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GHG Reduction Pathways Feasibility Study - Final Report

PORT MOODY City of the Arts

City of Port Moody

Project Number: 2021104

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1. EXECUTIVE SUMMARY

In 2019 the City of Port Moody declared a Climate Emergency acknowledging the urgent need to limit the impacts of climate change and set aggressive targets to achieve carbon neutrality by 2050 on a community basis, and by 2040 on a corporate basis.

To achieve this target, the City has developed a series of priority actions to identify and implement carbon reduction initiatives. One initiative, addressed by this project, is to conduct energy assessments of 22 City owned facilities for carbon reduction measures, evaluate potential savings and costs for each, and develop carbon reduction pathways for achieving the targets.

Using the results of the energy assessments, four different pathways were modelled, as outlined in the table below. Our pathways modelling yielded an estimated carbon emission reduction by 2030 and 2040 over 2017 base period levels for four different scenarios:

- Pathway 1: Equipment is replaced with the low GHG emission CRM recommend in the building audits and system redesign is not considered. It achieves the Climate Action Plan goals; however, it does not meet the Climate Ready Homes and Buildings Plan targets.
- Pathway 2: Building on low emission equipment replacement in Pathway 1, CRMs are selected to achieve lowest total project costs prior to 2030 and achieve all City emission reduction targets. System redesign CRMs are included.
- Pathway 3: Similar to pathway 2, but CRMs are instead prioritized by positive NPV and simple payback to achieve all City emission reduction targets. To achieve this, equipment renewal in some cases is accelerated by up to 10 years.
- Pathway 4: An alternative pathway that reduces the total project costs prior to 2030 by caping annual project costs before 2030. It does not achieve the 2030 emissions reduction target, but it does achieve the Community GHG emission reduction targets.

The results from this modelling are shown in the table for each pathway in Table 1 and financial analysis in Table 2.

Table 1: Pathways Results Summary

Pathway	Basis	Result % reduction in GHG emissions over 2017 base period levels	
		By 2030	By 2040
Target	*"Climate Ready Homes and Buildings Plan"*	***80%***	***100%***
1	Equipment Renewal	41%	54%
2	Total Project Costs Prior to 2030	80%	97%
3	Positive Simple Payback and NPV	80%	97%
4	Balanced Annual Project Costs	58%	97%

Table 2: Pathway Financial Analysis Summary

Pathway	Incremental Project Costs Prior to 2030*	Project Costs After 2030	NPV – 2050	No. Projects Prior to 2030
1	$661,000	$3,820,000	$88,000	22
2	$5,039,000	$3,667,000	-$4,340,000	32
3	$5,742,000	$2,964,000	-$4,325,000	51
4	$1,601,000	$7,105,000	-$4,684,000	47

**figures presented not adjusted for inflation*

All four pathways present unique characteristics, advantages, and disadvantages. Ultimately if the City wishes to achieve their target of 80% emission reductions by 2030 the most aggressive pathways (Pathway 2 or Pathway 3) needs to be followed.

Through full electrification and elimination of natural gas in City owned facilities, the City is able to achieve carbon neutrality on a *Scope 1 (direct)* emission basis (i.e. emissions associated with combustion of fossil fuels on site). This can be achieved through any of the options within Pathways 2, 3 and 4.

However, to achieve carbon neutrality on a *Scope 2 (in-direct)* emission basis, this relies in part on the Provincial government / BC Hydro reducing the electricity emissions factor associated with the BC Integrated Grid. This factor cannot be influenced by the City, and unless the emissions factor reduces significantly in the future, the City will be required to invest in renewables, offsets, renewable energy credits, and/or other means to close the gap to net zero on a Scope 2 (in-direct) basis.

It is important that the City reassess options to close the gap to net zero as the City moves closer to the 2030 target. The advancements of new technologies, available rebates, funding options, and more accurate forecasting of grid emission factors will help solidify the pathways moving forward.

Due to the ambitious 80% reduction by 2030 target, 41% of identified projects must be implemented before 2030, resulting in low total cost and NPV differences between Pathway 2 and 3. Therefore Pathway 2 due to its slightly lower upfront costs is recommended and shown in the image below. As can be seen, the total GHG emissions by 2030 hit the 80% reduction target, and by 2040 approach net-zero. Achieving net-zero emissions in 2040 is possible by combining Solar PV and purchased offsets and credits.

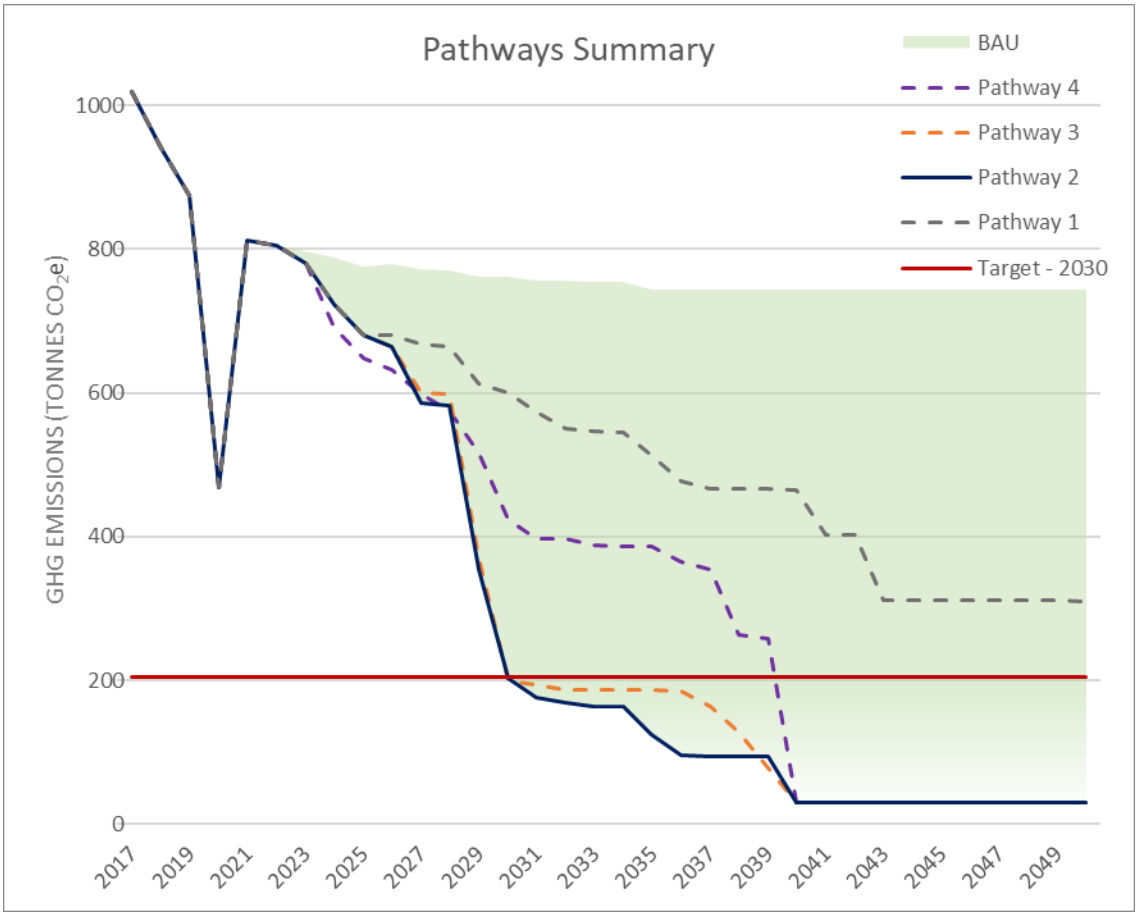


Figure 1: Recommended Pathway 2

If the City wishes to come close to achieving the net-zero by 2040 target, action needs to begin immediately to move forward with implementing high priority carbon reduction measures (CRMs) across the portfolio. In particular, a high importance should be placed on the Recreation Complex heat recovery measure. Every year that implementation of CRMs is delayed will compound the effort required to implement in later years of the pathway. Planning for implementation of CRMs, including capital budget requests and securing external funding, is a critical next step.

2. INTRODUCTION

2.1 Climate Action Plan

In 2019, The City of Port Moody declared a Climate Emergency to accelerate action to address climate change. From this declaration, the July 2020 Climate Action Plan was developed to set GHG Emission reduction targets and to outline steps that need to be taken to meet those targets.

City of Port Moody's Climate Action Plan is a community-wide plan that focuses on actions related to mitigation and adaptation towards climate change. The plan encompasses a broad spectrum of community aspects including the natural environment, transport and mobility, infrastructure, and buildings.

The Climate Action Plan recognizes that buildings in Port Moody are the source of almost half of the GHG emissions produced in the community, and 97% of these emissions are from fossil fuel energy sources such as natural gas. In the provision of its services, the City of Port Moody also owns and operates many buildings. The energy used at these City owned facilities results in 54% of GHG emissions for City operations. Most of this energy use is attributed to a few buildings that provide a great benefit to the community including, the Recreation Complex, City Hall, and other community centres.

In July 2022, the City outlined specific facility emission targets in the Climate Ready Homes and Buildings Plan. Together with the City's Climate Action Plan, several goals and targets that apply to civic facilities that prioritizes reducing greenhouse gas emissions from buildings, are detailed below:

Building-Related Climate Action Goals:

- Design/construct/renovate buildings that:
  - Are durable and more likely to withstand or recover quickly from the anticipated effects of climate change;
  - Use relatively little energy to operate; and
  - Provide a healthy indoor environment with good air quality.
- Design/construct/renovate buildings with:
  - Materials that are associated with low levels of embodied carbon; and
  - Materials that store carbon.
- Use sources of energy that produce lower amounts of greenhouse gas emissions and energy systems that are more likely to withstand or recover quickly from disruptive events.

Table 3: Building-Related Climate Action Targets

	Climate Action Plan	Climate Ready Homes and Buildings Plan
2030	All new and replacement heating and hot water systems are zero emissions	80% reduction in civic facilities emissions below 2017 baseline
2040	-	Civic builds achieve net zero emissions
2050	All buildings have replaced heating and hot water with zero emission systems	-

2.2 Project Introduction

The City of Port Moody has 22 civic sites with a total building service area over 230,000 ft^2. The major City buildings include City Hall, community centres, fire halls, daycares, police station, recreation centres, pools, and ice arena, and works shops. Minor City support facilities include residential, field houses and storage.

This report and analysis will support the targets and goals outlined in the Climate Action Plan. Specifically, this report aims complete the first civic facilities action item in the Climate Action Plan:

> ***"Perform comprehensive climate audits on all civic facilities and prioritize upgrades where feasible and highest risk."***

Through the Federation of Canadian Municipalities (FCM) Community Buildings Retrofit (CBR) initiative, the purpose of this program is to provide funding for a pathway study that provides valuable information for the City's capital planning decision making. The intent of the pathway study, as outlined in the FCM requirements, is to provide information that allows the City to craft capital plans that align with the City's GHG emission reduction goals, and encourage deep GHG emission reductions.

The graphic below outlines the study methodology, as per the FCM guidelines. The project consisted of multiple stages with the following deliverables, and then summarized in this report:

Deliverable 1: Detailed Energy Study Reports that identify carbon reduction measures (CRMs)

Deliverable 2: GHG Reduction workshops to engage stakeholders and define City opportunities, constraints and priorities that influence facility upgrade and capital planning decision making.

Deliverable 3: GHG Emission Reduction upgrade pathway

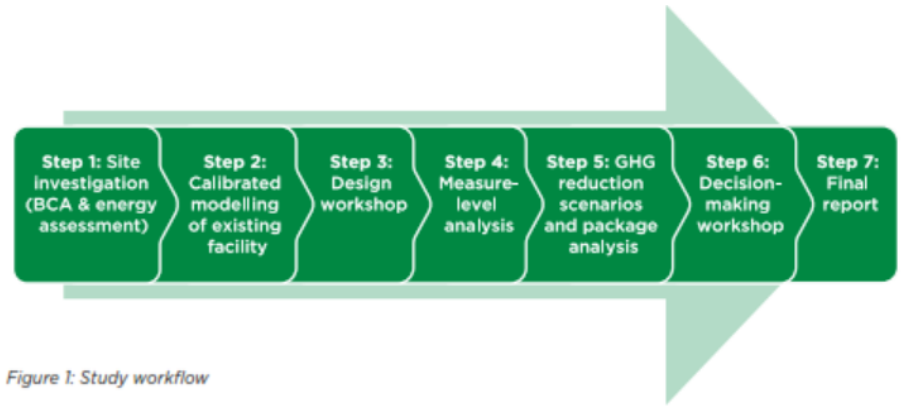


Figure 2: FCM Study Workflow

The following sections demonstrate multiple methods of prioritization for civic facility upgrades required to meet the Climate Action goals and targets outlined in the Climate Action Plan and listed above.

