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Peak Electrical Load impacts from High-Performance homes during extreme cold events

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Project Abstract

Utilizing an Alberta Ecotrust Foundation and ENBIX grant, Passive House Alberta (PHAb) initiated a small research project with a focus of obtaining real world data on the Peak Electrical loads from High-Performance homes during extreme cold events, when outdoor temperatures are at or below local design temperatures for an extended period. Such a time occurred in Alberta and western Canada mid January 2024 with outdoor temperatures down to -46 C recorded.

Data was obtained via a survey to homeowners and HVAC professionals and collection of historic electrical consumption data from utilities. Feedback on the occupant experience, comfort, equipment performance and commissioning, and resilience was obtained. Historical electrical data from "typical" homes in cold regions was collected to compare against.

This report references and builds off of the Electrification Without a Service Upgrade Report | ENBIX previously produced by Passive House Alberta.

Summary of results are as follows:|

- Most 15-min hr peak electrical loads were in the 10-15kW range
- By using a Circuit Pauser load share device to control the EV charging, all homes could have kept their 15-min peak load to 20 kW or under. This size of electrical load can be accommodated on a 100-amp, 240-volt electrical service to the house.
- The home with the highest 15-min peak load was 25 kW or 105-amps at 240-volts and included 8kW of EV charging.
- Many homes, not having this data or wanting a "future proof" option upgraded to a 200-amp electrical service.
- Very generally, homes with lower design heating loads had lower electrical peak loads and lower daily and weekly electrical peak consumption.
- No cold climate Air Source Heat Pump (ccASHP) failures or break downs were reported.
- Ground Source Heat Pumps (GSHP) had lower peak 15-min loads then ccASHP.
- No comfort concerns were reported by those with a high-performance building envelope.
- Depending on the ccASHP brand, below -25 C to -30 C the secondary heating system was in use.
- Commissioning the ccASHP such that the compressor "locks out", "cuts off" or simply turns off is a key way to reduce the 15-min peak loads. Running both the heat pump compressor and the secondary electric heating system increases the peak load.
- These results reinforce those from the Electrification Without a Service Upgrade Report , in that there is no calculated electrical code, nor actual measured data reason to upgrade to an electrical service bigger then 100-amps and 240-volts, for a high performance all electric single-family home.
- Electrical loads and consumption from the surveyed all electric high-performance homes were roughly double the electrical loads of "typical" homes. The "typical" homes would also have significant fossil fuel energy use, so the transition to all electric high-performance homes should reduce overall residential energy use.

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1. Survey details

A secure survey was created, based on industry professionals feedback and sent out via multiple channels for homeowners to fill out. 32 responses were received. Direct feedback from HVAC professionals was also requested about the performance and commissioning of cold climate Air Source Heat Pumps (ccASHP).

One year of historic electrical load data was obtained for an additional 8 single family homes, 10 units from a Passive House certified Multi Unit Residencial Buildings (MURB) and 55 random homes in cold climates. Various data point were also obtained from 3 other high performance MURBs.

For this report the Peak (largest) 15-minute average electrical load in kW was use. Instantaneous loads (less then a second in duration) may be higher, but obtaining data for them is difficult and their impact on the overall electrical grid is much smaller given the very short duration. The Peak (largest) 1-hour, 1-day and 7-day electrical consumption in kWh was also collected were available.

Electrical load or power is measured in Watts. It is the multiplication of the amperage times the voltage. 1 watt is a small amount of power so more often kilo Watts (1000 watts, kW) is used. It is analogous to the horsepower of your car.

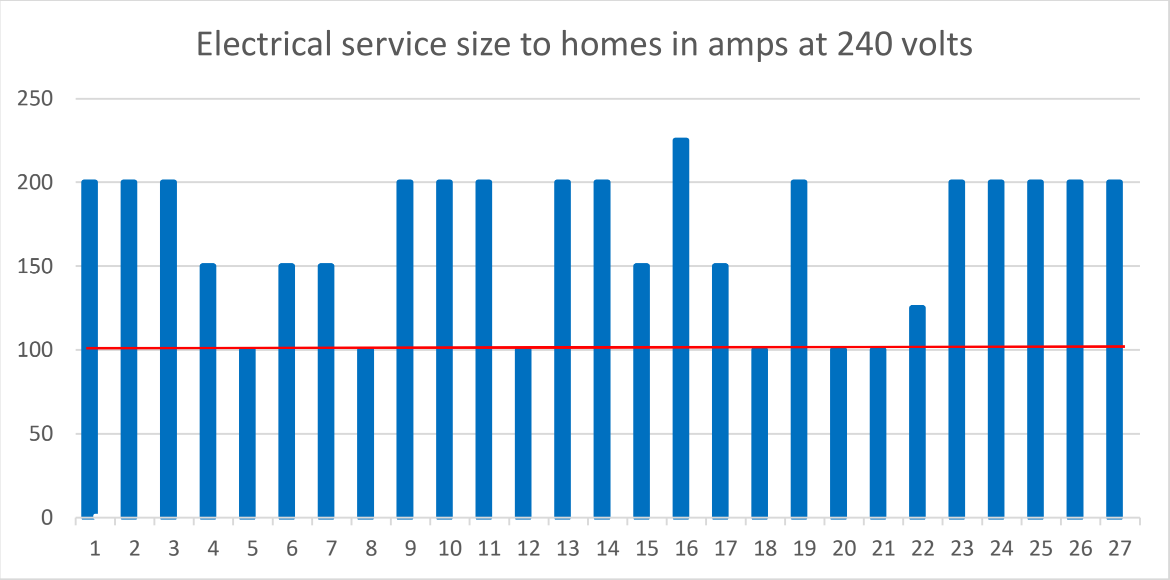
When electrical power is used over time, it is called electrical energy and most often expressed in kilo Watt hours (kWh) and is 1000 watts used continuously for 1 hour. It is analogous to the miles per gallon or liters per 100km rating of your car. Your utility bill charges you a certain dollar amount for each kWh you use.

Residencial electrical services run at 240-volts, so the amperage is the kW / 240 volts. A “typical” 100-amp, 240-volt electrical service can theoretically have up to (100-amps X 240-volts) = 24 kW of electricity running through it, for a short period of time. For continuous durations over 2-hours only 80% of the maximum electricity or (24kW X 0.80) = 19.2kW is allowed by the electrical code of Canada.

