Recommendations for achieving Zero Emissions Buildings in Vancouver

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Introduction and Context

The consulting team of Integral Group, Morrison Hershfield and BTY was retained by the City of Vancouver's to scope out new potential technical requirements for buildings that address both the Greenest City Action Team goals and the Renewable City Goals respectively:

- Achieving carbon neutral new construction, and to
- Eliminate the use of fossil fuels by 2050.

In addition to meeting these two objectives the City of Vancouver identified two other objectives:

- Reliable, user-friendly greenhouse (GHG) savings.
- A set of steps to achieve zero emissions new buildings.

The consultant team defined “reliable and user friendly GHG savings” as developing a methodology that yielded solutions that were not reliant on complicated mechanical systems being optimized in order to achieve savings. Put another way savings were seen as being more “reliable’ if they were derived from the envelope and heat recovery systems which require less maintenance and have longer service lives.

The research for this report was structured based on the scope outlined by the City of Vancouver which identified that the city was interested in developing a new approach to energy policy for new construction. The outlined a number of performance and administrative requirements for the consultant team to consider in order to establish a “stepped” trajectory to achieving passive house levels of performance. The scope of Integral’s work was to review these recommendations in detail, develop energy models, costing analysis, and test with industry the “construct-ability” of these proposals.

The Recommendations explored in this study were as follows:

- Using Energy Performance Targets rather than a reference building methodology.
  - Total energy demand and
  - Thermal energy demand.
  - GHG intensity
- The development of a single energy modelling platform
- Airtightness testing
- Commissioning Requirements.

The purpose of this research is to better inform the City of Vancouver’s reconsideration of its Rezoning Policy for “greener buildings”.

Summary of Energy Regulation Strategies:

A survey of global energy standards undertaken by Integral Group identified that there are three common ways of regulating energy use in buildings. They are:

A. The Prescriptive Approach:

The prescriptive approach can generally be defined as an itemized list of building performance requirements that impact energy usage. This generally includes requirements for building envelopes, mechanical systems, and electrical systems including lighting. The prescriptive approach is generally either the foundation or included in some way in all modern energy codes such as ASHRAE 90.1 and the NECB.

B. The Reference Building Approach:

This is one of two methodologies to energy standards that can be defined as a “performance approach”. It is referred to as “performance” because it is based on overall performance of a building rather than its component parts. The reference building methodology requires that a design team develop a "reference building," usually defined be prescriptive elements, to which the design team proposes different design strategies that result in equivalent or lower overall energy use.

C. Target Based Approach:

The second "performance approach" is the target-based approach. This approach defines an absolute energy use or emissions target for a building usually based on energy consumption per unit of floor area expressed over time. The most common expression of this is Kilowatt Hours/Square-meter/year. Building standards such as Passive House ™ and Architecture 2030™ both use a target based approach. It is also the predominant approach used by designers and energy modellers for designing and evaluating high performance buildings or net zero buildings.

Performance Targets

A target-based approach was identified as the preferred method of development for future energy standards. This is because the prescriptive approach was seen as being too difficult to scale and the most limiting from an innovation and design perspective. The reference building methodology was seen as being valid but not as effective as the target based approach in limiting energy use and greenhouse gas emissions.

Within the target based approach there were three different metrics that were reviewed as part of this analysis. They included Greenhouse Gas Intensity (GHGI), Thermal Energy Demand Intensity (TEDI), and Total Energy Use Intensity (TEUI). The findings of this study suggest that by using all three metrics in coordination with each other the objectives of the update to the 'Green Building Policy for Rezoning's' can be addressed. See below for a summary of how each of the metrics are proposed to be applied.

A. Greenhouse Gas Intensity

Greenhouse Gas Intensity (GHGI) is the measure of how much emissions per square meter are emitted as a result of a building's operation. It is measured in kilograms of carbon dioxide equivalent per square meter. (KgCo2e/sqm/yr.) The value of this metric is that it specifically measures the pollution that the environment is impacted by. Most energy codes in North America use energy use as a proxy for Greenhouse Gas emissions, operating under the paradigm that reductions in energy use will result in greenhouse gas reductions.

Recent energy models done by Integral Group exploring the impacts of more efficient building codes specifically in the Vancouver Climate zone has determined that increases in energy efficiency have in some cases, in some building types increased the carbon intensity of these buildings, and not lowered overall greenhouse gas emissions. This is primarily because regulations based on energy cost have prioritized the saving of electricity over natural gas, and electricity is lower in carbon intensity than natural gas.

It is for this reason that carbon intensity requirements are embedded in the Toronto Green Standard, and into building codes in the United Kingdom and Spain. By using a GHGI the City of Vancouver can clearly send the signal to the building developers and designers that while energy efficiency is important, emissions have to be reduced.

B. Thermal Energy Demand Intensity

The second key metric that this report proposes for and new framework for buildings is Thermal Energy Demand Intensity. (TEDI) TEDI is the measurement of how much energy a building requires to be thermally comfortable for occupants. The calculation does not consider the efficiency of equipment selected only the absolute inputs of energy required to heat a space to make it habitable.

The benefit of this metric is that it isolates the envelope as the primary variable in delivering energy efficiency performance. It should be noted that it is convention within building science field to factor in the heat recovery attained in the heat recovery ventilation into TEDI calculations as well. The impact however, of heat recovery on TEDI is much less significant than the envelope and orientation of a building. This factor supports the stated City objective of achieving “reliable, user friendly emissions reductions.”

This is demonstrated in the application of TEDI in energy standards such as Passive House ™.

C. Total Energy Use Intensity

The measurement of total energy use intensity is a measurement of the total energy use in a building including both the “process” loads and the “regulated” loads. The challenge of this approach is also its primary benefit. That is TEUI ‘caps’ total energy use motivating designers to find efficiencies in lighting and cooling power where possible, but this means it does not adjust well for exotic loads that cannot be reduced through design. These loads could include medical equipment or high concentrations of computer servers which are not uncommon in office environments.

