Towards Carbon Neutral Buildings in BC

Framework for High-Rise Multi-Unit Residential Buildings

June 12, 2012

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LETTER FROM THE EXECUTIVE DIRECTOR

Since its founding in 2005, Light House's mission has been to catalyse green building in BC. With global greenhouse gas (GHG) emissions continuing to rise, and the construction and operation of buildings continuing to be a major contributor to GHG emissions, this mission remains timely and increasingly critical.

It is encouraging to see that in a few short years, the conversation is now shifting from "what is a green building", to "what is a carbon-neutral building". We hope that this report helps to inform that new conversation, and contributes to the technical, social, and regulatory changes required to achieve carbon neutral building in BC.

While this report reflects the technical input (and passion) of much of the Light House team, it is important to note that this forward-looking project was conceived under the leadership of Helen Goodland, who stepped down as Light House's Executive Director September 20, 2011. Helen recognized the growing imperative to tackle carbon-neutral building in BC, and sought out the Swiss technical expertise of Intep LLC to help develop solutions. Even after leaving the organization, Helen helped maintain continuity in the development of this important report by graciously agreeing to provide project management and reporting support, and provided significant input into the report. For that, we extend to her our most sincere thanks.

The final framework presented in this report presents a major, yet simplifying, shift in the way in which we establish targets and measure the energy and carbon performance of buildings. While focusing on high-rise multi-unit residential buildings in southern coastal BC, we envision that the framework can (and should) be adapted to other building types and climates. As such, this report represents a big step of many required towards carbon neutral buildings in BC.

We would like to thank you for your interest in carbon-neutral building, and hope that you will join us on the path forward.

Sincerely,

Tracy Casavant, MES, PEng.
Executive Director
Light House Sustainable Building Centre Society

TECHNICAL TEAM

Light House Sustainable Building Centre

Vancouver, BC

Light House (www.sustainablebuildingcentre.com) Light House is a not-for-profit company dedicated to advancing green building and the sustainable infrastructure and economic systems into which green buildings are intrinsically integrated. We provide research, advisory and project management services to businesses, policy makers and the real estate and construction industries. Our team has applied our professional expertise and intimate knowledge of the green development landscape to support the public, real estate and construction sectors across Canada and internationally in their efforts to respond meaningfully and practically to goals for improved energy & carbon performance and resource management. Light House is a member of the BC Hydro Power Smart Alliance.

The Light House team incorporated the expertise of Helen Goodland RIBA MBA LEED AP (former Executive Director); Joanne Sawatzky MSc, LEED AP BD+C, Sr. Building Scientist; Jaspal Marwah, MCIP, Sr Planner; and Orianne Johnson MArch, cSBA, LEED AP BD+C, Green Building Project Co-ordinator. The Light House team was managed by Tracy Casavant MES, P.Eng., Executive Director.

Intep - Integrated Planning LLC

Minneapolis, MN

Intep (www.intep.com) is a consulting company providing real estate services with offices in the USA, Germany and Switzerland. One of their core competencies is sustainability consulting for private enterprise and public institutions. Intep provides services directly to clients that expect high-performance facilities. They base their unique approach on three key qualities: thinking in life cycles; developing the highest competencies; and creating holistic answers to complex questions.

Intep has consulted to clients on four continents and recognizes cities are uniquely situated to leverage global technologies, know-how and experience to make leading edge, high-performance buildings a reality while improving cost effectiveness and quality of their build environment. They have supported many cities like: Zurich, Munich and Berlin, with their implementation of sustainability strategies by developing frameworks and standards for sustainable construction including energy and CO_2 targets.

The Intep team was led by Stephan Tanner, AIA, Principal and also incorporated the technical expertise of René Sigg, Managing Partner.

BTY Group
Vancouver, BC

The BTY Group (www.bty.com) is one of Canada's most successful and experienced Cost Management and Project Management consultancies. Their primary services include Cost, Project and Program Management; Project Monitoring; Lenders Advisor and Risk & Value Analysis. They aim to be their clients' first resource on matters relating to the due diligence, valuing, planning, monitoring and management of investments/interests in the property, development and construction sectors.

Steve Hadden, MRICS, PQS, LEED AP, Senior Cost Consultant represented BTY Group on this project.

ACKNOWLEDGEMENTS

We wish to acknowledge the generous financial support from the Real Estate Foundation of BC, which works to advance knowledge and practices leading to more sustainable land use in BC. Their support for this project was critical, and we are grateful that the Foundation's leadership in recognizing the link between communities' goals for sustainable, lower carbon land use and objectives for carbon neutral building.

We would also like to acknowledge the financial and technical support of the City of Vancouver, which provided benchmark / baseline data as well as advice and direction as the one of Canada's municipal leaders in green building, and the first municipality in BC to set carbon neutral building targets

In-Kind Contributors

This report would also have not been possible without the in-kind contributions of expertise from Solterra Group of Companies, which provided thoughtful insight from the perspective of a progressive, experienced developer of high rise residential projects; the City of Vancouver; and the BTY Group, which brought their experience in costing green buildings to the analysis of the potential incremental costs associated with achieving a carbon neutral building.

We would also like to thank the Swiss Business Hub in Vancouver and the Swiss Canadian Chamber of Commerce (BC) for their assistance in facilitating an Ideas Exchange in March 2011 which led to a greater understanding of the complementarities in low-carbon building policy, design and construction between the cities of Zurich and Vancouver; forging connections to Swiss expertise, technologies and policy tools; and continuing to provide knowledge transfer opportunities.

External Reviewers

Lastly, in addition to the input of our technical team and funders, we would like to thank our external reviewers who generously donated their time and provided such thoughtful comments that helped to strengthen this report:

Josha McNab, Associate Director, Sustainable Communities Group, Pembina Institute

Jeff Fisher, Deputy Executive Director / Senior Policy Advisor, Urban Development Institute

Building Code Committee, Urban Development Institute

John Nicol, Senior Policy Analyst, Building and Safety Standards Branch

Front cover photo courtesy Solterra Development Inc

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EXECUTIVE SUMMARY

INTRODUCTION

At the provincial level, reducing greenhouse gas (GHG) emissions has become an important policy objective. For example, Bill 44, 2007[1] - the "Greenhouse Gas Reductions Target Act" - puts into law BC's target of reducing GHGs by at least 33% below 2007 levels by 2020 and includes the long-term target of an 80% reduction below 2007 levels by 2050. As buildings account for almost 35% of greenhouse gas (GHG) emissions from BC communities[2], many municipalities are actively seeking solutions to reduce GHG emissions from buildings. The City of Vancouver has already established a goal for all new buildings to be carbon neutral by 2020.

The objective of this project was to create a framework with defensible, actionable and measurable targets. The framework will also assist municipalities to develop policy tools and provide some direction on how to execute projects that achieve carbon policy goals.

This report represents the first phase of work of a much larger effort required to engage municipalities across the province in carbon neutral building. Advancing the framework will require complementary policy and regulatory changes at the local and provincial government levels. While this report provides some important considerations and options for such policy and regulatory changes, the scope of work does not extend into the development of such policies and regulations.

What is a Carbon Neutral Building?

For this framework, carbon neutral buildings refer to those with significantly reduced energy consumption combined with the increased use of low carbon energy sources to meet the remaining demand. This definition is consistent with existing Provincial and municipal regulations e.g., the City of Vancouver, in BC. The framework will not address carbon offsets, as these are best addressed outside the building regulatory process.

SCOPE: NEW HIGH-RISE MURBS IN SOUTHERN COASTAL BC

This report focuses on new high-rise multi-residential buildings (MURBs) in BC's southern coastal climate zone. High-rise (MURBs) represent an important and growing typology for municipalities in BC. High-rise MURBs also make an important contribution towards meeting sustainable community objectives. Finally, the City of Vancouver's goal for all new construction to be carbon neutral by 2020 places particular pressure on high-rise MURB developers, as high-rise MURBs have especially long development timelines.

Given the City of Vancouver's carbon neutral building goals, its availability of baseline data, and its willingness to participate in this research, the report places a special emphasis on the Vancouver context. As such, while the overall approach demonstrated in this report is transferable, the quantitative aspects of the framework presented in this report are specific to the BC southern coastal climate (ENERGY STAR® climate zone A).

The framework is currently focused on new buildings. Given the contribution of existing buildings to BC's carbon footprint, and the potential for significant carbon savings to be achieved via renovation and retrofit activities, existing buildings will likely be addressed in future related efforts.

[1] BC Greenhouse Gas Reduction Targets Act
[2] 2008. British Columbia Greenhouse Gas Inventory Report

BARRIERS TO CARBON NEUTRAL HIGH-RISE MURBS IN BC

MURB Development Process: For MURBs, the process from design to operation is fragmented, and involves many players, each of which has limited control on the overall process. Perhaps most critical, though, is the developer's lack of ongoing involvement in the building once it is complete.

Limitations of ASHRAE 90.1: ASHRAE 90.1 is the basis for energy performance requirements of the BC Building Code and Vancouver Building By-law, as well as for the Model National Energy Code for Buildings. ASHRAE 90.1 measures relative design energy against a modelled baseline, creating a tendency to present energy performance as a relative value rather than as an absolute measure.

Reliance on Third-Party Rating Systems: Some municipalities have opted to leverage third party rating systems. These systems generally do not reflect the disconnect between a building's development and its operations; can require lengthy post-occupancy reviews before certification (compliance) is determined; rely on ASHRAE 90.1 for energy performance goals; and do not have specific carbon criteria.

Envelope Performance: BC is believed to have the poorest average air leakage performance in Canada[3]. Air tightness testing is not current standard practice; therefore, one of the most effective means of measuring this performance is neither required nor widely used.

Considering the challenges, the policy framework:

- **Creates a level playing field** by establishing clear, absolute, measurable and common high-rise MURB energy and carbon performance targets;
- **Reflects the development process** by ensuring that any standards developed based on the framework would not require a lengthy post-occupancy review to determine compliance;
- **Does not require certification** by a third-party rating system;
- **Can be easily administered** and enforced by regulators; and
- **Improves envelope performance** design and measurement.

BEST PRACTICES: LOOKING TOWARDS EUROPE

DEFINING SYSTEM BOUNDARIES & UNDERSTANDING ENERGY FLOWS

European energy performance building calculations and targets are based on an approach that clearly defines energy system boundaries. **Primary energy** (also known as source energy) is defined as the raw energy found in nature. Primary energy can be non-renewable (e.g., crude oil, uranium, or coal) or renewable (e.g., water, solar radiation or wind). **Secondary energy** is energy comes from human induced energy transformation such as petroleum products, biofuels, electricity, etc. Secondary sources are sometimes referred to as energy carriers since they move useable energy from one place to another. **Site energy** (also known as final or delivered energy) is defined as the measurable energy supply for the building site. Site energy sources are natural gas, fuel oil, district heat or electricity, and can also include renewable energy produced on site (e.g. solar photovoltaic). **Useful energy** is defined as the energy that is directly accessible to the user. Useful energy includes space heat, domestic hot water or lighting. A technical overview of these concepts is presented in Appendix A of the report.

[3] Personal communication, John Nicol, Building and Safety Standards Branch

CALCULATING ENERGY AND CARBON PERFORMANCE

The calculation of energy performance and related GHG emissions relies on the use of energy factors and GHG coefficients, which are developed on a regional basis to ensure fairness, parity and comparability. This supports the creation of an energy standard rating for the building, which is determined ***prior*** to occupancy. In particular, primary energy factors are developed to appropriately allocate the impacts of the various primary energy inputs, with lower factors representing a lower impact. The calculation of energy performance and GHG emissions also takes into account utilization levels, which are established to represent the ratio of heat demand to heating energy demand for various systems, such as domestic hot water production. So long as all parties use the same information, a consistent and comparable approach to policy administration is established.

UNDERSTANDING ENERGY USE DEMANDS

Energy demand is defined by discrete categories. Heating, which includes energy demand for space heating and domestic hot water, is calculated at the useful energy stage. **Ventilation and air conditioning**, or "cooling energy", which includes the energy demand for ventilation, cooling and dehumidification, as well as humidification. Cooling energy demand is calculated at the useful energy stage. Cooling and heating energy can be converted to site energy demand with the help of the respective utilization levels and conversion losses. Lastly, building services includes the electrical energy demand for lighting, building services (base building consumption), as well as in-suite appliances and equipment (occupant consumption). The demand of this group of consumers equals the site energy.

SWISS BUILDING PROGRAMS

Switzerland has been leading the world in low carbon technologies, green buildings and sustainable transportation for a number of years. Swiss building codes are among the most stringent in the world and Switzerland has been leading the development of low-carbon building standards. There are similarities between BC and Switzerland in the structure and authority of building energy codes; the climate of Switzerland is also similar to that of southern coastal BC. Swiss experience shows that it is prudent to regulate both ends of the energy flow process, and then allow designers (and developers) determine the best response for their project. This approach clearly distinguishes between energy demand defined by building design, which can be regulated through planning and development regulations, and energy demand dictated by user behaviour.

MINERGIE®[4] is a Swiss-developed energy rating standard for new buildings and major renovations. With over 18,000 MINERGIE® certified buildings, Switzerland is home to some of the most advanced buildings in Europe. MINERGIE® sets a few simple-to-communicate standards that are performance based, thereby leaving design resolution in the hands of the consulting professionals and market forces. It is simple and transparent, yet delivers measureable energy and carbon performance metrics. MINERGIE® requires the submission of a detailed quantitative proof of energy performance comprising a series of spreadsheet-based energy performance reporting forms. These calculations are based on the standards set by the Swiss Society of Engineers and Architects. To maintain feasibility and general use, MINERGIE® stipulates that the additional costs must not exceed 10% of the building costs over a comparable code-compliant building.

[4] More information about MINERGIE® is found at www.MINERGIE.ch

GENERAL PRINCIPLES FOR LOW CARBON DESIGN

With the increased focus nationally and internationally on reducing GHG emissions from buildings, a number of common principles for low carbon design have emerged. The key principles related to high-rise MURBs are

- High performance envelope to reduce energy demand e.g., avoid thermal bridges;
- High performance mechanical systems to reduce energy demand e.g., heat recovery system for ventilation
- Efficient coverage of energy demand e.g., energy efficiency equipment;
- Meet demand with renewable sources; and
- Quality assurance.

APPLICATION OF BEST PRACTICES TO FRAMEWORK

The framework leverages the best practices as follows:

- **Defines the system boundary and energy flow**, as relied on across most of Europe, to support more relevant target setting;
- **Defines systems that consume building energy** (heating, lighting, etc.), their respective utilization levels, and influences (i.e., building design versus occupant behavior) to create regulatory clarity;
- **Sets absolute energy and carbon performance targets**, drawing on the experience of Switzerland e.g., with MINERGIE®, in setting targets that reflect leadership and practicality;
- **Uses the best practice principles of low carbon high-rise MURB design** to inform the evaluation of the feasibility of proposed energy and carbon performance targets; and
- **References Swiss data** to support the establishment and evaluation of energy and carbon performance targets.

FRAMEWORK FOR CARBON-NEUTRAL HIGH-RISE MURBS

BASELINE

The baseline average high-rise MURB energy consumption was set at 213 kWh/m^{2}y[5], which is, at best, equivalent to the current provincial standard of ASHRAE 90.1 (2004). Figure 1_{ES} breaks down the baseline into primary and site energy and presents the associated GHG emissions.

HIGH-RISE MURB PERFORMANCE TARGETS

As shown on Figure 2_{ES}, the recommended targets for high-rise MURBs in Vancouver and southern coastal BC (ENERGY STAR® Climate Zone A) are **< 100 kWh/m^{2}y for total primary energy (non renewable) with < 5.0 kgCO$_2$e/m^{2}y**. A target for useful energy consumption for heating and hot water is also included which is defined as < 50 kWh/m^{2}y. The final quantitative value of the targets may be slightly refined as the framework is implemented; regardless, targets around the proposed numbers are considered within the technical and economic reach of BC's development industry.

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[5] Based on data from RDH Building Engineering Ltd, Enersys Analytics, et al. *Energy Consumption and Conservation in Mid and High Rise Residential Buildings in British Columbia*. May 2011, commissioned by the City of Vancouver. Of the 39 buildings analysed, individual consumption varied from 144 to 299 kWh/(m^{2}y). This study provided data used to establish baseline high-rise MURB design and construction practices and quantitative energy and carbon performance. The study also provided insight into baseline demand allocation

FIGURE 1ES

HIGH-RISE MURB BASELINE

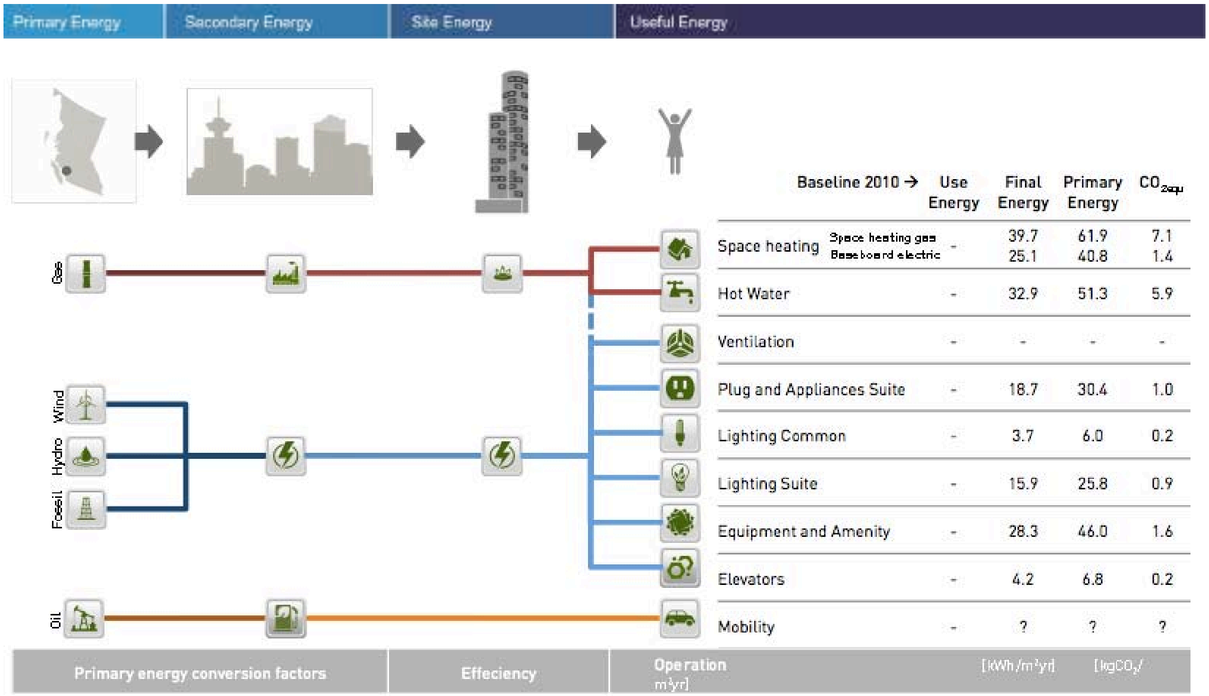


FIGURE 2ES

HIGH-RISE MURB 2020 TARGETS

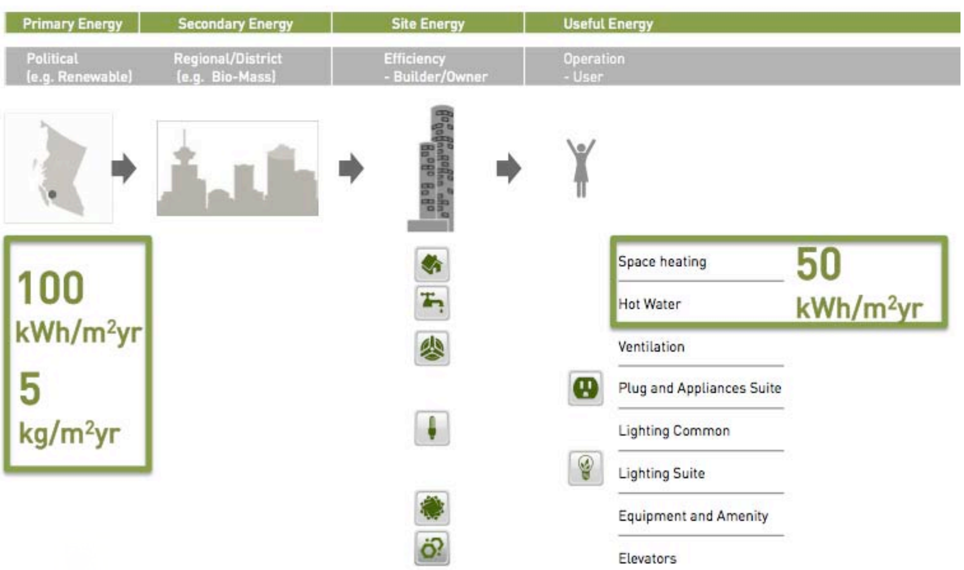


Figure 3_{ES} presents the energy system flow diagram used to develop the high-rise MURB targets. When compared to the energy flow diagram presented for the baseline in Figure 1_{ES}, the key difference is the addition of solar energy and reduction in fossil fuel usage.

