Reducing Greenhouse Gas Emissions from Canada's Built Environment

Report of the Standing Senate Committee on Energy, the Environment and Natural Resources

The Honourable Rosa Galvez, Chair
The Honourable Michael L. MacDonald, Deputy Chair

November 2018

Senate | Sénat
CANADA

For more information please contact us:

by email: ENEV@sen.parl.gc.ca
by mail : Standing Senate Committee on Energy, the Environment
and Natural Resources
Senate, Ottawa, Ontario, Canada, K1A 0A4

This report can be downloaded at: sencanada.ca/en/Committees/enev/Reports/42-1
The Senate is on Twitter: **@SenateCA**, follow the committee using the hashtag **#ENEV**

Ce rapport est également disponible en français.

SENATE | SÉNAT
CANADA

TABLE OF CONTENTS

MEMBERS OF THE COMMITTEE

The Honourable Rosa Galvez, *Chair*

The Honourable Michael L. MacDonald, *Deputy Chair*

The Honourable Senators:

Jane Cordy
Paul J. Massicotte
Mary Jane McCallum
Percy Mockler
Richard Neufeld
Dennis Glen Patterson
David Richards
Judith Seidman
Yuen Pau Woo

Ex officio members:

The Honourable Peter Harder, P.C. (or Diane Bellemare), (or Grant Mitchell)
The Honourable Larry W. Smith (or Yonah Martin)
The Honourable Yuen Pau Woo (or Raymonde Saint-Germain)
The Honourable Joseph A. Day (or Terry M. Mercer)

The Committee would like to recognize the following Senators who are no longer serving members of the committee whose contribution to the study was invaluable:

The Honourable Senators: Douglas Black, Tony Dean, Renée Dupuis, Joan Fraser (retired), Diane F. Griffin, Daniel Lang (retired), Elaine McCoy, Grant Mitchell, Pierrette Ringuette and Howard Wetston

Other Senators who have participated from time to time in the study:

The Honourable Senators: Salma Ataullahjan, Diane Bellemare, Lynn Beyak, Joseph A. Day, Michael Duffy, Nicole Eaton, Tobias C. Enverga (deceased), Stephen Greene, Janis Johnson (retired), Yonah Martin, Paul E. McIntyre, Don Meredith (retired), Ratna Omidvar, Nancy Greene Raine, Bob Runciman (retired) and Scott Tannas.

Parliamentry Information and Research Service, Library of Parliament:

Sam Banks, Jesse Good and Marc LeBlanc, Analysts

Senate Committees Directorate:

Maxime Fortin, Committee Clerk
Brigitte Martineau, Administrative Assistant

ORDER OF REFERENCE

Extract from the *Journals of the Senate*, Thursday, March 10, 2016:

The Honourable Senator Neufeld moved, seconded by the Honourable Senator Frum:

That the Standing Senate Committee on Energy, the Environment and Natural Resources be authorized to examine and report on the effects of transitioning to a low carbon economy, as required to meet the Government of Canada's announced targets for greenhouse gas emission reductions. Recognizing the role of energy production, distribution and consumption in Canada, the committee shall be authorized to:

(*a*)identify and report on the impact transitioning to a low carbon economy will have on energy end users, including Canadian households and businesses;

(*b*)identify and report on the most viable way the following sectors — electricity, oil and gas, transportation, buildings and trade-exposed energy intensive industries — can contribute to a low carbon economy in meeting Canada's emission targets;

(*c*)examine and report on cross-sector issues and undertake case studies, if necessary, on specific programs or initiatives aimed at reducing greenhouse gas emissions;

(*d*)identify areas of concern and make any necessary recommendations to the federal government that will help achieve greenhouse gas emission targets in a manner that is sustainable, affordable, efficient, equitable and achievable.

That the committee submit interim reports on identified sectors, cross-sector issues and case studies and submit its final report no later than September 30, 2017, and that the committee retain all powers necessary to publicize its findings until 180 days after the tabling of the final report.

After debate,

The question being put on the motion, it was adopted.

Charles Robert
Clerk of the Senate

Extract from the *Journals of the Senate*, Tuesday, September 26, 2017:

The Honourable Senator Neufeld moved, seconded by the Honourable Senator Martin:

That, notwithstanding the order of the Senate adopted on Thursday, March 10, 2016, the date for the final report of the Standing Senate Committee on Energy, the Environment and Natural Resources in relation to its study on the transition to a low carbon economy be extended from September 30, 2017 to June 30, 2018.

The question being put on the motion, it was adopted.

Nicole Proulx
Clerk of the Senate

Extract from the *Journals of the Senate*, Monday, June 11, 2018:

The Honourable Senator Galvez moved, seconded by the Honourable Senator Forest:

That, notwithstanding the orders of the Senate adopted on Thursday, March 10, 2016 and Tuesday, September 26, 2017, the date for the final report of the Standing Senate Committee on Energy, the Environment and Natural Resources in relation to its study on the transition to a low carbon economy be extended from June 30, 2018 to December 31, 2018.

The question being put on the motion, it was adopted.

Richard Denis
Clerk of the Senate

EXECUTIVE SUMMARY

Greenhouse gas emissions from buildings account for a large share of Canada's overall emissions. When emissions associated with the electricity generated for use in homes and buildings are included, building emissions in Canada add up to about 111 million tonnes of greenhouse gases, or 17% of the country's total emissions.

To meet its 2030 emission reduction targets, Canada needs to achieve emission reductions of 207 million tonnes across the whole economy in just 12 years. According to federal, provincial and territorial government plans, emission reductions from homes and buildings between now and 2030 can get Canada about 10% closer to its emission reduction targets. To accomplish this goal, all levels of government will need to coordinate their actions and fully implement their plans.

Reducing building emissions by over 20 million tonnes by 2030 will require all new buildings constructed between now and then to have improved energy use and emissions performance. It will also require existing homes and buildings that are already built to reduce their emissions, since these buildings will make up three-quarters of the building stock in 2030.

Incorporating energy efficiency and emissions reduction measures into new buildings is practical because new buildings can be designed to be higher-performing from the outset. For existing homes and buildings, energy efficiency investments may pay for themselves over time through reduced energy costs, but deep retrofits that achieve emission reductions of 40% or more, on the other hand, are still very expensive. For that reason, innovation is needed to lower the costs of retrofit technologies.

The largest source of emissions in homes and buildings is the burning of fossil fuels for space heating. There are three main ways to reduce emissions from space heating: the first is to increase the insulation and airtightness of buildings so less heat is lost; the second is to improve the energy efficiency of heating equipment and appliances; and the third is to switch from heating with fossil fuels to heating with non-emitting electricity, where possible.

There is currently underinvestment in the types of energy efficiency improvements that are needed to reduce building emissions in line with Canada's emission reduction targets. A mix of government policies can be used to address underinvestment, depending on circumstances. For example, financial incentives from government can spur efficiency investments. Alternately, carbon pricing can also spur efficiency investments considering that people who must pay for their emissions tend to seek ways to avoid emitting in the first place.

A key tool that the federal government is expected to use to achieve Canada's emission reduction targets in the building sector is the development and adoption of increasingly stringent national building codes. According to the federal, provincial and territorial plans, all jurisdictions will have adopted "net-zero energy ready" building codes that set a very high energy efficiency performance standard for new construction by 2030. For existing buildings, the federal government is expected to introduce a retrofit code that will require

buildings to measure and report on their energy performance, and which may require efficiency upgrades at major milestones in the lifecycle of a building.

While achieving emissions reductions from new and existing buildings is achievable, there are concerns that vulnerable populations in Canada may be burdened by increasingly stringent requirements for building energy and emissions performance. Government policy can be designed to minimize these burdens; however, seniors, low-income Canadians and individuals living in Northern and remote regions may be disproportionately affected by the proposed policy changes discussed in this report. First-time home buyers may also face affordability challenges upfront, although these will be reduced by lower energy costs over the long-term. On the other hand, there are many benefits to energy efficiency and emissions reductions that improve indoor environments and reduce climate impacts.

ADDRESSING CLIMATE CHANGE

Climate change is a destabilizing threat to global health and security that could define the current century more than any other. The effects of climate change are already observable. For example, since the 1960s, the earth's ocean heat content increased at all depths by approximately 0.7°C and global sea level has risen up to 21 centimetres.[1] Globally, 16 of the 17 warmest years since the late 1800s have occurred in the period from 2001 to 2016.[2] If temperatures continue to rise unabated, the world risks substantial species extinction, significant global and regional food insecurity, increased risks of violent conflict and large population displacements.[3]

Canada is seeing the effects of climate change. Temperatures in Canada have risen at approximately double the global rate.[4] The country's northern regions are particularly vulnerable to accelerated losses of sea ice and permafrost affecting wildlife and ecosystems. Climate change is also jeopardizing northern infrastructure including roads, buildings, communication towers and other facilities. According to the Final Report of the Federal, Provincial and Territorial Working Group on Adaption and Climate Resilience all regions will be affected:

> *Climate change is impacting the severity and frequency of extreme events, including the likelihood of flooding, droughts, storm surges, high winds, and heat waves. Changes in temperature and precipitation patterns have made the wildfire season longer, while drought- and pest-stressed forests, woodlots, and range-lands are increasing the severity of wildland fires. Sea level rise is increasing the frequency and height of storm surges, causing flooding in higher, previously unaffected areas and more frequent flooding in low lying areas.*[5]

The financial costs of these climate occurrences are mounting. According to the Insurance Bureau of Canada, expected losses due to severe weather currently exceeds $1 billion annually in Canada whereas in the 1980s and 1990s these costs averaged at below $300 million a year.[6]

While climate change is a pressing problem, many countries, including Canada, have postponed difficult decisions needed to curb GHG emissions. The 2017 Fall Report of the Commissioner of the Environment and Sustainable Development reported that Canada has failed to achieve every emission target it has set since 1992. These include reducing emissions to 1990 levels by 2000 (the Rio Earth Summit); 6% below 1990 levels by 2012 (Kyoto Protocol); and 17% below 2005 levels by 2020 (Copenhagen Accord). Reducing GHG emissions is a complex problem but inaction in addressing climate change will have severe consequences on this and future generations.

Considering that everyone shares the atmosphere, climate change solutions require an ambitious level of global cooperation. On 12 December 2015 in Paris, Canada and 194 other countries party to the United Nations Framework Convention on Climate Change (UNFCCC) reached an agreement (Paris Agreement) to limit rising global average temperatures to less than 2°C above pre-industrial levels, and aim to limit that increase of no less than 1.5°C.[7] This was a pivotal moment in the effort to address climate change, as both developed and developing countries were part of the agreement, representing nearly all of the world's anthropogenic emissions. In June 2017, the United States, a major GHG emitter, submitted a formal notice of withdrawal from the agreement. However, many U.S. states, municipalities, institutions and companies have maintained their commitment to reduce emissions to achieve Paris Agreement objectives.[8]

Climate change is occurring as global energy demand is growing. The International Energy Agency's 2017 World Energy Outlook estimates that global energy use will increase by nearly 28% by 2040 due to increased demand from emerging economies.[9] Of that increase, more than half (51%) comes from the demand for oil, natural gas and coal. Also, current low prices for oil are challenging policy efforts to switch to cleaner fuels.

A. Canada's Emission Commitment

GHGs are associated with almost every activity, product and service and are supported by long-lived capital infrastructure.[10] Addressing climate change will require a rapid and substantial retooling of energy systems that have supported economies for nearly a century. It is an energy transition chiefly driven by public policy through regulation, taxes and/or incentives and it will likely require a change in lifestyle and energy/resource consumption habits. It will not be cost-free, meaning that it will likely require higher demands on public revenues, result in higher energy prices, impact households and businesses, and will probably strand existing productive capital assets that support fossil fuel energy systems.[11]

In accordance with its contribution to the Paris Agreement under the UNFCCC, Canada committed to reduce its emissions by 30% below 2005 levels by 2030. This target is a minimum target. Further reductions will be needed to reach the Paris Agreement's goals. This envisions an 80% reduction in emissions from 2005 levels by the second

half of the century.[12] To avoid global temperature increases above 1.5°C this century, Canada, along with other countries, will need to reduce emission even further according to the latest report of the Intergovernmental Panel on Climate Change.

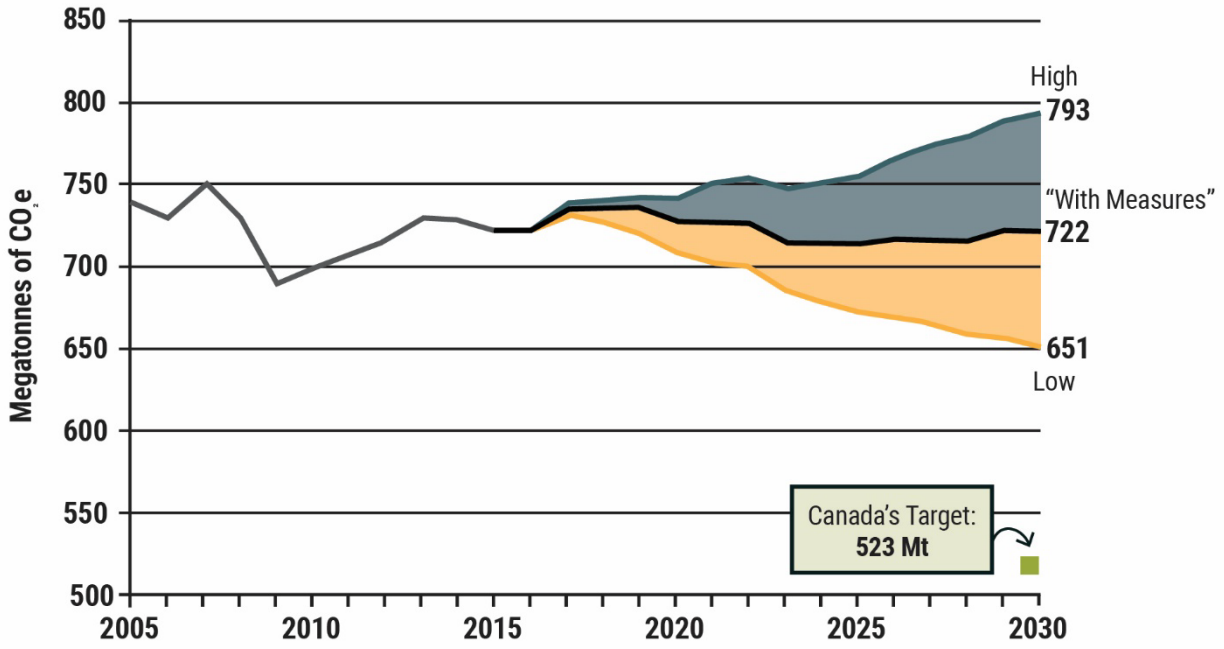
In the wake of the Paris Agreement, federal, provincial and territorial governments have committed to working together to reduce emissions. In December 2016, Canada's First Ministers released the Pan-Canadian Framework on Clean Growth and Climate Change, which was adopted by all Canadian provinces and territories with the exception of Saskatchewan. The Framework builds on previously announced initiatives, such as a national benchmark price on carbon emissions and an acceleration of the phase-out of traditional coal-fired electricity units.

The projections from Environment and Climate Change Canada illustrated in Figure 1 reflect forecasts for gross domestic product (GDP) and oil and gas prices and production. They also include "actions taken by governments, consumers and businesses put in place over the last two years, up to September 2017. This scenario does not account for all measures of the Pan-Canadian Framework as a number of them are still under development."[13] These actions are referred to by the Government of Canada as the "with measures" scenario.

The projections do not include additional policies and measures under development but have not yet been fully implemented. Some of these were announced as part of the Pan Canadian Framework such as pan-Canadian carbon pricing or federal regulations to reduce methane emissions in the oil and gas sector (methane is a GHG that is 25 times more potent in trapping heat in the atmosphere than carbon dioxide).

The projections show a range of GHG emission level outcomes based on the uncertainty inherent in modelling climate policy and other macroeconomic conditions that are beyond the control of government. The reference case scenario, which assumes business-as-usual oil and gas prices and GDP growth is contrasted with two scenarios: one assuming high oil and gas prices and GDP growth and another assuming low oil and gas prices and GDP growth.

Figure 1 – Canada's Domestic Emissions Projections (Mt CO_2e): Low, "With Measures" and High Scenarios



Note: In 1990, Canada's GHG emissions totalled 611 Mt CO_2e.

Mt CO_2e = megatonne (1 million tonnes) of carbon dioxide equivalents. Different greenhouse gases have different radiative forcing potentials depending on their lifetimes in the atmosphere and how efficiently they contribute to the greenhouse effect. The global warming potential of the different greenhouse gases can be expressed in relative terms to those of carbon dioxide, known as carbon dioxide equivalents, or CO_2e.

Source: Environment and Climate Change Canada, *Canada's Seventh National Communication on Climate Change and Third Biennial Report—Actions to meet commitments under the United Nations Framework Convention on Climate Change,* page 155.

Legend: Emissions projections in three scenarios:

1. High oil and gas prices and high GDP growth – blue line
2. Business-as-usual oil and gas prices and GDP growth – black line
3. Low oil and gas prices and low GDP growth – yellow line

Fuel Price Assumptions	High	With Measures	Low
Annual GDP Growth Rate (2015-2030) %	2.5	1.7	1.0
Crude Oil Price (West Texas Intermediate) 2014 US$/bbl	116	77	37
Heavy Oil (Western Canadian Select) 2014 US$/bbl	90	56	21
Natural Gas (Henry Hub) 2014 US$/GJ	4.67	3.77	2.86

These emissions projections incorporate oil and gas price forecasts set out in the National Energy Board's energy outlook, Canada's Energy Future 2016: Update – Energy Supply and Demand Projections to 2040, published in October 2016.

Figure 2 provides a breakdown of Canadian emissions by economic sector. In 2015, the upstream oil and gas and transportation sectors each accounted for nearly a quarter of total emissions in Canada. Emissions from buildings was 12%, followed by electricity generation at 11% and agriculture at 10%. Emission-intensive and trade-exposed industries consisting of steel, aluminium, cement, petrochemical, pulp and paper, fertilizer and mining production totalled 10% of total emissions in Canada. Petroleum refining, which is also an EITE industry, was of 3% total emissions. Table 1 provides the breakdown for different years including projections for 2020 and 2030.

Figure 2 – Breakdown of Canada's Greenhouse Gas Emissions by Sector, 2015 (Mt CO_2e)

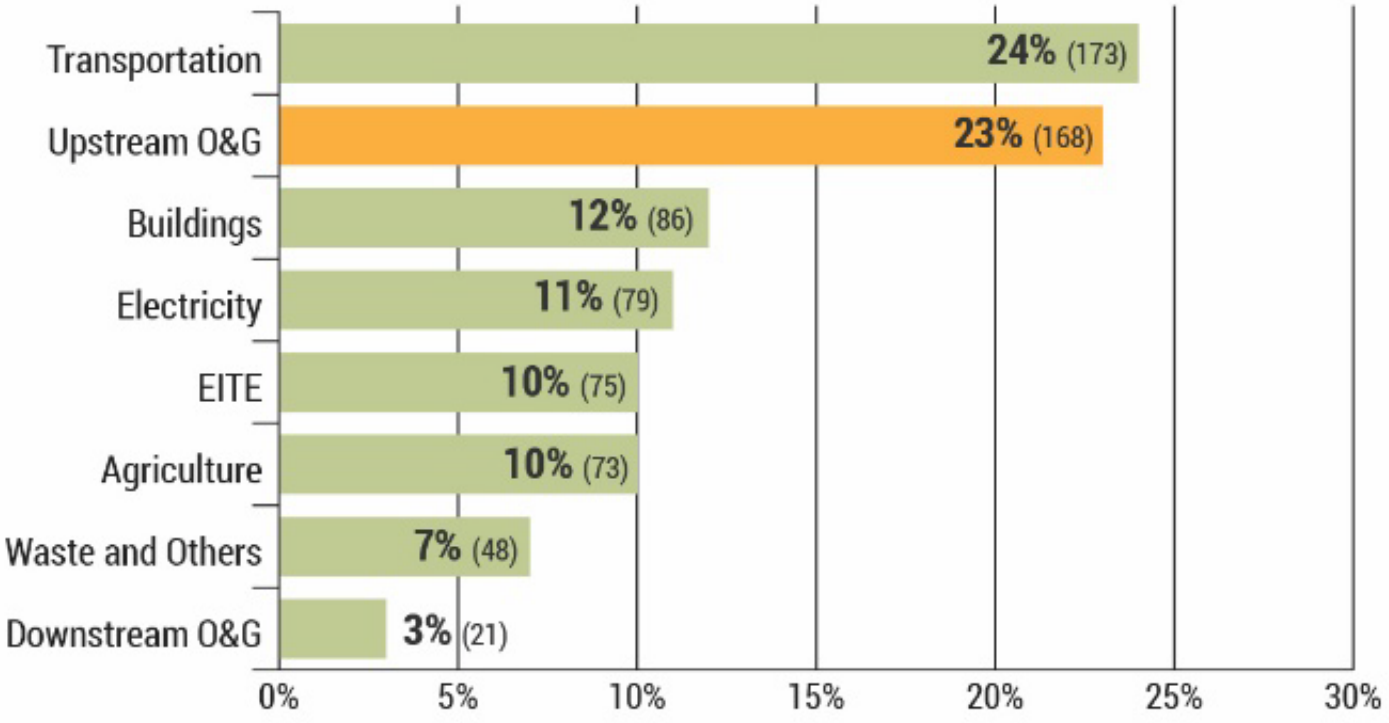


Table 1 – Emissions by Economic Sector 2005-2030 (Mt CO_2e)

	2005	2015	2020	2030
Upstream Oil and Gas	137	168	175	193
Emission-Intensive and Trade-Exposed Industries (Includes Petroleum Refining)	108	96	105	119
Electricity	117	79	71	46
Transportation	163	173	168	155
Buildings	85	86	88	83
Agriculture	74	73	71	72
Waste & Others	54	48	50	53
Total	***738***	***724***	***728***	***722***
Emission Target				***523***
Difference				***(199)***

Notes: Includes actions taken by Canadian governments, consumers and businesses put in place over the last two years, up to September 2017.

This report focuses on upstream oil and gas, while downstream oil and gas is addressed in the committee's report entitled *Decarbonizing Heavy Industry: the Low-Carbon Transition of Canada's Emission-Intensive and Trade-Exposed Industries*.

Numbers in all figures and tables may not add up to the total due to rounding.

Source: Figure 2 and Table 1 prepared by the Library of Parliament using data obtained from Environment and Climate Change Canada, Canada's 2016 Greenhouse Gas Emissions Reference Case, National and Provincial/Territorial Greenhouse Gas Emission Tables and *Canada's Seventh National Communication on Climate Change and Third Biennial Report—Actions to meet commitments under the United Nations Framework Convention on Climate Change,* Page 155.

