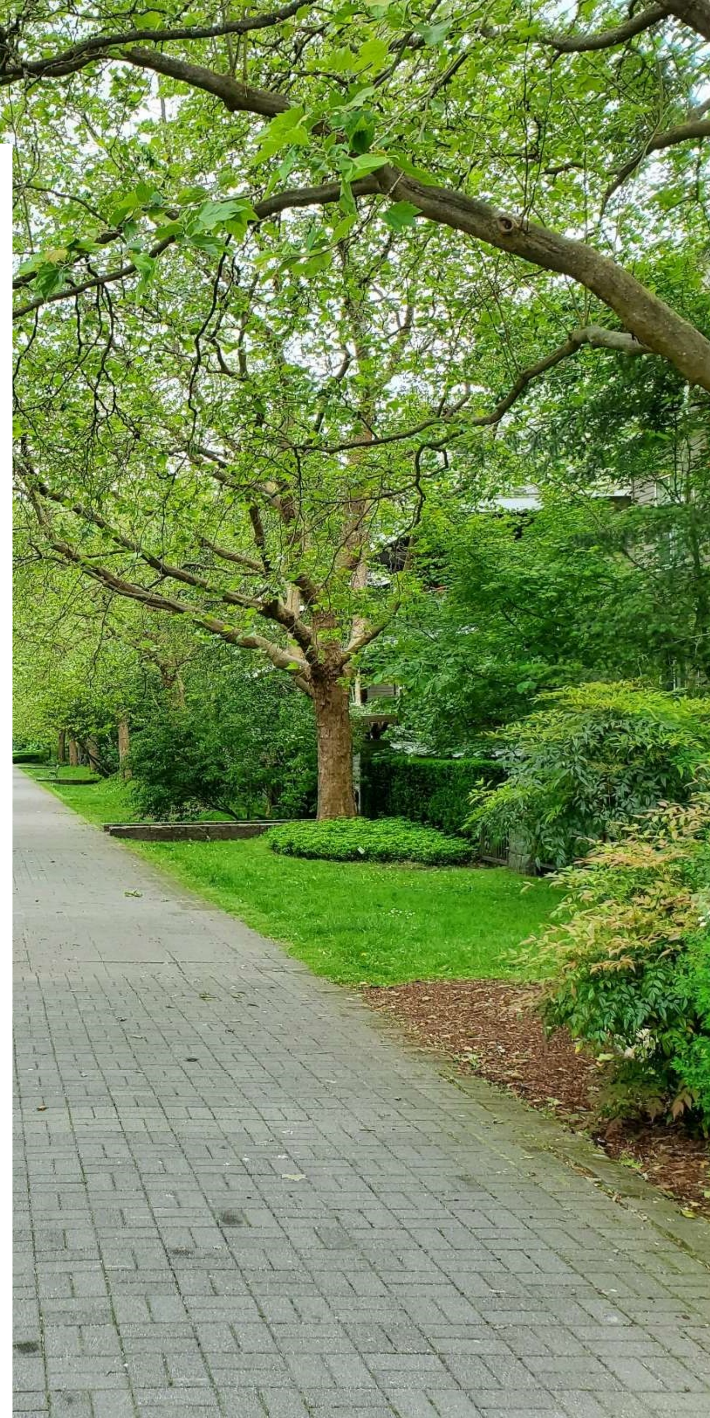

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LOW CARBON AND CLIMATE RESILIENT RETROFIT OPTIONS FOR UBC STRATA RESIDENTIAL BUILDINGS

NOV 29, 2022 – FINAL REPORT

Sustainability Scholar Project 2022-038

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DISCLAIMER

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This project was conducted under the mentorship of UBC Sustainability and Engineering – Campus and Community Planning staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of the University of British Columbia.

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The author acknowledges that the work for this project took place on the unceded ancestral lands of the xwməθkwəy̓əm (Musqueam) Nation.

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EXECUTIVE SUMMARY

With the changing global climate, Vancouver B.C. has seen an increase in the frequency of heat domes occurring during the summer months. Recent extreme heat events occurring in the summer of 2021 has brought into sharp focus the lack of cooling infrastructure that exists in a large number of residential buildings throughout the British Columbia lower mainland. Residents of Strata condominium buildings on the UBC campus reported evening indoor air temperature readings as high as 31°C (Tompkins, 2021). As part of UBC's Green Building Action Plan, the University also seeks to reduce operational carbon for heating of existing buildings. To tackle these two issues, the objective of the study is to review technologies that can retrofit cooling infrastructure and reduce operational carbon for heating at existing Strata residential buildings.

To meet this objective, a review of passive and active technical solutions is conducted to determine the most appropriate approach from a technological and practical perspective. Specific options that are reviewed are as follows:

- Passive Technical Option – Glazing Tinting Films
- Passive Technical Option – External Shading Systems
- Passive Technical Option – Natural Ventilation Systems
- Active Technical Option – Packaged Terminal Air Conditioner
- Active Technical Option – Integrated Heat Pump
- Active Technical Option – Ductless Split Heat Pump

Based on the fact that all passive technical options require a coordinated effort amongst Strata members and a majority vote, as well as the fact that passive options cannot offset peak cooling loads during a heat dome effect, it is concluded that these solutions are not appropriate to meet the objectives. As such, regulatory reviews and a review of barriers to retrofits focus on active technical options. Considering cost, technical implementation challenges, and ease of installation, the ductless split heat pump is the solution that poses the least amount of complications.

With the ductless split heat pump in mind, the study reviews the current regulatory requirements for retrofits. These include building code requirements, permitting requirements, Strata Council approval processes, and how the City of Vancouver currently handles heat pump installation permit requests. Available incentives are also reviewed for information.

Technical barriers and regulatory barriers are then reviewed to determine what needs to be overcome for condominium unit owners to be able to retrofit ductless split heat pumps at their units. There are structural, envelope, and electrical risks associated with retrofitting existing units. Regulatory barriers include a permitting process that is in place to handle larger scale projects that may be complicated for a mechanical contractor or Strata unit owner to navigate. Strata Councils are also a significant barrier as members have wide ranging professional backgrounds and council cultures can differ from building to building which can lead to an inconsistent application of governance. Navigating an approval process with these variables in place can be a complicated experience for owners wanting to retrofit for heat pumps in their unit.

The conclusion is that retrofitting ductless split heat pumps pose the least technical risk to an existing building but the risk is not null. These risks need to be mitigated by the Strata Council to preserve the integrity of the building in the long term. Owners also need guidance on how to initiate, implement, and navigate a retrofit project to ensure a positive outcome. Finally, there is an opportunity for Development Services at UBC Campus and Community Planning to consider streamlining of the current permit application process specifically for split heat pump installation. The intent of the permit process change at the City of Vancouver is to ultimately encourage installation of heat pumps and to reduce the administrative burden for the City.

The study recommends that the Strata Council hire envelope and electrical engineering consultants to perform an envelope review and electrical demand study respectively. Strata Councils should also provide clear guidelines outlining what documents are necessary for council approval reviews through the use of checklists. This report contains sample checklists for unit owners and for Strata Councils that outline specific process and cost responsibilities for each party. It is also recommended that Development Services consider streamlining the permit application process similar to that of the City of Vancouver mechanical permit process for ductless split heat pumps. This would reduce the administrative burden and also lower the barriers for unit owners to implement heat pump retrofit projects.

1 INTRODUCTION

1.1 Background

The heat wave that occurred in British Columbia between the last week of June and the first week of July 2021 saw record breaking temperatures across the province. Lytton, B.C. experienced a high of 49.6°C, Vancouver International Airport 32°C, and White Rock 38.5°C over the course of a week. (CityNews, 2021). At the University of British Columbia (UBC), residents reported evening indoor air temperature readings as high as 31°C (Tompkins, 2021). British Columbia's Chief Coroner reported that 619 deaths were linked to the heat wave (Office of the Chief Coroner, 2022). All these reports indicate an unprecedented weather phenomenon which climatologists are projecting is going to increase in frequency in the future from the effects of climate change (Albanese, 2019).

BC Hydro conducted a survey amongst households within the province and found that only 34% of respondents had cooling infrastructure in their homes (BC Hydro Power Smart, 2020). This is unsurprising given that the climate data referenced in the British Columbia Building Code is based on historical data that implies cooling infrastructure is not necessary in residential building typologies. However, as the climate changes and average temperatures are projected to increase, it must be assessed whether it is feasible to continue to omit cooling infrastructure in residential buildings in much of the province.

1.2 Objective

Given the growing concern of infrastructure shortfalls with respect to the changing climate in the province, there is an urgency to review the current technology and policy barriers that may exist that will hinder the implementation of the anticipated increase in demand of cooling retrofit projects in the future. This is a particular challenge for strata housing where individual ownership is governed by the Strata Act and Strata By-laws that are enforced by a Strata Council. This report aims to assess the different technologies that can be retrofitted for strata housing within UBC's local jurisdiction. Specifically, the objective is to review technical feasibility, policy, and challenges associated with strata governance that may pose as barriers to implementation.

Technology reviews are conducted to evaluate constructability, cost, benefits, risks, and how they align with UBC's Residential Green Building Action Plan (GBAP) which aims to reduce energy consumption associated with residential buildings within its jurisdiction. Policy reviews examine the permitting process as well as any Strata by-laws that may deter condominium unit owners from pursuing the installation of cooling infrastructure.

It is important to note that this report prioritizes solutions that are easiest to implement by individual unit owners in strata housing. While the GBAP gives focus to passive solutions to reducing the cooling load to buildings, they are difficult to implement in strata housing as they require majority consensus by owners in a building.

1.3 Methodology

The technology reviews conducted within the report are broadly divided into two categories – passive systems and active systems. The objective is to review each technology through the lens of the following key factors:

- Indoor thermal comfort impact
- Energy efficiency impact
- Constructability (feasibility and risks)
- Relative cost

The objective of the regulatory reviews is to identify specific policy barriers that may hinder swift implementation of retrofit projects. Key factors that are reviewed are as follows:

- Permit application process
- Strata Act and By-Laws

The evaluations are conducted through a review of literature that is available on the public domain, interviews with experts and stakeholders, drawing reviews, and site observations of the residential buildings throughout the UBC Campus. Ultimately the aim is to be able to answer the following questions and make recommendations based on the findings:

1. What are the technologies and solutions that currently exist to improve thermal comfort during summer months?
2. What are the current policies and regulations that govern building retrofits?
3. What are the variations in building geometry and materials?
4. What are the views of the industry experts with regards to solutions and policy?

The results of the research are presented throughout the report and culminate in recommendations in Section 7 Recommendations.

2 TECHNICAL OPTIONS - PASSIVE SYSTEMS

UBC's Residential GBAP outline objectives and strategies to reduce energy consumption and greenhouse gas (GHG) emissions within UBC's residential buildings. One such short term priority action is to "Undertake a study to identify envelope and mechanical design options that achieve comfortable indoor environment under predicted future climate conditions, with priority emphasis on passive approaches where feasible" (UBC - Campus and Community Planning, 2018). This section presents three passive system options that strata residential buildings may consider.

The primary intention of passive systems is to reduce solar heat gain from the sun through fenestrations (windows). This can be achieved by creating physical obstructions to prevent the infrared radiation from entering an indoor space or by having films and/or coatings that filter it out. Other passive approaches also include methods to induce outdoor air to pass through an indoor space without the use of mechanical equipment. This section broadly reviews three approaches – glazing tinting films, external shading systems, and natural ventilation. However, given the high level of obstacles to implementing these solutions in a Strata building, greater focus will be placed on mechanical solutions.

The challenge with implementing any of these solutions in a Strata building is the fact that they are whole building solutions. In other words, they are solutions where positive results can be best achieved when applied to the whole the whole building. This will require a majority consensus by unit owners to review and vote in favor to bear the cost of implementation. With the diversity of financial circumstances that can exist within a Strata, obtaining the three quarters majority for a new project will be challenging. Most Strata corporations have underfunded reserve funds and the appetite for owners to accept special levies for "whole building solutions" will be low (Olijnyk, 2021).

2.1 Glazing Tinting Films

2.1.1 System Description, Advantage, and Disadvantages

Glazing tinting films work by reducing the solar heat gain coefficient by applying a thin, tinted film on an existing glazing system. The film reduces the solar radiation transmitted through the window thereby reducing the heat gain experienced by a unit. A wide range of products are available that can be applied both on the exterior and interiors of windows. Table 1 lists a number of advantages and disadvantages.

Advantages	Disadvantages
• Reduces solar heat gain, therefore reducing the peak cooling load of a unit. • Materials are relatively inexpensive and can be bought at hardware stores. • Can be added on a unit-by-unit basis.	• Does not reduce heat gain due to conduction (not effective against the effect of heat waves). • Does not offset thermal mass heat gains during heat waves. • Does not reduce energy consumption for heating.