In order to mitigate this issue we recommend that while these exotic loads be modelled for the purposes of thermal energy demand calculations and GHGI calculations that they can be excluded for the purposes of TEUI. This will allow designers to focus on issues they can have some impact on while still accounting for carbon impacts and the building physics associated with large electrical loads that may produce sizable amounts of waste heat.

Finally with regards to energy modelling and verification of compliance with performance based metrics or EUI's the base input assumptions and how energy models are developed can have large impact on the metrics. The consultant team has recommended that specific energy modelling guidelines be developed to provide direction to both staff and applicants with regards to how these inputs should be portrayed. See the "Energy modelling" section of this report for more information.

Setting the Performance Targets:

Our methodology in setting the performance targets was to start with a framework that was 'base-lined' against the current requirements of the 'Green Building Policy for Rezoning's' and whose end state was passive house. This is consistent with the findings of the whitepaper noted before and has numerous market development advantages.

By setting an end-state that is based on a widely recognized and supported standard such as Passive House ™ the City of Vancouver can make use of educational programs and capacity building materials that are already developed. Risk is also insulated for the City as Passive House because Passive House is a widely vetted framework that has been applied to more than 25,000 buildings worldwide[1]. Thousands more buildings of all types have used and tested the principles and building science that underpins the standard so there is confidence that what is being proposed is viable.

Second given the stated goals of achieving carbon neutral operations in buildings, and eliminating the use of fossil fuels it was logical to target a level of performance that has demonstrated that is most effective at lowering or in most cases eliminating the need for combustion based heating appliances which are the primary source of GHG's in Vancouver's building stock.

The consultant team in discussion with the City of Vancouver identified 3 steps as being rational to get from where the building market is today to a future state where the majority of buildings achieving Passive House ™ levels of performance. This time frame is based on the latest international precedent on aggressively moving a given market to high performance buildings and energy codes. The best example is the Capital Region of Brussels who within 8 years were able to transform their building sector from a conventional energy code to a state where complete Passive House certification is required by building code for every building. It should be noted that this transformation was extremely well funded with lucrative cash incentives, a pervasive marketing and recognition strategy, as well as broad-based capacity building programs.

[1] https://en.wikipedia.org/wiki/Passive_house

The challenge with creating a framework based on performance targets is that different building types have different levels of energy usage. This can have a major impact on setting targets at conventional levels of performance. It should be noted that once buildings are targeting higher levels of performance the difference in the performance targets becomes negligible. For example Passive House has a single set of EUI targets for all building types. In order to deal with this complexity the consultant team is recommending targets for the following building types:

- Multi-unit residential
- Commercial Office
- Retail
- Hotel

For all building types not outlined above the study recommends that further work be done to refine the targets for other building types over time. In discussions with city staff it was noted that these types of buildings represent approximately 90% or more of the floor area that gets rezoned in the City of Vancouver. For other building types the consultant team recommends the use of an alternative framework until performance levels increase to Passive House levels or more work can be done to develop the required data. See the section of the report entitled 'Buildings Not Covered by the Performance Target Framework' for further details.

The possible steps for improvement were first evaluated by the consultant team based on the following comparison metrics:

- Total Energy Use Intensity
- GHG Intensity
- Thermal Demand Intensity
- Percent Energy Savings over Code
- Energy Cost Savings, and
- LEED Ea1 Credits

The cross referencing of these metrics proved useful to ground the provide the relative performance against city goals such as green house gas reductions and historic policy design frameworks such as energy cost savings, percent better than code and LEED credits.

The evaluation then focussed on "construct-ability" and by approximate costs provided by both Morrison Hershfeild and Integral Group, before being vetted more thoroughly from a number of costing perspectives. Given a ten-year planning horizon provided by the client the team determined that 3 incremental steps in improved performance for multi unit residential buildings was rational. Three steps allowed for increments 10-20Kwh of increased performance in thermal energy demand which when looked at in percentages follows a similar trajectory of approximately 20% increases that rezoning polices have used in the last two updates. This allowed for the city to adopt the first step this year as part of the Rezoning policy update and then update the standard again in 5 years to the second step and finally in approximately 10 years adopt the third step in the rezoning policy. The alignment of the proposed steps was also well suited to adopting an interim step immediately, then adopting the a target that was equal to the Passive House standard for "Very Efficient Buildings", (which is not as efficient as Passive House) and then finally adopting a standard roughly equal to standard Passive House.

Proposed Multi-Unit Residential Targets:

Metric	Current Rezoning Policy	Proposed Rezoning Policy (Best Practices)	Interim Step (High Performance Buildings)	Near Passive House Performance
GHGI (kg/sqm/yr)	20*	**6**	4	0

TEDI (Kwh/sqm/yr)	62*	**32**	15	5
TEUI (Kwh/sqm/yr)	170*	**120**	100	90

**results based on modelling not targets*

Below is a detailed summary of the proposed interventions that were developed by the consultant team and vetted by industry in order to the meet the performance requirements of the proposed tiers of performance for high-rise multiunit residential buildings. This includes both a point form and narrative summary.

