Canada's Path to Paris Targets

Forecasting Buildings GHG Emissions in Canada for Period 2019 to 2030

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Buildings Sector

Executive Summary Showing Results and Conclusions

Conclusions of Forecast for Emissions from Buildings

- The model forecasts emissions from the three categories of buildings, namely residential, commercial and industrial

- The Environment and Climate Change Canada (ECCC) released the Emissions Reduction Plan (ERP) in late March 2022
  - the ERP stated an emissions target in 2030 for buildings of 53 million tons (MT) of greenhouse gas (GHG) emissions

- The model forecasts emissions from buildings in 2030 as follows

	2019	ERP 2030 Target	Model 2030 Forecast
Residential	43	25	42
Commercial	33	18	31
Industrial	15	10	13
Total	91	53	86

- The conclusion from the model is that 2030 emissions from buildings will exceed the 2030 target in the Emissions Reduction Plan by 33 MT

Conclusions of Forecast for Emissions from Buildings

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Reasons why Model Forecasts ERP 2030 Target for GHG Emissions will Not be Met

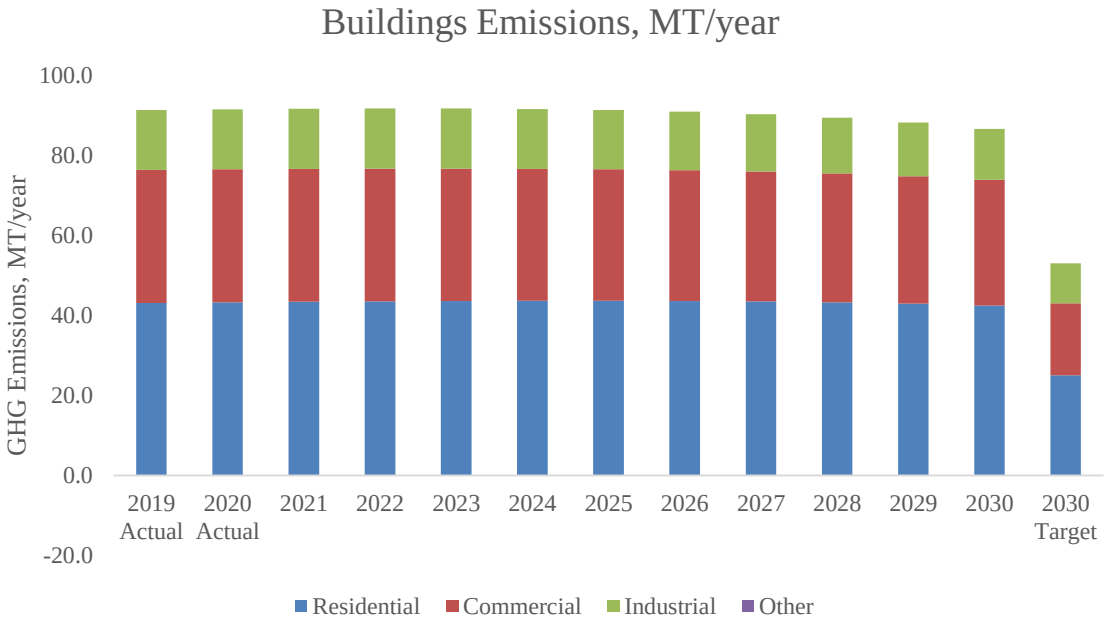
- The major tool to lower emissions is to replace hydrocarbon fuels (natural gas, heating oil and wood) with electricity supplying heat pumps, electrical baseboards and furnaces

- The model concludes that even assuming a dramatic increase in heat pump installations (25% annual growth from 2019 to 2030 versus historical 2.5% growth), not enough heat pumps are installed to make a meaningful decrease in the total area of buildings heating by hydrocarbon fuels
  - residential heat pumps and electricity supply in 2030 of 320,000 just balances new builds of 320,000, leaving none for retrofits

- Numbers of building supplied by hydrocarbon fuels in 2030
  - Residential — Units still using hydrocarbon fuels increase from 10.2 million in 2019 to 11.5 million in 2030
  - Commercial — Only 7% of commercial area converted to heat pumps
  - Industrial — Only 24% of industrial area converted to heat pumps

Forecast of Buildings Emissions for Period 2020 to 2030

- Emissions of 91 MT in 2019 are forecast to drop to 86 MT in 2030, or 33 MT above the 53 MT target in the 2030 ECCC ERP.



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Methodology of Model

Methodology of Model Used to Forecast Emissions of the Buildings Sector

- This presentation uses a model developed to make a specific forecast of GHG emissions for the building sector
  - it is used to draw the conclusions of a specific number for GHG emissions, and to comment on why this number is the result
  - An Intelligence Memo (IM) dated December 23, 2022 summarizes these conclusions
  - This presentation provides the analytical backup for the IM
  - Both documents are on the C.D. Howe Institute website

- This presentation is a different piece of work from the October 11 2022 IM done by Charles DeLand on emissions from buildings that focussed on residential housing (also on the C.D. Howe Institute website)
  - This earlier IM opined that Canada's emissions targets for buildings would not be met, but did not give a specific forecast. This IM attempts to make a specific numerical forecast for emissions from all buildings.

Methodology of Model Used to Forecast Emissions of the Buildings Sector

- Model starts with data from three Government of Canada sources
  - Emissions Reduction Plan (ERP) dated March 29 2022 from ECCC
  - National Inventory Report dated April 14 2022
  - Various NRCan websites

- These three documents are used to set the 2019 emissions and the 2030 target for emissions for the three subsectors that comprise the buildings sector
  - Residential
  - Commercial
  - Industrial

- Model then makes assumptions for the period 2019 to 2030
  - building area in 2019,
  - Supply from hydrocarbons, heat pumps and other electrical supply
  - Growth rate for area, supply from heat pumps for three subsectors

- Model then calculates GHG emissions for the three subsectors

Key Variables for Buildings sector

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Key Variables

- Area coverage of
  - residential buildings
  - commercial buildings
  - industrial buildings
- Future growth of area of buildings
- Emissions intensity per unit area of buildings
- Current source of energy for buildings
  - natural gas
  - electricity
  - heat pumps
- Emissions for various types of energy source
- Rate of future adoption of electricity and heat pumps

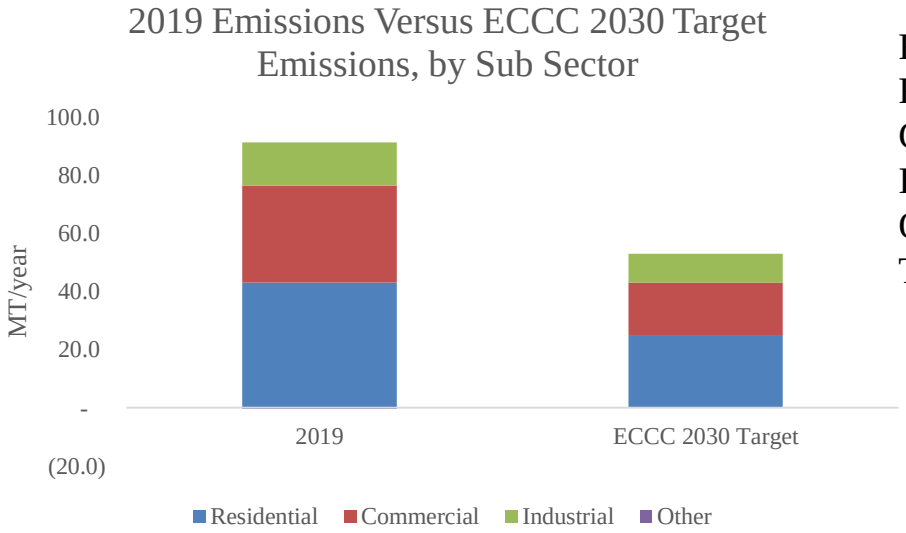
Methodology of Model Used to Forecast Emissions of the Buildings Sector

- The final result is a forecast of the total emissions of the entire building sector for each year from 2019 to 2030, broken down by each of the three sub sectors

Summary of 2019 Emissions and 2030 Targets for Buildings in Canada

Summary of ECCC 2030 Target Emission Reductions for All Sub Sectors

- ECCC 2030 Target of 53 MT assumes 38 MT reduction from the 2019 Emissions of 91 MT
- The numbers shown below are a reasonable allocation amongst these sub sectors of this 38 MT reduction
- Greatest reductions are for residential and commercial buildings



Factor analysis	
Residential	-18.0
Commercial	-15.0
Industrial	-5.0
Other	0.0
Total	-38.0

Summary of Forecast for Meeting Emissions Targets for Buildings

Building Emissions, MT

Sub Sector	2019	ECCC 2030 Target
Residential	43	25
Commercial	33	18
Industrial	15	10
Other	0	0
Total	91	53

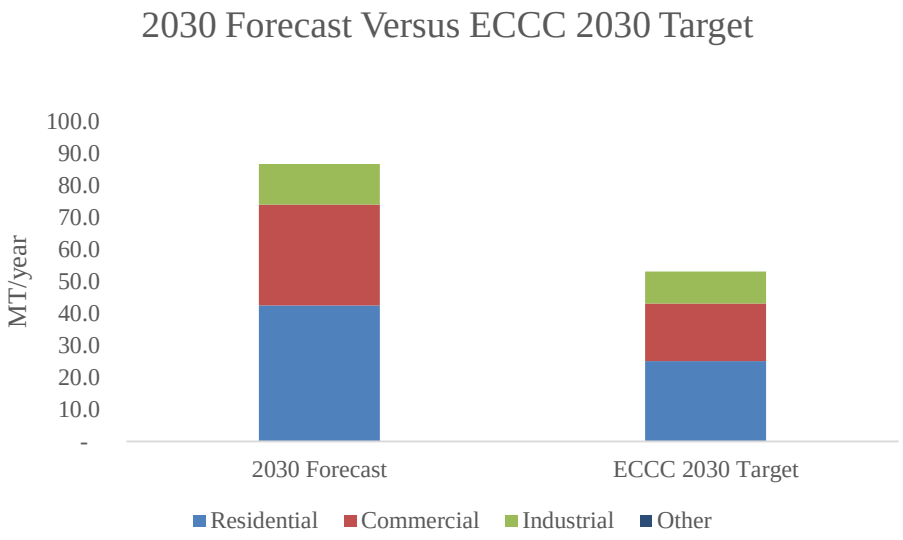
Notes:

1. 2019 emissions are from April 14 2022 National Inventory Report
2. ECCC 2030 Target emissions assume reductions in all three sub sectors

Summary of Emissions Reductions Forecasted by Model

Summary of Total Emission Reductions by 2030 for All Sub Sectors

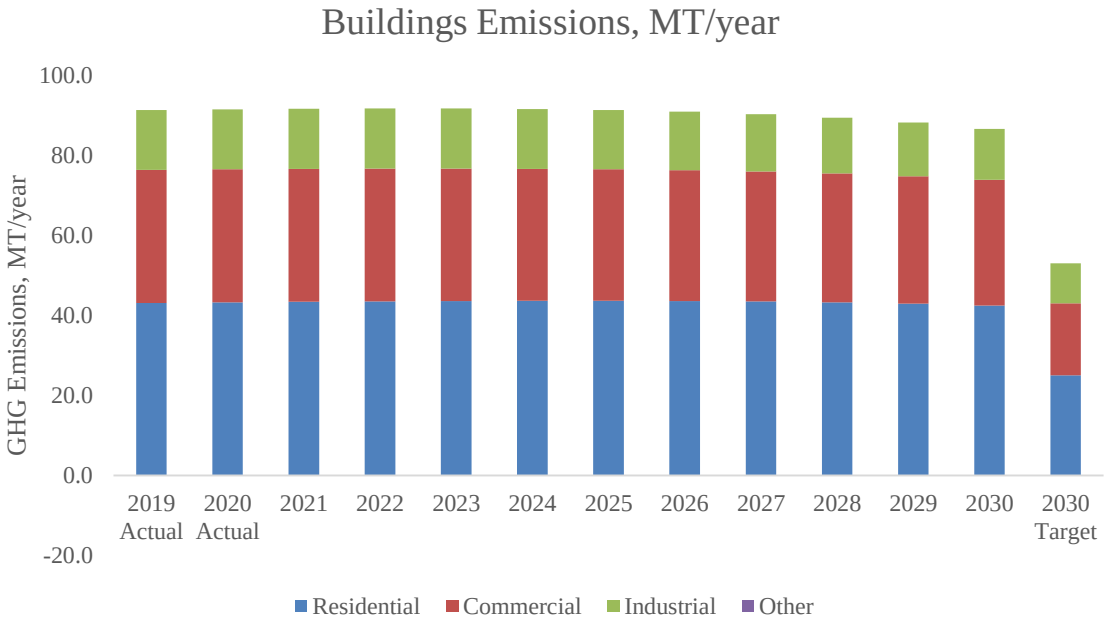
- Forecast from model shows total emissions in 2030 of 86 MT versus ECCC 2030 target of 53 MT, a shortfall of 33 MT
- Shortfall is largest for residential and commercial buildings



Factor analysis	
Residential	-17.0
Commercial	-13.0
Industrial	-3.0
Total	-33.0

Forecast of Buildings Emissions for Period 2020 to 2030

- Emissions of 91 MT in 2019 are forecast to drop to 86 MT in 2030, or 33 MT above the 53 MT target in the 2030 ECCC ERP.