Table 1: Glazing Tinting Films Advantages and Disadvantages

Glazing tinting films do offer a cost-effective solution to reduce the solar heat gains experienced by individual units. The film does not reduce the conductive heat transfer rates through glazing systems and does not prevent building structures that are not covered by the film from warming up. In other words, during heat wave events, the building structure will still warm up and release heat into units in the evening and conductive heat gains will still occur through windows.

2.1.2 General Implementation Challenges

The film can be applied by unit owners themselves if they have safe access to the exterior windows. Glazing systems are ultimately considered common property within strata buildings and therefore any application of the product would require prior approval of a council. Furthermore, as the tint can impact the aesthetic of a building, the same product would need to be applied to achieve aesthetic uniformity. This requires coordination and consensus among unit owners for effective implementation. Many contractors within the Metro Vancouver area do specialize in installation of tinting systems that can review building specific applications.

2.2 External Shading Systems

2.2.1 System Description, Advantages, and Disadvantages

External shading systems are another approach to reducing the peak cooling load of a building. These systems generally involve louvered panels or horizontal sunscreens that create a shade from the sun over glazing systems. Unlike tinted windows which reduce the solar heat gain coefficient, shading systems prevent solar radiation from reaching the window. This has a greater impact in reducing the overall heat gain experienced since the system can prevent direct sunlight from reaching any fenestrations. External shading has the greatest impact when installed on southern facing windows for overall reduction in building cooling load. The implication is that not everyone in the building may have an external shade installed if an economic approach is taken which has the potential to hinder obtaining majority consensus from unit owners. Advantages and disadvantages of the system are as follows:

Advantages	**Disadvantages**
• Highly effective at reducing solar heat gain and therefore reducing the peak cooling load of a unit. • Reduces glare	• Does not reduce heat gain due to conduction (not effective against the effect of heat waves). • Does not offset thermal mass heat gains during heat waves. • Most products add a dark tinting to windows which will affect the exterior aesthetic of a building. • Does not reduce energy consumption for heating.

Table 2: External Shading Advantages and Disadvantages

These systems offer an effective means of preventing solar heat gain through fenestrations, a major component of the cooling load in a building. There is also the added benefit of reducing solar glare within an indoor space. Like the tinted window systems, however, external shading systems do not reduce conductive heat gains and does not prevent the building structure from experiencing conductive heat gain (unless the external shades also cover the structure). As such, the result would be the same as the tinted film system during a heat wave event where the structure will still warm up and release heat during the evenings.

2.2.2 General Implementation Challenges

Retrofitting an external shading system on a building is a significant undertaking and will require design consultants. Depending on the complexity of the building and the system being considered, this may require an architect, envelope engineer, and structural engineer. The design process will entail a site review, preparation of recommendations and design options, and eventually the preparation of construction documents. Once construction documents are prepared, these can be put to a public tender to hire a contractor for installation. In terms of cost of the system, it is difficult to estimate as there are a number of factors that influence this. These factors include the size of the building, the type of existing structure, size of the fenestrations, materials chosen, etc.

What is certain is that a special levy will need to be voted on to finance design consultant fees and the construction of the external shading system. Strata reserve funds typically do not account for retrofits of this nature. As this is a whole building solution, implementation will require a three quarter majority to vote in favor to proceed. Securing this majority will be challenge for any Strata Council as there are no guarantees the system will be able to offset the impacts of a heat wave.

Once the Strata has approved the project, permit from UBC will be required. A Development Permit application and a Building Permit application with drawings and specification sealed by the professional design consultants involved in the design must be submitted to UBC Campus and Community Planning.

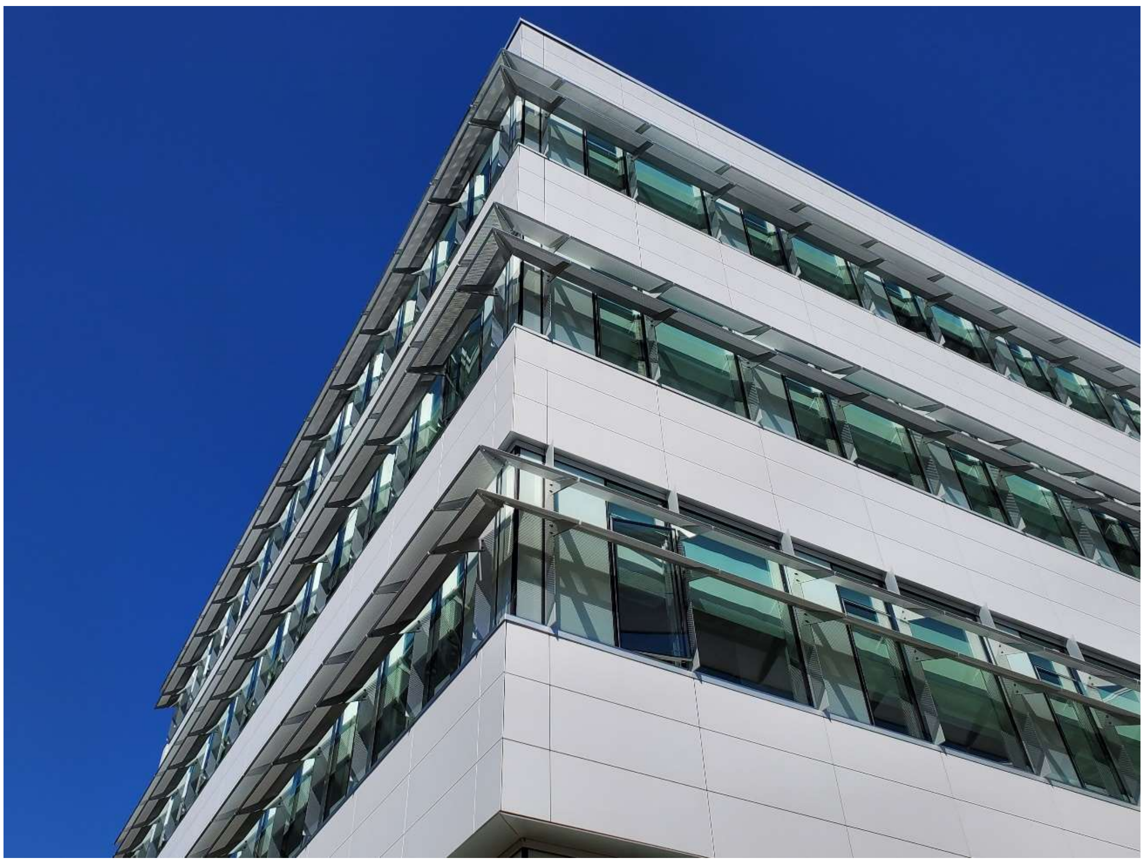

Figure 1: Horizontal External Shading Installed at UBC Earth Sciences Building

2.3 Natural Ventilation Systems

2.3.1 System Description

Natural ventilation is another popular passive approach to cooling buildings particularly for institutional buildings on the UBC campus. Passive approaches for cooling are also a popular solution in Passive House building designs to eliminate the need for mechanical cooling infrastructure. Natural ventilation works by designing a structure to encourage stack effect to induce outside air flow into a building or rely on cross ventilation as a result of wind.

Stack effect is a phenomenon where warm air rises within an unobstructed path to the upper floors of a building, creating a high-pressure zone. This high-pressure in turn creates lower pressure zones on the lower floors and then induces outside air to enter the building through exterior openings. The key point that ensures reliable and consistent stack effect is the presence of an unobstructed path for the air to flow. Some buildings achieve this through openings in interior walls and also create greater pressure differential through the application of a solar chimney in building design which effectively increases the height of a building.

Cross ventilation approaches rely on the wind and the resulting convective heat transfer. As the name suggests, cross ventilation is most effective when a unit has at least two openings in a suite to allow the wind to enter from one side of the unit and exit the other. This requires at least two openings that are ideally on opposite sides of the suite. This poses a geometric challenge in most existing multi-family residential structures since a single exterior wall exposure is most common. Larger units can exist as corner suites but this also does not offer optimal geometry for cross ventilation.

2.3.2 General Implementation Challenges

The biggest barrier to retrofitting natural ventilation design approaches to existing buildings is the nature of the building code required means of egress. Most multi-family low-rise, mid-rise, and high-rise residential units (town houses being the exception) have circulation corridors to provide access to suites. These corridors also have the function of being the primary means of egress from the building in the event of a fire. As such, the corridor walls must have a two hour fire rating to the suites. The walls between the suites must also have two hour fire rated walls under the design principle of fire compartmentalization.

Any building design modifications to optimize natural ventilation would necessarily require openings to be created on these walls. This introduces a number of complications in terms of the walls' fire separation integrity and is ultimately impractical to implement. Openings to these walls do occur with ductwork and there are methods that can applied to maintain the continuous fire rating of the wall. However, for natural ventilation, the goal is to allow the free movement of air within a space and not to constrain it with ductwork. Ultimately the necessity of a means of egress on each floor and the presence of fire rated walls is in direct contravention with the design principles that optimize natural ventilation.

3 TECHICNAL OPTIONS - ACTIVE SYSTEMS

The objective of active systems is to be able to offset the peak cooling load of building or unit. Traditionally, the summer design temperature of a building is prescribed in the building code and is based on historical average temperatures. Knowing that this is insufficient for heat wave events sizing of systems would be needed to handle heat waves in the lower mainland. By doing so, units and buildings will be protected against extreme heat events which improves their climate change resiliency. For populations that are highly vulnerable in warmer temperatures, this could mean the difference between life and death.

There is also an opportunity that active systems can further improve the efficiency of heating systems in existing buildings. This aligns with UBC's Green Building Action Plan to implement methods of heating that are more efficient in energy consumption and have lower GHG emissions. One such technology that can achieve this is the heat pump. The heat pump is capable of providing cooling and heating and this section will specifically focus on air-cooled systems. Secondly, given the challenges posed with passive ventilation systems, a major advantage of active systems is that they do not need to be a "whole building solution" and can be implemented on a unit by unit basis. For this reason the technology review will consider systems that are appropriate for individual unit installation.

Heat pumps in heating mode have a condenser section that extracts heat from ambient air and then pumps it into an indoor space. This is possible through the heat pump cycle which uses refrigerant as a medium and a compressor to super-heat the refrigerant to increase its temperature to a useful level. The figure below shows the basic cycle. The cycle runs in reverse when the unit is in cooling mode.

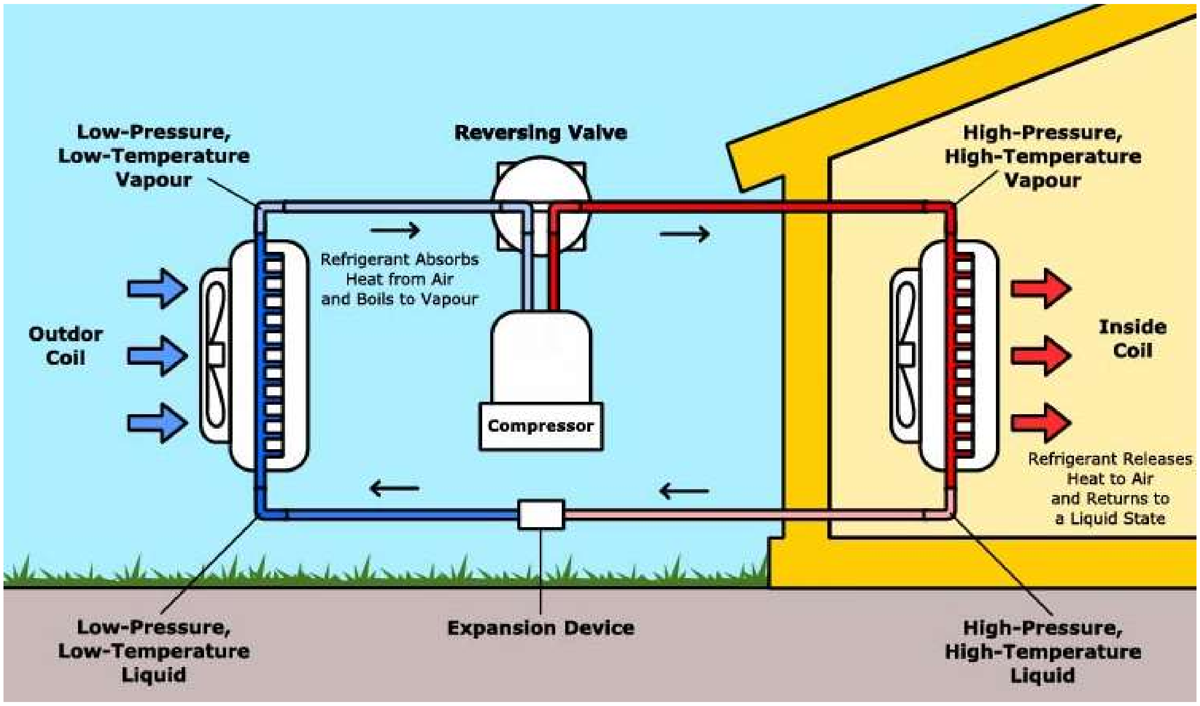

Figure 2: Heat Pump Cycle (US Department of Energy, 2022)

The advantage of an air-cooled system in a retrofit scenario is that the infrastructure needed is minimal compared to water cooled options and also requires less maintenance. Water-cooled systems require cooling towers, hydronic pumping equipment, and hydronic piping distribution. These systems offer advantages for new buildings but are difficult to retrofit in an existing building as the installation is invasive and costly. Air-cooled heat pumps ultimately require a less invasive installation process which will be discussed in this section.