To test the viability of the above framework targets, additional energy demand benchmarks from MINERGIE® are presented in Table 1_{ES}; the actual appropriate distribution of energy consumption to achieve the target of < 50 kWh/m^{2}y may be refined based on future research.

FIGURE 3_{ES}

HIGH-RISE MURB TARGET
ENERGY SYSTEM FLOW DIAGRAM

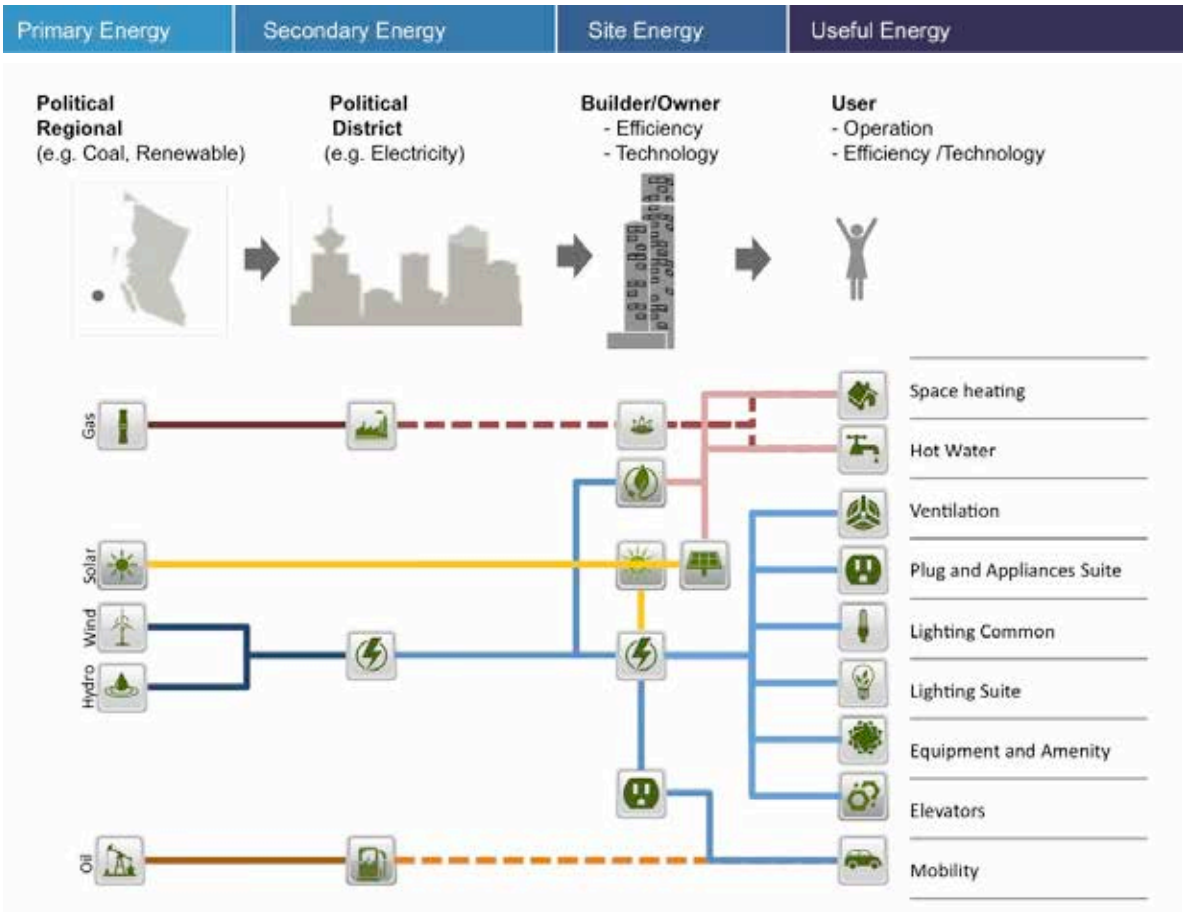


TABLE 1_{ES}

DETAILED ENERGY DEMAND PARAMETERS AND LIMITS

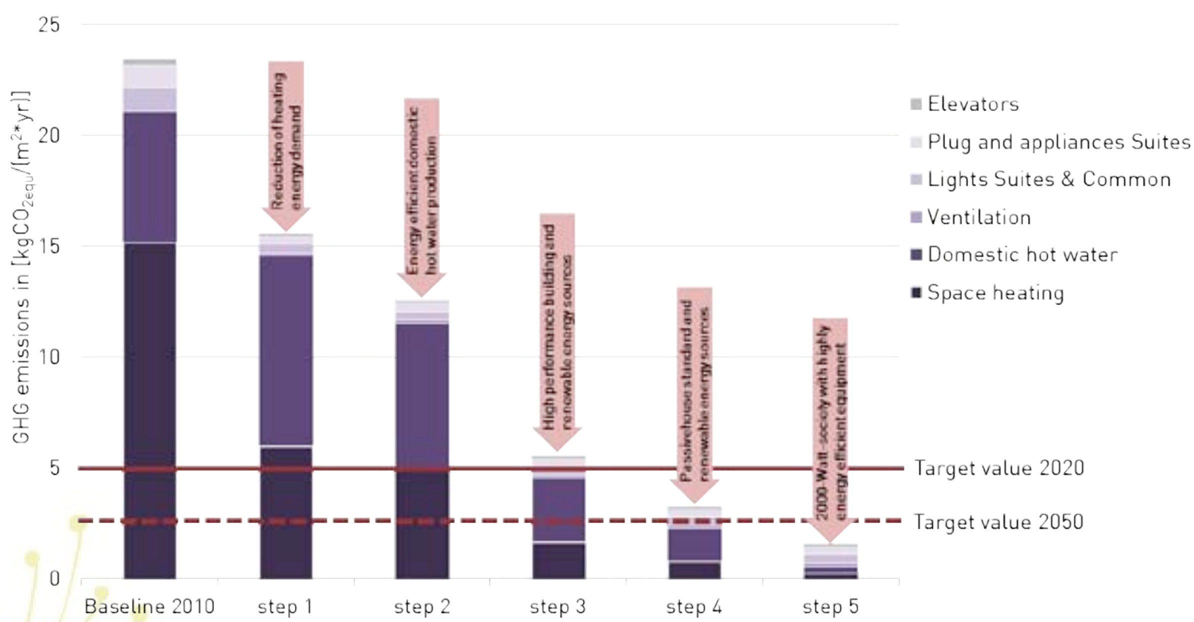
Utilization	Consumption benchmarks
Heating	**< 50 kWh/m²y (Target set for High-Rise MURBs, south coast BC)**
Space heat	= 24 kWh/m²y (from MINERGIE®)
Domestic hot water	= 21 kWh/m²y (from MINERGIE®)
Ventilation and AC	
Ventilation	= 5 kWh/m²y (from MINERGIE®)
Cooling/dehumidification	not subject to any energy related requirements.
Humidification	not subject to any energy related requirements.
Lighting	=13 kWh/m²y (from MINERGIE®)
Building services	
Equipment	= 14 kWh/m²y (from MINERGIE®)
Miscellaneous services	4 kWh/m²y for auxiliary equipment (from MINERGIE®), 4,000 kWhy per elevator.

LOOKING BEYOND 2020

International best practice indicates that the carbon and energy performance targets will ultimately be more stringent than those proposed in this framework for 2020. Figure 5_{ES} illustrates a possible trajectory to a suggested 2050 target of 2.5kg CO_2e/m^2y, consistent with the Swiss 2,000 Watt Society goals.

FIGURE 5_{ES}

LONG-TERM CARBON ROAD MAP FOR HIGH-RISE MURBS

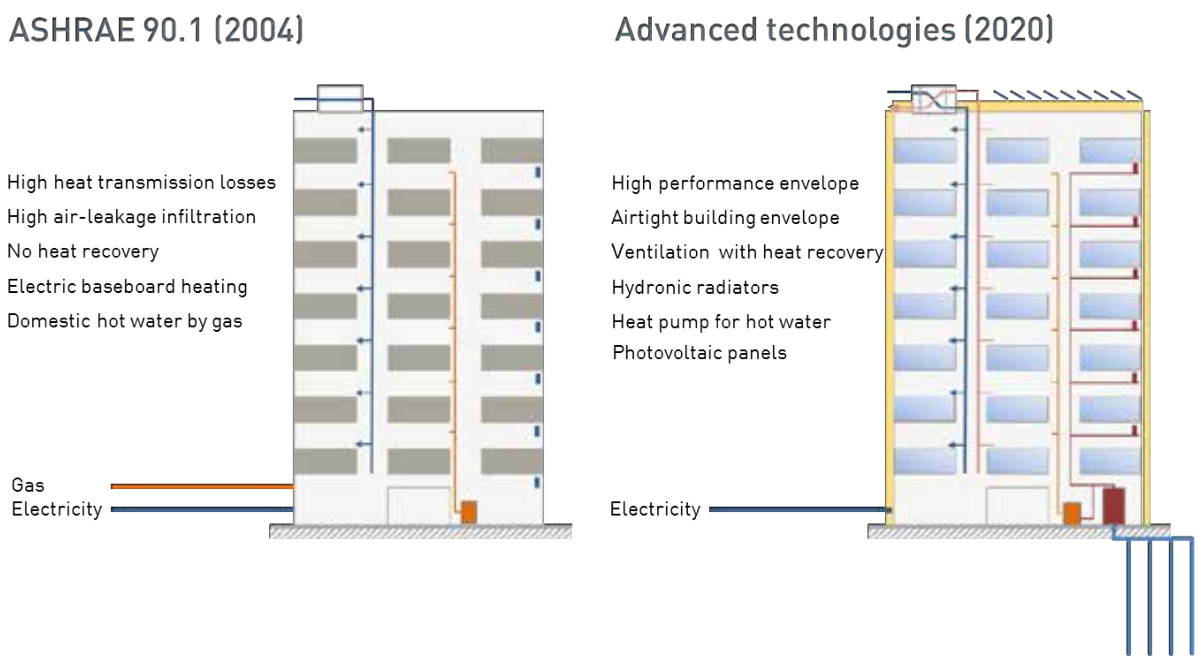


SCENARIO ANALYSIS: 2020 BUILDING

Representative baseline and low carbon high-rise MURBs were established (Figure 6_{ES}). Given that the targets would be performance-based, designers would of course have much flexibility in determining how to meet the target. The scenario shown in Figure 6_{ES} is one of many possibilities.

FIGURE 6_{ES}

REPRESENTATIVE BASELINE (ASHRAE 90.1 2004) & 2020 CARBON NETURAL HIGH-RISE MURBS



To compare the construction cost of the 2020 versus baseline design, additional assumptions were made, namely that the building was a 20 storey, 13,656.7 m^2 (147,000 ft^2) tower containing 224 dwelling units, comprising a six-storey podium with a 761.8 m^2 (8,200 ft^2) floor plate, and a 14-storey tower with a 650.3 m^2 (7,000 ft^2) floor plate.

It is estimated that that the 2020 carbon neutral building would cost approximately 10.5% more, compared to an ASHRAE 90.1 (2010) baseline building, and 14% more, compared to an ASHRAE 90.1 (2004) baseline (current practice). As industry becomes familiar with the low-carbon building design and construction, the cost premium over conventional practice will diminish.

ADVANCING THE FRAMEWORK

The advancement of this framework will require a substantial amount of work in the form of policy changes, additional technical studies, pilot projects, consultation, and education and outreach. Given the timelines set by Vancouver, as well as the general international direction with respect to carbon neutral building, such work needs to commence as quickly as possible.

In the longer-term, if this framework is adapted to existing buildings, then additional tools may be required. However, many of the policies, regulations, incentives, and education programs developed for application to new buildings will also likely be adaptable to a framework for existing buildings.

DEVELOP BC-SPECIFIC ENERGY DATA

In the short-term, Swiss energy factors and GHG coefficients can be used to calculate building energy and carbon performance. However, BC-specific factors should be established, with a comprehensive stakeholder process. The European context provides a road map e.g., the Swiss experience brought to this project via Intep or British efforts of the Building Research Establishment. This work should begin as soon as possible, and can be completed in parallel to any other implementation work.

DEVELOP NEW POLICIES AND REGULATIONS

Ideally, the framework is incorporated into regulatory changes to the BC Building Code and Vancouver Building By-law; Swiss and other European codes provide good examples. Future implementation work should include a detailed analysis of the BC Building Code and Vancouver Building By-law for current drivers and barriers to carbon neutral building, as well as establishing a multi-stakeholder committee to push for and oversee the necessary changes.

Even with building code changes, other complementary policy and regulatory changes will likely be required at the local government level. The report presents some general considerations for the following policy and regulatory tools:

- Official Community Plans (OCPs);
- Development permits and development permit area guidelines;
- Zoning bylaws;
- Other adopted policies;
- Building permit requirements and process;
- Building inspection requirements and process;
- Occupancy inspection / permit requirements and process;
- Compliance / verification tools; and
- Incentives

Vancouver is in an ideal position to be among the first municipalities in BC to pilot draft regulations, approvals processes, education and outreach programs, and other tools that are developed to implement the framework. The report presents a more detailed timeline for Vancouver.

SUPPORT STAKEHOLDER ENGAGEMENT & EDUCATION

Complementary education and outreach efforts are recommended to improve the energy literacy of developers, designers, and contractors, as well as of building operators and high-rise residential building suite owner and tenants. Furthermore, a robust and collaborative consultation process is required to move forward. The report identifies numerous stakeholder groups e.g., municipal staff and building operators; suggested organizations that can be key conduits for reaching those stakeholder groups; the role of that stakeholder group in implementation e.g., technical contributions or framework promotion; and some possible targeted education and outreach needs.

SUPPORT PILOT PROJECTS

Whole building pilot projects will be required to test draft / proposed regulations, approvals processes, education and outreach programs, and financing and incentive mechanisms, while smaller demonstration projects will be required for new products and technologies. It is possible that pilots for each typology and in each different climate zone might be required. Vancouver's timelines, a 'real-life' high-rise MURB demonstration project should also be found within Vancouver. Time is of the essence to ensure that such a pilot completes in time to inform changes required by 2020.

EXPAND AND ADAPT THIS FRAMEWORK

The establishment of the high-rise MURB framework presented herein represents the first of many phases of work towards the creation of carbon neutral buildings in BC. Future work will include expansion to other building typologies and other BC climate zone, and should be based on a collaborative process including many of the key stakeholders identified in this report. The general process for future work to establish typology and climate-specific frameworks is summarized below:

Determine Energy and Carbon Baseline: The baseline for high-rise MURBs in Metro Vancouver was established based on the RDH Engineering Ltd. Study. The report presents some suggestions for other data sources and methodologies to establish meaningful baselines by municipalities that do not have the resources to replicate the RDH study.

Establish Energy Use and Carbon Intensity Targets: Based on individual municipal goals, Provincial goals, benchmarks set by other municipalities such as the City of Vancouver, and international best practice, establish energy and carbon intensity targets, as well as timeframes for meeting those targets. As shown in this framework, such targets should focus on primary energy. International goals, such as those established by MINERGIE® can be used to verify the achievability of targets.

Once the framework is established, then draft policies, regulations, and other programs can be developed, taking into account some of the considerations outlined in this report. Pilot projects will help to ground-truth targets and the proposed policy framework before it is adopted. Then, performance should be systematically evaluated on an ongoing basis to inform the continued improvement of policies and regulations, as well as the updating of carbon and energy performance targets to more progressive levels.

LOOKING AHEAD TO 2050

The framework for carbon neutral high-rise MURBs presented presents some interim targets for 2020. Eventually, the framework should evolve to support even greater carbon emission reductions. Future targets should include embodied energy and mobility associated with buildings, such as those adopted by communities in Switzerland that are implementing the 2,000-Watt Society. Those targets include additional GHG emissions targets of 8.5kg CO_2e/m^2y for embodied energy and 5.0kg CO_2e/m^2y for mobility. As buildings become more efficient operationally, the impacts of choices related to building materials and transportation will become proportionally more important. By 2050, if embodied energy and mobility targets are added to the building operations target of 2.5kg CO_2e/m^2y, a total target of 16.0kg CO_2e/m^2y would be set (see Table 2_{ES}).

TABLE 2_{ES}

HIGH-RISE MURB ENERGY AND CARBON PERFORMANCE TARGETS FOR 2050

Multi Unit Residential Buildings	Primary Energy (non renewable) [kWhy]		Greenhouse Gas Emissions [kg/m^{2}y]	
	2020	2050	2020	2050
Target Value: Embodied energy	-	30	-	8.5
Target Value: Building operation	100	50	5.0	2.5
Target Value: Mobility	-	35	-	5.5
Total Target Value	**-**	**115**	**-**	**16.5**

TABLE OF CONTENTS

List of Figures

List Of Tables

GLOSSARY

Primary energy (source energy)
Primary energy is defined as the raw energy found in nature. It has not been subject to any technical conversion process or transportation. Examples: Crude oil, natural gas or coal deposits, uncut timber, solar radiation, potential hydropower in bodies of water, kinetic energy from wind. Primary energy includes non-renewable and renewable sources.

Secondary energy (energy carriers)
Secondary energy sources are sometimes referred to as energy carriers since they move useable energy from one place to another. The two most well known energy carriers are electricity and hydrogen.

Site energy (final energy)
Site energy is defined as the available useable energy on site. It includes all energy delivered to and consumed on site, as well as any energy generated and consumed on site.

Useful energy
Useful energy is defined as the energy that is directly accessible to the user like interior ambient heat and heat reduction (cooling), as well as hot water at the tap.