Summary of Various Methods of Reducing Emissions Used by Model

Key Variables for Buildings sector

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Key Variables and Methods to Reduce Emissions

- Area coverage of
  - residential buildings
  - commercial buildings
  - industrial buildings
- Future growth of area of buildings
- Emissions intensity per unit area of buildings
- Current source of energy for buildings
  - natural gas
  - electricity
  - heat pumps
- Emissions for various types of energy source
- Rate of future adoption of electricity and heat pumps

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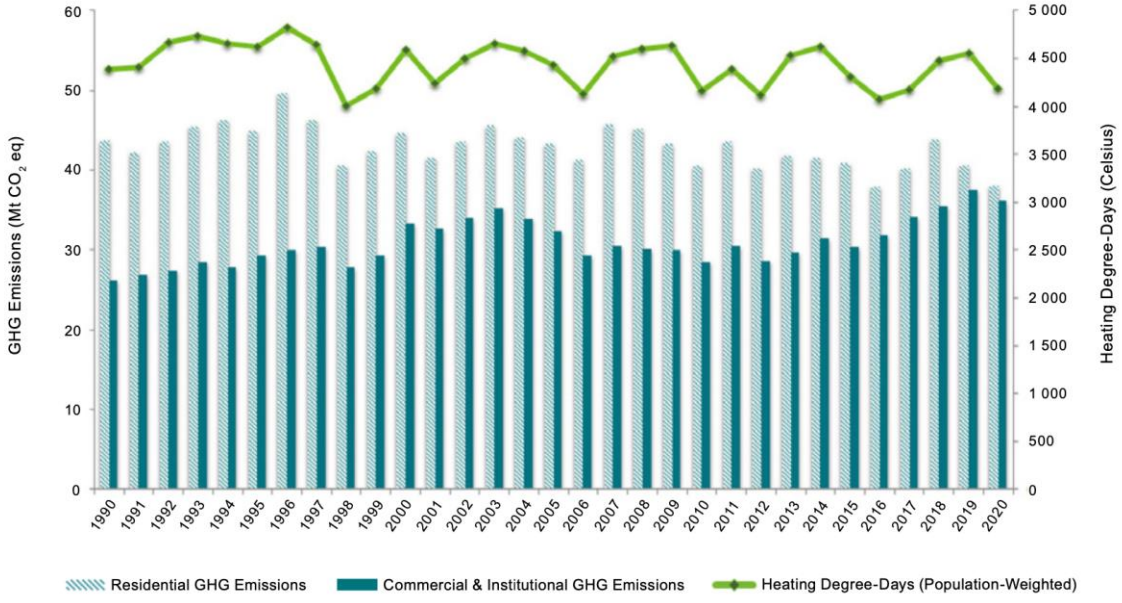
Detailed Material and Data in Model

Historical Emissions from Residential and Commercial Buildings

- Residential emissions are flat, commercial emissions are rising

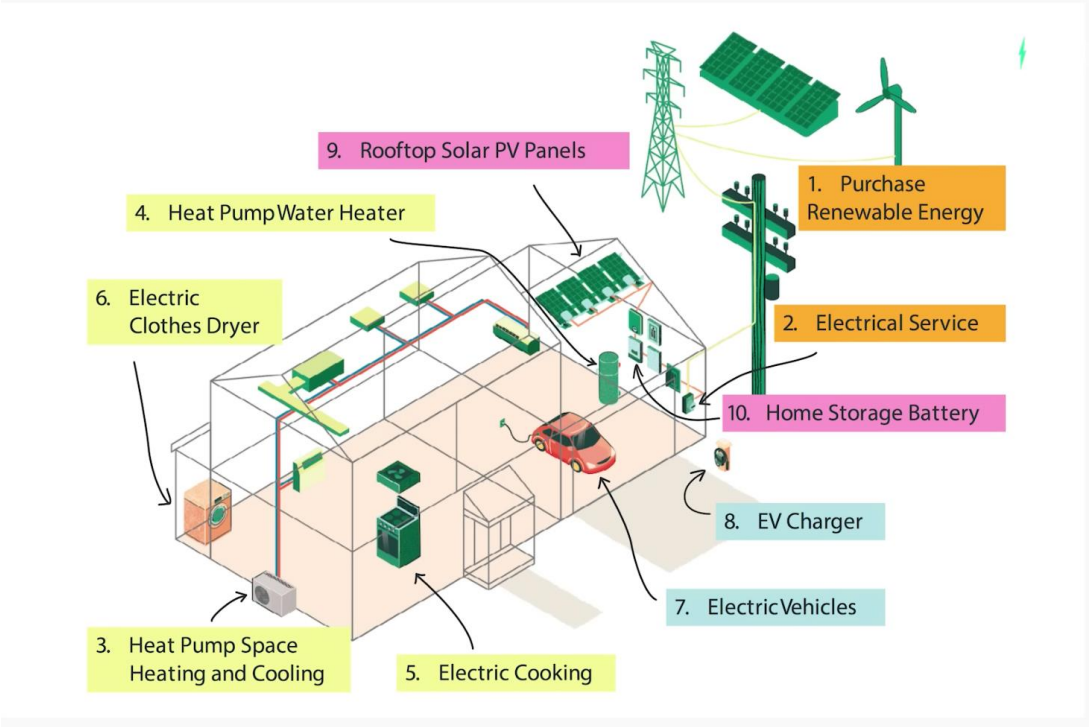
Figure 2–14 **Heating Degree-Days (HDDs) and GHG Emissions from the Residential and the Commercial and Institutional Subcategories (1990–2020)**



Source: NIR April 14 2022

Residential Buildings Future Conversion of Energy Sources

Schematic of an electrified Residential Building

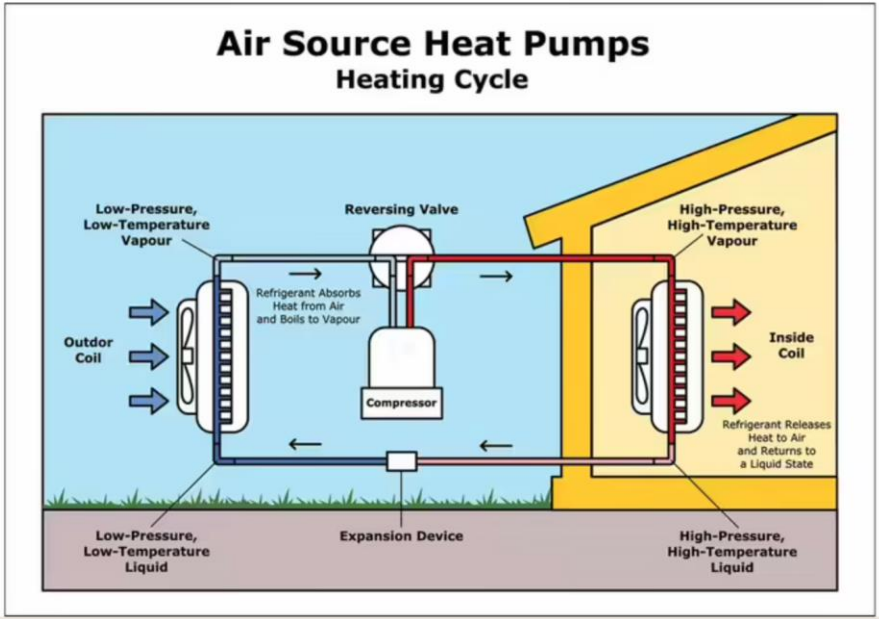


Key features are heat pumps and home storage battery

https://www.youtube.com/watch?v=gpGMjwX0c8A

Heat Pumps as a Future Source of Energy for Residential Units

Schematic of Operation of Heat Pumps



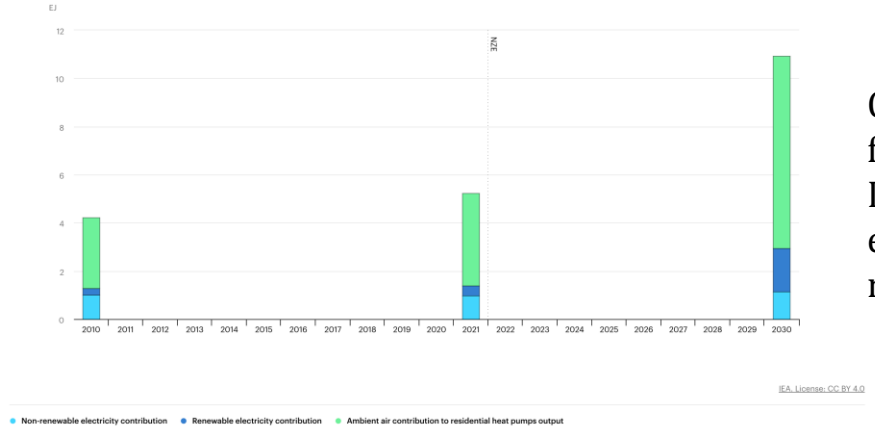
This illustration shows how an air-source heat pump takes heat from the air outside your home and pumps it inside through refrigerant-filled coils. SLAVE SPB/SHUTTERSTOCK

- A heat pump uses electricity to operate a compressor that moves vapour from cold temperatures into warmer inside environment

https://home.howstuffworks.com/home-improvement/heating-and-cooling/heat-pump.htm

Usage and Efficiency of Heat Pumps

- The advantage of heat pumps is that rather than directly creating heat, they exchange energy, extracting heat from an outside source and pumping it into a space
- Heat pumps can supply the same amount of useful heat with one-third to one-fifth of the electricity used by conventional electric equipment.
- Heat pumps could replace gas boilers and supply more than 80% of global space and water heating demand

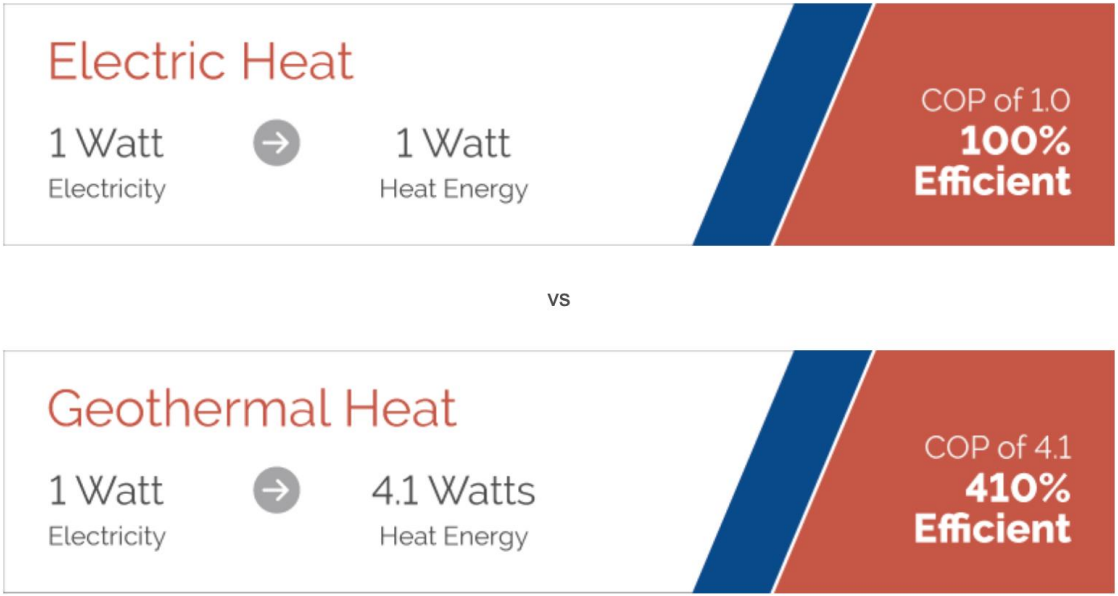


Green bar shows energy moved from ambient air to inside unit. Dark blue bar is renewable electricity, light blue bar is non renewable electricity.

Source: https://www.iea.org/reports/heat-pumps

Usage and Efficiency of Heat Pumps

- Heat pumps use less energy than heating by direct electricity systems such as baseboard heating or electric furnaces
  - the extra 3.1 units of energy come from the heat in the external source



Source: https://www.nordicghp.com/commercial-heat-pumps/

Capacity of Heat Pumps

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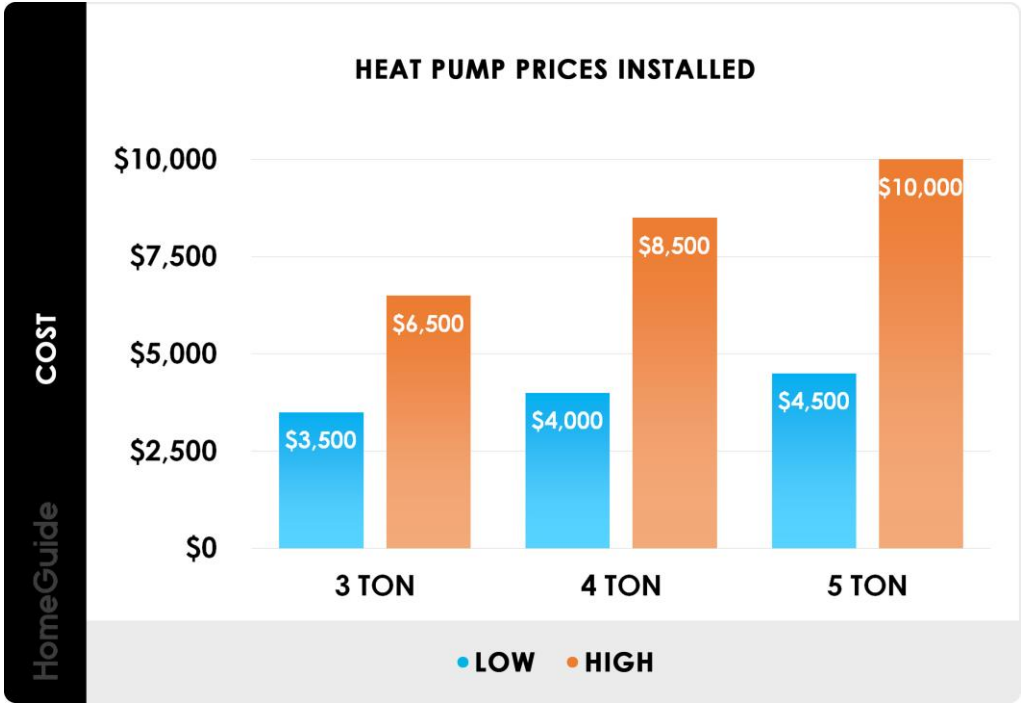
Heating Capacity of Heat Pumps

- Heat pump capacity is measured in “tons of refrigeration,” and one ton is the equivalent of 12,000 British Thermal Units (BTUs) per hour
- Table below shows the heat pump capacity required for various sizes of residential buildings

Home size (in square feet)	Heat pump size (in tons)	Heat pump size (in BTUs)
500 square feet	1 ton	12,000 BTUs
1,000 square feet	2 tons	24,000 BTUs
1,500 square feet	3 tons	36,000 BTUs
2,000 square feet	4 tons	48,000 BTUs
2,500 square feet	5 tons	60,000 BTUs
3,000 square feet	6 tons	72,000 BTUs

Source. https://www.cnet.com/home/energy-and-utilities/heres-how-to-pick-the-right-size-heat-pump-for-your-home/

Cost of Heat Pumps



Source. https://homeguide.com/costs/heat-pump-cost

Efficiency of Heat Pumps

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Current Heat Pumps Installed in Residential Units in Canada

- Heat pumps are less efficient at heating when it is very cold outside.
- Cold-climate, air-sourced heat pumps have been developed for places like Canada.
- These heat pumps cost more, but are more efficient at lower temperatures
- Rapid reductions in emissions from electricity supply and increased technology efficiency for heat pumps means lower CO_2 emissions than natural gas-fired boilers before 2025

Source. https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2019/market-snapshot-growing-heat-pump-adoption-how-does-technology-work.html

Current Usage of Heat Pumps in Residential Units

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Global

- About 190 million heat pump units were in operation in buildings worldwide in 2021, supplying about 10% of global heating needs in buildings

- IEA forecast has 600 million heat pumps by 2030, covering at least 20% of global heating needs.