3.1.1 Coefficient of Performance and Energy Efficiency Ratio

The efficiency of a heat pump's cooling capability is measured by its Energy Efficiency Ratio (EER) and its heating capability by the Coefficient of Performance (COP). Seasonal Energy Efficiency Ratio (SEER) is another measure of a unit's cooling efficiency that is widely used in industry but for the purposes of this report, EER will be used.

EER is the ratio between the cooling output in British thermal units per hour (Btu/h) to the electrical power input into the compressor in Watts (W). The higher the number, the higher the efficiency. To illustrate, if a unit had a cooling output of 12,000 Btu/h and an electrical power input of 1000 W, then the EER will be:

$$EER = \frac{12{,}000\,\frac{Btu}{h}}{1000\ W} = 12$$

Units on the lower end of the spectrum of efficiency have an EER of around 12 and high efficiency units may reach an EER as much as 18. It should be noted that EER varies as a function of ambient air temperature and published data is based on a standardized testing parameters to ensure values can be compared across different systems.

The Coefficient of Performance (COP) of a heat pump is the ratio of useful heating output to the electrical power input into the compressor. To illustrate, if a unit had a heat output of 3000 W and required 1000W of power, then the COP will be:

$$COP = \frac{3000\ W}{1000\ W} = 3$$

Most air-sourced heat pumps have COP ranging from 2 to 3.5 with the latter being more efficient. Electrical resistance heaters or electric baseboard heaters have a COP of 1 since the heat output is equal to the electrical power needed to generate this heat. It is for this reason that heat pumps consume less power for the same heating benefit. The operational GHG emissions emitted from power generation on the grid is therefore lower for a heat pump because it consumes less power. COP also varies as a function of ambient air temperature and published data is based on standardized testing parameters. As ambient air temperature drops further below zero degrees Celsius, the COP is reduced. The efficiency of a heat pump is reduced as the temperature drops.

3.2 Packaged Terminal Air Conditioner

3.2.1 Systems Description, Advantages, and Disadvantages

The Packaged Terminal Air Conditioner (PTAC) is a type of ductless air-cooled heat pump where both the condenser and evaporator are contained in a single unit. The unit is wall mounted on an exterior wall with the condenser portion of the unit sitting outside and the evaporator sitting inside. It has an integral supply air grille where the direction of airflow can be adjusted. A single unit is generally needed for a single room with an exterior wall.

PTACs are “thru-wall” systems where the full cross section of the unit must penetrate the wall. Units are typically supplied with a frame that can be installed on an exterior wall to ensure the opening is the right size and the unit can sit flush within. Remote thermostats can be tied into them for control or units can come with built-in controls. Below is a summary of advantages and disadvantages of the unit.

Advantages	**Disadvantages**
• Relatively economical cost. • The unit is stand-alone. No external components are necessary. • Can provide both heating and cooling.	• Requires a large opening in the envelope for installation. • Large opening increases risks of water ingress. • Compressors are internal to the unit and can be quite noisy for occupants. • May require structural engineer to detail exterior wall opening.

Table 3: PTAC Advantages and Disadvantages

PTAC cooling EERs are generally around 12 with COP values at around 3.5. From heating efficiency alone, there is a marked improvement compared to electric base board heaters.

3.2.2 Technical Implementation Challenges

In the retrofit context, the biggest barrier to PTAC installation is the size of opening on the exterior wall that is needed to install a unit. Structural reinforcement will likely be required given the size of the opening that is needed. Any work involved would require a structural engineer to review the feasibility and determine what type of reinforcement would be required to ensure integrity of the opening. This work would certainly require Strata Council Approval, building permits, and multiple disciplines of contractors to install.

In addition to a structural engineer, a unit owner may require the services of an envelope engineer. With PTAC units, water ingress is a high risk even in new construction projects. An envelope engineer would be able to review the specific exterior wall assembly and provide a design to minimize the risk of water damage as result of the large opening created. If a Strata chooses to pursue this option, the size and quantity of openings required through the existing building would be of concern and thorough review of existing conditions would be necessary by a consulting team. While the PTAC unit itself may not be expensive, the risks involved and the costs to mitigate these risks can be significant.

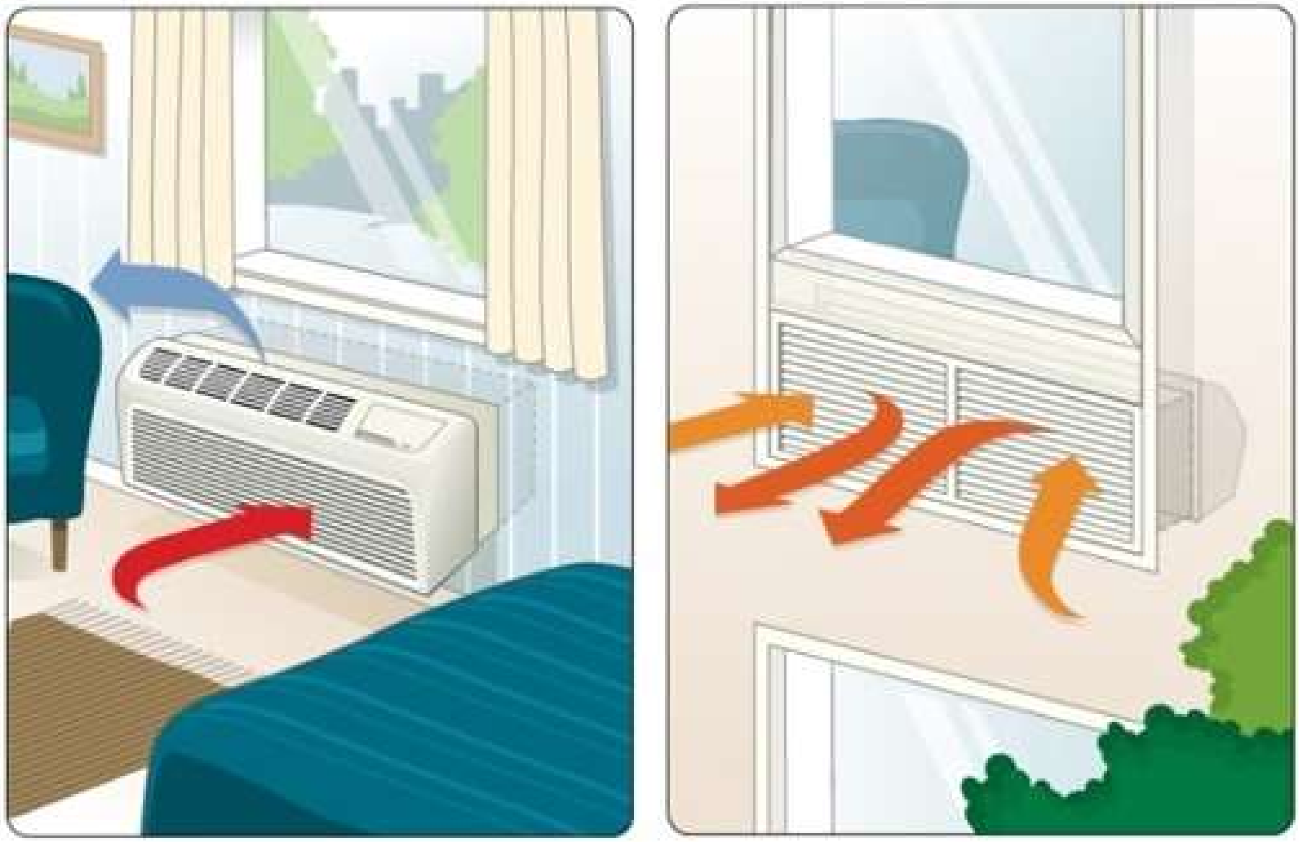

Figure 3: PTAC Indoor and Outdoor Diagrams (Amana, 2022)

3.3 Integrated Heat Pump

3.3.1 System Description, Advantages, and Disadvantages

Integrated heat pumps are similar to PTAC units in that they are "thru-wall" systems as well. The primary difference is that the condenser is located indoors but heat exchange to the outdoors is still possible with two 162mm (6 in.) diameter to 200mm (8 in.) diameter piped through the exterior wall directly to the outdoors. Manufacturers such as Innova (Innova, 2022) offer compact units with low profiles with integral supply grilles. A single unit will need to serve a single room with an exterior wall. Units can be controlled with remote thermostats or can come with built-in thermostats.

Advantages	Disadvantages
• Relatively mid-range in cost. • The unit is a stand-alone. No external components are necessary. • Can provide both heating and cooling. • Required opening is relatively small. • Compressors are internal to the unit but quieter than PTACs.	• Requires an opening large enough an envelope consultant should be involved. • Larger opening increases risks of water ingress. • May require structural engineer to detail exterior wall opening depending on location. • Not common.

Table 4: Heat Pump Advantages and Disadvantages

The integrated heat pumps offer an elegant solution but not many manufacturers are are present in the market. While the fundamental technology is not new, the compactness and small opening required is an innovation in the class of “thru-wall” systems. Units are therefore a bit more costly in comparison to PTAC units.

3.3.2 Technical Implementation Challenges

While the required opening size is smaller than what is necessary for a PTAC unit, integrated heat pump openings are not negligible. They are still around 150mm (6 in.) to 200mm (8 in.) in diameter which is roughly equivalent to what is necessary for a washroom exhaust duct termination at the exterior wall. Openings of this size may not require a structural engineer to review though the question should still be asked as wall construction can vary from building to building. The opening is still large enough where an envelope engineer should review how holes would be cored through existing walls. If this is not executed properly, water ingress is a risk. The risk is then compounded if multiple penetrations are created throughout a building so a technical sound and consistent strategy needs to be determined by an envelope consultant.

Figure 4: Innova ..2.0 Integrated Heat Pump (Innova, 2022)

3.4 Ductless Split Heat Pump

3.4.1 System Description, Advantages, and Disadvantages

The ductless split heat pump is perhaps the most common on the market. Many manufacturers are present in the market which is driven by cooling infrastructure demand in the equatorial regions. The heat pump cycle is the same as the PTAC unit and integrated heat pump. The primary difference is that for a split system, the condenser and compressor are located outdoors. An evaporator with a fan is located indoors with refrigerant piping connecting the two units. In cooling mode, the evaporator absorbs the heat from the room and rejects it through the outdoor condensing unit. In heating mode, the condensing unit extracts the heat from the outdoors and the evaporator releases it into the indoor room. The evaporator generally has motorized directional diffusers so the cold air or hot air can be diffused evenly across a room. Control of these units can be achieved through remote thermostats or through the more popular manufacturer supplied remote control.

Advantages	Disadvantages
• Relatively mid-range in cost. • Exterior wall penetration is small, can be caulked. • Can provide both heating and cooling. • Compressor is located in the outdoor condensing unit so indoor evaporator is very quiet. • Very common and abundant expertise	• Two pieces of equipment need to be installed – the indoor evaporator and outdoor condensing unit. • Condensate management needs to be considered. • Outdoor condensing unit can look quite prominent if not placed properly.

Table 5: Ductless Split Heat Pump Advantages and Disadvantages

A common concern for the outdoor condensing unit is the noise it generates during operation. Equipment cut sheets for the common manufacturers (Daikin, Mitsubishi, Fujitsu, and Carrier) indicate radiated noise levels not exceeding 40 db. Most noise by-laws require that noise cannot be greater than 45 db measured from the property line. It should also be noted that most compressors currently are all variable speed. They can turn down and operate at partial capacity when the indoor space demand is not high. In a climate like Vancouver, this means the condensing units will not be operating at maximum capacity for most of the time. It is also common to install condensing units on vibration isolation pads which further dampens noise.

A key advantage of the ductless split system is the size of the exterior wall penetration is small. At a minimum, two refrigerant pipes would need to penetrate through a single opening on the exterior wall. At most, this would also include the condensate pipe from the evaporator. Small penetrations of this size would likely not require a structural engineer’s review or an envelope engineer. For the sake of assurances, however, having an envelope engineer review and prepare a standard detail for a building is beneficial. Stratas would want to minimize the risk associated with introducing numerous penetrations through the building envelope and having a specialist consultant review the site conditions and prepare recommendations is the best approach.