Non-renewable primary energy
Primary (source) energy contained in finite non-renewable sources, which are depleted in the process of extraction like uranium, crude oil, natural gas and coal.

Renewable primary energy
Primary (source) energy contained in virtually limitless sources that are not depleted in the process of extraction like (thermal and photovoltaic) solar, ambient and wind energy, hydropower, as well as biomass.

Lighting
Lighting of interior and exterior spaces (architectural and decorative lights, security and emergency lights, exterior lights, etc.)

Building services
Operation of equipment deployed to enable the use of the spaces in which it is installed, or which it serves (excluding lighting, ventilation and air conditioning). Building services include large and small household appliances, consumer electronics, as well as office and communication equipment.

Miscellaneous building services
Transportation of people and goods, as well as miscellaneous building service systems.

Embodied energy
Embodied energy is the sum of non-renewable primary energy inputs (fuels/power, materials, human resources, etc.) that was used in the work to make any product. Embodied energy requires an accounting methodology which aims to find the sum total of the energy necessary for an entire product lifecycle. This lifecycle includes raw material extraction, transport, manufacture, assembly, installation, disassembly, deconstruction and/or decomposition. Due to its amortization period, embodied energy is typically calculated on a per-year basis.

Greenhouse gas (GHG) emissions
Amount of greenhouse gases which are emitted as a result of the delivery of net primary energy to site.

1 INTRODUCTION

Residential, commercial and institutional buildings account for almost 35% of greenhouse gas (GHG) emissions from BC communities[6]. Tackling GHG emissions from buildings is a critical component to achieving Provincial and municipal goals for substantial GHG reduction and long-term sustainability in BC. In particular, the City of Vancouver has established a goal for all new buildings to be carbon neutral by 2020, which sets a timeline for building performance that was an important driver of this study. The willingness of the City of Vancouver to participate and to supply robust baseline data was also an important consideration for the study.

Based on the outcomes of a March 2012 workshop in Vancouver organized by the Swiss Business Hub Canada and the Swiss Canadian Chamber of Commerce (BC), attended by development and design professionals from across the City, it was clear that a new framework would be required if our carbon neutral building goals were to be met.

The ultimate goal of this project is to develop such a framework to translate local governments' low- carbon and carbon neutral policy goals into an effective, actionable and measurable mechanism for building owners consistent with the business of real estate development. It is hoped that the framework will:

- Assist municipalities to develop policy tools to support effective and timely market adoption within the BC context
- Educate owners, developers, design consultants and planners on how to execute projects which achieve carbon policy goals
- Show that the energy and carbon goals are achievable, identifying potential barriers to adoption including technical and financial implications

Defining 'Carbon Neutrality"

The **City of Vancouver** describes carbon neutrality as being, "*[A]chieved through a process of measuring emissions, reducing use of carbon-based energy sources and producing the required energy through renewable means or offsetting any emissions such that there is no net carbon emitted through the operation of a building"*[a]

The **Province of BC** states that "[C]arbon neutrality is about achieving net-zero greenhouse gas emissions."[b], and notes that this is achieved first by reducing energy consumption and greenhouse gas emissions and then offsetting the remaining emissions.

The **Canadian Standards Association** (CSA) Registered Carbon Neutral™ labelling program for buildings[c] defines carbon neutral as "*The achievement of zero net GHG emissions from a specified Organization or Building. This is achieved by measuring GHG emissions and then – for all emissions identified – offsetting through the retirement of an equivalent amount of qualifying verified emission reductions or removals. Carbon neutral is not the same as zero emissions."*

The **European Union** requires that by December 31, 2020, all new buildings are nearly zero-energy buildings, which are defined as "a building that has a very high energy performance…. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby."

What is a 'Carbon Neutral' Building?

As the market shifts worldwide, especially in Europe, to carbon-based building policy, various definitions of a carbon-neutral building have emerged (see sidebar). The common theme in these definitions is recognition that striving for lower carbon emissions is generally achieved through the reduction of energy consumption to the point where the remaining demand can be largely met by renewable (low carbon) energy sources. These strategies greatly reduce the carbon intensity of buildings, but generally do not result in either zero net energy buildings, or in technically zero carbon or carbon neutral buildings.

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[6] 2008. British Columbia Greenhouse Gas Inventory Report

For this framework, carbon neutral buildings refer to those with significantly reduced energy consumption combined with the increased use of low carbon energy sources to meet the remaining demand. This definition is consistent with existing Provincial and municipal regulations e.g., the City of Vancouver, in BC. The framework will not address carbon offsets, as these are best addressed outside the building regulatory process.

Report Structure

This report is structured as follows:

- **Introduction**: project overview and definition of 'carbon neutrality';
- **Study Scope**: rationale for focusing on high-rise multi-unit residential buildings (MURBs) and the southern coastal climate, and an overview of the study process;
- **BC's Carbon Profile and Goals**: progress to date with respect to Provincial and municipal carbon-based policy and goals, including highlights from the City of Vancouver
- **Barriers on the Path to Carbon Neutral Buildings:** brief review of policy and market barriers, concluding with a discussion of how those challenges influenced this framework
- **Best Practices Leading to Carbon Neutral Buildings**: brief overview of selected best policy and building practices, with a focus on Switzerland, concluding with a discussion of how those best practices have shaped this framework
- **Framework for Low Carbon High-Rise MURBs**: framework itself, comprising
    - Baseline for high-rise MURB energy and carbon performance
    - Targets for high-rise MURB energy and carbon performance
    - Scenario analysis for a hypothetical Vancouver high-rise MURB
- **Advancing the Framework**: A discussion of possible actions needed to implement this framework as well as to adapt it to develop frameworks for other typologies and to other BC climate zones.

The report concludes with a Bibliography, and an Appendix containing technical background information.

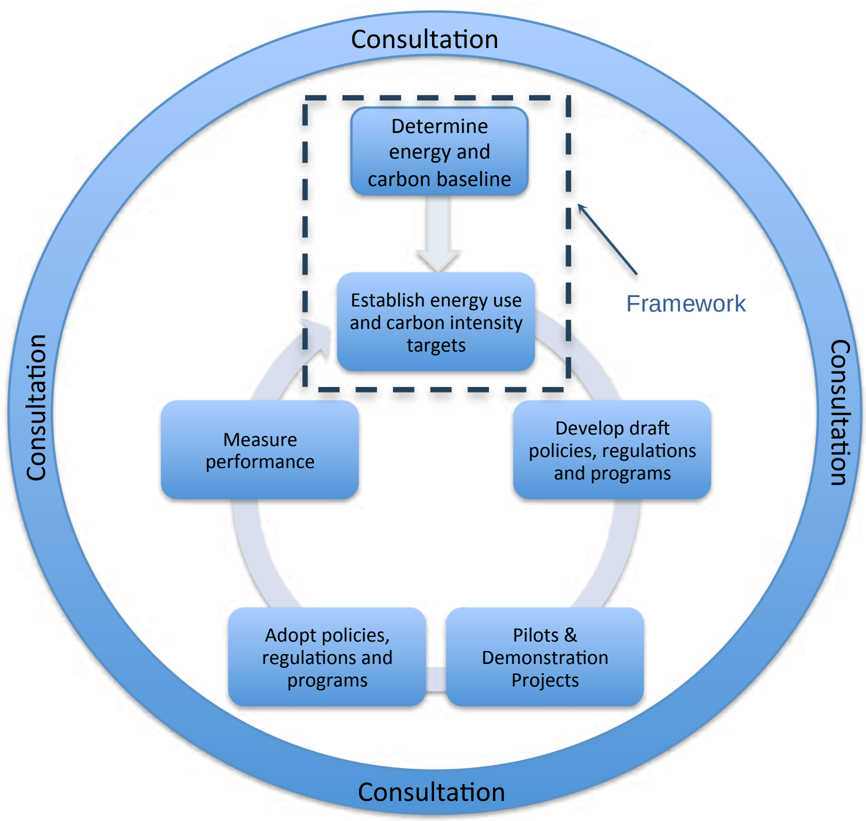
2 REPORT SCOPE

2.1 REPORT CONTEXT

As shown in Figure 1, this report represents the first phase of work of a much larger effort required to engage municipalities across the province in carbon neutral building. The framework presented herein will need to be expanded to other building typologies and to consider other BC climate zones. ASHRAE assigns four climate zones to BC; the BC Ministry of Environment lists five climate zones (Coast Mountains and Islands; Interior Plateau; Columbia Mountains and Southern Rockies; Northern and Central Plateaus and Mountains; and Great Plains). In addition, advancing the framework will require complementary policy and regulatory changes at the local and provincial government levels. While this report provides some important considerations and options for such policy and regulatory changes, the scope of work does not extend into the development of such policies and regulations.

FIGURE 1:

PROCESS FOR MOVING TOWARDS CARBON NEUTRAL BUILDINGS IN BC



2.2 HIGH-RISE MULTI-UNIT RESIDENTIAL BUILDINGS

This report addresses high-rise multi-unit residential buildings (MURBs) only, which represent an important and growing typology for municipalities in BC. In Vancouver, currently the largest urban centre in BC, 25% of all dwelling units are in buildings higher than 5 storeys. High-rise MURBs also make an important contribution towards meeting sustainable community objectives. Finally, the City of Vancouver's goal for carbon neutral buildings by 2020 places particular pressure on high-rise MURB developers, as high-rise MURBs have especially long development timelines.

2.3 BC SOUTH COAST

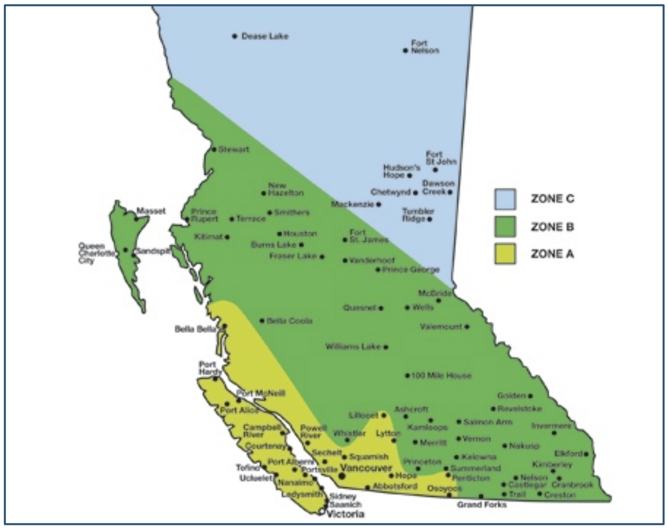
While the overall approach demonstrated in this report is transferable, the quantitative aspects of the framework presented in this report are specific to the BC southern coastal climate. That said, the quantitative aspects will provide a useful reference point for other BC climates.

As noted earlier, the City of Vancouver (Vancouver) is the first municipality to establish a timeline for achieving carbon neutral buildings, with a goal for all new buildings to be carbon neutral by 2020. In addition, the City of Vancouver has empirical data of high-rise MURB energy consumption that can be used as a performance baseline[7]. Therefore, Vancouver makes an excellent reference point for the development of a carbon neutral building framework in BC.

Performance targets for buildings in Vancouver will be relevant for buildings in the same climate zone as Vancouver – the southern coastal climate characterised as ENERGY STAR® climate zone A (see Figure 2.)

FIGURE 2:

ENERGY STAR® CLIMATE ZONES IN BC



2.4 PROCESS

The research and analysis feeding this report are based on four major components:

1. **Best practices:** Research was undertaken to examine international best practices and trends in building-related energy efficiency and carbon emission reduction policy. This work also included a qualitative analysis of issues, gaps and challenges between current standards and carbon-based policies in effect in Switzerland, which has had internationally recognized success in reducing carbon emissions from buildings. The findings were derived from a review of government reports and statistics, reports from industry associations, academic papers, and recent media articles.

2. **Data collection:** Data was compiled from a number of sources including the City of Vancouver, BC Hydro, Natural Resources Canada, the Swiss Society of Engineers and Architects (SIA) and a range of Canadian and international publications. They were used to develop assumptions about the anticipated policy and business impacts on energy efficiency in high-rise residential buildings for the energy and carbon emissions modeling component of the report.

3. **Energy and carbon emissions scenario analysis:** Benchmarking of current energy consumption and carbon emissions performance of high-rise MURBs was undertaken to provide a measurable starting point for the study and to provide a means to gauge the degree of "stretch" required to achieve the carbon neutrality goal. Carbon emissions were then forecast by extrapolating from proven Swiss standards.

[7] RDH Building Engineering Ltd, Enersys Analytics, et al. Energy Consumption and Conservation in Mid and High Rise Residential Buildings in British Columbia. May 2011. This research study was undertaken to assess the impacts of building enclosure rehabilitations on the energy consumption of mid- to high-rise (5 to 33 storey) multi-unit residential buildings. The study reviewed and assessed the actual energy consumption of multi-unit residential buildings, and the impacts of building enclosure rehabilitation related improvements on overall energy consumption. The information presented in RDH Engineering's report provides much of the baseline data for this study.

4. **Stakeholder consultation**: Individual stakeholder consultations were also used to inform the process. In particular, the City of Vancouver, Solterra Group of Companies, and the Urban Development Institute provided advice from the perspectives of municipal regulator and high-rise MURB developer. The draft report was also subject to a technical review by the Pembina Institute and the BC Building and Safety Standards Branch.

This work was then used to develop the framework (baseline and targets), and inform the financial analysis and considerations for advancing the framework.

3 BC'S CARBON PROFILE AND GOALS

3.1 PROVINCIAL & COMMUNITY CARBON PROFILE AND GOALS

In BC, reducing GHG emissions has become an important policy objective. Provincially, Bill 44, 2007[8] - the "Greenhouse Gas Reductions Target Act" - puts into law BC's target of reducing GHGs by at least 33% below 2007 levels by 2020 and includes the long-term target of an 80% reduction below 2007 levels by 2050. According to the BC Office of Housing and Construction Standards, residential space heating and cooling, water heating and the operation of appliances, electronic equipment and lighting account for approximately 17% of energy use in BC[9]. In 2008 (the most recent GHG emissions inventory), residential, commercial and institutional buildings accounted for almost 35% of GHG emissions from BC communities[10]. Table 1 presents the percentage of GHG emissions attributed to buildings from selected BC municipalities.

TABLE 1:

GHGS FROM ALL BUILDINGS IN SELECTED BC MUNICIPALITIES

City	% GHG emission from building sector[1]	City	% GHG emission from building sector[1]	City	% GHG emission from building sector[1]
Abbotsford	29.3%	Kamloops	29.2%	Richmond	39.5%
Burnaby	40.9%	Kelowna	27.8%	Saanich	33.9%
Chilliwack	32.2%	Nanaimo	28.4%	Surrey	34.5%
Coquitlam	40.4%	New Westminster	41.4%	Vernon	30.8%
Delta	38.2%	North Vancouver	48.8%	Victoria	51.5%
Fort St. John	25.9%	Prince George	33.0%	West Vancouver	53.5%

[1] *Community Energy and Emissions Inventory, http://www.env.gov.bc.ca/cas/mitigation/ceei/reports.html*

The 2007 BC Energy Plan[11] proposes aggressive targets for zero net greenhouse gas emissions and new investments in innovation. Of the plan's fifty-five policy actions, the following set the context for local governments' green building initiatives:

[8] BC Greenhouse Gas Reduction Targets Act
[9] BC Office of Housing and Construction Standards website, http://www.housing.gov.bc.ca/building/green
[10] 2008. British Columbia Greenhouse Gas Inventory Report
[11] BC Ministry of Energy, Mines and Petroleum Resources. *BC Energy Plan: A Vision for Clean Energy Leadership*

- All new electricity projects developed in BC will have zero net greenhouse gas emissions.
- Existing thermal generation power plants will reach zero net GHG emissions by 2016.
- Zero greenhouse gas emissions from coal-fired electricity generation.
- Clean or renewable electricity generation will continue to account for at least 90 per cent of total generation.
- Acquire 50% of BC Hydro's incremental resource needs through conservation by 2020.
- New energy efficiency standards to be implemented for buildings by 2010[12].
- To encourage clean or high efficiency cogeneration, BC Hydro is establishing a standing offer program with a set purchase price for power projects up to 10 megawatts.

The provincial government is responsible for the BC Building Code, which regulates safety in the design, construction and occupancy of buildings. In 2008, the BC Building Code was updated to include minimum energy standards for buildings. High-rise MURBs fall under Part 3 of the BC Building Code, which references ASHRAE[13] 90.1 (2004) or equivalent for energy efficiency.

The BC carbon tax came into effect July 1, 2008 and is currently fixed at \$30/tonne CO_2e. The Ministry of Finance estimated that the tax would save up to three million tonnes of CO_2 emissions annually. The tax applies to the purchase or use of fossil fuels within the province.

The adoption of the Local Government (Green Communities) Statutes Amendment Act (Bill 27, 2008) requires local governments to include targets, policies and actions for the reduction of GHGs emissions in their Official Community Plans by May 31, 2010[14]. Also, most BC communities have made the commitment to become carbon neutral by 2012. Out of 188 municipalities, 180 have signed the British Columbia Climate Action Charter[15], committing to measure and report on their community's GHG emissions profile.

Taken together, BC's energy and climate change policies represent an unequivocal commitment to GHG emission reduction and green buildings. Given the comprehensive suite of plans, codes and investments already in place, it is difficult to imagine a substantial deviation or retreat from the declared carbon emission reduction trajectory in the future.

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[12] B.C. Office of Housing and Construction Standards, Greening the Building Code website http://www.housing.gov.bc.ca/building/green/

[13] The ASHRAE standard is administered by the American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) and applies to the building envelope as well as the majority of mechanical and lighting systems.

[14] Green building and sustainable development policies and regulations are collated and summarized on the B.C. Climate Action Toolkit website, http://toolkit.bc.ca

[15] BC Climate Action Charter

3.2 CITY OF VANCOUVER'S CARBON PROFILE AND GOALS

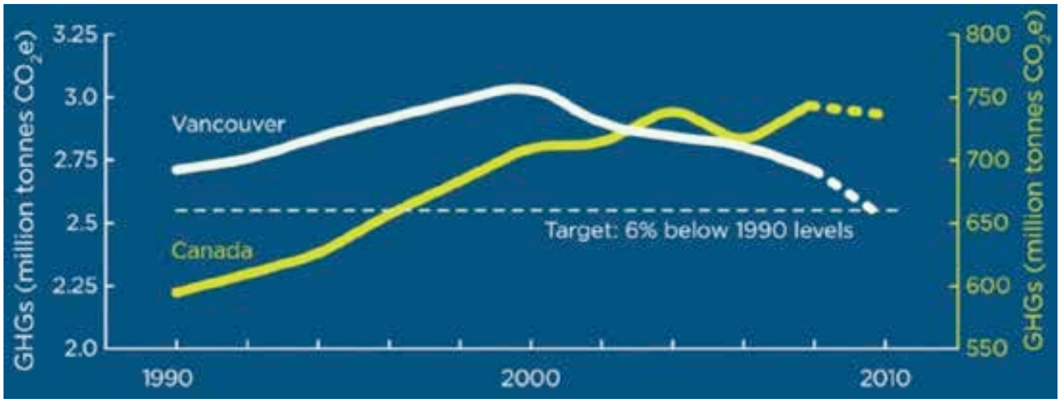
The City of Vancouver is BC's most populous municipality, with a population of approximately 603,000 people[16]. Recognized worldwide for its leadership in sustainability, the City of Vancouver has already legislated a number of GHG emission reduction targets[17]:

- **City operations** - 20 per cent below 1990 levels by 2010 (achieved).
- **City operations** - carbon neutral by 2012
- **Community emissions** - 6 per cent below 1990 levels by 2012 (on track); 33 per cent below 2007 levels by 2020; 80 per cent below 1990 levels by 2050.

