Task 1: Market Overview

IEA-HPT Annex 45: Hybrid Heat Pumps

Canada

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Contents

Photo Credit: NEB Publication, Canada's Renewable Power Landscape - Energy Market Analysis 2016

1 Background

To meet its Green House Gas (GHG) emissions reduction commitments, Canada has developed a Pan-Canadian Framework on Clean Growth and Climate Change (PCF) which outlines the commitments of the federal, provincial and territorial governments (Governments) to reduce GHG emissions and promote clean, low-carbon economic growth for Canadians [1].

It has been recognised, that residential and commercial buildings account for 17% of total greenhouse gas emissions in Canada and the PCF thus outlines a building strategy to improve the energy performance of new and existing buildings through better building codes and appliance labels that set higher standards for energy-using equipment.

Speeding up the development and mainstream adoption of clean and more energy-efficient equipment and technologies, which includes Hybrid Heating Systems, is a key component in achieving the goals of the PCF.

To support the commitments of the PCF, the Governments have outlined a series of aspirational goals for the energy performance of key technologies and their market transformation needs in a report released at the Energy and Mines Minister's Conference in August 2017 entitled "Market transformation strategies for energy-using equipment in the building sector" [2].

[1] https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework/climate-change-plan.html
[2] https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/emmc/pdf/Market-Transformation-Strategies_en.pdf

A series of stakeholder consultations were held to identify the barriers to market adoption of higher efficiency technologies needed to achieve the aspirational goals, and help develop the market transformation road map for space heating, and water heating [3].

Policy Recommendation:

Support a transformation of the residential and commercial space heating market to a 100% renewable heating source, through promoting the use of hybrid heating systems among other heat pump technologies, renewable energy use, and the introduction of new building code requirements and/or increased minimum appliance performance standards.

[3] http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/emmc/pdf/2018/en/18-00072-nrcan-road-map-eng.pdf

2 Energy Sources for Canada

From an energy perspective, Canada is very fortunate. We have a large land mass, small population and one of the largest and most diverse supplies of energy in the world. Our rivers discharge close to 7% of the world's renewable water – a tremendous source of hydroelectric power, providing 59.3% of Canada's total electricity generation. We have the third-largest global supply of proven oil reserves, are the fourth-largest producer and exporter of natural gas, and have the third-largest reserves of uranium. Our energy resources are a source of strength that continues to shape our economy and society [4], [5].

The Canadian coal industry produces coal for use in metallurgical applications (e.g., coking or steelmaking) and thermal applications (e.g., electricity generation). In 2017, Canada produced 61 million Tonnes of Coal and used about 38 million Tonnes split roughly equally between metallurgical and thermal applications, the balance being exported. In 2016, the Government of Canada announced its plan to eliminate the use of traditional coal-fired electricity in Canada by 2030. [6]

3 Energy Use

Canada is also a large consumer of energy. In 2012, Canadian total final energy consumption was 2.3 % of the global total. On a per capita basis, Canada's energy intensity is among the highest in the world.

Climate and geography play a key role in Canada's relatively high energy intensity. A cold and variable northern climate means more energy is consumed heating homes and businesses. Similarly, goods and people often travel further to reach their destinations due to Canada's large land mass. This requires more energy use compared to geographically smaller nations [7].

In 2013, the primary energy consumption in Canada was estimated to be 12,681 PJ [8]. Primary energy use encompasses the total requirements for all users of energy. Additionally, primary energy use refers to the energy required to transform one form of energy to another (e.g. coal to electricity). It also includes the energy used to bring energy supplies to the consumer
(e.g. pipeline). Further, it entails the energy used to feed industrial production processes (e.g. the natural gas used as feedstock by the chemical industries).

Secondary energy use is the energy used by final consumers in various sectors of the economy. This includes, for example, the energy used by vehicles in the transportation sector or the energy used to heat a house in the residential sector. The total secondary energy use in Canada is roughly 70%of the primary energy use at 9,042 .6 PJ. The breakdown of secondary energy use and GHG emissions in Canada, by fuel type and year are shown in Table A.

[4] Building Canada's Future Together (2018), https://www.nrcan.gc.ca/publications/11102
[5] NRCan – About Renewable Energy, https://www.nrcan.gc.ca/energy/renewable-electricity/7295
[6] NRCan – Coal Facts, https://www.nrcan.gc.ca/energy/facts/coal/20071
[7] Canada's Energy Future 2016, National Energy Board.

Table A. Canada’s Secondary Energy Use (Final Demand) and GHG Emissions by Energy Source [8]

Year		1990		2011	2012	2013	2014	2015
Total Energy Use (PJ)[a,b,c]		6,957.1		8,756.4	8,770.9	9,042.6	9,148.3	9,012.9
Energy Use by Energy Source (PJ)								
Electricity		1,428.6		1,767.6	1,753.5	1,790.4	1,812.9	1,783.8
Natural Gas		1,777.6		2,406.2	2,428.4	2,650.4	2,785.9	2,753.8
Motor Gasoline (1)		1,176.5		1,503.5	1,506.6	1,548.2	1,521.7	1,539.0
Oil (2)		1,202.2		1,457.2	1,413.0	1,418.5	1,391.0	1,353.7
Aviation Gasoline		5.5		2.1	2.6	2.2	1.9	2.2
Aviation Turbo Fuel		181.9		229.1	260.9	271.8	268.1	270.0
Still Gas and Petroleum Coke		309.9		500.5	498.0	476.7	468.3	470.8
Wood Waste and Pulping Liquor		341.0		363.6	356.3	390.8	423.2	387.5
Other (3)		313.3		353.4	376.2	319.7	318.2	289.9
Residential Wood		220.5		173.2	175.4	174.0	157.1	162.0
Total GHG Emissions								
Including Electricity (Mt of CO2e)[a,b,c,d]		401.1		487.8	486.1	498.2	495.0	489.2
GHG Emissions by Energy Source (Mt of CO2e)								
Electricity		80.4		75.2	69.5	71.5	67.2	65.2
Natural Gas		91.2		128.2	130.1	142.3	149.3	147.7
Motor Gasoline (1)		82.2		102.1	102.0	104.6	102.5	103.9
Oil (2)		87.8		106.6	103.4	103.8	101.7	99.0
Aviation Gasoline	0.4		0.2	0.2	0.2	0.1	0.2	
Aviation Turbo Fuel		12.9		15.8	18.0	18.8	18.5	18.6
Still Gas and Petroleum Coke		17.6		29.5	31.3	30.2	29.4	29.7
Wood Waste and Pulping Liquor		0.2		0.2	0.2	0.3	0.3	0.3
Other (3)		23.2		25.9	27.2	22.6	22.2	20.8
Residential Wood		5.18		4.07	4.12	4.09	3.69	3.80
Total GHG Emissions								
Excluding Electricity (Mt of CO2e)[a,b,c,d]		320.8		412.6	416.6	426.7	427.8	424.0