3.4.2 Technical Implementation Challenges

From a technical perspective, there are few barriers to implement a ductless split heat pump retrofit project. As most of the Strata residential buildings at UBC have existing electric baseboards for heating, there is a high likelihood that there is ample power at the suite electrical panel to power the heat pumps. This is, of course, assuming that the electric baseboard heaters are brought offline with the installation of the heat pump. Buildings with existing hydronic heating systems with natural gas supplying boilers, on the other hand, may be short on available power. In these instances, the original building power distribution system would not have been sized for electric heating so the capacity of the panels could be insufficient. If this is the case, a retrofit may entail electrical panel upgrades and service upgrades to the building if enough units wish to install heat pumps.

It should also be noted that UBC has developed its Neighborhood District Energy System (NDES) which provides buildings with thermal heat via an underground network of pipes. This thermal heat is then distributed via an internal network of hydronic piping to terminal units. In these instances, owners may only install cooling units that do not have a heating capability. Recommendations in this report relate to heat pumps only in buildings that are <u>not</u> connected to the NDES.

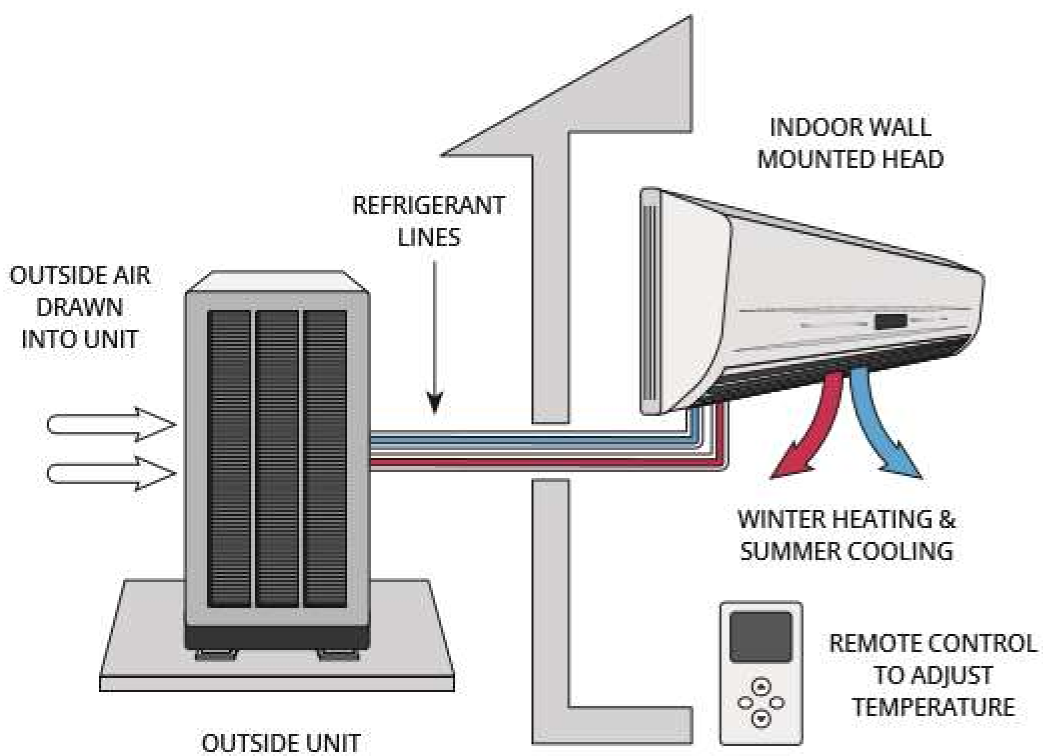

Figure 5: Split Heat Pump Schematic (Clean BC, 2022)

4 REGULATORY CONSIDERATIONS

4.1 Building Code Requirements

Buildings and retrofits within the UBC jurisdiction are currently governed by the British Columbia Building Code (BCBC) 2018 edition. The codes and standards that govern a heat pump retrofit project are as follows:

1. British Columbia Building Code 2018
2. British Columbia Plumbing Code 2018
3. British Columbia Fire Code 2018
4. CSA B52 mechanical Refrigeration Code
5. CSA C22 Canadian Electrical Code

The purpose of listing these codes and standards are to ensure that Strata Councils and unit owners are aware that these retrofits are governed by the requirements stipulated within these documents. All Property Managers, contractors, and Strata Councils must comply with these requirements and seek consultation from professionals if anything is unclear. Ultimately UBC will check to ensure that the requirements have been met as the Authority Having Jurisdiction (AHJ) and will also seek assurances from licensed professionals as required.

4.2 Current Permitting Requirements

The detailed permitting requirements for a retrofit project are outlined on the UBC Planning + Development website[1] (University of British Columbia, 2022). Currently for an owner to have a split heat pump installed to serve their unit, the following permits and permissions will be required for the project:

[1]https://planning.ubc.ca/planning-development/permits-and-business-licenses/building-and-trades-permits/building-permits-application-process

Permit	Submission Requirements	Estimated Review Period by Authority Having Jurisdiction
Development Permit Application (Note that one development permit application may be submitted for one property representing multiple units)	• Development Permit Application Form • Stata Council Approval Letter • Basic site/floor plan with outdoor condensing unit location. • Indoor evaporator unit and outdoor condensing unit cutsheets with sound data (must not exceed 45 dbA during the night time at point of reception per by-laws) • Photos indicating location of unit	2 – 3 weeks depending on completeness of application
Building Permit Application (Note that one building permit application must be submitted per unit)	• Building Permit Application Form • Strata Council Approval Letter • Basic site/floor plan with outdoor condensing unit location. • Development Permit Approval • mechanical Floor Plan Drawing • Indoor evaporator unit and outdoor condensing unit cutsheets	2 – 4 weeks depending on completeness of application
Construction Phase Permits	• Electrical Trade Permit Application Form and supporting documents (to Technical Safety BC)	2 – 4 Weeks

Table 6: Current Building Permit Requirements

Owners and contractors should be aware that these requirements are the same for major renovations and alterations to existing buildings. As such, there may be fewer items within the respective permit application forms that apply to a heat pump installation. The complexity of a heat pump installation may also differ depending on the building. A such, owners and contractors should verify the specific site conditions and confirm the permitting requirements on a project-to-project basis with the Strata Councils, Property Managers, and UBC.

4.3 Strata Council Approval Process

In the province of British Columbia, all Strata Residential buildings are governed by the Condominium Act (Queen's Printer - The Province of British Columbia, 2022). The Act specifically requires unit owners who intend on making alterations to the exterior to seek permission of the Strata Council to proceed. Part 5 – Bylaws, Section 115 Duties of the owner, Sentence (h) states:

“An owner shall receive the written permission of the strata council before undertaking alterations to the exterior structure of the strata lot, but permission shall not be unreasonably withheld.”

(Queen's Printer - The Province of British Columbia, 2022)

The Condominium Act also mandates that any newly formed Strata Corporation must adopt and enforce a set of By-Laws and Rules that govern the Strata building. These By-Laws and Rules contain similar wording to the Condominium Act that require owners to request permission to make any alterations to the exterior structure of the building. Wording may change from building to building but the By-Laws and Rules must not contradict the Condominium Act.

In British Columbia, most By-Laws and Rules as well as the Condominium Act do not specifically speak to split heat pump retrofits. However, absence of direct statements does not mean that they do not apply. The installation of an outdoor condensing unit and making a penetration through the exterior envelope for refrigerant piping and condensate piping is considered an “alteration to the exterior structure” and therefore permission would be required from Strata Councils.

4.4 Permit Requirements – Jurisdictional Scan

This section presents what the permitting requirements are in other municipal jurisdictions. For the most part, permitting requirements are similar for split heat pump systems amongst these jurisdictions with the exception of the City of Vancouver which recently streamlined its process. The examples listed here demonstrate the three major variations that exist between jurisdictions in British Columbia:

- Requirement of a Development Permit and Building Permit
- Requirement of a Building Permit only
- Streamlined split heat pump specific Mechanical Permit

4.4.1 City of Kamloops

For multi-unit residential buildings (MURBs), the City of Kamloops requires a development permit and a building permit for installing split heat pumps. The City has a set of guidelines published as part of the document "Multi-Family Residential Development Permit Area", the objective of which is to provide guidelines for the form and character of multi-family residential development in the city (City of Kamloops, 2022). The guidelines state that permits are exempt for "external renovations that do not affect the form and character of the building" but later states "HVAC units, mechanical and equipment rooms, and elevator penthouses should be integrated with the design of the building and screened with durable, design-compatible finishes". As such, it is unlikely that split heat pumps installed on balconies will be exempt from development permit applications. Once the development permit is approved, a building permit application can be made.

4.4.2 City of Langley

In the City of Langley, only a building permit application is required for Multi-Family Residential Alternations as outlined in the "Multi-Family Residential Building Information Guide, Building Division". It is not clear from publicly available information that a building permit application for split heat pumps will trigger the need for a review by the Planning Department. In review of the "Official Community Plan", there are guidelines associated to how mechanical units must be concealed by a screen if it is located on a roof (City of Langley, 2022). They do not explicitly state whether or not a review by the Planning Department is required for units located on MURB balconies. It would be prudent to verify exact requirements with the City before proceeding with any requirements.

4.4.3 City of Vancouver

As of July 1, 2022, the City of Vancouver published a streamlined permit process to simplify and increase its capacity to process applications to install new, or replace existing, heat pumps. The City no longer requires a Development Permit and Building Permit for the installation of heat pumps and will only require a Mechanical Permit. The simplified process aligns with initiatives that have been put in place by the municipality for a drive towards electrification as part of the Climate Emergency Action Plan. The permit application can be made by a licensed plumbing contractor, electrical contractor, gas contractor, or HVAC contractor.

The permit application can only be made when the installation follows specific pre-requisites outlined on the City's Mechanical Permit website[2]. These include the prescriptive requirements for the placement of the outdoor condensing unit on balconies, rooftops, structured parking, and at grade. The website[2] provides dimensioned diagrams of permitted installation locations for heat pumps and should be referred to for further information. This permitting process can serve as a model as a way to reduce review times and lower regulatory barriers to the installation of these systems.

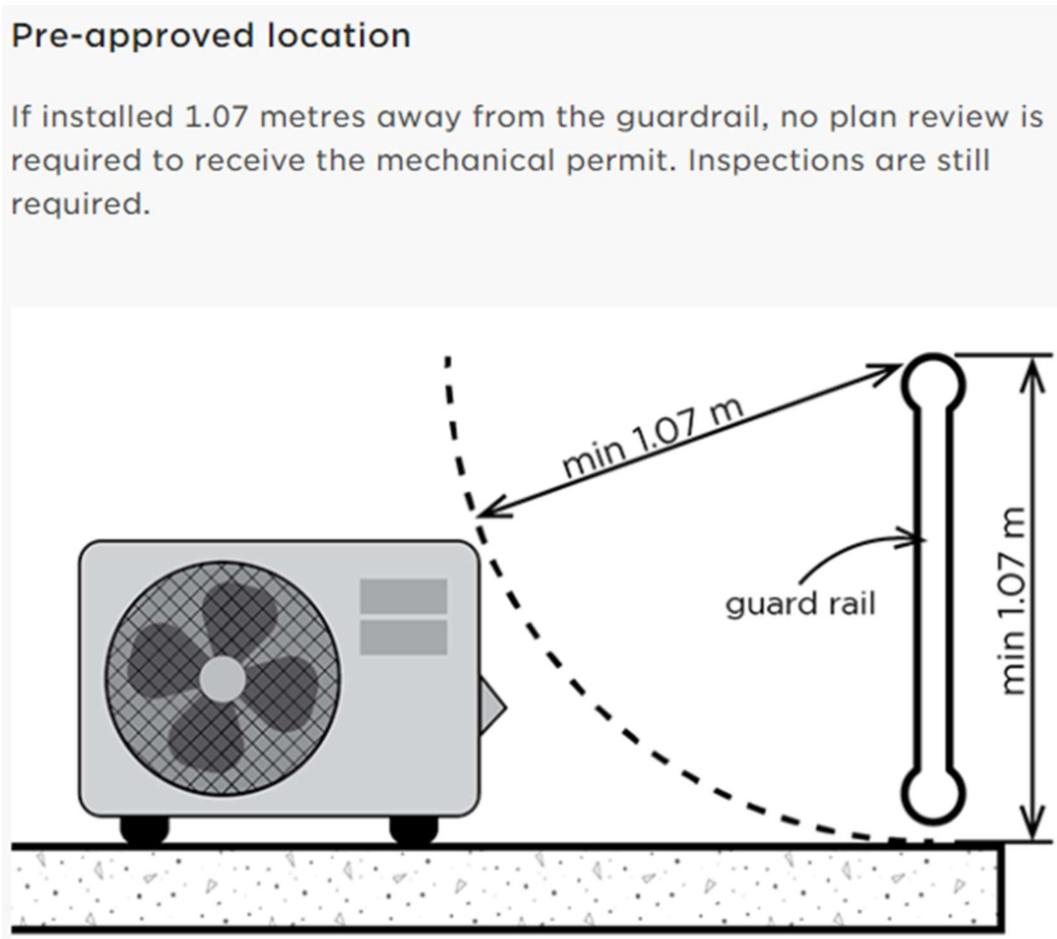

Figure 6: Sample Pre-Approved Installation Diagram for Balconies and Decks (City of Vancouver, 2022)

[2] https://vancouver.ca/home-property-development/mechanical-permit.aspx

4.5 BC Hydro Incentive Program

Finally, BC Hydro offers an incentive for ductless split heat pumps. The value of the rebate differs depending on the fuel source of the original fuel source of the base building. This is summarized in the table below. Fuel switching rebates have not been included in this table as it is assumed that this would require a larger undertaking for a multi-family building where natural gas serves hydronic boilers.

