City of Vancouver, BC, created and fully owns the Southeast False Creek Neighborhood Energy Utility. The network currently captures waste heat from the sewer pump station using a heat pump. On the coldest days of the year, the system is supplemented with high-efficiency natural gas boilers. The system provides space and water heating to about 395,000 m² of residential, commercial and institutional space. The total cost of the project was $32 million, which was fully covered through utility customer rates. There are many other district energy projects in Metro Vancouver, including systems fueled only by natural gas, ground-source heat pump systems, and hybrid systems that use natural gas with biomass, waste heat recovery or waste wood.

**Biomass Combined Heat and Power (CHP)**

**City of Charlottetown: Community district energy**
The City of Charlottetown, PE, has had a waste wood and woodchip fired combined heat and power (CHP) district energy system since 1986. The system is currently owned by Enwave. It provides heat to about 125 downtown buildings and generates electricity that is used internally or sold to the grid. Municipal waste and wood provide 85 percent of the system’s fuel, and oil provides the rest. This system was initially developed by a public utility but was later sold to a private firm.

**Cree Nation of Ouje-Bougoumou:**

**Ouje-Bougoumou District Energy System**
The Cree Nation of Ouje-Bougoumou, QC, has a district heating system powered by two biomass and two oil-fired boilers that provide 90°C water to 135 homes and 16 public buildings. The biomass boilers burn wood waste from a nearby sawmill and produce 75 percent of the system’s heating.

**Biomass heat only**

**City of Yellowknife: Biomass District Energy System**
The City of Yellowknife, NT, has a district energy system, fueled by biomass pellets, that heats a group of five municipal buildings. The system has reduced the GHG emissions from the buildings by 829 tCO₂e per year and is expected to save the city $140,000 to $160,000 annually.

**City of Revelstoke: Revelstoke Community Heating System**
The City of Revelstoke, BC, has a community energy system fired by waste biomass from the local sawmill. The $7.8 million system heats eight buildings—including an aquatic center, an arena and two schools, and reduces GHG emissions by 146 tonnes per year.

**Municipalité de Saint-Ubalde: Biomass-powered district energy**
The Municipalité de Saint-Ubalde, QC, has two district energy systems fueled by biomass pellets. One heats the church, library, city hall, post office and community centre. The other heats the offices, garage and workshop of a local business. The system has reduced the GHG emissions from the buildings by 131 tCO₂e per year.
**Geoexchange**

**Rural Municipality of Ritchot: Ile-des-Chenes Community Centre**

**New Build Energy**

The Rural Municipality of Ritchot, MB, expects high population growth in the next 15 years. In order to prepare for this projected growth, the municipality installed a district energy system powered by a ground-source heat pump. The system serves the community center, arena and fire hall. Energy costs for the new community center (which was built to meet LEED® Silver standards), arena and fire hall are expected to be about 60 percent lower than those for ordinary buildings of a similar size.

**City of Halifax: District cooling system**

The City of Halifax, NS, partnered with the provincial government and the federal Technology Early Action Measures program to install a district cooling system with a ground-source heat pump that uses sea water to chill an underground rock mass during the winter. That cooled rock mass then provides cooling in the summer. The project cost $3.6 million but avoided $0.83 million in capital costs for equipment replacement that would otherwise have been required. It reduces GHG emissions by 900 tCO₂e per year and saves $350,000 a year in electricity costs.

**City of Toronto: District energy systems, guidelines and sites**

The City of Toronto, ON, has released guidelines for building developers and owners, architects and engineers to support the design of buildings that are ready for connection to a district energy system. The city is already home to four district energy systems, including the University of Toronto system, the York University Keele Campus system, the Enwave steam and Deep Lake Water Cooling system, and the Regent Park system. More than 25 other locations have been identified as having potential to support new district energy systems throughout the city.

**City of Richmond: District energy systems**

The City of Richmond, BC, has a municipally owned corporation that manages the development, design, construction and operation of district energy utilities in Richmond. That corporation currently operates two district energy systems. One of these systems uses a ground-source heat pump to provide heating and cooling. The other currently uses natural gas boilers but will be converted to a heat recovery system that uses heat from a sewer—once the system is big enough to justify the investment. The city estimates that these systems will reduce the emissions of connected buildings by 70 to 80 percent at full build-out.

**Gas Combined Heat and Power (CHP)**

**City of Markham: Markham District Energy Inc.**

The City of Markham, ON, has a municipally owned district energy utility that operates two systems, each powered with a combined heat and power (CHP) plant and a gas-fired boiler. The systems reduce GHG emissions by 50 percent in the urban centres they serve. The systems have stimulated development and economic activity by offering enhanced reliability and resilience and by stabilizing energy costs.
Solar thermal and thermal energy storage

**Town of Okotoks: Drake Landing Solar Community district heating system**
The Town of Okotoks, AB, has a district heating system which serves 52 houses. The heat comes from garage-mounted solar thermal collectors. Excess heat is stored in boreholes, and the heat collected in the summer is used in the winter. The system circulates water at temperatures between 40 and 50°C. The low water temperature means that the solar thermal collectors work very efficiently, but also means that the homes must have air handlers that are specifically designed to heat the homes adequately.

Municipal policies

**City of Richmond: Requirement for new construction in city centre**
The City of Richmond, BC, requires all new construction in the city centre to include the appropriate mechanical equipment to be district-energy-ready.

What resources can support next steps?

  This comprehensive guide covers the why, when, what and how of district energy development. This guide is focused on providing municipalities the information they need to run successful district energy projects. It includes detailed advice on implementation and many case studies showcasing what other cities have done. It also includes levelized costs for various types of district energy systems, based largely on data available from Europe.

  This guide assists municipalities in developing stakeholder engagement strategies when considering district energy.

- **Plan4DE**, Sustainability Solutions Group
  This tool provides a high-level assessment of district energy options for different areas of a neighbourhood or city.

  This step-by-step guide helps project proponents and land-use planners who are developing a district energy system.

- **District Energy in Canada**, The Canadian Energy and Emissions Data Centre (CEEDC), 2019
  This report discusses the current status of district energy in Canada. It includes useful data on the operation of existing systems, including employment, customer types and system capacity. In addition to the report, there is also an inventory of district energy systems.

  Toronto’s guidelines for designing buildings that are district-energy-ready may be useful for cities that are considering encouraging or mandating the adoption of a district-energy-ready standard.
Endnotes

i In new developments, district energy systems powered by central gas boilers will produce significantly lower GHG emissions than individual gas boilers in each building; for existing developments, however, GHG reductions will be minimal.


iii Natural Resources Canada, Sustainable Buildings and Communities Group: Community Energy Systems.

iv The distribution network consists of underground insulated pipes that transport heated or cooled water between the energy source and the buildings. The temperature of the water in these pipes has gradually decreased as the technology has evolved. Current technology (third generation) uses pressurized hot water at temperatures slightly below 100°C. Future grids (fourth generation) may use distribution temperatures of 50°C (provided water standards are met for bacterial growth in systems that supply domestic hot water). Lower distribution temperatures will result in reduced heat loss.

v Over 68 percent of district energy systems in Canada today use natural gas as a fuel. (Source: Canadian Energy and Emissions Data Centre, District Energy in Canada, 2019)

vi Heat is typically transferred from the distribution network into the building via a heat exchanger. In such cases, the building’s HVAC system must run at temperatures lower than the temperature of the water supplied by the district energy system. Alternatively, municipalities may use low-temperature heat sources if they install heat pumps in each building. This requires more sophisticated HVAC equipment in every building. Such systems can be more efficient but will tend to be more expensive.


xii Ibid.

xiii Natural Resources Canada, Comprehensive Energy Use Database, Residential Sector, Table 2, 2016.

xiv Natural Resources Canada, Comprehensive Energy Use Database, Commercial/Institutional Sector, Table 4, 2016.


xvi City of Vancouver, False Creek Neighbourhood Energy Utility.


xviii Federation of Canadian Municipalities, Case study: Richmond’s sustainability initiatives—always ahead of the curve.


xx Ibid.

xxi Natural Resources Canada, Sustainable Buildings and Communities Group, Community Energy Systems.

xxi Vancouver Green Capital, Neighbourhood Energy Utility.

xxiii City of Vancouver, False Creek Neighbourhood Energy Utility.


xxvi Ibid., p. 57.


xxviii Federation of Canadian Municipalities, Case study: Richmond’s sustainability initiatives—always ahead of the curve.
Community-level solution
Wind and solar energy generation

What is community-level wind and solar energy generation?

Community-level wind and solar energy generation is a form of community renewable energy generation. For the purposes of this factsheet, “community renewable energy generation” refers to renewable energy projects, owned by local residents, businesses or municipalities, that provide electricity to multiple buildings within the community. Project sizes can vary significantly—from rooftop systems as small as a few kilowatts (kW) to multi-megawatt (MW) installations sited on larger municipal buildings or ground-mounted. This factsheet focuses on wind and solar community energy generation, but projects may also be developed for micro-hydro, geothermal, biomass or other sources of renewable energy.

Municipalities can be directly involved in community wind and solar energy generation by owning or leading the development of these systems in the community (which may include offering shares in the system to local residents and businesses) or by providing funding, land or infrastructure. Alternatively, municipalities can be indirectly involved by offering financial, administrative or educational support to help other parties establish community energy systems that offer renewable energy services to local customers.

Advantages

- Energy dollars remain in the community, through local energy generation and by potentially reducing energy spending.
- Community renewable energy projects cost less, due to economies of scale compared to smaller, customer-sited projects.
- Local economic development occurs through local jobs and non-energy spending.
- Projects can improve community resiliency at the local level by providing power to critical infrastructure during grid interruptions—if implemented with energy storage and designed as a microgrid that can be disconnected from the grid during outages.
- Greenhouse gas (GHG) emissions may be reduced and air quality improved by displacing electricity generation from fossil fuels.
- Renewable energy can be expanded to non-traditional segments, such as renters, apartment dwellers, and buildings without appropriate roof or land space for solar PV or other technologies.

Challenges

- Complex management structures may render project set-up challenging for some municipalities.
- Municipalities may lack expertise and awareness around energy projects, regulations and other actions required to establish community energy systems.
• The need for early engagement with the local utility is critical and is often overlooked.
• Local regulations may require the taxation of proceeds from energy sales.

• Provincial/territorial regulations and utility operations may pose a barrier, especially where net-metering is not offered or the governing regulations restrict the size, configuration or ownership of net-metered systems.

How does this solution work and why is it important?

This factsheet focuses on a community ownership model for wind and solar energy generation projects, where the projects are sited on a municipal building, municipally owned land, or other (privately owned) buildings within the community. Under this model, local households, businesses or the municipality own (or co-own) and develop a local renewable energy project and sell the electricity to the local utility.

On high-carbon grids, community wind and solar energy generation can reduce GHG emissions and air pollution by displacing electricity generated by fossil fuels. On low-carbon grids, community renewable energy projects can play an important role in ensuring adequate supplies of clean electricity for jurisdictions seeking to electrify heating and transportation. For all grid types, this model allows energy dollars to stay in the community, and supports local economic development by creating jobs in project construction and operation. Projects will also support the economy outside of the community, such as through consulting, contracting and other services.

Community energy generation can offer access to wind and solar power for those who do not have roof space or land to host their own system. It can also create an economy of scale that results in lower-cost access to renewable energy. These systems can be designed to operate as grid-tied assets or can be disconnected from the grid. They can also be paired with battery storage for increased supply and resiliency (see the text boxes, “Renewable energy procurement: Another option for municipalities” and “Storage-paired wind and solar”).

Need funding for your energy project? Contact FCM!

Access grants and loans for energy-efficiency and clean energy solutions that support service delivery in your community.

• Improve efficiency and reduce GHG emissions in municipal and community buildings
• Integrate renewable energy generation solutions
• Plan, refine and scale-up innovative financing programs for residential retrofits

Learn more!
Renewable energy procurement: Another option for municipalities

In addition to owning, promoting or participating in community renewable energy generation projects, municipalities may also pursue other paths to expand their renewable energy portfolios.

Municipalities can procure electricity from retailers or developers through Power Purchase Agreements (PPAs) for their own buildings or, in some cases, by aggregating the collective consumption of local community members. This may be done through traditional or virtual PPAs, depending on whether the municipality is in a regulated or deregulated electricity market:

- **Traditional PPA (deregulated markets only):** This is a contract for renewable energy delivery. The municipality still receives electricity service from its utility, but is also provided with a proportion of its electricity through a third-party retailer or developer. The municipality signs a PPA (i.e. a long term contract) with this third party, which will generate renewable energy either on- or off-site, which is then delivered to the municipality through the grid.

- **Virtual PPA (regulated and deregulated markets):** This is a financial contract that allows for the acquisition of off-site renewable energy. The municipality continues to purchase electricity from its existing utility company, while purchasing Renewable Energy Certificates “RECs” at a set fixed price from a renewable energy project developer. RECs reflect a value that is based on a project’s energy output and associated environmental attributes. The project developer sells the energy generated by the project at market price to the local grid and passes any difference between the market price and the set fixed price through to the municipality. Projects are often located in other jurisdictions to benefit from competitive renewable energy procurement programs, incentives and prices.
Storage-paired wind and solar

Historically, large-scale pumped-hydro storage comprised the vast majority of electricity storage. With the increased penetration of wind and solar energy, significant technological improvements, and cost reductions over the past few years, battery storage technologies have emerged as critical components of a modern, secure, reliable and low-carbon grid. Batteries have several distinct features that make them a unique resource:

- **Scalability**: Battery systems can be as small or large as desired and can be sited behind the meter (i.e. customer-sited) or at the transmission and distribution levels.

- **Versatility**: Battery storage can provide a range of services to utilities, system operators and customers, such as reducing peak capacity requirements, allowing for energy arbitrage, providing grid ancillary services, reducing building energy demand during peak periods, reducing bills, and increasing resiliency during outages.

- **Stackable value**: Battery systems are designed to provide multiple, stacked services to optimize value and financial returns. For example, the primary service may be solar self-consumption, but secondary services may include time-of-use optimization or demand charge management.

Wind/solar-plus-storage solutions can offer the following key benefits:

- enhanced resiliency during outages
- increased self-consumption of produced electricity and maximized exports to the grid
- reduced building peak demand charges
- optimized electricity purchases and exports under time-of-use rates

Battery costs vary significantly based on technical characteristics (such as power output and energy capacity). The estimated cost is $1,500–2,500 per kW of power installed ($500–750 per kWh of energy consumed). It should be noted that the simultaneous installation of a new solar PV system and battery storage can result in a 10 percent cost savings compared to adding battery storage to existing rooftop systems, because everything can be installed more efficiently.

Looking to the future, an increasing share of solar and wind uptake is expected to be storage-paired, as customer interest in self-supply continues to increase, battery costs continue to decline, and more jurisdictions implement changes to their electricity compensation mechanisms or rate structures (e.g. adopting net-billing, time-of-use rates or demand charges).
**Is this solution right for my municipality?**

To determine the GHG impact and economic feasibility of wind and solar community energy generation for your municipality, consider the following questions:

- **What is the carbon intensity of the grid?** The GHG emissions reductions achieved by switching to solar and wind are dependent on the carbon intensity of the displaced electricity. Solar and wind energy generation will reduce emissions less in areas that are already being supplied by a cleaner electricity mix than in locations with a carbon-intensive grid. Additionally, the coincidence between solar and wind energy generation and the jurisdiction’s peak load could impact the associated GHG reductions. For example, some utilities use carbon-intensive thermal-fired power plants during peak load hours to meet demand. This conventional, carbon-intensive generation is best displaced by solar generation in summer-peaking areas that have high coincidence between solar production and peak demand.ii

- **Is there a need to ensure adequate clean electricity supply to support future electrification?** While wind and solar may not reduce GHG emissions in the near-term in municipalities with low-carbon electricity grids, these renewable energy sources may play a critical role in ensuring adequate clean electricity supply as these municipalities prepare to electrify heating and transportation. Moreover, local wind and solar projects will allow energy dollars to be kept in the community.

- **How significant is your municipality’s renewable resource potential?** While community energy projects can use several renewable energy technologies, solar PV and wind are the most common. Figure 1 shows the technical potential across Canada for both solar (in terms of kWh produced per kW installed) and wind (in terms of wind speed).

---

**Figure 1:** Solar and wind potential across Canada (energyhub.org, 2019)

Solar

Wind

---

**FCM Green Municipal Fund**

193
While the numbers provide a high-level estimate of potential, you need to do a site-level assessment to account for local conditions and characteristics and accurately estimate the energy production of a project. A variety of tools are available to conduct an initial assessment of site-specific resource potential, including Natural Resources Canada’s RETScreen and the U.S. National Renewable Energy Laboratory (NREL) PVWatts® Calculator. If your municipality does not have in-house expertise to run these models (which is not uncommon), the analysis can usually be done by a consultant for just a few thousand dollars. These assessments are not rigorous enough to be “bankable,” but will provide a rough overview of the potential for solar or wind energy (or both) within your municipality, as well as a high-level financial overview to indicate whether a project may be worth exploring further (e.g. through full resource assessments, consulting or other steps).

- **Are the right enabling policies in place?**
  The enabling policy framework, as set by the local energy regulator, utility or provincial/territorial government, together with the local market conditions, will impact cost-effectiveness and dictate available options for revenue generation. As policies change (often in response to shifting political landscapes) the business case for renewable energy generation systems may change. Policies vary widely over time and across the country. Key policies include:

  - **Net-metering:** Under a net-metering arrangement, customers typically get full retail credit for energy exported. Where net-metering is in place, a municipality or other project participants finance or share the financing of the system. The system is installed at and generates electricity for a host site (such as a municipal building or local school). The utility bill savings the host enjoys are redistributed to project participants as monetary returns. Therefore, the objective is not to sell electricity, but to self-supply (i.e. to meet the energy needs of the host site). For a community-based project, this model usually entails establishing a co-op or other entity to represent members/owners (described further in the next section). Net-metering is currently in place in all provinces and territories across Canada, although at different rates.

  - **Virtual Net Energy Metering (VNEM) or similar policies:** Similar to net-metering, where excess renewable energy generated from a local household or business can be delivered to the grid, under VNEM, the utility bills of project owners or subscribers are directly credited (through bill credits) with the electricity produced by their share of the project. This setup results in energy generation and savings that are similar to individual homes, businesses or the municipality installing solar panels on their buildings or facilities. Currently VNEM is not widely available across Canada.

  - **Feed-in-tariffs, bilateral agreements and deregulated markets:** Municipalities or other project participants finance or share the financing of the system, which is installed to meet grid-level energy needs. The revenues generated from the energy sold to the grid are then shared among project participants as monetary returns. This model usually entails establishing a co-op or other entities to represent members/owners (described further in the next section).
**What does it take to implement?**

If community energy generation is appropriate for your municipality, you can take a number of actions to drive adoption, based on your municipality’s resources, objectives and appetite for risk. Figure 2 provides a high-level overview of possible actions.

**Figure 2: Possible actions for municipalities**

- **Direct involvement**
  - Lead/own
    - **Action:** Develop a new energy project or join an existing one (alone or with partners)
  - Participate
    - **Action:** Provide funding, land or infrastructure
  - Incentive/finance
    - **Action:** Launch incentive or financing programs for individuals or communities

- **Indirect involvement**
  - Education & support
    - **Action:** Launch a “one-stop shop” for community members looking to start a project
  - **Incentive/finance**
    - **Action:** Provide resources to educate and support (technical analysis, global awareness, etc.)

If your municipality is seeking direct involvement in a community energy project, consider the following options:

- **Lead or own a project by developing plans or joining an existing project.** You can lead projects by developing plans, financing projects (or securing financing) and seeking participants for local projects. This proactive approach allows you to align projects with your municipality’s energy and environmental goals and accelerate the deployment of clean energy technologies within your community. However, this approach typically involves greater risk, since revenues and energy benefits could be tied to asset performance ($/kWh).

- **Participate by providing land, infrastructure or financing.** Through such participation, your municipality can receive monetary and energy benefits without necessarily doing the leg work to develop and run the project. For example, your municipality could rent land for a wind project or offer a municipal building rooftop for a solar project. This approach is similar to leading or owning a project but involves less risk, since the benefits your municipality enjoys will not be tied to the project’s monthly financial performance. You can also encourage the participation of other community members.
If you choose to lead, own or participate directly in a community energy project, the following steps and considerations will be key:

- **Design the project with a renewable energy developer.** To lead or own a project, your municipality will need to create a bankable solar/wind resource assessment and energy yield forecast based on on-site measures, site selection, system sizing, financing approach, and other key considerations. The time required to develop a project can range from a couple of months (for small-scale projects) to multiple years (for larger projects).

