Zero Emissions Building Plan

7/12/2016

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1 Exec Summary

This Plan lays out four action strategies to require the majority of new buildings in Vancouver to have no operational greenhouse gas emissions by 2025 and that all new buildings have no greenhouse gas emissions by 2030.

These four strategies include:

1. Limits: establish GHG and thermal energy limits by building type and step these down over time to zero
2. Leadership: require City-led building projects to demonstrate zero emission building approaches where viable
3. Catalyse: develop tools to catalyse leading private builders and developers to demonstrate effective approaches to zero emission new buildings; and
4. Capacity Building: build industry capacity through information sharing tools and the development of a Centre of Excellence for Zero Emissions Building to facilitate the removal of barriers, the sharing of knowledge, and the development of the skills required to successfully achieve this goal

These strategies for achieving zero emissions new buildings were developed specifically to ensure comfortable and healthy indoor environments, maximize local economic development, ensure long-term building resilience, protect housing affordability and to facilitate achieving the City's Renewable City Strategy target to have all buildings in Vancouver (including those already built) use only renewable energy by the year 2050.

2 Background

The Greenest City Action Plan includes a target to achieve carbon neutral new construction by 2020. More significantly the Renewable City Strategy targets 100% of all energy used in Vancouver come from renewable sources by 2050. In this Strategy, it was estimated that of all the buildings (measured by floor space not number of structures) that are anticipated by 2050:

- 30% would be built prior to 2010
- 30% would be built between 2010 and 2020
- 40% would be built after 2020.

If all buildings are to use only renewable energy by 2050, the sooner new buildings achieve near zero emissions, the fewer buildings there will be that require costly and challenging deep energy retrofits to achieve the target.

Consequently, the Renewable City Strategy targeted new buildings to be zero emissions by 2030 and where possible sooner.

2.1 New Building Emissions Trends

Operational greenhouse gas emissions from new buildings vary widely by building type, size, the carbon intensity and amount of the energy used,

and policy or regulatory limits imposed on the building's design and construction. Building scale greenhouse gas emissions are measured in kg CO2e/m2 per year; since these are emissions per unit area they are referred to as emissions intensity or GHGI.

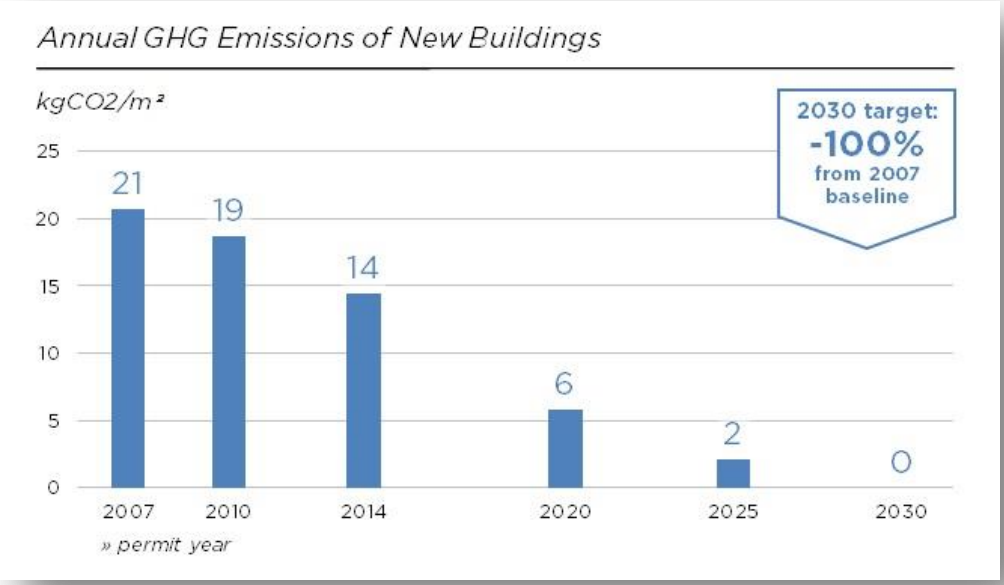

FIGURE 1: Aggregate GHG Emissions of All New Buildings Types

Total annual GHG emissions for a specific building type are calculated based on the modelled energy use of a typical sample building designed to its governing policy and/or regulatory requirements multiplied by the carbon intensity of the specific sources of energy sources used in that building.[1] Aggregate GHG emissions for all buildings types are based on a built area weighted average[2] of the emissions associated with each of the specific building types.

[1] Note that historic emissions for a specific building type are estimates only. Energy efficiency regulations do not *currently* control directly for GHG emissions so historic (and current) emissions by building type are based on modelled outcomes of *typical* design responses to energy efficiency regulations governing a building's design and construction in a given year.

[2] In 2007, only the Building Bylaw stipulated efficiency requirements (with the exception of a very limited number of buildings such as City facilities). Since then, rezoning policies as well as neighbourhood renewable energy system (NRES) connection requirements have introduced additional energy use limitations on large numbers of buildings in specific areas. GHG calculations (by building type) incorporate an estimate of how much new built area is impacted by rezoning conditions and/or NRES connection and therefore have lower GHG emissions than a building only impacted by the Bylaw.

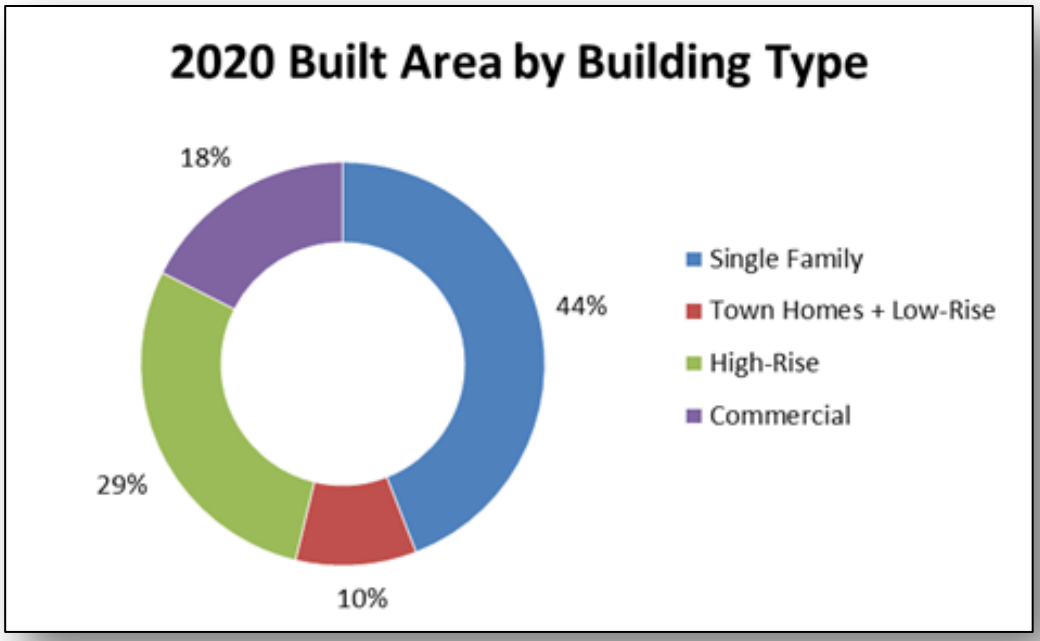

FIGURE 2: Built Area by Building Type

New development in Vancouver is predominantly residential with 82% of new building area being for houses, condominiums and apartments. Detached housing, referred to as "single family" but also including secondary suites, laneway houses and duplexes, represents the category of buildings with the most new development (by total floor area) per year. Even though significant and meaningful reductions in GHGI from new detached houses have been achieved since 2007, the significant amount of new development of this building type means additional improvements in performance must remain an important focus moving forward.

Mid and high-rise multi-unit residential buildings (over 6 stories in height) are the second most significant form representing 29% of new building area. Vancouver's efforts to reduce emissions from new mid and high-rise residential buildings have not been as successful in reducing emissions as they have been for houses and therefore must also be a form of development for particular focus. Fortunately, the expansion of neighbourhood renewable energy systems (NRES) and immediate changes outlined in this plan create two pathways to significantly reduce emissions from this critical form of development.

2.2 Renewable Energy in Vancouver

Unlike most jurisdictions around the world, Vancouver's electricity is already close to 100% renewable; Provincial legislation requires BC's grid to be supplied by a minimum of 93% renewable energy and the current mix is over 97% renewable and therefore has very low GHG emissions associated with its use. As a result, while electricity conservation remains important,

the focus of this plan is on reducing the demand for fossil fuel based natural gas used primarily for space heating and hot water and transitioning these functions to renewable sources such as electricity (including heat pumps), bio-gas, and neighbourhood renewable energy systems (NRES).

In addition, because grid provided electricity is almost entirely renewable in BC, this Plan does not focus initially on mandatory building scale renewable energy technologies such as solar photovoltaic (PV) as is the case in a number of other leading jurisdictions. This Plan provides flexibility for builders and owners in determining how best to achieve the targeted GHG emission outcomes. One key element of providing flexibility for solutions is through removing barriers to good technologies and solutions such as solar PV.

When a building is required to achieve zero emissions if the electricity grid is not 100% renewable then the buildings will be obligated to install an on-site renewable energy system (or secure a share of Vancouver-based renewable power systems where on-site systems are not viable) that produces enough renewable energy to offset the small portion of grid power that comes from fossil fuel based generation.

2.3 Passive House

Passive House (also Passiv Haus) is the most rigorous and widely applied global standard that has been developed and refined specifically for ensuring highly energy efficient building envelope and ventilation system design and construction.

This standard is supported by:

- professional and trades training programs;
- customized energy modelling software to ensure strict energy limits are not exceeded, good ventilation is provided, and thermal comfort is maintained;
- third party verification processes (90% of which can be completed prior to construction start); and
- Canadian, North American, and global networks of designers, builders, equipment manufacturers and researchers.

Hundreds of millions of square feet, primarily of residential development but also including many schools, offices, hotels, firehalls, museums, etc., have been built and certified to the standard worldwide.

Throughout this Plan, reference is made to the Passive House standard as near zero emission because buildings meeting the standard's criteria use virtually no space heating energy, limiting emissions to heating water and electricity use. While there is insufficient local data to conclude that this standard should be applied in its entirety to all building types under all conditions, the standard and its associated tools are seen as a key tool to

effectively transform the building industry to greatly improved building envelopes and ventilations system approaches.

