FRESCo
Building Efficiency

# MURB In-Suite Electrification Panel Management and Load Diet


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# 01 Executive Summary

The objective of this report is to understand the options available for multi-unit residential buildings (MURBs) and other forms of multi-family housing to undertake building electrification (i.e., fuel switching from gas to electricity) with in-suite air source heat pump technologies without needing to upgrade the suite or household electrical panel. Avoiding in-suite panel upgrades offers the potential to enable more rapid and lower cost electrification retrofits of existing gas-heated spaces. In-suite heat pumps offer a practical solution to reduce energy consumption and greenhouse gas emissions in multi-family buildings, while enhancing occupant comfort and safety with efficient heating and cooling. Electrification projects can be carried out as part of a comprehensive whole-building retrofit, or suite-by-suite using in-suite heat pump technologies. Considering the substantial costs associated with full building electrification, the diverse need of strata owners and housing providers, and the fact that specific suites within the building might be more prone to overheating, the phased approach to can often be advantageous. Additionally, in-suite heat pumps offer the potential to link directly to the suite's electrical meter, allowing for heating and cooling costs to be billed to the tenant rather than the landlord. These benefits make in-suite heat pumps a practical and efficient choice for building electrification.

Conversions from electric baseboard space heating to in-suite heat pumps in already-electrically heated buildings is a simple retrofit that can free up substantial electrical capacity in a building to pursue other fuel-switching retrofits such as domestic hot water heating or ventilation. In addition, it also frees up grid capacity, reduces bills to tenants and has the added benefit of providing cooling. These retrofits do not require load sharing devices as they can simply replace the existing baseboards within the existing electrical capacity.

However, one of the main challenges with electrifying in-suite loads in gas-heated buildings is the limited electrical capacity and/or physical space of existing suite panels. This limitation arises from the fact that the electrical infrastructure in in gas-heated buildings was not originally designed to support all-electric systems and appliances. Without prior consideration, adding electrical space heating and other hard-wired loads, such as EV chargers, into an existing panel with restricted capacity can result in overloading.

Addressing electrical capacity constraints for in-suite electrification could be done by upgrading the suite panels. However, this upgrade can be costly (estimated cost of $1,000 to $7,000 per suite), as well as time-consuming and intrusive since wiring runs behind walls and ceilings. In addition, upgrading the individual suite panels is likely to trigger upgrades to the main building electrical service and equipment in the main electrical room, which adds to the total cost of building electrification.

This report explores three strategies that offer potential to avoid electrical panel upgrades, which can be applied independently or in tandem with one another:

1. Minimizing the electrical demand of additional loads.
2. Reducing electrical loads within the suite (also referred to as "electrical load diet").
3. Implementing electrical load management strategies.

To understand the potential for in-suite electrification of buildings, this report provides an overview of the electrical infrastructure of different types of apartments and townhomes, summarizes in-suite space heating and cooling electrification opportunities and discusses the potential for EV charging to be connected to in-suite panels. Electrical capacity limitations, at the suite and building level are summarized and panel optimization strategies are explored.

The key findings of this report include:

**Potential for in-suite heat pumps without panel upgrades**

- Without regulatory changes, and without electrical panel upgrades, the installation of in-suite heat pumps on an existing in-suite panel are most viable in bachelor suites and small one-bedroom apartments (which make up a large percentage of BC apartment suites), and in newer apartments and townhomes with sufficient electrical capacity.

- In many low-rise and mid-rise MURBs, when heat pumps cannot be cost effectively connected to the in-suite panel, there are often options to connect to the main building electrical service. These options avoid individual in-suite panel upgrades but will likely trigger an upgrade to the main building electrical service, which could be comparably less costly. This option typically results in the heating and cooling costs being charged to the building owner, unless submetering is installed.

- When installing in-suite heat pumps in all or even a number of suites within an apartment, even if in-suite panel upgrades can be avoided, upgrades to the main building electrical service will likely be required. This is because a building's electrical systems were not originally designed to accommodate every suite panel operating at or near 100% of its available capacity (according to Rule 8-202 of the Canadian Electrical Code). New loads added to the suite (i.e., in-suite heat pumps) are counted at 100% of their load towards both the in-suite panel and the main building service. As a result, the main building service is likely to reach its calculated capacity after a number of suites have been electrified.

**Minimizing the electrical demand of additional loads**

- The feasibility of installing in-suite heat pumps without triggering electrical panel upgrades is improved when in-suite heat pumps are properly sized, and the lowest Minimum Circuit Ampacity (MCA) equipment is selected.

- While there are currently limited options available for low-power in-suite heat pumps, as market demand grows a multitude of new products will be introduced into the market.

**Reducing electrical loads within the suite**

- In apartments, there are only a few electrical load reduction opportunities that can free up electrical capacity in the existing panel to support the installation of an in-suite heat pumps without triggering a suite panel upgrade. These opportunities range from freeing up a few percent (e.g., replacing an older fridge with a newer high efficiency model), up to approximately 70 percent (e.g., replacing a large conventional range with a two-burner induction stove and a countertop oven or other appliances). Load reduction opportunities like removing the range may only be appropriate for some market segments, as it would require a shift in expectations for what appliances should be available in an apartment.
- Future technologies such as battery integrated ranges show great promise for reducing peak loads at the building level as well as freeing up capacity in the suite services which could be used for in-suite heat pumps. A battery range is in many ways a better solution than load sharing or removing the range altogether, but there is a significant concern of fire from large batteries that would have to be addressed.

**Implementing electrical load management strategies**

- Branch circuit switching products are the only load management products potentially allowed to manage non-EV loads, like heat pumps, under current regulations. These devices work by automatically switching between a primary load and secondary load, which is only powered when the primary load is not in use.
- In gas-heated suites with limited to no available electrical capacity or breakers, the most technically viable load to manage with the new heat pump is the kitchen range, which is not currently approved by existing regulation. The range is typically the largest load in an apartment, and almost always the only load large enough to share electrical capacity with a typical heat pump. Load management between a dryer and a heat pump, or between a dryer and a range, would likely not increase the calculated electrical capacity enough to enable in-suite heat pump installation. The City of Vancouver is currently exploring approving (with special permission) load management between an apartment range and in-suite heat pump on a 1958 apartment building electrification retrofit project (see section 5.5).
- No existing examples of load management products were identified to demonstrate the successful load management between apartment in-suite loads and heat pumps. There are dozens of load management products available in BC (see Appendix A). However, most are not allowed under current regulations to manage non-EV loads in buildings. Others are physically large (difficult to fit in small suites), very expensive (which makes them prohibitive for apartment suite retrofits), and have far more circuits, capacity and functionality than could be used in apartment suites.
- A small number of branch circuit switching products currently exist that are physically small and affordable enough to be applicable to in-suite load sharing, but they are all primarily designed for

detached homes to add EV charging. Regardless of their primary application, some of them could also serve to load switch between heat pumps and ranges. More testing, research and regulatory approval would be required before these products can be utilized as part of in-suite electrification retrofits.

**Connecting EV Chargers to In-Suite Panels**

- The feasibility of installing EV charging on row houses or individual apartment suite meters and panels depends on the type of building (townhome/apartment), whether or not the suite is already electrically heated, the layout of the electrical infrastructure and the physical proximity of the home/suite's meter and panel to the resident's parking stall, among other factors. In most cases, installing EV charging on apartment suite meters would be more challenging, and expensive, than connecting to common area panels and would use up available electrical capacity that could otherwise be used for an in-suite heat pump.

- In practice, EV chargers in buildings are typically connected to the building's common electrical panel. This is because common panels and meters are usually located in the basement or ground level closer to the parking, and MURB in-suite panels are generally further away. Circuit sharing between EV chargers is common. Leading installers of electric vehicle supply equipment (EVSE) typically consider installation only on the building's central meter, both in MURB strata and rental buildings. On the other hand, in row houses, EV chargers are typically connected to the suite panels due to proximity, but it depends on the parking location and electrical infrastructure.

**Key regulatory barriers to in-suite electrification without panel upgrades**

- The Canadian Electrical Code (CEC) (Rule 8-106 8) allows for the use of measured maximum demand load for the purpose of assessing the available electrical capacity of new loads. This approach would be more accurate than the calculated load approach and would typically indicate that there is more available capacity than the calculated load, potentially allowing for in-suite heat pump installations that the calculated load would not. However, in BC, the utilities do not measure demand for suite meters nor share the measured electrical consumption from each suite meter due to privacy concerns. Lack of access to the measured maximum demand load has been identified as a barrier to in-suite electrification without panel upgrades.

- The CEC method to determine the calculated load for a suite panel calculates the load required for an electric range by using 6 kW for ranges up to 12 kW, plus 40% of any range over 12kW [Rule 8-202 1) a) v)]. Even when no electric range exists in an apartment, or if the electric range was to be replaced with lower load appliances or load managed with the heat pump, the 6 kW still need to be added to the calculated load [Rule 8-202 1) a) vii)]. As a result, unless flexibility or changes were made in the regulation – the calculated load approach cannot be used to validate that sufficient electrical capacity exists for the installation of an in-suite heat pump, even if the capacity does exist.

In conclusion, while there are viable options for Multi-Unit Residential Buildings (MURBs) and townhomes to embark on building electrification using in-suite heat pump technologies without necessitating suite electrical panel upgrades, certain constraints exist due to current regulations, product availability, and industry awareness. The avoidance of in-suite panel upgrades presents the opportunity to accelerate and cost-effectively implement electrification retrofits in existing gas-heated spaces. As electrification retrofits gain traction, more opportunities will emerge to avoid panel upgrades, facilitating the transition to cleaner and more efficient building systems.

# MURB In-suite Electrification & Electrical Service Limitations

## 2.1 Electrical Infrastructure of a Building

A building's **electrical system** is a network of electrical panels interconnected by wires and overcurrent protection devices, such as breakers and fuses. MURBs have a main electrical utility service that branches out to:

- Common area electrical distribution meters and panels, such as hallways, elevators and stairways, amenities and parkades, where consumption is usually paid for by the strata or building owner.
- Suite electrical meters and panels, where consumption is usually paid by each suite resident.
- Commercial space meters and panels in mixed-used buildings, where consumption is usually paid by the commercial lot owner or tenant.

The electrical infrastructure of a building varies depending on its size, purpose, and layout. The physical configuration and location of the existing electrical infrastructure will determine the complexity and associated cost of retrofits and upgrades, such as hard-wired load additions. Figures 1 and 2 depict examples of the physical arrangement of wiring, metering, and panel distribution in a typical low-rise MURB and a typical mid to high-rise MURB. The main differences in the electrical infrastructure between the two building types lies in the location of the meters: in low-rise buildings, all meters are consolidated in a single electrical room, often situated on the ground floor or in an underground level near a parking garage, while in mid to high-rises, meters are often distributed throughout the building in meter closets located on every 2-4 floors.

