The Case for Building Electrification in Canada

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The Transition Accelerator
L'Accélérateur de transition

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About the Building Decarbonization Alliance:

An initiative of the Transition Accelerator, the **Building Decarbonization Alliance** is a cross-sector coalition that works to inspire and inform industry and government leadership, accelerate market transformation, and get the building sector on track to meet its emissions reduction goals. We convene conversations, conduct original research, and identify structural barriers to electrification—and work with our partners to overcome them.

About The Transition Accelerator:

The Transition Accelerator exists to support Canada's transition to a net-zero future while solving societal challenges. Using our four-step methodology, The Accelerator works with innovative groups to create visions of what a socially and economically desirable net-zero future will look like, and to build out transition pathways that will enable Canada to get there. The Accelerator's role is that of an enabler, facilitator, and force multiplier that forms coalitions to take steps down these pathways and get change moving on the ground.

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Cover photo of *825 Pacific Street* in Vancouver, BC by Ryan Snikvalds

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The Case for Building Electrification in Canada

The clock is ticking; we must act now to reduce greenhouse gas (GHG) emissions from Canada's buildings and the systems that support them. With this impetus, it's more important than ever for stakeholders to have clear and reliable information on the most effective pathways to decarbonizing our buildings. As governments, industry, and consumers seek to navigate the complex landscape of building decarbonization, the **Building Decarbonization Alliance (BDA) has emerged as a coalition of stakeholders committed to promoting electrification as a practical and viable solution.**

> *It's important that Canadians come to understand that electrification of the majority of our homes and buildings is possible, that it's the best way to decarbonize them to protect the climate, and importantly, that we have already been doing it in Canada for decades... what remains is to really scale it up in Canada in ways that have been demonstrated already elsewhere in the world.*
>
> – Bryan Flannigan, *Executive Director, Building Decarbonization Alliance*

In this position paper, the BDA provides a case for electrification to achieve net zero and highlights some key challenges we need to overcome to make it happen. Ultimately, the BDA believes that reaching net zero will require:

- The widescale replacement of fossil fuel-fired furnaces or boilers with electric heating equipment,
- The full decarbonization of the electricity grid, and
- The corresponding expansion of electricity supply coupled with peak load management and energy efficiency investments to mitigate and accommodate for increased electrical loads.

This position paper seeks to support further engagement with a wide range of stakeholders from multiple sectors who are involved in building decarbonization. We recognize that our collective understanding of this complex topic is still evolving, and that many organizations are currently working on this important file. With that in mind, **we welcome and encourage your comments, constructive feedback, and well-researched and substantiated points of view — both supporting and alternative.**

Electrification is the most viable pathway to lower building emissions

Canada has pledged to reduce its greenhouse gas (GHG) emissions to net zero by 2050.[i] With 18% of Canada's GHG emissions flowing from the building sector,[1,ii] and more than 77% of building emissions stemming from combusting fossil fuels for space and water heating,[2,iii] decarbonizing building heating will play a crucial role in meeting our climate objectives. With roughly 16M existing housing units, increasing by 200,000 per year,[iv] and 480,000 existing commercial buildings,[v] a conscious and coordinated effort is needed to decarbonize the sector.

As noted in The Transition Accelerator's Pathways to Net Zero report, **electrification is the most credible, capable, and compelling pathway to widespread building decarbonization.**[3,vi] The emergence and continued refinement of heat pump technologies[4] allows for an efficient use of clean electricity. Below, we outline how electrification can reduce emissions, provide a viable heating source, be an economical means of decarbonization, decarbonize all types of buildings, and provide additional non-energy benefits to Canadians (e.g., space cooling, improved indoor air quality, local jobs).

1 While the building sector is often denoted as accounting for 13% of GHG emissions in Canada in 2020, this estimate neglects electricity-related emissions due to building electricity consumption.

2 Calculated by dividing residential and commercial space and water heating emissions by total residential and commercial emissions across Canada in 2019.

3 Judicious use of other low-carbon fuels and building technologies to complement electrification may also be important in certain applications and locations. However, the majority of decarbonization in the short- to medium-term will be from electrification.

4 Air source heat pumps (ASHP) and ground source heat pumps (GSHP) heat and cool buildings by moving heat. Because it is only moving heat, this technology can achieve efficiencies of 300% or more. An ASHP heats by extracting heat from outdoor air, while a GSHP heats by extracting the geothermal energy stored in the ground.

