Electrification of Multi-Unit Residential Buildings

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A Message from the CEO of LandlordBC

It is widely accepted that the climate crisis, as a result of the emission of greenhouse gases (GHGs), is having serious negative impacts that threaten our health, environment, and economy. Like all Canadians, the residential rental housing sector needs to play its part in making the necessary changes. At the same time, LandlordBC advocates for the reduction of GHG emissions to be done in ways which minimize impacts on the affordability of rental housing.

De-carbonization, including the electrification of building systems in multi-unit residential buildings (MURBs,) has been identified as a key strategy on the path to addressing the climate crisis. The Building Electrification Road Map (BERM) envisions that by 2030, most replacement domestic hot water and space heating systems in BC's homes and buildings will be high-efficiency electric. To achieve this for MURBs within the rental housing sector it will be critical that we understand the opportunities and challenges for making this transition, and that is the purpose of this report. This project sought to present this issue in a manner that captures both the opportunities *and* the challenges associated with electrification.

The transition from the consumption of fossil fuels in space heating and domestic hot water represents many challenges and costs for rental building owners. Different rental buildings offer different opportunities for reducing energy use and GHG emissions. In rental buildings the problem of GHG emissions reductions must be viewed from a building life cycle perspective including the building age and characteristics, the climate at the building location, and the total number of units the building currently delivers. Ultimately, carbon emissions should be reduced at the fastest rate that technology permits without undue increased expense to renters or rental housing providers, since increased capital costs or operating costs negatively affect rental affordability and housing availability. Government subsidies should be available to make this transition achievable and affordable. In BC, the Province must ensure that there is a well-defined and transparent process, including cost-recovery and a mechanism to adjust existing tenancies that is fair for both landlords and tenants.

LandlordBC, as the leader in the rental housing sector in BC, aims to support the industry in gaining a better understanding of these issues to educate owners and managers, enabling them to make informed decisions regarding building retrofit options. This knowledge will be a critical component in the transition to low carbon buildings, while ensuring the industry can continue to effectively provide critical housing to British Columbians. We hope you find this report

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informative and look forward to continuing to play a leadership role for our members and the broader residential rental housing sector in the reduction of GHG emissions.

Sincerely

D. Hutniak

David Hutniak
CEO
LandlordBC

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Executive Summary

As nations around the world look for ways to reduce their greenhouse gas emissions (GHGs), there is a global trend towards decarbonization by phasing out technologies and energy sources that have high emissions and replacing them with low-carbon and zero-carbon alternatives. Electrification of building systems is a key strategy on the path to decarbonization. This project is focused on the electrification of Multi-Unit Residential Buildings (MURBs) in BC, with a focus on rental housing. The goals of this project are:

1. To develop an understanding of:
    - The current technologies available.
    - Technical and financial considerations for electrification retrofit strategies.
    - Current knowledge, capacity and barriers that the rental housing market faces for electrification retrofits.
2. To educate the rental housing industry regarding electrification retrofit opportunities and challenges in MURBs.

This education will be an essential component of preparing the industry for future efforts related to electrification. It will also better equip LandlordBC (LLBC) to participate as a well-informed industry leader in future discussions with key stakeholders on electrification and decarbonization. While this work may be of interest to a broad audience*, the intended audience for this project are owners and managers of rental housing in British Columbia*.

Consumption of fossil fuels in space heating and domestic hot water (DHW) is by far the largest contributor of greenhouse gasses (GHG) in BC's buildings. Converting to efficient electric heating with heat pumps is one of the key ways to dramatically reduce these emissions, which will help to achieve local, provincial, and federal GHG reduction targets. The Building Electrification Road Map (BERM) envisions that by 2030, most replacement domestic hot water and space heating systems in BC's homes and buildings will be high-efficiency electric. In order to achieve this within the rental housing sector, it will be critical for key stakeholders to understand the key opportunities and challenges for making this transition. LandlordBC, the leader in the rental housing sector, aims to support the industry in gaining a better understanding of these issues to educate owners and managers, enabling them to make informed decisions regarding building retrofit options. This knowledge will be a critical component in the transition to low carbon buildings, while ensuring the industry can continue to effectively provide critical housing to British Columbians.

Different approaches to electrification and associated technologies were investigated in an effort to better understand both opportunities and challenges. This report is not meant to describe all possible retrofits options but rather to highlight key options available with today's technology. As part of this project interviews were conducted with stakeholders including building owners and managers, BC Hydro, local governments, contractors, and equipment suppliers.

Key learnings from this project include:

- There is significant interest in exploring electrification opportunities within the sector, but also concern about potential costs and complexities associated with retrofitting older buildings.
- Owners and managers have limited knowledge on electrification opportunities and would benefit from additional support and information.
- There are a variety of drivers of landlords' interest in electrification. Key factors include:
    - Some landlords (particularly those interested in attracting institutional capital) see electrification as part of broader Environmental, Social & Governance (ESG) objectives, which are very focused on GHG reduction targets. In addition, some see electrification as a way to mitigate against future policies and regulations intended to drive down emissions.
    - There is significant interest among landlords in adding cooling to buildings, most of which currently do not have any active cooling systems. Of note, feedback from landlords on this issue was obtained prior to the extreme heat experienced in the summer of 2021. It is expected that the severe heat wave experienced in BC will amplify interest in cooling.
    - Landlords expressed a strong interest in the potential to transfer utility costs to tenants as part of retrofits that shift from central fossil-fuel systems to distributed, in-suite air-source heat pumps (ASHP) systems (this transition will need to respect the rights of existing tenants).
- The market that supports electrification in BC is still in the early stages of development. As a result, design knowledge is limited, product availability is limited, contractors are learning installation practices with their first projects and maintenance staff is learning new practices to ensure equipment is operating effectively and efficiently. More pilot projects, learnings from current and recent projects, and sharing knowledge will be critical to increasing industry capacity.
- There are technologies and approaches available now to electrify space heating, domestic hot water, and ventilation. Some of the key approaches are listed below (see the main report for more details and benefits and challenges of each approach):
    - Replacing (or augmenting) existing central heating systems with in-suite air source heat pumps (ASHPs). This includes:
        - All-in-one heat pumps that are installed on the interior of a unit (on an exterior wall).
        - Mini-split air source heat pumps (with an outdoor unit and a separate indoor unit).
    - Augmenting existing central heating systems with central ASHPs. Options include:
        - Retaining existing hydronic baseboards.
        - Replacing hydronic baseboards with newer, more efficient units.
    - Domestic hot water (DHW) heat pumps to replace (or augment) existing DHW equipment, including:
        - Heat pumps using CO_2 refrigerant.
        - Heat pumps using R410a refrigerant.
    - Heat pump makeup air units (MUAs) to replace (or augment) existing MUAs.

- Electrification can be a complex process. Common challenges to electrification include:
    - Higher capital costs and regulatory restrictions that limit a landlord's ability to recoup capital expenditures (note that this is partially addressed by BC's new Additional Rent Increase process, announced during the final weeks of this project).
    - The relatively high cost of electricity (compared with natural gas).
    - Increased complexity for planning and approvals relative to more conventional fossil-fuel-fired equipment retrofits.
    - Complexity and uncertainty regarding switching from a landlord-pays to a user-pays approach to utility costs as part of retrofits from central equipment to in-suite ASHPs.
    - Site-specific technical challenges (e.g., electrical capacity, equipment siting requirements, hazardous materials abatement).

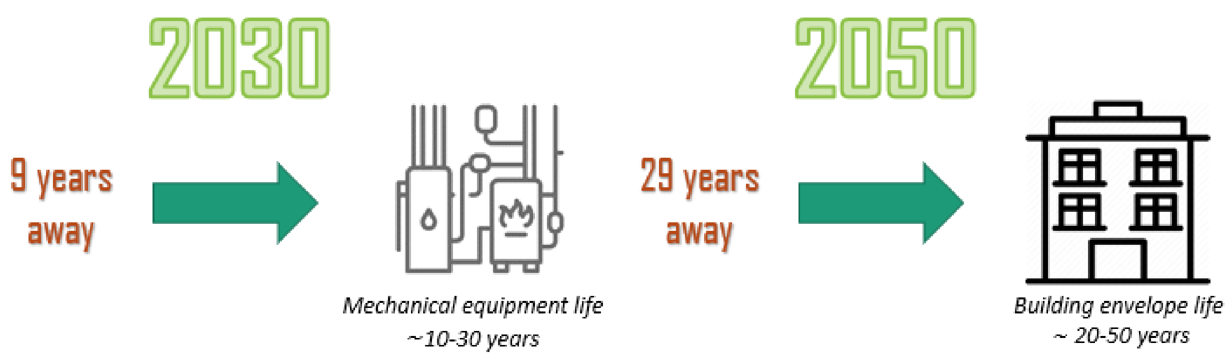
This project included engagement with, and education of, a wide variety of landlords across BC. This included one-on-one interviews, online engagement, a webinar, an article in *The Key* (an industry publication), and the development of a summary guide to electrification of rental apartment buildings (in addition to this report). Further work is needed to provide the required support to help the industry as the world decarbonizes. Key opportunities include the development of support programs that help landlords plan and implement electrification retrofits as well as additional incentives. Additional research and analyses on both the technical and practical aspects of such retrofits is required, as is streamlining local government and utility processes related to these retrofits. While electrification can be challenging, it presents an excellent opportunity to decarbonize, while modernizing and improving the existing building stock.

Why Consider Electrification?

It is important for owners of residential rental housing to take a long-term view when considering retrofit options since decisions taken today will impact the building performance, operating costs, and emissions for at least the next 10-50 years. With Federal, Provincial and Municipal emissions reduction targets set for 2030 (only 9 years from now) and 2050 (29 years away from now), it is expected that new regulations that will impact landlords will come into place within this time frame. It is recognized that some existing rental apartment buildings are approaching end of life and will be redeveloped in the near future. While some buildings will be replaced in the coming years, many will still be standing as new regulations come into effect to help achieve GHG reduction targets; it is these buildings that are the focus of this report.

David Hutniak, CEO of LandlordBC has said: *"Our sector is committed to energy efficiency retrofits and countering the impacts of climate change. The substantial investments necessary for electrification cannot be achieved without meaningful financial incentives and regulatory considerations from all levels of government. In addition, with many buildings at or near the end of their functional life, redevelopment of a portion of the stock will also be necessary to ensure that renters have access to robust supply of safe, healthy, and sustainable housing."*

Figure 1: Emissions reduction targets vs. life of building systems



What is Decarbonization vs. Electrification?

As nations around the world look for ways to reduce their greenhouse gas emissions, there is a global trend towards decarbonization by phasing out technologies and energy sources that have high carbon dioxide (CO_2) emissions and replacing them with low-carbon and zero-carbon alternatives. Decarbonization is not only for buildings, but also across all sectors: transportation, industrial processes, buildings and oil and gas.

There are multiple approaches towards decarbonization, which include electrification (using low-carbon electricity) as well as the use of low-carbon fuels (e.g., renewable natural gas, hydrogen), and significant improvements in efficiency. This project focuses on electrification, which is expected to be a key component of BC's decarbonization strategy, particularly in light of the province's relatively low GHG electricity supply.