- **Form a new legal entity.** To lead, own or participate directly in community energy projects, you may consider forming a special legal entity—usually a co-operative (co-op)—that is collectively owned and controlled by members. The co-op is then responsible for all administrative tasks related to the project. Municipalities and other project participants purchase securities in the form of shares or bonds that represent their share in the project and receive benefits accordingly. Creating an entity like this can be beneficial to ensure the independence of the project (e.g. with an independent board of directors) and to improve management of the project. Some entities may restrict ownership to local community residents and businesses or set minimum requirements for majority local ownership (e.g. “50 percent plus one” local ownership).

Your municipality may also consider the following indirect forms of involvement:

- **Set up municipal programs offering incentives or financing.** These types of programs can encourage participation in community energy projects. Such programs are becoming popular for individual rooftop solar systems, and can also be offered at the community scale. For example, you can offer an incentive to owners of multi-unit residential buildings to install rooftop solar. You may also support community energy systems by purchasing the renewable energy to expand your municipality’s clean energy portfolio and receive Renewable Energy Certificates (RECs).

- **Offer education and support.** This may include assisting with technical analysis, providing legal and regulatory support, launching a “one-stop shop” for community members wishing to start new projects, and promoting general awareness about community renewable energy projects and their benefits.

**Other key considerations**

A number of other considerations will be key if your municipality is involved in community energy projects, whether directly or indirectly:

- **Assess your internal capacity for project administration and development.** Community energy projects with complex structures require market, technical, legal and financial skills and knowledge. Your municipality should have sufficient internal capacity to handle tasks and identify partnerships or entities (consultant, service providers, etc.) that could support project development.
• **Ensure community engagement and social acceptance.** Adequate consultations will be needed with local community members to obtain their buy-in, particularly around land use. Project siting must balance both resource availability and social acceptance. Overlaying these two considerations on a map can be an effective tool for planning.

• **Engage with utilities.** While utilities do not need to be directly involved in community energy projects beyond their typical responsibilities regarding project inspection, interconnection, metering and other related aspects, some utilities have expressed interest in community-based energy projects and may be well-positioned to support and enable project development. In some cases, community energy projects may align with existing utility initiatives for energy procurement, demand-side management, environmental compliance and other goals. You should engage with utilities early on to determine what (if any) support they can provide and whether they need to upgrade infrastructure in order to receive the generated energy.

• **Review provincial/territorial and federal programs.** A number of provinces and territories across Canada, such as Nova Scotia and Alberta, have established programs to incentivize the deployment of community-based energy projects. Programs may offer direct financial incentives, capacity building or support in project development.

• **Understand tax implications.** Local regulations may result in the taxation of received monetary benefits. For example, revenues from wind or solar assets that are earned by an entity owned by the municipality will be taxed according to current corporate taxation laws.

### What are the GHG and financial impacts?

#### GHG reductions
The GHG emissions reductions from a community energy project are dependent on several parameters, including:

- the carbon intensity of grid electricity being displaced by the project
- uptake levels in the community
- project size
- the choice of generation technology (e.g. wind, solar) and its energy production potential

#### Project costs
Solar and wind costs have declined significantly over the past decade and are forecast to drop further over the coming decade. System costs are often quoted and presented in various metrics:

- **Unit installed cost**, such as dollars per watt, reflects the installed cost of a system, including equipment, auxiliary hardware, installation and other related costs.
- **Unit cost of energy**, such as levelized cost of energy (LCOE, expressed in dollars per kWh), reflects the full-unit cost of electricity produced by the project over its lifetime.
Table 1 presents rough cost estimates for different-sized solar and wind power projects, based on recently announced renewable energy procurement and auctions—and provides utility-scale costs of coal and natural gas for comparison purposes. Cost ranges reflect variations in local market competitiveness and soft costs (labour, permitting, transport, etc.). “Levelized cost of energy” metrics will also vary significantly by location, based on local resource potential, installed costs, and other site-specific factors (e.g. distance from interconnect, complexity of construction terrain for turbines, etc.). As with most technologies, as a result of economies of scale, the larger a system is, the lower the unit cost will be on a “dollar per watt” basis. This is particularly true for wind energy. In addition to the project installation and operation and maintenance costs shown below, community energy projects may incur additional costs for things like project development, feasibility studies and setting up legal entities.

### Table 1: Indicative cost estimates for solar and wind systems

<table>
<thead>
<tr>
<th>System size</th>
<th>Solar</th>
<th>Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small-scale</td>
<td>Community-scale</td>
</tr>
<tr>
<td>Unit installed cost ($/W)</td>
<td>2.5–3.5</td>
<td>1.5–2.5</td>
</tr>
<tr>
<td>Unit cost of energy ($/kWh)</td>
<td>0.2–0.3</td>
<td>0.1–0.15</td>
</tr>
</tbody>
</table>

Source: Estimates by Dunsky Energy Consulting, based on recent public project costs, industry input and professional judgement.

Wide-scale deployments over the past decade have resulted in significant cost reductions in solar PV and wind, with further cost reductions expected to occur over the next decade as a result of increasing uptake and technological advancements.
What have municipalities done?

**City of Nelson: Community Solar Garden**
City of New Westminster: Urban Solar Garden
The cities of Nelson and New Westminster, BC, launched the Community Solar Garden and the Urban Solar Garden, respectively. These solar gardens are centralized solar PV systems that are owned and operated by each city. The systems are funded by subscriptions from city residents, who can purchase panels and receive credits on their electricity bills for an amount proportional to their share of the energy produced for up to 25 years.

**Municipality of Pierre-De Saurel: Municipally owned wind farm**
The Municipality of Pierre-De Saurel, QC, built its own wind farm and created a separate legal entity that manages and is responsible for the wind farm. The municipality financed the project and is the sole owner. The wind farm has been in operation since 2016.

**City of Summerside**
The City of Summerside, PE, built its own 12 MW wind farm in 2009 with financial support from the provincial and federal governments. The wind farm is run by the city’s electric utility, which is 100 percent municipally owned. In 2018, it supplied 46 percent of the city’s electricity.

**City of Ottawa: Ottawa Renewable Energy Co-operative and CoEnergy**
The Ottawa Renewable Energy Co-operative (OREC) and its new cooperative, CoEnergy, develops or purchases solar PV projects in partnership with local schools, institutions, municipalities and businesses in Ottawa, ON. Electricity produced by these projects is sold to the grid or directly to the project host, and profits are returned to the co-op’s members in the form of dividends. Community grants from the City of Ottawa have helped to pay for energy audits of multi-unit residential buildings that will ultimately benefit from CoEnergy-led retrofit projects.

**City of Toronto: SolarShare**
SolarShare is a renewable energy co-operative, founded by the Toronto Renewable Energy Co-op, that develops solar PV projects across Ontario. Residents and businesses can invest in these projects by purchasing bonds that earn up to six percent interest.

**City of Boston: RFI on large-scale renewable energy projects**
The City of Boston, MA, along with 19 other municipal governments across the United States, has issued a Request for Information (RFI) to renewable energy project developers to understand how the aggregated load of the 20 cities (estimated at nearly 5.7 TWh) can be leveraged to obtain competitive prices under a power purchase agreement (either physical or virtual).
What resources can support next steps?

**Alberta Community Solar Guide:** *Organizing and owning community solar PV projects*, Pembina Institute, 2017
This guide includes a lot of general information on solar projects as well as specifics on Alberta’s electricity market and regulations.

This toolkit is heavily geared toward co-operative and independent legal entities and describes the basic steps to developing a co-operative.

**Least Conflict Lands: Municipal Decision Support Tool for Siting Renewable Energy Development**, Miistakis Institute, 2018
This document assesses work that other jurisdictions and organizations have undertaken to assist with municipal decision-making and siting for renewable energy development.

This report outlines the environmental, social and economic benefits of locally owned and operated renewable power.

**Business Renewables Centre**
The Business Renewables Centre (BRC) is a non-profit initiative seeking to catalyze the market for non-utility procurement in Canada to grow renewable energy development in the country.

**Progress and Potential for Community-scale Solar**, Rocky Mountain Institute, 2018
This report discusses how electric cooperatives can use distributed energy to save money.

**RETScreen**, Natural Resources Canada
RETScreen is a modelling software that allows users to identify, assess and optimize the technical and financial viability of potential clean energy projects.

**PVWatts® Calculator**, U.S. National Renewable Energy Laboratory (NREL)
This is an online calculator that allows users to size a solar photovoltaic (PV) system and estimate its performance and bill savings.

**WWF-Canada**
World Wildlife Fund Canada (WWF-Canada) has developed an interactive tool for Alberta, New Brunswick, the Bay of Fundy and Saskatchewan that helps identify renewable energy projects that avoid conflict with nature.
Endnotes

i This is the practice of purchasing and storing electricity during off-peak times when prices are low, and then utilizing or selling that stored power during periods when electricity prices are the highest.

ii These are the services needed to help maintain reliable operation of the interconnected transmission and distribution systems.

iii Maximum solar production usually occurs on summer days at around noon, whereas most Canadian provinces and territories are winter-peaking, meaning the highest power demand occurs in the early mornings or afternoons of winter days (because of the heating loads).

iv “Bankable” means that a project or proposal has “sufficient collateral, future cashflow, and high probability of success, to be acceptable to institutional lenders for financing.” (Source: BusinessDictionary)

v This depends on the net-metering legislation in place. Some jurisdictions may provide more or less than the retail rate.

vi This approach does still carry some risk, so due diligence may be required.
**Strategy**

**Lead by example**

**What are lead-by-example strategies?**

Municipalities can lead by implementing policies and demonstrating the practices they want to encourage within the community to reduce greenhouse gas (GHG) emissions and drive top-level energy performance in municipal buildings and facilities. Specifically, municipalities can use three main strategies in relation to buildings they own or those in which they lease significant space:

- **Energy performance standards:** Adopt high-performance building policies and practices, such as stringent building codes, targets, energy-efficiency procurement practices, and operational practices.
- **Benchmarking and disclosure:** Require benchmarking of building energy performance and public disclosure of that information.
- **Showcasing innovation:** Showcase and promote clean energy and energy-efficiency innovations through pilots and demonstration projects.

**Advantages**

- GHG emissions in municipal buildings are reduced and the buildings are more climate-resilient.
- Municipal asset management practices are strengthened (increasing asset value, reducing maintenance, replacement and repair costs, and reducing risks).
- Overall building stock is improved.
- Operational costs and wasteful spending are reduced.
- Local economic development is encouraged and the local workforce is trained.
- Municipalities can monitor progress toward energy and GHG reduction goals.
- There are opportunities to educate the broader community.
- Energy-efficient technologies and practices can be piloted and promoted, showcasing municipal leadership.
- Improvements safeguard the health and productivity of building occupants.
- Initiatives contribute to broader provincial/territorial and national policy and program objectives, for a stronger, larger community of building practitioners and leaders.

**Challenges**

- Benchmarking requires set-up time and ongoing (although low-level) commitment of resources to monitor progress.
- Financing may be needed to implement certain initiatives.
- Municipal accounting rules may need to be reviewed and modified to ensure that operation and maintenance (O&M) savings
FACTSHEET

generated through energy-efficiency projects are considered in capital expense decision-making.

- Internal capacity and support of senior leadership is required to develop policies, obtain broad buy-in and ensure uptake across departments.
- Some municipalities may not have the capacity or internal expertise to identify energy savings opportunities.
- Accounting rules may need to be adjusted to reserve energy cost savings from previous energy-efficiency projects to fund future projects.

How do these strategies work and why are they important?

Strategies that target municipally controlled assets are a logical starting place for encouraging GHG reductions and top-level energy performance. Because energy-efficiency and clean energy solutions can result in significant cost savings, lead-by-example strategies align well with long-term objectives for asset management and fiscal responsibility. As an added bonus, they send a clear signal to local contractors, who may adapt their own internal training and tools as a result. By setting in motion this chain of actions, municipal leadership can pave the way for the broader community to adopt similar practices at lower cost and with less hassle, whether by choice or as a requirement.

Energy performance standards, benchmarking and disclosure, and showcasing innovation are three broad strategies that can be used in a number of different ways to demonstrate leadership and encourage GHG reductions:

1. **Adopt high-performance building policies and practices:** Municipalities can require top-level building energy performance in a number of different ways through the adoption of building policies and practices. For example:
   - Adopt more stringent energy code or performance requirements for new buildings (e.g. link to existing standards like LEED® (Leadership in Energy and Environmental Design) or the Zero Carbon Building Standard).

Need funding for your energy project? Contact FCM!

Access grants and loans for energy-efficiency and clean energy solutions that support service delivery in your community.

- Improve efficiency and reduce GHG emissions in municipal and community buildings
- Integrate renewable energy generation solutions
- Plan, refine and scale-up innovative financing programs for residential retrofits

Learn more!
• Require stringent energy performance—or require performance improvements at the time of major retrofits to existing buildings (using performance standards such as ASHRAE 90.1 or ASHRAE 100).

• Set targets to reduce the energy consumption of all existing buildings over time. These targets would apply whether or not retrofits are planned.

• Require that estimates of lifetime energy costs or GHG emissions, or both, be included with all contractor bids. Consider this information when evaluating bids for major renovation work.

• Establish procurement requirements for the energy efficiency of products (e.g. ENERGY STAR®).

• Include objectives for energy savings or GHG emissions reductions, or both, in employee performance reviews and as top-level departmental objectives.

• Change operational practices and behaviours to improve energy management. This should include an educational component for operators and tenants.

• Require building commissioning for all new construction. When a new building is commissioned, it should undergo an intensive quality assurance process that begins during design and continues through construction and occupancy of the building. Commissioning ensures that the new building operates initially as the owner intended and that building staff are prepared to operate and maintain its systems and equipment.

• Require recommissioning or retro-commissioning to improve how the building equipment and systems function together. This is done for existing buildings, either by optimizing a building that was previously commissioned (recommissioning) or by performing commissioning activities for a building that wasn’t previously commissioned (retro-commissioning). Depending on the age of the building, re- or retro-commissioning can often resolve problems that occurred during design or construction, or address problems that have developed throughout the building’s life. Re- or retro-commissioning improves a building’s operation and maintenance (O&M) procedures to enhance overall building performance.

2. Require benchmarking and disclosure of energy performance: Benchmarking policies require building owners or operators to track, benchmark and report on their building energy performance. While many municipalities require this of commercial and residential buildings, they can also lead by example: they can require the same thing for their own building stock, showing transparency. Municipalities that do so have a better understanding of the performance of their assets and can more easily set goals, plan improvements and monitor progress. These policies also help municipalities identify and prioritize energy-efficiency and clean energy opportunities.


3. **Showcase clean energy and energy-efficiency innovations**: Municipalities can showcase and promote innovative GHG reduction strategies, create demand for clean energy and energy-efficient technologies and services, and drive local capacity for such products and services.

For example:
- Pilot new technologies and best practices through demonstration projects.
- Demonstrate proof of concept.
- Create learning opportunities for the public and private sectors.

---

**Metro Vancouver’s Carbon Price Policy showcases corporate innovation**

In 2017, Metro Vancouver adopted a Carbon Price Policy allowing Metro Vancouver to incorporate climate change mitigation into business cases. The policy also helps to mitigate the financial risk of potential increases in provincial or federal carbon taxes in the future, given that the service life of the municipal infrastructure can be as much as 50–100 years.

The Carbon Price Policy sets out a price of $150 per tonne of CO$_2$e for financial calculations when analyzing options for projects and initiatives in Metro Vancouver.


---

**Are these strategies right for my municipality?**

In deciding the best way for your municipality to lead by example, consider the following questions:

- **Does your municipality have a broader strategy in place to achieve corporate emissions reduction targets?** If so, you can take a systemic, portfolio-wide approach and identify the most substantial energy-efficiency and clean-energy projects and policies that would set an example.

- **Have you prioritized GHG reduction measures?** Once you’ve defined municipal priorities, you’ll be able to identify the most appropriate lead-by-example strategies.
What does it take to implement?

If your municipality is ready to pursue a lead-by-example strategy and drive top-level energy performance, you will need to take several actions. Although the implementation process will vary depending on the lead-by-example strategies your municipality chooses to pursue, the following steps can help guide you:

1. Obtain a municipal commitment.
2. Identify and prioritize actions to improve energy performance.
3. Engage stakeholders.
4. Implement building energy initiatives.
5. Evaluate performance.

Obtain a municipal commitment

The first step in implementing a lead-by-example strategy is to commit to improving energy performance in a portfolio of buildings. This step can involve setting out your objectives to adopt energy performance standards or to require benchmarking and disclosure. A municipal commitment also lays the foundation for showcasing innovation. Obtaining a municipal commitment involves two key actions:

- **Establish an energy policy team.**
  An interdepartmental team of personnel can initiate and lead the process of developing an energy performance policy for buildings your municipality owns or leases. This will help to ensure a robust policy that has broad support and considers your municipality’s operational context, goals and limitations. The approach used for municipal buildings as a group can also be applied within individual facilities.

- **Establish a formal commitment.** Based on input from the energy policy team, the next step is to formalize your municipality’s commitment to improving energy performance. You can use a range of mechanisms, including mayoral or executive initiatives, council resolutions, planning processes (e.g. creation or updating of energy plans) and zoning bylaws. Any formal statement of your municipality’s commitment should clearly outline your municipality’s objectives, including specific actions, and should include an evaluation and revision date (e.g. five years). Making the link between this new commitment and existing related initiatives can help secure support from elected officials and municipal departments. This leads to more effective implementation of energy-efficiency or clean energy projects.

Support in securing council commitment:

**FCM – ICLEI Partners for Climate Protection program**

The Partners for Climate Protection (PCP) program is a network of over 400 Canadian municipalities that have committed to a five-milestone program to reduce both corporate and community emissions. The PCP program is an avenue for municipalities to secure council commitment. Municipalities can access relevant tools and capacity support for energy and emissions monitoring and reductions.

Learn more about the [Partners for Climate Protection](#) program.
**Lead by example**

**Identify and prioritize actions to improve energy performance**

Once you’ve obtained a municipal commitment, you can then identify and prioritize the lead-by-example strategies you will apply—energy performance standards, benchmarking and disclosure or showcasing innovation, or some combination of these strategies.

To choose which buildings your strategies will focus on, it’s important to understand the energy use in the various facilities you own or lease. This allows you to target the facilities in greatest need of improvement or to prioritize the most cost-effective measures. By maximizing energy cost savings, you can demonstrate good asset management, pursue more substantial energy projects and generate momentum for clean energy and energy-efficiency activities in the public and private sectors.

Energy management assessment tools, such as Carbon Trust’s self-assessment tool, are a good starting place to identify strengths and zero in on the greatest opportunities for improvement. You can also prioritize measures based on your municipality’s broader objectives. For more detail, see the section, “What are the GHG and financial impacts?”

---

**Benchmarking best practices**

Benchmarking the energy and emissions performance of municipal facilities can help you understand the building stock, establish a baseline, prioritize facilities for improvements and track performance over time. Benchmarking results may be disclosed to the public to enhance visibility and support current and future energy rating and disclosure requirements. As projects are implemented, energy savings should be tracked and reported.

Financial assistance to support municipal benchmarking initiatives is available from Natural Resources Canada. You can also finance energy-efficiency and clean energy improvements through equipment leases or enter into energy service agreements (ESAs) by partnering with local energy service companies. See the Financing Options factsheet for more information.

Municipal facilities are often benchmarked using ENERGY STAR® Portfolio Manager, a standardized, free, secure, web-based building energy benchmarking platform available across Canada. Other tools include:

- **Standard Energy Efficiency Data (SEED) Platform**: This open-source web application complements Portfolio Manager and supports benchmarking programs by helping users manage and report building performance data securely and cost-effectively, using data from various sources.

- **RETScreen**: This is a software system developed by Natural Resources Canada for clean energy projects that analyzes the feasibility of energy-efficiency, renewable energy and cogeneration projects, as well as ongoing energy performance.
Engage stakeholders

Lead-by-example strategies require buy-in and engagement from a broad range of internal and external stakeholders. Consider the following activities:

- **Get buy-in and support from the mayor and city council and build a dedicated team across multiple departments.** This cross-cutting team (which may include energy and environment, procurement, legal, planning, and facilities management, among others) will work together to implement, monitor and continually improve actions. Identifying an energy-efficiency or clean energy champion within each department can also help ensure that your planned measures are implemented.