1. Electrification reduces emissions in the building sector

Most Canadian buildings can immediately reduce their emissions by switching to electric heat. All buildings can eliminate their onsite emissions when converting from natural gas, propane, or heating oil. In provinces with carbon intensive electricity grids (i.e., AB, SK, NS), emissions associated with electricity generation will remain; however, we estimate the installation of a heat pump will result in lower cumulative emissions over its lifetime.

Opportunities for reducing GHG emissions are jurisdiction dependent; while some provinces will benefit from displacing heating oil, others will benefit from improving the efficiency of their electrical heating *(Figure 1)*.[vii]

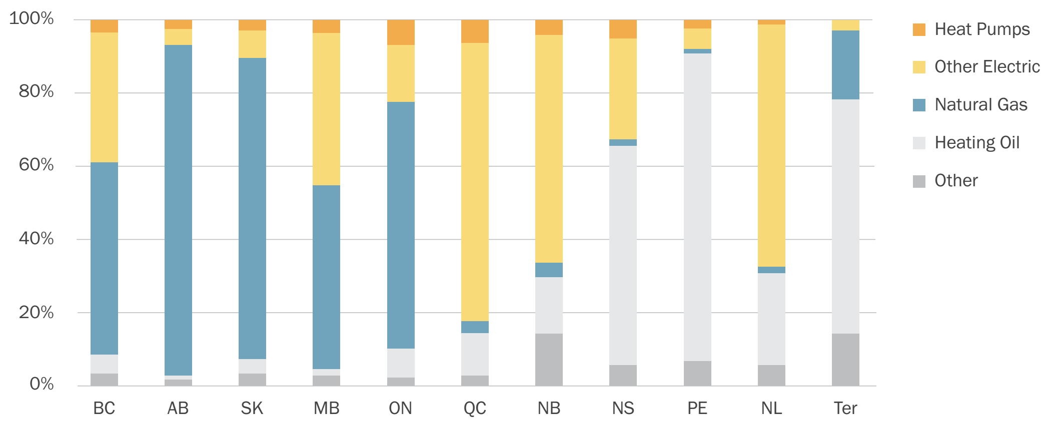

Figure 1: *Residential heating system stock varies across Canada*

Long-term, electrification will decrease emissions in all jurisdictions as the electricity grid becomes less carbon intensive.[5,viii] For example, we estimate that in Alberta — one of Canada's most emission-intensive grids — two hypothetical heat pumps installed today (with differing coefficients of performances or COPs)[6] will have lower cumulative lifetime emissions than using natural gas for heating *(Figure 2)*.[7] Grid emissions in the province have already decreased significantly, due in part to increasingly stringent carbon pricing policies that increased the cost of coal-fired electricity and led to retirement or conversion of coal-fired facilities.[ix]

5 The federal government has committed to achieving a net-zero grid by 2035, providing a strong signal to utilities, regulators, and industry to shift away from emissions-intensive generation.

6 The Coefficient of Performance (COP) represents the efficiency of a heat pump (i.e., the ratio of heat energy delivered to energy consumed).

7 In this example, Alberta's marginal electricity grid emissions are assumed to evolve from an estimated high of 842 kg CO_2e per MWh in 2018 to 0 kg CO_2e per MWh by 2035. For simplicity, a simple linear interpolation is used.

> BC Hydro is actively working with its partners to support GHG emissions reduction in buildings through electrification. From a utility perspective, a key to the success of building electrification is its thoughtful integration with energy efficiency and load management practices.
>
> – Robyn Wark, *Manager, Market Transformation, BC Hydro*

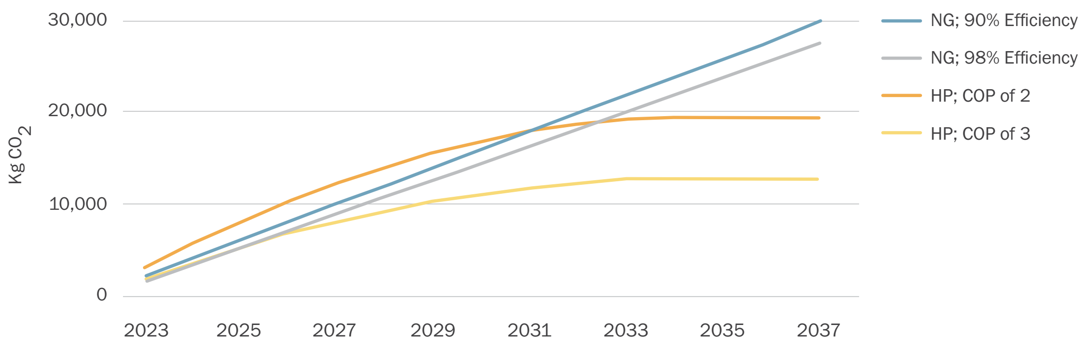

Figure 2: *The cumulative emissions of heat pumps in Alberta are lower than those for natural gas heating, assuming the grid is decarbonized by 2035*