Figure 2: Estimated energy mix change needed to meet BC's climate targets

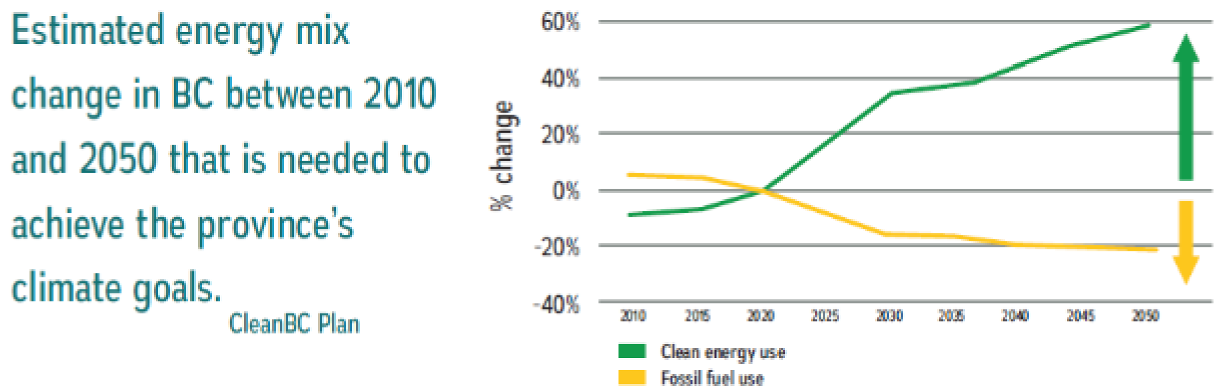


Image credit: Building Electrification Roadmap

Why the Focus on Building Electrification in BC?

Building electrification refers to the replacement of fossil fuel-based building systems, (such as space heating, domestic hot water, and cooking) with low carbon electric powered systems. It is increasingly seen as a key component of GHG reduction strategies; according to the Building Electrification Roadmap (BERM), in BC:

- Natural gas emits a factor of ~16 times more GHG emissions than electricity.
- In many municipalities, buildings can represent 30-60% of community emissions.
- 97% of emissions from buildings come from space heating and water heating.
- Air conditioning is in demand in older buildings as weather becomes hotter (and heat pumps can efficiently provide both heating and cooling).

Market Forces Driving Electrification

Electrifying building space heating, ventilation and domestic hot water systems provides numerous benefits that are driving the market. General benefits of building electrification in BC are shown below; additional benefits that are specific to particular technical approaches are listed in the '*Building Electrification – Approaches'* section.

Occupant Health and Comfort

As heat waves and wildfire seasons are becoming more frequent and intense, electrification provides the opportunity to make buildings more resilient and increase comfort. Few apartment buildings have cooling or air filtration, and heat pumps offer the potential to efficiently provide cooling. Heat pumps also have the ability to incorporate air filtration, and in some cases can be integrated with heat recovery ventilation (HRV).

Providing cooling, air filtration, and improved ventilation can significantly improve occupant comfort and health. This is particularly important for seniors or people with health challenges. BC recently experienced a record-breaking heat wave, and over 550 people are estimated to have died as a result.

Cooling in people's homes, once considered a luxury, is expected to become essential for the health and wellbeing of residents. In response to extreme heat events, tenant-installed portable air conditioners are becoming very common in buildings throughout BC. These portable units demand large amounts of power for the cooling they provide, and in extreme cases can overload electrical systems in the building. Heat pumps can often offer heating and air conditioning for a lower overall cost than separate air conditioning and heating systems.

Figure 3: Example of new in-suite heat pump vs. portable AC

 *Slim profile wall mounted air conditioner/ air-source heat pump which only requires two 6-8" holes through the wall or spandrel panel* *Image Credit: Clima Design Technologies*	 *Typical DIY portable air conditioner installation: these, like window air conditioners, are very low efficiency, and do not provide heating.*

Reducing Carbon Impact

Electrification dramatically reduces a building's GHG emissions. This helps achieve local, provincial, and national GHG reduction targets, as well as internal targets for companies that have them. The benefits of reducing GHG emissions (beyond the global environmental benefit of addressing climate change) include:

Risk mitigation: as local, provincial, and federal governments ramp up efforts to meet GHG reduction goals, it is expected that increased regulation and taxation will be implemented. While the details of such efforts are not yet clear, many companies see carbon reduction efforts as a way to mitigate against the risks such policies pose to their ability to profitably operate their portfolios in the coming years.

Attracting investment: recognition of Environmental, Social and Corporate Governance (ESG) is an important factor to attract investment, particularly those seeking institutional investors. GHG reductions form a core component of ESG for the building sector, which is seeing increasing investment from larger institutional investors. Some landlords also highlighted that electrification upgrades can be seen as a form of capital investment that modernizes and improves the building, leading to increased property value. Larger landlords in particular have indicated that they are increasingly developing more aggressive plans and policies to achieve GHG reductions.

Policy & Regulations Driving Electrification

Canada has committed, through all levels of government, to aggressive GHG emissions reductions targets to reduce the impact of climate change, and as mentioned above, electrification is a path to emissions reductions. To achieve these targets, several plans have been drafted for which we are beginning to see some concrete policies and regulations being put in place.

Below is a brief summary of some of the targets, plans and regulations across all levels of government that will impact the rental housing industry in BC.

Federal Level

Canada signed the Paris Climate Agreement with GHG emissions reduction targets for 2030 and a target of net-zero emissions (*first reduce emissions and then remove as many emissions as we create)* by 2050.

Some of the legislation, regulations and plans to achieve those targets are:

- Legislated carbon tax of $50/tonne CO_2equivalent (CO_2e) in 2022 increasing by $15 per year, until it reaches $170 CAD in 2030.
- Investments in green infrastructure are a key component of the COVID-19 economic recovery plans.
- In 2020, "A Healthy Environment and a Healthy Economy" plan (Canada's revised Climate Plan) was announced.
- In June 2021, "Canadian Net-Zero Emissions Accountability Act" passed to require national GHG emissions reduction targets to meet the Paris Climate Agreement.
- Billions of dollars have been added to the Federal budget to support building retrofits through energy audits, support programs and interest-free loans.

Provincial Level

BC has legislated targets for reducing GHG emissions through the Climate Change and Accountability Act. Targets which include reducing emissions to 40% below 2007 levels by 2030, 60% by 2040, and 80% by 2050. To meet the 2030 targets, the building and communities sector needs to reduce emissions by 59% to 64% from 2007 levels. While these targets are not binding or have no enforcement mechanisms, they give a strong indication of the government's intended direction.

Some of the legislation, regulations and plans to achieve those targets include:

- **Carbon Tax Act** began at $10/tonne CO_2e in 2008, currently at $45/tonne, with planned increases to $50/tonne by 2022. A carbon price helps provide an incentive for actions that produce fewer emissions. New revenue generated above the $30/tonne of GHGs level is used to protect affordability, maintain industry competitiveness, and encourage new clean initiatives.
- **CleanBC Plan (2018)** – proposes regulation, programs, and rebates to reduce emissions, such as:
  - Increasing energy efficiency standards for new construction to achieve 'net-zero energy-ready' by 2032 (BC Step Code – now a part of BC Building Code (BCBC)). This does not address GHG emissions directly.
  - Minimum requirement of 15% Renewable Natural Gas (RNG) for all buildings.
  - New energy efficiency standards for space heaters, water heaters and windows.

- **Building Electrification Roadmap** (2021) – lays a path with different actions required to achieve BC climate targets, some of those actions are:
    - Envisions that by 2030, most replacements for domestic hot water heating and space heating systems will be heat pumps.
    - Require building benchmarking - GHG performance data reporting and disclosure.
- **BC Retrofit Building Code** – new standards for building upgrades are being developed to be implemented by 2024, guided by the model National Energy Code. This new code aims to set requirements for upgrades to existing buildings to bring them up to modern standards for efficiency and comfort.
- **Financial support** through:
    - Billions of dollars added to the BC budget over a five-year period to meet its emissions targets.
    - Making investments in green infrastructure are a key component of the COVID-19 economic recovery plans.
    - CleanBC program, which provides multiple incentives, expert advice, and rebates for retrofits that reduce carbon.
    - Property Assessed Clean Energy (PACE) financing offerings are in development by the province. They offer financing and on-bill financing as alternative financing mechanisms for building electrification upgrades. In the case of the former, loans are tied to the assessed property, while in the latter they are tied to the utility meter.

Municipal Level

Many local governments have declared their intention to significantly reduce GHG emissions in new and existing buildings. Examples include Victoria, Metro Vancouver, Burnaby, New Westminster, District of Squamish, Port Moody, among others.

The City of Vancouver, for example, has extensive plans and targets already in place and are in the process of developing new regulations. They do have additional powers beyond what other local governments have (in light of the City of Vancouver Charter), such as the ability to create their own building bylaw. None the less, the significant size of the City of Vancouver gives them tremendous influence over the rental housing universe.

- **City of Vancouver Zero Emissions Building Plan (2016)/ Climate Emergency Action Plan (2020)** focuses on transitioning the local building industry away from fossil-fuel use to the use of renewable energy sources with low or no GHG emissions, such as hydroelectricity, biogas, and Low Carbon Energy Systems.
    - Several regulations have been implemented though the Vancouver Building By-Laws and rezoning requirements; comparatively little has been done to date regarding retrofits.
    - Some of the plans are for existing buildings are:
        - Target for all new and replacement heating and hot water systems to be zero emissions by 2025.
        - Energy and carbon reporting (benchmarking) in existing large homes, MURBs and large commercial buildings by 2023.

        - Potential for introducing by 2026-2032 performance and/or prescriptive carbon pollution regulations for MURBs giving priority to stratified condominiums; action on rental buildings are expected later.
        - Future requirements to drive phased retrofit planning by 2030-2040.
- **Financial framework:**
    - Facilitate owners' access to favorable financing and third-party investment in deep emissions retrofits.
    - Funding from different sources including the government, Federation of Canadian Municipalities, Union of BC Municipalities, and the Vancouver Economic Commission.

