



## REPORT

Report Date: April 25, 2022  
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VanRIMS No.: 08-2000-20  
Meeting Date: May 17, 2022  
[Submit comments to Council](#)

TO: Vancouver City Council

FROM: General Manager of Planning, Urban Design and Sustainability

SUBJECT: Annual Carbon Pollution Limits for Existing Large Commercial and Multifamily Buildings

### **RECOMMENDATIONS**

- A. THAT Council approve, in principle, an Annual Greenhouse Gas and Energy Limits By-law (the “new By-law”) as proposed in this report.
- B. THAT Council instruct the Director of Legal Services to bring forward for enactment the proposed new By-law, to implement Recommendation A, with certain key provisions to come into force and take effect on January 1, 2023.
- C. THAT, Subject to the approval of Recommendation A, Council approve, in principle, an amendment of the Building By-law generally in the form attached as Appendix A, which includes the removal of energy upgrade requirements for all buildings except one and two family houses.
- D. THAT Council instruct the Director of Legal Services to bring forward for enactment amendments to the Building By-law as set out in Appendix A, to implement Recommendation C, with certain provisions to come into force and take effect on January 1, 2023.
- E. THAT Council endorse the Regulatory Roadmap found herein, direct staff to continue to research and consult with stakeholders on the actions contained within it and update the Regulatory Roadmap as required.
- F. THAT Council direct staff to convene a Technical Advisory Committee and a Community Accountability Advisory Committee to advise staff on future policy and program development as set out in Appendix D.

## **REPORT SUMMARY**

This report advances the Climate Emergency Action Plan by introducing carbon pollution limits on the largest office and retail buildings in Vancouver. The proposed limits on greenhouse gas (GHG) emissions in 2026, limits on GHGs and heat energy in 2040, combined with the proposed Regulatory Roadmap will reduce GHG emissions from existing buildings 50% by 2030 compared to 2007.

Most large office and retail building owners have the professional resources to plan and undertake this work. Establishing these limits now prepares building owners and energy utilities to plan for deep emission retrofits and investments in renewable energy, including renewable gas and low carbon district energy. These initial limits will begin to significantly reduce emissions from commercial buildings but are not, on their own, sufficient to meet the 2030 reduction target.

This report also lays out a supplementary Regulatory Roadmap that establishes additional regulations and programs to be developed to support voluntary action necessary to meet the City's carbon pollution targets.

Through streamlining existing regulations and providing a suite of owner supports in partnership with industry, a number of barriers for taking early action and complying with future regulations will be addressed.

## **COUNCIL AUTHORITY/PREVIOUS DECISIONS**

In January 2019, Vancouver City Council declared a Climate Emergency in response to the United Nation's Intergovernmental Panel on Climate Change special report: *Global Warming of 1.5°C*.

On April 29, 2019, Council approved the Climate Emergency Response and associated targets and directed staff to develop strategies to achieve the six targets (referred to as "Big Moves") and report back to Council by fall 2020.

In November 2020, Council approved the Climate Emergency Action Plan (CEAP), including a roadmap to cut carbon pollution to 50% of 2007 levels by 2030 from existing buildings and directing staff to bring forward recommendations to limit carbon pollutions for large existing commercial buildings in accordance with the Zero Emissions Retrofit Strategy.

## **CITY MANAGER'S/GENERAL MANAGER'S COMMENTS**

The City Manager recommends approval of the foregoing.

## **REPORT**

### ***Background/Context***

In November 2020, Vancouver City Council approved the Climate Emergency Action Plan (CEAP), outlining six Big Moves to cut carbon pollution in half by 2030 and reiterated Vancouver's commitment to reduce GHGs 100% before 2050. Burning of natural gas in

buildings accounts for 57% of total carbon pollution generated in Vancouver (2020 inventory). Big Move 4 of the CEAP sets the goal to cut emissions from all buildings 50% by 2030 and by 100% before 2050.

The Zero Emission Building Retrofit Strategy (ZEB-R) that was approved by Council as a part of the 2020 CEAP included four core actions to achieve the 2030 and 2050 targets:

1. Set carbon pollution limits for existing buildings and streamline energy efficiency regulations
2. Support early owner action
3. Build industry capacity
4. Facilitate access to renewable energy

Vancouver's leadership in the area of existing building performance regulations and owner supports will complement and help enable the introduction of aligned regional and provincial regulations so as to scale the impact of the City's early action. Similarly, the planned Provincial regulations, if approved, will complement Vancouver's progress.

The City is already demonstrating leadership and reducing emissions from its own existing buildings in advance of regulations on private buildings in Vancouver. Where feasible, heating and hot water equipment is being replaced with heat pumps in existing City facilities. City owned buildings have reduced their emissions 37% since 2007 and are on-track to achieve a 60% reduction by 2030.

City staff have been in conversation with building owners, managers, utilities and other stakeholders about GHG emission regulations on existing buildings for the past three years. Through these discussions, staff have learned that utilities and building owners are already taking actions that position the City and the Province for success:

- FortisBC is a North American leader in gas utility efforts to reduce carbon pollution, rapidly expanding the supply of renewable gas while also investing over a \$100 million dollars annually in gas conservation programs
- BC Hydro's Electrification Plan includes broad suite of actions to increase the supply of zero carbon electricity and make it easier for customers to adopt heat pumps; these actions are critical to the City's ability to establish effective carbon regulations for buildings
- District heating utilities are transitioning to renewable energy sources to provide low carbon heat to buildings: Creative Energy is working with BC Hydro to install electric boilers; River District Energy is working with Metro Vancouver to utilize waste heat from the Burnaby Waste to Energy facility, and the City's Neighbourhood Energy Utility is currently seeking additional sources of low carbon energy to complement it's innovative sewer waste heat pumps.

### ***Strategic Analysis***

For commercial and multifamily buildings, the following actions are contained in this report:

- A. Enact initial GHG Intensity and Heat Energy Limits for large office and retail buildings and associated Energy and Carbon Reporting requirements and provide owner supports to facilitate success in meeting these
- B. Streamline existing regulatory requirements for energy upgrades
- C. Adopt a Regulatory Roadmap that directs staff to expand the number and types of existing buildings impacted by GHG regulations
- D. Develop and expand supports to catalyze voluntary emission reduction and climate resilience retrofits in multifamily buildings

## **A. GHG Intensity and Heat Energy Limits, Carbon Reporting, and Supports for Existing Large Office and Retail Buildings**

### Summary of Requirements

Adoption of building performance standards in U.S. cities such as New York, Boston and Washington D.C. and the work of local and national organizations to share best practices on retrofitting buildings to achieve deep reductions in carbon pollution have normalized the concept of performance-based GHG regulations for large commercial buildings. The requirements outlined below were developed by reviewing these best-practices and tailoring them to Vancouver's context with input from consultant teams, local industry and buildings owners. More details on the requirements, including their modelled impacts are described in Appendices C and H.

#### *Greenhouse Gas Intensity (GHGi) Limit*

Starting in 2026, office and retail buildings larger than 9,290 m<sup>2</sup> (100,000 ft<sup>2</sup>) in Vancouver will be required to keep annual greenhouse gas emissions below a GHG intensity limit. This limit will be based on the amount of natural gas and district energy used per unit of floor area multiplied by the carbon pollution impacts of those energy sources. Gas uses that are not associated with building heating and hot water, such as commercial kitchens, will initially be excluded from the limit. The main objective of the GHGi limit is to reduce emissions from the largest sources (heating and hot water) while transitioning to low-carbon and renewable energy sources.

2026 GHGi limits will only impact the worst-performing 25% (approximately 45) large office and retail buildings. Compliance can be accomplished by implementing low cost operational and capital measures that reduce waste heat, increase efficiency and have a positive return on investment. Buildings can also use low-carbon district energy and/or renewable gas to reduce their emissions, which is estimated to increase average operational costs for the impacted buildings by 2%.

In 2040, the largest existing office and retail buildings will be required to be zero emissions meaning all energy used must come from renewable sources. The actual GHGi limit will be amended if the carbon intensity of the renewable energy available (i.e. electricity, renewable gas, etc.) is non-zero. Establishing this limit of zero now will send a clear signal to building owners, utilities and district energy providers and justify market investment in zero carbon options, including renewable gas and zero carbon district energy.

#### *Heat Energy Limit*

Beginning in 2040, the largest office and retail buildings will also be subject to a Heat Energy Limit of 0.09 gigajoules of energy equivalent per square meter of gross floor area per year

(GJ/m<sup>2</sup>/year). This limit will ensure buildings start planning, investing in, and implementing energy conserving practices and significant energy efficiency retrofits as cost effective opportunities arise prior to 2040. The Heat Energy Limit focuses on reducing energy dependency so as to minimize operating costs, limits the amount of new electrical utility infrastructure required, and helps to ensure there will be sufficient renewable energy available to meet 100% of Vancouver's buildings needs.

Data from local energy studies and building retrofit projects and analysis performed by cost-consultants indicate that the majority of these capital investments will result in a positive net present value (NPV) over the lifetime of the major heating and cooling equipment. The positive NPV is due to equipment such as heat recovery chillers, that capture waste heat, and air-source heat pumps, that significantly increase buildings' energy efficiency, both which result in operational cost savings.

Future adjustments to the Heat Energy Limit will be developed with input from the proposed Technical Advisory Committee to allow for an equitable treatment of district energy connected buildings and to also drive reductions in electric heat energy.

The best opportunity to meet the 2040 Heat Energy Limit for most buildings will be when major heating systems need replacing which only occurs every 20 to 25 years. As a result, it is anticipated that most buildings will implement projects well in advance of 2040 to align with capital replacement needs, resulting in significant GHG emission reductions by 2030.

The modelled combined effect of 2026 GHGi and 2040 Heat Energy Limits is a reduction of 24,000 tonnes CO<sub>2</sub>e annually by 2030, or 9% toward our target of a 50% reduction.

### *District Energy Decarbonisation*

In November 2020, Council directed staff to investigate the feasibility of a carbon credit trading scheme for district energy connected buildings as a potential tool to catalyze the accelerated decarbonisation of energy supplied to these buildings. Based on research and analysis from Integral Group, staff do not recommend including a district energy system carbon credit trading system as part of the 2026 carbon pollution limits. Staff will continue to explore the option for potential inclusion as a compliance option for the 2030 limits.

Considerations to inform the establishment of such a system include:

- supply and demand for credits warrants the investment in developing and managing a credible system
- credit system accelerates the lowering of maximum allowed GHG emissions, supports investments in renewable energy, and avoids double counting of GHG reductions
- confidence that a carbon credit system would enable the BC Utilities Commission to approve future low-carbon rate applications

### *Energy and Carbon Reporting*

GHGi and Heat Energy Limits are based on annual energy use by energy type. To ensure buildings are meeting their limits and to provide the owners and operators with better building energy data, large commercial and multifamily buildings will be required to report their annual energy use starting in 2024. Implementation will be phased so that by 2026 all commercial and multi-unit residential buildings greater than 4,645 m<sup>2</sup> (50,000 ft<sup>2</sup>) are reporting. Reporting will be required to start before the GHGi limits take effect to ensure owners are aware if their

building(s) are compliant and enable them to take to take action to reduce their emissions in time to meet the regulated limits.

### *Initial Regulation Timeline*

<b>Initial Year</b>	<b>Regulation</b>
<b>2023</b>	Annual energy and carbon reporting: Commercial $\geq 9,290 \text{ m}^2$ (100,000 ft <sup>2</sup> )
<b>2024</b>	Annual energy and carbon reporting: Commercial $\geq 4,645 \text{ m}^2$ (50,000 ft <sup>2</sup> ) Multifamily $\geq 9,290 \text{ m}^2$ (100,000 ft <sup>2</sup> )
<b>2025</b>	Annual energy and carbon reporting: Multifamily $\geq 4,645 \text{ m}^2$ (50,000 ft <sup>2</sup> )
<b>2026</b>	GHGi limits come into effect for commercial office and retail buildings $\geq 9,290 \text{ m}^2$ (100,000 ft <sup>2</sup> ): Office = 25 kg CO <sub>2</sub> e/m <sup>2</sup> /year Retail = 14 kg CO <sub>2</sub> e/m <sup>2</sup> /year
<b>2040</b>	GHGi limits for Office and Retail $\geq 9,290 \text{ m}^2$ (100,000 ft <sup>2</sup> ): 0 kg CO <sub>2</sub> e/m <sup>2</sup> /year Heat Energy Limit for Office and Retail $\geq 9,290 \text{ m}^2$ (100,000 ft <sup>2</sup> ): 0.09 GJ/m <sup>2</sup> /year

These limits are new for Canada and the Vancouver market and will require clarification and adjustments as experience with them grows. Our consultations and best practice reviews indicated that the formation of a standing Technical Advisory Committee as well as a Community Accountability Committee to help identify, and recommend approaches to resolve, issues that emerge are critical to the success of these requirements. Additional information on these Committees is provided in Appendix E.

The proposed City limits are aligned with the proposed regulations by Metro Vancouver and the Province. Metro Vancouver is looking to establish similar GHGi limits and reporting requirements. The Province is proposing to both establish 2030 requirements for new and replacement heating and hot water equipment and also to establish a stringent GHG cap on natural gas emissions.

Staff will remain engaged with Metro Vancouver and the Province in the development of those requirements and will assess any needed modifications to ensure regulations are complementary.

### Commercial Building Owner Supports

In consultation with local industry, a number of initial owner supports were identified as important to ensuring the success of the proposed regulations. In partnership with industry associations and utilities, the City will expand the current BC Hydro/Fortis Gas building recommissioning (or “tune-up”) program so it is accessible to all buildings impacted by 2026 GHGi limits, help owners to develop deep emission retrofit plans to prepare to meet the 2040 Heat Energy Limits, create a retrofit information hub, and provide retrofit project support to owners lacking the technical expertise.

To support owners of commercial and multifamily buildings comply with the annual reporting requirement, the City will offer online resources, a help desk, workshops, an annual

performance scorecard with retrofit guidance and a financial incentive for multifamily buildings for professional support to report their data in advance of City requirements. These supports are described in additional detail in Appendix E.

The City will work to rapidly develop and launch these supports in partnership with industry. The City will also work in parallel with Metro Vancouver and the Zero Emission Innovation Centre<sup>1</sup> on a strategic approach to funding and service delivery to provide owner supports at a regional scale.

In 2022, the Vancouver Economic Commission (VEC) undertook research and engagement to understand the financial needs of commercial building owners in complying with future proposed carbon pollution limits on existing buildings. The key take-away from interviews and engagement was that availability of financing does not present a significant barrier for building owners in meeting these initial requirements. Based on the recommendations from VEC, the City will work with financial institutions to share information on regulatory requirements, and collaborate, where possible, to bring to market innovative lending opportunities for retrofits to ensure there is access to financing for all buildings that may need it.

## **B. Streamlining Current Regulations**

Upon enactment of the carbon reporting requirement and the GHGi limits for large office and retail buildings, the current energy upgrade requirements contained within Part 11 of the Building By-law for all existing buildings except for one and two family homes can be repealed.

The City's current Part 11 energy upgrade requirements typically apply to smaller renovations and changes in use and are not resulting in "whole building" capital planning and retrofit measures necessary for deep decarbonisation. The removal of these requirements will simplify the permitting process for applicants and staff, resulting in fewer requirements and faster approvals for other building renovations. Appendix A contains the specific requirements that would be removed if this recommendation is approved by Council.

## **C. Regulatory Roadmap**

While the recommendations contained in this report will significantly reduce carbon pollution from existing commercial buildings and help accelerate voluntary retrofits of multifamily buildings, additional measures will be necessary in order to meet the 2030 and 2050 GHG reduction targets. Further research and consultation will be needed before recommendations on an expanded set of regulations can be advanced in 2024. Staff are recommending that Council endorse the Regulatory Roadmap below and that staff continue research and consultation with industry.