Carbon dioxide accounts for a majority of the anthropogenic GHG emissions released in Canada. The next major GHG is methane followed by nitrous oxide. Not all GHGs have the same radiative forcing potential. For example, over a 100 year time horizon[i], methane is 25 times more potent in trapping heat in the atmosphere than carbon dioxide and nitrous oxide is nearly 300 times more potent than carbon dioxide. Table 2 provides a breakdown of GHG emissions in Canada expressed in carbon dioxide equivalent

[i] The 100 year time horizon is consistent with reporting under the UNFCCC.

(CO_2e) a commonly used standard that facilitates comparisons by adjusting for the global warming potential of each GHG in terms of how much carbon dioxide would be required to produce a similar warming effect.[14]

The 2030 target is ambitious. According to updated projections made by Environment and Climate Change Canada in December 2017, Canada must reduce annual emissions by 199 megatonnes of carbon dioxide equivalent (Mt CO_2e) in order to meet its 2030 target. [15] To put this into context, the required reduction is above the projected emissions from Canada's entire upstream oil and gas industry in 2030, which are expected to be 193 Mt CO_2e. However, this does not mean Canada should not be ambitious; if we delay emission reduction efforts it will only become more difficult to meet future targets. Canada's Commissioner of the Environment and Sustainable Development underscored the failure by successive federal governments in implementing measures to address oil and gas industry emissions as a reason for missing past emission targets.[16]

Achieving the 2030 target will require a herculean shift in how energy is produced and consumed in Canada. For the years beyond 2030, one must imagine a society essentially transformed and decarbonized. Witnesses offered conflicting testimony on whether or not the economy would be harmed by achieving government targets. In any case, a decarbonized society means new economic opportunities, lower pollution and better air quality, improved health

Table 2 – Breakdown by Type of Greenhouse Gas Emissions, 2014 (Mt CO_2e) - 100 Year Time Horizon

Sector	Carbon Dioxide (CO_2)	Methane (CH_4)	Nitrous Oxide (N_2O)	Hydrofluorocarbon (HFCs[4])	Perfluorocarbon (PFCs[4])
Oil and Gas	143	48	1	0	0
Electricity	77	0	0	0	0
Transportation	165	0	4	3	0
EITE	73	0	2	0	1
Buildings	77	3	1	6	0
Agriculture	15	29	29	0	0
Waste & Others	23	28	2	0	0
Total	**574**	**108**	**39**	**9**	**1**

Source: Table prepared by the Library of Parliament using data obtained by Environment and Climate Change Canada, Canada's 2016 greenhouse gas emissions reference case, Detailed emissions by gas and by economic sector.

outcomes and increased productivity through more energy efficiency improvements.[17]

Canada has a vast geography, relatively cold climate, low and dispersed population and a large resource-based industrial sector. Canada's per capita emissions are among the highest in the world[18] and every nation's effort to address climate change adds up and collective action will be the only way to meet this challenge. ***If Canada does not make a concerted effort to meet its own targets, then how can we, as an advanced economy, ask other nations to meet theirs?*** Canada's global reputation and credibility would be damaged if we failed to act.

Canadians must do their part to address climate change even if Canada's portion of global emissions is relatively small at 1.6%[19] and expected to decline as emissions from emerging countries, such as China, India, Brazil and Indonesia, increase in the future.[20] Global emission reduction goals may be more difficult to achieve since the announcement by the United States (U.S.) to withdraw from the Paris Agreement, but U.S. state actions buoy global climate change co-operation efforts.

It is estimated that the global market for clean technologies is approximately $5.8 trillion per year and growing at a rate of three percent annually. Canada should not miss this opportunity to capture local economic benefits and to export technologies and expertise in clean energy solutions.[21] Reducing or capturing emissions can create whole new industries and supply chains.

At the same time, the speed and magnitude of the transition being considered will affect the lives of all Canadians. The impacts of the transition may be unevenly felt depending on income levels or geographic location. Policies should be designed to ensure that the most vulnerable in society are not adversely affected and that all Canadians have an opportunity to benefit by the move to a cleaner economy. Likewise, policy design should take climate impacts into account because climate change will be felt differently across Canada, and at different timescales.

The question is how much of our welfare are we willing to risk to meet our climate change commitments? On the other hand, how much do we risk in delaying emission reduction policies? What is the cost of "business as usual?" If we wait until the future to act, it will likely be more costly to decarbonize since the pace of the transition would have to accelerate.

CANADA'S BUILT ENVIRONMENT

Canadians spend 90% of their time indoors making buildings an ever-present and essential part of modern living.[22] The building sector in Canada comprises approximately 14.1 million households and 482,000 commercial or institutional buildings. [23,24] These are our homes, work-places, hospitals, schools, stores and recreational centres. As Canada strives to achieve its climate policy objectives of reducing building sector GHG emissions and building resilience to the impacts of climate change, Canadians should expect changes in the form and function of their built environment, that will affect them in many ways for decades to come.

The low-carbon transition in the building sector affects us each quite personally because of how closely we connect to our built spaces. Our homes and buildings deeply influence how we live. They reflect who we are, individually and collectively, and represent not only our inheritance from the past but also our legacy for the future. The choices that we make today about our buildings will last for generations, so it is important to understand how our buildings contribute to, and are affected by, global climate change. Canadians that move homes frequently are less likely to invest in energy efficiency improvements.

In 2015, Canada's building sector emitted nearly 73 Mt CO_2e [ii], accounting for 12% of the country's total GHG emissions. When GHG emissions associated with the elec-tricity used in homes are included, building sector emissions were 111 Mt CO_2e during that year. But the sector has significant

ii But for the exception of the previous section, the GHG emission estimates contained in this report are based on Natural Resources Canada's National Energy Use Database. The emissions estimates in the National Energy Use Database differ from those presented in Environment and Climate Change Canada's National Inventory Report due to a different sectoral mapping of the building sector. The mapping in the National Energy Use Database is more suited to energy end-use analysis.

potential to reduce emissions between now and 2030. The Standing Senate Committee on Energy, the Environment and Natural Resources (the committee) heard that federal, provincial and territorial plans described in the *Pan-Canadian Framework for Clean Growth and Climate Change* (PCF) could help meet Canada's 2030 emission reduction goals by reducing building sector emissions by 21.6 Mt CO_2e annually by 2030. The committee believes that it is important that govern-ments measure and report on their progress in achieving these plans. Long-term policy planning increases certainty so that people and organizations can develop strategies and plan their investments accordingly.

A. Reducing Greenhouse Gas Emissions from the Built Environment

This report discusses several policy and technology pathways that the committee examined during its study on the transition to a low-carbon economy to reduce building sector GHG emissions. According to many witnesses, the priority strategy for reducing building sector GHG emissions should be to use less energy, to use energy more efficiently and to use lower-GHG energy sources where appropriate.

The committee heard that energy efficiency is a cost-effective climate mitigation solution with many benefits other than just reducing emissions. According to Sarah Stinson of Natural Resources Canada (NRCan):

> *Energy efficiency is effective as it delivers long-term results in the transition to a low-carbon economy. It does so by using less energy overall, freeing up energy in the grid to allow for electrification of other sectors, reducing costs for Canadians and making energy affordable, and supporting and incenting innovation to bring next generation, high-efficiency products and practices to market.*[25]

Energy costs in homes and buildings are a large, recurring expense. In 2013 alone, household and commercial building energy costs were $28.5 billion and $20.6 billion respectively.[26] Efficiency upgrades help reduce these costs. In that regard, witnesses noted that energy efficiency upgrades are one of the few climate solutions that can pay for themselves through avoided energy costs (although payback times vary for each efficiency project).[27] NRCan estimates that energy use in Canada would have increased by 55% between 1990 and 2014 without energy efficiency improvements. Economy-wide this translates to over $38 billion in energy cost savings in 2014 that are attributable to energy efficiency improvements over the period, and more than $17 billion in the building sector alone.[28] In the future, as carbon prices in Canada rise, energy efficiency investments will become even more valuable, especially in regions with GHG emission-intensive energy supplies.[29]

The committee heard that energy efficiency retrofits and new green construction can drive significant economic activity and job creation. According to David Lapp of Engineers Canada, each $1 million invested in energy efficiency improvements is esti-mated to generate up to $3 to $4 million in gross domestic product and between 30 and

52 job years.[30] Efficiency investments creates cost savings for building owners and users through energy conservation.[31]

Fuel switching – the other key element of the strategy for lowering building GHG emissions in Canada – involves substituting a lower GHG-emitting energy source for another one with higher GHG-emissions. A building that replaces its natural gas furnace with a heat pump powered by renewable electricity is an example of fuel switching.

The committee was told that fuel switching is technically feasible for most buildings, with some exceptions in specific regions, but that it may not always be the most economical or effective solution for reducing building GHG emissions.[32]

B. Climate Change Impacts and Adaptation

The focus of this study was not on the impacts of climate change on the built environment. However, the risks from climate change are real and the committee believes that Canadians, businesses, and governments need to prepare themselves.

For example, Craig Stewart of the Insurance Bureau of Canada explained that because of climate change, temperatures in Canada are projected to continue to rise and severe weather and heavy precipitation events will likely continue to increase in frequency and intensity. He noted that annual insurance losses from severe weather now exceed $1 billion a year, more than triple the average annual insurance losses seen during the 1980s-1990s.[33] For his part, Blair Feltmate of the Intact Centre on Climate Adaptation indicated that increased incidence of flooding across Canada driven by climate change "has now created a growing uninsurable housing market, from Halifax to Victoria, whereby people can no longer get insurance coverage for their homes for any kind of water damage in the basement. That, or they will have a very low cap on insurance that would be available to them."[34]

The committee was also told that some regions of Canada are more sensitive to the effects of climate change than others. According to Professor Warwick Vincent of Laval University's Institute for Northern Studies, Canada's North is "hyper-sensitive"[35] to the effects of climate change. He also noted that northern communities are already experiencing higher temperatures, thawing permafrost, flooding, diminished sea ice, changing coastlines, and ecosystem disruption. But all areas of the country, not just the North, are experiencing climate risk.

On this subject, the committee is concerned about Canada's preparedness to deal with the impacts of climate change. Although much is already known about how climate change will affect Canada in general (see NRCan's 2014 report, Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, for example), more needs to be done to understand how specific areas of the country will be affected in the short- and long-term. That information would help people and communities reduce their risk from the impacts of climate change.

Examples of gaps in information were provided to the committee. Mr. Feltmate warned that Canada's flood plain maps – an important tool for understanding where water will go when floods happen – are "25 years out-of-date, on average" and need to

be brought up to date.[36] Professor Vincent and his colleagues are engaged in creating risks maps that measure the stability of permafrost for northern construction, so that buildings remain solidly built,[37] but Mr. Stewart warned the committee that:

> *We are not ready. As a nation, we are especially ill-prepared for flooding. Too many people live and work in harm's way and are unprotected physically, financially and socially.*[38]

The risks posed by climate change lead the committee to believe that Canadians and their governments must consider climate impacts and adaptation as we invest in the built environment to reduce energy use and GHG emissions

The following sections focus on the challenges and opportunities for reducing GHG emissions from Canada's building sector based on witnesses' testimony. The first section discusses energy use and GHG emission trends in Canada's homes and buildings. The second section talks about a wide range of policy tools and technology solutions that could lower building sector GHG emissions, including: national building codes; energy efficiency standards and labels; technology research, development, and demonstration; fuel-switching for space heating; federal investments in buildings; and, the role of cities and urban design. Finally, the report concludes with the committee's comments about moving forward on reducing building GHG emissions.

ENERGY USE AND GREENHOUSE GAS EMISSION TRENDS IN CANADIAN BUILDINGS

Canada's building sector GHG emissions are driven mainly by energy use.[39] This section discusses some of the energy use and GHG emissions trends in Canada between 1990 and 2015.

A. Energy Use

Residential and commercial-institutional buildings in Canada today use more energy than ever before (see Figure 3). Between 1990 and 2015, total energy demand from these buildings sector increased by more than 17% to reach 2,554 petajoules (PJ) in 2015.[40] More specifically, residential energy demand increased by 8% and commercial-institutional energy demand increased by 35% during that period.[41] The National Energy Board estimates that energy demand will continue to rise in both market segments through 2040.[42]

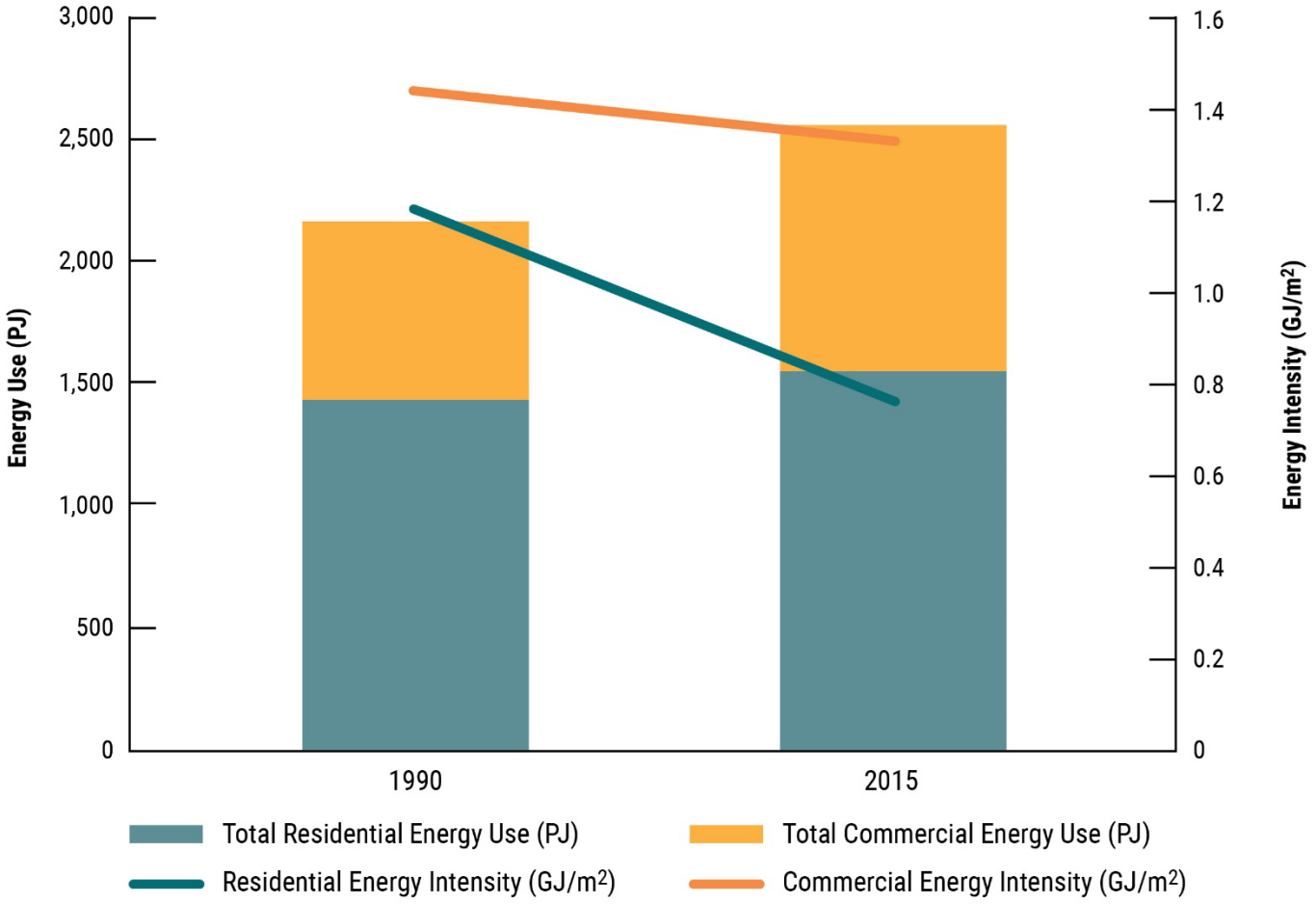
Figure 3 also shows that the energy intensity of buildings has improved in both segments, particularly in the residential segment. The amount of energy used per square metre of built floor space in the residential and commercial-institutional segments (the "energy intensity" of floor space) was 35% lower and 8% lower respectively in 2015 than it was in 1990.[43]

Types of Buildings

The residential segment of the building sector includes all buildings where people live.

The commercial-institutional segment of the building sector includes buildings associated with these activities: wholesale and retail trade, transportation and warehousing, information and cultural industries, offices, educational services, health care and social assistance, arts, entertainment and recreation, accommodation and food services, and other services.

Figure 3 – Residential and Commercial Energy Use and Energy Intensity



Note: Energy intensity is the amount of energy used per square metre of floor space.

Source: Figure prepared by the Library of Parliament using data obtained from Natural Resources Canada, "Table 1: Secondary Energy Use and GHG Emissions by Energy Source, Residential - Canada and Table 1: Secondary Energy Use and GHG Emissions by Energy Source," Comprehensive End Use Database, accessed on 29 January 2018.

The reason why energy demand continues to increase despite continuous improvements to energy intensity is because more and more buildings are built each year, and these buildings are larger, on average, than they used to be. As Ian Beausoleil-Morrison of Carleton University explained: "it has really been a case of taking one step forward by all of these efficiency gains and two steps backward by living in larger buildings and increasing the population."[44]

For example, in the residential sector, between 1990 and 2015:

- Over 4 million new households were built;[45]

- The average occupancy decreased from 2.81 to 2.54 persons per household; [46]
- The average new home is 17% bigger, now averaging 143 m^2;[47]
- The average floor space per person increased by 30%, so that now each person has nearly 12 m^2 to live in; [48] and,
- The average energy used per household decreased by nearly 25%, from 144 gigajoules (GJ) per year to 109 GJ per year.[49]

The commercial segment has followed similar trends: since 1990, total commercial floor space has gone up by nearly 50%, while the energy intensity of commercial floor space has improved by about 8%.[50] Between 2005 and 2030, commercial and institutional floor space is projected to grow by close to 50%, and the number of households are expected to increase by 40%.[51]

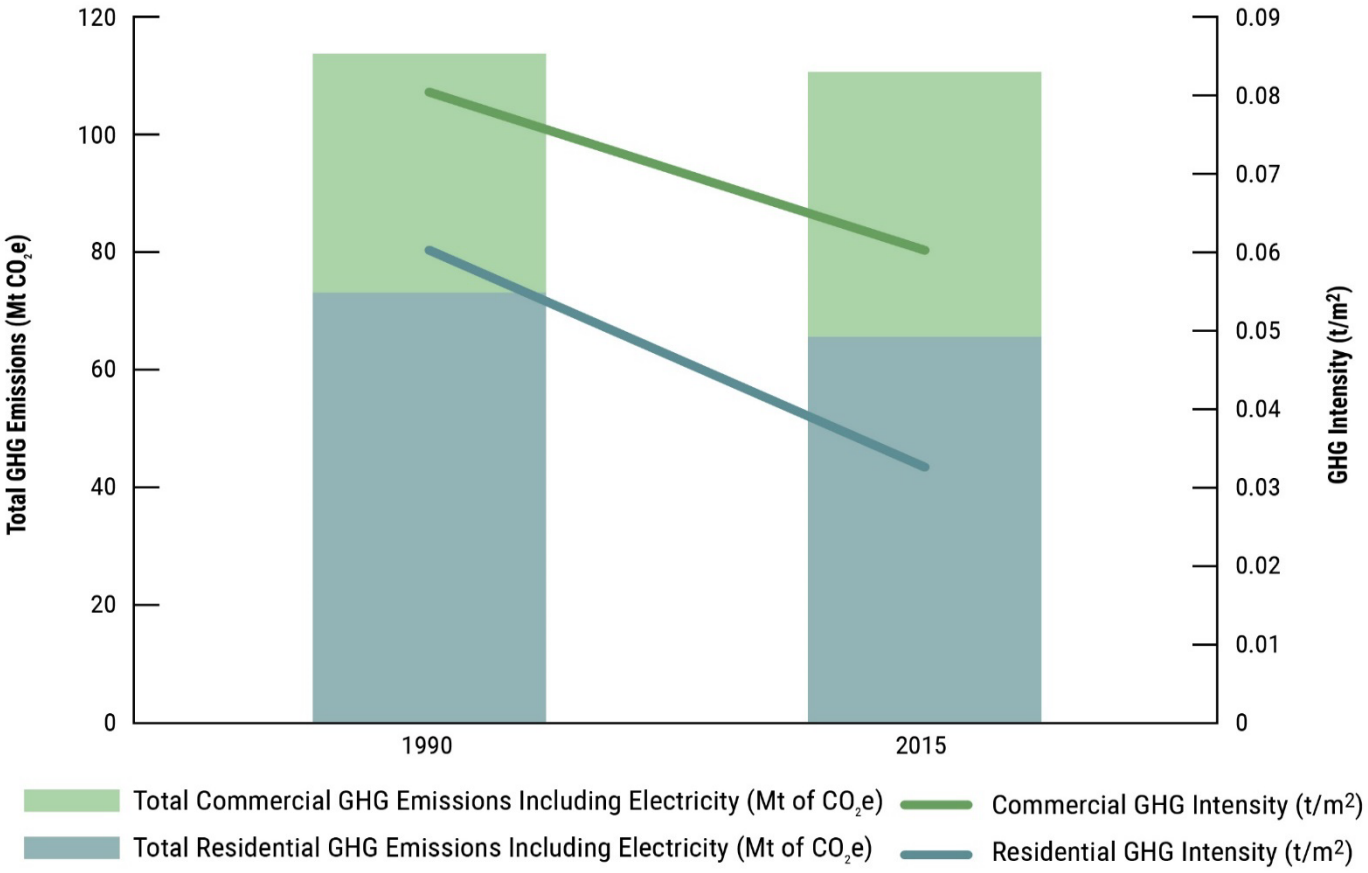
B. Greenhouse Gas Emissions

In 2015, buildings accounted for 12% of Canada's total GHG emissions, or 17% if the GHG emissions associated with the electricity used in homes are included. GHG emissions from buildings can be either direct or indirect. Direct GHG emissions come primarily from the combustion of fuel, such as natural gas, heating oil, and biomass fuels, and to a lesser extent from leaks in refrigeration and air conditioning systems. Indirect emissions include the GHGs produced from generating the electricity that is used in buildings, as well as the embodied emissions of the materials and methods used in the construction of buildings. Indirect electricity GHG emissions are significant but vary regionally depending on the emission intensity of the local electricity supply.

Figure 4 shows that between 1990 and 2015, total residential and commercial GHG emissions, including electricity GHG emissions, decreased by nearly 3% despite the increase in energy demand.[52] Over the period, residential GHG emissions fell by 10% to 65.4 Mt CO_2e, while commercial-institutional GHG emissions, driven by natural gas demand growth, rose by 10% to 45.2 Mt CO_2e.[53]

Figure 4 also shows that the GHG intensity of both the residential and commercial building segments improved over the period. As shown in the figure, the GHG intensity of built floor space in the residential and commercial segments improved by 46% and 25% respectively between 1990 and 2015.[54]

Figure 4 – Total Residential and Commercial-Institutional GHG Emissions and GHG Intensity



Note: Building GHG emissions include GHG emissions associated with electricity used in buildings. GHG intensity is the GHG emissions in tonnes of CO_2e per square metre (t CO_2e /m^2).