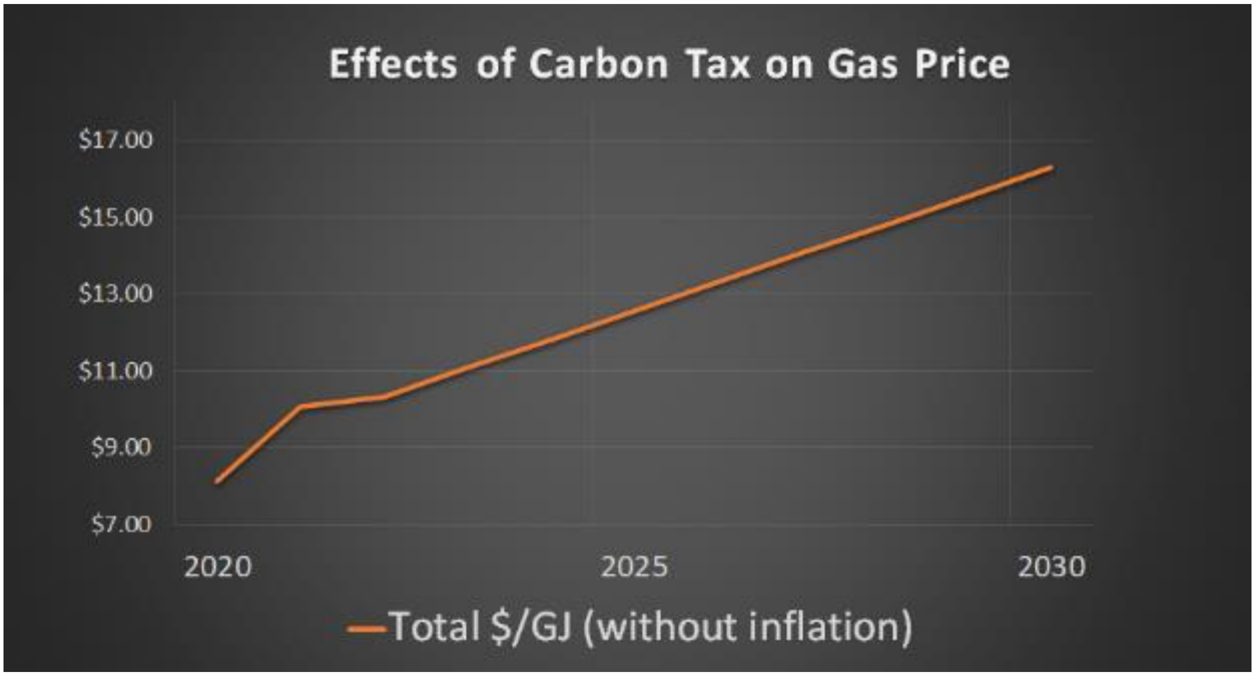
Carbon Tax and its Impact on Electrification

One of the main factors that will affect building operating costs is the Federal carbon tax. While up until now, BC had been setting the highest carbon taxes in Canada (currently at $45/tonne of CO_2e and set to increase to $50/tonne 2022), the Federal government has legislated for a Canada wide carbon tax starting at $50/tonne in 2022 and rising to $170/tonne by 2030. The graph below illustrates the impact on natural gas costs of the Carbon Tax as it increases from $40/tonne in 2020 to $170/tonne in 2030, *assuming no other rate increases*. It shows that the price of gas is expected to double from the $8/GJ (gigajoule) price in 2020 to $16/GJ in 2030 (exact blended price per GJ varies depending on the utility rate).

As an example, considering that the average GJ of gas required to provide heat and hot water to a rental unit is about 30 GJ per year, for a building with 100 units, the gas utility prices are expected to rise from approximately $24,000 per year in 2020 to $48,000 per year in 2030. Again, *this excludes any future increases in gas costs other than from carbon taxes.*

The price of gas is an important factor when considering electrification as the current cost of electricity is approximately three times more expensive than natural gas per unit of energy (this varies depending on the utility rate class of the customer). This means that high-efficiency electric systems need to operate about three times more efficiently than equivalent natural gas systems for energy costs to be equal. Currently, not all heat pump systems are expected to achieve the required efficiency year-round to overcome the difference in rates. As the Carbon tax increases it will narrow the gap between electricity and gas prices and (all else being equal) allow many heat pump systems to be able to outperform natural gas systems in energy operating costs.

Figure 4: Effects of Carbon Tax on Gas Price



** The graph does not include future increases in the price of gas beyond the impact of carbon taxes*

Building Electrification - General Considerations

This section outlines general considerations for electrification of space heating, ventilation and domestic hot water systems in rental apartment buildings. Additional considerations that apply to specific technical approaches are discussed in the 'Building Electrification - Approaches' section.

Rental Housing Industry Capacity and Knowledge Regarding Electrification Retrofits

Based on the feedback received from landlord interviews and polls, knowledge regarding electrification is low but the interest in electrification is high. There are some early adopters of electrification that have installed electric heat pump systems to either replace or work in tandem with natural gas systems. These include both larger and smaller landlords. The larger landlords are more likely to have personnel that are knowledgeable regarding electrification technology, though even most larger companies have limited knowledge and experience in this area. A wide variety of technology is available now to begin electrifying building systems. Each building is unique presents different opportunities and risks. A significant increase in industry knowledge and capacity will be required for the sector to successfully implement electrification retrofits.

Existing Electrification Retrofits

There are a growing number of detached homes in North America which have successfully "electrified" over the last two decades, however, electrifying larger buildings is more challenging. There are currently only a few completed examples in BC, but a larger number are in the planning phase. Additionally, increasing electrification in new construction will help increase building industry capacity, availability of equipment, and may result in lowering of retrofit costs.

Support required: Currently there is a lack of information on actual costs, savings and local experience for a wide range of multi-unit building electrification approaches and scenarios. In order to address this, more pilot projects and case studies are required. This will require millions of dollars in funding immediately in order for electrification to scale up in a significant way.

Limited Design, Contractor and Maintenance Staff Knowledge

Several previous heat pump installations have been designed incorrectly, which has caused operating issues and low efficiency. Heat pumps typically require a different approach to design than conventional gas or electrical resistance equipment. High quality design and installation practices will enable high levels of performance.

Installation and maintenance issues have also been observed. These include incorrect or overriden set points that prevent the equipment from running at optimum perfromance, and in many cases leads to lower efficiency auxiliary energy sources running when not required, which can increase operating costs.

Support required: Industry training on best practices and lessons learned is required to ensure engineers, contractors and maintenance staff understand how to optimally design, install and operate systems.

Process of Electrification

The process for implementing an electrification retrofit is often more involved and technically complex than a like-for-like replacement or even an upgrade from a low-efficiency to high-efficiency natural gas system. It is recommended that landlords seek support from experts with experience with the type of retrofits they would like to pursue to reduce risks.

The process typically requires:

- Identifying and analyzing retrofit options, using the option of a like-for like replacement as the base case for comparison. This phase should include:
    - an electrical capacity analysis,
    - identification and quantification of applicable rebates,
    - capital and utility cost estimates,
    - evaluation of co-benefits and risks; and
    - current building condition and site layout.
- Once the owner has discussed and selected an option, a design specification should be produced by a qualified HVAC designer. At this stage it should be determined what construction permits will be required so the proper documentation and drawings can be produced.
- Tendering to qualified contractors to get competitive pricing, ideally to those with specific experience with the system selected.
- Installation and proper verification of system balancing and commissioning is critical. Any number of unforeseen challenges may arise when new heat pump technology is adopted to old or existing buildings, despite the most careful design and installation. This is primarily due to hidden existing conditions that only become apparent once existing building infrastructure is connected to a new system. Balancing and commissioning the entire system (not just the heat pump equipment) can uncover and resolve many of these potential issues during the project when it is most advantageous and cost-effective to do so rather than needing service calls in the future.
- Post installation measurement and verification can help identify if the system is operating correctly and if adjustments are required. It can also provide valuable information to the industry by providing actual performance data and lessons learned.

Support required: Another avenue to support the industry is by offering programs or rebates that will support landlords with the process of evaluating and implementing electrification retrofits, including analyzing retrofit options, designing the right solution, finding suitable contractors, and ensuring that the equipment was installed correctly and is running as intended. It is recommended that measurement and verification of the systems be conducted to help collect information on actual system performance to advance the industry and inform future program development.

Key Technical Considerations

Several technical considerations are important when electrifying buildings systems:

Finding a Location for Outdoor Units

Air-source heat pumps require free flow of outdoor air; they have "Outdoor Units" which are normally located outside and can never be completely enclosed in a building interior. This can be a challenge in existing sites with limited free space, especially since municipalities often have strict rules that impact equipment siting. This may include considerations regarding exterior appearance and obstructed views, including for rooftop mounted equipment, as well as real or perceived noise impacts.

When reviewing the options of mounting heat pumps on balconies, walls or roof tops, the structural capacity will also need to be reviewed. The structural capacity varies greatly on the building design, condition, age and materials.

Parkades are a possible location for outdoor units, however this can cause problems by cooling the parkade and robbing heat from the building.

Support required: Municipalities should consider relaxed restrictions on appearance or simplify the approval process for new equipment mounted outside of the building since it limits options and adds cost, time and complexity to a heat pump retrofit.

Air-Source Heat Pump Capacity for Coldest BC Climates

Heat pump efficiency drops with lower outdoor air temperature. Currently there are many equipment options that can perform well in very cold weather (-25℃). In some cases, auxiliary heating is required to ensure the system can perform in all weather conditions.

Refrigerant Leakage Risk

Escaped refrigerants are a significant source of GHGs which could impact efforts to reduce GHG emissions by electrifying buildings with heat pumps. The exact amount of refrigerant leaked per system is currently unknown as it is not measured or tracked. The refrigerant currently sold in most common residential heat pump systems in BC is R-410a, which has a high Global Warming Potential (GWP). While new refrigerants are rapidly emerging and promise to offer far lower GWP, each refrigerant and technology provides a different performance across the range of outdoor temperatures and some have limited applicability to space heating or air conditioning.

Support required: rebates and support for technologies with low GWP refrigerants as well as setting best practices and enforcement for contractors to reduce both operational and end of life refrigerant leaks. Also, governments need to clarify the schedule of coming low GWP refrigerant regulations.

Systemic Barriers

Regulations on Rent Control & Tenant Disruption

Recuperating capital costs associated with electrification is a challenge for landlords as the Residential Tenancy Act (RTA) limits rent increases and the ability to shift utility costs to tenants. As a result, many landlords are unlikely to undertake such retrofits if they are unable to justify the capital expenditures with increased revenues and/or decreased operating costs.

Installation of in-suite heat pumps will often be one of the most practical ways to electrify a building's heating system, but it can cause some tenant disruption and add scheduling complexity if completed during an existing tenancy. In some cases, such retrofits may be staged so they are completed on tenant turnover, though it may often be impractical to stage a retrofit in this manner (particularly for a building with low tenant turnover). It is expected that the disruption and scheduling challenges associated with completing in-suite retrofits during an existing tenancy can usually be managed, but the added complexity compared with simply retrofitting using a new central fossil-fuel-fired system may discourage some landlords from moving forward with such projects.

The option to replace a boiler with a central heat pump is attractive in part because it can avoid requiring suite access. There are options available for electrifying existing central heating systems but in most cases such systems will not be able to fully meet a building's heating needs. These systems could be installed as "hybrid" systems that rely on natural gas to meet part of the building's heating load. See the '*Electrifying Central Hydronic Heating'* section for details. In addition, if cooling is desired, the baseboards in suites would have to be replaced with other types.

Some building electrification related upgrades will require work within the suites which causes tenant disruption as well as extra scheduling and planning. While disruptions can be communicated and mitigated with the tenants, it could dissuade landlords from moving forward with some building electrification retrofits.

Resources available: LandlordBC has done significant work with government to develop a robust and transparent process under the RTA to encourage and facilitate capital investments that can improve the quality, safety and energy efficiency of rental buildings.

Two changes to the RTA, discussed below, recently came in force (on July 1, 2021), while rent freezes continues to be in effect until Dec. 31, 2021.

Additional Rent Increases for Capital Expenditures (ARI): allows landlords to apply for an additional rent increase (on top of the allowable annual rent increase) to recoup the costs of necessary capital expenditures in the property.

If successful, the Residential Tenancy Branch (RTB)'s decision will set out the eligible rent increase based on a formula, which factors in the amount of eligible capital expenditures and the number of dwelling units, amortized over a 10-year period. The additional rent increase will be capped at a maximum of 3% per year (plus the annual rent increase) for a maximum of three years.