Based on the City's 2008 GHG emissions inventory, buildings account for 55% of the city's GHG emissions[18]. Therefore, to achieve many of the above gross targets, the City of Vancouver has focused on the building sector.

FIGURE 3

CANADA AND VANCOUVER GHG EMISSION REDUCTION TARGETS (SOURCE: CITY OF VANCOUVER)



The City is unique in BC that is governed by the Vancouver Charter[19], a provincial statute that enables the City to effect legislation including building and energy code bylaws. As a result, the Vancouver Building By-law has been updated to higher levels of energy efficiency than those expressed in the BC Building Code. Currently, the Vancouver Building By-law references ASHRAE 90.1 (2007) for high-rise residential buildings, with planned updates to ASHRAE 90.1 (2010) in 2012.

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[16] Census 2011 http://en.wikipedia.org/wiki/Vancouver and Vancouver Population Trends http://vancouver.ca/commsvcs/planning/stats/poptrends/index.htm
[17] The City of Vancouver's website provides details of the various GHG emission reduction policies http://vancouver.ca. However, the City s also a member of the United Nations Environment Program's Climate Neutral Network, which summarizes the various policies at http://www.unep.org/CLIMATENEUTRAL
[18] City of Vancouver, *2008 Greenhouse Gas Emissions Inventory Summary and Methodologies*
[19] Vancouver Charter, http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/vanch_00

In 2011, the City amended its policy for "Higher Buildings"[20]. It now requires all Higher Buildings must significantly demonstrate and advance the city's objective for carbon neutrality for new buildings with a stated objective to achieve a 40-50% reduction in energy consumption from 2010 levels. The City anticipates that this standard would result in an energy use intensity of approximately 115 kWh/(m^2y) for high-rise residential buildings.

In addition, City Council endorsed the Greenest City Action Plan[21] in 2009, which sets out a bold vision to be the greenest city in the world by 2020. The plan sets out 10 long-term sustainability goals. Of particular relevance to this study is a target for ***all new construction to be carbon neutral by 2020.*** To achieve this, the City projects reducing building energy consumption by 50%, then meeting the entire remaining demand with renewable energy.

4 BARRIERS TO CARBON NEUTRAL HIGH-RISE MURBS IN BC

4.1 MURB DEVELOPMENT PROCESS

For MURBs, the process from design to construction to operation is complex, fragmented, and involves many players, each of which has limited control on the overall process. Designers have only limited control of the construction and commissioning processes and almost no control over building operations. Contractors and operators have even less influence on those elements of building design that affect energy performance.

Perhaps most critical, though, is the developer's lack of ongoing involvement in the building once it is complete. The developer relinquishes control (and, therefore, responsibility) shortly after occupancy. Even with rental MURBs, the developer and owner are frequently different corporate entities. Ongoing management of operations is placed in the hands of a building management ("Strata") council, which in turn, hires a property management company. From the regulatory perspective, it is extremely difficult to enforce energy standards that require many months of post-occupancy data to prove compliance with policy standards. It is also difficult to hold a developer accountable for the actions of individual occupants with whom they have no contractual relationship. As a result, insurance and legal experts advise that there are liabilities associated with performance standards that cannot be confirmed until after the developer has left the project.

Given the situation described above, MURB developers are particularly interested in how the goal of low-carbon and/or carbon neutral buildings is articulated in terms of concrete performance criteria, building features and systems, roles and responsibilities as well as the implications for development timeframes and costs.

4.2 LIMITATIONS OF ASHRAE

ASHRAE 90.1 is an energy standard establishing minimum requirements for building energy performance. ASHRAE 90.1 was first published in 2001, with major updates in 2004, 2007, and 2010. Generally the standard covers the building envelope as well as most mechanical and lighting systems. ASHRAE 90.1 is applicable to MURBS greater than 3 storeys, but is not applicable to single-family homes or MURBs 3 storeys or less. The standard now comprises several prescriptive technology and design requirements with respect to building envelope design and HVAC system requirements. There are also minimum efficiency requirements for certain building systems equipment.

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[20] City of Vancouver, General Policy for Higher Buildings, amended February 1, 2011, http://vancouver.ca/commsvcs/guidelines/H005.pdf
[21] City of Vancouver, Greenest City 2020 website

ASHRAE 90.1 is the basis for energy performance requirements of the BC Building Code and Vancouver Building By-law, as well as for the Model National Energy Code for Buildings. However, when it comes to regulation and enforcement, both industry and regulators concur that ASHRAE 90.1 is complex, expensive and difficult to enforce. One of the key shortcomings is its lack of concrete holistic energy performance targets i.e., targets expressed as kWh per m^2. Rather than offer consistent, comparable and quantitative metrics, it measures relative design energy against a modelled baseline. Although the model attempts to predict actual performance, it allows for trade-offs and “work-arounds” for simulating the performance of design elements that are not pre-set in the software. While this provides some flexibility, the result is building-specific models that cannot be readily benchmarked.

This approach creates moving goal posts, in that the baseline energy performances of two 20 storey, 150,000 ft^2 MURBs are very likely to be completely different. Correspondingly, if each building designer set a goal of being 40% more efficient than the standard, the final energy (and by extension, carbon) performance of these two buildings can, and most likely would, be quite different.

It is also interesting to note that ASHRAE 90.1 exempts the consideration of some fairly typical high-rise residential components such as balcony slab edges, a major thermal bridge, from energy performance calculations and models.

4.3 THIRD PARTY RATING SYSTEMS

Some municipalities have opted to leverage third party rating systems such as LEED®, the Living Building Challenge® (LBC) and BuiltGreen™ to create policy and regulations designed to foster more energy efficient / less carbon intensive buildings. There have been challenges with this approach in terms of alignment to community priorities, length of time for certification, and cost to developers as well as with respect to regulatory review.

While these systems may work for certain building owners, the high-rise development industry requires regulations to proceed in sync with the design and construction process. LEED® and LBC® particularly require lengthy post-occupancy reviews. The particular challenge with LEED® (the most common tool for green building regulatory support) is that it references ASHRAE 90.1, and thereby suffers the shortcomings cited above. Notably, it specifically does not address carbon emissions.

In addition, the development industry has expressed some concern that reliance on third-party rating systems may be perceived as the offloading of regulatory approval responsibilities.

4.4 ENVELOPE PERFORMANCE

BC is believed to have the poorest average air leakage performance in Canada[22]. Improving air tightness requires attention to the façade assembly from the design stage through construction to the pressurization test at building prior to occupancy. While moisture control is considered as part of current building envelope design in BC, thermal performance is only indirectly considered and air tightness testing is not current standard practice. Further, addressing air leakage is not a mandatory part of the usual building deficiency process.

A poor air tightness testing result provides some of the most direct feedback to a building developer regarding the building performance; such testing helps to educate developers who are interested in improving building performance.

Any framework should incorporate mandatory air leakage testing to be effective; otherwise, other changes to insulation or mechanical systems will be undermined.

[22] Personal communication, John Nicol, Building and Safety Standards Branch

4.5 HIGH-RISE MURB PERFORMANCE DATA QUALITY & AVAILABILITY

This study was supported by the high-rise MURB energy performance data previously gathered by the City of Vancouver[23]. The availability of such baseline data facilitated the benchmarking of current design practice; establishment of a high-rise MURB energy and carbon performance baseline; determination of the resulting performance targets; and evaluation of the degree of stretch necessary to achieve the proposed targets.

However, generally, local governments do not consistently gather actual measurable data from recently completed buildings. This is partly due to the reliance on third party rating systems, which do not deliver quantitative and comparable performance data (see above), as a way to implement policies. The challenge is exacerbated by the number of different metrics and modelling procedures in use and the tendency to present energy performance as a relative value rather than as an absolute measure.

4.6 OVERCOMING THE BARRIERS

Considering the challenges, the policy framework should:

- **Create a level playing field** by establishing clear, absolute, measurable, and common high-rise MURB energy and carbon performance targets;
- **Reflect the development process** by ensuring that any standards developed to reflect such targets can be readily applied through regulation of development prior to occupancy (e.g., not requiring a lengthy post-occupancy review to determine compliance);
- **Not require certification** by a third-party rating system;
- **Be easily administered** and enforced by regulators;
- **Improve envelope performance** design and measurement; and
- **Support the establishment and continuous improvement of carbon-neutral building policy** by facilitating the collection of building energy performance data that will allow for benchmarking and the evaluation of success (or failure) of carbon-neutral building policy

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[23] RDH Building Engineering Ltd, Enersys Analytics, et al. Energy Consumption and Conservation in Mid and High Rise Residential Buildings in British Columbia. May 2011. This research study was undertaken to assess the impacts of building enclosure rehabilitations on the energy consumption of mid- to high-rise (5 to 33 storey) multi-unit residential buildings. The study reviewed and assessed the actual energy consumption of multi-unit residential buildings, and the impacts of building enclosure rehabilitation related improvements on overall energy consumption. The information presented in RDH Engineering's report provides much of the baseline data for this study.

5 BEST PRACTICES IN CARBON-BASED BUILDING POLICY: LOOKING TOWARDS EUROPE

5.1 EUROPEAN CONTEXT

There is an emerging global trend towards quantitative intensity-based building energy performance standards and an expansion of the scope of performance metrics to include GHG emissions. Carbon-based building policies are still new concepts in North America. Therefore, it is necessary to seek best practice examples from elsewhere.

A number of European countries are leading this effort globally. Those in the European Union fall under the EU Energy Performance of Buildings Directive (2010), which generally requires that member states establish quantitative targets for primary energy (kWh/m^{2}y), thereby formalizing the concept of energy system boundaries and principles of primary, secondary and site energy[24] (see section 5.1.1).

However, when it comes to the successful establishment of specific carbon-based building standards that are proving to actually deliver measurably low-carbon buildings, Switzerland has one of the longest and most successful track record. Swiss building stock now comprises some of the most energy efficient buildings in the world (of all different types, including high-rise MURBs). Therefore, best practices from Switzerland were explored in more depth (see section 5.2)

5.1.1 Defining System Boundaries & Understanding Energy Flows

European energy performance building calculations and targets are based on an approach to clearly defining energy system boundaries. It is important to consider the upstream production and transmission impacts of the energy that is consumed in a building in order to clearly understand and fully quantify energy and carbon performance. It is also necessary to take into account not only how the energy is used (energy utilization) but also the impacts of how it arrives at the building (energy flow) in order that the right energy source is used for the appropriate purpose:

> **Energy flow:** energy flows from the point of generation to its final use within the building and the stages of conversion along the way. It is important to consider the GHG emissions associated with the energy flows in order to encourage the best available fuel use choices from the climate change policy perspective.
>
> **Energy utilization:** there are numerous users of energy within a building. The size and functionality of equipment and appliances is determined by the building's configuration, orientation and location. Occupant behaviour and building operation are also key determinants of energy utilization.

As shown in Figure 4, the flow, conversion, and use of energy within the system can be classified into primary energy, secondary energy, site energy, and useful energy as follows:

> **Primary energy** (also known as source energy) is defined as the raw energy found in nature. It is energy that is embodied in sources which involve human induced extraction or capture, that may include separation from contiguous material, cleaning or grading, to make the energy available for trade, use or transformation. Primary energy can be non-renewable or renewable. Non-renewable primary energy is found in sources that are finite like crude

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[24] In January 2012, the European Parliament adopted a supplement to the Energy Performance of Buildings Directive (2010) which establishes a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements. Specifically, the directive requires that member states must establish quantitative metrics for primary energy (kWh/m^{2}y) thereby formalizing the concept of energy system boundaries and principles of primary, secondary and site energy.

oil, uranium, or coal. Renewable primary energy is found in sources like water, solar radiation or wind.

Secondary energy is energy embodied in commodities that comes from human induced energy transformation such as petroleum products, biofuels, electricity, etc. Secondary sources are sometimes referred to as energy carriers since they move useable energy from one place to another.

Site energy (also known as final or delivered energy) is defined as the measurable energy supply for the building site, which is used to power any consumers necessary to operate it. Site energy sources are natural gas, fuel oil, district heat or electricity. Renewable energy produced on site (e.g. solar photovoltaic) does not reduce the site energy count. It can however reduce the primary energy input as well as the GHG emissions or carbon footprint.

Useful energy is defined as the energy that is directly accessible to the user. Useful energy includes space heat, domestic hot water or lighting.

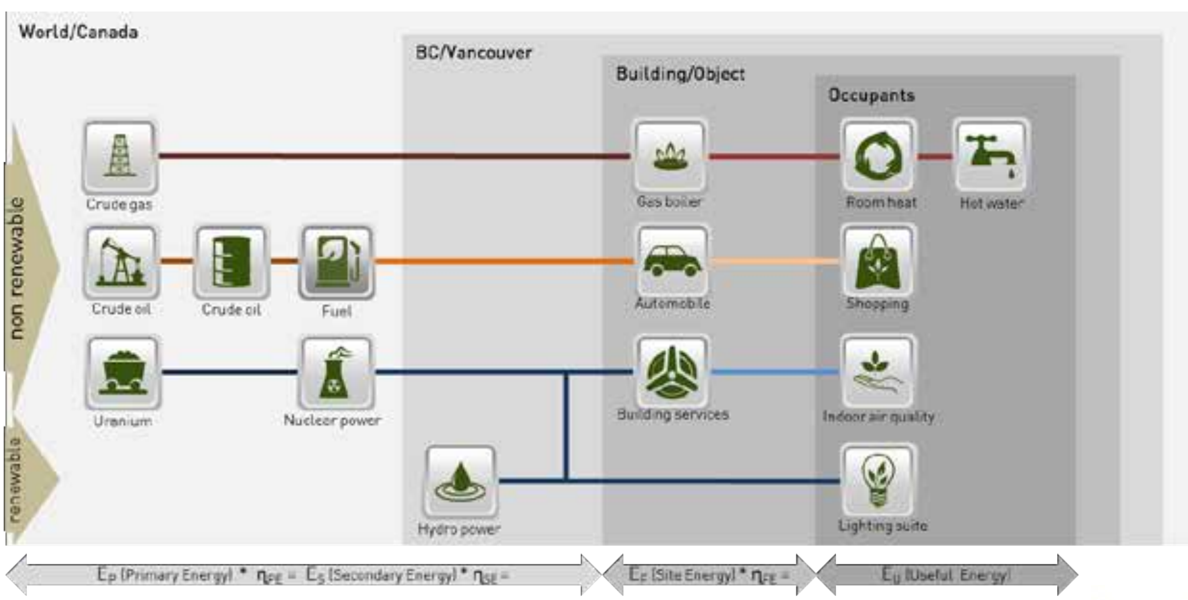
Building operation requires different types of energy such as natural gas, fuel oil and electricity. In general these types of energy rely on conversion of primary (source) energy into site energy and useful energy. Because the achievement of climate change goals is based on a combination of reduction measures at all stages of the conversion process, it is important to understand the differences between the various stages of energy and the consequent GHG emission impacts.

The most important implication of this approach is that it distinguishes between those energy flows that are defined by building design and those that are dictated by user behaviour. This last distinction is important, given that high-rise MURBs in BC are developed speculatively, with the developer playing no role in the operation and maintenance of the building.

A technical overview of these concepts is presented in the Appendix.

FIGURE 4

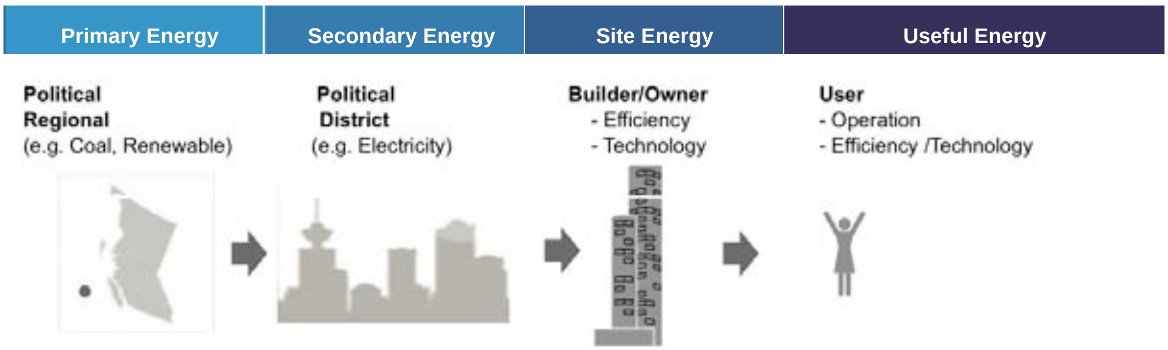
DEFINING THE ENERGY FLOW SYSTEM



An overview of how carbon-based building policy relates across the system of energy flows is presented in Figure 5.

FIGURE 5

RELATIONSHIP OF CARBON-BASED POLICY ACROSS THE ENERGY FLOW SYSTEM



5.1.2 Energy Factors and GHG Coefficients

For policy purposes, the calculation of energy and related GHG emissions relies on the development and adoption of energy factors and GHG coefficients, which are then used in calculations to demonstrate policy compliance. The factors are developed on a regional basis to ensure fairness, parity and comparability as defined below:

> **Primary energy factors:** are developed to appropriately allocate the impacts of the various primary energy inputs. Lower factors represent a lower impact.
>
> **Utilization levels:** present the utilization levels (ratio of heat demand to heating energy demand) used in Switzerland. They include heat loss during heat generation, distribution and storage) of domestic hot water heaters and new high-quality heating plants without domestic hot water production.

While it is clearly optimal to work with manufacturers and utilities to determine accurate levels, so long as all parties use the same information, a consistent and comparable approach to policy administration is established. This supports the creation of an energy standard rating for the building, which is determined ***prior*** to occupancy. It delivers energy consumption and carbon emission metrics that regulators can use for community reporting and trend analysis.

5.1.3 Understanding Energy Use Demands

There are various demands on the energy delivered to a building in terms of both quality and quantity. The energy demand for high-rise MURBs can be separated into discrete groups of consumers in Table 2.