3 Stepping Down GHG Emissions to Zero

Zero emissions new buildings will be achieved by incrementally lowering the permitted GHG emissions for new construction in Vancouver`s Building Bylaw over time. Currently, no jurisdiction in North America has building code requirements that establish specific limits on GHG emissions. Experience has revealed that indirect approaches such as regulating energy cost efficiency as compared to a `reference` building (as is the standard approach under the North American building efficiency standard ASHRAE90.1 and in LEED) have not been as effective as anticipated in reducing emissions in Vancouver.

This Plan establishes greenhouse gas intensity (GHGI) targets (GHG emissions per unit area per year) by building type and includes a stepped reduction timeline to reflect these targets as maximum permitted limits in Vancouver`s building policies and Building Bylaw.

Clearly defining and quantifying desired outcomes and providing a schedule for performance changes will enable industry to plan appropriately and to focus building design and construction innovation towards achieving these objectives.

3.1 Stepping Down GHG Emissions to Zero - Reduction Pathways

This Plan establishes two pathways by which GHGI limits for new buildings can be achieved in order to a) ensure reliable and durable emission reductions and to b) maximize co-benefits such as:

- local economic development
- healthy indoor building environments
- maximum occupant comfort
- protecting affordability
- future proofing to enable additional performance improvements post-occupancy
- resilience to climatic changes, extremes, and/or power outages.

3.1.1 Path One: High Performance Building Envelope and Ventilation Systems

A building envelope is like its skin – it includes surface elements such walls, windows, and the roof. Building envelope performance is primarily influenced by the amount and effectiveness of wall, roof and foundation insulation and the amount of windows and their energy efficiency. It is also impacted by how the building is designed to use the low angle of the sun in the winter to provide free heating while using shading strategies to keep out direct sunlight in the summer and avoid the need for air conditioning.

Ventilation `systems` are the means by which fresh air is provided for the building and stale air is exhausted.

Building envelope and ventilation system performance are interdependent. An efficient ventilation system cannot have warm air leaking out of the envelope in the winter (or cool air leaking out of the building during the hot summer) through poorly weather proofed walls and openings. At the same time, a healthy and durable building envelope depends on adequate airflow to avoid moisture accumulation which can lead to rot and mold. Very good draft proofing and the use of a `heat recovery ventilator` (HRV) that uses the energy of warm exhaust air to pre-heat fresh incoming air during the winter and vice versa during the summer are central to an energy efficient ventilation system.

A very efficient heat recovery ventilator (HRV) can pre-heat cold incoming fresh winter air from 0° C to 17 or 18° C just by recovering the heat energy from the exhaust air; because most of the fresh air heating is free, buildings can be well ventilated without concerns about the cost of doing so.

The first pathway to zero emissions buildings focuses on highly efficient building envelopes and ventilation systems because these systems do not depend on sophisticated maintenance staff or specialized contractors to ensure they are performing as designed. Given that 82% of the new development in Vancouver is residential and that most homeowners, strata councils, and apartment building operators are not building energy system experts, keeping the building systems simple is essential to reliable and durable building energy efficiency performance. In addition, these elements of a building are more difficult to upgrade once construction is completed. As the ultimate aim is to have all existing achieve 100% renewable energy or near zero emissions getting the envelope and ventilation systems right at the start are essential as these will be costly and disruptive to improve after the building is completed.

Co-Benefits of High Performing Building Envelopes and Ventilation Systems

High performing building envelopes result in more local jobs as insulation and windows are largely supplied from regional manufacturers. Installing these and weather proofing a building provide greater opportunities for local tradespeople than does the import of advanced energy system such as heat pumps or solar panels.

In addition, this pathway will result in increased occupant comfort and improved indoor air quality; buildings will be less drafty, there will be no chill from poorly performing windows, and a well-sealed and insulated building with triple-paned windows will be much quieter and easier to maintain.

3.1.2 Path Two: Neighbourhood Renewable Energy Systems

Neighbourhood energy systems are shared infrastructure platforms which provide heating and/or cooling for multiple buildings. In dense urban settings (as well as hospital or university campuses), these systems enable entire neighbourhoods to utilize nearly 100% renewable energy sooner than would otherwise be possible because of:

- economies of scale;
- incremental renewable energy technology costs can be amortized by a utility over 25+ years and repaid through operating cost savings due to free or low-cost energy sources such as sewer waste heat or clean wood waste;
- systems are continuously monitored to ensure performance objectives are met

Co-Benefits of Neighbourhood Renewable Energy Systems

- *Establishing and expanding neighbourhood renewable energy systems is essential to effectively reducing emissions from difficult-to-retrofit large occupied buildings; new buildings connecting to these systems help to expand RNES infrastructure and thereby increase the number of existing buildings that can be served with renewable energy*
- *New buildings that connect to a neighbourhood renewable energy system prior to the mandatory requirement for zero emissions new construction will be "zero emissions ready". They will not need to be retrofitted to achieve this objective at a future date because the neighbourhood system they are connected to can increase its mix of renewable energy over time;*
- *These systems foster overall energy resilience by utilizing a diversity of locally available free or waste energy sources such as sewer heat, commercial and industrial waste heat, or clean wood waste; creating a role for local energy or resources that would otherwise be wasted decreases Vancouver's overall dependence on imported sources of energy.*

One advantage of these systems is that they can provide renewable energy to all three building systems that require heat: space heating, ventilation air, and domestic hot water.

This pathway also results in reliable and durable GHG emission reductions by avoiding the need for complex mechanical systems in buildings. While this approach does depend on advanced renewable energy technologies, these systems are not operated or maintained by building owners but by an energy utility with professional and well trained staff. In this Plan, all buildings will be required to provide improved building envelopes and ventilation systems to improve

occupant comfort and health but because neighbourhood renewable energy systems significantly reduce GHG emissions, envelope and ventilation system efficiency improvements required for buildings connecting to these systems will be more modest than for other buildings.

Given the importance of these systems in reducing emissions not only from new buildings but also from existing buildings, the City must continue to work with the NRES utilities to ensure these systems are successfully implemented and expanded.

3.2 Stepping Down GHG Emissions to Zero - Metrics

This Plan depends upon three metrics for it to be successful. They are described here in descending order of priority for Vancouver.

3.2.1 Greenhouse Gas Intensity (GHGI - kg CO2e/m2 annually)

Incrementally lowering GHGI limits in policy and regulation is the cornerstone of this Plan. GHGI is determined by the total amount of energy supplied to the building by type (electricity, natural gas, hot water or steam) multiplied by the energy's carbon intensity (a measure of how much greenhouse gas emissions are associated with its use). This overall operational GHG emission total is then divided by the building area to calculate GHGI.

Carbon Accounting
Vancouver follows global best practice for city-level carbon accounting which requires it to use provincially established carbon intensities for energy sources such as electricity, natural gas, and transportation fuels.

Provincial changes to the accounting protocols for the carbon intensity of electricity are anticipated in the next year or two. If this occurs, the targets (as well as historic results) for new building GHGI established in this Plan will be revised to reflect this change.

3.2.2 Thermal Energy Demand Intensity (TEDI kWh/m2 annually)

Thermal energy *demand* intensity is the amount of heat that is required to keep a building comfortably warm regardless of how efficiently or inefficiently that heat is produced. This metric reflects building envelope performance. In order to ensure continually improving envelope efficiencies, specific time-stepped limits for TEDI are required.

3.2.3 Energy Use Intensity (EUI)

Energy *use* intensity is the total amount of externally provided energy to a building including not only for heating, ventilation, and hot water (that are the primary sources of GHG emissions in buildings) but also for air conditioning, fans, pumps, lighting and expected energy use from

appliances such as dishwashers and computers (referred to as plug loads). Time-stepped limits for EUI will ensure that even when energy provided to a building is renewable that it is being used efficiently and is not being wasted unnecessarily.

In jurisdictions where electricity is largely non-renewable, reducing overall energy use will effectively drive GHG reductions and is often the focus (directly or indirectly) of energy regulations and policy. As a result, there is significant global effort (public and private) to improve electrical efficiencies and reduce electricity use. Because overall energy use is not central to achieving GHG reductions in Vancouver (where we have more than 93% renewable electricity) and because the global electrical efficiency of lighting, devices and appliances is rapidly improving, it is not essential for Vancouver to drive innovation in this area.

For these same reasons, it is also not productive to establish *future,* time stepped EUI targets in this Plan. In order to ensure that energy is not being wasted, even if it is supplied from a renewable source, EUI limits reflecting established and proven good efficiency practices will be incorporated into rezoning and building bylaw updates at the time these are being developed.

3.3 Stepping Down GHG Emissions to Zero - Embodied Carbon

The City of Vancouver's green building and community-wide greenhouse gas emission reduction targets do not account for embodied (also referred to as upstream) emissions that occur as a result of energy used and GHGs emitted from building material resource extraction, production and transportation. In addition, under current policy and code requirements, the GHG emissions associated with the energy used in the operation of a building are significantly greater than the emissions embedded in the materials required for its construction. As result, this Plan is focused primarily upon reducing operational GHG emissions from new buildings.

That said, as this Plan is successfully implemented and operational emissions from buildings decline rapidly, the relative importance of addressing GHG emissions embodied in building materials will quickly become a significant consideration in efforts to reduce overall GHG emissions associated with buildings. Some building materials, such as wood, which is an abundant local and potentially renewable resource, can actually sequester carbon to reduce GHG emissions.

While historically it was difficult to quantify embodied emissions of building materials, new research and software tools have been developed specifically for the Canadian construction sector. These tools can be used quantify the embodied emissions from buildings on a detailed project basis for all building components and materials. In anticipation of the near term importance of measuring and reducing the embodied emissions of building materials, it is essential that the City

begin collecting data from new developments on their estimated embodied carbon in order to inform future incentive, policy, and potentially regulatory mechanisms targeted at reducing the embodied emissions of new buildings as these become an increasingly significant portion of overall building lifecycle emissions.

3.4 Stepping Down GHG Emissions to Zero - Policy and Regulatory Tools

In this Plan, GHGI and TEDI targets are established for each major building type and step down starting in 2016 in roughly 5 year intervals until all buildings achieve zero emissions by 2030, and for many building types, by 2025. The Building Bylaw and the Rezoning Policy for Green Buildings will be updated to reflect these targets as firm limits for the prescribed milestone years. Time stepped EUI targets have not been established in this Plan but will be established to reflect established good electrical efficiency practices for each update to the Policy and Bylaw.