Challenges to enabling electrification to reduce emissions

One of the most significant challenges, even in provinces with ample clean electricity, is expanding **the clean grid** to meet increased demand (notably **peak demand**). While federal regulations are in place to achieve a net-zero grid, it is not a trivial challenge. Barriers exist, ranging from the complex regulatory environment overseeing the expansion of electrical generation and transmission, to the significant capital investment required to achieve a net-zero grid. This problem will require people, investments, and creative solutions. Fortunately, this expansion will take place over decades; while an active problem that needs to be addressed, there is time to address it. Existing strategies can reduce the rate and scale of the grid's expansion, including energy efficiency, demand response, and thermal and electric storage. Indeed, electrifying a house via GSHP instead of ASHP can save society $40,000, mainly from reduced peak load.[x] However, there exists a misalignment between who pays (homeowners) and who benefits (utilities) from these technologies.

Emissions concerns also exist for **heat pump refrigerant leaks.** While their impact has been estimated to be less than the impacts of behind-the-meter natural gas leaks in homes,[xi] low global warming potential (GWP) refrigerants exist, are widely available, and are being used to further mitigate these impacts.[xii]

Electricity is the most viable fuel for building decarbonization

To ultimately meet the net-zero targets, electrification must be compared not only to the existing fossil fuel heating sources, but to heating with net-zero compatible fuels (e.g., renewable natural gas [RNG] and hydrogen). These fuels are other frequently cited approaches to building decarbonization. However, each has challenges and uncertainties making them less viable today as net-zero pathways.

RNG, being chemically identical to fossil natural gas, has the benefit of being compatible with existing natural gas infrastructure. In fact, Canadian gas utilities are already injecting RNG into their networks. However, RNG:

- Faces **supply constraints** as its sources (e.g., landfills or agricultural and forest wastes) are limited.[8,xiii,xiv] The best use for limited RNG is in end uses where technologic or cost limitations prevent electrification.
- May have **limited emission reduction potential** due to fugitive methane emissions from production, transportation, and distribution;[xv] some feedstocks continuing to be carbon intensive (e.g., landfill and wastewater sludge continuing to produce emissions);[xvi] and the time value of carbon (e.g., it can be several decades before there is a carbon benefit from turning wood waste to RNG).[xvii]

Hydrogen does not face the same supply constraints as RNG. Theoretically, zero-carbon hydrogen could be produced using zero-emission electricity (green hydrogen) or natural gas paired with carbon capture technology (blue hydrogen). However, hydrogen:

- Is **not currently produced at scale** as green hydrogen has high production cost and blue hydrogen requires carbon capture and storage technologies which are costly and technically complex.
- Has **uncertain emission reduction potential**. Blue hydrogen must address upstream methane emissions and improve carbon capture performance to be considered a viable net-zero pathway.[xviii]
- Has **unclear costs** regarding the safety and practicality of distributing and using hydrogen in buildings. The viability of converting the existing gas network to hydrogen remains unclear (e.g., suitability of existing piping infrastructure, how hydrogen will be produced, where production will be located).[xix]

Due to these existing constraints, the best use for RNG and hydrogen in the near term will be for end uses where limitations prevent electrification (e.g., industrial processes, transportation hubs), which is typically not the case for most building heating applications.[xx] Although there is still research to be done and information to be gathered, based on what we currently know, **electrification represents the only viable building decarbonization pathway that is ready to implement today across all parts of the country.**

8 The Canadian Gas Association (CGA) has estimated the ultimate potential supply of RNG to be 1,277 PJ. For context, in 2020, Canadian natural gas demand was 4,940 PJ — nearly four times the maximum potential supply.