For a capital expenditure to be eligible it must made for the purpose of:

- Maintaining, repairing, or replacing a major system or component such as electrical, mechanical, or structural that is necessary or,
- *Reduces greenhouse gas emissions or energy use* or,
- Improves the security of the rental property.

Ineligible expenditures include:

- Repairs needed as a result of inadequate repair or maintenance by the landlord.
- Expenditures where the landlord has recouped the cost from another source.

Ending Tenancy for Repairs or Renovations: landlords needing to end tenancy to conduct repairs or renovations will need to apply, through the RTB's online portal, to have an arbitrator review the intended work to determine if the landlord has met the criteria to warrant an end to the tenancy. If successful, the landlord will be issued an Order of Possession effective four months from the date it is received by the tenant.

For a tenancy to come to an end for repairs or renovation the landlord must intend in good faith to renovate or repair the rental unit and has all the necessary permits and approvals required by law to carry out the renovations or repairs. Additionally, the renovations must require the unit to be vacant and the renovations must be necessary to prolong or sustain the use of the rental unit or the building in which the rental unit is located. Further, the only reasonable way to achieve the necessary vacancy would be to end the tenancy agreement.

When making this application the landlord will need to have all necessary permits and approvals in place along with a detailed plan of the work to be done. The application, the RTB's online portal will require the landlord to apply for all affected units at the same time (giving all units the same end of tenancy effective date).

While the aim of this new process is to ensure tenancies do not unnecessarily come to an end while preserving the right of landlords to end tenancies, when necessary, it is a lengthy process that highlights the benefit of building upgrades which do not require tenant displacement. *It is expected that most electrification retrofits, which may also be done in conjunction with other upgrades (e.g., window replacements) can be done without tenant displacement.*

Responsibility for Energy Costs

For existing central systems, costs for heating and domestic hot water is typically the responsibility of the landlord. By shifting a portion of utility costs to tenants, energy consumption reduction is encouraged, which supports the goal of reducing electrical consumption and, which puts less pressure on the need for infrastructure upgrades. It will also allow for the shift from central hydronic systems to in-suite heat pump systems.

There are different approaches to transitioning a portion of utility costs from landlords to tenants:

- Retrofits only on tenant turnover: with this approach, heat pumps would only be installed in suites when a tenant moves out. The new tenancy would then exclude heat from the rent. The challenge with this approach is that it would require that the existing heating system be maintained until all units have been turned over and retrofit, which could take several years. From a technical perspective, many buildings would be able to handle having suites gradually taken off the central heating system, though this depends on the system configuration and it will become challenging to continue to operate central systems for smaller and smaller portions of a building as more units turn over.
- Revising rental agreements for existing tenancies in a fair and equitable way for all concerned. Tenants benefit from improved individual control, air filtration, and cooling, which are significant benefits. In this scenario landlords will incur a large capital expenditure all at once but would no longer be responsible for heating costs. In such a situation landlords would have to either:
    - A) Negotiate a change in tenancy agreements. Many tenants may be attracted to the prospect of having their own heat pump and the addition of cooling. The process of negotiation would be time consuming for both landlords and tenants and there is no guarantee that they will be able to reach a mutual agreement.
    - B) Remove heating from a service provided by the landlord and give tenants a reduction in rent that compensates them for the cost of paying for their own heating. Landlords would also, however, likely be able to make use of the ARI provisions in the legislation to increase rent to help recover the capital expenditures.

As it would challenging to accurately estimate what the heating energy cost would be for each individual tenant, and the actual cost would largely depend on tenant behaviour, this creates uncertainty and the potential for conflict between landlords and tenants that may lead to dispute resolution through the residential tenancy branch (RTB). Such disputes would be difficult and time consuming for landlords, tenants, and the RTB. The prospect of such disputes may discourage landlords from engaging in such projects. LandlordBC and industry stakeholders have indicated that immediate changes to the residential tenancy act are needed to address this issue so that there is a clear, simple process that is fair for all concerned.

Support required: Clarification is needed from the Provincial government as to how the shift in the responsibility for utility costs can be handled so it is done in a manner that is clear and fair to both landlords and tenants.

David Hutniak, CEO of LandlordBC indicated the importance of this issue: *"Electrification will require significant capital investments by building owners and we are confident that the Province expects consumers, in this case renters, to be part of the solution and share in the responsibility of countering the impacts of climate change. Shifting the responsibility for some utility costs to tenants to enable in-suite heat pumps, and give tenants control of and accountability for their own energy consumption, will be essential to making electrification work at scale. Existing legislation creates barriers that impede progress on electrification. In order to achieve this shift, the Province must ensure that there is a well-defined and transparent process, including cost-recovery and a fair mechanism to adjust existing tenancies."*

Product Availability

Since there are still not many heat pump systems installed for MURBs and the shift is just starting, product availability is still a challenge making like-for-like replacements an easier option for owner and managers. That said, there are a variety of products currently available on the market and options are improving.

Key Cost Considerations

Cost factors vary significantly between different buildings, climates, and technology types. Key cost considerations are discussed below.

Capital Cost and Return on Investment

There is a relatively high capital cost of substituting natural gas systems with high-efficiency electric space and domestic hot water systems including added construction permitting complexity for compared to replacing like for like.

As carbon tax rises, the capital cost differential is becoming less prominent in some cases.

Support available: There are multiple grants, rebates and support programs for building electrification including:

- CleanBC programs provide funding for electrification including for both energy studies (up to $40,000) and for capital projects (up to $200,000).
- BC Hydro and FortisBC Electric rebates for heat pumps.

- Municipal top-up rebates for some heat pumps or for reducing GHG emissions, although most of them at this time are mostly not eligible for rental properties.

Electrical Upgrades

Electrifying building systems may require additional electrical capacity. The buildings that do not have sufficient remaining electrical capacity will have to upgrade their building electrical infrastructure (great opportunity for buildings whose electrical wiring has reached end of life). While this study looks into electrifying space heating, domestic hot water and ventilation, it is recommended that other future electrical needs such as the installation of electric vehicle service equipment (EVSE, also referred to as charging stations) are considered when upgrading the building's electrical infrastructure. Incorporating technologies such as electrical battery storage and power management can also make buildings more resilient against future extreme weather events.

Upgrading the electrical service can come with a high capital cost and landlords report that significant additional time to coordinate with utilities can be required. In some areas the utility may have limited capacity to provide the additional power, which would require additional upgrades and associated costs.

Support required: utilities need to simplify the access to total building electrical consumption to determine if there is enough capacity for electrification, such a process is already available for the purpose of installing electric vehicle chargers but not for installing heat pumps. There are great rebate and support programs to retrofit electric vehicle chargers, including the electrical upgrades needed, a similar offer for heat pumps would greatly facilitate their adoption.

Presence of Asbestos & Aluminum Wiring

Retrofits that will require enclosure penetrations will have additional costs if asbestos is present, which can be an issue with a wide variety of renovations (i.e., other than electrification). An additional concern with aluminum branch circuit wiring is that it does not lend itself to wiring modifications. This can result in additional costs for electrical upgrades.

Risk of Innovation

New technologies and approaches need more care and attention to implement. Any time a new approach is being used this also presents more unknows, which can result in increased costs or performance levels that are below expectations. Some examples are discussed in the "Limited design, contractor and maintenance staff knowledge" section above.

Timing & Scheduling and Emergency Replacements

Upgrading to heat pumps will require additional design, planning, staging, permits and city requirements compared to simple like for like replacements.

Permitting practices vary by municipality; some have very quick turn-around times while some can take several months. The push for electrification at all levels of government has led to pressure to improve permitting practices and policies to enable a smoother and faster process.

Timing becomes a particular challenge for emergency equipment replacement, which may not allow for the additional time required to properly install a new system. These situations may result in owners having to install an undesirable solution, locking the building into an inefficient and high GHG equipment for decades. It is therefore critical that building upgrades be pursued in a proactive manner that enables landlords to have sufficient time to investigate their options, make an informed decision, and plan for their desired solution.

Support required: currently the process to electrify building systems often isn't clear and can add significant time and cost to a project. Local governments and utilities can help by streamlining their processes. Programs that support landlords in planning and implementing upgrades will also help, but without a streamlining of processes significant time will still be required.

Electricity Rate Structure

Current electricity rate structures often discourage electrification since common building areas are typically charged for peak kilowatt (kW) demands and tenants on BC Hydro's residential rates get charged a higher 'Step 2' rate if they increase their electricity consumption. Changes to rate structures are being considered that may help to encourage (or least not discourage) electrification.

General Symbiotic Actions

Before considering installing heat pumps, a wide range of measures to reduce heat loss and minimize domestic hot water consumption should be considered. Judicious selection of these measures together with heat pumps can minimize total capital and operating costs, and/or improve overall comfort.

Building Enclosure Improvements

(See previous discussion re redevelopment vs improvement decision making.)

Improving enclosure not only improves comfort, reduces noise, and extends the life of the building, it also reduces heat load and enables downsizing the mechanical equipment which can reduce electrical capacity required and equipment and operating costs.

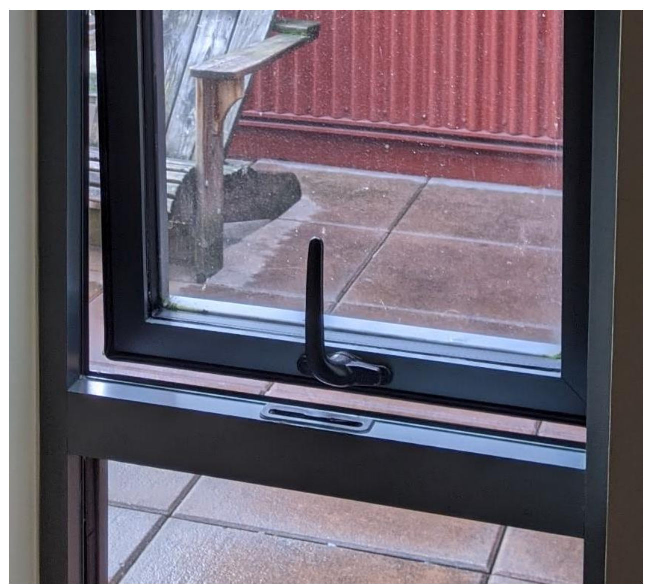
Varying levels of improvements are possible, from simple improvements that are inexpensive to more complex holistic retrofits. Measures can include:

- Air sealing drywall penetrations and wall to flooring gaps seal the apartments from each other, and from drafts from the outside walls. Typical details are electrical outlets, light fixtures, switch plates, the gap between the drywall and the flooring, and hydronic piping.
- Window upgrades (with high performance windows).
- Cladding (with additional insulation and air sealing).
- Roof upgrades (with additional insulation)

One consideration when improving the enclosure to making it more airtight is that improvements to ventilation may then be required.

Many landlords don't consider whole building enclosure retrofit due to the high capital cost, but even modest improvement can have big benefits, and when combined with heat pumps enable a more comfortable and efficient building.

Figure 5: Photos of modest enclosure retrofits

	
Typical unsealed radiator pipe through drywall	*Typical firestop caulking retrofitted to seal air leakage*
	
Typical single pane aluminum window; cold and drafty and causes mold and water damage on sills	*Typical upgraded window with double pane, well-sealed when closed, thermally broken and insulated frame. Higher performance triple pane windows are also widely available, and common in new construction.*

Heat Recovery Ventilation (HRV)

HRVs can make a significant reduction in heating loads in MURBs while improving air quality for residents. The majority of existing MURBs in BC do not have active ventilation. A small number of buildings have gas heated hallway make up air units (typically after 1985).