2. Peak Electrical Results

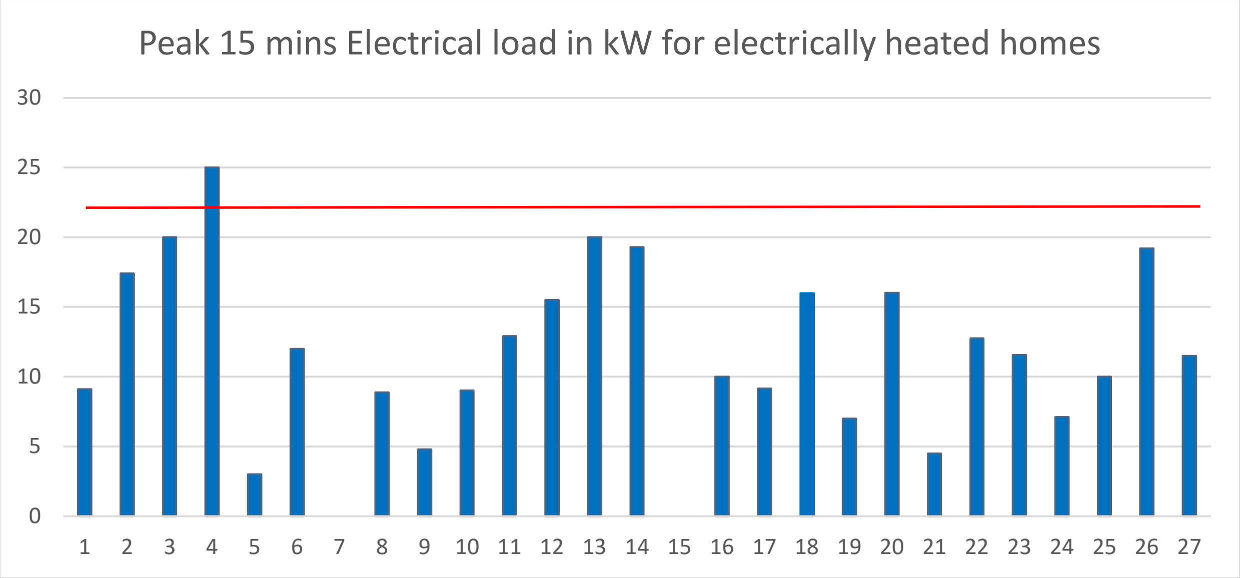
Based on the results of the surveys the Peak (highest) Electrical Loads in kW for 15 minutes, and consumption in kWh for 1 day and 7 consecutive days were obtained. Many of the surveyed High Performance, all electric homes used under 10kW of electricity for the 15 min peak. This is less then 50% of the 24kW theoretical peak electrical load that could be used on a 100-ampere, 240-volt service, for a short duration. A few homes had a 15-min peak in the 20-25kW range, which often included EV charging. 20kW is 83-amps and still below the common 100-amp electrical service size, but larger then the 80% 2 hours + long duration maximum. To help control the short- and long-term peaks, EV charging and possibly other large loads, should be monitored and controlled by a Circuit Pausing device.

Graph 1:



This graph shows the size of the electrical service to each of the surveyed homes. The red line is at 100-amps. Only 6 of the 27 homes did not upgrade their electrical service.

Graph 2:



This graph shows the peak 15-min electrical load of the surveyed homes from the grid. Only one at 25kW exceeded the short-term allowable load on a 100-amp 240-volt electrical service. From graph 1, all but 6 homes still upgraded their electrical service, without need. Zero values are when data was not available from that surveyed home.

For a Passive House Certified row townhouse complex each unit used less then 5kW for the 15 min peak load. For a Passive House duplex, one side with a floor area of 202m^2 (2175sq ft) had a peak 15-

min load of 7.11 kW of that only 2.15kW was electric resistance heat to keep the building warm, the rest was, cooking, cleaning and EV charging.

For a Deep Energy retrofitted townhouse complex each units 15-min peak load was in the 4.5kW to 13.3kW range with a 7.9kW average. Most of the units were of similar size so the large range had more to do with cooking and laundry being done at the same time as the heating load peak. The combined 15-min peak load from a 6-unit complex was between 40kW and 57.7kW. Based on this range, the 6-unit complex could be fed by a single 350 to 400-amp residential electrical service, when the electrical code minimum size calculation required a 125-amp, 240-volt electrical service to each of the 6 units.

Historical electrical data from a 16-unit PHIUS certified rental complex consisting of 1-, 2- and 3-bedroom suites showed peak 1-hour kWh values in the 3.34 to 7.39 kWh range. None of the peak hours occurred at the same time. The average of the units was 5.8 kWh. Longer 1-day and 1-week averages were also calculated to assess the longer-term electrical grid impacts. The unit average 1 day peak was 60kWh per and the average 1-week peak was 345kWh.

The 16 units used TOSOT (GREE) brand ccASHPs and required no electric resistance secondary heat in temperatures down to -46 C. No comfort or other concerns were reported from the renters.

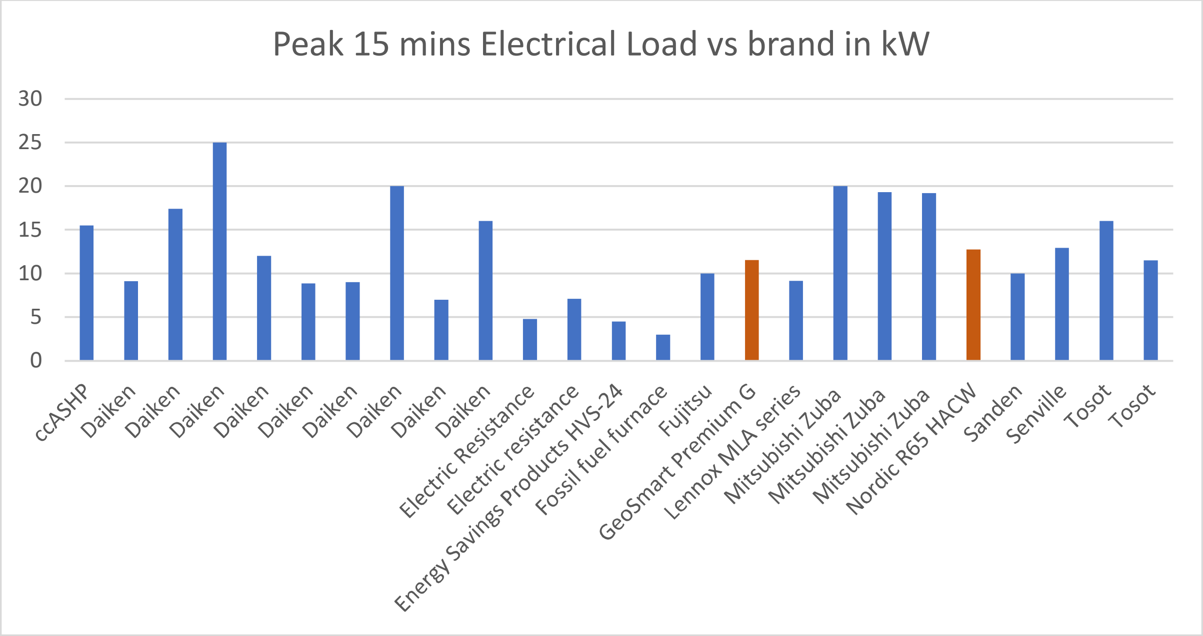
In two surveyed homes a Ground Source Heat Pump (GSHP) was used as part of a Deep Energy Retrofit with little to no building envelope improvements. As a GSHP uses the stable ground temperature as its heat sink it needs no secondary heating system and maintains a high Coefficient of Performance (COP) (around 3 or 4 for the two surveyed homes) regardless of outside temperatures. Without the building envelope upgrades the design heat load plus other coincidental loads resulted in peak 15min loads in the 9-12 kW range. The GSHP only used 2-5kW of electricity to keep the buildings warm. From this data, a GSHPs ability to limit peak load impacts on the existing electrical grid is substantial.