Table Notes:

(1) "Motor Gasoline" includes ethanol. See transportation tables fo details.
(2) “Oil” includes diesel fuel oil, light fuel oil, kerosene and heavy fuel oil.
(3) “Other” includes coal, coke, coke oven gas, LPG and Gas Plant NGL, steam and waste fuels from the cement industry.

Data Sources:

a) Statistics Canada, Report on Energy Supply and Demand in Canada, 1990–2015, CANSIM (Table 128-0016), Ottawa, 2017.
b) Natural Resources Canada, Residential End-Use Model, Ottawa, 2017.

[8] End Use Data Handbook Tables and National Energy Use Database
http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/trends/handbook/tables.cfm
http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/data_e/databases.cfm?attr=0

c) Canadian Industrial Energy End-Use Data and Analysis Centre, Development of Energy Intensity Indicators for Canadian Industry 1990 to 2015, Simon Fraser University, 2017.
d) Environment and Climate Change Canada, National Inventory Report 1990–2015: Greenhouse Gas Sources and Sinks in Canada, Ottawa, 2017.

4 Energy Use Related to Hybrid Heating Systems

In 2013, residential and commercial energy use accounted for about 2,440 PJ or 27% of the total secondary energy use in Canada and it can be seen that of that fraction, the energy required for space and water heating is the major , i.e. 1,260 PJ or 82% of residential use and 569 PJ or 63% of commercial use(See Figure B). This 1,829 PJ or 20% of the total secondary energy use in Canada, is where hybrid heating systems could have an impact, producing a significant reduction in fossil fuel use and reducing GHG emissions.

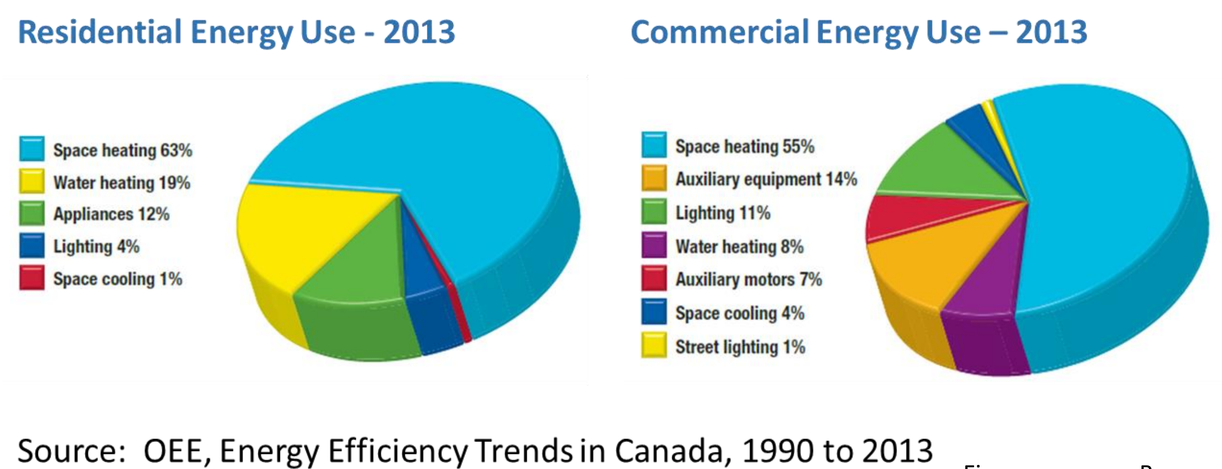

Figure B. Residential & Commercial Secondary Energy Use in Canada (2013).

There is roughly a 50/50 split between the use of gas and electricity for both space and water heating in Canada. The bulk of the electric heating will be resistance element based heating.

The GHG reduction impact of a hybrid heating system in any given province will be dependent on the GHG intensity of the electricity being used (in addition to the performance level of the heat pump used).

The Greenhouse Gas Intensity of Electricity in Canada

The greenhouse gas intensity of the electricity produced in Canada varies by province and territory [9]. The shaded map below, Figure C, based on 2017 figures, shows the relative GHG intensity of each province and territory. Regions shaded lightly have a GHG intensity below the national average of 140 g CO2/kWh, while those with dark shading have GHG intensities above the national average. Note: The GHG intensity of Natural Gas is approximately 200 g CO2/kWh.

9 Map Produced by the NEB. http://www.neb-one.gc.ca/nrg/sttstc/lctrct/rprt/2017cndrnwblpwr/ghgmssn-eng.html

Quebec has the lowest GHG intensity, at 1.2 g CO2/kWh, followed by Manitoba (3.4 g CO2/kWh), B.C. (12.9 g CO2/kWh), PEI (20.0 g CO2/kWh), Newfoundland and Labrador (32.0 g CO2/kWh), Ontario (40.0 g CO2/kWh), Yukon (41.0 g CO2/kWh), New Brunswick (280.0 g CO2/kWh), NWT (390.0 g CO2/kWh), Nova Scotia (600.0 g CO2/kWh), Saskatchewan (660.0 g CO2/kWh), Nunavut (750.0 g CO2/kWh), and Alberta (790.0 g CO2/kWh).