Canada

- In 2016, there were 767 000 heat pumps in Canada; most of them in Ontario and Quebec

- Baseboard heaters increased from 2,933,000 in 1990 to 4,390,000 in 2016

- New central air-sourced heat pump system would cost close to $14 000, while a baseboard heating system would be $2 300
  - heat pumps are eligible for grant of up to $5,000
  - heat pumps now eligible for 30% investment tax credit as of Nov 2022

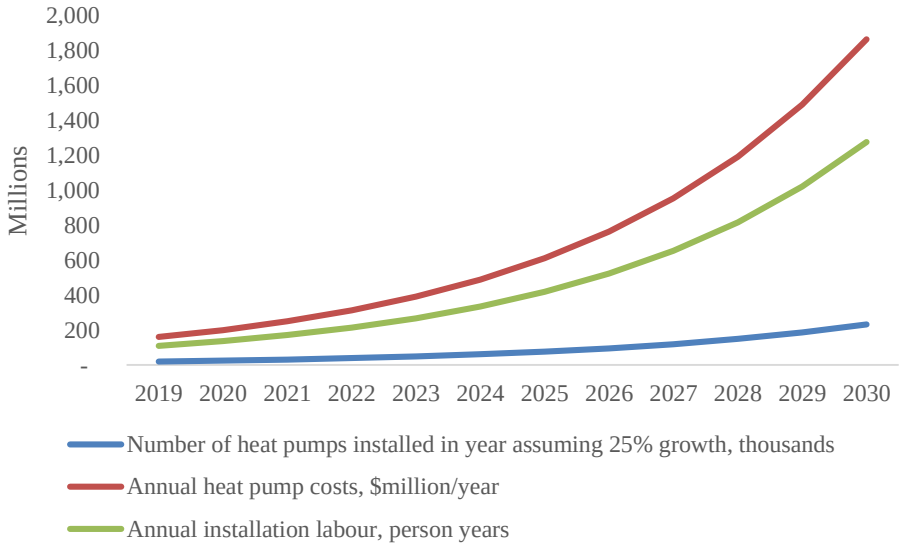
Source. https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2019/market-snapshot-growing-heat-pump-adoption-how-does-technology-work.html

Installation of Heat Pumps

- "A new heat pump costs $3,800 to $8,200 to install on average, depending on the size, efficiency rating, brand, and type. An air-source heat pump costs $4,000 to $8,000".
- All in, cost to install a typical heat pump is about $8,000.
- Estimate is 2 days to install a heat pump
- Assuming 25% annual growth in heat pump installation starting with 20,000 in 2019, this means about 230,000 heat pumps installed per year in 2030

Source. https://homeguide.com/costs/heat-pump-cost

Installation of Heat Pumps

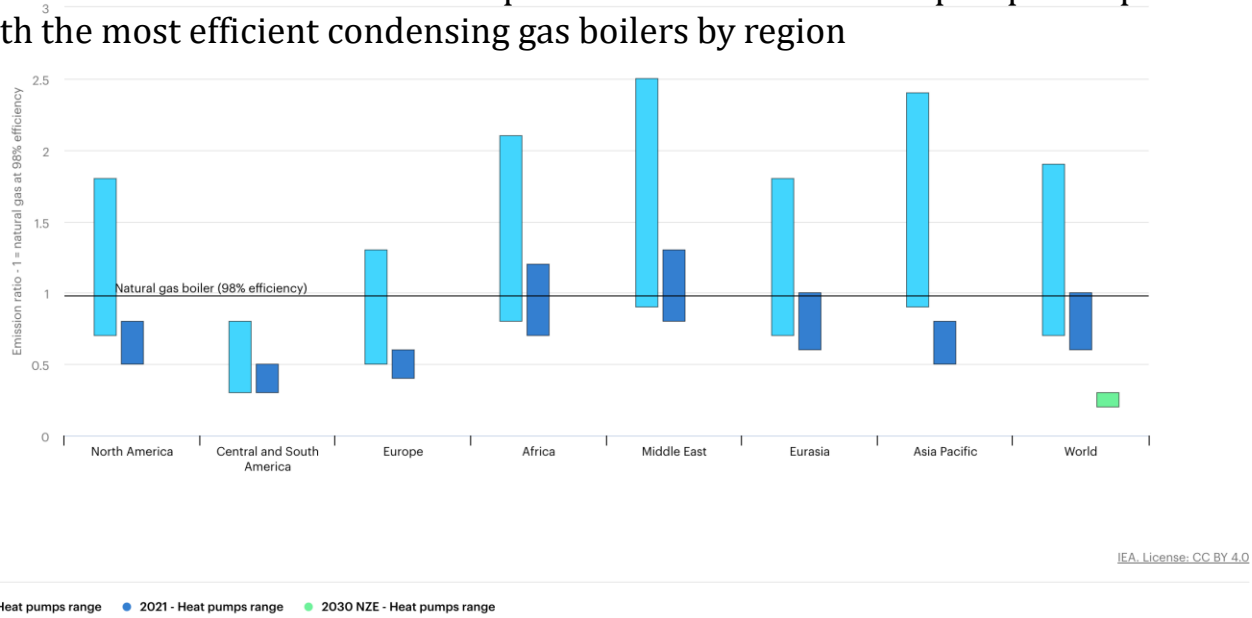


- Dramatic (25% per year) growth in heat pump installations increases from 20,000 per year in 2019 to over 230,000 per year in 2030
- This implies annual numbers in 2030 of over $1.8 billion cost of installation and over 1,200 person years of trades labour to install

Source. https://homeguide.com/costs/heat-pump-cost

Emissions from Heat Pumps

Relative CO2 emissions from the operation of air-source heat pumps compared with the most efficient condensing gas boilers by region



- Emissions from heat pumps will drop as emissions from electricity drop.

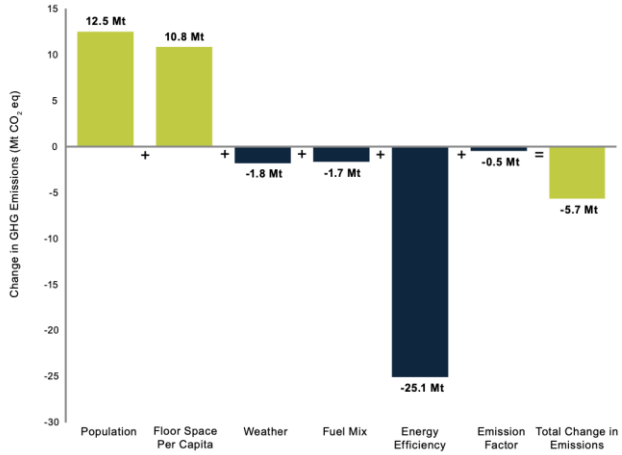
Source: https://www.iea.org/data-and-statistics/charts/relative-co2-emissions-from-the-operation-of-air-source-heat-pumps-compared-with-the-most-efficient-condensing-gas-boilers-by-region-in-the-net-zero-scenario-2010-2030

Residential Buildings

Past History of Emissions from Residential Buildings

- From 1990 to 2020, increasing population and floor space per capita is offset by energy efficiency (better insulation and more efficient natural gas furnaces).

Figure 2–12 **Factors Contributing to the Change in Stationary GHG Emissions from the Residential Category between 1990 and 2020**



Notes:

Floor space and population – Floor space refers to the change in total floor area over time. In the case of the residential sector, floor space is further broken down into the change in population and the change in floor space per capita.

Weather – Weather refers to the fluctuations in weather conditions, particularly outdoor winter temperature.

Fuel mix – Fuel mix refers to the relative share of each fuel used to provide heating.

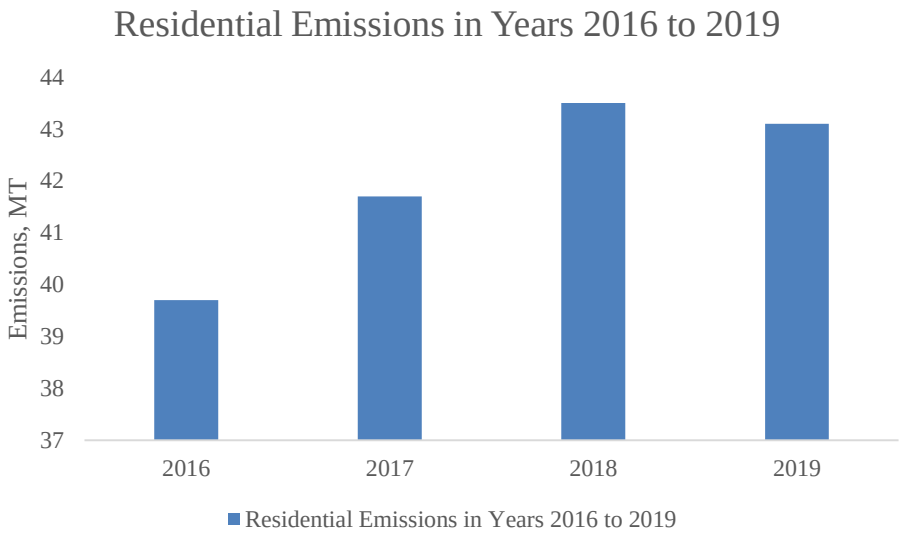
Energy efficiency – Energy efficiency refers to the efficiency of the buildings and heating equipment.

Emission factors – The emission factor effect reflects changes to where fuels are sourced and their energy content over time.

Source: NIR April 14 2022

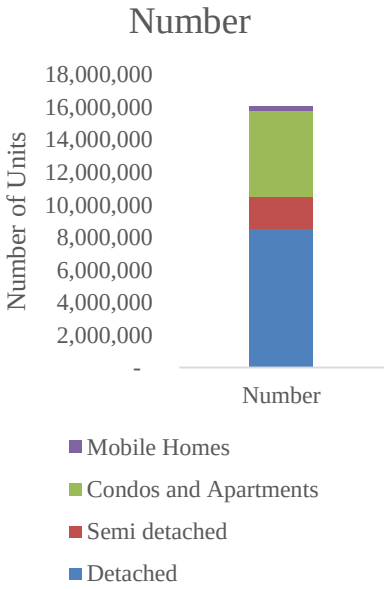
Historical Emissions from Residential Buildings

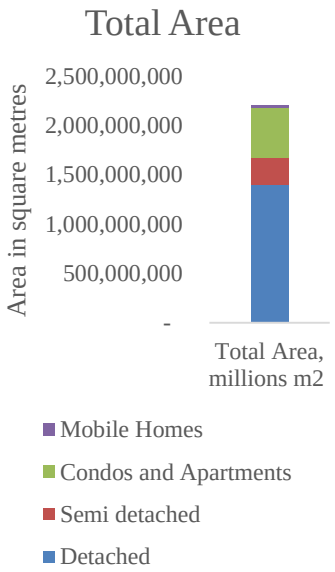
- A majority of space heating and water heating requirements are currently supplied by natural gas
- Emissions have risen by 7% in last four years from 40 MT to 43 MT
- Emissions intensity is about 0.02 T/square meter

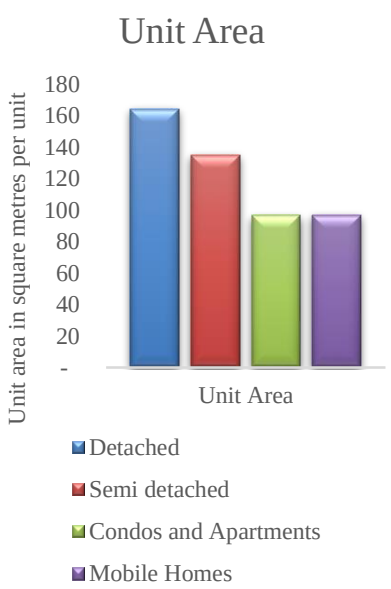


Data for Residential Buildings in 2019

Number, Total Area and Unit Area for Different Types of Residential Buildings in 2019



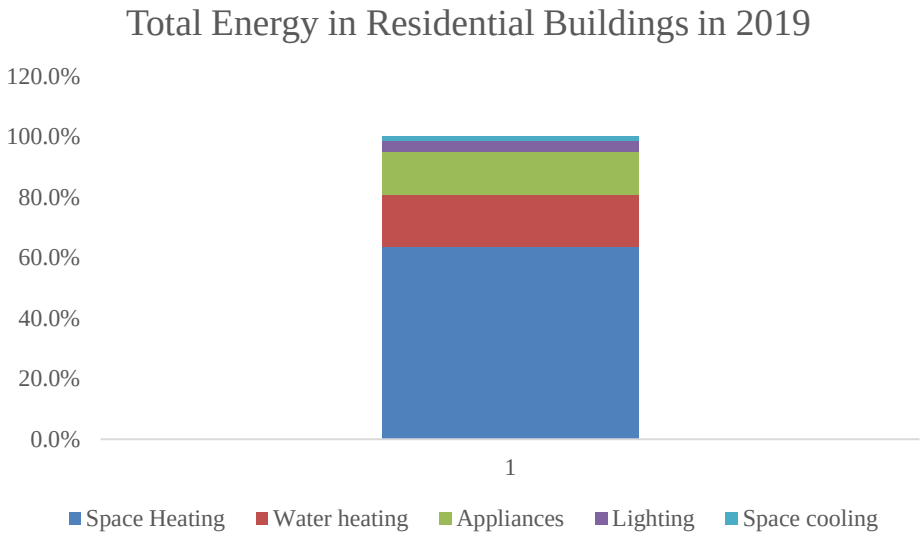




- Detached houses make up majority of number and total area, with largest unit area, condos and apartments are second, but with smaller unit area