2. Electrification provides a viable heating solution for Canadian winters

While harder to decarbonize sectors (e.g., aviation, heavy industry, agriculture) may need to rely on further technological breakthroughs to achieve net-zero emissions, the **technologies needed to reduce building-sector emissions in Canada already exist.** Advances have taken place to allow air source heat pumps to heat and cool Canadian buildings throughout the year, while ground source systems perform at great efficiencies year-round regardless of outdoor air temperature. Additionally, cold-climate air source heat pumps can operate in temperatures down to minus 30°C, reducing the need to activate back-up heating sources.[xxi]

As noted, **electric heating is commonly used in homes and businesses across Canada.** In the residential sector, more than 6 million or 40% of homes use electric heating, and more than 850,000 of those homes use heat pumps.[xxii] In the commercial and institutional (C&I) sector, electricity provides approximately 15% of building heat.[xxiii] Heat pump adoption is increasing; in fact, the number of heat pumps shipped in Canada surpassed natural gas furnaces in 2021 and 2022 *(Figure 3).*[xxiv]

> *There's lots and lots of data to show how heat pumps work consistently, even in very cold climates.*
>
> – **Martin Luymes**, *Vice President, Government and Stakeholder Relations, HRAI*

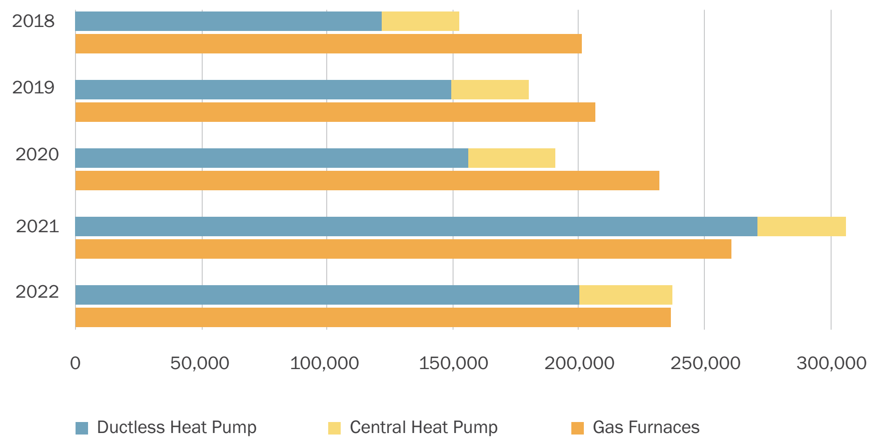

***Figure 3**: Canadian shipments of heat pumps topped gas furnace shipments.*

Globally, there is **growing consensus that heat pumps are a central building decarbonization technology.** The pace of heat pump uptake has increased considerably — in 2022, sales grew almost 38% year-over-year in the European Union while heat pumps outsold gas furnaces in the United States.[xxv,xxvi] Heat pumps already meet more than 10% of heating needs in buildings globally. To date, uptake is greatest in some of the world's coldest climates, demonstrating the real-world performance of this technology *(Figure 4).*[xxvii]

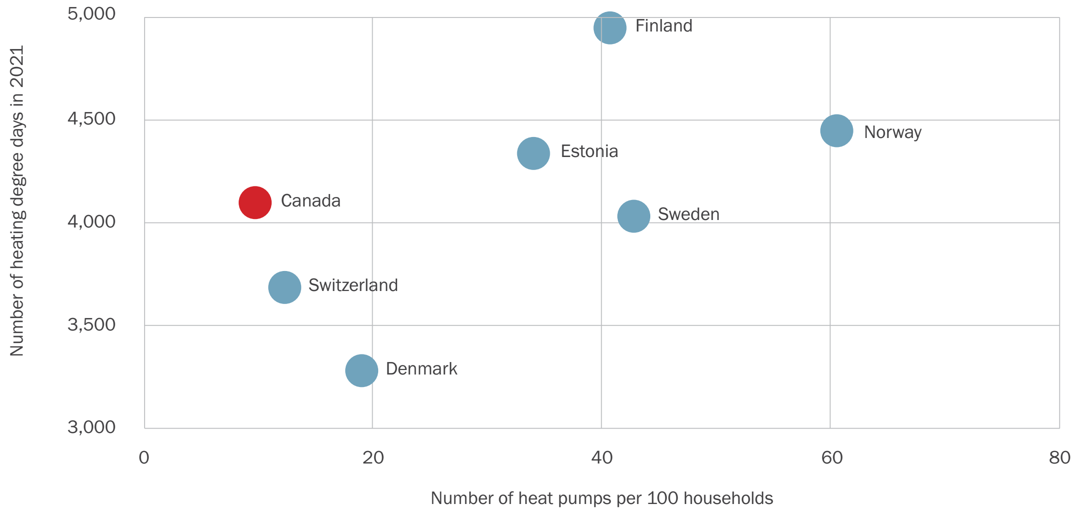

Figure 4: *Heat pump penetration is high in countries with similar heating requirements to Canada.*