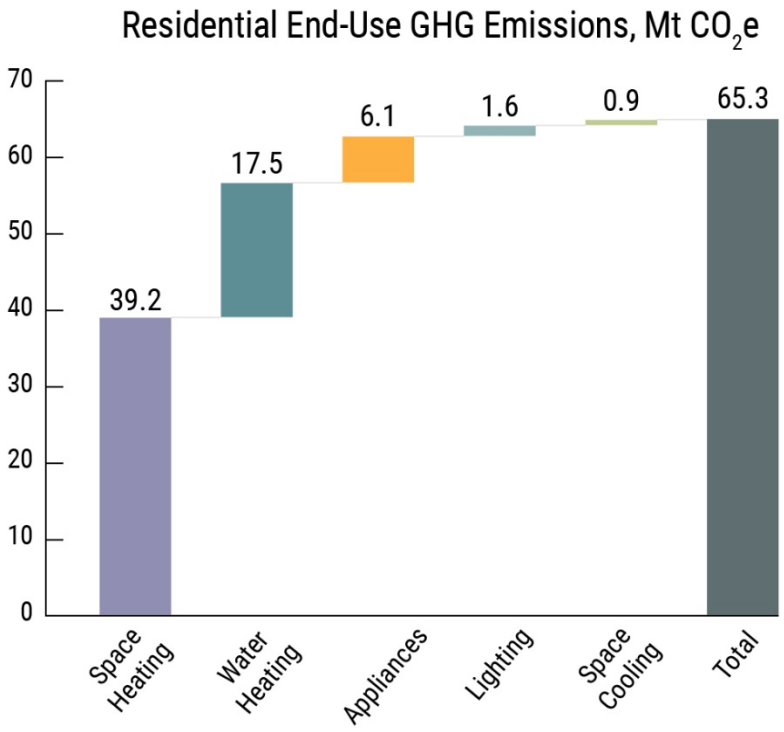
Source: Figure prepared by the Library of Parliament using data obtained from Natural Resources Canada, "Table 1: Secondary Energy Use and GHG Emissions by Energy Source, Residential - Canada and Table 1: Secondary Energy Use and GHG Emissions by Energy Source," Comprehensive End Use Database, accessed on 29 January 2018

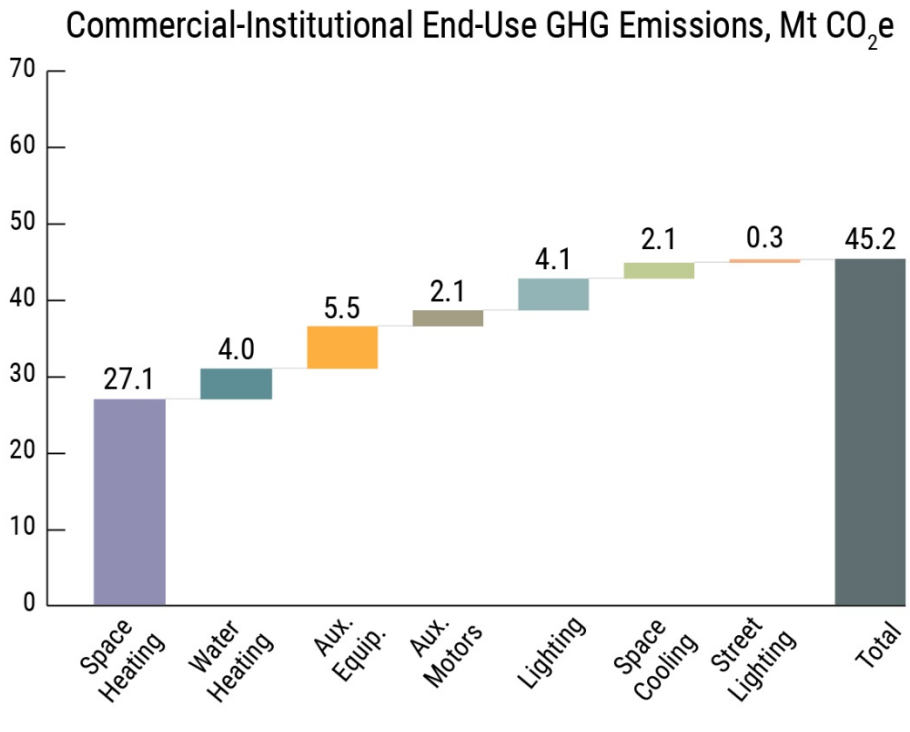
C. Sources of Energy Demand and Greenhouse Gas Emissions in the Building Sector

Residential and commercial buildings use electricity, natural gas, heating oil, wood, coal and propane for a variety of applications including space heating, water heating, powering appliances, lighting, and space cooling. Commercial-institutional buildings also use light fuel oil and kerosene, heavy fuel oil, and steam for a wider set of activities that includes powering auxiliary equipment, auxiliary motors and street lighting.

As shown in Figure 5, space heating is the activity that accounts for the largest share of GHG emissions in both the residential and commercial-institutional segments, followed by water heating for residential buildings and auxiliary equipment in commercial-institutional buildings.

Figure 5 – Residential and Commercial-Institutional GHG Emissions by End-Use (2015)





Source: Figure prepared by the Library of Parliament using data obtained from Natural Resources Canada, "Table 2: Secondary Energy Use and GHG Emissions by End-Use, Residential - Canada and Table 2: Secondary Energy Use and GHG Emissions by Activity Type – Including Electricity-Related Emissions," Comprehensive End Use Database, accessed on 29 January 2018

PATHWAYS TO REDUCING BUILDING GREENHOUSE GAS EMISSIONS

Looking ahead to 2030, what will the GHG emissions of Canada's buildings be? According to projections in Canada's 7th National Communication and 3rd Biennial Report, based on the policies that were in place as of September 2017, GHGs from buildings in 2030 will be 3 Mt CO_2e lower than in 2015 – a reduction of about 3%.[55] To achieve GHG emissions reductions from buildings at a level consistent with Canada's national GHG emission reduction targets, about 25 Mt CO_2e of reductions would be needed annually by 2030. Evidently, governments will need to take further actions to achieve the national targets.

All levels of government have a role to play in improving the emission profile of residential and commercial-institutional buildings in Canada. This is because responsibility for various aspects of the built environment is shared between federal, provincial, territorial, municipal and Indigenous governments. For the most part, over the last few decades the focus of federal policy has been aimed at improving energy efficiency and reducing energy consumption through programs and regulatory measures.[56]

In December 2016, Canada's First Ministers released the Pan-Canadian Framework on Clean Growth and Climate Change (the "Framework"), with the exception of Saskatchewan which did not adopt the Framework. The Framework provides a plan to reduce emissions across the economy to achieve the national GHG emission reduction target of a 30% reduction in GHGs from 2005 levels by 2030. The Framework's approach to reducing emissions in the building sector includes the following elements:

- making new buildings more energy efficient;
- retrofitting existing buildings, as well as fuel switching;
- improving energy efficiency for appliances and equipment; and

- supporting building codes and energy efficient housing in Indigenous communities.[57]

To develop and assess policy options to accomplish these goals, the Pan-Canadian Framework established the federal-provincial-territorial Specific Mitigation Opportunities Working Group. The Working Group's 2017 final report was submitted to the committee by NRCan as evidence. The report identifies and estimates the costs of different federal, provincial and territorial policy and program options with the potential to significantly reduce annual GHG emissions by 2030, including for the building sector.[58]

The federal government's overall policy approach for reducing building sector GHG emissions, which builds on the Working Group's final report can be found in Build Smart—Canada's Buildings Strategy: A Key Driver of the Pan-Canadian Framework on Clean Growth and Climate Change, a report from the August 2017 Energy and Mines Ministers' Conference. According to federal officials, the measures included in the Build Smart Strategy have the potential to cut building sector emissions by 21.6 Mt CO_2e by 2030.[59] The Build Smart Strategy sets five goals for federal, provincial, and territorial governments:

1) Federal, provincial, and territorial governments will work to develop and adopt increasingly stringent model building codes, starting in 2020, with the goal that provinces and territories adopt a "net-zero energy ready" model building code by 2030.

2) Federal, provincial, and territorial governments will work to develop a model code for existing buildings by 2022, with the goal that provinces and territories adopt the code.

3) Federal, provincial, and territorial governments will work together with the aim of requiring labelling of building energy use by as early as 2019.

4) The federal government will set new standards for heating equipment and other key technologies to the highest level of efficiency that is economically and technically achievable.

5) Provincial and territorial governments will work to sustain and expand efforts to retrofit existing buildings by supporting energy efficiency improvements and by accelerating the adoption of high-efficiency equipment while tailoring their programs to regional circumstances.[60]

The committee recognizes that there is no single policy or technology solution for reducing energy use and GHG emissions of Canada's buildings. Regional differences in climate and energy supply limit the viability of some options, as do differences in building type, class, and age. Consumer choice – how people interact with buildings, and the choices that they make about where and how to live and work – are also important factors. Other considerations, including cost, comfort, health, culture and security also influence how Canadians think about reducing energy and GHGs from buildings.

Given the wide range of policy and technology options that the committee has examined, this section is divided by different policy and technology themes, based on witnesses' testimony. The section examines:

- Canada's national building codes;

- Canada's energy efficiency regulations;
- energy efficiency labelling programs;
- technology research, development and demonstration;
- fuel switching for space heating;
- federal investments in buildings; and,
- the role of municipalities.

A. National Building Codes and Green Construction

The construction of new buildings and the substantial renovation of existing buildings in Canada are subject to building codes. Building codes are sets of rules governing the design, construction, alteration, maintenance and demolition of structures. Their main purpose is to set minimum standards for public health and safety, fire and structural protection, and energy and water efficiency. In Canada, jurisdiction over implementing building codes is a provincial responsibility. National building codes are developed and updated by the Canadian Commission on Building and Fire Codes (Commission), which is supported by the National Research Council Canada (NRC). The NRC publishes the codes as models for provincial and territorial building regulations. The adoption and enforcement of the codes are the responsibility of provincial and territorial authorities or of municipalities that have been delegated this authority. In some cases, the codes are amended to suit regional needs or jurisdictions publish their own codes based on the national codes.[61]

There are several building codes supported by the NRC but the National Building Code (NBC) is the one that sets out technical provisions for the design and construction of new buildings. The NBC details the requirements for energy-efficiency performance of buildings such as single-family homes and small buildings. A separate code, the National Energy Code of Canada for Buildings (NECB) sets out the technical requirements for the energy-efficient design and construction of buildings, such as high-rise towers or warehouses.

> *Building codes are essential if we're looking at this from a long-term perspective. When we build homes today, I am amazed at how inefficiently we build them, and they are going to be heating the outdoors for the next 50, 75, 100 years when we don't build them right. So, adopting stringent building codes is critical. […] The federal government in Canada doesn't have the jurisdiction to enforce building codes across the country. But it can build out model building codes, and it can work with its provincial counterparts to encourage them to adopt those building codes.*
>
> - *Phillipe Dunsky, Canadian Energy Efficiency Alliance*

Codes are revised approximately every five years. The revisions are meant to keep apace of improvements in technologies, materials and techniques applied to the construction industry. The latest published editions of the NBC and NECB were released in 2015.

Federal officials told the committee that the Government of Canada will update national building codes to lower building GHG emissions across Canada by 2030. In fact, the current update to the building codes is guided by commitments under the Pan-Canadian Framework to adopt increasingly stringent model buildings codes starting in 2020 with the goal of adopting "net zero energy ready" building codes by 2030, and to develop a model energy code for existing buildings by 2022.[62]

Sarah Stinson of NRCan told the committee that the federal 2017 Budget allocated $182 million, over eight years for new action on energy-efficient buildings, including building code development:

> *$99 million was earmarked to develop net-zero energy-ready codes for new buildings, and research, development and demonstration to lower costs of high-performance homes and buildings. $82 million was earmarked to retrofit existing buildings. This includes expanding energy bench-marking, optimization, new standards, and supporting provinces and territories to implement regulation of energy labelling and sharing of energy-use data.*[63]

1. Adding "Net-zero Energy Ready" to the National Building Code

The committee was informed that net-zero energy ready building standards for new homes and buildings would be added to the two national model codes (NBC and NECB) by 2022, targeting adoption by the provinces and territories by 2030.[64] In a brief submitted to the committee, the National Research Council Canada defined "net-zero energy ready" as follows:

> *A net-zero energy building is defined as a high-performance building that combines superior performance in energy efficiency with renewable energy production to offset all of the building's annual energy consumption. Aggregated over one year, a net-zero energy building produces as much energy as it consumes from utilities.*
>
> *A net-zero energy ready building is built to the same level of energy efficiency as a net-zero energy building but does not include renewable energy production which typically involves harvesting energy from the sun and converting it to electricity (by photovoltaic panels) and/or heat (by solar thermal panels).*[65]

The Specific Mitigation Opportunities Working Group estimated that if net-zero energy ready building codes are implemented by 2030, annual GHG emissions from homes and commercial-institutional buildings would each be reduced by 4 to 5 Mt CO_2e in subsequent years.[66] The Working Group estimated that the cost of reducing building GHG emissions by adopting net-zero energy ready buildings codes could range from negative – i.e., less than $0 per tonne of avoided GHGs (<$0/t CO_2e) for buildings where electricity is used as the main energy source – to more than $250/t CO_2e in buildings where natural gas is the main energy source.[67] The Working Group also noted that mitigation costs will depend on regional differences in climate, as well as how soon the codes are implemented.[68]

Duncan Hill of the Canadian Mortgage and Housing Corporation (CMHC) told the committee that "net-zero-energy housing is technically and financially achievable with commercially available materials, equipment and systems."[69]

Philip Rizcallah of the NRC told the committee that the Canadian Commission on Building and Fire Codes technical committees are conducting detailed cost-benefit analyses to understand the costs of achieving net-zero energy for different locations and building types.[70] Kevin Lee of the Canadian Home Builders Association (CHBA) noted that some CHBA members are already building net-zero energy homes, but at a high price. Citing research done by the Province of British Columbia, Mr. Lee told the committee that net-zero energy construction would increase the incremental capital cost of a British Columbia home by $27,000.[71]

According to research cited by the NRC, the incremental capital cost of building of a net-zero energy *ready* building is about 50% lower than for a net-zero energy building. The NRC explained that net-zero energy ready buildings cost less because they do not include technologies like solar panels to produce electricity.[72]

Some witnesses raised concerns about the costs of net-zero energy ready building codes. Mr. Lee worried that the added costs of building net-zero energy ready buildings could make housing prices unaffordable for some potential buyers.[73] Tom Williams of the Northwest Territories Housing Corporation believed that updates to the national building code should reflect northern economic realities and urged the federal government to "partner in research toward determining the true cost of adopting a net-zero energy code in the [Northwest Territories]."[74]

Responding to these concerns, federal officials told the committee that research and development on net-zero energy building technologies at the federal level is intended to lower technology costs and promote innovation in building practices.[75] Moreover, Michel Dumoulin of NRC told the committee that provinces and territories will have the flexibility in the updated national model codes to adopt specific performance levels with a gradual increase in performance toward adoption of a net-zero energy ready code by 2030.[76] Today, nine of 13 provinces and territories have adopted the current National Building Code for the residential sector and five have adopted either the 2011 or the 2015 version of the National Energy Code for Buildings, which covers commercial-institutional buildings.[77]

> *[…] It's in the best interests of Canada as a whole that everybody references the same and latest edition of the code at the same time. That helps on a number of fronts. One of them is economic mobility: You're not having a trade in Manitoba have to learn a whole new set of codes to work in Saskatchewan. It also helps with innovation. It helps industry to be competitive, because they're not creating three different products in various provinces across the country. We also understand there are challenges within the provinces and territories in adopting these codes in a timely manner. Ideally that would be the goal.*
>
> - *Philip Rizcallah, National Research Council*

Federal officials informed the committee that part of the program funding included in the federal Budget 2017 would be used to support the adoption of national codes by provinces and territories.[78] Ms. Stinson noted that there are several benefits to adopting national model codes, including: "cost savings, reduced peak [energy] demand, improved indoor environment and sustainability, and of course reduced GHG emissions."[79]

Some witnesses told the committee that adapting national codes to provincial, territorial, or even municipal circumstances could also be beneficial. Professor Vincent, for example, noted that the Northwest Territories considers the impacts of climate change in its building code, requiring "planning for instability, channelling away water and preventing flooding that perhaps is not occurring at the moment but that will occur in the future."[80]

2. Energy Retrofits for Existing Homes and Buildings

Energy retrofits in existing homes and buildings are an essential part of reducing emissions in the built environment because it is estimated that approximately 75% of the buildings that will be standing in 2030 have already been built.[81] In the words of Mr. Lapp: "new [buildings] account for a small portion of buildings in Canada. Addressing only this aspect will not be sufficient to achieve deep emission reductions in the building stock."[82]

To curb GHG emissions from the existing stock of homes and buildings, the federal government will create a national model code for existing homes and buildings. This new code (the "retrofit code") will establish retrofit requirements for existing buildings. The retrofit code is currently being developed through the code setting process led by the Canadian Commission on Building and Fire Codes, and federal officials said that it will be published in 2022 with the intent that provinces and territories will adopt the code by 2030.[83]

Joyce Henry of NRCan explained that the retrofit code would achieve GHG emission reductions by "expanding energy benchmarking, optimization and standards for buildings, and also to support provincial and territorial regulation of energy labelling and sharing energy-use data." Ms. Henry explained that "as Canadians renovate their houses…this code would work in such a way that it would support, through information on energy use

Committee members visited NS Power in Halifax, Nova Scotia. Their office building, a former electrical generating station, has achieved LEED Platinum certification from the Canada Green Building Council (CaGBC).

and management, the decisions Canadians are already going to make to retrofit their homes and the benefits out of that."[84] That said, Ms. Stinson told the committee that "what the retrofit code will look like, what it's stringency will be and when it comes into play – at time of sale, at time of renovation – all still needs to be determined through the existing code development process."[85]

Many witnesses addressed the questions of how many GHG emissions could be reduced from the retrofit code, and other measures targeting existing buildings, as well as how much such measures would cost. In that regard, the Specific Mitigation Opportunities Working Group modelled a mix of policy options including the retrofit code, financial incentives, loan programs, information programs, and energy use disclosure regulations and found that these measures could reduce GHG emissions from homes by 1 to 6 Mt CO_2e by 2030, with an additional 1 to 6 Mt CO_2e of reductions from commercial-institutional buildings.[86] The Working Group estimated that these policy measures would have a cost per tonne of residential GHG emission reductions that could range from less than \$0/t CO_2e (i.e. policies have a positive payback) to more than \$250/t CO_2e, depending on the main type of energy being used in homes. In the commercial-institutional segment, costs were projected to be less than \$0/t CO_2e (i.e. policies have a positive payback), due to a long ramp-up period, market transformation initiatives, and technological improvements.[87]

As is the case with existing national building codes, it will be up to provinces and territories to decide how the retrofit code will be adopted and enforced. Martin Gaudet of NRCan explained that even if a jurisdiction does not adopt the retrofit code, the information within it will be useful to homeowners and builders:

> *One of the benefits that will come out of developing these retrofit codes is that cost optimization packages will be developed for different types of buildings. From that, whether or not the jurisdiction chooses to implement them as a retrofit code, there is still opportunity to take those lessons learned to provide better information to the public, if they do want to renovate their home, for a particular vintage of home in a certain area, what might be the option for them to do that most cost effectively.*[88]

Some witnesses supported the idea of using a retrofit code to reduce GHG emissions from existing homes and buildings.[89] Thomas Mueller of the Canada Green Building Council, for one, emphasized that a retrofit code creates the opportunity for the existing stock of large buildings (over 25,000 feet) to improve their energy performance through deep retrofits that achieve a reduction in energy use of approximately 20 to 40% considering the return on investment that comes with the energy efficiency improvements.[90] The City of Toronto also supported a national retrofit code to drive retrofits to the City's nearly 18,000 buildings, many of which were built between the 1960s and early 1980s. Mary-Margaret McMahon, Councillor for the City of Toronto, recommended the following plan:

> *First, develop a model national energy and building code for existing buildings, identifying that when major retrofits are being made to an existing building, the energy efficiency performance of buildings must*

> *be improved to a new standard. Second, establish a federally coordinated energy reporting and benchmarking requirement similar to regulations being advanced in Ontario. Once that is established, then work with the provinces and cities to create regulations and program supports that will require low-performing buildings to be retrofitted for energy efficiency.*[91]

Dina McNeil of the Canadian Real Estate Association (CREA) told the committee that the CREA is concerned with the cost implications of the retrofit code on home buyers and sellers. Ms. McNeil cautioned that if home owners must pay "the cost of a [home energy] audit or the cost of improvements that an audit may recommend, some homeowners may decide not to sell their home."[92] In particular, Ms. McNeil noted that "owners of older homes could be particularly impacted, as could low-income homeowners, who may not be able to afford improvements that a new code would require."[93] To address these concerns, Ms. McNeil suggested that the retrofit code be applied to older homes on a sliding scale based on the age of the home.[94]

Along these lines, federal officials explained to the committee that sensitivity to the different classes and vintages of buildings will be integrated in the retrofit code.[95] In fact, Mr. Rizcallah also noted that it is very likely that the retrofit code will not require heritage buildings to meet the same energy performance requirements that more modern buildings must meet.[96]

Some witnesses felt that climate change adaptation should also be addressed in the retrofit code. Mr. Stewart, for one, recommended the following approach:

> *If we are thinking of a new national home retrofit program, for instance, or a new national building retrofit program that is focused on energy efficiency, we think that you could couple it with a resilience portion and do both – help increase efficiency but also help make it more weather resistant.*[97]

To that effect, some witnesses explained that standards are already being developed to meet this objective. Dwayne Torrey of CSA Group told the committee that his organization is participating in the Climate-Resilient Buildings and Core Public Infrastructure initiative launched by the NRC and Infrastructure Canada in 2016. The purpose of that initiative is to integrate climate resilience into building and infrastructure codes, specifications, guidelines, and assessment tools.[98] As Mr. Feltmate indicated, the first new standard is "a flood standard directed toward basement flooding, how to mitigate it and to provide guidance to homeowners and inspectors in reference to what can be done around the house to lower your flood risk profile."[99]

3. Federal Government Retrofit Incentives for Homes and Buildings

From April 2007 to March 2012, the federal government provided grants up to $5,000 through the ecoENERGY Retrofit–Homes Program to help homeowners make their homes more energy-efficient and reduce energy costs. More than 604,000 homeowners received federal incentives during that period.[100]

The federal government also offered incentives to building owners through the ecoENERGY Retrofit Incentive for Buildings. As part of that program, owners of small and medium-sized buildings in the commercial and institutional sector were offered financial incentives to make energy improvements to their buildings. These incentives were $10 per gigajoule of estimated energy savings or 25% of eligible project costs up to a maximum of $50,000 per project.[101]

These financial incentive programs for retrofits may have ended, but Mr. Hill told the committee that the CMHC provides mortgage insurance refunds of up to 25% on CMHC mortgage loan insurance premiums to home buyers as an incentive for building new energy efficient homes or for making energy efficiency renovations when purchasing an existing home.[102] According to its written brief, the CMHC provided $5.1 million in premium refunds to 4,132 eligible applicants between 2012 and 2017.[103]

Mr. Lee expressed the opinion that the federal government should introduce a "permanent refundable home renovation tax credit using the EnerGuide rating system" for energy efficiency. He recommended using tax credits instead of grants because he believed it would be easier to administer and it would be more effective in discouraging fraudulent claims.[104] Ms. McNeil also supported the use of federal credits or rebate programs to reduce the cost to homeowners of efficiency improvements, as a complement to provincial and territorial programs.[105]

Mr. Mueller told the committee that the Infrastructure Bank or infrastructure funding could encourage retrofit projects through loan guarantees designed to leverage private sector investment.[106] Mr. Mueller believed government assistance would help accelerate retrofit investments and overcome some of the barriers such as risk, uncertainty and the lack of information related to the potential for energy savings. He explained that Class B office buildings (generally slightly older, well-maintained buildings) are an opportunity because they often lack access to capital.