Source: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=25&page=0
https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=26&page=0

Uses of All Energy in Residential Buildings in 2019 by Activity



- 63% of energy use in residential buildings is for space heating, and 17% for water heating, fueled by natural gas, heating oil and electricity
- Balance of 20% is for appliances, lighting and space cooling, almost all of which is fueled by electricity

Source: NRCan, https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=2&page=0

Sources of All Energy in Residential Buildings in 2017 by Region

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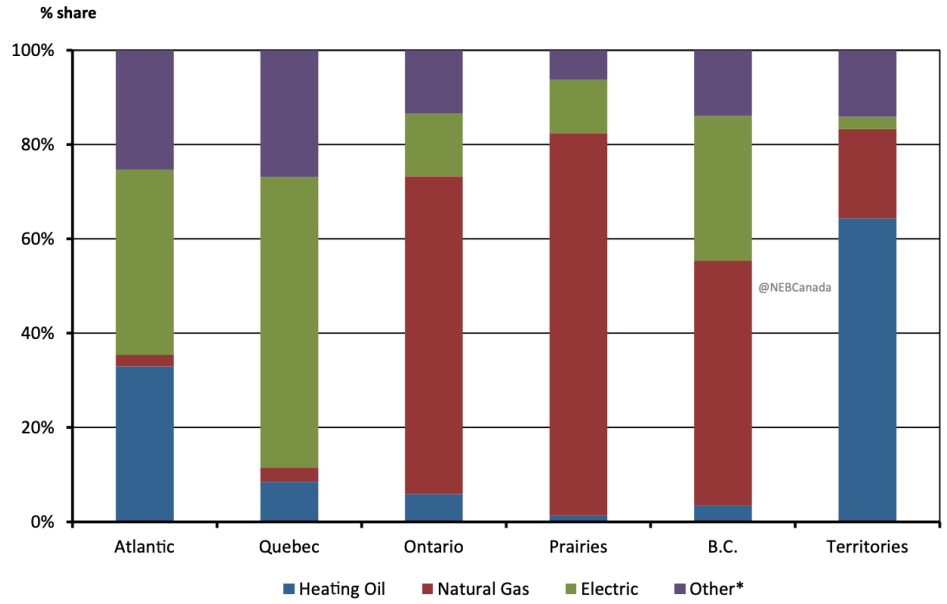
FIGURE 4.7

Share of Residential Heating System Type by Region, 2014



*Other includes wood, heat pumps and dual fuel systems such as wood combined with electric

Source: Natural Resources Canada

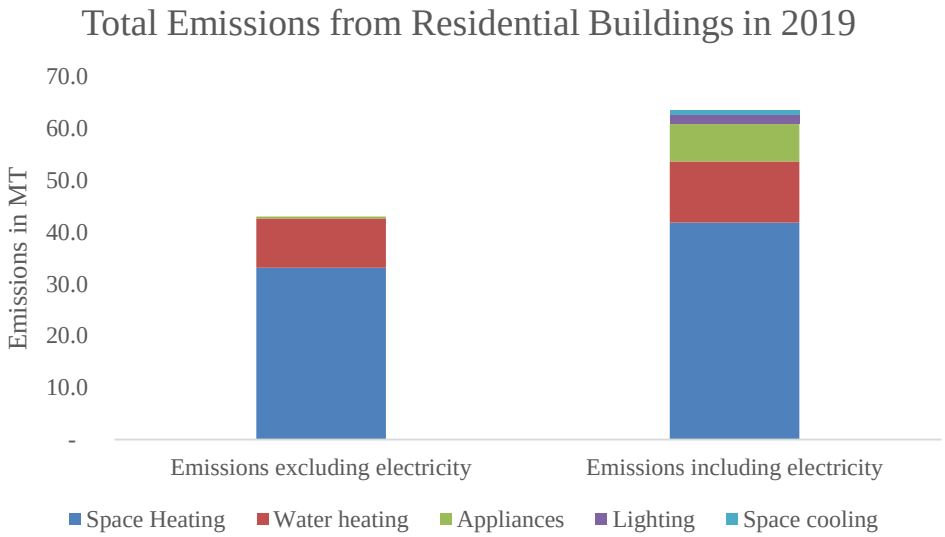
Electricity supplies more than 50% of Quebec

Natural gas supplies more than 50% of Ontario and Prairies

Heating oil supplies almost 40% of Atlantic

Source: https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/archive/2017/2017nrgftr-eng.pdf

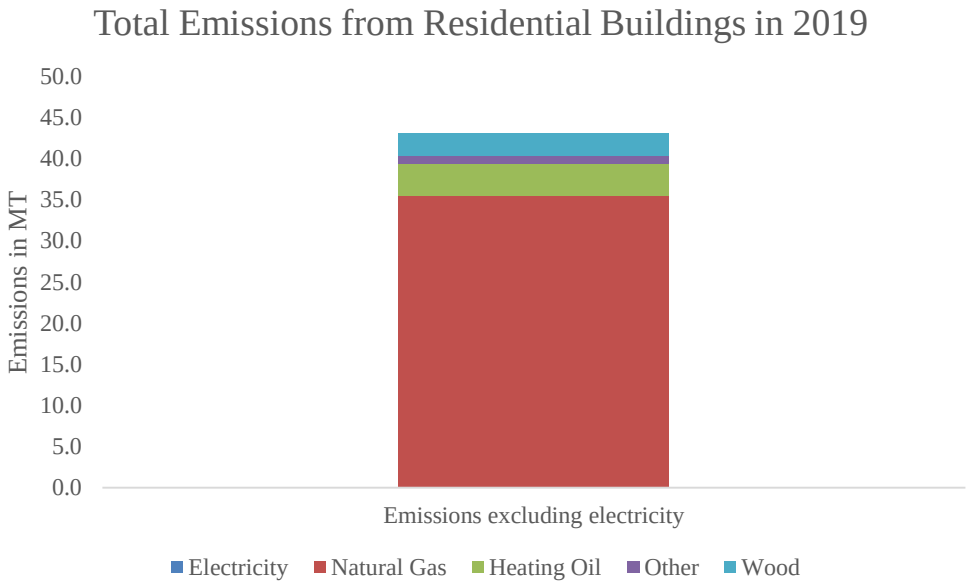
Emissions from Residential Buildings in 2019 for all Energy Used by Activity



- Assumption is that emissions from electricity are counted in the Electricity sector, so are not counted in Residential Building subsector (ERP confirms this)
- Correct number to use is for emissions excluding electricity (about 43 MT in 2019, mostly from space heating and water heating from natural gas)

Source: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=2&page=0

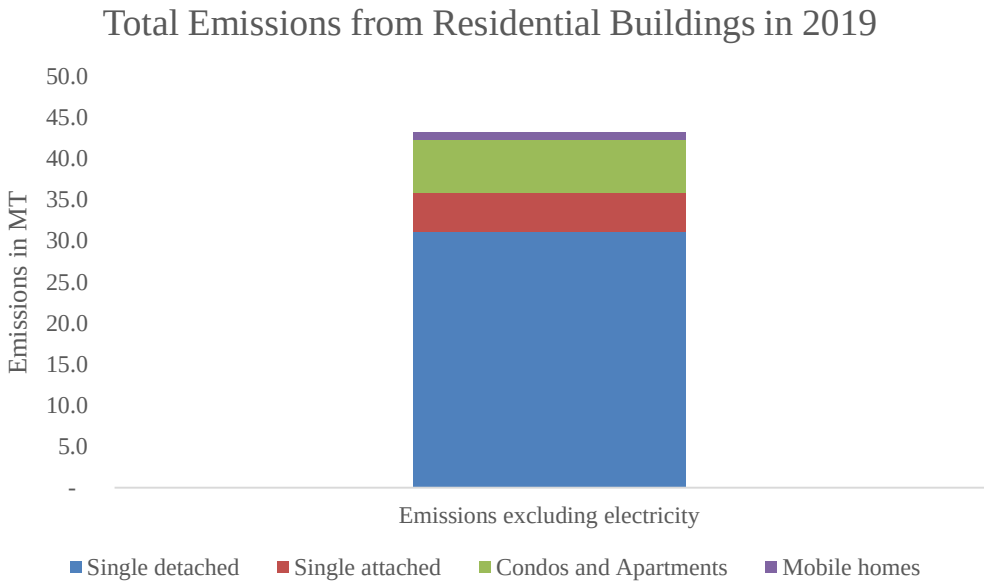
Emissions from Residential Buildings in 2019 for all Energy Used by Source of Energy



- Most emissions are from natural gas and heating oil

Source: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=AN&sector=aaa&juris=00&rn=2&page=0

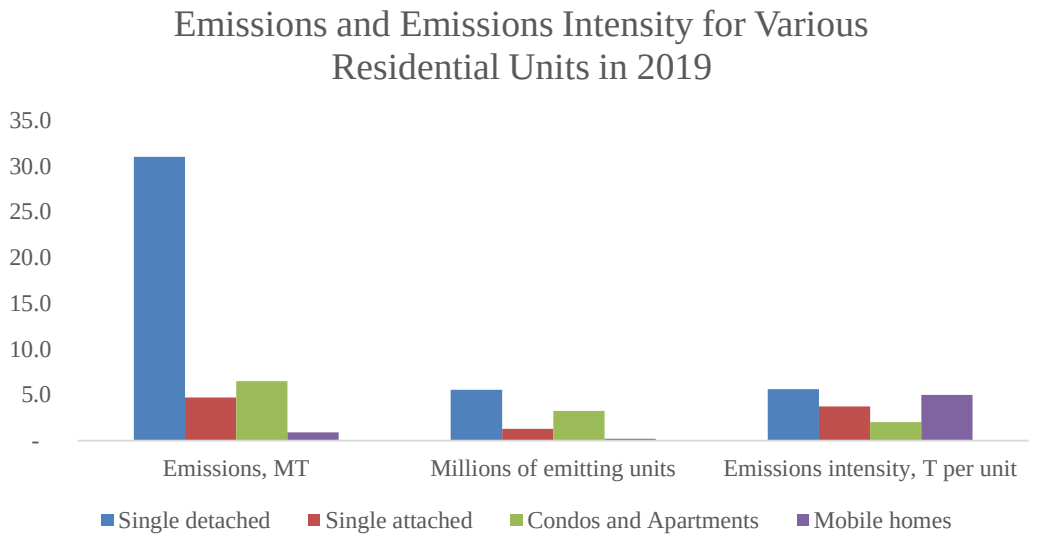
Emissions from Residential Buildings in 2019 for all Energy Used by Type of Building



- Most emissions are from detached houses

Source: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=8&page=0

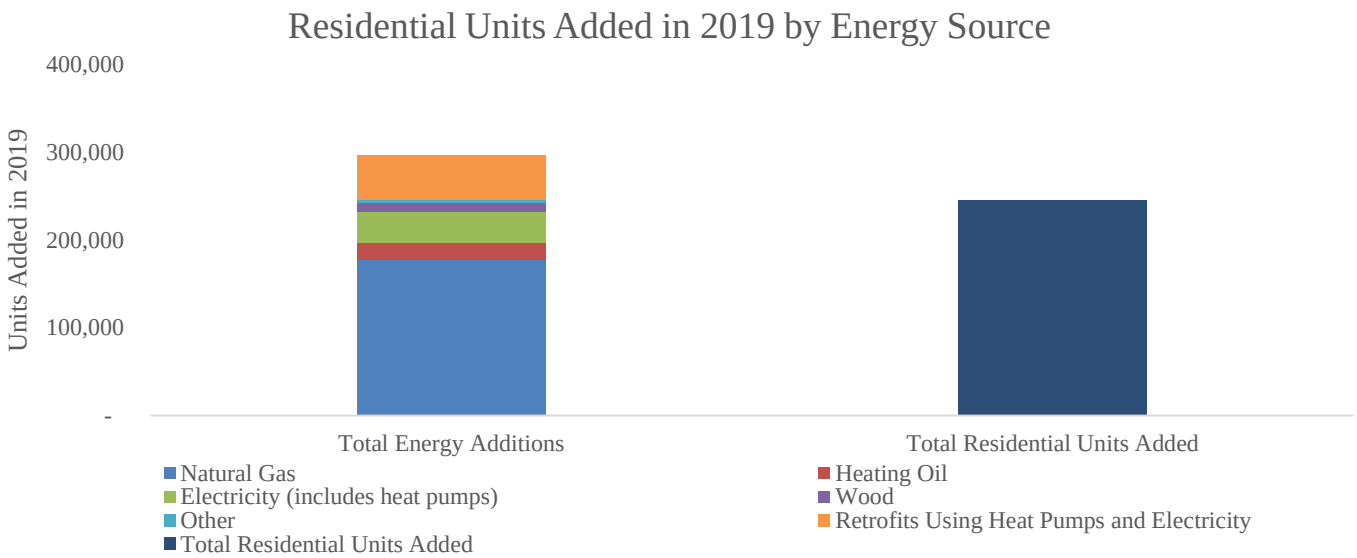
Emissions and Emissions Intensity from Residential Buildings in 2019



- Most emissions are from detached houses (left bars), because they form the largest number of units (middle bars), and each detached unit has the highest emissions intensity per unit (right bar)
- Policy should try to convert single detached units to heat pumps or electricity

