MORRISON HERSHFIELD

REPORT

Oshawa Creek and Black Creek Co-operative Homes – Heat Pump Energy Performance Study

233 Albert Street, Oshawa, Ontario

1779 Jane Street, Toronto, Ontario

Presented to:

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Project No. 220147100 April 20, 2022

INTRODUCTION

In response to the request for a performance study on the new heat pumps being installed at 1779 Jane Street in Toronto, Ontario, and 233 Albert Street in Oshawa, Ontario, Morrison Hershfield Limited (MH) is pleased to present this case study to The Agency for Co-operative Housing.

Heating at both co-operative housing complexes is provided via electric baseboard heaters. There was no cooling at either site locations. The heat pump installations not only provide greater efficiency with heating, but they will offer the added advantage of providing cooling during summer.

HEAT PUMPS

Heat Pump systems consist of an outdoor condensing unit, as well as an indoor fan coil unit. The condensing unit takes air from the outdoors by using a refrigerant circuit and components within the condensing unit to absorb heat from the outdoor air and converts the energy to a coil that is located within the fan coil unit. The fan coil unit is controlled by a thermostat that will cycle a fan and modulate the amount of heat required to satisfy the desired temperature set point. The air is distributed through supply air ductwork and diffusers that allow air into the space. Air is returned via return grilles and ductwork as it is pulled towards the fan coil unit due to negative pressure created by the fan. Back at the condensing unit, hot refrigerant gas that is used to heat the air then returns to the condensing unit cooler and the refrigerant cycle repeats itself.

The heat pump systems design can provide heating at full capacity down to a temperature of 0°F (-18°C) but can still provide heating down to a temperature of -22°F (-30°C) at a reduced capacity. As the outdoor air temperature decreases the ability of the heat pump to absorb heat from the cold air is reduced. This means that the amount of energy produced by the heat pump condensing unit is reduced. **Table 1** below shows a summary of some advantages and disadvantages of installing heat pumps for heating and cooling as opposed to electric baseboard heating

Table 1: Heat Pumps and Their Benefits vs Electric Baseboard Heating

Advantages	Disadvantages
Energy efficient	Efficiency goes down on very cold days
Reduced carbon footprint	More expensive than electric baseboard heating
Relatively high performance	

For this study, the coefficient of performance (or COP) of the heat pumps will be considered. The COP of a heat pump system is defined as the ratio of the heating capacity to the amount of power needed to produce that heat (or input power). The lower the outdoor temperature is, the more a system needs to work to produce sufficient heating indoors. This means that more power is needed to produce the same heating capacity which ultimately means the COP goes down. With heat pump technology there is a certain point based on the outdoor air temperature for which the heat output begins to reduce and at a certain point the equipment is no longer able to provide any heating at all due to the cold temperatures. Essentially, the colder the outdoor air temperature, the more difficult it is for the heat pump to absorb heat from the atmosphere and transfer it to the refrigerant therefore reducing the COP.

For a comparison of what used to be provided at each of these buildings that were provided with electric heating only, an electric baseboard heater has a constant COP of 1. That is for every kilowatt of energy put in, 1 kW of energy comes out as heat. The advantage of the heat pumps that are being provided at at Oshawa Creek and Black Creek Co-ops is that the COP will range between 1.2 – 3.7 with the lowest COP of 1.2 coming on days when the ambient outdoor air temperature is as low as -17°C. Since the buildings are in a region where the winter design temperatures in accordance with the Ontario Building

Code are -20°C, this means that for a majority of the heating hours for the year the heat pumps will operate at a higher COP than the currently installed electric baseboard heaters. There will be the period between when the outdoor air temperature will be below -17°C and the heat pumps will not be able to provide the necessary heat for the units, but the existing electric baseboard heaters will remain for those periods to cover the required heating for what is essentially 100 hours per year. The change to heat pump technology will provide energy cost savings moving forward.

FLOOR PLANS AND INSTALLATIONS

OSHAWA CREEK

Figure 1: 233 Albert St Oshawa Creek Cooperative Housing

Oshawa Creek Co-operative Homes Inc. is an eight-story apartment building. It consists of a total of 81 units. Common areas include the Co-op office, a common room and laundry facility. The development consists of 21 one-bedroom units, 45 two-bedroom units, and 15 three-bedroom units.