The City currently uses voluntary commitments from developers applying for rezoning to gradually drive improved green building outcomes. In general, GHGI and TEDI limits that will be required in the Rezoning Policy will be reflected in the Building Bylaw five years later. By aligning the limits for rezoning with the limits that will be required of all new construction within 5 years, the Rezoning Policy can help the industry evolve from one bylaw step to the next, and will provide demonstration projects for the building technologies and techniques that will soon be required by the Bylaw. This approach is often called a 'stretch code' or 'reach code'. It has been used effectively by the City of Toronto Green Standard and the Ontario Building Code since 2006 to provide clarity and predictability to industry on upcoming energy code changes.

> ***Prioritize Outcomes and Focus Policy Requirements***
> *In order to enable industry to transform rapidly and successfully towards meeting these aggressive time-stepped GHGI and TEDI targets, it will be important to ensure that the Green Building Policy for Rezonings is structured to enable a focus on these high priority outcomes.*
>
> *The effectiveness of the green building requirements in the current Rezoning Policy will be evaluated and outcomes will be prioritized. The 2016 update of the rezoning policy will include recommendations for achieving the highest priority green building outcomes.*

It also aligns with the approach currently recommended by the BC Provincial Energy Efficiency Working Group, and is a key recommendation of the Pembina Institute for governments seeking to rapidly improve building performance.

3.5 Stepping Down Emissions to Zero - GHG and Energy Targets

Extensive research, energy modelling, and stakeholder consultation was undertaken to understand current building design and construction practices and to inform stepped reduction GHG and thermal energy demand targets for each major building type that were deemed ambitious yet achievable. Detailed construction and operating cost analysis of building changes required to meet the 2016/2017 targets were undertaken to ensure that the new requirements do not increase the cost of housing in Vancouver.

It is anticipated that building practices and the availability of cost competitive building systems will evolve quickly in response to the initial targets. The viability and cost implications of subsequent targets (2020 and later) will be assessed in detail and will be used to inform recommended changes to the targets should it be determined that they are overly aggressive.

The GHG emissions reduction benefit for new buildings connecting to a Neighbourhood Renewable Energy System (NRES) will be recognized if the NRES is City owned, or once the renewable energy supply is secured (e.g. by legally binding agreement or equivalent regulatory approach) even if the implementation of the renewable energy plant is not yet completed. In addition, while the GHG target for all buildings of a specific type are consistent, the thermal energy demand targets for RNES connected buildings will not be as stringent since these buildings will be paying for renewable energy infrastructure through utility rates and achieving reliable GHG reductions through their use of low-carbon energy.

In order to achieve zero emissions in new buildings by 2025 (or in some cases 2030), any portion of non-renewable energy in grid provided electricity will be required to be offset by the installation of an on-site renewable energy system such as photovoltaic solar panels. In the case of high-rise buildings with relatively small roof areas compared to the overall building size, the small portion of non-renewable energy in electricity will be allowed to be offset via a community-scale renewable power system. As grid power is required by legislation to be 93% renewable and is currently 97% renewable, the size of on-site renewable systems to make up the remaining 0-7% required to achieve 100% renewable power will be small in size and will be very modest in cost.

3.5.1 GHG and Energy Targets - Building Energy Performance Modelling

To support the establishment of GHGI and TEDI targets and to facilitate compliance as these targets are introduced to building policy and regulations, energy modeling guidelines have been developed. The intent of the guidelines is to clarify and standardize energy modeling assumptions to align with the parameters used in developing the established performance targets.

The energy modeling guidelines establish a consistent methodology around parameters such as operating schedules, non-regulated loads, air leakage, and others so that proposed building designs are measured in a consistent manner against the policy and code requirements. One key element is that the guidelines establish requirements for how to properly represent envelope heat loss by incorporating thermal bridging that has historically been ignored in code compliance modeling.

It is important to note that actual building energy use and emissions may vary from the modeled results; *energy models results based on standardized assumptions regarding building use are comparative not predictive*. A useful analogy is the fuel efficiency ratings of cars and standardized test conditions (speed, vehicle loading, road conditions etc) used to determine a vehicle's rating. The actual fuel efficiency of the vehicle can differ significantly from the test results given actual driving habits, road conditions, and vehicle usage (towing, number of passengers etc).

It is also important to note that different building energy modelling tools can generate fairly different results. The modelling tools used for detached homes, high rise MURBs and Offices, and for Passive House design are all different and therefore comparison of modeled outcomes between different building types can be misleading. What is important is that modelling tools enable relative comparisons for buildings of the same type to enable target setting and compliance.

As the GHGI and TEDI limits, targets and outcomes get closer to zero emissions, current modelling tools *may* no longer be effective. Research into the appropriateness of different modelling tools will be ongoing through the implementation of this Plan.

3.5.2 GHG and Energy Targets - Detached Housing

Detached houses (including secondary suites, laneway houses, and duplexes) represent the largest amount of new construction in Vancouver accounting for an average of 44% of new development by area. Over 90% of new houses are heated with natural gas and as a result have a significant opportunity to reduce greenhouse gasses by improving the building envelopes. These buildings are exposed to the weather on all sides and tend to have complex shapes, increasing the surface area to volume ratio which increases energy use. Since there are no rezoning for new one and two family homes, the City has historically lacked tools to encourage innovation and "better than code" energy performance.

Despite these challenges, Vancouver significantly reduced emissions and energy use in new homes with the 2014 Building Bylaw by prescriptively requiring better insulation, higher performing windows, increased air tightness requirements, the use of heat recovery ventilators, and requirements for more efficient equipment such as furnaces. As

industry adapts to these significant changes, only minor improvements will be introduced between now and 2020.

One minor improvement will be setting a maximum allowed total GHG emission impact for new detached homes. The maximum allowed limit will be based on the average carbon footprint of a new home in Vancouver. Effectively, this will require larger than average homes to pursue greater energy efficiency or the use of additional renewable energy technologies sooner than the rest of the market. All grid connected space heating, domestic hot water heating, fireplaces (indoor and outdoor) and outdoor heating would be considered in setting the average. These larger than average projects will help drive innovation and the adoption of leading practices making improvements in more modest sized houses easier in the future.

While an envelope focus as the pathway towards zero emissions has been initially successful with the most recent changes to the Vancouver Building Bylaw, it is not envisioned that the Building Bylaw will mandate Passive House levels of performance for all new detached houses when zero emissions will be required in 2025. This is because achieving a Passive House level of envelope performance may be very challenging while still maintaining the complex building shapes required to maintain a early 20th Century housing character. A slightly higher TEDI combined with renewable energy based heating equipment, such as air-to-water heat pumps, will allow zero emissions to be achieved while still allowing for significant architectural variety.

Successfully transitioning detached homes to zero emissions will require the development of new incentive tools. This is because, unlike other building forms which have "better than code" requirements for rezoning, the City currently lacks tools to encourage innovations in energy efficiency performance for detached houses. In addition, the Vancouver homebuilding industry in comprised of a large number of small companies, many of them run by immigrants whose first language is not English, being responsible for no more than a few dozen homes out of the 1000 that are built each year. As a result, an ongoing investment in training, peer-to-peer exchanges, and capacity building is essential.

2007 Baseline		Current Bylaw		2020 Bylaw		2025 Bylaw	
GHGI	TEDI	GHGI	TEDI	GHGI	TEDI	GHGI	TEDI
23	113	12	84	7	55	0	30

GHG emissions for new detached houses, representing over 40% of all new development in the City, were significantly reduced as a result of improved envelope and efficiency requirements in the 2014 Building Bylaw; these emissions are almost 50% lower than the 2007 baseline. This Plan does not include any significant new regulatory requirements before 2020 but focuses on the provision of incentives for innovation and an investment in knowledge sharing and training.

3.5.3 GHG and Energy Targets - Low-Rise MURB Targets

Low rise MURB's (including rowhouses and 4-6 story multi-unit residential buildings) in Vancouver are predominantly wood framed, most have punched windows, they include relatively modest amounts of window area, and typically only have one or two sides exposed to the outdoor air. These factors, combined with the early adoption of the Passive House Standard by some rental apartment building developers, create an ideal opportunity to transition rapidly to high performing building envelopes and Passive House levels of performance.

The primary challenge in this transition is that these buildings have not historically been required to achieve high levels of energy efficiency, so success will depend upon immediate incentives for innovation, resources and tools to build the design knowledge and construction skills required. Because of the similarities in construction between 1&2 family homes and low-rise MURBs, aligning the requirements will help facilitate improved availability of high performing building elements such as windows, reduce confusion, and improve enforcement success. In addition, some design relaxations may be required to accommodate extra insulation and enable simplified building shapes.

Requirement Type	Current Bylaw		Current Rezoning		2016 Bylaw Updates		2016 Rezoning Update		2020 Rezoning Update		2025 Bylaw Requirement	
	GHGI	TEDI	GHGI	TEDI	GHGI	TEDI	GHGI	TEDI	GHGI	TEDI	GHGI	TEDI
Bylaw or Rezoning	12.5	50	10.5	42	5.5	35	5	25	4.5	15*	0	15*
NRES Connected							5	35	4.5	35	0	TBD

* Passive House or equivalent performance

Low-rise multi-unit residential buildings are the ideal building form and construction type for cost effective high performing building envelopes and ventilation systems. This Plan proposes immediate updates to the Building Bylaw targeting a reduction of nearly 50% in GHG emissions for new low-rise residential development and establishes the target for all low-rise MURB developments that are rezoned as of 2020 to achieve Passive House performance.

3.5.4 GHG and Energy Targets - High-Rise MURB Targets

High-rise MURBs represent the most significant challenge for achieving zero emissions given the changes from current design and construction practice required and the fact that it is the second most prevalent form of new development in the City representing 29% of new development floor area. These buildings typically include large amounts of glass and exposed concrete (slab ends and balconies), both of which result in significant heat losses and are leading to a growing reliance on air conditioning. In addition, they have historically used a ventilation approach that results in most of the conditioned air being lost to the outside (such as up the elevator shaft) before it reaches the units, which is very inefficient and can lead to poor indoor air quality. An unintended consequence of the City's 2011 and 2014 Rezoning Policy for Green Buildings is that it forced builders away from inexpensive to install, low carbon electric baseboard heat and led them to more expensive hydronic heating systems that use natural gas.

Despite these challenges, rapid improvements can be made immediately through the restructuring of the rezoning policy to reduce exposed concrete, improve window performance, shift towards direct ventilation and heat recovery ventilators, and allowing the use of electric heat once again. These requirements can each be stepped up while technologies for renewable creation of hot water at the scale required in MURBs are encouraged and then become normal practice.