2.3 Project Objectives

The objectives of this project include:

- To enable the City to **meet their Climate Action goals** and objectives outlined above through conducting comprehensive climate audits on City owned facilities.
- To produce **carbon audit reports** that outline a list of tangible carbon reduction measures that could be implemented to achieve deep carbon reductions aligned with a pathway to net-zero by 2040 as outlined in the Climate Ready Homes and Buildings Plan.
- To provide the City with recommendations on a **pathway** to achieve deep carbon reductions that balances the greatest impact and greatest return for cost, and incorporate projects into the municipal budgeting and asset management process.
- To identify **potential grant and incentive programs** applicable to measures and actions that will result from the carbon reduction studies.
- To meet the requirements of the **FCM GHG Reduction Pathway Feasibility Study** program.

3. METHODOLOGY

The following outlines in brief the approach our team took to develop the carbon reduction pathways presented in this report.

3.1.1 Utility Data Gathering and Analysis

During the study, electricity, and natural gas data for 22 City owned facilities was obtained by Prism Engineering from the City and entered PUMA online utility monitoring software through the FCM Energy Monitoring Grant. PUMA was then used to analyze the existing energy use profiles at a building level, as well as providing us with a consolidated 2017 baseline for emissions from which the pathway emission reduction targets are based upon.

3.1.2 Site Visits

During fall 2022 site reviews were conducted with City representatives for 17 facilities to review building operations and to assess opportunities for carbon emission reductions for development of the Carbon Reduction Measures (CRMs). The review included an audit of the facilities heating, cooling and ventilation systems and controls, electrical capacity, and lighting systems. The City provided additional equipment lists, building drawings and studies to help support our review.

3.1.3 CRM Development and Analysis

Carbon Reduction Measures used in this Pathways Study were identified from detailed energy studies, and analysed with the following objectives:

- to develop a working model of the equipment and energy related systems in the building, including building operation and use;
- to review and analyze the energy use history and develop energy use baselines by equipment or system from which savings could be measured;
- to provide an analysis of existing electrical system and HVAC system performance and general condition;
- to determine opportunities for GHG emission reductions, and identify the impact of system upgrades on building performance, occupants and operations; and
- to provide a summary of carbon reduction upgrades and a financial analysis.

High-level cost estimates have been included for each proposed measure, including installation and equipment costs. Pathway cost analysis takes into consideration projections of future inflation and time value of money. Assumptions are detailed in Section 5.2.1.

3.1.4 Pathway Development and Analysis

The scope of the project is unique in the sense that a holistic approach must be taken to look at not only the best way to group energy and GHG reduction measures within facilities, but also how to strategically bundle projects to maximize the benefit for the City and emission reduction targets. This differs from a typical facility level study that may focus solely on the cost/benefit of individual measures.

Our six-step approach to deep carbon retrofits of existing facilities is outlined in the diagram below and represents a framework to base the pathway development. This approach is then

balanced with the City's needs, opportunities, and implementation barriers to prioritize projects.

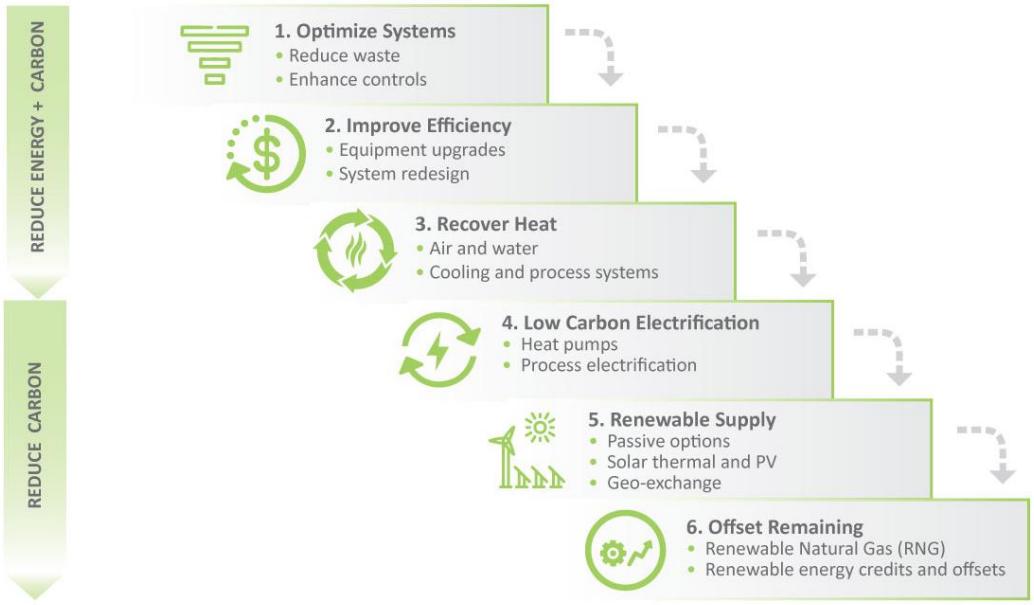


Figure 3: Net Zero pathway approach

From two workshop sessions, pathway key decision-making topics were identified based on discussion of current City policies, decision making processes and Climate Action targets. Within the context of City corporate operations, these topics were identified as the important information required for decision making. From these key decision topics, specific pathway goals were set:

Table 4: Summary of Pathway Goals

Topic	Pathway Goal	Pathway
Alignment with Emission reduction Targets and Goals	Achieve emissions reduction targets/goals	2, 3, 4
Equipment Renewal	Align equipment replacement with prescriptive climate action plan goals	All
Project Costs	Minimum costs required to achieve all climate action targets and goals	2, 4
Return on Investment	Maximize the long-term financial benefits to the City	3
Balanced	Balance project costs with emission reduction targets and goals	4

From the pathway goals, specific CRM metrics that describe each goal were identified. The CRM metrics employed are listed in Table 5.

Table 5: Summary of CRM Metrics

CRM Metric	Description
$/tonne	Cost investment required per tonne GHG emission reduction per year - indicates the financial efficiency for each CRM.
Simple Payback	The number of years required for utility cost and carbon tax savings to offset the initial incremental project implementation cost. It is an indicator of a project's ability to "break even" versus like-for-like replacement.
Net Present Value (NPV)	Comparison of lifetime project cash flow, accounting for inflation and utility rate escalation. Indicates the future value of CRMs for comparison in today's monetary value.
CRM cost	Total cost of implementing a CRM
GHG Emissions per project	GHG emission reductions per CRM
Equipment age	Age of energy consuming equipment. Replacing equipment significantly early increases the overall cost to the City, as equipment is scrapped before the full value of equipment life has been achieved.
Number of projects prior to 2030	Implementing many projects at one time requires significant project management resources. Recognising that the City has limited resources, prioritizing high GHG emission reducing projects is preferred to lessen the administrative burden on the City project teams.

Pathways were then developed by ranking the importance of each CRM metric against the pathway goal. The following table summarizes the pathway goals and the order of metric application in the final pathways. The first metric sets the measure selection floor, the second metric is coarse pathway refinement, and the third metric fine tunes the model to achieve City targets and pathway goals. Each pathway project selection was reviewed to ensure technical feasibility of measure implementation order.

Table 6: Pathway Development Summary

	Pathway 1: Equipment Renewal	**Pathway 2: Total Project Costs Prior to 2030**	**Pathway 3: Positive Simple Payback and NPV**	**Pathway 4: Balanced Annual Project Costs**
CRM Metric	Equipment replaced with identified CRM	Minimize total project costs prior to 2030	Positive simple and NPV	Minimize annual project costs while accelerating emission reductions
$/tonne				
Simple Payback				
NPV				
CRM cost				
GHG Emissions per project				
Equipment age and renewal				

CRM Metric Order of Application Key
1
2
3

4. OVERVIEW OF PORTFOLIO

4.1 Portfolio Energy Performance

The majority of emissions stem from recreation buildings. Figure 4 and Figure 5 below show that recreation sites outstrip other building use types in both total GHG emissions and GHG emission intensity (GHGi), respectively. The Recreation Complex is by far the largest GHG Emitting building by gross GHG emissions and the Rocky Point Pool and Westhill Community Centre top the GHG emissions per floor area. This is typical of pools with large process load (pool heating) and exaggerated because they are outdoor pools.