TABLE 2

DEFINITIONS OF ENERGY USE DEMANDS

Energy use	Definition	
Heating	Includes energy demand for **space heating** and **domestic hot water** - calculated at the useful energy stage. Both can be converted to site energy demand with the help of the respective utilization levels and conversion losses. The useful energy demand for heating can be covered in whole or part by local production from renewable energy systems (e.g. solar thermal) within the limits of the energy calculation. The deployment of renewable systems for electricity production can be used to offset site energy outside of the limits of the energy calculation.	
Space heat	*Energy demand of the equipment used to generate space heat and to preheat ventilation air.*	
Domestic hot water	*Energy demand of domestic hot water heating.*	
Ventilation, air conditioning	"Cooling energy" includes the energy demand for **ventilation, cooling and dehumidification** as well as **humidification**. Cooling energy demand is calculated at the useful energy stage and can be converted to site energy demand with the aid of the respective utilization levels for the cooling system in use.	
Ventilation	*Electrical energy demand of equipment used to move air in mechanical ventilation systems including electrical components for heat recovery, pumps, etc.*	
Cooling/ dehumidification	*Energy demand of equipment used to cool and dehumidify interior ambient air, including demand of cooling coils, pumps and fans.*	
Humidification	*Energy demand of equipment used to humidify interior ambient air including demand for various humidification sources (e.g. steam, mist).*	
Building services	Includes the electrical energy demand for **lighting, building services** (base building consumption), as well as in-suite **appliances** and **equipment** (occupant consumption). The demand of this group of consumers equals the site energy.	
	Base building consumption	**Occupant consumption**
Lighting	*The energy demand of artificial lighting for common spaces.*	*The energy demand of artificial lighting for in-suite spaces.*
Equipment	*Energy demand of equipment deployed to enable the use of the spaces in which it is installed, or which it serves (e.g. pool pumps).*	*Energy demand of equipment deployed to enable the use of the spaces in which it is installed or which it serves (e.g. dishwasher, TVs, etc).*
Miscellaneous building services	*Energy demand of auxiliary equipment used for space and domestic hot water heating, moving people and goods (e.g. elevators), as well as other technical building systems*	

5.2 SWISS BUILDING PROGRAMS

5.2.1 Why Switzerland?

Switzerland has been leading the world in low carbon technologies, green buildings and sustainable transportation for a number of years. It has been repeatedly rated number 1 in the world in the biannual Environmental Performance Index issued by the Yale University Center for Environmental Law and Policy[25].

There are also similarities in the structure and authority of building energy codes. Similar to Canada, Swiss energy codes are defined at the “Kanton” (provincial/state) level and make reference to national association-based standards and guidelines (Swiss Architect and Engineer Association (SIA)). Yet, Swiss building codes are among the most stringent in the world and Switzerland has been leading the development of low-carbon building standards.

Swiss experience shows that it is prudent to establish regulatory parameters in such a way that the construction market has maximum flexibility in the way that it responds to the challenges. This is most effectively accomplished by regulating at either end of the energy flow process and letting the design team determine the best response for their project. Further, this approach clearly distinguishes between those energy uses that are defined by building design (which fall under building regulations) and those that are dictated by user behaviour (which are managed through other policy mechanisms).

Switzerland’s regulatory system provides a good role model for BC in the effective delivery simple, measurable, comparable and enforceable building energy performance predictions in a way that offers maximum flexibility to industry.

In addition, there are similarities between the southern portion of BC and Switzerland in terms of climate and a reliance on hydro electricity. As shown on Figure 6, the City of Zürich provides a comparable model to Vancouver in terms of geographic size, population and density. The City of Zürich has adopted the 2,000-Watt Society (see below) as the primary policy directive that takes low carbon building design, construction and operation to performance levels that are close to carbon neutral.

[25] http://epi.yale.edu/epi2012/rankings

FIGURE 6

GEO-CLIMATIC COMPARISON BETWEEN VANCOUVER AND ZÜRICH

	Vancouver	Zürich
		
Population	603,502	372,047
Area	$115km^2$	$92km^2$
Electricity supply	90% hydro, 10% fossil	60% hydro, 40% nuclear
Heating degree days	2,364	2,683

5.2.2 Swiss Building Programs

While the intention of this study is not to propose or promote a third party rating system, it is instructive to review Swiss experiences in advancing low-carbon buildings and the various standards that support their policy goals. The 2,000-Watt Society articulates a quantitative yet equitable energy vision for Switzerland. The MINERGIE® energy rating standard has been in place longer than many North American systems and has been very successful at supporting clear policy goals and delivering desired standards.

2,000-Watt Society

The 2,000-Watt Society energy vision was developed by the Swiss Federal Institute of Technology in order to support a balance between industrialized and developing countries and thus make it possible for all people to enjoy a good standard of living. The concept is based on each person in the developed world cutting their overall energy consumption to the current world average of 2,000 Watts per day, without lowering their standard of living. The 2,000-Watt-Society takes a holistic approach to carbon neutrality. A building's carbon footprint includes its construction, retrofits, maintenance and operation during use, as well as deconstruction at the end of its useful life. Embodied energy and associated GHG emissions from the manufacture and transportation of building components as well as the footprint created by the building's operation are counted continuously during the building's use. Energy and GHGs related to everyday personal travel and associated transportation infrastructure make up the mobility category and are also included.

The City of Zürich has committed to the vision of the 2,000-Watt Society and has set a 2050 target for GHG emissions from residential building at 16.5 kg CO_2e/m^2y; operation of 2.5 kg CO_2e/m^2y and 8.5 kg CO_2e/m^2y for embodied energy and 5.5 kg CO_2e/m^2y for mobility. The 2,000-Watt Society template offers a policy trajectory and a defined final target.

MINERGIE®

To drive forward carbon emission reduction goals in new buildings and major renovations, the Swiss Confederation, the Swiss cantons and the Principality of Liechtenstein along with some central European businesses and communities are working with the MINERGIE®[26] energy rating standard for new buildings and major renovations.

With over 18,000 MINERGIE® certified buildings, Switzerland is home to some of the most advanced buildings in Europe. MINERGIE® supports lower energy consumption at a high level of comfort. MINERGIE® is used heavily to support policy directives because it is objective-oriented and focused on GHG emissions. It sets a few simple-to-communicate standards that are performance based, thereby leaving design resolution in the hands of the consulting professionals and market forces. However, there are certain minimum standard features and components that are required. They have proven easy to regulate and provide defined energy and carbon emission reduction benefits.

MINERGIE® functions as an energy performance rating standard. It establishes the framework, process and metrics necessary to regulate building energy and carbon emission outcomes and to communicate policy goals. MINERGIE® is not the same as a third party rating system (such as LEED®). An energy performance rating provides both the municipality and the developer with reassurance that the project meets the required standard in a timely manner. In Switzerland, MINERGIE® is also used as a label for public education purposes. While there are advantages to this approach, it is not a necessity. It can be used solely as a regulatory tool, although experience shows that once industry is familiar with the system, it can be used to competitive advantage.

Energy performance ratings are not new. The automobile industry has provided fuel efficiency ratings for vehicles for many years. The public is now conversant with the rating system and how to determine performance and compare data. The ratings assume hypothetical standardized usage and clearly do not try to predict user behaviour. Policies, regulations and education related to fuel-efficient vehicle operation are important but handled elsewhere.

MINERGIE® requires the submission of a detailed quantitative proof of energy performance (for heating, hot water, ventilation and air conditioning). This proof is the core of the regulatory process and comprises a series of spreadsheet-based energy performance reporting forms. These calculations are based on the Swiss standards SIA 380/1 and 380/4 of the Swiss Society of Engineers and Architects (SIA). MINERGIE® is applicable to the high-rise MURB development industry because it follows the conventional development process and limits scope to those factors that are directly affected by the design of the building rather than by the users. It is simple and transparent, yet delivers measureable energy and carbon performance metrics for which the developer can be accountable.

To maintain feasibility and general use, MINERGIE® stipulates that the additional costs must not exceed 10% of the building costs over a comparable code-compliant building. Achieving the 2,000 Watt Society standard requires the adoption of the much more demanding MINERGIE-P® standard.

[26] More information about MINERGIE® is found at www.MINERGIE.ch

5.3 GENERAL PRINCIPLES FOR LOW CARBON DESIGN

With the increased focus nationally and internationally on reducing GHG emissions from buildings, a number of common principles for low carbon design have emerged e.g., from the application of MINERGIE® or as reflected in the Royal Institute of British Architects' Principles of Low Carbon Design and Refurbishment. The key principles related to high-rise MURBs are summarized in Figure 7.

FIGURE 7

DESIGN PRINCIPLES TO REDUCE CARBON EMISSIONS FROM HIGH-RISE MURBS

Principles	Pre-Design	Design	Execution	Operation
High performance envelope to reduce energy demand *Most important energy reduction strategy. Reducing overall energy demand also reduces size and capacity of building systems. Most components that make up the building envelope offer extended lifecycles, which means that a high-performance building envelope is unlikely to require upgrades within 30 to 40 years from construction. High performance envelopes also greatly improve tenant/ user comfort*				
Low surface-to-volume ratio, compact conditioned volumes	●	●		
Optimal use of daylighting, high solar heat gains	●	●		
Minimize air leakage		●	●	
Well insulated building envelope	●	●		
Avoid thermal bridges		●		
High performance mechanical systems to reduce energy demand *It is key to optimize mechanical equipment operation and adjust it to actual use patterns. Systems performance is heavily reliant on an effective and complete commissioning process, which should extend into monitoring and verification. Access to ongoing performance data is very important for fine-tuning policy standards, confirming how well new technologies are working and reporting on actual carbon emission reduction success.*				
Heat recovery system for ventilation	●	●		
Well organized floor plans, wet-room clusters	●	●		
Continuous chases and accessible mechanicals	●	●		
Efficient coverage of energy demand *Reduce distribution losses and increase utilization rates and efficiency of system e.g., well insulated distribution lines, low design temperatures, efficient heat recovery equipment, efficient heat pumps, etc. European heat pump technologies are achieving coefficients of performance (COPs) in excess of 300% compared to 97% for high efficiency gas boilers. Electric resistance heating (e.g. electric baseboard) should be avoided due to the poor primary energy performance. However, it could remain permissible under special circumstances (e.g. historic preservation).*				
Simple and efficient systems		●	●	
Energy-efficient lighting		●	●	

Principles	Pre-Design	Design	Execution	Operation
Energy-efficient equipment and systems			●	
Meet demand with renewable sources *As the amount of energy expended on heating is reduced with the application of improved envelope and efficient system performance, domestic hot water and household electricity become proportionally more significant uses. In energy efficient buildings, renewable energy sources can make economic sense. When incorporated into buildings that have pursued passive design principles, optimized envelope performance and reduced overall energy demand, solar thermal water heating can make a significant and cost-effective contribution. A limitation for renewable energy application in high-rise residential buildings is the relatively small amount of roof area*				
High percentage of renewable energy sources	●	●		
Use of renewable energy sources on site	●	●		
Quality assurance *Quality assurance becomes an important focus during design, bidding and construction.*				
Goal achievement checks during planning, implementation and operation		●	●	●
Optimizing of building services and systems			●	●
Operator / tenant user manuals and education			●	●

Key: Most important … Least important

5.4 APPLICATION OF BEST PRACTICES TO FRAMEWORK

5.4.1 Summary

The best practices were identified for their relevance and applicability to BC high-rise MURBs and to the regulatory processes currently in effect. They were also assessed for their ability to address the challenges identified in achieving the low-carbon goals expressed by BC municipalities. The framework leverages the best practices described as follows:

- **Defines the system boundary and energy flow**, as relied on across most of Europe, to support more relevant target setting;
- **Defines systems that consume building energy** (heating, lighting, etc.), their respective utilization levels, and influences (i.e., building design versus occupant behavior) to create regulatory clarity;
- **Sets absolute energy and carbon performance targets**, drawing on the experience of Switzerland e.g., with MINERGIE®, in setting targets that reflect leadership and practicality;
- **Uses the best practice principles of low carbon high-rise MURB design** to inform the evaluation of the feasibility of proposed energy and carbon performance targets; and
- **References Swiss data** to support the establishment and evaluation of energy and carbon performance targets (see below).

5.4.2 Use of Swiss Data to Develop the Framework

To date, primary energy factors for BC are only available for electricity provided by BC Hydro and for natural gas provided by Fortis BC:

Electricity (provided by BC Hydro): 0.0079 kg/MJ (=0.0284 kg/kWh)

Natural gas (provided by Fortis BC): 0.0755 kg/MJ (=0.2718 kg/kWh)

For the purposes of this study, Swiss primary energy factors and GHG coefficients were used for the benchmarking and target-setting calculations where BC data does not yet exist. While not a perfect match for BC factors, the Swiss factors provide a reasonable approximation of the relative impacts of different fuel sources and represent a good starting point for discussion given the similarity in generation and production. Energy calculations are based on SIA 380/1 for heating energy and SIA 380/4 for electrical uses.

It should be noted that the development of primary energy factors and GHG coefficients for BC needs to be completed and would involve a comprehensive stakeholder process (and, therefore, was outside the scope of this study). However, given the similarities between Switzerland and BC in terms of energy generation mix, climate, etc., it is anticipated that BC factors would be in a similar range.

For reference, selected Swiss primary energy conversion factors and GHG emission coefficients for electricity generation and district heating systems are presented in Table 3, while utilization levels for heating plants and water heaters are presented in Table 4 and Table 5, respectively [SIA 380/1, 2009].

TABLE 3

SELECTED SWISS PRIMARY ENERGY CONVERSION FACTORS AND GHG EMISSION COEFFICIENTS

Method of Production	**Primary Energy Factor** non-renewable source [-]	**GHG Emissions Coefficient** [kg/kWh]
Electricity		
Hydro	0.04	0.014
Photovoltaic	0.40	0.094
Wind	0.11	0.029
Cogeneration, natural gas	3.28	0.738
Heating		
District heat (incl. incinerator heat)	0.80	0.162
Central heat, natural gas	1.56	0.313
Air-to-liquid heat pump, electricity	1.19	0.101
Cogeneration plant, natural gas	0.64	0.137

TABLE 4

UTILIZATION LEVELS OF HEATING-ONLY PLANTS (WITHOUT DOMESTIC HOT WATER PRODUCTION)

Heating Plant	Utilization levels [-]
Oil and natural gas	
Condensing	0.85 … 0.95
Non-condensing	0.80 … 0.90
Wood	
Wood chips, pellets	0.70 … 0.75
Cordwood	0.65 … 0.70
District heat	0.93 … 0.97
Electric resistance	0.93 … 0.97
Electric liquid-to-liquid heat pump	3.40 … 4.70

TABLE 5

UTILIZATION LEVELS OF DOMESTIC HOT WATER HEATERS

Water Heater	Utilization levels [-]
Gas boiler	0.90 … 0.95
Electric boiler	0.80 … 0.85
Electric air-to-liquid heat pumps	2.20 … 3.00

6 FRAMEWORK

6.1 HIGH-RISE MURB BASELINE – SOUTHERN COASTAL BC

6.1.1 Baseline High-Rise MURB Design and Construction Practices

The southern coast of BC (ENERGY STAR® Climate Zone A) differs climatically from the rest of Canada. Summers are mild and air conditioning is rarely necessary. Winters are also temperate and mild, but rainfall is significant in quantity and duration. Both electricity and natural gas are comparatively inexpensive and in good supply. This has led to buildings that have been designed with a high proportion of glass in the envelope. These towers tend to incorporate reinforced concrete structures, with structural elements also used as components of the building enclosure.

Prior to this study, the City of Vancouver retained RDH Building Engineering Ltd to assess the as built performance of 39 high-rise residential towers constructed between 1974 and 2002. The results published in their report *Energy Consumption and Conservation in Mid and High Rise Residential Buildings in British Columbia* (May 2011) provide a comprehensive evaluation of baseline performance and an excellent description of building design and construction practices. The following description is extracted from the RDH report.

In Vancouver, approximately 50% of the natural gas and 35% of the electricity is consumed in residential buildings resulting in 1,370kt CO_2e in emissions from the consumption of natural gas (90.4% of the total emissions from buildings) and 145kt CO_2e from electricity[27]. MURBs, consume approximately 32% (16% of total) of the residential gas and 50% (17% of total) of the residential electricity[28]. There is no data available, which breaks out consumption by mid- to high-rise MURBs,

A typical MURB in BC uses natural gas and electricity energy sources in both the suites and in the common areas. Within each suite, electric baseboard heaters normally provide space heating and are usually thermostatically controlled. Electricity is also used to power appliances, lights, fans, miscellaneous electrical devices and plug-loads. Natural gas domestic hot water heating is common. Natural gas fired boilers are also typically used in buildings with recreational amenities, such as swimming pools. Distribution systems for domestic hot water vary in efficiency and have a significant impact on the amount of gas used. Buildings may also have in-suite fireplaces for aesthetic or partial space heating purposes (Figure 8).

Natural gas is typically used to heat ventilation air from rooftop units. The heated air is distributed to the building corridors and suites by positively pressurizing the corridors. In this ventilation system, the make-up air units (MAUs) heat outdoor air up to 15-21°C (year round). The MAU may not be considered by some to be a heating device; however it does provide a significant quantity of heat energy to the incoming air-stream, which in turn offsets heating required within suites. Heated air from make-up air units is ducted down to the central corridor spaces on each floor. A MAU set point of 20-22°C is typically being set by HVAC service contractors and/or the stratas.

From the corridors, this pressurized ventilation air is assumed to find its way into suites through door undercuts or other air-leakage pathways. Air is exhausted from individual suites by means of exhaust fans, through air leakage paths (both known and unknown) and occupants opening windows and exterior doors. In reality, this pressurized corridor approach suffers from a number of problems relating to the provision and distribution of this heated ventilation air. Air supplied to corridors may or may not find its way into all suites on a floor, as door undercuts may be blocked-off, due to pressure imbalances from wind and stack effect, or the fact that the air supplied to the hallways can more easily flow through elevator and other shaft openings than into the suites. Because the pressurized corridor distribution system is relatively ineffective at distributing ventilation air to suites – this ventilation system results in significant energy inefficiencies because the air is heated.

6.1.2 Baseline High-Rise MURB Energy Performance

For this study, the baseline average energy consumption of a sample of MURBs in BC's south coast (e.g., Metro Vancouver, Victoria) is approximately 220 kWh/m^2y site energy (213 kWh/m^2y for high-rise MURBs in the Vancouver) based on the RDH Engineering study[29]. Of the 39 buildings analysed, individual consumption varied from 144 to 299 kWh/(m^2y) as shown in Figure 9. Energy consumption is broken out in Figure 10. The baseline is estimated to be, at best, equivalent to ASHRAE 90.1 (2004), which is the current provincial standard.