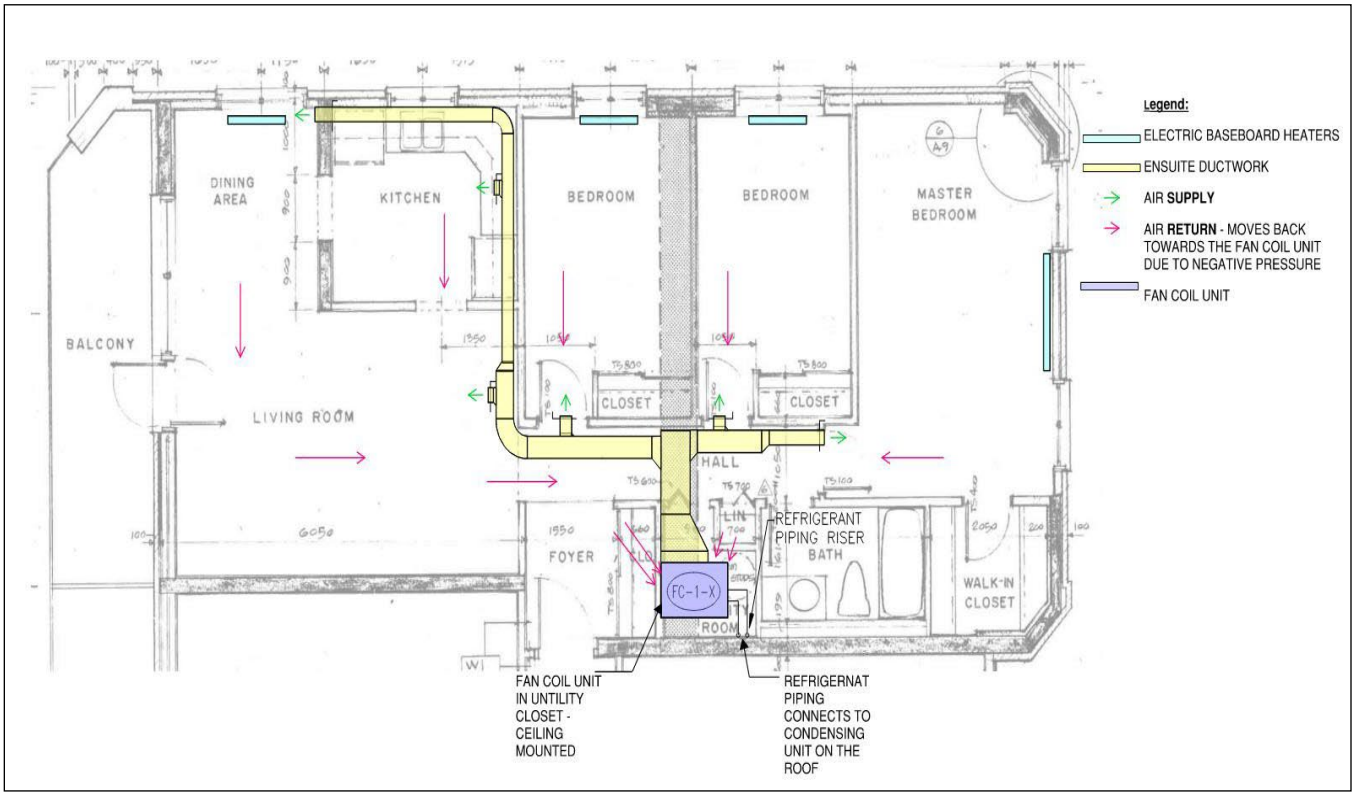

Figure 2: Typical Three-Bedroom Suite Layout with Redesign

As part of the new heat design, a total of 11 condensing units are needed to supply heating and cooling for the entire building. **Figure 2** shows a typical three-bedroom suite layout, where the ductwork, shown in yellow, runs throughout the entire suite, supplying warm or cool air to each room. Heating and cooling are provided by one fan coil unit located in the utility closet of every suite, shown in purple. The refrigerant piping from each fan coil unit is routed up through the utility room and connected to its corresponding rooftop condensing unit. Due to the reduced heat pump efficiency during the very cold days, the existing electric baseboards will remain by the windows of every room in order to provide sufficient heating within each suite, shown in blue.