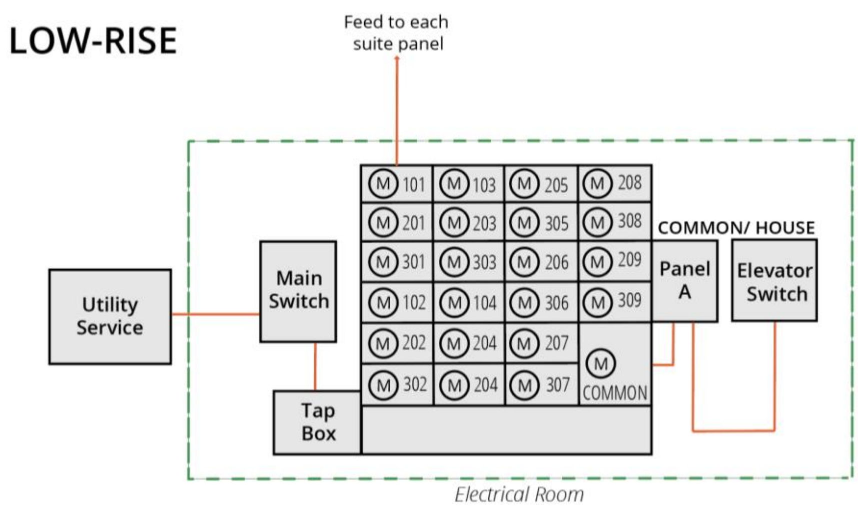


**Figure 1. Electrical system in a typical low rise MURB**
Created by: FRESCo

## MID-HIGH RISE

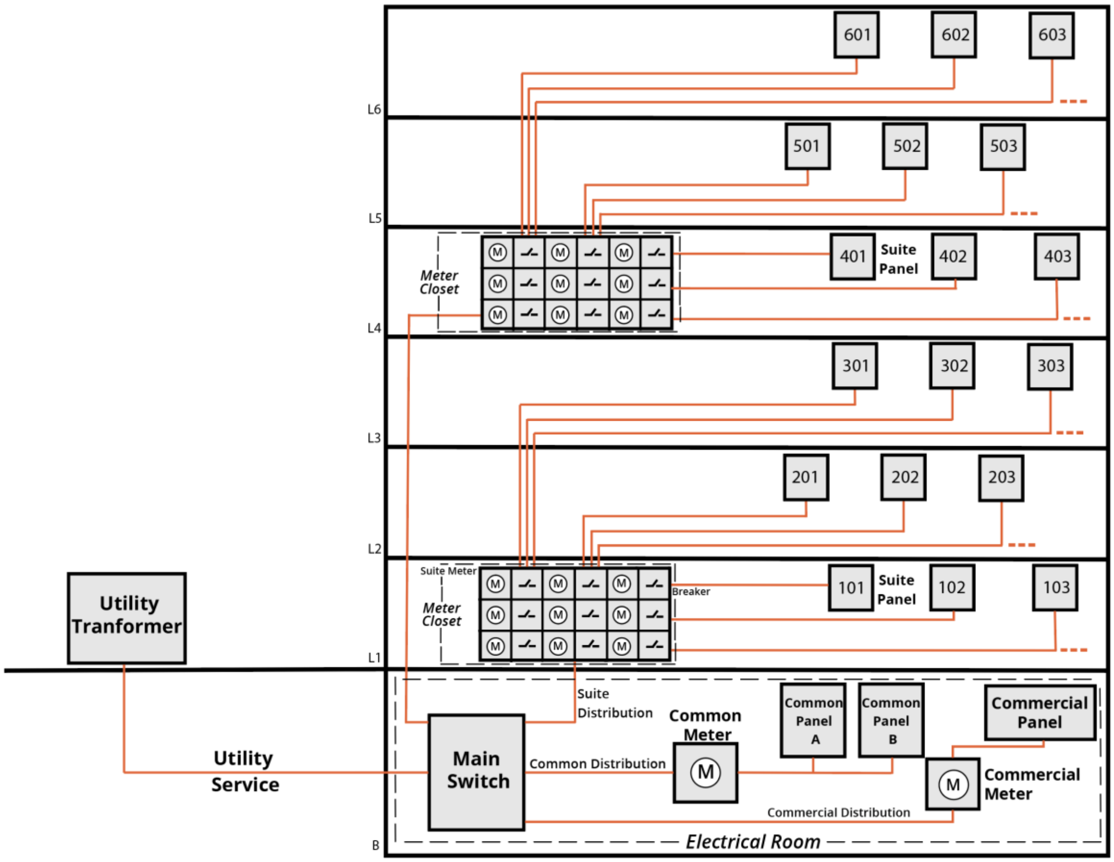


**Figure 2. Electrical system in a typical mid to high-rise MURB**
Created by: FRESCo

**Row houses (townhomes)**

The electrical infrastructure in row houses, or townhomes, differs based on their construction. Figure 3 illustrates this contrast, where the infrastructure can resemble that of a detached home, with each row house having its own meter, along with individual systems for heating, hot water, laundry, and EV chargers. Alternatively, in some townhomes, the electrical infrastructure can be similar to an apartment, with meter centers situated in shared electrical rooms, and each townhome using shared central systems for heating, hot water, laundry, and EV chargers for some or all of the row houses.

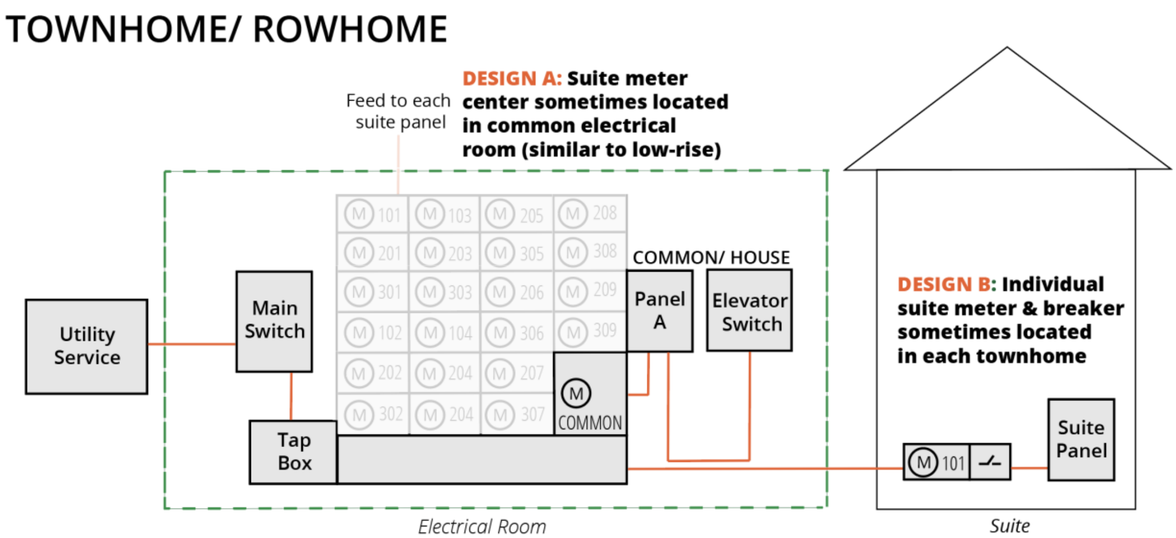


**Figure 3. Individual vs. shared electrical systems in row houses**
Created by: FRESCo

**Suite panels and loads**

In MURBs and row houses, each suite has its own electrical panel which feeds any systems and appliances that serve that individual suite. The voltage to the suites is either single-phase 120/208V in three-phase four-wire main service, or single-phase 120/240V in single-phase three-wire services.

Table 1 describes the general electrical capacity in Amperes (A) of typical apartment suites, or dwelling units, to illustrate electrification constraints. While this data is extracted from th*e Accelerating Electrification in Multifamily Buildings* report (Aitchison et al., 2021) based on a sampling of MURBs in California. Audits have identified similar configurations and electrical capacity in BC MURBs.

Table 1 also outlines the evolution of in-suite panel capacity, which has transitioned from 30 to 60 A in buildings constructed until the mid-1970s, then increased to 60 to 90 A in structures from the late 1970s to the early 2010s, and finally to a minimum of 100 A in newer buildings. Panel size, available circuits and power allocated per suite have followed a similar trend – increasing in electrical capacity per suite. This data indicates that newer buildings offer greater electrical capacity for electrifying in-suite loads compared to older buildings.

| Table 1. Electrical Infrastructure Conditions by Building Vintage | | | | |
|---|---|---|---|---|
| Electrical capacity per suite (A) | | | | |
| **Infrastructure type** | **Pre-1950** | **1950-1974** | **1974-2010** | **2010-present** |
| **Whole-building infrastructure (overall service size) per suite** | 10-20 A | 15-45 A | 25-70 A | 25-70 A |
| **Suite electrical service** | 30-40 A | 30-60 A | 60-90 A | 100 – 150 A |
| **Appliances and end use (branch/circuit) infrastructure** | Two 15 A circuits | Two to six 15 A circuits and one two double-pole* 20-30 A circuits | Five to seven 15-20 A circuits and one to three double-pole* 20-50 A circuits | Six to eight 15-20 A circuits and three to four double-pole* 20-50 A circuits |
| ***Double-pole circuits are typically 208-240V circuits serving larger loads.** | | | | |

## 2.2 In-Suite Electrification Opportunities

The systems and appliances that can be electrified (fuel-switched from natural gas to electricity) within a suite can include:

- Space heating
- Domestic hot water
- Clothes dryer
- Kitchen range
- Fireplaces

The potential for in-suite electrification opportunities lies in which loads are located in the suite panel vs. central loads connected to the main building service. Table 2 describes in-suite loads and central loads in row houses and MURBs of different vintages.

| Table 2. In-suite Load vs. Common Area Load Electrification Opportunities | | |
|---|---|---|
| **Load** | **In-suite Load** | **Central Load** |
| **Space heating** | Row houses typically have electric baseboards.<br><br>Some apartment buildings built on or after 1990s have electric baseboards. | Apartment buildings built before 1990s typically have central gas boilers.<br><br>Some apartment buildings built on or after 2000s have central Variable Refrigerant Flow (VRF) systems.<br><br>Some row houses may have furnaces. |
| **Domestic hot water** | Row houses & some all-electric apartment buildings. | Apartment buildings typically have central gas systems. |
| **Clothes dryer** | Row houses, as well as apartment buildings built on or after 1990s, typically have in-suite laundry.<br><br>Row houses tend to have large family-sized electric resistance laundry dryers in the suites compared to apartment suites, which tend to have either no in-suite laundry (older stock) or small compact units (newer stock). | Apartment buildings built before 1990s, and many rental buildings of varying vintages, have common area laundry. |
| **Kitchen range** | Typically, in-suite electric ranges.<br><br>Some newer strata buildings have gas ranges. | N/A |
| **Fireplaces** | Typically, only found in strata buildings. | N/A |

### Viability of in-suite electrification

- **Space heating:** The highest potential for in-suite building electrification is with space heating using in-suite heat pump technologies.  There are multiple options of in-suite heat pumps available. As long as a suitable in-suite heat pump option can be selected that meets the heating and cooling loads of the apartment and there is sufficient electrical capacity, replacing central gas heating with an in-suite heat pump system is a viable option.
- **Water heating:** There are some opportunities to electrify gas hot water in row houses and any suite that has a tank-style hot water heating system. However, in most suites that are connected to a central natural gas hot water heating system there may be limited space and in-suite electrical capacity to fuel

switch to a tank-style in-suite hot water heating system (resistance or heat pump). In most cases, the more viable option for building electrification of hot water is to fuel switch to a central hot water heating system (for example, $CO_2$ Air Source Heat Pump Water Heater)

- **Gas fireplaces:** Can be electrified with electric fireplaces or decommissioned and removed. Gas fireplaces are typically only present in strata buildings.
- **Gas ranges:** Can be electrified with high efficiency induction ranges. This type of upgrade is more likely to occur at end-of-life time of replacement or during a kitchen renovation.

## 2.3 Connecting EV Chargers to In-Suite Panel

The feasibility of installing EV charging on row houses or individual apartment suite meters and panels depends on the type of building (townhome/apartment), whether or not the suite is already electrically heated, the layout of the electrical infrastructure and the physical proximity of the suite's meter and panel to the resident's parking stall, among other factors.

**Row houses/Townhomes** often have a carport adjacent to or under the suite and as a result vehicle parking is typically in close proximity to dwelling electric meter and panel for other connection options, including EV charging. Additionally, the laundry dryer in older homes is often on the ground floor; this facilitates using commonly available load-managing devices offered specifically for sharing or switching between the EV charger and the dryer.

It is important to note that gas-heated townhome complexes may be more challenging to electrify than gas-heated apartments. Townhouse complexes often have multiple transformers, each shared by one or more townhome blocks, which are often loaded to very different degrees. Different unit owners may desire to add heat pumps and/or EV charging at different times, which can lead to an uncertain pathway to complete complex electrification as available electric capacity is claimed bit by bit. To ensure cost effective and well-planned building electrification of townhome complexes, an electrical capacity plan or electrical planning report is recommended.

**MURBs** could potentially have EV charging connected to each suite meter and panel. This would be feasible in low rises where the electrical room that has the suite meters is located in the parkade, and the distance for connections is not too great to each dedicated parking stall. However, in this scheme, power would be split between the EV charger and the feed to the suite, therefore load sharing between loads in the suite (such as a dryer or a heat pump) and the EV could only be accomplished with remote communication. In practice, EV chargers are typically connected to the building's common electrical panel, and circuit sharing (between 4 and 8 EV chargers) is common. Leading installers of electric vehicle supply equipment (EVSE) typically consider installation only on the building's central meter, both in strata and rental buildings.

An emerging alternative to the heavy electrical demands of many EVs in a parkade is shared electric micro-mobility (e-scooters and e-bikes). These forms of transportation demand only on the order of 1% of the electrical capacity demanded by electric cars, and the shared scheme provides flexible options for residents.

Many townhomes and some recent MURBs (or older ones in specific locations such as Vancouver Island), are electrically heated (baseboards) and typically have sufficient electrical capacity for upgrading the space heating with heat pumps to add cooling, and to add EV charging.

## 2.4 Electrical Capacity Limitations

**In-Suite Capacity Limitations**

One of the primary challenges with electrifying in-suite loads is that the existing suite panels have limited electrical capacity and physical space to connect new loads. This is mainly because, in gas heated buildings, the panel and the electrical infrastructure feeding the panel (feeder wires, overcurrent protection devices, and main service) were not designed and sized to provide for all electric systems and appliances. This is particularly challenging in older buildings built on or before the 1970s where the existing electrical infrastructure may already be insufficient to support the increasing number of modern appliances and electrical loads often found in a modern home.