Where low-carbon energy is available by connecting to a Neighbourhood Renewable Energy System, GHG reductions will be reliably and durably reduced. When starting from a context of low GHG emissions (RNES connection), requiring significant additional investment in the building envelope provides highly diminished return (in the form of additional GHG reductions) for the capital costs involved. As a result, the TEDI limits for these buildings, while require some improvements in the envelope and ventilation systems, will be less aggressive than the TEDI limits for buildings that are not connected.

Requirement Type	Typical Outcome of Current Requirements		2016 Limits		2020 Limits		2025 Limits	
	GHGI	TEDI	GHGI	TEDI	GHGI	TEDI	GHGI	TEDI
Bylaw	20.0	55	20.0 *	55*	6.0	32	5	TBD
Rezoning	16.5*	46*	6.0	32	5.0	18	0	TBD
RNES Connected	5.5	46	6.0	40	5.0	40	0	TBD

* Typical outcomes of the Rezoning Policy for Green Buildings which has been in place since 2011 will be reflected in the building bylaw in 2017.

This Plan targets an immediate reduction in GHG emissions of 64% for rezoned high-rise MURBs that are not connected to a RNES. This can be achieved by restructuring and updating of the rezoning policy in the fall of 2016 without increasing the cost of new development. The added expense of improved building envelopes and ventilation systems will be offset by the reduced construction costs cost of not forcing developers to install hydronic heating.

3.5.5 GHG and Energy Targets - Office

Office buildings tend to use more electricity and require less heating than residential buildings resulting in much lower GHGI impacts than high-rise MURBs under current policy requirements. This is due to very low use of hot water, ventilation systems with much lower distribution losses, and higher density of occupants and equipment which both emit heat and thereby lower heating system energy demands.

Despite their already relatively low GHGI, there are immediate opportunities for further improvement. This is due to the fact that office buildings typically have a different ownership structure than residential buildings and incremental constructions costs associated with higher energy efficiency requirements can be recovered through operating costs savings. In addition, office building tenants typical place a higher value on green building performance than residential building purchasers or tenants, possibly as a result of corporate social responsibility and/or recognition that green buildings typically foster more productive working environments. As a result, office developers have been demonstrating innovation in building envelope, heating, and ventilation system design that establish proven if not-yet-common approaches for energy and GHG emissions reductions.

Requirement Type	Typical Outcome of Current Requirements		2016 Limits		2020 Limits		2025 Limits	
	GHGI	TEDI	GHGI	TEDI	GHGI	TEDI	GHGI	TEDI
Bylaw	9.5	40	9.5	40	3.0	27	0	21
Rezoning	7.5	30	3.0	27	1.0	21	0	TBD
RNES Connected	3.0	30	3.0	27	1.0	27	0	TBD

This Plan recommends an immediate 65% reduction in GHG emissions for office buildings. Unlike residential develop, new office buildings already rely upon complex mechanical systems and typically have trained and dedicated operations staff. As a result, improvements in this form of development will result from both improved building envelopes as well as a shift to renewable energy heating systems (either connection to a NRES or the use of heat pump technologies).

3.5.6 GHG and Energy Targets - Other Building Types

All other building types (excluding residential and office) such as food service, hotels, retail, light industrial, hospitals, schools, etc. represent an estimated 13% - 16% of new development by area in an average year. Given the wide diversity of building types, the specific energy use characteristics each type, and the small amount of new development of each type specific GHG and TEDI targets have not yet been developed. As better data becomes available and further research can be completed, specific targets will be proposed. In the interim, rezoning policy and building code updates will rely upon a "% better than" approach as compared to established standards. The most obvious shortfall of this approach will remedied by shifting from the existing energy cost efficiency requirements to energy use efficiency requirements.

3.6 Stepping Down GHG Emissions to Zero – Compliance with Targets

Building codes evolved historically to ensure health and safety outcomes. As a result, most compliance and enforcement tools are oriented to ensuring these outcomes. There is a growing awareness across North America that carefully constructed energy policies and regulation have been undermined by the absence of clear compliance processes and enforcement mechanisms. In addition, there are a number of prescriptive requirements for new buildings that do not directly result in reduced energy use or emissions but are essential to help ensure that design outcomes are actually achieved.

A number of tools will be used at different points in the building lifecycle to encourage and confirm compliance with the policy, as well as to assess whether the policy is delivering the intended outcomes. Compliance and measurement of outcomes should be demonstrated at each phase of the building lifecycle, throughout design, construction, and post-occupancy.

3.6.1 Compliance with Targets - Process and Tools

In order to facilitate compliance with building energy and emission performance policy and regulation, requirements and a process for demonstrating compliance must be clearly established and communicated with industry. This will include need to include clearly defined roles for suppliers, design professionals, commissioning agents,

permit processing and inspections staff. Digital tools for submitting documentation and doing initial quality control checks, along with training sessions and videos regarding compliance expectations and process will greatly assist in streamlining this essential work for both applicants and staff.

Compliance of the proposed design with the targets described in the preceding sections will be demonstrated by applicants submitting project information in a standardized form that includes how the modeled intensities compare to the targets, as well as key design values that will allow staff to assess the application for possible anomalies or to seek more detail. Key values will include such metrics as overall ventilation rate, heat recovery effectiveness at rated and design conditions, assembly total effective R-value, window-to-wall ratio, and more. This format will serve as a quality control mechanism for applications for re-zoning, and should be updated at each phase of the permitting process.
In addition to requiring compliance of the design with the performance targets, applicants will be required to demonstrate compliance of the building construction through testing of the building air-barrier, commissioning of the building systems, and measurement and benchmarking of the building energy use once occupied.

3.6.2 Compliance with Targets - Air barrier testing

Air-tightness of the building is a critical factor in creating long-lasting, reliable energy performance. To ensure that buildings are designed and constructed to deliver this performance, a successful air-tightness test of the building will be required prior to occupancy permit being granted. There are different standards available in North America to draw from, including the Seattle standard, which has been in effect for over five years now, and the adoption of which would allow industry and officials to draw on local knowledge and expertise.

The Seattle standard requires whole-building air leakage testing to ASTM E779 with some modifications, and buildings must achieve a maximum air leakage of 2 L/s per m^2 of façade area, at a pressure of 75 Pascals. To help builders achieve this, there are also requirements for the individual components to meet maximum leakage rates, including windows, elevator doors, loading docks and others.

In the Seattle example, buildings that do not meet the standard are required to be re-inspected and re-sealed. In adopting this standard for Vancouver, additional compliance and enforcement measures could be considered, such as mandatory re-testing or re-training of the builder's quality control staff.

3.6.3 Compliance with Targets - Commissioning

Commissioning is a quality control process of verifying that a building's systems operate as intended, and is typically conducted by a third-party

Commissioning Agent. The commissioning agent works for the building owner or developer to verify that the building operates as designed, and validates that the design and operation meet the original requirements set out for the building at the beginning of the project. To do this, the commissioning agent periodically reviews the project during all phases of design, construction, and handover. They will focus particularly on active building systems such as the Heating, Ventilation, and Air-Conditioning (HVAC), plumbing, and lighting systems and their controls, to ensure that they operate as intended under a variety of conditions. This process will often include a follow-up review after the building is occupied in different seasons to ensure both heating and cooling system function correctly. Industry standards for commissioning include ASHRAE Guideline 0-2005 and Guideline 1.1-2007, and use of these guidelines are consistent with the requirements of LEED, as well as the City of Seattle Energy Code and California's Title 24 requirements.

Requiring commissioning be conducted by a Commissioning Agent according to these guidelines will support the policy goal of actually realizing modeled efficiency and reduced carbon performance in new buildings.

3.6.4 Compliance with Targets - Benchmarking

An important tool in measuring outcomes once buildings are built is the benchmarking of building energy use and emissions. Benchmarking involves the measurement and monitoring of key performance indicators of the building including energy use (of each major building system) and emissions, and comparing these metrics against those of other buildings in a common database, such as the US EPA's Energy Star Portfolio Manager. While the City is working with the Province and other interested local governments to develop energy benchmarking reporting regulation for all large existing buildings, updates to the rezoning policy will require energy metering of each major building system for new buildings, a benchmarking service contract is in place to ensure this data is compiled post-occupancy, and that a covenant on the property requires the owner to release non-personal data to the City.

> ***Essential Feedback Mechanism***
> *Modeled energy data is an imperfect tool to achieve real and durable GHG reductions. By metering and reporting the actual performance of new buildings, the outcomes of GHG and energy policies can be directly measured, and adjustments can be made to increase effectiveness and efficiency of the requirements. Equally important is that this data will help inform industry as to what building designs, systems, and construction approaches are most effective in achieving real GHG and energy savings.*

3.7 Carbon Neutral New Buildings

The Greenest City Action Plan includes a target to have all new buildings carbon neutral by 2020. Carbon neutrality is achieved through a combination of energy use reduction, transition to renewable energy sources, and/or by offsetting a building's operational GHG emissions with reductions in emissions elsewhere (typically through the purchase of a carbon offset).

This Plan establishes GHG limits by building type to be reflected in the building bylaw that step down to zero for most new building by 2025 and for all buildings by 2030. The Building Bylaw does not provide the flexibility to have a firm, non-zero carbon limit in 2020 (ie the GHGI limits in this Plan) and to also have a limit of zero that can be achieved through the purchase of an offset.

Staff will explore the potential of having GHGI limits in the rezoning policy, where the City has greater flexibility for establishing expectations for new buildings) along with the requirement for carbon neutrality where the latter might be achieved through the purchase of a carbon reduction credit. Carbon reduction credits could be achieved through City (or City recognized) programs that incrementally reduce GHG emissions in Vancouver. This rezoning requirement and the creation of a Carbon Reduction Credit Program could potentially generate an estimated $700,000/year for City (or City recognized) programs, such as home energy retrofit incentives, to generate the required carbon reductions to achieve carbon neutrality. Such a system could be in place between 2020 (carbon neutral requirement) and 2025 when near zero emissions will required in the building bylaw.