All the lower 15-min peaks came from close to Passive House performance level building envelopes (roughly equivalent to NECB tier 5). This reinforces the design principle that wherever possible, building envelope performance should be a priority.

Overall, these results reinforce the ability of achieving the goal of maintaining the electrical service connection to a single-family home at 100-amps and 240-volts.

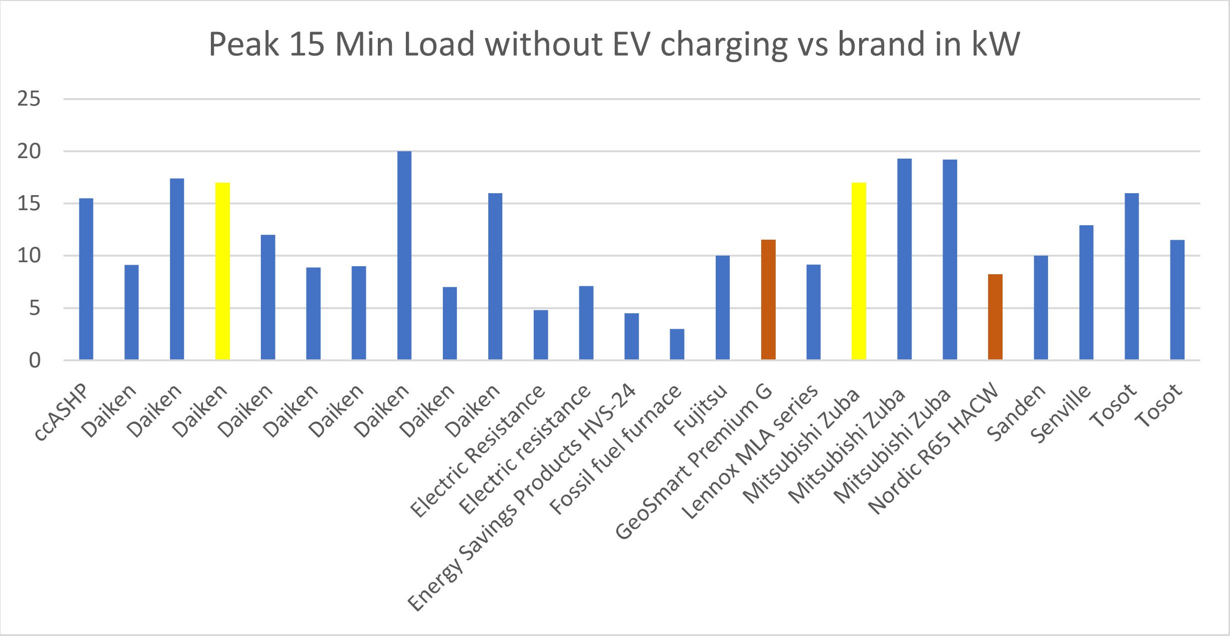
The brand of heat pumps was also collected from the surveyed homes and shown below vs the peak heat load. The Mitsubishi Zuba systems are all on the higher end of the range, this may be due to how they are commissioned, which is discussed later in the report. They could have also been installed in larger homes or homes with lower performance building envelopes.

Graph 3:



The two GSHPs are shown in orange, others are all ccASHP of some type.

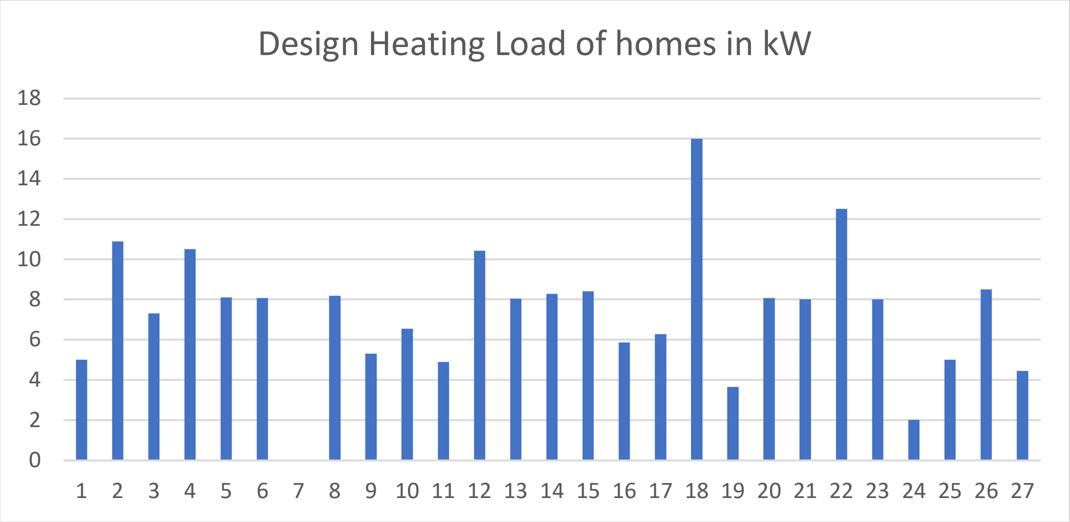
Graph 4:



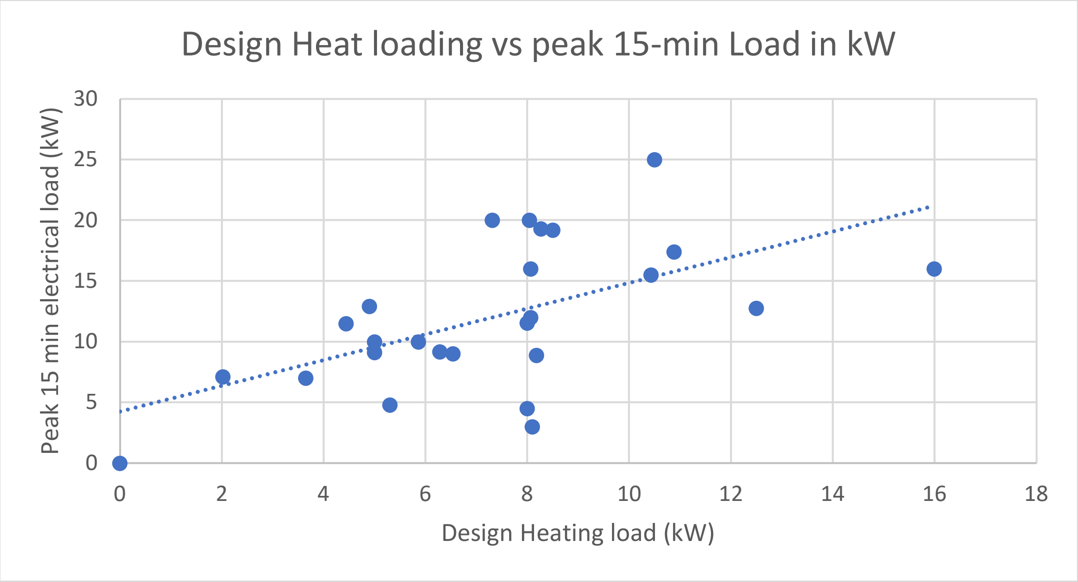
The two sample home with EV charging are shown in yellow, GSHPs remain in orange.

The design heating load of each surveyed home was also obtained from the Energy model. It is the calculated amount of heat (in kW) required to maintain a constant indoor temperature for that home in its climate. When graphing the design heating load vs the peak 15-mins electrical load of each surveyed home a slight correlation was observed, in that lower design heating loads resulted in lower peak 15-min loads. However, there was large variations which could be explained by coincidence loads (loads occurring at the same time as the heating system working at full capacity). With high performance building envelopes, the design heating load is low enough that the peak 15-min is likely to occur with cooking and other loads. These cooking and other loads will also be a larger % of the total peak 15-min load. With lower performance envelopes the peak 15-min is more likely to occur at the coldest time of night, but when little else is running. EV charging will always have a significant but controllable impact on the peak 15-min loads. The peak electrical 1-hr consumption from one 2-bedroom suite in the 16-unit PHIUS MURB occurred in March 2024, not during the January extreme cold event, showing how non-space heating loads can add up.

The design heating load vs peak electrical 15-min, 1-day and peak 7-day graphs are shown below.
Graph 5:

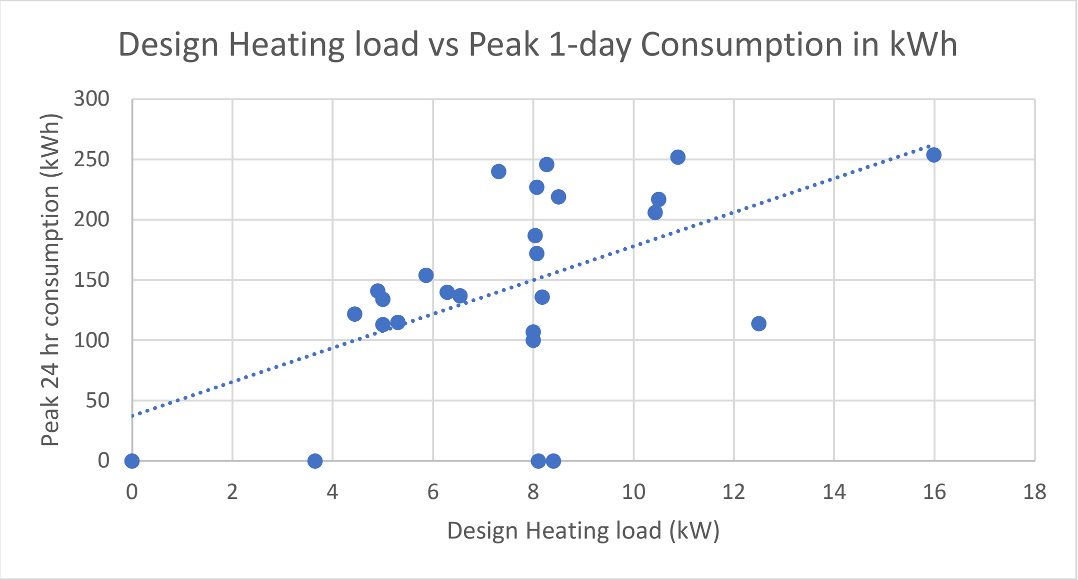


Graph 6:



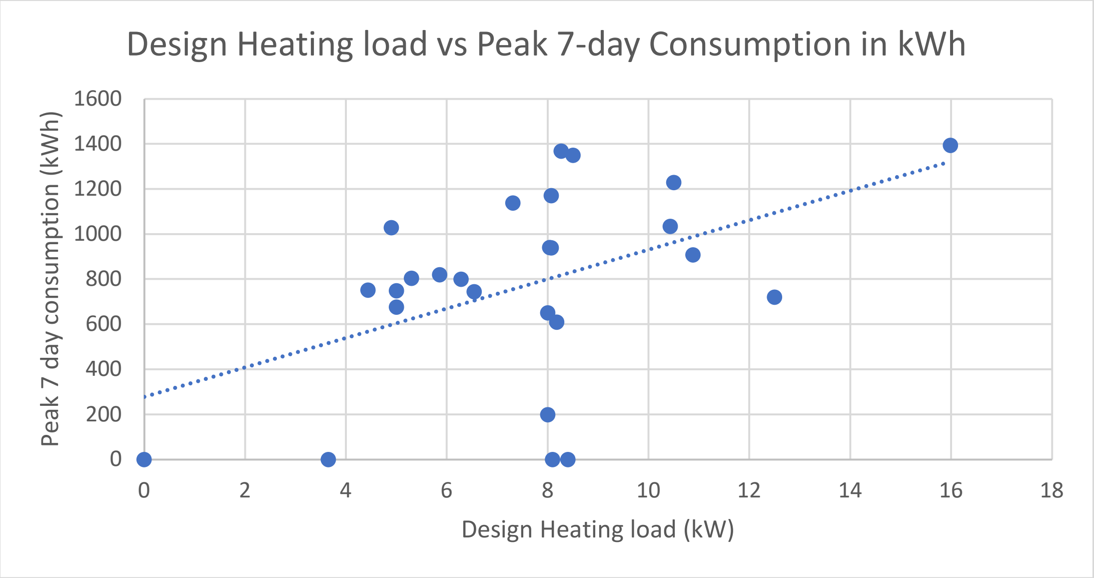
Zero value points are where data was not available. Trend line added.