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<sup>1</sup> <https://www.zeic.ca/>

The table below outlines the overall Regulatory Roadmap across all building types as currently envisioned:

Table: Potential Regulatory Requirements - Phasing, 2022-2050

Phase	Details
2022 - 2024	<ul style="list-style-type: none"> <li>• Analysis and stakeholder consultation on performance and prescriptive regulations</li> <li>• Launching of initial Multifamily owner supports and Multifamily/Commercial demonstration programs</li> <li>• Recommendations for 2026 – 2040 brought to Council</li> </ul>
2026	<ul style="list-style-type: none"> <li>• Time-of-Replacement Requirements come into effect for select, secondary and amenity heating equipment, e.g.: <ul style="list-style-type: none"> <li>○ Pools</li> <li>○ Fireplaces and decorative gas appliances</li> <li>○ Rooftop heating units</li> <li>○ Make-up-air units</li> </ul> </li> <li>• Sub-metering requirements for major heating and hot water equipment</li> </ul>
2030	<ul style="list-style-type: none"> <li>• Updated GHGi for Office and Retail &gt; 9,290 m<sup>2</sup></li> </ul>
2030	<ul style="list-style-type: none"> <li>• GHGi Limit effective for: <ul style="list-style-type: none"> <li>○ Office &amp; Retail &gt; 4,645 m<sup>2</sup></li> <li>○ Hotels &gt; 4,645 m<sup>2</sup></li> <li>○ Assembly &gt; 32,500 m<sup>2</sup></li> <li>○ Other Commercial building types &gt; 4,645 m<sup>2</sup> (<i>to-be-determined</i>)</li> <li>○ Multifamily buildings &gt; 9,290 m<sup>2</sup></li> </ul> </li> </ul>
2030 - 2032	<ul style="list-style-type: none"> <li>• Phased Deadlines for Equipment Replacement of select secondary heating equipment, potentially including: <ul style="list-style-type: none"> <li>○ Rooftop heating units</li> <li>○ Make-up-air units</li> <li>○ Pools</li> <li>○ Fireplaces and decorative gas appliances</li> </ul> </li> </ul>
2040 - 2050	<ul style="list-style-type: none"> <li>• GHGi limits for Commercial and Multifamily Buildings &gt; 4,645 m<sup>2</sup> (all uses): 0 kg CO<sub>2</sub>e/m<sup>2</sup>/year</li> <li>• Heat Energy Limit for additional commercial building types</li> </ul>

Additional details, including rationale for further research on these potential regulatory requirements are described in Appendix C.

#### D. Supports to Catalyze Voluntary GHG and Resilience Retrofits in Multifamily Buildings

Multifamily buildings including condominiums, rental apartment, non-market and coop housing buildings represent 24% of building-sector carbon pollution. They also provide the most affordable housing for renters, young families, and citizens that are disproportionately impacted by climate change. Initial GHGi limits for existing multifamily buildings will be established by 2024 to take effect by 2030. These initial limits will not be designed to drive major capital investments in the replacement of heating and hot water equipment with heat pumps given the challenging economics of these changes and the importance of protecting housing affordability and tenants.



Staff recommend that City leverage its Capital Budget for the Deep Emissions Building Energy Retrofits and our partnerships to provide significant new supports for voluntary retrofits in these buildings, especially for work that will reduce carbon emissions while also reducing overheating during increasingly frequent summer heat waves. Our research and consultation indicated that tools and changes to facilitate City and Strata approvals for heat pumps and passive cooling measures, incentives for heat pumps and targeted envelope improvements, deep retrofit planning tools (especially integrated with capital plans depreciation reports), and energy efficiency retrofit coaching and easy to access information could rapidly accelerate GHG reduction and resilience measures in these buildings. See Appendix E for additional details on multifamily supports.

### **Stakeholder and Community Input**

From February to April 2022, over 400 representatives were engaged through the process including property managers and building owners, individual condominium owners, strata corporations and rental and nonmarket housing providers from both commercial and multifamily buildings. In addition, 32 partner organizations, including industry associations, local utilities and district energy service providers were also engaged to promote and participate in the process. The consultation process included a series of five online information sessions and three workshops. In total, 418 stakeholders received the engagement emails and 313 stakeholders participated in the online sessions.

The City also convened an external advisory committee to advise staff on the development of the GHGi and Heat Energy Limits. The Committee was comprised of 25 representatives from building management companies, owner associations, utility and district energy companies, regional and provincial government, mechanical contractor companies and associations and mechanical consulting firms. The Committee met five times between the Fall of 2021 and Spring of 2022.

The recommendations found in this report were adjusted in response to feedback during engagement. There is general support for the recommendations found herein, and especially for the building owner supports and the recognition of the sensitivity around regulating multifamily buildings. There was stronger support for the 2026 regulations as they require less significant changes and present fewer technical uncertainties than the 2040 requirements. However, all agreed that urgent and meaningful climate action for existing buildings is needed and appropriate. Details can be found in Appendix F.

### ***Implications/Related Issues/Risk***

#### ***Financial***

The initial implementation and roll-out of this program is estimated to cost \$5.4M in 2023-2024 and is comprised of one-time Commercial/Multifamily Carbon Reporting and Limits software (42%); Owners Supports including education campaign, retrofit planning and execution, pilot programs (36%); four RFT staff to support the launch of carbon reporting and limit regulations, develop and manage owner supports and research additional regulation (22%). The source of funding is the approved Multi-year Capital Budget for the Deep Emissions Building Energy Retrofit Program.

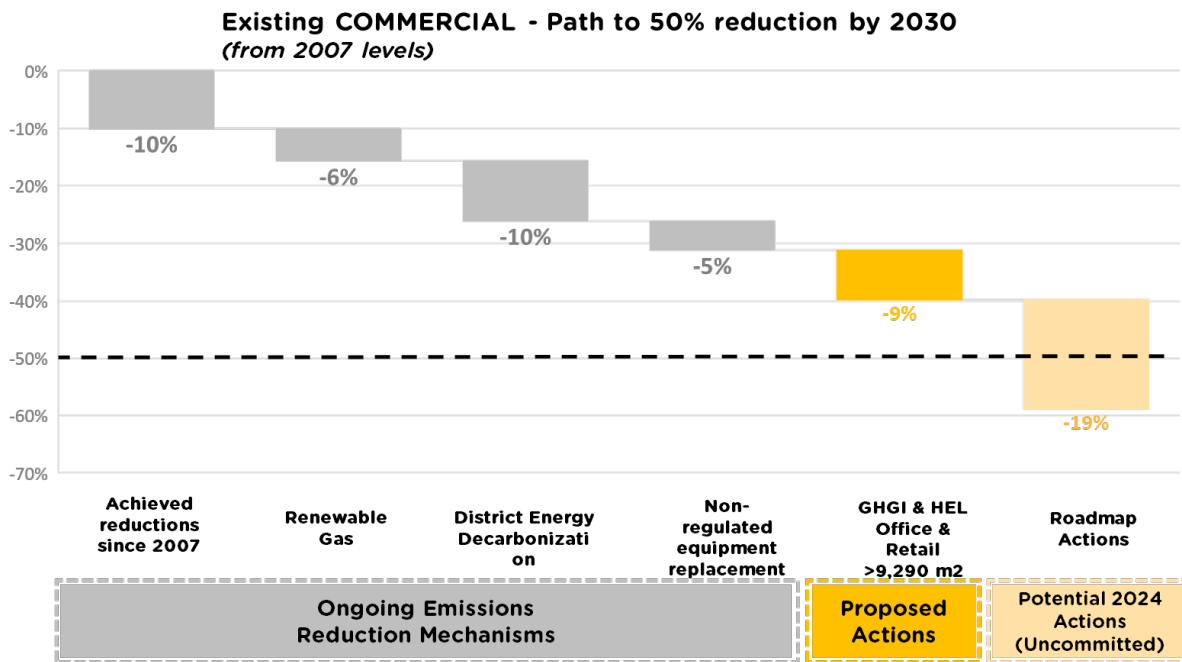
Ongoing program costs (2025+) for regulatory development and implementation are estimated to be \$1M per year including staffing and technology systems costs and will be subject to approval of the 2023-2026 Capital Plan as well as annual Capital Budget.

**Human Resources/Labour Relations**

Four RFT positions are required to support the launch and implementation of the proposed regulations, the development of further regulations (Roadmap recommendation E) and owner support/pilot programs. These positions will be funded as per financial implications above.

**Environmental**

The anticipated GHG reductions by 2030 from the initial carbon pollution regulations on office and retail buildings larger than 9,290 m<sup>2</sup> is 24,000 tonnes CO<sub>2</sub>e. This represents a 9% reduction in commercial building GHG emissions. This is equivalent to removing 6,000 gasoline fuelled cars from the road. These initial regulations combined with historic energy efficiency efforts, increased supply of renewable energy, and voluntary energy retrofits are anticipated to reduce emissions from commercial buildings by 40% by 2030. Potential future City regulations could reduce these emissions an additional 19%.



For multifamily buildings, historic increases in emissions since 2007<sup>2</sup>, increases in renewable gas in the base gas blend, proposed regulations in the roadmap, and voluntary retrofit could achieve a 30% reduction in multifamily building GHG emissions by 2030.

Adoption of these initial regulations will align and support the proposed regional existing building carbon pollution limits by Metro Vancouver, the Provincial government’s proposed update to the Energy Efficiency Act that would require 100% efficient equipment at the time-of-replacement

<sup>2</sup> Because of the rapid construction of new multifamily buildings in the past 15 years, there has been an increase in emissions over this time period.

starting in 2030, and the proposed implementation of a stringent Provincial cap on emissions from natural gas.

Meeting the Climate Emergency Action Plan targets depends on action at all levels of government. The GHG emission reductions achieved since 2007, and the projected future reductions from renewable gas and non-regulated equipment replacement are made possible because of supportive Provincial policies and energy utility action. Staff will continue to collaborate with Metro and the Province in the development of proposed requirements and, if/when they are put in place, assess whether City regulations should be modified to support the success of a broader framework and a simplified policy framework provided it will enable the City to meet its objectives.

### ***Equity***

The recommendations of this report focus on large commercial buildings where owners and managers have the best opportunities for deep emission reductions and have the resources to plan and implement the required changes.

Nevertheless, engagement with commercial building tenants revealed that small businesses that have operations with significant GHG emissions sometimes lack viable reduction options. For this reason, restaurants inside of large office and retail buildings were excluded from the initial GHG limits. Similarly, hotel owners and operators severely impacted by COVID are not initially covered by these carbon regulations.

Finally, staff recognize that multifamily residential buildings such as apartments, non-market housing, and even condominiums may have people who are disproportionately impacted by climate changes and face resource limitations to undertake the capital investments required for deep emissions reductions. Engagement with these building owners and occupants revealed deep concerns about affordability and vulnerability to heat waves. As a result, the City will focus initially on working with government and energy utility partners to provide supports for these buildings to undertake voluntary emission reductions and seek to align these with the provision of cooling and air filters wherever possible.

Households with combined incomes of less than \$50,000 per year will not be required to reduce emissions but instead, through voluntary programs such as the Resilient Rental Retrofit Program being launched in partnership with Landlord BC and the non-market housing supports being recommended concurrent with these new commercial building regulations, will begin to benefit from the transition via the introduction of cooling and air filters.

### ***Legal***

Section 306 of the Vancouver Charter authorizes Council to enact by-laws regarding construction of buildings where the conservation of energy and the reduction of greenhouse gases is concerned. It also authorizes Council to regulate plumbing and heating facilities in buildings, and to fix standards for plumbing and heating facilities. Council is also authorized to require permits to enforce its regulations. The proposed Annual Greenhouse Gas and Energy Limits By-law will rely on these powers.

**CONCLUSION**

The recommended actions herein advance the Climate Emergency Action Plan Big Move 4 by introducing initial carbon pollution limits for the largest commercial buildings in Vancouver. These recommendations will accelerate the transition towards zero carbon pollution from existing commercial buildings, facilitate related regional and provincial action to scale Vancouver's impact, and help to catalyse voluntary GHG reduction and resilience retrofits in multifamily buildings which provide homes for our most vulnerable citizens.

\* \* \* \* \*

*Note: A By-law will be prepared generally in accordance with the provisions listed below, subject to change and refinement prior to posting.*

BY-LAW NO. \_\_\_\_\_

**A By-law to amend the Building By-law No. 12511  
Regarding Energy Reporting**

THE COUNCIL OF THE CITY OF VANCOUVER, in public meeting, enacts as follows:

1. This By-law amends the indicated provisions of Building By-law No. 12511.

2. In Book I, Division B, Part 11, Article 11.2.1.2., Council:

a.) strikes out Sentence 11.2.1.2.(9) as follows:

"

**9)** The upgrade requirements for energy efficiency to *existing buildings* shall conform to the upgrade mechanism model in Notes to Part 11 for energy efficiency except for

- a) *buildings* designed and constructed in conformance with ASHRAE 90.1-2007 or as deemed acceptable to the *Chief Building Official*,
- b) *buildings* designed and constructed in conformance with Article 9.25.2.1. of Building By-law No. 9419,
- c) *buildings* where the *alteration* is limited to the upgrade of energy related specific equipment, as listed in Table 11.2.1.2.-A, provided the replacement equipment complies with industry standards for "high efficiency," and
- d) *multifamily buildings* not more than 3 storeys in *building height* may comply with the energy efficiency upgrade requirements of Table 11.2.1.4.(2).

"

b.) strikes out Table 11.2.1.2.A as follows:

"

**Table 11.2.1.2.-A**  
**Energy Related Equipment**  
Forming part of sentence 11.2.1.2.(9)

Equipment Type	Specific Equipment
Basic Building Systems	Boilers
	Furnaces
	Hot Water Tanks
	Lighting Systems
	Energy Reduction Sensors (occupant, light, etc.)

Renewable Energy Systems	Photovoltaic system
	Solar Thermal system
	Biofuel-based Energy system
	Geothermal Heating system
	Geothermal Electric system
	Wave & Tidal Power system
High Performance Energy Systems	Ground Source Heat Pump system
	Air Source Heat Pump system
	Waste Heat Recovery system

",

- c.) renumbers Sentence 11.2.1.2.(10) as Sentence 11.2.1.2.(9)., and
  - d.) renumbers "Table 11.2.1.2.-B" as "Table 11.2.1.2.-A".
3. In Book I, Division B, Part 11, Sentence 11.2.1.2.(6), Council strikes out the words "F4, S4, N4, A4 and E4" and substitutes "F4, S4, N4 and A4".
  4. In Book I, Division B, Part 11, Sentence 11.2.1.2.(8), Council:
    - a.) strikes out the words "Sentence (10)" and substitutes "Sentence (9)", and
    - b.) strikes out the words "F4, S4, N4, A4 and E3" and substitutes "F4, S4, N4 and A4".
  5. In Book I, Division B, Part 11, Sentence 11.2.1.2.(9), Council:
    - a.) in clause 11.2.1.2.(9)(d) strikes out the words "Table 11.2.1.2.-B" and substitutes "Table 11.2.1.2.-A", and
    - b.) in the notes to Table 11.2.1.2.-A, renumbers all references to "Table 11.2.1.2.-B" as "Table 11.2.1.2.-A".
  6. In Book I, Division B, Part 11, Sentence 11.2.1.6.(1), Council strikes out the words "F4, S4, N4, A4 and E4" and substitutes "F4, S4, N4 and A4".
  7. In Book I, Division B, Part 11, Clause 11.4.7.1.(1)(a), Council strikes out the words "F4, S4, N4, A4 and E4" and substitutes "F4, S4, N4 and A4".
  8. In Book I, Division B, Part 11, in note A-11.2.1.2., Council:

a.) strikes part of the Notes for Existing Buildings, as follows:

<b>TABLE A-11.2.1.2.-C</b>		
<b>Alternative acceptable solutions for Energy Efficiency</b>		
<b>General Objective Statement:</b> Improve the energy and GHG emissions performance of buildings, systems or components.		
<b>Solution Location:</b> E1 through E5 – Project Location. E6 and E7 – Building Location		
E Level	Building System	Alternative Acceptable Solution Options <sup>(1)</sup> (Choose one)
<b>E1 Level Objective Statement:</b> Review and maintain, or upgrade, basic efficiency of equipment or components.		
<b>E1</b>	Envelope	<ol style="list-style-type: none"> <li>1) Reduce air leakage of all Glazing &amp; Doors (per 5.4.3.2 of ASHRAE 90.1-2016)</li> <li>2) Upgrade all Opaque Doors performance (per 5.5.3.6 of ASHRAE 90.1-2016)</li> </ol>
	HVAC <sup>(3)</sup>	<ol style="list-style-type: none"> <li>1) Upgrade Dead Band settings (per 6.4.3.1.2 of ASHRAE 90.1-2016)</li> <li>2) Upgrade Set-point Overlap Restrictions (per 6.4.3.2 of ASHRAE 90.1-2016)</li> <li>3) Upgrade Off-Hour Controls (per 6.4.3.3 of ASHRAE 90.1-2016)</li> <li>4) Upgrade Ventilation System Controls (per 6.4.3.4 of ASHRAE 90.1-2016)</li> <li>5) Upgrade Heat Pump Auxiliary Heat Controls (per 6.4.3.5 of ASHRAE 90.1-2016)</li> <li>6) Upgrade Freeze Protection and Snow/Ice Melting Systems (per 6.4.3.7 of ASHRAE 90.1-2016)</li> <li>7) Upgrade Ventilation Controls For High-Occupancy Areas (per 6.4.3.8 of ASHRAE 90.1-2016)</li> <li>8) Upgrade DDC Controls (per 6.4.3.10 of ASHRAE 90.1-2016)</li> <li>9) Inspect and remediate HVAC Insulation (per 6.4.4.1 of ASHRAE 90.1-2016)</li> <li>10) Inspect and remediate Duct and Plenum Leakage (per 6.4.4.2 of ASHRAE 90.1-2016)</li> <li>11) Upgrade Heat and Cool Limitation (per 6.5.2.1 of ASHRAE 90.1-2016)</li> </ol>
	SWH <sup>(4)</sup>	<ol style="list-style-type: none"> <li>1) Upgrade all SWH Piping Insulation (per 7.4.3 of ASHRAE 90.1-2016)</li> </ol>
	Lighting	<ol style="list-style-type: none"> <li>1) Upgrade internal Exit Signs to not exceed 5W per face</li> <li>2) Functional Testing (per 9.4.3 of ASHRAE 90.1-2016)</li> </ol>
<b>E2 Level Objective Statement:</b> Review and maintain, or upgrade, basic efficiency of sub-systems.		
<b>E2<sup>(2)</sup></b>	Envelope	<ol style="list-style-type: none"> <li>1) Reduce air leakage of all Loading Dock Doors (per 5.4.3.3 of ASHRAE 90.1-2016)</li> <li>2) Upgrade all Floor Insulation (per 5.5.3.4 of ASHRAE 90.1-2016)</li> <li>3) Reduce total Skylight Fenestration/Glazing Area to 3% of gross roof area (per 5.5.4.2.2 of ASHRAE 90.1-2016)</li> </ol>
	HVAC <sup>(3)</sup>	<ol style="list-style-type: none"> <li>1) Upgrade Chilled Water Plant Monitoring (per 6.4.3.11 of ASHRAE 90.1-2016)</li> <li>2) Upgrade Economizer Fault Detection and Diagnostics (per 6.4.3.12 of ASHRAE 90.1-2016)</li> <li>3) Clean and Balance all Air Systems (per 6.7.2.3.2 of ASHRAE 90.1-2016)</li> <li>4) Balance all Hydronic Systems (per 6.7.2.3.3 of ASHRAE 90.1-2016)</li> <li>5) Remove Wood-Burning Fireplace unit</li> <li>6) Replace gas fireplace pilot light with electronic ignition unit with energy rating over 50</li> </ol>

		<ol style="list-style-type: none"> <li>7) Install makeup air supply per code to balance exhaust fan(s) over 300 cfm</li> </ol>
	SWH <sup>(4)</sup>	<ol style="list-style-type: none"> <li>1) Upgrade SWH system Temperature Controls (per 7.4.4.1 of ASHRAE 90.1-2016)</li> <li>2) Upgrade SWH system Temperature Maintenance Controls (per 7.4.4.2 of ASHRAE 90.1-2016)</li> <li>3) Upgrade SWH system Outlet Temperature Controls (per 7.4.4.3 of ASHRAE 90.1-2016)</li> <li>4) Upgrade SWH system Circulating Pump Controls (per 7.4.4.4 of ASHRAE 90.1-2016)</li> <li>5) Upgrade Pool systems (per 7.4.5 of ASHRAE 90.1-2016)</li> <li>6) Upgrade pipe risers to incorporate Heat Traps (per 7.4.6 of ASHRAE 90.1-2016)</li> </ol>
E2 <sup>(2)</sup>	Lighting	<ol style="list-style-type: none"> <li>1) Upgrade to Local Control (per 9.4.1.1.(a) of ASHRAE 90.1-2016)</li> <li>2) Upgrade to Restricted to Manual ON (per 9.4.1.1.(b) of ASHRAE 90.1-2016)</li> <li>3) Upgrade to Restricted to Partial Automatic ON (per 9.4.1.1.(c) of ASHRAE 90.1-2016)</li> <li>4) Upgrade to Bilevel Lighting Control (per 9.4.1.1.(d) of ASHRAE 90.1-2016)</li> <li>5) Upgrade all Automatic Daylighting Responsive Controls for Sidelighting (per 9.4.1.1.(e) of ASHRAE 90.1-2016)</li> <li>6) Upgrade all Automatic Daylighting Controls for Toplighting (per 9.4.1.1.(f) of ASHRAE 90.1-2016)</li> <li>7) Upgrade to incorporate Automatic Partial OFF (per 9.4.1.1.(g) of ASHRAE 90.1-2016)</li> <li>8) Upgrade to incorporate Automatic Full OFF (per 9.4.1.1.(h) of ASHRAE 90.1-2016)</li> <li>9) Upgrade to incorporate Scheduled Shutoff (per 9.4.1.1.(i) of ASHRAE 90.1-2016)</li> <li>10) Upgrade to control Parking Garage Lighting (per 9.4.1.3 of ASHRAE 90.1-2016)</li> <li>11) Upgrade to incorporate Additional Controls for Special Applications (per 9.4.1.3 of ASHRAE 90.1-2016)</li> <li>12) Exterior Lighting Control (per 9.4.1.7 of ASHRAE 90.1-2016)</li> <li>13) Reduce total Skylight Fenestration/Glazing Area to 3% of gross roof area (per 5.5.4.2.2. of ASHRAE 90.1-2016)</li> </ol>
	Exterior or Patio Heating	<ol style="list-style-type: none"> <li>1) Remove exterior space heating system</li> <li>2) Upgrade energy intensity (per 10.2.2.22.(3)) and system controls per 10.2.2.22.(4)</li> </ol>
<b>E3 Level Objective Statement:</b> Review and and improve energy performance of systems.		
E3 <sup>(2)</sup>	Envelope	<ol style="list-style-type: none"> <li>1) Provide a Building Envelope Assessment Report, to be signed and sealed by a design professional, report to include: effective R-value, blower test, list of upgrades to achieve a compliance rating using COMcheck<sup>(5)</sup> software (latest version).</li> <li>2) Reduce air leakage of all Fenestration &amp; Doors (per 5.4.3.2 of ASHRAE 90.1-2016)</li> <li>3) Upgrade all Below-Grade Wall Insulation (per 5.5.3.3 of ASHRAE 90.1-2016)</li> <li>4) Inspect and remediate all ceiling space and floor space equipment and services including ductwork, plumbing, insulation, penetrations, dampers, valves, coils, pans and drains.</li> <li>5) Inspect and remediate all floor/crawl space services (ducts, plumbing, insulation, penetrations, drains etc)</li> </ol>
	HVAC <sup>(3)</sup>	<ol style="list-style-type: none"> <li>1) Provide an HVAC System Assessment Report, to be signed and sealed by a design professional. Report to include: systems reviews, upgrade and re-commissioning options, with estimates for energy savings and cost paybacks.</li> </ol>



		<p><b>2)</b> Upgrade all ducts, plenums, and insulation (per 6.4.4 of ASHRAE 90.1-2016); inspect and remediate HVAC Insulation (per 6.4.4.1 of ASHRAE 90.1-2016); and inspect and remediate Duct and Plenum Leakage (per 6.4.4.2 of ASHRAE 90.1-2016)</p> <p><b>3)</b> Incorporate Exhaust Air Recovery systems (per 6.5.6.1 of ASHRAE 90.1-2016)</p> <p><b>4)</b> Incorporate a Service Water Heating Recovery system (per 6.5.6.2 of ASHRAE 90.1-2016)</p> <p><b>5)</b> Upgrade all Kitchen Exhaust and Replacement Air systems (per 6.5.7.2 of ASHRAE 90.1-2016)</p> <p><b>6)</b> Upgrade all Laboratory Exhaust and Replacement Air systems (per 6.5.7.3 of ASHRAE 90.1-2016)</p> <p><b>7)</b> Balance all systems (per 6.7.2.3 of ASHRAE 90.1-2016)</p>
<b>E3<sup>(2)</sup></b>	SWH <sup>(4)</sup>	<p><b>1)</b> Provide an HVAC System Assessment Report, to be signed and sealed by a design professional</p> <ul style="list-style-type: none"> <li>• Report to include: systems reviews, upgrade and re-commissioning options, with estimates for energy savings and cost paybacks.</li> </ul> <p><b>2)</b> Upgrade SWH system Controls (per 7.4.4 of ASHRAE 90.1-2016)</p>
	Lighting	<p><b>1)</b> Provide a comprehensive Lighting System Assessment Report to be signed and sealed by a design professional</p> <ul style="list-style-type: none"> <li>• Report to include: systems reviews, upgrade options, with estimates for energy savings and cost paybacks.</li> </ul> <p><b>2)</b> Upgrade total Exterior Lighting Power (per 9.4.2 of ASHRAE 90.1-2016) of the suite.</p> <p><b>3)</b> Meet the interior lighting power allowance by the Building Area Method (per 9.5 of ASHRAE 90.1-2016)</p> <p><b>4)</b> Meet the interior lighting power allowance by the Space-by-Space Method (per 9.6 of ASHRAE 90.1-2016)</p>
	Exterior or Patio Heating	<p><b>1)</b> Remove exterior space heating system</p> <p><b>2)</b> Upgrade energy intensity, system and unit/zone controls (per 10.2.2.22.(3) and (4)), and circulation fans (per 10.2.2.22.(5))</p>
<b>E4 Level Objective Statement:</b> Review and improve energy performance of larger systems.		
<b>E4<sup>(2)</sup></b>	Envelope	<p><b>1)</b> Reduce air leakage of entire Building Envelope (per 5.4.3 of ASHRAE 90.1-2016)</p> <p><b>2)</b> For single retail/tenant spaces &lt; 500 m<sup>2</sup>) Perform an Air Leakage / Blower test and remediate</p> <p><b>3)</b> Upgrade all Roof Insulation (per 5.5.3.1 of ASHRAE 90.1-2016)</p> <p><b>4)</b> Upgrade all Above-Grade Wall Insulation (per 5.5.3.2 of ASHRAE 90.1-2016)</p> <p><b>5)</b> For single retail/tenant spaces &lt; 500 m<sup>2</sup>) Replace storefront window(s) to meet the By-law.</p> <p><b>6)</b> Reduce total vertical Fenestration/Glazing Area to 40% of gross wall area (per 5.5.4.2.1 of ASHRAE 90.1-2016)</p> <p><b>7)</b> Upgrade all Fenestration/Glazing Performance (per 5.5.4.3 and 5.5.4.4 of ASHRAE 90.1-2016)</p> <p><b>8)</b> Inspect and remediate roof systems including membrane, parapets, scuppers, drains, gutters, downspouts and drains.</p>
	HVAC <sup>(3)</sup>	<p><b>1)</b> Upgrade all Zone Thermostatic Controls (per 6.4.3.1 of ASHRAE 90.1-2016)</p> <p><b>2)</b> Upgrade HVAC to incorporate Economizers (per 6.5.1 of ASHRAE 90.1-2016)</p> <p><b>3)</b> Upgrade Heat Rejection Equipment (per 6.5.5 of ASHRAE 90.1-2016)</p>

		<p><b>4)</b> Upgrade to Air and Service Water Heating Heat Recovery systems (per 6.5.6 of ASHRAE 90.1-2016)</p> <p><b>5)</b> Upgrade entire Radiant Heating system (per 6.5.8 of ASHRAE 90.1-2016)</p> <p><b>6)</b> (Re-)Commission all systems (per 6.7.2.4 of ASHRAE 90.1-2016)</p>
	SWH <sup>(4)</sup>	<b>1)</b> Upgrade all Service Water Heating Equipment Efficiency (per 7.4.2 of ASHRAE 90.1-2016)
	Lighting	<b>1)</b> Lighting Control (per 9.4.1 of ASHRAE 90.1-2016)
	Exterior or Patio Heating	<p><b>1)</b> Remove exterior space heating system</p> <p><b>2)</b> Upgrade exterior space heating system (per 10.2.2.22)</p>
<b>E5 Level Objective Statement:</b> Review and bring to present VBBL energy requirements, entire system(s) affected by vertical addition.		
<b>E5<sup>(2)</sup></b>	Envelope	<p><b>1)</b> Upgrade insulation levels of entire Building Envelope (Opaque Areas) (per 5.5.3 of ASHRAE 90.1-2016)</p> <p><b>2)</b> Upgrade all Fenestration/Glazing (per 5.5.4 of ASHRAE 90.1-2016)</p>
	HVAC <sup>(3)</sup>	<b>1)</b> Upgrade all HVAC Controls, Insulation and Leakage (per 6.4 of ASHRAE 90.1-2016)
	SWH <sup>(4)</sup>	<b>1)</b> Upgrade Service Water Heating system to meet the Mandatory Provisions (per 7.4 of ASHRAE 90.1-2016)
	Lighting	<b>1)</b> Upgrade Lighting system to meet the Mandatory Provisions (per 9.4 of ASHRAE 90.1-2016)
<b>E6 Level Objective Statement:</b> Reconstruct entire building systems to meet energy efficiency requirements of present Vancouver Building By-Law.		
<b>E6</b>	Envelope	<b>1)</b> Upgrade all aspects of Building Envelope (per Section 5 of ASHRAE 90.1-2016)
	HVAC <sup>(3)</sup>	<b>1)</b> Upgrade all aspects of HVAC (per Section 6 of ASHRAE 90.1-2016)
	SWH <sup>(4)</sup>	<b>1)</b> Upgrade all aspects of SWH (per Section 7 of ASHRAE 90.1-2016)
	Lighting	<b>1)</b> Upgrade all aspects of Lighting (per Section 9 of ASHRAE 90.1-2016)
<b>E7 Level Objective Statement:</b> Reconstruct building to meet energy efficiency requirements of present Vancouver Building By-Law.		
<b>E7</b>	Energy	<b>1)</b> Upgrade existing building (per VBBL 1.3.3.7 Energy Use)

**Notes to Table A-11.2.1.2.-C:**

- (1) References to ASHRAE 90.1 in Table A-11.2.1.2.-C can be considered guidance for determining the scope of work when applying the upgrade requirements to low-rise multifamily projects, otherwise these projects may apply the energy upgrade requirements of Table 11.2.1.4, per the options provided within Sentence 11.2.1.2.(9)(d).
- (2) BOMA BEST (Path 1) may be substituted as the solution for upgrade level E2. BOMA BEST (Path 2) may be substituted as the solution for upgrade levels E3, E4 or E5. BOMA BEST is a Canadian industry standard for commercial building sustainability certification. Official certification documentation produced by BOMA would be required for acceptance as an alternative acceptable solution option.

The intent of the inclusion of the BOMA BEST rating system is to recognise the efforts made towards improved building performance. BOMA BEST Path 1 or Path 2 will be accepted provided

- a) the BOMA BEST certification is administered by BOMA,
- b) BOMA BEST Path 1 - BOMA BEST (Level 1, 2, 3, 4) provides proof of a valid Certification and ongoing commissioning per BOMA's BEST Practice Q.3 (Preventative Maintenance Program), and
- c) BOMA BEST Path 2 - BOMA BEST (Level 1-AL2, 2, 3, 4) provides proof of a first-time Certification (to at least Level 1 with an ASHRAE Level 2 audit) within the previous 18 months, or a valid Certification and an increase in BOMA BEST's Energy Performance Benchmark Scale by at least one level within the previous 18 months, or advancing Certification (from one level to another) within the previous 18 months.

Proof means in the form of official certified documentation produced by BOMA, or a single Commissioning/Energy Report developed and provided by a qualified consultant, contractor, or other expert in this specialized field.

(3) HVAC – Heating, Ventilating and Air Conditioning

(4) SWH – Service Water Heating

(5) COMcheck – software developed by the US Department of Energy for use with ASHRAE 90.1-2016 Building Envelope Trade-Off option

- b.) in the first paragraph associated with header "Hazard Index Table" strikes out the words "Table A-11.2.1.2.-D" and substitutes "Table A-11.2.1.2.-C",
- c.) in the third paragraph associated with header "Hazard Index Table" strikes out the words "see Note A-11.2.1.2.(10)" and substitutes "see Note A-11.2.1.2.(9)", and
- d.) renumber Table "A-11.2.1.2.-D" as "A-11.2.1.2.C".

9. In Book I, Division B, in the notes to Part 11, Council strikes out Note A-11.2.1.2.(10) and substitutes the following:

**A-11.2.1.2.(9) Restricted Change of Occupancy.** The term "restricted change of occupancy" refers to a change in major occupancy restricted to a specific set of uses as set out in Article 11.2.1.2.(9) that are limited both in scope and risk such that it does not increase the overall hazard.

