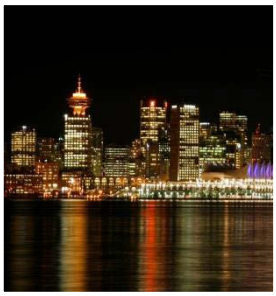
Renewable City Strategy



November 2015

CITY OF VANCOUVER

Executive Summary :: Achieving 100% Renewable Energy for Vancouver

Imagine a city where jobs and businesses are diverse and economically strong; where homes and offices have clean and comfortable environments that are less expensive to heat and cool; where the transportation system is abundant and efficient, a city that supports a thriving economy while improving affordability and provides citizens the opportunity to be healthy and mobile. Imagine a city powered only by renewable energy.

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

Target 1: *Derive 100% of the energy used in Vancouver from renewable sources before 2050*
Target 2: *Reduce Greenhouse Gas emissions by at least 80% below 2007 levels before 2050*

Geographic Scope: The geographic scope of the *Renewable City Strategy* covers the area within the City limits, and any facilities owned or operated by the City of Vancouver outside those limits.
Emissions Scope: The *Renewable City Strategy* will track emissions in accordance with the most stringent international reporting standards (currently the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories*).

Strategic Approach

1. **Reduce energy use**
   Advance energy conservation and efficiency programs which are the most cost-effective way to a renewable energy future.
2. **Increase the use of renewable energy**
   Switch to renewable forms of energy that are already available to us, and make improvements to our existing infrastructure to use it to its fullest potential.
3. **Increase the supply of renewable energy**
   Increase the supply of renewable energy and build new renewable energy infrastructure.

Primed for Success

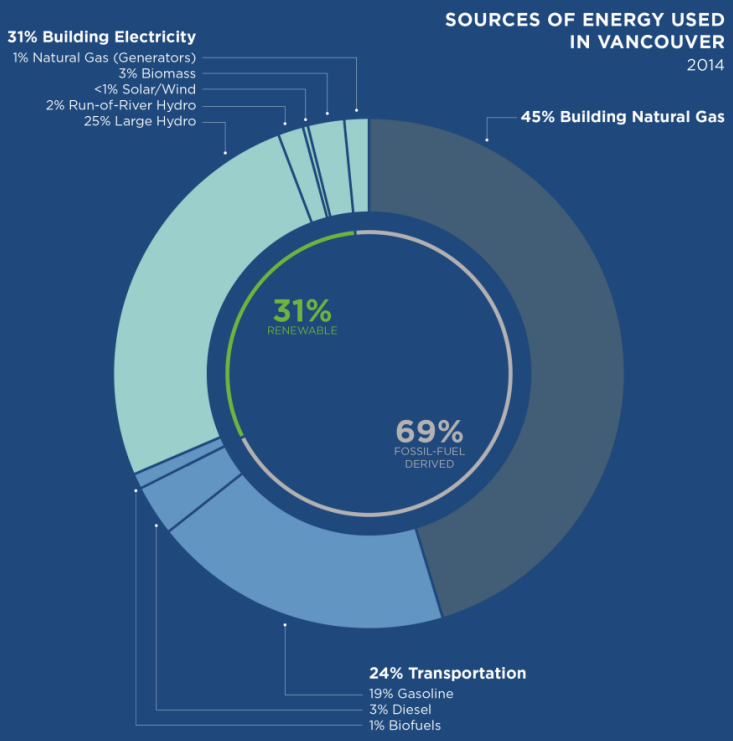
Vancouver has all the conditions needed to successfully derive 100% of its energy from renewable sources before 2050. Vancouver is building on 25 years of action and success to tackle climate change for the benefit of all who live in, work in and visit Vancouver, and for the benefit of the world. Vancouver, a city of 605,000 people and an area of 115 *sq. km*, is already a world leader in the development of complete, compact, and livable communities that already have greenhouse gas emissions per person amongst the lowest in the developed world. Serviced by a clean and reliable electrical system, which also powers much of the city's transit system, Vancouver is primed to capitalize on the electrification of both its buildings and its transportation system. Vancouver's brand, valued at US$31bn when measured by investment, reputation and performance, demonstrates the economic importance of existing in harmony with nature.

The Opportunity

The technological and business transformation of energy efficiency, conservation and management coupled with new renewable energy generation is set to define the economy of the future. The *Renewable City Strategy* positions Vancouver to increase its economic diversity for a stronger, more resilient economy. A healthy environment is essential to attracting and retaining the very best minds, establishing Vancouver as an innovation hub with high and inclusive employment, and positioning Vancouver in the vanguard of long-term economic stability and success. The City of Vancouver can be the catalyst for change through its own internal operations, as well as public pilots and demonstrations. Ensuring that the city's neighbourhoods, communities, buildings, transportation system, businesses and individuals embrace renewable energy will mean a better, healthier quality of life for Vancouverites today and into the future.

Energy Use in Vancouver Today

Vancouver's energy use is currently 31% renewable, with the fossil fuel fraction dominated by natural gas for space heat and hot water, and gasoline for personal and light-duty vehicle use. Vancouver's energy use and resulting greenhouse gas emissions, are dominated by buildings and transportation. These two sectors are the primary focus of the *Renewable City Strategy*.



Zero-Emission Building Priorities

B.1 New buildings to be zero-emission by 2030

B.1.1 Adopt and demonstrate zero-emission standards in new City of Vancouver building construction
B.1.2 Ensure rezoning policy leads the transition to zero-emission buildings
B.1.3 Incentivize and streamline the development of exemplary buildings
B.1.4 Establish and enforce specific greenhouse gas intensity limits for new developments
B.1.5 Develop innovative financing tools to help fund new zero-emission buildings
B.1.6 Establish partnerships to build industry capacity
B.1.7 Mandate building energy benchmarking and labelling requirements

B.2 Retrofit existing buildings to perform like new construction

B.2.1 Use the Zero-emission New Building Strategy to reduce the need for building retrofits
B.2.2 Mandate energy efficiency improvements for existing buildings
B.2.3 Provide flexibility to achieve energy efficiency requirements through the support of on-site generation or neighbourhood energy system connection
B.2.4 Facilitate modest retrofits through structured guidance and the provision of incentives
B.2.5 Increase renewable energy use by large energy consumers

B.3 Expand existing and develop new Neighbourhood Renewable Energy Systems

B.3.1 Expand existing Neighbourhood Renewable Energy Systems
B.3.2 Enable the conversion of the downtown and hospital steam systems from natural gas to renewable energy
B.3.3 Enable the development new neighbourhood renewable energy systems for downtown and the Cambie corridor
B.3.4 Continue to enforce, and update as required, building and renewable energy supply policies that support neighbourhood renewable energy systems

B.4 Ensure grid supplied electricity is 100% renewable

B.4.1 Partner with utilities to increase the supply of renewable energy
B.4.2 Partner with utilities to implement a smart grid that meets Vancouver's energy needs

A Vision for Vancouver's Buildings in 2050

By 2050, about 40% of Vancouver's buildings will have been replaced and built to the carbon-neutral standards set out in the *Greenest City 2020 Action Plan* or to zero-emission standards which will have come into effect before 2030. Of the buildings which remain there will be an even split between those built to current standards and those built to standards pre-dating 2010. The vast majority of buildings that have not been built to zero-emission standards will have undergone deep retrofits to bring their energy performance up to the standards expected of new construction, or have been connected to the one of Vancouver's renewable neighbourhood energy systems. These changes will cut city-wide building energy use by over a third compared to 2014.

Current business-as-usual energy use with existing City and Provincial policies would likely mean an increase in city-wide electricity use by 2050 of approximately 10% over 2014, with large amounts of fossil-fuel-derived energy remaining. The *Renewable City Strategy* would lead to an increase in electricity use of about 20% by 2050 over 2014 levels, but would in the process eliminate Vancouver's need for fossil fuels.

Building performance improvements and the expansion of neighbourhood renewable energy systems that can provide heating and cooling will limit increases in electrical demand. There will be only minimal need for large electrical generation and transmission infrastructure investments – British Columbia's electrical grid can be capitalized upon and optimized to meet demand with only modest generation additions. The use of on-site power generation from solar or the meeting of heating needs through air-source heat pumps or geoexchange systems will further limit the need for new electrical generation. For those buildings that cannot be brought to perform to zero-emission standards and that cannot be connected to renewable neighbourhood energy systems, biomethane will be used to meet heating needs, although this need is expected to be minimal and biomethane will play a more significant role in the transportation system as an energy-rich mobile fuel.

The incremental electrical demand increase over business-as-usual will in part be due to the electrification of personal transportation. Since typical daily commutes are short in Vancouver, and the need for personal vehicle use will decline substantially by 2050, vehicle electrical demand will constitute only about 5% of total annual city-wide electrical demand, with this deamdn required to be met through home and work-place charging infrastructure. New smart-grid technologies will manage electrical distribution, on-site generation, and electric vehicle charging.

Renewably Powered Transportation Priorities

T.1 Use land-use and zoning policies to develop complete compact communities and complete streets that encourage active transportation and transit

- T.1.1 Foster land use as a tool to improve transportation consistent with the direction established in *Transportation 2040*
- T.1.2 Enhance and accelerate the development of complete streets and green infrastructure
- T.1.3 Enhance the pedestrian network according to the direction established in *Transportation 2040*
- T.1.4 Enhance cycling infrastructure and encourage more bike trips according to the direction set in *Transportation 2040*
- T.1.5 Use parking policies to support sustainable transportation choices and efficient use of our street network
- T.1.6 Optimize the road network to manage congestion, improve safety, and prioritize green transportation

T.2 Improve transit services as set out in *Transportation 2040*

- T.2.1 Extend the Millennium Line in a tunnel under Broadway
- T.2.2 Improve frequency, reliability, and capacity across the transit network
- T.2.3 Develop a transit supportive public realm with improved multimodal integration and comfortable waiting areas
- T.2.4 Work with the transit authority and other partners to transition fossil fuel powered transit vehicles to renewable energy

T.3 Transition light-duty vehicles (cars and light trucks) to be predominantly electric, plug-in hybrid or sustainable biofuel powered

- T.3.1 Develop vehicle and fuel standards to support renewably powered vehicles
- T.3.2 Develop supporting infrastructure that meets the needs of renewably powered vehicles

T.4 Develop car-sharing and regional mobility pricing to encourage rational journey choice

- T.4.1 Support increased car-sharing and the uptake of renewably powered vehicles in car-sharing fleets.
- T.4.2 Advocate for comprehensive regional mobility pricing

T.5 Better manage commercial vehicle journeys and transition heavy-duty (commercial) vehicles to sustainable biofuels, biomethane, hydrogen and electricity

T.5.1 Improve the delivery of commercial freight, goods, and services according the direction set in *Transportation 2040*

T.5.2 Work with fleet operators and contractors to transition to renewably powered vehicles

A Vision for Vancouver's Transportation System in 2050

Vancouver will continue its efforts to build a city that is compact and complete, allowing most people to meet their daily needs through walking, cycling, and transit. Longer journeys will be made on transit that is predominantly electrified, complemented by renewable fuels like sustainable biofuel, biomethane, or hydrogen. The number of people living and working in the city will grow significantly by 2050, and while the number of private vehicles per person could decline by as much as 15%, the total number is expected to increase by 15%. Even with this growth, the actions outlined in the *Renewable City Strategy* - including thoughtful land use planning and infrastructure investments that improve green transportation options - could reduce total annual vehicle kilometres travelled by 20% over 2014.

The *Renewable City Strategy* priorities will help transition private vehicles to using only renewable energy sources. By 2050 about 25% of Vancouver's personal vehicles would be electric using renewably generated electricity, 45% plug-in hybrids using renewable electricity and sustainable biofuels, and the remainder conventional hybrid vehicles running on sustainable biofuels. The compact nature of Vancouver means daily commutes are short enough to allow the vast majority of plug-in hybrid journeys to use only the vehicle's battery. Given the anticipated growth in both electric and plug-in hybrid vehicles, it will be critical to provide charging infrastructure at home, work, and on-the-go locations. The effect of autonomous cars on our transportation system is expected to be marked, although it is unclear if the effect will in aggregate be positive or negative.

As fewer people drive for personal trips, the proportion of transportation energy attributable to commercial vehicles will increase. Less important than the number of commercial vehicles is the distance they travel and the weight of goods they haul. Improving how goods, freight, and services are provided will be paramount, although it is as yet unclear if electrification, biofuels, biomethane or hydrogen will dominate heavy-duty vehicle types.

City Services Renewable Energy Priorities

The City of Vancouver can catalyze change by being a leader in the use of renewable energy in its own operations and empowering change through the full array or services it provides; to do this:

S.1 The City will adopt a comprehensive approach to the consideration of climate change as part of its service planning

S.2 The City will adopt a comprehensive approach to pricing carbon emissions for municipal operations

S.3 The City will develop a framework to assess how City enabling tools may be used to support the transition to 100% renewable energy

S.4 The City commits to keep abreast of financing mechanisms available that enable the delivery of renewable energy technology and other green infrastructure

Economic Opportunity Priorities

The Renewable City Strategy provides a significant economic opportunity for Vancouver that will be capitalized on through:

E.1 Support innovators through business and technology research, incubation, acceleration, and demonstration.