Graph 7:



Zero value points are where data was not available. Trend line added

Graph 8:



Zero value points are where data was not available. Trend line added

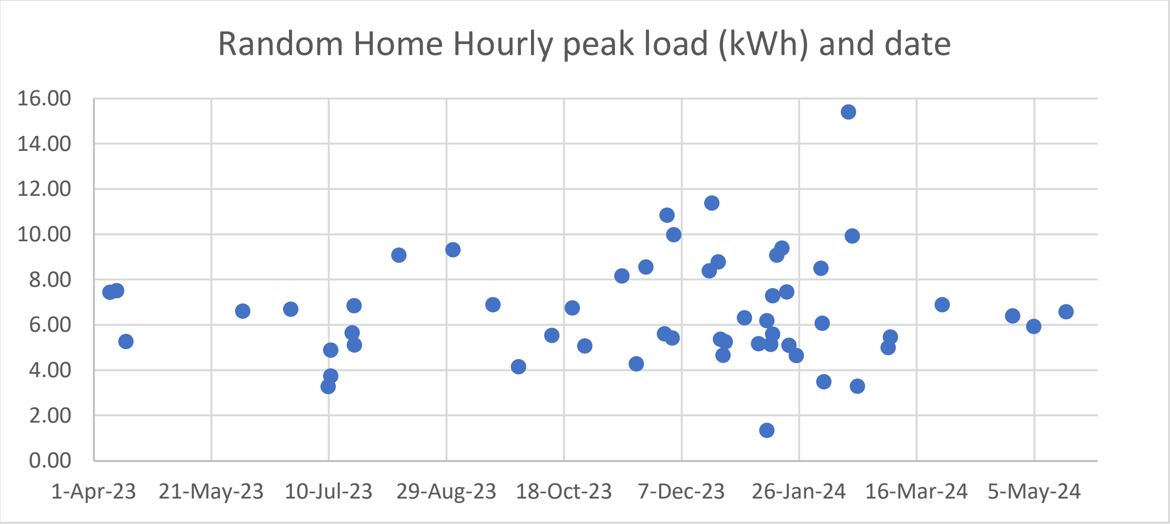
3. Electrical Grid Implications and mitigations

Higher values of both the peak 15-min load and longer 1- and 7-day peak consumptions will impact the grid, but the 15-min peak has the larger impact as the electrical system operators must balance electrical loads with electrical generation on a second-by-second basis. During extreme cold temperature events almost all heating systems will be running to keep their buildings comfortable. Large design heat loads in all electric buildings will almost always result in larger electrical usage.

For comparison purposes, historical 1 hr electrical data from 55 random homes in cold climates (Edmonton Ab, Dawson Creek BC and Fort St John BC) was obtained from the utility providers. Details of the homes are not known, due to privacy concerns, but it can be assumed that space and Domestic Hot Water heating is with fossil fuel.

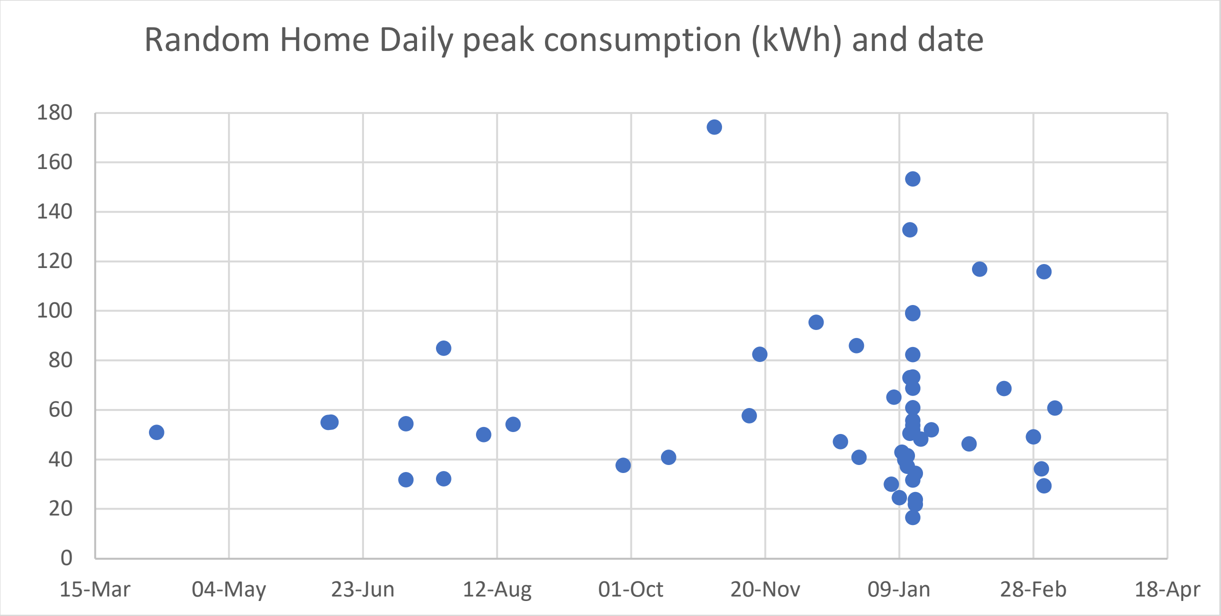
Results are shown here.

Graph 9:



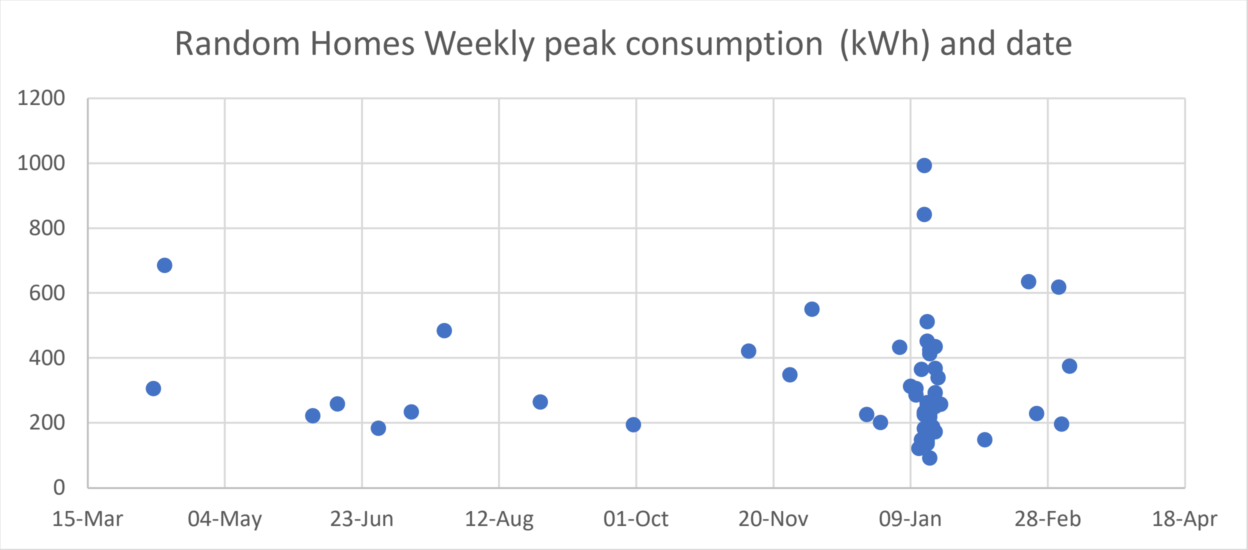
Assuming the homes are heated via fossil fuel, the electrical peaks could occur at any time of year, as cooking, cooling and other loads occur year-round. The average hourly peak is 6.5kW, with many occurring in the winter, and another grouping during the AC cooling season. Without having access to 15-min peak data it is difficult to compare these hourly peaks to the 15-min peaks from high performance all-electric homes, which were mainly in the 10-15kW range.