Stepping Down GHG Emissions to Zero - ACTIONS

Establishing and effectively transitioning the building bylaw and other City policies to require new buildings meet specific GHG and energy use targets is the cornerstone of this Zero Emissions Building Plan. This will require the following actions:

- Update the Building Bylaw in the fall of 2016 to reflect the targets described in Section 3.5.3 above for 4-6 story MURBs
- Restructure the Rezoning Policy for Green Buildings in the fall of 2016 to focus on key outcomes and reflect the targets for low-rise MURBs, high-rise MURBs, and office buildings as detailed in 3.5.3, 3.5.4, and 3.5.5 above
- Incorporate requirements for calculating and reporting embodied emissions in the restructured Rezoning Policy for Green Buildings
- Beginning in the fall of 2016, periodically review and revise as required NEU connection requirement zones to only mandate connection in areas where low-carbon outcomes capable of achieving these targets have been secured

- Undertake additional research and consultation and report back with recommendations on changes and approaches for embedding future stepped reductions prior to 2020 and 2025 respectively.
- Ensure that new policy and code requirements are supported with investment in the development of compliance processes, tools, and training for both staff and applicants prior to the requirements taking effect
- Incorporate air barrier testing, building energy system commissioning, and benchmarking in the Rezoning Policy for Green Buildings in the fall of 2016 and seek future opportunities to incorporate these into the building bylaw
- Research and consult with stakeholders on the viability of establishing a carbon reduction credit program for achieving carbon neutral buildings through the Rezoning Policy for Green Buildings and report back to Council with recommendations prior to 2020.

4 City Leadership

Achieving zero emissions for almost all new buildings permitted in Vancouver by 2025 will require early leaders to start demonstrating what is possible immediately. Large complex buildings often take 6 years or more from the initiation of permitting to the availability of occupied and operational building performance data to inform the real world effectiveness of the approaches taken. Building suppliers need local demand and lead time to enable their investment in the development, manufacture, and approvals for new products to meet industry needs in Vancouver. Finally, leading designers and builders must gain practical experience with zero emission buildings under a wide variety of conditions and building uses in order to learn what works (and what doesn't) and refine their approaches.

Similar to requiring LEED Gold for new civic facilities when the City first began to support a shift in the broader market towards green buildings, if the City wants to achieve zero emissions for most buildings by 2025, it is essential that it lead by example now.

City commitment to demonstrate that zero emission buildings are possible will:

- Inform what approaches work best under what conditions
- Identify regulatory, permitting, and financing barriers so that these can be removed
- Build real development experience that can be shown to and shared with private industry
- Help catalyze the development of the professional services, builder skills, and the supply of building components required to achieve zero emissions

- Enable the public to experience the benefits of these buildings beyond their operational cost savings

The City is involved in a wide variety of building projects. Some of these projects are already underway while for others, the design team and program have not yet been established. Some new projects are for City owned and operated facilities like branch libraries and swimming pools while a more significant amount of development involves City owned land or City Owned buildings being led by a development partner as an in-kind amenity for the neighbourhood. In these latter cases, negotiation with the development and operating partners will be required to demonstrate the value and secure their commitments to showcasing a zero emissions building approach.

In addition, some City facilities have the opportunity to connect to neighbourhood renewable energy systems and thereby greatly reduce their GHG emissions via this pathway while others must focus on high performing building envelopes.
This diversity of both building types and the nature of City involvement creates many opportunities to showcase leadership in zero emission buildings but it also creates complexity. In order to enable a focus on transformational change on building GHG emissions, City projects that pursue Passive House or a Zero Emissions approach will not also be mandated to achieve LEED gold certification.

4.1 City Leadership - City Owned and Operated Civic Facilities

City owned, developed, and operated new buildings provide the greatest flexibility for demonstrating zero emissions leadership as there are no partners involved with their own interests and limitations to accommodate. Incremental construction costs can be recouped through operational savings. Passive House Certification will be required for all city owned buildings, as well as the requirement to use only low carbon fuel sources unless both or either is deemed unviable. In the case of specialized facilities where the energy demand is less dominated by building envelope losses (such as outdoor pool), while Passive House Certification will be assessed for its suitability as zero emissions approach, other opportunities may be explored in lieu of Passive House Certification to demonstrate leadership with a method that does not include such a strong focus on the building envelopment improvements.

Fire hall 17, one of the next City owned and operated facilities to be built which is very similar to residential development for much of its programming, is being planned to achieve Passive House Certification, , and use only low carbon fuel sources to the greatest extent possible, in order to show early leadership in achieving near zero emissions.

4.2 City Leadership – In Kind Development Contributions

Developers often volunteer to develop a public amenity on behalf of the City such as rental housing or a day care when seeking to rezone a development; the City will work with these partners to assess the viability of these “in-kind” developments to demonstrate Passive House or another near zero emissions approach. This form of “in-kind”

development represents a significant amount of new building area each year but complexity can arise when these developments are not stand-alone buildings but are incorporated into a portion of a larger building. While these building portions may need to share mechanical systems with the larger building and it may not be possible to certify just the City's portion to the Passive House Standard, the City will seek to require these elements to demonstrate zero emissions leadership to the extent possible given these limitations.

4.3 City Leadership - Affordable Housing Leadership

The Vancouver Affordable Housing Agency (VAHA) has a mandate to identify where the greatest impact can be made, and act as a catalyst for innovative housing ideas and models. VAHA sees zero emissions buildings and the Passive House standard in particular as an important opportunity for housing innovation.

VAHA has already incorporated the requirement to assess projects against Passive House standards as part of its RFP process and is assessing proponent team capacity and experience to successfully deliver Passive House projects as part of its proposal review. As a result of this "action while planning" VAHA is already aiming to deliver 3510 Fraser Street, one of its very first projects, as Passive House Certified.

In addition, the City has been working closely with BC Housing in the development of this Plan. BC Housing has been a leader in sustainable affordable housing for over a decade and has over 50 buildings registered with the Canada Green Building Council, 34 of which have achieved certification, almost all to LEED Gold. Given all of the

Passive House for Affordable Housing in the U.S.
As of this year, housing agencies in eleven US states have prioritized Passive House in their applications for affordable housing funding, with twenty four additional states actively working to develop similar programs.
The catalyst for this in 2014 when the Pennsylvania Housing Finance Agency (PHFA) and a group of 25 stakeholders including builders, architects and cities initiated a project with the target of all affordable housing in Pennsylvania be designed and constructed to a Net-Zero-Energy-Capable standard by 2030.

The standard proposed to achieve this was Passive House. By incorporating Passive House into its scoring criteria for the award of limited federal funding (via a 9% tax credit) available for affordable housing, nearly 40% of the 2015 affordable housing proponents in Pennsylvania applied as Passive House Projects. The construction cost premium calculated between Passive House projects and non-Passive House was less than 2%. 8 out of the 39 projects that were awarded 2015 funding were Passive House totaling 422 new affordable housing units.

The first state after Pennsylvania to announce a prioritization of Passive House was New York. This caught the attention of the White House, which has incorporated Passive House into their comprehensive plan to bring renewable energy and energy efficiency to households across the U.S.

sustainable new construction projects they completed, BC Housing has found that those with simple designs that rely primarily on passive elements rather than complex mechanical systems use less energy and are easier and more affordable to maintain. This discovery has led to BC Housing exploring other green building certification options including Passive House. They have targeted Passive House certification as a requirement in RFPs for several of recent new construction projects, and have shortlisted two projects in the City of Vancouver on which to pursue Passive House certification.

BC Housing believes that Passive House has the potential to help create affordable housing that is more energy efficient, and more affordable and easier to operate. Furthermore they have committed to compiling and sharing their experience on all Passive House (and other near zero emission) projects to facilitate capacity building in the BC development industry.

4.4 City Leadership - Procurement Process

Additional City leadership to demonstrate a more cost effective process to achieve high quality, highly energy efficient buildings that the City should explore and pilot is in new building design procurement. Constructing an innovative public building begins with the procurement process. As evidenced in places as diverse as The Netherlands and Edmonton, AB, changing the process by which governments procure their green buildings can have a significant impact on the architectural, lifecycle cost and energy performance outcomes of the buildings constructed. Through comparing the procurement changes that were implemented in jurisdictions seen as leaders in procuring exemplary and innovative buildings, a number of commonalities are present:

- Creating a multi-staged RFP process that creates a design competition focusing on a streamlined set of selection criteria that value architectural excellence, awards, and design;
- Transparently stating the project budget in the RFP and requesting that teams prepare their submissions to best demonstrate near zero emissions allows for greater creativity and typically requires an integrated team approach thereby helping to reduce risks;
- Creating the space for dialog with invited, shortlisted firms following the RFP in order to understand the proposed designs, and potential technical or economic risks; and
- In Europe, using Building Information Models (BIMs) as a requirement for project management and a part of the proposal submission package.

The BC Construction Association launched a “Construction Innovation Project” in 2016, with the goal of facilitating change in industry and government to meet the building and infrastructure needs of the 21st

Century. One component of this is a recommendation for government and industry to launch an Innovative Procurement Initiative, recognizing that the current status quo is stifling, rather than catalyzing innovation.

> *As it stands, the procurement process needs to be fixed. There has to be a shift from a culture of "lowest bid" to focus increasingly on quality and "whole-life" value.* – BC Construction Association, December 2015 [1]

City Leadership ACTIONS

In response to these opportunities and challenges, this Plan commits the City to:

- Build all new City owned facilities, and VAHA developments to be Passive House Certified and use only low carbon fuel sources, or other near zero emissions approach where technically, financially, and operationally feasible
- Require partners undertaking in-kind developments on behalf of the City to pursue Passive House Certification and use only low carbon fuel sources, or other near zero emission outcomes for the entire or City-portion of new developments where viable
- Direct City staff to investigate and pilot new procurement process(es) for City-led Passive House or alternate near zero emissions new development and assess/showcase the value of such a process as a tool for industry change
- Leverage the experience gained from the above actions to inform a more specific policy to define and govern outcomes for "City-led" projects by 2018.

5 Catalyzing Leadership

Rapid and effective transformation of the entire local development and building industry will require more than defined GHGI and TEDI reduction targets and government leadership. New design approaches must be learned, tried and refined. While technologies exist to achieve zero emissions buildings, many of the required elements such as super-efficient windows, prefabricated insulated wall panels, heat recovery ventilators, and air source heat pumps for domestic hot water are not readily available in our local market due to (current)

Supporting early innovators will signal market demand for super-efficient building components, support building design evolution, catalyze new training and education initiatives, and build broader industry confidence that zero emissions buildings are achievable.

Ultimately, early showcase projects by public and private sector leaders will reduce the incremental costs of zero emission buildings and inform effective, streamlined, and flexible future regulations to ensure all buildings ultimately achieve these outcomes.

[1] https://www.bccassn.com/media/bcca-report-construction-innovation-2016.pdf

low demand. Finally, it takes time for local industries to research, develop, and get approvals for new building products. In order to be competitive and to flourish; they need local demand for zero emissions buildings now in order to commit to these investments.