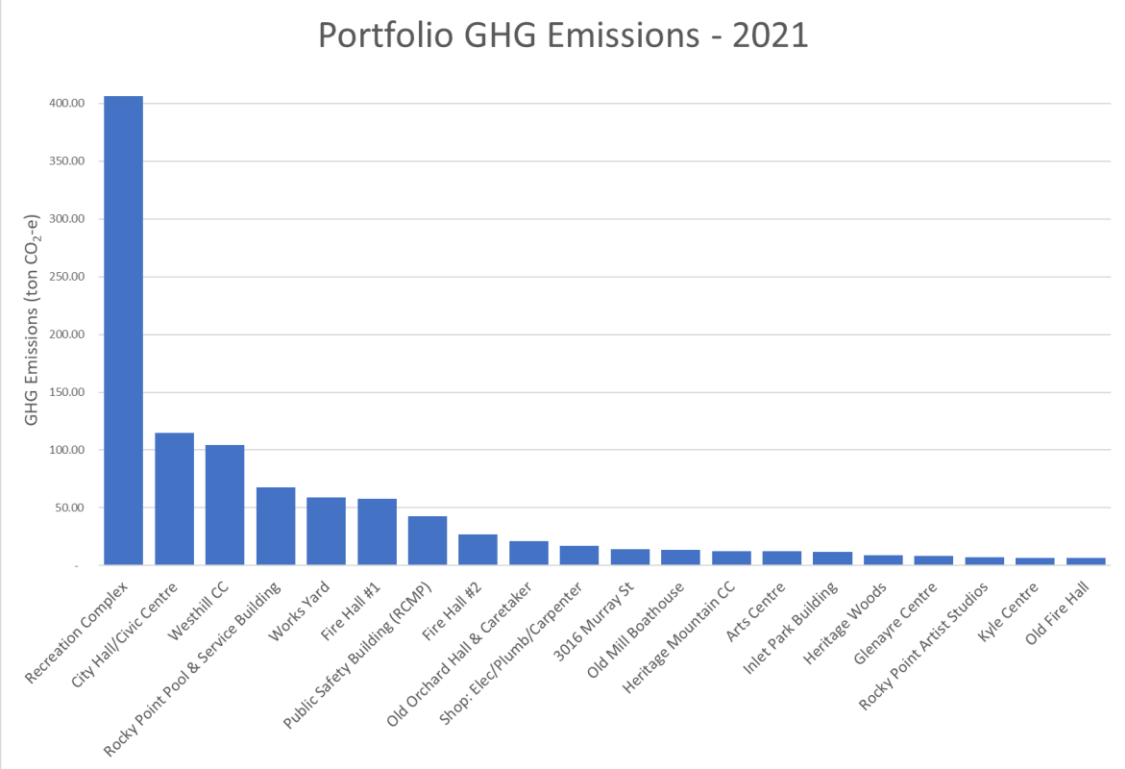


Figure 4: Summary of Portfolio GHG Emissions – 2021

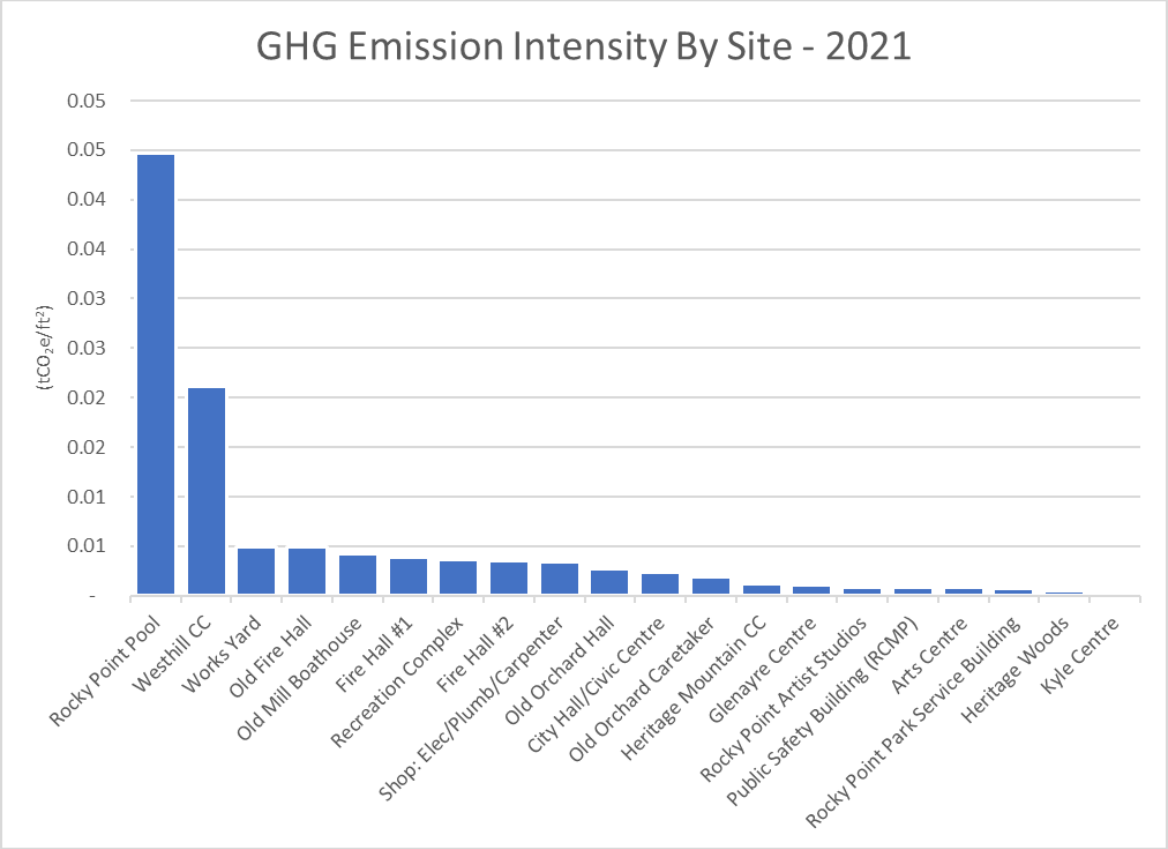


Figure 5: Summary of GHG Emission Intensity – 2021

4.2 Workshops

Two stakeholder workshops were conducted during the study..

Workshop #1 was conducted on August 8th, 2022. Table 7 summarized of the key workshop takeaways.

Table 7: Summary of Workshop 1

Topic	Key Points	Integration Into Pathway
Align with City Policy	Climate Action Plan	Baseline year 2017
	New targets from Climate Ready Homes & Buildings Plan	80% reduction for municipal facilities by 2030
Project Schedule	Project Milestones GHG reduction milestones	-

	Annual planning milestones	
Barriers to Plan Implementation	City Priorities	Council priorities may change with election cycle
	Emission reduction opportunities	Facilities team focuses on ensuring City service continuity. Unforeseen equipment failures are opportunity for upgrades, but budget for upgrades not pre-approved
Which non-energy benefits are most important to the City?	Strategic	• City adopted in Sept 2022 the Extreme Weather Resilience Plan • Identify measures with both emission reductions and improve climate resiliency of City services: Extreme heat, add cooling. • Public perception • Improved IAQ
	Financial	• Reduce up front cost • Long term savings
	Facilities	• Alignment with capital plans and asset renewal • Occupant comfort
	Maintenance	• Simplicity of proposed systems • Avoid proprietary systems • Reduce maintenance and downtime
Are there any decarbonization measures that you think WON'T work? If so, which one(s)?	Solar PV	Previous study showed low ROI
	Pool heat pumps	• Heat pump at Westhill pool that never worked properly. It was decommissioned and replaced with condensing boiler. • Opportunity for Rocky Point pool. Heating equipment is slated for capital renewal in 2024
What additional measures or suggestions do you have about how your buildings could be decarbonized?	DDC	• DDC upgrade I coming, RFP posted. • Adding some sub metering as part of DDC upgrades
	RCMP Building	• Site has funding to re and re existing system. Mechanical equipment in building is reaching end of life. • No DDC control previously.

What is Port Moody's capital planning schedule?	**Capital projects is 5yr rolling cycle plan.** **Facility condition reports completed in 2013 and due for update**	**Only like-for-like replacements have budget approval**
Opportunities	Upcoming capital renewal projects	• 2024 Rocky Point Pool heating equipment renewal • 2023 Westhill Community Centre renovation • DDC upgrades out for RFP

Workshop #2 was conducted on March 14th, 2023. This workshop included an overview of the energy audit findings, and a presentation of a draft pathway analysis. The key takeaways from the meeting are summarized in below.

Table 8: Summary of Workshop 2

Topic	Key Points	Integration Into Pathway
Project Costs	City Budget	Interested in potential fund for infrastructure and investments.
	External Funding	• Looking to maximize the funding opportunities. • Include discussion on funding opportunities.
	Pathways presentation	• Incremental costs over approved budget • Looking to translate pathway in terms of cost above and beyond the incremental costs: simple payback, NPV, Up front cost is the most important.
Decision Making	Need to have more capital planning and funding discussions internally	• Present to council • 2021 a resolution was approved for Port Moody staff to suggest creative funding mechanisms to council. Example: Directing other revenue streams into GHG planning fund

Non-energy impacts	**Climate Change**	• **Resilience measures** • **IAQ** • **Cooling**
	Training and Maintenance	• Training an issue in adopting new technology. • Overcome with initial and ongoing training. Use contractors for specialities • Unions are an important consideration. • Risk for increased downtime and cost when contracting out
	Measures considered but not included	• Impact of building portfolio purchase/selling • District Energy • Solar PV • High efficiency fuel equipment (GSHP, CHP) • Renewable natural gas • Global warming potential of refrigerants

4.3 Carbon Reduction Measures

The following section provides a brief overview of CRMs identified for implementation as part of our detailed studies on the 22 City owned facilities. For CRM descriptions and savings details, refer to individual building energy audits.

4.3.1 Controls

Energy and emissions savings can be achieved by improving the control strategies of existing equipment. Many buildings in the municipal portfolio have limited or no control systems. Upgrading controls allows for implementation energy reducing strategies such as equipment scheduling, identifying equipment failures, temperature setbacks, and changes to control sequencing and strategies.

These measures typically have relatively low persistence when compared with equipment efficiency upgrades, and it is expected that to ensure lasting energy reductions recommissioning should be conducted on a periodic basis every three to five years.

4.3.2 Domestic Hot Water Electrification

Most domestic hot water is heated by natural gas fired heaters; however a handful of sites have electric resistance heaters. While electric resistance heaters produce DHW with relatively low emissions, there are more efficient heaters on the market that utilize heat pumps which can provide DHW with a coefficient of performance (COP) of ~3.5. This measure considers the installation of DHW heat pump systems where appropriate to replace gas fired heaters, thus reducing GHG emissions as well as total site energy use.

4.3.3 HVAC Efficiency

This category of CRM represents improving energy efficiency of existing HVAC equipment to reduce GHG emissions. In certain instances, this includes additional equipment such as pool covers to reduce heat loss or replacing of existing low carbon energy source equipment to support site electrification and address climate resiliency, such as replacing electric resistance heating with air source heat pumps.

4.3.4 Ventilation Electrification

This category of CRM includes furnaces, rooftop units, makeup air units and air handling units. An opportunity exists to retrofit existing gas fired ventilation units at end of life with dual fuel or fully electric ASHP packaged systems. By implementing this measure, many facilities may eliminate or drastically reduce fuel consumption. Furthermore, heating only units may benefit from the ability of heat pumps to also provide cooling during extreme heat events.

4.3.5 Heat Recovery

Heat recovery systems allow heat typically rejected from the building to be recaptured and used elsewhere.

In the Port Moody portfolio, the most significant emissions reduction measure is heat recovery from the ice plant at the Recreation Complex. The heat absorbed from the ice rinks is currently rejected to atmosphere outside, despite heating loads being present within the building. This

CRM proposes connecting the ice plant to the existing heating system to offset heating energy consumption.

Other heat recovery opportunities include using low grade heat exhaust air streams to pre-heat ventilation air.

4.3.6 Heating Plant Electrification

For facilities with hydronic (hot water) systems, there is an opportunity to upgrade existing natural gas boilers with air-to-water heat pumps. Older facilities typically require high temperature heating supply water, however low carbon electrification of heating plants using heat pumps produces low temperature heating water. Mechanical system upgrades to allow for low temperature heating may be required to support heat pump technology, most notably in the Civic Centre and City Hall. However, pools do not require such extensive upgrades and present excellent emissions reduction opportunities using heat pumps.

4.3.7 Unitary Heating Equipment

Some vehicle storage areas, workshops, garages and heated outdoor areas utilize gas fired infrared radiant heating tubes, gas fired unit heaters and hydronic unit heaters. To reduce GHG emissions, two main options exist: split-system air source heat pumps (ASHPs) be installed where possible, or electric infrared unit heaters.

4.3.8 Lighting

Lighting is not a significant source of GHG emissions, however the process of electrifying mechanical HVAC equipment will increase a building's electrical demand. Reducing the electrical load on the building through LED lighting retrofits may prevent or reduce the costs of electrical service upgrades required to accommodate heating electrification.

4.3.9 Envelope

Compared to mechanical system upgrades identified above, envelope measures described below tend to be more expensive and disruptive to occupants for less incremental GHG emission reductions. Envelope upgrade projects reduce the overall energy consumption of the building by reducing the impact on outdoor conditions on the indoor environment. Envelope thermal performance is important to the building's overall energy performance.

It is recommended to upgrade the facilities with envelope deficiencies including replacing poor performing windows, skylights, and doors and exterior envelope assemblies to National Energy Code of Canada for Buildings (NECB) prescriptive requirements.

4.3.10 Other Measures Considered

District Energy System

District energy systems (DES) describes a central heating or cooling system that serves multiple buildings. Most importantly DES are only as efficient as the central heating system. Benefits include the ability to decarbonize multiple buildings at one time and the ability to recover heat between buildings. However, system losses are greater the longer energy has to be transported and DES systems have a high implementation cost.

Given the physical distribution of buildings in the portfolio, DES would be prohibitively expensive. However, there is an opportunity to interconnect the Rec Complex and City Hall to capitalize on the availability of recoverable heat at the Rec Complex. Further discussion on this idea is detailed in the Civic Centre and Rec Complex energy audits. However, due to the significant investment and availability of other effective GHG reduction alternatives. It was not included in the pathway.

High Efficiency Fuel Equipment

Given the tight target set by the City for 2030, replacing existing fuel consuming equipment with more efficient equipment will "lock" the City into scope 1 emissions until that equipment reaches end of life, typically 15 to 25 years. Secondly, while natural gas is a lower cost fuel source, the efficiency gains from combine heat and power (CHP) or gas source heat pumps (GSHP) typically cost similar amounts to electrification, without the GHG emission reductions.

5. PATHWAYS

5.1 Summary of Results

The table below summarizes the results of each pathway compared to the emission reductions targets laid out in the Climate Action Plan and the Climate Ready Homes and Buildings Plan.

The Climate Action Plan approaches municipal facility GHG emissions from a prescriptive lens, defining what equipment will be replaced with low carbon equipment. The Climate Ready Homes and Buildings Plan sets more ambitious emissions reduction targets by defining emission reductions relative to 2017.

