RENEWABLE ENERGY STRATEGY FOR CITY-OWNED BUILDINGS

2015 – 2040

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1. EXECUTIVE SUMMARY

Strategy Objectives & Principles

Vancouver has the goal to derive 100% of its energy from renewable sources by 2050. In order to achieve this, buildings' energy consumption, constituting the largest single source of emissions, needs to be decarbonized. This project outlines the Renewable Energy Strategy for City-owned buildings, covering both retrofits of existing facilities and new construction. Two guiding principles underlie the City-owned buildings strategy:

1. Ensure that the *City shows leadership* by achieving the required GHG emission reductions and renewable energy transition before the city-wide targets.
2. Achieve the transition to 100% renewable energy in the *most cost-effective way*.

Background

The City currently owns 558 buildings. As the owner and operator, the City of Vancouver has free rein over its buildings. This allows the City to be more aggressive in the renewable energy transition than private sector builders.

City-owned buildings produced about 16,000 tonnes of CO_2 e in 2015, largely due to natural gas consumption (87% of 2015 building energy emissions). The renewable energy share of energy used in City-owned buildings currently stands at approximately 50% of facilities' energy requirements. This is due to the high proportion of renewable energy in electricity supplied by BC Hydro and the renewable natural gas purchased from FortisBC to replace conventional natural gas in the City Hall building.

The Real Estate and Facilities Management (REFM) department is responsible for the management, operations and development of civic facilities and thanks to its actions, total GHG emissions from civic buildings have declined by 23% in 2015 vs 2007, despite a 20% increase in City-owned building floor area.

Strategy Targets & Milestones

It is the recommendation of this project that the REFM department sets the following long-term and interim targets for civic facilities:

1. Achieve 100 % renewable energy and a 100% reduction in GHG emissions by 2040 (10 years prior to city-wide targets).
2. Construct new civic facilities to be zero-emission starting in 2018 (12 years preceding general building policy requirements).
3. Set ambitious 5 year milestones, including 70 % renewable energy by 2025, coupled with a 55% reduction in GHG emissions compared to the 2007 baseline.

For comparison, the Climate Leadership Team, appointed by the BC government, recommended a building strategy for the province that by 2030 reduces GHG emissions from

the sector by 50 % versus 2015 (CLT, 2015). The Team recommended public buildings start using carbon sequestering materials and be built to nearly zero energy starting in 2016 to lead the way to the 2030 target (CLT, 2015).

Strategy Framework

Nine pillars have been identified that, when combined and correctly planned, have the potential to achieve the transition to 100% renewable energy. The 75 largest GHG emitting facilities, responsible for 88% of total 2015 GHG emissions, were the focus of the analysis and need to be prioritized for a cost-effective transition. Uncertainty revolves around the evolution of natural gas prices, BC's carbon tax and renewable energy technologies' maturity and cost-competitiveness, all of which could change the dynamics of the transition to 2040.

Important assumptions underlie the framework:

- City-owned building floor area will increase by 20% by 2040 compared to 2015.
- 2040 Business As Usual (BAU) emissions are 2015 emissions plus 20% for new buildings.
- The 100% emission reduction is calculated compared to 2040 BAU GHG emission figures.
- Zero emission buildings will produce 95% less emissions than the existing civic building stock, leaving 5% of emissions for potential natural gas back-ups and contingencies.
- Electricity in Vancouver will be at least 97% renewable from 2025 onwards.
- Neighbourhood renewable energy systems will be 100% renewable by 2040, with system back-ups being supplied by renewable natural gas or other renewable sources.

Based on identified civic buildings best suited for each conversion strategy and via extrapolation, anticipated GHG emission reductions were calculated for each pillar:

PILLAR #	PILLAR NAME	POTENTIAL GHG SAVINGS 2040 BAU vs 2015 (tonnes of CO_2e)	POTENTIAL GHG SAVINGS (%)
1	Zero Emission New	3,000	19%
2	Zero Emission Renewal	3,200	20%
3	Neighbourhood Renewable Energy Systems	5,800	37%
4	Energy Retrofits & Optimization	1,600	10%
5	Gas Conversion to High Efficiency Electric Heating	1,900	12%
6	Low Thermal Demand Retrofits	650	4%
7	On-site Anaerobic Digestion	400	3%
8	On-site Renewables	400	3%
9	Renewable Natural Gas	1,700	11%
	TOTAL	**18,650**	**100%**

Table 1: The proposed nine transition pillars and their associated potential GHG savings to 2040.