- **Train staff to ensure that energy-related improvements are sustained.** You can coordinate training sessions for employees and facility maintenance teams. Your municipality can conduct these sessions or you can engage external organizations such as the Canadian Institute for Energy Training. Energy training can be included in employee onboarding sessions, awareness and engagement campaigns, competitions, and initiatives to report energy waste (e.g. leaks, doors left open, lights on, etc.).

- **Partner with external stakeholders to achieve your lead-by-example objectives.** These stakeholders can include:
  - Other local governments and regional entities—to enhance public awareness, compare implementation approaches and exchange information
  - Provincial/territorial energy offices—for technical and financial assistance
  - Utilities and other energy-efficiency program administrators—for technical and financial assistance
  - Energy service companies—to perform energy audits and upgrades
  - Non-profit organizations—to aid in planning and implementing energy-efficiency projects

- **Communicate results to sustain momentum and support for energy-related activities.** Staff will want to know the results of their efforts and the progress being made toward goals. You can celebrate successes and re-evaluate activities that require improvement. It’s also important to engage the community, to ensure public support and buy-in for allocating taxpayer dollars to the program.

Implement building energy initiatives

Action plans and funding strategies can help you implement successful energy-efficiency and clean energy initiatives:

- **Create an action plan.** A regularly updated action plan can serve as a roadmap to achieve municipal energy-efficiency and clean energy goals by systematically improving energy performance in new and existing buildings. To create an action plan:
  - Establish energy performance targets for each building.
  - Consider a staged approach to implementing measures to meet your performance targets. This approach could focus on the most cost-effective and feasible measures first, and then on longer-term projects.
• Base your energy management practices on the standard principles of ISO 50001.
• Identify the resources necessary to implement your action plan.
• Determine the responsibilities of internal and external parties.
• Develop a process to evaluate progress.

**Identify funding options.** Upfront costs can be a barrier that hinders municipal efforts to improve energy efficiency in facilities and operations and switch to cleaner energy, even though such investments earn returns over time. It is critical to leverage existing resources. Funding options for energy-efficiency investments are summarized below.

- **Capital and operating budgets:** Using funds from your capital or operating budget avoids the need to negotiate financing arrangements and pay interest. However, municipal accounting rules may need to be reviewed and possibly modified to ensure that capital projects for clean energy and energy efficiency are credited with the operation and maintenance (O&M) savings generated.

- **Green revolving funds:** Many municipalities fund purchases of energy-efficient technologies and clean energy projects that generate cost savings by setting up an internal capital pool dedicated to such projects. A portion of the cost savings generated by each project is used to replenish the fund, allowing for reinvestment in future projects of similar value. These are known as green revolving funds. They serve as an ongoing funding vehicle to help drive energy efficiency and sustainability over time.

- **Energy performance contracts:** An energy performance contract is an arrangement with an energy service company or energy service provider that allows a municipality to finance energy-saving capital investments, typically over a term of 7-15 years, with no initial capital investment. The energy service company often provides a guarantee that energy cost savings will meet or exceed annual payments covering the cost of the capital investments being funded. For example, The Atmospheric Fund (TAF) developed the Energy Savings Performance Agreement (ESPA™) to help multi-residential, institutional and commercial buildings finance energy-efficiency retrofits without drawing on building owners’ capital or reserves.

- **Lease purchase agreements:** A tax-exempt lease purchase agreement (also known as a municipal lease) allows governments to finance purchases and installation over long-term periods using operating budgets rather than capital budgets. Tax-exempt lease purchase agreements typically require only internal approval, a process that can often take as little as one week (as opposed to months or years for bonds). You can expedite the process by adding energy-efficiency projects to existing tax-exempt lease purchase agreements.

- **Government loans, rebates and other assistance:** Some provincial governments have created municipal financing authorities to contribute to the financial well-being of municipalities. Through these financing authorities, municipalities can access
low-cost, flexible long-term and short-term loans, equipment financing and other services. Other assistance is available through FCM (grants and loans for innovative and impactful projects), the federal, provincial and territorial governments, utilities, and energy-efficiency program administrators. (For more information, see the section, “What resources can support next steps?”)

• **Public bonds:** Bonds are well-suited for energy-efficiency and clean energy projects since they allow amortization of capital costs over a multi-year repayment term. Municipalities can recover their costs through energy savings over the life of the project.

• **Partnering with neighbours:** Partnering with neighbouring cities and towns to aggregate purchases can achieve economies of scale to reduce costs. Moreover, partnering can create a peer network for exchanging information and sharing best practices.

**Evaluate performance**

A critical component of any project is to measure whether it has achieved its intended energy performance goals. Evaluating performance involves several steps:

• **Develop an evaluation plan.** The plan should include key performance metrics (quantitative and qualitative).

• **Establish a baseline at the outset of the project (for new and existing buildings).**

• **Collect and track data throughout the process.**

• **Conduct a formal evaluation to measure results.**

• **Commit to ongoing benchmarking of energy performance.** You can use a tool like ENERGY STAR® Portfolio Manager.

You can evaluate, measure and verify results yourself or use an independent third-party evaluator. Evaluation, measurement and verification should follow internationally recognized protocols (e.g. the International Performance Measurement and Verification Protocol). You may need to adapt these protocols to suit the size of your municipality or project and your capacity and resources.

You can follow up on this evaluation by further showcasing the most innovative and successful projects.

**What are the GHG and financial impacts?**

GHG reductions, costs and cost savings associated with lead-by-example practices and policies will vary considerably depending on the local context. See the text box, “City of Spruce Grove Green Building Policy,” for an example of what was achieved by one Alberta municipality.

In addition to increasing building efficiency and reducing GHGs, lead-by-example strategies present several co-benefit opportunities:

• Make municipal buildings more climate-resilient.

• Pilot new technologies.

• Train and invest in the local energy-efficiency workforce.

• Educate the broader community.

• Showcase municipal leadership.

For example, installing solar PV panels on a high-visibility municipal building rooftop, with accompanying training and education campaigns, provides benefits well beyond GHG reductions.
City of Spruce Grove Green Building Policy

To manage energy costs and reduce emissions, the City of Spruce Grove, AB, created its Green Building Policy. As part of this policy, Spruce Grove requires Leadership in Energy and Environmental Design (LEED®) certification for all new, existing and leased buildings. Since 2005, the city has upgraded many of its facilities, including renovating city hall to LEED® standards. One of the city’s newer buildings, constructed in 2016, a 7,172 m² public works facility, features a geothermal heating system, a solar wall, solar water heating, rainwater recovery, and wash bay water recycling.

The benefits of the City’s LEED® requirements have been multifold:

- Between 2011 and 2016, the city reduced emissions from its entire building portfolio by 992 tonnes (20 percent).
- The public works facility uses about 40 percent less energy than a conventional building of the same size.
- The city’s 2015 corporate energy costs were the lowest recorded per-unit cost in its history (since 1996). If prices in 2015 were equal to those in 2003, and if the city had made no conservation efforts, its energy bill would have been $2.5 million, more than double its current expenditure.
- The public works facility uses a rainwater catchment system to wash its vehicle fleet, with any surpluses used for landscape watering.
- The city’s new and renovated buildings have better air quality and lighting, and more natural light. City employees are proud of the building, and it has created a more positive work atmosphere.

The city also replaced the majority of its traffic signal lights with LEDs and approved a flexible development standard (among other projects) that has yielded additional environmental, economic and social benefits.

What have municipalities done?

Energy performance standards

Town of Banff: Green Buildings and Facilities

Since 2007, the Town of Banff, AB, has had a policy requiring that all new municipal buildings greater than 500 m² be built to meet or exceed the LEED® Silver standard. New municipal buildings smaller than 500 m², renovations and other projects where a LEED® standard may not apply are designed and built to reflect similar triple bottom line principles. Co-benefits include alignment with energy management and GHG emissions commitments, reduced operating and life cycle costs of buildings, and encouragement of materials reuse and recycling. In addition, the policy clearly outlines specific responsibilities for various municipal departments, including planning and development, engineering, operations and corporate services.
**City of Calgary: Sustainable Building Policy**
Under the Sustainable Building Policy of Calgary, AB—the first such policy in Canada—all new occupied city-owned and city-funded buildings in excess of 500 m² must meet or exceed the LEED® Gold standard for new construction. Major renovations of occupied facilities must meet or exceed either the LEED® Certified standard for new construction or the LEED® Silver standard for commercial interiors. Minor renovations, unoccupied buildings, landscape and non-building infrastructure, and buildings less than 500 m² are directed to follow the City of Calgary’s sustainable building best practices.

**City of Mississauga: Green Building Standard for Municipal Buildings**
The Green Building Standard for Municipal Buildings being developed by the City of Mississauga, ON, will demonstrate that the city is “walking the walk” in addition to supporting green development in the private sector. The current draft version of the Green Building Standard identifies 16 critical LEED® credits and prerequisites that all new construction and major renovation of municipal facilities must achieve. Larger projects must achieve LEED® Silver certification, while small projects must focus on the 16 critical credits and prerequisites and attempt to achieve LEED® Silver certification, where possible.

**Town of Richmond Hill: Corporate GHG targets**
The Town of Richmond Hill, ON, first adopted a corporate GHG reduction target in 2004 of 20 percent below 2000 levels by 2009 (as well as a community reduction target of six percent below 2000 levels by 2010). Between 2000 and 2009, with population growth and a 33 percent increase in the total square footage of corporate facilities, the town reduced emissions associated with its corporate facilities by 36 percent. One step the city took was to install a ground source heat pump to serve the heritage component of the new Centre for the Performing Arts building.

**City of Toronto: Toronto Green Standard**
The City of Toronto’s Green Standard for new city-owned and private developments consists of tiers of performance measures with supporting guidelines that promote sustainable site and building design. Tier 1 of the Toronto Green Standard is required for planning approval, while Tiers 2 to 4 are higher-level voluntary standards associated with financial incentives, and are verified post-construction.

**City of Vaughan: 2019–2024 Corporate Energy Management Plan**
Vaughan’s Corporate Energy Management Plan outlines the Ontario city’s short-term (2024 and 2030) and long-term targets to reduce building energy and GHG emissions. The plan is based on the CaGBC Zero Carbon Building Standard to eliminate GHG emissions associated with the operations of new buildings by 2030 and eliminate GHG emissions from all buildings by 2050. The city’s plan highlights past successes and outlines next steps, actions and implementation plans, including the funding and capacity building needed to achieve the short- and long-term goals.
Lead by example

Benchmarking and disclosure

**City of Edmonton: Building Energy Benchmarking Pilot Program**
The three-year building energy benchmarking pilot program launched by the City of Edmonton, AB, aims to improve building energy efficiency and contribute to significant energy savings and GHG reductions by providing owners with information about their buildings. The pilot involves 55 properties (60 buildings), including offices, community recreation centres, arenas and waste management facilities. In the second year of the pilot, participating city buildings experienced a 1.7 percent reduction in total energy use.\(^\text{i}\)

**Showcasing innovation**

**City of Airdrie: Arena upgrades**
Following an energy audit indicating that the city’s 25-year-old arena could lower its carbon footprint by installing more insulation and new siding, the City of Airdrie, AB, made these upgrades in 2017. The upgrades increased the arena’s insulation level from R-2 to R-20.

**City of Calgary: Rooftop solar installations on municipal buildings**
The City of Calgary, AB, has installed more than 20 solar systems on municipal buildings, including fire stations, recreation centers and water treatment plants, to offset consumption and reduce energy costs.

**District of Hudson Hope: Rooftop solar project**
More than 500 kilowatts of power from grid-tied solar PV arrays now power nine municipal facilities in the District of Hudson Hope, BC, supplying 50–100 percent of the facilities’ electricity needs and expected to save the district millions of dollars over the coming decades. The project is expected to reduce electricity costs for these buildings by an average of about 75 percent and contribute to long-term economic development. It is also a source of community pride.

**City of Varennes: Varennes Net-Zero Library**
The City of Varennes, QC, built a net-zero-energy library which opened in 2014. The library was the first net-zero institutional building in Canada.

What resources can support next steps?

**Partners for Climate Protection (PCP) Milestone Tool, FCM and ICLEI-Local Governments for Sustainability (ICLEI Canada)**
This tool helps municipalities develop corporate and community-wide energy and emissions inventories and plan and measure actions to reduce GHGs. To access this tool, your municipality must be a member of the PCP program.

**ENERGY STAR® benchmarking for commercial and institutional buildings, Natural Resources Canada, 2019**
ENERGY STAR® provides information on energy benchmarking, including the benefits and barriers to managing a building’s energy performance, how to register and use ENERGY STAR® Portfolio Manager, ENERGY STAR® scores, high-performance certification in Canada, resources, financial assistance and examples of results from Canadian buildings.
This guide presents an overview of common barriers and discusses opportunities for organizations to make meaningful changes. It outlines a holistic approach to managing energy, including best practices and a roadmap to improving energy performance.

This guide explains how building owners and managers can successfully use recommissioning as a cost-effective method to reduce expenses and increase revenue through improved building operations.

Technical Reference: Canadian Energy Use Intensity by Property Type, ENERGY STAR® Portfolio Manager, 2019
This reference table is designed to help building operators and managers to compare their property’s energy use intensity (EUI) to the national median (or mid-point) energy use of similar properties.

This report aims to support local and provincial/territorial governments that are developing energy benchmarking strategies and regulations. It outlines a standard, national approach to achieving three goals: simplify the process of policy development and implementation; provide reliable data that will support strategic investments in building improvements and help achieve reduction targets in energy use and GHG emissions; and provide a consistent approach for building owners and managers to participate in benchmarking programs across Canada.

Municipal Collaboration for Sustainable Procurement
Municipal Collaboration for Sustainable Procurement (MCSP) is a member-based network of 20 Canadian municipalities, colleges and universities, which strives for operational excellence by collaborating and sharing resources to further sustainable (green, social and ethical) purchasing. Members share information, resources and technical expertise on sustainable procurement and other key supply chain topics.

This guide provides a step-by-step approach to improving energy efficiency in new and existing municipal buildings and operations.
Endnotes

i Beyond buildings, lead-by-example policies and programs can also extend to land-use planning (e.g. green belts), vehicle purchases (e.g. greening municipal fleets), and other transportation-related opportunities to reduce GHG emissions (e.g. encouraging low-emission commuting options). These options are not specifically addressed in this factsheet.

ii For more information on benchmarking, see the factsheet, Home/Building Energy Rating and Disclosure.

iii Proof of concept is evidence, typically collected through an experiment or pilot project, which demonstrates that a design concept, business proposal, etc., is feasible.

iv An interdepartmental team can include departments such as facilities/operations/public works, engineering, finance, legal, communications, planning, and environment/energy.

v American Council for Energy-Efficient Economy (ACEEE), Local Policy Toolkit, Public Buildings.

vi Natural Resources Canada, Financial assistance for benchmarking, labelling and disclosure initiatives.

vii Natural Resources Canada, ENERGY STAR® Portfolio Manager.


ix See the Canadian Institute for Energy Training.


xi City of Edmonton, Edmonton’s Year 2 Building Energy Benchmarking Report, April 2019.
Strategy
Incentive programs
What are incentive programs?
Incentive programs offer support (financial and non-financial) to reduce participants’ costs and improve the business case for energy-efficiency and clean energy measures, thus removing barriers and increasing uptake of those technologies.

Because financing programs are addressed separately in this roadmap, this factsheet focuses on the following types of incentives that municipalities can offer:

- discounts
- rebates
- tax credits
- education and training (e.g. offering third-party training to municipal building operators)
- technical services (e.g. offering home audits to identify energy-efficiency opportunities)
- other services (e.g. no-cost installations or project management services for low-income or small business participants)

This factsheet places the greatest focus on programs that offer discounts and rebates. Municipalities can offer such programs independently or as top-ups to existing incentives on offer from provinces/territories, utilities or energy-efficiency program administrators within their jurisdictions.

Advantages
- Incentives are a tried-and-tested approach to accelerating the adoption of clean and efficient technologies.
- Incentive programs can be less complex to administer than other programs designed to reduce cost barriers (such as financing, which requires partnering with financial institutions or longer-term agreements with participants).
- Local residents and businesses save money.
- Dovetailing with existing provincial/territorial or utility programs can maximize impact and reduce the strain on municipal funds.

Challenges
- Programs may require significant monetary resources from municipalities, especially if no federal or provincial/territorial grants can be leveraged.
- Administration costs as a percentage of program costs can be high for municipalities that aren’t able to achieve economies of scale. Smaller municipalities may need to pool resources with neighbouring communities.
- Dovetailing with existing provincial/territorial or utility programs can introduce challenges around coordination and savings claims.
- There is a risk of free-ridership, in which participants accept the incentive even though they would have installed the energy-efficient measure without the incentive.
Incentive programs

How does this strategy work and why is it important?

Driven by different value propositions, governments and utilities across North America have offered a wide variety of incentive programs over the past decades to promote, support and accelerate the adoption of clean and efficient technologies.

Municipalities can offer incentive programs to residents and businesses to accelerate uptake of clean energy and efficient technologies and practices in their communities, through either stand-alone programs or as top-ups to existing initiatives offered by federal or provincial/territorial governments or utilities. Financing incentives, discussed in the Financing Options factsheet, can include programs like Property Assessed Clean Energy (PACE), in which participants receive an upfront or subsidized loan that they pay off via their property taxes.

Other types of incentives include:

- **Discounts**: Discounts can take various forms, including municipally administered and subsidized sales of specific energy-efficiency measures, and discounts on the services of implementation partners (who receive a rebate from the municipality in return for offering the discount).

- **Rebates**: Cheques are written to participants after they provide proof of purchase or installation, provided that they have met any program-specific criteria.

- **Tax credits**: Governments can offer tax credits for implementing energy-efficiency retrofits.

- **Education and training**: Municipalities can subsidize third-party training or offer sessions to homeowners or businesses (for example, through the Canadian Institute for Energy Training, or CIET). This can raise awareness of energy-efficiency opportunities and benefits.

Another option is to provide the services of an onsite energy manager, to help businesses identify opportunities and implement projects.

- **Technical services**: These can include audits that identify energy-efficiency opportunities (e.g. based on the ASHRAE standard) and feasibility or scoping studies for developing business cases.

- **Other services**: Other alternatives to direct payments include no-cost installations, and project management services (often offered to low-income or small business participants).

**Need funding for your energy project?**

**Contact FCM!**

Access grants and loans for energy-efficiency and clean energy solutions that support service delivery in your community.

- Improve efficiency and reduce GHG emissions in municipal and community buildings
- Integrate renewable energy generation solutions
- Plan, refine and scale-up innovative financing programs for residential retrofits

**Learn more!**
Is this strategy right for my municipality?

Although no specific criteria restrict municipalities from using incentive programs to promote clean and efficient technologies in their jurisdictions, it’s important to consider your municipality’s local priorities and circumstances:

- **What are your objectives and policy drivers?** If the objective of reducing greenhouse gas (GHG) emissions is the overriding policy driver, then municipalities with newer housing stock may want to prioritize commercial and institutional buildings as areas with the greatest potential. If the driver is reducing energy costs, then particular areas of investment (e.g. high-energy-use buildings) may be more appropriate. The key is to identify the results that matter and then develop a program to achieve those results.

- **Will incentives address the market barriers?** It is critical to understand the barriers facing adoption of a given technology and the potential impact of those barriers within your municipality. For example, there are cost barriers to the adoption of rooftop solar, so a financial incentive is appropriate for this technology. However, if a market segment is not aware of the technology or does not trust it, or if a trained contractor is not available within your municipality to install it, then financial incentives alone will not encourage uptake, and options such as technical support or bulk purchases may be more appropriate. The key is to identify the right incentive to address the specific barriers for a given technology.

- **Are sufficient funds available?** Incentive programs can be funded through municipal resources, or they can leverage grants, loans and other funding sources from federal or provincial/territorial entities. If no external funding resource can be leveraged, consider whether your municipality can allocate funds to the program, the amount of funding it can provide (on a total-budget and per-participant basis), and whether those funds will achieve municipal objectives in a cost-effective way.