If considering any upgrades to the heating system, it's worth considering one of these two HRV approaches:

Centralized HRV's are challenging and costly to retrofit to existing buildings, some MURBs in BC have retrofitted them have been reported by building managers to have poor performance.

In-suite HRV's are available which can efficiently provide good ventilation in the suite. Decentralized equipment provides flexibility to either install HRVs in all units at once, or gradually on tenant turnover. These units come in two main types: ducted and alternating flow. Ducted units require extensive ducts to be added in the suites, which is very costly, especially in slab buildings. Alternating flow units are simpler to retrofit since they are mounted entirely within the wall cavity but require at least two enclosure penetrations in each suite and maintenance requires suite access (for filter changing).

Both centralized and in-suite HRV's can be applied to centralized or in-suite suite heating electrification approaches. Both approaches can also work in conjunction with central make-up air (MUA) heat pumps.

Building Electrification - Approaches

This section describes several key technical approaches to electrifying space heating, domestic hot water and ventilation in existing residential rental housing that are particularly applicable to the rental market sector, it also briefly mentions other less common approaches. This report is not meant to describe all possible retrofits options but represents many of the viable options based on today's technology.

There are a variety of approaches to electrification, a wide range of products available today and new products entering the market to meet the varying needs of different buildings. Certain approaches are better suited for certain specific building conditions such as building construction, height, existing mechanical systems, climate zone and an owner's priorities (reduce emissions, improve comfort, reduce operating costs, etc.). Properly selecting the right solution for the specific building will maximize the benefits and minimize the capital investment required.

For the purposes of this report, key approaches are grouped into the following categories:

- Electrifying In-Suite Heating
- Electrifying Central Hydronic Heating
- Electrifying Central Make-up Air
- Electrifying Domestic Hot Water Heating

For each approach we will discuss their relative benefits, challenges, available technologies, symbiotic efforts and financial implications.

While electric cooking appliances and electric vehicle chargers are also a way to electrify buildings, this report focuses of space and domestic hot water heating only as they represent the biggest opportunities to reduce building emissions.

Electrifying In-Suite Heating

This approach involves shifting from central hydronic heating to distributed in-suite heating using air-source heat pumps. This approach has widespread applicability for rental apartment buildings that use central hydronic heating (hot water baseboards).

Many of the landlords interviewed for this study were intrigued by this approach and commented positively on the advantages of adding cooling, the possibility of shifting heating costs to the tenant, and achieving deep GHG reductions.

Benefits and Considerations

Benefits - the primary benefits of this approach are:

- **Added cooling:** the added cooling provided by ASHPs will increase tenant comfort, especially during heat waves and wildfire smoke conditions where opening windows is discouraged. ASHPs will also remove the need of portable or through wall air conditioning units, quite common specially in hotter climate zones like the Okanagan; replacing these with new, efficient heat pumps would be a significant upgrade that would improve efficiency, reduce utility costs and noise while ensuring effective cooling.

- **Individual comfort control:** by installing air-source heat pumps in each suite, each tenant can independently control their own heating and cooling. In contrast, existing central heating systems provide limited control over suite heating and with the added heat contribution from the uninsulated hot water pipes running throughout the building walls, some tenants need to resort to opening windows during the heating season to regulate the temperature in the suites. The limited ability of temperature control in existing older hydronic systems causes energy waste and poor tenant comfort.
- **Transferring heating cost to the tenant meter:** in-suite heat pumps would typically be wired to the electrical panel in the suite which is tied to the tenant's meter. This approach encourages conservation as people are more aware of their energy consumption when they pay for their own use, see the *Responsibility for Energy Costs* section above for further discussion.
- **Product availability:** there are several products in the market for both packaged and mini-split heat pumps including cold climate rated units that can operate efficiently even at -25°C.
- **An auxiliary heat source is often not required for in-suite heat pumps**. In-suite air to air heat pumps can operate efficiently and with adequate capacity, even in cold temperatures. Using a central heat pump system would typically require an auxiliary heating source, which would normally be a natural gas boiler.
- **Installation without tenant displacement** of in-suite heat pumps can be very simple, and has the flexibility of all-at-once, or phased implementation (e.g., replacement only during suite turnover). Installation by a trained crew going through all suites at once can reduce cost and allows the hydronic system to be retired before the next winter, maximizing rebates and GHG savings. Can be installed without displacing tenants
- **Avoiding costs of replacing a failing hydronic system** is a valuable benefit if the central hydronic system will be completely replaced by in-suite ASHPs. Leaky pipes and hot water radiators can be a source of expensive damage and stress for both landlords and tenants. Since the pipes are inside walls and ceilings, replacement requires extensive drywall work. The reduction in risk of damage may also enable a reduction in insurance costs.
- While removing the hydronic baseboards is not absolutely necessary, it could be scheduled for a time when the suite gets a full renovation. It will allow valuable floor space to be recovered and will provide a more flexible furniture layout.
- **Low operating noise**: while outdoor noise concerns are sometimes raised by inspectors during the building permit application process, installed units have proven to have low noise levels reported by neighbours to be so quiet they don't hear them.

Figure 6: Photos of damage from leaking hydronic systems

	
Damage from leaky hydronic systems; damaged flooring	*Damage from leaky hydronic systems; damaged ceiling drywall*

Considerations:

- **Enclosure penetrations:** enclosure penetrations are required; either a small hole for refrigerant lines for mini-splits, or two 6-8" holes for all-in-one units. This involves risk of asbestos in the drywall, as well as a risk of installation errors leading to air sealing leaks and water ingress from the outer wall if the external duct cover is not fitted and sealed properly.
- **Available heat pump sizes:** there are many well established products to serve this application. Most, however, are originally designed to be sold into the detached home market, and therefore are sized larger than typically required for apartments, particularly studio apartments. Oversizing has disadvantages, including: reduced performance, higher costs, higher power ratings (potentially leading to additional costs for electrical upgrades), and larger physical size. Paying careful attention to equipment specifications can help mitigate oversizing issues, for example by choosing equipment that performs well at a low output. Some manufacturers mentioned they are interested in bringing smaller capacity systems to the market to meet the needs of smaller spaces with lower heat loads.
- **Condensate and defrost drainage** are a complicating factor for all distributed in-suite ASHPs. Condensate dripping from poorly installed air conditioners is a problem familiar to many people. When air is cooled, depending on humidity, water may condense out of it. Heat pumps in heating mode also produce water, which is collected in a pan in the bottom of the equipment. If drained outdoors and poorly located, the water may freeze into ice on walkways creating slipping hazards. Mini-split outdoor units around low rises typically drain directly to the ground or roof. Some require heated pans to prevent freezing. Water from all-in-one units must be piped out from the unit to drain. This may be to outdoors through a gravity drain, or indoors to bathroom or kitchen plumbing drains. Typically, low-cost plastic tubing is used, sometimes with a very small low voltage pump.
- **Transferring heat to bedrooms** is another challenge to be solved for in-suite heat pumps. If smaller capacity units were available in the market, each bedroom could have an individual heat pump, unfortunately the smallest capacities in the market are too big making it too costly and challenging to install several heat pumps for one suite. Some potential solutions are:

  - **Heat pumps with multiple heads:** these are available for mini-splits but costs are higher, there is also one all-in-one product with a remote head, but it is not currently available in BC. This solution will be most practical with bigger heat pumps.
  - **Adding transfer fans** which blow heated air from the living room heat pump through the wall or door to the bedrooms.
  - **Auxiliary heat:** one last solution would be to install electric baseboard heaters for auxiliary heating in the bedrooms. It will require additional electrical capacity, which is already scarce in existing buildings trying to electrify different systems including adding electric vehicle chargers.
- **Symbiotic Efforts:** As mentioned in the "*General Considerations*" section, enclosure upgrades and HRV's will lower the heat load and improve comfort, which reduces the capacity required for the heat pump and the electrical load. Some models of in-suite heat pumps even include built in ventilation with heat recovery, promising to simplify installation and reduce the number of enclosure penetrations. However, cost effective products are not widely available on the market.
- **Cost considerations:** in-suite ASHPs are estimated to have an installed capital cost between $4 to $10,000 per suite. The cost varies due to different factor such as:
  - Ease of penetrating and resealing the enclosure (including presence of asbestos).
  - Need of electrical upgrades within the suites or the main building service.
  - Number of units required per suite (depends on the ease of transferring heat from one room to another).
  - Need of auxiliary heat (for extremely cold climates or for rooms away from the unit).
  - Location of the heat pumps.

  Since this approach provides an opportunity of reducing the majority of the building's heating GHG emissions, substantial funding is available from CleanBC (up to $200,000 for capital costs).

Technologies and Application Approaches

These are the two main technologies proposed for this approach, full descriptions are found further down this section:

A) **All-in-one air-source heat pumps**: only require a single unit located indoors.

B) **Mini-split air-source heat pumps**: require a 'split system' of an outdoor compressor and an indoor head.

Alternatives to heat pumps:

- **Electric Baseboards:** While it is feasible to electrify existing buildings using electric baseboards, there are several disadvantages compared to heat pumps:
  - Baseboards use about 2 to 3 times more electricity than heat pumps which leads to higher energy costs and higher infrastructure requirements at both a building and grid level.
  - Baseboards are excluded from rebates that prescribes "high efficiency electric" heating.

  - Baseboards do not offer the benefit of air conditioning.

    Electric baseboards can be used as auxiliary form of heating in conjunction with heat pumps. Some existing electric baseboard buildings are augmenting baseboards with heat pumps, mainly motivated by a desire for cooling.

  A scenario where electrifying with electric baseboards would be feasible would be in buildings with very good enclosures and heat recovery ventilation (typically only achievable in MURBs with a deep enclosure retrofit). The tight enclosure reduces the heating load to the point that only a few small electric baseboards are required to heat the space.

- **Variable Refrigerant Flow (VRF)** systems are another "in-suite" subvariant which are not a focus of this report. VRF systems consist of an outdoor compressor unit, connected to multiple indoor units, and can vary the amount of refrigerant flow between the units to enable differing levels of heating and cooling to different zones. They are not commonly considered for MURB retrofits due to relatively high cost and installation complexity. VRF technology requires refrigerant piping to be routed to each suite from a central location; this is problematic for retrofits due to aesthetics, risk of damage and cost of wall/floor penetrations and runs through walls and ceilings. The many piping connections also carry a high potential for refrigerant leakage which presents its own global warming potential as well as health risks to building occupants.

  VRF systems offer an efficiency benefit of being able to transfer waste heat from warmer zones to colder zones where heating is needed. However, this potential only exists when both heating and cooling demands occur simultaneously; typically only on sunny days in late spring and early fall. This technology is more commonly applied to new construction; hospitality (hotels), commercial buildings (offices), and institutional (schools); where internal heat loads and solar heat gain offer significant waste heat recovery opportunities.

Technology A: All-in-One ASHP Conversion from Central Hydronic

This approach involves providing suite heating with in-suite newer style 'all-in-one' air source heat pumps and decommissioning or removing the central hydronic system.