Any electrification or the addition of electrical loads further reduces the already limited panel capacity. Among these loads, space heating is the most demanding, constituting a significant energy load, typically accounting for 60% of the electrical load of an average MURB suite across BC.

**Whole building capacity implications**

Electric load management and calculation within MURBs, MURB suites, and townhomes involves a complex interplay of factors and considerations. When new electrical devices are added to a building, compliance with the Canadian Electric Code (CEC) Section 8 is necessary to ensure the building's electrical system can legally accommodate the additional load. Typically, this is evaluated through a process known as a load calculation, which takes into consideration various factors, including the types of devices, their usage patterns, and the building's size. This calculation helps determine the minimum electrical capacity that the building infrastructure needs in order to supply power to the building's existing electrical devices in the building and any new loads.

Load calculations for each suite panel per Rule 8-202 of the CEC consider different demand factors for different load types (e.g., appliances, heating, cooling, EV charger). The demand factors can allow for some loads to be taken at less than 100% to help simulate the fact that not all loads will be on at the same time. This means that even if a panel has a rated capacity, for example, of 60 A, the sum of all the connected loads may be higher than 60 A.

In addition, Rule 8-202 in the CEC offers specific demand factors for sizing the building service and feeders supplying the suite panels. These factors are detailed in the rule, and they decrease from 100% to 10% as the number of suites increases. In essence, this means that the building's electrical system isn't originally designed to accommodate every suite panel operating at or near 100% of its available capacity. Table 1 shows an example of how, in 1950-1974, a dwelling unit was provided a 30-60A panel but the whole-building infrastructure supplying the panel only had the capacity for 15-45A per dwelling unit.

An additional CEC rule, Rule 8-106 8) allows for the use of measured maximum demand load over a 12-month period for the purpose of assessing the available electrical capacity of new loads. A measured maximum demand load is defined as the measurement of the highest rate of consumption of electricity for over a period when demand is highest. This approach would be more accurate than the calculated load approach and would typically indicate that there is more available capacity than the calculated load, potentially allowing for in-suite heat pump installations that the calculated load would not. However, in BC, the utilities do not measure maximum demand (in kW) for suite meters nor share the measured electrical consumption (in kWh) from each suite meter due to privacy concerns. Although aggregate level suite consumption data (in kWh) is available, lack of access to the measured maximum demand load (in kW) at the individual suite level has been identified as a barrier to in-suite electrification without panel upgrades.

While it's possible to add more load to each suite panel, this approach carries the risk of overloading the building's electrical system, as it was not sized with the assumption that each panel would operate at full capacity simultaneously. This emphasizes the need for prudent management of electrical loads at both the in-suite panel and building levels to ensure the safe and reliable delivery of electrical service to all residents.

**Electrical upgrade implications**

Addressing electrical capacity constraints for electrification could be done by upgrading the suite panel, as well as the building electrical infrastructure, and if needed, the utility service connection. However, this upgrade can be costly, time-consuming, as well as intrusive since wiring runs behind walls and ceilings.

No comprehensive cost ranges for electrical upgrades are available for MURB retrofits in BC.  For reference, Table 3 shows typical cost ranges, in US dollars, for upgrading electrical infrastructure, taken from the *Accelerating Electrification in Multifamily Buildings* report (Aitchison, 2021). This table illustrates that the cost and complexity of electrical upgrades can be high, and extremely variable per building.

In the cost ranges, the lower limit represents a typical multifamily building that has 20 or fewer units and doesn't have major upgrade hurdles. The upper limits of the cost ranges represent more complicated upgrades typically associated with commercial or large multifamily properties. These estimated costs include ancillary costs such as drywall repair.

**Table 3. Estimated Cost Ranges for Electrical Infrastructure Upgrades & Utility Service Upgrades**

| Electrical Infrastructure Upgrades | Cost* |
|---|---|
| Add circuits for a new electric appliance | $500-$2,000 |
| Upgrade subpanel | $1,000-$7,000 |
| Replace disconnects at meter bank | $1,000-$3,000 |
| Upsize feeder cable | $1,000-$10,000 |
| Convert from single to three phase | $10,000-$100,000 |

| Utility Service Upgrade | Cost* |
|---|---|
| Service line disconnect | $500-$5,000 |
| Overhead service connection | $3,000-$10,000 |
| Underground service connection | $10,000-$50,000 |
| Pole-mounted transformer | $3,000-$5,000 |
| Pad-mount transformer | $10,000-$30,000 |
| Subsurface transformer | $40,000-$80,000 |
| **Cost figures in USD as of the year 2021.* | |

***Note:*** *Electrical infrastructure upgrades are building-specific and can vary greatly from building to building. These estimated costs may not reflect actual costs for specific buildings.*

Table 3 informs that some of the measures suggested in this report intended to avoid panel upgrades can be more expensive than the upgrades themselves. Either opting for electrical upgrades or connecting heat pumps to the common meter rather than individual suite panels, might be a more cost-effective choice. Note however, that the latter option leaves electrical consumption on the owners meter, which the owner may not prefer.

## 2.5 Panel Optimization Strategies

This section explores some strategies to avoid potentially costly and time-consuming in-suite panel upgrades to accommodate electrification. To carry out a cost-efficient electrification retrofit, the first step is to evaluate the building's existing electrical infrastructure and identify solutions that make the best use of that infrastructure.

The three main strategies that emerged to optimize the use of an in-suite panel and avoid a panel upgrade:

- **Strategy #1: Minimization of electrical demand of additional loads.** Selecting high efficiency, low capacity and power draw heat pumps to optimize available electrical capacity. Where possible, planning heat pump retrofits with other energy efficiency upgrades, such as enclosure, can reduce heating and cooling loads and allow for smaller sized lower power draw heat pumps to be installed. *Enclosure upgrades are not part of the scope of this study so will not be detailed any further.*

- **Strategy #2: Electrical load diet.** Reduction of existing in-suite loads to make room for additional loads.

- **Strategy #3: Electrical load management.** If there is still not enough capacity to accommodate all new loads, some loads can be shared to control and prevent multiple devices from operating simultaneously.

# Strategy #1: Minimization of electrical demand of additional loads

## 3.1 Opportunities for Minimizing Heat Pump Loads

In-suite heat pump technologies offer significant potential for providing space heating electrification and cooling for apartment suites and townhomes. A key challenge is the potentially high electrical load these heat pumps may add to suite panels. To address this challenge the initial strategy should be to minimize the electrical demand of heat pumps before considering load sharing or costly electrical panel upgrades.

Most heat pump products available in the market today are much larger than needed for the typical smaller sized bachelor to one bedroom apartment and for smaller apartment bedrooms. The majority of these systems are designed for detached homes, which require higher power than apartments. Most apartment in-suite heat pump retrofits to date have been in suites heated by electric baseboards (primarily to add air conditioning), and since these have far more electrical power available at the panel, installing oversized heat pumps has not been a problem. The historic lack of smaller sized in-suite heat pump technologies and lack of knowledge about calculating heat loads for apartments has resulted in most suppliers, contractors and Engineers defaulting to specifying the same oversized equipment in electrification retrofit projects. The industry must learn to identify lower capacity and lower power draw heat pumps for gas to heat pump retrofits in apartments with low heating and cooling loads.

Properly sizing heat pumps and selecting the lowest Minimum Circuit Ampacity (MCA) equipment to meet the heating and cooling needs of the suites will help mitigate the additional load on the panel, potentially eliminating the need for panel upgrades. As electrification (fuel-switching) retrofits of apartments becomes more prevalent, it is likely that more low-power heat pumps will become available in Canada.

## 3.2 In-Suite Heat Pump Technologies

There is a wide variety of in-suite heat pump technologies available and under development (see Appendix B). The most commonly available products for in-suite electrification, and their potential for load minimization, are discussed in this section.

- **Mini and Multi-splits.** These are the most commonly available products for in-suite electrification. Unfortunately, almost all products are designed for the detached homes market. FRESCo has found these heat pumps are usually significantly oversized for most apartment retrofits. The minimum head size is nominally 9,000 BTU/h, and most owners prefer one head per bedroom as well as the living room. The NEEP Cold Climate list has only 24 multi-head products listed with a nominal 18,000 BTU/h rating or less, and none under 17,000 BTU/h. Also, there has not been a concerted effort by manufacturers to minimize the rated minimum circuit ampacity (MCA). Most models are intended for 208 or 240V connections, and typically have an MCA of 20 to 40A. Some heat pumps draw only 7A of power while running at full power but are rated with MCA of 20A. Since the CEC normally is based on MCA, this is a limiting factor for the whole building load.

Table 4 shows example lower MCA multi-split products more suitable to in-suite apartment use than larger units.

| Table 4. Example of Multi-Splits with Lower MCA | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Brand** | **Series** | **Type** | **Indoor units** | **Rated Btu/h Heating Output at 17F** | **Voltage (V)** | **MCA** | **BTU/h at Design Temp per MCA** |
| **Daikin** | Cirra | Multi-split | 2 | 10,700 | 208/240 | 10.9 | 982 |
| **Tosot** | M-Series | Multi-split | 2 | 14,700 | 208/240 | 14 | 1,050 |
| **Panasonic** | Multizone | Multi-split | 2 | 17,400 | 208/230 | 13.6 | 1,279 |

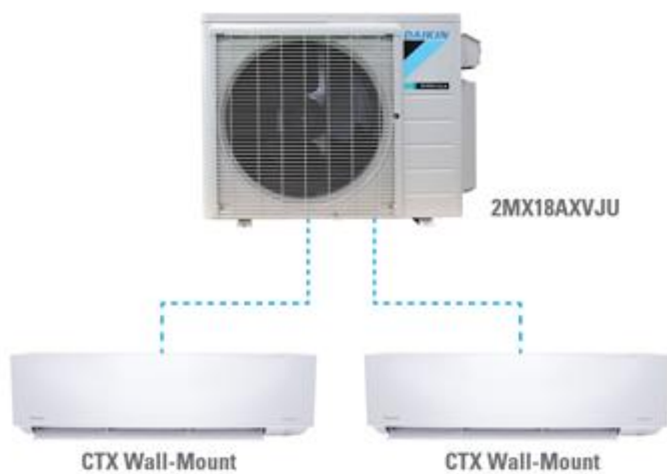


**Figure 4. Example of multi-split with lower MCA.**
Source: Daikin

- **Apartment Sized Splits** There is a new class of smaller multi-splits emerging intended for apartments which have heads in the 5,000 to 7,000 nominal BTU/h range, and a specific focus on reduced MCA. Three head units with 18,000BTU/h nominal outdoor units allow one head in the living room and one in each bedroom for 2-bedroom suites.

  FRESCo has discussed these products with representatives from three major manufacturers, but specifications have not been released yet.

- **Single-Package Vertical Heat Pump (SPVHP)** This type of product contains the heat pump, indoor and outdoor coils and fans all packaged together in a vertical box from floor to ceiling. These are typically installed in a corner of the room adjacent to the exterior wall with a rectangular enclosure penetration for heat exchange. Lower efficiency versions of this type of heat system have been common in hotels and have been considered for retrofit to overheating apartments in glass towers in BC. They take approximately 2x2 feet of floor space but are considered more aesthetically pleasing than traditional horizontal "PTAC" hotel air conditioners. The NEEP Cold Climate list has a specification for SPVHP, with slightly reduced performance requirement compared to the mini-split specification. Only two manufacturers are listed, with only 3 models each: EPHOCA (the US brand for Innova), and Ice Air.

The smallest Ice Air model (SPXC12) features a heating capacity of 11,400, and an MCA of 9.8A (1,163 BTU/h per MCA, which is better than most mini-splits). It operates in heat pump mode down to at least –5F and can be configured with built-in electric resistance backup heat to operate below that temperature.

**Figure 5. Example of Single Package Vertical Heat Pump**
Source: Ice Air

- **All-in-one heat pumps** This product class, often included in the category of Packaged Terminal Heat Pump (PTHP), also contains all parts in a single box, but these are more compact and mount on the wall, with heat exchanged through two 8" penetrations. Only two brands are currently available in BC (Innova and Olimpia Maestro, although two others have indicated they intend to offer similar products in BC in the future. They offer power as low as 9.4A on 115V, but since these models are very compact, heating output declines more significantly with outdoor temperatures than it does from mini-splits, and therefore they are more reliant on backup electric resistance heating, which is higher power.

**Figure 6. Example of all-in-one heat pump**
Source: Norm's Plumbing and Heating

- **Window-saddle heat pumps:** The Gradient heat pump is designed for single room heating and cooling for older buildings with vertically sliding windows and is currently shipping in bulk for large scale trial applications in the US and is expected to be more available in 2024.