- **Does your municipality have sufficient internal resources and capacity for program management?** In-house delivery of incentive programs requires dedicated staff and resources to manage program administration, marketing, and evaluation, measurement and verification (EM&V) activities. You should consider whether your municipality’s existing staff have the capacity to undertake these tasks, whether additional staff may be required, or whether resources can be pooled with neighbouring communities to design and implement a program. If you do not have sufficient internal capacity, third-party program administrators can handle day-to-day program operations, design and evaluation.
Incentive programs

What does it take to implement?

If your municipality considers an incentive program effective and feasible, you will need to consider a variety of factors related to program design, rollout and management prior to implementation. These considerations are outlined below.

Designing for equity

Municipalities may choose to offer additional incentives aimed at low- to moderate-income households, in recognition of the social benefits resulting from clean and efficient technologies. For example, municipal programs may cover 100 percent of the incremental cost of the measures for qualifying homes or businesses rather than the portion of such costs offered to other participants.

Examples include direct install programs, which generally provide low-cost efficiency upgrades at no cost to customers (e.g. lights, faucet aerators, power strips), or fully subsidized energy assessments and building envelope improvements. Direct install programs are highly effective at eliminating many barriers (such as split incentives, upfront costs, access to capital, and program complexity) that prevent these sectors from making energy-efficiency upgrades. Programs can directly target customers or property owners.

Program design

- **Define program objectives.** Prior to designing incentive programs, you should define program objectives, including anticipated outcomes and quantitative goals. This may include setting targets for economic, environmental and social benefits.
- **Set your eligibility criteria.** This involves several steps:
  - **Define the target sector(s).** Before designing a program, define the specific market (residential, commercial, etc.) and segment (e.g. low-income, single-family, multi-family, small business, institutional buildings) to be served. This is because different markets and segments face different barriers. Some programs designate a portion of funds or top-up incentives for low-income households or small businesses, to enable greater participation (see the text box, “Designing for equity,” for more information).
  - Many programs also align eligibility criteria with that of pre-existing provincial/territorial programs or other incentive programs, to simplify program design.
• **Identify the target measures or technologies.** You also need to identify the measures or technologies that the program will target. Pre-defined or prescriptive eligibility criteria ensure that the program leads to tangible GHG reductions; however, this approach may not support all technology options that are of interest to participants. To simplify program design, you can align with pre-existing criteria such as ENERGY STAR® or the Consortium for Energy Efficiency (CEE) tiered models. Programs targeting building envelope upgrades should encourage comprehensive retrofits rather than one-off upgrades, in order to maximize savings and create cost efficiencies to the extent possible. However, this can lower participation as higher upfront costs are generally incurred, so it is important to weigh different options and offer a range of programs to meet a variety of needs.

• **Select a program type.** Based on your municipality’s priority areas, the barriers you have identified, and program eligibility criteria (which define the sectors and measures you will target), you can select a program type (e.g. rebates, education, other services, etc.).

• **Establish levels for rebates and funding, and design other program elements.** To be effective, rebate and funding incentives should reduce participant costs enough to drive uptake, while remaining cost-effective for the funder (for more information, see the text box, “Using cost-effectiveness frameworks to help guide program choices”). Most programs also set a cap on the maximum number or value of incentives to be provided to a single project or participant.

Additionally, common practices for incentive programs include gradual stepping down of rebate levels over time to avoid a “boom-bust” pattern that may otherwise result from the sudden removal of incentives. As noted above, some programs designate funds or top-up incentives for groups that face higher barriers to undertaking energy-efficiency projects, such as low-income households or small businesses, to enable greater participation.

To ensure maximum impact for dollars invested, you can design programs to reduce the number of “free riders”—i.e. participants who would have installed the energy-efficiency measure anyway, but still take the incentive because it is offered. You can do this, for example, by ensuring that incentives are high enough to actually change purchasing decisions rather than just being a “bonus” for individuals who would install it anyway. Free ridership can also be minimized through other program design aspects, such as requiring participants to apply for program funding before purchasing the measure, or conducting surveys asking if they are planning to install the measure even without the incentive.

• **Design the application process.** Depending on the program type, consider designing the application process so that it does not create additional barriers for the target market by being overly burdensome. Consider which information is absolutely necessary and which is simply nice to have, and whether you are excluding anyone by designing the process in a certain way.

• **Establish goals and performance indicators to measure and track program success.** These can include metrics for program uptake, energy savings and GHG reductions.
Using cost-effectiveness frameworks to help guide program choices

Utilities or energy-efficiency program administrators often complete cost-effectiveness testing to decide if they should pursue incentive programs. While municipalities are not required to complete such testing, a framework for assessing cost-effectiveness may be useful for estimating the benefits to your community of a potential program. For example, you may consider applying the Societal Cost Test to assess costs and benefits to society as a whole. This test views costs and benefits from a broad perspective, monetizing issues that society wants addressed (i.e. “externalities”), such as GHG emissions reductions, improved air quality, and improved comfort and health. Other cost-effectiveness tests can assess program impacts through different lenses, such as that of the program administrator or program participant. Regardless of the lens chosen for assessing cost-effectiveness, take care to align the analysis with your desired policy goals and other objectives.

Program rollout and management

- **Coordinate with other entities and link to existing programs.** Energy-efficiency and renewable energy incentive programs exist in most provinces and territories and are offered by government entities, utilities or other third parties. You will need to coordinate with the relevant entities. Once you verify whether your municipality’s residents or businesses are eligible for such programs, you can coordinate with program administrators to determine whether a municipal top-up incentive is needed, whether such an incentive is feasible, and what the best mechanism would be. In these cases, aligning application processes or partnering with the other entity so that applicants only need to approach one organization (i.e. a “one-stop shop”) can help to increase uptake and reduce administration costs. Additionally, both organizations must agree on the mechanism to be used for claiming energy savings and GHG reductions and attributing them to the program.

- **Design and implement a marketing program.** Effective marketing campaigns are critical to program success. Marketing campaigns can take various approaches, including:
  - Stakeholder engagement, through technical support and guidance, training, advisory groups, or partnerships with utilities or program administrators.
  - Communication and outreach, through means such as promotional materials, websites, information booths at local events, and campaigns.

- **Handle program administration.** Day-to-day program administration efforts include reviewing and processing applications, collecting data, reviewing and approving progress reports and final reports, processing rebate payments, following quality assurance procedures, and other miscellaneous tasks.
• **Do evaluation, measurement and verification to assess program performance.** Assessing program performance against set targets requires careful data tracking and analysis, which can be performed in-house or by third parties. Depending on the level of rigour required or desired by your municipality, this can be as simple as using deemed energy savings and multiplying those numbers by agreed-upon GHG emissions intensities (using provincial or territorial data sources if municipal ones are not available), or as complex as detailed verification of GHG reporting following a standardized process such as ISO 14064-3.iii Municipalities should have a clear understanding of reporting requirements (if any) and their level of complexity before deciding whether to conduct evaluation, measurement and verification in-house or to bring in a third party.

• **Monitor and update the program.** Updates may be needed to program incentive levels, eligibility criteria or other attributes, based on participant feedback and quality assurance checks, to reflect changing market conditions such as cost reductions, technology advancements and variation in program uptake (over- or under-subscription).

---

**Best practices in program design**

**Engaging contractors:** Engaging local contractors is essential to ensure that the program design aligns with available equipment, accepted practices, and local contractor skills. Moreover, incentive programs can require the use of pre-qualified partners (such as contractors, electricians and installers) to ensure quality installation and equipment performance. This also provides enhanced consumer protection and allows contractor networks to be leveraged effectively for program marketing.

**Coordinating with existing financing programs:** Integrating and streamlining incentive programs with existing financing programs offered by the municipality or other entities can maximize program impact and minimize market confusion.
What are the GHG and financial impacts?

Table 1 provides an overview of the GHG and financial impacts that can be expected from incentive programs. See “What have municipalities done?” below for concrete examples of the GHG reductions achieved by some municipal programs to date.

Table 1: Typical GHG and financial impacts of incentive programs

<table>
<thead>
<tr>
<th>Impact</th>
<th>Key factor(s)</th>
<th>Typical ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG reductions</td>
<td>• GHG reductions are dependent on program uptake and depth of GHG reductions associated with the funded projects, and can be estimated as follows: [ \text{# of projects} \times \frac{\text{GHG reductions per project}}{\text{GHG reductions}} ]</td>
<td>Energy savings can range from less than five percent of a building's energy use (for low-cost options such as lighting) to 30 percent or more (for comprehensive upgrades). The associated GHG reductions are much more variable and therefore difficult to provide.</td>
</tr>
<tr>
<td></td>
<td>• Program design, particularly choices around which participants and measures will be eligible, will have an impact on the volume of participants, the quality of the projects, and the GHG reductions associated with the program. For example, a program that provides incentives for lighting to all households will have a high volume of participants but fewer GHG reductions, whereas a program that provides incentives for building insulation improvements for a specific subset of households will have a lower volume of participants but greater GHG reductions.</td>
<td></td>
</tr>
</tbody>
</table>
### Incentive programs

<table>
<thead>
<tr>
<th>Impact</th>
<th>Key factor(s)</th>
<th>Typical ranges</th>
</tr>
</thead>
</table>
| **Program incentive costs**        | • The cost of the actual incentives is largely a product of uptake and the incentive level provided, and can be estimated as follows: \[ \text{total cost of incentives} = \text{# of projects} \times \$ \text{ per project} \]  
  • Municipalities should set a target for the total amount of incentive monies to be distributed or, alternatively, a deployment target with associated budget.  
  • See “What have municipalities done?” below for a sampling of rebates offered through a variety of municipal programs. Generally, municipalities fund such programs through their own resources or by leveraging grants, loans and other funding sources from federal or provincial/territorial entities. | Incentive costs can range from 50 to 90 percent of a program’s overall budget, depending on the level of administration and staffing required, as well as the overall uptake. |
| **Program marketing and administration costs** | • Programs incur fixed costs for additional staff salaries, program marketing, evaluation, and other administrative requirements.  
  • They also incur variable costs linked to program volume. | Generally, 5–15 percent of the incentive program’s total budget goes toward administrative costs (which would not include staff salaries and other direct program costs). |
What have municipalities done?

Heat pumps (fuel switching)

**British Columbia: Municipal top-up rebates**
The City of North Vancouver, Regional District of Comox Valley, City of Victoria and other municipalities across BC offer a minimum of $350 as a top-up incentive to residents in their jurisdictions for switching from a fossil fuel heating system (oil, natural gas or propane) to an electric air-source heat pump. This incentive is a top-up to complement the existing provincial incentive program.

Envelope upgrades

**Brazeau County: Municipal Energy Efficiency Rebate Program**
The Municipality of Brazeau County, AB, offers its residents rebates of up to $1,500 on ENERGY STAR® windows and rebates of up to $3,500 on attic, wall, basement or floor insulation.

**City of Medicine Hat: EnerGuide® Ratings for New Homes Incentive Program**
The City of Medicine Hat, AB, offers performance-based rebates of up to $10,000 for the construction of new homes that meet a program-specific energy-efficiency standard.

Rooftop solar

**City of Edmonton: Change Homes for Climate—Solar Program**
The City of Edmonton, AB, currently offers a $0.40/W incentive for installing a residential solar PV system that can be paired with a $0.90/W incentive offered by the province, saving Edmonton households approximately one-third of the cost of going solar.

What resources can support next steps?

**Financial incentives by province, Natural Resources Canada**
This web page provides details on incentives related to energy efficiency from provincial/territorial governments, major Canadian municipalities and major electric and gas utilities.

This report explores some of the policies and programs available across Canada that encourage energy efficiency, renewable energy, sustainable development, and other related objectives. The report discusses municipal, provincial/territorial, federal and industry programs and incentives.

This resource reviews the issues and approaches involved in testing the cost-effectiveness of energy efficiency measures. It discusses each of the five standard cost-effectiveness tests and clarifies key terms.
**Incentive programs**

This resource reviews the concepts, issues, theory and design options for setting incentives. While the incentive examples provided are outdated, the document provides valuable background information.

**Tax Incentives for Clean Energy Equipment**, Canada Revenue Agency
This documentation reviews federal income tax incentives for homeowners in Canada to make investments in clean energy, including first-year capital cost allowances (CCAs) that allow taxpayers to deduct the capital costs of eligible properties.

This chapter of the National Action Plan for Energy Efficiency reviews best practices in designing energy-efficiency programs. It discusses how to identify target measures and how to design programs and delivery strategies to maximize impacts and improve cost-effectiveness. It also considers the role of measurement and evaluation.

**ENERGY STAR® Partner Resources**
The resources listed on this web page explore different types of programs that include ENERGY STAR® certified measures. The listed resources cover a number of topics, including: best practices in program design for residential new construction programs; designing and implementing programs using residential and commercial ENERGY STAR® measures; and using ENERGY STAR® in commercial and industrial programs.

This guide outlines policy considerations such as setting incentives and assessing cost-effectiveness. It also discusses program planning and implementation considerations such as developing a longer-term strategy, keeping programs simple and streamlined, coordinating with partners and other players, and determining an effective framework for evaluation, measurement and verification.

**American Council for an Energy-Efficient Economy (ACEE)**
This website contains a wealth of resources on energy efficiency programs and policies, including incentive programs.
Incentive programs

Governments often use incentive programs as a mechanism to meet environmental and social policy objectives. Utilities, on the other hand, have traditionally used incentives to increase the uptake of technologies among their customers, to leverage the benefits associated with energy efficiency and other clean technologies. These economic (and other) benefits could include avoided energy and generation capacity costs, environmental compliance and other system benefits.

A split incentive involves circumstances in which the party paying for energy-efficiency or clean energy technologies is different than the party that receives the associated benefits.

Specific evaluation, measurement and verification activities can include: applying pre-determined, average (deemed) energy savings and GHG reductions to installations; data logging; billing analysis; and detailed post-installation energy audits. Additionally, more complex programs require final project reports to ensure that the project has fulfilled its requirements, as well as quality control checks on a sample of projects to ensure that the projects are complying with requirements. Process evaluations can also be included, to assess customer and partner satisfaction and identify opportunities to improve the program.


Financing options

What are financing options?

Financing options have become an increasingly popular tool to support the adoption of efficient, clean energy technologies by addressing market barriers and increasing access to low-cost, long-term capital. Municipalities can use innovative financing options to target clean energy and energy-efficiency improvements in local homes and businesses, municipal buildings, and community-scale initiatives. They can take three main actions:

- Support third-party financing through enabling policies and programs.
- Deliver financing programs for local homeowners and businesses.
- Access financing for improvements in municipal buildings.

This factsheet discusses several innovative financing models:

- Programs that municipalities can offer to homeowners and businesses:
  - Property Assessed Clean Energy (PACE) and local improvement charges (LIC)
  - on-bill financing (OBF) (for municipalities that operate their own utility or that partner with a local utility)
  - credit enhancements to reduce lending cost or lender risk

- Options for municipalities to access financing for municipal facilities:
  - utility on-bill financing (OBF)
  - equipment leases
  - energy service agreements (ESAs)

Each of these innovative financing models can also be used to finance community energy projects. For more information on community-level solutions, see the District Energy Systems and Wind and Solar Energy Generation factsheets.

Advantages

- Financing can help reduce key barriers associated with upfront costs and lengthy project payback periods.
- The ability to repay upfront costs over time using energy bill savings means that projects can be cash-flow neutral or positive.
- Financing can encourage uptake in hard-to-reach market segments such as rental properties.
- Attaching financing to the property, rather than an individual, allows transferability of payments and benefits. This helps overcome the “split incentive” barrier.
- Programs can be tied to local municipal priorities (e.g. community energy plans, jobs, water conservation, improving building stock).
Financing options

- Borrowers may be able to transfer the cost of improvement projects from their capital budgets to their operating budgets, thereby streamlining decision-making and budgeting.
- Negative perceptions may exist about potential impacts on municipal credit ratings and debt limits.
- Mortgage lenders and insurers may be concerned that PACE/LIC financing will take priority for repayment over mortgages, should owners come under financial pressure.
- Financing can increase the debt burden on local households.
- Providing financing may expose the municipality to financial risks related to defaults and arrears owing, depending on the model and on project performance.

Challenges

- The municipality may need to raise program capital.
- Some municipalities may be challenged to deliver complex financing structures.
- Administrative costs can be high, relative to program loan volumes, posing risks to programs that the municipality is striving to keep revenue-neutral.
- Negative perceptions may exist about potential impacts on municipal credit ratings and debt limits.
- Mortgage lenders and insurers may be concerned that PACE/LIC financing will take priority for repayment over mortgages, should owners come under financial pressure.
- Financing can increase the debt burden on local households.
- Providing financing may expose the municipality to financial risks related to defaults and arrears owing, depending on the model and on project performance.

How does this strategy work and why is it important?

Emerging models for financing clean energy and energy efficiency encourage longer-term and low-cost lending by providing security to lenders. This is often done by tying the financing to the property or equipment, rather than to the owner.

Key financing options include:

1. **Property Assessed Clean Energy (PACE) or local improvement charges (LIC):**
   These are secure repayment mechanisms for loans that finance energy-efficiency and renewable energy upgrades and other improvements, like water conservation measures. The loans are repaid through a special assessment applied to the municipal property tax bill. PACE programs can be administered by municipalities, provincial entities or third parties, but the municipality is always involved because it must process and collect payments. Provincial or territorial legislation is needed as a prerequisite to these programs.
2. **On-bill financing (OBF):** With on-bill financing, also referred to as on-bill repayment (OBR), loans financed by the utility or a third-party lender are repaid through a line item on the utility bill. Underwriting is typically informed by the customer’s utility bill payment history. Municipalities can offer on-bill financing to homeowners, businesses and community projects. On-bill financing is best-suited to municipalities that operate their own utility, but is also possible if municipalities partner with a local utility. Municipalities can use this type of financing from a local utility or a third party to finance their own clean energy or energy-efficiency upgrades.

3. **Credit enhancements:** These are tools to reduce the lending cost or lender risk associated with financing clean energy or energy-efficiency improvements.
   - **Soft loans** are loans with preferential interest rates or extended repayment periods, both of which are often achieved through co-lending agreements between governments and private lenders.
   - **Interest rate buydowns** involve an arrangement where the municipality covers at least part of the interest on the loan.

4. **Equipment leases:** These are agreements where, typically, a third party rents energy-efficiency or renewable energy equipment to the building occupant or owner. The user pays a rental fee for the lease duration, with the option to purchase the equipment or return it to the lessor at the end of the period. Leases are usually offered by third-party financiers, but a municipality may launch an awareness-raising program to encourage uptake in the community. Municipalities may also use equipment leases for their own facilities.

5. **Energy service agreement (ESA):** An ESA is a private sector financing tool for efficiency measures, where repayments are set as a portion of the demonstrated energy and operational savings. This tool is typically leveraged by municipalities to finance projects for their own facilities by partnering with energy service companies (ESCOs).

   * **Loss reserves** are reserves that protect the lender from a significant portion of potential loss, allowing the lender to offer lower interest rates, provide longer terms and expand eligibility.

   While municipalities do not traditionally offer loans themselves, they can support projects in the community via private lenders by offering credit enhancements.
These types of financing can reduce market barriers associated with the high upfront costs and long investment payback times of some energy-efficiency and clean energy measures. They can also address barriers associated with split incentives.

Generally, municipalities can take three types of action related to financing for clean energy and energy-efficiency in buildings:

- **Support third-party financing:**
  Municipalities can support third parties that offer financing by creating enabling policies (e.g. municipal bylaws to enable PACE/LIC) or by actively incentivizing the development of third-party programs (e.g. offering property tax exemptions or deferrals, or credit enhancements).

- **Deliver financing programs:** This usually entails a municipality designing, administering and operating a financing program. The program can either use municipal resources as funding or leverage private capital. In some cases, program delivery can be delegated to third parties.

- **Access financing for municipal building retrofits:** Municipalities can leverage third-party capital to minimize investment cost to the municipality.

**Is this strategy right for my municipality?**

Not all financing options are suitable for all types of energy project or for all municipalities. Table 1 summarizes the criteria under which each financing option would be applicable to your municipality, and the possible municipal roles.