Original Base Building Heating Fuels Source	**Available Rebate**	**Requirements for Residential Buildings Located in UBC**
Electric	BC Hydro - $1000	Serves one zone HSPF ≥ 10.00 SEER ≥ 16
Electric	BC Hydro - $1000	Serves multiple zones HSPF ≥ 9.30 SEER ≥ 16

Table 7: BC Hydro Rebates[3] (BC Hydro, 2022)

5 BARRIERS TO RETROFIT IMPLEMENTATION

With the technical options and regulatory requirements presented to retrofit active systems, the various barriers to implement projects of this nature can be summarized. To reiterate, the focus will be on active mechanical systems and not on passive systems. The passive system approach, while encouraged by the UBC Green Building Action Plan, is unlikely to obtain consensus among owners in a Strata residential building given the specific minimal impact that it would have in relieving the heat experienced during an extreme heat event.

[3]https://www.bchydro.com/powersmart/residential/rebates-programs/home-renovation/renovating-heating-system.html

5.1 Technical Risks for Active Systems

The technical risks for active systems can be broken down into three major categories: structure, building envelope, and electrical power. The degrees of these risks differ depending on the system selected and the existing building conditions. In all instances, consulting a specialist engineer will be prudent to mitigate these risks. Discussion of risk mitigation will occur in Section **Error! Reference source not found. Error! Reference source not found.** by Strata Councils.

5.1.1 Building Structural Risks

In general, the risks associated with structural compromise of the building vary depending on the design of the building and materials it is constructed from. The larger the opening required, the larger the risk of structural compromise. In all instances, a professional structural engineer should perform a review of any planned openings and provide advice on whether structural reinforcement is required.

5.1.2 Building Envelope Risks

Compromise of the building envelope poses another risk in all active system installations presented. In all instances, a penetration would be necessary in the retrofit and the risk increases proportionally to the size of the opening required. Water ingress is the primary concern which has consequences of mold, water damage, and in worst cases, structural compromise. It is therefore sensible to consult a professional envelope engineer to review existing conditions prior to making any openings through the existing exterior wall of a building. The PTAC unit option will pose the greatest risk as it requires the largest opening in terms of water ingress and structural compromise. The split heat pump will be the lowest risk as the opening size is the smallest and the integrated heat pump risk would fall in between the two options.

5.1.3 Building Electrical System Risks

The risks associated with building electrical systems are largely to do with available capacity. The concern is that if new pieces of equipment are added to a building or suite, the existing power distribution system would not be adequate to absorb the additional power needed. At the suite level, the concern would be that the suite electrical panel does not have the capacity to power additional pieces of equipment. At the building level, the issue would be that the electrical service from the grid to the building is insufficient if enough units are installed. The consequence of a lack of capacity is costly electrical upgrades that are needed to increase capacity of these features to make the retrofit feasible.

The exposure of risk depends on what heating system is serving the base building. If the building relies on natural gas as the fuel source for heating to serve hydronic boilers, there is a risk that there is insufficient electrical power to add heat pumps at a large scale. Buildings that have electric heating (e.g. electric baseboard heating) have lower risk since heat pumps consume less power than the existing system. Between the three presented active mechanical systems, power consumption would not vary significantly. The existing building system will entirely drive the level of risk.

5.2 Regulatory Barriers

There are no regulatory or current code barriers present that would prevent the installation of new active systems. If the demand for installations increases in the future as the climate changes, then there is a risk that enforcement capacity of existing regulations and policy will be overwhelmed. Current building permitting requirements at UBC allow for heat pump retrofits to occur. However, the need for a development permit, building permit, and trade permit could slow down the approval process if permit applications increase. Either the capacity of permit reviewers will need to increase to handle the demand or, the permit review process will need to be streamlined to be able to efficiently handle higher volumes of permit applications.

5.3 Owner Education and Awareness

A major barrier to mass adoption of heat pumps in the province is owner education and awareness. Implementing a heat pump retrofit project can be daunting task when the requirements and expectations are not clearly defined. HVAC systems can be intimidating since system operation and their installation requirements are not common knowledge. In addition to this, navigating the permitting process and managing specialist contractors to perform the work adds to the complexity and can overwhelm even industry professionals. The lack of easy access to this information can act as a barrier as it would discourage those who wish to add cooling and improve the heating efficiency of their homes.

5.4 Strata Councils

Strata Councils can be another major barrier for owners to embark on a retrofit project to install heat pumps in their units. By nature, Strata Council members are composed of individuals with wide ranging capabilities and professional backgrounds. The culture within a Council can also vary widely from building to building. While the Condominium Act governs the basic set of Rules and By-Laws a Strata must adopt, additional resolutions can be adopted. The main function of the Strata Council is governance of the building by enforcing the Rules and By-Laws. These have mechanisms in place for making modifications to an owner’s Strata lot and to limited common property such as balconies.

Heat pump retrofit projects would require permission from a Strata Council given how substantial a change this would make within an owner's unit and to limited common property – the building envelope and/or the balcony. Issues arise when the Rules and By-Laws do not clearly define the approval process, or the documents required to obtain approval from the Council. This ambiguity can lead to inconsistent reviews by Council, or in the worst case, continuous requests for further information to satisfy the Council. Education, awareness, and transparency by all parties involved increases the likelihood of successful retrofit projects. As demand for heat pump retrofits increase, a bottleneck may be created in the ability for strata Councils to improve their climate change resiliency and reach decarbonization goals. It is imperative that guidelines and expectations are clearly laid out between Strata Councils and unit owners.

6 CONCLUSIONS

Considering the risks posed by a heat pump retrofit to a building structure, building envelope, and electrical systems, the ductless split heat pumps pose the least amount of risk. By installing these units it is possible to add cooling infrastructure which increases resiliency to extreme heat events as a result of climate change. Heat pumps also improve the heating efficiency by consuming less energy for the same heating effect which ultimately reduces its GHG emissions. The technology is widely available with many reputable manufacturers already participating in the market. Licensed refrigeration contractors are widely present within the Vancouver market, so expertise is abundant to assure competent installations. Risks are not absent and must still be managed and recommendations on how to mitigate these risks will be discussed in Section **Error! Reference source not found.** Technical Risk Mitigation by Strata Councils.

UBC Development Services at Campus and Community Planning may need to consider streamlining their application and review processes if there is an increase in demand for heat pump retrofits. Given the advantages that ductless split heat pumps offer, it may be pertinent to implement a streamlined permit application process specifically for this type of unit not only to reduce review times but also to ensure that existing permit review resources are not overburdened.

Finally, it will be necessary for condominium unit owners and Strata Councils to be provided with guidance how to navigate a heat pump retrofit project and what the expectations are for each party. The owner will need access to resources on the technical requirements, what documents are expected of them to obtain Strata Council approval, what role the contractors play, and what the permitting process is to effectively manage a project. Owners will also need to be made aware of incentive programs that exist within the province to subsidize projects. Strata Councils will need guidance on how to put in place a clearly defined set of submittals to be able to govern heat pump retrofit projects and how to mitigate risks associated with these projects on behalf of the owners. These defined set of submittals can be presented in the form of checklists and will increase transparency and improve project outcomes through fair enforcement.

7 RECOMMENDATIONS

7.1 Guidance to Strata Councils

7.1.1 Technical Risk Mitigation

To minimize the technical risks involved with the installation of a ductless split heat pump system; the following recommendations are presented. Ultimately risk mitigation should occur at the building level and a set of rules and guidelines will need to be developed to achieve this. The technical risks are broken down into three categories – building structure, building envelope, and building electrical systems. As such, it is recommended that Strata Councils initiate the following recommendations:

1. **Retain the services of a professional envelope engineer to review the existing exterior envelope.**
   The aim of the envelope engineer will be to review the existing building envelope and any existing documentation that may exist (drawings and specifications) and recommend how best to make penetrations through the exterior envelope. Strata Councils should request that the envelope engineer prepare envelope penetration details for the possible options that unit owners may encounter when proceeding with a ductless split heat pump installation. This will minimize the risk of water ingress and resulting water damage. Should the envelope engineer identify the need for a structural engineer, Strata Councils should follow this directive. The Strata Corporation would bear the one-time cost of this study and provide access to this document for use by the Owners.

2. **Retain the services of a professional electrical engineer to review existing building electrical infrastructure.**

   The aim of the electrical engineer will be to review the existing building electrical infrastructure to determine what the impact of mass heat pump retrofits would be and to determine whether any electrical upgrades are necessary. A study should be conducted to first review the residential suite electrical panels to see if there is sufficient capacity for the panel to handle the installation of split heat pumps and whether sufficient room exists for additional breakers should they be required. The second part would be to perform a building electrical demand study to determine if there is sufficient capacity in the building electrical service and distribution to handle the future demand of heat pump installations for all units. Based on the study, the electrical engineer can provide a report to the Strata Council with observations and recommendations for the council to act on. The Strata Corporation would bear the one-time cost of this study and provide access to this document for use by the Owners.

7.1.2 Provide owners with Review Checklists

Once reviews have been completed by the engineers and recommendations have been given to Strata Councils, it is recommended that Strata Councils present the findings to unit owners and supply owners with a Review Checklist for owners to follow. A sample checklist intended for owners, the Owner Checklist, is included in Appendix A that outlines the process they should follow and what documents need to be compiled for review by a Strata Council. These documents ensure the intent of the project is clearly identified and risks are mitigated.

A key component of the owner Checklist is to obtain the standard penetration details prepared by the envelope engineer from the Strata Council. The approval process is the opportunity for the Council to review what specific penetration detail would apply to the owner's unit and provide them with this detail so the owner's contractor may follow it. The intention is that the Strata Council, with the help of their property manager, ensures that the correct penetration methodology is implemented to ensure consistent installation.

Appendix B includes a Sample Strata Checklist which outlines what activities Strata Councils should undertake ahead of any owner initiated heat pump retrofit projects. It is important that the right framework is in place prior to the increase in demand for approvals to ensure that Councils are not overwhelmed and that the projects are all implemented in a fair, transparent, and equitable manner. The table below summarizes the major phases a Strata Council can follow for activities they need to undertake for these heat pump projects.

Phase	**Objective**
Consultant Engagement Phase	The objective of this phase is for the Strata Council to engage different Consultants to perform studies to review technical feasibility of installing heat pumps. The Consultant's role is to prepare technical solutions, identify risks, and make recommendations on how to mitigate these risks. • Envelope Consultant • Electrical Consultant
Checklist Publishing Phase	The objective of this phase is for the Strata Council to publish a checklist of the required documents required for review and expectations for unit owners electing to install heat pumps in their units. This phase is to be executed once the Consultants have completed their studies and have provided their recommendations. This is to ensure that the Strata Council is equipped with the necessary information to be able to review requests for heat pump installation approvals.
Management Phase	The objective of this phase is to manage approval requests to ensure consistency of installation throughout the building. Unit owners are to submit approval requests through this framework. The Strata Council and the Property Managers will be responsible for reviewing applications and providing unit owners with the necessary information to support the heat pump project.

Table 8: Major Activities for Strata Councils by Phase

7.2 Guidance to Owners

For unit owners, the recommendations boil down to following the framework created by their Strata Councils. Appendix A includes the owner Checklist which breaks down a split heat pump retrofit project into four major phases:

Phase	Objective
Site Review Phase	The objective of this phase is for the owner to engage a mechanical contractor to review the physical unit and determine the feasibility of installation. Based on the site review, the mechanical contractor will prepare a quotation for the unit owner to consider. This will provide the owner with price information and scope of the project.
Document Preparation for Strata Council Approval Phase	The objective of this phase is for the mechanical contractor to prepare documents for the owner regarding the details of the heat pump installation. The owner may then take these documents and submit to their Strata Council for formal approval of the project.
Permit and Construction Phase	The objective of this phase is for the mechanical contractor to submit the required documents to demonstrate technical compliance and approval by the UBC Permitting Department. Once approvals are received, construction and installation can commence.
Project Close Out Phase	The objective of this phase is for the owner to ensure that the agreed upon installation is complete to their satisfaction. This is the owner's opportunity to identify deficiencies to the mechanical contractor. Once the owner is satisfied, the mechanical contractor is to provide all manuals and warranty certificates.

Table 9: Major Activities for owners by Phase

It is important for the owner to clearly understand the role of the owner, the contractor, and the Strata Council as it will ultimately be the owner's responsibility to keep them accountable. Clear division of work between these three parties ensure a smooth execution of the project but accountability is key.