Source: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=8&page=0

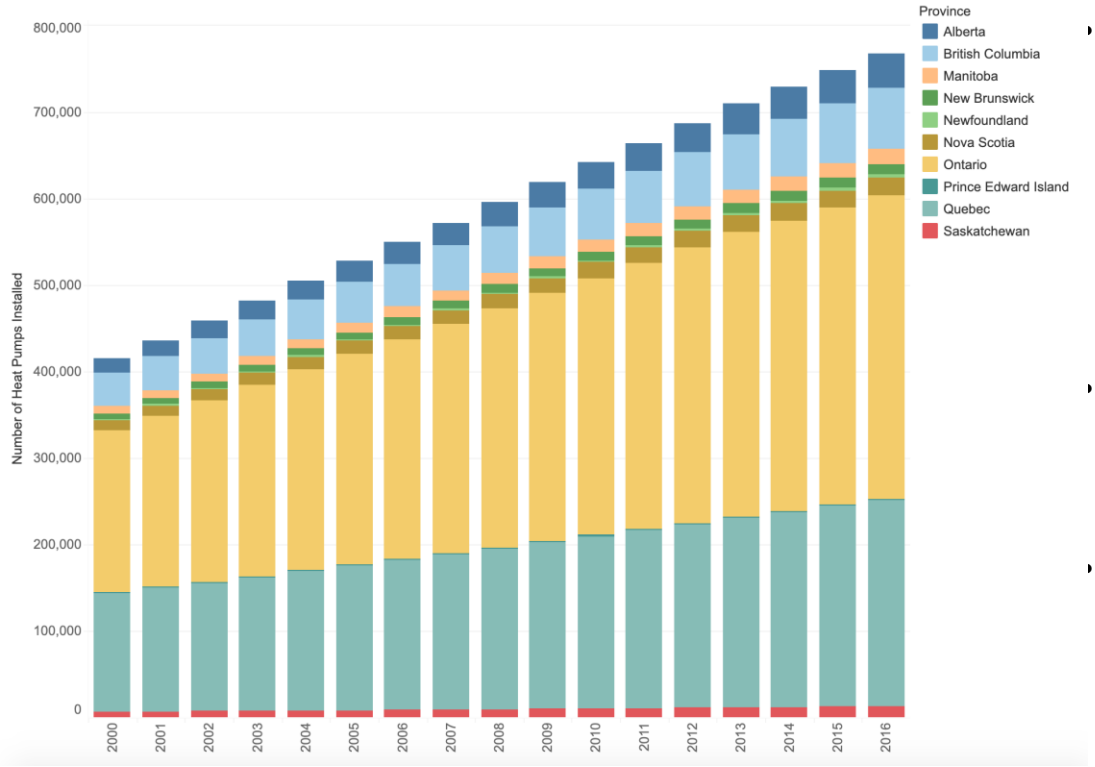
Annual Construction of Various Units of Residential Buildings in 2019



- This chart shows new builds in 2019 were about 246,000 (right bar)
- New builds would be the first and easiest candidates to convert to electric heat pumps instead of gas or heating oil
- But data shows new builds mostly (177,000) heated by natural gas (blue in left bar)
- Heat pumps and electricity were 35,000 in new builds (green) and 51,000 in retrofits (orange)

Source: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=25&page=0
https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=26&page=0

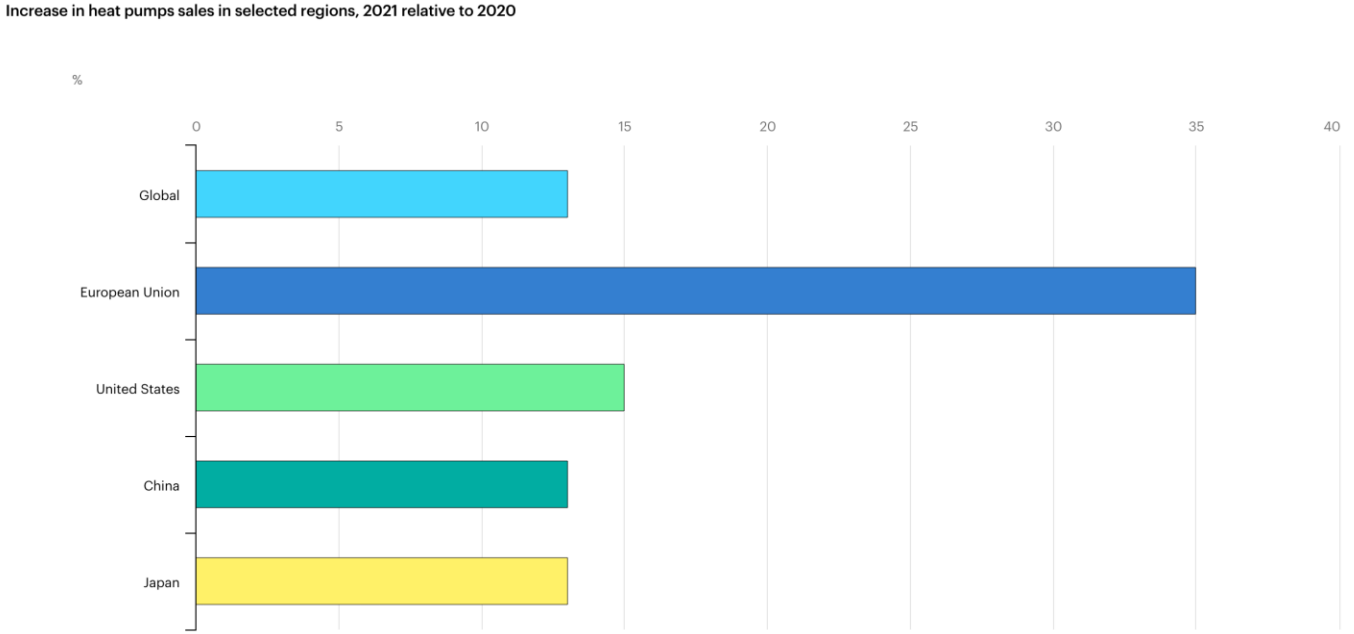
Historical Numbers of Heat Pump in Canada



- Assumption is that most heat pumps are in detached and attached houses.
- About 50% in Ontario and 30% in Quebec.
- Projection is 800,000 units in 2019.

Source. https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2019/market-snapshot-growing-heat-pump-adoption-how-does-technology-work.html

Current Growth Rate of Heat Pump Installations in Various Countries



- Growth rate for heat pumps in the United States is 15% per year

Source. https://www.iea.org/reports/heat-pumps

CER Forecast for Residential Energy Use in 2019 to 2030 Period

- The CER forecast in 2017 entitled Canada's Energy Future used three cases to look at a variety of items, including a forecast of energy use in residential and commercial buildings

- The most aggressive CER scenario (called the Technology Case) assumes heat pumps installations increase to 15% of new heating device purchases in 2025, for both new buildings and retrofits in existing buildings. The share of installations increase to 30% by 2040.

- The Technology Case considers, in addition to higher carbon prices, the impact on the Canadian energy system of greater adoption of select emerging production and consumption energy technologies.

Source. https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/archive/2017/2017nrgftr-eng.pdf(HCP)

Assumptions for Electricity and Heat Pump Installations in 2019 to 2030 Period

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Government Incentives to Use Heat Pumps

- Incentives for heat pumps in residential buildings ($5,000 grant) and commercial and industrial buildings (30% investment tax credit) should increase heat pump installations
- Assumption for model is that growth rate for heat pumps will be 25% per year

Electricity

- Installations in 2019: 65,000 (historical rate of 3% from 2000 to 2019)
- Growth rate in 2019 to 2030 period: 3% (historical rate from 2000 to 2019)

Heat Pumps

- Installations in 2019: 20,000 (historical rate of 2.5%)
- Growth rate in 2019 to 2030 period: 25%

Source: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=20&page=0

Construction of Model to Forecast Emissions from Residential Units in 2019 to 2030 Period

Conclusions to be Drawn from 2019 Data for Residential Buildings

- Total emissions from all residential units are 43 MT excluding electricity

- Natural gas, heating oil, wood and other supply about two thirds of units (about 10.2 million units)
  - 8.3 million natural gas, 1.2 million heating oil. 0.7 wood and other

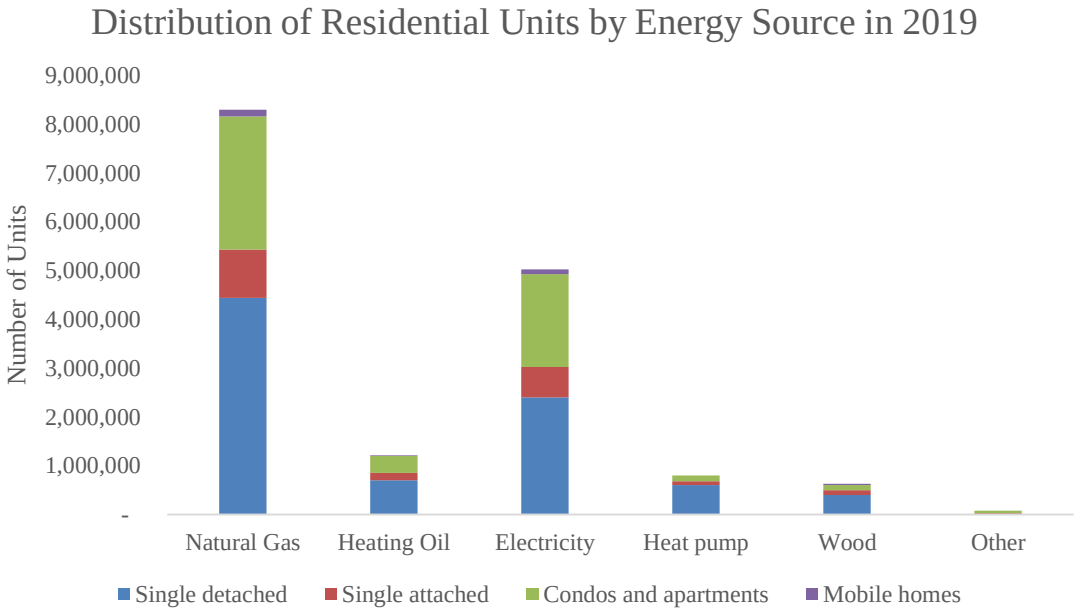
- Largest emissions come from single homes and condo and apartment buildings using energy sources of
  - natural gas used for space heating and water heating in Ontario and Prairie provinces, and
  - heating oil used for space heating in Atlantic provinces

- Electricity supplies energy for about one third of units (about 5.8 million units), mostly in Ontario and Quebec
  - these electricity units include about 5.0 million baseboard heating units and 0.8 million heat pump units in 2019

Source: Shows a reasonable allocation of units to various energy sources

Distribution of Residential Units by Energy Source in 2019

Chart shows sources of energy for all 16 million residential units in Canada in 2019. Natural gas is largest, followed by electricity and heating oil. Heat pumps are about 800,000 units, or 5% of all units



Source: Shows a reasonable allocation of units to various energy sources

Conclusions to be Drawn from 2019 Data for Residential Buildings

- Existing stock of these 16 million units is

- detached homes	8.536 million
- attached homes	1.972 million
- condo and apartment buildings	5.25 million
- mobile homes	0.277 million
- Total	16.035 million

- The breakdown of these units by energy source is estimated to be (millions)

	Electricity	Heat Pumps	Natural Gas	Heating Oil	Wood, Other	Total
Detached homes	2.400	0.600	4.436	0.700	0.400	8.536
Attached homes	0.625	0.080	0.992	0.150	0.125	1.972
Condos and apts	1.900	0.120	2.730	0.350	0.150	5.250
Mobile homes	0.097	0.000	0.135	0.015	0.030	0.277
Total	5.022	0.800	8.293	1.215	0.705	16.035

Source:https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=20&page=0

Conclusions to be Drawn from 2019 Data for Residential Buildings

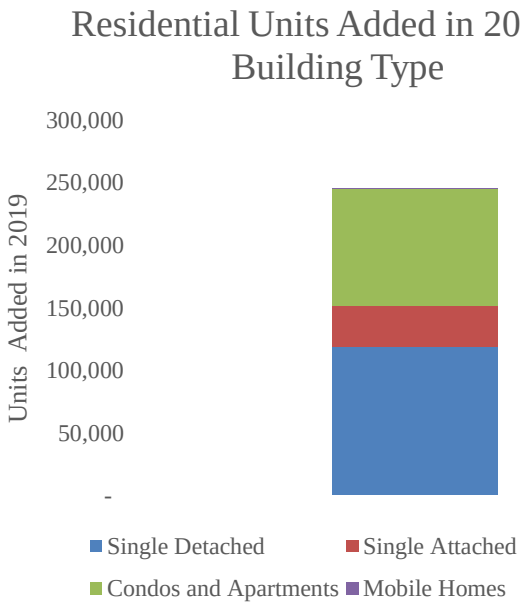
- Emissions per unit from different units still using emissions emitting energy

	Total Emissions, MT	Emitting Number of Units	Emissions Per Unit, T/unit
Detached	31.0	5.54	5.6
Attached	4.7	1.27	3.7
Condos and Apartments	6.5	3.23	2.0
Mobile Homes	0.9	0.18	5.0
Total	43.1	10.213	4.2

Source:https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=20&page=0

Annual Residential Housing Starts in 2019

- Residential housing starts in 2019 were 246,000. Most are either single detached or condos and apartments.



Source: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=20&page=0

Housing Starts, Electricity and Heat Pump Installations in 2019 to 2030 Period

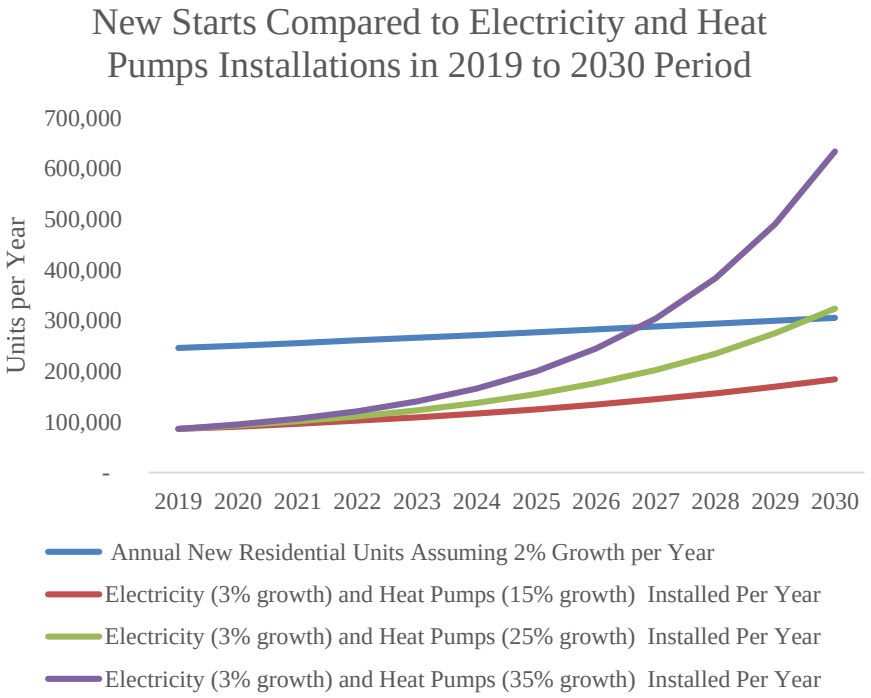
- Annual new housing starts growth of 2% barely equals electricity (3% annual growth) and heat pump installations (25% annual growth) in 2030.