**Figure 7. Example of Window Saddle Heat Pump**
Source: Gradient

# Strategy #2: In-Suite Electrical Load Diet

## 4.1 Opportunities for In-suite Load Reduction

The focus of this discussion is limited in-suite heat pump electrification of suites heated using gas or hot water baseboards.[1]

The strategy of reducing existing loads in the suite (strategy #2), in combination with minimizing the electrical demand of the additional loads (strategy #1), in some cases, may free up sufficient surplus capacity that enables the installation of an in-suite heat pump without the need for load management technologies (strategy #3) or a suite panel upgrade.

However, while there are opportunities to reduce in-suite loads in apartments, these opportunities are limited compared to single-family homes and are contingent on the market (resident demographic), ownership and type of suite. For example:

- **Type of suite:** in-suite electrical load reduction opportunities depend on where the loads are. For example, row houses with distributed in-suite loads, vs. apartments, where loads are centralized. This would include laundry (clothes, washers and dryers). In a row house there is typically laundry in every home, whereas in an apartment laundry may be in-suite or in shared centralized laundry rooms on each floor or in one area.

- **Market, occupants and ownership:** The practicality of in-suite load diets can vary depending on the market segment, the occupants and whether or not the building is owner-occupant or rental.

    - Upscale condominiums or higher end rentals are more likely to have in-suite laundry compared to most private rental stock which does not have in-suite laundry.

    - Depending on the market sought by the owner, downsizing the range *(typically on 30 or 40A 208/240V breakers)* is a possibility. Many 55+ specific rentals or social housing residents are single occupants and seldom use more than two elements, and rarely the oven.

    - Owner occupied apartments are often renovated with the addition of in-suite laundry, hard-wired microwaves and a new range. Unless efficient and lower capacity appliances (such as heat pump dryers) are encouraged, or required, these renovations risk using up available panel capacity that could have been used for an in-suite heat pump for heating and cooling.

## 4.2 Tactics for Load Diet

The loads found in the suite panels of a gas heated MURB suite may include:

- Lights and plug circuits
- Kitchen loads:

[1] Suites that are already heated using electric baseboards are not considered here since retrofitting with heat pumps in these cases would result in a load reduction, rather than an increase. Electrically heated domestic hot water tanks are also excluded from consideration, as they are predominantly found in electric baseboard-heated suites.

    - Range (or separate stove and oven)
    - Fridge
    - Dishwasher (if present)
    - Hard-wired microwave (if present)
- In-suite laundry loads:
    - Electric washer and dryer (if present)

The following tactics, where applicable, can be used to free up electrical capacity in the panel.

**Ranges.** Ranges in all gas heated suites typically comprise the largest electrical load. This means that the most significant and cost-efficient load reduction consists of replacing an existing electric range with a smaller 2-burner induction cooktop and a countertop plug-in convection oven (or other supplementary cooking appliances such as air fryers). However, there may be countertop space limitations and this type of change might not be suitable for all suites or building types and occupant lifestyles/preferences.

**Washer and dryer.** Replacing an existing two-piece in-suite washer and dryer with an all-in-one washer and heat pump clothes dryer (or only dryer), can be effective as washers and dryers commonly draw a significant load. However, this would only be possible in cases where an in-suite washer/dryer already exists. Given the considerable cost of replacing two major appliances, this tactic would also be most suitable for cases where the appliances were due for replacement due to end-of-life or other reasons.

**Domestic hot water heaters.** Where applicable, upgrading in-suite electric resistance domestic hot water heaters with heat pump water heaters can be an option. Heat pump water heaters are between two and four times more efficient and are available with lower power. One barrier, however, is that installing heat pump water heaters indoors risks cooling the space. The solution is to duct the unit outdoors, which is not feasible in all layouts. Given the considerable cost of replacing a domestic hot water heater, this tactic would also be most suitable for cases where it was due for replacement, due to end of life or other reasons.

### 4.3 Available lower-power appliances

Table 5 shows some of the existing loads that pose the best opportunity to free up capacity and sometimes space in the panel, the lower-load alternative with which it can be replaced, as well as the cost and load-freeing potential of each. These substitutions can increase panel capacity by as little as few Watts (e.g., replacing an older fridge with a newer one), to a significant number of Watts and approximately 70% of the load by replacing a large conventional range with a two-burner induction stove.

However, as is noted in Table 5, increasing panel capacity with a load diet will not result in a substantial change in the result of a CEC load calculation due to Rule 8-202 1) a) v) and vii). These rule establish a 6kW minimum calculated load for ranges, even when replaced with lower load appliances or no electric range exists in the apartment. As a result, unless flexibility or changes were made in the regulation, the electric range load diet strategy would not be acceptable to validate that sufficient electrical capacity exists for the installation of an in-suite heat pump, even if the capacity does exist.

| Table 5: MURB Suite Existing Loads vs. Lower-Load Alternatives | | | | |
|---|---|---|---|---|
| **Existing Load** | **Lower-Load Alternatives** | **Load & Panel Space Reduction Potential** | **Upgrade Cost Range** | **Recommendation** |
| *Kitchen* | | | | |
| **Electric range** (40A- 240V- 9,600-14,800W) | Two-burner countertop induction stove (15A- 120V- 1,800W) Countertop oven (15A – 120V – 1,800W) | 6,000-11,200W +1 double pole breaker slot | Stovetop $180-$636 Oven $175-$300 | • Lowest cost option to free up capacity and a 40A/2 pole breaker<br>• Need to confirm if residents accept smaller appliances<br>• Need to address CEC requiring 6kW of load minimum for ranges |
| **Electric range** (40A- 240V-,9,600-14,800W) | Lower power electric range (40A- 240 V, 1,800-3,100W) | 7,800-11,700 W | $800 - $1,200 | • Most practical opportunity for kitchen load reduction but won't free up breakers<br>• Need to address CEC requiring 6kW of load minimum for ranges |
| **Classic refrigerators** (6.5A-115V- 747W) | Frigidaire Energy Star 18.3-cu ft top-freezer refrigerator (3A- 120V- 360W) | 387W | $890- $1,199 | • Not accounted separately by CEC<br>• Upgrade to Energy Star models only to reduce energy bill |
| **Dishwasher** (115V, 1,200W) | N/A | N/A | N/A | • Not accounted separately by CEC if <1,500W<br>• Upgrade to Energy Star models only if >1,500W |
| **Hard-wired microwave** (115V, 1,300W) | N/A | N/A | N/A | • Not accounted separately by CEC if <1,500W |

| | | | | |
|---|---|---|---|---|
| | | | | • Upgrade to Energy Star models only if >1,500W |
| *Laundry* | | | | |
| **Residential washing machine and electric resistance clothes dryers** (15A -208/240V, 2,900W washing machine and 30A - 240V dryer, 5,700W) | All-in-one washer and heat pump dryer (15A-120V- 1,200W) | 4,500W<br>+1 double pole breaker slot | $999, $2,494 | • Good opportunity to free up a 30A/2 pole breaker<br>• Need to use spare 15A breaker for new equipment<br>• Higher cost than range option |
| **Electric resistance clothes dryers** (30A and 240V dryer, 5,500W) | Heat pump clothes dryer (15A- 120V- 1,800W) | 3,700W<br>+1 single pole breaker slot | $1,599-$2,449 | • Opportunity to free up capacity and a single pole breaker slot<br>• Similar cost to going with all-in-one unit |
| *Lighting* | | | | |
| **Florescent** (0.25A- 120V- 30W) | LED lightbulbs (0.075A- 120V- 9W) | Total 630W per suite *(0.175A, 21W per bulb, approx. 30 bulbs per suite)* | Total: $150-$300 *($5-$10 per bulb, approx. 30 bulbs per suite)* | • Small reduction<br>• Not accounted separately by CEC if <1,500W |
| **Incandescent** (0.5A- 120V, 60W) | LED lightbulbs (0.075A- 120V- 9W) | Total 1,530W per suite *(0.425A, 51W per bulb, approx. 30 bulbs per suite)* | Total: $150-$300 *($5-$10 per bulb, approx. 30 bulbs per suite* | • Small reduction<br>• Not accounted separately by CEC if <1,500W |

### 4.4 Future technologies

Battery-integrated ranges are a new product class which could reduce in-suite cooking loads considerably. Ranges use a high amount of power, but for a short time. A battery could supply this high power, while the connected load could be reduced to a small battery charger requiring only a 120V 15A circuit, versus the current 208/240V 40A circuits that typical ovens use. Two of the products currently under development are Impulse and Charlie by Channing Street Copper Company.

It is worth noting that there may be regulatory hurdles for these products, as there has been a rapid increase in the incidence of fires caused by charging lithium-ion batteries for electric micro-mobility and other devices. For example, City of Vancouver reported that 34 fires were caused by rechargeable batteries from January 1, 2021, to August 22, 2022 (City of Vancouver. N.d).


**Figure 8. Example of future battery-integrated range**
Source: Channing Street Copper Company

# Strategy #3: In-suite Electrical Load Management

Load management is another strategy that should be explored to avoid electrical panel upgrades. Load management technologies that can work with the EVSE are commonly used in MURBs. However, there are no documented examples of these technologies being used in apartments to manage loads like heat pumps with kitchen or laundry appliances such as ranges and dryers. There were also no documented examples of EVSE load management technologies being used within-suite apartment panels.

## 5.1 Energy Management System Archetypes

Energy management systems (EMS) are devices that control loads that are connected to a residential electrical panel. EMS can manage electrical loads that otherwise might overload a branch circuit, panel, or residential service. EMS were classified into archetypes, as follows:

- **Branch circuit sharing** consists of sharing power between devices on the same branch circuit.
  - **Dynamic branch circuit sharing** involves allocating devices a portion of the available power based on software and/or pre-set inputs and/or communications between the device(s) and EMS.
  - **Branch circuit switching** deactivates one device on a branch circuit to stay within the power constraints of the circuit (determined by the circuit breaker protecting the branch circuit).

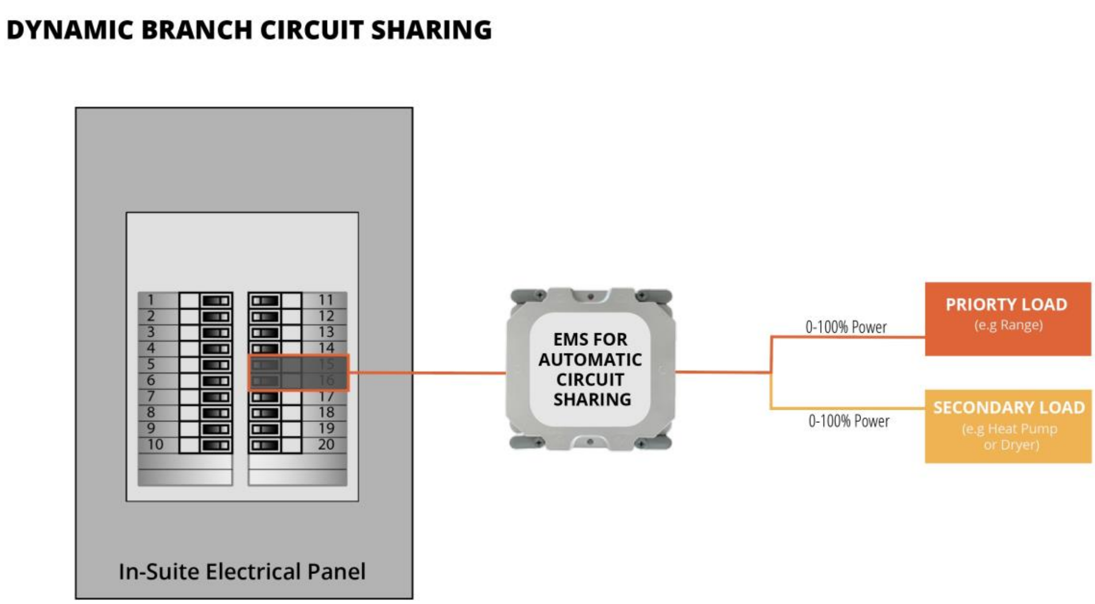


**Figure 9: Example of Dynamic Branch Circuit Sharing.**
Created by: FRESCo.

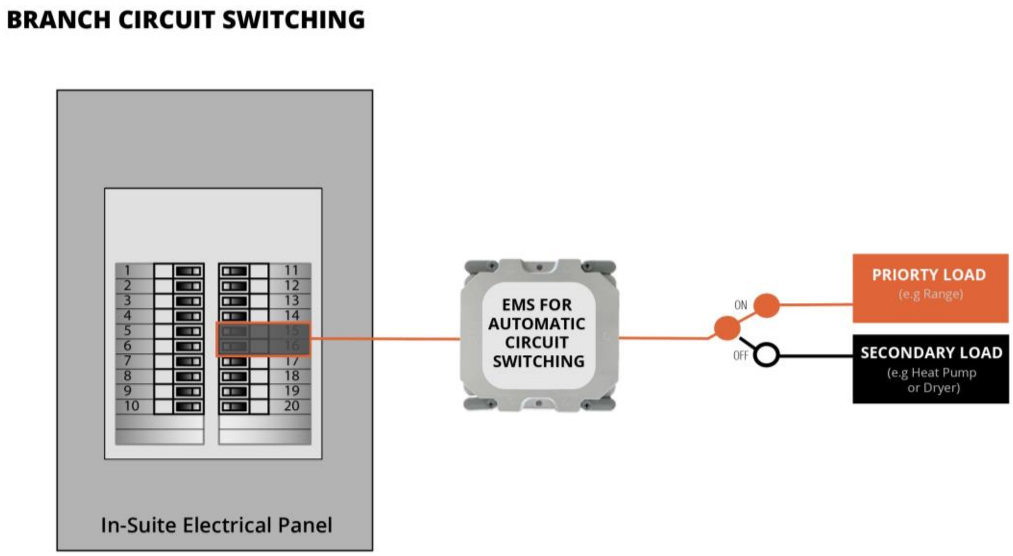


**Figure 10: Example of Branch Circuit Switching.**
Created by: FRESCo.

- **Feeder monitoring with controls** manages device power usage based on the available capacity of the feeder (i.e., the in-suite panel's feeder in MURBs). The impacted devices may be based on a hierarchy determined by software, user-input data, field wiring, or factory settings.
  - **Feeder monitoring with dynamic controls** involves reducing the consumption of one or more end uses to reduce the load on the feeder when at or near capacity.
  - **Feeder monitoring with switching controls** involves switching one or more end uses ON or OFF to reduce the load on the feeder when at or near capacity.