While it is intended that designers and owners seeking to apply this requirement refer to the hazard index table A-11.2.1.2.-B, for the purposes of this Article – they may substitute the aggregate suite area of the suite in lieu of the building area where the change of major occupancy is wholly contained within the original suite.

For example: a suite of 300 m<sup>2</sup> is being repartitioned and converted from a "business office" use (Group D) to a suite of "retail toystore" use (Group E) of 150 m<sup>2</sup> and second suite of "health care office" use which are fully contained within the original 300 m<sup>2</sup> suite area. The aggregate suite area is therefore permitted to be used for the purposes of determining the appropriate hazard index which is then established as follows:

- Business Office (300 m<sup>2</sup>) – 4 (original)
- Retail Toystore (150 m<sup>2</sup>) – 4 (new)
- Health Care Office (150 m<sup>2</sup>) – 3 (new)

By comparison, a larger toystore, such as the conversion of the original 300 m<sup>2</sup> suite area into a toystore, would result in a hazard index of '5' which would not meet the requirements of Article 11.2.1.2. for a "restricted change of occupancy" as it represents an increase in hazard.

While the hazard index table is a useful tool for assessment, it is also important to understand that no table can address all possible combinations of uses. Designers and owners should exercise caution when making judgments of relative hazards in this regard.

".

10. A decision by a court that any part of this By-law is illegal, void, or unenforceable severs that part from this By-law, and is not to affect the balance of this By-law.

11. This By-law is to come into force and take effect on January 1, 2023.

ENACTED by Council this                      day of    , 2022

\_\_\_\_\_  
Mayor

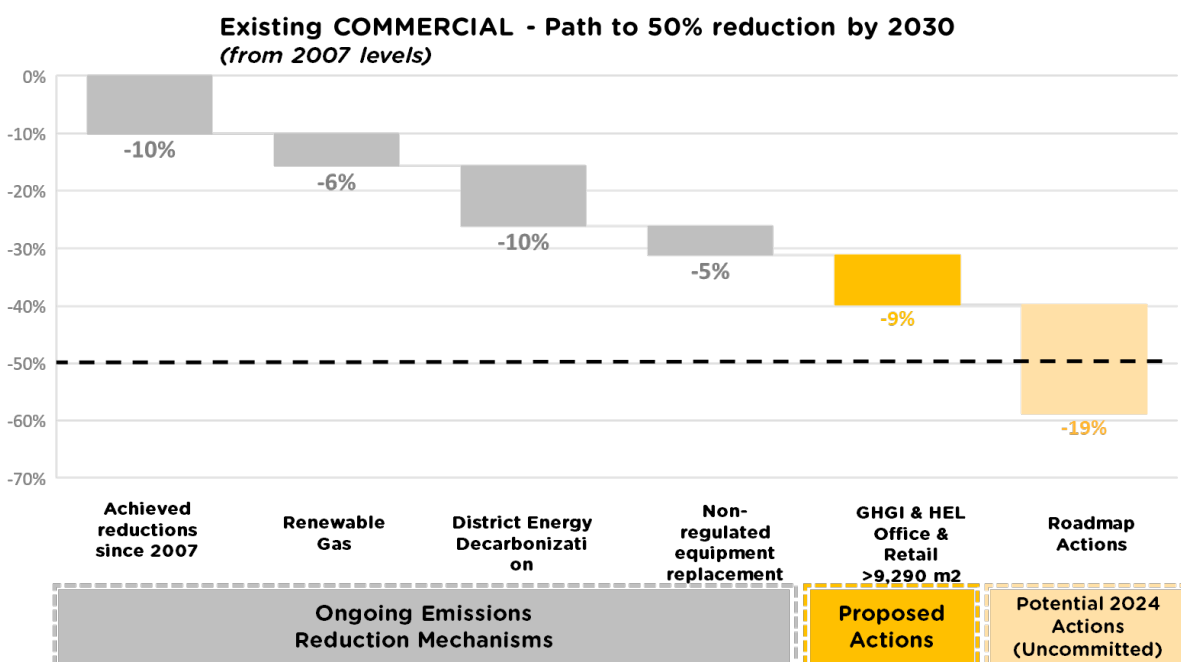
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City Clerk

## Appendix B – Details on GHG Intensity and Heat Energy Limits for large office and retail buildings and associated Energy and Carbon Reporting requirements and Commercial Building Owner Supports

### Rationale

The GHGi and Heat Energy Limits for large office and retail and the proposed future regulations described in the Regulatory Roadmap combined with historic reductions, an increasing supply of renewable gas, decarbonisation of the district energy utilities and voluntary action by owners have been modelled to result in a reduction of 164,000 tonnes CO<sub>2</sub>e or 59% reduction below 2007 from existing commercial buildings by 2030.

These emission reductions depend on the Province proceeding with its announced equipment efficiency standards, Metro Vancouver with potential future carbon pollution regulations for existing buildings, BC Hydro implementing its Electrification Plan, and FortisBC and Creative Energy getting approval for and proceeding with their renewable gas and renewable energy projects.



### 2026 GHGi Limits

#### Rationale

The City needs to establish the regulatory framework now to catalyze action to meet future targets. The 2026 targets will:

- Raise awareness among building owners and the broader industry on the need to orient building mechanical upgrade and replacement projects to achieve reductions in GHG emissions and catalyze early owner action;
- Initiate capacity-building within industry;

- Increase the awareness and catalyze owner action to implement cost effective, building commissioning and operational optimization to address energy waste and lower costs
- Increase market demand for low-carbon, renewable energy

The recommended requirements will be the first of their kind in Canada but are in-line with the emerging best practice of “Building Performance Standards” (BPS) that have now been adopted by multiple jurisdictions in North America.<sup>3</sup> To date, six jurisdictions in North America have adopted Building Performance Standards—New York City, Boston, Washington DC, St. Louis, Washington State, and the State of Colorado—while over 25 other jurisdictions have committed to doing so by 2024.<sup>4</sup> This approach is also consistent with the regulations that the Metro Vancouver Board has directed staff to research and consult on.<sup>5</sup> A *Best Practice Review* was completed by the consulting team of Integral Group, WSP and IMT for the City, which directly informed the creation of this policy.

#### *2026 Impacts on Covered Buildings*

As the energy and carbon reporting requirements are not yet in place, the City of Vancouver contracted with Integral Group and WSP to model and estimate the energy and carbon performance of all the large office and retail buildings in the City and analyse potential compliance pathways and their cost-effectiveness. This work is described in detail in Appendix G. Figure 1 and Figure 2 below show the distribution of estimated GHG performance of office and retail buildings, respectively, with the dotted line indicating the number of buildings that are projected as not meeting the 2026 GHGi limit.

Approximately 125 office buildings and 50 retail buildings will be covered by this initial regulation. Of those, the consultants estimate that 45 will need to take action to reduce their GHG emissions to comply with the 2026 limits. Most of these buildings will choose to undertake recommissioning, or a building tune-up, which will result in GHG reductions of 5-10% that have positive net-present-value due to energy cost savings. For buildings that need to achieve GHG emissions reduction greater than 10%, they will choose to make changes to building operations, replace or retrofit mechanical equipment, and/or purchase renewable gas or low/zero-carbon district energy. If a building chooses to purchase renewable gas or a blend of zero carbon district energy as a means of compliance, the cost for most buildings over the limit will be approximately 2% of monthly operational expenses or less. Details on potential compliance options, the savings achieved, and the cost impacts are included in Appendix G.

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<sup>3</sup> Nadel, S. and A. Hinge. 2020. Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals. Washington, DC: American Council for an Energy Efficient Economy.

<sup>4</sup> <https://nationalbpscoalition.org>

<sup>5</sup> [http://www.metrovancouver.org/services/air-quality/climate-action/climate2050/Climate2050Docs/Climate2050BuildingsRoadmap\\_Final\\_October2021.pdf](http://www.metrovancouver.org/services/air-quality/climate-action/climate2050/Climate2050Docs/Climate2050BuildingsRoadmap_Final_October2021.pdf)

Figure 1: Estimated GHGi distribution for office buildings > 9,290 m<sup>2</sup>

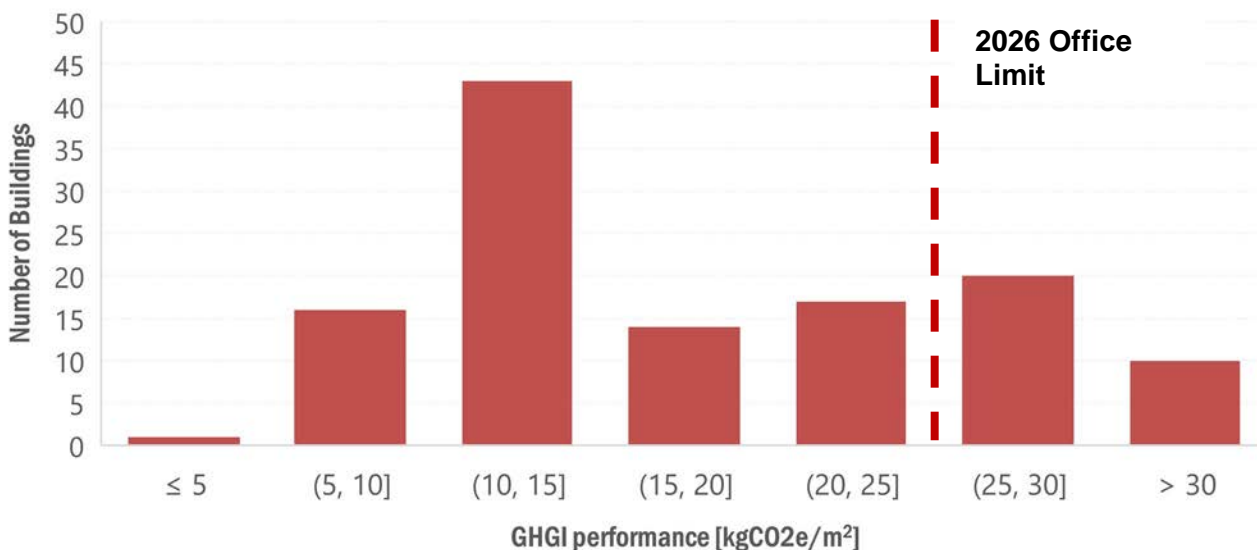
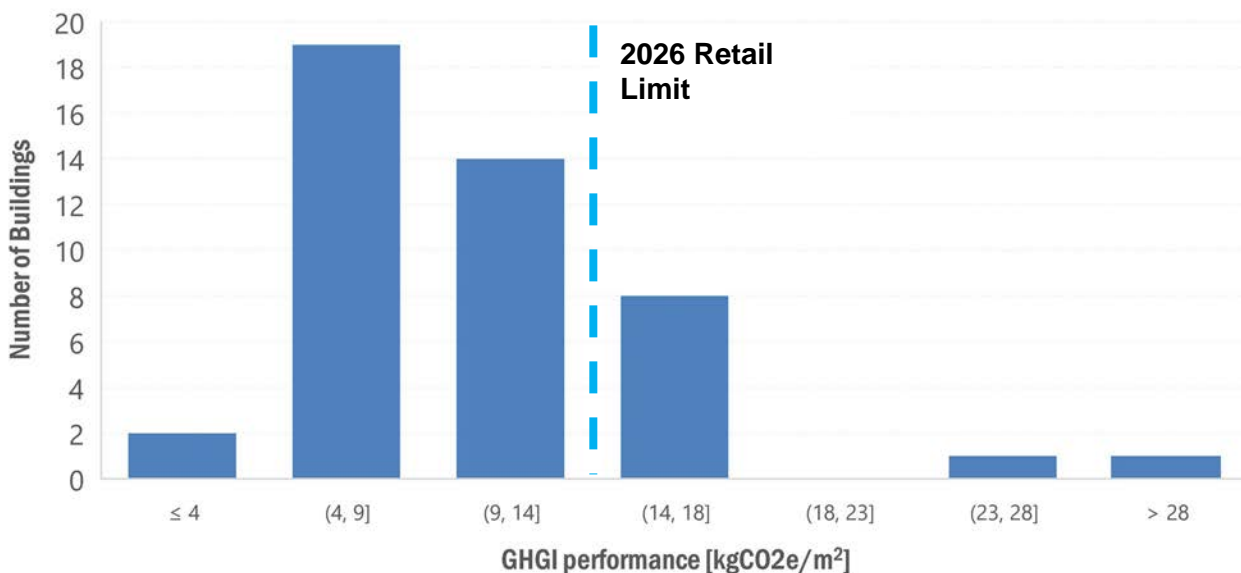


Figure 2: Estimated GHGi distribution for retail buildings > 9,290 m<sup>2</sup>



### Specialized Tenant Uses

The purpose of the GHGi regulation is to reduce carbon pollution via the increased efficiency of space heat and domestic hot water equipment and the use of renewable energy. Specialized tenant uses of gas within large office and retail buildings (e.g., restaurants) typically make up a small percentage of a building’s overall emissions and require a different approach to decarbonisation. The City will allow the exclusion of select uses (e.g., restaurants) that are unrelated to core building operations.

### Cost of Non-Compliance

Buildings will be required to pay \$350 per tonne of CO<sub>2</sub>e they are in excess of the allowed annual limit. The fee was informed by two modelling exercises conducted by Navius, Integral

Group and WSP in 2021, and was determined to reflect the price threshold required to drive action from building owners. This is also similar to the cost of non-compliance (factoring in USD to CAD exchange rates) used by New York City for Local Law 97 to drive deep emission reduction action by building owners.

2040 GHGi and Heat Energy Limits

Table 1. GHGi Limit by Building Type

Building Type	GHGi Limit* (kg CO <sub>2</sub> e/m <sup>2</sup> /year)	Heat Energy Use Limit (GJ/m <sup>2</sup> /year)
Large Office Buildings ≥ 9,290 m <sup>2</sup> (≥ 100,000 ft <sup>2</sup> )	0	0.09
Large Retail Buildings ≥ 9,290 m <sup>2</sup> (≥ 100,000 ft <sup>2</sup> )	0	0.09

\*All energy used will be provided from renewable sources by 2040. The actual GHGi limit will be amended as we approach 2040 if the carbon intensity of the renewable energy available is non-zero.

*Rationale – 2040 GHG Intensity Limit and Heat Energy Limit*

Primary heating equipment in commercial buildings requires replacement or major capital investment every 20-25 years. Given the large amount of waste heat in office and retail buildings due to high occupant and equipment densities, traditional gas fired boilers can be cost effectively replaced by heat pumps using today’s technology if modest amount of combustion is allowed for peaking and back-up. A 2040 Heat Energy Limit provides owners enough time to significantly reduce heat energy use from gas or district heat in conjunction with needed equipment replacements. Roughly 5% of these systems need replacing each year so setting this limit now could result in 40% of these buildings reducing heat energy use and associated GHG emissions by 60%-80% by 2030. A Heat Energy Limit will result in significant reductions in energy costs (and future cost risk given difficult to predict future energy costs) and will constrain the amount of renewable energy required in the future. With such significant reductions in energy use, a GHGi limit of zero requiring buildings to only use renewable energy by 2040 will not have major cost implications compared to natural gas, especially if the carbon tax on fossil fuels continues to escalate as anticipated.

Establishing these limits now will send a clear signal to building owners, utilities and district energy providers to justify market investment in zero carbon options, including renewable gas and zero carbon district energy. A GHG Intensity limit of 0 kg CO<sub>2</sub>e/m<sup>2</sup>/year is required to do this.