Quebec, Ontario, Manitoba, and British Columbia have a sizeable fraction of their electricity generated from hydroelectric sources, whereas, Saskatchewan and Alberta produce most of their electric power from Coal. In the Far-North, e.g.Northwest Territories, Yukon, and Nunavut, a sizeable fraction of the electricity can be from Diesel power generation. Because of the different sources of electricity, there is a wide variation in the cost of electricity across Canada (see Table B below).

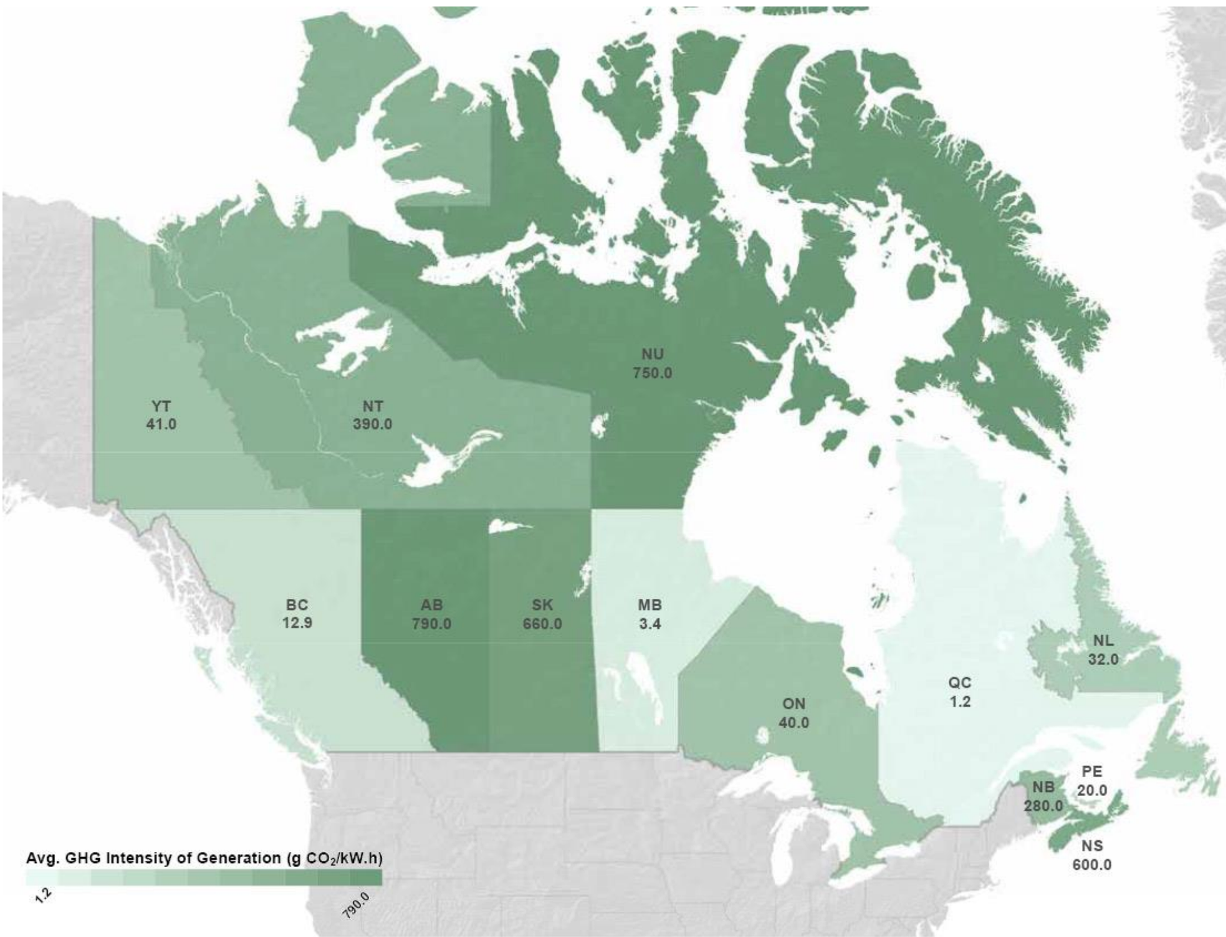

Figure C. Greenhouse gas intensity of electricity generation by province and territory

Currently, the cost of Natural Gas is significantly lower than that of electricity, in most if not all provinces (see Table B and C below). This would tend to deter the use of an all electric heat pump system where low cost natural gas is available. The use of hybrid heating systems could help change the market transformation dynamics in favour of higher efficiency space and water heating, while retaining a low cost heating option.

In Canada, the analysis tool RETScreen [10], is available for download in many languages. The latest version, RETScreen Expert, is a clean energy management software system for energy efficiency, renewable energy and cogeneration project feasibility analysis as well as ongoing energy performance analysis. Based on the project location and taking into account, local weather, building design, HVAC system performance, and utility costs RETScreen enables professionals and decision-makers to rapidly identify, assess and optimize the technical and financial viability of potential clean energy projects. This decision intelligence software platform also allows managers to easily measure and verify the actual performance of their facilities and helps find additional energy savings/production opportunities.

Table B. 2017 Average Natural Gas Commodity Prices (CA $/GJ) [11]

Source	Cost
Henry Hub	3.66
Alberta NIT	2.06
Dawn, ON	3.76
Station 2, Westcoast Spectra, BC	1.48

2017 Average Electricity Commodity Prices (CA $/MW.h)

Source	Cost
Alberta (AESO On-Peak)	23.82
Ontario (IESO On-Peak)	20.40
Ontario (IESO On-Peak + Global Adjustment)	120.92

Note: 1.000 $/GJ = 0.278 $ / MWh

[10] RETScreen Download, https://www.nrcan.gc.ca/energy/software-tools/7465

[11] NEB Commodity Prices and Trade Updates – Monthly Data Tables, July 2018. https://www.neb-one.gc.ca/nrg/ntgrtd/mrkt/prcstrdrtcl/index-eng.html

Table C. Residential Electricity Cost by Canadian City (CA $)[12]

Residential

One Month Bill For:

	1,000 kWh	¢/kWh
Halifax NS	$ 161.46	16.146
Regina SK	$ 159.41	15.941
Saskatoon SK	$ 159.37	15.937
Ottawa, ON	$ 137.90	13.790
Moncton NB	$ 129.70	12.970
Saint John NB	$ 115.91	11.591
St. John's NL	$ 111.52	11.152
Vancouver BC	$ 110.79	11.079
Calgary AB	$ 106.02	10.602
Edmonton AB	$ 104.50	10.450
Winnipeg MB	**$ 87.12**	**8.712**
Montreal QC	$ 70.70	7.070

Note: 10 Cents/kWh = 100 $/MWh

[12] Survey of CanadianElectricity Bills, Manitoba Hydro
https://www.hydro.mb.ca/accounts_and_services/rates/pdf/survey-of-canadian-electricity-bills.pdf

5 Possible role for hybrid systems in Canada

Most existing homes are heated using fossil fuel.