- The first three pillars – zero emission new buildings, zero emission renewal and neighbourhood renewable energy systems – are estimated to achieve 76% of the desired global emission reduction target. Their successful implementation will therefore be crucial.
- Low thermal demand envelope retrofits and on-site renewables are projected to contribute around 7% to the total emission reduction.
- On-site renewables and energy retrofits & optimization are promising options that might account for greater shares as technologies mature and specific sites are assessed for GHG reduction conversion strategies.

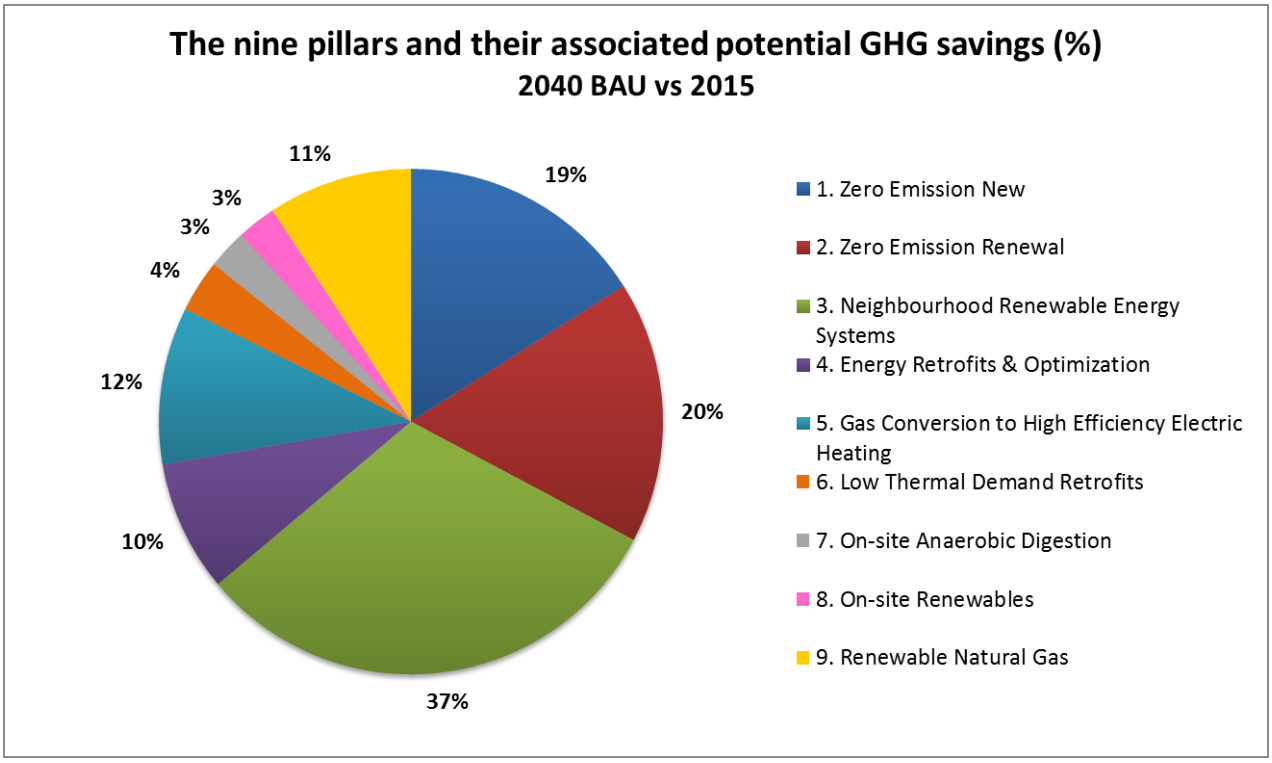

Figure 1: The proposed nine transition pillars and their associated potential GHG savings to 2040.

The calculated potential GHG savings and relative contribution of each pillar to the 100% GHG reduction target should not be seen at their face values. Instead, these figures provide an indication of the likely importance of each opportunity and are meant to drive investment decisions. Importantly, if one pillar's contribution decreases significantly, others will have to be stepped up in order to achieve the overarching 100% renewable energy target by 2040.

A Cost-effective Strategy & Transition Framework

All proposed carbon reduction measures have associated costs. Therefore, technical feasibility, ease of implementation and the nine pillar's relative life cycle costs were the main factors considered when assessing their likely contribution. Current price premiums of sustainable construction practices and new equipment installations are expected to progressively decline with technological progress, economies of scale, and better optimization.