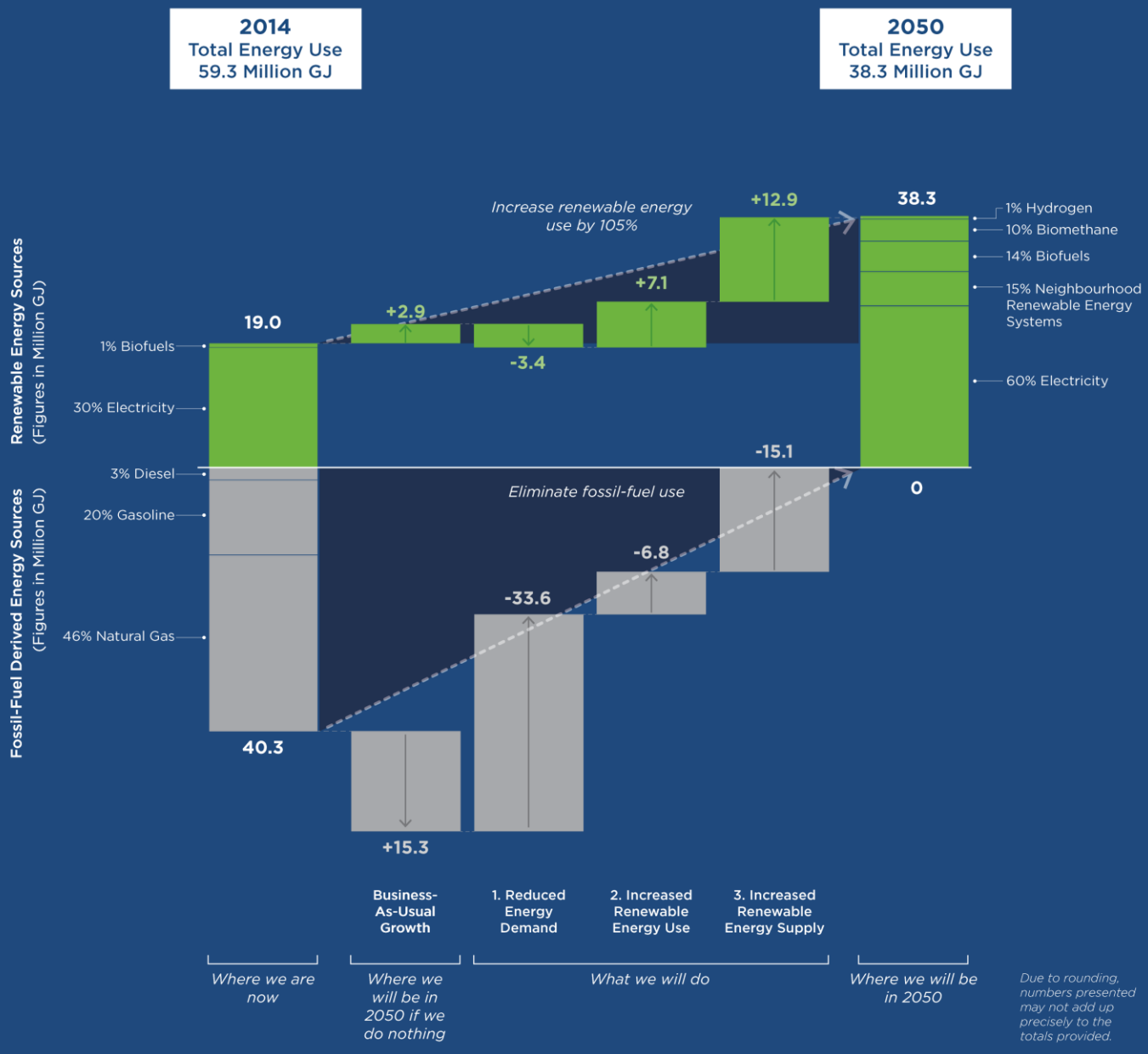
E.2 Actively work with businesses to increase the use of renewable energy

E.3 Target key events and organizations that represent cleantech and renewable energy to strengthen Vancouver's economy

E.4 Attract 'green capital' and enable more innovative financing mechanisms for clean and renewable businesses

Vancouver's Potential Energy System Transformation

Below are the modelled effects of implementing the *Renewable City Strategy*. The cumulative effect of the strategy is to reduce total energy use by one third over 2014 levels, saving 21 million GJ of energy a year, a reduction over business-as-usual energy demand of more than 50%, saving 39 million GJ of energy annually. Improvements in building performance, reductions in personal vehicle use through active transport, and improvements in vehicle efficiency account for 45% of total city-wide energy system changes. The increased use of existing renewable energy sources like the expansion of neighbourhood renewable energy systems, increased transit use and the expansion of car-sharing could account for about 20% of city-wide energy use changes. Finally, the increase of renewable energy supply through new neighbourhood renewable energy systems and the use of biofuels, biomethane and hydrogen could account for 35% of changes in Vancouver's energy system.



Due to rounding, numbers presented may not add up precisely to the totals provided.

How to Read the Strategy

The Renewable City Strategy provides a vision and direction to using only renewable energy sources to meet Vancouver's energy needs. It is not intended to be prescriptive or provide a detailed roadmap. The strategy is structured to provide an overview of what the 100% renewable energy commitment means and how it was developed, followed by some context in which the strategy must be considered, before discussing in detail the technological options and actions that can be taken to transition Vancouver's buildings and transportation to use only renewable energy. There are summary sections (on blue pages) at the start of the document and also at the front of the Building and Transportation sections. Throughout the document, reference is made to the City of Vancouver or "the City," which refers to the municipal corporation, while references to the "city" (with a lower-case "c") make reference to the community as a whole.

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OVERVIEW : Where We Are and Where We Are Going

Imagine a city where jobs and businesses are diverse and economically strong; where homes and offices have clean and comfortable environments, are less expensive to heat and cool; where the transportation system is abundant and efficient, a city that supports a thriving economy while improving affordability and provides citizens the opportunity to be healthy and mobile. Imagine a city powered by renewable energy.

Goals and Targets

The City of Vancouver's mission statement is "to create a great city of communities that cares about its people, its environment, and the opportunities to live, work, and prosper." The *Renewable City Strategy* is at its core a strategy that focuses on these three pillars: Vancouver's people, economy, and environment. The transition to using 100% renewable energy, and the arrival at that goal, provides an opportunity to enhance each of these pillars.

People: Vancouver is defined by its residents and their diversity, ability to adapt, visionary outlook, and desire to be involved in shaping their city. Moving towards the use of 100% renewable energy provides the opportunity for communities to be more vibrant, integrated, and considerate of their impacts. The energy used in daily life through transportation choices, heating and cooling homes, and managing waste is integral to delivering the communities Vancouverites want.

Economy: The transition to the use of 100% renewable energy provides the opportunity for innovation and development of new business models, products, and technologies. Local innovation can be shared internationally, reinforcing Vancouver's leadership in environmentally responsible urban stewardship.

Environment: Evolving to a renewable-energy future provides many environmental benefits in addition to reduced greenhouse gas emissions. Concurrent benefits include better air quality, a healthier lifestyle, enhanced natural habitat, reduced pollution risk from leaks and spills, and preparation for the anticipated impacts of a changing climate such as extreme weather events.

Where Are We Now?

Known for its mild coastal climate and mountain views, Vancouver is the largest city in British Columbia and the eighth-largest city in Canada. Vancouver has an ethnically and linguistically diverse community where half its residents speak a first language other than English, and an economy that is the second-most diversified in Canda. At the time of first European contact in the late 18th century, the Musqueam, Squamish, and Tsleil-Waututh peoples lived in the area that is now Vancouver. All are Coast Salish First Nations, sharing cultural and language traits with people in the Fraser Valley and Northern Washington State, and the City of Vancouver acknowledges their unceded traditional territories.

Vancouver has grown a lot in the past 129 years and now uses over 59.3 million gigajoules (GJ) of energy a year—that's enough energy to get to the moon and back 6,500 times—and releases 2.8 million tonnes of carbon dioxide (CO_2) as a result. The focus of the *Renewable City Strategy* is on the sectors of our city that consume the most energy: buildings and transportation. Additionally, there are many other sources of greenhouse gas emissions that the City will continue to address in partnership with other stakeholders.

Of our total energy consumption in buildings and transport, about 31% is currently renewable, thanks mostly to the province's large hydroelectric generating facilities. A small portion of gasoline and diesel within BC is also regulated to come from renewable sources.

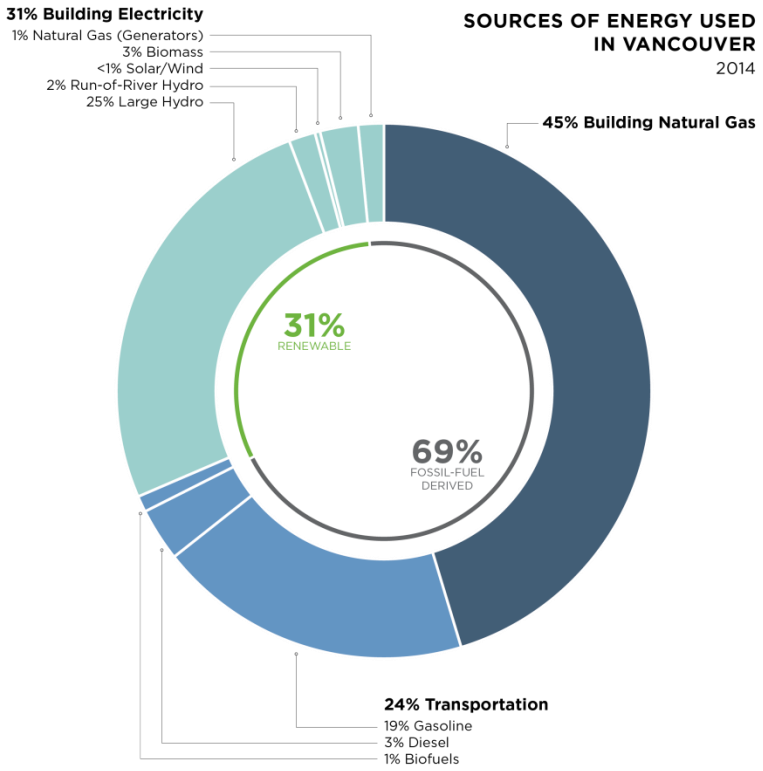


Figure 1 **- Vancouver Community Wide 2014 Energy Use (directly recorded and modelled)**

Goal

The goal of *Renewable City Strategy* is that Vancouver will become a city that uses only renewable sources of energy while respecting the principles of sustainability.

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

Renewable energy technologies are in the ascendancy as they mature and become cost competitive, and many more new technologies are under development or yet to be realized. As long as they meet the above definition, new innovations will be considered as the *Renewable City Strategy* is updated and refined.

Transportation: Renewable energy sources for transportation include responsibly sourced and processed biofuels, hydrogen from the electrolysis of water using renewable electricity, biomethane (also called "renewable natural gas" or "biogas") and renewable electricity.

Buildings: Renewable energy sources for buildings must typically provide heating and cooling or electricity. Electrical needs can be met by both large and small hydro projects, photovoltaics and wind; space heat can be met with biomethane, heat pumps or resistance heating using renewable electricity or renewable waste streams such as, biomethane, recycled wood and sewer heat, with geoexchange systems able to provide renewable heating and cooling.

Targets

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

Scope

Geographic Scope: The geographic scope of the *Renewable City Strategy* covers the area within the City limits, and any facilities owned or operated by the City of Vancouver outside those limits.
Emissions Scope: The *Renewable City Strategy* will track emissions in accordance with the most stringent international reporting standards (currently the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories).

Almost all aspects of our daily lives require some form of energy, which generates carbon pollution in the form of greenhouse gases: energy to heat our homes and workplaces, energy to produce the food and products we consume, and fuel to transport people and goods. Much of this energy produces carbon dioxide – the most significant greenhouse gas because it is released in such large quantities. Other greenhouse gases – methane, oxides of nitrogen (NO_x), and certain industrial gases – are also released by industrial processes, agricultural activity, the manufacture of goods, and most prominently when we burn fuel.

The second target ensures that a focus on renewable energy sources does not overlook greenhouse gas emissions reductions. The dual targets ensure that the city's waste management system, responsible for about 8% of Vancouver's community emissions in 2014, is truly integrated into our energy system.

The City will take action where it has influence over Scope I emissions—those emissions that result directly from energy use, such as the use of natural gas or diesel to produce energy for buildings (of all types), in the manufacture of goods and products, or in the use of gasoline, diesel, and other fossil fuels in the transportation system for road, railway, waterborne, air and non-road vehicles. The City will also take action on Scope II emissions – those that result from the production of energy from another source, most typically electricity generated outside the city or in the production of steam in neighbourhood energy systems. Carbon emissions derived from the disposal of solid and liquid waste, as well as the combustion of compostable materials, will be addressed directly (for example, through landfill gas capture), and as inputs to the energy system (by, for example, using biomethane from landfill gas to power vehicles

The City will also continue to support reductions in energy use and greenhouse gas (GHG) emissions for Scope III emissions – those emissions that result from consumption, or "embedded emissions", such as transportation energy use outside the city, or in the production of the goods we consume, most notably food, or the buildings we construct. It should also be noted that even in a 100% renewable energy city there will still be very small amounts of fossil fuel burned, one example of which is likely to be vintage and classic cars; the number of these cars is already small and will remain immaterial to the strategy's broader goals.