**Table 1:** Target area, municipal role, and applicability criteria by financing option

<table>
<thead>
<tr>
<th>Program type</th>
<th>Target area</th>
<th>Municipal role</th>
<th>Applicability criteria and other considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property Assessed Clean Energy (PACE) or local improvement charges (LIC)</td>
<td>Municipal buildings</td>
<td>Local homes and businesses</td>
<td>Community energy</td>
</tr>
</tbody>
</table>

- | ✓ | ✓ |

- The municipality must have control over the property tax roll.
- Enabling provincial legislation for PACE/LIC must be in place.
- Municipal council must adopt a bylaw that enables PACE/LIC.
### Financing options

<table>
<thead>
<tr>
<th>Program type</th>
<th>Target</th>
<th>Municipal role*</th>
<th>Applicability criteria and other considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>On-bill financing/repayment (OBF/OBR)</strong></td>
<td>Municipal buildings ✓</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Local homes and businesses -</td>
<td>-</td>
<td>• The municipality must be served by a utility that offers an OBF/OBR option. In some cases in the United States, OBF for municipal buildings can extend to 10-year terms.</td>
</tr>
<tr>
<td></td>
<td>Community energy ✓ ✓</td>
<td>Access funds</td>
<td>• The municipality must be served by a municipally owned utility that has a billing system capable of offering OBF, or must partner with a local utility that has this capability.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Support or deliver</td>
<td>• The local regulatory body (i.e. utilities commission) and province/territory must allow on-bill charges to be added.</td>
</tr>
<tr>
<td><strong>Credit enhancements</strong></td>
<td>Municipal buildings -</td>
<td>-</td>
<td>Deliver</td>
</tr>
<tr>
<td></td>
<td>Local homes and businesses ✓</td>
<td>✓</td>
<td>• The municipality must have access to capital and create a partnership with financial institutions that would offer enhanced loans or leases.</td>
</tr>
<tr>
<td><strong>Equipment lease</strong></td>
<td>Municipal buildings ✓</td>
<td>-</td>
<td>Access funds</td>
</tr>
<tr>
<td></td>
<td>Local homes and businesses -</td>
<td>✓</td>
<td>• No specific criteria</td>
</tr>
<tr>
<td></td>
<td>Community energy ✓ ✓</td>
<td></td>
<td>• Note that equipment leases (as an alternative to purchases) may allow facility-level improvements that are paid back through operational savings rather than capital expenditures.</td>
</tr>
</tbody>
</table>
### Financing options

<table>
<thead>
<tr>
<th>Program type</th>
<th>Target</th>
<th>Municipal role</th>
<th>Applicability criteria and other considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy service agreement (ESA)</td>
<td>Municipal buildings</td>
<td>✔️</td>
<td>Access funds</td>
</tr>
<tr>
<td></td>
<td>Local homes and businesses</td>
<td>–</td>
<td>• No specific criteria</td>
</tr>
<tr>
<td></td>
<td>Community energy</td>
<td>✔️</td>
<td>• Note that the municipality can issue a call for tenders for an ESA, to improve a local facility or to establish a community energy project through a power purchase agreement (PPA).²</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• A municipality can create a dedicated revolving loan fund that collects a portion of savings generated in one facility to finance improvements in another.</td>
</tr>
</tbody>
</table>

a See Table 2 for additional information regarding the types of actions associated with each potential role.
b PACE/LIC enabling legislation is currently in place in Alberta, Ontario, Nova Scotia and Yukon.
c A Power Purchase Agreement is a contract to buy power directly from a renewable energy generator, rather than the local utility.

### What does it take to implement?

If any of the financing options for clean energy or energy efficiency are feasible and meet your municipality’s needs, the next step is to identify the role you can play to advance this strategy. You have several options:

- **Support third-party financing programs** in your community.
- **Deliver financing programs** for local homeowners and businesses and community energy projects.
- **Access financing** for your own municipal building retrofits.

Table 2 highlights examples of possible municipal actions, recognizing key distinctions that may apply to small and medium-sized municipalities compared to larger ones.
## Table 2: Potential municipal actions

<table>
<thead>
<tr>
<th>Municipal role</th>
<th>Potential actions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small and medium municipalities</td>
</tr>
</tbody>
</table>

### Support
- **Enable**
  - To enable PACE/LIC, adopt an appropriate council program bylaw or opt in to existing provincial programs (if applicable).

### Incentivize
- **Issue tax exemption or deferral for properties that utilize financing for retrofits.**
- **Partner with local utility to offer OBF to benefit the community.**
- **Issue tax exemption or deferral for properties that utilize financing for retrofits.**
- **Use credit enhancement tools (e.g. loss reserves, interest rate buydowns, or co-lending) to reduce lenders’ risks and expand eligibility.**
- **Partner with local utility to offer OBF to benefit the community.**

### Deliver
- **Public capital**
  - Design and administer a financing program.
  - Design and administer a financing program.
  - Manage an endowment fund tasked to finance public and private retrofits.

- **Private capital**
  - Design and administer a program.
  - Partner with other municipalities to aggregate loan portfolios and seek partnerships with private lenders.
  - Design and administer a program.
  - Seek partnerships with private lenders.

### Access funds
- **Issue a Request for Information (RFI) or request quotes from local energy service companies to engage in an energy service agreement.**
- **Seek municipal lease offers from private financial institutions or equipment suppliers.**
- **Seek on-bill financing options from investor-owned or private utilities.**
  - Issue a Request for Information (RFI) or request quotes from local energy service companies to engage in an energy service agreement.
  - Establish an internal energy improvement revolving fund to finance improvements and capture savings to invest in further improvements.
  - Seek municipal lease offers from private financial institutions or equipment suppliers.
  - Seek on-bill financing options from investor-owned or private utilities.
Financing options

If you choose to deliver your own financing program, you will need to consider a variety of factors related to program design and rollout:

- **Choose the delivery entity.** You can operate and administer your municipal financing program internally or work with an external third party.

- **Determine project eligibility.** Your program must have a well-defined list of project types and measures that are eligible to receive financing. These eligibility requirements are usually set in accordance with municipal priorities. Focus on financing projects that have high upfront costs and extended lifetimes or paybacks, to alleviate barriers to market entry. A broader range of eligible measures will allow your program to finance a greater number of projects, but may lead to less substantial greenhouse gas (GHG) reductions, as requirements for project eligibility are less demanding in terms of expected outcomes. Conversely, narrower eligibility criteria may reduce participation, but result in greater GHG reductions per project. Further, you can design your program to enhance social equity (see the text box, “Designing for equity”).

---

**Designing for equity**

Financing programs can promote equity in several ways. For example, they can focus on low- and moderate-income (LMI) households or small businesses. Doing so requires sound analysis to identify gaps in measures, strategies and markets.

Typically, these disadvantaged segments include a high portion of rental properties, so financing programs can be aimed at helping landlords overcome the “split incentive” barrier (i.e. circumstances where the party incurring the costs of clean energy and efficient technologies is different than the party that receives the associated benefits). Financing tools that tie repayment to the property (PACE/LIC) or meter (OBF) rather than the customer can help reduce repayment and performance risk. This can lead to lower financing costs, and expanded access to capital for LMI and small business borrowers and lenders.

Financing should work closely with other social initiatives and borrowing strategies—such as “direct install” programs, which offer efficiency upgrades at no cost—to reduce participation barriers.

Further, attention should be paid to the impact that financing can have on debt burdens and exposure to risk in the LMI/small business sector. Financing programs that expand access to capital for non-creditworthy customers may make retrofits more affordable, but also run the risk of increasing debt burdens on vulnerable households and businesses.

Financing programs can also promote equity by targeting other socially disadvantaged groups, as well as non-profit housing providers and private rental operators offering affordable housing.
• **Determine participant eligibility.** Typically, programs differentiate between consumer financing and business financing, as the underwriting and creditworthiness assessments differ significantly between the two sectors. The underwriting rigor and criteria used to assess applicants (e.g. credit score, property tax payment history, utility bill history, etc.) will influence program participation as well as alter the risk to your municipality.

• **Decide whether to include incentive tie-ins.** Best practices for financing programs include integrating and streamlining the program with existing rebates and incentives from the municipality or other entities, to allow participants to leverage multiple programs seamlessly.

• **Identify program partners.** The engagement, recruitment and solicitation practices of program partners—primarily local contractors and program lenders—are key to ensuring program success. Contractors are often customers’ first point of contact. They are well-positioned to play a significant role in marketing the program and signing on customers. To attract financing partners, it’s important to demonstrate an attractive risk-return profile, via effective program design and credit enhancements.

It is a common practice to pre-qualify and register contractors and lenders as certified program partners. You should engage with partners early in the program design phase, and clearly highlight their roles and responsibilities, as well as the value proposition for participation.

• **Locate program capital.** Generally, programs can be funded either publicly or privately. Table 3 highlights key options for raising program capital. You can also use other options, as well as hybrid solutions.

### Table 3: Options for program capital

<table>
<thead>
<tr>
<th>Capital option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public capital</strong></td>
<td></td>
</tr>
</tbody>
</table>
| **Internal resources** | Municipal revolving fund  
                      An initial injection of funds by the municipality, with project paybacks recycled to offer new capital for future projects |
| General reserves     | Funds that have been put aside by the municipality for future operating expenditures or capital spending |
| **External resources** | Green bonds  
                      A municipal green bond issued to raise capital through the debt capital market |
| Federal or provincial funds | Grants, loans and other funding sources from federal or provincial entities |
| Private sources      | Traditional debt from private financial institutions (this option is rarely used because municipalities can typically raise capital at very low costs through municipal bonds) |
| **Private capital**  | Funds from private financers that go directly toward the program, with no municipal capital |
Mitigating mortgage lender concerns with residential PACE/LIC programs

While early financing programs had their share of success, they also faced various regulatory challenges and concerns. As PACE/LIC loans are designed to have priority lien over mortgages in case of defaults, mortgage lenders have held some objections to the programs. In the United States, the Federal Housing Administration and Federal Housing Finance Agency have announced that they will not insure mortgages on homes that have PACE liens. In Canada, no official policy direction has been issued by the Canada Mortgage and Housing Corporation or Canadian Bankers Association (CBA) on PACE/LICs.

As a mitigation strategy, several governments have taken action to address lenders’ concerns. For example, California established a loan loss reserve to protect mortgage holders in the case of default. Similarly, Toronto’s Home Energy Loan Program requires homeowners to get their mortgage lender’s consent prior to qualifying for the program. Restricting eligibility requirements to those with uninsured mortgages may mitigate such concerns, but can lead to program equity concerns.

What are the GHG and financial impacts?

This section provides information on the GHG reductions and the costs associated with municipal financing programs for clean energy and energy-efficiency measures in local homes and businesses. To learn more about projects in municipal buildings or community energy projects, please see the Lead by Example and Wind and Solar Energy Generation factsheets, respectively.

**GHG reductions**

The GHG reductions that may be enabled by a financing program are dependent on program uptake (volume) and the depth of GHG reductions associated with funded projects (quality). Experience shows that financing programs often have a trade-off between driving higher loan volume through lighter requirements or pushing deeper GHG reductions and higher-quality improvements with more stringent requirements and stricter underwriting. At the same time, the overall success of financing programs is based on demand for the offering—which is very difficult to gauge, especially in early stages.

The choice of program model and partners, and the criteria for participation, underwriting, and project and measure eligibility, are all critical variables in achieving the balance between volume and quality.
Program capital
The capital costs to the municipality of a financing program depend on the source of capital being used as well as the demand for program funds (i.e. program uptake by homeowners or businesses). For an indication of the range of capital costs, please see examples of municipal financing programs in the next section.

Program administration
The administrative cost burden of a financing program is highly dependent on the program model. Financing programs incur fixed costs to cover staff salaries, program marketing and evaluation. There are also variable costs linked to program volume. Generally, programs are designed to be revenue-neutral, with administrative costs recovered through a fixed administrative fee paid by participants.

What have municipalities done?

Property-assessed financing programs

**Halifax Regional Municipality: Halifax Solar City LIC Program**

In 2013, the Halifax Regional Municipality, NS, launched the Solar City pilot program to finance solar hot water systems for eligible private residences. In 2016, a revised version of the program was launched and expanded to include solar photovoltaic (PV) and solar hot air technologies. In addition to private residences, the expanded program was also open to not-for-profits, places of worship, cooperatives and charities across the municipality. The Solar City program provides financing at a fixed interest rate of 4.75 percent, to be repaid over a 10-year period. Financing is tied to the property, but re-payment is separate from the annual tax bill. Between 2013 and 2019, more than 620 property owners financed $13.2 million in projects through the program. In 2018, an increase in program participation was noticed after a new provincial rebate for solar PV systems was announced and integrated with Halifax’s Solar City program. The program is designed to be revenue-neutral, with the 4.75 percent interest rate used to recover the municipality’s borrowing costs and program administrative costs.

A revenue-neutral program offers value because the benefits of the program come at no net cost to the municipality.

Other program costs
If the chosen program model offers any (non-rebate) financial incentives to participants or financers, the associated costs would also have to be accounted for. For example, if the municipality offers a tax break to households participating in a certain program, the lost tax revenue would be considered a program cost. Similarly, municipalities that invest in credit enhancement tools to expand the underwriting criteria through a loan loss reserve or to reduce the cost of borrowing through an interest rate buydown would have to consider the added cost of these interventions.
Nova Scotia Municipal Clean Energy Financing programs
A number of municipalities across Nova Scotia have launched financing programs similar to Halifax Solar City, including the districts of Lunenburg, Digby, Barrington and Colchester as well as the Town of Bridgewater. The municipalities offer homeowners between $10,000 and $20,000 for eligible upgrades, including energy-efficiency measures, heat pumps, thermal storage units, solar PV and electric vehicle charging stations. The program is being administered by Clean Foundation on behalf on the municipalities.

City of Toronto: Toronto Home Energy Loan Program (HELP)
The City of Toronto, ON, offers up to $75,000 in low-interest financing to homeowners for energy retrofits through Toronto’s Home Energy Loan Program (HELP). The program uses local improvement charges (LICs) to collect payments through a home’s property tax bill. Additionally, the city runs a parallel program—the High-Rise Retrofit Improvement Support Program (Hi-RIS)—which targets apartment buildings. Both programs are currently funded and administered by the city. A two percent administrative charge is applied to the principal amount borrowed by the homeowner. The HELP and Hi-RIS programs won a 2016 FCM Sustainable Communities Award in recognition of their success in stimulating energy and water retrofits in the residential sector in Toronto. Between 2014 and 2016, HELP and Hi-RIS supported 125 homes and six apartment buildings, respectively, with more than $6.3 million. The programs are projected to reduce GHG emissions by more than 47,000 tonnes over the lifetime of the supported projects.

Quebec: Financement innovateur pour des municipalités efficaces (FIME)
The Association Québécoise pour la maîtrise de l’énergie (AQME) supported the launch of the “Financement innovateur pour des municipalités efficaces (FIME)” pilot program, which offered loans for energy-efficiency retrofits to homeowners in Varennes, Verchères and Plessisville, QC. Participating households achieved an average of 28 percent in annual energy savings and $911 in annual cost savings.

County of Sonoma: PACE financing
In California, the County of Sonoma, CA, provides PACE financing through the Sonoma County Energy Independence Program (SCEIP). The financing is available for energy-efficiency, renewable energy and water conservation projects, to property owners within the geographic boundaries of the county. SCEIP is the longest running PACE program in the United States and offers the lowest interest and fees when compared to other PACE programs with equivalent terms. From 2009 to 2016, the program has had 240 participants per year on average, providing an average of $30,000 USD per participant.

Municipal buildings

Government of Quebec: Maximum net present value (NPV-Max) for energy service agreements
In 2009 the Government of Quebec adopted the “Regulation respecting construction contracts of public bodies” (RLRQ, chapter C-65.1, r.5) to govern how public energy-efficiency retrofit projects are evaluated and selected. It is unique in North America as it requires proposals to be based on the maximum net-present value (NPV-Max), which provides a clear indication of the cost-to-benefit ratio of the
proposed efficiency project over the life of the installed measures. The application of this model to contracts for energy service agreements (ESAs) offers an opportunity to evaluate how NPV-Max analysis can increase the breadth and depth of energy savings in public facilities and deliver significantly improved benefits under an ESA contract. This policy can easily be applied to municipal ESA procurement contracts.

**City of Pittsburgh: Green Initiatives Trust Fund**
The City of Pittsburgh, PA, provides a continuous and secure source of funding through the Green Initiatives Trust Fund, which uses money from energy-saving measures to finance future energy-efficiency projects within the city. Initiatives include energy audits, aggregated energy purchases, renewable energy generation, efficiency upgrades at city-owned facilities, and other green initiatives in the Pittsburgh Climate Action Plan.

**Green bonds**

**City of Ottawa: Green Debenture Framework**
The City of Ottawa, ON, led the way in November 2018 with a breakthrough $102 million issue of 30-year green bonds, the proceeds of which were used to finance light rail transit in the nation’s capital.

**City of Toronto: Green Debenture Program**
The City of Toronto, ON, established its Green Debenture Program in July 2018 to leverage the city’s low borrowing interest rates to help finance transit and other capital projects that contribute to environmental sustainability. The expected growth of green capital projects will allow the city to be a regular issuer of Green Debentures. The city’s Green Debentures have the same financial and legal characteristics of other city bonds, but the net proceeds are used exclusively to fund projects supporting its environmental sustainability strategies.

**Endowment for clean energy**

**Greater Toronto and Hamilton Area: TAF (The Atmospheric Fund) financing**
In 1991, the City of Toronto, ON, established the Toronto Atmospheric Fund—now The Atmospheric Fund—with the goal of investing in emissions reduction initiatives across the Greater Toronto and Hamilton Area. TAF was funded by the city using a $23 million endowment and operates as an arms-length organization, offering financing to local energy-efficiency and renewable energy projects, among other initiatives, in the Greater Toronto and Hamilton Area. TAF has financed projects in a wide range of areas ranging from the building sector—including social housing—to transportation and waste management.
What resources can support next steps?

**On the Money: Financing tools for local climate action**, ICLEI – Local Governments for Sustainability and FCM, 2019
This guidebook features some funding mechanisms that municipalities are starting to use in advancing their emissions reduction projects. The guide explains these often complex and hard-to-grasp approaches in easy-to-understand ways with current municipal examples.

**Financing Energy Efficiency Retrofits in the Built Environment**, Natural Resources Canada, 2016
This report examines different innovative financing mechanisms used to promote energy-efficiency upgrades in the housing and buildings sectors, with a focus on various initiatives in Canada, the United States and the United Kingdom. It also identifies best practices for program models.

This document presents an overview of the range of energy-efficiency financing tools currently in use in North America, with a focus on mechanisms that require or can be enhanced by government leadership.

This tool is intended to support local decision-makers in answering key questions related to financing programs, by offering an overview and insight into the use of different customer-facing financing tools in different market segments.

**Endnotes**

1. A split incentive involves circumstances in which the party paying for energy-efficiency or renewable energy technologies is different than the party that receives the associated benefits—as is common for rental properties (with tenant-landlord relationships) and investment properties (where return-on-investment exceeds typical investment horizons).
Strategy

Home/building energy rating and disclosure

What are home/building energy rating and disclosure policies and programs?

Home and building energy rating and disclosure (HERD/BERD) policies and programs are strategies for transforming the market over the long term. Energy ratings and disclosures provide information to owners, managers, buyers and renters about the energy performance of homes and buildings, and cost-effective ways to improve it. This helps consumers become more educated and demand energy-efficient buildings. Municipalities can use HERD/BERD strategies in three ways:

- Create voluntary HERD/BERD policies and programs.
- Create mandatory HERD/BERD policies and programs.
- Support provincial/territorial or federal HERD/BERD policies.

HERD/BERD is considered a key instrument in a broader energy-efficiency strategy to achieve greenhouse gas (GHG) reduction goals and overcome information barriers in the building sector. This strategy can also serve as a critical tool for assessing the market and monitoring and enforcing policies.

Advantages

- Municipalities get valuable information on local building stock to support policies, enforce regulations and monitor progress toward reductions in energy use and GHG emissions.
- Building owners have increased knowledge and awareness of energy performance and opportunities for improvement.
- Improved buildings command higher premiums when sold or rented and make cities more desirable for residents and businesses.
- Demand increases for energy-efficient products and skilled workers, creating economic growth and jobs.

Challenges

- A mandatory program may be challenged by industry if the benefits are not well understood or if industry is not consulted in the policy design process.
- If not mandatory, participation may be limited to those who are already leading in high-performance buildings and homes.
- Lack of understanding and trust in the ratings can limit HERD/BERD impact.
- Energy savings and GHG reductions may be limited unless enabling HERD/BERD policies are part of an energy-efficiency ecosystem, which may include incentives, financing and building codes.
- Higher premiums for energy-efficient home and building sales and rentals can negatively impact lower-income households.
How does this strategy work and why is it important?