- Pathway 1 achieves the prescriptive goals; however, it does not meet the relative emissions reductions.
- Pathways 2 and 3 present two different approaches to achieving both prescriptive and relative emission reduction targets while considering the financial impact of ambitious GHG emission reductions. The 2030 results of pathways 2 and 3 indicate that with significant resources (both financial and human) the City's targets and goals are achievable.
- Pathway 4 represents an alternative pathway that spreads out the up-front capital costs over time to align with the current assumed availability of City financial resources. It does not achieve the 2030 relative emissions reduction target, but it does achieve the 2030 prescriptive goal to replace heating and hot water systems with zero emission systems, and all 2040 targets.

Table 9: Summary of Pathway Results

Pathway	Basis	Result % reduction in GHG emissions over 2017 base period levels	
		2030	2040
1	Equipment Renewal	41%	54%
2	Total Project Costs Prior to 2030	80%	97%
3	Positive Simple Payback and NVP	80%	97%
4	Balanced Annual Project Costs	58%	97%
Target	Climate Ready Homes and Buildings Plan	**80%**	**100%**

In Table 10 below, all pathways presented have significant implementation costs. From workshop discussions, the City does not currently have dedicated funding mechanisms for projects beyond the BAU scenario. External funding opportunities are discussed in Section 6, however additional funding will need to be allocated if the City wishes to meet their GHG reduction targets modelled by the pathways. Therefore, for the City to meet it's GHG emission

reduction commitments, a dedicated emissions reductions fund (or similar) will need to be developed to support a successful pathway implementation.

Table 10: Summary of Pathway Financial Analysis

Pathway	Incremental Project Costs Prior to 2030*	Project Costs After 2030	NPV – 2050	No. Projects Prior to 2030
1	$661,000	$3,820,000	$88,000	22
2	$5,039,000	$3,667,000	-$4,340,000	32
3	$5,742,000	$2,964,000	-$4,325,000	51
4	$1,601,000	$7,105,000	-$4,684,000	47

**figures presented not adjusted for inflation*

5.2 Pathway Assumptions and Inputs

5.2.1 Assumptions

A number of assumptions have been applied to each pathway model, as outlined in the table below. Additional assumptions specific to each pathway are listed separately in each respective pathway section of the report.

Table 11: General Model Assumptions (All Pathways)

Affected Model Element	Assumption
Changes to City Operations	Modeling the impact on achieving emission targets was not evaluated for changes to City services, new buildings, buildings removed from the City's portfolio or significant operational changes.
Building Information Availability	While this project has included review of the majority of City owned facilities, sites that the City of Port Moody owns but not operate have not been included in our analysis. General recommendations and future steps from this project may apply to these buildings but they have not been modelled in the pathways shown. This also applies for any new buildings which may be constructed in the future.
Business as Usual Projection (BAU)	Business as usual is based on like-for-like replacement of existing equipment at end of life and no changes to building operations.

Pathway Start Point	**Electricity and natural gas consumption for 2022 provided by PUMA provides the last actual utility consumption data used in the pathways modelled in this report.** **All pathways assume implementation of carbon reduction measures will begin in 2024.**
Emissions factors	Emission factors for both electricity and natural gas are a critical model input, and present a significant sensitivity in the results. The following emission factors have been applied: Natural Gas: 0.0498 tCO_2e/GJ (Natural Resources Canada) Electricity: • Prior to 2022: BC Govt – Integrated Grid Factor[1] . • 2023 to 2050: Eighth National Communication and Fifth Biennial Report on Climate Change (2022), Environment and Climate Change Canada While the emission factor for natural gas will remain relatively constant, the factor for electricity is subject to fluctuation and has varied from as low as 25.3 tCO_2e/GWh in 2018 to 41.6 in 2011. This has a large impact on the pathway's models. Assumptions around projected future changes to emission factors are described below.
Equipment Life	Equipment serviceable lifespans informed equipment replacement year. Equipment life is based on ASHRAE recommendations.
Project Costs	Unless otherwise stated, the costs of CRM's are considered to be the incremental cost above like-for-like replacement. This represents the additional cost above the BAU scenario. For the purpose of our models, the project costs do not include potential incentives and rebates. More information on external funding sources is discussed in Section 6.
Annual inflation	3.0%
Annual utility inflation	2.5%
Discount Rate for NPV	3.0%

[1] https://www2.gov.bc.ca/gov/content/environment/climate-change/industry/reporting/quantify/electricity

Emission Factors

Historical Factors

The GHG intensity of the BC electricity grid is a significant factor to the selected pathway. Historical electrical emission factors used in this study are published by the BC Government using the Greenhouse Gas Industrial Reporting and Control Act (GGIRCA) methodology.

According to the 2020 BC Best Practices Methodology for Quantifying Greenhouse Gas Emissions[2] for public sector, local government, and community emissions, for the 2021 reporting year onwards, the emission factor will align with GGIRCA intensities[3] using a grid-based, instead of provider-based, approach. Recent guidance from BC Hydro also suggests moving to the GGIRCA "BC Integrated Grid" emission factors as a standardized approach.

The Carbon Emission Reduction model uses the GGIRCA BC Integrated Grid factor to determine the 2017 GHG emissions baseline.

Future Predicted Factors

Predicting the BC integrated grid emissions factor changes with full certainty is not possible. The Government of BC does not publish projected electrical grid emission intensities. Environment and Climate Change Canada (ECCC) publishes GHG emission factors for BC electricity, though the methodology is different to that of the GGIRCA. ECCC emissions intensity of electricity is determined by electricity generated in B.C.; the Government of B.C.'s includes the importing and exporting of electricity in addition to generation.

There are two main variables that are likely to impact the BC Integrated Grid emissions factor in the future. These are described in Table 12 below.

[2] https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/methodology/2020-pso-methodology.pdf

[3] https://www2.gov.bc.ca/gov/content/environment/climate-change/industry/reporting/quantify/electricity

Table 12: GHG Emission Factor Variables

Variable	Description	Timeframe	Expected Impact to GHG Factor
GHG factor calculation methodology	A potential change to the underlying methodology used to account for exported electricity as well as imported electricity would involve a shift from a gross import model to a net import model.	Near future (appx 2-3 yrs)	Decrease (medium)
100% Clean Energy Standard	The BC Government / BC Hydro plans to adopt a 100% clean energy standard, which would ensure all electricity generated in BC is from fully renewable resources. Site-C coming online within the next 5-10yrs impact GHG factors	Future (5-10 yrs)	Decrease (significant)

The Carbon Emissions Reduction model forecast uses the published ECCC data. Historical BC Integrated Grid factors from 2007 to 2020, as published on the Ministry's website[3] as well as the ECCC published projections, are displayed in Figure 6 below.

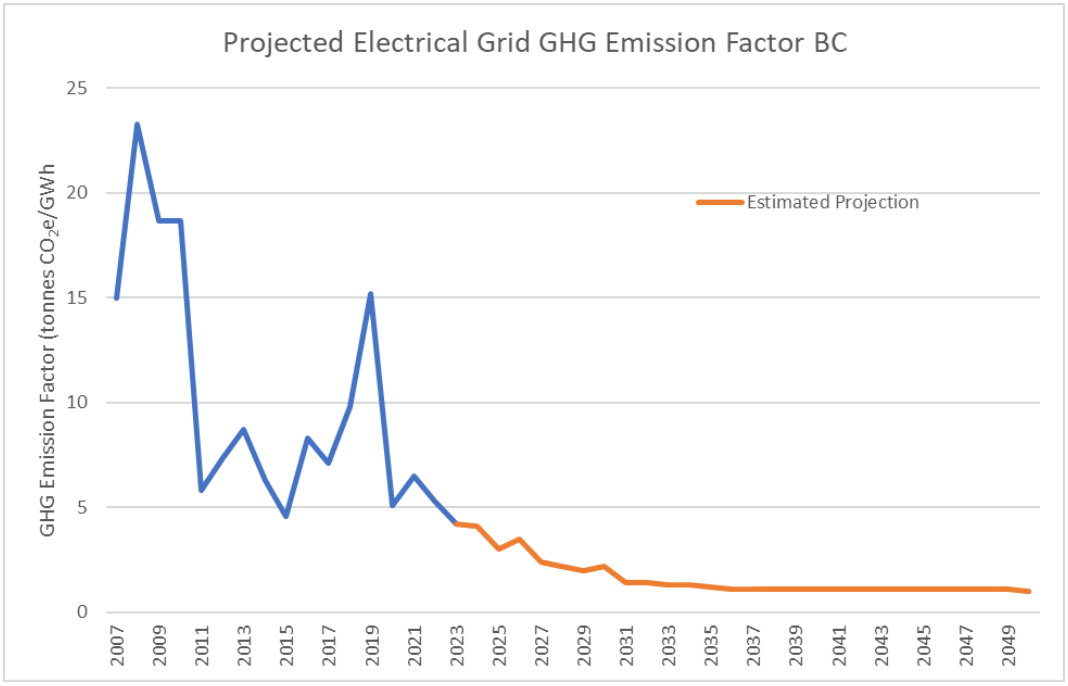


Figure 6: BC Grid Electricity Emission Factor (historical and predicted)

5.2.2 Model Inputs & Limitations

A number of data inputs into the Emission Reduction Model have been applied. These have been summarized below.

Table 13: Model Inputs

Model Input	Description	Notes - Confidence
Utility Data	Electricity and natural gas data for the period 2017 to 2022 was used to develop the emissions profile as a starting point.	2017 emissions are used as the baseline from which future reduction targets are measured.
Carbon Reduction Measures (CRMs)	The pathways presented utilize the results of the identified CRMs from our individual energy audit reports on City facilities to project the potential for carbon reduction across the portfolio.	The analysis reflects the potential for carbon reduction in these facilities as observed today. However, the facilities, equipment, and space usage will change in some areas between now and 2040, which will impact the CRMs that are viable in the future.
CRM savings	CRM emission reductions are based on engineering calculations and models detailed in the facility energy audits.	Site visits and available documentation was used to identify potential CRMs, however the values presented for potential emission reductions are estimates and cannot be guaranteed. GHG reductions and costs can vary significantly as each facility has unique characteristics, such as building envelope, mechanical systems and facility use. The impact of CRMs on GHG emissions is therefore representative of the potential reduction.

CRM costs	**We have used estimates from previous projects, information from suppliers, and other in-house tools to estimate the cost to implement each CRM.** **CRM costs also include estimates of 'soft' costs such as engineering, contingencies, commissioning, and contractor markups.**	**The costs associated with fully implementing each measure are based on estimates. These costs are not guaranteed and will vary in many cases once detailed engineering and design has been conducted.** **Cost of measure implementation will also vary over time and cannot be predicted into the future.** **All CRM costs have been adjusted for annual inflation based on the year the pathway assumes the CRM will be implemented.** **All CRM costs exclude incentives and rebates . A list of potential incentives is included section 6.2.**

5.3 Business As Usual

The business as usual (BAU) case represents the City's GHG emissions based on the budgeted capital planning funds. At the time of this study, only like for like replacement of equipment is approved.

Most GHG emissions in the Port Moody building portfolio are from fuel fired equipment. Under a like for like replacement regime there are three factors in fuel consumption, operations, wear and technology.

Operation: Fuel consumption can be reduced by matching equipment operation with building load. This is typically achieved with low-cost no-cost measures such as improved controls and recommissioning. Controls and recommissioning are considered low persistence fuels savings, and require frequent operation review to ensure measures are maintained.

Wear: As this equipment ages, wear and tear reduces the fuel efficiency of equipment. This is typically marginal in equipment that has been well maintained.

Technology: Energy efficiency standards gradually increase over time. In the past inefficient atmospheric style heating equipment was acceptable, but now condensing equipment is the standard. Condensing equipment can improve fuel efficiency by 20% if installed in optimal conditions, often not possible without system redesign. Secondly, many sites have already replaced low efficiency with higher efficiency equipment in the past 5 years, such as the Westhill pool and Fire Hall #1 boilers. Therefore, these sites will not achieve any efficiency gains at end-of-life renewal.

Combined, these three factors only make small emissions reductions. It is estimated that like for like replacement of existing equipment will only **reduce emissions by 6%**.

Of note in the pathway is the significant emissions dip in 2020. This is due to facility closures during the Covid-19 pandemic. As expected, they returned in 2021 and 2022 as public facility operation and occupancy restrictions were lifted.