Importantly, conventional capital cost comparisons are deemed insufficient in the context of climate change. Current analysis does typically not take account of externalities associated with GHG emissions. The City's Sustainability Group is currently working on developing a carbon pricing methodology which the REFM department will apply to future project evaluations.

Research has also shown that energy efficiency and zero emission buildings bring about multiple benefits, such as macroeconomic development, health and well-being and a more climate resilient community. Future civic zero emission building projects and carbon reduction measures will therefore be assessed based on full life cycle cost benefit analysis taking account of both externalities and multiple benefits.

2. ACKNOWLEDGEMENTS

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4. GLOSSARY

Anaerobic Digestion: A series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen. The process is used for industrial or domestic purposes to manage waste and/or produce fuels. One of the end products is biogas, which can be combusted to generate electricity and heat, or it can be processed into renewable natural gas and transportation fuels.

Biogas: In the absence of oxygen (i.e., through anaerobic digestion) organic matter, or biomass, can be repurposed into a renewable fuel source called biogas. Biogas can be upgraded to natural gas quality. It can then be used on-site to generate heat and electricity, or it can be injected into the gas grid or used as a vehicle fuel.

Biomethane: When biogas is upgraded to pipeline-quality natural gas, it becomes biomethane which can be used as a direct replacement for natural gas.

City-owned buildings: also referred to as civic facilities or Real Estate and Facilities Management (REFM) facilities in this report; buildings that are owned by the City of Vancouver and managed by the City's REFM department.

City Council: Vancouver City Council is made up of the Mayor and 10 Councillors who are elected at large for a four-year term. The Mayor is the Chair of City Council.

The City: Spelled with an upper case *C* throughout this report; all City departments and staff working for the City of Vancouver (shortened to City staff) under the direction of the City Manager and responsible for carrying out City operations.

City-wide: Spelled with a lower case *c* throughout this report; Vancouver wide.

CO_2e: Carbon dioxide equivalent: CO_2 is the most prevalent greenhouse gas after water vapour and has therefore become the proxy by which we measure greenhouse gas emissions. However, carbon dioxide is only one of many greenhouse gases that are emitted. Other greenhouse gases are methane, nitrous oxide and ozone – all of which occur naturally in our atmosphere. To take into account the emission of other greenhouse gases when calculating the level of greenhouse gas emissions, scientists have devised an equivalent measure – CO_2e – allowing other greenhouse gas emissions to be expressed in terms of CO_2 based on their relative global warming potential (GWP).

Embodied emissions: Also known as 'embodied carbon' is the amount of carbon released from material extraction, transport, manufacturing, and related activities for a given product or energy use.

Geothermal/Geoexchange: Energy systems that obtain heat from the earth and/or use the ground for cooling.

Heat pump: A device that transfers heat from a colder area to a hotter area by using mechanical energy. Heat pumps can draw heat from air external to a building ('air source') or from geothermal energy ('ground source').

Neighbourhood renewable energy system: Also called district energy system; a local energy network that has a neighbourhood energy centre to generate heat which is piped to local buildings for space heat, hot water and, in some cases, cooling.

Passive House: Passive House (Passivhaus in German) is an energy efficient building design approach and globally recognized certification system for near-net zero energy buildings. It applies to all forms of buildings and requires an 80-90% reduction in energy use for heating as compared to typical North American practices. Passive House buildings focus on complete insulation coverage (i.e. thermal bridge-free design), high performing windows, and ventilation with heat recovery. They harness natural heating from sunlight to minimize the need for purchased energy. Passive Houses require quality craftsmanship and provide excellent comfort and indoor air quality for occupants while minimizing energy costs.

Photovoltaic (PV): A method of converting solar energy into direct current electricity (as opposed to heat) using semiconducting material.

Renewable energy: Energy that is naturally replenished as it is used.

Renewable natural gas (RNG): After biogas is purified (or upgraded) into pipeline-quality biomethane it becomes fully interchangeable with conventional natural gas that can be used in buildings or vehicles. We then call it renewable natural gas.

Sewer heat: Wastewater (what gets flushed down toilets, mixed with millions of gallons of hot water from showers, dishwashers, washing machines, and more) maintains a fairly constant temperature as it travels through sewers to the treatment plant.