Municipalities can either enact their own energy rating and disclosure policies or support those of other jurisdictions. These policies are the first step in creating energy rating and disclosure programs and can take several forms:

- **Home Energy Rating and Disclosure (HERD):** HERD typically applies to single-family residential homes, including single detached and attached homes, duplexes, townhomes and rowhouses. It involves homeowners obtaining an energy evaluation and posting the home's energy rating in all advertising when the home is for sale or rent.

- **Building Energy Rating and Disclosure (BERD):** BERD applies to commercial buildings, including office and retail buildings, and multi-family residential buildings. It also applies to municipal and other public buildings. BERD policies are typically implemented in one of two ways:
  - **Sharing information about the building at time of sale or rent:** As with HERD, building owners complete a building energy evaluation and post the energy rating in all advertising when the building is for sale or rent.
  - **Benchmarking building energy performance:** Owners of buildings (typically buildings of a minimum square footage) annually report their energy (and water) consumption to the municipality, which then discloses that information publicly.

The HERD or BERD energy evaluations include recommendations for energy performance improvements. Energy performance improvements can be voluntary, encouraged (e.g. through incentives), or mandated through building codes and minimum energy-efficiency requirements for new construction and major retrofits in existing buildings.

---

**Need funding for your energy project? Contact FCM!**

Access grants and loans for energy-efficiency and clean energy solutions that support service delivery in your community.

- Improve efficiency and reduce GHG emissions in municipal and community buildings
- Integrate renewable energy generation solutions
- Plan, refine and scale-up innovative financing programs for residential retrofits

[Learn more!](#)
As more homes are rated and information is disclosed when a home is advertised for sale, opportunities to improve energy performance and reduce costs are identified.

Upgrades are made over time, improving the home’s energy performance, rating and value (as well as homeowner comfort and bill savings). Data may be used by government or industry to monitor progress on GHG reduction goals, develop better consumer products and services, or better target energy-efficiency programs.

**Figure 2: BERD—How it works**

| Benchmarking program is implemented | Building data is benchmarked & disclosed to market | Data informs policy & programs that support energy efficiency | Data informs owners, managers, tenants & investors; tenants demand energy-efficient buildings | Building owners invest in energy-efficiency improvements | Energy and financial savings and GHG reductions are achieved |

---

Updated rating

![Improvements](image1)

Data

![Rating](image2) $\rightarrow$ Sale

![Improvements](image3)

_owner 1_

 OWNER 2

 OWNER 3

Data

 owners, managers, tenants & investors; tenants demand energy-efficient buildings

Building owners invest in energy-efficiency improvements

Energy and financial savings and GHG reductions are achieved
While the European Union and the Australian Capital Territory have had mandatory HERD/BERD programs in place for over 10 years, HERD/BERD is still relatively new in North America.

In Canada, the 2016 Pan-Canadian Framework on Clean Growth and Climate Change signaled the federal government’s intent to make building energy labeling mandatory as early as 2019. In response to the Pan-Canadian Framework, the federal government is offering financial assistance for jurisdictions to implement benchmarking, labelling and disclosure policies and programs. Several provinces and territories have signaled their intent to explore HERD/BERD strategies in their climate plans and strategies (e.g. BC’s CleanBC). As of September 2019, Ontario is the only province that has mandated building energy benchmarking, and Nova Scotia has a voluntary HERD pilot.

Province- or territory-wide energy rating and disclosure policies and programs can provide the scale necessary to build market capacity, increase access, and ensure consistency for those who operate across municipal boundaries (such as real estate professionals, building owners and building managers). However, municipalities across North America are leading the way.

In Canada, the City of Edmonton and Metro Vancouver have voluntary HERD and BERD pilots in place. In the United States, 25 cities have building energy benchmarking and disclosure policies in place. For example, municipalities like Berkley, CA, Portland, OR, and New York City are implementing mandatory HERD or BERD policies to support their corporate GHG reduction goals. Others are implementing voluntary pilots to provide proof of concept, help inform policy or help prepare the market for eventual regulation.

Specific actions that municipalities can take are summarized in Table 1. It should be emphasized that municipalities of any size can enact voluntary or mandatory HERD/BERD policies and programs—especially in cases where provincial/territorial governments do not act. Municipalities with resource constraints can partner with other municipalities to adopt a boilerplate policy or program design. For example, the U.S. City of Milwaukie, OR (population 20,000), used a mandatory HERD policy adopted by the City of Portland, OR, as a model for its own policy. Regardless of the path chosen, it will be important for municipalities to coordinate with their provincial or territorial partners on HERD/BERD initiatives.
**Table 1: Actions for creating or supporting HERD/BERD policies and programs**

<table>
<thead>
<tr>
<th>Create voluntary or mandatory HERD/BERD policies and programs</th>
<th>Support provincial/territorial or federal HERD/BERD policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Lead by example in public buildings.^a</td>
<td>• Lead by example in public buildings.</td>
</tr>
<tr>
<td>• Conduct pilot programs to prepare the market.^a</td>
<td>• Conduct pilot programs to support provincial/territorial and federal policy.</td>
</tr>
<tr>
<td>• Promote policy (e.g. through a targeted marketing/awareness campaign or by training members of the industry).^a</td>
<td>• Advocate for provinces and territories to make HERD/BERD mandatory for buildings.</td>
</tr>
<tr>
<td>• Monitor and enforce compliance for homes and buildings that fall under regulation.^b</td>
<td>• Administer or facilitate the program on behalf of the province or territory.</td>
</tr>
<tr>
<td>• Offer additional incentives to encourage home and building performance improvements (e.g. tax rebates, direct incentives).^a</td>
<td>• Conduct education and training, marketing, and awareness campaigns.</td>
</tr>
<tr>
<td></td>
<td>• Monitor and enforce compliance of mandatory policies.</td>
</tr>
<tr>
<td></td>
<td>• Offer additional incentives or link to provincial/territorial, federal, utility or other program incentives to support home and building performance improvements.</td>
</tr>
</tbody>
</table>

^a Applicable to voluntary or mandatory HERD/BERD policies and programs  
^b Applicable to mandatory HERD/BERD policies and programs

---

**Is this strategy right for my municipality?**

To determine whether HERD/BERD policies and programs are the right tool for your municipality, consider your local priorities and circumstances:

- **Does your municipality have the will and authority to regulate?** Consider the environment in which you operate: does your municipality have authority to enact and enforce HERD/BERD policies? Some important first steps are to educate council and obtain their support for policy and regulation, seek advice from legal counsel, and learn from the experience of other jurisdictions that have crafted policies.

- **Does your municipality have the capacity to administer and deliver?** Successfully implementing HERD/BERD policies and administering programs will require appropriate levels of funding and dedicated resources. Consider the expected program participation rate and the capacity of existing industry to deliver services (e.g. the number of energy advisors who can conduct energy evaluations). If there is not enough capacity to meet demand, you may choose to phase program roll-out—for example, by age of building (new vs. existing) or by type or size of building. Another alternative is to create a program that progresses from voluntary to mandatory.
A phased approach will give industry time to ramp up and your municipality time to build administrative capacity.

- **What is the local context and impact on industry?** It is crucial to give due consideration to how key stakeholders may be affected by HERD/BERD policies and programs. Industry generally has a desire to support government goals. You should engage the sector during the policy design process to identify potential risks and roadblocks and discuss how the new policies and programs can best be integrated into existing processes. It is important to provide a clear signal to the market about the direction your municipality intends to take, and to engage with stakeholders early and throughout the process.

**What does it take to implement?**

There are several key design elements to consider before creating or supporting HERD/BERD policies and programs:

- **Decide whether your programs will be voluntary or mandatory.** Voluntary programs can help increase industry and public awareness and acceptance of HERD/BERD. This can also allow time to build administrative and industry capacity, prepare the market, and prove the feasibility and value of a mandatory approach. However, voluntary programs have not yet been shown to lead to large-scale adoption, even when significant incentives are provided to encourage participation.

- **Specify which buildings should be targeted.** It is important to clearly define what type of buildings will be subject to HERD/BERD policies and programs and whether any exemptions may apply. For example, mandatory HERD programs may apply to all new and existing single-family homes, but deferrals or exemptions may be applied to certain types of buildings, such as seasonal buildings, heritage homes, income-qualified housing, and buildings in remote areas. Many mandatory BERD programs start with public buildings (i.e. municipalities leading by example), and later phase in privately owned buildings over 100,000 ft², 50,000 ft² and then 20,000 ft². To this end, you should seek to understand the composition of your building stock—including the proportion of GHG emissions that come from buildings, the split between commercial and residential buildings, and the attributes of buildings in each sector. A building’s attributes include what type of building it is, whether it is owned or rented, the household’s income level, and its energy end uses.

- **Identify which stakeholders should be involved and when to engage them.** Key industry stakeholders that may be affected by HERD/BERD policies and programs should be engaged early and throughout the process. When developing programs, it’s important to involve them from the program design phase through implementation and evaluation. It is critical to provide a clear signal to the market, in advance, about the direction your municipality intends to take, and to ensure that industry has enough capacity to deliver the requisite services. Early stakeholder engagement will also help to mitigate potential industry concerns and pushback (likely more of an
issue for mandatory programs). Industry stakeholders can inform critical design elements (which can help you integrate the program into existing processes). They can also provide subject matter expertise on potential roadblocks and issues, as well as feedback on the types of support that may be needed to help the market transition. Key industry stakeholders include:

- homebuilders (associations)
- real estate professionals (associations and boards)
- energy advisors (i.e. those who conduct home energy evaluations)
- building organizations and associations (e.g. REALPAC, the Building Owners and Managers Association (BOMA), the Canada Green Building Council, the Retail Council of Canada, and the Canadian Healthcare Engineering Society)
- government stakeholders (local, provincial/territorial, federal)
- utilities and demand-side management program administrators (regarding access to data and links to complementary initiatives such as incentives and financing)
- appraisers
- engineers, designers, energy consultants and other service providers (e.g. renovation contractors)
- financial institutions

**Choose the energy rating system you will use.** A critical component of any program is the energy rating system used to evaluate energy performance and recommend cost-effective improvements. Consider the rating system early in the program design stage—particularly the assessment methodology and tools, and how well it is understood by those who will need to interpret the information for their clients (e.g. builders and real estate professionals) and those who will incorporate the information into their renovation plans (i.e. home and building owners). Carefully consider the appropriate balance between being comprehensive and accurate, and being easily understood by a broad audience. See the text box, “EnerGuide Rating System,” for a description of a commonly used energy rating system.

**EnerGuide Rating System**

A single, standardized tool like Natural Resources Canada’s EnerGuide Rating System offers the ability to compare homes easily. This home energy rating tool has strong brand recognition, federal government support, a robust infrastructure to manage data, and an associated network of Registered Energy Advisors. However, EnerGuide has several disadvantages, including the public’s lack of understanding of the rating, as well as the cost, time and complexity of performing home evaluations. Also, the tool’s recommendations report does not link to incentive programs. As a result, municipalities that use the EnerGuide Rating System may need to customize it for their own purposes. This may mean developing a simplified report or label to better communicate results while maintaining public trust in the results. For example, Portland, OR, uses the U.S. Department of Energy’s Home Energy Score and database but the city has customized its scorecard to account for Portland-specific factors and make information clearer for participants.
**Figure 3: Energy-efficiency ecosystem**

- **Understand the broader energy-efficiency “ecosystem” that your HERD/BERD program can link to.** Your ability to encourage home and building owners to renovate following energy rating and disclosure (and the ensuing GHG emissions reductions) will be limited if you don’t take a coordinated approach. Simply providing information (even if recommendations are tailor-made) is insufficient to trigger broad home improvement investments. The recommendations should be embedded within an integrated policy framework and energy-efficiency ecosystem that includes incentives, tools, resources and a skilled workforce (see Figure 3).

  To ensure that your program is part of a healthy energy-efficiency ecosystem, consider the following actions:

- **Link to incentives.**
  - **Offer rebates or financing, as a stand-alone offer or to top off existing programs** available through other entities (e.g. federal, provincial/territorial, utility, or not-for-profit organizations).
  - **Include information on mortgage options when making recommendations for improvements.** For example, qualified home-buyers may be eligible for purchase-plus-improvements mortgages, which allow homebuyers to borrow a percentage of the as-improved value of a home to put toward the cost of renovations. In addition, mortgage insurers like the Canada Mortgage and Housing Corporation (CMHC) offer...
refunds of up to 25 percent on mortgage loan insurance premiums when homeowners buy or build an energy-efficient home, or when they buy an existing home and make energy-saving renovations.

- **Build industry capacity.** You can support energy advisor training and certification, offer technical support through an industry help desk, and develop a quality assurance strategy. The existence of a network of qualified energy advisors that provide credible ratings will lead to greater trust in the system. Building capacity will ensure that energy evaluations are provided in a reasonable time frame and avoid delaying the home/building sale process. This is crucial in order to obtain buy-in from real estate professionals and building owners. Also, builders of high-performance homes and qualified renovation contractors will be needed to support home and building owners in following through on recommendations from their energy evaluations.

- **Decide who will administer the program.** Your municipal HERD/BERD program can be administered in-house (if adequate knowledge and resources are available) or by a third party.

- **Plan how you will communicate to the public about HERD/BERD.** A successful communications strategy will raise awareness of the value of HERD/BERD, build trust in the system and encourage home improvements. Consider the following practices:
  - Test communication materials with focus groups.
  - Use a simple and positive message.
  - Cover multiple channels with tailored messaging to reach a variety of audiences.
  - Set up a help desk.

---

**Designing for equity**

Providing information on energy performance and how to improve energy efficiency can benefit low- and moderate-income (LMI) households and small businesses—but there are risks. The cost of an energy evaluation can be a significant barrier to these disadvantaged groups. Municipalities must carefully consider the cost and complexity of the chosen energy rating system, and whether exemptions or incentives should be offered to alleviate potential negative impacts on these markets.

Disclosure of ratings brings value to more energy-efficient homes and buildings, which can lead to increased purchase or rental costs for higher-performing properties. Escalating prices for more efficient properties can further push LMI households and small businesses toward inefficient homes and buildings. Applying a social equity lens can help municipalities evaluate how HERD/BERD impacts the most vulnerable, understand their needs, and identify solutions.
What are the GHG and financial impacts?

**Energy savings and GHG reductions**

While energy evaluations and ratings do not reduce energy consumption or GHG emissions directly, they are foundational to establishing market conditions that encourage home and building owners to invest in energy efficiency. In fact, evidence suggests that HERD/BERD policies and programs do lead to an increase in building performance upgrades, which in turn reduce GHG emissions. Reductions in energy use and GHG emissions depend on various factors, such as the scope of the policy or program (e.g. how many buildings are affected), the effectiveness of implementation, the level of support and enforcement, and the energy use of the affected buildings (e.g. size, age, efficiency). Reductions in energy use and GHG emissions have been supported by HERD/BERD programs in many jurisdictions:

- For commercial benchmarking programs in North America, participating buildings have demonstrated an annual average energy reduction of two percent.\(^v\)
- In the residential sector, evidence from the EU shows that 12–37 percent of homeowners that participated in mandatory energy rating and disclosure programs made improvements (and of those, 30 percent made more improvements than planned).\(^ix\)
- Although the City of Edmonton’s voluntary program has seen modest participation (two percent of existing home sales), 10–15 percent of those households completed home improvements.\(^vi\)

- Evidence from the European Union suggests that HERD, when integrated into an energy efficiency ecosystem, accelerates GHG emissions reductions. After the EU implemented its Energy Performance of Buildings Directive and Energy Efficiency Directive in 2007, energy consumption per residential dwelling dropped by about five percent between 2007 and 2013, and GHG emissions per residential dwelling dropped by 10 percent (from 2.22 tCO\(_2\) per dwelling to 1.98 tCO\(_2\) per dwelling).\(^vii\) The reduction in residential energy consumption has also accelerated since 2007 (from an average decrease of 2.1 kWh/m\(^2\) per year in 2006 to an average decrease of 3.8 kWh/m\(^2\) per year from 2007 to 2013).

**Supporting cost savings**

The U.S. Department of Energy estimates that homeowners can save 5–30 percent on energy bills by making the energy-efficiency upgrades identified in energy audits.\(^viii\) In addition, there is a strong correlation between high-performance buildings and sale price:

- In the EU, better-performing buildings yield up to 5–10 percent higher sale or rental prices per energy class on average.\(^ix\)
- U.S. studies have shown that energy-efficient buildings have occupancy levels up to 10 percent higher than less efficient properties, as well as rental premiums over 10 percent higher and sale prices up to 25 percent higher.\(^x\)
Program costs and municipal resources
Costs will vary depending on the program delivery model chosen, the role a municipality plays, and the level of support the municipality provides to the market. This section highlights various costs that can be associated with implementing HERD/BERD policies and programs.

Program administration
Administrative costs are highly dependent on the program model selected, but can include:

- **General overhead and administration:** These are costs such as support staff (including front office, human resources and procurement staff), office supplies, legal fees, office leases, utilities and telephone.

- **Program administration:** This category includes staff to manage the program and deliver training to building owners, real estate professionals, home builders and energy advisors. It also includes costs to manage a help desk; collect, track and analyze data; deliver marketing and communications; and do quality assurance and program evaluation. Each of these program costs can be delivered by municipal staff or contracted to delivery agents.

- **Compliance and enforcement:** In the case of a mandatory HERD/BERD policy, the level of compliance and enforcement imposed will impact costs. For example, a municipality may simply encourage compliance (with limited or no enforcement) or it may enforce compliance, which would require mechanisms to track compliance, issue warnings and apply fines or penalties.

Infrastructure
Several critical infrastructure components for HERD/BERD will require investment.

**HERD**
A central database is a key tool for monitoring and enforcing compliance, tracking and measuring building stock performance, and facilitating integration with the home sale process. Through a central database, municipalities can collect home energy performance data and link ratings to other platforms, such as real estate listing websites like REALTOR.ca. Natural Resources Canada now has a beta application programming interface (API) and a MyEnerGuide website, to provide open access to EnerGuide home energy rating data. This will support efforts by provinces, territories and municipalities. The API will allow any web interface to retrieve and display data.

Many programs include a dedicated help desk to provide information and guidance to participating home and building owners, energy advisors and industry.

**BERD**
Municipalities implementing BERD policies and programs must select a tool for reporting building energy and GHG emissions data. Most programs reviewed for this factsheet have opted for ENERGY STAR® Portfolio Manager, a standardized, free and secure web-based platform for building energy benchmarking, available across Canada and the US. In Canada, Portfolio Manager is the only standardized energy benchmarking tool available, and it has wide market adoption—with more than 16,500 buildings using the tool as of March 2017. One of the many features of the tool is
that it provides certain building types with an ENERGY STAR® performance score. While this tool is free and can be used for benchmarking as well as the gathering and sharing of data, municipalities require additional IT infrastructure to store data, clean and analyze the data for reporting purposes, or disclose information on a public website.

New tools or software programs can help offset program costs. For example, the U.S. Department of Energy’s Standard Energy Efficiency Data (SEED) Platform™ is an open-source web application that supports benchmarking, labelling and disclosure programs. The SEED Platform helps users manage portfolio-scale building performance data securely and cost-effectively, using data from a variety of sources. A Canadian version of the SEED Platform is now available through OPEN Technologies, and can be accessed by any municipality for benchmarking and labelling and disclosure programs.

Incentives
Successful programs link energy ratings and recommendations with financial support to help home and building owners cover the costs of obtaining an energy evaluation and then undertaking renovations. The value of incentives offered will vary by municipal program. See the text box, “City of Edmonton HERD incentives,” for an example of the types and value of incentives offered by the City of Edmonton.

Other program costs
Other costs may include running pilots to test processes and functionality, build capacity and prepare the market prior to roll-out of a large-scale program.

City of Edmonton HERD incentives
The voluntary HERD program in Edmonton, AB, offers the following financial incentives:

- $200 per new home disclosed (up to 10 homes for home builders)
- Links existing homes to Energy Efficiency Alberta (EEA) $300 instant rebate for pre-evaluation
- Additional $100 to disclose on web platform
- $250 for post-upgrade home energy evaluation
- Top-up incentives for home improvements (incremental to EEA offering)
What have municipalities done?