The step from fossil fuel heating to heat pump heating could be expensive and end users may not have enough confidence in the new technology. Lifetime energy costs are significantly lower with a hybrid heating scenario compared to the full-electric heat pump only scenario (Note: The first cost of a Hybrid Heating System is higher than that of a heat pump only system, but comparable to that of a natural gas-fired furnace fitted with an air conditioning system).

A hybrid system is a happy medium between “all fossil fuel” and “heat pump only” heating, that should provide a system COP > 1.0 (on primary fuel) and reduced GHG emissions.

Any existing Canadian home adding air conditioning should consider adding a heat pump instead, for a minimal cost increase. The resultant hybrid heating system, would yield an overall system COP > 1.0 and reduced GHG emissions.

Most newly constructed Canadian homes include fossil fuel space heating and an electric Air Conditioning (AC) unit as a part of the package offered by builders. It would be very easy to include a Heat Pump instead of the AC unit, for a minimal cost increase. The resultant hybrid heating system would yield an overall system COP > 1.0 and reduced GHG emissions.

Third party controls developers are working to support hybrid heating systems, with different priority settings, e.g. “green operation”, “lower cost operation”, etc. The simplest controls use the outdoor air temperature or the rate of home heating to determine whether or not the Furnace (Boiler) or the heat pump should operate to heat the home. More sophisticated controls use the outdoor air temperature to determine whether heat pump operation is possible and then use a pre-programmed or internet determined “time of use” cost for natural gas and electricity to decide whether the Furnace (Boiler) or Heat Pump would be more economical and/or efficient to run.

6 Perfomance standards

At the time of writing, there are no Canadian Performance Standards for Hybrid Heating Systems. The Canadian Standards Association (CSA) Technical Committee for Energy Efficiency and Related Performance of Fuel-burning Appliances & Equipment, will address this shortfall at its next meeting, to be held on November 7th , 2018.

7 The Housing Market

Of the 15 million occupied dwellings in Canada, approximately 6 million use natural gas for space and/or water heating [13]. Because of Canada's climate, approximately 64% of the energy used in Residential Housing can be attributed to space heating alone [14] (82% if you include water heating as well [15]).

7.1 Housing in Canada – Snapshot 2018

Canadians use significant amounts of energy to heat, cool and ventilate their homes, to operate lights and appliances and to heat water. According to the latest data available (2015), residential energy use was 1,544 petajoules (1 PJ = 10^6 GJ) which accounted for 16.6% of secondary energy use in Canada. It is interesting to note that since 1991, Canada's housing stock increased at 1.4%; however, the residential energy use only increased by 0.3% [NRCan 2016]. Space and domestic water heating energy requirements account for over 80% of residential energy demand in most regions.

The residential housing stock consists of 15.03 million units as per the latest data available from the Statistics Canada [NEUD 2017]. About 54.6% of this stock are detached single-family dwellings, 11.6% are low-rise row and semi-detached dwellings, 12.5% low-rise multi-unit residential buildings and the rest are mid- or high-rise apartments. Over the years, the average size of Canadian dwellings has also steadily increased. Today's housing has, on an average, 156 m^2 (1,680 ft^2) of conditioned floor space compared to an average of 116 m^2 (1,255 ft^2) for houses built about 40 years ago [Purdy, 2017].

As shown in Figure 1, about 47% of the housing stock was built prior to 1983 prior to any requirement for energy efficiency measures. Since 1985, national and provincial building codes slowly started requiring insulation and ventilation measures.

Vintage as per major code changes	Number of Dwellings		Average Size	Average Energy Use
	(thousands)	%	sq m	GJ/year
Before 1946	1,651	11%	125.8	146.0
1946-1983	5,408	36%	119.9	111.5
1984–1995	3,131	21%	136.5	100.5
1996-2005	2,356	16%	145.9	89.5
2006-2011	1,344	9%	150.8	83.5
2012-2016	1,139	8%	156.0	74.0
Total	**15,029**		**133.6**	**104.2**

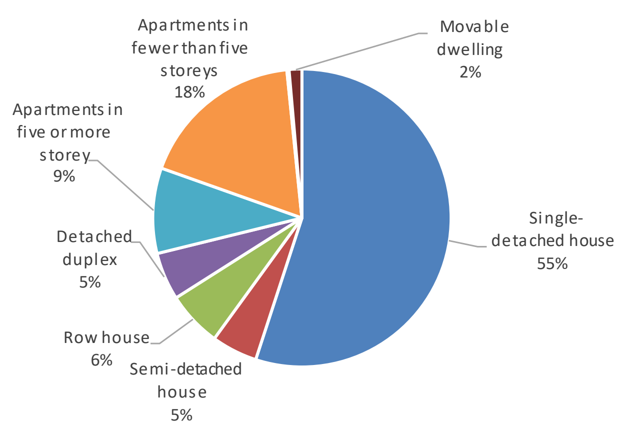

Figure 1. Canadian housing stock in 2016 [NRCan 2017].