4. Green Construction

The building and renovation industries will play a critical role in helping reduce building sector GHG emissions. Some witnesses emphasized that the transition to lower-GHG emitting buildings would represent a significant economic driver for the building industry.[107]

The committee heard that new and existing buildings should be considered on a life cycle basis that takes into account the costs and environmental impacts of a building across all the stages of its full life cycle from materials acquisition through construction, operation and maintenance, and retrofit to demolition. Mr. Lapp, for example, expressed the conviction that building codes would be improved by adopting such a life cycle assessment (LCA) approach.[108]

The committee heard that many different building service professionals play important roles in reducing energy use and GHG emissions throughout the life of a building. Architects and engineers, for example, make design choices up front that have a lifelong impact on building energy use and GHG emissions. As Emmanuelle van Rutten of the Royal Architecture Institute of Canada explained:

> *At the scale of individual buildings, architects can reduce operational and*

> *embodied carbon production through passive design strategies, energy efficiency measures, design for increased durability and resilience, innovations that find ways to use less space, integration of renewable energy sources, specification of low impact building materials, promoting stair use and cycling, integration of electrical vehicle charging stations, and the design to help shift people's behaviour to more sustainable patterns. These strategies serve not only to reduce emissions but to increase human health and productivity.*[109]

Mr. Lapp told the committee that there will be a need for new energy advisers, energy modellers and building science engineers as more stringent building codes are implemented. He explained that Engineers Canada publishes a national guideline on the principles of climate change adaptation and mitigation to assist professional engineers in considering the implications of climate change in their professional practice.[110]

Similarly, Martin Luymes of the Heating, Refrigeration and Air-conditioning Institute of Canada noted that in the retrofit marketplace contractors can be "ambassadors of efficiency," if they are trained to see opportunities for energy efficiency upgrades when they are in homes and buildings.[111] He noted that as codes and building systems become more sophisticated, the need for upskill trained workers will also increase.

Industry witnesses from the building materials sector told the committee that different types of building materials should compete on a life cycle basis with other materials. Representatives of the Cement Association of Canada and the Forest Products Associations of Canada argued that all federal spending on building materials for infrastructure and buildings should be assessed on a life cycle basis that considers a range of environmental impacts, including the GHG performance of the material.[112]

Pierre Boucher of Canadian Construction Innovations (CCI) explained to the committee that the construction industry is a "heavy consumer of Canada's resources and energy."[113] He told the committee that the sector's energy intensity and related GHG emissions have been growing by 2.5% each year recently, driven by economic growth in the sector.[114] He argued that a key challenge to improving the construction industry's energy and GHG performance is the lack of granular data on various building components systems to support LCA for buildings. Moreover, he explained that energy management systems and energy benchmarking in the industry are not widespread, particularly in the heavy civil sector.[115]

On occasion, motivated building owners and developers decide to build homes and buildings to stringent energy efficiency and GHG performance standards that exceed minimum standards. One such standard is Passive House, which is one of the most stringent voluntary certification standards for homes in Canada. The committee is grateful to have met the Peters Family at their beautiful family home in Prince Edward Island, which they chose to build to the Passive House standard to reduce their environmental impact and improve the air quality, noise reduction, and comfort of their home.

Other high-performance voluntary codes exist, including Leadership in Energy and Environmental Design (LEED) stan-dards and the Canada Green Building Council's (CGBC) zero-carbon building standard. As Mr. Mueller explained, CGBC's zero-carbon building standard is Canada's first green building program developed to assess carbon emissions in new and existing commercial, institutional and multi-family buildings.[116]

Committee members learned more about the Passive House certification when visiting the Peters' home close to Long River, Prince Edward Island.

The committee heard that even when there is a clear business case to be made for investing in energy efficiency, some building owners prioritize other investments. By way of partial explanation, Jim Lord of Ecovert Sustainability Consultants noted that it takes builders and developers with the right kind of mindset to invest up front in efficiency for long-term energy savings and environmental benefits. In Mr. Lord's own words:

> *The big challenge we find is there are two types of owners, particularly in the new construction. There are owners who will build the building and own it for the next 20 years. They're very concerned about energy efficiency, so they will put a few extra dollars up front and it will pay amazing dividends over the years. Then there are other major projects where they will build it and then pass it over to someone else. That's the example of a condominium. I put an extra $100,000 in the boiler, but I'm not going to get that money back.*[117]

Mr. Hill attributed such underinvestment to a lack of information. He argued that with clear information on the costs of energy-efficiency retrofits and the expected return on investment, home and building owners and developers would perceive less risk on their efficiency investments.[118]

B. Energy Efficiency Regulations and Labelling

Responsibility for energy efficiency is shared between the federal, provincial and territorial governments. The federal government regulates energy-consuming goods that are imported into Canada for sale, or that are manufactured in one province and shipped to another for sale, while provincial regulations

apply to products that are manufactured or sold within their own borders.

NRCan is the key federal government department for energy research and development and energy efficiency. Its Office of Energy Efficiency provides targeted programs to improve energy efficiency, including tools, grants and incentives, and information. NRCan estimated that there is the potential for 10.4 Mt CO_2e of GHG emission reductions that could be achieved by 2030 by increasing the stringency of Canada's *Energy Efficiency Regulations* through a series of planned amendments.[119]

Regulations under the federal *Energy Efficiency Act* set energy efficiency standards for a range of products and equipment, with the goal of removing the least energy-efficient equipment from the Canadian market.[120] They establish minimum energy performance standards as well as reporting and labelling requirements for specified categories of regulated products, such as household appliances (refrigerators, electric and gas ranges and clothes washers and dryers, for example), water heaters, certain heating and air-conditioning equipment, lighting and electronic products, including televisions. The regulations first came into effect in 1995 and are regularly amended to increase the stringency of existing performance standards or to introduce performance standards for new products.

The federal government has committed to improving the energy efficiency of appliances and equipment by setting new standards for heating equipment and other key techno-logies to the highest level of efficiency that is economically and technically achievable. To that end, in March 2017, it gave notice of its intent to increase the stringency of existing energy efficiency standards for 11 product categories and to introduce energy efficiency standards for six new product categories, including commercial oil or gas boilers and commercial water heaters.121 These new and updated standards are part of a 2016 commitment with the United States to better align and further improve energy efficiency standards by 2020.

> *Initiatives like ENERGY STAR, R2000 and CHBA's net zero home labelling program enable homeowners to choose higher levels of performance on a voluntary basis, moving the market forward without damaging affordability in entry-level homes. This approach supports innovation and provides market streamlining, ensuring that incremental costs are optimized and linked to homeowner benefits. Providing leading-edge, voluntary programming is key to advancing energy efficiency and supporting innovations in housing while protecting choice and affordability. Regulation, if necessary, can follow after costs have been reduced.*
>
> - *Kevin Lee, Canadian Home Builders Association*

1. Energy Efficiency Labelling

As part of the Pan-Canadian Framework, officials from NRCan advised the committee that the federal government is "working with provinces and territories to implement mandatory labelling of home energy ratings and building energy use to help demonstrate the improved performance of new buildings, so consumers and building owners can see the impact it would have."[122] To do so, the federal government is developing a national data

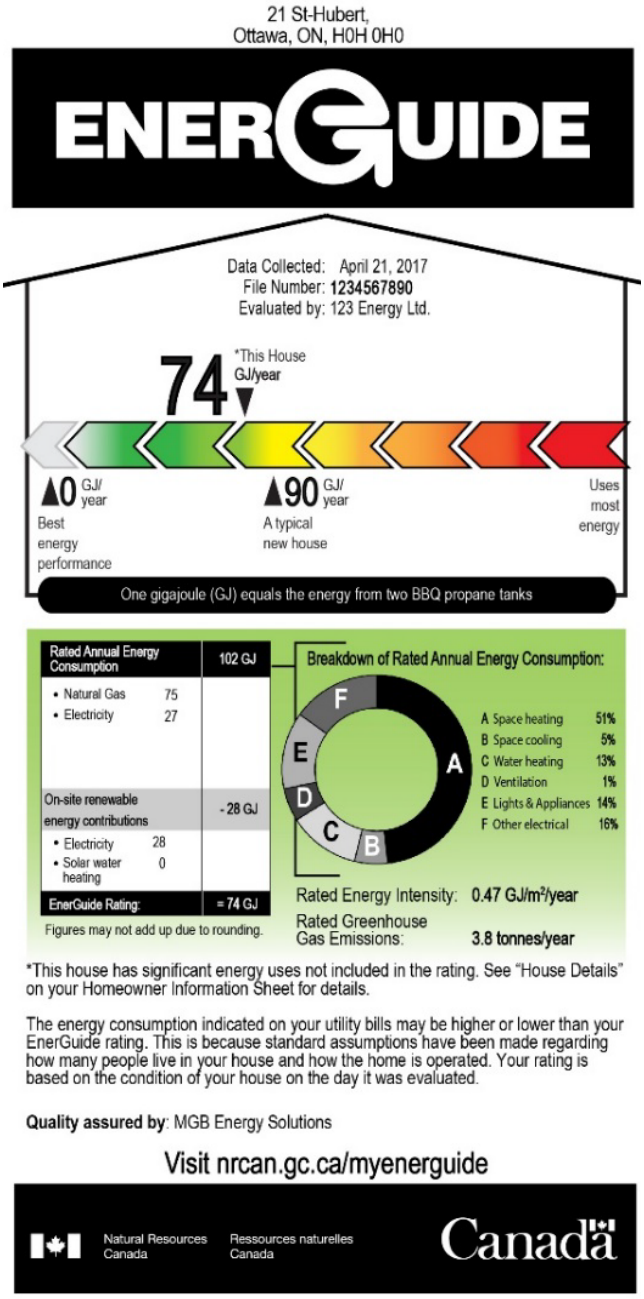
platform for energy benchmarking to support provincial and territorial energy rating and disclosure programs.[123]

Many witnesses supported making energy benchmarking and labelling in homes and buildings mandatory under national and regional buildings codes. Mr. Mueller told the committee, "you get the best data if you make energy benchmarking and reporting on buildings, energy and products mandatory."[124] He also said the following: "you need to label the building. There needs to be public disclosure on how the building performs."[125]

Canada has labelling tools to provide energy benchmarking information on a range of products such as major household appliances, heating and cooling equipment and room air conditioners, as well as new and existing homes and buildings themselves: EnerGuide, ENERGY STAR, and R-2000. Homes and buildings with these labels are more efficient than the average home or building built in Canada: an ENERGY STAR certified home is 20% more efficient than the average house built in Canada and a R-2000 certified home is 50% more efficient.[126]

The EnerGuide label compares a product's energy performance to others in the same class of products. The label is required for certain products specified in the *Energy Efficiency Regulations*, while it is voluntary for other products.[127]

EnerGuide for houses is a voluntary energy performance rating and labelling program for new and existing houses. It estimates how energy is used in a home and encourages measures to reduce energy use. Introduced in 1998, it has since been used to estimate the energy efficiency of more than 1 million homes. Homeowners or home buyers can purchase an



Example of an EnerGuide Label for a new home

Source: Natural Resources Canada

EnerGuide home evaluation from a certified energy advisor, which includes an assessment of the home's insulation, heating system, and air leakage, among other things. EnerGuide evaluations can be used to assist existing homes in planning home renovations or upgrades to maximize energy savings, or to help

builders identify upgrades in the design and construction phase to increase the energy performance of new homes.[128]

The committee heard that the EnerGuide rating system is an effective and valuable tool that could help Canada achieve its climate change objectives. Mr. Lee told the committee that:

> *The EnerGuide rating system provides home energy information through its label and reports to help increase energy literacy and should be used by all regional programs and mandatory labelling regimes as Canada's single national home energy labelling system. It is the equivalent of nutrition labels on food products. We need one strong, well-supported national system, and that label needs to be mandatory on the resale of homes, but this system deserves the major government investment that it warrants given the importance being placed on improved energy efficiency in the built environment.*[129]

ENERGY STAR is a voluntary program created by the United States Environmental Protection Agency (EPA) in 1992 and administered in Canada by NRCan. The ENERGY STAR label identifies energy-using products that have been tested and certified to meet or exceed high efficiency standards. It can be used not only for products, but new homes, and commercial and industrial facilities as well. Commercial, industrial, and institutional sector organizations can use the ENERGY STAR Portfolio Manager tools to benchmark and manage their energy performance.[130]

> *From 2011 to 2016, ENERGY STAR generated 2 megatonnes of GHG reductions and $1 billion in energy savings for Canadians. More than 74,000 homes in Canada have been certified ENERGY STAR by 700 participating builders.*
>
> *- Sarah Stinson, NRCan*

ENERGY STAR certified homes have more insulation, air sealing to reduce drafts and cold spots, high performance windows and high efficiency heating and cooling systems. When built and performing to ENERGY STAR standards, these homes are 20% more energy efficient than a typical home and can save up to $300 a year in utility costs.[131]

For energy management of commercial-industrial buildings, the ENERGY STAR Portfolio Manager is a free, interactive energy management tool that allows users to assess, monitor and optimize energy and water consumption and waste across a portfolio of buildings securely online.[132] According to Kevin Radford of Public Services and Procurement Canada (PSPC), the federal government is currently using the Portfolio Manager to

> *evaluate the energy performance of all of our Crown-owned office buildings, both to establish a baseline and to identify and prioritize energy savings and [GHG] reduction opportunities. This is the first time that an entire portfolio*

has been benchmarked at any level of government.[133]

R-2000 is a premium voluntary standard for homes developed by NRCan. On average, it is 50% more energy-efficient than a typical new home that is built to code. All R-2000 homes must be built by a R-2000-certified contractor. R-2000 homes have high insulation levels in walls, ceilings and basements, high-efficiency windows and heating appliances, tight building envelopes, whole-house mechanical ventilation, and water-conserving fixtures. Once built, an R-2000 home is evaluated by a third-party inspector and then certified by the federal government.[134]

Ms. Stinson told the committee that R-2000 has driven innovation in building technologies since it was first created 40 years ago. She explained that an R-2000 house built in 2005 is as energy-efficient as a typical house built today. The R-2000 standard was last updated in 2012. According to Ms. Stinson, "R-2000 accounts for 22 per cent of energy-efficiency improvements in the residential sector since 1980."[135]

C. Technology Research, Development, Demonstration and Deployment

Research, development and demonstration (RD&D) can help improve energy efficiency and reduce GHG emissions by improving how homes and buildings are designed, constructed, operated and renovated. RD&D promotes technology innovation and lowers the cost of technology deployment.[136] In Budget 2017, the federal government committed $48.4 million to a new program, the Energy Efficient Buildings Research, Development and Demonstration program designed to support the development and implementation of buildings codes for existing buildings and new net-zero energy-ready buildings through RD&D.[137] Federal RD&D is carried out in federal research centres like CanmetENERGY's facility in Varennes, Quebec, which the committee visited, the NRC's Construction Research Centre, and the Canadian Centre for Housing Technology jointly-operated by NRCan, NRC and the CMHC.

Dean Haslip of NRCan's CanmetENERGY emphasized how important simulation and modelling of energy use in buildings is to informing policy development and technological priorities:

> *From a research and development perspective, it's important to understand how energy is used in a building, what the factors are that contribute to energy use and how these factors interrelate. Modelling and simulation is an important tool to help us establish this level of understanding. It can be used to estimate the energy and GHG reductions associated with energy-efficiency improvements and the cost of making those improvements to identify the most promising directions for future technology development and also to support the development of policies, programs and new building codes.*[138]

NRCan's RETScreen Expert is an example of an energy management software that supports simulation and energy modelling.[139] This tool is available free-of-charge and can be used to identify, assess and optimize the technical and financial viability of clean energy projects and verify energy performance.[140] Other energy modelling and performance benchmarking tools are also available free of charge on NRCan's website.

Representatives from NRCan told the committee that because space heating is responsible for producing most building sector GHG emissions reducing energy used for space heating is a RD&D priority. As Ms. Stinson explained, the RD&D challenge for reducing space heating energy use involves making sure that buildings are well insulated, and that heating equipment is as efficient as possible.[141] Depending on whether the buildings are a new construction or an existing building, the technology solutions being looked at could be different. Mr. Haslip said that for existing buildings, for example, NRCan is "using panelized, prefabricated wall assemblies that can be measured beforehand, assembled in a factory and then brought to a house or a building and assembled around the building like a jacket."[142] In new constructions, NRCan is exploring high-performance building envelope assemblies which include the use of next generation insulating materials. Innovative building components, such as ultra-efficient windows, smart home thermostats and sensors, and energy management controllers are technologies that may be applicable in both new and existing buildings to reduce heating energy use.

Iqaluit airport was built with a system of 'thermosyphons' to draw away heat before it reaches the permafrost below.

1. Technology for Northern and Remote Buildings

The strategy for reducing energy use and GHG emissions in northern and remote buildings is the same as elsewhere: use less energy, be more energy efficient and proceed with fuel switching where appropriate. That said, northern and remote buildings have unique challenges that can require different technological solutions. These challenges include the extreme climate and the logistical and cost issues that arise from living in remote locations. Another is the fact that 72 out of 99 communities in the Yukon, Northwest Territories, Nunavut, Nunavik and Nunatsiavut rely almost exclusively on diesel power generation. There are close to 40 more diesel-dependent communities located below the 60th parallel.[143]

Another challenge raised by witnesses is the high level of "core need" for housing in northern and remote communities. Indeed, the committee was told that many households in the Northwest Territories and Nunavut are located in housing stock that is

"substandard or overcrowded or pays excessive shelter costs and has low to moderate income."[144] Stephen Hooey of Nunavut Housing Corporation told the committee that even simple solutions like effi-ciency and air-tightness, which are effective in theory, can achieve less than optimal results when deployed in the real world, noting that air-tightness in overcrowded homes can create mould issues that affect occupants' health.[145]

Housing providers in the North are using readily-available technologies to reduce energy use in existing buildings. These measures focus on efficiency solutions like improved insulation and ventilation systems, installing LED lighting, replacing old, inefficient appliances with energy-efficient appliances, replacing outdated hot water heaters or hot water systems, and replacing outdated boilers and furnaces.[146] For new buildings, high-efficiency and improved insulation and ventilation systems are the priority.[147]

Witnesses said that in recent years, government-funded housing construction has increasingly been for multi-residential buildings with improved energy efficiency. New prototype multi-family apartment buildings are now equipped with electric space heating, solar panels, and cold porches to minimize heat loss.[148]

Mr. Haslip highlighted CanmetENERGY's Rapidly Deployable Northern House as an example of a building technology that could be adapted to northern climates and communities – it is a highly-efficient home or office space designed for northern climates that is shipped flat-packed and can be assembled within hours by an untrained team of 3 to 4 people. The Rapidly Deployable Northern House is still under development and is being field-tested in northern locations.[149]

Some witnesses expressed scepticism about electrifying space heating in northern Canadian buildings due to dependence on diesel fuel for heat and electricity.[150] Mr. Hill noted however, that the CMHC is completing a study with the Yukon government on the feasibility of replacing oil-fired furnaces with electric heat.[151]

A federal and territorial priority under the Pan-Canadian Framework is to reduce the dependence of northern and remote communities on diesel-electricity. Lyse Langevin of Indigenous Services Canada highlighted the connection of Pikangikum First Nation to Ontario's electricity grid as an example of a project to reduce diesel-dependence.[152] Mr. Hubbard also noted that the recently-launched Clean Energy for Rural and Remote Communities program addresses diesel-dependence by funding biomass heating, energy efficiency, energy storage, smart-grid technologies, hydro, wind, solar, and geothermal projects.[153]

The federal government and many other partners are engaged in RD&D on "cost-optimal"[154] technology solutions for northern and remote homes and buildings. Such partnerships can include federal and independent agencies; Indigenous organizations, governments and communities; research organizations (e.g., Polar Knowledge Canada); territorial and provincial governments; non-profit organizations (e.g., Arctic Energy Alliance); and housing providers and researchers (e.g., Yukon Housing Corporation, the Nunavut Housing Corporations, and the Northwest Territories Housing Corporation).