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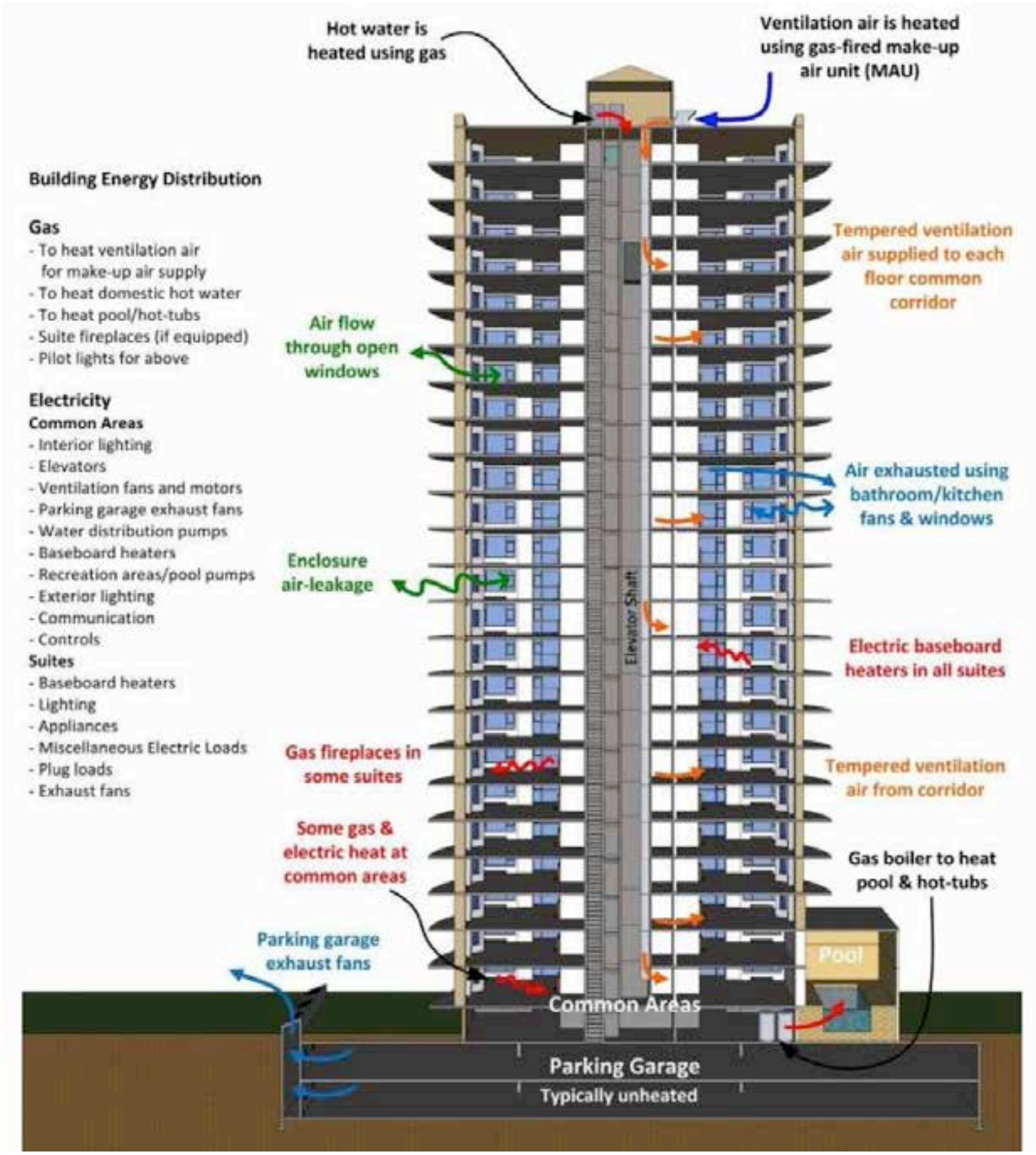
[27] City of Vancouver, *2008 Greenhouse Gas Emissions Inventory Summary and Methodologies*

[28] RDH Building Engineering Ltd. *Energy Consumption and Conservation in Mid and High Rise Residential Buildings in British Columbia.* 2011

[29] ibid, p.44

FIGURE 8

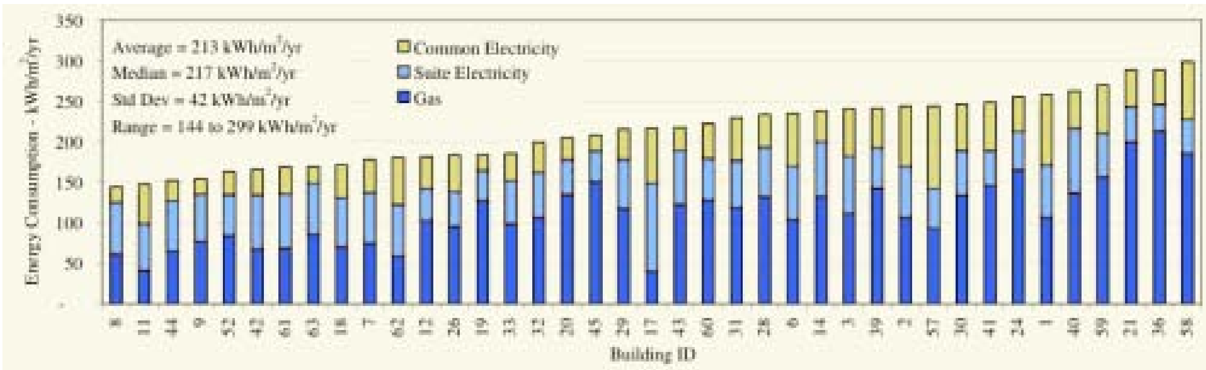
SCHEMATIC OF A TYPICAL HIGH-RISE MURB HEATING AND VENTILATION SYSTEM



Source RDH Building Engineering Ltd

FIGURE 9

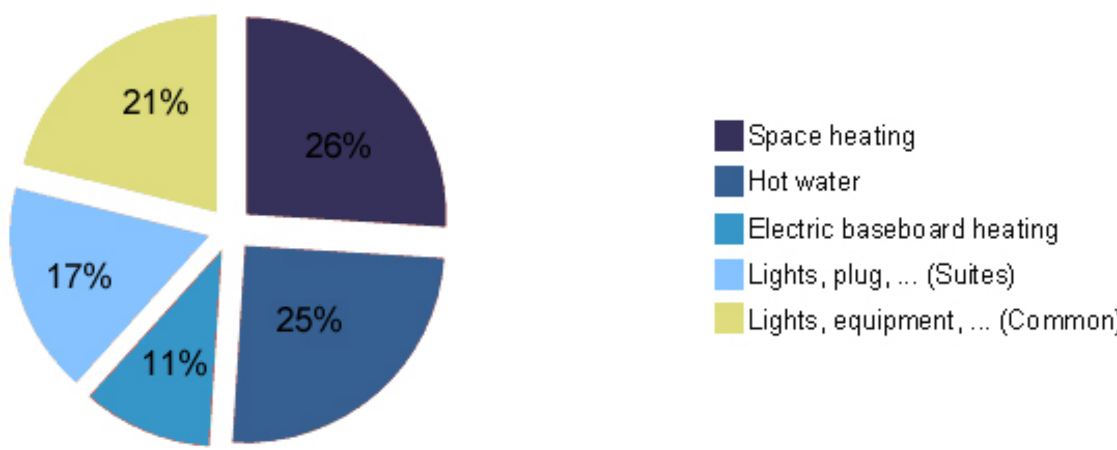
TOTAL ENERGY USAGE PER GROSS FLOOR AREA FOR HIGH-RISE MURBS IN VANCOUVER



Source: RDH Building Engineering Ltd

FIGURE 10

BASELINE AVERAGE ENERGY CONSUMPTION

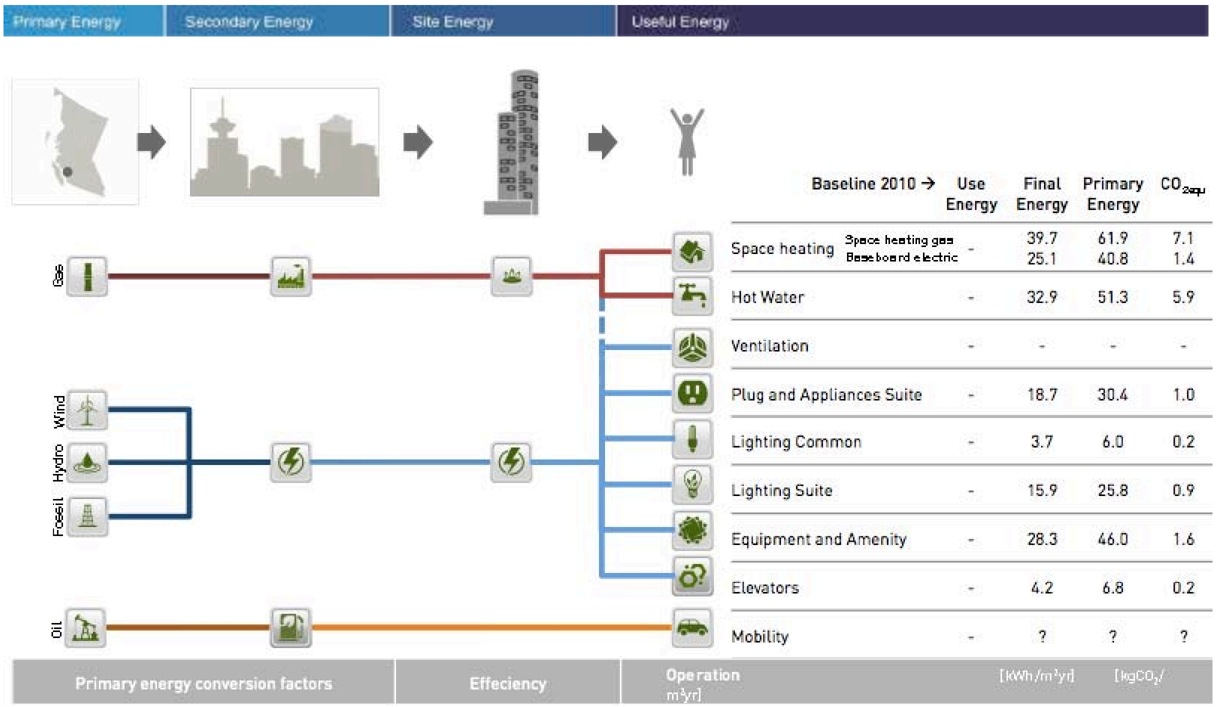


Source: RDH Building Engineering Ltd

Figure 11 shows the baseline high-rise MURB performance broken out into primary and site energy and also presents the associated carbon emissions. The primary energy factors and GHG coefficients were derived using BC data where they exist and Swiss data to fill any gaps as described in section 5.4.

FIGURE 11

ENERGY AND CARBON PERFORMANCE OF BASELINE HIGH-RISE MURB



6.2 HIGH-RISE MURB PERFORMANCE TARGETS

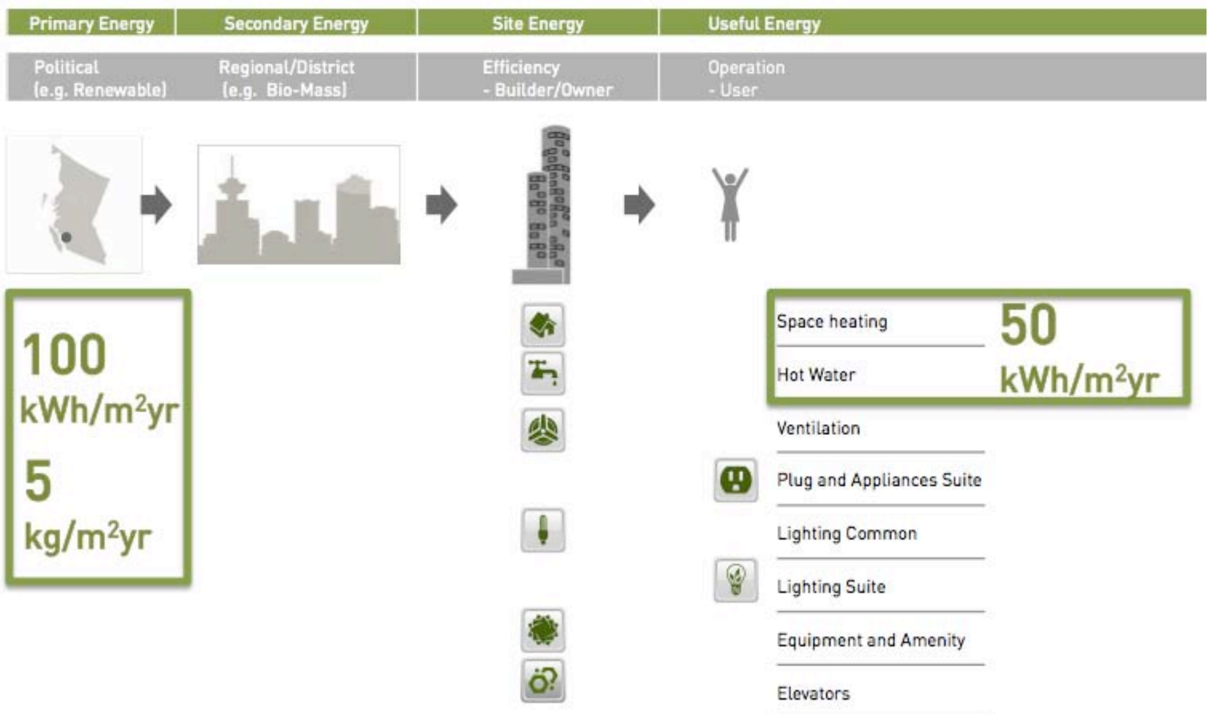
Figure 12 presents the framework for primary energy and GHG emissions target limits for high-rise MURBs in Vancouver and southern coastal BC (ENERGY STAR® Climate Zone A). The proposed performance targets, which could be adopted into standards, meet the City of Vancouver's goal for carbon neutral new construction as of 2020. To meet the intent of the City of Vancouver's target of carbon neutrality in operation by 2020 for high-rise MURBs, a target for total primary energy (non renewable) is defined as < 100 kWh/m^2y with < 5.0 $kgCO_2e/m^2y$. These targets ensure the right energy source is selected for the right purpose.

A target for useful energy consumption for heating and hot water is also included which is defined as < 50 kWh/m^2y. This target directly addresses base building design as it is driven by envelope design and equipment specification.

The final quantitative value of the targets may be slightly refined as the framework is implemented; regardless, targets around the proposed numbers are considered within the technical and economic reach of BC's development industry. For example, the City of Vancouver's higher buildings policy, which would apply to MURBs taller than approximately 114 m, already requires that new higher buildings achieve a 40-50% reduction in energy consumption compared to 2010 levels. For that policy, the City assumed a baseline ASHRAE 2007 building of 192 kwh/m^2; a 40% reduction from that baseline results in a performance of 115 kwh/m^2.

FIGURE 12

2020 LOW CARBON POLICY FRAMEWORK FOR HIGH-RISE MURBS



To test the viability of the above framework targets, additional energy demand benchmarks from MINERGIE® are presented in Table 6 to demonstrate the relative distribution of energy consumption that would meet the targets. For example, MINERGIE® sets a total useful heating energy consumption target of < 45 kWh/m^{2}y, comprising < 24 kWh/m^{2}y for space heating (53%) and < 21 kWh/m^{2}y for domestic hot water (47%). The actual appropriate distribution of energy consumption between space heating and hot water to achieve the target of < 50 kWh/m^{2}y for high-rise MURBs in southern coastal BC may be refined based on future research.

TABLE 6

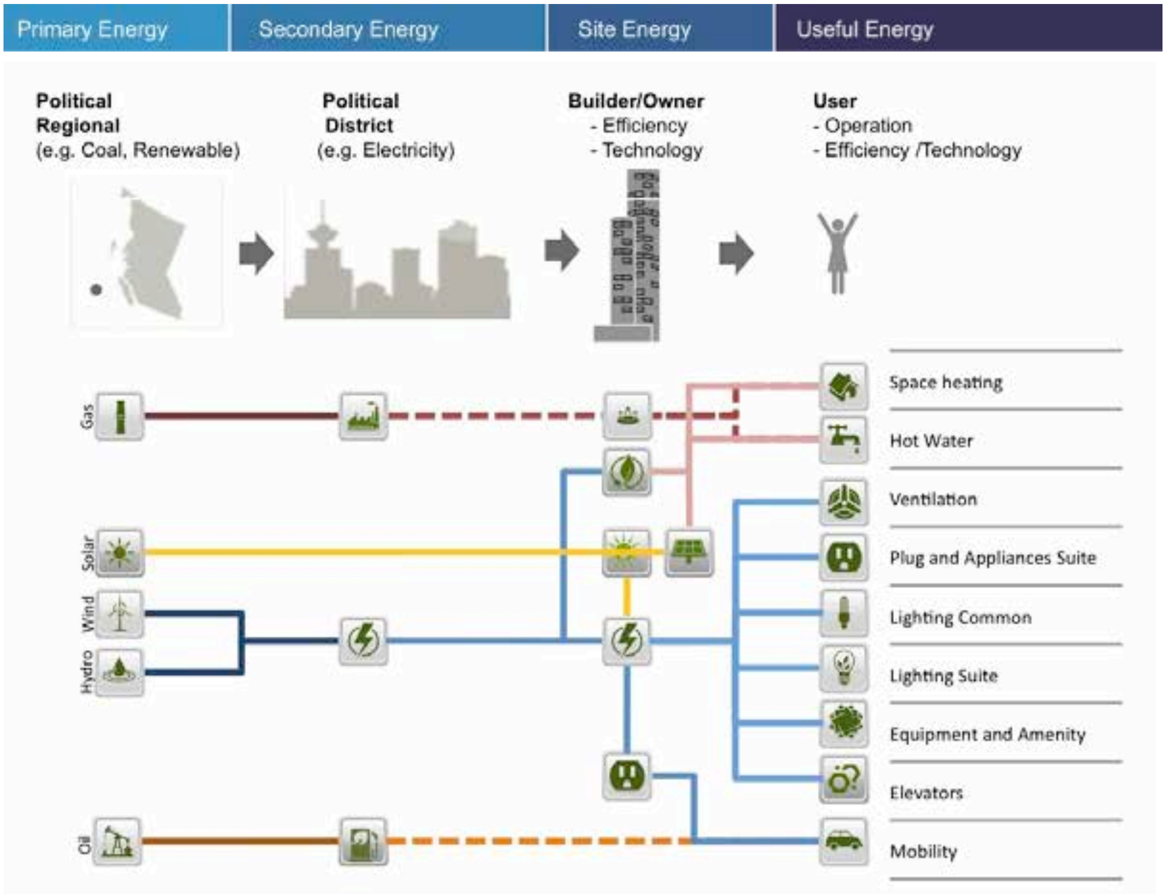
DETAILED ENERGY DEMAND PARAMETERS AND LIMITS

Utilization	Consumption benchmarks
Heating	**Target set in BC framework plan = < 50 kWh/m^{2}y**
Space heat	The energy demand of the equipment used to generate space heat and to preheat ventilation air - measured at the useful energy stage – is assumed at:
	= 24 kWh/m^{2}y (from MINERGIE®)
Domestic hot water	The energy demand of domestic hot water heating is assumed at:
	= 21 kWh/m^{2}y (from MINERGIE®)
Ventilation and AC	
Ventilation	The electrical energy demand of equipment used to move air in mechanical ventilation systems including electrical components for heat recovery and pumps is assumed at:
	= 5 kWh/m^{2}y (from MINERGIE®)
Cooling/ dehumidification	The energy demand of equipment used to cool and dehumidify interior ambient air including the energy demand of the cooling coil, pumps and recirculation fans **is not subject to any energy related requirements**.
Humidification	The energy demand of the equipment used to humidify interior ambient air including the energy demand for various humidification sources (e.g. steam, mist) **is not subject to any energy related requirements.**
Lighting	The energy demand of interior and exterior artificial lighting is assumed at:
	=13 kWh/m^{2}y (from MINERGIE®)
Building services	
Equipment	The energy demand of equipment deployed to enable the use of the spaces in which it is installed, or which it serves (e.g. dishwasher, refrigerator in kitchens) is assumed at:
	= 14 kWh/m^{2}y (from MINERGIE®)
Miscellaneous services	The energy demand of auxiliary equipment used for space and domestic hot water heating, transportation of people and goods, as well as other technical building systems is assumed at:
	4 kWh/m^{2}y for auxiliary equipment and **(from MINERGIE®)** **4,000 kWhy** per elevator.

Figure 13 presents the energy system flow diagram used to develop the high-rise MURB targets. When compared to the energy flow diagram presented for the baseline in Figure 11, the key difference is the addition of solar energy and a shift away from fossil fuels.