Strategic Approach to the Renewable Energy Transition

The City's strategic approach to renewable energy is structured to reflect that energy efficiency and conservation measures have the largest long-term impact and are the most cost effective, and that increasing the use of existing renewable energy resources is more cost effective than building new.

1. **Reduce energy use.**
   Advance energy conservation and efficiency programs which are the most cost-effective way to a renewable energy future.
   eg. increase building insulation requirements; improve walking and cycling networks
2. **Increase the use of renewable energy.**
   Switch to renewable forms of energy that are already available to us, and make improvements to our existing infrastructure to use it to its fullest potential.
   eg. switch to an electric vehicle; expand the number of buildings connected to the Southeast False creek Neighbourhood Energy Utility
3. **Increase the supply of renewable energy.**
   Increase the supply of renewable energy and build new renewable energy infrastructure.
   eg. increase the amount of rooftop solar power generation; supply more biofuels for transportation

This approach will move the City towards deriving 100% of its energy from renewable sources. The sections that follow outline how these principles will be reflected in action. The anticipated reductions in carbon pollution that will result the actions outlined in the *Renewable City Strategy* to transform the way we use energy and the systems that supply our buildings and vehicles are shown below.

Renewable City Strategy: A Strategy in Context

Strategic City Plans

The City of Vancouver has a series of plans that are integrated to achieve multiple concurrent benefits, the *Renewable City Strategy* being the latest addition and for which there will be:

Complete Integration

- *Greenest City Action Plan*
- *Transport 2040*
- *Zero-emission New Building Strategy* (under development)
- *Neighbourhood Energy Strategy*
- *Long-term Financial Sustainability Guiding Principles*
- *Healthy City Strategy*
- *Building Retrofit Strategy*
- *Rezoning policy for Sustainable Large Developments*

Partial Integration

- *10-year Capital Strategic Outlook*
- Mid- to long-term Financial and Capital Plans and Budgets
- *Regional Context Statement* (in response to *Metro Vancouver Regional Growth Strategy*)
- *Vancouver Economic Action Strategy*
- *City of Vancouver Digital Strategy*
- *Climate Adaptation Strategy*
- *Waste Management and Resource Recovery Long Range Strategy* (under development)
- Community Plans and Public Benefit Strategies (ongoing)

The *Renewable City Strategy* is the natural continuation of the *Greenest City Action Plan* that establishes the City's environmental targets to 2020. Many of the initiatives in the *Greenest City Action Plan* will have been embedded and mainstreamed within the City and its services by 2020; however the need to make transformational change in our energy system continues and it is prudent to start that planning now. The *Renewable City Strategy* is the response to that prudence, and compliments the City's existing plans that constitute the City's strategic approach to the three pillars of sustainability- social (Healthy City Strategy), economic, (*Vancouver Economic Action Strategy*) and environmental (*Greenest City Action Plan*).

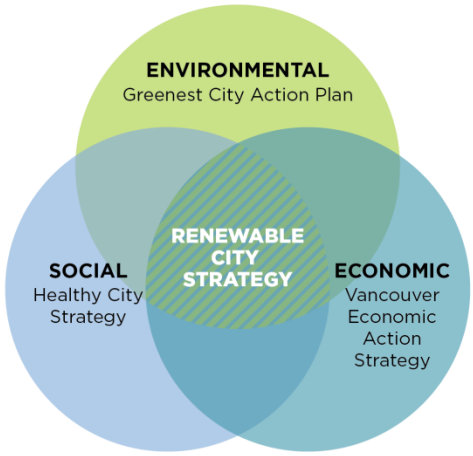


***Figure 2 – Renewable City Strategy* link with sustainability principles**

Regional Planning

The City of Vancouver cannot act in isolation when transitioning to using 100% renewable energy. Metro Vancouver's *Regional Growth Strategy* describes how the region as a whole is to respond to increases in population and jobs, and contains strategies to advance five goals related to urban development in key areas: the regional economy, the environment and climate change, housing and community amenities; and the integration of land use and transportation. Vancouver's *Regional Context Statement* describes our own city's response to growth and development imperatives.

Through Metro Vancouver's *Integrated Air Quality and Greenhouse Gas Management Plan* and *Integrated Solid Waste and Resource Management Plan*, Metro Vancouver has established clear frameworks by which political, policy and service roles can act to support the use of renewable energy sources at the regional level.

Provincial Policy

The Provincial Government of BC has in place a number of plans that support the development of 100% renewable energy resources. The City of Vancouver encourages the current and successive Provincial Governments to continue with these commitments, devote additional resources to this transition and accelerate the pace at which their initiatives are implemented.

- BC Climate Action Plan (successor under development)
- BC Energy Plan
- BC Bioenergy Strategy
- BC Air Action Plan

Federal Policy

The Federal Government's most relevant policies related to renewable energy are currently limited to infrastructure planning and funding. There is need for more explicit federal policies and programs to support renewable energy, energy efficiency improvements, and the pricing of carbon pollution.

Strategy Consultation and Development

The *Renewable City Strategy* has been developed in cooperation with a wide range of stakeholders.

The *Renewable City Action Team* was convened with representation from local environmental and civil society non-profit organizations, academia, regional and provincial government, the business community, and the local utilities. The *Renewable City Action Team* provided strategic oversight of the strategy's development and gave access to the latest thinking on renewable energy and greenhouse gas emission reduction, while ensuring that the strategy addressed the multiple needs of Vancouver's residents. The City of Vancouver would like to thank the *Renewable City Action Team* for their thoughtful comments and guidance in helping develop the *Renewable City Strategy* and look forward to their continued involvement as the *Renewable City Strategy* is implemented.[1] The members of the *Renewable City Action Team* were:

[1] Representation on the *Renewable City Action Team* does not explicitly or implicitly represent endorsement of the *Renewable City Strategy* by the individual or organization presented.

Gregor Robertson *(Co-Chair)*, Mayor, *City of Vancouver*
David Boyd *(Co-Chair)*, Adjunct Professor School of Resource and Environmental Management, *Simon Fraser University*
Alex Lau, Vice President, *Golden Properties Ltd.*
Allan Neilson, General Manager Policy Planning and Environment, *Metro Vancouver*
Brent Gilmour, Executive Director, *Quality Urban Energy Systems of Tomorrow (QUEST)*
Cara Pike, Executive Director, *Climate Access*
David Porte, Chair, *Urban Development Institute*
Ian MacKay, CEO, *Vancouver Economic Commission*
James Tansey, Executive Director Centre of Social Innovation and Impact Investing, *University of British Columbia*
Joanna Sofield, General Manager PowerSmart, *BC Hydro*
Marc Lee, Senior Economist, *Canadian Centre for Policy Alternatives*
Mark Jaccard, Director School of Resource and Environmental Management, *Simon Fraser University*
Merran Smith, Executive Director, *Clean Energy Canada*
Peter Robinson, CEO, *David Suzuki Foundation*
Ross Beaty, Executive Chairman, *Alterra Power Corporation*
Susanna Laaksonen-Craig, Head Climate Action Secretariat, *Government of BC*
Tom Pedersen, Executive Director, *Pacific Institute of Climate Solutions*
TransLink, *Transportation Planning and Policy*
Wal Van Lierop, President and CEO, *Chrysalix Venture Capital*

International thought-leaders and peer organizations also provided feedback on initial drafts of the plan. The City of Vancouver particularly looked to the City of Stockholm's *Roadmap for a Fossil Fuel Free Stockholm 2050* and the City of Copenhagen's *CPH 2025 Climate Plan* as world leading cities with to ambitious but achieve climate and energy plans. These cities also provided a comparable context for Vancouver with similar populations, climate, energy systems and public desire to act. Industry and technology associations also provided input on the technical aspects of moving to the use of 100% renewable energy.

Members of the *Carbon Neutral Cities Alliance*, that comprises the world's 17 leading cities taking action on climate change, provided review and feedback on initial drafts of the strategy, as did some delegates from international organizations who had attended the *Renewable Cities Global Learning Forum in May 2015.* The Forum was a collaboration between the City of Vancouver and the Simon Fraser Centre for Dialogue, that brought together over 300 delegates to discuss the challenges, barriers, and opportunities of becoming a renewable city.

Through the summer of 2015 the City held *The Bright Green Summer*, a series of events and engagements for the public to learn about the *Greenest City 2020 Action Plan* and *Renewable City Strategy*. During the *Bright Green Summer* the City went out to public events such as the Pacific National Exhibition showground, 'Doors Open Vancouver', Pop-up City Hall, downtown Block Party and the Vancouver Public Library summer reading events, to share information on the existing and new *Greenest City* goals, and collect stories and feedback. A renewable energy focused micro-conference brought together 40 sustainability professionals with a range of expertise from green buildings to sustainable transportation who together created a vision of what a renewable city could look like. The City also administered a survey through the City's Talk Vancouver platform reached collected feedback on renewables from over 850 people, 76% of whom supported the direction the City is taking in its climate action work.

Implementation

The *Renewable City Strategy* sets the strategic direction for Vancouver to achieve its 100% renewable energy goals. It is not intended to be a detailed roadmap or technology guide, but instead is a foundation for more detailed planning in the future. Project and technology support that result from the *Renewable City Strategy* will be assessed using techno-economic and socio-economic approaches to ensure that the route followed is technically, economically and socially responsible. The *Renewable City Strategy* proposes a viable route to using 100% renewable energy – it does not purport to be the *only* route to that success.

Following the successful model of implementing the *Greenest City 2020 Action Plan*, departments will be identified that are best suited to implement specific actions and projects. These strategic internal partnerships will deliver outcomes based on already established core relationships while fostering new ones. Continuing to embed the transition to renewable energy within City administration is critical to developing the leadership that will bring long term success. Specific work-plans will be brought forward for Council's consideration as the opportunities arise.

There is a broad need for partnership with the business community, academia, non-profit organisations, surrounding municipalities, other levels of government, public agencies and the public at large to ensure the success of the *Renewable City Strategy*.

The City will ensure that the public is widely engaged and consulted as the strategy moves into implementation. Empowering Vancouver's citizens and communities are empowered to participate in the energy revolution will be a critical success factor. It is important that Vancouver residents and businesses not only understand the changes that will come with a renewable city, but are mobilized to become the agents for and investors in those changes. Vancouver has the capability to be a world-leading knowledge hub for the integration of renewable energy into urban centres. At its heart, a renewable city strategy is not about energy: it is about quality of life, health, affordability, a strong and sustainable economy for generations to come.

The City will develop performance and reporting metrics to support the implementation of the Renewable City Strategy, reporting to Council annually, and revisiting the strategy to ensure that the course it has plotted is still valid and appropriate –this will be updated every four years and major project funding synchronize with the City's capital planning process. The City also commits to share its lessons and learning regionally, nationally and internationally so that others can gain from Vancouver's experience and also make the transition to use 100% renewable energy.

CONTEXT :: Setting the Stage

The Vancouver Stage in 2015

City Profile

In 2013 there were over 605,000 people in the city's 115 *sq. km* area, with the majority of the city street system forming an easily navigable grid. The city is made up of large areas of residential property, many commercial buildings, and a growing number of mixed-use buildings. Vancouver has only three large industrial facilities, a handful of medium-sized industries and a myriad of light-industrial and small-and-medium enterprises.

Metro Vancouver

The City of Vancouver is part of Metro Vancouver, a region made up of 21 municipalities, one treaty First Nation and one electoral area, which together have an area of nearly 2,900 *sq. km* and in 2013 a population of 2.5million.

Population and Job Increases

In the past 25 years Vancouver's population has grown by 34%, with jobs increasing by 30% and energy use by about 15%. Over the same time Vancouver's carbon emissions have dropped by 7%, and are expected to keep falling; showing that the city can continue to grow and be economically strong while removing the burden of polluting carbon emissions. Over the next 35 years the city's population is expected to grow by about 30% (170,000 people), creating 32% more jobs.

Business Profile

Vancouver's business profile is comprised mainly of small-and-medium enterprises, with a growing digital sector and little heavy industry. Over 90% of Vancouver businesses have fewer than 50 employees, and over 70% have 10 employees or fewer. This gives the economy strength through diversity, but so many individual stakeholders makes engaging the business community challenging.

Port Metro Vancouver

Port Metro Vancouver is Canada's largest port, shipping goods valued at over $500 million a day. Port Metro Vancouver acts as Canada's primary gateway to Asia-Pacific economies, and anticipates an increase in container volumes by 70% by 2030 for the two terminals it operates in Vancouver, with significant growth also expected in bulk shipping of agricultural products like grain.

Vancouver's Brand

Vancouver's brand, valued at US$31bn in 2015 when measured by investment, reputation and performance shows that sustainability and existing in harmony with nature are integral to Vancouver's success. Vancouver is recognized globally for its reputation in sustainability, green technology, and environmental protection. This brand value encourages businesses to move and invest here, attracts talented workers, encourages outstanding students and researches to study here and underpins our long-term economic stability.