BLACK CREEK

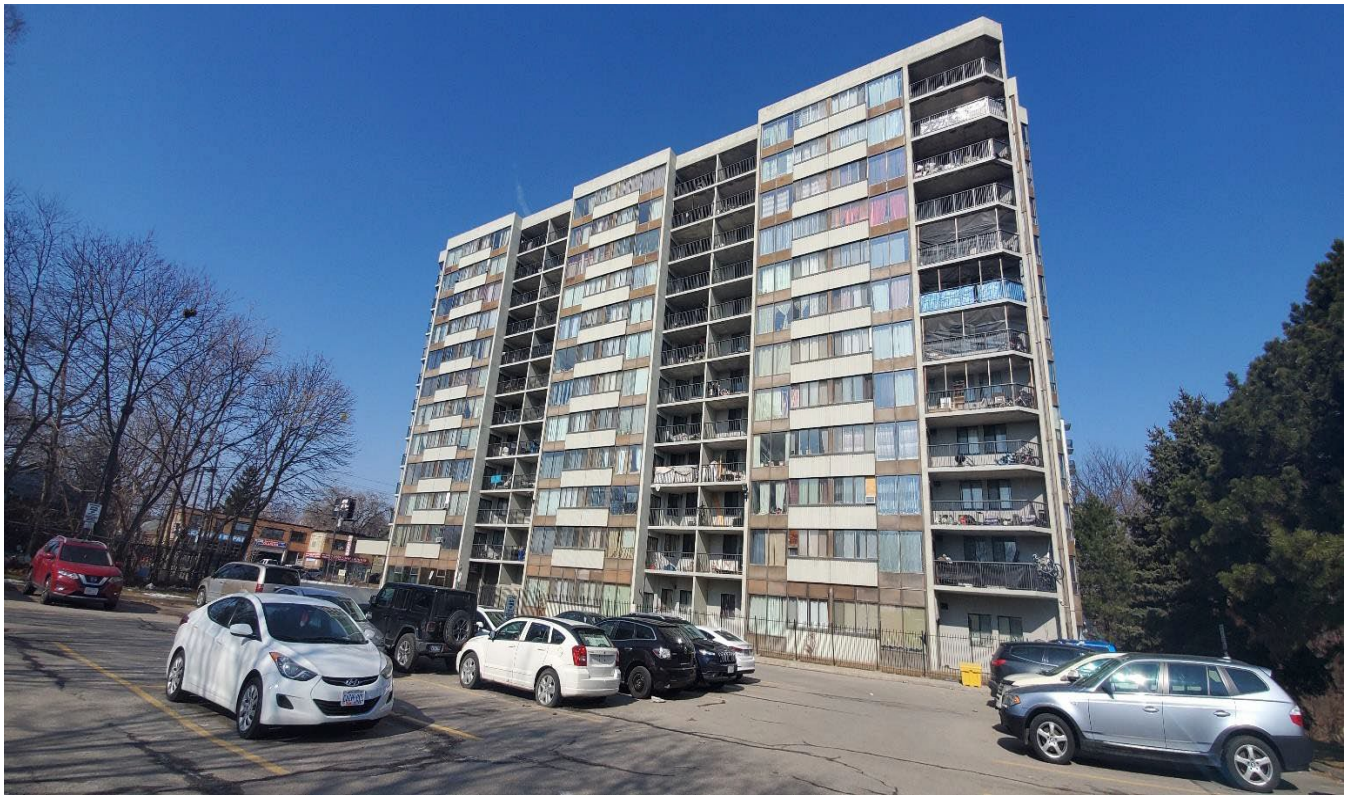

Figure 3: 1779 Jane St, Black Creek Cooperative Housing

Black Creek Cooperative housing is a 12-story building consisting of 140 suites. The 2nd through 12th floor each have 12 suites which consist of one one-bedroom suite, nine two-bedroom suites, and two three-bedroom suites. The ground floor has eight suites which consist of six two-bedroom suites and two three-bedroom suites. The west side of the ground floor has common areas consisting of the property management offices, lobby, and multi-purpose room. The rest of the ground floor consists of service rooms.

The new design for heating and cooling at Black Creek (shown in **Figure 4**) would be provided by an air-cooled condensing unit, located on the balcony of each suite, shown in pink. There will be wall-mounted ductless split heat pump units within each room in the suite, shown in purple. The refrigerant piping from each ductless split heat pump would connect to its corresponding condensing unit on the balcony.