Challenges to improving Canadians' ability to electrify buildings

Heat pumps can add complexity in undertaking a retrofit; incentive program participant feedback often cites **additional complexity and time needed** to find the right heat pump, a qualified installer, the applicable subsidies, and the required approvals as key barriers to pursuing their projects. The need for **auxiliary heating equipment** for certain use cases (e.g., regions with sustained low temperatures, buildings that are inefficient or have constrained electric services) and for retrofitting more complicated systems (e.g., steam systems, radiant heaters, higher temperature hydronic systems) add further costs and complexity.

A variety of heat pump technologies is required to meet the needs of Canada's six climate zones. **Cold climate models remain less widely available** (especially hydronic units, all-in-one models, and water heaters).[xxviii,xxix] Availability gaps continue to exist for certain heat pump technologies (e.g., low GWP refrigerants, high temperature units, low-capacity models).[xxx] In some cases the primary barrier is not a technical one; manufacturers have raised the need to streamline the certification process to help bring new heat pump technologies to market.[xxxi] In addition, with most heat pumps manufactured outside Canada, there are concerns that global manufacturing capacity is insufficient to meet projected heat pump demand.[xxxii]

3. Electrification is an economical pathway to decarbonize buildings

Heat pumps will reduce monthly energy costs for homeowners that heat with electric resistance, fuel oil, or propane.[xxxiii] While natural gas was historically a cheaper alternative, price increases, the federal carbon price, and improved efficiencies in electrical heating have resulted in **comparable or lower operating costs for heat pumps compared to natural gas** in most jurisdictions. *Figure 5* shows, for example, that the cost of heating in Manitoba with heat pumps is comparable to natural gas heating, in Nova Scotia heating via heat pump is the cheapest option, while in Alberta the cost of heating with the most efficient heat pumps is comparable to natural gas heating. In all provinces, higher efficiency heat pumps are less costly than fuel oil or propane.[xxxiv,xxxv,9]

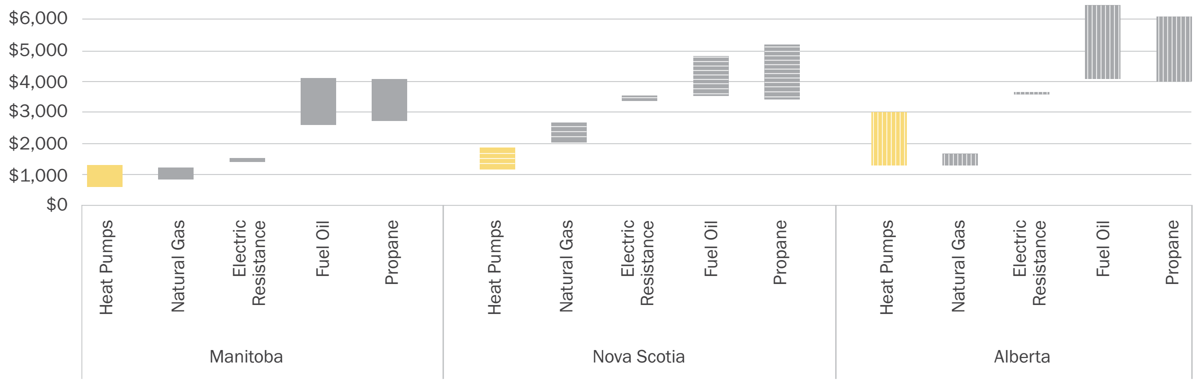

***Figure 5:** Annual costs can be lower for heat pumps than other heating systems in single family homes when accounting for energy prices, basic charges (e.g., monthly fees), and the federal carbon charge. The range of prices for each heating system is due to different system efficiencies (e.g., GSHP being more efficient then an ASHP, or a high-efficiency furnace vs a conventional furnace).*

> *We have conducted multiple analyses of the pathways to decarbonize buildings across Canada and the USA. We consistently find that building electrification — whether for all or most heating needs — is essential to decarbonize the sector.*
>
> – Philippe Dunsky, *President, Dunsky Energy + Climate Advisors*

Operational cost savings can help offset the higher up-front cost for a heat pump to yield a **competitive total lifetime cost of ownership.** When compared to natural gas space and water heating supported with an air conditioner, a recent analysis in Southern Ontario determined that the 15-year total cost of ownership is lower for both cold climate ASHPs and GSHPs.[xxxvi] With predictions of declining heat pump upfront costs due to reductions in equipment and soft installation costs,[xxxvii] total cost of ownership will become even more attractive.