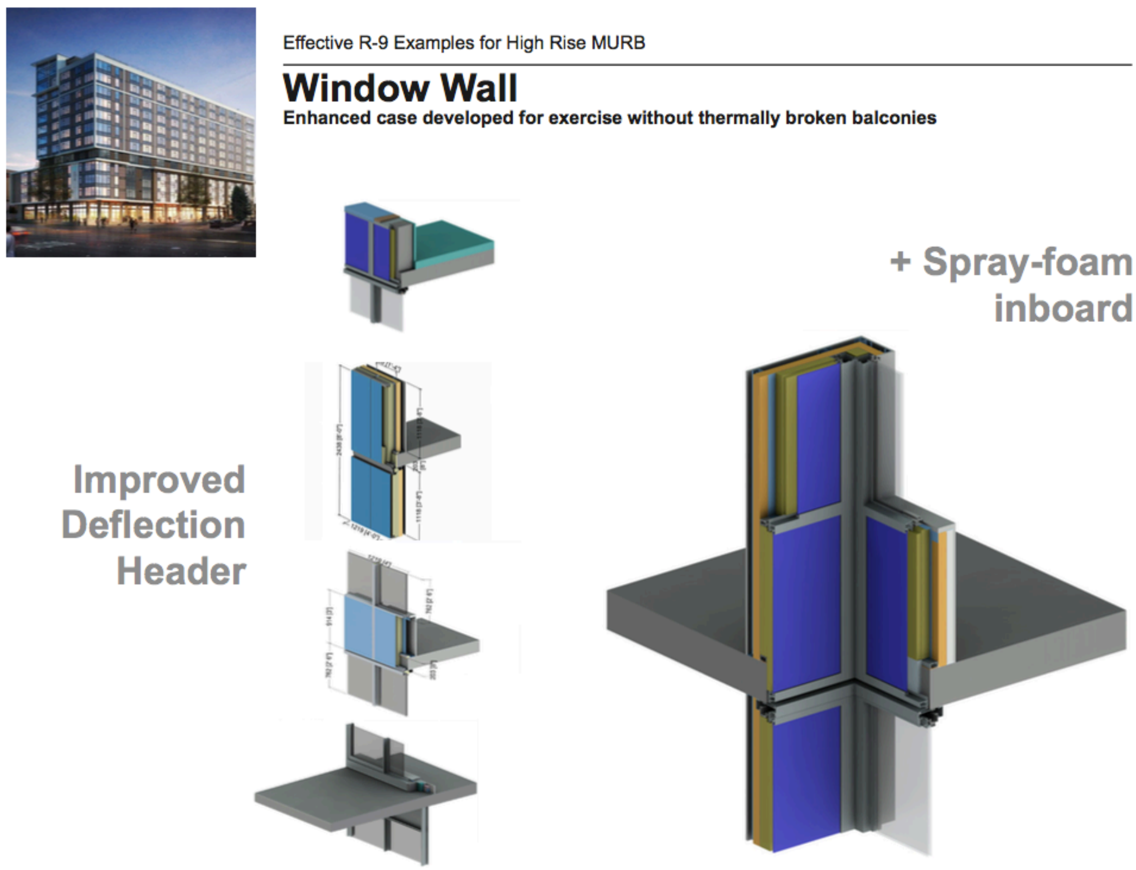
Building scenarios for High Rise MURB

Proposed Rezoning Policy (Best Practices)	Interim Step (High Performance Buildings)	Near Passive House Performance

• **Suite HRV & Electric Baseboards**
• **50% WWR**
• **R-9 Walls**
• **High performance double-glazed windows**
• **With DE connection = R5 wall OR 10% more glass**
	• **High performance triple-glazed windows**
	• **Non-gas corridor MUA and DHW**
	• **R-12 walls**
	• **More pressure on one of the following:**
	  ○ **Glazing ratios**
	  ○ **R-values**
	  ○ **Better HRV efficiency**
		• **Manage corridor ventilation / pressurization**
		• **Pressure on form factor OR windows and walls**

Proposed Rezoning Policy (Best Practices)

The interventions taken to get to the proposed rezoning policy represent a combination of current market driven designs and an economical approach to achieving a high performance MURBs. The form and massing is similar to a typical Vancouver high-rise and the number of non-thermally broken balconies included in the model is similar to current market construction. Windows are high performance double glazed units commonly used in current market developments. An overall glazing ratio of 50% was used. While not uncommon, 50% is based on consultant team experience, and industry consultation, at the lower end of what is typically seen in today's market developments. Wall performance can be easily achieved with standard steel stud construction that is externally insulated with mineral wool. However, other window wall products that can achieve the required level of performance also exist locally should another method be preferred for constructability. The only system that cannot feasibly be used to meet the new rezoning policy thermal energy demand target is an internally insulated concrete wall. Below is an example of a high performance widow wall assembly that would meet the requirements of the proposed rezoning policy: (Source: Morrison Hershfield)



The mechanical system is assumed to be basic central boiler that supplies heat to a make-up air unit to provide heating, while in-suite heating is provided by electric baseboards. However, a district energy connection would allow for lower wall performance values, or 10% more glazing.