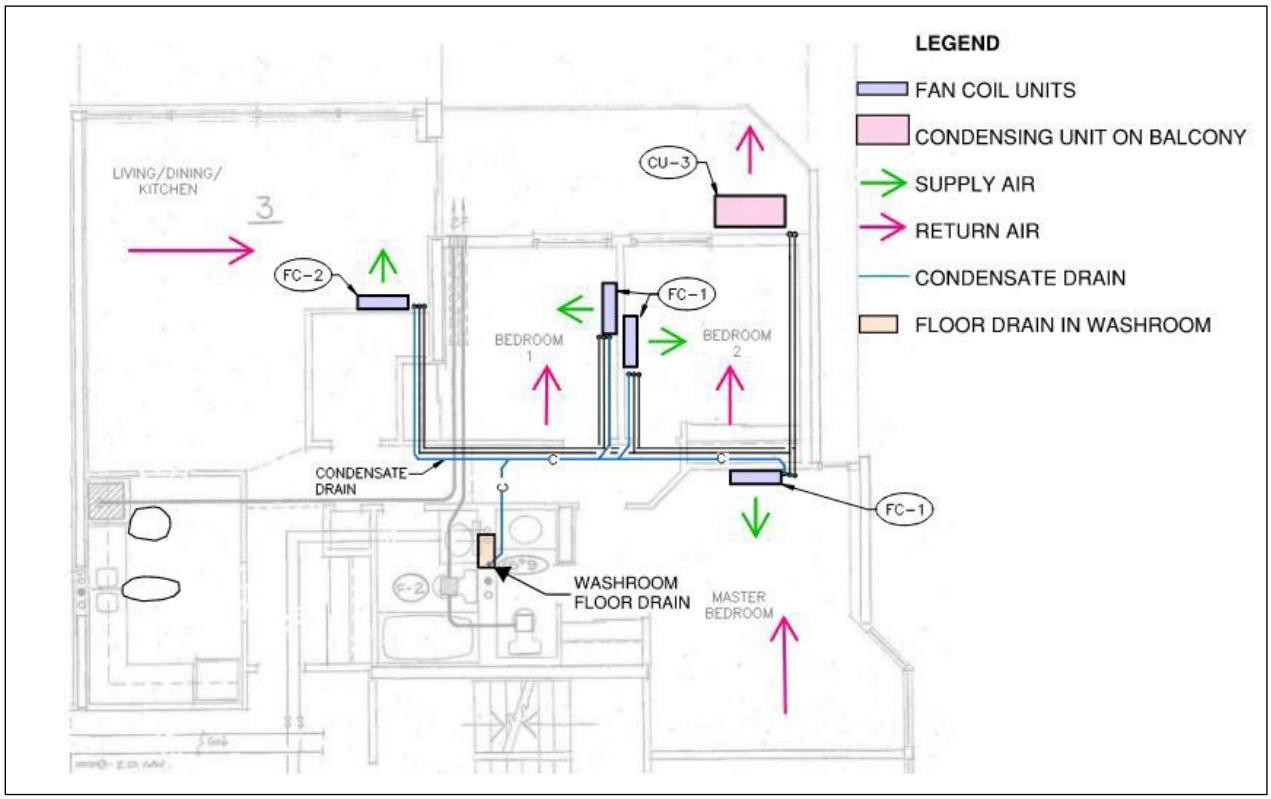

Figure 4: Typical Three-Bedroom Suite Layout with Redesign

FINDINGS

An energy analysis was carried out where the baseline energy consumption was found by reviewing hydro bills over an entire year and deducing what amount of energy is typically consumed when there is no heating is taking place. That baseline energy was then compared to what the energy consumption would be based on the performance coefficients of the heat pumps operating at different outdoor temperatures throughout the heating months. It was found that the energy consumption due to heat pumps was reduced by **21-34%** for Oshawa Creek, and **18-30%** at Black Creek.

OSHAWA CREEK RESULTS

As shown in **Figure 5**, the lower the outdoor air temperature, the less efficient the heat pumps and so more energy is consumed in order to provide the necessary heat. As the outdoor air temperature increases, the heat pump's efficiency increases, and less energy is consumed (more savings in energy). The benefit of the heat pump technology is realized at temperatures between -17°C (0°F) where the COP is 1.7 to an outdoor temperature of approximately 4°C (40°F) when the COP is as high as 3.7. Whereas in comparison with the existing electric baseboard technology has a constant COP of 1.0 whenever heating is required.

It can be seen on the graph that there are no energy savings happening below -17°C. That is because electric baseboard heaters will likely be operating at these lower temperatures since the heat output of the heat pumps will reduce to zero.