Social Cost of Carbon (SCC): The SCC is a measure of the incremental additional damages that are expected from a small increase in CO_2 emissions (or conversely, the avoided damages from a decrease in CO_2 emissions). Estimates of the SCC therefore provide a way to value CO_2 emission changes in cost-benefit analysis where the goal is to provide informed analysis to decision makers that quantifies the incremental mitigation benefits associated with a policy action and compares them to the incremental costs of abatement.

Solar thermal: Solar thermal collectors circulate a fluid which is heated by the sun's radiant energy. The heated fluid can then produce space heating, although it is more common to use these systems for hot water.

5. CONTEXT

5.1. City of Vancouver Renewable City Strategy

This project supports the City of Vancouver's Renewable City Strategy which outlines the pathway for Vancouver to derive 100% of its energy from renewable sources by 2050. In line with the city-wide strategy, for the purpose of this report, renewable energy is defined as energy that is naturally replenished as it is used (COV, 2015a).

In 2015, City Council adopted two main targets:

- Target 1: Derive 100% of the energy used in Vancouver from renewable sources before 2050.
- Target 2: Reduce greenhouse gas (GHG) emissions by at least 80% below 2007 levels before 2050.

When combined, residential, commercial, and industrial buildings are the largest single source of GHG emissions in Vancouver, constituting 56% of the city's total in 2014 (COV, 2015a). Accordingly, the City is tackling building energy use where it has the largest carbon reduction impact – primarily in space heating and hot water.

5.2 Project Objectives, Principles and Uncertainty

Project Objectives

The purpose of this project is to outline, for adoption or further discussion, the Renewable Energy Strategy for City-owned buildings. It follows the fundamental transition steps set out in the city-wide renewable city strategy and covers both retrofits of existing buildings and new construction of City-owned facilities. Importantly, this project follows two guiding principles:

1. Highlight how the *City can lead by example* and achieve the reduction of GHG emissions and transition to renewable energy before the required city-wide targets.
2. Achieve the transition to 100% renewable energy for civic facilities in the *most cost-effective way*.

Project Principles & Uncertainty

This report is not intended to be a detailed roadmap or technology guide. Instead, it lays out the framework for transitioning to renewable energy and provides a summary of the main opportunities, their potential contribution and builds the foundation for more detailed planning and budgeting. As with any long-term strategy, there is uncertainty involved when projecting 25 years into the future. Throughout this project, assumptions were made and recommendations adopted that seem most advantageous based on current knowledge, data and market conditions. As the future unfolds, opportunities and priorities might change, requiring a refreshed evaluation.

In particular, factors that could evolve and thereby change the dynamics of the transition are natural gas prices and British Columbia's (BC's) carbon tax. Currently, BC levies a carbon tax of $30 per metric tonne of carbon dioxide on about 70% of BC GHG emission sources, including fuels like gasoline, diesel, and natural gas (COV, 2015a).

Commodity Prices & Renewables

Oil and natural gas prices have fluctuated remarkably in recent years. Low or high oil prices could have a major impact on the global energy system over the next decades, and depending on how the fuel substitution dynamics play out, the carbon dioxide consequences could be significant. Researchers have also developed different scenarios depending on whether oil and natural gas prices decouple (see for example McCollum et al, 2016). In 2015, City-owned buildings relied on natural gas for 43% of their energy demand (see *table 2*). If the current, historically low price of natural gas increases, through higher carbon taxes or a rise in the fuel price itself, this would provide an incentive for a faster transition to renewables.

Moreover, renewable energy technologies are maturing and becoming cost competitive, with more new technologies to be developed as we move forward to 2050. Markets are changing rapidly with innovation and economies of scale. The most commercially viable forms of low

carbon and renewable energy sources are therefore likely to change until 2040 and their suitability for building integration and maintenance requirements are bound to evolve.

5.3. Project Methodology

This report does not provide a detailed analysis of potential GHG reductions for each of the 558 civic buildings. Instead, its purpose is to:

1. Lay out the framework and main opportunities for carbon reductions
2. Identify civic facilities best suited for each conversion strategy
3. Provide examples of civic facilities and carbon reduction projects
4. Calculate anticipated GHG emission reductions for each pillar, based on identified buildings and via extrapolation.

Based on historical trends, and considering that the construction boom linked to the 2010 Olympic Games will not be repeated in the medium-term, it was assumed that there will be a 20% increase in City-owned building floor area by 2040.