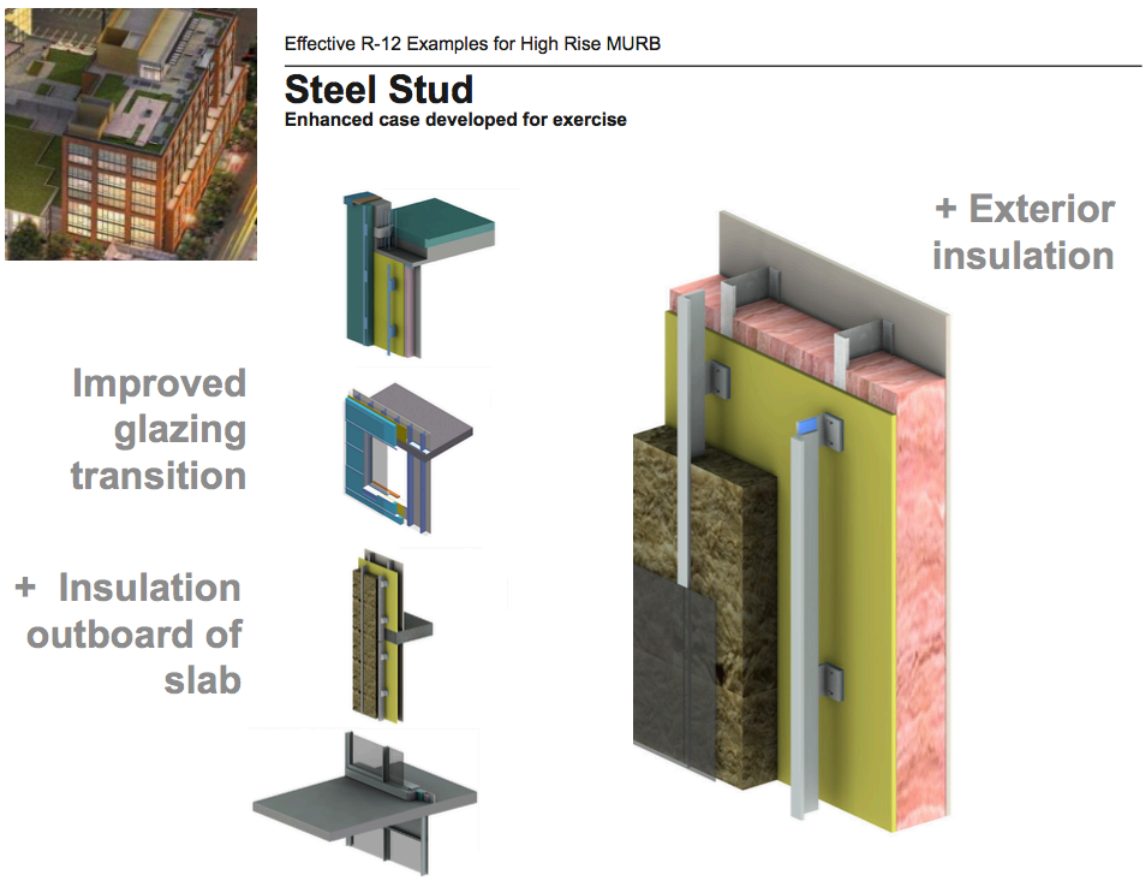
It should be noted that there are infinite solutions to achieving the proposed thermal demand targets that involve trade offs between glazing ratios, the amount of balcony area, how those balconies are affixed to the building and what type of wall system is used. The consultant team attempted to set this initial target so that the levels of glazing and amount of balconies affixed using extruded slabs were similar to what is today's market developments.

Interim Step (High Performance Buildings)

The primary solutions developed to achieve the interim step that is proposed before net zero ready buildings is based on reducing both the total amount of balcony area, and the window-to-wall ratio to 45%. These two strategies combined with the addition of triple glazing lower thermal energy demand to the desired target. Most

of the wall systems used to achieve the proposed rezoning policy levels of performance can also be used to achieve the interim step levels, with marginal increases in the amount of insulation added to each system.
The greenhouse emissions target proposed for the interim step makes the use of natural gas prohibitively difficult to use as the primary heating fuel in this tier of performance. The central HVAC systems must use either low carbon district energy, or some form of electrically-driven heat-pump technology to meet the GHGI target. At this level, heat recovery in domestic hot water systems also helps buildings to achieve their GHGI and TEUI targets, but is not absolutely necessary.

Below is an example of a high performance steel stud wall that would meet the requirements of the proposed interim step. (Source: Morrison Hershfield)



In addition to specifying higher performance equipment and making intentional decisions around fuel choice to lower emissions design strategies for this proposed tier of performance would benefit from alternative approaches to balcony design. For example overall wall performance can be dramatically improved without adding any extra insulation if a different approaches to balcony design such as "Juliette" balconies, "hung" balconies are used instead of extruded slabs.

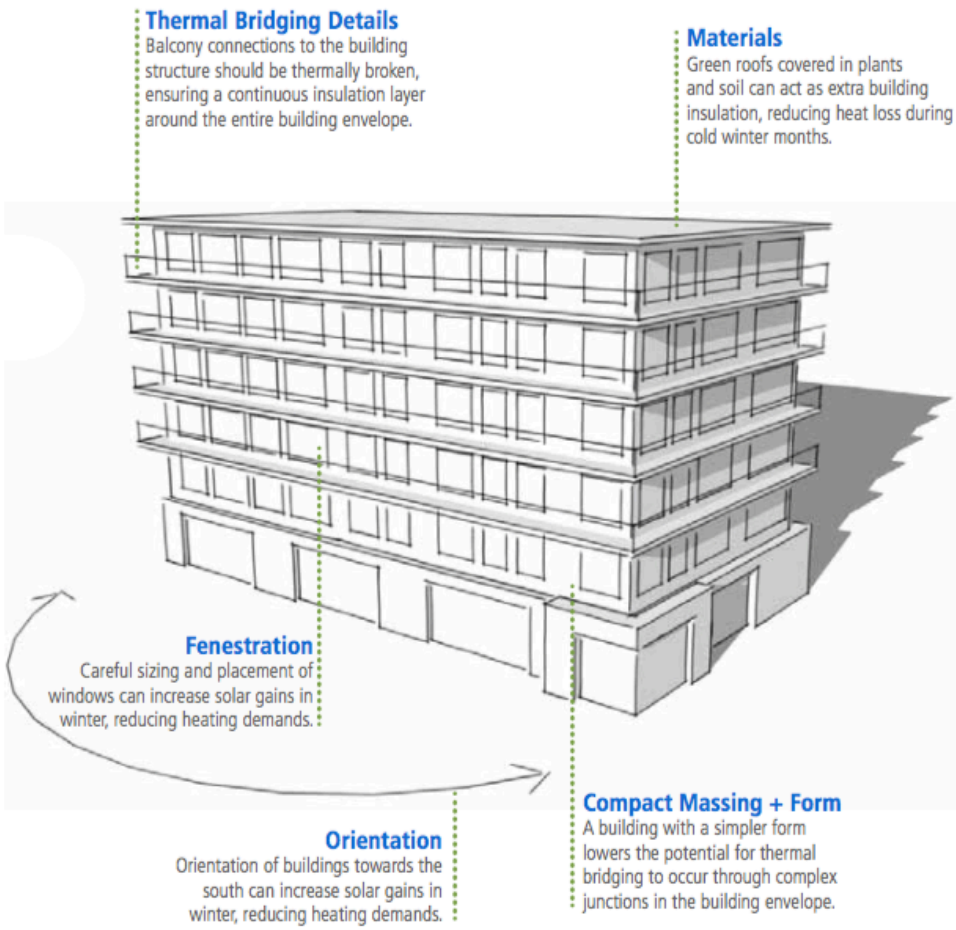
Hung Balcony: (photo credit ZGF architects)