- The Pembina Institute projects that reaching net-zero in 2050 will require carrying out retrofits at an annual pace of nearly 600,000 homes (11.4 million in total) and the equivalent of 32 million square meters of commercial property per year until 2040, at a cost of roughly $21 billion per year.

Source: Emissions Reduction Plan dated March 29 2022, Page 34

Housing Starts, Electricity and Heat Pump Installations in 2019 to 2030 Period

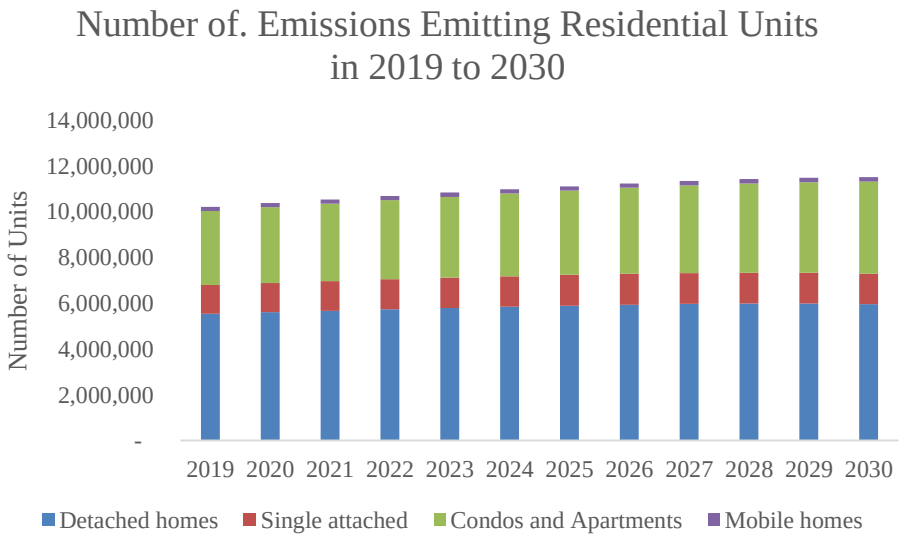
- Chart shows high heat pumps annual growth rate (25%) needed to equal (in 2030) residential unit new starts growing at 2% per year



Source: Calculations from Model

Number of Emissions Emitting Residential Units in 2019 to 2030 Period

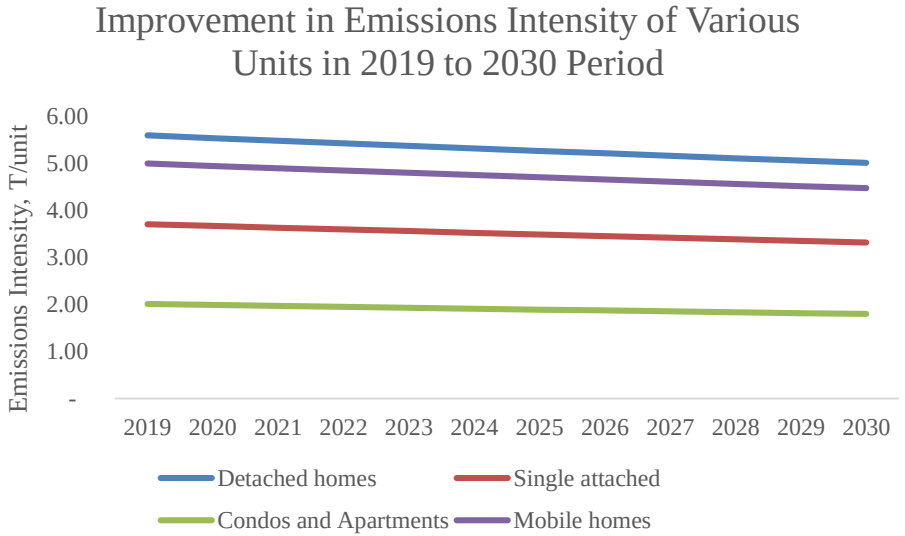
- Since electricity and heat pump installations are less than new housing starts,
  - some of new housing starts will still require an emissions emitting source of energy (natural gas or heating oil)
  - the total number of emission emitting units will increase
  - therefore the total amount of emissions will actually increase



Source: Calculations from Model

Assumed Improvement in Emissions Intensity of All Residential Units in 2019 to 2030 Period

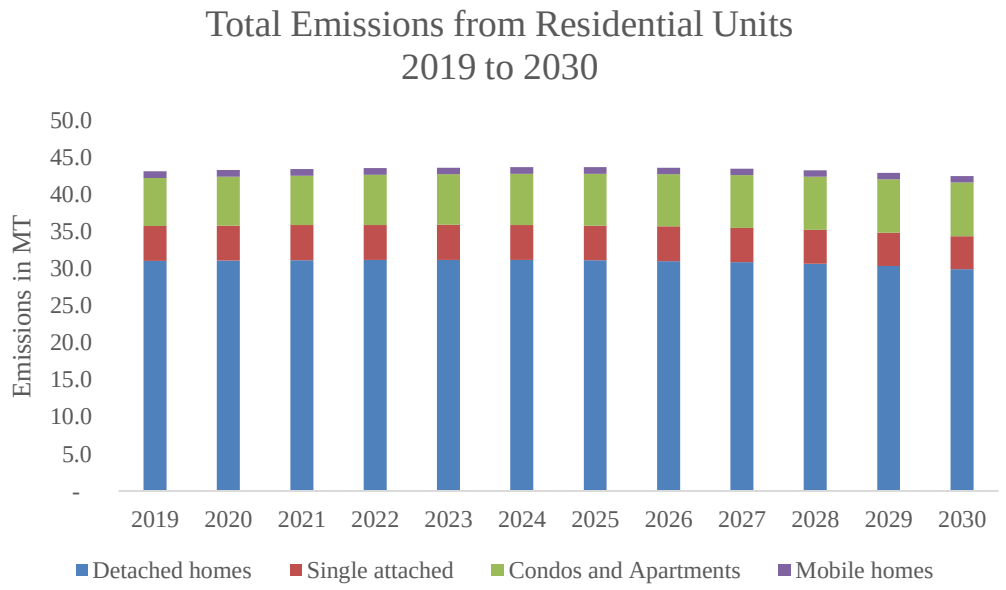
- Historical data shows significant reduction in emissions due to better insulation and more efficient natural gas heating units
  - assumption is that this will continue to improve at 1% per year for all residential units, thereby reducing emissions intensity per unit



Source: Calculations from Model

Forecast of Emissions from Residential Buildings in 2019 to 2030 Period

- Emissions decrease slightly from 43.1 MT in 2019 to 42.4 MT in 2030, versus target of 25 MT
  - Increase in number of emissions emitting units is offset by decrease in emissions intensity of emissions emitting units



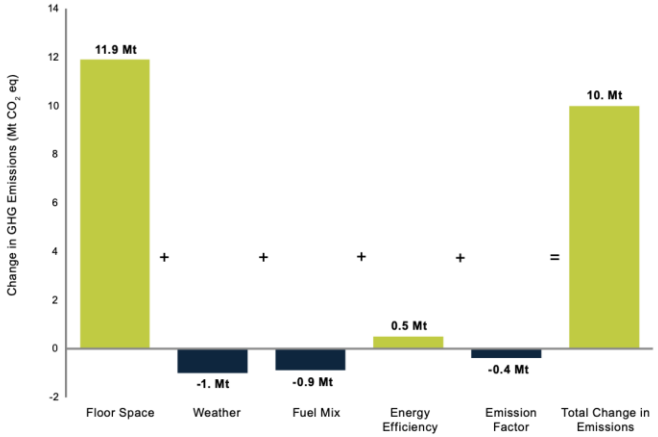
Source: Calculations from Model

Commercial Buildings

Past History of Emissions from Commercial Buildings

- Increasing floor space results in increase in emissions

Figure 2–13 **Factors Contributing to the Change in Stationary GHG Emissions from the Commercial and Institutional Category between 1990 and 2020**



Notes:

Floor space and population – Floor space refers to the change in total floor area over time. In the case of the residential sector, floor space is further broken down into the change in population and the change in floor space per capita.

Weather – Weather refers to the fluctuations in weather conditions, particularly outdoor winter temperature.

Fuel mix – Fuel mix refers to the relative share of each fuel used to provide heating.

Energy efficiency – Energy efficiency refers to the efficiency of the buildings and heating equipment.

Emission factors – The emission factor effect reflects changes to where fuels are sourced and their energy content over time.

Source: NIR April 14 2022

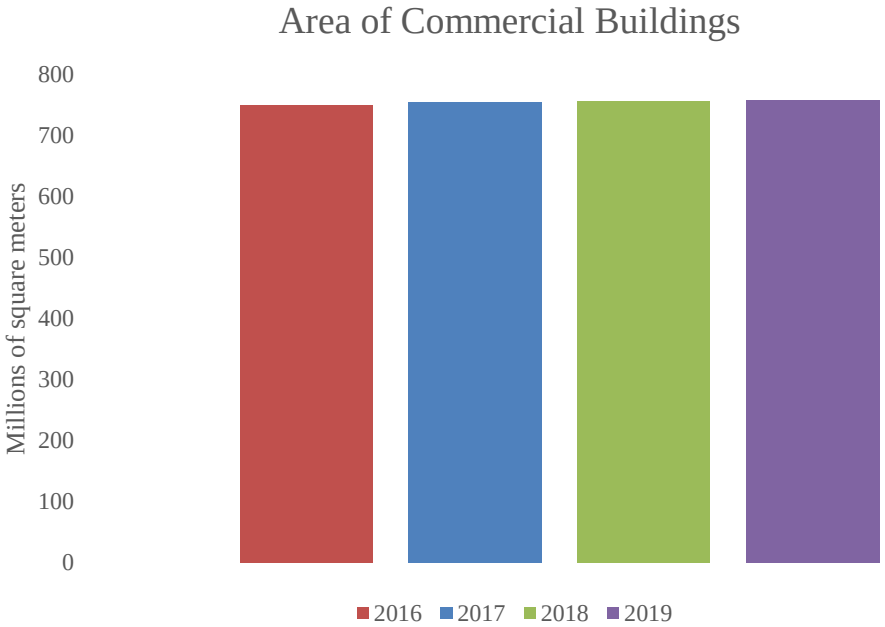
Installation of Heat Pumps in Commercial Buildings

- Commercial building heat pumps are larger than residential heat pumps
- For example, a 1,000,000 square foot commercial building would need 2,000 tons of heat pumps versus 4 tons for a typical 2,000 square foot house

Source: https://www.triair.ca/blog/overview-of-commercial-heat-pumps/

Area of Commercial Buildings in 2019

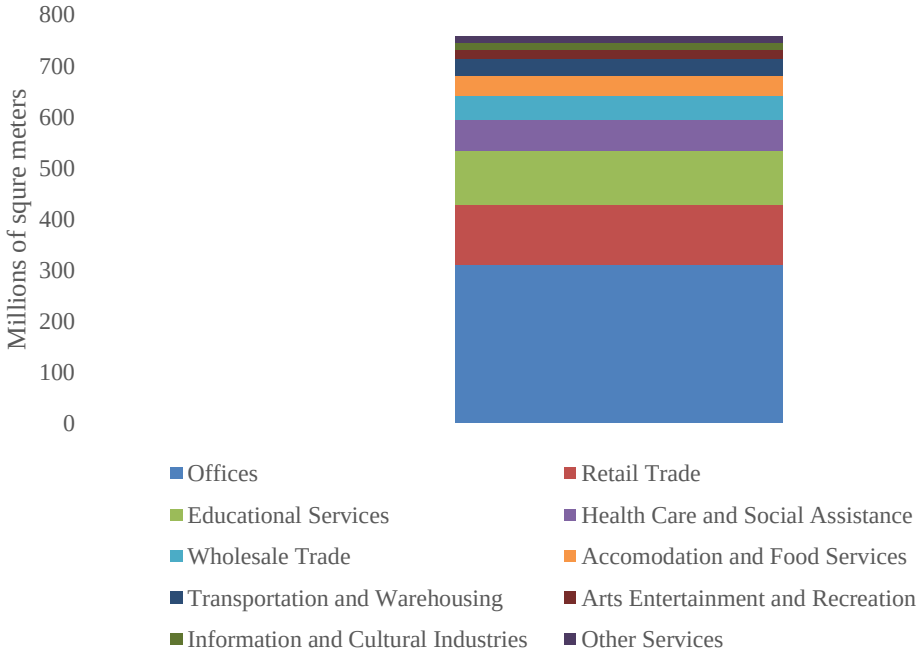
- Area of commercial buildings have remained constant at 750 million square meters for last four years
- Assume area growth of 0.1% per year from 2019 to 2030



Source. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=AN&sector=com&juris=00&rn=11&page=2