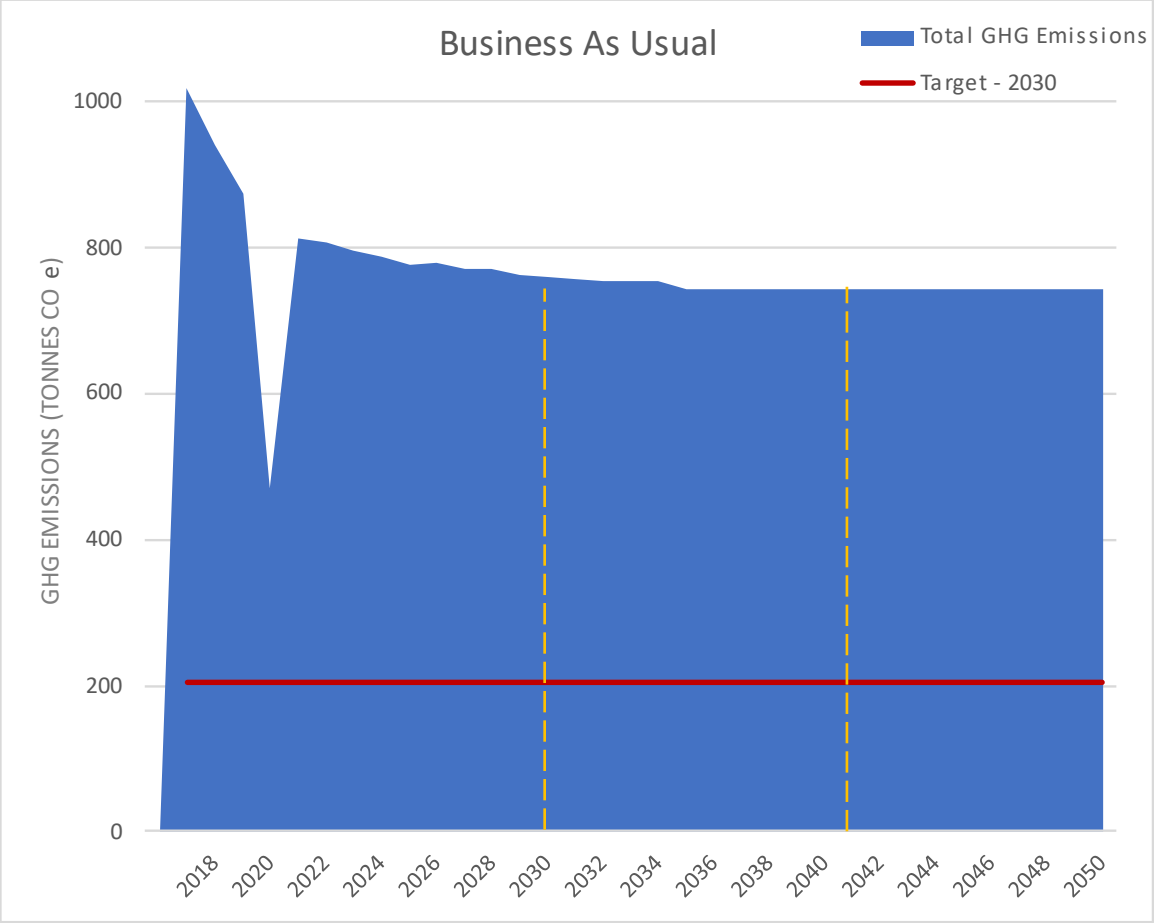


Figure 7: Business as Usual

5.4 Pathway 1: Low Emission Equipment Renewal

This pathway demonstrates the lowest additional budget commitment from the City based on only replacing equipment as it reaches end of serviceable life with low carbon alternatives. This does not include efficiency retrofits that require re-design or upgrades that would be necessary to maintain facility operation.

Based on replacing existing equipment alone, the City will achieve the corporate *Climate Action Plan* goal that all replacement heating and hot water systems are zero emissions by 2030 and community 2023 emissions reductions target. However it does not achieve the 2050 corporate goal, 2050 community target in the *Climate Action Plan* or 2040 corporate emissions targets set out in the *2022 Climate Ready Homes and Buildings Plan*.

Of note in the pathway presented is that the Recreation Complex would still be the largest GHG emission source of the portfolio. In this scenario, it is assumed that the heat recovery CRM at the Recreation Complex is not implemented because it is a system redesign CRM and not required for the facility to provide services. The critical path to achieving the 2030 target requires that heat recovery CRM at the Recreation Complex be implemented, as the emissions savings from that CRM alone is greater than the 2030 target emissions.

This pathway results in a **41%** reduction in GHG emissions by 2030, and **54%** reduction by 2040.

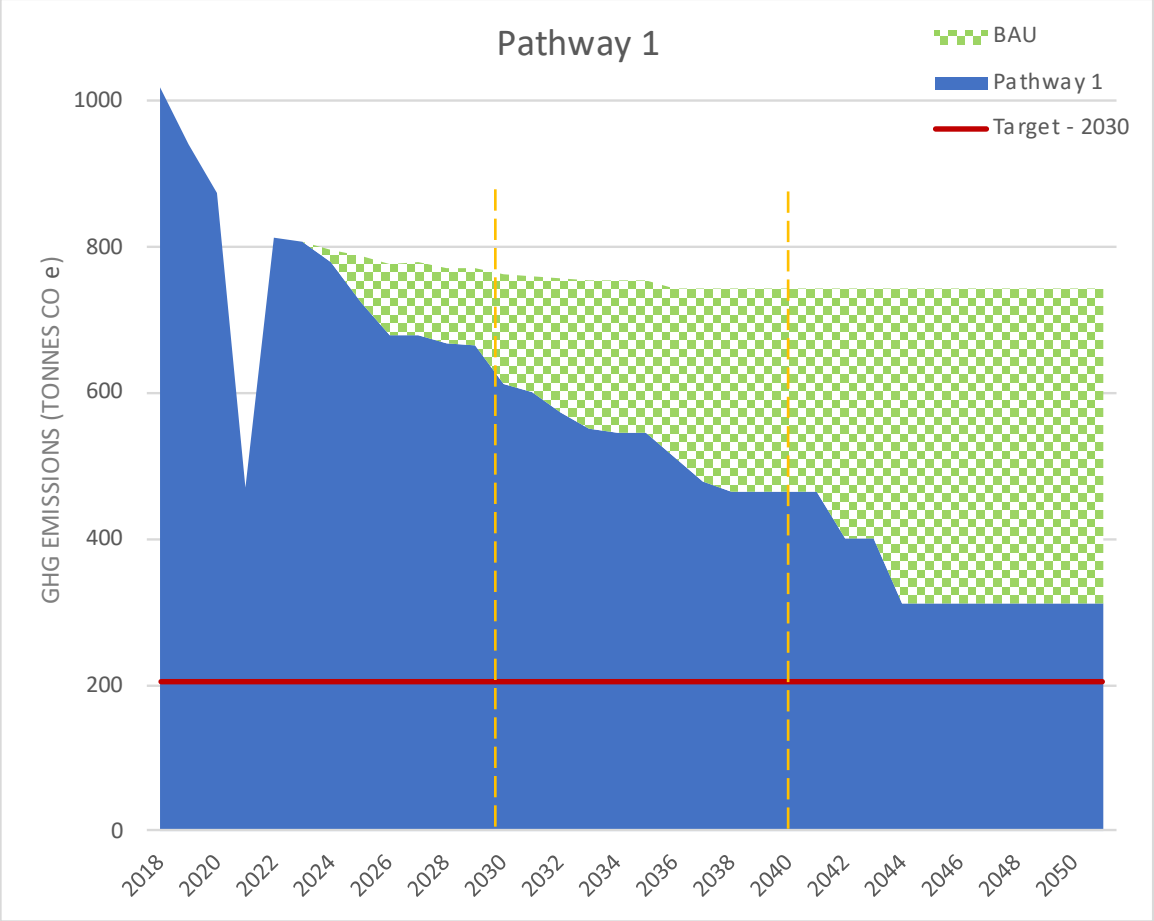


Figure 8: Pathway 1

Table 14: Pathway 1 Assumptions

Affected Model Element	Assumption
Remaining Life	For measures addressing equipment, the remaining life was estimated based on equipment age and typical life spans. All equipment is assumed to be replaced in the estimated replacement year.
Lighting	Lighting is not a significant emissions source, and lighting systems have long lifespans. It is assumed in this pathway that lighting system renewals would not be funded in favour of funding low emission equipment renewal.

The financial analysis shown in the graph below demonstrates that the incremental cost to replace equipment with energy efficient and low carbon CRMs will result in a positive return on the City's investment over time. The largest investment will come in 2041, with the anticipated replacement of the City Hall and Civic Centre heating plant.

As explained in Table 11, the costs represented in the graph below are the incremental costs for CRM's, not the total measure costs.

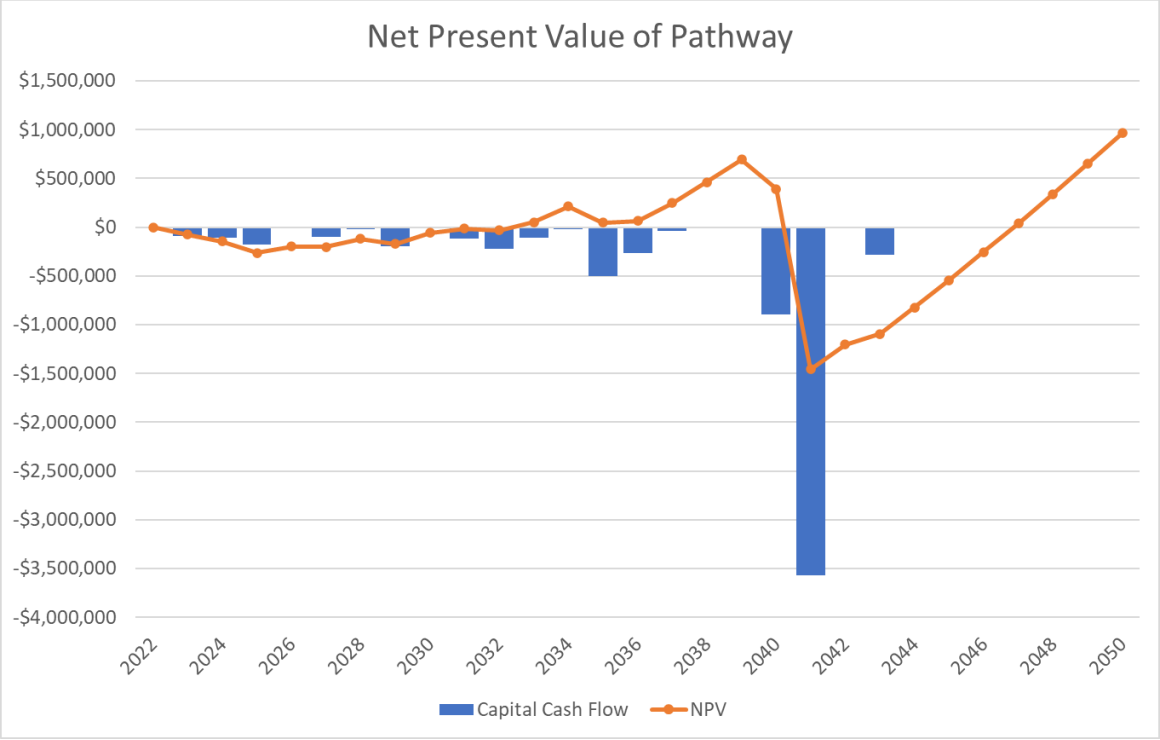


Figure 9: Pathway 1 Estimated Future Cash Flow and NPV by Year

5.5 Pathway 2: Lowest Capital Cost

The City has committed to ambitious GHG emission reductions. From the two project workshops, total up-front capital costs were the most important consideration to achieving these targets. Pathway 2 recognizes the financial investment is a major barrier for the City, and presents the lowest capital cost to the City in achieving all emissions targets.

In Pathway 1 all CRMs were implemented based solely on when their associated equipment was due for replacement (end of life), and the pathway did not achieve the City's emissions targets. Therefore, for Pathway 2 to achieve all City climate goals and targets, all CRMs identified including system re-design CRMs were selected.