Pamela Hine of the Yukon Housing Corporation recommended to the committee that northern housing stakeholders should be involved with setting the research agenda for RD&D

partnerships.[155] According to Mr. Hooey, that research agenda should be focused on "building science to improve energy efficiencies, as well as to assess risks associated with climate change to identify appropriate mitigation and adaptation strategies."[156] In response, Ms. Atkinson advised the committee that the CMHC will launch "new demonstrations and solutions lab initiatives that northern housing stakeholders can apply to help them innovate, problem solve and advance the environmental sustainability of northern housing."[157]

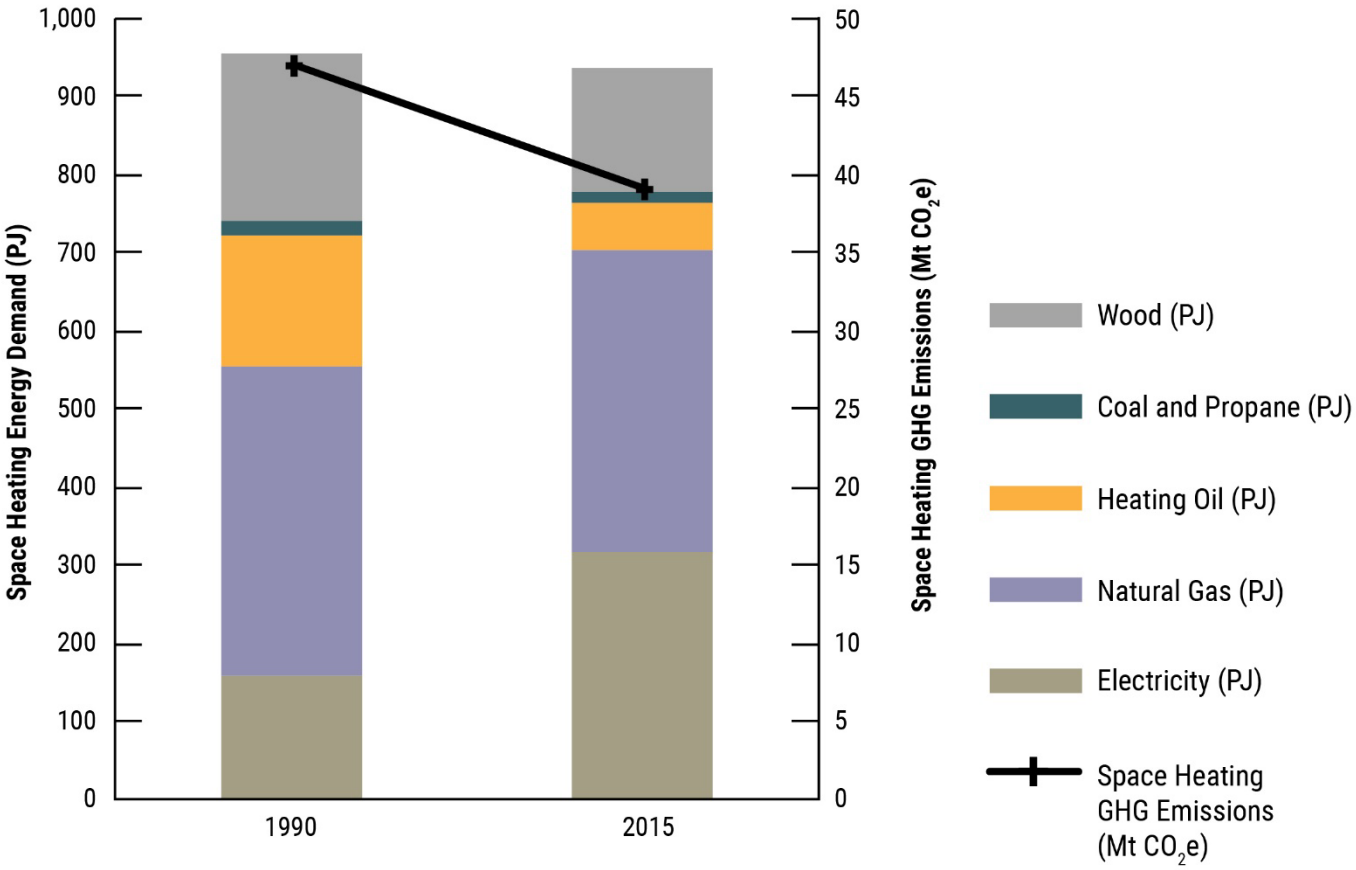
D. Fuel Switching for Space Heating

The energy expenditures of households and buildings across Canada varies primarily due to different heating methods and heating needs.[158] For example, buildings in Atlantic Canada have limited access to natural gas and face cool weather. For these reasons, homes and buildings in the region have among the highest average expenditures on energy in Canada. Buildings in British Columbia, on the other hand, have average household energy costs, as a share of total expenses, that is the lowest in Canada due to the province's abundant supplies of lower-cost electricity and milder climate.[159]

The Special Emissions Working Group estimated that fuel switching and the integration of renewable energy technologies into homes and buildings could deliver GHG emission reductions of up to 6 Mt CO_2e by 2030.[160] The Working Group estimated that the cost to do so could range from less than \$0/t CO_2e to more than \$250/t CO_2e of GHG emission reductions depending on the main energy sources being used in buildings.[161]

As shown in Figure 6, residential energy demand for space heating decreased by 2% between 1990 and 2015, and GHG emissions decreased by 16%, a reduction of nearly 8 Mt CO_2e.[162] These gains came mainly from energy efficiency improvements like increased insulation, air tightening of building envelopes, using more efficient heating equipment, and from fuel switching for heating needs.[163] Figure 6 shows that fuel-switching for space heating took place as household demand for electricity displaced demand for higher-emitting energy sources like heating oil, coal, propane, and wood. Witnesses explained that continuing to electrify space heating in buildings could drive further GHG emissions reductions, but the carbon-intensiveness of regional electricity supplies and the cost associated with electrification could be prohibitive in some jurisdictions.[164]

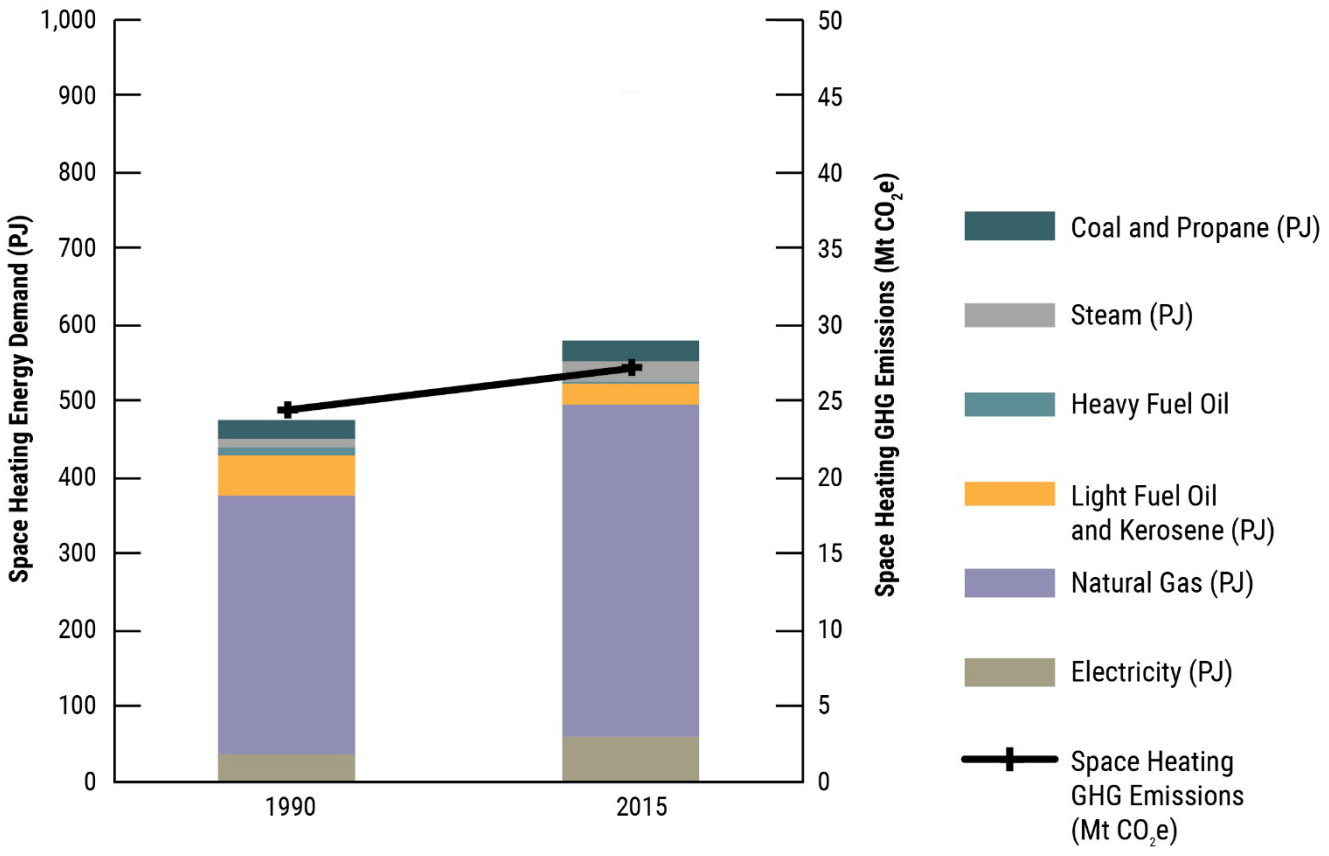
Figure 6 – Residential Space Heating Energy Use by Energy Source (PJ) and Total Residential Space Heating GHG Emissions (Mt CO_2e)



Source: Figure prepared by the Library of Parliament using data obtained from Natural Resources Canada, "Table 7: Space Heating Secondary Energy Use and GHG Emissions by Energy Source – Including Electricity-Related Emissions, Residential Sector - Canada," Comprehensive Energy Use Database, accessed on 29 January 2018.

On the other hand, Figure 7 shows that energy demand for space heating increased by 23% in the commercial-institutional segment between 1990 and 2015; GHG emissions increased by nearly 3 Mt CO_2e during that period, an increase of 11%.[165] Growth in energy demand led to an increase in emissions in the sector despite energy-efficiency improvements and some fuel switching.[166]

Figure 7 – Commercial-Institutional Space Heating by Energy Source and Total Commercial Space Heating GHG Emissions, 1990-2015



Source: Figure prepared by the Library of Parliament using data obtained from Natural Resources Canada, "37: Space Heating Secondary Energy Use and GHG Emissions by Energy Source, Commercial-Institutional - Canada," Comprehensive Energy Use Database, accessed on 29 January 2018.

Several technology solutions that are available, or that are under development, could facilitate fuel switching in Canada. Some witnesses noted that cost is a key barrier for uptake of such solutions, as is the availability of lower-GHG energy sources like biomass and renewable energy.[167] Bruce Passmore of the Heating, Refrigeration and Air-conditioning Institute of Canada told the committee that even if there are good alternative heating technologies available, they may not proliferate as long as natural gas continues to be inexpensive and used extensively for heating. As Mr. Lumyes explained to the committee:

> *Reliance on natural gas in the heating sector is a challenge. It's so dominant and the cost per cubic metre of natural gas has never been lower. As long as we face those market conditions, we have a serious challenge trying to move*

> *people from fossil fuels to more friendly technologies. That's the biggest challenge facing the market.*[168]

The committee heard about several different options for fuel-switching in the buildings sector. The following discussion highlights just a few of these.

1. Electrification of the Building Sector

Replacing fossil fuels as a source of heat in homes and buildings with non-emitting sources of electricity generation is seen as a pathway to GHG emission reductions. Many witnesses pointed to the electrification of the buildings sector as part of a larger strategy to reduce emissions. The committee's interim report on the electricity sector discusses electrification as a key part of the transition to a low-carbon economy.

Mike Cleland of the University of Ottawa expressed caution in moving too quickly in electrifying the commercial-institutional segment of the building sector. He told the committee that "over the long run, as buildings achieve extremely high efficiency levels, electricity for space heat will become a viable option. Those sorts of buildings are still rare and will continue to be rare for some time to come."[169]

Mr. Beausoleil-Morrison indicated that it could be possible to reduce, or even eliminate the use of natural gas as a source of heating in houses, but that it would have to be replaced by another source of heating.[170] In that regard, he said the following:

> *if we replace it with electricity, then one or two things could happen. If we replace it with electricity, we create a large increase in demand for electricity. We have to grow the central electricity generation systems. We need more generating capacity somehow. If that new generating capacity comes from burning coal or burning more natural gas, we will not improve the situation. We will just displace where the emissions are generated. That will only be helpful if the new generation we add to the grid is emissions free.*[171]

2. Heat Pumps

Heat pumps use electricity to exploit renewable energy sources for space heating and cooling. There are two basic types of heat pumps: ground sourced and air sourced. Ground sourced heat pumps use water through a system of pipes to extract heat from the earth in the winter. In the summer, the piping system uses the earth as a sink to remove heat from a home. Air source heat pumps draw heat from the outside air during the heating season and reject the heat outside during the summer season.[172] One goal of the Build Smart Strategy is to improve the technical and financial performance of heat pumps and to accelerate their adoption in homes and buildings.[173]

Mr. Hill said that heat pumps today have a high upfront capital cost and may not be appropriate in all locations.[174] He noted that as Canada increases its share of clean electricity, the GHG emission reduction benefits of heat pumps will increase.[175] He emphasized that RD&D is needed to demonstrate the financial benefits of heat pumps, and to help potential buyers evaluate the performance and possible gains from

such an investment.[176] He noted that heat pumps have made fantastic gains in efficiency and performance in recent years.[177]

Using solar energy is one of different options for fuel-switching in the buildings sector

3. Solar

One way to use the power of the sun is to produce electricity for homes and buildings with solar panels. As more net-zero energy homes are built, solar-powered electricity will be a critical technology at the scale of individual buildings.

Witnesses also highlighted the potential for thermal uses of the sun's power, through passive solar construction for example. Mr. Beausoleil-Morrison explained that passive solar "simply means allowing sunlight to pass through windows and designing houses to make better use of that."[178] Another solar thermal technology is panelized solar walls, which are panels that are mounted on the exterior walls of a building to pre-heat air using the power of the sun.[179]

On a larger scale, RD&D projects are looking at how to store the thermal energy of the sun seasonally so that heat can be stored in the summertime and drawn down in the wintertime for space and water heating. Mr. Haslip highlighted the Drakes Landing Solar Community, as an example of this technology. Drakes Landing is a community of 50 homes in Okotoks, Alberta that operates solar thermal collectors and seasonal thermal energy storage in this manner. Mr. Beausoleil-Morrison noted that his research finds that "90 to 95 per cent of a typical house's thermal energy needs [can be met] through solar energy using these kinds of concepts."[180]

E. Federal Investments in Buildings

In June 2017, the federal government launched the Low Carbon Economy Fund as part of the Pan-Canadian Framework. The Fund provides $2 billion over a five-year period starting in 2017-18 to support provincial and territorial actions that reduce GHG emissions. Improving the energy efficiency of homes and buildings is cited as an example of the type of initiatives the Fund was designed to support.[181]

Another federal initiative is the green infrastructure funding under the Investing in Canada Plan,[182] which helps offset the costs of upgrading public infrastructure.[183] The Canada Infrastructure Bank was also created as an additional investment vehicle to leverage and build new green infrastructure.

Mr. Mueller advocated that federal funding received by buildings should be conditional on lowering emissions. He told the committee that

> *any federal funding that goes to either institutional or com-*

mercial buildings should have requirements around zero carbon. We recommend that programs like the Low-Carbon Economy Fund, the Canada Infrastructure Bank and the National Housing Strategy also attach requirements around low or zero carbon or retrofit targets for existing projects.[184]

1. National Housing Strategy

In November 2017, the federal government announced a 10-year, $40 billion National Housing Strategy aimed at reducing homelessness and improving the availability of housing in Canada. The goal of that strategy is to remove 530,000 families from housing need and invest in the construction of up to 100,000 new affordable homes.[185] Approximately half of the funding will be used to help provinces and territories build more affordable housing. Key spending commitments under the National Housing Strategy include a $15.9 billion federally-managed National Housing Co-Investment Fund that is expected to create up to 60,000 new units of housing and repair up to 240,000 units of existing affordable and community housing; a $4.3-billion Canada Community Housing Initiative, with federal funds cost-matched by provinces and territories to support affordable community housing; and a $4-billion Canada Housing Benefit to provide benefits directly to households in housing need.[186] According to the federal government, the National Housing Strategy "housing investments should support Canada's climate change agenda."[187]

Mr. Hill indicated that sustainability was a central theme heard during the National Housing Strategy consultation process.[188] For her part, Luisa Atkinson of CMHC explained to the committee that energy efficiency would be used as criteria to prioritize applications for funding under the strategy. She said:

> *[t]he National Housing Strategy will help shift and prepare the housing sector to build a higher degree of environmental efficiency […] Applications for federal funding for new construction and repair or renewal of affordable housing projects will be prioritized based on how energy efficient they strive to be.*[189]

2. Northern and Indigenous Housing

Under the National Housing Strategy, the federal government has committed to "co-develop federally supported distinctions-based First Nations, Inuit and Métis Nation housing strategies that are founded in principles of self-determination, reconciliation, respect, and co-operation."[190] On this subject, officials from Indigenous Services Canada explained that "Indigenous organizations and the government have been collaborating to develop effective long-term approaches to housing that meet the needs and aspirations of Indigenous peoples in the forms of distinctions-based national housing strategies for First Nations, Metis and Inuit people."[191]

Witnesses who have spoken on this matter agreed that a commitment to a nation-to-nation, Inuit-to-Crown, government-to-government relationship with Indigenous peoples is required to develop any federal strategy for addressing Indigenous housing needs, including for energy use and GHG emissions. Ms. Hine provided examples to the committee to highlight the importance of developing such a relationship:

> *[e]leven out of 14 of our First Nations in the Yukon are self-*

governing, and all maintain their own building and housing infrastructure. […] Yukon First Nations have raised concerns with federal approaches to Indigenous housing issues that seem to not capture or adequately represent their reality. We hope to see this addressed in the work on the Indigenous housing strategy and that we start to look for solutions that go beyond the narrow definition of on- and off-reserve […] We look at our First Nations partners as governments. We have embraced the commitment to nation-to-nation negotiations. We do not look at our partners as on- or off-reserve. We come up against barriers when there are federal programs that have been developed based on the narrow definition of on-reserve or off-reserve.[192]

In that regard, Ms. Atkinson highlighted the example of the Plateau Subdivision in Iqaluit, the first Arctic subdivision based on sustainable development principles, as an example of a housing project advanced by partnerships between governments:

> *This award-winning project was funded by CMHC and the Federation of Canadian Municipalities' green municipal enabling funds. The City of Iqaluit offered the land and its planning authority set sustainability standards for developers. The project was carried out in consultation with the residents. As a result, there was a neighbourhood with protected natural features, such as berry picking areas, walking trails and snowmobile trails. Roads were aligned with prevailing winds to reduce the snow clearing costs and homes were built to R2000 standards or greater.*[193]

Houses in Baker Lake, Nunavut

Some witnesses said that it is important that designs and strategies for housing and buildings in Indigenous communities that reduce GHG emissions are also sensitive to the social, economic, and cultural realities of Indigenous life. Ms. Hine told the committee that

> *designing housing and buildings that reduce greenhouse gas emissions need to be balanced with integrated designs that are both culturally and socially appropriate.*[194]

Similarly, Mr. Williams told the committee that the Northwest Territories Housing Corporation's partnership with Inuvialuit Regional Corporation incorporates "traditional designs into our delivery. It has a ways to go yet, but we have to relish the idea. […] Indigenous populations lived in these types of housing for years, and we're willing to look at how we incorporate these designs to make it work for everybody."[195]

Ms. Atkinson noted that constructing homes and buildings in the North is made more difficult by "a lack of sustainable land available for housing; logistics and the cost of transporting construction materials and equipment to the North; and the specialized and often costly materials and building practices needed to build houses for an extreme climate."[196]

As Mr. Williams explained, climate change is also changing building practices:

> *Extreme weather itself places limitations on work sites and work schedules. Additionally, more and more, the N.W.T. Housing Corporation has had to consider the effects of climate change on construction, ensuring that buildings are not built on known vulnerable permafrost areas, conducting geotechnical surveys where warranted and incorporating foundations like space frames that are more suited to permafrost situations.*[197]

Officials from Indigenous Services Canada advised the committee that investments by the department in First Nations housing "strongly encourage compliance with current building codes."[198] Ms. Langevin noted that First Nations communities generally construct housing consistent with national and provincial building codes, which may include energy efficiency and upgraded materials. She said the following:

> *with regards to targeted investments contained in Budgets 2016 through 2018, all construction and renovation projects must meet national or provincial building codes applicable to the regional location of the First Nations community, and inspection certificates are required upon completion.*[199]

3. Federal Procurement

Considering that governments are significant purchasers of goods and services, the way in which they spend these funds can have a significant impact on the economy. Under the Pan-Canadian Framework, governments have committed to using their procurement power and policies to help build demand for low-carbon goods and services, support clean technology development and create opportunities for Canadian innovations domestically and abroad.

The federal government is uniquely positioned to use procurement to leverage innovation and low-carbon goods. As central purchasing agent, Public Services and Procurement Canada (PSPC), manages approximately $18 billion of procurements on behalf of other federal departments and agencies. It manages the largest real property holdings in Canada, with a portfolio worth an estimated $6.8 billion, including infrastructure such as bridges, docks and dams. To meet accommodation requirements, it also manages rental payments of approximately $1.3 billion on 1,586 lease transactions across Canada annually.[200] This allows the federal government to have a direct and significant impact on greening government operations and reducing emissions.

The federal government has committed to reduce GHG emissions within federal buildings and fleets to 40% below 2005 levels by 2030 or sooner, to use 100% clean electricity by 2025,[201] and to be an early adopter of building standards to be established through the Pan-Canadian Framework for all new federal government buildings.[202]

To help achieve these targets, PSPC will embed GHG reduction considerations "into the design and approval stages of our proposed projects. Starting [fiscal year 2017/18] and going forward, [PSPC] has decided that any real property project with an impact on energy, from roof replacement to elevator maintenance, to heating, to ventilation and air conditioning equipment replacement, will consider [GHG] emissions as part of the life-cycle investment decisions."[203]

Additionally, through its procurement responsibilities PSPC supports the Build in Canada Innovation program, which helps Canadian companies bring innovative products from the final stages of development into the marketplace. In serving as a test bed for products, PSPC can de-risk, cultivate and help establish GHG and energy reduction technologies.

Witnesses noted that the federal government's procurement power gives it the flexibility to take risks with public infrastructure and funds that is crucial in driving innovation and sustainability objectives. According to James Tansey of the Centre for Interactive Research on Sustainability at the University of British Columbia, "one of the most important uses of public funds is to rethink procurement and public spending and how that can align with and support the sustainability and innovation agenda."[204] This was echoed by Mr. Boucher who told the committee the following:

> *Through the tender documents, [procurement] defines the ability of the players to introduce new processes and materials depending on how prescriptive they are in their very specific areas. The industry could perform better if the procurement process in Canada was geared toward innovation and if energy conservation goals were considered in a more constructive way.*[205]

Witnesses from Engineers Canada and the Royal Architecture Institute of Canada encouraged the federal government to

demonstrate leadership by investing in and supporting technologies for federal infrastructure assets that set standards of excellence in environmental sustainability.[206]

Federal government office buildings in Gatineau, Quebec

The procurement process can also be used to leverage more energy-efficient rental spaces, both by government and the private sector. Mr. Dunsky noted that some companies have begun requiring that the office space that they lease be LEED-certified, and that this requirement has "dramatically changed the marketplace" in that the fear of losing an important tenant caused building owners to make energy efficiency improvements that they might not otherwise have considered.[207]

Mr. Mueller also emphasised the power of the federal government's procurement policy to bring about change in the marketplace. He explained the positive impact that a LEED Gold policy for new federal office buildings implemented by the federal government in 2005 had on the construction of green buildings in Canada. He stated:

> *That had a huge value for the private sector because the government was essentially de-risking green building construction for the private sector and look where the private sector is now: there are billions of dollars in investments of pension fund and equity money going into green building construction across the country, in any centre in Canada. The government does an important role both for its own building stock but also for the institutional, commercial sector and non-government building stock.*[208]

Witnesses also pointed to some of the challenges of using procurement processes and public funds to obtain, support and promote low-carbon building materials and innovative technologies. One of those challenges is that there may be a reluctance to spend more money in upfront construction costs even if it means lowering overall operating costs in the long run. For example, Ms. van Rutten mentioned that "it's often quite hard to convince clients that the capital investment will achieve long-term results."[209] This point was also made by Taki Sarantakis of Treasury Board of Canada Secretariat, who said: "you have a lot of people who just look at the upfront capital cost and say, 'If it costs $100 to build the arena this way and $110 to build the arena with state of the art green technology and generation, I just want to pay the $100.' That's a choice people are making."[210]

Another challenge, according to Mr. Boucher, is that builders "only build based on procurement" and procurement contracts are often awarded to the lowest bidder.[211] He told the committee that this can stifle innovation, particularly where energy reduction technologies may carry a capital cost that is higher initially. He stated:

> *When you go to the lowest compliant bidder, you get the lowest amount of quality materials because you have to build within that price. It's risky enough to start with, with all the unforeseen conditions that you might find, but if you are bidding a project and you have to be the lowest bidder, it does not give you much margin to add to that building. So that has to change.*[212]

Adopting new, innovative building solutions can seem risky for public institutions charged with spending public money. As noted by Mr. Tansey, "embracing the willingness to take risk around those kinds of government and public expenditures […] doesn't necessarily come naturally to public institutions."[213] By way of example, he explained that Brock Commons, an innovative 18-storey cross-laminated timber residence building, would not have been built if it were not for the leadership of the University of British Columbia administration, which valued sustainability and accepted the risk associated with the investment decision.