Housing Cost

The cost of housing in Vancouver is high. To ensure that residents stay here, that the city attracts the best possible people to work here, and to maintain diversity, it is important to ensure housing is affordable for all parts of the community. A move to more efficient, renewably powered homes and better transit provides the opportunity to better meet these needs.

Decreasing Energy Demand

Through energy efficiency and conservation measures, the city's energy use has been decreasing by about 0.8% a year. To ensure the city's energy use is sustainable there is a need to accelerate this reduction so that energy demand reaches a level that can be supplied by renewable sources.

Transportation Fuel Supply and Prices

Much of Vancouver's transportation fuel comes from within Canada, but its price is still affected by world trends. Gas and diesel prices have risen steadily over the past decade and in the medium-to long term are expected to continue in the same direction. There is ongoing volatility of these prices, making it difficult to predict how much fuel bills will be in the future.

Low Cost Natural Gas

Just a decade ago natural gas prices were double what they are today and were rising. Limited supplies meant that natural gas could command a price premium. The discovery in North America of large quantities of shale gas has now caused the price to crash and this low cost is expected to remain for years to come. What's not included in this price are the health and environmental damages caused by climate change that results, in part, from burning large amounts of natural gas.

British Columbia's Carbon Tax

The Province of BC has in place a carbon tax equivalent to 30*$/tCO$_2$e* levied on about 70% of BC fossil fuel emission sources including the most common fuels like gasoline, diesel, propane and natural gas. The tax, launched in 2008 at 5*$/tCO$_2$e* and increased by $5 per year until 2012, is revenue neutral having been balanced by reductions in personal income and corporation tax rates. Provisions are made to reduce the tax collected from low income families and those in northern BC that have greater heating needs.

Renewable Electricity

Vancouver is fortunate to have electrical power which comes mostly from large hydro-electric dams, with small amounts of small-hydro generation, wind, biomass and natural gas. As the sole electrical utility supplying Vancouver, BC Hydro is mandated to produce as much power as BC needs from facilities within the province – it cannot plan to import power to meet demand in BC – and it is regulated to do so with 93% of the total generating capacity met by clean sources.

Infrastructure

Vancouver's infrastructure is in good condition compared to many cities worldwide. This infrastructure allows the city to operate smoothly and effectively, however maintaining our infrastructure is critical. In some cases, no reasonable amount of investment can keep pace with demand. The road space in Vancouver, for example, is at its maximum – no amount of investment can change that, and we must learn how to use our road space differently when creating a vibrant urban landscape.

Transit (Public Transport)

Vancouver's transit system is one of the busiest in North America, and is one where demand exceeds capacity. Finding sustainable funding sources to maintain and expand capacity and reliability in public transportation and rapid transit is integral to reducing vehicle use and achieving our 100% renewable energy goals.

The World Stage in 2015

The Consequences of Continuing to Use Fossil Fuels

Climate change is having impacts across the world; 2014 was the hottest year on record and 2015 is on track to break that record. The burning of fossil fuels, amongst other things, worsens air quality, has direct impacts on human health, and accelerates the loss of natural habitats and impacts agricultural production. The release of carbon dioxide into the atmosphere from burning fossil fuels is affecting Vancouver and its surroundings through sea level rise, more frequent and more severe heat waves, increased frequency and severity of storms, increased winter rainfall, summer droughts and less snow. These changes will continue to worsen in the foreseeable future. There is a need to not only take action to prevent this (climate mitigation), but also prepare for it (climate adaptation).

Population and Urban Growth

The world's population, including Canada's, continues to increase with most of that growth occurring in urban environments. Cities are the engines of the global economy and are responsible for about 70% of the world's greenhouse gas emissions. The benefits that fossil fuels have brought to humanity over the past 100 years or more can no longer be relied upon to continue into the future – in fact, to continue to improve the standard of living for everyone in Vancouver we must transform our city so that it derives all its energy from renewable sources.

Call to Action

There is consensus among world leaders, scientists, and businesses that climate change must be addressed quickly and aggressively if we're to avoid devastating social and economic upheaval world-wide. In April 2015 more than 40 CEO's from some of the world's largest companies, representing 20 economic sectors, with operations in more than 150 countries have called for bold action on climate, while committing to reduce their own corporate emissions. In May 2015 Pope Francis released his encyclical that warned there would be serious consequences for all of humanity if we fail to take action on climate change. These calls to action make clear that climate change is not a problem that can be left to future generations. The world conversation on climate change is one wholly focused on action and the Renewable City Strategy is an affirmation of Vancouver's commitment to continue to take action now and into the future.

United Nations Climate Conference 2015

The United Nation Framework Convention on Climate Change (UNFCCC) will hold its 21st Conference of the Parties (COP21) in Paris in December 2015. The objective of COP21 is to establish a legally binding and universal agreement on climate action, with intent to limit world greenhouse gas emissions to hold the increase in global average temperature below two degrees – the generally accepted limit if irreparable ecosystem damage is to be avoided. Together, the 149 countries that have submitted commitments to the UNFCCC produce over 90% of current global emissions, compared to the 14% of global emissions produced by the 35 countries that signed the Kyoto Agreement in 1997, the first and now expired global climate agreement. The stage is set for a significant shift in the way the world is tackling climate change.

Action from the World's Big Emitters

The world's two biggest economies, China and the United States, were in 2010 responsible for over 38% of global greenhouse gas emissions. In November 2014 China and the U.S. signed a joint announcement in climate change and clean energy cooperation that committed the U.S. to cut its emissions by 26 to 28% below 2005 levels by 2025 mandated and for China's greenhouse gas emissions to peak in 2030. With the world's largest economies supporting climate action and clean energy, the stage is set for step changes in how the world derives its energy.

Municipal Leadership on Climate Action

Urban areas are home to the majority of the world's population and are on the front line of climate change impacts. As a result cities and their mayors are leading in responding to and averting the worst effects of climate change. Some cities are acting in the absence of national leadership and are primed to make even more progress with better harmonized national policy. In 2014 the United Nations launched the Compact of Mayors a global initiative for cities to commit to action on climate change and report their progress. Currently the Compact of Mayors has 197 members, including Vancouver, from 53 countries.

The Social Cost and Regulation of Carbon

The emission of carbon pollution has social costs that are not reflected in its direct price. These "externalities", as they are called by economists, include human health impacts, sea level rise, lost agricultural productivity and habitat loss. To illuminate and mitigate the full impacts of burning fossil fuels, it is important to price their 'externalities'. That price may take the form of a tax on those who emit the carbon, like we have in BC, or it may take the form of a 'cap and trade' system in which carbon emissions become a commodity like any other that can be traded, like existing programs in Ontario, Quebec, California and Europe.

Properly pricing carbon supports better decisions when investing in energy systems, whether a county building a power plant or an individual is buying a car. According to the World Bank there are about 40 nations and 20 sub-national jurisdictions that have in place a price on carbon (either as a direct tax or through a trading system) covering about 12% of global greenhouse gas emissions. Beyond direct pricing of carbon pollution, regulations that discourage fossil fuels are already in place in China, South Korea, Japan, the United States and India to name just a few of Canada's trading partners. The move away from fossil fuels is underway and only expected to accelerate - Sweden has recently become the first country to commit to become fossil fuel free.

Underway Now: **The City of Vancouver is advocating for an integrated regional, national and international price on carbon**

The is a need to account for the economic impacts of carbon emissions and support a transition away from the use of fossil fuels as our primary energy source. The most effective way to do this is to put on price the emission of carbon pollution. Given that the environmental and social impacts of carbon pollution are felt globally the price applied to emissions must also be global. This is most likely to be made a reality through the setting of regional and national carbon pricing mechanisms that can then be internationally harmonized. The need for governments to establish an incrementally increasing carbon tax is paramount.

Fossil Fuel Divestment and Renewable Energy Investment

The movement by pension funds, private equity, academia and some governments to withdraw investments in companies that extract fossil fuels is one of the fastest divestment movement in history, if not the fastest. Some are removing finance from fossil fuel extraction companies on moral grounds, while for others it is simply seen as the prudent long-term investment decision. Investment in renewable energy projects (excluding large hydro) jumped by nearly 17% in 2014 compared to 2013; 2014 also seeing an all-time high in the capacity of wind and solar power installations, 20% higher than in 2013.

Change Is Inevitable

The world is moving away from fossil fuels and Vancouver can either postpone action and play catch-up at a later date, or continue to take advantage of emergent social and economic opportunities. The transition is not about abstinence or making sacrifices; it is about growing a city that better meets our needs. The transition to renewable energy, although likely to be quicker, is not so different from moving to kerosene from whale oil or the revolution that happened when horse and

buggy became the motor car. In both cases the inevitable change brought improvements and opened more doors. The early improvements in quality of life these new sources of energy provided are now commonplace, and as our increased dependence on fossil fuel for building energy use and transportation has become damaging to our ecosystems and healthy we have outgrown their relative utility. A renewable future will afford society the next set of opportunities across a broad spectrum of our lives and our children will look back and ask, “What took you so long?”

The Transition to Renewable Energy

A Strengthening Economy

The transition towards the use of only renewable energy provides business opportunity through catalysing the development of new renewable energy and energy efficiency technologies and galvanizing the emergence of new business models to capitalize on the change. Preparing Vancouver for the economy of the future, one which is diversified, not tied to fossil fuels, adaptable, and resilient, is foundational to successfully eliminating our dependence on fossil fuels.

A robust and thriving renewable economy will attract and retain human capital, promoting higher and more inclusive employment. Being at the vanguard of the renewable energy revolution will create wealth through innovation and the development of intellectual property and will attract new investment from all aspects of the business and social society.

Affordability

The move to derive 100% of Vancouver's energy from renewable resources will ensure that the city remains economically strong and culturally vibrant. There will be changes in some aspects of the city, but these changes are aimed at employing technologies, like rooftop solar panels and electric vehicles, that have lower operating costs than fossil fuel equivalents and for which the up-front costs are rapidly coming down. Buildings that use less and conserve more energy reduce the energy bills for renters and owners alike. A move towards electrification and the use of renewables to produce that electricity, with BC's regulated utilities, provides more certainty in long-term energy costs when compared to the variability in fossil fuel prices, and technologies like solar panels even allow residents or communities to produce their own electricity. Communities that prioritize active transportation and that are well served by transit can save money by reducing the need to buy fuel for their cars, and can increase job opportunities.

The consequences of inaction, such as poor air quality and detrimental health impacts, can be avoided through the adoption of renewable energy. The world is moving towards controlling and limiting carbon pollution – the move away from fossil fuels has started, and as a city it is prudent to prepare for that. Over the past decade, hundreds of requirements for carbon reduction, energy efficiency, and renewable energy have been brought in around the world, and this trend is not only expected to continue but to accelerate. The *Renewable City Strategy* embraces these changes and is preparing the city to best meet the needs of its citizens now and into the future. The transition to the use of only renewable energy will need to manage up-front costs with lower operating costs, and through the *Healthy City Strategy* and Mayor's Task Force on Affordable Housing, the City of Vancouver will continue to work with residents, community associations, social enterprises, and other levels of government to support its residents in the transition.

In many cases, carefully designed policies and actions can support the use of renewable energy without customers even realizing it. The Southeast False Creek Neighbourhood Energy Utility, having displaced natural gas use, provides low-carbon heating at rates currently comparable to BC Hydro and with a long-run trend to be cheaper. The Provincial renewable and low-carbon fuel requirement regulation currently saves nearly one million tonnes of greenhouse gas emissions a year with few consumers realizing, and the Provincial carbon tax has cut emissions without harming economic activity.

Financing the Transition

The rationale to act now to both mitigate and adapt to climate change is twofold. First, acting now has a larger and longer lasting positive impact than delaying; the less is done to mitigate climate change the worse the impacts will be and the more it will cost to adapt in future. Secondly, some investment decisions made today will last for 100 years or more, it is imperative to ensure market choices and consumer choices are made not for short term gains, but in the interest of long-term security.

Traditional financing mechanisms can be applied to non-traditional technologies, as has been the case for electric vehicle development. New technologies also often benefit from feed-in tariffs that secure a set price for the energy they produce—this mechanism has been used to great effect in many places to increase the amount of wind and solar power generation at both the utility and community scales. There are also emergent financing mechanisms such as green bonds that support green infrastructure projects. Carbon tax revenues and other environmental levies can raise revenues for green funds that can be used for climate action as direct investment, tax relief, low-interest loans, and other supporting mechanisms.

The Path to Renewable Energy

The transition to the use of 100% renewable energy will not simply be a steadily increasing portion of renewable energy use. Currently Vancouver's energy system is dominated by grid-supplied electricity, natural gas, gasoline, and diesel. Each of these and their respective uses will undergo technological, market, and regulatory changes at different times and at different rates, as will the technologies that replace them. The changes in the energy system are likely to be typified by rapid step changes, although renewable energy projects are now starting to provide superior long-term price guarantees compared to fossil fuels. With such an array of factors influencing how the energy system is going to change, it is not possible to make long-term financial predictions of the costs and revenues, although it is clear that a reduced dependency on fossil fuels and the adoption of renewable energy has a broad array of benefits, both financial and societal. The City will continue to use proven approaches such as strategic partnerships, financing from senior levels of government, and its own finances to support the transition.