Voluntary HERD programs

City of Edmonton: Change Homes for Climate pilot
The City of Edmonton, AB, is running a voluntary, opt-in, three-year HERD pilot for new and existing homes. The program includes low-rise residential buildings (single-family homes and multi-family residences up to and including three-storey apartments) covered under Part 9 of the 2014 Alberta Building Code. The pilot is intended to last three years, from June 2017 though spring 2020, and is designed to develop and test the approaches, processes, systems and tools that will be needed for widespread home energy labeling. It also aims to build energy literacy and capacity among industry partners and demonstrate the feasibility and value of a mandatory approach. Homeowners have access to financial support for an energy assessment and home upgrades, if they agree to disclose the rating on the city’s online disclosure platform. The goal is to pave the way for the regulation needed to ensure long-term market transformation and GHG reductions.

Metro Vancouver: RateOurHome pilot
RateOurHome.ca was created to support market transformation by filling the market information “gap” about a home’s energy performance, spurring the market to value homes with better energy performance, and creating a pathway toward Metro Vancouver’s GHG emissions reduction goal of an 80 percent reduction by 2050. The pilot launched in 2016 and was a two-year project aimed at encouraging builders and homeowners to voluntarily obtain an EnerGuide home energy evaluation and disclose their rating on an online public platform. The pilot ended in 2018, but the online map showing home ratings in different locations is still available, and the steering committee continues to advance home energy labelling discussions across the region.

Efficiency Nova Scotia: Real estate pilot
Efficiency Nova Scotia offers $99 home energy assessments and encourages homeowners to post their ratings on the ViewPoint Realty website and to speak with their real estate agent about posting an MLS® listing. A dedicated web page provides information to home sellers, buyers and real estate agents about how to obtain an energy assessment and disclose it, as well as the benefits and additional resources.

Mandatory HERD programs

City of Portland: Home Energy Score ordinance
As of January 1, 2018, sellers of single-family homes in Portland, OR, are required to obtain and disclose a home energy report estimating energy use, associated costs, and cost-effective solutions to improve the home’s efficiency. A policy development process throughout 2016 led to unanimous adoption of the Home Energy Score ordinance in December 2016. Portland views home energy scores as one policy tool the city has available to catalyze change in the residential sector by providing information to both buyers and sellers of homes.
City of Berkley: Building Energy Saving Ordinance

As of December 2015, all sales transactions in Berkley, CA, of home and buildings under 25,000 ft² must comply with Berkley’s Building Energy Saving Ordinance (BESO). Reporting requirements for buildings over 25,000 ft² are being phased in, starting in 2018 with those over 50,000 ft². BESO is deemed a critical component of Berkeley’s Climate Action Plan, which sets a target of a 33 percent reduction in emissions by 2020, followed by an 80 percent reduction by 2050. BESO requires building owners and homeowners to complete comprehensive energy assessments and publicly report the results, to identify energy-saving opportunities. Energy assessors must be certified Home Energy Score providers. They provide recommendations on how to save energy and link building owners to incentive programs for energy-efficiency upgrades. Energy-efficiency improvements are voluntary and encouraged.

City of Austin: Energy Conservation Audit and Disclosure Ordinance

The Energy Conservation Audit and Disclosure Ordinance (ECAD) established by Austin, TX, serves as a mechanism to support the city’s 2007 Climate Protection Plan. Austin Energy is the ninth largest municipal utility in the United States, serving 320,000 residential customers and 40,000 commercial customers. ECAD audits are compulsory before the sale of a house with a few exceptions, the most notable of which is if a home has recently performed energy-efficiency renovations. Auditors must be certified by the Residential Energy Service Network (RESNET) or the Building Performance Institute (BPI). The ECAD home audit costs less than $300 and evaluates the appropriateness of common cost-effective updates for each home. Homeowners receive information about Austin Energy’s loans and rebates, as well as suggestions for increasing the home’s energy efficiency through improvements to attic insulation, duct systems, windows and air conditioning equipment.

Voluntary BERD programs

City of Edmonton: Building Energy Benchmarking Program

The Building Energy Benchmarking pilot program run by the City of Edmonton, AB, aims to improve building energy efficiency and contribute to significant GHG reductions by providing owners with information about their building. The program uses ENERGY STAR® Portfolio Manager. For owners and operators of buildings over 20,000 ft² the program provides technical support, customized building benchmarking reports, tenant education, and access to financial incentives (up to $10,000 per building). The pilot is intended to help building owners prepare for a planned building energy labelling requirement.

Mandatory BERD programs

Province of Ontario: Energy and Water Reporting and Benchmarking for privately owned buildings

The Province of Ontario’s Energy and Water Reporting and Benchmarking (EWRB) initiative is designed to help building owners and managers improve their building’s energy and water efficiency. Designated privately owned buildings greater than 50,000 square feet (which account for about 19 percent of Ontario’s total GHG emissions) are required to report annual energy and water consumption and performance data.
Province of Ontario: Energy and Water Reporting and Benchmarking for public sector [Revoked]
From 2012 until December 31, 2018, Ontario required annual energy reporting and public disclosure for each prescribed building in Ontario’s Broader Public Sector (BPS), per O. Reg. 397/11 under the 2009 Green Energy Act. Ontario’s BPS owns or leases a substantial amount of provincial building space (about 19 percent of all commercial and institutional building space). These public buildings use about three percent of the province’s energy supply, and about eight percent of the energy used in all buildings in Ontario. This regulation was revoked on January 1, 2019, per the Green Energy Repeal Act of 2018, but the requirements for BPS energy planning and reporting were rolled into the 1998 Electricity Act under O. Reg. 507/18.

United States: City, county and state policies
As of June 2019, almost 50 jurisdictions in the United States (municipal, state and national) have policies on building benchmarking and transparency for existing buildings, as shown in Figure 4 below.

Figure 4: US city, county and state policies for existing buildings: Benchmarking, transparency and beyond (June 2019)
What resources can support next steps?

**National building energy benchmarking initiative**, Natural Resources Canada
This website provides tools and additional resources to support benchmarking, labelling and disclosure programs (e.g. factsheets, guides and an online database platform) and supports the development of a national building energy benchmarking tool. Natural Resources Canada has partnered with the U.S. Environmental Protection Agency to “Canadianize” the ENERGY STAR® Portfolio Manager to support data collection, benchmarking and reporting on energy and water consumption.

**Setting Energy Data Free: Unlocking Access to Home Energy Use Data**, Natural Resources Canada
This brochure describes an initiative to build an “application programming interface” to provide open access to information about EnerGuide’s home energy ratings. Natural Resources Canada’s EnerGuide database contains data from over a million EnerGuide home evaluations. The interface acts like a “server,” allowing users to assess, retrieve and display data from the EnerGuide dataset. Access to data will support provinces, territories and municipalities in designing energy-efficiency policies and programs. Open access to the data will also enable research and provide information to homeowners and homebuyers.

This report aims to support local and provincial/territorial governments that are developing energy benchmarking strategies and regulations. It outlines a standard, national approach to achieving three goals: simplify the process of policy development and implementation; provide reliable data that will support strategic investments in building improvements and help achieve energy and GHG emissions reduction targets; and provide a consistent approach for building owners and managers to participate in benchmarking programs across Canada.

This web page provides information on benchmarking and transparency policies, and links to additional resources and local policy toolkits.

**BuildingRating.org**, Institute for Market Transformation
An international exchange for information on building rating policies and programs, this online hub provides tools and resources about HERD/BERD policies and programs in jurisdictions around the world.

**Concerted Actions**, European Commission
This website aims to support the implementation of the EU’s Energy Efficiency Directive, Renewables Directive and Energy Performance of Building Directive. The objectives are to enhance and structure the sharing of information and experiences from member states; promote best practices to improve and strengthen implementation of the directives; and encourage dialogue between member states on common approaches, to accelerate harmonization.
Endnotes

i Energy rating and disclosure programs are commonly implemented in two steps, starting with enabling legislation (i.e. policies). Once legislation is in place, the designated implementing authority designs the program in consultation with key industry stakeholders and the public. The program design includes details on the rating system, schedule, non-compliance penalties and more, while the enabling policy simply provides the framework for the program to be implemented.

ii The EU Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive of 2007 are the EU’s main legislative instruments promoting the improvement of the energy performance of buildings. The EPBD mandates that all 28 member states require buildings to have an energy rating and disclose it on all advertising when posted for sale or rent. It also mandates minimum energy performance requirements for new construction, major renovations or retrofits, and building elements, and calls for measures and instruments (e.g. financial) to offset the cost of upgrades.

The Australian Capital Territory House Energy Rating Scheme enacted in 1999 requires a home’s energy performance to be calculated and disclosed when a home is sold or rented.

iii Ontario’s Energy and Water Reporting and Benchmarking requirement for large buildings.

iv For example, real estate professionals are generally supportive of voluntary HERD/BERD policies, but some associations have opposed mandatory programs. As an example, see the Ontario Real Estate Association’s September 2015 Submission to The Ministry of Energy: Home Energy Rating and Disclosure (HER&D) Program.

v Based on a review by Dunsky Energy Consulting of reporting and benchmarking programs in Canada and the United States (based on published data from 2019 to 2017).

vi Interview with Mike Mellross, Director of Energy Efficiency Policy, City of Edmonton, December 2018.


xii See Natural Resources Canada’s Energy Star Portfolio Manager Access Page.
Strategy
Local development policies and bylaws

What are local development policies and bylaws?

Although Canadian municipalities generally do not have the legal authority to adopt their own building or energy code requirements (with the exception of Vancouver—see “Unique authority allows Vancouver to lead” below), they can create local development policies and bylaws to set building requirements that exceed or complement the provincial code. This strategy can reduce energy use and greenhouse gas (GHG) emissions and may help achieve sustainability and other development objectives, such as more compact, livable cities and increased employment. In addition, because municipalities implement building and energy codes adopted by their province or territory, they are uniquely positioned to prepare their staff and communities for upcoming code changes. Municipalities can act in several key ways:

- Adopt local development policies and bylaws to promote or require improved design and construction and greater use of clean energy and energy-efficiency technologies in homes and buildings.
- Ready staff and local markets for model building and energy code changes anticipated from provincial/territorial and federal governments.
- For municipalities in British Columbia: Adopt various levels of the stretch code (i.e. BC Energy Step Code).

Advantages

Local development policies and bylaws

- Energy use and GHG emissions from residential and commercial buildings are reduced.
- Other sustainability and development objectives may be addressed (e.g. more compact, livable cities).

Readying for new building and energy codes

- The local construction industry is more prepared.
- Municipalities demonstrate leadership on energy efficiency and emissions reductions.

Challenges

Local development policies and bylaws

- Municipal capacity to implement and enforce new policies and bylaws may be limited.
- Changes may be met with resistance from the development community.
- Development policies may increase the cost of construction but reduce operating costs over the life of the building and insulate the owner from escalating utility costs.

Readying for new building and energy codes

- Training and other enabling activities may not lead to direct GHG reductions.
- Studies are needed to define costs, benefits and approaches.
How does this strategy work and why is it important?

Municipalities have several options for using local development policies and bylaws to exert control or influence over building construction and renovation:

- Set building requirements that are more stringent than code (e.g. require permits for new developments or major retrofits, or require a certified commissioning agent’s report prior to issuing occupancy permits).
- Offer incentives related to permits or development charges (e.g. reduced fees or expedited approvals).
- Create sustainability checklists and other tools for developers.
- Review existing policies to ensure they are not inhibiting the construction of high-performance buildings.

Municipalities in some jurisdictions may have additional levers at their disposal, depending on the approach taken by the specific provincial or territorial government. For example, municipalities in British Columbia have the option of adopting various levels of the voluntary, locally mandated Energy Step Code, which is aimed at achieving greater energy savings than base code.

To set the stage for municipal action, municipalities can ensure that staff and the community are prepared for federal, provincial and territorial changes to model building or energy codes.

Unique authority allows Vancouver to lead

The Vancouver Charter grants the city unique powers compared to other communities under the BC Municipalities Act. To date, the city is the only municipality in Canada that has developed custom requirements regulating the design and construction of new buildings and where provincial code requirements do not apply. Under the authority of the Vancouver Charter, the city has developed its own regulations related to building energy use, such as insulation and lighting requirements, and has announced its intention to require zero emissions in all new buildings by 2030.

Sources: BC Office of Housing and Construction Standards, What Local Governments Need to Know about the Building Act (June 2016)
City of Vancouver, Vancouver Building By-law (CBO) (2019)
Local development policies and bylaws

How do building codes work in Canada?

Model building codes, such as the National Building Code of Canada and the National Energy Code of Canada for Buildings, outline requirements for the design and construction of buildings. These model codes are federal but have no force in law until they are adopted by provinces and territories and enforced by municipalities. Provincial and territorial governments can choose to adopt codes in their entirety, adopt them with modifications, or develop customized building code requirements.

Readying for new building and energy codes

The federal, provincial and territorial governments of Canada have committed to developing and adopting increasingly stringent energy codes for new buildings, aiming for provinces and territories to adopt “net-zero energy ready” codes for new buildings by 2030. The federal government has also committed to developing a code for existing buildings (i.e. a retrofit code) by 2022, which will outline requirements for renovations.

If provinces and territories adopt these model codes or similar ones, municipalities will need to adjust local planning and development practices accordingly—and can play an important role in readying their communities for the changes ahead, through several actions:

- Hold consultations with local industry.
- Offer training and support on codes for high-performance buildings—to municipal staff or local industry, or both.
- Hire municipal staff with expertise in high-performance buildings.
- Partner with utilities and other agencies on initiatives and incentives for high-performance buildings.

In British Columbia, municipalities also have the option of adopting various levels of the locally mandated Energy Step Code, which provides an incremental and consistent approach for achieving energy-efficient construction. To date, more than 30 communities in BC have either begun consultations related to the Energy Step Code, or already reference the Step Code in a local policy, program or bylaw. Municipalities elsewhere could have similar options in the future, depending on provincial/territorial action in their jurisdiction.

Local development policies and bylaws

Although most municipalities are bound to the building code adopted by their province or territory, municipalities can use policy tools that apply to the individual building or site level to address energy use and emissions in the built environment. See Table 1 for some key examples.
What are “net-zero” buildings?

The phrase “net-zero” is common in the world of green construction today, but its meaning can vary depending on the context in which it is used.

A net-zero energy building generates as much energy on-site as it uses on an annual basis. Net-zero energy ready refers to a building designed such that it could become a net-zero energy building through the installation of solar panels or other on-site demand-side energy sources. Codes can either be prescriptive, with specific requirements for individual measures (e.g. requirements for the energy efficiency of windows), or performance-based, using modelling to demonstrate compliance with requirements for energy use per unit area. The government of Canada has committed to developing a net-zero energy ready model building code by 2030, and the BC Step Code will require all new construction to be net-zero energy ready by 2032.

A net-zero emissions building offsets any on-site fossil fuel use through the generation (or purchase) of low-carbon energy or the purchase of offsets. The building bylaws of Vancouver and Toronto go a step further, with zero-emissions building requirements, which do not allow for any fossil fuels to be burned on-site and require electricity to come from low-carbon fuels.

“Net-zero” can also be used to describe whole neighbourhoods, where each building may not meet net-zero energy or emissions requirements, but where the neighbourhood does as a whole.
Table 1: Municipal policy levers for high-performance buildings

<table>
<thead>
<tr>
<th>Policy lever</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building requirements beyond code</td>
<td>Through bylaws, municipalities can set building requirements that complement or exceed code. Municipalities can pass bylaws to require a wide range of building measures that reduce GHG emissions beyond what is required by code—such as green roofs, solar-ready homes, siding that promotes passive solar heating, EV-ready buildings, placement of vegetation, energy reporting and disclosure, and more. For example, municipalities can tie local permit requirements for new construction or major retrofits to practices that lead to high-performance buildings; and the requirements could align with recognized buildings standards, such as Passive House or LEED®. Municipalities in Canada and worldwide are increasingly using this strategy to lead the way on climate action, and are introducing new and innovative approaches—including capping emissions for existing buildings. At a minimum, municipalities can review their existing policies to assess how they may be adjusted to encourage, and not inhibit, the construction of high-performance buildings. For example, in some cases municipalities have authority over fire safety codes, which may need to be updated to allow for options like advanced construction practices for wood buildings or smaller clearances between buildings.</td>
</tr>
<tr>
<td>Incentives related to permits or development charges</td>
<td>Incentives such as reduced fees and expedited approvals of permit applications can encourage sustainable development. Reduced permitting and development fees and wait times can be of great value to developers and, if attached to sustainable development requirements, may incentivize the construction of buildings with reduced emissions and energy use.</td>
</tr>
<tr>
<td>Sustainability checklists for developers</td>
<td>Municipalities can encourage developers to complete checklists at the time of permitting and rezoning that assess how their development is rated on a range of criteria. Although not linked to mandatory actions on the part of developers, sustainability checklists can raise developer awareness of potential sustainable design measures and local government priorities. The checklist can request information on sustainable building features like construction materials and accessibility to transportation. Municipalities can encourage developers to complete a sustainability checklist at the time of permitting or rezoning.</td>
</tr>
</tbody>
</table>

a Passive House and LEED® (Leadership in Energy and Environmental Design) are examples of certifications for high-performance buildings. These certifications outline building material specifications or performance requirements. Certified buildings are third-party verified. Many certifications are internationally recognized and have been developed by experts in high-performance buildings. Aligning local requirements with third-party building certifications can help to ensure that developers use industry-accepted best practices for the construction of high-performance buildings.
In addition to the above building and site-level policies, policies related to land use can also be used to reduce GHG emissions related to new buildings:

- **Development charges:** Municipalities may apply charges to new developments, reflecting the cost of the infrastructure and services, such as water and sewer, needed to service the area. Development charges can incentivize compact growth. Some municipalities may also have the ability to reduce charges for high-performance buildings and sustainable development.

- **Zoning:** High-density and mixed-use zoning can be used to allow for more efficient land use, which in turn can reduce GHG emissions related to building energy use, transportation and more.

### Solar-ready and EV-ready buildings

Municipalities are increasingly leveraging development permit requirements to require that developers prepare buildings for solar PV and electric vehicle charging infrastructure.

Policies that promote solar-ready buildings ensure that new construction can support the future installation of solar systems. These policies can include requirements related to roof area and angle, solar PV conduits, and wall space for structural and electrical equipment.

To ensure that buildings meet the technical requirements for EV charger installation, policies can include specifications related to electrical capacity, pre-wiring and more.

---

**Is this strategy right for my municipality?**

In deciding whether to engage local industry and the community around high-performance buildings, prepare municipal staff and industry for code changes, or develop new policies or bylaws, consider the following questions:

- **Has your province/territory signalled what new building or energy codes it will adopt and when?** Provincial and territorial governments have committed to adopting net-zero energy building codes for new buildings by 2030, but the pace of code improvements will likely be specific to the province or territory. When assessing the need to ready local industry, consider the information provided by your province or territory about the timing and nature of code changes.

- **How fast is your municipality growing?** If you expect little new construction, building retrofits may be a better focus for initial training or policy development.
If you anticipate considerable new construction activity, you may need to address both new and existing buildings.

- **How equipped is your local construction industry?** Assessing the local construction industry’s expertise in high-performance buildings and the industry’s readiness to implement building codes properly will show you how much training and capacity building is needed, and where municipal efforts are most critical. This assessment will help you decide whether to focus on preparing developers, contractors, engineers, architects, technicians or other groups.

- **Does your staff have the capacity to implement new policies?** Developing policies requires internal resources. The process may involve multiple departments, consultations with the public and industry, cost-benefit studies, risk assessments and more. It is simpler and more cost-effective for municipalities to align policies with third-party building standards than to develop and continuously update their own standards. Once you’ve established policies, ongoing staff time will be required to enforce them. The amount of effort required to develop and enforce a policy will vary, depending on the type of policy.

- **Is this policy area within municipal jurisdiction?** In cases where bylaws are in conflict with provincial/territorial law, the provincial or territorial requirements will take precedence. If you aren’t sure about the scope of your municipal authority, seek legal council.

### What does it take to implement?

If your municipality decides to take action related to codes, policies or bylaws, consider the following steps:

- **Decide whether your instrument will be voluntary or mandatory.** Voluntary sustainability checklists are straightforward, uncontroversial initiatives for municipalities. On the other hand, development controls, and changes to bylaws, permitting fees or other charges, will likely be met with greater resistance and may be more challenging to implement, but are likely to have more impact in reducing energy use and GHG emissions.

