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Musqueam First Nation Public Buildings Decarbonization Plan

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Disclaimer

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organizations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability and climate action across the region.

This project was conducted under the mentorship of xʷməθkʷəy̓əm (Musqueam Indian Band) staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of xʷməθkʷəy̓əm (Musqueam Indian Band) or the University of British Columbia.

Territory Acknowledgement

The author acknowledges that the work for this project took place on the unceded ancestral lands of the xwməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), Stó:lō and Səl̓ílwətaʔ/Selilwitulh (Tsleil- Waututh) Nations.

Project Objective

Musqueam Public Works Department operates and maintains multiple public buildings on Musqueam Indian Reserve #2. The buildings are used for different purposes by the community members including but not limited to gatherings, ceremonies, workshops and education, and community events. All the public buildings have space heating and hot water equipment.

The purpose of this project is to assess different aspects of a building decarbonization plan including capital cost, operation and maintenance cost, utility bills, and Greenhouse Gas (GHG) GHG emission reduction potential. The budget cost impact will be determined based on the upfront cost including equipment and installation, and utility bill cost of using different heating, cooling, and water heating systems in the buildings. The building energy performance will be compared to a baseline and will be assessed based on the lifecycle of the equipment. In the baseline scenario, natural gas is used in public buildings in space heating and hot water systems with the existing equipment. The decarbonization plan is focused on replacing the existing systems with heat pumps for space and water heating.

Scope of the work

This project originally involved six buildings with different uses located in the Musqueam Indian Reserve #2. This project focuses on the three main buildings that have higher energy consumption and are more frequently used in the community. The scope of the work includes sizing the alternative Heating, ventilation, and air conditioning (HVAC) equipment, estimating the capital cost associated with system replacement, and calculating the estimated utility bill change and GHG emission reduction from the decarbonization plan.

Current Buildings Performance

In order to analyze and evaluate retrofit alternatives, it is crucial to understand the actual performance of each building. The Musqueam Public Works Department has provided energy audits conducted in 2021, along with the electricity and natural gas consumption data to date. The energy audits include general information about the current mechanical systems, their conditions, and potential opportunities for improvement.

After analyzing the energy consumption data for each building, an estimate of the energy consumption per square foot for each building was compared to a baseline based on Energy Star. The Energy Star benchmark provides the average building energy performance based on a portfolio of buildings depending on their use.

In addition to the average energy consumption throughout the year, the energy audits provided the heating peak load from recent years that is required to size the correct mechanical equipment to provide thermal comfort in the buildings. The heating peak load considers the current operating hours of each building, which are 200 hours per month.

Current Mechanical Systems

The three buildings investigated in this work have air handling central units that provides heating to the building, and in some cases supported by a secondary system such as a natural gas boiler. The efficiency of the Air Handling Units (AHUs) is assumed to be 80%. Each of the AHUs has a different capacity to meet the building's thermal comfort requirements. The capacity and type of existing HVAC equipment is extracted from the energy assessment reports.

Retrofit Solutions

The retrofit solutions investigated in this work is focused on replacing the HVAC equipment in the buildings. Replacing the old systems with new HVAC equipment can significantly reduce greenhouse gas emissions and ensure compliance with current energy efficiency and environmental standards, referred to as baseline requirements. Heat pumps are a cost-effective solution due to their high efficiency in both heating and cooling modes, leveraging ambient air temperatures to transfer heat rather than generating it from scratch. This study will investigate the cost associated and GHG emission reduction potential of replacing the existing systems with air source heat pumps.

Retrofit Budget Cost

The first step in determining the retrofit cost is to calculate the size of the heat pump required to provide thermal comfort to each building. There are two ways to size the heat pump for the building: using the current mechanical system capacity or using the heating peak load.

While sizing the heat pump based on the existing mechanical system capacity, it is important to consider the current equipment efficiency, which determines the actual capacity required for replacement, and the heat pump coefficient of performance (COP).

To calculate the heat pump size considering the historical heating peak load, it is necessary to determine the consumption per hour. Therefore, dividing the heating peak load by the operating hours (approximately 200 hours) gives us the maximum capacity required. Once the maximum capacity required is calculated, the efficiency of the current mechanical equipment should be incorporated to obtain the actual capacity required. Therefore, we can determine the heat pump size required for each building based on the real heating peak load.

The difference between the two methods arises from various factors including the original sizing accuracy of the HVAC system, the building's operational patterns, and occupants' energy use behaviors. Poor airtightness and inadequate insulation can increase heating and cooling demands, while neglected maintenance can reduce system efficiency.

To obtain the correct size of the heat pump, it is necessary to perform an energy model that incorporates the envelope properties, mechanical systems involved, equipment, lighting, operating schedule, etc. For the purpose of this project, the two methods provide a budget range to evaluate the cost-benefit opportunity of replacing the mechanical equipment for each building.

Green House Gas Emissions Reduction

Since the current mechanical systems operate with natural gas as the primary source, there is an opportunity to reduce greenhouse gas emissions by replacing natural gas consumption with electricity. According to sources such as the Government of Canada's Greenhouse Gas Equivalencies Calculator, natural gas typically emits about 53.07 kg CO_2 per GJ, and BC Hydro reports an emissions factor of approximately 0.0062 kg CO_2 per kWh (1.72 kg CO_2 per GJ) for electricity, reflecting the low carbon intensity of hydroelectric power in British Columbia.

To estimate the greenhouse gas (GHG) emissions that would be generated by the heat pump, we need to calculate the natural gas consumption considering the equipment efficiency of 80%. Then, dividing the natural gas consumption by the heat pump COP will determine the electricity consumption that will replace the gas consumption associated with space heating. Finally, summing up both the electricity consumption generated by space heating and the building equipment will give us the total electricity consumption.

Utility Bills Savings

To estimate the bill savings, we assume the average cost of natural gas in Vancouver is around $11 per GJ, while the average cost of electricity is around $0.12 per kWh. These rates are based on current pricing data from FortisBC for natural gas and BC Hydro for electricity.

First, we calculate the current total cost per year including electricity and natural gas. Secondly, the natural gas cost associated with space heating is converted to electricity due to the heat pump retrofit and added to the current electricity consumption to obtain the total electricity consumption after the retrofit. The table below illustrates an estimate of the possible savings that can be achieved per year for each building after replacing the mechanical equipment with heat pumps:

The analysis shows that despite there won't be considerable cost savings from replacing the mechanical equipment with heat pumps, the reductions in greenhouse gas emissions are significant. The reason for the modest cost savings is due to the low cost of natural gas in Vancouver.

When comparing the energy performance of the buildings with the Energy Star baseline after the retrofit, we notice that only one building does not meet the baseline benchmark. However, there is a significant reduction in energy consumption per square foot.

Retrofit Implementation Timeline

Considering that the Office building was upgraded last year, and mechanical equipment typically needs replacement every 15-20 years, the next retrofit for this building should be planned around 2040. However, both the Cultural Centre and the Recreation Centre buildings were built in 2010 and have not been upgraded since then. These buildings should undergo retrofitting between 2025 and 2030.

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