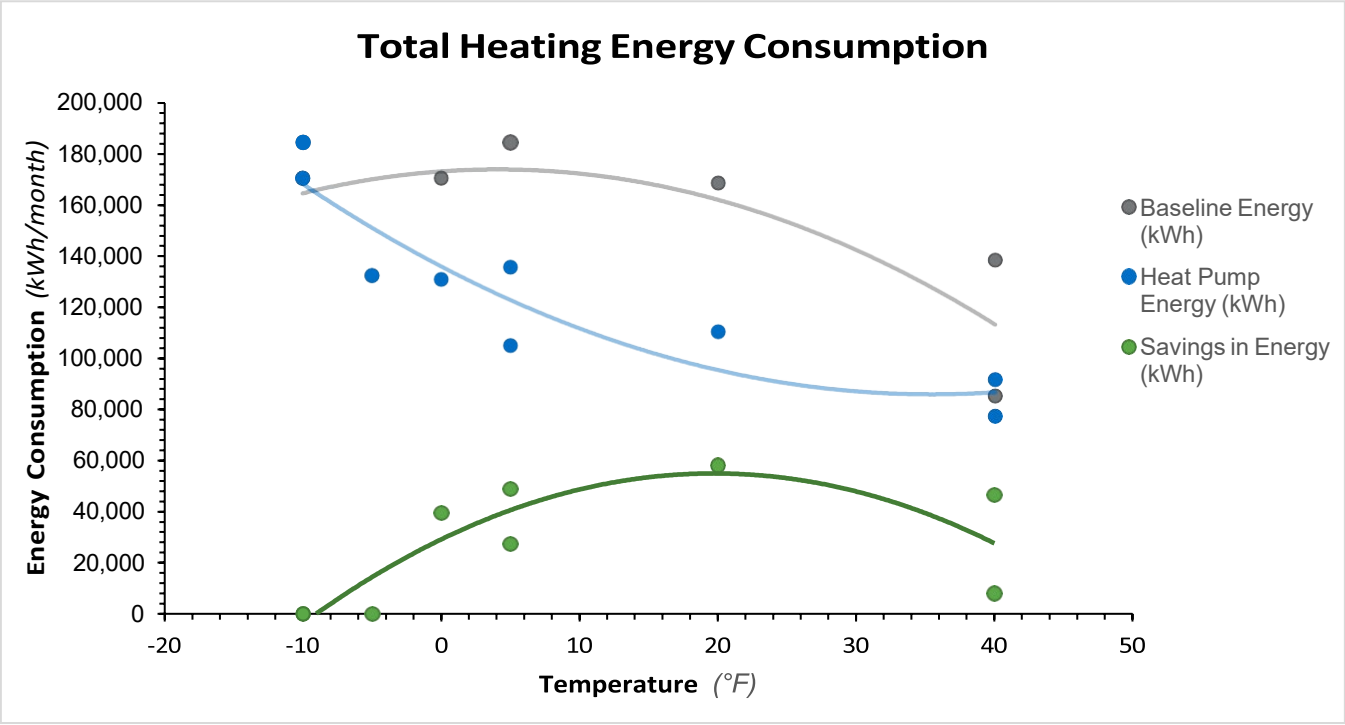

Figure 5: Oshawa Creek - Total Heating Energy Consumption

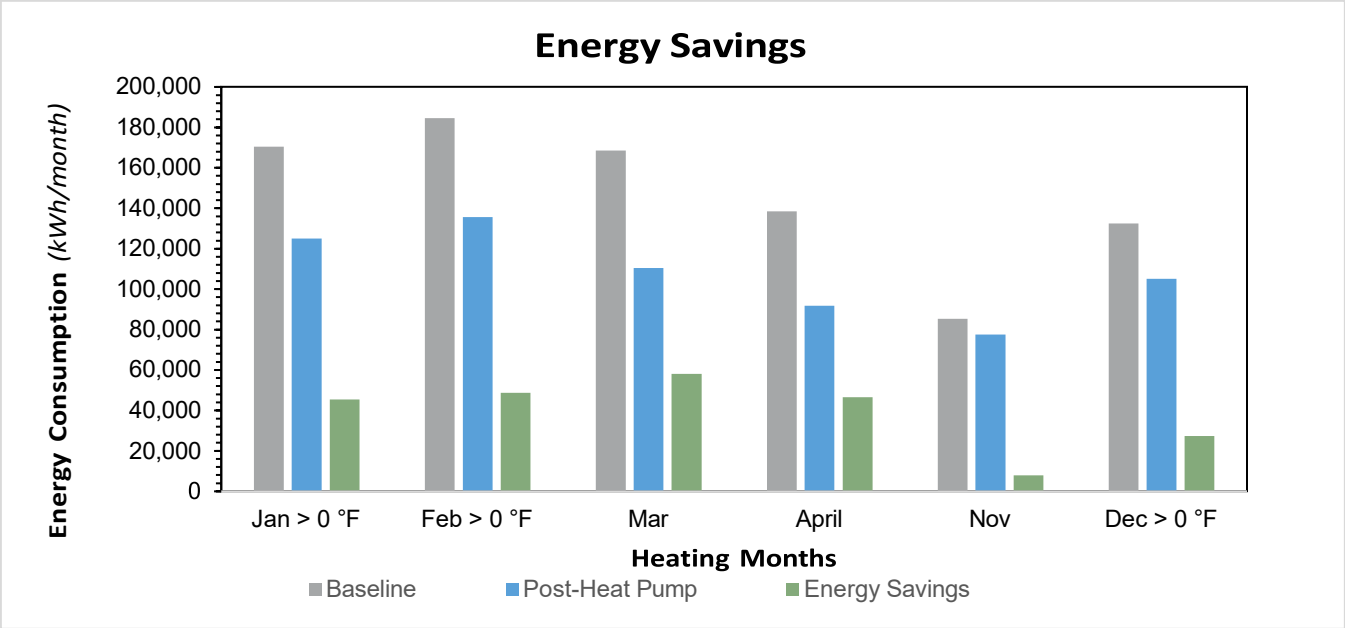

Figure 6: Oshawa Creek - Energy Savings

Figure 6 shows the approximate amount of energy savings per month due to the use of heat pumps alone where outdoor temperatures are above -17°C (0°F). This is all showing an ideal situation where the most savings would occur during heating season. However, on days where the temperature drops below -17°C (0°F), as previously mentioned there would be no savings as the electric baseboard heaters would be used instead of the heat pumps due to the cutoff point when the heat pump would no output heating due to the outdoor temperature. Therefore, the savings shown in the chart would be reduced by a factor of however many cold days (below -17°C (0°F)) there are.