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[13] Canada's NaturalGas, https://www.canadasnaturalgas.ca/en/explore-topics/natural-gas-use

[14] From National Energy Use Database, 2014: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=2&page=0

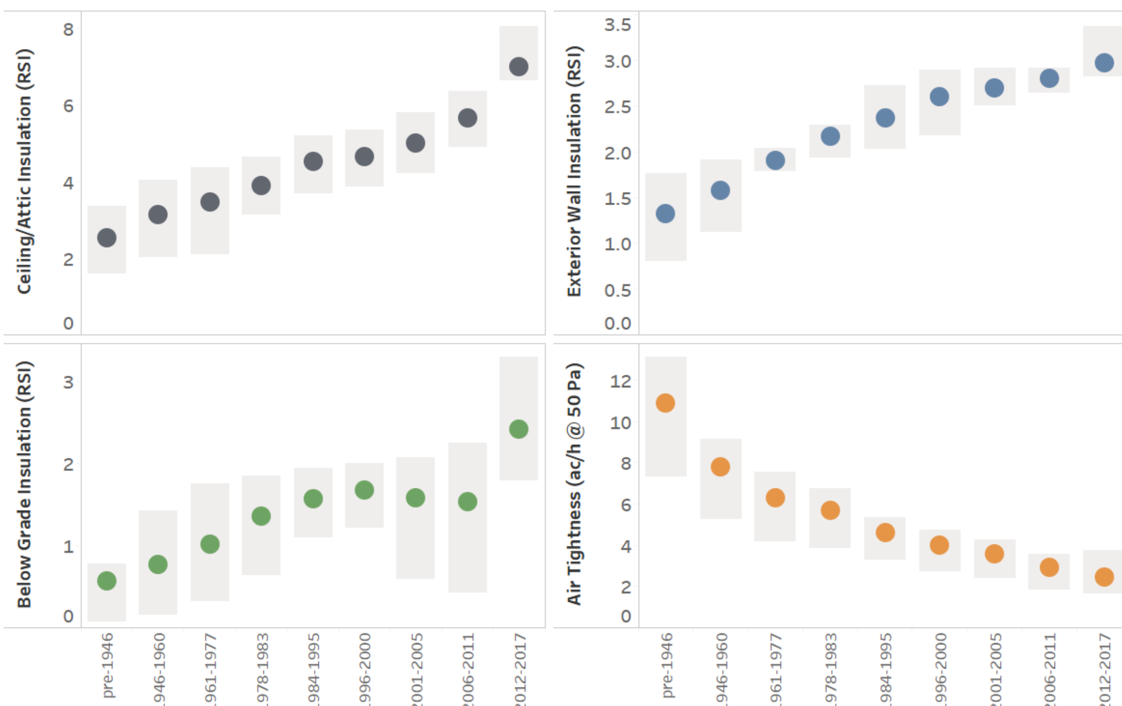
[15] Improving Energy Performance in Canada, Report to Parliament Under the Energy Efficiency Act 2015–2016 https://www.nrcan.gc.ca/energy/publications/17756

Today's new construction of homes include the high levels of insulation, lower airtightness, high performance windows, efficient heat recovery ventilation (HRV) systems and very efficient condensing fuel-fired space heating and domestic hot water systems. Code changes were, however, gradual over the years; and, first time in 2012 as major change, National Building Code introduced key section on energy efficiency covering the whole house. Typical thermal characteristics are as follows in Table A:

Table A: Thermal Characteristics Required by The National Building Code.

Components		Heating Degree Days (deg C-days on 18 C base)		
		<5000	5000 to 6999	> 7000
Effective Insulation, m2K/W, RSI	Attic/roof	8.67	10.43	10.43
	Walls - above grade	4.67	5.02	5.02
	Walls - below grade	3.08	3.85	3.85
	Foundation floor	1.96	3.72	4.59
Airtightness, ACH @ 50 Pa		2.5	2.5	2.5
Furnace / Boiler, AFUE	Fuel fired	92%	95%	95%
Heat Recovery Ventilation		65%	65%	65%
Domestic hot water, EF	Fuel fired	0.67	0.67	0.67

Figure 2 shows the profile of envelope insulation levels (effective thermal insulation value in m2K/W) and average air-tightness levels for dwellings. Each bar represents a range of values for the 25th and 75th percentiles with a median value (dot). Over the years, the overall insulation levels have significantly improved; code changes since the year 2000 have raised the minimum insulation levels.



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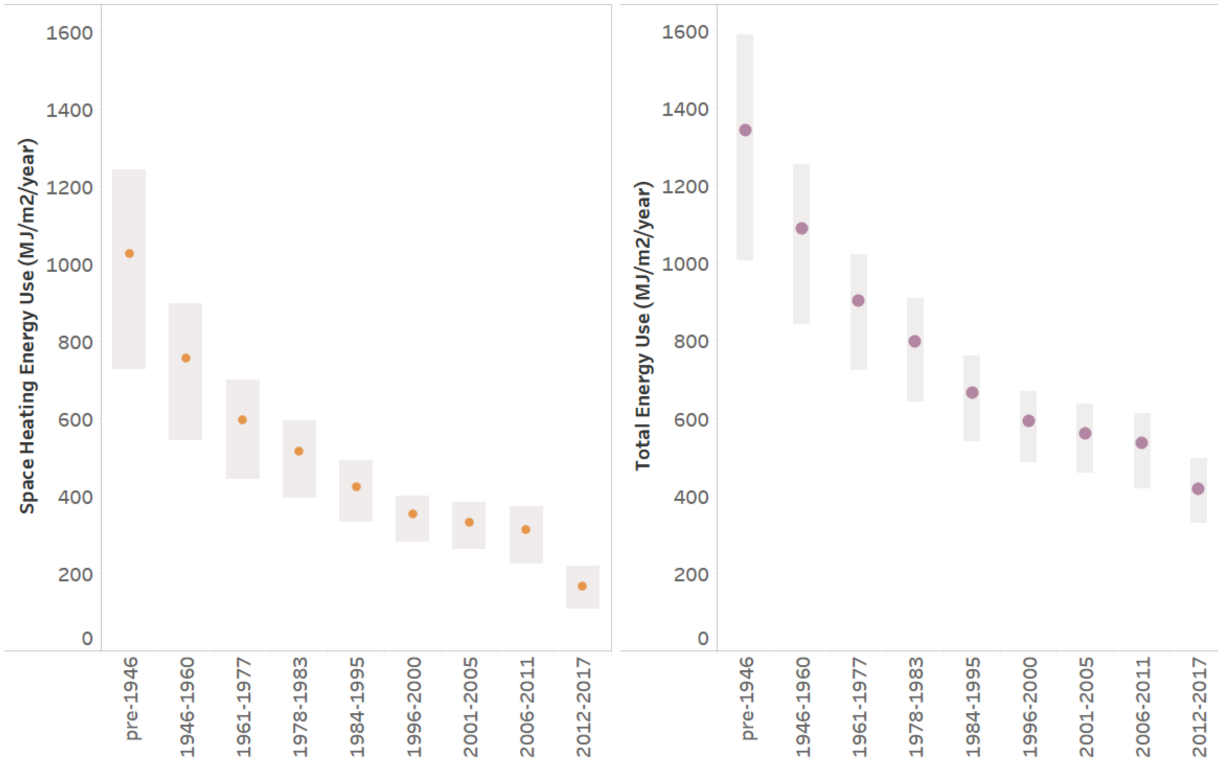