Graph 10:



For the random homes, most of the Daily peak consumptions occurred during the same extreme cold event in Jan 2024 as for the High-performance homes, but the random homes would most likely all have significant fossil fuel consumption in addition to electrical during these times. The average random home daily consumption was 60kWh, while the average for the surveyed High-performance homes was 140kWh.

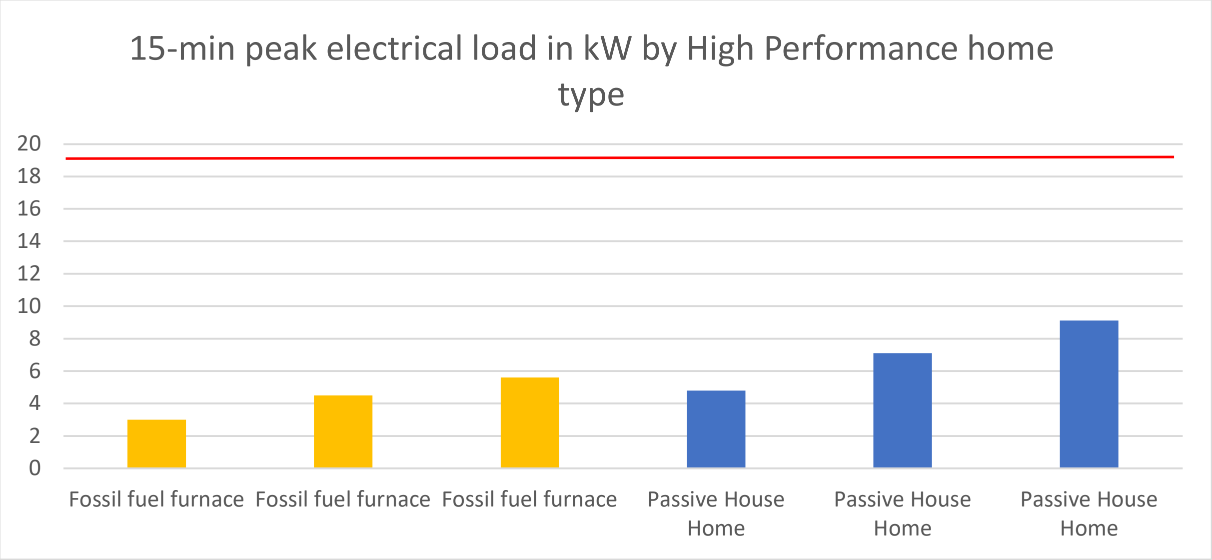
Graph 11:



Again, most of the Random home weekly peaks occurred on the Jan extreme cold event with an average of 319 kWh of electricity used. The high-performance homes average was 748kWh.

The peak 15-min electrical loads in the few high performance building envelope homes heated with a fossil fuel furnace were 3kW, 4.5kW and 5.62kW. The Homes built to the Passive house standard had peak 15-min loads of 4.8kW, 7.11kW, 9.11 kW and 10 KW. These peak 15-min loads are larger than fossil fuel heated homes, but still much less then the 19.2 to 24kW that the home is theoretically allowed to use from its 100-amp, 240-volt electrical service connection, for short or long durations.

Graph 12:



The red line is the 19.2kW long term max allowable load on a 100-amp, 240-volt electrical service.

The GSHP peak 15-min heating only loads of 2-5kW are in the same range as the peak 15-min electrical loads of fossil fuel heated homes in the survey, so their grid impact is very similar. For this reason, increasing the use of GSHP on an individual lot basis or as part of a district energy system should be encouraged.

From this limited data set it appears that transitioning current fossil fuel heated homes to High-performance all-electric homes could result in around twice the electrical consumption from those homes in the cold months, less if GSHPs are used. Given that the current average Albertan home uses 7,200 kWh per year of electricity but also uses 110GJ or 30,556 kWh of fossil fuel per year, by prioritising High-performance construction, significant overall energy savings could be achieved.

To reduce grid impact in the future, coincidental loads that are not space heating related, could be turned off or controlled via utility “demand response” measures.

Vehicle to grid charging

Many surveyed homes had peak 15-min loads of 10-15kW, which is also in the size range of level 2 Electric Vehicle (EV) chargers and Electric Vehicles have an average battery size of 40kWh (Electric vehicles | Battery | Capacity and Lifespan (eonenergy.com)), so the potential of using Vehicle to Home (V2H) or Vehicle to Grid (V2G) charging to reduce extreme cold events grid impacts is significant. Allowing utility demand response or demand control of Electric Vehicles (EV) charging has great potential, specifically charging up EVs before an extreme cold weather event is forecast and then discharging them when the event occurs. This functionality has been called Virtual Power Plants (VPP) as it accesses the stored electrical energy in EVs distributed around a large area.

Examples and links to some VPP projects follow:

California Virtual Power Plant Bill Uses RPS-like Strategy - Energy Changemakers

VIRTUAL POWER PLANTS PROJECTS | Department of Energy

Pathways to Commercial Liftoff: Virtual Power Plants (energy.gov)

Five Ways States Can Unlock Virtual Power Plants for Grid Flexibility and Decarbonization | LinkedIn

Virtual power plants, DERs and home electrification get boost from trio of new Maryland laws | Utility Dive

Virtual Power Plants Are the Key to a Resilient, Clean Energy Grid | Northeast Energy Efficiency Partnerships (neep.org)

Various code and certification issues remain with V2G, V2H and VPP in Canada. Pilot projects and examples are few but include two just commencing in Alberta.