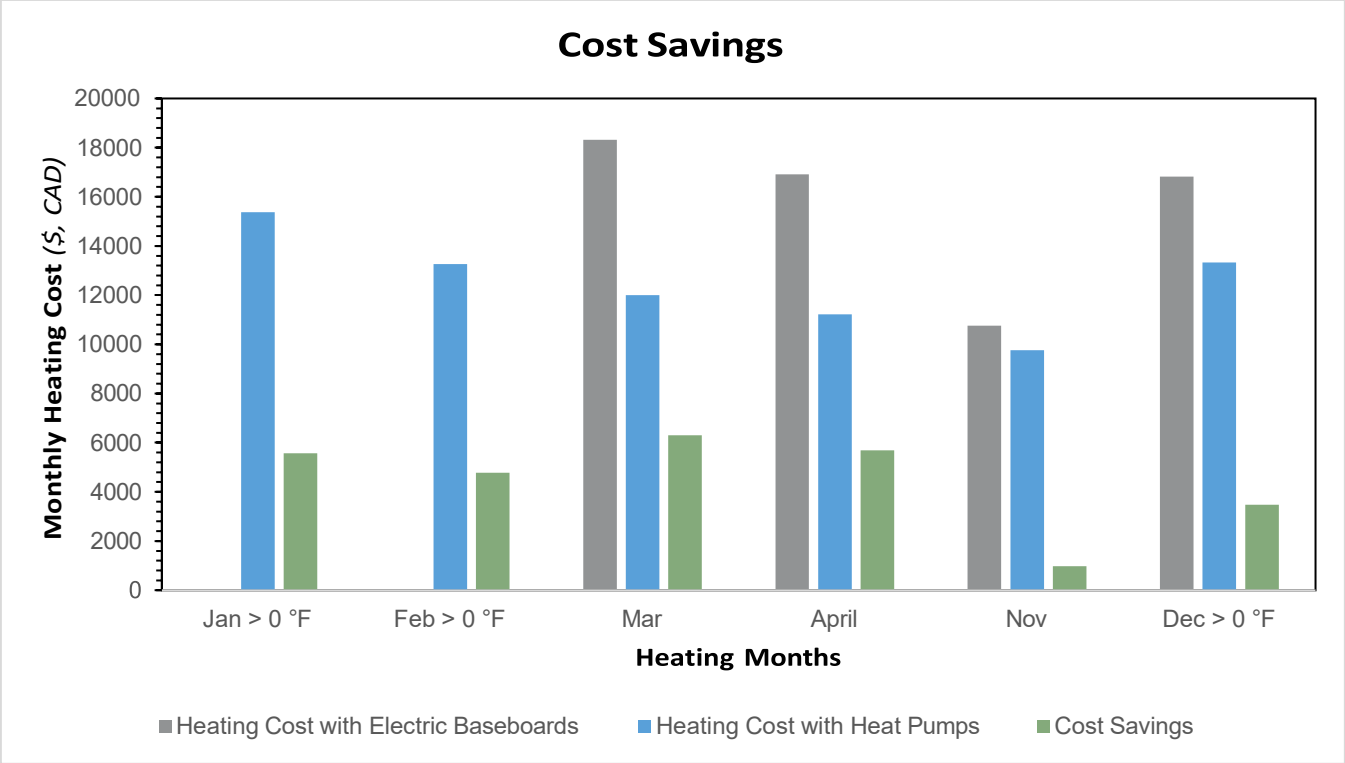

Figure 7: Oshawa Creek - Cost Savings

A brief cost analysis was also carried out to provide an idea of what the average operating cost savings would be with the heat pumps retrofits. Average cost savings at Oshawa creek was found to be around $4,500, as shown in **Figure 7**. Similar to the energy savings chart, cost savings were analyzed for conditions using only heat pump (above -17°C (0°F)). Since the low-end outdoor temperatures below -17°C (0°F) would utilize the electric baseboard heaters, no savings would be happening for those days. Though the very cold days in heating seasons are limited and equate to less than approximately 100 hours per year, they need to still be considered.

BLACK CREEK RESULTS

A savings analysis was also carried out on Black Creek housing, and the results are displayed in **Figures 8** and **9**. No cost savings analysis was conducted as MH was only provided with the monthly energy consumption from the hydro bills; no costs were given.The benefit of the heat pump technology is realized at temperatures between -17°C (0°F) where the COP is 1.2 to an outdoor temperature of approximately 4°C (40°F) when the COP is as high as 3.2. The existing electric baseboard technology has a constant COP of 1.0 whenever heating is required (at temperatures below -17°C (0°F)).

It can be seen on the graph that there are no energy savings happening below -17°C (0°F). That is because electric baseboard heaters will likely be operating at these lower temperatures since the efficiency of the heat pumps would be reduced.