7.3 Permit Process Streamlining

The final recommendation is for UBC to consider streamlining the permit application process. While the current permit application process does not prevent owners to engage in heat pump retrofit projects, the demand for this type of approval could increase in the future as the instances of heat waves increase and average temperatures increase over the summer months. The City of Vancouver recently adopted a streamlined permit process specifically for split heat pump retrofits to increase their efficiency and capacity to handle such requests as discussed in Section 4.4. It is recommended that UBC adopt a similar process to minimize the reliance on additional resources needed to handle permit reviews in the future. The recommendation is to make a residential retrofit split heat pump permit application path with the following:

1. **Consider removing the need for a Development Permit.**
   Provided that the prescriptive requirements are met below, the Development Permit applications step may be skipped since assurances that are reviewed at this stage have demonstrated compliance.
2. **Consider removing the need for signed and sealed mechanical Drawings specifically for ductless split heat pump retrofit projects for residential buildings only.**
   With prescriptive requirements listed below, the necessity for an professional mechanical engineer is reduced as risk are sufficiently mitigated by the Strata Councils.
3. **Consider providing detailed physical requirements for ductless split heat pump condensing unit placement for balconies and at grade and make compliance a prerequisite for any permit review.**
   This prescriptive requirement would ensure the requirements outlined in the traditional Development permit stage are complied with.
4. **Consider requiring all split heat pump retrofit permit applications to append the envelope penetration details as prepared by the envelope engineer.**
   This provides assurance that the Strata Council has retained an envelope consultant to ensure that risks have been mitigated in regard to water ingress and water damage as a result of penetrating the existing envelope.
5. **Consider requiring licensed contractors to make the permit applications and require them to append their Red Seal certificates as part of the supporting documents.**

This is to ensure that only verified contractors can perform the work to further mitigate the risks. Since certain permitting steps are going to be skipped in this process, it is imperative that a minimum level of competence is verified in the application process.

The idea is for the mechanical contractor to make this permit application to the office that issues permits. Provided that all the prerequisites are met, the hope is that the review process is more efficient and utilizes less resources.

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APPENDIX A – SAMPLE OWNER CHECKLIST

SAMPLE UNIT OWNER CHECKLIST FOR HEAT PUMP INSTALLATION PROJECTS

Disclaimer:

This checklist is intended to provide suggested guidance to unit owners and Strata Councils. Actual requirements may differ, and owners, contractors, Strata Councils, and Property Managers must verify these requirements with all stakeholders and Authorities Having Jurisdiction.

Sample Checklist Purpose:

The purpose of this sample checklist is to provide guidance to unit owners on how to start and manage a heat pump installation project in partnership with a mechanical contractor. The project phases are outlined so owners know what to expect and what responsibilities they have as interface to the Strata Council. Strata Councils may want to develop checklists for their unique building to provide guidance to individual unit owners.

Project Phase Breakdown and Objective:

A summary of each of the 4 major phases and their objectives is provided below.

Phase	Objective
Site Review Phase	The objective of this phase is for the owner to engage a mechanical contractor to review the physical unit and determine the feasibility of installation. Based the site review, the mechanical contractor will prepare a quotation for the unit owner to consider. This will provide the owner with price information and scope of the project.
Document Preparation for Strata Council Approval Phase	The objective of this phase is for the mechanical contractor to prepare documents for the owner regarding the details of the heat pump installation. The owner may then take these documents and submit to their Strata Council for formal approval of the project.
Permit and Construction Phase	The objective of this phase is for the mechanical contractor to submit the required documents to demonstrate technical compliance and approval by the UBC Permitting Department. Once approvals are received, construction and installation can commence.

Project Close Out Phase	The objective of this phase is for the owner to ensure that the agreed upon installation is complete to their satisfaction. This is the owner's opportunity to identify deficiencies to the mechanical contractor. Once the owner is satisfied, the mechanical contractor is to provide all manuals and Warranty Certificates.

Cost Responsibilities:

The unit owners are responsible for all costs associated to the services and equipment provided by the contractors to install the heat pump(s). Typically mechanical contractors will carry the cost of permits and peripheral administrative costs and a review of the scope of work should be reviewed when a quotation is prepared.

SAMPLE CHECKLIST:

Site Review Phase	☐ **(1)** owner to engage mechanical contractor to review site conditions to determine the following items: ☐ **(1a)** Location of outdoor condensing unit needs to be determined. ☐ **(1b)** Location of indoor evaporator unit locations. ☐ **(1c)** Approach to general refrigerant piping routing and concealment methods. ☐ **(1d)** Piping envelope penetration locations. ☐ **(1e)** Review of electrical panel to determine power availability and breaker space. ☐ **(2)** mechanical contractor to provide formal quote to owner. Quote to include detailed scope of work, list of all sub-contractors engaged for the project, and warranty information.
Document Preparation for Strata Council Approval Phase	☐ **(3)** mechanical contractor to prepare **Strata Council Approval Document Package** which shall include: ☐ **(3a)** Sketch (CAD Drafted) floor plan with outdoor condensing unit(s) and indoor evaporator unit(s) location clearly identified. ☐ **(3b)** Heat pump cutsheets which include the following information: • Overall unit dimensions for outdoor condensing unit(s) and indoor evaporator units(s). • Power information – voltage(V), phase(Φ), frequency(Hz), and Maximum Overcurrent Protection (Amps) • Outdoor condensing unit radiated noise information – must not exceed 45 decibels to comply with noise by-law. ☐ **(3c)** Produce copy of Refrigeration contractor License Certificate and Certificate of Liability Insurance. ☐ **(4)** owner to submit **Strata Council Approval Document Package** to Strata Council and Property Manager. ☐ **(4a)** owner to obtain **Strata Council Approval Letter** to proceed with project. Provide mechanical contractor with letter. ☐ **(4b)** owner to obtain **Typical Penetration Detail(s)** from Strata Council and Property Manager to follow for project. Provide mechanical contractor with Penetration Detail(s).

Permit and Construction Phase	☐ **(5)** mechanical contractor to submit required permit applications to UBC appending documents prepared in steps **(3a)**, **(3b)**, **(3c)**, **(4a)**, and **(4b)**. Refer to UBC for all permitting requirements (This will include a Development Permit and Building Permit). ☐ **(6)** owner to provide mechanical contractor with Strata By-Laws to ensure they are aware of all rules associated to construction. ☐ **(6)** mechanical contractor to commence construction upon receiving approval from UBC and coordinate building access with the owner and Property Manager. ☐ **(7)** mechanical contractor to coordinate all Site Inspections with the Authority Having Jurisdiction.
Project Close Out	☐ **(8)** Upon completion of project, the mechanical contractor shall provide the owner the following services and for project close out: ☐ **(8a)** A walk through with the owner to demonstrate unit operation. ☐ **(8b)** Turn-over all permitting and inspection reports issued by the Authority Having Jurisdiction. ☐ **(8c)** Manufacturer supplied Installation and Operating Manuals for the equipment. ☐ **(8d)** Warranty certificate clearly indicating the date that the warranty period starts and ends.

APPENDIX B – SAMPLE STRATA CHECKLIST

SAMPLE STRATA COUNCIL CHECKLIST FOR HEAT PUMP INSTALLATION PROJECTS

Disclaimer:

This checklist is intended to provide suggested guidance to unit owners and Strata Councils. Actual requirements may differ, and owners, contractors, Strata Councils, and Property Managers must verify these requirements with all stakeholders and Authorities Having Jurisdiction.

Sample Checklist Purpose:

The purpose of this sample checklist is to provide guidance to Strata Councils on how to prepare for and manage heat pump installation projects initiated by unit owners. The project phases are outlined so Strata Councils know what to expect and what responsibilities they have the body that governs the building. Strata Councils may want to develop checklists for their unique building to provide guidance to current and future council members.

Project Phase Breakdown and Objective:

A summary of each of the 4 major phases and their objectives is provided below.

Phase	**Objective**
Consultant Engagement Phase	The objective of this phase is for the Strata Council to engage different Consultants to perform studies to review technical feasibility of installing heat pumps. The Consultant's role is to prepare technical solutions, identify risks, and make recommendations on how to mitigate these risks. • Envelope Consultant • Electrical Consultant
Checklist Publishing Phase	The objective of this phase is for the Strata Council to publish a checklist of the required documents required for review and expectations for unit owners electing to install heat pumps in their units. This phase is to be executed once the Consultants have completed their studies and have provided their recommendations. This is to ensure that the Strata Council is equipped with the necessary information to be able to review requests for heat pump installation approvals.

Management Phase	The objective of this phase is to manage approval requests to ensure consistency of installation throughout the building. Unit owners are to submit approval requests through this framework. The Strata Council and the Property Managers will be responsible for reviewing applications and providing unit owners with the necessary information to support the heat pump project.

Cost Responsibilities:

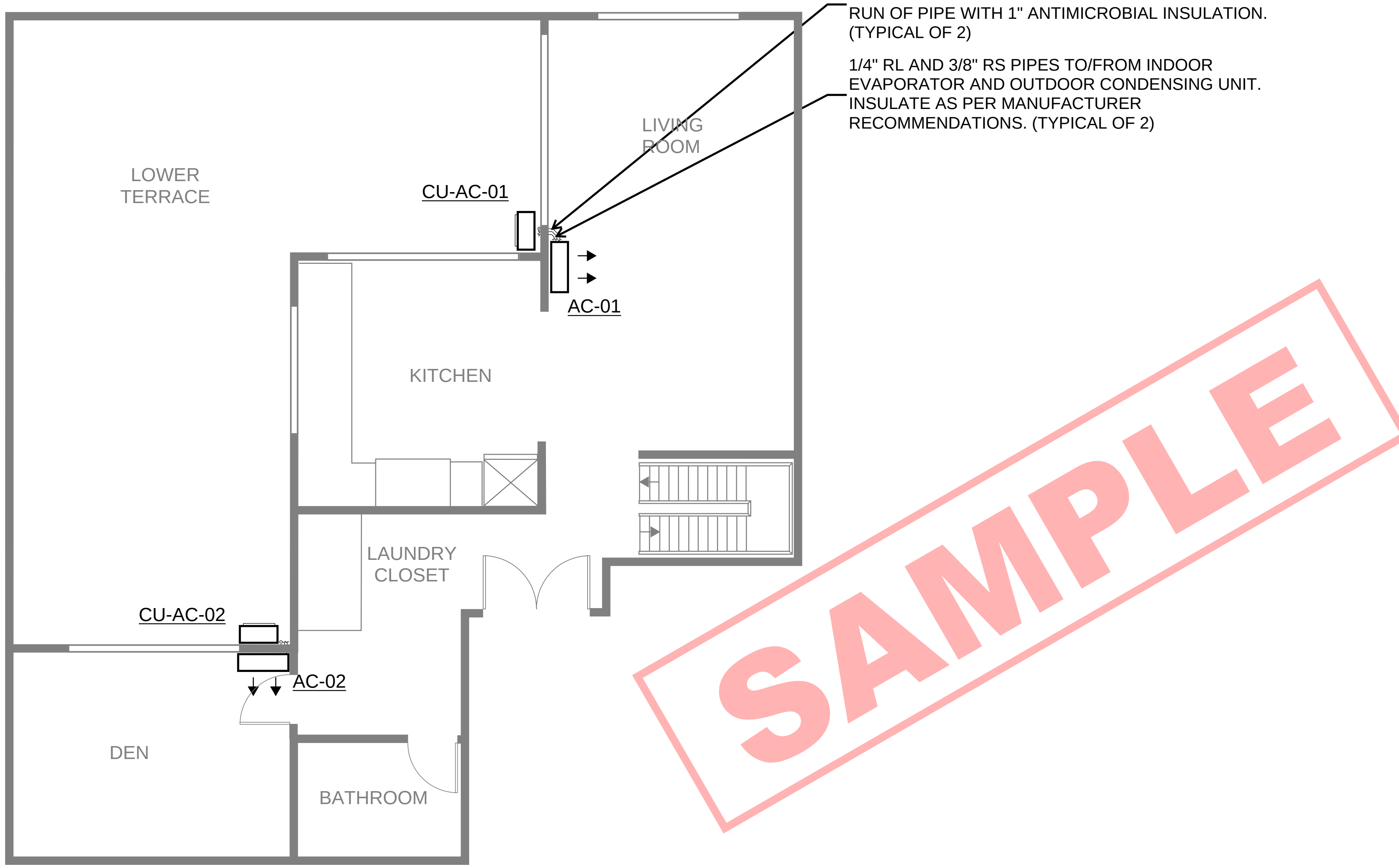
The Strata Corporation will need to bear the cost of the consultants needed to execute the studies for the envelope and electrical demand studies. This is because the result of the studies will apply to all owners and paves the way for the Strata Council to be equipped with the necessary information to be able review heat pump installation approval requests.