This pathway results in an **80%** reduction in GHG emissions by 2030, and **97%** reduction by 2040. Note that the remaining 3% of emissions by 2040 represent the residual emissions associated with the electricity used. To close this remaining gap will require measures beyond system efficiency and fuel source CRMs and is discussed further in Section 7. All pathways are sensitive to unforeseeable changes, such as utility costs and GHG emission factors and are discussed in Section 6.

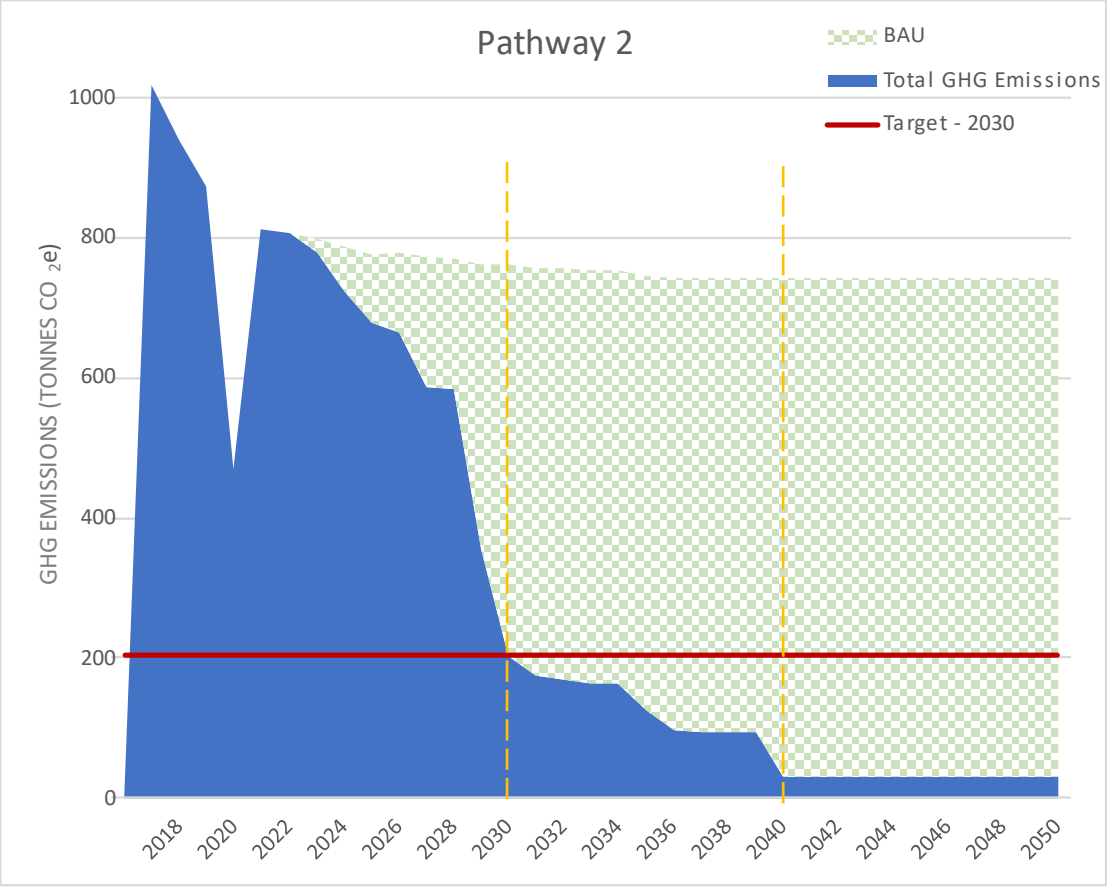


Figure 10: Pathway 2

Table 15: Pathway 2 Assumptions

Affected Model Element	Assumption
Remaining Life	For measures addressing equipment, the remaining life was estimated based on equipment age and typical life spans. All equipment is assumed to be replaced in the estimated replacement year.
Accelerated equipment renewal	To achieve the final 2030 target, four CRMs were implemented earlier than their replacement year by 5 years or less. These projects were: • Rec Complex Dehumidifier Electrification • Rec Complex MUA-4 replacement and heat recovery • Fire Hall #1 Domestic hot water electrification • Firehall #2 Rooftop Unit electrification
Efficiency	Efficiency CRMs not related to equipment replacement were included prior to 2030. These measures were: • Recreation Complex - Ice plant heat recovery • Westhill Community Centre - Pool covers • Carpenter Shops - Upgrade controls • Works Yard – Upgrade controls
Cost per annual tonnes of GHG emissions avoided	CRMs were filtered to achieve the target 2030 emissions reductions by excluding any projects costing more than $4,200 per tCO_2e avoided. This number was the lowest cost per annual tCO_2e avoided required to achieve the 2030 target.
GHG Emissions per project	CRMs were filtered to achieve the target 2030 emissions reductions by limiting the minimum annual tCO_2e avoided per project to 2.7. This number was the lowest annual tCO_2e avoided per project required to achieve the 2030 target.

The financial analysis in the graph below shows the increased capital cost to the City prior to 2030 to achieve its 2030 targets; the most significant being the Recreation Complex ice plant heat recovery project, assumed to be implemented in 2029 to align with the dehumidifier equipment renewal date. Further, the ice plant heat recovery (2029) and Civic Centre and City Hall heating plant electrification (2040) have significant impact on the NPV analysis, as both projects are significant expenditures with modest changes to utility costs.

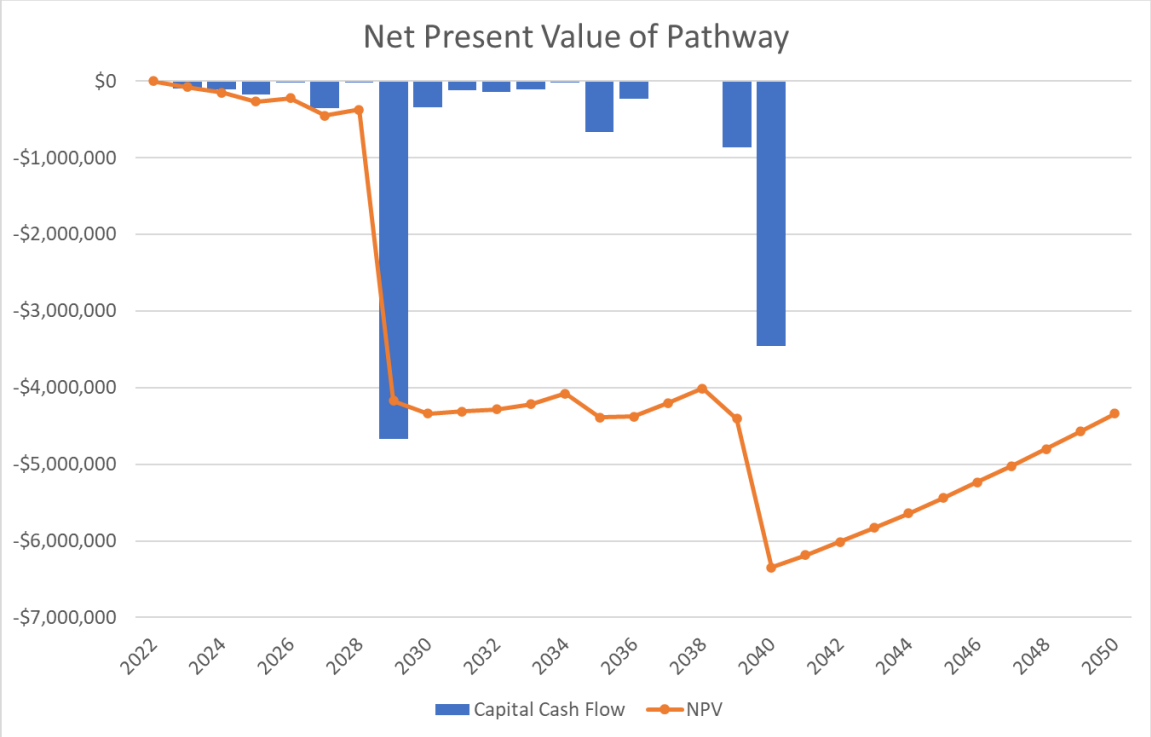


Figure 11: Pathway 2 Estimated Future Cash Flow and NPV by Year

5.6 Pathway 3: NPV & Simple Payback

Pathway 3 prioritizes CRMs with positive net present values (NPV) and simple payback to accelerate the City's return on investment. By prioritizing these projects early, the financial savings will accrue over a longer time to offset CRMs with poorer financial performance but are necessary in order to meet reduction targets.

This pathway deviates from pathway 1 and 2, as it allows equipment to be replaced early, by up to 10 years, and does not have a minimum emissions reductions per project requirement. This results in significantly more projects being implemented prior to 2030 than in pathways 1 and 2.

This pathway results in an **80%** reduction in GHG emissions by 2030, and **97%** reduction by 2040. Note that the remaining 3% of emissions by 2040 represent the residual emissions associated with the electricity used. To close this remaining gap will require measures beyond system efficiency and fuel source CRMs and is discussed further in Section 7. All pathways are sensitive to unforeseeable changes, such as utility costs and GHG emission factors and are discussed in Section 6.

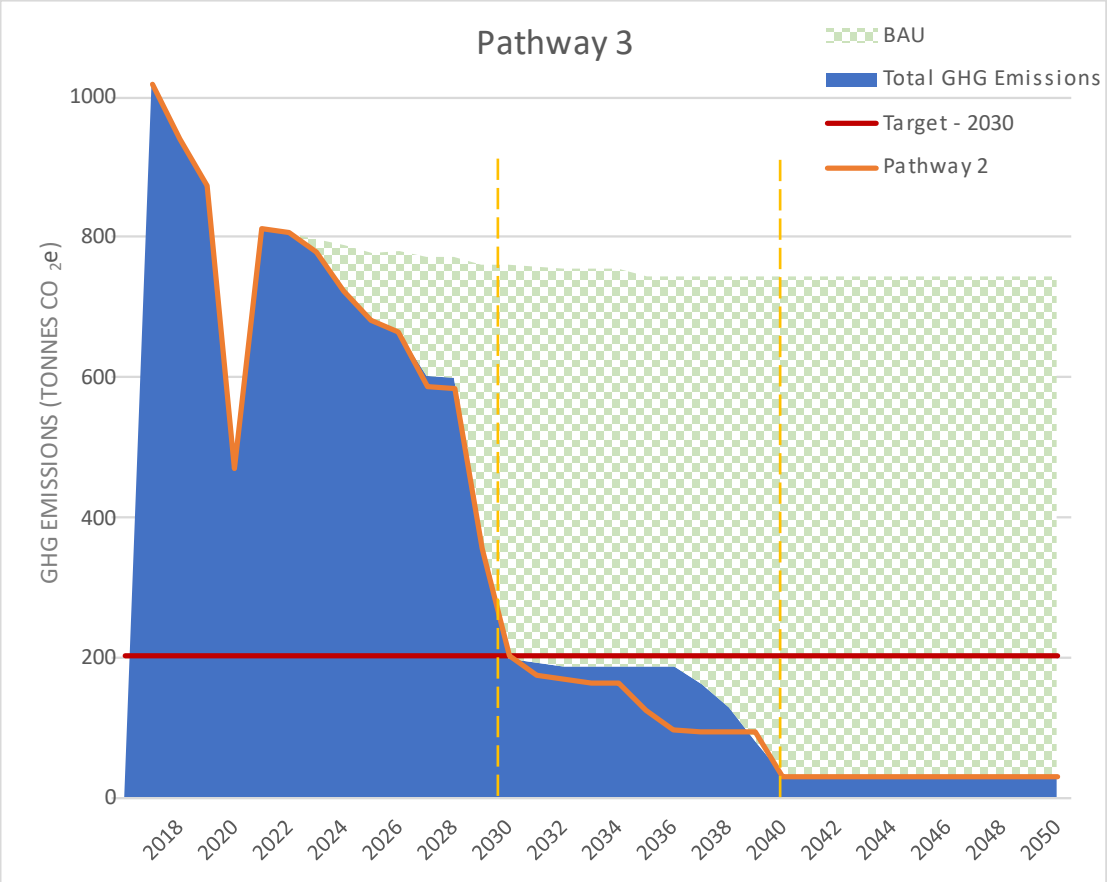


Figure 12: Pathway 3

Table 16: Pathway 3 Assumptions

Affected Model Element	Assumption
Remaining Life	For measures addressing equipment, the remaining life was estimated based on equipment age and typical life spans. Equipment is replaced up to 10 years early if it has a positive NPV and simple payback.
Efficiency	Efficiency CRMs not related to equipment replacement were included prior to 2030. These measures were: • Recreation Complex - Ice plant heat recovery • Westhill Community Centre and Rocky Point Pool - Pool covers • Heritage Mountain - Variable flow heating pump • Works yard – Retrofit garage ventilation, upgrade to electric infrared heating • Upgrade controls
Cost per annual tonnes of GHG emissions avoided	CRMs were filtered to achieve the target 2030 emissions reductions by excluding any projects costing more than $5,000 per annual tCO_2e avoided. This number was the lowest cost per annual tCO_2e avoided required to achieve the 2030 target.
NPV and Simple Payback	All CRMs with positive NPV and positive simple payback were included prior to 2030.