- **Consult stakeholders.** Be aware of potential impacts on stakeholders, including (but not limited to) developers, homebuyers, business owners, local industry, and industry associations (e.g. homebuilders’ associations). Policies that encourage the construction of high-performance buildings will lead to numerous community benefits, including reduced emissions, improved air quality, lower monthly energy bills, and more—but these policies may also lead
Designing for equity

Green building requirements may lead to higher construction costs, which are expected to be passed on to home/building buyers or renters. Without policy interventions, this may have the effect of pushing low-to-moderate income households and businesses into less efficient buildings, leading to higher monthly bill payments for these already-vulnerable segments. Offsetting green building premiums through incentive programs for low- or moderate-income participants can be an effective way to ensure equity in access to high-performance construction.

What are the GHG and financial impacts?

GHG reductions
The magnitude of impacts associated with building and energy code changes and development policies and bylaws can be significant. For example, in British Columbia, the Energy Step Code is 10–80 percent more efficient than code, depending on the step adopted. In the United States, stretch codes are typically 15–20 percent more energy-efficient than base code.\textsuperscript{vii} Experts estimate that a national net-zero energy ready code covering the residential and commercial sectors would result in a 7–9 percent reduction in Canadian building sector emissions.\textsuperscript{viii} It should be noted, however, that in specific municipalities, the emissions reductions achieved through initiatives focused on high-performance buildings will be dependent on both the carbon intensity of the electricity grid and the heating fuel mix.

Program costs
Program costs will vary based on the nature and type of strategy pursued. In estimating costs, municipalities should consider the internal and external resources required for development, outreach, implementation, assessment, reporting and enforcement activities. Municipalities may need to hire new staff with specialized expertise in high-performance buildings.
What have municipalities done?

City of Toronto: Toronto Green Standard
The Toronto Green Standard was initially introduced in 2006 as a voluntary standard for new development. Over time, the standard has evolved to include multiple tiers for energy and emissions performance. In 2018, Version 3 of the standard was released. It is now mandatory, and includes four tiers of performance targets that approach zero emissions for all new buildings by 2030. Profiles of buildings constructed to tiers 2, 3 and 4 can be found on the City of Toronto website, and include project energy savings and specific energy-efficient measures used.

City of Surrey: Sustainable Development Checklist
The City of Surrey, BC, has developed the first part of a mandatory sustainability checklist. The city requires developers to complete the checklist as part of the land use development application process. The second part of the checklist is being developed and will accompany building permit applications. The purpose of the checklist is to make applicants more aware of the sustainability implications of their proposed design, with the aim of increasing the sustainability of project proposals.

City of Burnaby: Electric vehicle charging requirements for new buildings
Through a 2018 amendment to a city zoning bylaw, the City of Burnaby, BC, established a requirement for all dwelling unit parking spaces to have an energized outlet capable of providing Level 2 charging or higher. The amendment includes provisions for the city’s director of planning and building to specify additional technical requirements, including those related to metering and performance standards.

Leading-edge approach targeting existing buildings: New York City’s Climate Mobilization Act
Widely regarded as one of the most ambitious climate actions by a municipality to date, New York City Council recently passed the Climate Mobilization Act. The act addresses large buildings over 25,000 square feet and phases in caps on GHG emissions starting in 2024. The centrepiece of the law requires large buildings to cut their GHG emissions by 40 percent by 2030 and 80 percent by 2050.

Initially, only the highest emitting buildings (roughly 20 percent) will need to make improvements to comply. Starting in 2030, however, approximately 75 percent of buildings will need to make improvements as requirements become more stringent. Emissions caps will lower again in 2035, 2040 and by 2050.

Building owners will be allowed to purchase renewable electricity to achieve emissions targets, rather than relying totally on efficiency improvements to their buildings, but it is not clear the extent to which this will be allowed. Those who do not comply with the act will face a penalty in the form of a carbon tax.

Although this approach may not currently be replicable across Canadian municipalities (outside of Vancouver), it provides inspiration for what is possible and illustrates what’s being done by leading municipalities at the global level.
What resources can support next steps?

This FCM-funded study assessed the barriers and solutions for accelerating green development in Canada, based on case studies of development projects in four mid-sized growing Ontario cities. The report provides guidance to municipal staff on selecting and designing the right policy levers and processes to support net-zero energy development. It also provides a sample community improvement plan that includes supporting programs, which could be adapted and adopted by Canadian municipalities.

**Energy Regulations for Existing Buildings**, Pembina Institute and TAF (The Atmospheric Fund), 2017
This discussion paper highlights the need for existing building codes, provides additional information about the types of codes in Canada and how they are developed and brought into force, and presents key components of a retrofit strategy for the building sector.

**Zero Carbon Building Standard**, Canada Green Building Council, 2018
This new standard offers voluntary green building certification aimed at commercial, institutional and multi-family buildings in Canada.

**National Model Codes**, National Research Council Canada
This website provides information about Canada’s model code system, including code publications.
Local development policies and bylaws

Endnotes

i Municipalities elsewhere could have similar options in future, depending on provincial/territorial action in their jurisdiction.

ii A stretch code is a voluntary, locally mandated code or alternative compliance pathway that is more aggressive than base code and is aimed at achieving greater energy savings.


iv Ibid.

v The BC Energy Step Code is an example of stretch code—a voluntary, locally mandated code aimed at achieving greater energy savings than the base code.


viii In planning how to meet Canada’s climate commitments under the Paris agreement, all orders of government in Canada developed policies and quantified the emissions reduction potential for sectors across the Canadian economy. See the *Specific Mitigation Opportunities Working Group Final Report*.


x City of Toronto, *Tier 2, 3, and 4 Project Profiles*, 2019.
APPENDICES
Appendix A: Building-level analytics

This appendix provides additional detail around the analytics conducted on the building-level solutions.

**Quantitative assessment of GHG and financial impacts**

Indicative estimates of the GHG and financial impacts associated with each technology—by baseline fuel or energy source—are presented on a per-building basis. Costs assessed are those of the solution itself, excluding any incentives or other program and administrative costs that may be incurred by a municipality. The savings are the savings realized by the building owner or occupant. Example measures (i.e. specific options chosen as examples of the building-level solutions) are assessed for an average residential or office building (as relevant)—with the exception of the “high-efficiency indoor ice rinks” solution, which is assessed for an average municipal arena. Assumptions about average residential and office buildings are presented in each factsheet, along with definitions of the example measures being assessed.

For each building, FCM calculated GHG and financial impacts as follows:

- **Annual GHG reductions** are based on the specific example measures described within the factsheets, and are calculated using provincial/territorial average data on grid carbon intensity and climate, as relevant (see Appendix B for detailed assumptions). Note that the GHG impacts of multiple measures may not be additive. This is important with regard to solutions that target the same end use—such as improved HVAC controls and heat pumps; the GHG impact of implementing both measures in the same building may be lower than the sum of the impacts of each individual measure, due to the interactive effects of the measures.

For the purposes of this roadmap, high-impact measures are those that save at least 1 kgCO₂e/m² per year per building. This translates into 2.9 tCO₂e per year for a “typical” commercial or municipal (office) building and 0.14 tCO₂e per year for “typical” residential building.

---

1 Specifically, heating degree days are used to calculate the impact of envelope upgrades and HVAC controls; typical hourly temperature profiles are used to calculate the impact of heat pumps; and data on solar insolation feed into the calculations for solar thermal and solar PV.
• **Annualized return on investment (ROI)** is based on the measures described within the factsheets and is calculated using provincial/territorial average data for energy rates and climate (see Appendix B for detailed assumptions). The annualized return on investment takes into account the incremental capital cost, annual incremental costs or savings (e.g. from reduced energy bills, incremental maintenance needs, etc.) and the lifetime of the measure. The calculation does not account for any federal, provincial/territorial, utility or other incentives that may be available in certain regions and which can significantly change the business case. Annualized ROI is calculated as follows:

\[
\text{Annualized } \text{ROI} = \left( \frac{\text{measure life} \times (\text{annual cost savings with current rates} - \text{annual incremental costs})}{\text{incremental measure cost}} \right)^{\frac{1}{\text{measure life}}} - 1
\]

For example, a measure that has a cost of $1,000 and saves $100 a year for 15 years would have an annualized ROI of 2.7 percent.

While there is no universal benchmark for what is considered to be a “good” or “bad” annualized ROI, this roadmap applies the following categories in summarizing results:

- **Negative**: < 0
- **Low**: ≥0% to <4%
- **Medium**: ≥4% to <8%
- **High**: ≥8%

Note: For measures with no associated upfront “investment” costs, return on investment cannot be calculated. In such cases, a **net present value (NPV)** is provided instead. NPV expresses the current value of all future cash flows generated by a project, including the initial capital investment. A positive NPV indicates that the discounted savings exceed the discounted costs over the life of the technology. NPV is calculated as follows:

\[
\text{NPV} = \sum_{year = 1}^{\text{measure life}} \frac{\text{annual cost savings} - \text{annual incremental costs}}{(1 + \text{discount rate})^{\text{year}}} - \text{upfront cost of measure}
\]

In calculating NPV, the analysis assumes a real discount rate of three percent.
The factsheets on building-level solutions present a more detailed set of results than those found in Part 2 of this roadmap (in the section, “Key solutions for reducing building emissions”). In addition to more detailed estimates of GHG reductions and return on investment, the factsheets provide estimates on the cost per tonne of CO$_2$e abated and, for heating-related measures, the proportion of heating provided by each fuel in each province and territory. More specifically:

- **Costs per tonne of CO$_2$e abated ($/tCO$_2$e)** are based on the measures (i.e. the specific options) described within the factsheets, and are calculated based on provincial/territorial average data for grid carbon intensity, energy rates and climate (see Appendix B for detailed assumptions). This metric does not account for any federal, provincial/territorial, utility or other incentives that may be available in certain regions and which can significantly change the business case. This metric helps municipalities understand how cost-effective a technology is in reducing GHG emissions, based on the latest publicly available data from March 2019.

This metric effectively tells you the price carbon would need to be at in order to make the measure cost-effective, incremental to the carbon price in March 2019 (since this carbon price is already captured in the energy rates used in the analysis). Technologies with negative cost-per-tonne values save money while also reducing emissions (often referred to as “win-win” or “no regret” measures). Note that different types of measures with a negative cost per tonne cannot be ranked as more or less cost-effective or impactful at reducing GHG emissions based solely on this metric, as this will depend on the value of the financial investment and the GHG reductions over the life of the asset.

This metric is calculated as follows:

$$\text{Cost per tonne} = \frac{-NPV}{\text{levelized CO}_2\text{e savings}}$$

Where NPV is defined as above and levelized CO$_2$e savings are defined as follows:

$$\text{levelized CO}_2\text{e savings} = \sum_{\text{year}=1}^{\text{measure life}} \frac{\text{annual CO}_2\text{e savings}}{(1 + \text{discount rate})^{\text{year}}}$$

In other words, levelized CO$_2$e savings are the cumulative CO$_2$e savings over the useful life of a measure, adjusted to reflect an annual “discount” in savings (i.e. where realized future savings decline in value over time.) The analysis assumes a real discount rate of three percent.
• **Proportion of heating provided by each fuel:** This metric, based on provincial/territorial averages, aims to help municipalities understand which fuels are most prevalent in existing buildings, as relevant to heating measures.

**Limitations**

Several important caveats should be considered when reviewing the analytics around the building-level solutions:

• **This analysis focuses on the most impactful building technology solutions within each end use, from a GHG perspective.** For example, the research did not look at efficiency measures for air conditioning, conventional furnaces, small appliances (e.g. dehumidifiers, air purifiers) or municipal pools; nor did it examine duct sealing and insulation, heat recovery ventilators or lighting controls. Similarly, additional approaches for reducing emissions of municipally owned utilities are not addressed here, such as time-of-use rates, load shifting, and other demand management strategies.

• **Technology solutions are evaluated on a per-building basis, based on a simplified analytical approach, as described above.** The analysis is based on specific, defined example measures (i.e. options for implementing the solutions), provincial/territorial average data, and simplified building archetypes for residential buildings and offices. Actual GHG and financial impacts will vary by municipality and building type. For example, heating fuel mix may vary significantly across municipalities within a province/territory, especially between rural and urban areas. Likewise, GHG and financial impacts will be different for a firehall compared to an office building, and for existing buildings will depend on the baseline conditions of the building in question. Additionally, cost-effectiveness values do not consider any federal, provincial/territorial, utility or other incentives that may be available in certain regions and which can significantly change the business case.

• **Each building technology is evaluated in isolation of other measures.** Given that projects may involve the interplay of multiple technologies to achieve GHG emissions reductions or other objectives, the synergies between such technologies are noted where relevant, but the sum of their collective impact is not quantitatively assessed. If more than one of these technologies is implemented in the same building, the GHG impacts may be less than the sum of the GHG impacts of each individual measure.

• **The financial impacts assessed are applicable to the building owner, not the municipality.** They do not include program or administrative costs (should the given technology be promoted by a municipality) or consideration of impacts on municipal tax revenues (should the technology lead to increased property values).
Qualitative assessment of potential co-benefits

This roadmap also presents information on the co-benefits associated with each solution, alongside the GHG and financial impact information, in order to give a holistic picture of the potential impact of each solution. As described above, the GHG benefits, and the financial benefits resulting from reduced energy spending, reduced maintenance resources/costs and extended equipment life, are both quantified where possible, but other benefits may also result. The following additional “co-benefits” are qualitatively assessed (see “Key solutions for reducing building emissions” in Part 2 of this roadmap):

- **Jobs**: new jobs in construction, installation, maintenance and management
- **Resilience**: enhanced resilience to climate change impacts; enhanced energy security
- **Health and comfort**: improved health from reduced air pollution; increased health and comfort of building occupants

The realization of these co-benefits will depend on local conditions. This roadmap’s qualitative assessment of the general potential for co-benefits is based on FCM’s professional judgment and took the following factors into consideration:

- The number of potential co-benefits associated with each solution
- The likelihood that the solution will lead to the co-benefit
- The likely magnitude of each co-benefit’s impact
- The relative magnitude of co-benefit impacts across measures

Other co-benefits are considered in the factsheets but are not summarized within the “Key solutions for reducing building emissions” section, because they are too variable and too dependent on local conditions to assess with accuracy, even qualitatively. Benefits that fall into this category include:

- **Environmental benefits**: improvements to local air quality; enhanced water conservation
- **Other economic benefits**: reduced exposure to energy price volatility; increased municipal tax revenues; increased employee productivity; reduced employee turnover
Appendix B: Provincial/territorial data inputs

Figure B-1: Carbon intensity of electricity generation by province/territory (2017)

Data from Canada’s Official Greenhouse Inventory (2017 data). PEI data assumes that 60 percent of electricity consumed is imported from NB based on the PEI Provincial and Territorial Energy Profile from the Canada Energy Regulator.

Figure B-2: Assumed energy rates by province/territory (based on data accessed in March 2019)

All rates exclude taxes and are based on data from Canadian utilities (for electricity and gas prices) as well as Natural Resources Canada and Statistics Canada (for oil prices).

Note: Missing data bars reflect lack of available data, which in some cases is due to limited use of specified heating fuel.
**Figure B-3:** Proportion of residential space heating energy provided by electricity, gas and oil, by province/territory (2016)

Numbers don't add up to 100 percent because some heating is provided by wood or propane.

Sources: Natural Resources Canada, Comprehensive Energy Use Database (2016 data).
Standing Senate Committee on Energy, the Environment and Natural Resources, Powering Canada’s Territories, 2015.

**Figure B-4:** Proportion of commercial space heating energy provided by electricity, gas and oil, by province/territory (2016)

Numbers don't add up to 100 percent because some heating is provided by wood or propane.

Sources: Natural Resources Canada, Comprehensive Energy Use Database (2016 data).
Standing Senate Committee on Energy, the Environment and Natural Resources, Powering Canada’s Territories, 2015.
**Figure B-5:** Heating degree day values used for each province/territory


**Figure B-6:** Cities used for annual heating temperature profiles for each province/territory

<table>
<thead>
<tr>
<th>Province/territory</th>
<th>City</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>Vancouver</td>
</tr>
<tr>
<td>AB</td>
<td>Calgary</td>
</tr>
<tr>
<td>SK</td>
<td>Saskatoon</td>
</tr>
<tr>
<td>MB</td>
<td>Winnipeg</td>
</tr>
<tr>
<td>ON</td>
<td>Toronto</td>
</tr>
<tr>
<td>QC</td>
<td>Montreal</td>
</tr>
<tr>
<td>NB</td>
<td>Fredericton</td>
</tr>
<tr>
<td>PE</td>
<td>Charlottetown</td>
</tr>
<tr>
<td>NS</td>
<td>Halifax</td>
</tr>
<tr>
<td>NL</td>
<td>St. John’s</td>
</tr>
<tr>
<td>YT</td>
<td>Whitehorse</td>
</tr>
<tr>
<td>NT</td>
<td>Yellowknife</td>
</tr>
<tr>
<td>NU</td>
<td>Iqaluit</td>
</tr>
</tbody>
</table>

For the calculations in this roadmap, FCM used data on hourly air temperatures for a typical year in each of these cities, as shown on the Government of Canada Climate website, *Canadian Weather Year for Energy Calculation (CWEC)*, accessed on September 30, 2019.
Appendix C: Additional guides and resources for implementation

Equitable clean energy

**A Guidebook on Equitable Clean Energy Program Design for Local Governments and Partners, Urban Sustainability Directors Network (USDN) and The Cadmus Group, September 2018**
This guidebook includes 12 key principles of equitable clean energy program design for low- and moderate-income households. These cross-cutting concepts should be front of mind throughout program design and implementation, to support better outcomes for municipalities and the communities they serve.

**Energy Poverty and Equity Explorer Tool, Canadian Urban Sustainability Practitioners (CUSP)**
This tool allows users to explore and understand the prevalence and extent of energy poverty in different neighbourhoods, cities and provinces/territories across Canada. Users can measure energy cost burden alongside drivers and characteristics like the age, type and condition of area housing, affordability of housing, household income, and poverty. With this information, policy-makers and program managers can more effectively target, address and overcome the root causes of energy cost burden. The tool also includes demographic data that will allow policy-makers, program managers and advocacy organizations to investigate how energy poverty is exacerbating existing inequities and explore the issue at various geographic scales.

**Equity & Inclusion Lens Handbook, City of Ottawa and City for All Women Initiative (CAWI), 2018**
This handbook is part of a toolkit that includes snapshots about specific groups of people at risk of exclusion, and other materials to assist municipalities.

**Stakeholder engagement**

**City Energy Project Resource Library, Institute for Market Transformation and Natural Resources Defense Council**
This online library contains resources on bold yet practical ways to deploy energy efficiency at the city level. These solutions can boost local economies, reduce pollution, and create healthier, more prosperous communities nationwide. Developed in partnership with 20 cities and counties across the United States, the library distills lessons learned and best-in-class practices on several topics, including how to reach community stakeholders and communicate progress and results.

This guidebook is intended for anyone seeking to engage and collaborate with their neighbours and other stakeholders to make the neighbourhood an amazing place to live, work, and play. It includes new tools and resources and information on how to access an “amazing neighbourhoods” network where you can learn how people are using this and other resources.
Other resources to support implementation

**Smart Energy Communities Benchmark, Quality Urban Energy Systems of Tomorrow (QUEST) and Pollution Probe, 2019**

This is the first tool of its kind to apply a systems approach to evaluating how the policies and processes of multiple sectors (including local governments, utilities, and public and private sector leaders) are advancing the Smart Energy Communities approach. Developed with senior advisors across Canada, in collaboration with nine pilot communities, this resource has several aims:

- Define the policies and processes required by local governments, utilities and the real estate sector to transition to Smart Energy Communities.
- Improve community energy practitioners’ understanding of the pathways to becoming Smart Energy Communities.
- Develop a roadmap for actions that participating communities can take to become Smart Energy Communities.
- Create a platform to showcase the tool and allow communities to evaluate their own progress over the long term.


This guide aims to help communities move community energy plans from vision to implementation. It includes 10 strategies that provide insight, advice and a proposed path forward. The strategies can help foster widespread political, staff and stakeholder support, build staff and financial capacity, and embed energy considerations into local plans, policies and processes. It includes a short Community Energy Implementation Readiness Survey to help you assess your community’s readiness to implement your municipal community energy plan.

**Embedding Sustainability into the Culture of Municipal Government, Network for Business Sustainability, The Natural Step Canada, and Dr. Stephanie Bertels (Simon Fraser University)**

This report aims to help municipal change agents advance a culture of sustainability in their organizations and become role models for others in the community.