A couple of brands are currently available which only require two small (6-8") holes through the enclosure, and more models are being actively developed. Older design units, which require a large rectangular hole through the wall are referred to as "PTHP" (Packaged Terminal Heat Pump) or "through wall" units and are commonly used in hotels and motels. These units are often very noisy, low efficiency and have poor controls with single stage on/off compressors hence are not recommended for high efficiency electrification retrofits.

Table 1: All-in-One ASHP Conversion from Central Hydronic summary

AC Added	Yes	**$ / suite** *estimated*	$4-10,000
Responsibility for energy cost	Can be transferred to tenant	**GHG reduction** *estimated*	95% *of heating*

Specific Benefits:

- **High GHG reduction:** this approach provides an opportunity of reducing the majority of the building's heating GHG emissions.
- **No outdoor unit:** these ASHPs do not require a separate outdoor unit which offers a great opportunity specially for high-rise buildings that don't have a practical way to locate outdoor units or for buildings where aesthetics of outdoor units is a concern.
- **Simpler electrical connection:** only requires a 120 volt connection and can even be installed by plugging to a regular outlet.

Specific Considerations:

- A suitable location on an outdoor wall needs to be found. As shown in the photo below, wall to ceiling sliding glass patio doors limit mounting locations. Vertical, horizontal and above window mounting units are available.

Figure 7: Photos of All-in-one heat pumps

	
Overview of suite interior - the box on the wall is the ASHP	*Outdoor dampers from which outdoor air is drawn in and blown out (each set of two holes represents one ASHP)*

Technology B: Mini-Split Style

There are two key applications of in suite mini-split ASHPs:

- Application B.1 – full conversion from central hydronic heating.
- Application B.2 – augmenting central hydronic heating.

Application B.1 – Full Conversion from Central Hydronic Heating

This approach involves providing suite heating with in-suite mini-split style air source heat pumps and decommissioning or removing the central hydronic system.

Table 2: Mini-split ASHP Conversion from Central Hydronic summary

AC Added	Yes	**$ / suite** *estimated*	$4-10,000
Responsibility for energy cost	Can be transferred to tenant	**GHG reduction** *estimated*	95% *of heating*

Specific Benefits:

- **High GHG reduction**: this approach provides an opportunity of reducing the majority of the building's heating GHG emissions.
- **Higher efficiency:** Mini-splits can have slightly higher efficiency than all-in-ones, resulting in slightly lower bills & lower electrical load.

Specific Considerations:

- Finding a suitable location for the large outdoor units is not always easy. The location needs to be functional for the equipment and in some cases, it might need to be hidden from view to comply with local municipality requirements. Some outdoor units can be mounted on balconies, which can make them barely noticeable, and others can be mounted on the roof, and sides of the building.

Figure 8: Photos of Mini-split heat pumps replacing a central hydronic system

	
Mini-split heat pump head in newly renovated suite	*Mini-split heat pumps; corresponding outdoor units*

Application B.2 – Augmenting Central Hydronic Heating

This application involves providing suite heating with in-suite mini-split style air source heat pumps to complement a central hydronic system by providing heating in the spring and fall is by mini-splits with the boiler off. In peak winter months the gas boiler is used.

Table 3: Mini-split ASHP augmenting hydronic approach summary

AC Added	Yes	**$ / suite** *estimated*	$4-10,000
Responsibility for energy cost	Can be split between landlord and tenant	**GHG reduction** *estimated*	50% *of heating*

Specific Benefits:

- **Sharing electric utility costs:** since this approach is adding the benefit of cooling to the tenants while keeping the central heating, there are examples where landlords have negotiated with tenants to split the utility costs of the heat pumps (connected to tenant suite meters).
- **Reducing gas utility costs:** by using the heat pumps for suite heating in the shoulder season, the landlord saved on gas costs as the boiler is operating for a shorter period of the year.
- **Higher efficiency:** mini-splits can have slightly higher efficiency than all-in-ones, resulting in slightly lower bills & lower electrical load.
- **Low operating noise**: while noise cconcerns are sometimes raised by inspectors during the building permit application process, installed units have proven to have low noise levels reported by neighbours to be so quiet they never hear them (sound levels are well below background sounds of birds and distant traffic even in quite residential neighbourhood).
- **Retaining boiler**: if the existing hydronic boiler is in good condition and is expected to last for several more years, this is a solution that can help provide cooling and taking benefit of some heating at a higher efficiency than what the gas boilers would do.

Cost considerations: estimated to have an installed capital cost between $4,000 to $10,000 per suite. The cost varies due to different factor such as:

- Location of the outdoor units - Some outdoor units are mounted on balconies, others are mounted on the roof, and sides of the building.
- Ease of penetrating and resealing the enclosure (including presence of asbestos).
- Need of electrical upgrades.
- Number of units required per suite (depends on the ease of transferring heat from one room to another).
- Need of auxiliary heat (for extremely cold climates or for rooms away from the unit).

Specific Considerations:

- Finding a suitable location for the outdoor units is not always easy. The location needs to be functional for the equipment and in some cases, it might need to be hidden from view to comply with local municipality requirements.

Figure 9: Photos of Mini-split heat pumps augmenting a central hydronic system

Example of mini-split heat pumps on balconies; used for summer air conditioning, spring and fall heating to complement high temperature hydronic system for peak winter heat. (Image credit: Google Maps)

Mini-split head above and hydronic baseboard below

Outdoor unit mounted on the side of the balconies, good solution for low rise buildings (Image credit: Google Maps)

Electrifying Central Hydronic Heating

This approach involves replacing or complementing central hydronic boilers with central air source heat pumps to heat the water.

Benefits and Considerations

Benefits:

- **Avoided or limited work in the suites:** if hydronic baseboards aren't replaced, limited to no work would be needed in the suites, avoiding tenant disruption.
- **Enables significant GHG reductions,** but fewer reductions than are achieved with systems that completely replace central systems with in-suite heat pumps. This is a result of the fact that when electrifying a central hydronic system it is usually only possible to electrify a portion of the total load, with natural gas still meeting the remaining load.

Considerations:

- **Challenges to adding cooling:** it's not possible to add air conditioning without additional cost and complexity; existing hydronic baseboard heaters cannot provide air conditioning and would have to be replaced with water sourced heat pumps and a heat rejection device such as a dry cooler, cooling tower or chiller. Additionally, the central system can only be in either heating mode or air conditioning hence it is not possible for some suites to select heating and others air conditioning at the same time.
- **Challenges to transferring the heating costs to tenants:** since the system will remain central, to transfer the heating costs to the tenant's individual "energy meters" would need to be added, which would require additional cost and complexity, including having to manage the billing to the tenants.
- **Space requirements for heat pump:** Central Hydronic Air-Source Heat Pumps require extensive space for air circulation, either on rooftops or in a dedicated yard on-grade; they are also subjected to the weather and vandalism; and they all have operating restrictions around some minimum outdoor air temperature, when space heating is needed the most.
- **High water temperature** is required for hydronic baseboards in typical apartment buildings to adequately heat the buildings. Most (though not all) central hydronic heat pumps are incapable reaching this temperature, which has presented a major challenge to central hydronic retrofits. High temperatures are only required on colder days, but due to practical concerns in existing buildings it is common practice to maintain high temperatures year-round. Central hydronic heat pumps require a 'tandem' configuration with multiple stages to reach these high temperatures increasing system cost, reducing efficiency and increasing power demand. Additionally, the water returning to the boilers is typically only slightly lower temperature than the supply water. This low "delta-T" is difficult for central heat pumps to work with and reduces capacity and efficiency.
- **Issues with existing piping:** hydronic distribution piping and baseboard radiators are prone to problems such as leaks, occasional air locks that prevent heat to reach certain areas and temperature control zones that cover building sections rather than individual suites. These issues would continue even if the system was retrofitted to central ASHPs.
- **Retaining the gas boiler** in conjunction with an air source heat pump is an option to avoid the expense of multi-stage heat pumps or baseboard replacement while also serving as a complete backup in case the heat pump had issues or was being serviced. The disadvantages of retaining the boiler would be the additional maintenance cost of the boiler, the risk of leaks and the added

system complexity, reduced GHG savings and the potential risk that controls may be bypassed, and the boiler left on year-round, eliminating GHG savings.

Technologies and Approaches

These are the two main approaches proposed for this approach, full descriptions are found further down this section:

A) **Keeping existing hydronic baseboards**: to reduce costs.

B) **Replacing hydronic baseboards**: to maximize benefits and performance but increasing capital costs.

Approach A: Retaining Existing Hydronic Baseboard Heaters

This approach involves retaining the existing hydronic baseboard heaters. Since they will require higher water temperature to provide the required space heating it is estimated that the space heating load which could be met with existing hot water baseboards by heat from a central ASHP is limited to about 65%, while the peak heat would still need to be provided by the boiler.

Table 4: Retaining existing hydronic baseboard heaters approach summary

AC Added	No	**$ / suite** *estimated*	$7-9,000
Responsibility for energy cost	Remains on landlord	**GHG reduction** *estimated*	65% *of heating*

Specific Benefits:

- **No disruption to the suite** itself, which simplifies the process and avoids disruption of tenants.

Cost considerations:

- **Lower capital costs** than approach B.

Specific considerations:

- **This approach provides a smaller portion of heating load** with the heat pump than other strategies, and therefore GHG reductions are not as high.
- **It is not possible to provide cooling** with this approach.

Approach B: Replacing Existing Hydronic Baseboard Heaters

This approach involves replacing the existing hydronic baseboard heaters in the suites with either larger baseboard units that will allow the hydronic system to operate at lower temperatures while still meeting the required heating load. Even with bigger baseboard heaters, it is estimated that 85% of the space heating load could be met with heat provided from the central ASHP while the peak heat would still need to be provided by the boiler.

Table 5: Replacing existing hydronic baseboard heaters approach summary

AC Added	No	**$ / suite** *estimated*	$11-13,000
Responsibility for energy cost	Remains on landlord	**GHG reduction** *estimated*	85% *of heating*

Specific Benefits:

- **Higher reduction of GHGs** compared to retaining the existing baseboard heaters.
- **It is possible to provide cooling,** though doing so can add significant expense and complexity.

Cost considerations:

- **Higher capital costs** needed to replace the baseboards.

Specific considerations:

- **Required work in the suites** will cause tenant disruption and could bring challenges if asbestos is present in the walls.
- **Loss of floor space:** the larger baseboard heaters will take up more floor space which might limit the furniture placement specially in small suites.

Alternative approaches:

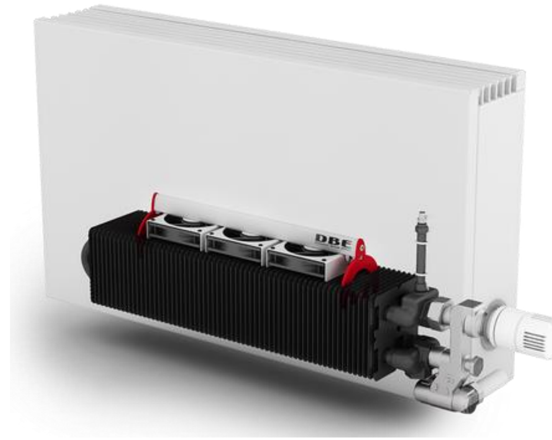
- **Water source heat pumps (WSHPs)** offer an alternative solution to either using the existing hydronic baseboards or new hydronic baseboards. WSHPs in this application are a heat pump that can heat or cool a suite and be controlled by the individual tenant. They are still dependent on the building hydronic system and require a heat rejection device to dispose of surplus heat from the system such as a dry cooler, cooling tower or chiller.