SAMPLE CHECKLIST:

Consultant Engagement Phase	☐ **(1)** Strata Council to engage the following consultants to perform studies that are specific to the building: ☐ **(1a)** Electrical Consultant to perform building demand study to determine if any electrical distribution or power upgrades are required. ☐ **(1b)** mechanical Consultant to support the Electrical Consultant by providing typical outdoor condensing unit capacity information. ☐ **(1c)** Building Envelope Consultant to review building envelope penetration options and prepare **Typical Penetration Details** for each penetration type. ☐ **(2)** Based on studies and recommendations, the Consultant Team shall prepare **Technical Guidelines** for adoption into the Strata By-Laws and Rules. These technical guidelines shall include: ☐ **(2a)** Location of outdoor condensing units. ☐ **(2b)** Details in the limits to heat pump unit capacity based on power requirements (if any). ☐ **(2c**) Condensate drainage strategy. ☐ **(2d)** Library of **Typical Penetration Details** that will be needed to be submitted to UBC as part of the permit application process by the mechanical contractor.
Policy Adoption Phase	☐ **(3)** Strata Council to prepare a draft amendment for adoption into the Strata By-Laws and Rules. This amendment needs to be put to a vote under the procedures outlined in the Strata By-Laws and Rules. This amendment shall include: ☐ **(3a)** A proposed Resolution for adoption into the Strata By-Laws and Rules for voting by unit owners. ☐ **(3b)** Outline the **Strata Council Approval Document Package** which includes list of all required documents from owners for a heat pump installation approval request. See step (4) for full list. ☐ **(3c)** The **Technical Guidelines** prepared by the Consultant team.

Policy Management Phase	☐ **(4)** Strata Council to request the unit owner to provide a **Strata Council Approval Document Package** which needs to include: ☐ Sketch (CAD Drafted) floor plan with outdoor condensing unit(s) and indoor evaporator unit(s) location clearly identified. ☐ Heat pump cutsheets ☐ Copy of mechanical contractor's quote to the unit owner ☐ Copy of mechanical contractor's Refrigeration contractor License Certificate and Certificate of Liability Insurance ☐ **(5)** Provide the owner with a Strata Council Approval Letter to facilitate the permit approval process. ☐ **(6)** Provide the owner with Typical Penetration Detail(s) to facilitate the permit approval process.

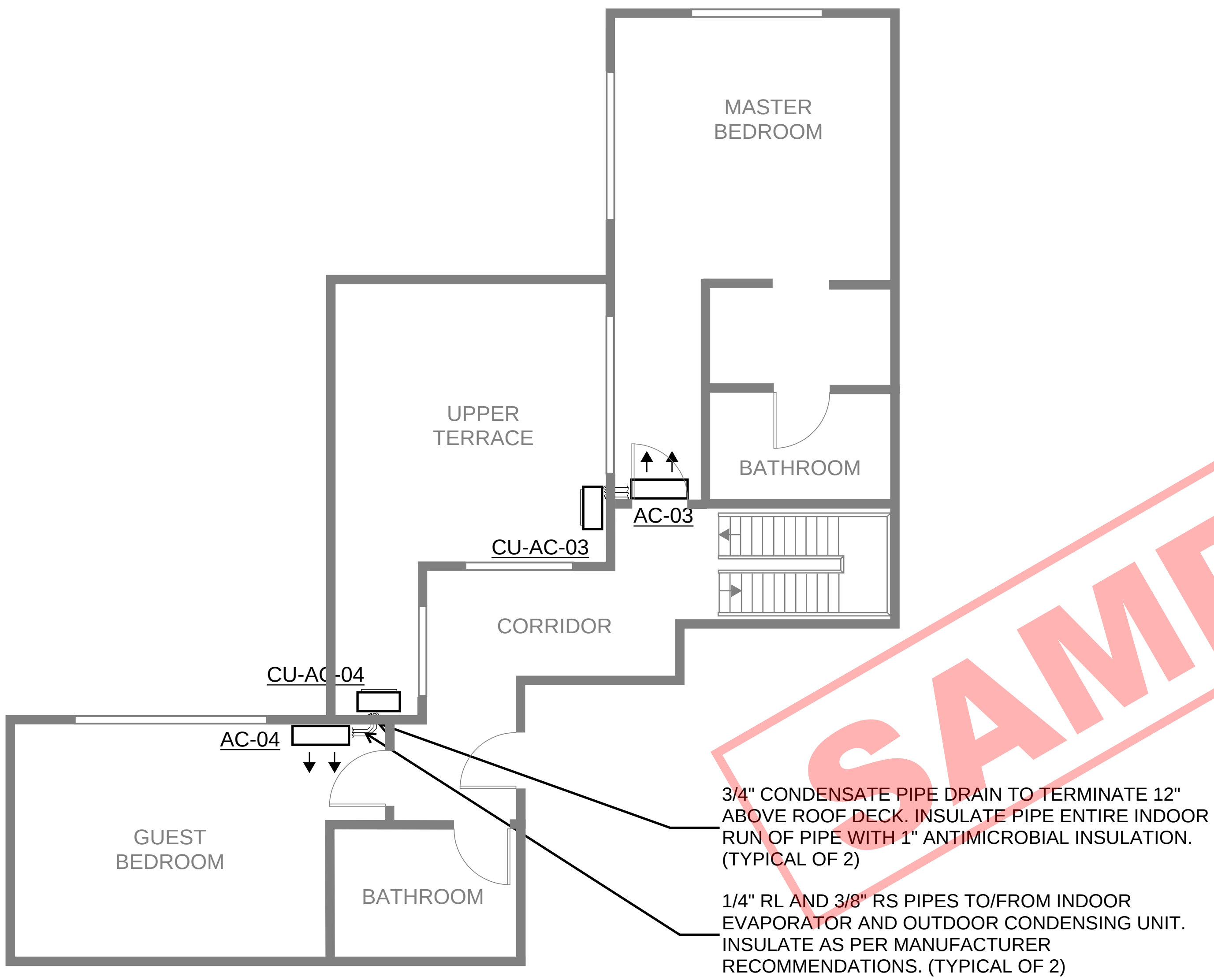
APPENDIX C – SAMPLE MECHANICAL DRAWINGS AND CUTSHEETS

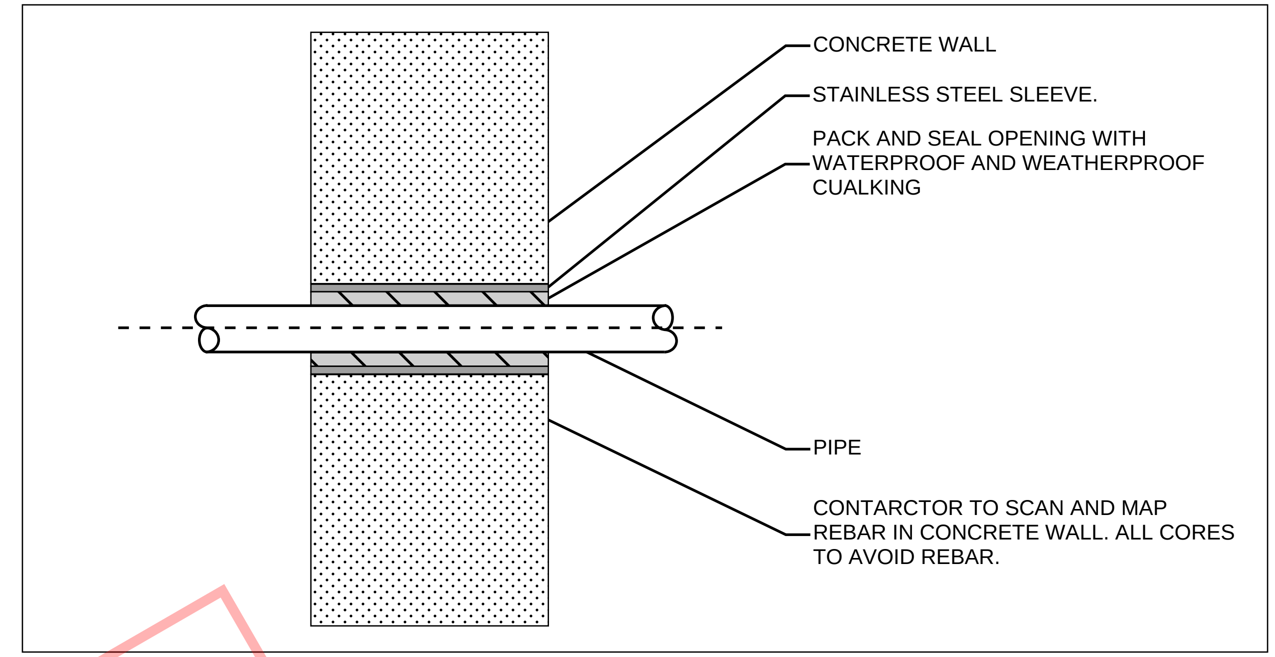


3/4" CONDENSATE PIPE DRAIN TO TERMINATE 12" ABOVE ROOF DECK. INSULATE PIPE ENTIRE INDOOR RUN OF PIPE WITH 1" ANTIMICROBIAL INSULATION. (TYPICAL OF 2)

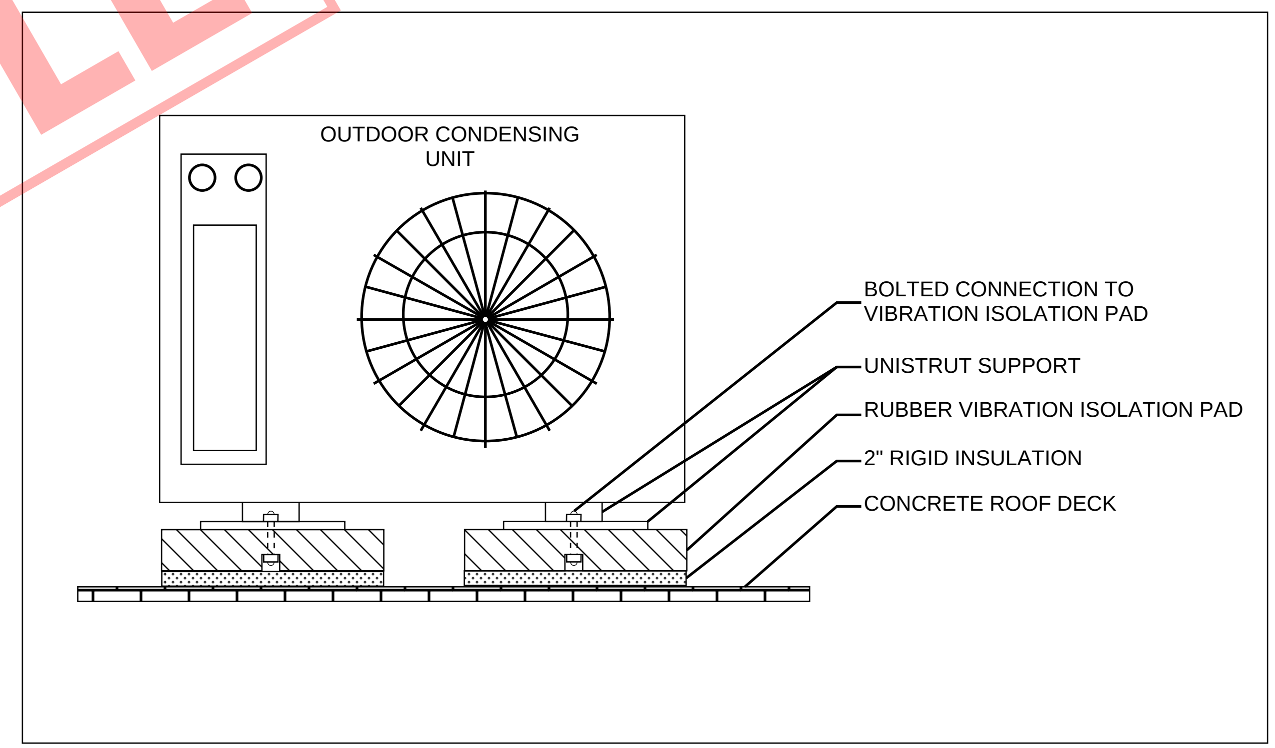
1/4" RL AND 3/8" RS PIPES TO/FROM INDOOR EVAPORATOR AND OUTDOOR CONDENSING UNIT. INSULATE AS PER MANUFACTURER RECOMMENDATIONS. (TYPICAL OF 2)

PROJECT:				
LEVEL 1 - H.V.A.C. PLAN DRAWING TITLE:				M-1
DATE:	N.T.S. SCALE:	0 REVISION NUMBER:	REVIEW ISSUED FOR:	DRAWING NUMBER:





1 / M-2 EXTERIOR WALL PENETRATION DETAIL



2 / M-2 EXTERIOR WALL PENETRATION DETAIL
N.T.S.