In the commercial sector, other factors tend to drive electrification. Historically there has been relatively little growth in heating electrification,[xxxviii] due in part to low natural gas rates, concerns about increased electrical demand charges, and the tendency of engineers and HVAC professionals to default to familiar systems. The sector faces increasing pressure from investors, customers, and regulators to decarbonize their buildings. Demand for net-zero buildings is increasing with growing consumer awareness, corporate ESG targets, and a growing trend to regulate emissions in buildings from municipal governments (e.g., Toronto, Vancouver).[xxxix,xl]

9 While Manitoba and Nova Scotia rates were determined by third parties, we estimated Alberta's costs for this report.

Challenges to improving the cost effectiveness of electrification

While total cost of ownership is promising, heat pumps' **higher upfront costs** relative to fossil fuel-based heating equipment is an ongoing barrier to adoption. This barrier can be exacerbated by the **additional costs and complexity if there is a requirement to upgrade** a building's electrical panel and utility service to handle the increased electrical load. Widespread building electrification will also result in a **concentration of fossil fuel utilities' system costs** due to less consumption and fewer fossil fuel ratepayers; an area requiring further analysis. These factors could disproportionately impact **lower-income households** who are already struggling and who will need additional support to electrify.

4. Electrification helps decarbonize both new and existing buildings

The effects of climate change are being felt today, with extreme weather events becoming more and more the norm. The longer we wait to act, the more severe and irreversible the effects, and the greater the costs to both reach our emission reduction targets and to abate the effects. Ultimately, new buildings will need to be built to stop using GHG emitting fuels, while existing buildings will all need to reduce their current emissions.

In **new buildings**, the most cost-effective way to have a decarbonized building by 2050 is to ensure that the building is built to **net zero emissions standards** (e.g., using British Columbia's new Zero Carbon Step Code). This requires an energy efficient building to reduce the heating load. As it is more cost-effective to build an efficient building initially than it is to retrofit it to make it efficient at another point in the future, it is imperative that we stop designing and building buildings fueled by fossil fuels.

> “
>
> *Electric heat pumps are energy efficient. They work even better when coupled with building envelope improvements that keep the heat inside and save electricity during critical times — freeing up clean electricity for even more heat pumps!*
>
> – **Brendan Haley**, *Director of Policy Research, Efficiency Canada*

In **existing buildings**, electrification and energy efficiency improvements are currently the best means to use energy that is non- or low-GHG emitting and to reduce overall energy demand. While ideally a retrofit project would take on building envelope improvements and electrification in tandem, this is not always feasible (e.g., due to constraints on capital, timing, resource availability). Since the most economic time to upgrade to a heat pump is at the end of life of the existing heating system, and there are only one or two such opportunities between now and 2050 (due to the expected lifetime of heating equipment), it is appropriate to **proceed with electrification without a deep energy efficiency retrofit; those upgrades can be completed later.**

To meet our long-term building emission goals, we need to accelerate the pace of decarbonizing the sector — stopping constructing new buildings fueled by natural gas and oil, and instead ensuring that new construction is all-electric. In addition, we need to ramp up rates of decarbonizing existing buildings. Acting quickly can position Canada as a leader in building decarbonization, taking advantage of **economic opportunities in the low-carbon economy transition** (e.g., increasing jobs, increasing manufacturing capacity, exporting equipment).

Challenges to accelerating building electrification

For **new construction, net zero emission building codes** help create a supportive policy environment for building electrification technologies — accelerating their adoption while reducing building emissions. Codes that set clear targets and timelines can accelerate innovation, create demand, and ensure quality. The federal government will begin addressing emissions in their 2025 model codes, with Provinces and Territories responsible for adopting and enforcing such codes. Moving from energy-focused to emissions-focused codes requires significant change, necessitating additional training for design, construction, and enforcement.

In **existing buildings**, there is room to **improve industry's understanding of the most feasible and cost-effective pathways** for decarbonizing their building. This is particularly applicable in the context of determining the preferred approach to a deep energy retrofit that includes fuel switching. Generally, older and leakier homes see greater benefits from deep retrofits before electrifying their heating system.[xli] As such, homeowners should consult an energy advisor to help determine the best sequencing for their home.