Juliette Balcony: (photo credit NBBJ)

Near Passive House Performance:

Achieving a near net zero level of performance requires buildings to lower glazing ratios to 40% and either further reduce total balcony area, or thermally break balconies so as to minimize heat loss. At this tier, there is also a need to focus on overall building design such that a rational form with an economical approach to building articulation is created. Building form is critical. A building will not meet the proposed targets without focusing on a rational form that is optimized for passive solar heating and minimization of thermal bridging. See image below for examples of strategies of how buildings can achieve an efficient rational form.

In addition to a well considered architectural strategy higher performance wall and window systems equivalent or better to those used in interim level of is also required. It should be noted that there are presently no “window wall” systems that can be used to achieve the required levels; however, other prefab (eg: precast concrete) or built on-site (eg: steel stud with exterior rock wool insulation.) solutions are available. Mechanical solutions for Tier 4 are similar to those in Tier 3, with the additional need for some kind of electrical solution to heat domestic hot water.



Finally, the achievement of Carbon target at this level of performance means that current conventional approaches to domestic hot-water supply will not be able to be used. Buildings that use low carbon district energy will have a significant advantage in achieving the targets. In buildings that will not have access to low carbon district energy solutions, some kind of electrically driven domestic hot-water solution that incorporates heat recovery is required. These systems are not common place in the market currently, but there are local suppliers that do offer commercially available products with warranties and full product support for consumers.

Example of the a in-building domestic hot water heat pump and heat recovery system: (Source: International Waste Water Systems)

Proposed Commercial Buildings Targets:

Metric	Current Rezoning Policy	**Proposed Rezoning Policy**	No Interim Step Proposed:	Near Passive House Performance
GHGI (kg/sqm/yr)	20*	**3**		0
TEDI (Kwh/sqm/yr)	62*	**27**		21
TEUI (Kwh/sqm/yr)	150* (170**)	**100 (170**)**		80

**results based on modelling not targets*
*** Target for Retail Buildings.*

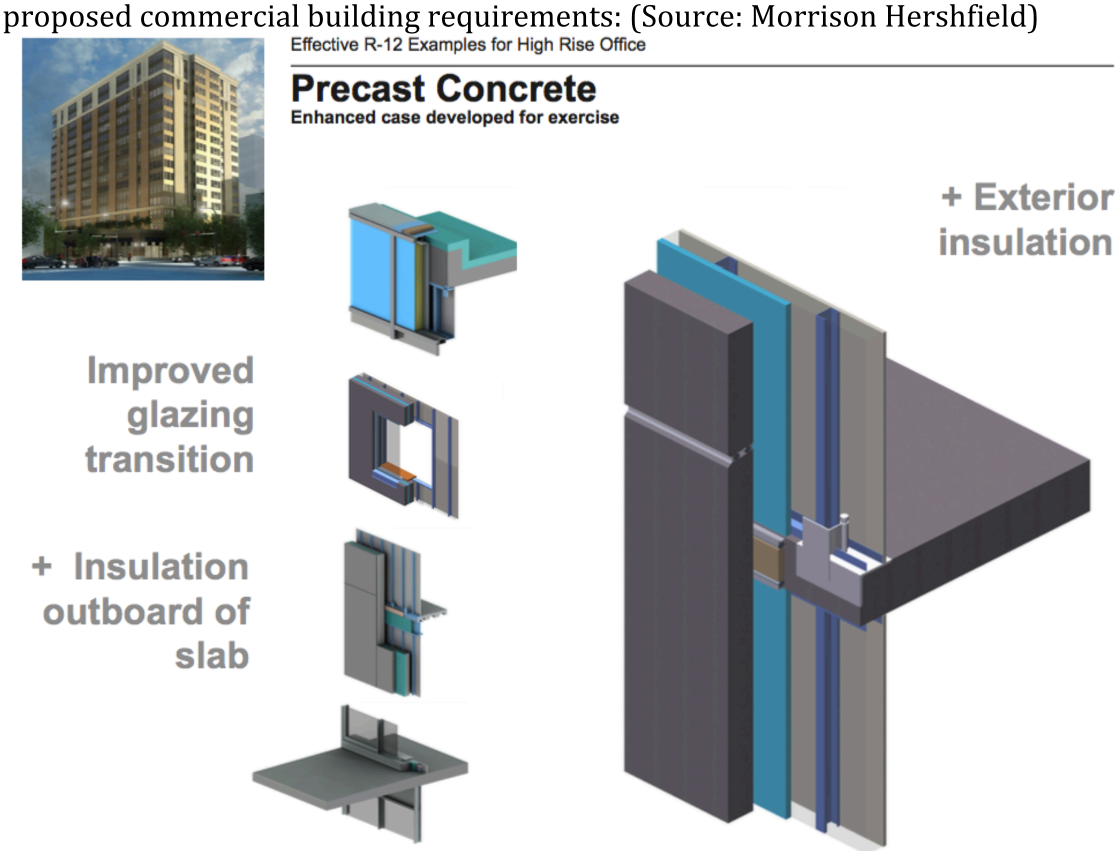
Less steps were defined for commercial buildings because, generally commercial buildings were more efficient than residential buildings, and were less carbon intensive. This allowed them to start at an advanced position relative to residential buildings requiring fewer steps to get to “Passive House” like performance. Further it is recommended that the commercial TEDI target be applied to the retail with an adjusted total EUI to reflect the higher lighting loads in retail spaces.