Renewable Energy Cost Reduction

If humanity is to avoid catastrophic climate impacts we cannot extract all the fossil fuels we already know about; and as those reserves become progressively more expensive to extract, renewable energy technologies become ever more cost competitive. The cost of renewable energy technologies has dropped consistently over the past decades, and solar has seen a particularly rapid cost reduction decline and associated burgeoning of world-wide installation. The regulated nature of BC's electrical utilities provides price certainty and limits costs increases for electrical customers when compared to fossil fuels. Current fossil fuel prices may be low compared to a few years ago, but have a long-term upward trend. According to the US Energy Information Administration the inflation adjusted cost of fossil fuels approximately doubled between the mid-1970s and 2011. Over the same time period, the cost of solar photovoltaic panels dropped approximately hundred-fold, the cost of wind approximately thirty-fold; and the cost of geothermal and biomass by about 50%. Fossil fuels prices, like all commodities, respond to a variety of unpredictable factors affecting their supply with prices often changing daily; although renewable energy technologies are also subject to many factors their price is much more predictable, currently acting more like that of digital technologies and less influence by their inputs (wind and sunshine). The diminishing cost and cost certainty of renewable technologies coupled with the increasing price of fossil fuels and their price volatility make a strong case for more stable investment and cost management with renewable energy sources.

Technological Revolution

The technological and digital revolution that has come in the past decade is showing no sign of slowing down. The "internet of things", the explosion of mobile technology, the role of disruptive technologies like autonomous vehicles and home electricity storage as well as changes in our own behaviour will define what the transition to 100% renewable energy looks like. Such disruptive changes, their scale, interplay and timings cannot be predicted beyond knowing that they will come and the *Renewable City Strategy* must be adaptive enough to not only respond, but maximize the opportunities they bring.

The City's Role

Direct Control: City Regulatory Powers

The City of Vancouver has control over municipal infrastructure (active transport infrastructure, roads, parking, sewers, water distribution, etc.) and regulatory powers established by the Vancouver Charter. Under the Vancouver Charter the City can guide development and urban design through land use and zoning /rezoning policies and guidelines. The City also has the direct power to regulate building standards and ensure building safety. The City has the necessary authorities to establish neighbourhood renewable energy utilities, as has been done in Southeast False Creek, River District and Northeast False Creek. However, at the moment in Vancouver there is only one electrical and one natural gas utility to serve the city; both are regulated by the BC Utilities Commission, which is under Provincial oversight.

Partial Control: Transportation

While the City of Vancouver has little to no direct jurisdictional control over vehicles, it has a strong influence over travel behaviour through land use and transportation planning, including signal operation, how streets are designed and space allocated, and where services and amenities are located. Public transportation infrastructure, including bridges and the Major Roads Network, is the shared responsibility of the City and TransLink, the local transit authority that also delivers the regional transit system.

TransLink's Board of Directors is appointed with Provincial oversight by the Mayors' Council, itself an advisory body made up of mayors and representatives from cities throughout the Metro Vancouver region, of which Vancouver is one. The Province of BC is also represented on the TransLink board and influences TransLink strategic planning heavily. TransLink is required to provide a regional transportation system that supports Metro Vancouver's *Regional Growth Strategy*, air quality and greenhouse gas reduction objectives, and the economic development of the region.

Vehicle fuel efficiency and pollution standards for new vehicles are set by the Federal Government. Until 2014, the regional AirCare program ensured that vehicles, once purchased, met air pollution standards. Metro Vancouver is working with the Provincial Government and other partners to explore new programs for managing emissions from light and heavy-duty vehicles.

Partial Control: Waste

The City of Vancouver has a degree of jurisdictional control over the local waste management system. Vancouver is also part of a regional waste system managed by Metro Vancouver, under Provincial oversight, that combines private and public haulage and disposal. Residential waste collection and disposal in Vancouver is managed in part by the City through its own collections and the Vancouver Landfill in Delta. Private haulers play an important role in waste collection and disposal, and primarily serve the industrial, commercial, institutional and multi-family residential sectors.

Limited Direct Control: Lands Under Provincial and Federal Control

Large transportation infrastructure like rail lines and the container and shipping facilities at Port Metro Vancouver are under federal jurisdiction and thus the City's regulatory authority and ability to influence renewable energy behavior is quite limited. Similarly, there are some First Nations Reserves within the City's boundaries, and while the City has some regulatory authority over such lands, these areas are primarily under federal jurisdiction and so again the City's regulatory authority is quite limited within the sphere of renewable energy matters. Finally, provincial legislation exempts provincially-owned land from certain types of Vancouver's land use and development laws and so further limiting the City's regulatory authority over this type of land. Nonetheless, with respect to all lands subject to Provincial or Federal jurisdiction, the City will advocate for action to support the use of renewable energy.

No Direct Control: Fostering Change through Influence and Advocacy

The City will always work to establish an environment that fosters inclusiveness and innovation; using its powers of advocacy and influence, as well as working in strategic partnerships the City will act to expand the use of renewable energy, even in areas where it has no direct jurisdiction.

Vancouver has a long history of supporting climate action, from the *Clouds of Change* reports in 1990, to the *Community Climate Change Action Plan* in 2005 and the *Greenest City 2020 Action Plan* in 2011, and now the *Renewable City Strategy*. These plans and the progress they have delivered have been built upon strong and broad public, business and political support, as well as partnerships with local utilities, the development community, academic institutions and NGOs.

The City of Vancouver has ensured that there is strong organizational capacity across all its city-wide functions. To achieve a 100% renewably powered future, this capacity will have to be expanded, not only for the City's own operations but to lead and guide the public and business communities. There is also the need to ensure that renewable, clean, green, and emergent technologies are readily available and that people have the skills to implement them. The City can educate and empower people and businesses to change and directly engage in energy production and conservation, while itself leading both locally and internationally.

Based on current regulatory powers and which organizations hold those powers the City of Vancouver has regulatory authority over about 40% of fossil fuel energy reductions and renewable energy increases; this is predominantly due to the City's ability to regulate building standards. The Province of BC through its ability to regulate utilities and the transit system as well as control vehicle fuel standards has authority over about 40% of the changes that need to take place; the Federal Government, primarily through its regulation of vehicle efficiency standards, is responsible for about 20% of the required changes. It must however be noted that the City has limited authority over existing utilities and any changes to those systems would significantly impact Vancouver's ability to achieve the 100% renewable energy target.

Figure 3 **– City of Vancouver's Jurisdictional Role**

City Services as a Catalyst for Renewable Energy

The City of Vancouver can catalyze change by being a leader in the use of renewable energy in its own operations, and already has 46 hybrids and 29 electric vehicles in its fleet of 180 light-duty vehicles. The City has fitted 107 idle-stop devices to its fleet vehicles to limit emissions from idling, and since 2008 has cut fleet emissions by 10% and overall corporate emissions by 25%.

The City also provides a range of services to its citizens, and the pursuit of 100% renewable energy will be integrated into those services. Vancouver's services are funded through property taxes (56%), utility fees (20%), and user fees (24%) such as parking meter revenues and business licenses.

Licensing Powers Quick Start: **The City of Vancouver will investigate how best to use its licensing and permitting powers to accelerate the adoption of renewable energy**

The City will investigate and make recommendations on how its business licensing and permitting authority can be used to support the market adoption of renewable energy for activities undertaken within the city.

Given the limited funding sources available to municipalities throughout Canada, taking into consideration businesses and residents' ability to pay taxes and fees, the City will work in partnership with senior levels of government, charitable foundations and private financiers to enable the private sector to develop viable and cost-effective renewable energy technologies.

The mid- to long-term implications of transitioning Vancouver to 100% renewable energy will be determined as part of the City's strategic service, capital and financial planning, taking into consideration long-term financial, environmental and social sustainability. The approach will consider the following:

- Where the City has regulatory authority to enable and/or require the transition to 100% renewable energy (typically in building codes, land use, licensing and permitting and bylaw enforcement), the City, in consultation with key stakeholders, will develop strategies that set clear and attainable goals, timelines, and implementation plans;
- Where other levels of government have regulatory authorities to enable and/or require the transition to 100% renewable energy, the City will focus on education and advocacy to support the case for such regulation;
- Where businesses, consumers, academia or other entities are the key agents for change, the City will focus on strategic partnership, education and advocacy; and
- Where its municipal operations are involved, the City will develop implementation and funding strategies that balance financial, environmental and social considerations.

Purchasing Power Quick Start: **The City of Vancouver will investigate how best to use its purchasing power to accelerate the adoption of renewable energy**

The City will investigate and make recommendations on how to use its purchasing power to support the adoption of renewable energy.

City Service Delivery Renewable Energy Priorities

S.1 The City will adopt a comprehensive approach to the consideration of climate change as part of its service planning

The City commits to develop a strategy to support the transition to 100% renewable energy as part of its strategic service, capital and financial planning. Ensuring that service plans and associated funding strategy supports the transition to renewable energy is critical to meeting the City's renewable energy and greenhouse gas goals. Since infrastructure decisions made today will have impacts that last for 50, 80 or even 100 years, it is important that the City plan accordingly.

S.2 The City will adopt a comprehensive approach to pricing carbon emissions for municipal operations

To support adoption of renewable energy technologies for its municipal operations, the City will develop a robust approach to pricing carbon pollution and incorporate it into decision making processes.

S.3 The City will develop a framework to assess how City enabling tools may be used to support the transition to 100% renewable energy

To facilitate and/or expedite the transition to 100% renewable energy, strategic enabling tools may be considered. The role of incentives to support technologies in their early deployment can be effective in helping new technologies establish a market share. The development of an evaluation framework with clear guiding principles and value for money parameters will assist the City in identifying and evaluating potential enabling tools.

S.4 The City commits to keep abreast of financing mechanisms available that enable the delivery of renewable energy technology and other green infrastructure

Financing mechanisms such as green bonds, carbon taxes and green funds have emerged in recent years to finance green infrastructure projects; these and other mechanisms are rapidly changing how infrastructure, services and technology can be financed. The City will consider all appropriate funding mechanisms when formulating its long-term capital funding/financing strategy.

The Economic Opportunity of Renewable Energy

Imagine a city where jobs and businesses are diverse and economically strong, where businesses both big and small invest in the city, and where businesses thrive using only renewable energy.

Vancouver's Economy Now and to Come

The *Renewable City Strategy* provides a significant economic opportunity for Vancouver, and supports the delivery of the *Vancouver Economic Action Strategy*. Within the next fifteen years, global investment in clean energy is expected to constitute almost three quarters of total global energy investment; in fact, Canada already has more jobs in clean energy than in oil and gas. This global move away fossil fuels is driven by a desire from businesses, governments, and citizens alike to secure stable and reliable energy at a predictable cost. Renewable energy generation and storage technologies like wind, solar, and home battery storage are rapidly dropping in price at both the industrial and local scales. This is creating new business models, where individuals and neighbourhoods are no longer passive consumers, but active "pro-sumers" producing, using, and selling their products and services.

Around the world, cities are capitalizing on these trends, with Vancouver and the Vancouver Economic Commission at the fore. Even in the face of world economic challenges Vancouver has, over the past five years, enjoyed steady economic growth. Cleantech is the fastest-growing business sector in Canada, and Vancouver is home to more than 25% of those firms; the Vancouver region alone is responsible for more than 75% of the world's hydrogen fuel cell research and development.

Vancouver has always been a place of innovation, home to world-changing ideas and businesses. Business has proven to be a powerful driver for change. Businesses in Vancouver are delivering solutions to sustainability challenges, testing alternatives to traditional ways of operating, and sharing these innovations around the world. Demand has skyrocketed for goods and services that align with the values of health, well-being, environmental sustainability, and social equity. That demand is coming from both international and local markets.

Underway Now: **Expand and accelerate the *Green and Digital Demonstration Program***

The Vancouver Economic Commission's Green and Digital Demonstration Program*, which leverages City assets and infrastructure to pilot, demonstrate, and accelerate the commercialization of cleantech and digital innovations, has raised the profile of emerging businesses and fast-tracked their growth. As this program develops further, the Vancouver Economic Commission will emphasize clean energy pilots and demonstrations, to ensure that Vancouver entrepreneurs know the business environment is ready for clean energy technologies and the digital technologies that support them.*

The extent to which Vancouver remains competitive and resilient, and generates opportunity for our future citizens will be defined by our efforts to mitigate and adapt to climate change, as well as our efforts to future-proof our economy. As a city we must continue building a resilient economy, one that can withstand the boom and bust cycles that are amplified when economies hang their success on a small handful of industries. Investment now in a renewably powered economy is an investment with lasting returns. Further developing Vancouver's renewable energy advantage is not only necessary for creating a healthy and sustainable city, but also an incredible opportunity to generate wealth, build resiliency in the face of volatile energy prices and climate change risks, and improve social equity.

Business Emissions Quick Start: **Use the Vancouver *Business Energy and Emissions Profile* to develop a targeted business energy use reduction and fuel switching strategy**

The Vancouver Business Energy and Emissions Profile *provides data on energy cost drivers for different business types within the city, and provides a window into where strategies to take action could be most effective in both cost and energy use reduction.*

Economic Opportunity Priorities

E.1 Support innovators through business and technology research, incubation, acceleration, and demonstration.