Types of Commercial Buildings

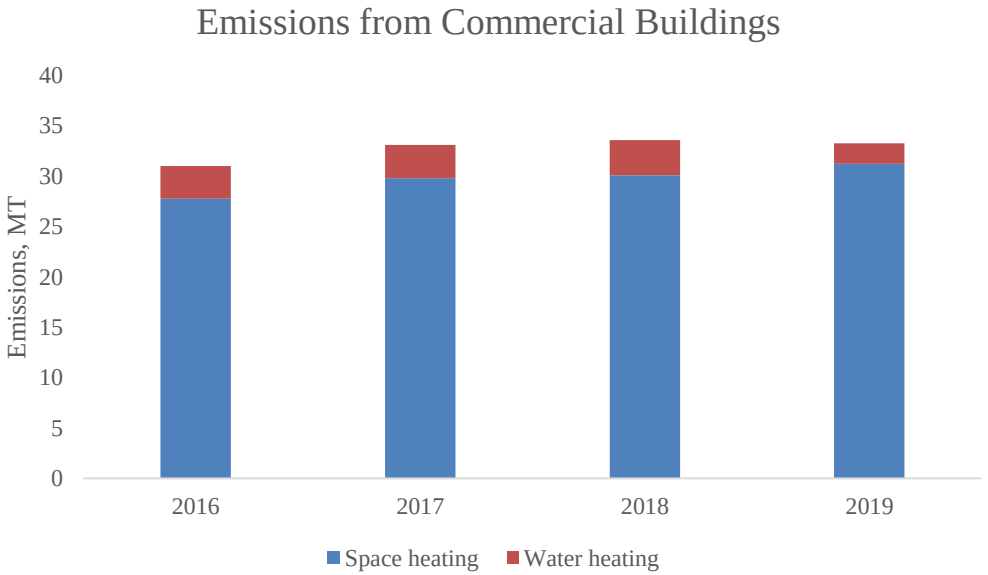
- Offices, stores and schools make up 70% of commercial building area



Source. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=AN&sector=com&juris=00&rn=11&page=2

Historical Emissions from Commercial Buildings

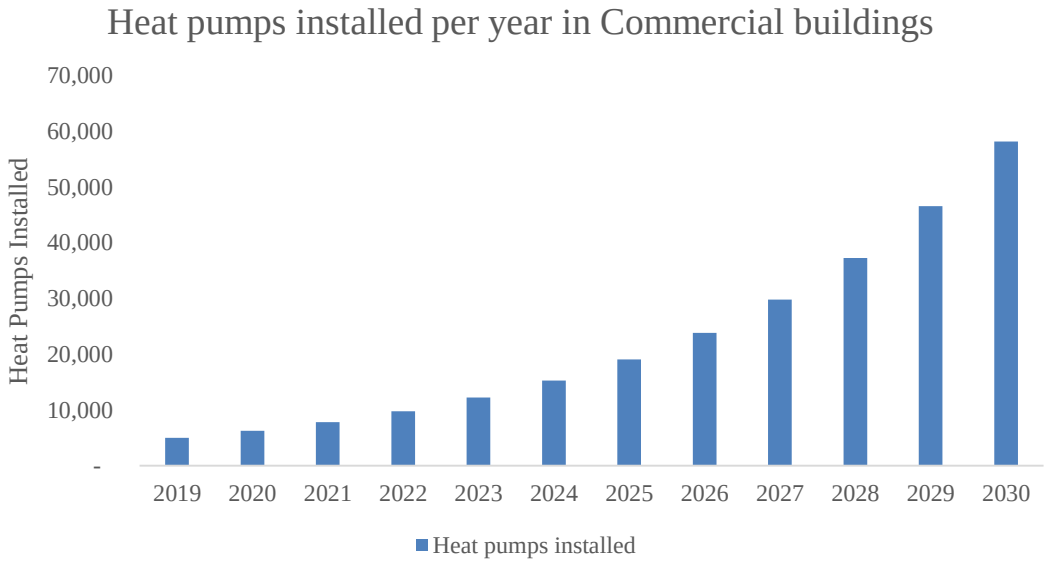
- Almost all of space heating and water heating requirements are currently supplied by natural gas
- Emissions have risen by 10% in last four years from 30 MT to 33 MT
- Emissions intensity is about 0.044 T/square meter



Source: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=AN&sector=aaa&juris=00&rn=31&page=0

Heat Pumps Installed in Commercial Buildings

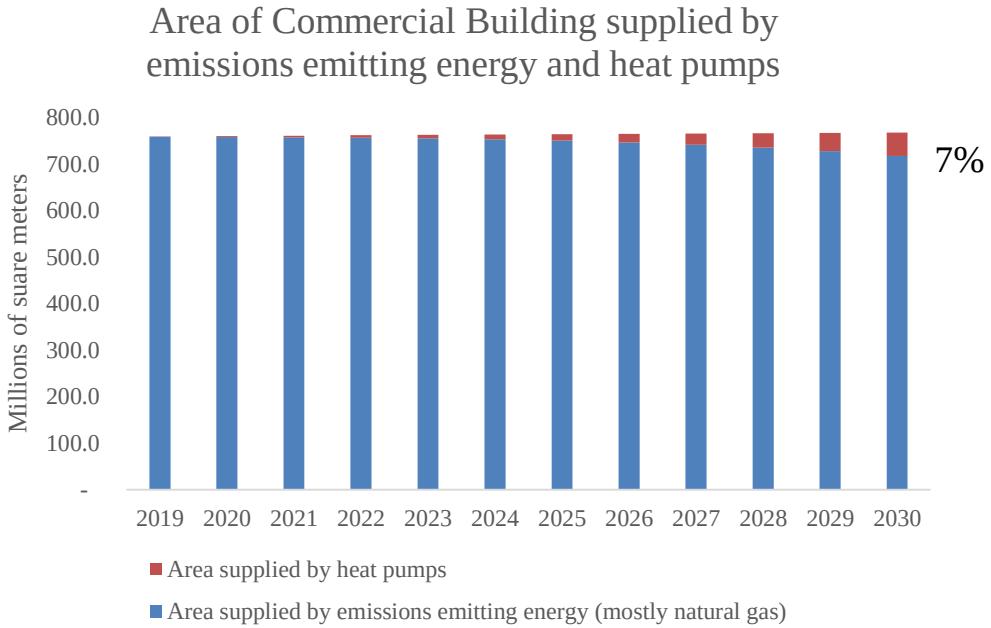
- Model assumption is that heat pumps start at 5,000 4 ton units (20,000 tons) in 2019 and grow at annual rate of 25% per year



Source: Calculations from Model

Area of Commercial Buildings

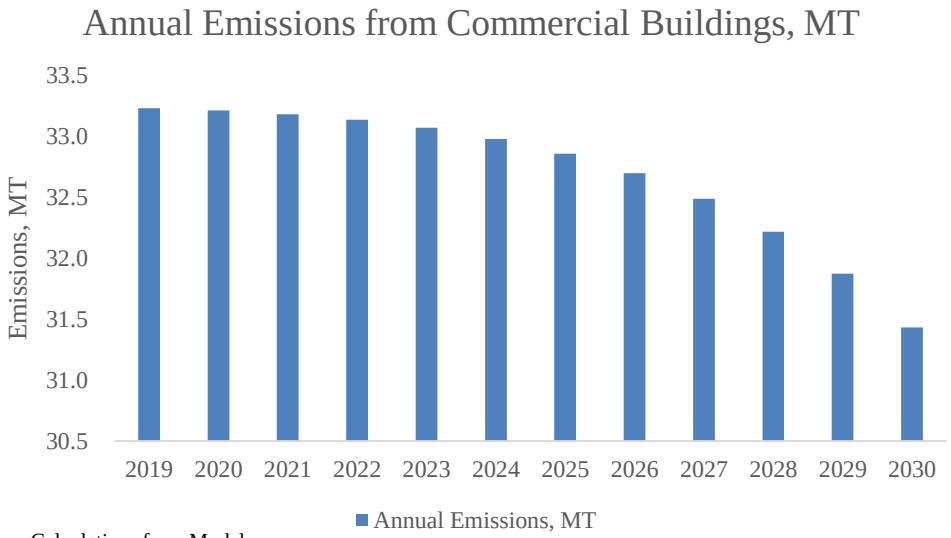
- Even with 25% growth in heat pump installation per year between 2019 and 2030, area heated by heat pumps remains a small portion (7%) of total area of commercial buildings



Source: Calculations from Model

Forecast of Emissions from Commercial Buildings

- Emissions decline very slowly due to slow growth in heat pumps
  - Assumptions are that
    - Almost all commercial buildings currently use natural gas or other hydrocarbons for space heating
    - Annual heat pump installation replaces area that was previously supplied by natural gas or other hydrocarbons



Source: Calculations from Model

Simple Analysis of Emissions from Commercial Buildings 2019 to 2030

- Factor analysis shows that decrease in emissions from 33.2 MT in 2019 to 31.4 MT in 2030, versus the 2030 target of 18 MT for 2030

Emissions in 2019	33.2
Increase due to added area	0.4
Decrease due to Heat Pumps	-2.2
Emissions in 2030	31.4

Source: Calculations from Model

Industrial Buildings

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Data on Industrial Buildings

- More difficult to get specific data on industrial buildings since NRCan data only reports emissions from all industrial activities, not just buildings

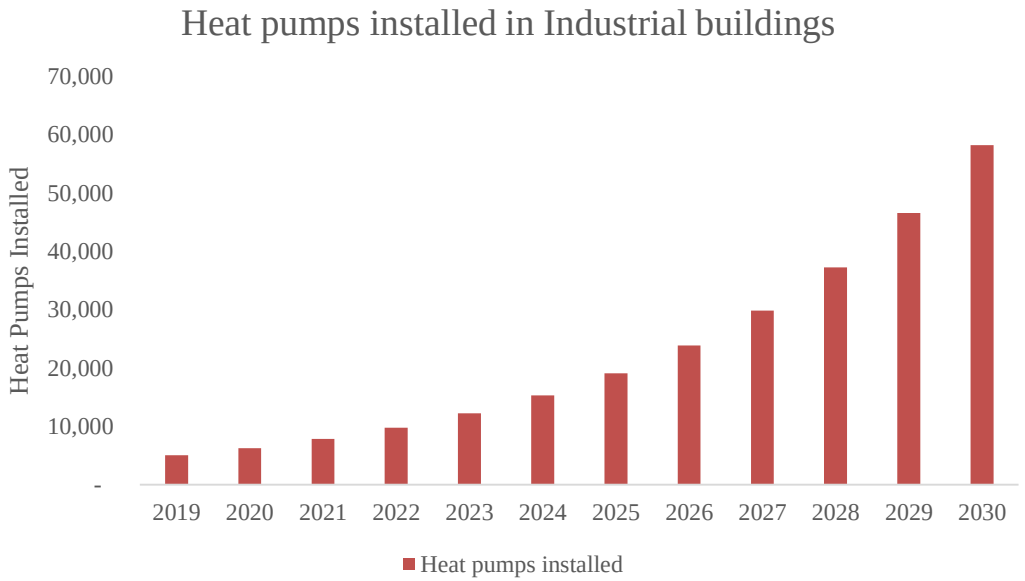
- Some industry data shows that industrial space is about 2 billion square feet (about 185 million square meters) , and growing at about 1% per year

- Industrial buildings are for things such as power plants, car factories, steel and pulp mills and other large buildings with high ceilings, poor insulation and doors that open to the outside
  - given this, an appropriate emissions intensity for industrial buildings is 0.08 tons per square meters, which is twice the emissions intensity factor for commercial buildings of 0.044 tons per square meter

Source: https://renx.ca/canadian-industrial-space-demand-strong-2019#:~:text=There's%20approximately%20two%20billion%20square,points%20from%20a%20year%20earlier.

Installation of Heat Pumps in Industrial Buildings

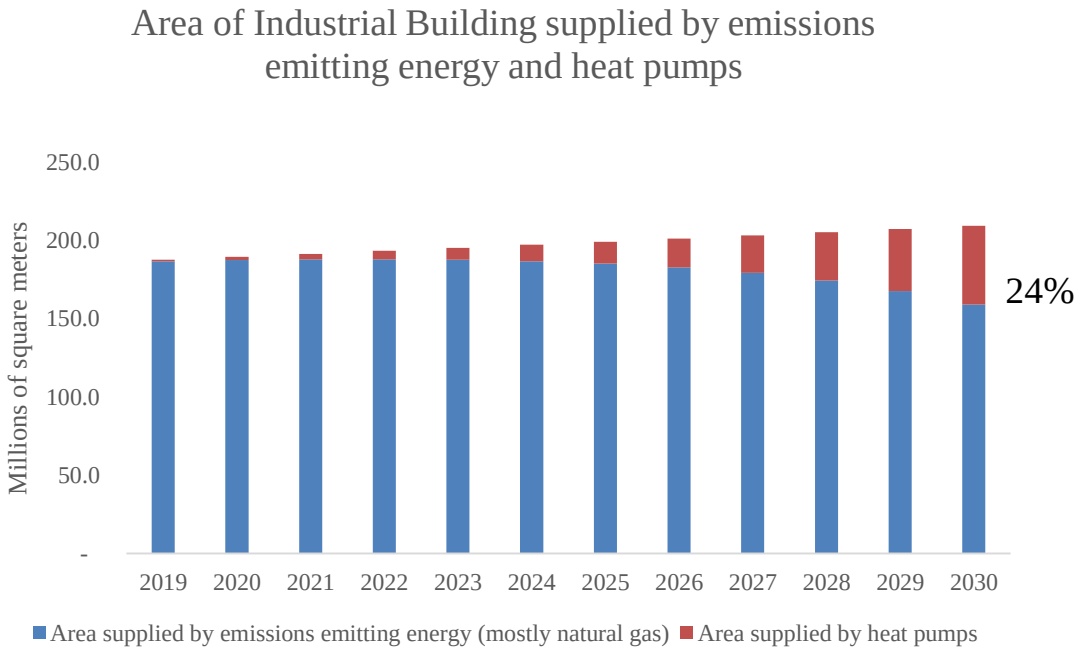
- Model assumption is that heat pumps start at 5,000 4 ton units (20,000 tons) in 2019 and grow at annual rate of 25% per year