Below is a detailed summary of the proposed interventions that were developed by the consultant team in order to the meet the performance requirements of the proposed tiers of performance for commercial buildings.

Proposed Rezoning Policy	Near Passive House Performance
• High performance heat pump systems • Heat recovery • ASHP OR low-carbon district energy connection • 60% WWR • R-12 walls • Triple-glaze U-0.23 windows • Gas-based domestic hot water	• R-16 walls • 50% WWR • Triple-glaze U-0.23 windows • Better heat recovery efficiency • Lower glazing ratios at 50% • High performance domestic hot water systems

Proposed Rezoning Policy:
Reaching the Proposed Rezoning Policy targets requires commercial buildings to shift toward the use of high performance heat pump systems that drive down both TEUI and GHGI. A glazing ratio of 60% and R-12 walls represent lower-cost approaches to reaching the targets; however, triple-glazed windows were required. Building heating and cooling systems must use either a district energy connection or an air source heat pump (ASHP), while domestic hot water can still use a natural gas-based system.

Below is an example of a precast concrete wall system that would meet the proposed commercial building requirements: (Source: Morrison Hershfield)



Near Passive House Performance:
As in the other typologies noted above, a shift to this level of performance will require a movement toward higher performance walls, lower glazing ratios, and improved heat recovery efficiency. Wall performance needs to achieve R-16 values. It should be noted that currently there are no curtain wall systems that meet this level of performance. This means absent of advancements in curtain wall technology adoption of this performance would mean a shift in the industry towards a punched wall envelope system. This is significant because while there are examples of "Triple A" office buildings that are punch wall in Vancouver (eg: Cathedral Place, and 1075 W Georgia) common practice in contemporary office buildings has been to use curtain wall.

A similar situation occurs at this level of performance with regards to domestic hot-water as was outlined above in the multiunit residential case. Buildings that are not connected to low carbon district energy systems will require an electrically based heating system for their domestic hot water needs.

Further Analysis:
It is recommended that further analysis be done to define targets for Hotel Buildings. Hotel buildings while similar to multi unit residential do have much higher domestic hot-water loads making both their energy use and GHG emissions much different.

Sensitivity & Costing Analysis

The proposed steps for the rezoning policy were reviewed by staff from Integral Group, Morrison Hershfeild, and Enersys Analytics. Each step was reviewed from the perspective how each step could be rationally be achieved by using a variety of fuel choices including: electricity, natural gas, and district energy. The envelope strategies were sourced from the 'Building Envelope Thermal Bridging Guide' and the HVAC systems were sourced from a pool of recently completed Integral Group buildings.

Construction Costs:

High level costing was completed by both Integral Group and Morrison Hershfeild and then was reviewed in detail by BTY Group quantity surveyors. It should be noted that the costing modes used my BTY are the same ones used for project financing and design build contracts. The purpose the costing was to assess the relative costs of the proposed targets as compared to current City of Vancouver requirements.

The base-line costing models for the project were the same building archetypes that were used for the energy modelling. In all cases the building attributes that were used in the baseline were, in opinion of the consultant team, the most economical way a building would meet the current City of Vancouver's Green Rezoning Policy energy requirements. These assumptions were then tested in a workshop with designers, contractors, and product suppliers as to their accuracy. The models were then adjusted based on this industry input.

The consultant team then developed a range of packages that were used to meet the proposed targets in most cost effective manner. These packages all included at least three different solutions for each tier of performance. These included a:

- Natural Gas based HVAC system, an
- Electrical HVAC systems with heating only and, a
- Electrical HVAC systems with heating and cooling, and a
- Low-carbon district energy solution.

It should be noted that at the upper tiers of performance the natural gas based systems could not be reconciled with the GHGI targets.

All of the variations were again tested with members of the UDI codes committee, and an advisory committee that was composed of energy efficiency experts in a workshop format. The solutions were tested to ensure that they were rational in their response to the target from both a cost and constructability perspective.

In addition to developing the potential additional costs of an new performance requirements, analysis was also undertaken to asses any potential savings of removing the current rezoning requirements. The Urban Development Institute's code committee provided cost premiums from their own projects and estimated that the cost impacts of the current rezoning policy was between 5% and 7% of construction costs. This translated into $6 to $15 per square foot. The savings of removing these requirements is expressed in the table below as "savings from stream-lining current requirements."

The table below is a summary costs per square foot:

COST SUMMARY	
Requirement	**$/ft² vs 2014 Rezoning**
Build to the first step of the Rezoning Policy	(1.2) to 3.2
New Administrative Costs:	0.9 to 1.7
Construction Cost Difference (total of first two lines)	(0.3) to 4.9
Savings from streamlining current requirements	(6 to 15)
TOTAL	**(1.1 to 15.3)**
Construction Cost Difference in 850/ft² Suite	($950 to 13,000)
Monthly Energy Cost Difference in 850/ft² Suite	$60
Annual Strata Fees, Etc. Difference in 850/ft² Suite	($200)

In addition to developing a robust construction cost assessment the consultant team in cooperation with the City of Vancouver developed a long-term net-present value (NPV) analysis of the different recommendations. The NPV calculation included a "levelized" costing analysis that took into account what the "total cost of energy" would be for each of the scenarios. This total cost of energy includes the following:

- Construction Costs
- Fuel costs over 25 and 30 year time horizons including projected increases in utility rates over time.
- Maintenance Costs
- Replacement costs for major building components.
- A capital discount rate to account for capital devaluation over time.

All of these factors were put into a model that allowed options to be compared to business as usual (BAU) scenario over a 23 years (to 2040). The purpose of this modelling and NPV analysis was to determine whether the proposed targets would be a net-benefit to the home-owner over time. Put another way, did consumers who possibly had to pay higher first costs recover these costs over the lifetime of the asset?