Energy studies and retrofit projects conducted in recent years demonstrate that the proposed 2040 limits are achievable. 32 out of 36 office and retail buildings that were studied by SES Consultants in Southwestern British Columbia could meet a heating energy use limit of 0.09 GJ/m<sup>2</sup>/year by implementing heat recovery or heat pump projects (including complementary enabling measures) with two-thirds of these projects having a positive net-present-value, or less than \$1 million in costs when considering incremental cost vs like-for-similar replacement at time of major equipment investment. The remaining one-third of projects have a negative net-present-value if trying to meet the 2040 limit under current conditions but this negative business case is small and it is anticipated that additional and more cost effective reduction measures will be identified prior to 2040. This analysis shows that meeting the Heat Energy Limit can be



achieved in most cases without requiring large capital investments that do not have a positive business case over the lifetime of the equipment. <sup>6</sup>

Table 2 - SES Consultants Energy Studies on Office & Retail > 9,290m<sup>2</sup> <sup>7</sup>

Building Type	Site ID	Heating Energy Source	Gas - Baseline (GJ)	District Energy - Baseline (GJ)	GHGi Baseline (kgCO <sub>2e</sub> /m <sup>2</sup> )	Heat Energy Baseline (GJ/m <sup>2</sup> )	GHGi Post-retrofit (kgCO <sub>2e</sub> /m <sup>2</sup> )	Heat Energy Post-retrofit (GJ/m <sup>2</sup> )
Office	1	Steam		5,732	6	0.12	1.8	0.00
Office	2	Steam		9,488	10	0.21	4.9	0.05
Office	3	Steam		21,510	28	0.56	12.6	0.11
Office	4	Steam		6,624	10	0.19	1.0	0.00
Office	5	Steam		2,500	4	0.08	3.3	0.06
Office	6	Steam		12,043	19	0.37	5.8	N/A
Office	7	Gas	11,783		19	0.38	3.7	N/A
Office	8	Steam		8,965	20	0.40	6.2	N/A
Office	9	Steam		3,797	10	0.20	3.1	N/A
Office	10	Steam		9,062	26	0.52	11.4	0.09
Office	11	Steam		5,425	17	0.35	5.3	0.01
Office	12	Steam		6,199	21	0.43	9.2	0.08
Office	13	Steam		6,754	23	0.47	10.9	0.11
Office	14	Steam		2,471	9	0.17	2.7	0.00
Office	19	Gas	7,964		37	0.75	8.9	0.03
Office	20	Steam		9,727	53	1.05	-	0.00
Office	22	Gas	4,779	-	28	0.56	3.4	0.02
Office	23	Gas	3,639		23	0.45	7.2	0.07
Office	25	Gas	1,795		13	0.26	3.5	0.02
Office	26	Gas	2,109		16	0.32	3.7	0.01
Office	28	Gas	1,581		14	0.27	3.8	0.02
Office	31	Gas	46		0	0.01	0	N/A
Office	32	Gas	1,847		23	0.47	8.4	0.09
Office	35	Gas	1,481		27	0.53	12.2	0.18
Retail	37	Steam		9,293	24	0.49	7	0.00
Retail	38	Gas	10,196		4	0.09	2	0.03
Retail	39	Gas	3,630		8	0.16	0	N/A
Retail	40	Gas	14,617		35	0.70	15	0.20
Retail	41	Gas	7,055		8	0.15	2	0.00

Steam = district energy system supplied steam for space heating and/or service hot water

<sup>6</sup> SES Consultants 2022. Unpublished data shared with the City staff.

<sup>7</sup> *Ibid*. Select data presented in the table. Question marks denote where data was available to calculate a post-retrofit TESI

### **Energy and Carbon Reporting**

Energy and carbon reporting requires building owners to report on annual energy use to allow for an ongoing review of a building's energy and carbon performance as compared to its past performance and to its peers. Energy reporting requirements have been widely implemented across the North America and Europe. Forty-one U.S. jurisdictions and the province of Ontario require buildings above a certain size threshold (often 50,000 ft<sup>2</sup>) to annually report energy information to the regulating jurisdiction. In the City of Vancouver, thousands of buildings already track their energy and carbon performance.

#### *Rationale*

Energy and carbon reporting is required to show compliance with GHGI and Heat Energy Limits. In addition, a reporting requirement is a critical first step to successfully reducing large existing building carbon pollution because it is not possible to manage what is not measured. The data generated from this reporting program will be used for the following purposes:

- Inform setting future GHGI limits, Heat Energy Limits, and designing effective owner support programs.
- Target the highest carbon-polluting buildings for improvement and stimulate energy retrofits.
- Assess effectiveness of specific regulations and support programs in reducing carbon pollution.
- Support communication about the market transformation to zero emissions buildings
- Support building owners and managers increase knowledge of their building energy performance and make plans to reduce their carbon pollution

#### *Covered Buildings and Timeline*

Implementing mandatory energy and carbon reporting for commercial and multifamily residential buildings over 4,645 m<sup>2</sup> (50,000 ft<sup>2</sup>) will cover approximately 55% of the floor area, and would impact 10% of the total buildings within the City of Vancouver excluding detached homes. Table 3 outlines the timeline for phasing in the requirement by building type:

*Table 3: Energy and Carbon Reporting Requirements*

<b>Building Type</b>	<b>Covered Building Floor Area</b>		<b>Reporting Year</b>	<b>Buildings Covered, Cumulative</b>
	<b>square meters (m<sup>2</sup>)</b>	<b>square feet (ft<sup>2</sup>)</b>		
<b>Commercial</b>	≥ 9,290	≥ 100,000	2024	250
	≥ 4,645	≥ 50,000	2025	700
<b>Multifamily</b>	≥ 9,290	≥ 100,000	2025	1050
	≥ 4,645	≥ 50,000	2026	1500

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## Appendix C – Details on the Regulatory Roadmap

PHASE	DETAILS
2022 - 2024	<ul style="list-style-type: none"> <li>• Analysis and stakeholder consultation on performance and prescriptive regulations</li> <li>• Launching of initial Multifamily owner supports and Multifamily/Commercial demonstration programs</li> <li>• Recommendations for 2026 – 2040 brought to Council</li> </ul>
2026	<ul style="list-style-type: none"> <li>• Time-of-Replacement Requirements come into effect for select, secondary and amenity heating equipment, e.g.: <ul style="list-style-type: none"> <li>○ Pools</li> <li>○ Fireplaces and decorative gas appliances</li> <li>○ Rooftop heating units</li> <li>○ Make-up-air units</li> </ul> </li> <li>• Sub-metering requirements for major heating and hot water equipment</li> </ul>
2030	<ul style="list-style-type: none"> <li>• Updated GHGi for Office and Retail &gt; 9,290 m<sup>2</sup></li> </ul>
2030	<ul style="list-style-type: none"> <li>• GHGi Limit effective for: <ul style="list-style-type: none"> <li>○ Office &amp; Retail &gt; 4,645 m<sup>2</sup></li> <li>○ Hotels &gt; 4,645 m<sup>2</sup></li> <li>○ Assembly &gt; 32,500 m<sup>2</sup></li> <li>○ Other Commercial building types &gt; 4,645 m<sup>2</sup> (<i>to-be-determined</i>)</li> <li>○ Multifamily buildings &gt; 9,290 m<sup>2</sup></li> </ul> </li> </ul>
2030-2032	<ul style="list-style-type: none"> <li>• Phased Deadlines for Equipment Replacement of select secondary heating equipment, potentially including: <ul style="list-style-type: none"> <li>○ Rooftop heating units</li> <li>○ Make-up-air units</li> <li>○ Pools</li> <li>○ Fireplaces and decorative gas appliances</li> </ul> </li> </ul>
2040-2050	<ul style="list-style-type: none"> <li>• GHGi limits for Commercial and Multifamily Buildings &gt; 4,645 m<sup>2</sup> (all uses): 0 kg CO<sub>2</sub>e/m<sup>2</sup>/year</li> <li>• Heat Energy Limit for additional commercial building types</li> </ul>

### **2030 GHGi Limits for Office & Retail Buildings**

A 2030 GHGi limit for office and retail buildings >9,290 m<sup>2</sup> that is intermediary between the 2026 and 2040 limits may be necessary to catalyze action by these buildings to significantly reduce carbon pollution before 2030 in the absence of broad voluntary commitments. Introducing an initial GHGi limit to cover office and retail buildings between 4,645 m<sup>2</sup> and 9,290 m<sup>2</sup> will also be consulted on as an additional or alternative approach to introducing prescriptive regulations. Further, if cost effective opportunities for expanded renewable energy use by district energy utilities emerge, lowering the GHGi for connected buildings may foster action and contribute significantly towards meeting the 2030 reduction target of 50%. City staff will pursue both a voluntary approach and research and consult on a regulatory option in the lead-up to 2024.

### **GHGi for Other Commercial Buildings**

Carbon pollution regulations for additional building types such as large assembly spaces, hotels and warehouses will be necessary for 2030. Research and consultation will be conducted to

develop requirements that address the unique challenges and opportunities to decarbonize the following building types:

- **Hotels.** While recently impacted by the COVID-19 pandemic, large hotels have high emissions intensities due to their significant demand for hot water and space heating, and the range of mechanical systems and fuel types.
- **Large Assembly.** Vancouver is fortunate to be home to some large, world class assembly spaces such as the Convention Centre, BC Place, and Rogers Arena. These buildings may have significant opportunities to reduce emissions but at the same time, given the nature of their use, some special constraints.
- **Warehouse and Light-Industrial.** Potential requirements will focus on reducing carbon emissions from space heating and hot water usage, as that is where cost-effective opportunities exist. Industrial process loads will remain out of the scope of the requirements.

### ***GHGi Limit for Multifamily Buildings***

Setting a GHGi for large multifamily buildings will be challenging because this building type includes both the most affordable housing in the City (non-market housing), a large supply of affordable older rental buildings, and many newer condominiums. There are high GHGi buildings across all three of these categories. The City will explore setting initial limits that impact the worse performing 10% of the largest condominiums in order to increase awareness and interest in low carbon heating and hot water equipment and to initiate reporting that will better inform future opportunities. Initial GHGi limits for multifamily buildings would not require major capital investments so as not to impose a financial burden on impacted buildings, and avoiding direct or indirect negative consequences on the affordability of multifamily homes – a critical equity consideration for the City.

### ***Prescriptive Equipment Requirements***

Prescriptive requirements seek to achieve energy and carbon reductions by targeting specific types of common heating equipment. The City of Vancouver has the authority to establish minimum performance requirements for equipment and products installed through the Building By-law. Advancing prescriptive requirements in Vancouver before 2030 will help develop the local market, inform provincial equipment regulations, and address emissions where carbon pollution limits may not be feasible.

Rooftop heating units, secondary heating systems and amenity heating systems are large sources of GHG emissions in the City and are widely used among commercial and multifamily buildings and have a good business case to replace with high efficiency, low carbon heat-pump alternatives. Many commercial buildings in Vancouver less than 9,290 m<sup>2</sup> use rooftop heating units as their primary source of space heating. Replacing this equipment with heat pumps would result in a 50-95% reduction in GHG emissions for the impacted buildings. Some types of secondary and amenity heating equipment in multifamily, such as make-up-air units and gas fireplaces, are responsible for a significant share of a building's emissions when they are present and cost-effective zero carbon alternatives are available today. Smaller commercial buildings and multifamily buildings are not a good fit for GHGi and Heat Energy Limit regulations because they typically have simpler heating systems that rely on a few pieces of equipment and they do not have energy managers, nor the management expertise necessary to plan for and comply with complex requirements. Most small commercial and multifamily buildings rely on contractor advice for heating equipment replacement, which is also a better fit for prescriptive equipment requirements.

The following prescriptive requirements will be researched and consulted on leading up to 2024:

***Rooftop Heating Units***

Commercial, retail, warehouse and light-industrial buildings commonly use packaged rooftop heating and cooling units. When replaced with a heat-pump or heat-pump with gas back-up, these systems can achieve a 50–95% reduction in carbon pollution for a range of small commercial buildings, while also achieving energy-cost savings.<sup>8</sup> If implemented, this requirement would impact an estimated 3,000 commercial and institutional buildings, catalyzing 150–200 equipment replacements per year, and would result in annual reductions of 75,000–105,000 tCO<sub>2</sub>e when fully implemented.

***Secondary Heating Systems***

Secondary or amenity heating systems in multifamily buildings (particularly condominiums) are responsible for a significant amount of carbon pollution. These systems, including make-up-air units, gas fireplaces, and pool boilers have commercially available low and zero-carbon alternatives. Equipment incentives could help spur action in the short term, while prescriptive requirements can be phased-in within the next decade. Decorative gas fireplaces are a significant carbon pollution problem in condominiums, as they are typically low efficiency units (less than 30%) and not metered, meaning owners can use them as much as they like without paying any extra (building gas costs are divided among all unit owners in a building and incorporated in the monthly strata fees).

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<sup>8</sup> Based on energy modelling of B.C. buildings and field testing in the U.S.

## Appendix D – Recommended External Advisory Committees

A *Technical Advisory Committee* will be convened to provide ongoing advice to staff on the technical aspects of GHGi limits, heat energy use limits, and other proposed regulations. The committee will be comprised of building owners and technical experts specializing in building energy performance and low carbon retrofits, and will support staff on:

- Establishing normalization factors for GHGi and heat energy use limits to account for operational differences between buildings
- Identifying lack of clarity, technical implementation challenges, and/or unanticipated impacts arising from the City reporting, GHGi, and Heat Energy Limits and develop recommendations to address these that meet the intent of these requirements and would be practical for regulatory implementation
- Setting performance limits and other retrofit regulations designed to reduce carbon pollution from other existing building use types and sizes
- Reviewing future limits based on measured building performance
- Defining the requirements for the *2040 Retrofit Plan*

A *Community Accountability Advisory Committee* will also be convened to advise City staff on the social equity impacts of the regulation. The committee will be comprised of stakeholder organizations and representatives from under-represented and marginalized communities, including organizations that represent Indigenous residents, renters, commercial tenants, seniors, non-profit housing providers, racial equity–focused and disability rights organizations, and housing affordability organizations. The committee will support City staff on:

- Setting performance limits and other retrofit regulations for the purpose of reducing carbon pollution from existing buildings for other building use types and floor area thresholds
- Reviewing limits based on their impact on residents and business and identifying how to mitigate negative impacts.
- Providing input on the design of support services and programs so that they benefit under-represented and marginalized communities.

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## Appendix E – Owner Supports

### Commercial Buildings

#### *Building Tune-Up Program*

The City will seek to partner with FortisBC to develop and deliver a Building Tune-Up program to increase operational efficiencies and implement low and no-cost upgrades that improve building systems' performance and reduce building carbon pollution by up to 15%. The program would include funding for a detailed energy study and for technical support in implementation of measures. The Building Tune-Up program will be modelled after a highly successful current utility program that will be modified to ensure support for Vancouver building owners impacted by City regulations that are excluded from access to the existing program.

#### *Supports for 2040 Retrofit Planning and Implementation Support*

A concierge service that is staffed by technical experts will be developed to simplify the potentially complex retrofit process by providing building owners with a single point of contact to discuss retrofit projects and plan future capital replacement work to comply with 2040 GHGi and Heat Energy Limits. The service will also provide assistance to commercial buildings that have a boiler or other piece of major mechanical equipment that is due for replacement, so that owners can access information and advice that will assist them make a replacement choice that aligns with future carbon pollution regulations. This service will be aimed at building owners with less capacity to appropriately identify retrofits, as well as long term capital replacement planning.

The City will work with implementation partners to provide building owners with access to a virtual energy audit and retrofit planning tool and provide expert help for them to populate the tool with key building inputs. Support for smaller owners will also include creating a customized 2040 retrofit plan that is aligned with a building's capital investments and planned improvements. 2040 Retrofit plans will enable building owners, their consultants and mechanical contractors to identify and sequence retrofit measures.

#### *Resources, Supports and Voluntary Commitments to Achieve 2030 Targets*

The City will continue to support the development of case studies, industry dialogues, project tours and events to enable owners and operators to exchange ideas and solutions, and develop best practice guides focused on retrofitting commercial and multifamily buildings to achieve deep reductions in carbon pollution.

The City, in partnership with industry, will develop an online resource hub that is populated with a wide range of information that will be useful for owners and managers seeking to plan and implement building upgrades and retrofits to reduce GHG emissions towards zero.

The City will also be pursuing partnerships with industry associations and individual building owners and managers to catalyze voluntary action by the largest commercial buildings in Vancouver to achieve carbon pollution reductions in advance of City regulation. This will include exploring the recruitment of a critical mass of buildings and industry associations to form a 2030 District in Vancouver.<sup>9</sup>

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<sup>9</sup> <https://www.2030districts.org/>

Each District commits to meeting 50% reductions in energy, water and transportation related emissions as established by Architecture 2030 in its 2030 Challenge for Planning.

## Energy and Carbon Reporting

To support owners of commercial and multifamily buildings comply with the annual reporting requirement, the City will offer the following support services:

- An online resource hub will be created to facilitate access to how-to guides, frequently asked question, resources and best practices.
- A helpdesk will be staffed to assist with individual questions and support.
- Workshops will be held to train building owners and managers on how to use the North American standardized reporting tool, Portfolio Manager, including “train the trainers” sessions for capacity building within industry associations and building management companies.
- Each year buildings reporting to the City will receive a Performance Scorecard that will compare each individual buildings to others of the same type and have a carbon pollution retrofit checklist to guide building owners towards next steps to ensure they are planning in advance to meet future regulatory requirements.
- For multifamily buildings reporting before their initial year in the regulation, the City will subsidize the costs for professional assistance in preparing and submitting the report, with first priority on providing this support for smaller MURBs, coops, and non-market housing buildings.