Figure 3. Profile of annual space heating and total energy use for dwellings.

Figure 3 shows the weighted average data for the annual space heating requirements and total energy use profiles. The median value for space heating requirements for new housing (2014) is about 264 MJ/m²/year compared to 335 MJ/m²/year for house built about 15 years ago during 1995-2000. The combined effects of significant improvements in insulation levels, more airtight construction practices, and improved efficiencies in mechanical equipment have led to better overall energy efficiency.

Referenced Documents:

NRCan 2017. Natural Resources Canada, Residential End-Use Model, Ottawa, February 2017. **http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/trends/comprehensive_tables/list.cfm**

NEUD 2017. Energy Efficiency Trends in Canada 1990-2014. Natural Resources Canada, Ottawa, Ontario. **http://oee.nrcan.gc.ca/publications/statistics/sheu/2011/pdf/sheu2011.pdf**

Purdy J. and Parekh A. 2017. Thermal and Mechanical Systems Descriptors for Simplified Energy Use Evaluation of Canadian Houses. Proceedings of Canadian Building Science and Technology Conference, Vancouver, BC.

7.2 Commercial Buildings

The information about commercial buildings is more difficult to find, but the Office of Energy Efficiency (OEE), through data collected by Statistics Canada has compiled information in the National Energy Use Database, notably, Table 18: Building characteristics, energy use and energy intensity by primary activity and year of construction, 2014 [16].

[16] OEE, National Energy Use Database: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=SC&sector=aaa&juris=ca&rn=18&page=1

Building characteristics, energy use and energy intensity by primary activity and year of construction, 2014

Primary activity	Year of construction	Buildings		Floor space		Energy use		Energy intensity
		#	QI	millions of m^2	QI	PJ	QI	GJ/m^2
Office buildings (non-medical)	Total	97,029	A	281.2	A	317.6	A	1.13
	Before 1920	5,176	B	19.1	C	24.2	F	1.27
	1920 to 1959	18,584	B	35.2	B	46.1	C	1.31
	1960 to 1969	8,207	B	36.3	B	39.4	B	1.09
	1970 to 1979	26,389	B	49.3	A	61.2	A	1.24
	1980 to 1989	13,205	B	59.1	B	57.6	B	0.97
	1990 to 1999	12,805	C	41.8	B	47.1	B	1.13
	2000 to 2009	9,706	C	22.2	B	25.4	B	1.15
	2010 or later	2,957	C	18.2	F	16.6	F	0.91
Medical office buildings	Total	15,928	B	15.6	A	20.1	A	1.28
	Before 1920	396	F	0.1	F	0.1	F	1.03
	1920 to 1959	1,516	C	1.3	B	1.8	B	1.36
	1960 to 1969	1,530	C	2.2	F	3.9	F	1.75
	1970 to 1979	2,466	C	2.4	B	3.4	C	1.42
	1980 to 1989	3,997	C	5.1	B	5.1	B	1.00
	1990 to 1999	2,691	F	2.1	F	3.1	F	1.49
	2000 to 2009	3,141	F	1.9	B	2.0	B	1.07
	2010 or later	191	F	0.5	F	0.6	F	1.28
Elementary and/or secondary schools	Total	17,501	A	70.8	A	62.2	A	0.88
	Before 1920	549	C	2.3	C	1.8	C	0.79
	1920 to 1959	4,181	A	17.0	A	14.1	A	0.83
	1960 to 1969	4,248	A	20.6	B	20.4	B	0.99
	1970 to 1979	2,606	A	10.8	B	8.3	B	0.77
	1980 to 1989	1,740	C	6.6	F	5.9	F	0.89
	1990 to 1999	1,969	C	7.6	C	6.6	C	0.86
	2000 to 2009	1,923	C	4.9	B	4.0	C	0.82
	2010 or later	284	F	1.0	F	1.1	F	1.08
Assisted daily/residential care facilities	Total	11,391	A	19.9	A	25.8	A	1.30
	Before 1920	963	C	1.2	C	1.6	C	1.33
	1920 to 1959	2,147	B	2.7	B	3.4	C	1.28
	1960 to 1969	1,127	B	3.6	B	4.8	B	1.35