Finally, an equitable transition requires that **lower-income household** be supported in decarbonizing their homes. As these households have more barriers to overcome (e.g., greater thresholds on upfront costs, split incentives for renters), additional financial and process supports will help ensure they do not lag in electrifying their homes. Several provinces currently have income-qualified programs supporting home decarbonization.[xlii]

5. Electrification provides additional benefits to Canadians

"

A cleaner energy grid combined with energy efficient electric technologies, such as heat pumps, will result in buildings that are better for occupants and the climate. Beyond reducing greenhouse gas emissions, Canadians will benefit from better indoor air quality, access to cooling, and better energy efficiency as we move to electrify buildings.

– Mariko Michasiw,
B2E Program Manager, ZEIC

Building electrification via heat pumps provides many benefits to Canadians in addition to reducing emissions:

- **Improving air quality and health** by reducing the need for fossil fuel combustion (primarily a benefit within households when replacing appliances like gas stoves). Combustion emissions in buildings have been found to contribute to the largest share of premature deaths associated with air pollution in the United States; a greater air quality risk than the transportation or industry sectors.[xliii]
- **Improving comfort and resiliency** by installing heat pumps that provide both heating and cooling for indoor spaces. For the more than 5.5 million households without air conditioning *(Figure 6)*,[xliv] heat-related health impacts are a growing public health risk as a direct result of climate change.[xlv] Average annual temperatures in Canada are rising at approximately twice the global mean rate, and dangerous heat events are projected to increase in frequency and intensity in the years to come.[xlvi]
- **Providing Canadians with jobs**, including the tradespeople, designers, consultants, builders, developers, and equipment vendors that all play critical roles in promoting, installing, and maintaining the infrastructure required to electrify buildings. Estimates range from requiring 100,000s to millions of additional job years to support building decarbonization in Canada.[xlvii,xlviii]

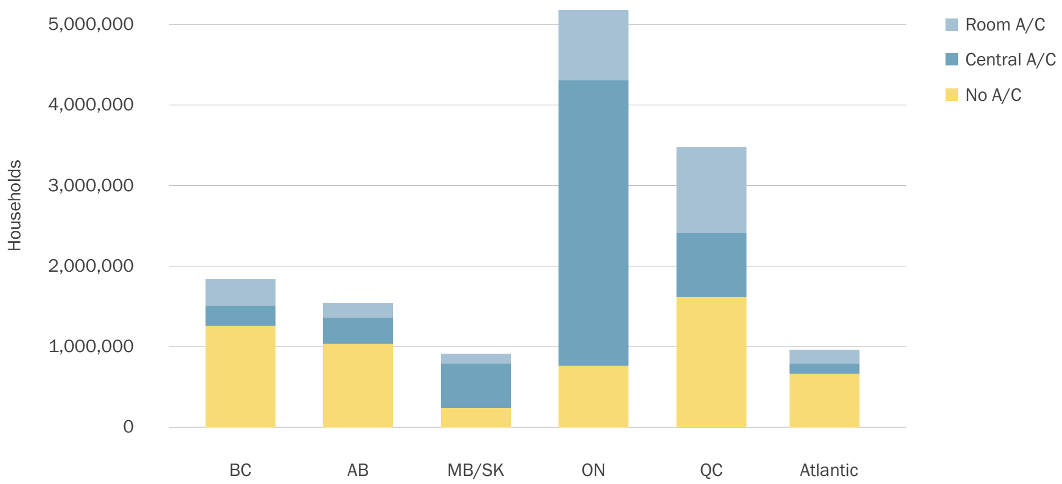

***Figure 6:** More than 5.5 million homes across Canada did not have air conditioning in 2015.*

Pursuing building electrification will be beneficial for Canadian's homes, health, and economy.

Barriers to obtaining the benefits of electrification

A **skilled workforce** is required to grow building decarbonization activities. However, job vacancies in relevant trades (e.g., electrical, construction, and other installers or repairers) continue to increase, indicating a lack of qualified workers. Heat pump installation requires skilled professional to adequately size the equipment and carry out plumbing and electrical tasks. In fact, installation is the most labour-intensive part of the heat pump value chain.[xlix] Improper installation can lead to underperforming systems and recurring maintenance issues, such as leaks and electrical issues. For commercial buildings, the heating design requirements and system configurations vary among buildings, adding to the complexity of installation in this sector. It is also important for installers to inform customers on appropriate handling and maintenance techniques. Otherwise, a heat pump may not operate efficiently during its lifetime. To take advantage of the economic opportunity building electrification presents, local workers must be upskilled or reskilled.