## Multifamily Buildings

One way that the City can protect Vancouver residents who are most vulnerable to building overheating as the climate warms is removing barriers to installing heat pumps in multifamily buildings. This may include:

*Heat Pump Incentives* – Working with the Province and BC Hydro to offer incentives for ductless mini-split heat pumps and packaged-terminal heat-pumps that can be installed in individual units or at a building scale.

*Permit Streamlining* – Making it less expensive, simple and take less time to obtain a permit from the City to install heat pumps in multifamily buildings

*Strata Building Decision Supports* – work with the Condominium Home Owners Association to develop tools and identify changes required to facilitate owner and strata confidence in planning for and approving heat pump installations.

*Depreciation Report and Capital Planning Support* – Providing guidance to building owners and a financial incentive to cover the incremental work and costs to incorporate GHG emission reduction into a depreciation reports and capital plans.

*Retrofit Accelerator Programs* – The City will partner with industry associations to launch support programs specific to the needs of the non-market housing, market rental and condominium sectors. These programs will include access to technical expertise, energy coaching, planning and implementation support, in addition to capital incentives for heat pump retrofits.

- *Resilient Rental Retrofit + Pilot Program* -- The City (\$2M contribution) has partnered with LandlordBC and the Province of BC (\$1.5M contribution) to launch a comprehensive support program for rental buildings that includes energy audits, planning and implementation support, and large financial incentives for heat pump retrofits in up to 20 rental buildings in order to daylight opportunities for widespread low-carbon transformation of the sector.



- *Non-Market Housing Retrofit Program* – Concurrent to this report, the City is recommending a \$2 million grant to the BC Non-Profit Housing Association to fund a retrofit program that will help housing operators identify opportunities for installing heat pumps, top-up Provincial heat pump financial incentives, support retrofit implementation with professional energy coaches and training for building operators.

Similar to these approaches for rental and non-market housing, the City must also create a resource centre for condominium owners and strata buildings. Such a program can be developed by leveraging the experience of Metro Vancouver, Vancouver, and CHOA from the Strata Energy Advisor pilot program.

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## Appendix F – Summary of Stakeholder Engagement

From February to April 2022, over 400 representatives were engaged through the process including property managers and building owners, individual condominium owners, strata corporations and rental and nonmarket housing providers from both commercial and multifamily buildings. In addition, 32 partner organizations, including industry associations, local utilities and district energy service providers were also engaged to promote and participate in the process. The consultation process included a series of five online information sessions and three workshops. In total, 418 stakeholders received the engagement emails and 313 stakeholders participated in the online sessions.

The City also convened an external advisory committee to advise staff on the development of the GHGi and Heat Energy Limits. The Committee was comprised of 25 representatives from building management companies, owner associations, utility and district energy companies, regional and provincial government, mechanical contractor companies and associations and mechanical consulting firms. The Committee met five times between the Fall of 2021 and Spring of 2022.

The recommendations found in this report were adjusted in response to feedback during engagement.

### Summary of Feedback

- The Carbon and energy reporting requirement was supported by commercial building stakeholders as long as individual buildings data is not publically disclosed. Multifamily buildings require supports, which are described in the previous section of this report.
- Commercial building stakeholder felt the initial 2026 GHGi limits are reasonable.
- The 2040 Heat Energy Limit for office and retail would be challenging to meet, but the limit and timeframe are consistent with what the leaders in the industry are aiming to achieve. Broader industry success in meeting this requirement will require public sector investments in owner supports.
- The 2040 Heat Energy Limit may create unanticipated and exceptional technical challenges for some buildings to meet and the City needs to create a mechanism to identify and develop ways to address these issues as they emerge, including potential amendments to bylaw (as per the mandate of the Technical Advisory Committee).
- Rental owners want the City to recognize the pressures and barriers that rental housing faces and to avoid additional stressors on the industry. They were satisfied with the recommendations as they focus on support programs for their sector in the short term.
- There was general acceptance of the regulations among commercial tenants with control over their heating systems and/or high-intensity gas use that lease space in large office and retail buildings that would be subject to GHGi and Heat Energy Limits
- The greatest concern from stakeholders arose from individual condominium owners, strata corporations and rental housing providers about the need for clarity and support in addressing the complexities of implementing potential future regulations described in the Roadmap, the importance of providing incentives and financing options, and the importance of considering the impacts on housing affordability.
- There was a sense of urgency and a call for greater action across all stakeholder groups suggesting a broad appetite and support for action on limiting carbon pollution from existing buildings

## Appendix G – Technical Appendix

# City of Vancouver Report on GHGI Limits: Technical Appendix

March 31, 2022

Prepared for:  
Micah Lang, City of Vancouver

By:  
Integral Group



### a) Introduction

A consultant group consisting of Integral Group, WSP and the Institute for Market Transformation (IMT) were commissioned to support the City of Vancouver in developing greenhouse gas (GHG) emissions reduction targets and policies for large existing commercial buildings. The purpose of this technical memo is to provide detail on the methodology and findings of this work. The overall technical approach is as follows:

1. **Building Stock Characterization and Clustering:** Multi-parameter clustering of the existing building stock was developed to capture variations in performance. Energy use data was estimated using existing studies and reference cities. Estimated energy use across the building clusters was then mapped to understand the distributions of energy use and emissions.
2. **Energy Efficiency Measure (EEM) Packages:** For each building archetype, baseline equipment and envelope assumptions were developed, up to four levels of improvement. These were then grouped into 10 packages.
3. **Energy Modelling:** Energy models for each cluster were iteratively calibrated using robust building audit data, and the impact of all 10 measure packages were modelled for each archetype.
4. **Cost Modelling:** Energy models were calibrated and matched with cost models across all upgrade packages to generate first cost and lifetime cost estimates, and GHG emissions.
5. **Standard setting:** Drawing on the building distributions, EEM results, and cost results, proposed GHG emissions standards were developed for each building type. The consultant team also provided extensive recommendations to the City on policy options and potential alternative compliance pathways.
6. **Citywide Modelling:** Models were aggregated into a bottom-up model of citywide building energy use and emissions, looking at the impact of various implementation pathways.

This abridged technical appendix document focuses on items 1-4, to show the key technical grounding for the report, and excludes discussion of the standard-setting and citywide modelling elements, as they are discussed in the main council report in the section on the proposed GHGI targets for large office and retail, and the section on the impacts of the proposed policy.

## **b) Building Stock Characterization**

The consultant team first sought to characterize the existing building stock and identify representative building archetypes to serve as the basis for energy efficiency measure recommendations and policy development. The key archetypes analyzed are listed in Table 1. The floor areas listed below are sourced from property tax data maintained by BC Assessment and the City of Vancouver.

Table 4: Office and Retail Stock > 10,000 m<sup>2</sup>

Major Use Type	Office	Retail	Count	Total Floor Area (m <sup>2</sup> )
Automobile Shop		ü	3	46,600
Commercial		ü	25	910,060
Department Store		ü	1	10,589
Food Market		ü	1	16,025
Office	ü		189	3,697,366
Retail		ü	1	16,242
Shopping Centre		ü	9	531,369
Stores		ü	6	134,250
<b>Office Total</b>			189	3,697,366
<b>Retail Total</b>			46	1,665,135
<b>Grand Total, Large Office &amp; Retail</b>			235	5,362,501

In the absence of comprehensive energy use data that can be mapped back to each building included in the study, energy use for buildings of interest was estimated using the results of previous studies conducted for the City of Vancouver by Morrison Hershfield and RDH Building Science in 2020.<sup>10</sup>

- The Morrison Hershfield 2020 study on hourly energy use included hourly models of electricity use calibrated to 2016 data for high-rise offices, low-rise offices, and non-food retail buildings, and envelope sensitivity analyses for office and retail archetypes. Envelope sensitivities based on the RDH 2020 study along with equipment efficiencies, were used to estimate electricity and gas EUIs were estimated for each building in the dataset using "new construction" EUIs and linear regression equations for quantifying dependence on vintage.
- Hourly loads were translated to annual EUI, and gas use was estimated using appropriate equipment efficiencies. In general, the team noted that gas use was higher for pre-1975 buildings, as the Province of British Columbia (BC) implemented a version of the 1970 National Building Code (NBC) in 1973 as its first provincial building code. Older buildings are assumed to have higher heat loss from the envelope, resulting in higher overall gas use even with lower building utilization intensity. Figures 1 and 2 show the linear regression relationships used to assign gas and electric use based on building

<sup>10</sup> McClung, R. and M. Schoenfeld. 2020, May 27. *Multi-family and Commercial Archetypes Hourly Electricity Profiles*. Morrison Hershfield. Prepared for the City of Vancouver.  
Ek, M. and C. Love. 2020. *Commercial Electrification Study – Final Report*. RDH Building Science Inc. Prepared for BC Hydro.

vintage for large office and retail.<sup>11</sup>

Integral Group and WSP have conducted over 50 energy audits on office and retail buildings in the City of Vancouver over 10,000 m<sup>2</sup>. These buildings make up over 25% of the total large office/retail dataset—however, due to confidentiality agreements with clients, the audit data was anonymized and could not be matched to any individual buildings in the tax dataset. In addition, the audits were conducted over a 10 year period, and thus do not all represent the same weather year. Rather, the EUI estimates were used to validate the data at regular percentile intervals. Audit data is observed to be slightly higher than estimated data which aligns with expectations, as these energy audits were contracted due to the building's prior performance.

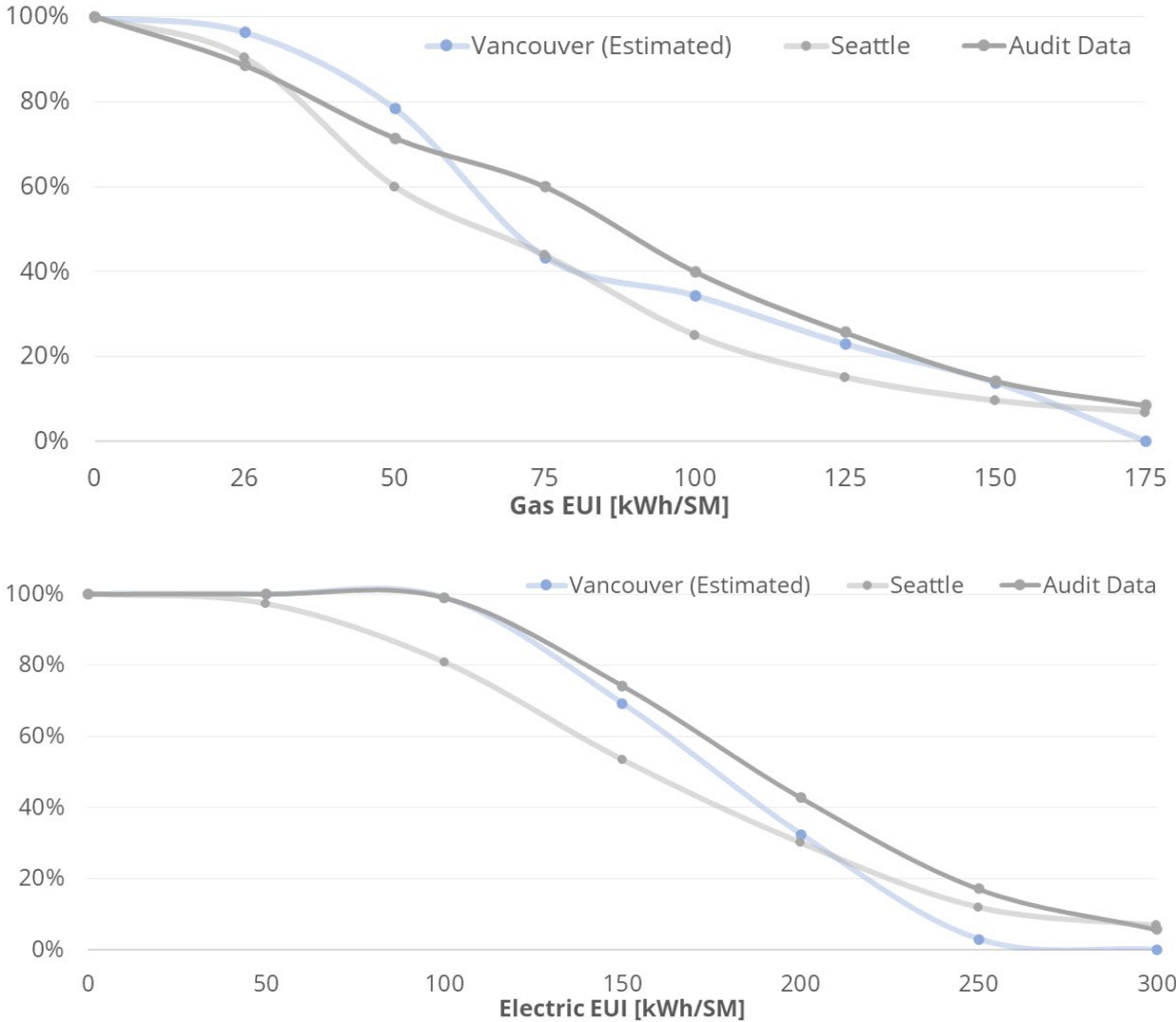
As a second stage of validation, the estimated EUI data and anonymized edit data was compared against the City of Seattle's energy benchmarking data. The City of Seattle is located in the same climate zone (4C) as Vancouver and has a similar building stock in terms of vintages, types, and sizes. The City of Seattle has been collecting energy benchmarking data on all commercial and multifamily buildings over 20,000 ft<sup>2</sup> since 2012.<sup>12</sup> Absent enforcement for benchmarking programs (such as the voluntary program operated by Building Benchmark BC) reporting rates tend to top out at 50-75%, but Seattle's program has been at over 95% compliance for many years, and the retuning program the City has introduced is ensuring independent accuracy verification. Thus, the data represents a true representation of the full distribution of energy performance. Figure 2 shows the gamma distribution of the Seattle EUIs (light grey), the WSP/Integral Audit data for Vancouver (dark grey), and the estimated EUIs for all large Vancouver buildings generated above (blue). The graphs show reasonably good alignment between the three datasets. Audit data is observed to be slightly higher than estimated data which aligns with expectations. The main caveat that should be noted is that the linear regression process in general does not generate "outlier" values since, by definition, outliers represent buildings performing outside any predictable range due to unique, site-specific factors—both the audit and Seattle benchmarking data have more outliers than the estimated dataset, as seen in the bottom-right of the graphs.

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<sup>11</sup> RDH. 2017. *Exploring Options for 80% GHG Reductions in Downtown Building*. City of Vancouver. RDH Building Science Inc. Prepared for the City of Vancouver.

<sup>12</sup> City of Seattle. *Energy Benchmarking*. Accessed March 2022. <https://www.seattle.gov/environment/climate-change/buildings-and-energy/energy-benchmarking>

Figure 3: Comparison of Gas (top) and Electricity (bottom) EUIs generated with reference data sets



The database was then partitioned into representative sub-archetypes using k-means clustering conducted based on normalized electricity and gas EUIs, program, vintage, size. Silhouette analysis conducted indicated that 7-9 clusters may be the statistical sweet spot for the data in question; 8 clusters were finalized after discussion with the city of Vancouver. The building count, building age, floor area, and mean EUIs for each cluster have been provided in Table 5. The 'Mixed use' cluster consists of an Office/Retail mix where the major property type constitutes less than 70% of the building GFA (for example, a building that is 55% office and 45% retail).