In order to achieve zero emissions for most building types by 2025, it is essential that the City develop tools to encourage innovation and offset incremental costs so as to catalyze voluntary leadership by private developers in demonstrating effective approaches for achieving zero emission new buildings as soon as possible.

5.1 Principles for Effective Catalysts

Preliminary staff analysis of effective (and less effective) approaches to catalyzing early leadership indicates that a range of tools tailored to the opportunities and challenges of specific building types will be required. The following principles will guide the development of these catalyst tools:

- Appeal and Clarity – catalyst tools must be tailored to local market conditions and priorities so as to provide clear and measurable appeal to builders and developers

- Timeliness –certainty on whether or not a proponent will qualify for and be able to access the catalyst must be provided in a timely manner in order to influence key project decisions

- Scale – in order to be effective, catalysts must help drive sufficient scale of demand for zero emissions buildings and their components to attract investment and competition to effectively reduce the incremental costs

- Diversity –experience and confidence in effective zero emission buildings must be fostered amongst multiple designers, developers, and builders before zero emissions can be expected for broad segments of the market

- Consistency –criteria and expectations regarding zero emissions buildings must remain fairly consistent from year to year to enable industry to focus on the desired outcomes and optimize their solutions by learning from prior projects

Underlying these principles is the understanding that market transformation does not begin to accelerate until leadership and innovation are supported; it is of paramount importance that effective tools to catalyze zero emission building leadership are made available as soon as possible, even if the catalyst program is not of sufficient initial scale or includes some imperfections. Early and visible success

will attract not only participants but partner commitments and program details can be refined over time.

Note that while a catalyst program will be initially developed for zero emission new construction, consideration will be paid to the potential for expanding the partnerships and structures created to also deliver catalyst tools for deep building energy/emission reduction retrofits in the future.

5.2 Catalyst Approaches

Before describing possible catalyst tools (in Section 5.3) that will be considered for to reward private leadership, three general approaches have been identified and should be explored as standalone or a combination of options for each targeted building type.

A. Fixed Criteria: offering a benefit or reward for developers that commit to building to a specified set of criteria (such as Passive House). This approach is very useful when there is a high degree of certainty in viable and optimal outcomes as these can be clearly defined and there are no delays created in determining if a proponent qualifies.

B. Component Offers: offering a benefit or reward for building that utilize a defined building element such as a heat pump for domestic hot water or super-efficient windows. This approach has the benefit of generating high volumes of market demand and industry experience with a given technology to rapidly increase competition in its supply. Driving demand for key zero emission building elements can bring down the cost of a more complete building approach such as Passive House without limiting uptake to those proponents willing to make that full commitment. In addition, component offers can be structured to simultaneously support building energy or emissions retrofits when the same technology could easily be used in existing buildings.

C. Project Competition: offering a prize or benefit for winners of a call for projects competition assessed and judged against defined criteria. This approach can be very powerful when desired and potentially competing outcomes can be generally defined but when win-win solutions or the optimal balance between these outcomes requires testing and experimentation. This approach enables leading designers and builders to demonstrate what is possible (and what is not) to their industry peers and can be used to develop

ground-tested, well informed policies with already built showcase projects.

As an additional benefit to this approach, competitions are inherently interesting to the public and would create an opportunity to engage and educate Vancouverites on the appeal and benefits of zero emission buildings. One notable disadvantage of this approach is that it can increase project timelines as proponents go through the call for competition submission, evaluation, and award process.

Brussel's BATEX Program

The Brussel's Region successfully partnered with their building industry to transition new buildings from amongst the least efficient in Europe to having all new residential and office buildings meet Passive House performance in just over seven years. This was achieved through the BATEX or Exemplary Buildings program.

BATEX offered a prize of up to 100 euros per square meter through 6 calls for projects judged to be of exemplary design and fit with their neighbourhood that achieved the highest levels of energy efficiency while remaining cost effective. The program aimed to stimulate innovation and demand for high performing buildings by encouraging private sector leaders to demonstrate what was possible and the best approaches for achieving these aims.

The BATEX program catalyzed private sector leaders to innovate and demonstrate to their peers as well as to the government how best to achieve multiple but clearly defined objectives. 243 projects representing over 6 million square feet of new development participated in the program over a period of seven years. BATEX built sufficient local industry confidence and capacity to deliver beautiful and high performing buildings to enable the introduction of effective legislation requiring all new buildings to achieve passive house performance levels beginning in 2015.

http://document.ibgebim.be/opac_css/elecfile/BRO_BE_Batex_EN_BR.pdf

5.3 Catalyst Tools

A wide range of tools are potentially available to the City to catalyze private leadership in demonstrating cost effective and attractive approaches to zero emission building. These should be explored in the context of the challenges and opportunities presented by specific building types and in consideration of the principles established in Section 5.1:

A. City Charges and Taxes: reducing or waiving City charges such as permit fees, development cost levies, or even property taxes would decrease the overall project costs and could be an effective tool to catalyze zero emission buildings. In considering these tools, administrative costs and the value of lost revenues will need to be addressed.

B. Expedited Permitting: developers and builders have indicated that decreased permitting times would reduce their costs and risks in a project and could be an effective catalyst tool. That said, this approach might be very complex and time consuming to establish as there are many steps to a permit approval and expediting each of these may be impractical; alternatively creating a whole new process could also be challenging especially for a time limited incentive program. In addition, large complex projects such as those going through a rezoning process involve complex back-and-forth negotiations which it may be difficult to expedite with certainty.

C. Public Benefit Negotiations: If the incremental costs for early adopters of Passive House or other zero emissions building approaches could be defined and taken into account when negotiating public benefit expectations for large new developments, the overall project costs and therefore the need for other catalyst tools would be reduced.

D. Parking Requirements: Below grade parking can be expensive to build and for small or unusually shaped sites, meeting the City's parking requirements can sometimes make development unviable. There may be opportunities to allow greater use of existing parking incentives such as those provided for additional bicycle parking or the provision of car sharing vehicles and parking for zero emission buildings.

E. Design Prize: A competition with a cash prize awarded for the winning submission for attractive, cost effective designs that effectively achieve near zero emissions for various building types could be a powerful catalyst tool. Design teams could be motivated by the offered prize and potential prestige to overcome design challenges. In addition designs could be made publicly available to showcase how to design zero emissions building and if the designs are flexible enough to be useful in a variety of contexts, they would

reduce the overall cost of building a near zero emission building by avoiding the need for custom design expenses.

F. Exemptions to form of development and land-subdivision requirements: exemptions or partial relaxations of City requirements for land-division or form of development might be an effective catalyst with negligible negative impacts if carefully limited in scale and duration. For example, one builder recently offered to commit to build two Passive House certified homes if permitted to subdivide a 50' lot into two 25' lots (smaller than City standard sizing). In addition, design guidelines protecting neighbourhood character are developed to apply to an entire zoning area, typically in older single family neighbourhoods. These guidelines can result in very complex building shapes which make it more challenging and costly to build highly efficient envelopes such as those required to meet Passive House. A limited number of exemptions to these guidelines for early Passive House showcase buildings might be on avenue gain neighbourhood feedback on new, energy efficient building forms while learning what creative designers and builders can do to address neighbourhood fit.

G. Buildable Area: Allowing even modest amounts of additional buildable area for near zero emission buildings would be a very effective catalyst for private leadership. That said, doing so in an outright fashion would require extensive public engagement, could take a significant time to implement, and could lead to land speculation – a high cost for a temporary incentive. Enabling modest floor space exclusions at the Director of Planning discretion for passive design buildings or features might offer an opportunity to find an effective balance and create a catalyst for zero emission buildings.

5.4 Catalyst Tools for Targeted Building Types

5.4.1 Catalyst Tools - Detached and Row House Developments

The relatively small size and simplicity of detached and row housing make the scale and administrative ease of a permit discount program for early leaders in demonstrating near zero emissions building approaches like Passive House for these buildings viable and could be launched in the near future. For detached housing, it would be beneficial to explore the ideal balance between GHG reduction levels via envelope and simple mechanical solutions, cost, and neighbourhood fit. This form of development would be a good candidate for a design competition with a cash prize. Criteria for judging winners would

include envelope performance, GHG reduction, replicability of solution (eg cost effectiveness), and neighbourhood fit.

Targeted technology incentives for domestic hot water heat pumps and highly efficient HRVs and windows may be complementary to the competition based approach. Given Vancouver's concurrent focus on supporting and piloting of incentives for detached home energy retrofits, targeted technology incentives might be supportive of both objectives and should be explored with other levels of government.

Additional opportunities to catalyze zero emission detached and row housing that need to be explored further include: limited and time bound relaxations to lot sub-division restrictions and neighbourhood design guidelines and/or expedited permitting (especially in outright zones).

Especially important in this sector are efforts to engage local builders from ethnic communities to inform the incentives offered for these building types to ensure universal appeal and access considerations are incorporated.

5.4.2 Catalyst Tools - Low-Rise MURBs

Low-rise (4-6 story) MURBs are an ideal building form for achieving Passive House. As this Plan recommends the 2020 update of the Green Building Policy for Rezoning's require these buildings meet the Passive House standard and given the body of global and rapidly developing local knowledge for how to cost effectively do so, catalyst tools for this form should be focused on meeting Passive House outcomes.

Passive House MURBs Underway
Presently there are 3 passive House Multi Family projects (comprising approximately 200 homes) under construction in Vancouver. In addition there are two multifamily projects in permitting comprising another 100 homes. Most projects are rental projects, with one market condo project and one market cohousing project.

In addition to the catalyst tools to be explored for detached housing, the synergies demonstrated between Passive House and low-rise rental MURBs – both in built form and in the business case of their development, mean that opportunities for alignment between tools to catalyze zero emission buildings and the Rental 100 program need to be explored.

5.4.3 Catalyst Tools - High-Rise MURBs and Offices

Given the predominance of concrete and glass in the construction of high-rise MURBs combined with the limited amount of global data on the incremental costs, code barriers and constructability, establishing firm TEDI outcomes for zero emission buildings beyond those established for 2016 and 2020 will require additional research and pilot projects

undertaken in partnership with private developers. A design competition to show case attractive, cost effective, near zero emission high rise building design approaches may be an important tool. In addition, understanding and proving out viable electric and heat pump solutions for domestic hot water in MURBs will be critical in order to achieve zero emissions for new MURBs by 2025.

Supporting early developer leadership will require tools to share in the risk and incremental costs of innovation. In addition to the tools to be described for detached housing, public benefit negotiations for high-rise towers may be a key tool in this sector.