FIGURE 13

HIGH-RISE MURB TARGET ENERGY SYSTEM FLOW DIAGRAM



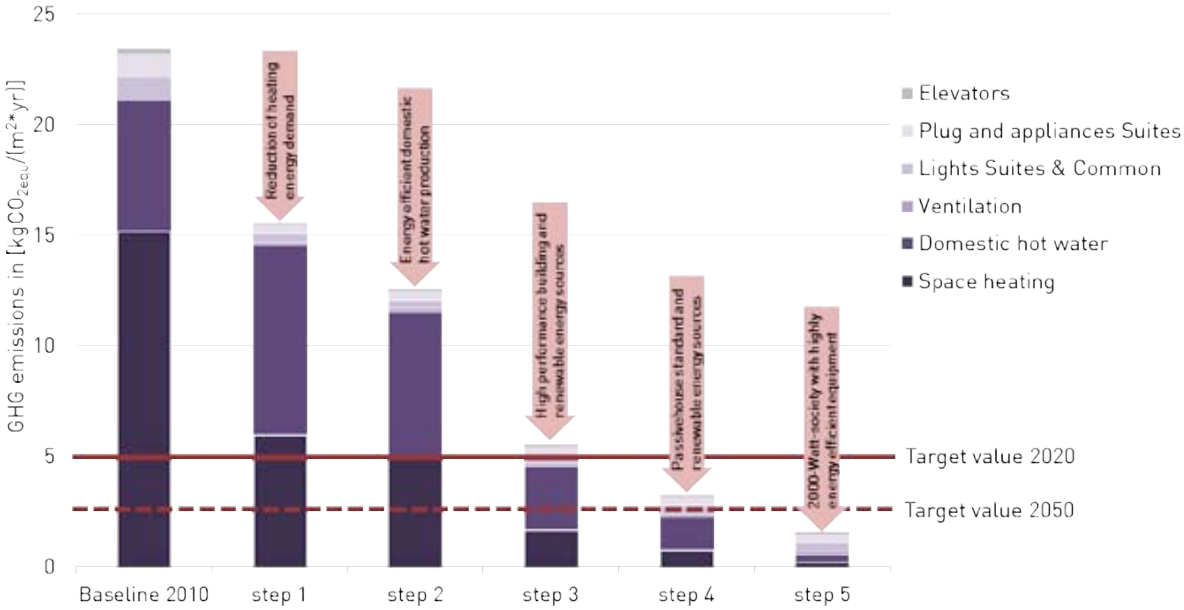
6.2.1 Looking Beyond 2020

Adoption of the proposed framework will set BC on the path to greater energy performance and further carbon emissions reductions over time. It is important to communicate clearly to industry that the targets proposed for 2020 (which is short term from the real estate development perspective) are set into a longer-term continuum of required GHG emission reductions.

Figure 14 illustrates the incremental carbon emission performance improvements from current practice to the 2020 target value of 5kg CO_2e/m^2y and beyond to a suggested 2050 target of 2.5kg CO_2e/m^2y. Target values are achieved through continued reduction of the energy demand in combination with increased fractions of renewable energy production.

FIGURE 14

CARBON EMISSION REDUCTION TRAJECTORY FOR HIGH-RISE MURBS TO 2050



Step 1 includes a 50% reduction of the heating energy demand through increased performance of the building envelope (already being pursued by the City of Vancouver)

Step 2 includes additional reduction of greenhouse gas emissions with the help of more energy efficient domestic hot water production (e.g. heat pump, district heat).

Step 3 (2020) represents further improvements to the building envelope to meet the 2020 target of 5kg CO_2e/m^2y. Space heat is generated with the help of heat pumps.

Step 4 Even further improvements to the building envelope (e.g., passive house standards). This step includes a high proportion of renewable energy sources for space heating and domestic hot water production.

Step 5 (2050) achieves the target values of the 2,000-Watt Society with the help of highly energy efficient appliances and building services.

6.3 SCENARIO ANALYSIS: 2020 BUILDING

6.3.1 Comparison of Future High-Rise MURB Design to Baseline Design

Based on the 'average' high-rise MURB presented in the RDH study and on the proposed targets and principles of low carbon design presented above, representative baseline and low carbon high-rise MURBs were developed. The baseline building is estimated to meet ASHRAE 90.1 (2004) standards i.e., the current provincial building code. [Note: The City of Vancouver has already adopted ASHRAE 90.1 (2007) and is working towards updating its energy code to ASHRAE 90.1 (2010) by the end of 2012.]

Figure 15 illustrates the baseline and low carbon high-rise MURBs, including a range of technologies typically found in a low-carbon building (refer to Principles of Low Carbon Design earlier in this report). Given that the targets would be performance-based, designers would of course have much flexibility in determining how to meet the target. The scenario shown in Figure 15 is one of many possibilities.

For example, it is possible that the reduced space heating demand represented by the targets could be met with electric baseboards, provided the primary carbon intensity target was still met. Of course, there would be other issues to consider, such as whether this is the highest and best use of BC Hydro's electricity, given the limited likelihood of additional large-scale hydroelectricity generation being constructed. Direct electrical heating systems like electric baseboards would also not meet the minimum standard of the 'quality of electricity' as it relates to the 'ratio of energy to energy'.

FIGURE 15

COMPARISON OF 2020 CARBON NEUTRAL HIGH-RISE MURB DESIGN TO BASELINE DESIGN (ASHRAE 90.1 (2004))

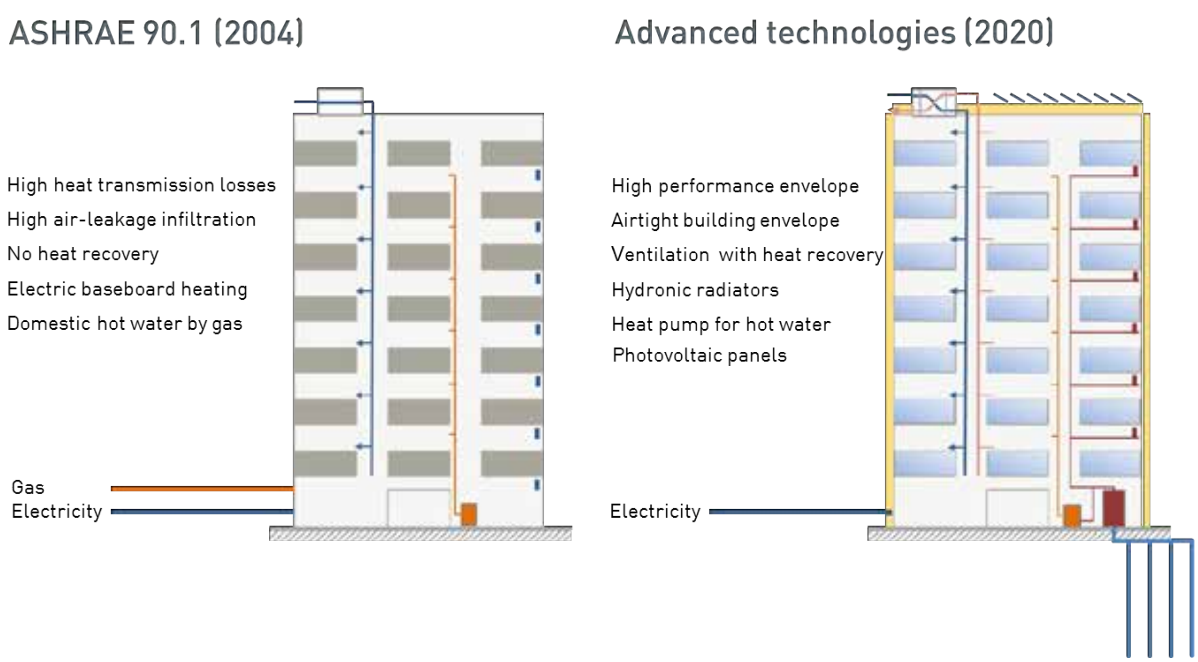


Table 7 presents a summary of the estimated building performance characteristics of the baseline and carbon neutral high-rise MURBs. This further illustrates the degree of "stretch" necessary to achieve the proposed performance goals.

TABLE 7:

COMPARISON OF KEY 2020 CARBON NEUTRAL VS BASELINE (ASHRAE 90.1 (2004)) SYSTEMS

System	Baseline (ASHRAE 90.1 2004)	Carbon Neutral MURB 2020
Walls	< 0.57 W/(m^2K) [R-10]	< 0.15 W/(m^2K) [R-37.9]
Windows	< 3.98 W/m^2K [0.70 Btu/hr ft^2 F]	< 1.00 W/m^2K [0,18 Btu/hr ft^2 F]
Roof	< 0.57 W/(m^2K) [R-10]	< 0.15 W/(m^2K) [R-37.9]
Air-leakage infiltration	No blower door test required.	Blower door test required at completion
Domestic hot water	Central gas boiler	Heat pump and hydronic radiators
Ventilation	No heat recovery	Heat recovery
Heating system	Make-up air unit and electric baseboard	Hydronic radiators

6.3.2 Financial Analysis

To compare the construction cost of the carbon neutral versus baseline design, additional assumptions were made, namely that the building was a 20 storey, 13,656.7 m^2 (147,000 ft^2) tower containing 224 dwelling units. In keeping with Vancouver's building typology, it is assumed the building has a six-storey podium with a 761.8 m^2 (8,200 ft^2) floor plate, and a 14-storey tower with a 650.3 m^2 (7,000 ft^2) floor plate.

As shown in Table 8, it is estimated that that meeting the proposed 2020 performance targets would increase costs for the proposed 2020 building by approximately 10.5% compared to an ASHRAE 90.1 (2010) baseline building, which reflects the City of Vancouver's proposed Building By-law changes for 2012. The proposed 2020 targets would add approximately 14.5% to construction costs compared to current practice - an ASHRAE 90.1 (2004) baseline. Incentives from energy utilities are available, but have not been factored in, as they will have little impact on the overall capital costs. The key elements responsible for the cost increases are the exterior enclosure, finishes, mechanical, and general requirements and fee. ***As industry becomes familiar with the low-carbon building design and construction, the cost premium over conventional practice will diminish.***

TABLE 8:

PRELIMINARY CONSTRUCTION COST COMPARISON

	Baseline ASHRAE 2004	Best practice ASHRAE 2010	Carbon Neutral (2020 Targets)
Cost/Floor Area	$221 /ft²	$229 /ft²	$253 /ft²
	Incremental Cost Increase	3.6%	10.5%

7 ADVANCING THE FRAMEWORK

The advancement of this framework will require a substantial amount of work in the form of policy changes, additional technical studies, pilot projects, consultation, and education and outreach. Given the timelines set by municipalities such as Vancouver, as well as the general international direction with respect to carbon neutral building, such work needs to commence as quickly as possible.

The framework is currently focused on new buildings. Given the contribution of existing buildings to BC's carbon footprint, and the potential for significant carbon savings to be achieved via renovation and retrofit activities, it is highly probable that municipalities will strengthen their focus on existing buildings in addition to new buildings. The inclusion of existing buildings in our efforts to reduce carbon emissions makes sense from a technical perspective, but also from an economic one. For example, the development industry has stated that it hopes to see economic balance between the resale and new housing markets.

In the longer-term, if this framework is adapted to existing buildings, then additional tools may be required. However, many of the policies, regulations, incentives, and education programs developed for application to new buildings will also likely be adaptable to a framework for existing buildings.

7.1 DEVELOP BC-SPECIFIC ENERGY DATA

While the Swiss energy factors and GHG coefficients can be used to at least relatively compare buildings in BC, and to determine if they will roughly meet the proposed target, BC-specific primary (source) energy factors and GHG coefficients should be developed, not just for direct natural gas and BC Hydro-delivered electricity, but for other sources such as biomass or sewer het recovery as well as for BC's other utilities.

In Switzerland, as in the rest of Europe, primary energy factors and GHG emission coefficients have been established through a comprehensive stakeholder process (comprising utilities, government AND non-government agencies, research institutes, etc.) for a range of non-renewable energy sources, as well as for different methods of electricity generation.

This work will require the involvement of a comprehensive set of stakeholders, such as utilities, government and non-government agencies, research institutes, etc. The European context provides a road map for such efforts e.g., the Swiss experience brought to this project via Intep or the British efforts led by the Building Research Establishment (BRE).

This work should begin as soon as possible, and can be completed in parallel to any other implementation work.

7.2 DEVELOP NEW POLICIES AND REGULATIONS

Ideally, the framework is incorporated into regulatory changes to the BC Building Code and Vancouver Building By-law. Certainly, outside of the City of Vancouver, changes to the BC Building Code would ensure a 'level-playing field' for developers. However, it should also be noted that "[L]ocal governments are not legally required to administer all of the BC Building Code – or any of it for that matter. A great many jurisdictions do not include Part 10 in the building bylaw …".[30]

Even with such building code changes, other complementary policy and regulatory changes should be considered at the local government level. The most important decisions affecting a building's energy and carbon performance are generally made at the very beginning of the design process.

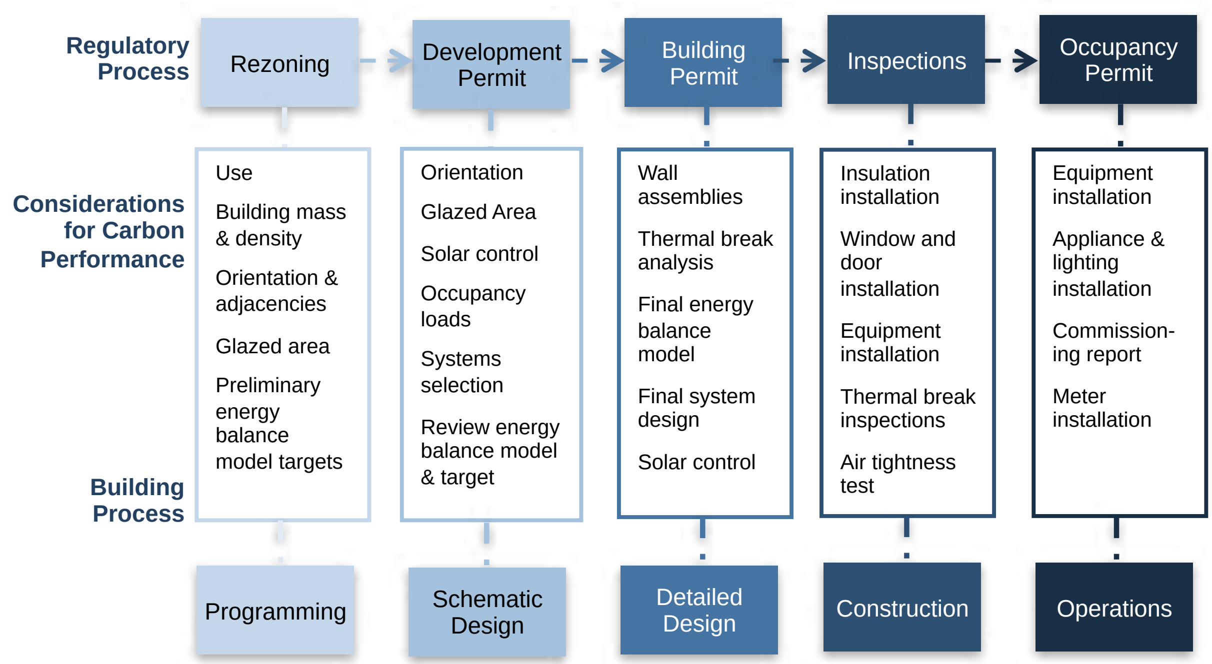
[30] Personal communication, John Nicol, Building and Safety Standards Branch

Therefore, it is imperative that carbon emission reduction goals are reflected in the upstream, as well as the downstream, planning and development regulations.

Figure 16 illustrates the ideal regulatory sequence as it aligns with the planning and development process, as well as some of the considerations for energy and carbon performance at each stage.

FIGURE 16

CONSIDERATIONS FOR CARBON PERFORMANCE THROUGHOUT THE REGULATORY PROCESS



Changes to policy and regulation will need to consider the management and allocation of risk both for the development industry and governments. In addition, as has been learned from attempts to support other building performance innovations, insurance requirements can have unintended consequences. The insurance industry should be part of any stakeholder group collaborating on the development of new policies and regulations.

For the City of Vancouver, such a sequence represents changes to the status quo. For other municipalities in BC, there are additional regulatory changes required. For example, development permits and occupancy permits are not used by all municipalities. In addition, not all municipalities in BC will have the foundation policy with respect to goals for carbon neutral building in place.

The general policy and regulatory tools that might be used to implement the framework are described below. These policy and regulatory needs will need to be explored more broadly and deeply as part of the implementation of this framework. An additional consideration meriting future technical, legal, and financial analysis is the implication of making any of these changes on the ability of a private sector developer or municipality to accrue voluntary or certified carbon credits.

Official Community Plans (OCPs):

The majority of BC municipalities have now updated their OCPs to include GHG reduction targets and actions. However, as a foundation for carbon neutral buildings, OCPs, or some related policy document similar to Vancouver's GCAP, should explicitly state a goal for carbon neutral or low carbon buildings. Community Energy Plans or Integrated Community Sustainability Plans might also be appropriate places for such targets. Such goals should then also reference the adaptation of this framework as one of the key actions by which the goals for low carbon / carbon neutral building will be met.

Municipalities will also need to ensure that their OCPs clearly identify areas and conditions where development permits are required, and those areas should of course contain the types of buildings a municipality is targeting for carbon neutrality.

Development Permits & Development Permit Area (DPA) Guidelines:

As shown in Figure 21 above, the development permit stage is the stage where corresponding schematic designs should show the proposed use of low carbon design strategies such as building mass and solar control. Logically, development permit area guidelines would be a useful tool for encouraging such design practices. Unfortunately, BC municipalities are currently limited with respect to what they can include in DPA guidelines, as they cannot reference any requirements inside a building. Barring Provincial changes to these restrictions, creative use of application forms and information requests should be explored to ensure that appropriate design strategies are implemented at this stage.

BC Building Code and Vancouver Building Bylaw

Building codes should be one of the most powerful tools to help communities achieve carbon neutral buildings. The City of Vancouver has committed to revising its Building Bylaw as needed to support its carbon neutral building goals, and is in a position to pilot changes that could provide helpful direction for future BC Building Code revisions. Future implementation work should include a detailed analysis of the BC Building Code for current drivers and barriers to carbon neutral building, as well as establishing a multi-stakeholder committee to push for and oversee the necessary changes.

Ideally, the BC Building Code ultimately undergoes changes so that it can support the rest of BC's municipalities in their efforts to work towards carbon neutral buildings. This will create a level playing field for the development industry, and also reduces the collective resource requirements of many municipalities developing work-around policy.

However, should some municipalities wish to move more towards carbon neutral building before changes to the BC Building Code can be made, there are some regulatory options in the short and medium-term.

Zoning Bylaws

Given the possibility that the timing for changes to the BC Building Code will likely be slower than some municipalities striving for carbon neutral building will require, municipalities may wish to explore the use of Zoning and other bylaws to support the adoption of this framework. Even with changes to the BC Building Code, complementary changes to zoning policy may be instituted. For example, the City of Vancouver's Greener Sites Policy triggers a low carbon energy solutions study for sites greater than 2 acres seeking a rezoning. Such a study could help to advance the implementation of district energy, which would in turn help to support lower carbon buildings. However, it should be noted that the development industry prefers to see zoning bylaws focus strictly on land use issues.

The use of zoning and other bylaws in BC to require or encourage developers to meet energy use or carbon intensity targets, such as those proposed here, could be explored in future, especially given the probability that changes to the BC Building Code will not be expedient.