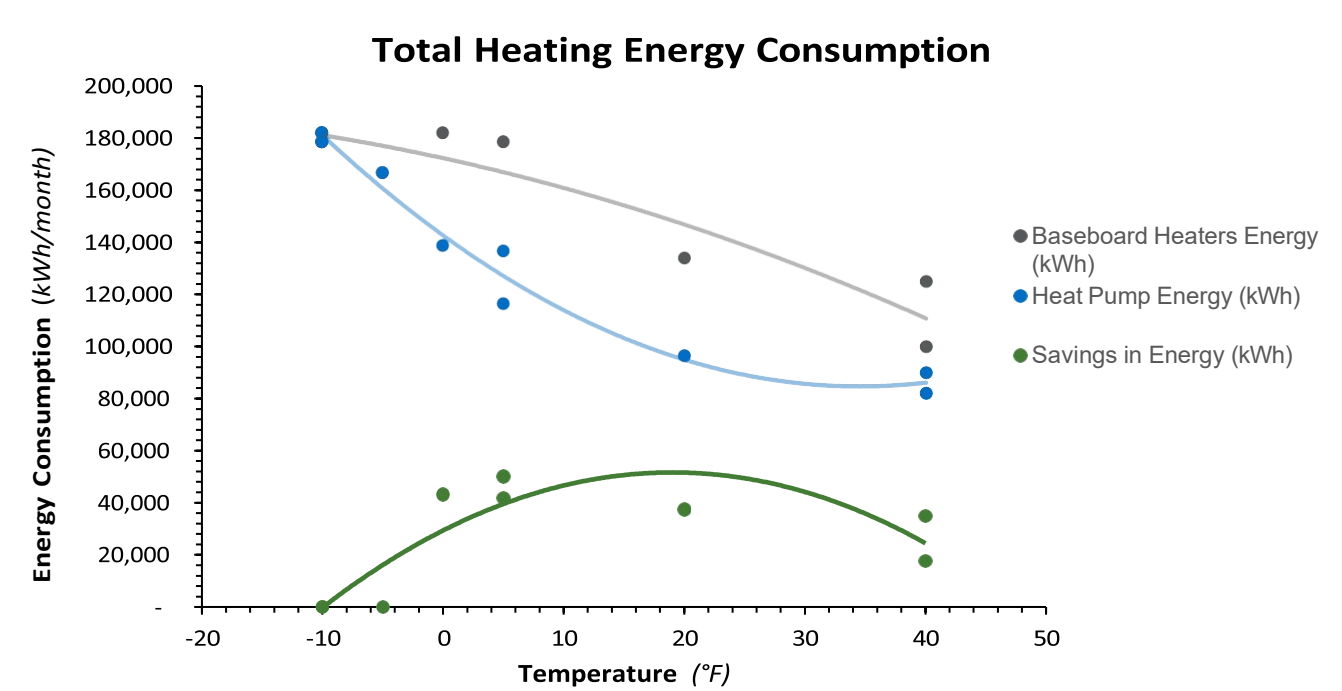

Figure 8: Black Creek - Total Heating Energy Consumption

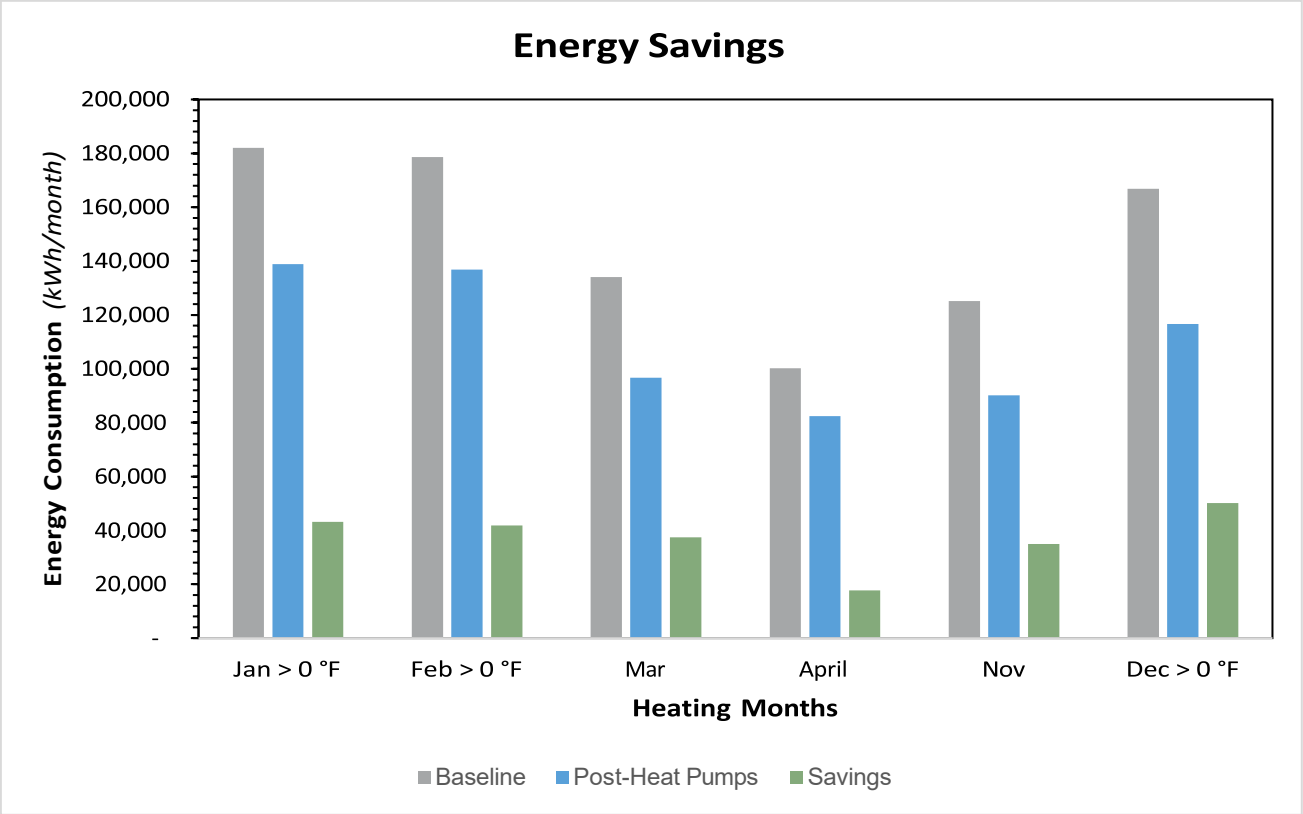

Figure 9: Black Creek - Energy Savings

CLOSE OUT

Findings show that the addition of heat pumps to both developments provide energy savings of up to 21-34% at the Oshawa Creek development, and 12-30% at Black Creek housing. A cost savings analysis was carried out for the Oshawa Creek site, and it was found that hydro bill costs could drop as much as $4,500. In addition to the energy and cost savings benefits during heating seasons, incorporating the new heat pump designs at both developments will have the added benefit of providing air conditioning for cooling. While this will result in higher hydro bills through the summer during the cooling-summer seasons, there will be improved ventilation, air circulation and thermal controllability provided to the occupants throughout the year with the incorporation of heat pump systems .