Due to the ambitious emissions reductions set by the *Climate Ready Homes and Buildings Plan*, there is not a significant difference in overall project costs or cumulative emissions avoided prior to 2030 when comparing pathways 2 and 3. This is demonstrated by the orange line representing pathway 2 in Figure 12 above. 40% of the projects implemented prior to 2030 are the same in both pathways.

Compared to Pathway 2, Pathway 3 increases capital expenditure before 2030 by 14%, but has a 16% higher NPV by 2030. However, by 2050 NPV is almost identical for both pathways.

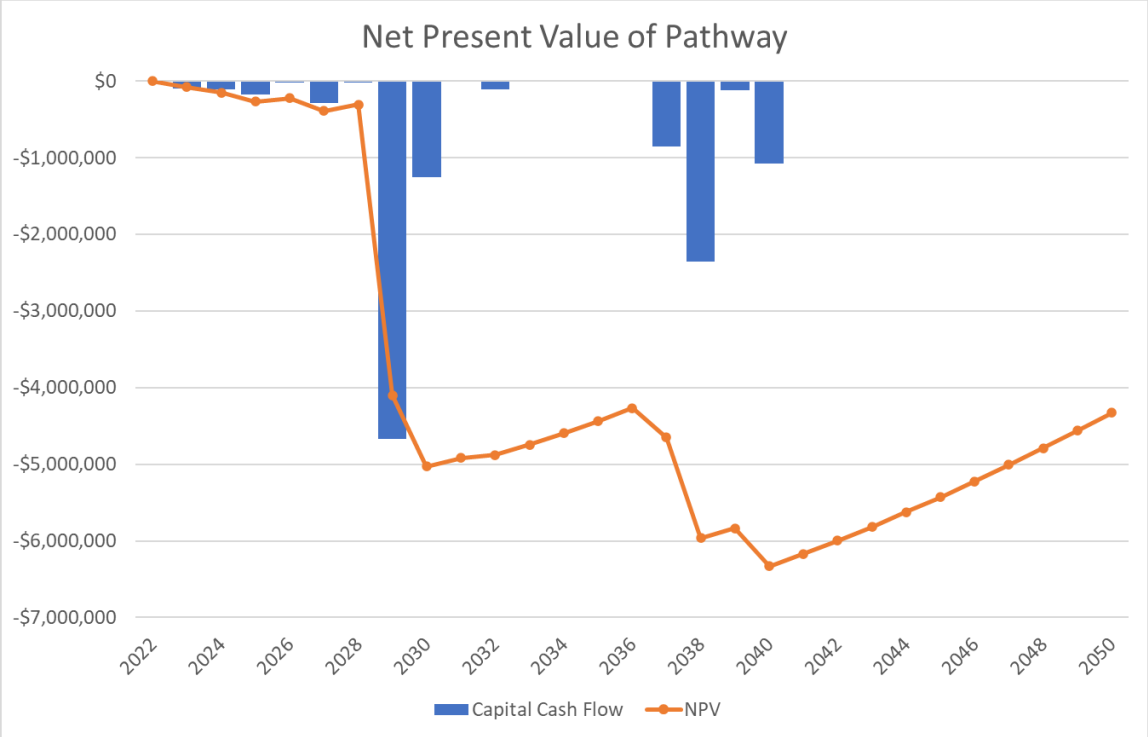


Figure 13: Pathway 3 Estimated Future Cash Flow and NPV by Year

5.7 Pathway 4: Balanced Annual Costs

Pathway 4 recognises the importance of time for the City to identify funding sources and prepare for large projects. This pathway attempts to balance the significant capital investment required by evenly spreading out annual capital expenditures while still achieving the 2040 target. By comparison, the cost for Pathway 4 prior to 2030 is 30% of Pathway 1.

In this scenario the Recreation Complex heat recovery CRM, which is by far the largest emissions reduction project and that with the highest cost, is implemented at the latest possible date of 2040.

This pathway results in a **58%** reduction in GHG emissions by 2030, and **97%** reduction by 2040. Note that the remaining 3% of emissions by 2040 represent the residual emissions associated with the electricity used. To close this remaining gap will require measures beyond system efficiency and fuel source CRMs and is discussed further in Section 7. All pathways are sensitive to unforeseeable changes, such as utility costs and GHG emission factors and are discussed in Section 6.

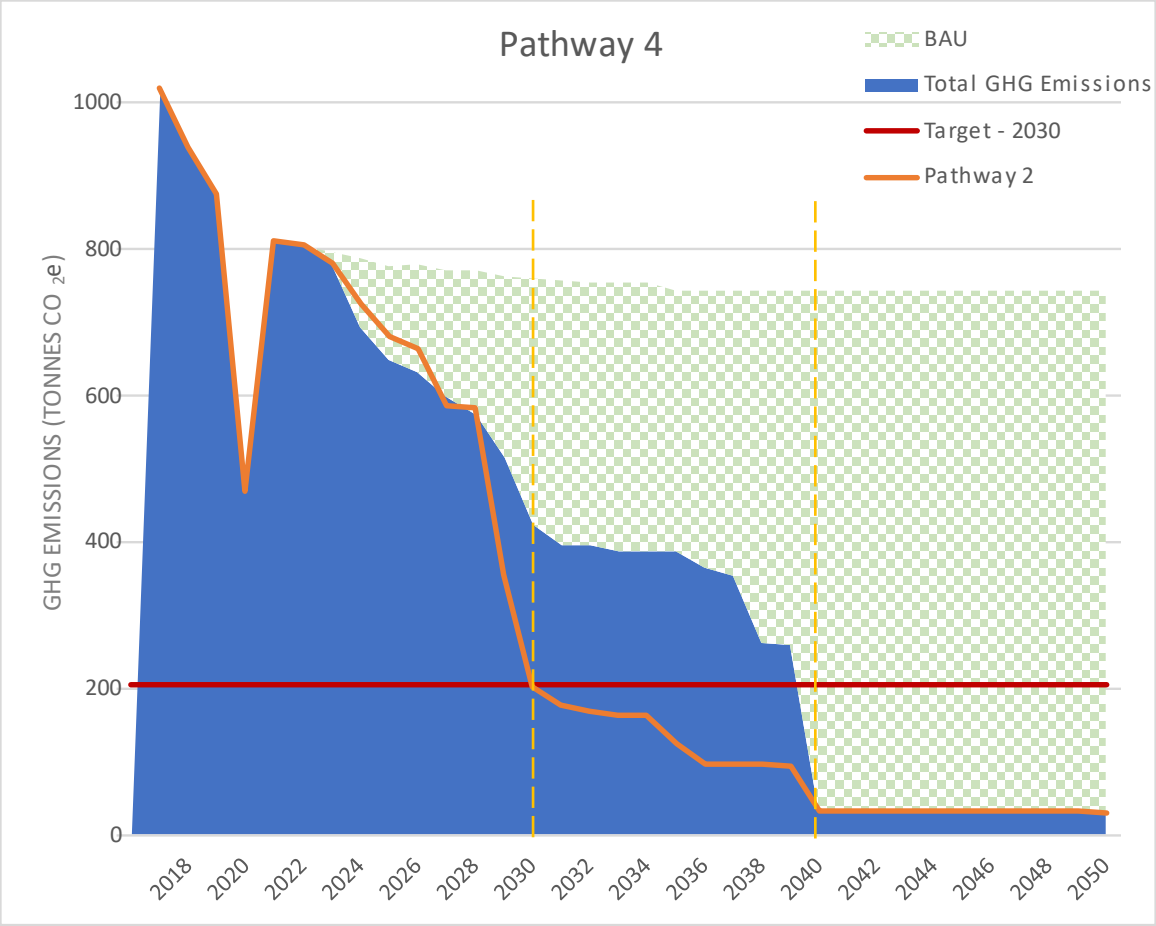
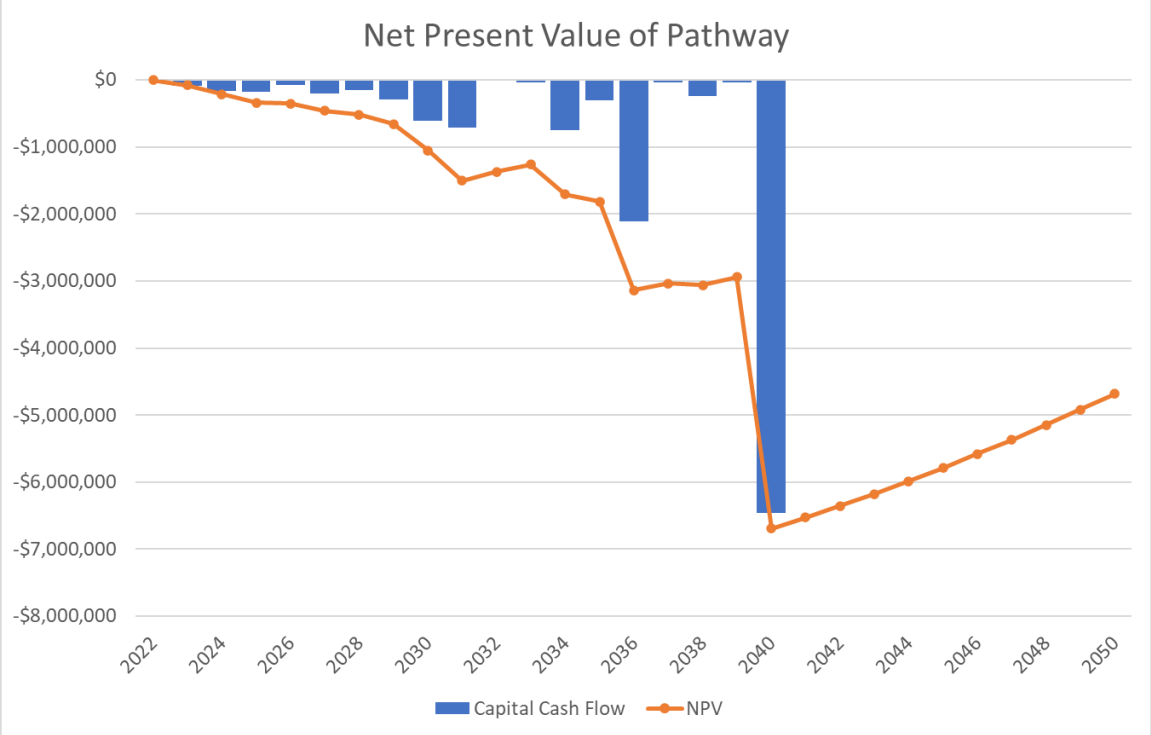


Figure 14: Pathway 4

Table 17: Pathway 4 Assumptions

Affected Model Element	Assumption
Remaining Life	For measures addressing equipment, the remaining life was estimated based on equipment age and typical life spans. No CRMs are implemented after the equipment's anticipated remaining life. Equipment is replaced up to 5 years early to balance annual project costs.
Annual Project Costs	Implementation year of CRMs were selected so that total annual costs (incremental) to implement CRMs did not exceed $200,000 prior to 2030.