	1970 to 1979	1,558	B	2.4	B	3.6	B	1.49
	1980 to 1989	1,323	B	1.9	B	2.7	B	1.44
	1990 to 1999	1,838	B	1.6	B	1.9	B	1.21
	2000 to 2009	1,796	B	5.3	A	6.8	A	1.29
	2010 or later	639	C	1.2	F	0.9	F	0.74
	Total	62,105	A	93.4	A	76.1	A	0.82
	Before 1920	491	F	2.3	F	1.0	F	0.45
	1920 to 1959	7,117	B	9.4	B	7.8	B	0.83
	1960 to 1969	4,034	F	3.3	C	2.5	B	0.76
Warehouses	1970 to 1979	14,696	B	19.3	A	17.4	A	0.90
	1980 to 1989	10,006	B	20.6	B	17.5	B	0.85
	1990 to 1999	13,565	B	14.0	B	12.9	B	0.92
	2000 to 2009	11,117	B	23.2	B	16.1	A	0.69
	2010 or later	1,080	F	1.2	C	0.9	C	0.77
	Total	12,714	A	17.8	A	22.1	A	1.24
	Before 1920	471	F	0.8	C	1.4	C	1.71
	1920 to 1959	2,859	B	2.6	B	2.8	B	1.08
	1960 to 1969	1,122	B	1.7	B	2.6	B	1.49
Hotels, motels or lodges	1970 to 1979	2,779	B	3.2	A	5.1	A	1.61
	1980 to 1989	1,806	C	2.9	B	4.1	B	1.44
	1990 to 1999	1,811	C	3.0	B	2.3	B	0.76
	2000 to 2009	1,494	B	2.9	B	3.0	B	1.05
	2010 or later	371	F	0.7	F	0.7	F	1.01
	Total	798	A	15.4	A	37.7	A	2.45
	Before 1920	23	C	1.1	C	2.2	C	1.99
	1920 to 1959	162	A	4.4	A	11.8	A	2.68
	1960 to 1969	148	A	2.4	B	5.7	A	2.41
Hospitals	1970 to 1979	124	B	1.6	B	4.6	B	2.98
	1980 to 1989	102	A	2.0	B	4.2	B	2.08
	1990 to 1999	58	F	1.9	F	4.2	F	2.24
	2000 to 2009	158	F	1.1	F	2.5	C	2.36
	2010 or later	23	F	1.0	F	2.5	F	2.40
	Total	19,386	A	22.5	B	42.1	A	1.87
	Before 1920	1,354	F	0.4	F	0.5	F	1.14
Food and beverage stores	1920 to 1959	4,330	B	3.0	F	4.1	B	1.37
	1960 to 1969	1,586	F	0.8	B	2.7	C	3.18

	1970 to 1979	2,503	C	1.5	B	4.3	B	2.89
	1980 to 1989	1,624	B	2.2	C	3.6	C	1.59
	1990 to 1999	3,173	B	3.7	A	9.7	A	2.64
	2000 to 2009	3,550	B	5.1	B	11.4	A	2.24
	2010 or later	1,267	F	5.8	F	5.8	F	1.01
Non-food retail stores	Total	61,672	A	85.9	B	95.9	A	1.12
	Before 1920	2,554	F	1.0	F	1.8	F	1.74
	1920 to 1959	11,239	C	7.8	B	9.0	B	1.16
	1960 to 1969	7,180	F	12.5	C	16.6	C	1.33
	1970 to 1979	15,516	C	36.5	F	32.6	F	0.89
	1980 to 1989	8,443	C	9.5	C	11.7	C	1.23
	1990 to 1999	6,344	C	10.1	B	13.9	C	1.38
	2000 to 2009	4,251	B	6.2	B	8.3	C	1.34
	2010 or later	6,143	F	2.5	F	2.1	F	0.84
Other activity or function*	Total	183,880	A	180.5	A	215.6	A	1.19
	Before 1920	15,131	C	10.4	B	10.8	B	1.04
	1920 to 1959	34,625	A	26.1	A	35.0	A	1.34
	1960 to 1969	21,821	B	27.9	B	29.2	B	1.05
	1970 to 1979	27,225	A	25.7	A	41.1	A	1.60
	1980 to 1989	26,850	B	29.6	B	27.0	A	0.91
	1990 to 1999	24,722	B	32.2	B	34.1	A	1.06
	2000 to 2009	26,976	B	22.0	A	31.1	B	1.42
	2010 or later	6,530	C	6.6	B	7.3	B	1.10
Canada	Total	482,402	A	803.1	A	915.2	A	1.14
	Before 1920	27,108	B	38.9	B	45.5	B	1.17
	1920 to 1959	86,760	A	109.6	A	136	A	1.24
	1960 to 1969	51,004	A	111.3	A	127.6	A	1.15
	1970 to 1979	95,861	A	152.7	A	181.7	A	1.19
	1980 to 1989	69,096	A	139.5	A	139.4	A	1.00
	1990 to 1999	68,978	A	117.8	A	135.8	A	1.15
	2000 to 2009	64,112	A	94.7	A	110.8	A	1.17
	2010 or later	19,483	B	38.7	C	38.5	B	0.99

Footnotes:
*"Other activity or function" includes all other commercial/institutional buildings.

Legend:
Quality Indicators (QI) classify each estimate according to its quality as follows: A–20% or less, B–between 20% and 30%, C–between 30% and 40%, and F–more than 40%.

8 Trial projects

Project 1 – Residential Hybrid Heating System Evaluation.