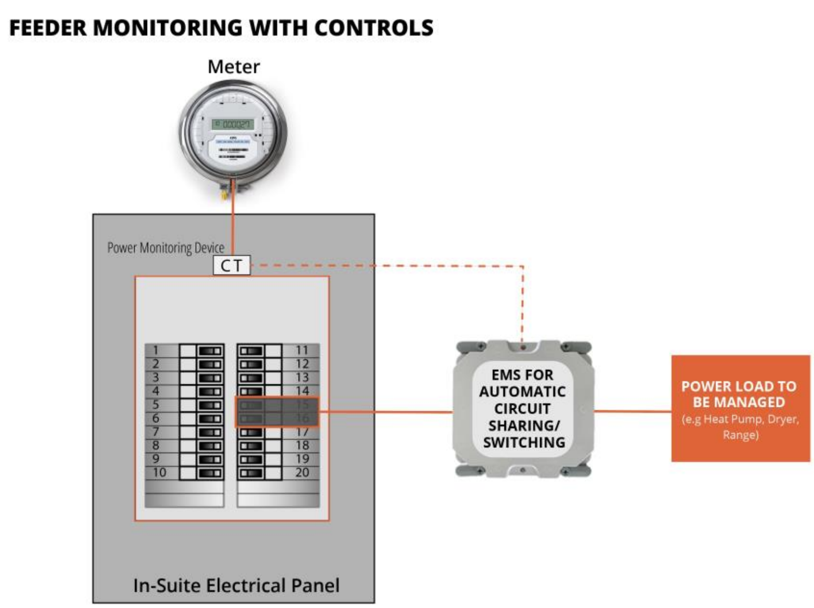


**Figure 11: Example of Feeder Monitoring with Controls.**
Created by: FRESCo.

- **Feeder monitoring panel with controls,** also known as smart panels, involves controlling, via an EMS in the panel, one or more devices on separate branch circuits so as not to exceed the allowable capacity of the panel.

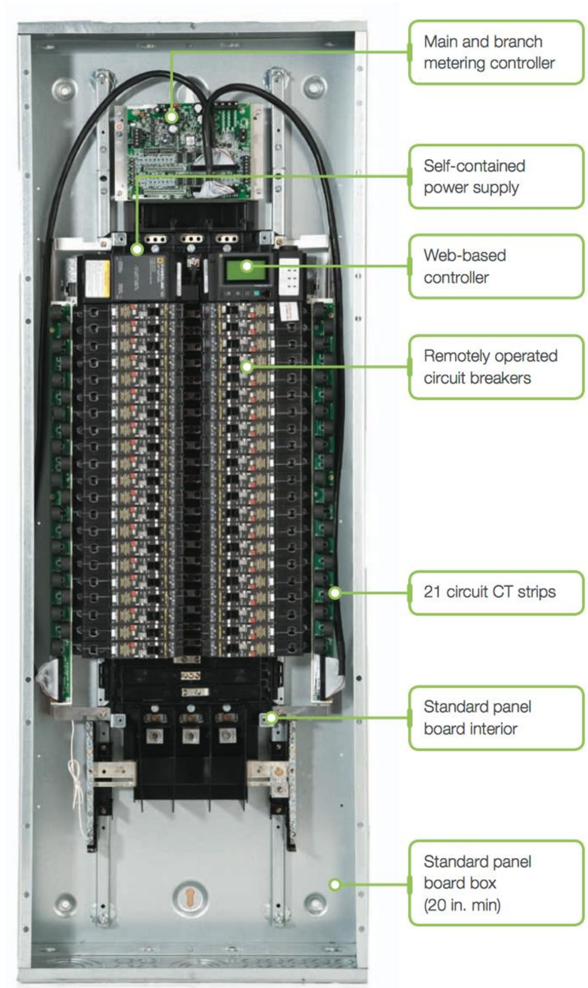


**Figure 12: Example of Smart Panel with Built-in EMS**
(Created by: FRESCo; panel photo: Fisher Lighting and Controls)

### Archetypes suitable for MURB in-suite use for non-EV loads

Analysis of technical feasibility and regulatory constraints was done to identify the applicability of these EMS archetypes for in-suite use. The table below shows how some of these archetypes are not technically suitable to use for in-suite panels, and others that are, are not allowed by regulation.

| Table 6: Archetypes Suitable for MURBs In-suite Use for Non-EV loads | | | |
|---|---|---|---|
| **Archetype** | **Technical Feasibility** | **Compatibility with Heat Pumps or Appliances** | **Calculated Load Reduction Allowed by Regulations** |
| *Branch Circuit Sharing* | | | |
| **Dynamic branch circuit sharing** | Yes, but devices are not currently available for non-EV loads. | Uncertain whether heat pump equipment will function with partial power. | No – CEC Section 8 does not have any rules regarding load calculation reductions for dynamic sharing devices, other than EVEMS. |
| **Branch circuit switching** | Yes | Uncertainty whether heat pump equipment will be affected by frequent switching. | Yes – CEC rule 8-106 2) and rule 8-106 4). |
| *Feeder Monitoring with Controls* | | | |
| **Feeder monitoring with dynamic controls** | Yes, but devices are not currently available for non-EV loads | Uncertain whether heat pump equipment will function with partial power. | No – CEC Section 8 does not have any rules regarding load calculation reductions for dynamic sharing devices, other than EVEMS. |
| **Feeder monitoring with switching controls** | Yes, but devices are not currently available for non-EV loads. For MURBs, monitoring of single suite panel is not sufficient to prevent a building-level overload. | Uncertainty whether heat pump equipment will be affected by frequent switching. | No – CEC Section 8 does not have any rules regarding load calculation reductions for circuit sharing devices, other than EVEMS. |
| **Feeder monitoring panels with controls (Smart panel)** | Yes, but size and cost may be a barrier for retrofits projects. For MURBs, monitoring of single suite panel is not sufficient to prevent a building-level overload. | Uncertain whether heat pump equipment will function with partial power, and uncertainty whether equipment will be affected by frequent switching. | No – CEC Section 8 does not have any rules regarding load calculation reductions for circuit or dynamic sharing devices, other than EVEMS. |

Branch circuit switching and feeder monitoring with switching controls are technically feasible but given that this technology shuts off the secondary load completely when the primary load is on, this could inconvenience occupants. Also, in the current market, the research team has not been able to identify any heat pumps that have already been tested to work with EMS technology. Without testing the impacts of switching current heat pump models on and off on a semi-regular basis is unclear.

Branch circuit switching is the only EMS technology for loads other than EV chargers, which is both technically feasible and currently allowed by the CEC. Some of the products available in the market for this type of technology are described in Section 5.2, and their potential is further explored in Section 5.5 and Section 6.

Dynamic branch circuit sharing and feeder monitoring with controls are not currently allowed by regulation. Section 8 of the CEC does not provide pathways for these EMS archetypes to be used to reduce non-EV calculated loads.

Feeder monitoring panels with controls, also known as smart panels, offer the benefit of lower energy costs through more efficient energy usage. However, even if they feature load-sharing technologies, they cannot be used to reduce calculated non-EV loads under the current regulations beyond single-branch circuit switching. In addition, existing smart panels are expensive, and potentially cost more than the in-suite panel upgrade itself (refer to Appendix A for cost information). Smart panels are also too large to be suitable for in-suite apartment electrification retrofits and they require upgrading to a 100-200 Amp service, defeating the whole purpose of using them to avoid in-suite panel upgrades.

## 5.2 Available technologies for in-suite load management

Appendix A shows a list of available load management products. However, most of these products cannot be employed for managing non-EV loads (such as heat pumps) as reviewed in Section 5.1.

Branch circuit switching products are the only load management products potentially allowed to manage non-EV loads under current regulations. These devices work by automatically switching between a primary load and secondary load, which is only powered when the primary load is not in use. There are two types of devices: ones that connect at the wall outlet and others that connect at the circuit within the panel.

There are a few branch circuit switching products suitable for in-suite electrification retrofits available in Canada, as follows. Their suitability was assessed by considering factors like their physical size and cost in relation to the expense associated with an in-suite panel upgrade.

- **NeoCharge Smart Splitter.** Connect to an existing 240V wall outlet. It is suitable for in-suite applications given its small size and flat configuration that can fit behind existing appliances with the receptacles conveniently placed on the sides. It is one of the lowest cost options at $580 - $650 CAD.

- **Appliance Buddy Plus Auto.** Connects to an existing wall outlet and features different models designed for common outlet ratings. It monitors the amperage of the connected loads and allows the secondary load to run only when there is enough amperage available. It is also small in size and has a small screen that displays information such as kWh. The cost is approximately $500 - 600 CAD.

- **Dandy LOADMISER Energy Divider Controller.** Installed at the panel and features an adjustable range of 5 to 50 Amp for the circuit upstream rating. It is intended as a load saving device and uses a CT and an optional time clock to operate a contactor to cut off power to the non-essential load. It is suitable for existing installations and connects in series of the primary load. The cost ranges between $1,499 - $1,599 CAD.

- **SimpleSwitch 240.** Installed on an existing 240V, 15-50A circuit. This device allows the primary load to draw up to 150 W of power while the secondary load is on. It can fit in an existing panel given its small size. The cost is currently at $947 CAD.


- **DIVVEE-40.** Connects to a 40 A circuit and the box can be connected anywhere in the home. It intercepts the circuit and a common application is load switching between range and EV. Manufactured in Canada. The cost is approximately $1,000 - $1,200 CAD.


## 5.3 OpenADR /EcoPort(CTA-2045) Potential for Appliance Load Sharing

***No current application of these standards for load sharing between appliances was identified.*** *This section is included for reference since these standards may be considered for utility demand control in the future, and possibly for load sharing within buildings and suites.*[2]

OpenADR is a software standard which allows appliances to communicate bidirectionally to utilities and to other appliances. EcoPort is the associated hardware connector standard (similar to USB) (Northwest Energy Efficiency Alliance (NEEA), n.d.) .

Theoretically, these standards could be applied to load share at the suite level or building level. However, since they rely on communication (by cable, wifi, cellular, or FM radio) and on programming installed in the appliances, they may be considered less reliable (by Authorities Having Jurisdiction (AHJ's), Engineers and building owners) for preventing breaker trips than the dedicated EMS devices discussed in Sections 5.1 and 5.2.

The primary use of OpenADR is to allow electric utilities to reduce peak demand by turning off home appliances, primarily hot water heaters, but it can also be used with Air conditioning/heat pumps, ovens and

[2] https://neea.org/img/documents/How-Will-All-These-Smart-Appliances-Talk-to-the-Smart-Grid-Product-Council.pdf

dryers. Significant legislation is established or underway in the US to mandate that all new water heaters (including small tank type heat pumps offered by AO Smith and Rheem, and larger units such as SANCO2) be equipped with these devices. Since the same products are sold in Canada, it will be available here as well.

Some smart thermostats, including Ecobee and Johnson Controls, are equipped with OpenADR and referred to as “Programmable Communicating Thermostats (PCT’s)”. These could conceivably be used to allow heat pumps to load share with other appliances in suites. Only one mini-split manufacturer (Mitsubishi) was identified as participating in the development of these standards, but no examples of use were found (see Figure 13).