Adopted Policies

The creation and adoption by Councils of custom policies might also be an avenue for BC municipalities wishing to adopt the framework. For example, the District of North Vancouver used this approach to adopt its green building standards. Council endorsed two corporate policies containing the standards, one for private sector projects and one for municipally owned projects. Compliance is mandatory for OCP, zoning, and subdivision applications, and voluntary for development permit and building permit applications, with incentives provided to encourage voluntary compliance. Municipalities considering this approach are strongly advised to seek legal counsel to ensure compliance with the Community Charter and related legislation. In addition, the development industry is not supportive of this type of instrument.

Building Permit Requirements and Process

Changes can be made to the administrative requirements for the building permit process e.g., requiring the submission of a completed energy balance worksheet as part of a permit application. It is possible that some municipalities would include requirements that the additional reports and information be completed by third-party certified professionals e.g., P.Engs or even some new future Green Building Science professional, to minimize administrative costs to the municipality.

Building Inspection Requirements and Process

Building inspection is a critical component for compliance, but remains one of the most challenging areas. Compliance remains an issue world-wide, even in jurisdictions with strong energy regulations and standards, such as California or Denmark[31]. Changes here will be two-fold. First, municipalities will likely need to increase the information requirements at inspection. For example, an air leakage testing report will be required. Secondly, physical inspection of the aspects of the building related to energy performance might be required. Ideally, current building inspectors would include the inspection of items such as thermal breaks in their scope of work. Practically, building inspections remain focused on adherence to the BC Building Code or Vancouver Building Bylaw, with a continued focus on fire and safety. While separate electrical and plumbing inspectors often exist, there is usually no mechanical inspector, let alone someone who would be specifically inspecting the correct use and construction of low carbon designs and technologies. Further investigation into the potentially evolving role of building inspectors is required. The advantages and disadvantages of third-party inspection reports might also be considered; it should be noted that a precedent for third-party inspection reports already exists; for example, the City of Vancouver requires inspection reports from building envelope professionals on certain projects.

[31] Personal communication, John Nicol, Building and Safety Standards Branch

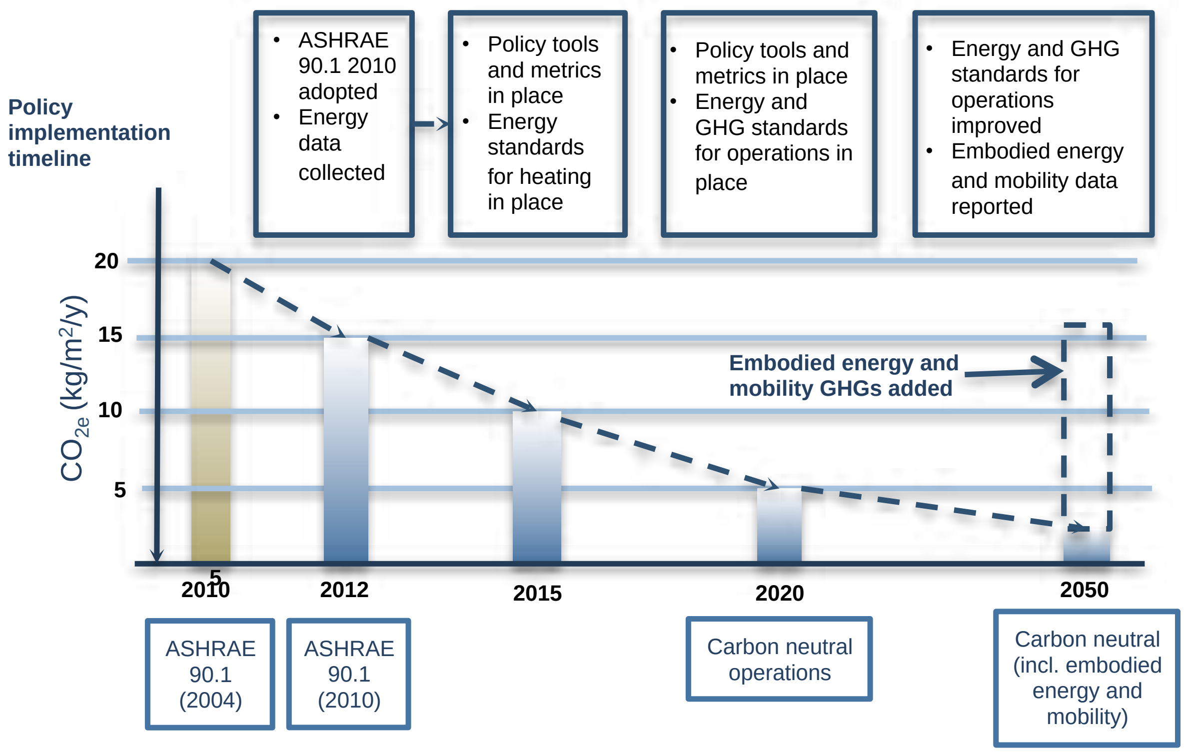
Occupancy (Inspection/) Permit Requirements & Process	Changes at this stage would be similar to those required at the building inspection stage. It should be noted that not all municipalities require an occupancy permit; however, a pre-occupancy inspection usually occurs.
Compliance / Verification Tools	As explained earlier, one of the advantages of MINERGIE® is that compliance can be verified via straightforward spreadsheet calculations. Similar tools could be developed for use instead of the current energy modelling reports. Such an approach would create more regulatory consistency and result in more easily comparable building performance. Approvals officers, plan checkers, and similar staff will require training in reviewing and using the submitted information. Building permit documents would need to incorporate submitted information to ensure on-site inspection can be completed effectively. Developers and design professionals will also require training in providing the information. It should be noted that the development of some of these is predicated on the availability of energy factors and utilization rates for BC, or indeed, for the various climatic regions of BC. This represents a significant amount of highly technical work. With respect to the City of Vancouver's timeline, this is critical work that should begin as soon as possible. This work should also be part of the general adaptation of this framework to other regions in BC.
Incentives	Municipalities such as the City of Vancouver and the City of North Vancouver are already using incentives such as increased height or density to encourage compliance with green building objectives. Incentives could be an important part of the overall policy and regulatory toolbox for promoting carbon neutral building as well.

Given its GCAP goals and existing high-rise MURB baseline work, as well as its unique position with respect to having control over its building code, the City of Vancouver is in an ideal position to be among the first municipalities in BC to pilot draft regulations, approvals processes, education and outreach programs, and other tools that are developed to implement the framework.

In this regard, Vancouver's changes to its Building Bylaw become particularly important, as they will likely form the basis for changes to the BC Building Code. With respect to its 2020 carbon neutral building target, Vancouver should pursue changes to institute energy and carbon performance standards e.g., for high-rise MURBs, by adopting the targets proposed in this framework. In the time leading up to 2020, it is recommended that the policy process be designed first and the building performance metrics be implemented after. The suggested process is illustrated in Figure 17.

FIGURE 17

VANCOUVER POLICY IMPLEMENTATION TIMELINE AND ANTICIPATED BUILDING PERFORMANCE (OPERATIONS)



7.3 SUPPORT STAKEHOLDER ENGAGEMENT & EDUCATION

One of the important features of the framework is that it respects the split in responsibility for building energy performance between developers (responsible for design and construction) and operators / tenants. The framework targets and associated possible policy and regulatory changes apply specifically to the design and construction stage. Therefore, it will be important to support complementary education and outreach efforts targeted at improving the energy literacy of developers, designers, and contractors.

With respect to education and outreach, we recommend that the operations stage also be included to ensure that carbon neutral buildings perform as built. In particular, there is still much room for progress with respect to the energy literacy of building operators and high-rise residential building suite owner and tenants; the latter group is now responsible for a large spike in plug load demands that has been offsetting other efficiency gains in recent years.

Table 9 presents stakeholder groups who should not only be engaged as part of a robust and collaborative consultation process moving forward, but will also likely seek educational programs and tools to help them play their role in implementing the framework.

TABLE 9

STAKEHOLDER ROLES FOR IMPLEMENTATION

Stakeholder Group	Related Organizations	Implementation Role	Possible Targeted Education / Outreach Programs
Municipal Staff	Green Building Leaders, UBCM, Planning Institute of BC	Champions and/or peer advisory Policy & regulatory implementation	Knowledge exchange Inter-climate zone collaboration Training and overall education re: framework
Developers and Builders	Urban Development Institute (UDI), Regional Construction Associations, NAIOP (for other typologies) trade associations	Private sector perspective Pilot project champions and partners Construct carbon neutral buildings	Pilot projects Education re: low carbon design practices Overall education re: framework Financing for case studies
Building Inspectors	Building Officials Association of BC See also Municipal Staff	Building inspection perspective Building permit and inspection policy and regulation	Technical training "what to look for" and/or possible training program for a new type of green building inspector Overall education re: framework
Designers (Architects and Engineers)	Association of Professional Engineers and Geoscientists of BC, Architecture Institute of BC, UDI	Technical advisors re: targets and implementation Design of compliant buildings	Overall education re: framework Book of details, assemblies and strategies showing how targets can be met
Condominium Owners	Condominium Home Owners Association of BC	Advisory re: implications of new building systems on operations & maintenance logistics and costs. Advisory re: long-term monitoring programs	Overall education re: framework Occupant behaviour management policies, tools and incentives
Building Operators	Building Owners and Managers (BOMA) BC	Ensuring that the low carbon technologies and systems are properly operated and maintained Provision of baseline data	Overall education re: framework Training re: the operation and maintenance of low carbon building technologies e.g., heat pumps (perhaps even a certification program) Occupant behaviour management policies, tools and incentives
Green Building Product and Technology Providers	Various European Chambers of Commerce Various European Consulates Economic Development Officers / Organizations in BC	Supporting pilots and demonstration Sourcing / developing new products and technologies Technical advisors re: products and their impact on energy and carbon	Overall education re: framework

Stakeholder Group	Related Organizations	Implementation Role	Possible Targeted Education / Outreach Programs
	Canadian Green Building Council – Cascadia Chapter Regional Construction Associations	performance Providing technical advice on the book of assemblies	
Insurance Industry	Homeowner Protection Office (HPO) Underwriters' Laboratory Commercial insurance brokerage firms	Technical advisors for new policies and regulations	Overall education re: framework
Utilities	BC Hydro Fortis Corix Terasen Plus numerous other utilities authorized by the BC Utilities Commission e.g., Pacific Northern Gas	Provision of baseline data Partner for developing energy factors and related parameters Support for pilots and demonstration projects Technical advisor re: code changes Provider of energy conservation / renewable energy incentives Owner / operator of some energy systems	Overall education re: framework
Province of BC	Ministry of Energy and Mines – Energy Efficiency Branch and Building and Safety Standards Branch	Possible changes to BC Building Code Technical and financial support for implementation work	Overall education re: framework Research study: drivers and barriers in BC Building Code Case studies / text templates for new codes and standards
Academic and Training Institutions	Various across BC, with a focus on: mechanical engineering, building science, architecture, planning Industrial Training Authority	Develop training programs related to all the above professionals Support research needed to develop energy factors and related parameters Support research and technology verification related to demonstrating new low carbon products and processes	Overall education re: framework Adaptable training modules

7.4 SUPPORT PILOT AND DEMONSTRATION PROJECTS

Whole-building pilot projects will be required to test draft / proposed regulations, approvals processes, education and outreach programs, and financing and incentive mechanisms. It is possible that pilots for each typology and in each different climate zone might be required. As most building development in BC occurs in the private sector, it is critical to engage the private sector for these projects.

Pilot projects will not only demonstrate the feasibility of meeting targets, but will help to provide valuable feedback regarding changes to regulations and approval processes e.g., was application information too difficult to provide?

Given the role of the City of Vancouver in piloting the implementation of the framework for Carbon Neutral Buildings in BC, at least for high-rise MURBs, it makes sense that a 'real-life' high-rise MURB demonstration project should also be found within Vancouver. A carbon neutral high-rise MURB has not yet been built in the Vancouver housing market. A pilot project will be a valuable for both industry and regulators from the standpoints of policy development, public education, financial viability and technical design. It should be noted that time is of the essence to ensure that such a pilot completes in time to inform changes required by 2020.

To achieve the framework targets, **new products and technologies** will likely be employed. In many cases, European technology exists but has yet to be used within BC. There will be a need for demonstration projects for these individual products and technologies; such demonstration projects may or may not be part of a whole building pilot project.

7.5 EXPAND AND ADAPT THIS FRAMEWORK

As shown earlier in Figure 1, the establishment of the high-rise residential framework presented herein represents the first of many phases of work towards the creation of carbon neutral buildings in BC.

The work completed herein will need to be expanded to other building typologies and to consider other BC climate zones. ASHRAE assigns four climate zones to BC; the BC Ministry of Environment lists five climate zones (Coast Mountains and Islands; Interior Plateau; Columbia Mountains and Southern Rockies; Northern and Central Plateaus and Mountains; and Great Plains).

The general process to establish the framework for each major building typology within each of BC's major climate zones is described below. Ideally, several municipalities in the same climate zone would be involved, whether collaboratively, or as an advisory group to a regional municipal champion. The involvement of the Province is also key, as the implementation of this framework province-wide will be likely be greatly aided by changes to various Provincial legislation and policies, whether the Building Code or subsequent Energy Plans. The process should also actively engage the private sector – developers, builders, architects, and engineers.

Determine Energy and Carbon Baseline

The baseline for high-rise MURBs in Metro Vancouver was established based on the RDH Engineering Ltd. Study. While the depth of the study was useful in creating the baseline used here, meaningful baselines can still established for regions that do not have the resources to replicate the RDH study. For example, municipal building permit data can be 'mined' to characterize buildings of the chosen typology and/or a consultative process can be used to establish 'typical' building design. BOMA or similar organizations, as well as local utilities, may help to characterize mean and median natural gas and electricity consumption values for the typology, especially if permit data can be used to establish addresses for representative buildings. Using the references provided herein plus local knowledge, the allocation of current natural gas and electrical consumption to end user categories e.g., domestic hot water, could be estimated. And of course, the energy flow analysis presented herein must also be applied to baseline data to ensure the baseline corresponds to proposed targets.

Establish Energy Use and Carbon Intensity Targets

Based on municipal and Provincial goals, as well as benchmarks set by other municipalities such as the City of Vancouver, establish energy and carbon intensity targets, as well as timeframes for meeting those targets. As shown in this framework, such targets should focus on primary energy.

International goals, such as those established by MINERGIE®, can be used to verify the achievability of targets.

The energy flow analysis presented herein must also be applied to ensure targets are established for the correct part of the energy flow system, and that the targets respect the development process.

Once each framework is established, then draft policies, regulations and other programs can be developed, taking into account some of the considerations outlined in this report. Pilot projects will help to ground-truth targets and the proposed policies, regulations and programs before they are adopted. Then, performance should be systematically and continuously evaluated to inform the continued improvement of policies, regulations and programs, as well as the ongoing updating of carbon and energy performance targets to more progressive levels. The data submitted as part of the compliance and verification spreadsheets will form an important part of the overall performance measurement.

7.6 LOOKING AHEAD TO 2050

Adoption of the proposed framework for high-rise MURBs sets BC on a path to ongoing energy performance improvements and sustained carbon emissions reductions beyond 2020. Future targets may consider including the embodied energy and mobility associated with buildings. Communities in Switzerland are implementing the 2,000-Watt Society, which includes additional GHG emissions targets of 8.5kg CO_2e/m^2y for embodied energy and 5.0kg CO_2e/m^2y for mobility. As buildings become more efficient operationally, the impacts of choices related to building materials and transportation will become proportionally more important. When these targets are added to the target for building operations of 2.5kg CO_2e/m^2y, the total 2050 target could be 16.0kg CO_2e/m^2y, as shown in Table 10.

TABLE 10

POSSIBLE HIGH-RISE MURB ENERGY AND CARBON PERFORMANCE TARGETS FOR 2050

Multi Unit Residential Buildings	Primary Energy (non renewable) [kWhy]		Greenhouse Gas Emissions [kg/m^2y]	
	2020	2050	2020	2050
Target Value: Embodied energy	-	30	-	8.5
Target Value: Building operation	100	50	5.0	2.5
Target Value: Mobility	-	35	-	5.5
Total Target Value	**-**	**115**	**-**	**16.5**

BIBLIOGRAPHY

2006 B.C. Building Code

B.C. Climate Action Toolkit website, http://toolkit.bc.ca

B.C. Greenhouse Gas Reduction Targets Act, passed November 2007
http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_07042_01

B.C. Ministry of Energy, Mines and Petroleum Resources. *B.C. Energy Plan: A Vision for Clean Energy Leadership*, February 2007. http://energyplan.gov.bc.ca/PDF/BC_Energy_Plan.pdf

B.C. Ministry of Environment, *British Columbia Greenhouse Gas Inventory Report 2008*, September 2010 http://www.env.gov.bc.ca/cas/mitigation/ghg_inventory/pdf/pir-2008-full-report.pdf

The British Columbia Climate Action Charter Between The Province of British Columbia and The Union of British Columbia Municipalities and Signatory Local Governments, 2007
https://ubcm.civicweb.net/Documents/DocumentList.aspx?ID=1683#http://www.cd.gov.bc.ca/ministry/whatsnew/climate_action_charter_update.htm

BTY Group, *Improved Housing Energy Performance Cost Analysis Report Nr 1,* October 21, 2011
http://www.housing.gov.bc.ca/building/bcbcsurvey/pdf/EnergyandAffordability.pdf

City of Vancouver. *2008 Greenhouse Gas Emissions Inventory Summary and Methodologies*, December 2009.
http://vancouver.ca/sustainability/documents/2008GHGInventoryMethodologiesDocument20091210.pdf

City of Vancouver. Greenest City 2020 website http://vancouver.ca/greenestcity

City of Vancouver. *Greenest City Green Buildings Summary Report*, 2010
http://talkgreenvancouver.ca/sites/default/files/attached/Draft%20GC2020%20Green%20Building%20Action%20Plan%20(long).pdf

City of Zurich Office for Environmental and Health Protection Zurich (UGZ). *On the way to the 2000-Watt Society: Zurich's path to sustainable energy use*, April 2011
http://www.thinkswiss.org/attachments/-01_On%20The%20Way%20To%20The%202000-Watt%20Society.pdf.

The David Suzuki Foundation, author Nicholas Heap. *Hot Properties: How Global Warming Could Transform BC's Real Estate Sector*, September 2007
http://www.davidsuzuki.org/publications/downloads/2007/DSF_HotProperties_final1.pdf

Economist Intelligence Unit. *A Summary of the Livability Ranking and Overview,* February 2011

Kyoto Protocol to the United Nations Framework Convention on Climate Change, 1998
http://unfccc.int/resource/docs/convkp/kpeng.pdf

LiveSmart B.C., *Carbon Neutral B.C.: Transforming B.C.'s Public Sector*, 2011
http://www.livesmartbc.ca/attachments/carbon_neutral_action_reports/CarbonNeutralBC-transformingBCpublicsector.pdf

Living Futures Institute, *Living Building Financial Study Report*, April 2009
http://www.cascadiagbc.org/lbc/member/living-building-financial-study

RDH Building Engineering Ltd. *Energy Consumption and Conservation in Mid and High Rise Residential Buildings in British Columbia* (prepared for the City of Vancouver and others), May 2011

United Nations Environment Program, Climate Neutral Network website
http://www.unep.org/climateneutral