The financial analysis in the graph below reveals that while initial capital expenditures are low, about 30% of pathway 2, this pathway cannot reach the 2030 target and has an 8% lower NPV than pathway 2 by 2050, indicating that the Recreation Complex heat recovery has significant impact on the pathway's NPV.



6. IMPLEMENTATION CONSIDERATIONS

If the City intends to achieve the 80% reduction by 2030 and 100% by 2040 objectives, they will need to act immediately to begin moving forward with implementing carbon reduction measures (CRMs) across the portfolio. Every year the aggressive implementation of CRMs is delayed will compound the effort required to implement the pathway in later years and reduce the City's total emission reduction impact. There is an urgency to act swiftly, and substantial investment in the short term will ultimately set the City up for success in the long term.

6.1 Pathway Sensitivities

Planning for implementation of CRMs, including policy, coordination between departments and capital budget requests, are critical next steps. During this process, sensitivity of the pathways to assumptions identified in Section 5.2 should be considered. The following table outlines the significant factors and uncertainties within the pathway models identified in stakeholder workshops.

Table 18: Summary of Implementation Considerations

Model Factor	Description
Cost	Project costs were the largest barrier identified by the project team. The targets set by the City are ambitious for a tight time frame. Significant funding and personal resources will need to be dedicated to completing CRMs prior to 2030.
City Resources	Most buildings in the City's portfolio will require upgrades as part of all pathways, resulting in significant number of projects that need to be managed within the City. This will weigh on the capacity of City employees to manage multiple large projects at once. Additional resources / hiring may be required.
Equipment Renewal	Achieving the targets requires most buildings in the City's portfolio to have their heating, cooling and ventilation systems upgraded prior to 2030, thereby concentrating capital renewal costs in addition to the project incremental costs in the next seven years.
Skilled Labour	Availability of labour, both within the City and from external contractors will influence CRM implementation. The Province of BC in it's 2022 Labour Market Outlook anticipates more job openings than available workers for skilled trades. This projected labour shortage may increase project timelines, or impose a premium on projects to complete them sooner.

Equipment Supply Chains	Equipment supply chains were significantly impacted during the COVID pandemic. In addition, labour shortages and high demand have increased the frequency of equipment delivery delays. It will be important for the City to consider the impact of equipment availability into project timelines and implementation planning.
Unforeseen Events	Unforeseen emergencies impact available budgets and resources for implementing CRMs. Providing services to the residents of Port Moody is the number one priority, and therefore high service impact emergencies, such as equipment failure preventing service provision, can cause budget allocations to change. Further, the City will need to balance returning critical equipment to operation with emissions reductions, should emergency replacement be required.
Regulatory Changes	As federal and provincial governments work towards achieving jurisdictional GHG emission targets, changes to existing emissions reductions regulations may occur. This may include the potential for accelerating the carbon tax escalation rate, and imposing GHG emission intensity limits on buildings or equipment emission limits (as the City of Vancouver is doing). Implementing CRMs early may allow the City to avoid non-compliance penalties from changing regulatory requirements and reduce the financial burden of these changes on the City in the future.
Population and Services	Services the City provides to the community and the associated corporate GHG emissions are linked to population size. The City is expected to increase by 40% by 2050 and presents one of the largest sensitivities to the future projections of the pathways presented. To maintain the projected pathways, the City may want to consider a policy that ensures all new buildings are net-zero carbon.
BC Electrical Grid GHG Emissions	The GHG intensity of the BC electricity grid is a significant factor to the selected pathway. While the BC electrical grid generates extremely low emission energy, there are still emissions associated with electrical consumption. As Port Moody electrifies it's heating equipment, the grid emission intensity will become a greater factor in annual City GHG emissions. Further discussion on electrical grid emission projections is included in section 5.2.1.

6.2 Funding

CleanBC

A number of CRMs may be eligible for funding through the CleanBC Custom[4] or Custom-Lite[5] program. This provincially funded program provides funding for projects that decrease natural gas consumption through electrification, whilst meeting other program criteria.

It is recommended that high priority CRMs are brought forward with CleanBC to evaluate potential funding. Our team can support with these applications.

FCM

The Federation of Canadian Municipalities (FCM) also provides funding towards GHG reduction pathways. Several potential grants could be applied, including the 'Capital Project – GHG Impact Retrofit' stream[6]. This grant provides funding up to 25% as a grant, and up to $5m as a loan.

6.3 Climate Change Adaptation and Resiliency

The City of Port Moody in the *Climate Action Plan* has identified significant impacts that climate change will have on the Port Moody region. In recognition that carbon reduction facility upgrades are required, a climate mitigation and adaptation lens was applied to selection of the CRMs.

The primary climate change impacts identified in the *Climate Action Plan* that were considered in the climate adaptation lens included:

Facility Climate Change Impact	Climate Adaptation Lens
Higher Summer Temperatures	Many buildings reviewed as part of this study did not have mechanical cooling systems. Where possible, electric heat pumps were recommended not solely for their significantly lower emissions than fuel heating, but also for their ability to provide cooling. Therefore, installing heat pumps will reduce emissions while addressing the increased summer cooling required to adapt to the impacts of climate change.

[4] https://betterbuildingsbc.ca/incentives/cleanbc-custom-program/

[5] https://betterbuildingsbc.ca/incentives/cleanbc-custom-lite-program/

[6] https://fcm.ca/en/funding/gmf/capital-project-ghg-impact-retrofit

Increased intensity of weather events	**With increased intensity of storms, the likelihood of power outages increases. CRMs selected use electrification as the primary method of reducing emissions by relying on low carbon intensity of the BC electrical grid.** **Fuel energy systems are similarly susceptible to electrical outages and electrical energy HVAC systems, as fuel burning equipment typically requires electricity to distribute energy, such as fans and pumps. Thus, both types of equipment will require electric back-up systems to operate in the event of power outages.** **Solar PV presents an opportunity to produce low emission energy to bring the City to its net zero target while also providing back-up energy (when coupled with battery storage).**
Increased forest fire smoke	Climate change projections for the lower mainland indicate there will be increased size and frequency of wildfires, and an associated reduction in outdoor air quality from smoke particulate. Replacement of ventilation units for GHG emission reductions presents an excellent opportunity to protect indoor air quality during wildfire seasons by selecting equipment capable of operating with MERV air filters.

7. GETTING TO NET ZERO

All of the pathways presented in this report achieve zero emissions for scope 1, or direct energy consumption on site. However, scope 2 emissions in-direct emissions represent the remaining 3% of emissions presented in Pathways 2, 3 and 4. These residual emissions are due to GHG emissions from the BC Integrated electrical grid.

To achieve net zero emissions, the City will be required to invest in renewables, offsets, and/or other means to close the gap to net zero on a scope 2 basis. The following sections discuss options to address these residual scope 2 emissions.

7.1 Solar PV

Solar photovoltaic panels offer a zero emissions form of renewable energy that can be used to offset electric grid energy consumption. In order to offset the remaining 30 tonnes/year (3%) of GHG emissions from electricity consumption, approximately **2.6 GWh of solar PV** would be required. Based on Natural Resources Canada's solar resource potential maps it is anticipated the City of Burnaby could generate electricity at a rate of 202.7 kWh/m^2. This amounts to over **3.2 acres of solar PV, or two soccer fields**. Based on the existing footprint of Port Moody Buildings, only 50% of all roof area would be required. From the 2017 Recreation Complex Solar PV feasibility study, the Recreation Complex would offset 20% of the remaining emissions. This would cost an estimated **$7 million, not including any structural improvements, and offset 100% of remaining emissions.**

A solar PV system would consist of solar modules on the roof and an inverter(s) tied into the main breaker panel. When the solar modules are exposed to sunlight, electric power is generated, and the facility draws electricity from the PV system. During design, investigation would be required to determine if roofs identified for solar PV installation are structurally able to support the weight of the recommended system. The location and orientation of any solar array can significantly impact generation, such as shading impact from nearby buildings and trees, and dirt and debris.

7.2 Renewable Natural Gas (RNG)

Natural gas is primarily used for space and water heating equipment. Renewable natural gas (RNG) is interchangeable with fossil fuel-based natural gas and can be used to power traditional natural gas equipment such as boilers, hot water tanks, rooftop heating units, and gas ranges. It is made by capturing the methane released during the decomposition of biomass (organic waste), purifying it, and then injecting it into conventional natural gas supply lines to help lower the overall GHG intensity of that supply.

Current calculation practices for RNG vary; British Columbia's methodology assumes that most biomass sources have absorbed their CO2 content from the environment over a relatively short timeframe (less than 100 years). The emissions resulting from the combustion of biomass is of

the same quantity as was previously absorbed, resulting in no net change in atmospheric CO_2. As a result, the CO_2 released from the combustion of RNG may be considered carbon neutral.[7]

In situations where electrification is not feasible due to electricity or technological constraints, RNG may represent a viable short-term alternative. Note, there is no separate "RNG pipe," and it becomes mainly an accounting exercise of dedicating RNG on paper to facility operation. The building will still receive and combust the same natural gas mix as all other buildings.

Renewable natural gas should represent a last resort measure where other measures like facility optimization and equipment upgrades have been implemented to reduce natural gas consumption as much as practicable. The RNG supply is growing but is still limited, and the feasibility of significant RNG supply replacing NG supply is uncertain. Therefore it is not a solution to offset long term or extensive natural gas use. RNG is not considered zero carbon but may be permitted in some instances as a final step to close emission target gaps, similar to credits and offsets.

7.3 Credits and Offsets

Carbon credits, offsets, and Renewable Energy Credits (REC's) are alternative financial methods to compensate for GHG emissions emitted, and can potentially be used to bring the City to net zero emissions.

Carbon offsets and credits are purchased through brokers, online retailers and trading platforms. The funds are then used to fund GHG emission reduction or sequestration projects elsewhere. The key to the impact of credit and offset purchases are the quality of the product; that is ensuring that the emission are actually reduced elsewhere. Selecting credits from reputable organisations that comply with international standards should be the first consideration. The current Government of Canada benchmark offset price is $65/tonne CO_2e and escalating to $170 in 2030. It should be noted that the market for credits and offsets is still developing as GHG emission reporting and limits are still voluntary. It is expected that as GHG emission limits become stricter over time, the demand for credits will increase the market cost for emission credits and offsets.

It is estimated that it would cost a minimum of **$5,000 to get to net zero in 2040** under Pathways 2, 3 or 4 through the purchase of offsets, however this cost will likely be larger in the future.

[7] 2020 BC Best Practices Methodology for Quantifying Greenhouse Gas Emissions

8. CLOSING REMARKS

The City of Port Moody has multiple opportunities to reduce GHG emissions and achieve its targets. Through both workshops and close engagement with City staff, it is clear that the City's current capital plan will fall short of allowing the necessary retrofits to occur that are required to achieve the GHG reduction targets. This is demonstrated in the Business As Usual pathway model. This study highlights the importance of prioritizing equipment replacement with low carbon options, and accelerating key projects. These key projects include:

- Recreation Complex Heat Recovery;
- Rocky Point Pool covers and pool heating electrification;
- Westhill Pool covers and pool heating electrification;
- Civic Centre heating plant electrification; and
- Fire Hall #1 heating plant electrification.

To best achieve all of the City's emission reduction targets and goals, Pathway 2 is recommended. This pathway places a focus on fewest number of projects and lowest capital cost to the City prior to 2030, and has the largest NPV in 2050.

However, the City cannot rely on carbon reduction measures alone to achieve net zero carbon emissions. The measures outlined in our studies rely on low-carbon electricity and highly efficient use of fossil fuels to reduce GHG emissions as low as possible, but not to zero. To achieve zero carbon in the City's operations a detailed energy procurement strategy is required. This strategy would balance installing on-site renewable energy, purchasing of renewable natural gas and purchasing GHG offsets and credits.

Looking to the future, the province of British Columbia is developing an existing buildings renewal strategy. This strategy will highlight multiple potential methods of reducing GHG emissions including new regulations, building carbon emission limits, and updates to building code. Planning for GHG emission reductions presented in the pathways will not only allow Port Moody to achieve the City's Climate Ready Homes and Buildings Plan targets, but will position the City well into a low carbon future.