Moreover, officials from Treasury Board and Public Services and Procurement Canada confirmed that the federal government currently does not consider the carbon footprint of materials as a condition of federal procurement. That said, Nick Xenos of Treasury Board of Canada Secretariat, explained that efforts are underway to explore that option:

> *We are having discussions with the National Research Council [Construction Research Centre] because that's exactly the problem we're trying to figure out. How do we look at materials and their embodied carbon? What is the competetive advantage for Canadian materials versus others?*[214]

F. Role of Municipalities and Urban Design

Municipalities influence a large share of national GHG emissions. According to Mr. Tansey, more than 80% of the population in North America live in urban areas, and cities generate approximately 70% of the region's GDP and are responsible for 80% of the GHG emissions.[215]

The built environment in municipalities is one important driver of municipal energy use and GHG emissions. In Toronto, for example, homes and buildings account for more than half of the city's GHG emissions.[216]

Municipalities have a central role to play in reducing GHG emissions from homes and buildings and municipal governments are leading in many ways. One is by setting ambitious goals for energy and GHG emission reductions. For example, the City of Toronto aims to retrofit all existing buildings by 2050, with a reduction of approximate 40% in GHG emissions on average;[217] Vancouver aims to achieve 100% renewable energy by 2050, including renewable heat for all new buil-

dings;[218] and Guelph aims to cut the energy use of homes and buildings by 50% by 2031.[219]

Witnesses also discussed how some municipalities have adopted local building codes that build on provincial and territorial codes. The City of Whitehorse, for example, has required mandatory EnerGuide testing and labelling on all new housing since 2012, while Toronto and Vancouver recently introduced new building codes that emphasize not only overall energy performance, but also how the building envelopes – the exterior parts of a building, which include the walls, windows, doors, roofs, and foundation walls, for example that act as a barrier between the interior and exterior environmental conditions – themselves are built.[220] These measures translate to real energy savings; in Whitehorse, for instance, approximately three out of every four new homes exceeds the National Building Code 2010 heating load targets by at least 50%.[221]

Discussing whether municipal building codes have faced much public opposition, Mr. Lord told the committee that he has not observed much objection from developers, city councils, or the public to municipal building codes in cities that have adopted them.[222] Although representatives from the City of Halifax indicated that the city's facilities exceed minimum provincial standards,[223] they also pointed out that not all municipalities have the legislative authority to develop building codes that go beyond provincial or territorial building codes.[224]

1. Local Improvement Charge Programs

The committee heard that some municipalities are developing innovative programs to encourage private investment in energy efficiency and clean energy and are looking for government support. Representatives from the cities of Toronto and Halifax discussed how local improvement charges (LICs) could be used in municipalities across Canada to spur energy and water savings. A LIC program allows property owners to access capital for efficiency upgrades by entering into financing agreements with the municipality. The municipality then recovers the principal and interest through property taxes.[225] As LIC financing agreements are tied to the property, and not the owner, potential future changes in ownership become less of an economic disincentive for owners considering efficiency investments.[226]

Representatives from the cities of Halifax and Toronto noted however, that there are challenges that other levels of government can help address with LICs. For example, the City of Toronto wants to expand its use of LICs for energy efficiency to 5,000 homes and 10 multi-residential buildings by 2020, but it found that applicants to its LIC program with CMHC-insured mortgages are ineligible as a result of CMHC rules.[227] Ms. McMahon asked that the federal government address this barrier for homeowners with CMHC-insured mortgages so they can use LIC financing to lower their household energy use and GHG emissions.[228]

Another barrier to municipal LIC programs was raised by Shannon Miedema of the City of Halifax. Ms. Miedema discussed Halifax's Solar City program, a LIC program to finance solar PVs and solar thermal technologies. The Solar City program, which has so far reduced Halifax's GHG emissions by 917 t/ CO_2e annually, [229] was designed to be replicated in other cities, but Ms. Miedema explained that so far uptake has been limited because many municipalities lack the jurisdiction to start their

own programs. She recommended the following:

> *[a]ll provincial and territorial governments need to acknowledge the critical role of municipalities in mitigating climate change and conduct a review of their municipal governance statutes with a goal of enabling and empowering local governments to act on climate change.*[230]

2. Flexible Funding for Municipal Climate Change Initiatives

Representatives from the cities of Halifax and Toronto also told the committee that greater flexibility in how the federal government funds climate change programs could spur new green municipal initiatives.[231] Ms. Miedema explained that federal funding for climate change programs is mostly negotiated bilaterally with provinces and territories, and that it can take too long to negotiate when cities have shovel-ready local projects to begin.[232]

To improve federal funding of municipal climate change initiatives, the City of Halifax and five other cities (Vancouver, Edmonton, Ottawa, Toronto, and Montreal) have proposed to establish the Low Carbon Cities Canada (LC3) initiative. Proponents shared a joint-funding request presented to the federal government with the committee. The request is for $150 million to establish a new national organization with local LC3 Centres in the six cities. LC3 would support local projects that lower urban GHG emissions in the areas of building retrofits, low-carbon alternatives to heating fuels, electrification of transportation, shared mobility and a zero-waste circular economy. Its core tools would consist of impact investing of working capital in low-carbon ventures, grant-making, and leading new programs and policy research for low-carbon technologies, financial tools, and social solutions.[233]

In addition to the LC3 proposal, Ms. Miedema suggested that federal funding for the Green Municipal Fund (GMF) could be increased to fund municipal climate change initiatives more directly. According to her, more GMF funding that is not "caught up with the dynamics of the province and the federal relationships, and where the federal government could more strongly influence what that funding is used for, would benefit everybody in achieving those reduction targets."[234]

> *Municipalities must be key partners in the implementation of the pan-Canadian framework. In order to scale up local innovation, municipalities need to be able to access the national programs announced in Budget 2017, including the Low Carbon Economy Challenge. Our message is this: With clear predictable access to green infrastructure investment, local governments are ready and eager to scale up local green innovation. Eligibility criteria and processes need to work for municipalities, especially smaller communities that can too easily be excluded. GHG measurement and reporting will be vital, but the so-called climate lens needs to reflect municipal capacity and local realities and must be consistent across Canada.*
>
> - *Brock Carleton, Federation of Canadian Municipalities*

Likewise, Ms. McMahon suggested that the federal government could provide dedicated funding to municipalities through green infrastructure programs. She advised that programs "should be designed to leverage

provincial and private investments but be flexible in delivery to allow local implementation."[235]

3. Building Municipal Resilience to Climate Change

The committee was told that municipalities are vulnerable to the impacts of climate change and are particularly at risk due to flooding.

Finally, witnesses warned that municipalities are vulnerable to the impacts of climate change and are particularly at risk due to flooding. The committee was told that approximately 20% of flood-related insurance claims come from properties located in floodplains.[236] Mr. Stewart explained that municipalities can face twin pressures to permit development in flood zones despite the risk of flooding: from the public because waterfront properties are often the most desired in a community, and from municipal budget needs, since waterfront properties usually support higher property taxes.[237] Mr. Stewart praised Ontario's leadership in the 1960s for taking decision-making power for municipal development in floodplains from munici-palities and putting it in the hands of conservation authorities. He attributed this decision for Ontario's lowest per-capita draw on federal disaster financial assistance programs in the country.[238]

That said, it is not just municipalities in flood-plains that are at risk of flooding: 80% of flood-related insurance claims are the result of storm water drainage.[239] Mr. Feltmate told the com-mittee that a lot of aging municipal infrastructure isn't equipped to handle large bursts of rain, which are increasing in frequency and severity.[240] The flood risk of storm water is compounded by the prevalence of impermeable asphalt and concrete in some areas, which hinders absorp-tion of large downpours. Mr. Feltmate noted that the Intact Centre on Climate Adaptation is working to develop a

> *flood standard right now for new community design in the country. This comprises about 20 factors and features that, when built into new residential communities going forward, will make it such that when the big storms hit, the probability of flooding in communities will be much lower than if you didn't put these features in place.*[241]

Another factor that Mr. Feltmate said is contributing to flood damage losses in the residential segment is that more homes now have finished basements.[242] When finished basements flood, the cost of damages is higher

than for a non-finished basement. Mr. Feltmate recommended that property owners, home inspectors, and building service professionals be trained to recognize and mitigate flood risk.[243] The Intact Centre on Climate Adaptation provides checklists and cost estimates for home owners and contractors to protect homes from flooding. New construction and engineering flood standards for basements and building durability are currently being developed through the NRC Climate-Resilient Core Public Infrastructure initiative.[244]

MOVING FORWARD

The federal government's Build Smart Strategy to reduce GHG emissions from Canada's homes and buildings will make a contribution to Canada's GHG emission targets when it is implemented. Government energy efficiency policies have a proven track record of reducing GHG emissions. Some of the most effective measures for lowering GHG emissions – building codes, energy efficiency regulations, energy efficiency labelling, fuel switching, and government incentives – are being implemented now and it can be expected that such measures will contribute to a further reduction of GHG emissions from the building sector. Of course, delays in the full implementation of these measures or an uneven implementation across Canada would have a negative impact on the extent of these reductions.

A key challenge that the federal government faces with its Build Smart Strategy is to ensure that the timelines to adopt increasingly stringent national model building codes match Canada's climate policy ambitions. Although the committee heard many testimonies about the benefits of harmonizing Canada's disparate building codes, it also heard that despite decades of effort, not all jurisdictions have adopted the same codes. On that subject, it is still not clear if Pan-Canadian Framework commitments will lead jurisdictions to do so now. Nevertheless, the committee is convinced that GHG emissions from the building sector will decrease if all jurisdictions adopt higher performing codes.

The timeline for the federal government to develop a number of policy initiatives that are linked together, including updated national building codes, the retrofit code, more stringent energy efficiency regulations, and its data platform to support energy benchmarking, is ambitious. Kenneth Green of the Fraser Institute told the committee that "[w]e do not at present have the technology to rapidly decarbonize society affordably."[245] The committee is hopeful that the federal government can deliver on these aspects of the Built Smart Strategy's critical path to 2030, since code development, standard setting, and energy benchmarking are well-established processes. That said, the committee will continue to follow the government's progress on these initiatives. We expect that the federal government will monitor and report on its progress under the Build Smart Strategy.

The importance of retrofits to homes and buildings for lowering GHG emissions is paramount considering that many of the GHG emissions in the building sector are locked into existing homes and buildings. The implementation of the retrofit code and other policy measures are tools to encourage home and building owners to invest their own money, time, and energy to reduce their buildings' GHG emissions. That said, the committee is concerned about what the retrofit code could mean for Canadian households and businesses, particularly in terms of keeping housing affordable and protecting peoples' investments. Many details about what the retrofit code will be and how it will work are still unknown and representatives from the federal government indicated that no decisions about the retrofit code have been made yet. For this reason, it is not yet possible for the committee to examine the costs and benefits of the retrofit code.

Considering the committee's interest in the subject, it could be the topic of a future study.

Reducing GHG emissions from the building sector is a worthy goal that Canadians should endorse. It is, indeed, reasonable that we are expected to change our behaviours and adapt to this pressing matter to achieve this goal. Reducing building emissions could help Canadians save money in the long term and improve the comfort of the spaces that they live and work in. However, this comes with its challenges. Not all Canadians can afford to reduce their household's carbon footprint in a manner that is in line with the government's GHG emission reduction targets. Members of this committee are convinced that making strategic and calculated choices about the carbon footprint of buildings today will leave an enduring, low-carbon heritage for future generations.

APPENDIX A – LIST OF WITNESSES

March 22, 2016	
Environment and Climate Change Canada	Dan McDougall, Assistant Deputy Minister, Strategic Policy Branch Derek Hermanutz, Director General, Economic Analysis Directorate, Strategic Policy Branch Mike Beale, Assistant Deputy Minister, Environmental Stewardship Branch
April 12, 2016	
National Energy Board	Jim Fox, Vice President, Integrated Energy Information and Analysis Shelley Milutinovic, Chief Economist
April 14, 2016	
Natural Resources Canada	Jeff Labonté, Director General, Energy Safety and Security Niall O'Dea, Director General, Electricity Resources Branch Marc Wickham, Director, Science and Technology Programs, Innovation and Energy Technology Sector, Office of Energy Research and Development Drew Leyburne, Director General, Energy Policy Branch Patricia Fuller, Director General, Office of Energy Efficiency Paula Vieira, Director, Transportation and Alternative Fuels Division Laura Oleson, Director, Demand Policy and Analysis, Office of Energy Efficiency, Energy Sector Debbie Scharf, Director, Equipment Division
April 19, 2016	
Canadian Council on Renewable Electricity	Jacob Irving, President, Canadian Hydropower Association
April 21, 2016	
Canadian Nuclear Association	John Barrett, President and Chief Executive Officer

May 3, 2016	
Ecologic Institute US	Max Gruenig, President
TransAlta Corporation	Don Wharton, Managing Director for Carbon Transition
May 5, 2016	
Canadian Electricity Association	Sergio Marchi, President and CEO Devin McCarthy, Director, Generation and Environment
Capital Power	Martin Kennedy, Vice President, External Affairs
Nova Scotia Power Inc.	Terry Toner, Director, Environmental Services
Canadian Biogas Association	Jennifer Green, Executive Director Kevin Matthews, Director Donald Beverly, Director
May 10, 2016	
As an individual	Andrew Leach, Associate Professor, Alberta School of Business, University of Alberta Mike Cleland, Senior Fellow, University of Ottawa
HEC Montréal	Pierre-Olivier Pineau, Professor, Chair in Energy Sector Management
May 12, 2016	
Association of Major Power Customers of BC	Brian Wallace, Counsel Carlo Dal Monte, Director, Energy, Catalyst Paper Corporation Karina Brino, President and CEO, Mining Association of BC
May 17, 2016	
SaskPower	Mike Marsh, President and Chief Executive Officer Guy Bruce, Vice President, Planning, Environment and Sustainable Development
BC Hydro	Chris Sandve, Director of Policy and Reporting
May 19, 2016	
Transport Canada	Ellen Burack, Director General, Environmental Policy Jim Lothrop, Director General, Sustainable Transportation Stewardship

May 31, 2016	
National Airlines Council of Canada	Marc-André O'Rourke, Executive Director Teresa Ehman, Chair, Environment Subcommittee
Green Aviation Research and Development Network	Sylvain Cofsky, Executive Director Fassi Kafyeke, Senior Director, Strategic Technology and Advanced Product Development, Bombardier Aerospace
June 2, 2016	
Ontario Power Generation	Jeff Lyash, President and Chief Executive Officer
NB Power	Neil Larlee, Director, Strategic Planning
June 9, 2016	
Canadian Hydrogen and Fuel Cell Association	Eric Denhoff, President and Chief Executive Officer
Renewable Industries Canada	Andrea Kent, President
Canadian Automated Vehicles Centre of Excellence	Barrie Kirk, Executive Director
September 27, 2016	
Association of Canadian Port Authorities	Wendy Zatylny, President Debbie Murray, Director, Policy and Regulatory Affairs
Conference Board of Canada	Louis Thériault, Vice President, Public Policy
September 29, 2016	
Canadian Natural Gas Vehicle Alliance	Bruce Winchester, Executive Director
Pollution Probe	Steven McCauley, Acting Chief Executive Officer
October 18, 2016	
Electric Mobility Canada	Chantal Guimont, President and Chief Executive Officer
Canadian Trucking Alliance	Jonathan Blackham, Policy and Government Affairs Assistant
October 20, 2016	
Coal Association of Canada	Robin Campbell, President
October 25, 2016	
VIA Rail Canada	Yves Desjardins-Siciliano, President and Chief Executive Officer Pierre Le Fèvre, Senior Advisor to CEO and Chief Executive Officer Bruno Riendeau, Director, Safety and Environment

Railway Association of Canada	Michael Bourque, President and Chief Executive Officer Michael Gullo, Director, Policy, Economic and Environmental Affairs
October 27, 2016	
Canadian Vehicle Manufacturers' Association	Mark Nantais, President
Fertilizer Canada	Garth Whyte, President and Chief Executive Officer Clyde Graham, Senior Vice President
November 1, 2016	
Canadian Manufacturers & Exporters	Mathew Wilson, Senior Vice President, National Policy Nancy Coulas, Director, Energy and Environment Policy
CMC Research Institutes, Inc.	Richard Adamson, President
November 3, 2016	
Canadian Urban Transit Association	Alex Maheu, Director, Public Affairs Jeff Mackey, Policy Analyst
Hydro-Québec	Louis Beauchemin, Senior Director, Subsidiary Management France Lampron, Director, Transportation Electrification
November 24, 2016	
Sustainable Development Technology Canada	Leah Lawrence, President and Chief Executive Officer
Alberta Innovates	John Zhou, Vice President, Clean Energy
November 29, 2016	
C.D. Howe Institute	Benjamin Dachis, Associate Director, Research
December 1, 2016	
PTAC Petroleum Technology Alliance Canada	Soheil Asgarpour, President
December 6, 2016	
Council of Canadian Academies	Eric M. Meslin, President and Chief Executive Officer Eddy Isaacs, Scientific Advisory Committee Member
In Situ Oil Sands Alliance	Richard Sendall, Chairman Patricia Nelson, Vice Chair

December 8, 2016	
Federation of Canadian Municipalities	Clark Somerville, President Dallas Alderson, Manager, Policy and Research
As an individual	Mark Jaccard, Professor, Simon Fraser University
December 13, 2016	
Canada West Foundation	Trevor McLeod, Director of the Centre for Natural Resources Policy
December 15, 2016	
Canadian Energy Research Institute	Allan Fogwill, President and Chief Executive Officer
January 31, 2017	
Global CCS Institute	Jeff Erikson, General Manager, Americas Region
February 2, 2017	
Institute for Oil Sands Innovation	Qi Liu, Scientific Director
Emissions Reduction Alberta	Steve MacDonald, Chief Executive Officer
February 16, 2017	
Canada Mining Innovation Council	Carl Weatherell, Executive Director and Chief Executive Officer
As an Individual	Jennifer Winter, Assistant Professor, School of Public Policy, University of Calgary
February 28, 2017	
Chemistry Industry Association of Canada	Bob Masterson, President and Chief Executive Office David Podruzny, Vice-President, Business and Economics
Petroleum Services Association of Canada	Mark A. Salkeld, President and Chief Executive Officer
March 2, 2017	
Forest Products Association of Canada	Robert Larocque, Vice President, Climate Change, Environment and Labour Kate Lindsay, Director, Environmental Regulations and Conservation Biology
Mining Association of Canada	Brendan Marshall, Vice President, Economic and Northern Affairs
March 9, 2017	
Canadian Steel Producers Association	Joseph Galimberti, President
March 28, 2017	
Aluminium Association of Canada	Jean Simard, President and Chief Executive Officer

March 30, 2017	
Cement Association of Canada	Michael McSweeney, President and Chief Executive Officer Adam Auer, Vice-President, Environment and Sustainability
Canada's Ecofiscal Commission	Chris Ragan, Chair
April 6, 2017	
Environment and Climate Change Canada	John Moffet, Acting Associate Assistant Deputy Minister, Environmental Protection Branch Derek Hermanutz, Director General, Economic Analysis Directorate, Strategic Policy Branch Matt Jones, Director General, Climate Policy Office, Strategic Policy Branch Helen Ryan, Director General, Energy and Transportation, Environmental Protection Branch
Department of Finance Canada	Sean Keenan, Director, Sales Tax Division, Tax Policy Branch Gervais Coulombe, Chief, Sales Tax Division, Tax Policy Branch
April 11, 2017	
Shell Canada	Tim Wiwchar, Portfolio Business Opportunity Manager
Big Moon Power	Lynn Blodgett, President and Chief Executive Officer Jamie MacNeil, Country Manager
April 13, 2017	
Canadian Gas Association	Timothy M. Egan, President and Chief Executive Officer
The Canadian Chamber of Commerce	Katrina Marsh, Director, Environment and Natural Resources Policy

May 11, 2017	
International Energy Agency	Tim Gould, Head of Energy Supply Outlook Division Jean-François Gagné, Head of Energy Technology Policy Division Sylvia Bayer, Country Desk Officer in the Energy Policy and Security Division Aad van Bohemen, Head of Energy Policy and Security Division Peter Fraser, Head of Gas, Coal and Power Division
June 8, 2017	
Newfoundland and Labrador Oil & Gas Industries Association	Robert Cadigan, President and Chief Executive Officer
Canadian Association of Petroleum Producers	Terry Abel, Executive Vice-President Patrick McDonald, Director, Climate and Innovation
June 15, 2017	
Canadian Labour Congress	Donald Lafleur, Executive Vice-President Chris Roberts, Director, Social and Economic Policy
Canadian Fuels Association	Peter Boag, President and Chief Executive Officer Lisa Stilborn, Vice-President, Ontario Division
September 19, 2017	
Natural Resources Canada	Martin Gaudet, Deputy Director, Housing Division, Office of Energy Efficiency, Energy Sector Dean Haslip, Director General, CanmetENERGY-Ottawa, Innovation and Energy Technology Sector Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector
September 21, 2017	
Canada Mortgage and Housing Corporation	Duncan Hill, Manager, Housing Needs Research
CSA Group	Michael Leering, Director, Environment and Business Excellence Dwayne Torrey, Director, Construction and Infrastructure

September 26, 2017	
As an Individual	Ian Beausoleil-Morrison, Professor, Faculty of Engineering and Design, Carleton University
Canadian Association for Renewable Energies	Bill Eggertson, Executive Director
September 28, 2017	
As an Individual	James Tansey, Executive Director, Centre for Interactive Research on Sustainability, University of British Columbia
October 3, 2017	
Canadian Construction Innovations	Pierre Boucher, President Jim Ilkay, Senior Partner, Innovia Corporation
Canadian Home Builders' Association	Kevin Lee, Chief Executive Officer
October 5, 2017	
BC LNG Alliance	David Keane, President and Chief Executive Officer
The Conference Board of Canada	Louis Thériault, Vice-President, Industry Strategy and Public Policy
October 17, 2017	
Public Services and Procurement Canada	Kevin Radford, Assistant Deputy Minister, Real Property Branch Veronica Silva, Director General, Technical Services
Treasury Board of Canada Secretariat	Taki Sarantakis, Associate Secretary Nick Xenos, Executive Director, Centre for Greening Government
October 19, 2017	
National Research Council Canada	Michel Dumoulin, Acting Vice-President, Engineering Philip Rizcallah, Director, Research and Development, Construction
Canada Green Building Council	Thomas Mueller, President and Chief Executive Officer
October 24, 2017	
Federation of Canadian Municipalities	Brock Carlton, Chief Executive Officer Matt Gemmel, Policy Advisor