Table 6: Gross Floor Area (GFA) and EUI by Cluster

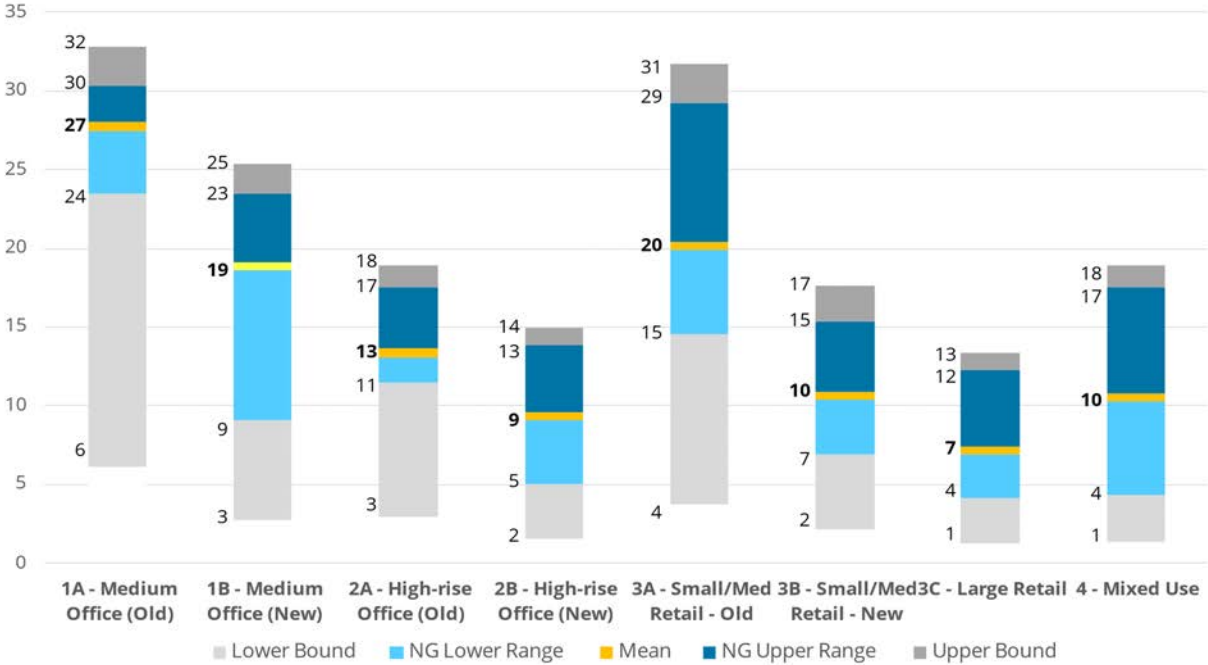
#	Cluster Name	Count	Year Built Mean	Total Cluster GFA (m <sup>2</sup> )	Mean GFA (m <sup>2</sup> )	Min GFA (m <sup>2</sup> )	Max GFA (m <sup>2</sup> )	Gas EUI Mean	Electric EUI Mean	GHGI Mean (kgCO <sub>2e</sub> /m <sup>2</sup> )
1A	Med. Office, Old	36	1955	436,318	12,100	9,300	18,500	148	228	30.0
1B	Med. Office, New	26	1993	339,870	13,100	9,600	17,400	100	202	20.8
2A	Large Office, Old	23	1960	808,291	35,100	19,500	79,500	72	165	18.2
2B	Large Office, New	30	1995	980,856	32,700	19,300	71,100	49	147	11.3
3A	Med. Retail, Old	8	1937	144,158	18,000	10,600	57,700	100	182	20.7
3B	Med. Retail, New	14	2002	184,567	13,000	9,600	16,700	54	139	11.7
3C	Large Retail	18	1997	735,776	40,900	18,700	135,600	40	145	12.3
4	Mixed Use	12	1991	893,121	74,400	19,400	228,800	60	146	12.7

Building EUIs were then translated to Greenhouse Gas Intensities (GHGI). In order to allow greenhouse gasses to be used as a reasonable planning tool, the City of Vancouver has selected the historical average of 11 tCO<sub>2e</sub>/GWh for regulatory enforcement and modelling. Many Vancouver buildings are also served by one of several different district energy system (DES) utilities, including a legacy steam system and two newer system using a mix of natural gas and wastewater heat recovery, as well as numerous smaller systems serving individual developments.

Figure 2 shows the ranges of modelled GHGIs. The dark blue shows the upper half of the normal distribution for gas GHGI, the light blue is the lower half of the normal distribution for gas GHGI, while the yellow bar is the average GHGI for natural gas-heated buildings. The grey shows the range of distributions for other fuels; the dark grey is the upper half of the DES distribution; the light grey is the lower range for DES and electrically heated buildings. This demonstrates several important points:

- While newer high-rise offices and large retail buildings generate more GHGs on an absolute basis, they are much more efficient on a per-floor area basis, and outperform most older medium-size office and retail buildings.
- Depending on cluster, the least-efficient natural-gas heated buildings are 50%-200% more GHG-intensive than the least efficient gas-heated buildings.
- There is as much as a 10-fold difference between the GHGI of the most efficient electric buildings and the least efficient Creative Energy buildings.
- The upper and lower bonds are the bounds on a normal statistical distribution of energy use and emissions—in the real world, outlier buildings are likely to perform far worse than these buildings.

Figure 4: GHGI ranges by cluster (kgCO<sub>2</sub>e/m<sup>2</sup>)



As the building counts within each clusters were too small to create meaningful histograms of EUI and GHGI distributions, the team aggregated back up to the office and retail building types. This level of aggregation is more appropriate for target setting, as targets will be set for the sector as a whole, not for individual analysis clusters. Table 17 shows the percentile distribution of GHGIs for large office buildings, retail buildings, all large office and retail buildings on the Creative or NEU District Energy Systems (DES), and all large office and retail buildings studied for this project. These percentiles were then used as a first pass estimation of what GHGI limits would hit the worst-performing 20%-25% of these buildings:



Table 7: Greenhouse Gas Intensity (GHGI) percentiles for onsite and district energy use (kgCO<sub>2</sub>e/m<sup>2</sup>)

Percentile	Office	Retail	DES	Both
Count	121	46	54	167
1%	5.3	3.8	6.2	4.0
5%	7.3	4.2	7.0	5.3
10%	9.3	4.7	8.6	6.9
20%	10.9	6.0	10.7	9.0
25%	11.4	6.8	11.0	9.9
30%	12.2	7.0	11.6	10.6
40%	13.2	8.2	12.9	11.8
50%	15.1	9.3	14.3	13.2
60%	19.8	10.1	15.0	14.9
70%	23.5	11.9	22.0	19.9
75%	24.9	12.1	23.9	22.7
80%	27.3	13.7	27.7	24.7
90%	29.8	16.3	31.5	29.0
95%	31.3	17.9	31.7	30.7
99%	32.1	28.0	32.2	31.9

### c) Estimating Savings and Compliance Paths

#### i) Measure Packages

For each archetype, the consultant team developed a set of assumptions about baseline conditions and various Carbon-Reduction Measures that were most commonly implemented in the region. These assumptions were developed based on audit data on over 50 facilities collected by the consultant team, as well as consultant experience in the local region. For each major energy-related building system, up to four levels of upgrades were identified. These were then grouped into 10 retrofit packages to represent different levels of investment and intervention in the building:

1. *Tune-Up*: Controls optimization, set-point adjustments, commissioning – these measures were also included in other 9 packages
2. *Minimum Equipment Intervention*: Planned building-level like-for-similar HVAC upgrades only
3. *Like for Similar*: Planned building-level envelope and HVAC equipment upgrades
4. *Minimum Fuel Switch*: Lowest first cost fuel switching option (either in building or at DE plant)
5. *Partial Fuel Switch*: Partial fuel switching for 50-75% GHG reduction, without envelope measures
6. *LFS + Partial Fuel Switch*: Planned upgrades to envelope + partial fuel switch
7. *LFS + Full Fuel Switch*: Planned upgrades to envelope + Full fuel switching
8. *Fuel Switch Ready*: Envelope improvements and upgrades to be ready for future enhanced fuel switch, with no HVAC improvements other than RCx
9. *Deep Retrofit*: A holistic package of envelope measures, HVAC system changes, etc., including complete electrification
10. *Max Potential*: Best in class envelope measures, system changes, and complete electrification

Since the goal of the program is to drive electrification and deep GHG savings, only the “minimum equipment intervention” and “like for similar” packages include new gas-fired equipment; these packages provide reference comparisons to the other packages. In addition,

as the standard will not regulate electric use and the GHGI of the electric grid is low, lighting, plug loads, and solar photovoltaic measures were excluded from Integral and WSP's energy and cost modelling for this project. In addition, many buildings have already upgraded lighting already, and so including lighting is not always appropriate. Nonetheless, excluding these low-cost measures reduces the cost-effectiveness of the packages relative to many real-world projects.

The baseline and measure level assumptions are provided for the older office and retail archetypes are presented below in Table 4 as an example. The three HVAC variations represent three different sub-archetypes with different baseline heating systems. Newer buildings generally have better wall and roof insulation and more glazing, and so the packages for newer buildings include fewer envelope measures, but are otherwise similar. Table 5 shows how these measures combine into packages.

Table 8: Carbon reduction measure matrix for the **older** office and retail archetypes and sub-archetypes

	Level 0	Level 1	Level 2	Level 3	Level 4
Walls (W)	Concrete or Veneer-Clad Wall with No insulation (R-1.5)	Interior existing walls retrofit with 2" of spray foam (R-5)	Over-clad wall with 4" new exterior insulation (R-15)	Interior Retrofit + Re-Clad	
Roof (R)	3" Insulation in Roof (R-10)	Re-roofed with 5" of insulation (R-20)	Re-roofed with 7" of insulation and parapet changes to reduce thermal bridging (R-30)		
Window (G)	Single glazed aluminum frames (U-1.1, SHGC-0.5)	Standard double-glazed, air-filled aluminum frames (U-0.45, SHGC-0.35)	Improved double-glazed, argon-filled aluminum frames (U-0.35, SHGC-0.3)	Triple-glazed, argon-filled aluminum frames (U-0.30, SHGC-0.3)	
Air Seal (AS)	Very Poor Air Sealing	Improved air sealing	Further improved air sealing	Air sealing to current energy step code requirements	
HVAC Distribution (SYS)	Existing - VAV	Optimize Fan/pump system optimization with high efficiency component upgrades and speed drives	Add Energy Recovery Ventilator (ERV) plus CO2 control to existing VAV system	Low-temp hot water systems, Energy Recovery Ventilator (ERV), Dedicated Outdoor Air System, 4-pipe Fan Coils	
HVAC Plant A (F.A) - Central	Central boiler and chiller, no fuel switching	New condensing gas-fired boiler and chiller upgrade	Max allowable (per electric service) electric resistance boiler - DHW/space heating	Water to water heat pump / heat recovery chiller - 50% GHG reduction	Water-to-water + Air Source Heat pumps + Electric boiler backup - 99% GHG reduction
HVAC Plant B (F.B) - DES	District Steam Gas-Fired Boiler; Building Chiller	District Steam Gas + Electric Boilers (electric meeting 15% of demand); Building Chiller	District Steam Gas + Electric Boilers (electric meeting 40% of demand); Building Chiller	Building Water to water heat pump / heat recovery chiller - 50% GHG reduction	Low-Temp Hot Water water-water heat pump - 75% GHG reduction
HVAC Plant C (F.C) - RTU	Typical DX RTU w/ 80% eff furnace, constant speed fan W/ RTU damper control	Best in Class RTU w/ 85% efficiency, VAV and enhanced control	New heat pump RTUs w/ gas backup @ 0°C	New heat pump RTUs w/ electric backup @ 0°C + ERV	
Controls (C)	No improvement	Controls retrocommissioning with new CO2 and motion sensors	Controls retrocommissioning + fault detection and diagnostic software		

Table 9: EEM Package Assignment for the Older Office Archetypes

	Tune-Up	Minimum intervention	Like for Similar	Minimum fuel switching	Partial Fuel Switch	LFS + partial fuel switch	LFS + full fuel switch	Fuel Switch Ready	Deep Retrofit	Max Potential
Walls (W)	W0	W0	W1	W0	W0	W1	W1	W2	W2	W3
Roof (R)	R0	R0	R1	R0	R0	R1	R1	R2	R2	R2
Window (G)	G0	G0	G1	G0	G0	G1	G1	G2	G2	G3
Air Seal (AS)	AS0	AS0	AS1	AS0	AS0	AS1	AS1	AS2	AS2	AS3
HVAC Distribution (SYS)	SYS0	SYS1	SYS1	SYS1	SYS1	SYS1	SYS2	SYS0	SYS2	SYS3
HVAC Plant A (F.A)	F0.A	F1.A	F1.A	F2.A	F3.A	F3.A	F4.A	F0.A	F4	F4
HVAC Plant B (F.B)	F0.B	F0	F0	F1	F2	F2	F3	F0	F3	F4
HVAC Plant C (F.C)	F0.C	F1	F1	F2	F3	F2	F3	F0	F3	F3
Controls (C)	C1	C1	C1	C1	C1	C1	C1	C2	C2	C2

**d) Energy and Emissions Modelling**

3D prototype energy models were constructed for each archetype in eQuest energy simulation software and calibrated based on the building stock characterization data. The “Level 0/Baseline” envelope and mechanical design inputs were used in the calibration model. Where other information is not available, building code at the time of construction minimum design performance (i.e., lighting and outdoor air ventilation) was assumed, based on the cluster median construction year. The measure packages were then evaluated in the energy modeling analysis to assess greenhouse gas emissions reduction potentials. GHG reductions for all 16 cluster + archetype models are presented below in Table 4.

Table 10: GHG Savings Results (All Energy Sources)

Cluster #	Cluster Name	Archetype	Tune-Up	Minimum equipment	Like for Similar	Minimum fuel switching	Partial Fuel Switch	LFS + fuel switching	LFS + full fuel switch	Fuel Switch Ready	Deep Retrofit	Max Potential
1A	Medium Office (Old)	Older Office with Central Plant	8%	27%	69%	59%	57%	78%	93%	74%	93%	93%
1A	Medium Office (Old)	Older Low-Rise Office with RTUs	8%	1%	46%	77%	84%	84%	93%	58%	94%	94%
1A	Medium Office (Old)	Older Office with District Energy	5%	6%	62%	21%	43%	75%	84%	74%	88%	91%
1B	Medium Office (New)	Newer Office with Central Plant	8%	26%	41%	57%	54%	61%	90%	48%	91%	91%
1B	Medium Office (New)	Newer Low-Rise Office with RTUs	8%	3%	14%	72%	79%	74%	89%	35%	91%	91%
1B	Medium Office (New)	Newer Office with District Energy	5%	6%	26%	20%	42%	54%	74%	47%	84%	88%
2A	High-Rise Office (Old)	Older Office with Central Plant	8%	21%	67%	54%	50%	74%	88%	72%	89%	90%
2A	High-Rise Office (Old)	Older Office with District Energy	5%	5%	63%	20%	42%	75%	84%	73%	87%	88%
2B	High-Rise Office (New)	Newer Office with Central Plant	8%	21%	36%	52%	45%	53%	86%	44%	86%	86%
2B	High-Rise Office (New)	Newer Office with District Energy	5%	5%	24%	19%	41%	52%	72%	44%	80%	83%
3A	Medium Retail (Old)	Older Low-Rise Retail with RTUs	8%	-4%	40%	80%	88%	88%	93%	57%	93%	93%
3B	Medium Retail (New)	Newer Low-Rise Retail with RTUs	8%	-1%	15%	71%	82%	80%	89%	41%	90%	90%
3C	Large Retail	Newer Retail with Central Plant	8%	20%	36%	52%	51%	59%	87%	45%	87%	87%
3C	Large Retail	Newer Retail with District Energy	5%	4%	24%	19%	41%	52%	78%	45%	85%	86%
4	Mixed Use	Newer Office/Retail with Central Plant	8%	25%	38%	55%	50%	57%	87%	43%	88%	87%
4	Mixed Use	Newer Office/Retail with District Energy	5%	4%	23%	19%	41%	51%	74%	42%	82%	84%
<b>Min</b>			<b>5%</b>	<b>-4%</b>	<b>14%</b>	<b>19%</b>	<b>41%</b>	<b>51%</b>	<b>72%</b>	<b>35%</b>	<b>80%</b>	<b>83%</b>
<b>Max</b>			<b>8%</b>	<b>27%</b>	<b>69%</b>	<b>80%</b>	<b>88%</b>	<b>88%</b>	<b>93%</b>	<b>74%</b>	<b>94%</b>	<b>94%</b>

Key findings from the energy modelling include:

- *Minimum Intervention* (i.e., HVAC replacement with modern gas-fired equipment) produces minimal savings and may even increase emissions in some archetypes
- *Minimum Fuel Switch* (i.e., electric boilers, or heat pump RTUs with gas backup)

produces sufficient savings for the likely near-term targets at lower capital costs and may be a sufficient end point for higher-performing buildings, but will increase operating costs and may have grid impacts that were beyond the scope of this study.

- *Partial Fuel Switch* produces nearly the same GHG savings as the more extensive *Like-for-Similar + fuel switch* in newer buildings and buildings with RTUs, without the need for envelope work.
- *Fuel Switch Ready* retrofits in buildings that recently replaced HVAC equipment can reduce GHGs by 35-74%.
- *Like-For-Similar envelope replacement + full fuel switch* produces nearly as significant emissions savings (74%-93%) as *Deep Retrofit* or *Max Potential* packages.
- Deeper envelope improvements have limited additional GHG savings relative to business-as-planned (BAP) envelope improvements, but more substantial EUI and TEDI reductions.