**Figure 13: Ecoport/OpenADR communication adapter for Mitsubishi heat pump**
Source: Northwest Energy Efficiency Alliance

## 5.4 Loads/equipment compatible with in-suite EMS technologies

**Range and Heat Pump Switching**

*(See section 5.5 for an example of this application and further rationale, and section 6.1 Table 5 for code implications.)*

Range and heat pump switching is the combination of most interest, and appears to be technically feasible, although it would require regulatory special permission.

Retrofitting a heat pump into a suite is the most desired additional load. The range is by far the highest power dedicated load which is present in almost all apartment suites. Ranges can use very high power but are only used for very brief periods of time on any given day. While operating they produce waste heat which can compensate for a heat pump not operating.  Most apartments suites, unlike detached homes, are buffered by shared walls, floors, and ceilings with their neighbours, and thus do not rapidly decline in temperature if the heating source is off for short periods of time.

Range and heat pump sharing was suggested and discussed by several individuals FRESCo has spoken with (electricians, architects, owners and an electrical planner). No specific examples nor equipment specially intended for this application were identified. One manufacturer (Neocharge) indicated through email that they have several dozen users who use the product for switching "between two appliances" (other than car charging), including some who shared a heat pump with a range, but did not identify specific instances.

The control scheme (or "sequence of control" in HVAC terminology) for switching between the range and heat pump needs to be considered. Cooking is a task which cannot be interrupted by an automatic device. Ranges operate with thermostats and the varying load cannot be predicted or limited. Therefore, full circuit switching, under intentional control of the resident is recommended, rather than partial power sharing.

***All references and discussions concluded that the heat pump should be the primary device, and the resident should be instructed to turn off the heat pump with the remote to be able to use the range.***

**Ranges** are typically "dumb" devices, that will not be impacted by being switched off. The exception is ranges with clocks that will be turned off and not automatically reset to the correct time. This is a very minor inconvenience since few residents ever use these clocks, and some models have battery backup. This problem can also be avoided if the EMS allows minimal power to be allocated to the range even when turned off. Otherwise, placing a blank over the clock face and/or removing the power wire to the clock are simple solutions that disable the clock to prevent confusion about the clock resetting.

**Heat Pumps** applicable to in-suite use often have options for connections to Wi-Fi, proprietary smart thermostats, and other communication options (including OpenADR in the future). Conceivably this could allow load sharing with other appliances. However, no references to the use of communication for load sharing have been found, and if it is not reliable it could result in tripped breakers.

**Domestic Hot Water (DHW) In-suite Heaters**

(*Note this does not apply to gas heated apartments in BC, since DHW is central*)

In-suite DHW tank heaters are found in electrically heated suites, and in gas heated townhomes. In electrically heated suites, sharing is likely not required since these buildings usually already have excess electrical capacity. Gas heated townhomes undergoing electrification retrofits may consider load sharing between an electric DHW heater with other electric loads.

DHW heaters are an attractive load for utility demand control since hot water is stored in the tank and will still be available to the resident if the heater is off for a period of time. There is significant promotion and legislation of this application, and it is likely to become prevalent. Many electric DHW tank heater products with OpenADR communication have recently become available. This could conceivably be used to load share with other appliances, but the caveat to reliability applies. Combining utility control of water heaters with in-suite load sharing may prove difficult. Another consideration is that heat pump water heaters are likely to be used to minimize the connected load and to reduce energy consumption. Since these are typically sized to run for longer periods of time per day (e.g., 16 out of 24 hours), turning them off may prevent the heat pump from keeping up with demand for hot water.

**Laundry Dryers** are another low priority load similar to DHW. Much of the discussion for DHW heaters applies, with the exception that dryers run for far less hours per day and there is often more flexibility as to when a dryer is used. However, not all buildings have in-suite laundry, especially the older ones, and this would only apply to a limited number of MURBs.

## 5.5 Real World Example: Exploring Load Management Between Range and Heat pump

FRESCo staff are currently working on a 1958 apartment building in the LandlordBC and City of Vancouver Rental Apartment Retrofit Accelerator (RARA) pilot program which will replace the gas-fired hydronic heating with mini-split heat pumps in each suite. The suite feeders are 60A, 240V. The owner was interested in exploring all options, including powering the mini-splits from the main building service, as well as connecting to the suite meters. The suites have typically sized ranges, on 240V with a 30A breaker, and three 15A breakers for refrigerators, lights and plugs.

An electrician was engaged as part of a design-build exercise. The electrician, who had experience with many mini-split heat pump installations in apartment buildings, suggested, without prompting by FRESCo, that switching between the range and the heat pump be considered. They carried the conversation to the City of Vancouver electrical inspector and electrical planner and reported that they were receptive to the possibility, subject to the caveat of how it would work to switch.

The electrician proposed the schema of:

- Heat Pump as primary load
- Stove operation would be disabled for the normal mode while the heat pump would be free to operate under the control of the thermostat.
- To use the stove, the occupant would first need to turn the heat pump off (typically done with the remote control's "off" button) and wait for a short period for the heat pump to shut down.
- The load control device would allow the range to turn on after it senses the heat pump load drop to a quiescent level (typically less than an Amp).
- After cooking is completed, the occupant would need to turn the heat pump back on again (with the remote).
- They proposed a control box could be mounted in the wall cavity above the panel and be hard-wired from there to the heat pump and the range receptacle.
- This same concept is applied in the illustration below with an example plug-in smart splitter box (not hard-wired).

An example device which could technically work for circuit sharing between a range and a heat pump is the Neocharge Smart Splitter. This product is relatively low cost ($580-$650 CAD) and can fit behind the range without causing it to protrude. The heat pump should be the primary load and prevent the stove from operating until the heat pump current drops to a low pre-set level after being turned off by the resident. This device does not require re-wiring.

This proposed solution only addresses the problem of in-suite electrical capacity, but it does not solve the problem of electrical capacity at the main building service. If the main building electrical service was not upgraded, and all heat pumps were turned on at once, the main building electrical service could be overloaded. Although this method is practical, it requires special permission from the AHJ, since it is not within the code. See Table 5 on Section 6 for more details.

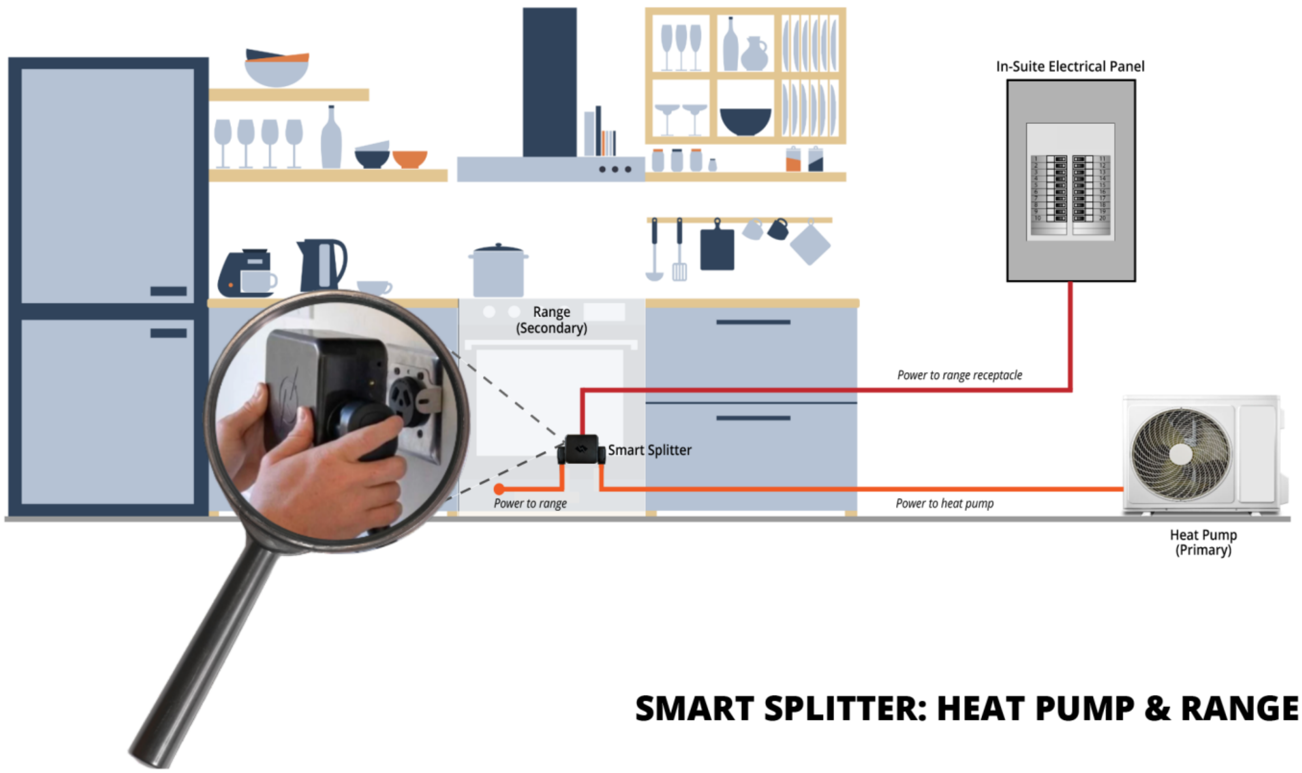


**Figure 14. Example of Smart Splitter for Heat Pump and Range.**
Created by: FRESCo

The table in Figure 15 illustrates the existing and proposed loads for electrification of a gas heated apartment by sharing the range circuit with a heat pump.

| | |
|---|---|
| **Suite type** | 1 Bedroom |
| **Floor area** | (472 ft2) |
| **Heating** | Central gas/ Hot water baseboards |
| **Hot Water** | Central Gas |
| **Laundry** | Central Coin-op (not in suites) |

| | **Existing: 60A service, typical simple gas heated apartment** | | | | | | **Proposed: Range shared with heat pump using NeoCharge (no panel upgrade)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Load** | **Details** | **Device Volts** | **Device MCA** | **Circuit Size (Amps)** | **Calculated Power (W)** | **Connection** | **Details** | **Device Volts** | **Device MCA** | **Circuit Size (Amps)** | **Calculated Power (W)** | **Connection** |
| **Heat Pump** | None | | | | | | Mini-split 2 head, nominal 18MBH | 240 | 18 | 30 | 4,320 | ***Plug-in/ Circuit Shared*** |
| **Range** | Typical electric 4 burner stove with full size oven | 240 | 38 | 40 | 9,000 | Dedicated circuit | Same | 240 | 40 | 40 | 9,000 | ***Plug-in/ Circuit Shared*** |
| **Refrigerator** | Typical 10+ year old fridge | 120 | 3 | 15 | 400 | Dedicated circuit | Same | 120 | 3 | 15 | 400 | |
| **Standard Loads** | Lighting and plugs | 120 | 12 | 15 | 1,453 | Plug | Same | 120 | 12 | 15 | 1,453 | |
| | Microwave | 120 | 12 | 15 | 1,440 | Plug | Same | 120 | 12 | 15 | 1,440 | |
| **Laundry** | Central coin-op laundry (no in-suite laundry) | | | | | | | | | | | |
| **Domestic Hot Water** | Central gas (no in-suite domestic hot water heating) | | | | | | | | | | | |

**Figure 15: Example Panel Loads of Circuit Sharing Between Range and Heat Pump.**
Created by: FRESCo.

# 06 Key Findings and Solution Pathways

## 6.1 Solution pathways

Given the limitations and technical challenges discussed in this report, this section explores the potential feasibility of using the 3 strategies defined above (minimizing loads, load diet and load management) to recommend possible solutions that could be explored further to enable in-suite heat pump retrofits while avoiding electrical panel upgrades.

The only in-suite heat pump electrification solution which is currently technically feasible in BC without the need for building/electrical code or other regulatory amendments is adding a heat pump to a new or spare breaker in the panel. This would only be feasible in newer apartments and townhomes with higher electrical capacity, and potentially in small suites (bachelor or small one-bedroom apartments) in older buildings. Other solutions presented In Table 5 could be feasible in the future if some code and technical considerations are resolved.

***It is important to note that AES Engineering is working with the City of Vancouver on an Energy Management Bulletin that seeks to address some of the Code challenges discussed here. The bulletin will include some special permissions being considered by the City of Vancouver's building inspectors.***

Table 5 shows a summary of the different solution pathway scenarios explored and their considerations, impact on residents and estimated costs.