The Vancouver Economic Commission in partnership with the City will develop support mechanisms for renewable energy and energy efficiency research, development and commercialization. It is important to create the conditions for businesses to thrive and be successful. Renewable energy companies are a subset of Vancouver's thriving green economy sectors and will need support in the areas of innovation, financing, talent, and scaling up for global distribution. Technology research and development activities can often be supported through grants and academic partnerships; however, commercialization presents challenges for entrepreneurs that need not only business strategy and marketing support but office and industrial space and the launching of cleantech and clean energy accelerator programs will help remove those barriers.

E.2 Actively work with businesses to increase the use of renewable energy

The Vancouver Economic Commission and the City of Vancouver are already working with businesses, regional government, community organizations, and academic institutions to make the False Creek Flats the greenest place to work in the world. Redeveloping this central industrial and employment area will lead it to be a showcase of sustainability and innovative business models and a home to green buildings; build on resilient and smart infrastructure; become a hub for green economy industries; and support emerging "circular economy" initiatives. This area affords the city the opportunity to attract new, impact-based investment will drive business transformation within the city. New infrastructure will likely be required to support green enterprise and may include centralized alternative fueling infrastructure for publicly and privately operated return-to-base fleets or new community-scale energy facilities.

The Vancouver Economic Commission will continue to provide leadership and engage with businesses to deliver the actions of the green economic strategy, particularly through online engagement and education through which there will be an emphasis on business case for renewable energy opportunities. Vancouver businesses have shown leadership, yet despite technological advances and cost reductions in renewable technologies the business community and the City will need to work together to overcome barriers and find technical and financial pathways to support businesses with adoption of new technologies and become more energy efficient..

E.3 Target key events and organizations that represent cleantech and renewable energy to strengthen Vancouver's economy

The City will continue to leverage key events and partner with strategic and government organizations to emphasise renewable energy investment. Vancouver's clean energy ecosystem brings together major firms, start-ups, developers, financiers, and NGOs to share best practices and foster collaboration. Ensuring that Vancouver has access to both human and financial capital is imperative to maintaining the strength of the city's strategic partners and send a strong market signal that will contribute to the city's continued success.

Vancouver's green brand is exceptionally strong and attracts companies and talent with similar core values. Through events such as GLOBE and TED, Vancouver has already established itself as the world stage for environmentally responsible business. Broadening this further to support the City's renewable energy goals can drive even stronger green economic activity.

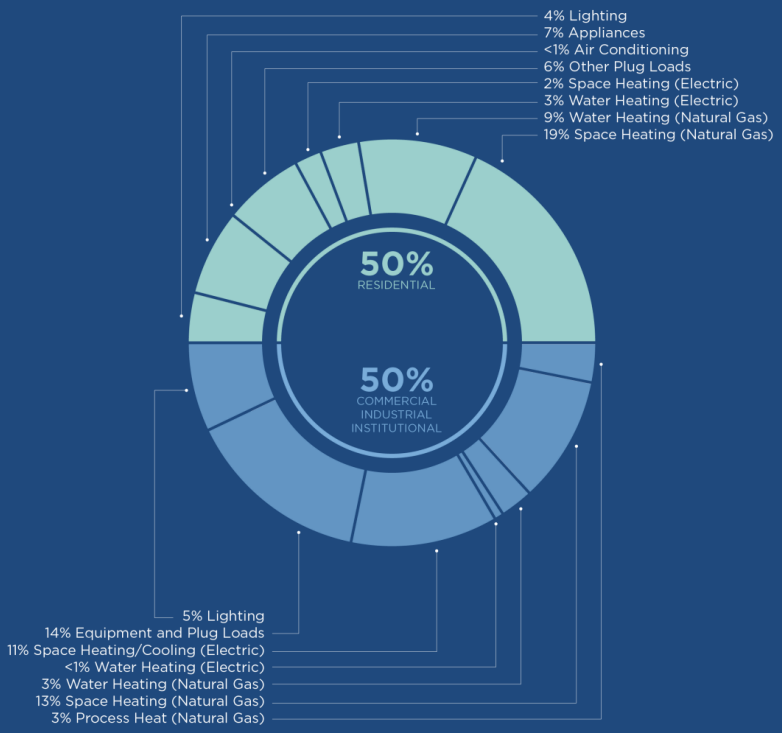
E.4 Attract "green capital" and enable more innovative financing mechanisms for clean and renewable businesses

Vancouver has an existing capital attraction initiative, which will be extended and expanded to specifically target investors in renewable energy from global angel investor communities and venture capitalists, to private equity and pension funds. Vancouver is world renowned for its engineering talent and culture of entrepreneurial spirit, but lacks access to investment capital. This capital is needed to build materials management facilities, establish manufacturing facilities, or convert fleets or infrastructure to more sustainable systems.

Expanding the Vancouver Economic Commission's existing work to focus on angel investors, venture capital, private equity, and large institutional funds as well as crowdfunding and citizen driven finance, can help attract renewable energy expertise, capital and companies. It is important to send a strong market signal to investors that Vancouver is the place where ideas come to reality and is *the* place to invest.

Summary :: Achieving Renewable Building Energy Use in Vancouver

Imagine a city where homes and offices have clean and comfortable environments, are less expensive to heat and cool, and use only renewable sources of energy.



Zero-Emission Building Priorities

Based on the end uses presented in the pie-chart above the City of Vancouver has established the following building priorities:

B.1 New buildings to be zero-emission by 2030

B.1.1 Adopt and demonstrate zero-emission standards in new City of Vancouver building construction
B.1.2 Ensure rezoning policy leads the transition to zero-emission buildings
B.1.3 Incentivize and streamline the development of exemplary buildings
B.1.4 Establish and enforce specific greenhouse gas intensity limits for new developments
B.1.5 Develop innovative financing tools to help fund new zero-emission buildings
B.1.6 Establish partnerships to build industry capacity
B.1.7 Mandate building energy benchmarking and labelling requirements

B.2 Retrofit existing buildings to perform like new construction

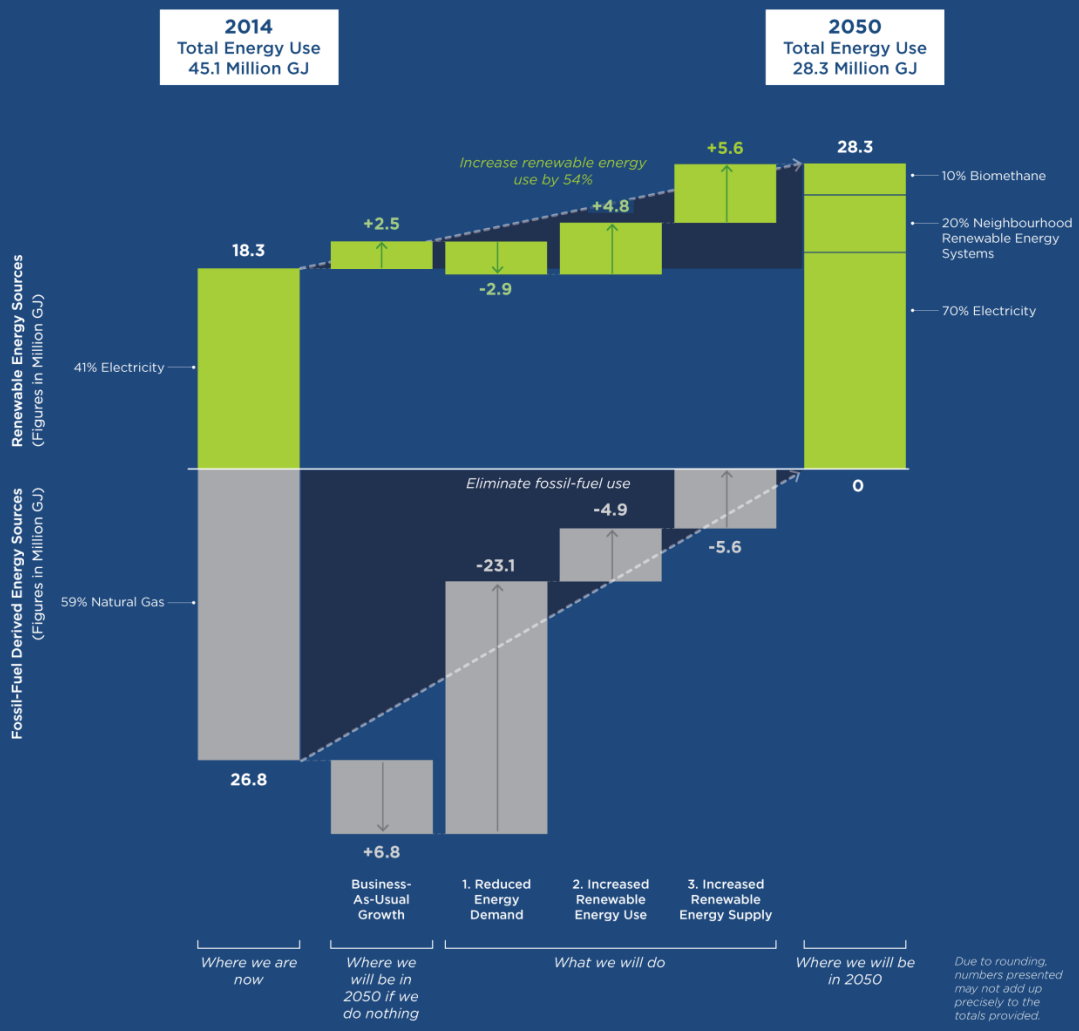
B.2.1 Use the Zero-emission New Building Strategy to reduce the need for building retrofits
B.2.2 Mandate energy efficiency improvements for existing buildings
B.2.3 Provide flexibility to achieve energy efficiency requirements through the support of on-site generation or neighbourhood energy system connection
B.2.4 Facilitate modest retrofits through structured guidance and the provision of incentives
B.2.5 Increase renewable energy use by large energy consumers

B.3 Expand existing and develop new Neighbourhood Renewable Energy Systems

B.3.1 Expand existing Neighbourhood Renewable Energy Systems
B.3.2 Enable the conversion of the downtown and hospital steam systems from natural gas to renewable energy
B.3.3 Enable the development of new neighbourhood renewable energy systems for downtown and the Cambie corridor
B.3.4 Continue to enforce, and update as required, building and renewable energy supply policies that support neighbourhood renewable energy systems

B.4 Ensure grid supplied electricity is 100% renewable

B.4.1 Partner with utilities to increase the supply of renewable energy
B.4.2 Partner with utilities to implement a smart grid that meets Vancouver's energy needs



A Vision for Vancouver's Buildings in 2050

By 2050, about 40% of Vancouver's buildings will have been replaced and built to the carbon-neutral standards set out in the *Greenest City 2020 Action Plan* or to zero-emission standards which will have come into effect before 2030. Of the buildings which remain there will be an even split between those built to current standards and those built to standards pre-dating 2010. The vast majority of buildings that have not been built to zero-emission standards will have undergone deep retrofits to bring their energy performance up to the standards expected of new construction, or have been connected to the one of Vancouver's renewable neighbourhood energy systems. These changes will cut city-wide building energy use by over a third compared to 2014.

Current business-as-usual energy use with existing City and Provincial policies would likely mean an increase in city-wide electricity use by 2050 of approximately 10% over 2014, with large amounts of fossil-fuel-derived energy remaining. The *Renewable City Strategy* would lead to an increase in electricity use of about 20% by 2050 over 2014 levels, but would in the process eliminate Vancouver's need for fossil fuels.

Building performance improvements and the expansion of neighbourhood renewable energy systems that can provide heating and cooling will limit increases in electrical demand. There will be only minimal need for large electrical generation and transmission infrastructure investments – British Columbia's electrical grid can be capitalized upon and optimized to meet demand with only modest generation additions. The use of on-site power generation from solar or the meeting of heating needs through air-source heat pumps or geoexchange systems will further limit the need for new electrical generation. For those buildings that cannot be brought to perform to zero-emission standards and that cannot be connected to renewable neighbourhood energy systems, biomethane will be used to meet heating needs, although this need is expected to be minimal and biomethane will play a more significant role in the transportation system as an energy-rich mobile fuel.

The incremental electrical demand increase over business-as-usual will in part be due to the electrification of personal transportation. Since typical daily commutes are short in Vancouver, and the need for personal vehicle use will decline substantially by 2050, vehicle electrical demand will constitute only about 5% of total annual city-wide electrical demand, with this deamdn required to be met through home and work-place charging infrastructure. New smart-grid technologies will manage electrical distribution, on-site generation, and electric vehicle charging.

BUILDINGS :: Making Building Energy Use Renewable

Imagine a city where homes and offices have clean and comfortable environments, are less expensive to heat and cool, and use only renewable sources of energy.

Building Energy Demand

When taken together, residential, commercial and industrial/institutional buildings form the largest single source of emissions in Vancouver, constituting 56% of the city's total in 2014. The City of Vancouver is tackling building energy use according to where it can have the largest carbon reduction impact, primarily space heating and hot water.

Consistent with the strategic approach of the *Renewable City Strategy*, reducing building heat energy demand is the City's first priority, followed by the recovery of waste heat by, for example, using the heat from dishwasher water to preheat shower water or recovering heat from large computer data and server centres; finally, the remaining energy demand will be supplied by an increased proportion of renewable energy use. Actions to increase renewable energy supply and electricity generation will be considered after energy demand has been reduced.