Finally, while an envelope focused solution (beyond what is envisioned for the 2016 rezoning policy update) is less critical for the office sector to achieve zero emissions new buildings, it is also anticipated that the occupant comfort and productivity benefits combined with lower expected incremental costs of achieving Passive House envelope outcomes mean that a more modest incentive may be sufficient to catalyze leadership and innovation in this sector.

5.4.4 Catalyst Tools - Leadership on Special Sites

Some projects and sites in Vancouver present unique opportunities to demonstrate leadership in establishing neighbourhood renewable energy systems or building to Passive House performance outcomes. These are sites where, even though the City may not be leading the development, it is a key partner in the project moving forward or where environmental leadership (beyond general rezoning policy requirements) are already an expectation for the site. In these cases, the City should work collaboratively with the project developer to assess if there are mutually beneficial opportunities for developing the site to the Passive House levels or performance when an NRES is not viable.

Examples where there may be opportunities for the City to partner with a developer to demonstrate leadership might include:

- Vancouver Art Gallery
- Jericho Lands
- Some large development sites along the Cambie Corridor
- Etc

Even if the permitting and development of the site is still a number of years away, there are immediate benefits to committing to zero emissions leadership. Committing or establishing requirements to build to the Passive House standard for a large future development signals to industries such as window and prefabricated wall manufacturers that there will be a strong and ongoing local demand for high performance building products. Given that code and policy requirements will be evolving rapidly, early commitments such as these pose low risks given that by the time development occurs, bylaw or rezoning requirements may require near or zero emissions anyway.

5.4.5 Catalyst Tools – Financing Approaches

A key opportunity to catalyze developers of condominium projects to invest in meeting zero emission buildings before they are required to do so would be the creation of and/or increased use of innovative financing tools.

Smart investments in reduced energy use will pay for themselves over time. The challenge faced by condominium developers is that since they immediately sell the buildings they develop, they cannot recover their incremental capital costs spent on energy efficiency improvements through the resultant operating cost savings. Innovative tools exist where the incremental costs of efficiency are financed separately from the rest of the development costs. The loan for these costs is transferred to strata which repays this loan through a line item on the strata fees collected from owners.

Energy Efficiency Strata Loan for Condos with City Loan Loss Guarantee

An energy efficiency loan program for new condos was first established in North America by the Toronto Atmospheric Fund (TAF) to overcome the energy efficiency split incentive. Condo developers in Toronto were previously unwilling to construct buildings that exceeded minimum energy standards because of the increased sale price due to higher construction costs and the resulting loss of competitiveness with other new developments. These barriers were overcome by TAF loaning the developer an amount equal to the incremental costs to construct a building that exceeds the building code energy performance by a specified percentage. The loan is assigned to the condominium home owners association to repay. Through energy modelling, the energy upgrade measures beyond code requirements were designed so that the monthly energy cost savings would exceed monthly loan repayment. Through marketing and the disclosure documentation required by law, potential buyers were made aware of the energy performance and the anticipated cost savings associated with the measures, as well as the loan that would be required to repay through their monthly condo fees. This tool holds significant potential for the voluntary construction of near zero emission condos in Vancouver, as it:

- *Removes the split incentive for energy efficiency in new construction;*
- *Creates a clearer picture of energy costs for the buyer; and*
- *Makes condo buyers able to afford a higher performing building for the purchase price of a code minimum alternative.*

Catalyst Tool ACTIONS

Developing and testing new design approaches, fostering the skills required to building to achieve zero emissions, and creating demand for new high performing building products to establish local production capability all require time. In order to require most buildings to achieve zero emissions by 2025, it is essential to begin providing catalysts for private sector leaders to demonstrate

cost effective approaches to zero emissions building immediately. This will require catalyst tools for detached and row housing as well as multi-unit residential buildings, negotiations with developers of special sites with unique leadership opportunities, and the exploration of innovative financing tools as summarized by the following actions:

- Develop a program to provide catalyst tools such as design competitions, expedited permitting, permit fee reductions, or others for zero emissions detached and row house buildings targeting dozens of units per year for at least three years at which time the program should be reassessed
- Explore and recommend additional catalyst tools such as supplementary incentives for the Rental 100 Program for passive house low-rise multi-unit residential buildings targeting hundreds of units per year between now and 2020
- Explore and recommend catalyst tools for high-rise MURBs and office buildings structured to inform the ideal balance between high-performing building envelopes, renewable energy technologies, and cost effectiveness
- Engage developers of special sites in Vancouver to identify opportunities to develop these sites so that buildings achieve zero or near zero emissions Explore and recommend required City actions to support the development and availability of innovative financing approaches for zero emissions or near zero emissions condominium buildings so as to decrease the need for other catalyst tools

6 Capacity Building

Designing and constructing near-zero emission buildings requires specialized knowledge and skills. To date, the local building industry has had limited experience in these types of buildings, particularly compared to our counterparts in areas of Europe. The local knowledge and skills that do exist are currently with a small group of early adopters who have pursued Passive House standards on a handful of very recent projects. Similarly, many Vancouver residents are unaware of zero emission buildings and the long-term benefits these buildings provide.

In order to rapidly transition to near-zero emission buildings in Vancouver, the capacity of the building industry will need to be increased. This means providing resources and training, encouraging knowledge-sharing and supporting peer-to-peer learning. Lessons learned by one designer can help another avoid similar pitfalls. Similarly, major energy savings realized on one project can be adopted by others to make similar gains. Capacity building will also include strengthening the relationship between the City and the building industry, with an emphasis on single-family-home builders to ensure that they are well supported with training and resources.

The following section outlines the recommended actions for rapidly increasing capacity in Vancouver's building industry to design, build and operate near-zero emission buildings. These actions recognize and build on the work already being done by various levels of government, industry associations, academic institutions

and professional bodies. Many of the capacity-building actions recommended below will be delivered in partnership with other organizations.

6.1 Capacity Building - Generating knowledge

Near-zero emission buildings are already being built in Vancouver. These projects provide ideal quick-start learning opportunities. To maximize the learning potential, it's recommended that funding be offered to "early adopter" designers of near zero-emission buildings to produce written case studies that summarize their design methodology, design outcomes, successes and lessons learned on the project. Leading designers have told us they would be willing to "share their story" so that others can learn from them – replicating and building upon their successes and avoiding similar pitfalls. The specific terms of the case study would be refined through consultation with the design community, but would likely include design methodology, key design details (wall assemblies, mechanical equipment, etc.), challenges encountered, project costs, and modelled energy performance.

In addition to the written case study, designers will be required, as a condition of the design funding, to offer technical tours of their buildings and/or to present their project at a local knowledge-sharing conference or event. A technical tour is an ideal way for other architects, designers and engineers to see a zero emissions building first-hand and ask questions directly to the design team. This tour would look at the nuts-and-bolts of the building and would be geared towards peers in the industry. (Public tours of zero emissions buildings are discussed in Section 6.2).

Secondly, it's recommended that funding be provided to support the creation of new resource guides and training opportunities, to address industry-identified knowledge and skills' gaps. The production of resources such as reports, design details, and construction best practices, would be done through partnerships with existing organizations such as the Homeowner Protection Office, BC Hydro, the Architects Institute of B.C. The BC Construction Association, for example, has indicated that resources aimed at improving procurement practices would lead to more innovation and leading-edge construction. Similarly, this funding would support training that would be delivered through a partner organization (an example would be to offer subsidized rates for Canadian Passive House Institute's certification courses). While some knowledge and skills gaps are known today, it's expected that additional gaps will emerge as more designers and builders begin to tackle near-zero emission buildings. The case studies produced by designers will be specifically required to identify gaps.

Lastly, projects selected under the building incentive program will be required to provide post-occupancy energy performance reports, which will compare measured energy consumption with the modelled energy performance of the buildings. The energy performance report will include an audit, to identify the potential causes of difference between

the modelled and actual performance. Through our consultation with the building industry, stakeholders identified actual building performance as a key knowledge gap today as virtually no publicly accessible post-occupancy monitoring information is available. The performance monitoring reports are intended to be public, though there may be some information that is private. The information gained through evaluating the operations of zero emissions buildings will be invaluable in determining if and when new design approaches are effectively in reducing GHG emissions and for refining design approaches going forward.

6.2 Capacity Building - Public Engagement

Stakeholders have told us that there is currently limited market demand for high-performance buildings, largely because of lack of awareness. Further, we've heard that there are persistent "urban myths" about the cost and performance of Passive House-like buildings. These urban myths persist in the public as well as amongst developers. A key piece of capacity building is therefore aimed at sharing information with the public about the real cost and performance of high-efficiency buildings, as well as promoting the other benefits of zero emissions buildings such as improved air quality, quietness and better temperature regulation.

As a condition of receiving design funding (Action 6.1.1), designers will be required to facilitate a public tour of their high-performance buildings. This tour will be geared toward the general public and not technical experts. The intent of the tour will be to showcase the aesthetic quality of the building, its high livability (quietness, natural temperature control, etc.) and its energy performance features.

A strong communication program is critical for engaging the public and raising awareness and demand for zero emissions buildings. Leading jurisdictions such as Brussels have implemented successful campaigns that featured regular high-profile zero emissions building ribbon cutting ceremonies, high-quality photography, glossy journals, and coffee table books to convey the aesthetic quality of Passive House buildings. These programs went beyond simply conveying information--they help build cachet around zero emissions buildings. It is recommended that a similar communications program be developed for the zero emissions building program, customized for the Vancouver market, which would include a variety of forms and mediums.

It's also recommended that innovative and aesthetically pleasing zero emissions buildings in Vancouver be recognized in both public and industry settings. This could be done in conjunction with existing building conferences and awards programs and/or through a dedicated Zero Emissions Award and Recognition Event. These showcases would provide opportunities to recognize leading developers, designers and builders. It would also raise the public profile of high-performance buildings (Wood Works BC's annual Wood Design Awards draws hundreds

of attendees). These events could be coordinated to include public tours of the zero emissions buildings.

6.3 Capacity Building - Sharing knowledge

A key piece of the Zero Emissions Building Plan is ensuring that knowledge gained by early adopters is disseminated widely such that the capacity of the industry as a whole can be accelerated. It's particularly important to support designers and builders who in the past may not have been fully engaged. Single-family home builders, for example, will need new tools and training to successfully deliver zero emissions buildings. Focussing specific effort on these builders will mean a smoother transition and ultimately a more skilled workforce.