Canadian Propane Association	Nathalie St-Pierre, President and Chief Executive Officer Greg Thibodeau, Manager, Marketing, Pembina Pipeline Corporation Guy Marchand, President and Chief Executive Officer, Budget Propane 1998 Inc. Taylor Granger, Business Development Leader, SLEEGERS Engineered Products Inc.
October 26, 2017	
BOMA Canada	Benjamin L. Shinewald, President and Chief Executive Officer
Engineers Canada	David Lapp, Practice Lead, Globalization and Sustainable Development
Royal Architectural Institute of Canada	Bruce Lorimer, Interim Executive Director Emmanuelle van Rutten, Regional Director, Ontario North, East and Nunavut
November 2, 2017	
Insurance Bureau of Canada	Nadja Dreff, Director, Economics and Assistant Chief Economist Craig Stewart, Vice-President, Federal Affairs
December 7, 2017	
Office of the Auditor General of Canada	Julie Gelfand, Commissioner of the Environment and Sustainable Development David Normand, Director Elsa DaCosta, Director Doreen Deveen, Director
February 8, 2018	
As an Individual	Blair Feltmate, Head, Intact Centre on Climate Adaptation, University of Waterloo
Canadian Energy Efficiency Alliance	Philippe Dunsky, Vice-Chair Martin Luymes, Chair
February 15, 2018	
As an Individual	Warwick F. Vincent, Full Professor, Centre for Northern Studies, Laval University
QUEST	Brent Gilmour, Executive Director Tonja Leach, Managing Director

March 1, 2018	
Ecovert Sustainability Consultants	Jim Lord, Founding Principal
Yukon Housing Corporation	Pamela Hine, President
Government of the Northwest Territories	Tom R. Williams, President and Chief Executive Officer, Northwest Territories Housing Corporation
Nunavut Housing Corporation	Gary Wong, Director of Infrastructure Stephen Hooey, Chief Operating Officer
March 22, 2018	
Energy Services Association of Canada	Stuart Galloway, Chief executive Officer
March 27, 2018	
City of Toronto	Jim Baxter, Director, Environment and Energy Division Mary-Margaret McMahon, Councillor
City of Halifax	Maggie MacDonald, Managing Director, Government Relations and External Affairs Shannon Miedema, Energy and Environment Program Manager, Planning and Development
March 29, 2018	
Canadian Real Estate Association	Dina McNeil, Director of Government Relations Dil Puar, Manager of Government Relations
Heating, Refrigeration and Air-conditioning Institute of Canada	Warren Heeley, President Martin Luymes, Director, Programs and Relations Bruce Passmore, Board Chair
Canada Mortgage and Housing Corporation	Luisa Atkinson, Director, First Nation Housing
Crown-Indigenous Relations and Northern Affairs	Mark Hopkins, Director General, Natural Resources and Environment Branch, Northern Affairs Organization
Indigenous Services Canada	Lyse Langevin, Director General, Community Infrastructure Branch, Regional Operations
April 17, 2018	
Fraser Institute	Kenneth P. Green, Senior Director, Natural Resource Studies
Clean Energy Canada	Dan Woynillowicz, Policy Director, Morris J. Wosk Centre for Dialogue, Simon Fraser University

April 19, 2018	
Smart Prosperity Institute	Stewart Elgie, Co-Chair William Scott, Research Associate
April 26, 2018	
Natural Resources Canada	André Bernier, Senior Director, Electricity Resources Branch, Energy Sector Dean Haslip, Director General, CanmetENERGY-Ottawa Joyce Henry, Director General, Office of Energy Efficiency, Energy Sector Terry Hubbard, Director General, Petroleum Resources Branch, Energy Sector John Kozij, Director General, Canadian Forest Service Amanda Wilson, Director General, Office of Energy Research and Development, Innovation and Energy Technology Sector
June 14, 2018	
Office of the Auditor General of Canada	Julie Gelfand, Commissioner of the Environment and Sustainable Development Kimberley Leach, Principal

APPENDIX B – FACT FINDING MISSIONS – LIST OF WITNESSES

Western Canada – October 2-7, 2016 (Vancouver, Kitimat and Prince George, British Columbia, Calgary, Alberta and Estevan, Saskatchewan)	
Alberta Electric System Operator	Miranda Keating Erickson, Vice President Operations Angela Anderson, External Relations Advisor
ARC Financial Corp	Peter Tertzakian, Chief Energy Economist and Managing Director
Canada's Oil Sands Innovation Alliance	Dan Wicklum, Chief Executive Officer
Canfor Pulp Ltd	Martin Pudlas, Vice President, Operations Peter Lovell, General Manager Robert Thew, Manager, Strategic Capital and Energy
CanmetENERGY	Cécile Siewe, Director General, Devon Research Center Jinwen Chen, Director, Hydrocarbon Conversion Michael Layer, Senior Program Manager
Legislative Assembly of Saskatchewan	Lori Carr, Member of the Legislative Assembly
Pembina Institute	Chris Severson-Baker, Managing Director
Petroleum Technology Research Centre	Norm Sacuta, Communications Manager
Powertech Laboratories	Madhvi Ramnial, Manager, Client Engagement and Business Development Angela Das, Senior Manager, Advanced Transportation Jeff Turner, Project Manager, Electric Vehicles and Energy Systems David Facey, Legal Counsel Frankie Nash, Policy Analyst

Rio Tinto	Blair Dickerson, Vice President Richard Prokopanko, Director of Government Affairs Gareth Manderson, General Manager Kevin Dobbin, Manager Communications and Communities, BC Works Manny Arruda, Casting Coordinator, BC Works Alain Bouchard, Business Partner HSE Graham Caven, Reduction PTA Trainer, BC Works Carolyn Chisholm, Principal Advisor, Vice President Canada Office Marion Egan, Executive Assistant, BC Works Joe Velho, Coordinator, BC Works
SaskPower	Howard Matthews, Vice President, Power Production Sandra Beingessner, Executive Co-ordinator, Executive Offices Dave Jobe, Director, Carbon Capture and Storage Mike Zeleny, Tour Ambassador, Carbon Capture and Storage
Seven Generations Energy Ltd	Alan Boras, Director, Communications and Stakeholders Relations
University of Calgary	Dan McFadyen, Program Director, School of Public Policy Robert Mansell, Academic Director, School of Public Policy Shantel Jordison, Manager, Extractive Resource Governance Program
University of Northern British Columbia	Daniel Weeks, President Daniel Ryan, Interim Vice President, Academic and Provost Geoffrey Payne, Interim Vice President, Research Tim Tribe, Vice President, Advancement Robert Knight, Vice President, Finance and Business Operations Chris Buse, CIRC Project Lead

	Stephen Déry, Canada Research Chair in Northern Hydrometeorology Kevin Ericsson, Chief Engineer David Claus, Assistant Director, Facilities Management
Vancouver Fraser Port Authority	Duncan Wilson, Vice President, Corporate Social Responsibility Carrie Brown, Director, Environmental Programs Evangeline Englezos, Director, Community and Aboriginal Affairs Christine Rigby, Environmental Specialist, Air Emissions
Ontario – November 14-17, 2016 (Sarnia and Hamilton, Ontario)	
ArcelorMittal Dofasco	Sean Donnelly, President and Chief Executive Officer Tony Valeri, Vice President, Corporate Affairs Henry Wegiel, Director, Trade and Government Relations Ian Shaw, Manager, Energy Management Jim Stirling, General Manager, Environment Richard Do Couto, Specialist, Corporate Responsibility Tom Kuhl, General Manager of Primary Manufacturing Technology Dan Evans, Reliability Coach Errol Hilado, Process Reliability Specialist
BioAmber	Mike Hartmann, Executive Vice President Ann Waddell, Vice president, Government Affairs Fabrice Orecchioni, Chief Operations Officer
Bioindustrial Innovation Canada	Sandy Marshall, Executive Director
Biox Corporation	Alan Rickard, Chief Executive Officer Courtney Quinn, Vice President, Finance Ryan Doell, Operations Manager Bozena Millivojevic, Production Manager

Canadian Fuels Association	Lisa Stilborn, Vice President, Ontario Division Erin Brophy, Communications Manager
CanmetMATERIALS	Philippe Dauphin, General Manager Mark S. Kozdras, Program Manager, Automotive Materials Hitesh Jain, Manager, Business and Contracts
Chemistry Industry Association of Canada	Bob Masterson, President and Chief Executive Officer David Podruzny, Vice President, Business and Economics Erika Adams, Director, Communications
City of Hamilton	His Worship Fred Eisenberger, Mayor Andrew Grice, Director, Water and Wastewater Operations Geoff Lupton, Director, Energy, Fleet and Traffic John Mater, Director, Corporate Assets and Strategic Planning Dan Chauvin, Director, Woodward Upgrades Dan McKinnon, General Manager, Public Works Mark Bainbridge, Acting Director, Hamilton Water Greg Crone, Strategic Initiatives and Policy Advisor Frank Gazzola, Superintendent, Energy Engineering Plamen Nikolov, Senior Project Manager, Capital Works
Imperial	Brian M. Fairley, Sarnia Refinery Manager George E. Vincent, Senior Regulatory Affairs Advisor Dave Luecke, Sarnia Chemical Plant Manager Jon Harding, Community Affairs and Aboriginal Relations Advisor

McMaster University	Ishwar Puri, Dean Faculty of Engineering Rob Baker, Vice President Research Nick Markettos, Acting Director, McMaster Institute for Transportation and Logistics Altaf Arain, Director, McMaster Centre for Climate Change Gillian Goward, Acting Associate Dean Research and External Relations Lori Dillon, Manager, Research Communications Alex Lawson, Executive Advisor, Public Affairs Kristen Munro, Manager, Public Affairs Ali Emadi, Director of MacAUTO Saeid Habibi, Professor, Mechanical Engineering Megan Wood, Team Lead, McMaster Engineering EcoCAR3 Team Theo Abraham, Communications Manager, McMaster Engineering EcoCAR3 Team
NOVA Chemicals	Rob Thompson, Regional Manufacturing Director Ken Faulkner, Director of Government Relations Meaghan Kreeft, Communications Consultant
Sarnia-Lambton Chamber of Commerce	Shirley de Silva, President and Chief Executive Officer Monica Shepley, Manager of Advocacy and Policy Development Mark Lumley, Chairman, Board of Directors Michael Kooy, 1st Vice Chair Peter Smith, Co-Chair, Energy Committee Alex Palimaka, Board Member Cathy MacLellan, Vice President Human Resources and Outreach, Ubiquity Solar Ed brost, President, Je&M Consulting Ltd. Maike Luiken, Bluewater Technology Access Centre

	Joe Lasowski, CF Industries
Sarnia-Lambton Economic Partnership:	George Mallay, General Manager.
Shell	Helen Bennett, Emerging Regulatory Policy Issue Advisor
Union Gas	Sarah Van Der Paelt, Director, Distribution Business Development and Strategic Accounts
Suncor Energy	Michael Kandravy, Director, Fuels Quality and Regulatory Affairs Michael Southern, Manager, Government Relations
Western Sarnia-Lambton Research Park	Tom Strifler, Executive Director Katherine G. Albion, Commercialization Centre Director Victoria Townsend, Research Engineer and Project Manager Stephen Reaume, Coordinator Mike Nesdoly, Manager, Applied Research and Innovation
Quebec – February 7-8, 2017 (Montreal and Varennes, Quebec)	
AQPER (Association québécoise de la production d'énergie renouvelable)	Jean-François Samray, President and Chief Executive Officer
CanmetENERGY	Gilles Jean, Managing Director Lisa Dignard, Director, Integration of Renewable and Distributed Energy Resources R&D Program Éric Soucy, Director, Industry R&D Program Chantal LeRoy, Acting Director, Building R&D Program Amélie Richard, Commercialisation Officer
City of Laval	Stéphane Boyer, City Councillor Ian Dessureault, Environment Services
Écotech Québec	Denis Leclerc, President and Chief Executive Officer Marie-Hélène Labrie, Vice-President of the Board Élise Laferrière, Vice-Presidente, Partnerships and Operations

Gaz Métro	Stéphanie Trudeau, Principal Vice-President, Regulations, Clients and Communities Frédéric Krikorian, Director, Sustainable Development, Public and Governmental Affairs
Hydro-Québec's Research Institute	Jérôme Gosset, Director Jean-Pierre Tardif, Advisor – Communications and Marketing
McGill	Jim Nicell, Professor & Dean of Engineering Subhasis Ghoshal, Director, Trottier Institute for Sustainability in Engineering and Design Lauren Penney, Manager, Trottier Institute for Sustainability in Engineering and Design Benoit Boulet, Associate Dean, Research & Innovation François Bouffard, Associate Professor Yixin Shao, Professor Jeff Bergthorson, Associate Professor
Union des producteurs agricoles	Pierre Lemieux, Second Vice-President Daniel Bernier, Research and Agricultural Policy Advisor – Environment
Eastern Canada – May 1-4, 2017 (St. John's, Newfoundland and Labrador, Summerside, Prince Edward Island, Saint John, New Brunswick and Halifax, Nova Scotia)	
Amec Foster Wheeler	Jonas Roberts, Climate Change Consultant, Environment and Infrastructures
CarbonCure Technologies	Jennifer Wagner, Vice-President, Sustainability
City of Summerside	His Worship Bill Martin, Mayor Norma McColeman, Deputy Mayor Greg Campbell, Councillor Brian McFeely, Councillor Gordie Whitlock, Councillor Bob Ashley, Chief Administrative Officer Greg Gaudet, Director of Municipal Services J.P. Desrosiers, Director of Community Services

	Rob Philpott, Director of Finance Mike Thusuka, Director of Economic Development Lorri Laughlin, Director of Communications Sam Arsenault, Waste Water Operations Supervisor Chad Fraser, Waste Water Treatment Operator
Dalhousie University	Dr. Richard Florizone, President Dr. Steven Mannell, Director, College of Sustainability Dr. Jeff Lamb, Deputy Chair, Dalhousie Facilities Management Dr. Ian Hill, Professor Dr. Mita Dasog, Assistant Professor Sara Daniels, Government Relations Advisor Emma Norton, Alumna Rochelle Weber, Student Jon-Paul Sun, Student Colby Deighton, Student
Emera	Chris Huskilson, President and Chief Executive Officer Robert Hanf, Executive Vice-President, Stakeholder Relations and Regulatory Affairs Lisa Merrithew, Vice-President, Communications and Corporate Affairs Sharon Scattolon, Facilities Manager Brad Stronach, HVAC Technician
Emera Newfoundland and Labrador	Norm Dimmell, P.Eng., Vice-President, Corporate Services
Fortis Inc.	Barry Perry, President and Chief Executive Officer Nora Duke, Executive Vice-President and Chief Human Resource Officer Gary Smith, President, Newfoundland Power

	Karen McCarthy, Director, Communications and Corporate Affairs Paul Fitzpatrick, Director, Regulatory and Compliance
Government of Newfoundland and Labrador	Walter Parsons, P.Eng., Assistant Deputy Minister, Energy Perry Canning, Assistant Deputy Minister, Mines
Irving Oil	Jeff Matthews, Chief Business Development Officer Graham Little, Government Relations Specialist James Walsh, Manager, Government Relations
J.D. Irving	Mary Keith, Vice-President, Communications Mark Mosher, Vice-President, Pulp & Paper Dion Hanrahan, Vice-President, Industrial Business Development Chris MacDonald, Director, Government Relations
McInnes Cooper	J. Alex Templeton, Associate
Nalcor	Gilbert Bennet, Executive Vice-President, Power Development Mark King, Stakeholder Relations and Communications Gayle St. Croix, Communications Consultant
Narl Refining LP	Tim Derksen, Management Program
NB Power	Keith Cronkite, Senior Vice-President Business, Development and Strategic Planning Brett Plummer, Vice-President Nuclear and Chief Nuclear Officer Robert Scott, Director, Government Relations Kathleen Duguay, Manager, Community Affairs and Nuclear Regulatory Protocol
Newfoundland and Labrador Environmental Industry Association	Kieran Hanley, Executive Director

NS Power	Karen Hutt, President and Chief Executive Officer Sasha Irving, Vice-President Corporate Affairs and Stakeholder Relations
Prince Edward Island Climate Change Secretariat	Todd Dupuis, Executive Director
Prince Edward Island Energy Corporation	Heather MacLeod, Manager, Energy Assets
St. John's Board of Trade	Dorothy M. Keating, Chair Nancy Healey, Chief Executive Officer Rhonda Tulk-Lane, Policy and Advocacy Specialist
Transportation, Infrastructure and Energy Efficiency - Prince Edward Island	Mike Proud, Manager, Office of Energy Efficiency
Trout River Homes Inc.	Terry and Natalie Perry, Owners Ralph and Beth Peters, House Owners
University of Prince Edward Island's Climate Lab	Dr. Adam Fenech, Director Hope Parnham, PhD Student
University of Prince Edward Island	Dr. Robert Gilmour, Vice-President Academic and Research

[1] United States Global Change Research Program (USGCRP), *Climate Science Report: Fourth National Climate Assessment, Volume I*, 2017.
[2] Ibid.
[3] United Nations, Intergovernmental Panel on Climate Change, *Climate Change 2014: Impacts, Adaptation, and Vulnerability*.
[4] Government of Canada, Clean growth and climate change working group reports, *Working Group on Adaptation and Climate Resilience*.
[5] Ibid.
[6] Figures are adjusted to 2016 dollars. Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 2 November 2017 (Craig Stewart, Vice-President, Federal Affairs, Insurance Bureau of Canada).
[7] United Nations Framework Convention on Climate Change, The Paris Agreement.
[8] United States Climate Alliance, *States United For Climate Action*; America's Pledge, About.
[9] International Energy Agency, World Energy Outlook 2016 –Executive Summary.
[10] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 10 May, 2016 (Mike Cleland, Senior Fellow, University of Ottawa, as an individual).
[11] The Conference Board of Canada, *The Cost of a Cleaner Future: Examining the Economic Impacts of Reducing GHG Emissions*, 6 September, 2017.
[12] Government of Canada, *Canada's Mid-Century Long-Term-Greenhouse Gas Development Strategy*, 2016.
[13] Environment and Climate Change Canada, *Canada's Seventh National Communication on Climate Change and Third Biennial Report—Actions to meet commitments under the United Nations Framework Convention on Climate Change*, 2017.
[14] Government of Canada, Global warming potentials.
[15] Ibid.
[16] Senate, Standing Committee on Energy, the Environment and Natural Resources, Evidence, 1st Session, 42nd Parliament, 7 December, 2017 (Julie Gelfand, Commissioner of the Environment and Sustainable Development, Office of the Auditor General of Canada).
[17] Government of Canada, Canada's Mid-Century Long-Term-Greenhouse Gas Development Strategy, 2016.
[18] The World Bank, Data, *CO2 emissions (metric tons per capita)*.
[19] Environment and Climate Change Canada, Global Greenhouse Gas Emissions, figure is based on 2013 global emissions.
[20] Ibid.
[21] Government of Canada, Clean growth and climate change working group reports, Working *Group on Clean Technology, Innovation and Jobs*.
[22] *Build Smart: Canada's Buildings Strategy—A Key Driver of the Pan-Canadian Framework on Clean Growth and Climate Change*, Energy and Mines Ministers' Conference, St. Andrews by-the-Sea, New Brunswick, August 2017.
[23] Natural Resources Canada, "Table 20: Residential Sector - Canada," Comprehensive Energy Use Database. The Comprehensive Energy Use Database was accessed on 29 January 2018 and is the basis for all energy and GHG emissions data cited in this report.
[24] Statistics Canada, The Daily, *Survey of Commercial and Institutional Energy Use, 2014*, 16 September 2016.
[25] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).

[26] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).
[27] Ibid.; Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Dean Haslip, Director General, CanmetENERGY-Ottawa, Natural Resources Canada); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 8 February 2018 (Philippe Dunsky, Vice-Chair, Canadian Energy Efficiency Alliance).
[28] Ibid.
[29] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 28 September 2017 (James Tansey, Executive Director, Centre for Interactive Research on Sustainability, University of British Columbia); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 30 March 2017 (Chris Ragan, Chair, Canada's Ecofiscal Commission).
[30] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 October 2017 (David Lapp, Practice Lead, Globalization and Sustainable Development, Engineers Canada).
[31] Ibid.; Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 October 2017 (Thomas Mueller, President and Chief Executive Officer, Canada Green Building Council).
[32] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Dean Haslip, Director General, CanmetENERGY-Ottawa, Natural Resources Canada); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 September 2017 (Ian Beausoleil-Morrison, Professor, Faculty of Engineering and Design, Carleton University, as an individual); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 21 September 2017 (Duncan Hill, Manager, Housing Needs Research, Canada Mortgage and Housing Corporation).
[33] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 2 November 2017 (Craig Stewart, Vice-President, Federal Affairs, Insurance Bureau of Canada).
[34] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 8 February 2018 (Blair Feltmate, Head, Intact Centre on Climate Adaptation, University of Waterloo, as an Individual).
[35] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 15 February 2018 (Warwick F. Vincent, Full Professor, Centre for Northern Studies, Laval University, as an individual).
[36] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 8 February 2018 (Blair Feltmate, Head, Intact Centre on Climate Adaptation, University of Waterloo, as an Individual).
[37] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 15 February 2018 (Warwick F. Vincent, Full Professor, Centre for Northern Studies, Laval University, as an individual).
[38] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 2 November 2017 (Craig Stewart, Vice-President, Federal Affairs, Insurance Bureau of Canada).
[39] Natural Resources Canada, "Table 1: Residential Sector - Canada and Table 1: Commercial Sector - Canada," Comprehensive Energy Use Database, accessed on 29 January 2018.
[40] Ibid.
[41] Ibid.