POWER.HOUSE - Canada's 'First-of-Its-Kind' Virtual Power Plant | Electricity Canada

Power House Feasibility study (alectra.com)

A innovative virtual power plant solution to reshape Alberta Electricity Grid and enable the widespread adoption of renewable energy and high energy-tier buildings - Emissions Reduction Alberta (eralberta.ca)

Residential VPP Grid Services Demonstration for effective management of DERs and EVs - Emissions Reduction Alberta (eralberta.ca)

4. Air Source Heat Pump (ASHP) Performance Results and Findings

Primary heating system vs Secondary heating system vs Supplemental heating system:

The national building code requires that a correctly sized heating system is provided to all buildings. The heating source that is used most often is called the Primary Heating System. ASHPs, even cold climate ASHPs lose heating capacity and electrical performance as the outdoor air temperature drops, meaning with current technology below -25C (-30C and lower for some equipment) some additional heating source is required. If the additional heating system runs at the same time as the Primary heating system, it can be called a Supplemental heating system. If the primary heating system completely turns off, then it is called a Secondary Heating system. Both Primary and Secondary heating systems need to be sized for the total design heat loss on the building. Supplemental heating systems can be sized smaller as they work with the Primary heating system to meet the design heat loss of the building.

Correctly designed and installed Ground Source Heat Pumps (GSHP) do not need a Secondary or Supplemental heating system as they exchange heat with the ground which provides a much more stable source of heat, so their heat production efficiency varies little, regardless of the outdoor air temperature.

A Backup heating system implies that the primary heating system fails or is broken. ASHPs do not fail nor are they broken at extreme low outdoor air temperatures; they just no longer work efficiently. So generally, the term Backup heating system should not be used in the context of ASHPs.

As with many terms, their use and meanings may vary by location.

Secondary heating system types and selection

There are two main types of secondary heating systems: Electric Resistance and Fossil Fuel, generally in the form of Propane or Natural (methane) gas. Nearly all Fossil Fuel heating systems require electricity to run the fans and equipment controls. Inefficient single speed furnace fan motors can consume 300-500watts when running, however this is a much lower electrical load then from Electric resistance heating systems. The selection of a Secondary heating systems from the options will depend on the goals, values, location and utility costs of the occupant. Considerations include:

- Resiliency: Resilience has various definitions, the dictionary defines it as the capacity to withstand or to recover quickly from difficulties or challenges. In a building context Resiliency is a buildings ability to not be impacted by changes in the outdoor environment, be it extreme cold or heat or wind, or water or rain or air quality or reliability of the utility grids.

  If the Building is in a rural location, where power outages can be more common, and it has an existing propane tank on the property then a low cost and Resilient Secondary Heating system would be a propane furnace / air handler unit. From the survey results of an HVAC company with ASHP experience, the propane versions of the more common Natural (methane) gas furnace / air handler cost as little as $30 more for material as all that changes is the burner. The propane tank combined with a small battery or generator could provide all the heat and power the home needs during a blackout.

  Another form of Resiliency comes from a high performance building envelope that reduces the heat loss in winter, and controls the gain in the summer, which if taken to the Passive House standard level of performance will reduce the peak heat load of the building considerably and allow an extended period of time with no heat before damage to the home would occur. One survey home turned off all heat in their Passive House for 10 hours overnight with outdoor temperatures of -34 C and the house only dropped 2 C. Another surveyed Passive House Home under construction with a 95% complete building envelope maintained indoor temperature overnight with -39 C outdoor temperature using a single electric resistance construction heater slightly smaller than the Design Heat load. The owner stated, “the house just didn’t care about the weather outside”.

The most durable and longest lasting form of Resiliency comes from a high-performance building envelope as the envelope can’t have a mechanical break down, does not need software updates, can’t be “hacked” and does not need fuel or power to run.

“The greenest unit of energy is the unit of energy that is never generated thanks to efficiency and conservation.” – Amory Lovins, 1990.

- Lower Green House Gas Emissions (GHGE): An all-electric building will produce less operational green house gas emissions then one that uses fossil fuels. In locations, such as Alberta currently with an electrical grid that uses primarily fossil fuels to generate the electricity, on site renewable energy generation is key to reduce the system wide GHGE. As Alberta’s and other electrical grids move to decarbonize, using an electric Secondary heat source will produce lower GHGE.

- Extreme cold grid impacts: During extreme cold events current technology ASHP will most likely not be working so the Secondary heating system will be providing all the heat and an electric resistance heating system will use more electricity than a fossil fuel heating system. Because of this a fossil fuel secondary heating system will have a smaller electrical grid impact then an Electric one. Having a high-performance home with a much-reduced design heat load will reduce the required heat from either system.

- Equipment cost: From the survey results, depending on the equipment manufacturer, material and installation labour costs are similar for a ducted, forced air heating and cooling system using either an:
    - indoor air handler ASHP with a 10kW electric resistance secondary heating element or
    - a fossil fuel furnace commissioned as the secondary system to an ASHP coil

- Operational Energy cost: The cost of the energy to run the secondary heating system is made up of two parts the fixed Connection fees to connect to the utility grid and the variable Energy and transmission costs based on the quantity of energy used. In many parts of Alberta, the annual fixed connection fees to connect to a Natural (methane) Gas distribution network range from $400 to $650. If the Natural (methane) Gas Secondary Heating system is only used in temperatures below -25 C the fixed connection fees are likely to be more then the cost of the Natural (methane) Gas consumed during those temperatures. If the building is designed to be close to Net zero on site Energy using a solar PV system including the electricity used by the electric resistance secondary heating system, then the utility costs can approach zero on an annual basis, depending on the fixed transmission fees and the consumption and generation electricity rates and other factors.

ASHP Commissioning

How the ccASHP was commissioned, specifically how and when the Primary and Secondary heating system work together or switch between the two, was an important factor in the occupant's comfort and the peak electrical loads. An air handler type ASHP heating and cooling system can be set up in two main ways:

1. The Primary ASHP compressor shuts off at a certain outdoor temperature and the Secondary heating system turns on. This can be called the "cut off temperature" or the "balance point."
2. The Primary ASHP compressor continues to run at a lower efficiency (COP) and the Secondary heating system also turns on to ensure the indoor temperature is maintained.

Selecting brands (such as Daiken, Fujitsu and others) that can be commissioned the first way should be a priority. To date a method to turn off (cut off or lock out) the Mitsubishi Zuba brand ccASHP compressors has not been found. Because of this, from survey data, up to 6kW can be added to the peak 15-min load from the compressor unit running along with the secondary electric resistance heater.

Based on the surveyed homes designing and commissioning the HVAC system such that the Primary and Secondary heating systems do not run simultaneously minimized the peak 15-min load.