To meet this hierarchy, the city's buildings may be broadly categorized as falling into two categories:

1. high density areas where space heat and hot water demand can be effectively served by a neighbourhood renewable energy system; or
2. lower-density areas where buildings' heat needs are lower and there is capacity to generate renewable energy on-site, or where renewable grid electricity is available.

Building Energy Use and Systems

Building Envelope

The building envelope is the fabric of the building, its walls, roof, windows, doors, etc.; the envelope is intended to keep weather out as well as manage heat and airflow, all in an effort to maintain a comfortable internal environment. Continual advances in both materials and building design are contributing to the development of new windows, insulation, and roofing that can significantly reduce heat loss, as can design changes that limit energy-inefficient features such as expansive glazing.

Building Systems

Building systems mostly consist of the heating, ventilation, and air conditioning systems (HVAC) as well hot water equipment. The building type obviously affects the size, nature, and complexity of these systems, including appliances and plug loads (like TVs, smartphones, computers, etc.), while some buildings also have more specialist systems like elevators, loading equipment, and server rooms. It can also be expected that home storage (batteries) will start to become an important component of future building systems.

Building and Neighbourhood Renewable Energy Options

Solar Energy (PV and Thermal)

Solar systems take the energy in sunlight to make either electricity (PV) or heat (thermal).

Photovoltaic (PV) Systems

A residential solar energy system uses solar modules, made up of photovoltaic (PV) cells, to harvest the sun's energy and convert it to electricity. A grid-tied system is the most common type of residential solar system. It allows the building to use its own solar-generated electricity, but when the PV system isn't producing electricity, such as at night, electricity is provided by the electrical grid. One of the benefits of a grid-tied system is that any excess electricity produced by the system can be fed back to the utility grid through a process known as net metering, a capability which already exists in BC.

The amount of energy that a PV system can provide depends on many factors such as the configuration and maximum size of the roof, its orientation, shading, and geographic location of the building. In Vancouver it's possible for a PV system to meet about half the current annual energy needs of a typical single-family home.

Solar Hot Water Systems

Solar thermal systems (also known as active solar systems or solar hot water systems) involve turning solar radiation into heat. Solar thermal collectors circulate a fluid which is heated by the sun's radiant energy. The heated fluid can then be pumped through a heat exchanger to provide space heating, although it is more common to use these systems for hot water. A solar hot water system can provide water-heating needs all year round. In the summer, solar-thermal systems can meet all the hot water needs, and in winter about 25% of the needs for a single family home. Given that hot water is the second-highest utility cost in a typical household after space heating, there is the potential to make significant energy improvements with solar thermal systems.

Wind

Small wind turbines are available that can produce enough energy to partially meet the electricity needs of a home; however, the larger the development, the smaller the portion of the total building load can be met by wind turbines. Small wind turbines are very different from large wind turbines. Large turbines, often grouped in wind farms, are widely used by utilities across Canada to provide electrical energy to electricity grids. Although home- or development-scale wind turbines may look like miniature versions of large turbines, there are important differences in technology, purchase decisions, technical suitability, and cost of generated electricity. For on-grid systems, small wind turbines can help supplement and reduce dependency on grid electricity. The largest challenge with on-site wind power is ensuring that there is enough wind to generate electricity and that that wind is consistent enough to support the financial investment. Wind power is an important consideration when looking to on-site energy generation, but its viability is very site specific.

Heat Pumps and Geoexchange

Heat pumps are devices that can take heat from the air or ground and use it to provide space heat or hot water. A heat pump is very much like a fridge running in reverse: rather than keeping a space cold, a heat pump can use the heat from outside air or the ground to keep a building warm or cool as needed and produce hot water. Heat pumps use electricity to move the heat from one place to another and have excellent performance characteristics. Domestic heat pumps are commercially available and already widely used to meet the complete space heat needs of homes and developments.

Geoexchange systems, sometime also called geothermal heat-pumps or ground-source heat-pumps, use the heating or cooling properties of the ground that make a basement warmer in the winter and cooler in the summer to heat or cool a

building as required. The technology is commercially available today, but takes more advanced planning and construction techniques to lay the pipes that run through the ground to collect the heat. The upfront capital costs of geoexchange systems are more than those of conventional heating systems, but their operating costs are lower, leading to a total lifetime system cost that is lower.

Retrofit Incentive Program Quick Start: **The City will develop and implement a home retrofit incentive program**

The City will develop and implement a financial incentive program to support one- and two- family home owners retrofit their homes to reduce fossil fuel use and for the remaining energy help convert their heating systems to use technologies, like heat pumps, that can heat homes using only renewable energy. The City will seek to leverage funding through other levels of government and strategic partners to increase the reach of the program.

Neighbourhood Renewable Energy Systems

Neighbourhood renewable energy systems are local energy networks in which a neighbourhood energy centre generates heat that is piped to local buildings for space heat, hot water, and, in some cases, cooling. The system eliminates the need for each individual building to have its own boiler, hot water heating, and in some cases cooling equipment, and is more efficient. Such systems are widespread in northern Europe and have been used for decades. Vancouver's climate, well-designed buildings, and good construction quality mean that neighbourhood energy systems can be optimized to provide only space heat and hot water. The energy is typically distributed through a network of hot water pipes, which are efficient and compatible with a wide variety of renewable energy sources such as heat pump systems that recover waste heat from cooling systems and sewage, or clean wood waste. Some older systems use steam pipes to distribute energy to buildings—these systems can be converted from fossil fuels to renewable energy sources such as wood waste, but are not compatible with technologies that make use of heat pumps.

The inherent benefit of neighbourhood renewable energy systems is that their energy centres—where the heat is produced—can be updated and retrofitted to use the cleanest and best energy source available. Neighbourhood renewable energy systems also provide economies of scale to make use of renewable energy sources that are not cost-effective for an individual building to use. The neighbourhood renewable energy systems infrastructure platform does not lock a customer building into a certain energy source or set it on a path that cannot be changed at a later date. Regardless of the energy source for the system, neighbourhood energy systems can easily be built at the same time as new buildings are constructed, and the system can be expanded to meet growing need or replace old natural gas boilers. To be financially viable, neighbourhood energy systems need high-density development to ensure that the capital cost of the system is spread amongst users efficiently. In the case of these high-density developments, neighbourhood energy systems provide the lowest-cost solution—with utility rates that can be cheaper than conventional heating systems.

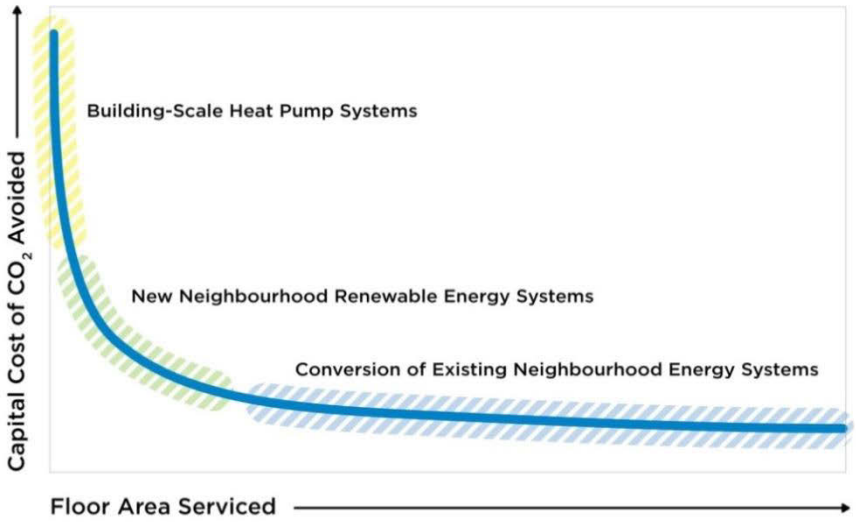


Figure 4 **– The Suitability of Neighbourhood Renewable Energy Systems to High Density Development**

Waste as an Energy Resource

So as not to encourage waste production as a means of increasing energy supply, materials should be managed according to the pollution prevention hierarchy in the B.C. Recycling Regulation, preventing reusable and recyclable materials from being sent for energy recovery. The *Renewable City Strategy* focuses on waste streams that originate from renewable resources, such as wood, food scraps and sewage. Non-renewable materials and waste streams will continue to be actively managed for the most responsible outcomes, but they will not be considered as inputs to the long-term renewable energy system of our future.

In many cases, there are already technologies that recover value from materials found in municipal solid waste. Anaerobic digesters produce biomethane from food scraps, clean wood combustion systems produce heat, and paper and plastics recycling allows the manufacture of new products. The City will work to expand the use of technologies that allow waste to be better utilized. The aim of the waste system is to avoid residuals – what's left after all the utility of a resource has been recovered - and residuals are likely to remain for the foreseeable future. With new technologies and management approaches, as it does now, the City will fully consider what these residuals are and how they will be disposed of in the most responsible manner.

Liquid waste can also provide a renewable source of energy. The City already uses sewage heat recovery in its Southeast False Creek Neighbourhood Energy Utility to provide heat and hot water to buildings in and around the Olympic village. The City will continue to explore future sewage heat opportunities, as well as work with Metro Vancouver to beneficially use the biomethane produced by the region's wastewater treatment facilities, which are owned and operated by Metro Vancouver.

Reducing Building Energy Demand

New Building Envelope Performance

The vast majority of non-renewable energy used in buildings in Vancouver is used to produce heat—typically through burning natural gas—and therefore reducing building heating demands is the foundation to achieving the City's 100% renewable energy target.

The initial focus must be upon the near-permanent elements of buildings—the envelope—because once constructed, building envelopes last a long time before they need significant updates or retrofitting. While lighting and appliances can reasonably be expected to change every 10 years or so, buildings do not have their windows changed or walls re-insulated nearly as often. Improving the energy performance of high-rise building envelopes after initial construction is even more challenging than for a single-family home. High-rise building retrofits require disruptions to, and potentially the need to temporarily relocate, large numbers of unrelated occupants for long periods of time; a single-family home retrofit has fewer people to coordinate and is likely quicker. Ensuring that buildings meet zero-emission standards from the time they are built with an initial focus on the building envelope, is the most effective way to ensure that buildings use as little energy as possible. As a result, the City is looking to accelerate the construction of zero-emission new buildings, while the City will seek to connect those large buildings that have already been built, and will still be standing in 2050, to a neighbourhood renewable energy system.

A zero-emission building is only viable if it is ultra-energy efficient, through the use of Passive House or ultra-low thermal demand design philosophies. With energy use substantially reduced, a zero-emission building can then meet its energy needs through either on-site generation or connection to an off-site renewable energy source like a neighbourhood renewable energy system or the electrical grid. Electrical power in BC is legally regulated to be 93% clean or renewable (and in recent years has been as much as 97–98% clean); however, using electricity for resistive space heat and hot water is expensive when compared to natural gas, which has halved in price over the last five years. Ultra energy-efficient buildings afford owners and occupants much lower electrical bills, avoid fossil fuel bills altogether, and do not overly burden the electrical grid. The use of resistance heat only makes sense when buildings meet ultra-low energy standards, and in many circumstances, heat pumps provide a better alternative to resistive heat. The design principles used to achieve ultra-low energy better manage not only building heating, but also building cooling mitigating occupant heat stress, particularly for vulnerable populations.

Civic Passive House Quick Start **: The City will support a Passive House or ultra-low thermal demand design philosophy for City buildings**

The City can help catalyze a change in building design through its consideration of Passive House or a low thermal demand approach as the default option for new City facilities. The City will investigate when the Passive House design philosophy and implementation is appropriate for City buildings and under which circumstances the approach does not currently deliver the best energy, greenhouse gas, occupant, and functional outcomes.

The City is about to trial the use of Passive House principles for one of its new fire halls. This will allow the City to better understand the opportunities Passive House can provide as well as increase the City's understanding of the design philosophy to better evaluate and introduce Passive House principles into the City's requirements for its own buildings.

As both new and retrofitted buildings start to incorporate more effective energy conservation principles, such as solar shading, solar orientation considerations, and the ability to generate their own power, the urban landscape will change. Building and neighbourhood design has never been static, and new designs will have to manage aesthetic appeal with the incorporation of design principles that support reduced energy use and increased energy generation and better allow buildings and neighbourhoods to cope with a changing environment.

Building Envelope Performance Retrofits

Buildings that have not originally been built to zero-emission standards will undergo some form of retrofit before 2050. That retrofit is likely to take place for one of two reasons:

1. some aspect of the building has reached the end of its useful life - the lighting, heating system or roof for example; or
2. the building owner feels that the building is in need of an update, so it will be more appealing to buy/rent, has lower energy bills, and so on.

In the first case, the rate at which lighting, appliances and similar components are replaced is much quicker than that for major components like walls, roofs or windows. For those components that are replaced sooner, global market forces are shaping efficiency improvements. The technology is improving rapidly and is easy to update – all you have to do is plug it in! Lighting, although not as easy to replace as appliances, is relatively simple to upgrade, and with the advances in LED technology, LEDs can be expected to meet almost all lighting needs by 2050.

For major components that have reached the end of their useful life and are replaced less frequently, it is possible to use the natural building renewal cycle to accelerate the rate at which zero-emission standards are met. When a building undergoes major retrofit it will have to be compliant with the zero-emission standards required of a new build. This in turn limits the energy demand that a neighbourhood renewable energy system would have to meet.