[42] National Energy Board, *Canada's Energy Future 2016: Energy Supply and Demand Projections to 2040*, 2016.
[43] Natural Resources Canada, "Table 1: Residential Sector - Canada and Table 1: Commercial Sector - Canada," Comprehensive Energy Use Database, accessed on 29 January 2018.
[44] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 September 2017 (Ian Beausoleil-Morrison, Professor, Faculty of Engineering and Design, Carleton University, as an individual).
[45] Natural Resources Canada, "Table 1: Residential Sector - Canada," Comprehensive Energy Use Database, accessed on 29 January 2018. Calculations of household occupancy calculated by the Library of Parliament using data obtained from Statistics Canada, "Table 17-10-009-01: Population estimates quarterly," accessed on 11 June 2018.
[46] Ibid.
[47] Ibid.
[48] Ibid.
[49] Ibid.
[50] Natural Resources Canada, "Table 1: Commercial Sector - Canada," Comprehensive Energy Use Database, accessed on 29 January 2018.
[51] Specific Mitigation Opportunities Working Group, *Final Report*, 2016.
[52] Natural Resources Canada, "Table 1: Residential Sector - Canada and Table 1: Commercial Sector - Canada," Comprehensive Energy Use Database, accessed on 29 January 2018.
[53] Ibid.
[54] Ibid.
[55] Environment and Climate Change Canada, *Canada's Seventh National Communication on Climate Change and Third Biennial Report—Actions to meet commitments under the United Nations Framework Convention on Climate Change*, 2017.
[56] Specific Mitigation Opportunities Working Group, *Final Report*, 2016; Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).
[57] Environment and Climate Change Canada, *Pan-Canadian Framework on Clean Growth and Climate Change : Canada's plan to address climate change and grow the economy*., 2016.
[58] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).
[59] *Build Smart: Canada's Buildings Strategy—Critical Path to 2030*, Energy and Mines Ministers' Conference, St. Andrews by-the-Sea, New Brunswick, August 2017.
[60] *Build Smart: Canada's Buildings Strategy—A Key Driver of the Pan-Canadian Framework on Clean Growth and Climate Change*, Energy and Mines Ministers' Conference, St. Andrews by-the-Sea, New Brunswick, August 2017.
[61] Natural Resources Canada, *The National Building Code of Canada*, 21 March 2018.
[62] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 October 2017 (Michel Dumoulin, Acting Vice-President, Engineering, National Research Council Canada).
[63] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).
[64] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).
[65] National Research Council Canada, "Senate Standing Committee on Energy, the Environment and Natural Resources Submissions (Low-Carbon Economy)," Written response to the Senate Standing Committee on Energy, the Environment and Natural Resources, 29 November 2017.
[66] Specific Mitigation Opportunities Working Group, *Final Report*, 2016.

[67] Ibid.
[68] Ibid.
[69] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 21 September 2017 (Duncan Hill, Manager, Housing Needs Research, Canada Mortgage and Housing Corporation).
[70] Ibid.
[71] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 3 October 2017 (Kevin Lee, Chief Executive Officer of the Canadian Home Builders' Association).
[72] National Research Council Canada, "Senate Standing Committee on Energy, the Environment and Natural Resources Submissions (Low-Carbon Economy)," Written response to the Senate Standing Committee on Energy, the Environment and Natural Resources, 29 November 2017.
[73] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 3 October 2017 (Kevin Lee, Chief Executive Officer of the Canadian Home Builders' Association).
[74] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Tom R. Williams, President and Chief Executive Officer, Northwest Territories Housing Corporation, Government of the Northwest Territories).
[75] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Dean Haslip, Director General, CanmetENERGY-Ottawa, Natural Resources Canada); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 April 2018 (Terry Hubbard, Director General, Petroleum Resources Branch, Energy Sector, Natural Resources Canada).
[76] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 October 2017 (Michel Dumoulin, Acting Vice-President, Engineering, National Research Council Canada).
[77] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).
[78] Ibid.
[79] Ibid.
[80] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 15 February 2018 (Warwick F. Vincent, Full Professor, Centre for Northern Studies, Laval University, as an individual).
[81] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).
[82] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 October 2017 (David Lapp, Practice Lead, Globalization and Sustainable Development, Engineers Canada).
[83] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 October 2017 (Philip Rizcallah, Director, Research and Development, Construction, National Research Council Canada); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).
[84] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 April 2018 (Joyce Henry, Director General, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).
[85] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).
[86] Specific Mitigation Opportunities Working Group, *Final Report*, 2016.

[87] Ibid.
[88] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Martin Gaudet, Deputy Director, Housing Division, Office of Energy, Natural Resources Canada).
[89] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 October 2017 (Thomas Mueller, President and Chief Executive Officer, Canada Green Building Council); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 October 2017 (Emmanuelle van Rutten, Regional Director, Ontario North, East and Nunavut, Royal Architecture Institute of Canada); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 27 March 2018 (Mary-Margaret McMahon, Councillor, City of Toronto).
[90] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 October 2017 (Thomas Mueller, President and Chief Executive Officer, Canada Green Building Council).
[91] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 27 March 2018 (Mary-Margaret McMahon, Councillor, City of Toronto).
[92] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Dina McNeil, Director of Government Relations, The Canadian Real Estate Association).
[93] Ibid.
[94] Ibid.
[95] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 October 2017 (Philip Rizcallah, Director, Research and Development, Construction, National Research Council Canada).
[96] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 October 2017 (Philip Rizcallah, Director, Research and Development, Construction, National Research Council Canada).
[97] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 2 November 2017 (Craig Stewart, Vice-President, Federal Affairs, Insurance Bureau of Canada).
[98] National Research Council Canada, "The National Research Council Canada and Infrastructure Canada take the lead in preparing Canada's buildings and infrastructure for climate resiliency," *Innovation Success Stories*, 23 February 2018.
[99] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 8 February 2018 (Blair Feltmate, Head, Intact Centre on Climate Adaptation, University of Waterloo, as an Individual).
[100] Natural Resources Canada, "Senate Standing Committee on Energy, the Environment and Natural Resources Submissions (Low-Carbon Economy)," Written response to questions from the Senate Standing Committee on Energy, the Environment and Natural Resources, 19 September 2017.
[101] Ibid.
[102] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 21 September 2017 (Duncan Hill, Manager, Housing Needs Research, Canada Mortgage and Housing Corporation).
[103] Canada Mortgage and Housing Corporation, "Senate Standing Committee on Energy, the Environment and Natural Resources Submissions (Low-Carbon Economy)," Written response to the Senate Standing Committee on Energy, the Environment and Natural Resources, 11 October 2017.
[104] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 3 October 2017 (Kevin Lee, Chief Executive Officer of the Canadian Home Builders' Association).

[105] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Dina McNeil, Director of Government Relations, The Canadian Real Estate Association).
[106] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 October 2017 (Thomas Mueller, President and Chief Executive Officer, Canada Green Building Council).
[107] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 October 2017 (Thomas Mueller, President and Chief Executive Officer, Canada Green Building Council); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 October 2017 (Emmanuelle van Rutten, Regional Director, Ontario North, East and Nunavut, Royal Architecture Institute of Canada); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Martin Luymes, Director, Programs and Relations, Heating, Refrigeration and Air-conditioning Institute of Canada).
[108] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 October 2017 (David Lapp, Practice Lead, Globalization and Sustainable Development, Engineers Canada).
[109] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 October 2017 (Emmanuelle van Rutten, Regional Director, Ontario North, East and Nunavut, Royal Architecture Institute of Canada).
[110] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 October 2017 (David Lapp, Practice Lead, Globalization and Sustainable Development, Engineers Canada).
[111] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Martin Luymes, Director, Programs and Relations, Heating, Refrigeration and Air-conditioning Institute of Canada).
[112] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 30 March 2017 (Michael McSweeney, President and Chief Executive Officer, Cement Association of Canada); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 2 March 2017 (Robert Larocque, Vice President, Climate Change, Environment and Labour, Forest Products Association of Canada).
[113] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 3 October 2017 (Pierre Boucher, President, Canadian Construction Innovations).
[114] Ibid.
[115] Ibid.
[116] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 October 2017 (Thomas Mueller, President and Chief Executive Officer, Canada Green Building Council).
[117] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Jim Lord, Founding Principal, Ecovert Sustainability Consultants).
[118] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 21 September 2017 (Duncan Hill, Manager, Housing Needs Research, Canada Mortgage and Housing Corporation).
[119] *Build Smart: Canada's Buildings Strategy—Critical Path to 2030*, Energy and Mines Ministers' Conference, St. Andrews by-the-Sea, New Brunswick, August 2017.
[120] Natural Resources Canada, "Senate Standing Committee on Energy, the Environment and Natural Resources Submissions (Low-Carbon Economy)," Written submission to the Senate Standing Committee on Energy, the Environment and Natural Resources, 19 September 2017.
[121] *Notice of intent to improve the energy efficiency of appliances and equipment through Amendment 15 to the Energy Efficiency Regulations*, Canada Gazette, Part I, Vol. 151, No. 9, 4 March 2017 [Archived Content].

[122] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Martin Gaudet, Director, Housing Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).
[123] *Build Smart: Canada's Buildings Strategy—Critical Path to 2030*, Energy and Mines Ministers' Conference, St. Andrews by-the-Sea, New Brunswick, August 2017.
[124] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 October 2017 (Thomas Mueller, President and Chief Executive Officer, Canada Green Building Council).
[125] Ibid.
[126] Natural Resources Canada, "Senate Standing Committee on Energy, the Environment and Natural Resources Submissions (Low-Carbon Economy)," Written submission to the Senate Standing Committee on Energy, the Environment and Natural Resources, 19 September 2017.
[127] Natural Resources Canada, *Energy-efficient products*, accessed on 11 April 2018.
[128] Natural Resources Canada, *EnerGuide home evaluation*, accessed on 11 April 2018.
[129] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 3 October 2017 (Kevin Lee, Chief Executive Officer of the Canadian Home Builders' Association).
[130] Natural Resources Canada, *ENERGY STAR in Canada*, accessed on 11 April 2018.
[131] Natural Resources Canada, *ENERGY STAR certified homes*, accessed on 11 April 2018.
[132] Ibid.
[133] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 17 October 2017 (Kevin Radford, Assistant Deputy Minister, Real Property Branch, Public Services and Procurement Canada).
[134] Natural Resources Canada, *R-2000: environmentally friendly homes*, accessed on 8 July 2018.
[135] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).
[136] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Dean Haslip, Director General, CanmetENERGY-Ottawa, Natural Resources Canada).
[137] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 April 2018 (Terry Hubbard, Director General, Petroleum Resources Branch, Energy Sector, Natural Resources Canada).
[138] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Dean Haslip, Director General, CanmetENERGY-Ottawa, Natural Resources Canada).
[139] Ibid.
[140] Ibid.
[141] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada).
[142] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Dean Haslip, Director General, CanmetENERGY-Ottawa, Natural Resources Canada).
[143] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Lyse Langevin, Director General, Community Infrastructure Branch, Regional Operations, Indigenous Services Canada).
[144] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Tom R. Williams, President and Chief Executive Officer, Northwest Territories Housing Corporation, Government of the Northwest Territories); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Stephen Hooey, Chief Operating Officer, Nunavut Housing Corporation).

[145] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Stephen Hooey, Chief Operating Officer, Nunavut Housing Corporation).
[146] Ibid.
[147] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Stephen Hooey, Chief Operating Officer, Nunavut Housing Corporation); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Luisa Atkinson, Director, First Nation Housing, Canada Mortgage and Housing Corporation); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Pamela Hine, President, Yukon Housing Corporation); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Tom R. Williams, President and Chief Executive Officer, Northwest Territories Housing Corporation, Government of the Northwest Territories); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Lyse Langevin, Director General, Community Infrastructure Branch, Regional Operations, Indigenous Services Canada).
[148] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Lyse Langevin, Director General, Community Infrastructure Branch, Regional Operations, Indigenous Services Canada).
[149] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Dean Haslip, Director General, CanmetENERGY-Ottawa, Natural Resources Canada).
[150] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Stephen Hooey, Chief Operating Officer, Nunavut Housing Corporation); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Pamela Hine, President, Yukon Housing Corporation).
[151] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 21 September 2017 (Duncan Hill, Manager, Housing Needs Research, Canada Mortgage and Housing Corporation).
[152] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Lyse Langevin, Director General, Community Infrastructure Branch, Regional Operations, Indigenous Services Canada).
[153] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 April 2018 (Terry Hubbard, Director General, Petroleum Resources Branch, Energy Sector, Natural Resources Canada).
[154] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Pamela Hine, President, Yukon Housing Corporation).
[155] Ibid.
[156] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Stephen Hooey, Chief Operating Officer, Nunavut Housing Corporation).
[157] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Luisa Atkinson, Director, First Nation Housing, Canada Mortgage and Housing Corporation).
[158] National Energy Board, *Market Snapshot: Household energy expenditures highest in the Atlantic region, lowest in British Columbia*, 23 November 2016.
[159] Ibid.
[160] Specific Mitigation Opportunities Working Group, *Final Report*, 2016.
[161] Ibid.
[162] Natural Resources Canada, "Table 7: Space Heating Secondary Energy Use and GHG Emissions by Energy Source – Including Electricity-Related Emissions, Residential Sector - Canada," Comprehensive Energy Use Database, accessed on 29 January 2018.

[163] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Dean Haslip, Director General, CanmetENERGY-Ottawa, Natural Resources Canada); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 September 2017 (Sarah Stinson, Director, Buildings and Industry Division, Office of Energy Efficiency, Energy Sector, Natural Resources Canada); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 September 2017 (Ian Beausoleil-Morrison, Professor, Faculty of Engineering and Design, Carleton University, as an individual).

[164] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 21 September 2017 (Duncan Hill, Manager, Housing Needs Research, Canada Mortgage and Housing Corporation); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Tom R. Williams, President and Chief Executive Officer, Northwest Territories Housing Corporation, Government of the Northwest Territories); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Stephen Hooey, Chief Operating Officer, Nunavut Housing Corporation); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 5 May 2016 (Sergio Marchi, President and CEO, Canadian Electricity Association).

[165] Natural Resources Canada, "37: Space Heating Secondary Energy Use and GHG Emissions by Energy Source, Commercial-Institutional - Canada," Comprehensive Energy Use Database, accessed on 29 January 2018.

[166] Ibid.

[167] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 20 March 2018 (Bruce Passmore, Board Chair, Heating, Refrigeration and Air-conditioning Institute of Canada); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 21 September 2017 (Duncan Hill, Manager, Housing Needs Research, Canada Mortgage and Housing Corporation); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 September 2017 (Ian Beausoleil-Morrison, Professor, Faculty of Engineering and Design, Carleton University, as an individual).

[168] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Martin Luymes, Director, Programs and Relations, Heating, Refrigeration and Air-conditioning Institute of Canada).

[169] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 10 May 2016 (Mike Cleland, Senior Fellow, University of Ottawa, as an Individual).

[170] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 September 2017 (Ian Beausoleil-Morrison, Professor, Faculty of Engineering and Design, Carleton University, as an individual).

[171] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 September 2017 (Ian Beausoleil-Morrison, Professor, Faculty of Engineering and Design, Carleton University, as an individual).

[172] Natural Resources Canada, *Air-Source Heat Pumps*, 27 March 2017.

[173] *Build Smart: Canada's Buildings Strategy—Critical Path to 2030*, Energy and Mines Ministers' Conference, St. Andrews by-the-Sea, New Brunswick, August 2017.

[174] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 21 September 2017 (Duncan Hill, Manager, Housing Needs Research, Canada Mortgage and Housing Corporation).

[175] Ibid.

[176] Ibid.

[177] Ibid.

[178] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 26 September 2017 (Ian Beausoleil-Morrison, Professor, Faculty of Engineering and Design, Carleton University, as an individual).
[179] Ibid.
[180] Ibid.
[181] Environment and Climate Change Canada, *Low Carbon Economy Fund*, 25 October 2017.
[182] Infrastructure Canada, *Investing in Canada Plan: Canada's Long-Term Infrastructure Plan*, April 2018.
[183] *Build Smart: Canada's Buildings Strategy—A Key Driver of the Pan-Canadian Framework on Clean Growth and Climate Change*, Energy and Mines Ministers' Conference, St. Andrews by-the-Sea, New Brunswick, August 2017.
[184] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 19 October 2017 (Thomas Mueller, President and Chief Executive Officer, Canada Green Building Council).
[185] Government of Canada, *National Housing Strategy*, November 2017.
[186] Ibid.
[187] Ibid.
[188] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 21 September 2017 (Duncan Hill, Manager, Housing Needs Research, Canada Mortgage and Housing Corporation).
[189] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Luisa Atkinson, Director, First Nation Housing, Canada Mortgage and Housing Corporation).
[190] Ibid.; Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Lyse Langevin, Director General, Community Infrastructure Branch, Regional Operations, Indigenous Services Canada).
[191] Ibid.
[192] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Pamela Hine, President, Yukon Housing Corporation).
[193] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Luisa Atkinson, Director, First Nation Housing, Canada Mortgage and Housing Corporation).
[194] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Pamela Hine, President, Yukon Housing Corporation).
[195] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Tom R. Williams, President and Chief Executive Officer, Northwest Territories Housing Corporation, Government of the Northwest Territories).
[196] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Luisa Atkinson, Director, First Nation Housing, Canada Mortgage and Housing Corporation).
[197] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Tom R. Williams, President and Chief Executive Officer, Northwest Territories Housing Corporation, Government of the Northwest Territories).
[198] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 29 March 2018 (Lyse Langevin, Director General, Community Infrastructure Branch, Regional Operations, Indigenous Services Canada).
[199] Ibid.
[200] Public Services and Procurement Canada [PSPC], *2017–18 Departmental Plan*, p. 20.
[201] Treasury Board of Canada Secretariat, "Federal Government to significantly reduce its own greenhouse gas emissions," News release, 2 November 2016.
[202] Environment and Climate Change Canada, *Achieving a Sustainable Future – A Federal Sustainable Development Strategy for Canada 2016-2019*, p. 22.

[203] Senate, Standing Committee on Energy, the Environment and Natural Resources, Evidence, 1st Session, 42nd Parliament, 17 October 2017 (Kevin Radford, Assistant Deputy Minister, Real Property Branch, Public Services and Procurement Canada).
[204] Senate, Standing Committee on Energy, the Environment and Natural Resources, Evidence, 1st Session, 42nd Parliament, 28 September 2017 (James Tansey, Executive Director, Centre for Interactive Research on Sustainability, University of British Columbia).
[205] Senate, Standing Committee on Energy, the Environment and Natural Resources, Evidence, 1st Session, 42nd Parliament, 3 October 2017 (Pierre Boucher, President, Canadian Construction Innovations).
[206] Senate, Standing Committee on Energy, the Environment and Natural Resources, Evidence, 1st Session, 42nd Parliament, 26 October 2017 (David Lapp, Practice Lead, Globalization and Sustainable Development, Engineers Canada, and Emmanuelle van Rutten, Regional Director, Ontario North, East and Nunavut, Royal Architecture Institute of Canada).
[207] Senate, Standing Committee on Energy, the Environment and Natural Resources, Evidence, 1st Session, 42nd Parliament, 8 February 2018 (Philippe Dunsky, Vice-Chair, Canadian Energy Efficiency Alliance).
[208] Senate, Standing Committee on Energy, the Environment and Natural Resources, Evidence, 1st Session, 42nd Parliament, 19 October 2017 (Thomas Mueller, President and Chief Executive Officer, Canada Green Building Council).
[209] Senate, Standing Committee on Energy, the Environment and Natural Resources, Evidence, 1st Session, 42nd Parliament, 26 October 2017 (Emmanuelle van Rutten, Regional Director, Ontario North, East and Nunavut, Royal Architecture Institute of Canada).
[210] Senate, Standing Committee on Energy, the Environment and Natural Resources, Evidence, 1st Session, 42nd Parliament, 17 October 2017 (Taki Sarantakis, Associate Secretary, Treasury Board of Canada Secretariat).
[211] Senate, Standing Committee on Energy, the Environment and Natural Resources, Evidence, 1st Session, 42nd Parliament, 3 October 2017 (Pierre Boucher, President, Canadian Construction Innovations).
[212] Ibid.
[213] Senate, Standing Committee on Energy, the Environment and Natural Resources, Evidence, 1st Session, 42nd Parliament, 28 September 2017 (James Tansey, Executive Director, Centre for Interactive Research on Sustainability, University of British Columbia).
[214] Senate, Standing Committee on Energy, the Environment and Natural Resources, Evidence, 1st Session, 42nd Parliament, 17 October 2017 (Nick Xenos, Executive Director, Centre for Greening Government, Treasury Board of Canada Secretariat).
[215] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 28 September 2017 (James Tansey, Executive Director, Centre for Interactive Research on Sustainability, University of British Columbia.
[216] City of Toronto, *TransformTO: Climate Action for a Healthy, Equitable, Prosperous Toronto—Results of Modelling Greenhouse Gas Emissions to 2050*, April 2017.
[217] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 27 March 2018 (Mary-Margaret McMahon, Councillor, City of Toronto).
[218] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 24 October 2017 (Brock Carlton, Chief Executive Officer, Federation of Canadian Municipalities).
[219] Ibid.
[220] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Pamela Hine, President, Yukon Housing Corporation); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Jim Lord, Founding Principal, Ecovert Sustainability Consultants); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Tom R. Williams, President and Chief Executive Officer, Northwest Territories Housing Corporation, Government of the Northwest Territories).

[221] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Pamela Hine, President, Yukon Housing Corporation).
[222] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 1 March 2018 (Jim Lord, Founding Principal, Ecovert Sustainability Consultants).
[223] Ibid.
[224] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 27 March 2018 (Shannon Miedema, Energy and Environment Program Manager, Planning and Development, City of Halifax).
[225] Dunsky Engineering Consulting, *Local Improvement Charge (LIC) Financing Pilot Program Design for Residential Buildings in Ontario*, June 2013.
[226] Ibid.
[227] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 27 March 2018 (Mary-Margaret McMahon, Councillor, City of Toronto).
[228] Ibid.
[229] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 27 March 2018 (Shannon Miedema, Energy and Environment Program Manager, Planning and Development, City of Halifax).
[230] City of Halifax, "Senate Standing Committee on Energy, the Environment and Natural Resources Submissions (Low-Carbon Economy)," Written submission to the Senate Standing Committee on Energy, the Environment and Natural Resources, 27 March 2018.
[231] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 27 March 2018 (Shannon Miedema, Energy and Environment Program Manager, Planning and Development, City of Halifax); Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 27 March 2018 (Mary-Margaret McMahon, Councillor, City of Toronto).
[232] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 27 March 2018 (Shannon Miedema, Energy and Environment Program Manager, Planning and Development, City of Halifax.
[233] Low Carbon Cities Canada, *Accelerating urban climate solutions across Canada*, February 2018.
[234] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 27 March 2018 (Shannon Miedema, Energy and Environment Program Manager, Planning and Development, City of Halifax).
[235] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 27 March 2018 (Mary-Margaret McMahon, Councillor, City of Toronto).
[236] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 2 November 2017 (Craig Stewart, Vice-President, Federal Affairs, Insurance Bureau of Canada).
[237] Ibid.
[238] Ibid.
[239] Ibid.
[240] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 8 February 2018 (Blair Feltmate, Head, Intact Centre on Climate Adaptation, University of Waterloo, as an Individual).
[241] Ibid.
[242] Ibid.
[243] Ibid.
[244] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 21 September 2017 (Dwayne Torrey, Director, Construction and Infrastructure, CSA Group).
[245] Senate, Standing Committee on Energy, the Environment and Natural Resources, *Evidence*, 1st Session, 42nd Parliament, 17 April 2018 (Kenneth P. Green, Senior Director, Natural Resources Studies, Fraser Institute.