The results of this analysis are that solutions based on highly efficient envelopes and electric baseboards for heating had similar net present values over 24 years as solutions that had district energy based heating systems. Further that these systems had similar present values as buildings built to base building code while in the District Energy scenario achieving a 75% reduction in GHG's.

	Present Value of All Costs*	"Carbon intensity" ($kgCO_2/m^2$)"
Vancouver Building By-law	**7,161,000**	**20.2**
Proposed Rezoning Policy – Electric Baseboard Option	**7,001,000**	**5.9**
Proposed Rezoning Policy – District Energy Option	**7,186,000**	**5.1**

*Includes all fuel and maintenance costs between 2017 and 2040.

Soft Costs

With regards to soft costs not discernable differences were forecast in the design stage by the consultant teams. While the overall costs of mechanical engineering design fees may be reduced due to the reduced need for complicated mechanical systems, these cots may be offset by an increase in envelope consulting fees and or architecture to compensate for increased due diligence on the envelope. Typically building designs fees are a factor of construction costs so with project costs remaining relatively constant there would be no reason to forecast an increase in design fees.

The consultant team was also asked to explore what the impact of the administrative requirements would be if they were adopted as proposed.

Administrative Requirement	**Permitting Stage**	**Approximate Cost**
1. Sealed Energy Modelling: Energy modelling costs should be constant or less under the new administrative requirements based on the elimination of the redundant LEED energy model.	RZ/BP/OC	Potentially a $10,000 savings
2. Air-tightness Testing: This would include the development of a Air tightness testing plan and the test itself.	BP/OC	$20,000-$60,000 premium depending on the size, and complexity of project and experience of contractor
3. Commissioning Requirements Commissioning costs can vary based on the system used. IE: Less complex systems will need less commissioning.	BP/OC	Up to $40,000 premium depending on the size, and complexity of project
4**. Embodied Carbon Calculations**	DP/BP(?)	$5-10,000 based on the amount of materials and whether there are existing retained pieces of structure

The following is an itemized summary of how the administrative costs were developed and the assumptions in which they are based.

Buildings Not Covered by the Performance Target Framework.

In recognition that at conventional levels of energy performance there is a wide spectrum of performance targets for buildings not noted above, and noting that there is a very small number of buildings that will be impacted by this anomaly we recommend that the City of Vancouver use a reference building approach because of its adaptability to numerous building types and its ability to normalize and adjust to unique circumstances.

Based on the energy modelling analysis completed, we recommend a target of:
40% better *Energy Use* than ASHRAE 90.1 2010 including "Appendix G"

This target is roughly equivalent to the commercial targets proposed above based on our modelling of commercial office buildings. This also represents an 18% improvement over the current policy, which is consistent with other updates made to the rezoning policy in the past. Specifically the improvement mandated when the policy was first introduced in 2010.

Administrative Requirements

Energy Modelling Guidance & Sign Off

As part of the development of a more rigorous energy framework that includes energy use intensity targets the consultant team recommends the development of program specific energy modelling guidelines. The intent of the guidelines is to standardize certain energy modeling assumptions to align with the assumptions used in developing the established performance targets and lower the margin for error by providing specific guidance where other standards may be vague or open to interpretation. The guidelines aim to strike a balance between allowing maximum design flexibility, and innovation towards meeting the performance targets, and constraining certain inputs that are less influenced by design to ensure that all projects can be rewarded for energy efficiency equitably and consistently. The energy modeling guidelines should establish a consistent methodology around the following minimum set of parameters:

- Operating schedules,
- Non-regulated loads such as plugs, and elevators,
- Air leakage rates,

Even more critical, the guidelines should also clearly establish requirements for how to properly represent envelope heat loss by incorporating thermal bridging. This factor has historically been ignored in code compliance modeling. This will ensure that more accurate design performance criteria is included in energy models which is critical to identifying and improving any efficiency weaknesses in the design.

Finally we recommend that the energy model be “sealed” by a registered professional. By explicitly requiring “Professional sign off” of energy models there is direct professional accountability for the way buildings are being represented in simulation efforts. We recognize that while in some cases professionals are already sealing energy models it is still inconsistent across the industry, and further without the addition of Professional Practice guidelines the sealing of these models to date carries with it little to know legislative weight.

The addition of professional practice guidelines will for the first time in the province define the duty and scope of what professional practice for energy modelling. This will allow professional associations to enforce discipline on energy modellers that have been found to be in violation of professional ethics. Now that the City of Vancouver in cooperation with the BC Hydro, APEGBC and AIBC have committed to the development and enforcement of these guidelines professional sign off will have a much greater impact.

Air Tightness Testing

In recognition that there needs to substantial increase in capacity in the local market with regards to Air Tightness testing and that the most logical place to source expertise, lessons learned and possible training opportunities is Seattle, Washington where Air Barrier testing has been in place for over 5 years we recommend that the city of Vancouver adopt the City of Seattle standard for air-tightness testing.

Referencing the Seattle standard and requirements will allow both applicants and Vancouver building code officials to interact directly with experts who have either undertaken the testing them selves or have been responsible for reviewing results. It will also expedite the creation of companion literature to support industry in the transition.

As capacity grows we recommend that the City of Vancouver review advancements in the Canadian market and adjust as necessary.

Proposed Requirement:

- The air leakage rate of the building envelope shall not exceed 0.40 cfm/ft2 at a pressure Air leakage requirements for fenestration are outlined in Table C402.4.3 according to various testing procedures.
  - Example: windows must achieve 0.20 CFM/ft2
- Additional air leakage requirements are outlined for:
  - Doors/openings to shafts, chutes, stairways and elevator lobbies
  - Air intakes, exhaust openings, stairways and shafts
  - Stairway and shaft vents
  - Outdoor air intakes and exhausts
  - Loading dock weather seals
  - Vestibules
  - Recessed lighting
  - Walk-in coolers and walk-in freezers
  - Refrigerated warehouse coolers and refrigerated warehouse freezers

Testing:

- Testing done in accordance with ASTM E779 with the following modifications:
  - Tests shall be accomplished using either both pressurization and depressurization or pressurization alone, but not depressurization alone.
  - The test pressure range shall be from 25 Pa to 80 Pa, but the upper limit shall not be less than 50 Pa, and the difference between the upper and lower limit shall not be less than 25 Pa.
  - In the pressure exponent n is less than 0.45 or greater than 0.85, the test shall be rerun with additional reading over longer time interval.