  Central heating and cooling may be combined in a single Air-Source Heat Pump Chiller that can operate to maintain hydronic system temperatures for the WSHPs at high efficiencies. However, there is a significant additional cost and installation complexity for this central equipment plus the additional cost per each WSHP in the suites; suite WSHPs only function as zone terminals and do not operate as a source of heating or cooling themselves.

  WSHPs offer a real efficiency benefit of being able to transfer waste heat from warmer zones in a building to colder zones where heating is needed. However, this is highly dependent upon variations in building occupancy, the configuration and orientation of the building; all respective to simultaneous heating and cooling loads that may occur.

Figure 10: Photos of technologies used in central system retrofits

<table>
<tr>
<td>

Example of existing hydronic baseboard heater</td>
<td>

Example of newer higher efficiency hydronic baseboard heater with build in fans for better heat distribution

(Image credit: Jaga)</td>
</tr>
<tr>
<td>

Example of existing (original) 1965 gas boiler</td>
<td>

Example of currently available large air to water heat pump considered for use in the central system. Requires open outdoor space

(Image credit: Aermec)</td>
</tr>
</table>

Alternative technologies to central air source heat pumps:

These alternatives are included for information only as they will involve typically higher capital costs and complexity compared to air-source heat pumps.

Ground loop or **"Geothermal" systems** circulate hydronic water through a closed-loop series of multiple wells to transfer heat in and out of the ground and utilize it as a thermal storage mass. This only works well in areas of roughly equal heating and cooling season demand (which is not the case in almost all of BC). The number of wells, and their depths, is highly dependent upon the total building heating load and ground conditions on site. The multiple wells usually require a large amount of real estate, which usually carries a prohibitive cost.

The technology is well-established and relies on known engineering practices with geology and mechanical systems design. The mechanical equipment used for these systems is common and proven for decades in areas of the US with roughly equal air conditioning to heating demands: heat pumps or reversing chillers, heat exchangers and pumps. All of the equipment can be located inside a building, protected from the weather and vandalism.

Drawbacks to these systems include their high capital cost, risk of fouling in the underground pipes (which cannot be accessed for maintenance), and thermal saturation which occurs over time as more heat is extracted from the soil (winter) than rejected to the soil (summer).

Ground Water Heat Pump (GWHP) systems are usually more efficient than Geothermal closed loop systems. Instead of multiple wells with underground piping using the ground as a heat sink mass, GWHP systems typically only require 2 wells and utilize groundwater aquifers. One well is used for extraction and one for injection. The challenge with GWHP systems lies with proper well design, drilling and installation for extraction and re-injection to the aquifer. This often becomes an iterative process between hydrogeologic engineering, drilling and testing.

These systems are well-established and rely on known engineering practices with hydrogeology and mechanical systems design. The mechanical equipment used for GWHP systems is common and proven for decades: heat pumps or reversing chillers, heat exchangers and pumps. All of the equipment can be located inside a building, protected from the weather and vandalism.

The major drawbacks to GWHP systems are the risk of well discovery, since one cannot be certain of the actual aquifer conditions until capital is committed to engineering, drilling and testing the wells. There is also added regulatory complexity to using groundwater. Although GWHP systems are non-consumptive in nature (they return the same water to the aquifer that was extracted), they are charged by provincial regulatory authorities for consumptive use. These factors combine to increase costs, complexity, and project timelines.

Electrifying Central Make Up Air (MUA)

This approach involves replacing gas heated central MUA systems which provide hallway, and in some cases suite ventilation, with an air source heat pump system.

Since MUA systems are only common in MURBs from the late 80's onwards, this approach will not be applicable older MURBs built before the late 1980's. Many older buildings (1960's or prior) tend to have no central MUA; small hallway exhaust fans appeared in later construction, followed by small unheated supply fans, and finally heated central MUA's became prevalent in the late 80's.

Benefits and Considerations

Benefits:

- **Strong economics:** in many circumstances since the capital cost is relatively low and there are high rebates from CleanBC.
- **No tenant disruption:** since these are mounted outside the building it requires no work in the suites.
- **Limited amount of added central cooling:** a small amount of central air can be added with this approach. Air conditioning applied this way is very limited and has no individual control; it will likely not satisfy demand for cooling, though could reduce some of the issues presented by overheating.

Considerations:

- **Added equipment weight:** ASHPs are typically heavier than existing MUA units so the installation may require structural evaluation and upgrades.
- **Added electrical load:** existing gas heated MUAs only require a small electrical connection to operate. An ASHP MUA will require a larger electrical connection that will vary in cost depending on the available spare capacity of the building and how easy it is to route the new electrical connection to the new MUA.
- **No cost transfer of energy costs to tenants:** since this measure only applies to a "common" central air supply, the utility costs will remain on the main common meter.
- **Auxiliary heating:** may be needed for peak heating loads and can be provided by a 'hybrid' MUA that has an electric resistance heater or a gas heater. While using an electric resistance heater will completely electrify the MUA, it will add a considerable amount of electrical load which might not be available from the existing electrical service.
- **Equipment noise:** the heat pump compressors could be noisier than the existing MUA. This can be mitigated through acoustic mitigation measures (e.g., sound baffles).
- **Symbiotic efforts:** improvements to existing ventilation can enable loads to be reduced. This may include relatively simple measures such as recommissioning or improvements that enable demand-controlled ventilation. More significant retrofits of ventilation (including the use of heat recovery ventilation systems either in-suite or centralized) are another way to significantly improve ventilation and system efficiency.

Technologies and Application Approaches

This approach involves a replacing an existing gas heated MUA with an air-source heat pump MUA that can have use either electric resistance or gas as auxiliary heating for peak heating loads.

Table 6: MUA approach summary

AC Added	Yes ***partial***	**$ / suite** *estimated*	$500-700
Responsibility for energy cost	Remains on landlord	**GHG reduction** *estimated*	95% *of outdoor air heating*

Figure 11: Photos of heat pump MUA installed on a large apartment tower

Large apartment building consisting of a tower plus a 6-story podium (foreground)

Outdoor heat pump unit located on roof of the lower podium section of the building

Electrifying Domestic Hot Water Heating

This approach involves replacing a gas heated central domestic hot water heating with an air source heat pump system.

Benefits and Considerations

Benefits:

- Opportunity to reduce GHG emissions even further with low GWP refrigerant options.
- Technologies available to work in most climates.
- Possible to do an installation without having to provide auxiliary heat.

Considerations:

- **Typology considerations:** Most domestic hot water (DHW) systems in MURBs are central, thus the landlord pays for the energy consumption. Central heat pump DHW systems can be installed to replace or augment conventional DHW systems.
    - Townhomes, and some newer buildings, often have individual DHW tank heaters, most commonly electric resistance heated. Converting from central to distributed DHW heat pumps (i.e. one in every suite) is sometimes possible, provided suite configuration/space allow for it.
- **Installation:** a suitable location will need to be found for the outdoor heat pump units; the benefit is that current technologies offer smaller modular units which tend to be easier to locate than a single bigger ASHP. A suitable location for the storage tanks will also need to be found; ASHP systems typically require more storage tanks than traditional fossil-fuel fired systems. While the storage tanks can remain in the existing mechanical room, the additional number of tanks may require structural assessment or reinforcement, particularly when the mechanical room is not located in the basement. Consideration also needs to be given on the electrical and pipe connections required between the outdoor units and the storage tanks.
- **Design and implementation risk:** since this is a relatively new approach for the BC market many local engineers and contractors are unfamiliar with design requirements specific to heat pump systems, which are different from traditional fossil-fuel systems. Improper design will lead to higher energy consumption and insufficient hot water. It is recommended that engineers and contractors installing their first applications seek the advice of the equipment manufacturers to ensure that installation is done following their recommendations, there will be special requirements for different types and brands of equipment.
- **Symbiotic Efforts:**
    - **Water efficiency upgrades** reduce the demand for hot water. Shower heads are typically the largest single consumption of domestic hot water in a MURB, and the majority of existing rentals are predominantly fitted with showerheads rated at 2.5 gpm (gallons per minute) or higher. Replacing these with well accepted 1.5 gpm low flow units results in ~40% shower water savings and may result in approximately 25% reduction in capital and operating costs for a new heat pump system.
    - **In-shower heat recovery:** another significant reduction in hot water can result from in-shower heat recovery, such as horizontal in-tub heat recovery units.

- **Hybrid/ventless heat pump washer-dryer combos** also reduce domestic hot water demand and use about half the electricity of the standard type, leaving more electrical power available for heat pumps.

Technologies and Application Approaches

These are the two main technologies proposed for this approach, full descriptions are found further down this section:

A) **ASHPs with CO_2 refrigerant**: CO_2 has a lower global warming potential when released to the atmosphere (from leaks), making it a preferred choice to reduce emissions. CO_2 can also operate across lower outdoor air temperatures (-25℃).

B) **ASHPs with R410a refrigerant**: is the most common refrigerant used in current heat pumps, global warming potential is 2,080 times greater than CO_2. The outdoor air temperature limit is -10℃ and auxiliary heating will often be required.

Cost considerations:

Costs will vary depending on:

- Type of equipment selected varies between brands and models, typically
- Need for auxiliary heat
- Location of the outdoor units and storage tanks

Table 7: ASHP for central DHW approach summary

AC Added	N/A	**$ / suite** *estimated*	$2-3,000
Responsibility for energy cost	Remains on landlord	**GHG reduction** *estimated*	95% *of DHW heating*

Technology A: ASHPs with CO_2 Refrigerant

CO_2 refrigerant is uniquely suited for domestic hot water applications as it can efficiently heat water up from the city cold water supply, which is typically supplied at temperatures in the range of 10℃, up to well over the 60℃ required to store domestic hot water.

Residential/commercial-scale systems are used in modular configuration (approximately 5 modules per 100 residents) to serve MURBs. There have been recent improvements to this technology that make it easier to apply in MURBs and it is becoming increasingly popular.

Larger central units, some traditionally used for industrial applications, are now entering the residential market.

Specific benefits:

- These systems can operate efficiently even with cold outdoor temperatures below -25℃, thus can be used without auxiliary heating in much of BC.

Technology B: ASHPs with R410a Refrigerant

Residential/commercial-scale systems are used in modular configuration (approximately 2 modules per 100 residents) to serve MURBs.

Specific benefits:

- **The technology is well established** and there is a wide variety of equipment available. This is becoming less of a factor as CO_2 technology is rapidly becoming more widely established and available.
- **Can potentially be combined with other end uses**, such as space heating or ventilation.

Specific considerations:

- **Operating temperature:** these systems are not able to provide the heat required in outdoor temperatures below -10°C. Auxiliary heat will be required in many installs. This can be provided by electric resistance (which increases electrical requirements) or can be provided by retaining the existing gas heater. Either option will add additional operating costs and complexity in the way the system in controlled to avoid the auxiliary heat to operate when it's not needed.