Secondly, a growing global market for heat pumps provides a potential **manufacturing opportunity**. While most heat pumps are currently imported to Canada, there's an opportunity for "Made in Canada" heat pumps to be used locally and exported to countries with similar climate profiles.

The Building Decarbonization Alliance is here to help scale electrification

The time to scale up building electrification across the country is now. There are tried-and-true policies that governments can put in place to support this scale-up; recent research identified six key policy categories that drive building decarbonization, and assessed their uptake in global markets *(Figure 7)*.[i] While some policies are already in place, there is still work to do to align our policy environment with leading jurisdictions worldwide.

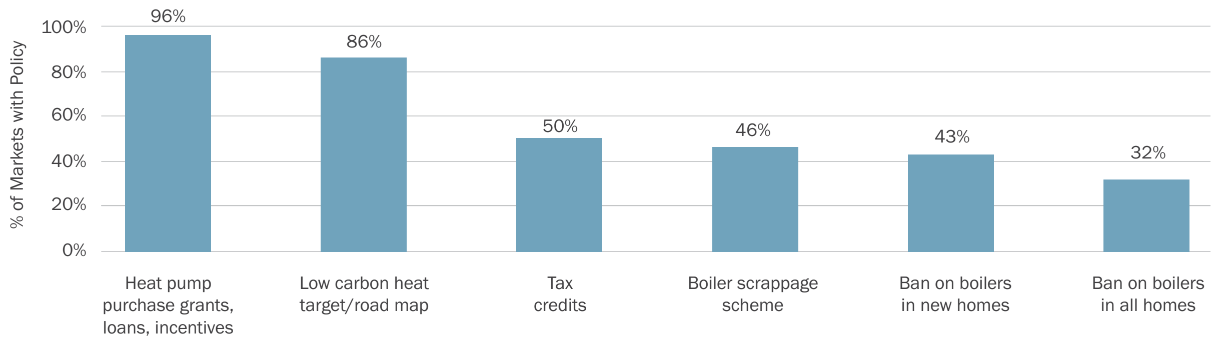

Figure 7: *As of 2022, most developed markets have a heat pump purchase grant, loan, or incentive in place (96%). A considerable number of developed markets also use stricter measures, like bans on boilers in new homes (43%) and bans on boilers in all homes (32%).*[ii]

Acting as a convening body and coordinated voice, the Building Decarbonization Alliance will:

- **Work with industry leaders** (e.g., manufacturers, builders, utilities, the financial sector, government) to facilitate ongoing discussion, information-sharing, and action to support electrification efforts.
- **Support activities** to move Canada towards a net-zero future, for example:
  - Support the development and implementation of policies that promote electrification.
  - Gather key building electrification data (e.g., installation and operations costs and performance).
  - Provide rigorous analysis to support decision-makers across the country, including creating an open-source building decarbonization model to understand the impacts of electrification.
- **Support workforce** training by developing strategies to improve readiness across the country.

Our priority areas for policy support, to be validated with further stakeholder input, include:

1. **Stop the flow of new emissions** by promoting approaches for requiring net zero new construction.
2. **Enable the transition** by reducing regulatory barriers and clarifying the impacts of building decarbonization for electric utilities.
3. **Support the technology** for electrification (e.g., by determining the impact of moving from air conditioners to heat pumps, by making it easier for new technologies to get certified in Canada, or by supporting low GWP refrigerants' entry in the Canadian market).

This work will support our vision of *"a **future where electrified buildings are part of an affordable and resilient energy system** that contributes to a prosperous, sustainable, and decarbonized Canada"* and our mission *"to serve as a **cross-sectoral coalition working to accelerate the electrification** of buildings in Canada."* While we recognize the role of other solutions (e.g., low-carbon fuels) and their potential to help achieve a net-zero building sector, the focus in the immediate term needs to be on ready-to-deploy solutions (i.e., electrification).

If you are interested in supporting our work, **visit www.buildingdecarbonization.ca or reach out to us at info@buildingdecarbonization.ca** to find out how you can help accelerate building electrification.

Endnotes:

i Net-Zero Advisory Body (2023). 2022 Annual Report. Accessed at: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050/advisory-body/first-annual-report-to-minister.html

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