**Table 5. Theoretical Solution Pathways to Add In-Suite Heat Pump Without Suite Panel Upgrade**

| Scenario | Solution | Feasibility | Load Calculations & Code Considerations | Impact to Residents | Estimated Cost |
|---|---|---|---|---|---|
| SUITES WITH EXISTING RANGE (NO DRYER) | **Add breakers for heat pump** | - Bachelor and 1BR apartments<br><br>- Needs a heat pump with electrical rating of <3.5kW that can meet heating/cooling loads<br><br>- Needs available panel space, 1 pole for 1 head, and 2 poles for 2 heads.<br><br>- Needs sufficient building service capacity. | - Bachelor and 1BR apartments could potentially accommodate a heat pump of <3.5kW in a 60A panel without an upgrade. Heat pumps of this range are available with 1 & 2 heads. 2BR and larger with a 60A panel likely wouldn't have enough spare capacity.<br><br>- Newer apartments and townhomes with sufficient electrical capacity (e.g., 100A panel or higher) could potentially accommodate a multi-head heat pump with minimal MCA.<br><br>-Allowed by CEC.<br><br>- Building service capacity still needs to be calculated, which varies depending on the number and size of suites. It adds the total heating load at 100% demand separately from the suites. | None | Adding a new circuit: $500-$2,000. |

| | | | | | |
|---|---|---|---|---|---|
| | **Replace range with plug-in stove top & oven** | - Needs heat pump with elec. rating of <6kW and fits in the existing 30-40A breaker and meets heating/cooling loads.<br><br>- A viable option as there is heat pumps available for that capacity.<br><br>- Needs sufficient building service capacity.<br><br>- **Must discuss with a building inspector to seek special permission.** | - Heat pump to replace the load of the range (min. 6kW per CEC)<br><br>- CEC calculated load still requires 6kW at 100% demand to be accounted if no range. **Must discuss with a building inspector to seek special permission.**<br><br>- Building service capacity still needs to be calculated, which varies depending on the number and size of suites. It adds the total heating load at 100% demand separately from the suites. | Smaller appliances and the need to reconfigure kitchen counter space. | New appliances<br><br>$355-$936<br><br>Adding a new circuit $500-$2,000 |
| | **Share circuit between the range and the heat pump** | - Needs heat pump with elec. rating of <6kW and fits in the existing 30-40A breaker and meets heating/cooling loads.<br><br>- A viable option as there are heat pumps available well under that capacity.<br><br>- Needs sufficient building service capacity<br><br>- **Must discuss with a building inspector to seek special permission.** | - **Key Opportunity**<br><br>-Heat pump to share the load of the range (min. 6kW per CEC), they are both counted at 100% demand factor.<br><br>- Building service capacity still needs to be calculated, which varies depending on the number and size of suites. It adds the total heating load at 100% demand separately from the suites.<br><br>**A. Load switching is allowed ('interlocking'):**<br>Rule 8-106 2: 'Where two or more loads are installed so that only one can be used at any one time, the one providing the greatest demand shall be used in determining the calculated demand'.<br><br>However, a bulletin from City of Vancouver (for 2-4 dwellings) mentions that you cannot interlock essential loads. **Must discuss with a building inspector to seek special permission.**<br><br>*Essential loads: Electric hot water heater/tank, electric space-heating except as permitted by 8-106 3). Any loads as may be prescribed by the City Electrician.*<br>*Non-Essential loads: Electric ranges, dryer, sauna, water heater for steamer, swimming pool, hot tub, or spa, EVSE, AC.*<br><br>**B. Load Sharing is not allowed:**<br>There are no provisions in the CEC for load sharing between heat pump and a range. **Must** | Heating and cooling must be turned off while cooking. | EMS product $400-$1,600 |

| | | | | | |
|---|---|---|---|---|---|
| | | | **discuss with a building inspector to seek special permission.** | | |
| **SUITES WITH EXISTING RANGE + DRYER** | **Add breakers for heat pump** | - Bachelor apartments<br><br>- Needs heat pump with electrical rating of <3.5kW that can meet heating/cooling loads<br><br>- Needs available panel space, min. 1 pole for 1 head.<br><br>- Needs sufficient building service capacity. | - Bachelor apartments can accommodate heat pump of <3.5kW in a 60A panel without an upgrade. There are heat pumps available in this range.<br><br>- 1BR and larger wouldn't have enough spare capacity.<br><br>-Allowed by CEC<br><br>- Building service capacity still needs to be calculated, which varies depending on the number and size of suites. It adds the total heating load at 100% demand separately from the suites. | None | Adding a new circuit $500-$2,000 |
| | **Replace washer & dryer with all-in-one heat pump combo** | Does not increase calculated electrical capacity enough to enable heat pump installation. Can be used in combination with other strategies. | - Load calculations don't show a significant difference from the option above as the dryer has a 25% demand factor and heat pumps have 100% demand factor so removing the dryer doesn't reduce sufficient load.<br><br>- Allowed by CEC | Smaller laundry capacity | New appliance $2,000- $2,500<br><br>Adding a new circuit $500-$2,000 |
| | **Share circuit between dryer and range** | Does not increase calculated electrical capacity enough to enable heat pump installation. | - The load calculations consider the range at min. 6kW at 100% demand while the dryer is counted at 25% (e.g., 5,760W @25% = 1,440W). Based on this the higher load of the range would need to be the one used for the calculations not freeing enough capacity.<br><br>- Building service capacity still needs to be calculated, which varies depending on the number and size of suites. It adds the total heating load at 100% demand separately from the suites.<br><br>**A. Load switching is allowed ('interlocking'):**<br>Rule 8-106 2: 'Where two or more loads are installed so that only one can be used at any one time, the one providing the greatest demand shall be used in determining the calculated demand'.<br><br>However, a bulletin from City of Vancouver (for 2-4 dwellings) mentions that you cannot interlock essential loads. | The dryer must be turned off while cooking. | EMS product $400-$1,600 |

| | | | | | |
|---|---|---|---|---|---|
| | | | **Must discuss with a building inspector to seek special permission.**<br><br>*<u>Essential loads:</u> Electric hot water heater/tank, electric space-heating except as permitted by 8-106 3). Any loads as may be prescribed by the City Electrician.*<br>*<u>Non-Essential loads</u>: Electric ranges, dryer, sauna, water heater for steamer, swimming pool, hot tub, or spa, EVSE, AC.*<br><br>**<u>B. Load Sharing is not allowed:</u>**<br>There are no provisions in the CEC for load sharing between a dryer and a range. **Must discuss with a building inspector to seek special permission.** | | |
| | **Share circuit between dryer and heat pump** | Does not increase calculated electrical capacity enough to enable heat pump installation. | - The load calculations consider the heat pump at 100% demand while the dryer is counted at 25% (e.g., 5,760W @25% = 1,440W). Based on this, the higher load of the heat pump would need to be the one used for the calculations not freeing enough capacity.<br><br>- Building service capacity still needs to be calculated, which varies depending on the number and size of suites. It adds the total heating load at 100% demand separately from the suites.<br><br>**<u>A. Load switching is allowed ('interlocking'):</u>**<br>Rule 8-106 2: 'Where two or more loads are installed so that only one can be used at any one time, the one providing the greatest demand shall be used in determining the calculated demand'.<br><br>**<u>B. Load sharing is not allowed:</u>**<br>There are no provisions in the CEC for load sharing between a dryer and a heat pump. **Must discuss with a building inspector to seek special permission.** | Heating and cooling must be turned off while using the dryer. | EMS product $400-$1,600 |

## 6.2 Summary of key findings

**Potential for in-suite heat pump installation without panel upgrades**

- Without regulatory changes, and without electrical panel upgrades, the installation of in-suite heat pumps on an existing in-suite panel are most viable in bachelor suites and small one-bedroom apartments (which make up a large percentage of BC apartment suites), and in newer apartments and townhomes with sufficient electrical capacity.

- In many low-rise and mid-rise MURBs, when heat pumps cannot be cost effectively connected to the in-suite panel, there are often options to connect to the main building electrical service. These options avoid individual in-suite panel upgrades but will likely trigger an upgrade to the main building electrical service, which could be comparably less costly. However, this option typically results in the heating and cooling costs being charged to the building owner, unless submetering is installed.

- When installing in-suite heat pumps in a number of suites within an apartment, even if a suite panel upgrade can be avoided, upgrades to the main building electrical service will likely be required. This is because the Canadian Electrical Code (CEC) does not count all existing suites at 100% of their panel capacity (they decrease from 100% to 10% as the number of suites increases—Rule 8-202). This means that the building's electrical system isn't originally designed to accommodate every suite panel operating at or near 100% of its available capacity. In addition, new loads added to the suite (i.e., in-suite heat pumps) are counted at 100% of their load towards both the in-suite panel and the main building service. The main building service will reach its calculated capacity after a number of in-suite heat pumps have been added.

**Minimizing the electrical demand of additional loads**

- The feasibility of installing in-suite heat pumps without a suite electrical panel upgrades is improved when in-suite heat pumps are properly sized, and the lowest Minimum Circuit Ampacity (MCA) equipment is selected.

- While there are currently limited options available for low-power in-suite heat pumps, new products will be introduced into the market in the near future.

**Reducing electrical loads within the suite**

- Some electrical load reduction opportunities exist that can free up electrical capacity in the existing panel to support the installation of heat pumps without triggering a suite panel upgrade. These opportunities range from freeing up a few percent (e.g., replacing an older fridge with a newer high efficiency model), up to approximately 70 percent of the load (e.g., replacing a large conventional range with a two-burner induction stove and a countertop oven or other appliances). Load reduction opportunities, like removing the range, may only be appropriate for some market segments and could require a shift in expectations.

- Future technologies such as battery integrated ranges show great promise for reducing peak loads at the building level as well as freeing up capacity in the suite services which could be used for in-suite heat pumps. A battery range is in many ways a better solution than load sharing or removing the range altogether, but there is a significant concern of fire from large batteries that would have to be addressed.

**Implementing electrical load management strategies**

- Branch circuit switching products are the only load management products potentially allowed to manage non-EV loads under current regulations. These devices work by automatically switching between a primary load and secondary load, which is only powered when the primary load is not in use.

- The most technically viable load to manage within an apartment suite is the range, which is not currently approved by existing regulation. Load management between a dryer and a heat pump, or between a dryer and a range, would likely not increase the calculated electrical capacity enough to enable in-suite heat pump installation. The City of Vancouver is currently exploring approving (with special permission) load management between an apartment range and in-suite heat pump on a 1958 apartment building electrification retrofit project (see section 5.5).

- No existing examples of load management products were identified to demonstrate the successful load management between in-suite loads and heat pumps. There are dozens of load management products available in BC (see Appendix A). However, most are not allowed under current regulations to manage non-EV loads in buildings. Others are physically large (difficult to fit in small suites), very expensive (which makes them prohibitive for apartment suite retrofits), and have far more circuits, capacity and functionality than could be used in apartment suites.

- A small number of branch circuit switching products currently exist that are physically small and affordable enough to be applicable to in-suite load sharing, but they are all primarily designed for detached homes to add EV charging. Regardless of their primary application, some of them could also serve to load switch between heat pumps and ranges. More testing, research and regulatory approval would be required before these products can be utilized as part of in-suite electrification retrofits.

**Connecting EV Chargers to In-Suite Panel**

- The feasibility of installing EV charging on row houses or individual apartment suite meters and panels depends on the type of building (townhome/apartment), whether or not the suite is already electrically heated, the layout of the electrical infrastructure and the physical proximity of the suite's meter and panel to the resident's parking stall, among other factors. In most cases, installing EV charging on apartment suite meters would be more challenging than connecting to common area panels and would be using up available capacity that would be needed for installing in-suite heat pumps.

- In practice, EV chargers are typically connected to the building's common electrical panel, and circuit sharing between EV chargers is common. Leading installers of electric vehicle supply equipment (EVSE) typically consider installation only on the building's central meter, both in strata and rental buildings.

**Key regulatory barriers to in-suite electrification without panel upgrades**

- The Canadian Electrical Code (CEC) (Rule 8-106 8) allows for the use of measured maximum demand load for the purpose of assessing the available electrical capacity of new loads. This approach would be more accurate than the calculated load approach and would typically indicate that there is more available capacity than the calculated load, potentially allowing for in-suite heat pump installations that the calculated load would not. However, in BC, the utilities do not measure demand for suite meters nor share the measured electrical consumption from each suite meter due to privacy concerns. Lack of access to the measured maximum demand load has been identified as a barrier to in-suite electrification without panel upgrades.

- The CEC method to determine the calculated load for a suite panel calculates the load required for an electric range by using 6 kW for ranges up to 12 kW, plus 40% of any amount over 12kW [Rule 8-202 1) a) v)]. Even when no electric range exists in an apartment, or if the electric range was to be replaced with lower load appliances or load managed with the heat pump, the 6 kW still need to be added to the calculated load [Rule 8-202 1) a) vii)]. As a result, unless flexibility or changes were made in the regulation – the calculated load approach cannot be used to validate that sufficient electrical capacity exists for the installation of an in-suite heat pump, even if the capacity does exist.