Peer-to-peer learning has been shown to be a one of the key ways to increasing knowledge in the building industry. For example, New York's Building Energy Exchange (BEEx), a non-profit created and partially supported by the City of New York, has helped build a strong green buildings' network in the city (focussed primarily on architects and designers) and facilitates ongoing peer-to-peer learning events and exhibitions. BEEx has become a hub for the zero emissions building industry in New York. Closer to home, Wood Works BC is a highly successful capacity-model with a strong educational and networking component. Over the past two decades, Wood Works BC has been particularly effective at identifying barriers to wood construction and working with stakeholders to remove those barriers.

Building on these successful models, it is recommended that a Centre of Excellence for Zero Emissions Building be established in Vancouver for near-zero emissions buildings. The Centre of Excellence will a central hub to disseminate case studies and resource guides, host panels and events, facilitate tours, share performance data from demonstration buildings, link with education partners to support and promote training, and identify barriers and knowledge gaps. The centre will serve as a neutral space where developers, designers, and builders can voice their concerns and work with City staff to resolve them. In this way, the centre will act as the "living room" for the local green building community, where relationships can be built. The Centre could also be used to deliver mission-related programs on behalf of the City and/or its partners. There is currently no such venue in Vancouver and this has been identified by stakeholders as a missing piece in the local green building industry.

The centre of excellence is envisioned as an independent entity focused on building industry capacity to design, build, and operate near zero emissions buildings. It would be supported by and serve a coalition of partners with a strong interest in transforming the building industry not just in Vancouver but across BC. A number of stakeholders including BC Hydro, BC Construction Association, Wood Works BC, SFU Properties Trust, BCIT, BC Housing, the provincial government and other local governments have expressed a strong interest in partnering with the City to create and support the ongoing success of a Centre of Excellence

for Zero Emissions Building either through providing funding, sharing data, supporting programming and events, or partnering on training and resources. The Centre is expected to offer far-reaching benefits in terms of greenhouse reductions, education and skills training, and economic growth. The purpose, key roles, and organizational structure are outlined below.

Purpose

The Centre of Excellence for Zero Emissions Building will serve the building industry by compiling and sharing knowledge, identifying and facilitating the removal of barriers and building a community, with particular emphasis on groups that may not have been fully engaged in the past.

Key functions

The main functions of the centre of excellence for Zero Emission Building are as follows:

1. To provide a central source of information and resources, including case studies, performance monitoring reports, technical papers, and design details.

2. To ensure industry segments such as multicultural single-family home builders who often do not access new information and training through conventional means are engaged and supported in this transition.

3. To identify knowledge gaps and regulatory/permitting barriers to near-zero emissions building and work with partners to identify and implement solutions.

4. To serve a neutral space to facilitate dialogue between developers, designers, builders and the City and build relationship through networking events, panels, and exhibitions.

5. To showcase zero-emissions buildings to the public through a range of communications, tours, public space activations, and an annual awards event.

6. To administer mission-related programs, such as building incentive programs, on behalf of the City and/or partner organizations.

Organizational Structure

The Centre of Excellence for Zero Emission Building is envisioned as an independent entity accountable to dedicated board of directors for

implementing its agreed-upon mission. Ideally, an existing third-party organization will operate the Centre of Excellence to minimize the start-up time required and to leverage existing organisational resources and staffing. The third-party organization will need to have a proven track record in delivering large projects, particularly in work related to sustainability and buildings, and be able to attract funding on an ongoing basis. The Centre will need a dedicated leader and several staff to administer the programming, serve as a knowledge hub, and ensure ongoing funding support. To this end, it is anticipated that an executive manager would be needed with training and experience in the field of architect and green buildings. This manager would oversee the operation of the Centre and guide the overall programming. It is anticipated that the Centre will need at least two additional staff with some background in the field of green buildings and strong communications skills. In order to ensure the centre is well managed, accountable for implemented it agreed to mission, and connected to key private and public sector partners, a separate board of directors or steering committee will be established. The board of directors or steering committee will include representatives from all major funding partners, as well as from key stakeholder groups.

The centre for excellence is intended to be a physical space. The space would provide office space for staff as well as exhibition space, to show green products and technologies related to near-zero emissions buildings as well as host training sessions, dialogues and networking events. Ideally the space would be able to accommodate speakers and small panel discussions. The physical space could be located within a building currently operated by a partner organization or in a building owned by the City. The space should be in a central located easily accessible by practitioners as well as the public (i.e., it should be visible).

In addition to a physical space, the Centre will have a comprehensive website, which will serve as a publicly-accessible repository for case studies, technical report, performance monitoring report and design details. The website would include a calendar of events and training, including courses offered by partner organizations such as AIBC, APEGBC, and HPO. In addition to the website, the Centre would include a variety of social media platforms to communicate with stakeholders and the public.

The organizational structure and financial model for the Centre of Excellence, including the physical space, staffing, board/steering committee, and funding sources, requires significant detailed planning. This planning will be done in partnership with key stakeholders over the next six months, at which time a detailed report will be brought back to Council for consideration.

NYC's Building Energy Exchange

The Building Energy Exchange (BEEx) was established in 2014 by the City of New York as a non-profit. The City provided seed funding and continues to provide office and exhibition space. BEEx currently has four full-time staff and is overseen by a board of directors made up of government and industry representatives and leading professionals.

Be-ex initially focused on lighting retro-fits but has since expanded to energy efficiency, specifically for commercial buildings larger than 50,000 square feet. They focus their capacity-building efforts on architects and designers as these professionals are involved in almost all projects..

Be-ex's capacity building work includes:

- *Hosting exhibits, panel discussions, speakers and networking events*
- *Serve as a resource hub for energy efficiency and lighting*
  - *Courses*
  - *Case studies*
  - *Technical reports*
- *Provide an online calendar of courses and training opportunities, many of which are delivered by partner organizations*
- *Act as a liaison between City and architects/designers*
- *Provide space for stakeholder engagement on City-led initiatives*
- *Establishing formal partnerships with industry stakeholders to share information and resources*

In a relatively short period of time, BEEx has established itself as a recognized hub for the local architectural and design community. They have built a sizable, engaged audience interested in near-zero emission and passive house buildings.

6.4 Capacity Building - Removing Barriers

Existing City of Vancouver regulations, policies, design guidelines, and requirements that establish expectations and requirements for new buildings can create challenges to building zero emission buildings. For the past 5 years, the City has been working to identify and resolve barriers to higher performing buildings. One example was the provision of a wall thickness exclusion for highly insulated buildings so that they are not penalised with a loss of allowable building area. Recently Council approved amendments for detached houses in RS-1 zones (the majority of single family lots in Vancouver are in RS-1 zones) that provide the Director of Planning discretion to relax height and setback requirements for projects that achieve Certified Passive House to make use of the square footage gained from the wall thickness exclusion.

This approach must be expanded to other zones and building types as slightly thicker walls and higher roofs are required to provide highly efficient building envelopes.

More barriers have already been identified and more will emerge as the City and private sector leaders accelerate the development of near zero emission buildings. Resolving some of these barriers will be straightforward, such as accepting Passive House energy model results to show compliance with policy and bylaws while others will require the careful balancing of several public policy objectives.

Interdepartmental cooperation and accountability will be required to modify policies, bylaws and guidelines and create flexibility to resolve design challenges such as:

- Simple, cubic building forms are most energy efficient (and contribute to the ease of installing insulation and air barrier systems) but can conflict with step back, access to light, and "traditional character" requirements that increase building articulation and therefore roof and wall area as well as complexity
- Orientation for effective solar access and logical location of solar panel mounting can conflict with the form and material guidelines in some district schedules. The main conflict is where the guidelines speak to traditional roof forms and materials as seen from the street view, which may be the only aspect useful for solar installations.
- Policies that require builders to provide access to private outdoor space leads to the proliferation of cantilevered balconies which add cost and create complex heat loss challenges; alternative options for the provision of suitable private or semi-private outdoor spaces must be explored to balance affordability, sustainability and liveability outcomes.

Vancouver's Building By-law can also create barriers to zero emissions buildings. For example, the By-law requires a ducted kitchen exhaust from a range hood regardless of whether the range is gas or electric. In other jurisdictions, the use of a recirculating hood with charcoal filter paired with an electric range and a commissioned heat-recovery-ventilation unit is a permitted approach for maintaining indoor air quality. Similarly, the Bylaw considers wood buildings and some highly energy efficient window framing materials such fibreglass as to be fire hazards in buildings over 4-6 stories in height. There is growing a body of evidence that these materials can be safe if their use is properly regulated. Research into these challenges and alternate approaches is required to inform possible By-law changes.

Finally, the importance of City staff training on Passive House and zero emission building techniques and materials cannot be understated. Removing barriers in our regulations, policies and guidelines hinges upon City staff being able to understand this work and its intent, and feel comfortable implementing it.

Capacity Building ACTIONS
In order to successfully transition the majority of new buildings to zero emissions by 2025 while fostering the greatest opportunities for local economic development, it is essential that the City and other invested stakeholders work together to foster the capacity to design, build, permit, and produce components for zero emissions buildings. This will require investments to generate and share knowledge, increase public awareness, and to remove policy and permitting hurdles as summarized by the following actions:

- Provide funding for designers to prepare case studies and lead technical tours of zero emissions buildings
- Develop resource guides to document effective approaches to common challenges
- Invest in training programs for designers and trades
- Require post-occupancy performance evaluations of zero emissions buildings
- Organize opportunities for the public to learn about and experience the quality of zero emission buildings through the showcasing of beacon buildings, provision of public tours, and by making passive house units available for short term occupancy
- Establish a Centre of Excellence for Zero Emissions Building and website to foster the development and sharing of knowledge and skills regarding effective approaches to zero emissions buildings
- Identify and resolve City policy and process barriers to passive house and other near zero emission buildings
- Provide training and tools for City staff to facilitate permitting of zero emissions buildings

7 CONCLUSIONS

Meeting the City's 2050 target to use only renewable energy will require the majority of new buildings be designed and built to achieve zero emissions by 2025 and all new buildings to achieve this target by 2030. While meeting these aggressive targets and timelines is achievable, especially given that our electricity is almost 100% renewable already, it will require a restructuring of the City's policies and tools as well as leadership by the City and industry to demonstrate effective approaches for achieving this goal. It will also require a collaborative approach amongst many stakeholders to share knowledge, remove barriers, and ensure that the required skills are developed and widely available in BC.

This collaborative effort to transform how new buildings are designed and built will not only reduce their GHG emissions but will also make them healthier and more comfortable for their occupants. In addition, this innovation in the building industry will make buildings more resilient to changes in weather, climate and energy prices while providing significant opportunities for local professionals, trades, and industries.