PROJECT:				
LEVEL 2 - H.V.A.C. PLAN DRAWING TITLE:				M-2 DRAWING NUMBER:
DATE:	N.T.S. SCALE:	0 REVISION NUMBER:	REVIEW ISSUED FOR:	

Job Name:	
Tag#	

Submittal Data Sheet

FTX09AXVJU / RX09AXVJU

0.75-Ton Wall Mounted Heat Pump System

Complete warranty details available from your local dealer or at www.daikincomfort.com. To receive the 12-Year Parts Limited Warranty, online registration must be completed within 60 days of installation. Online registration is not required in California or Quebec. *If product is installed in a commercial application, limited warranty period is 5 years.*

Indoor Specifications

	Cooling		Heating	
Airflow Rate (cfm)	H	M	H	M
	431	322	402	322
	L	SL	L	SL
	249	219	249	219
Sound (dBA) H / M / L / SL	43 / 36 / 30 / 25		43 / 36 / 29 / 25	
Dimensions (H × W × D) (in)	11-1/3 × 30-29/32 × 9-27/32			
Weight (Lbs)	20			

Outdoor Specifications

Compressor	Hermetically Sealed Swing Type			
Refrigerant	R-410A			
Factory Charge (Lbs)	1.54			
Refrigerant Oil	PVE (FVC50K)			
Airflow Rate (cfm)	Cooling		Heating	
	H	1,083	H	1,103
Sound Pressure Level (dBA)	46		48	
Dimensions (H × W × D) (in)	21-11/16 × 26-1/2 × 11-3/16			
Weight (Lbs)	57			

Efficiency

Cooling		Heating	
SEER	19	HSPF	10.0
EER	12.5	COP	4.06

Performance

Cooling (Btu/hr)	
Rated (Min/Max)	8,900 (4,400 / 10,200)
Sensible @ AHRI	8,040
Moisture Removal gal/h	.08
Standard Operating Range	50°F – 115°F
Extended Operating Range*	-4°F - 115°F

Rated Cooling Conditions: Indoor: 80°F DB/67°F WB
Outdoor: 95°F DB/75°F WB

***With field settings and wind baffle**

Heating (Btu/hr)	
1:@ 47° Rated (Min/Max)	10,000 (4,400 / 13,000)
2: @ 17° Rated	5,700
Operating Range	5°F – 65°F

1: Rated Heating Conditions: Indoor: 70°F DB/60°F WB
Outdoor: 47°F DB/43°F WB

2: Rated Heating Conditions: Indoor: 70°F DB/60°F WB
Outdoor: 17°F DB/15°F WB

Electrical

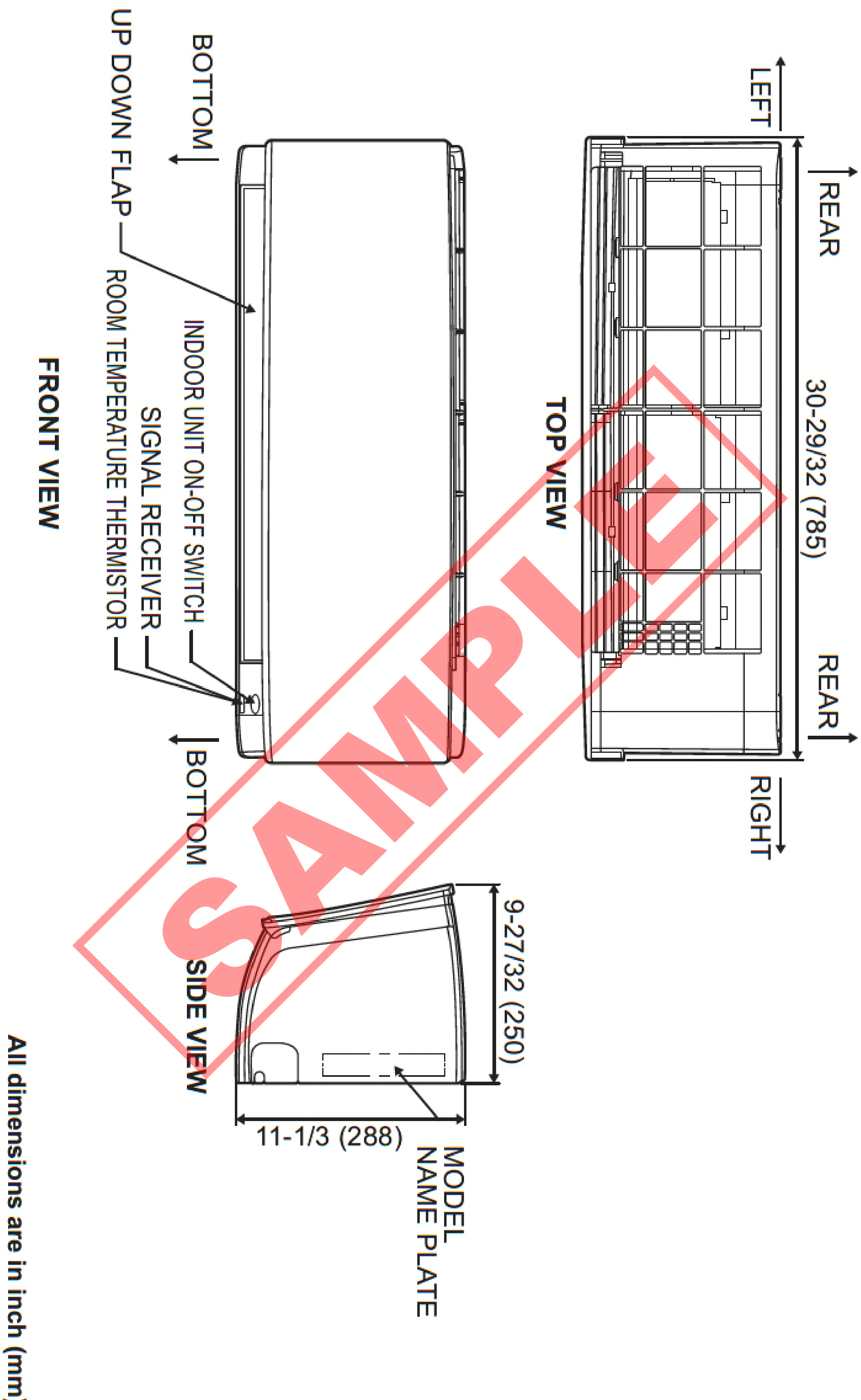
	208/60/1	230/60/1
System MCA	8.7	8.7
System MFA	15.0	15.0
Compressor RLA	8.5	8.5
Outdoor fan motor FLA	0.36	0.36
Outdoor fan motor W	41	41
Indoor fan motor FLA	0.30	0.30
Indoor fan motor W	38	38

MFA: Max. fuse amps **MCA**: Min. circuit amps (A) **FLA**: Full load amps (A)
RLA: Rated load amps (A) **W**: Fan motor rated output (W)

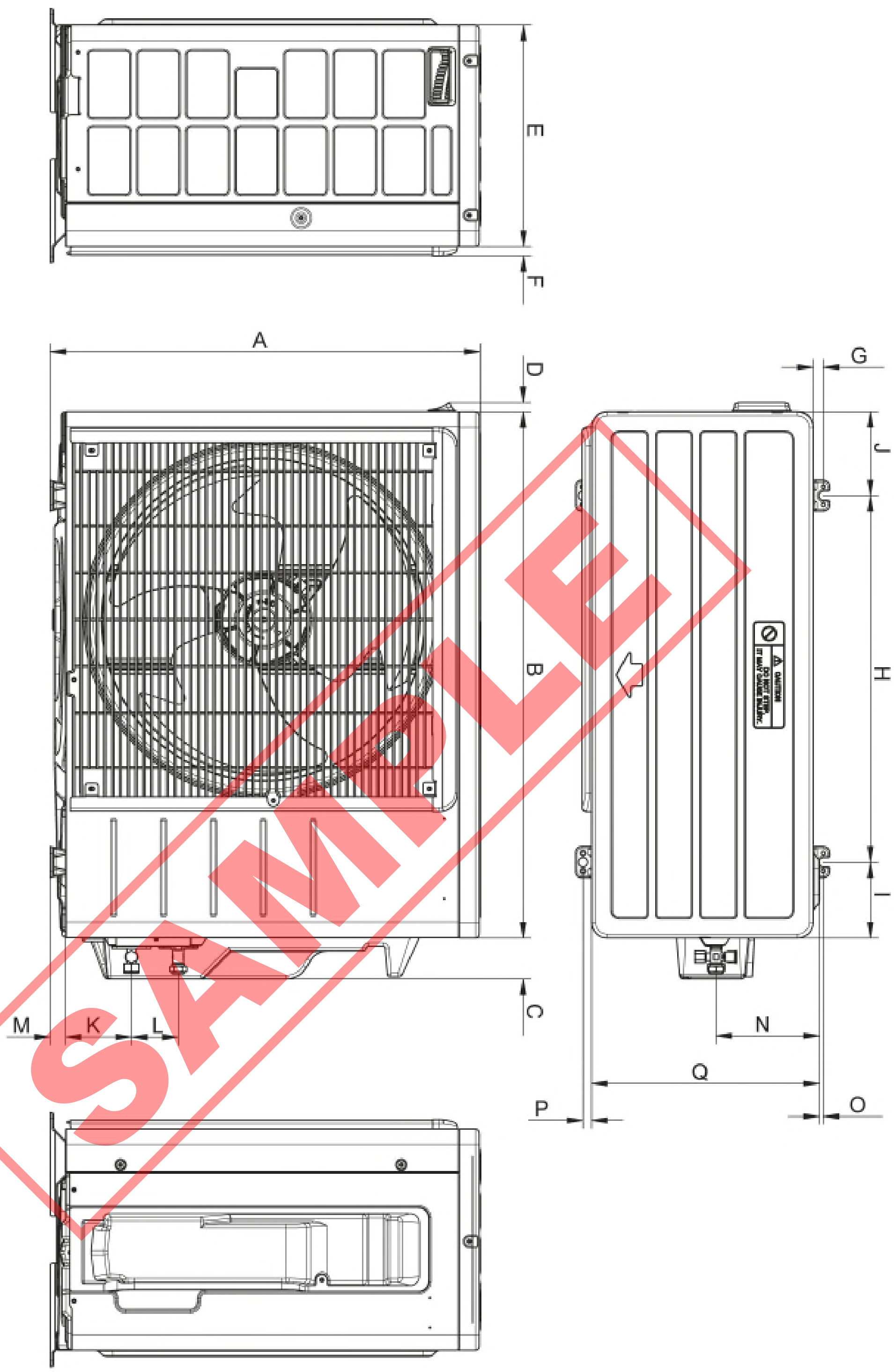
Piping

Liquid (in)	1/4
Gas (in)	3/8
Drain (in)	3/4
Max. Interunit Piping Length (ft)	65.625
Max. Interunit Height Difference (ft)	49.25
Chargeless (ft)	32.8
Additional Charge of Refrigerant (oz/ft)	.21

Daikin North America LLC 5151 San Felipe, Suite 500 Houston, TX 77056
(Daikin's products are subject to continuous improvements. Daikin reserves the right to modify product design, specifications and information in this data sheet without notice and without incurring any obligations)


LEFT
RIGHT
REAR
REAR
30-29/32 (785)
TOP VIEW
BOTTOM
BOTTOM
UP DOWN FLAP
INDOOR UNIT ON-OFF SWITCH
SIGNAL RECEIVER
ROOM TEMPERATURE THERMISTOR
FRONT VIEW
9-27/32 (250)
SIDE VIEW
11-1/3 (288)
MODEL
NAME PLATE
All dimensions are in inch (mm)
SAMPLE

RX09AXVJU Dimensional Data



Model \ Dimension	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
09/12	21-11/16 (550)	26-1/2 (675)	2-1/16 (53)	15/32 (12)	11-3/16 (284)	15/32 (12)	1/2 (13)	18-1/2 (470)	3-13/16 (97)	4-1/4 (108)	3-3/8 (86)	2-3/8 (60)	25/32 (20)	5-1/4 (133)	3/16 (5)	7/16 (11)	11-1/2 (292)

All dimensions are in inch (mm)

Indoor Unit		
Included	Part Number	Description
	BRP072A43	Wireless Interface Adaptor
	AZAI6WSCDKB	DKN Residential Cloud Wi-Fi Adaptor for Single- and Multi-Zone System (S21)
	BRC944B2-A08	Wired Remote Controller kit
	BRCW901A08	Wired Remote Controller Cable – 25ft (Included in above kit)
	BRCW901A03	Wired Remote Controller Cable – 10ft
	DACA-CP1-1	Inline Condensate Pump (Fits inside all Daikin wall & floor mount units)
	DACA-CP4-1	External Condensate Pump

Outdoor Unit		
Included	Part Number	Description
	DACA-WB-1	Powder-Coated Wall-Mounted Bracket
	KPW937F4	Air direction adjustment grille (09 & 12)
	KEH067A41E	Daikin BMS Drain Pan Heater Small RX09,12 & RXN09,12
	KKG067A41	Back protection wire net (09 & 12)