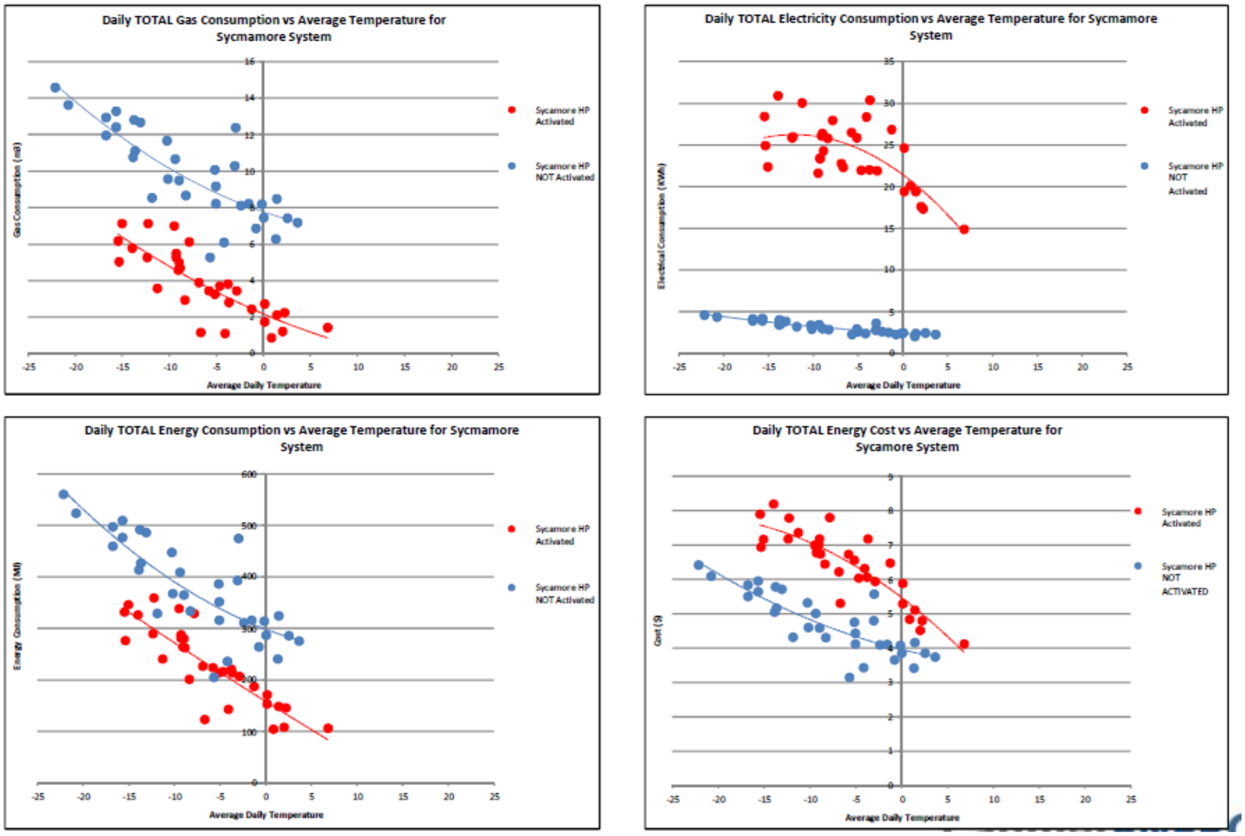
CanmetENERGY in Ottawa has been monitoring a Residential Hybrid Heating System at a builder show home (Sycamore) in the Orleans region of Ottawa. The home is one of three, Elderberry, Sycamore and Walnut, where the Elderberry and Walnut homes have conventional heating and the Sycamore has the hybrid heating system (Figure X). The gas only heating transition temperature was set as -15 °C.

Specifications	**Elderberry**	**Sycamore**	**Walnut**
Area (sq")	1674	2317	3218
Volume (m^3)	577.4	803.9	1139.56
Bedrooms	3	3	3
Bathrooms	3	3	3
Furnace Model	Lennox EL 195UH0	Dettson Chinook	Lennox EL 195UH0
Furnace Heating Output	42,000		85,000
Furnace Blower Fan Power (HP)	1/2		3/4
Zoning	NO	YES	NO
Heat pump	NO	YES	NO
Duct System	Traditional	Dettson (Smart Duct)	Traditional

Houses being monitored.

The results to date show that operating the heat pump can reduce overall energy consumption, but in Ontario, the operating cost is higher (Figure Y).

Heat Pump Mechanical Performance



Energy Consumption and Energy Cost With the heat pump operating (Red) and without the heat pump Operating (Blue).

The average total energy consumption was reduced by 39% but the total energy cost was increased by 36%.

If the heating transition temperature were to be set at a higher temperature, e.g. +5 °C, The hybrid heating system would be economic in Ontario, but the GHG emissions would be a lot higher. In other provinces the results could be very different.

Project 2- Commercial Hybrid Heating System Evaluation.

CanmetENERGY in Ottawa is preparing to evaluate a Commercial Hybrid Heating System in a Small Office application.

In 2010, CanmetENERGY in Ottawa had purchased and arranged the installation of a modulating condensing, heating only, Roof Top Unit (RTU) in parallel with the existing building HVAC system that includes two Lennox two-stage, mid-efficiency rooftop units. The two systems could be isolated from each other and operated independently after a manual switch-over. A comparative performance evaluation of the two heating systems was conducted by periodically switching from one heating system to the other. Both heating systems had their means of ventilation disabled, i.e. sealed shut, because of occupant comfort complaints (An old HRV unit attached to the ductwork had also been removed).

The condensing rooftop unit showed significant energy savings (beyond the nominal 10% equipment efficiency difference), however, cost savings were not enough to provide a reasonable payback in this case (because of the relatively low heating load). The original HVAC system also included 6 Tons of air conditioning, which the condensing rooftop did not have.

Our proposed project; "**Demonstration of a Hybrid Condensing Roof-Top / Electric Heat Pump Unit in a Small Office Application"**, has the following overarching objective, i.e. Recommendations will be made with regards to the feasibility of retrofitting heat pumps in commercial heating systems, with a view to promoting the use of commercial hybrid heating systems.

Proposed Evaluation
We are proposing that the condensing rooftop (heating only) be re-commissioned and upgraded into a hybrid commercial heating system (heating & cooling), through the addition of 4 x 1.5 ton cold climate mini-split heat pumps, installed within the rooftop casing.

There are several reasons for doing this:
- To raise the heating system operating COP to greater than 1.0

- The combined use of the condensing rooftop (for the coldest weather) and the electric heat pump for milder weather will raise the system efficiency from 90% to 98 % to a higher COP possibly as high as 1.5
- To increase the system cooling SEER from 14 to closer to 20.
- The mini-split heat pumps utilised, have a lot better modulation and are a lot more efficient than the cooling units utilised in most commercial equipment.
- To demonstrate that gas & heat pump will work together on a commercial scale.
- This could be the first commercial size hybrid heating system demonstrated in Canada. The technology has the potential to significantly reduce GHG emissions from commercial heating systems.
- To improve occupant comfort in both the heating and cooling season.
- One issue experienced by the occupants of Building 1A, is the cooling of the air in the ductwork during off-cycles and the subsequent blast of cold air delivered when the heating cycle re-starts. Because the heat pumps will be able to operate at a low heating level, the heating on-cycles can be extended, with a minimisation of the off-cycles.