TOSOT (rebranded Gree units) ccASHP units have been used in over 300 High-Performance homes in Edmonton and northern Alberta and in some instances were installed without any secondary heating system. In temperatures down to -46 C the TOSOT ccASHP equipment kept all 16 units in a PHIUS MURB at their set points with no secondary heating system. The design heat loss for the entire 659m^2 building was only 13kW, individual rental suites in the 60-100m^2 floor area range had corresponding suite design heat losses in the 1.15kW to 1.91kW range.

Ductless ASHP are likely to have a safety shut off temperature, but it may be below the outdoor air temperature when the Coefficient of Performance (COP) of the unit drops below 1. Confirm with your installer and supplier at what temperature a ductless ASHP should be turned off (manually) and the Secondary electric resistance heaters turned on (manually).

To limit the grid impacts how to lock out (turn off) the ASHP compressor should be confirmed prior to purchasing the equipment and designing the mechanical system with the Primary and Secondary heating systems both sized to 100% of the heating design load if preferable to using a Supplementary heating system.

ASHP Testing

Testing that the secondary heating system turns on at the correct temperature is another key to ensuring occupant comfort. From HVAC professionals feedback as well as a few of the survey homes experienced issues and indoor temperature drops as the Primary heating to Secondary heating system transition did not occur correctly. The temperature at which the switch occurs will vary based on the performance of the ASHP (cold climate rated or not), the equipment manufacturer and the installers experience. Controlling the indoor air handler fan to not blow cold air into the house while the switch is occurring should also be designed and tested.

Testing to confirm that the design parameters were achieved should also be performed. In code minimum construction the testing portion of Commissioning is rarely completed, especially regarding the ventilation flow rates and thus the heated or cooled air distribution. In High Performance homes ventilation testing is more often a requirement. Testing of the ventilation distribution system to confirm the design flow rates are achieved on site, to each room, is always recommended, to ensure occupant comfort.

ASHP produces air at a lower temperature then a fossil fuel furnace, so the ducts often need to be larger to allow more air to be moved through them to provide the same heating to the home. In new construction duct work needs to be custom designed for heat pumps. In Deep Energy Retrofits the existing furnace ductwork can often be reused for a ASHP as long as the building envelope has been improved so the design heating load is reduced. Testing the existing ductwork to ensure the correct air flow is provided to all rooms and the max air flow is sufficient to provide the required reduced design heating demand is recommended.

5. Window Performance

When warm moist air contacts a cold enough surface, condensation will occur. In buildings the window sill is likely to be one of the coldest surfaces. Higher quality and higher performance windows combined with a high quality, air tight and thermal bridge free installation will result in warmer window sill temperatures and less condensation. Code minimum buildings solve this thermodynamic problem by placing a heating source (furnace vent) below each window to blow sufficient warm air over the cold window sill to remove the condensation when it occurs.

Leaving tight fitting blinds closed will reduce the amount of warm air contacting the cold window sill and increase condensation. Lowering the indoor relative humidity will reduce the amount of moisture in the air that can condense on the window surface, but it has health implications for the occupants as dry air dries out the mucus linings of people’s nose and mouth. This leaves people more susceptible to virus and bacteria infections as one of the mucus linings roles is to stop viruses and bacteria from entering our bodies. It also leads to dry skin during the winter.

Of the surveyed homes, those with higher performing windows reported less condensation and were able to maintain indoor relative humidity at a higher level, in the 30-35% range. At outdoor temperatures in the -34 C to -46 C some window condensation is likely to occur as windows are not designed for such extreme conditions.

Choosing window sill materials that are water resistant and will not swell or promote mold growth is an important design choice.

6. Comfort Experiences

Some occupants that had recently moved into a high-performance home or had a Deep Energy Retrofit performed noted increased comfort during the extreme cold, compared to previous homes. No high-performance building envelope home occupants reported any comfort concerns. One homeowner that installed a high-efficiency GSHP but performed limited building envelope improvements noted minor comfort concerns in that the air felt cold. The relative humidity also had to be lowered to around 25% to minimize windowsill condensation. A high-performance building envelope is what provides comfort, in the form of consistent temperature, limited condensation on window sills, relative humidity in the good (>30%) range and no drafts. Mechanical systems attempt to give the appearance of comfort but can not always overcome a code minimum building envelope and thermodynamics.

7. Frequency of extreme cold events

Between 1981 and 2010 Calgary (Canadian Climate Normals 1981-2010 Station Data - Climate - Environment and Climate Change Canada (weather.gc.ca)) had on average 22 days below -20 C but only 4 days below -30 C. The Edmonton airport had 36 days below -20 C and 10 days below -30 C. So extreme cold is a small but nonzero event. As ccASHP technology improves to effectively work below -30C (some equipment already does) then the effect of extreme cold events will decrease.

8. Distributed vs centralised electrical secondary heating systems

A centralized electric resistance secondary heating system located as part of the air handler or elsewhere in the main supply duct is a low cost and simple to install system. Unless it is a modulating element its impact on the peak-15 min load is large, as it is either on or off. A distributed electric resistance secondary heating system consisting of multiple smaller electric resistance wall panels or baseboards each with its own thermostat control could have a lower peak 15-min impact as only the rooms the occupants are in would be heated and other rooms could be turned down. Before ccASHP became widely available many Passive House homes were heated using only electric resistance heat as the up-front capital costs and maintenance are very low.

9. Thermal storage opportunities

There are various forms of building level thermal storage: such as in floor hydronic heating of thermal mass, thermal batteries using phase change materials and hot water storage tanks. All of these systems have the potential to “time shift” and reduce the peak 15-min loads by heating up the storage materials prior to extreme cold event using low cost and low carbon electricity and then using the stored-up heat during times of peak. Designing cost effective equipment that can be installed to replace the common furnace and then scaling up production are roadblocks to these options.

10. Conclusions

Although based on a limited sample size, this report shows that even in cold climates actual peak electrical loads and consumption from High Performance all electric single-family homes are small enough to be met by a 100-amp, 240-volt electrical service, when EV charging is controlled via a circuit pauser. Putting the homes together into some form of a multi-unit complex further reduces the peaks. When combined with the results of the Electrification Without a Service Upgrade Report | ENBIX report, there appears to be no electrical code or measured actual value reason to upgrade from a 100-amp, 240-volt electrical service as part of full electrification, as long as a high performance building envelope or a GSHP is incorporated.

In comparing the surveyed High Performance all-electric homes to 55 random cold climate likely fossil fuel heated homes, going high performance and all electric roughly doubles the 15-min, 1 day and 1-week electrical consumptions, while saving significant fossil fuel consumption. Ground Source Heat Pumps have similar peak electrical loads as the random homes, but no fossil fuel consumption. Their use should be encouraged.

It will be up to local utilities to determine what impact these increased electrical loads will have on the generation and distribution mix of the future electrical grid as the number of all-electric high-performance homes increases to meet Canada’s green house gas emission reduction targets.