Source: Calculations from Model

Area of Industrial Buildings

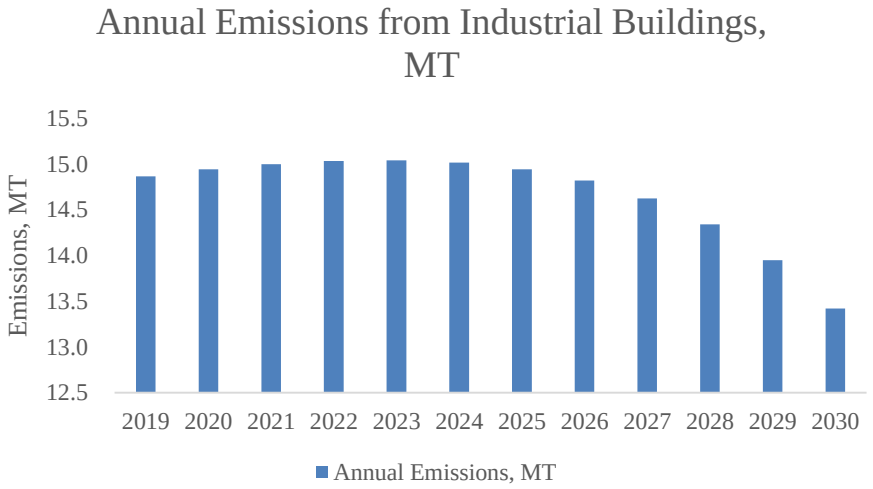
- Since industrial buildings have a lower total area, a 25% growth in heat pump installation per year between 2019 and 2030 causes area heated by heat pumps to form a significant portion (24%) of total area of industrial buildings



Source: Calculations from Model

Forecast of Emissions from Industrial Buildings

- Emissions decline very slowly due to slow growth in heat pumps
  - Assumptions are that
    - Almost all industrial buildings currently use natural gas or other hydrocarbons for space heating
    - Annual heat pump installation replaces area that was previously supplied by natural gas or other hydrocarbons



Source: Calculations from Model

Simple Analysis of Emissions from Industrial Buildings 2019 to 2030

- Factor analysis shows that decrease in emissions from 14.9 MT in 2019 to 12.7 MT in 2030, versus the 2030 target of 10 MT for 2030

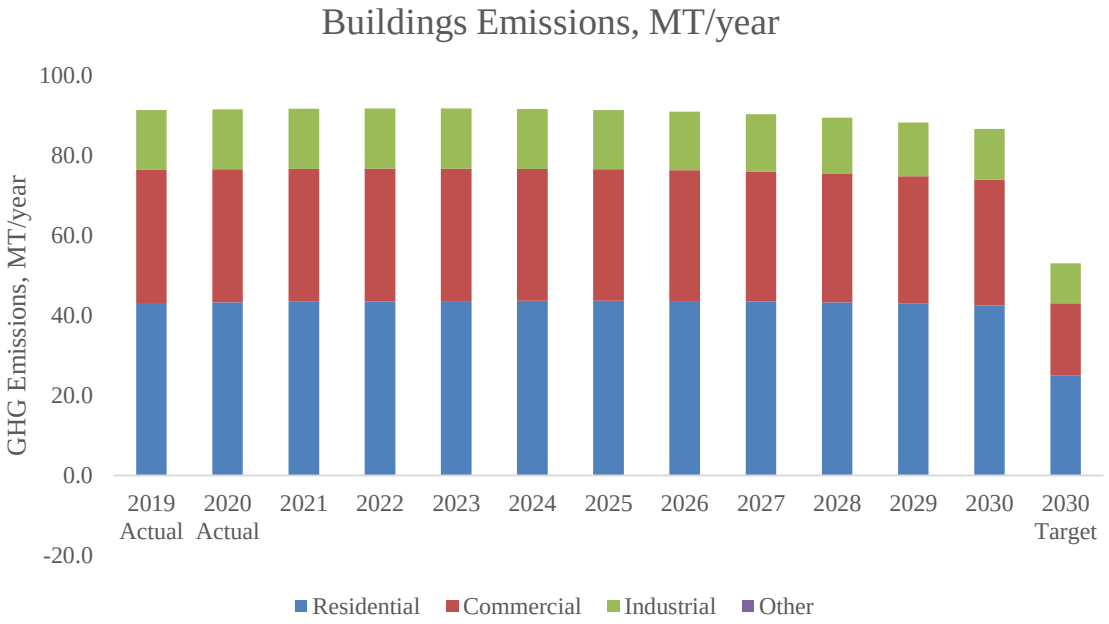
Emissions in 2019	14.9
Increase due to added area	1.9
Decrease due to Heat Pumps	-4.1
Emissions in 2030	12.7

Source: Calculations from Model

Final Summary of of Buildings Emissions for Period 2020 to 2030 Using Model

Forecast of Buildings Emissions for Period 2020 to 2030

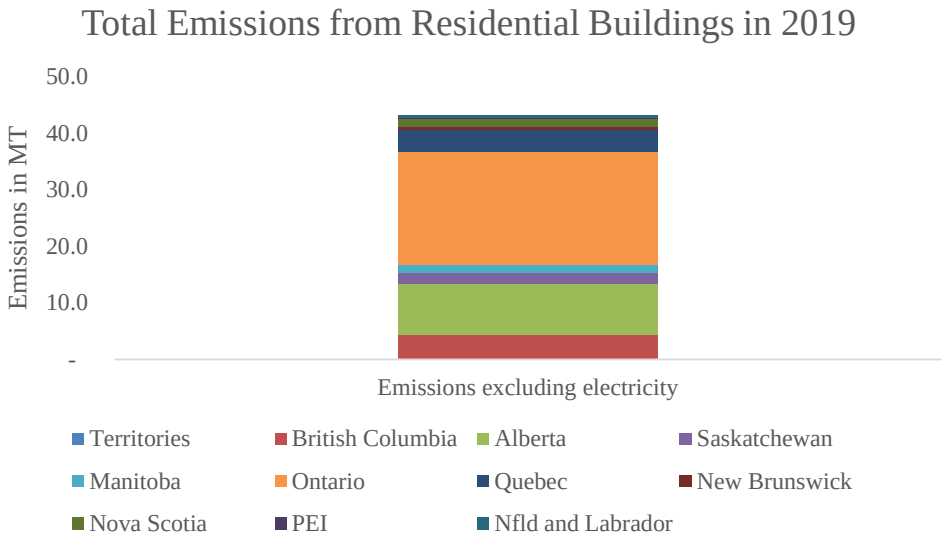
- Emissions of 91 MT in 2019 are forecast to drop to 86 MT in 2030, or 33 MT above the 53 MT target in the 2030 ECCC ERP.



Source: Calculations from Model

Backup Charts

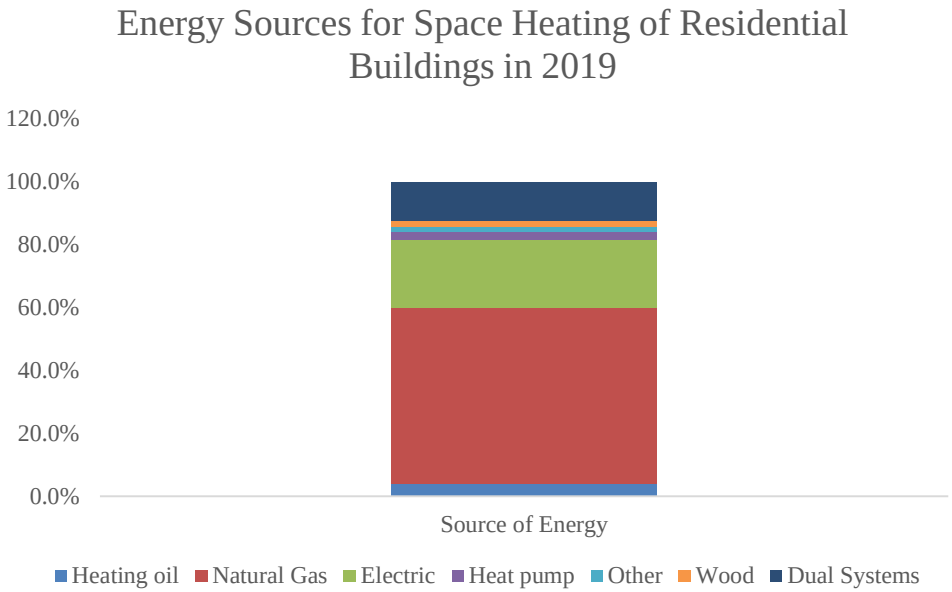
Emissions from Residential Buildings in 2019 for all Energy Used by Region



- Most emissions are in provinces with limited electric space heating (Ontario, Prairie and Atlantic provinces)
- Quebec, Newfoundland, Manitoba and B.C. have significant electric space heating due to large hydro power facilities

Source: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=3&page=0

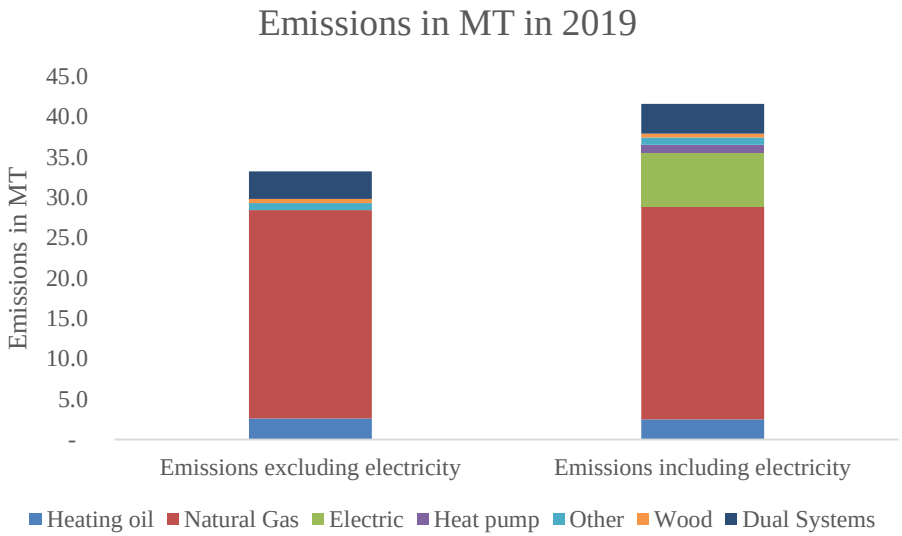
Sources of Energy in Residential Buildings in 2019 for Space Heating



- 56% of energy comes from natural gas, 4% from heating oil (mostly Atlantic provinces), 21% from electricity (mostly baseboard and in Quebec), 3% from heat pumps, remaining 16% from wood and dual systems

Source :https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=10&page=0

Emissions from Residential Buildings in 2019 for Space Heating



- Assumption is that emissions from electricity are counted in the Electricity sector, so are not counted in Residential Building subsector
- Correct number to use is for emissions excluding electricity (about 33 MT in 2019, mostly from natural gas)

Source: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=res&juris=ca&rn=10&page=0

CER Forecast for Residential Energy Use in 2019 to 2030 Period

- The CER forecast in 2017 entitled Canada's Energy Future used three cases to look at a variety of items, including a forecast of energy use in residential and commercial buildings
- The most aggressive CER scenario (called the Technology Case) assumes heat pumps installations increase to 15% of new heating device purchases in 2025, for both new buildings and retrofits in existing buildings. The share of installations increase to 30% by 2040.
- The Reference Case is based on a current economic outlook, a moderate view of energy prices, and climate and energy policies announced at the time of analysis.
- The Higher Carbon Price Case considers the impact on the Canadian energy system of higher carbon pricing than in the Reference Case.
- The Technology Case considers, in addition to higher carbon prices, the impact on the Canadian energy system of greater adoption of select emerging production and consumption energy technologies.

Source. https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/archive/2017/2017nrgftr-eng.pdf(HCP)

CER Forecast for Residential Energy Use in 2019 to 2030 Period

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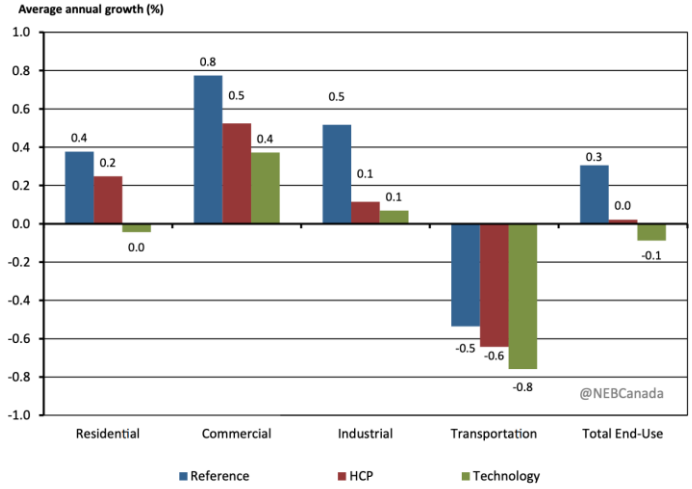
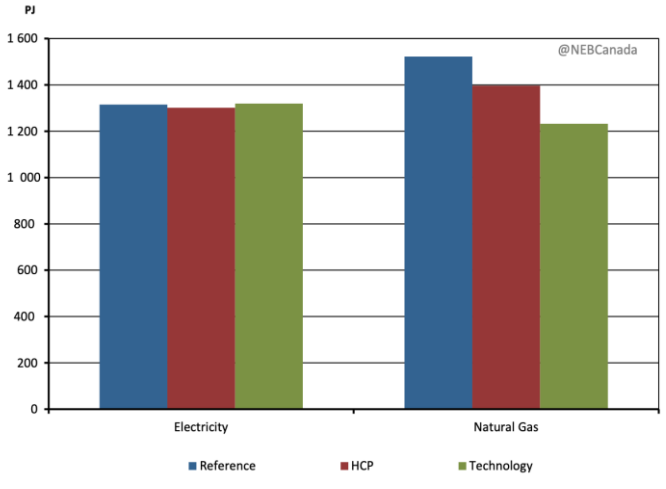
FIGURE 4.10

Residential and Commercial Electricity and Natural Gas Demands in 2040, All Cases





The Technology Case assumes heat pumps installations increase to 15% of new heating device purchases in 2025, for both new buildings and retrofits in existing buildings. The share of installations increase to 30% by 2040.

Source. https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/archive/2017/2017nrgftr-eng.pdf(HCP)