Alternative technologies to central air source heat pumps:

Heat recovery heat pumps are available that can extract heat from the building's sewage drain line and their main advantage is that they are unaffected by the outdoor weather. These systems may require auxiliary heat, which can be provided from the existing DHW plant. The installation requires careful coordination between the existing DHW plant; waste main leaving the building; and suitable space in the parkade to locate the system (typically taking up one or two parkade stalls). There could also be some risk to extracting too much heat from a drain line, which could lead to other issues.

Figure 12: Photos of various heat pump central domestic hot water systems

Example of high efficiency CO_2 based modular DHW heat pump array; so quiet you can barely hear them running.

(Image credit: Rod Nadeau)

Example of R410A heat pump hot water system mounted on the roof.

Example of hot water storage tanks and electric resistance backup tank heater

Tank type heat pump water heater (HPWH); suitable for in-suite use located in a closet.

(Image credit: Home Inspection Geeks)

Education and Engagement Efforts for the Rental Housing Industry

To help the rental housing industry become more informed on opportunities and challenges for building electrification, several education and engagement efforts were completed as part of this project. The main goal of these efforts was to enable building owners and managers to make informed decisions regarding building retrofit options. Below is an overview of these efforts, which include outreach to the owners/managers of thousands of buildings throughout BC:

One-to-One Interviews

15 one-on-one interviews were held with a variety of landlords representing a range LandlordBC members. These include individuals that own a small portfolio, family-owned business with large portfolios, and large REITs or pension fund-owned companies. This provided insights into the current state of landlord interest and knowledge regarding electrification.

Online Engagement Session

Description: 1.5-hour long webinar hosted by LandlordBC and presented by FRESCo. The engagement session shared the key considerations and electrification approaches from the study and gave key landlords an opportunity to provide input before the subsequent educational materials and the project report were developed and distributed.

Date: May 13, 2021

Results:

- Several landlords attended the webinar along with the CEO of LLBC.
- Important feedback was provided, which informed the development of subsequent materials.

Webinar "Climate change policy, regulation, and MURB retrofits: Are you ready for what's coming?"

Description: 1-hour long webinar with time for questions from the audience was hosted by LandlordBC and presented by FRESCo. The goal was to reach out broadly to landlords and others in the rental industry to share the key considerations and electrification approaches from this study.

The webinar was advertised to both LLBC's members and non-members through different channels including newsletters, email lists (with approximately 10,000 emails) and social media (including Facebook, Twitter, Instagram and LinkedIn). The webinar was also recorded, shared with webinar registrants and posted on LLBC's YouTube channel.

Date: June 16, 2021

Results:

- 99 people registered and received the recording, 59 attended the live webinar.
- ¾ of the attendees were owners or property managers including a mix of all sizes of building portfolios.
- Polls conducted during the webinar showed that:
    - 91% of the property managers and owners expressed interest or potential interest in exploring electrification in their buildings, while 9% were not interested.
    - 70% of the attendees had little knowledge regarding electrification retrofits.
- The webinar and the topic were well received and had good engagement from the audience.

The high interest shown in the webinar and in electrification is encouraging, particularly given that it occurred during a time when there were many other significant topics requiring landlords' attention (e.g., COVID-19, changing residential tenancy regulations).

Summary Guide

Description: brief summary guide (7 pages) that highlights key electrification opportunities and challenges for rental MURBs. The guide is intended as quick overview for a wide audience. It also directs the reader to the full report and to the recording of the webinar described above, which is on LandlordBC's YouTube channel.

The guide was distributed through different channels including LLBC's newsletters, email lists (with approximately 10,000 emails) and social media (including Facebook, Twitter, Instagram and LinkedIn). The guide is available to the general public on LandlordBC's website at: https://landlordbc.ca/murb-retrofits-opportunities-for-electrification/

Date of publication: October 2021

Results: The summary guide is expected to reach an estimate of 14,000 people (7,000 people have access to the secure members only section of LLBC's website plus another 7,000 followers through social media platforms).

Article "Climate Change Policy, Regulation, and MURB Retrofits" in 'The Key' Magazine

Description: an article focusing on the electrification approaches included in this report to be published in the fall edition of LLBC's 'The Key' magazine. It also directs the reader to the full report and to the recording of the webinar described above, which is on LandlordBC's YouTube channel .

The magazine is distributed to LLBC's members and non-members by email and mailed in printed format to 3,000 addresses, including large corporations who may share it will many different people. The magazine is also available on LandlordBC's website restricted to members only.

Date of publication: October 2021

Results: The article is expected to reach the magazine's estimated readership of approximately 5,000 people.

Next Steps & Areas for Future Study

The following items were identified as a good opportunity to either expand or continue the efforts of supporting the rental building industry on the topic of electrification:

Support programs for heat pump retrofits – while there is a high level of interest in electrification the complexities involved with such projects, combined with the lack of knowledge in the industry, suggest a need for support for landlords interested in pursuing electrification retrofits. Such programs could support landlords with evaluating opportunities on specific buildings and supporting them through the process of planning and implementing projects. They should also include additional rebates to incentivize electrification retrofits as well as post installation measurement and verification to confirm performance.

Detailed technical and financial studies – complete detailed analysis on how to apply a particular electrification technology, including analysis of costs and the impact of existing rebates and the recently announced Additional Rent Increase (ARI) process to recuperate capital invested for retrofits.

Pilots that look at different electrification approaches – pilots can help create case studies to help break the barrier of the innovation risk and inform the industry on lessons learned and actual costs. It is recommended that post installation measurement and verification is included into the pilots as it can provide valuable information to the industry by providing actual performance data and lessons learned.

Streamline heat pump retrofit process – investigate ways to streamlining the heat pump retrofit process from the requirement and permitting side that involves utilities and municipalities.

Technologies that are needed in the market – investigate the technologies needed in the market to facilitate building electrification and overcome some of the know challenges. For example: smaller capacity in-suite heat pumps.

Transitioning to a "user pays" model for utility costs – investigation into issues surrounding the potential shift of utility costs from landlords to tenants is needed to provide more clarity for landlords and tenants. Existing tenants have rights by way of their existing tenancy agreements (and the Residential Tenancy Act) that must be respected. It would be beneficial if a clear, simple, and fair process be established for transitioning to a user-pay model for utility costs. particularly when shifting from centralized to distributed systems (e.g., in-suite heat pumps).

Relative longevity and maintenance costs of gas equipment vs heat pumps – many opinions and personal anecdotes are expressed about the longevity of condensing boilers and of heat pumps. We are not aware of any systematic study to better inform this piece of the total cost of electrification.

Publish the results of M&V & Financials on the initial CleanBC funded Electrification Projects – several projects have received CleanBC funding to pursue electrification. It would be beneficial to have an evaluation of these projects and their performance.

Further study on electrical infrastructure capacity – there is concern among the industry that the existing electrical infrastructure will run into limitations as more buildings move towards electrifying building systems and adding EV chargers. Some relevant questions to answer could be: If a certain percentage of buildings fully or partially electrify, what would that mean to the added electrical demand and how would that impact the grid? What would be the new peak load if we electrify the percentage of apartment buildings that is required to meet climate goals? How much additional load will heat pumps add to the summer load versus the use of low efficiency portable air conditioners?

Public health implications on building overheating – after a high recorded death toll related to the recent heat wave, it would be important to investigate the overall health implication of rising temperatures and more frequent extreme heat in buildings.

Market statistics of existing MURB fuel sources and end use consumption – to best guide investment from public funding as well as inform private investment, it would be useful to have more knowledge of MURB statistics on type of gas heating for domestic hot water, ventilation and perimeter space heating. This could be broken down by building size, typology (high-rise vs low-rise) geographic region, type of ownership, hydronic heating type (high temp baseboards vs in-floor radiant) etc. As well, some analysis of end use of domestic hot water would be helpful.

Appendix I: Terms and Acronyms

Air Conditioning (AC)

Air Source Heat Pump (ASHP)

BC Building Code (BCBC)

Building Electrification Road Map (BERM)

Carbon Dioxide (CO_2)

CO_2equivalent (CO_2e): A carbon dioxide equivalent or CO_2 equivalent, is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide.

Decarbonization: phasing out technologies and energy sources that have high carbon dioxide (CO_2) emissions and replacing them with low-carbon and zero-carbon alternatives.

Domestic Hot Water (DHW)

Electrification: refers to the replacement of fossil fuel-based building systems, (such as space heating, domestic hot water, and cooking) with low carbon electric powered systems.

Environmental, Social & Governance (ESG)

Gallons Per Minutes (GPM)

Gigajoules (GJ)

Global Warming Potential (GWP): was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO_2).

Greenhouse Gasses (GHG)

Ground Water Heat Pump (GWHP)

Heat Recovery Ventilation (HRV)

Kilowatt (kW)

LandlordBC (LLBC)

Make-up Air (MUA)

Multi-Unit Residential Building (MURB)

Packaged Terminal Heat Pump (PTHP)

Property Assessed Clean Energy (PACE)

Renewable Natural Gas (RNG)

Residential Tenancy Act (RTA)

Residential Tenancy Branch (RTB)

Return on Investment (ROI)

Variable Refrigerant Flow (VRF)

Water Source Heat Pumps (WSHP)

Appendix II: Summary of Support Required for Building Electrification

Category	**Support required**
Rental Housing Industry Capacity and Knowledge Regarding Electrification Retrofits	
Existing Electrification Retrofits	Currently there is a lack of information on actual costs, savings and local experience for a wide range of multi-unit building electrification approaches and scenarios. In order to address this, more pilot projects and case studies are required. This will require millions of dollars in funding immediately in order for electrification to scale up significantly.
Limited Design, Contractor and Maintenance Staff Knowledge	Industry training on best practices and lessons learned is required to ensure engineers, contractors and maintenance staff understand how to optimally design, install and operate systems.
Process of Electrification	Support the industry by offering programs or rebates that will support landlords with the process of evaluating and implementing electrification retrofits, including analyzing retrofit options, designing the right solution, finding suitable contractors, etc. It is recommended that measurement and verification of the systems be conducted to help collect information on actual system performance to advance the industry and inform future program development.
Key Technical Considerations	
Finding a Location for Outdoor Units	Municipalities should consider relaxed restrictions on appearance or simplify the approval process for new equipment mounted outside of the building since it limits options and adds cost, time and complexity to a heat pump retrofit.
Refrigerant Leakage Risk	Rebates and support for technologies with low GWP refrigerants as well as setting best practices and enforcement for contractors to reduce both operational and end of life refrigerant leaks. Also, governments need to clarify the schedule of coming low GWP refrigerant regulations.
Systemic Barriers	
Responsibility for Energy Costs	Clarification is needed from the Provincial government as to how the shift in the responsibility for utility costs can be handled so it is done in a manner that is clear and fair to both landlords and tenants.
Key Cost Considerations	
Electrical Upgrades	Utilities need to simplify the access to total building electrical consumption to determine if there is enough capacity for electrification, such a process is already available for the purpose of installing electric vehicle chargers but not for installing heat pumps. There are great rebate and support programs to retrofit electric vehicle chargers, including the electrical upgrades needed, a similar offer for heat pumps would greatly facilitate their adoption.
Timing & Scheduling and Emergency Replacements	Currently the process to electrify building systems often isn't clear and can add significant time and cost to a project. Local governments and utilities can help by streamlining their processes. Programs that support landlords in planning and implementing upgrades will also help, but without a streamlining of processes significant time will still be required.