In order to make this project as comprehensive as possible, a number of sources were considered:

- *Building Energy and GHG Emission Databases* – The REFM department manages databases on civic facilities' past and current energy consumption and associated GHG emissions which formed the foundation of this project's analysis.
- *Stakeholder Engagement* – City staff were consulted for their knowledge and opinion on current and future development plans, in particular regarding zero emission buildings, neighbourhood renewable energy systems, anaerobic digestion facilities, and renewable natural gas. Moreover, various individual and stakeholder priorities and input were consulted and included in this project.
- *Carbon Neutral City Alliance Best Practices* – Several member cities' strategies of the Carbon Neutral Cities Alliance (CNCA) (an organization that comprises the world's 17 leading cities taking action on climate change) were reviewed to identify current best practices.

8. CONCLUSION

This project has laid out the pathway and framework for transitioning City-owned buildings to 100% renewable energy. Ambitious targets and milestones are proposed that set out a plan for the City to achieve the renewable energy transition and complete GHG emission reduction from its facilities by 2040, 10 years prior to Vancouver wide targets.

Since 87% of 2015 building emissions are linked to natural gas consumption, predominantly used for space heating and hot water, the focus of the developed framework is first to reduce the need for heating requirements and second, to find alternatives to fossil fuel based energy. Consequently, the foundation of the decarbonisation strategy is the reduction of building energy demand, improved energy efficiency and expanded renewable energy provision.

Nine pillars make up the transition framework and have been ranked according to their potential contributions based on the technical effort required and their cost-effectiveness:

- The three major opportunities – zero emission new buildings, zero emission renewal and neighbourhood renewable energy systems – are estimated to achieve about three quarters of the desired total emission reduction target.
- The conversion from natural gas to electricity for space heating, energy retrofits & optimization projects and RNG are all expected to contribute about 10% to the transition.
- Low thermal demand envelope retrofits, anaerobic digestion, and on-site renewables are projected to make up less than 5% each of the total GHG emission reduction.
- Energy retrofits & optimization and on-site renewables are promising options that might account for greater shares as technologies mature and specific sites are assessed for optimal conversion strategies.

The calculated GHG emission savings of each pillar by 2040, laid out in this report, provide an indication of the potential importance of each opportunity and are meant to drive and direct investment decisions.

Importantly, should one pillar contribute significantly less than anticipated, others will have to be stepped up to ensure that the overall target of 100% renewable energy for civic facilities will be achieved. As with any long-term strategy, uncertainty revolves around a number of factors, in particular how natural gas prices and BC's carbon tax will evolve as well as the cost-competitiveness of renewable energy technologies. Changes in any of these elements could alter the incentives and dynamics of the transition process, requiring a refreshed evaluation.

Ultimately, whether the proposed targets set out in this strategy are to be achieved will depend on the timely implementation of the proposed pillars and the City's determination to direct the necessary investment funds to decarbonizing its own facilities. The benefits of such achievement would be multiple:

1. Reducing GHG emissions from City-owned buildings contributes to restoring our climate and environment.
2. Demonstrating leadership has social benefits since the City acts as a catalyst of change in the wider community.
3. Embracing renewable energy generates economic benefits. Through the use of local and renewable energy the City will enjoy long-term rate stability that outperforms conventional fossil fuel options.
4. Developing zero emission buildings and energy retrofits will benefit the local construction industry by creating know-how and employment opportunities.

8.1. Final recommendations

Looking beyond the developed framework and nine transition pillars laid out in this report and considering future technological progress, there is room to even imagine further stretched targets and potential future developments. Today, industry and academia are working on solutions that render buildings and building materials 'carbon negative' as well as on technologies that capture CO_2 from the atmosphere.

A carbon negative building is one where excess energy generated is diverted to the community grid where it is then used to power other public buildings. Similarly, 'plus energy' is a term used in building design to describe a structure that produces more energy than it uses. Examples of such building materials and facilities appear around the world.

Moreover, the emerging field of carbon dioxide removal offers hope. Carbon removal technologies, also known as 'carbon negative' technologies, afford cities the opportunity to turn the current GHG emission paradigm on its head by enabling cities to subtract more GHG emissions from the atmosphere than they emit. Such solutions and innovations are, of course, still in their infancy. And there is a danger that they could breed complacency.

Importantly, therefore, the strong focus must remain on reducing the use of fossil fuels while aiming even higher and supporting ambitious pilot projects. Through investment and human ingenuity cities have the potential to see immense positive impacts as they become healthier, more prosperous, and innovative.

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