### e) Cost Modelling:

The capital cost and life-cycle cost analysis for each package builds on and aligns with the process used to develop the calibrated baseline models and measure matrices.

- Characteristics of clusters/archetypes used to set baseline features for modeling are also used to find exemplar facilities within the WSP capital planning / condition assessment database (and other datasets, where relevant)
- Measures are described in more detail to suit how they would achieve the associated energy-related improvement for the selected facilities (matching the measures to building)  
These more detailed descriptions offer some feedback to the modeling process, but are mostly used by a third-party cost consultant to develop measure-level pricing
- Measure-level pricing is adjusted for appropriate equipment downsizing benefit for each package, based on the approximate load reduction from the corresponding energy model

The energy savings by fuel from the models and adjusted package-specific capital costs are inputs to a life-cycle cost analysis (LCCA) for each package, including the “do nothing” case which reflects only energy savings and no equipment change. The LCCA process includes accounting for capital (initial capital, replacement, residual value); energy cost (escalating at agreed-to rates over time); cost of Carbon; and interest and discount rates specified by the City of Vancouver. The lifecycle cost analysis was run on a 25-year period, from the property owner’s perspective. Key variables assessed included: TVM Factors (Inflation, energy escalation, discount rate); capital cost (and replacement / residual costs); Operations and Maintenance (O&M) costs (minimal/no difference assumed); energy cost and future increases; and carbon price.

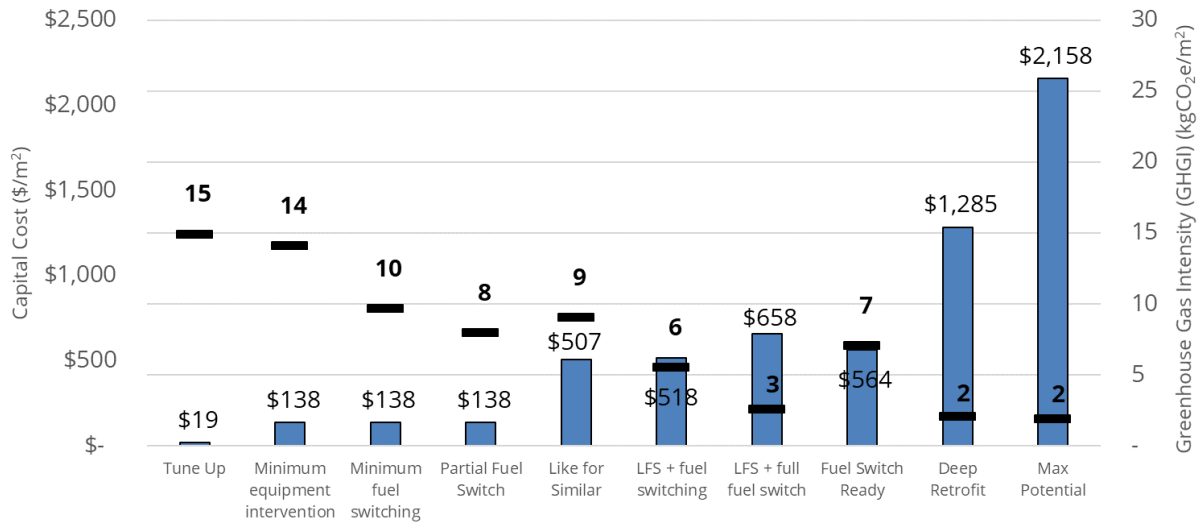
Each package can then be compared to any of three relevant baselines, as described above: Do Nothing (i.e., energy only change), Minimum Equipment (i.e., typical HVAC renewal) or Like-for-similar (i.e., Minimum Equipment and required enclosure renewal). These three base cases reflect three possible reference-points for different policy-scale and facility-scale decision making.

Packages range widely in price per m<sup>2</sup> with equipment-only changes in \$100-200/m<sup>2</sup> cost like-for-similar changes in \$500-700/m<sup>2</sup> and deeper packages, which include renewal of facades and

transformation of HVAC systems towards energy efficient and low-carbon choices, range from \$800-2200/m<sup>2</sup>, in the range of a new construction project.

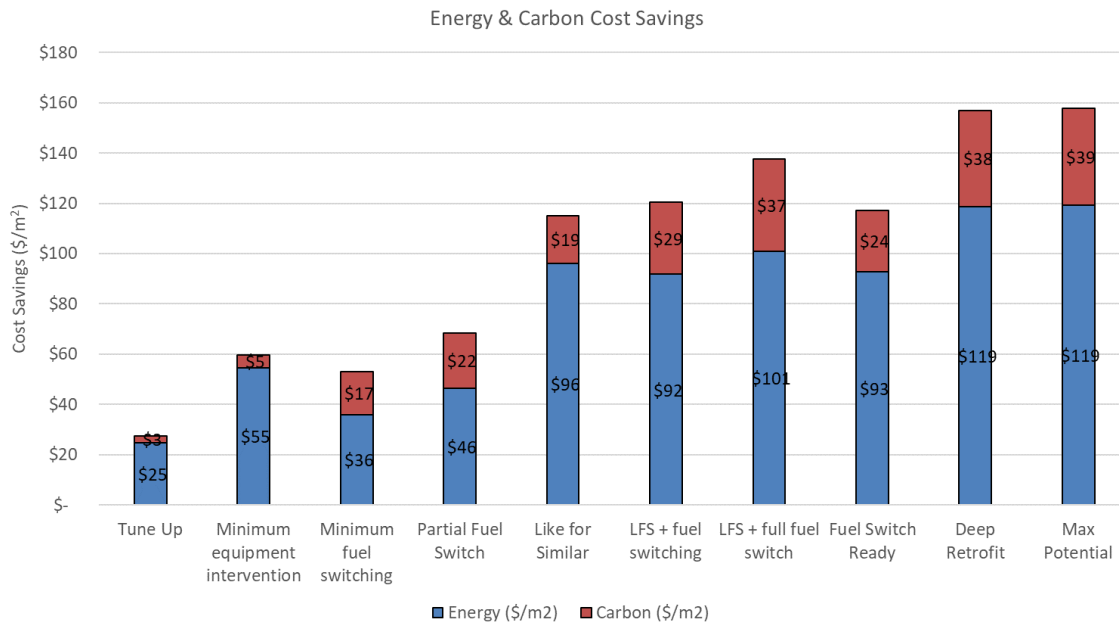
Figure 3 shows the overall package costing analysis results for capital costs per unit of floor area and the resulting estimates GHG performance. Note that throughout the costing analysis and citywide analysis sections, all GHG emissions results include emissions from all energy sources, including electricity.

Figure 5: Capital cost vs. GHGI averages for all large archetypes studied



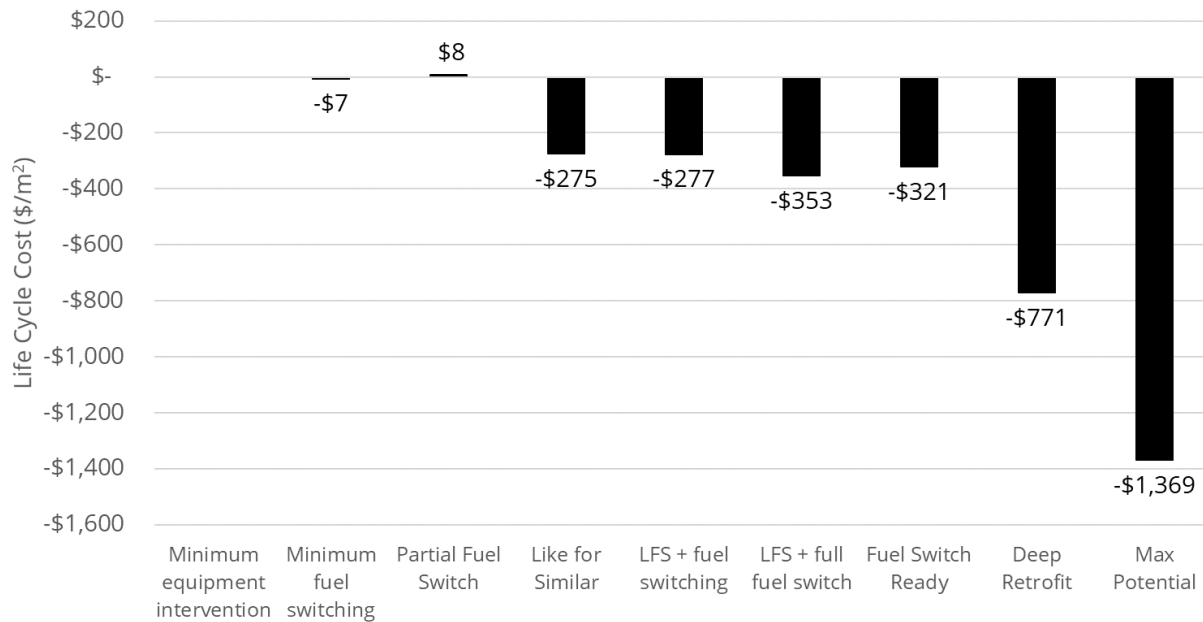
In general, these results show that deep reduction packages are 1-2 orders of magnitude more costly than minimum action packages, and that packages that achieve at least 5 kgCO<sub>2</sub>e/m<sup>2</sup> (without RNG) all have capital costs over \$50/ft<sup>2</sup>, with LFS + full fuel switch being the cheapest of the deeper reduction packages. Figure 4 shows projected energy and carbon costs over 25-year period:

Figure 6: Package Costing Analysis Results: Energy and Carbon Cost per m<sup>2</sup> vs. Baseline Models



All facilities are likely to require at least one significant replacement of major HVAC equipment over the course of a 25-year study period. When compared to that case, alternate equipment choices such as heat recovery chillers and heat-pump rooftop units employed in the minimum and partial fuel-switch cases offer life cycle cost neutral alternatives. The results are similar when comparing buildings that have to invest in enclosure upgrades as well (i.e., like-for-similar) compared to their fuel-switched alternatives.

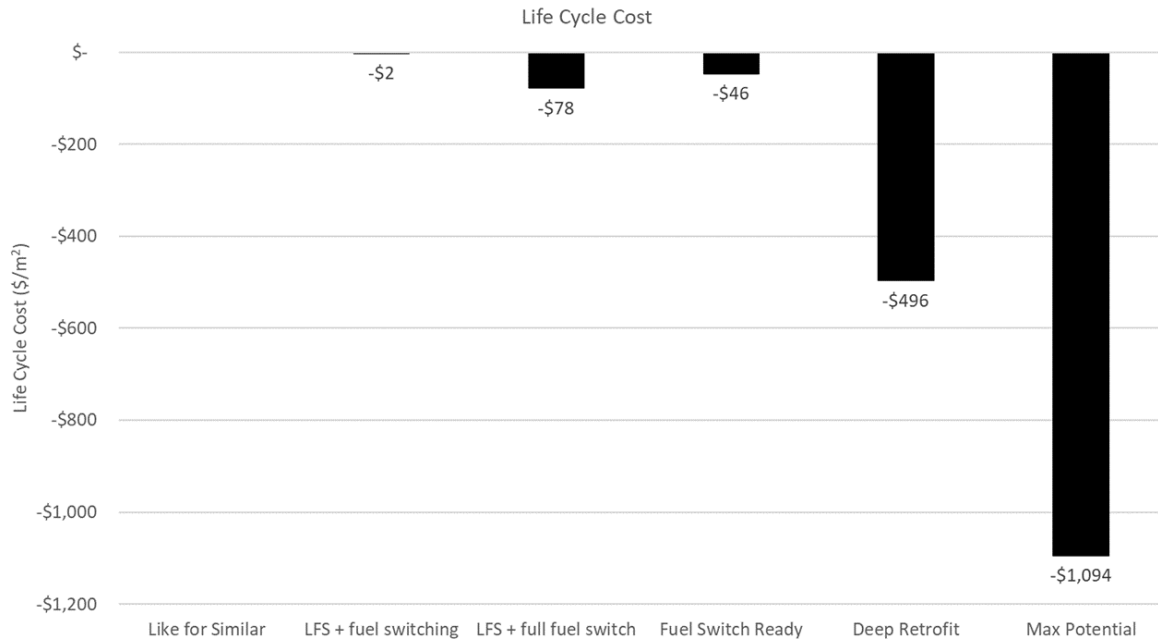
Figure 7: Incremental Lifecycle Return on Investment (i.e., negative means increased cost) vs. Minimum Equipment replacement for all large archetypes studied





For a building that will be upgrading its envelope, incremental LCC should be compared against the *LFS* package, rather than other baseline packages. Figure 6 shows this comparison; for a fair comparison, only packages that include envelope measures are included in this graph:

Figure 8: ILCC per m<sup>2</sup> vs LFS

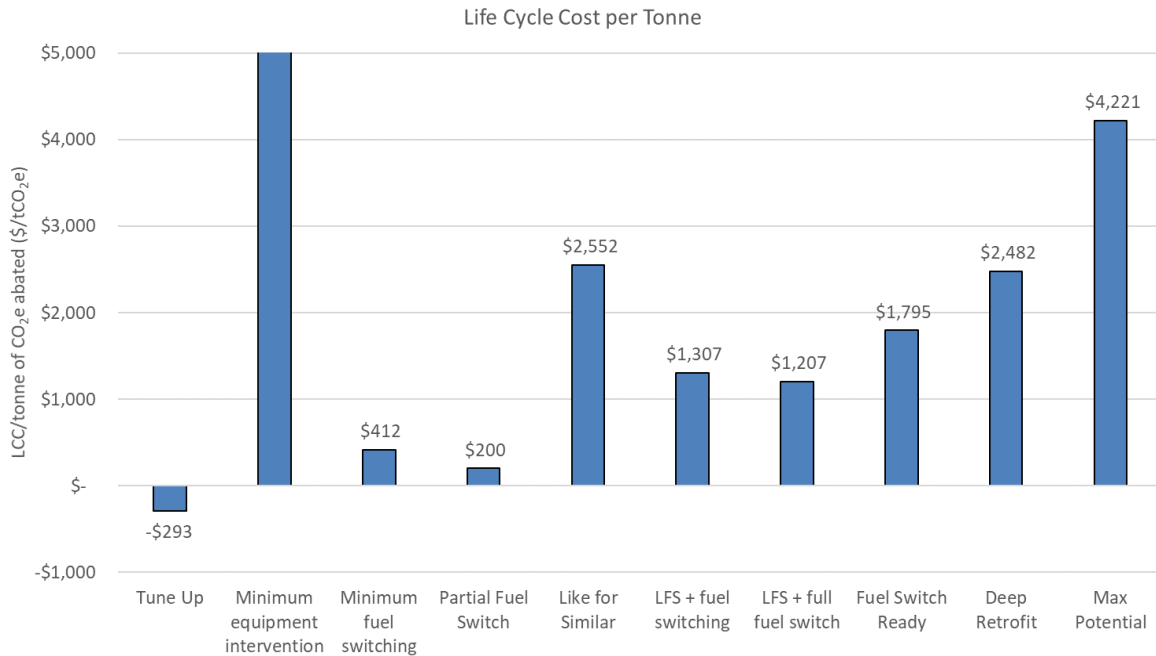


Incremental comparison of packages to a planned capital replacement of like-for-similar, including envelope, shows that:

- Including some fuel switching is nearly the same life cycle cost
- Including *more fuel switching* or being *Fuel Switch Ready* are less than \$100/m<sup>2</sup> over 25 years.
- Both *Deep Retrofit* and *Max Potential* packages significantly less cost-effective, as discussed.

To understand the carbon abatement cost of the packages, the consultant team calculated lifecycle costs per tonne of GHGs (tCO<sub>2</sub>e) abated. Figure 7 shows the carbon abatement costs of all packages relative to 2019 baseline performance (again, accounting for inflation and cost escalation):

Figure 9: Life-cycle Cost/tonne of GHG abated (ILCC/tonne) vs Baseline Models



However, in the long-term, all facilities will require action towards decarbonisation at the site level if the long-term goal is to decarbonize the entire stock. As such, comparing all options that achieve significant emissions reduction (i.e. >50% average reduction or <8 kgCO<sub>2</sub>e/m<sup>2</sup>/year) to their like-for-similar reference case shows that the cost of minor investment (Partial Fuel Switch and LFS+Fuel Switching) is paid-for by incremental energy and carbon cost savings, but deeper investment in site-level reductions (i.e. >80% or <3 kg CO<sub>2</sub>e/m<sup>2</sup>/year) will require >\$500/ton across the Vancouver stock.

Figure 10: Lifecycle Cost per tCO<sub>2</sub>e, relative to a like-for-similar replacement. (Negative means cost savings)