- differential of 0.3 inches water gauge (2.0 L/s m2 at 75 Pa)
- Air barriers permitted to be on the inside or outside of the building envelope.

Compliance:
While the Seattle energy code gives the building official authority to accept or reject any test we recommend that the test be reviewed only for completeness to ensure that it has been done correctly according to the standard. The City will collect the testing data initially for data collection purposes, and we further recommend that the test be reviewed and signed by the owner, and the contractor prior to occupancy.

http://www.seattle.gov/dpd/cs/groups/pan/@pan/documents/web_informational/p2235344.pdf

Additions to Existing Buildings
We recommend that additions must also follow the air barrier rules, although the existing building does not. The addition must be carefully separated from the existing building during testing.

How the standard compares to ASHRAE 90.1 Requirements
"The 2012 Seattle Energy Code introduces explicit requirements for a building air barrier and requires all buildings to have an air leak test at 75 PA of less than 0.4 CFM/ft2 of above-grade envelope. The building air barrier, materials and, assemblies are similar to those required by ASHRAE 90.1 – 2010 but 90.1 does not require testing." – Seattle.gov
http://www.seattle.gov/Documents/Departments/OSE/SEC2012toASHRAE90-1-2010_20June2014.pdf

Ventilation Requirements:

Currently the City of Vancouver requires adoption of all ASHRAE 62.1 2007 ventilation requirements as a condition of its Green Rezoning Policy. The complete adoption of the standard is a perquisite of LEED 2009 NC. The requirement varies from the National Building Code requirement, which cites both an older version of the standard and does not adopt the standard in its entirety.

One of the beneficial impacts of adopting ASHRAE 62.1 2007 is that it compels that air be supplied to all rooms within multi-unit residential buildings. This has led to a design response of installing suite-by-suite Heat Recovering Ventilators (HRV's). While other strategies such as in suite transfer grills between the hallway and rooms have been used, the HRV's provide both higher levels of air quality and improved energy efficiency and have become industry standard under the green rezoning policy.

We recommend that at a minimum the adoption of this standard as base requirement of rezoning's continue, and that the City consider adopting the 2010 version of the 62.1 standard to remain consistent with the current version of the

LEED rating system. It is important that the city not regress to either a lesser standard or an alternate ventilation requirement at this time given that the costing and the development of TEDI, and total EUI's and GHGI's all used some form of HRV in their development.

Commissioning requirements:

Commissioning is the process of verifying that the building's systems operate as intended and according to the owner's requirements as set forth in project documents. Another way of saying this is that if an owner needs a building to function with an interior space at a certain temperature, with a certain amount of ventilation this is a check done at both the design and construction phase to ensure what is designed and installed will accomplish these outcomes. Commissioning helps fill the gap between the design team, whose members usually aren't meant to be responsible for checking minor construction details, and subcontractors, who may inadvertently err on key items like fan power settings or sensor locations.

The following is intended to define the scope of what commissioning is for the purposes of both current and future policy development in the City of Vancouver. The scope starts with the 'Commissioning Agent' checking both the plans and the installations to provide a comprehensive assessment of the HVAC and Electrical systems strategy. This includes a review of the design and installation of the following:

- Heating, cooling, refrigeration, ventilation systems and controls
- Lighting and day-lighting controls
- Domestic hot water systems
- Renewable energy systems

The base level of commissioning contemplated for the City of Vancouver begins during the development of the contract documents prior to building permit and concludes with the submission of a commissioning report at occupancy. It will require meetings with the design team and ownership group, onsite testing and inspections, and the preparation of reports and checklists.

We recommend that a Registered Professional either an (Engineer or Architect) be responsible for both the commissioning plan and final commissioning report that will be submitted to the City. The professional responsible for submitting this report is typically referred to as the "Commissioning Agent". The Commissioning Agent can be a member of the design team or a separate entity.

We recommend that the commissioning reviews be done in accordance ASHRAE Guideline 0–2005 and ASHRAE Guideline 1.1–2007 for HVAC&R systems. These standards are consistent with LEED prerequisites, and both the City of Seattle Energy Code and Title 24 in California. The advantage of using these standards is that it is tapping into already existing capacity built up through the implementation of LEED in the local market and the education programs already offered by the CaGBC. The industry uses these standards currently and there are additional resources and guidance developed both by ASHRAE and CaGBC that can aid Commissioning Agents and Regulators in the submission and review of documentation.

The Commissioning Authority will agree to undertake the following at various stages of permitting:

1) At Building Permit, prepare a short Commissioning Plan that includes the following.
   a) Review the Owner's Project Requirements (OPR), Basis of Design (BOD), and project design, summarize and provide commentary where required.
   b) Develop a Commissioning plan outlining roles and responsibilities on the design and construction team.
   c) Confirm incorporation of Commissioning requirements into the construction documents.
   d) Develop and append construction checklists.

2) at Occupancy Permit, Prepare a short Commissioning Report that includes the following:
   a) Develop a system test procedure with a brief narrative as to how and why what tests are being undertaken.
   b) Verify system test execution.

The Commissioning report should summarize how design and instillation has met with OPR and BOD requirements it should also note issues that arose during the commissioning process and how they were resolved. It should also note any further actions that the owner needs to take in the warranty period of the equipment to ensure efficient operation, or that the system is balanced and optimized.