**Other barriers to implementation**

- **Contractors' limited familiarity** with EMS products, particularly for controlling non-EV loads. Dunsky (2022) indicated that certain EMS devices, such as AC Dandy Load Miser for branch circuit switching and DCC-9 for feeder monitoring, are recognized as tools for controlling EV loads. However, electricians, engineers and vendors do not commonly perceive EMS as an option for managing equipment loads other than EVSE (Electric Vehicle Supply Equipment). In ad-hoc conversations FRESCo has had with electricians, we have been made aware that these devices are also commonly used for hot-tubs in detached homes. At least one electrician independently suggested installing a MURB in-suite heat pump on the same circuit as a range and indicated they have suggested this in the past for air conditioner installations.

- **Lack of incentives** to promote EMS products. Electrical contractors are sometimes incentivized to recommend service upgrades because these upgrades can be more profitable for them. The profitability of electrical service upgrades can be a barrier to considering alternative solutions like EMS.

- **Lack of regulations** or requirements to consider alternatives like EMS before upgrading services from utility providers.

- **Discretion in inspection**. Some electrical inspectors may have varying levels of discretion when it comes to load calculations and service upgrade requirements. This could lead to unexpected cancellation of the proposed MURB in-suite EMS project.

**Limited availability** of equipment with lower electrical ratings. In most cases it takes a proactive effort to find these options and it may be a special-order product, which adds cost and time to the purchase.

**Future Technologies**

Many promising products that will help avoid panel upgrades are expected to be developed and/or enter the Canadian market. Some need regulatory changes while others would only need testing and certification.

- **Battery integrated ranges** show great promise for reducing peak loads at the building level as well as freeing up capacity in the suite services which could be used for in-suite heat pumps. A battery range is in many ways a better solution than load sharing. Removing the existing 6kW allowance for ranges from the code may be a substantial hurdle however. Since the original conception of the CEC range use has declined, but plug-in loads such as microwaves and toaster ovens has increased. There is significant concern of fire from large batteries, from incidence of fires in home charging of electric mobility devices and from "battery walls" for detached homes with photovoltaics.

- **Smaller capacity heat pumps** are expected to increase in availability in BC, which will be easier to fit into limited suite panels. This includes the "apartment sized multi-split" product niche, as well as more on-wall All-in-one products. Gradient Comfort systems has indicated it plans to expand its product line beyond the current window saddle application which can only be applied to buildings with vertical sliding windows. Since this unique product is actually "monobloc" with hydronic connections between the outdoor unit and indoor (water lines, not refrigerant) it may be quite flexible.

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# Appendix A

Compilation of load management products available in Canada and some of their features and characteristics.

### Table A-1: List of Load Management Products and Brands

| Brands | Products | Description | Product Cost Range | Size (in) | Suitable for in-suite installation | Example Suppliers in Canada |
|---|---|---|---|---|---|---|
| **Branch Circuit Switching** | | | | | | |
| **AC Dandy** | Dandy Loadmiser™ Energy Divider Controller (D-LM-1/2/3/4) | Load saving device for non-essential loads connected to an essential load circuit. It cuts off power to the non-essential circuit only. Adjustable 5 to 50 Amp of the circuit upstream rating. | $1,499 - $1,599 CAD | 12 x 14 x 4.5 | Yes | AC Dandy; Canada Breakers; Simple Solar; GESCAN |
| **BSA Electronics** | Appliance Buddy™ Plus Auto | Fully automatic 2-way switcher allows sharing of common 15-20 Amp 12oV wall outlet for appliances. It cuts off power to the non-essential circuit only. | $500 - $600 CAD | Unknown | Yes | BSA Electronics |
| **DIVVEE** | DIVVEE -40 | Connects to a 40 A circuit and the box can be connected anywhere in the home. It intercepts the circuit, and a common application is load switching between range and EV. | $1,000 - $1,200 CAD | 12 x 12 x 4 | Yes | Load share Technologies; A.M. Agency; Bartle & Gibson; Cascadia Sales; Wesco – Burnaby |
| **NeoCharge** | NeoCharge Smart Splitter | Connect to an existing 240V wall outlet. It is suitable for in-suite applications given its small size and flat configuration that can fit behind existing appliances with the receptacles conveniently placed on the sides. | $580 - $650 CAD | 5.3 x 5.3 x 2.8 | Yes | NeoCharge; SUN Country; EVANNEX |
| **Simple Switch** | **Simple Switch 240** | Installed on an existing 240V, 15-50A circuit. This device allows the primary load to draw up to 150 W of power while the secondary load is on. It can fit in an existing panel given its small size. | $947 CAD | 7.6 x 7.6 x 4.9 | Yes | Guillevin; Alberta Breaker |
| **Dynamic Branch Circuit Sharing** | | | | | | |
| **EVOCharge** | iEVSE 40 Amp EV charging station | Level 2 EVSE. Up to 40 amps of power delivered to the connected EV and controllable through the EvoCharge app (start, stop and schedule charging). Connects to home Wi-Fi network. | $699 USD | 11 x 7.5 x 3.2 | No, EV charging only | EVOCharge |
| **Feeder Monitoring with Switching Controls** | | | | | | |
| **BlackBox Innovations** | BlackBox EVEMS/EMS | Allows installation of up to an 11.5kWh or 48/50A electric vehicle charger on an existing electrical service. Approved to use with other devices that can be load shared. | $895+ USD | 8 x 6 x 4 | Yes | Blackbox Innovations |

| Brands | Products | Description | Product Cost Range | Size (in) | Suitable for in-suite installation | Example Suppliers in Canada |
|---|---|---|---|---|---|---|
| **RVE** | DCC-9; DCC-10; DCC-11; DCC-12 | Electric Vehicle Energy Management System (EVEMS) that allows a charger to be connected directly to the main power supply of a MURB dwelling or other electrical panel. Detects when total power consumption exceeds 80% of main circuit breaker capacity and temporarily de-energizes the EV charger. | $1,295 - $2,195 CAD | Ranges from: 11 x 10 x 5 to 16 x 16 x 8 | Yes | RVE Electrical Distributors (e.g., Rexel; GESCAN). |
| **Simple Switch** | **Simple Switch 240CT** | Measures power load on the whole panel and switches off the connected appliance if whole-panel load exceeds 80% threshold. | $1,047 CAD | 7.6 x 7.6 x 4.9 | Yes | Simple Switch Canada; EV Perks; Kilowatt Shop |
| **Feeder Monitoring with Dynamic Controls** | | | | | | |
| **ChargePoint** | ChargePoint Home Flex | Level 2 EVEMS for personal charging. Connected to an app to schedule charging to begin at off-peak hours to save on energy costs. Flexible power output up to 50A. | $1,999 USD | Varies: 50 x 71 x 17 with pole | Not in suite, yes in MURBs | ChargePoint |
| **GENIUS** | GENIUS EV CaaS | Level 2 EVEMS for multi-residential parkades. All-in-one system for dedicated shared EV charging. Bills tenants individually (per kWh) as they use their EV charger. Can scale as demand increases. | $3,996 - $5,000+ USD | Unknown | Not in suite, yes in MURBs | Koben Systems |
| **Intellimeter** | i-meter EVCMC (EV Charging Management Controller) | Level 2 EVEMS that alternates and distributes power to multiple EV chargers. Monitors the total charge to ensure that the contracted demand or ampacity of the breaker is never exceeded by disconnecting car chargers gradually. | Unknown | 68 x 28 x 8 | Not in suite, yes in MURBs | Not available in Canada yet |
| **Variablegrid** | VarianPRO | Level 2 EVEMS for multi-residential buildings. Building load sensing, multi-level electrical topology (manages constraints at both the subpanel and circuit level), balanced round-robin scheduling at circuit level, and close to 100% utilization of EV subpanels and circuits using power allocation harvesting. | Unknown | Unknown | Not in suite, yes in MURBs | Variablegrid |
| **Variablegrid** | VarianSense | 2-tier product for townhome complexes to protect both individual townhome subpanel and the site's main electrical service. In combination with the VarianPRO, it allows installation of multiple EV chargers. | Unknown | Unknown | Not in suite, yes in townhome complex | Variablegrid |
| **Siemens-ConnectDER** | ConnectDER | Meter Socket adapter (MSA) allows connection of solar panels or EV chargers to a home panel. | Unknown | 6.7 x 6.7 x 5.2 | Maybe (meter connection) | Not available in Canada yet |
| **Feeder Monitoring Panel with Controls (Smart Panel)** | | | | | | |

| Brands | Products | Description | Product Cost Range | Size (in) | Suitable for in-suite installation | Example Suppliers in Canada |
|---|---|---|---|---|---|---|
| **GENIUS** | Koben Genius Smart Electric Panel | Smart panel to allow premises to become “smart grid” ready and integrates with EV charging, solar, battery storage, generator. | $3,995 - $5,000 USD | Unknown dimensions | Not likely due to size | Koben Systems |
| **Lumin** | Lumin Smart Electrical Panel | Smart panel capable of providing real-time energy consumption data and circuit-level control with advanced load control and energy automation. | $4,000 USD and up | 17.5 x 17.5 x 4 | Maybe | Lumin |
| **SPAN** | SPAN Panel | Smart panel with Wi-Fi connectivity, indoor and outdoor rated, and 32 controllable circuits. Battery backup, optimized scheduling and customized controls. | $3,500 USD | 39 x 14 x 6 | Not likely due to size | Not available in Canada yet |

# Appendix B

### Table B-1: Description of Types of In-Suite Air Source Heat Pumps (ASHP) Technologies

| Type of ASHP | Example | Description |
|---|---|---|
| **Mini-Split** |  Image Source: Fujitsu | A mini-split air source heat pump system has an outdoor compressor unit and one indoor unit connected by refrigerant and power lines. The indoor unit has its own fan and evaporator coil and will independently service a single room or zone. |

| Type of ASHP | Example | Description |
|---|---|---|
| **Multi-Split** | <br>Image Source: Fujitsu | A multi-split air source heat pump system has an outdoor compressor unit and 2-8 indoor units connected by refrigerant and power lines.<br><br>Each indoor unit has its own fan and evaporator coil hence the systems can provide conditioned air to multiple rooms/zones.<br><br>While some systems will allow up to eight rooms/zones to be heated by one outdoor unit, typically only two to four indoor units are installed on each outdoor unit split system. |
| **All-In-One** |  | All-in-One (AIO) systems are high efficiency air-source heat pumps in a single-package design with no outdoor unit. The indoor unit is mounted on an interior wall and sealed to two 6-8" vents with pass-through penetrations in an exterior wall. Each indoor unit directly distributes heat into the room/zone where it is placed. |

| Type of ASHP | Example | Description |
|---|---|---|
| |  Image Source: Norm’s Plumbing and Heating | |
| **Single Package Vertical Heat Pump (SPVHP)** |  Image Source: Ice Air | Single Package Vertical Heat Pumps do not require an outdoor unit. They typically occupy an approximately 2x2 footprint in the corner of a room adjacent to an exterior wall and require a rectangular enclosure penetration for rejecting or accepting heat. They can serve single or multiple rooms if ducting is added. |

| Type of ASHP | Example | Description |
|---|---|---|
| **Ducted All-In-One (with built in HRV)** |  Photo Source: EPHOCA website | Ducted All-in-One (Ducted AOI) systems are high efficiency air-source heat pumps with no outdoor unit and attached to an interior ducting system to distribute heat through multiple diffusers in multiple rooms.  The indoor unit requires two external vents and is typically ceiling mounted. |
| **Window Saddle** |  | Window saddle heat pumps are a new product category designed to meet all or the majority of an apartment's heating and air conditioning load. The original target market is New York City, which experiences colder weather than the BC lower mainland. They are designed to be simple and cost-effective to install (mount over a windowsill), require no building envelope penetrations, no refrigeration connections and plug into a standard 120-volt electrical outlet.<br><br>Early products are now being shipped, and other models are in development. |

| Type of ASHP | Example | Description |
|---|---|---|
| |  Photo Source: Gradient website | Since the indoor and outdoor units are connected by field connectible hydronics (water tubes), different physical configurations may be possible to accommodate window types other than vertical sliders. |
| **Packaged Terminal Heat Pump (PTHP)** |  | Packaged Terminal Heat Pumps are ductless air-source heat pumps with all components packaged in a single unit. Since most units operate only above 0C outdoor temperatures, the built-in resistance heating can be used often during the winter. They are mounted *through* large holes in exterior walls generally 42”x16”. Each indoor unit directly distributes heat into the room/zone where it is placed.<br><br>There is *one* product (by Ice Air) in this class which is high performance and on the NEEP CC list. This product is a good option as a drop-in replacement upgrade to for low-cost retrofits, such as hotels to social housing.<br><br>This product class is unlikely to be chosen for retrofits in buildings |

| Type of ASHP | Example | Description |
|---|---|---|
| |  Photo Source: Steven Winter Associates | which do not already have PTHP's, because it would require large horizonal rectangular holes cut through the walls. |