In the second case, where building retrofitting is desirable rather than essential, it is much more difficult to urge a building owner to undertake a retrofit that achieves deep energy reductions. In these cases approaches must be used that foster voluntary retrofitting, or mandate only modest retrofit requirements. In the cases the retrofit would require connection to a neighbourhood renewable energy systems in high density neighbourhoods, use of a heat-pump or on-site renewable energy generation (see below).

For both new and existing buildings poor system integration and optimization means that in the short-to-medium term maximizing the performance of the building envelope yields the best energy efficiency improvements.

Building Equipment Performance Requirements

The rationale for requiring the most efficient building equipment available at the time of construction or an upgrade to that standard at the time of retrofit is the same as that for the building envelope – act in the timeliest fashion to secure the most improvement. The hierarchy of building improvements prioritizes building envelope over building equipment upgrades, since building equipment upgrades are less enduring and realise smaller gains in overall energy performance.

Increase Building Renewable Energy Use

Expand Existing Neighbourhood Renewable Energy Systems

Energy efficiency improvements alone are not enough to achieve a renewable energy future; buildings must switch the sources of energy they rely on from fossil fuels to renewable sources. As such, the existing Southeast False Creek Neighbourhood Energy Utility system will be expanded to serve more buildings in the Southeast False Creek area and the False Creek Flats. Also, in accordance with the City's Neighbourhood Energy Strategy, the City intends to enable the establishment of additional neighbourhood renewable energy systems (see p.31 for more details).

The existing Southeast False Creek Neighbourhood Energy Utility uses waste heat from sewage to provide hot water to 4.2 million *sq. ft.* of buildings, with the system expected to expand to 7.8 million *sq. ft.* by 2022. City of Vancouver Council has already established through the Neighbourhood Energy Strategy (Energy Centre Guidelines) a preference for the use of waste heat (from sewers or cooling/refrigeration processes) to supply renewable energy to neighbourhood renewable energy systems, but if this isn't available renewable energy conversion options like the gasification and combustion of clean wood waste can provide a viable alternative.

Industrial Facilities' Transition to Renewable Energy

The City will continue to preserve its industrial lands to secure the long term economic strength of Vancouver. Such lands also have the opportunity to become significant renewable energy hubs through local and on-site generation, because of their significant amounts of roof space and underutilized land. The price of land, and its prominence on a business' balance sheet, is an important factor in moving Vancouver businesses to be more renewable. Vancouver cannot expand any further – it is bound on all sides. With land at such a premium, land values have been rising for the past decade and this trend is unlikely to change. Vancouver currently has little large or heavy industry, but that which does exist serves regional, national and international needs. Changing transportation patterns coupled with less favourable land economics are likely to mean that these heavy industries will have relocated outside the city by 2050.

The urban metabolism of the industrial sector in Vancouver is driven by the large number of light-to-medium industrial enterprises that service the city, for which there is an incentive to remain close to customers and not relocate out of the city. These businesses are the focus of preserving industrial lands within the city. The anticipated rise in energy prices will generate an incentive to become more energy efficient. Light- to medium- industry tend to own or lease equipment they use, which is the primary driver of their energy bills, as well as owning or having signed long-term leases for their premises. These businesses, even if they are not now, will become more energy aware as the cost of fossil fuels rise and that of renewable energy drops, and as they start to identify new business models driven by energy efficiency and renewable energy opportunities. Businesses are by their nature very effective at managing their costs, and the market changes in energy supply and equipment performance will drive change for these businesses.

Increase Building Renewable Energy Supply

New Neighbourhood Renewable Energy Systems

In 2012, Vancouver City Council approved the *Neighbourhood Energy Strategy* and *Energy Centre Guidelines*, which set the long-term vision for the development of neighbourhood renewable energy systems in Vancouver with a focus, beyond the expansion of Southeast False Creek, on the following areas of opportunity:

- Enable the conversion of the existing Downtown and Children's and Women's/Vancouver General Hospital campus steam heat systems from fossil fuels to renewable energy sources;
- Enable the establishment and expansion of new neighbourhood energy systems to serve high density areas in the Downtown, Cambie Corridor, River District and Central Broadway areas that are undergoing rapid development; and
- Enable the expansion of neighbourhood energy systems to replace boiler equipment in existing gas-heated buildings.

The strategy allows the City to provide leadership and support with the minimum of regulation the development of renewable energy systems that result in short-to-medium term low-carbon energy, long-term cost-competitive energy rates with the capability to be fully renewable, and stimulating green economic growth.

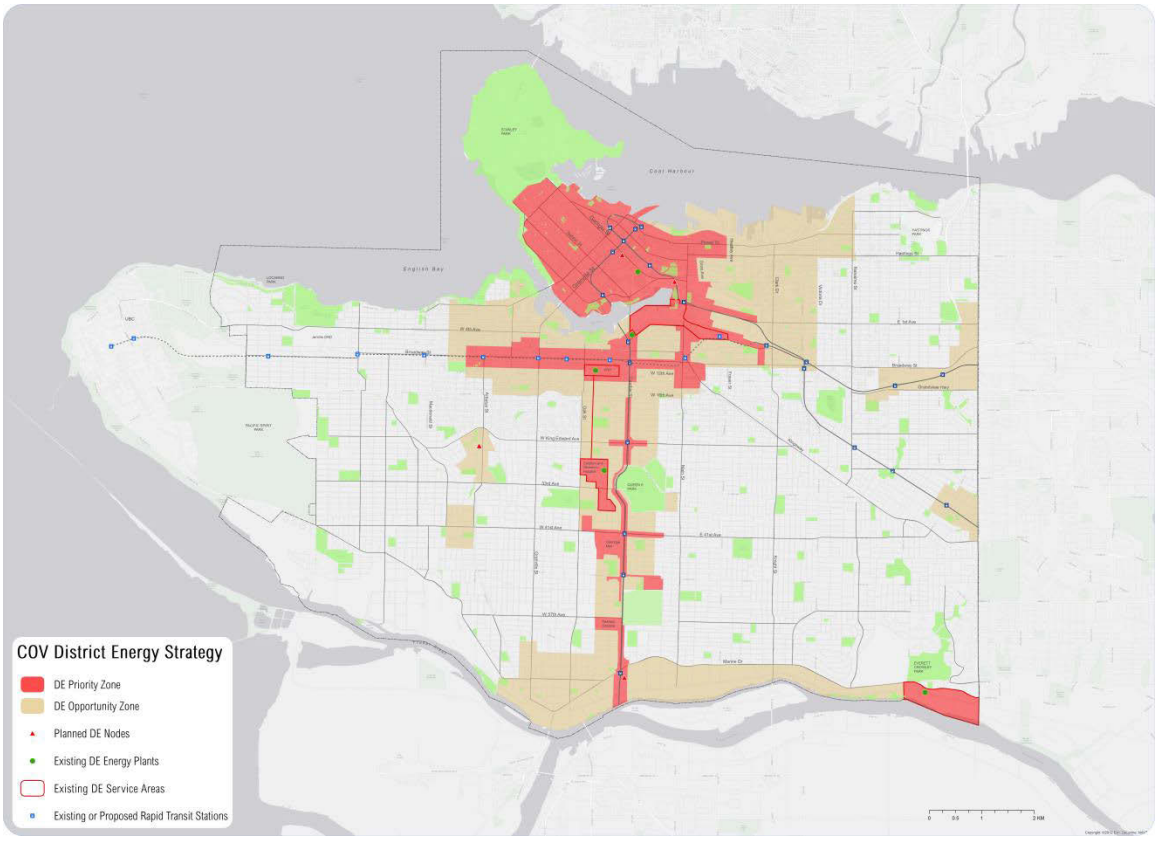


Figure 5 **– Neighbourhood Renewable Energy System Service Areas**

On-Site Renewable Energy Generation

Areas with low population density - those with a lot of single family homes or low-rise condos and apartments - do not use enough energy for heating to merit being connected to a neighbourhood energy system. The cost of building the system and then connecting to it is too high when spread between a small number of homes/units. As such, low density development must have its thermal needs (both space and hot water) switched from natural gas to renewable electricity from the grid or from on-site renewable energy generation.

Civic Renewable Generation Quick Start : **The City will support new renewable energy technologies for City buildings**

The City will actively consider new technologies, materials and approaches that support the strategic approach of the Renewable City Strategy. *For civic facilities that need retrofit or that are to be newly built the City will consider new and appropriate technologies that will enhance building performance, improve conditions for occupants and increase the use and/or generation of renewable energy.*

On-site renewable energy generation is more applicable to low-density sites since there is often space available on site to generate enough electricity and/or heat to meet the demand of a zero-emission building. On-site renewable energy generation can come from solar power or solar thermal, on-site wind generation, or heat pumps (that would likely use grid supplied electricity). With the anticipated improvements in building efficiency, and an already effective electrical grid the need for on-site rooftop solar power generation specifically will likely be determined by the market price of the technology, the cost to produce electricity and the larger system needs of the electrical grid. Unlike in many parts of North America, the comprehensive roll-out of rooftop solar PV is unlikely to be an imperative for success in meeting the City's renewable energy goals, but can give the public and businesses the opportunity to meet their own energy needs, yield a potential source of income through the sale of excess power, and provide a tangible way in which the people, communities and businesses can contribute to the move towards a renewably powered future. With wider uptake of distributed generation, on-site generation can allow buildings and neighbourhoods to be more resilient to disruption and outages, particularly during extreme weather events.

Solar Quick Start : **The City will streamline the process for the installation of rooftop solar systems**

The City will streamline the process to install rooftop solar systems to allow solar technologies to be implemented quickly as demand grows. The generation of on-site power and heat will play an important role in achieving the use of only renewable energy. Ensuring that renewable energy technologies can easily be implemented will be important in ensuring that market forces decide the most cost effective way to supply renewable heat and power.

Increasing Renewable Grid Electricity Supply

With current building practice Vancouver's demand for electricity can be reasonably expected to be about 8-10% higher in 2050 than it is today, although there would still be significant use of fossil fuels. Through significant energy efficiency and conservation efforts, the direction outlined in the *Renewable City Strategy* will enable Vancouver to make much wider use of renewable electricity while only increasing demand by about 20% over current levels, or 10% more than could be expected were current municipal and provincial policies maintained.

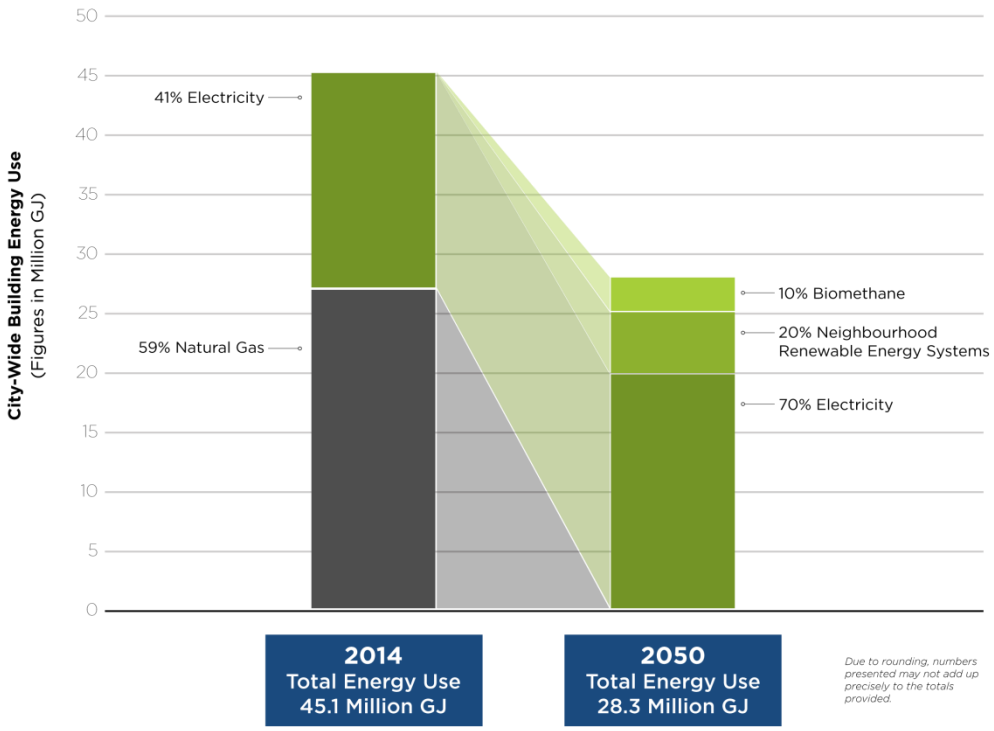


Figure 6 **– City-wide Building Energy Demand Reduction 2010-2050**

Across the province there is a need to increase grid-scale renewable electricity generation, not just for Vancouver. The attainment of 100% renewable energy use does not come solely through on-site generation. BC Hydro – the sole electrical utility supplying Vancouver – is legally required to develop *Integrated Resource Plans* (IRPs) to detail the utility's plans for meeting customer demand over the coming 20-30 years. Consistent with the *Renewable City Strategy*'s own strategic approach to reducing energy demand ahead of increased renewable energy use, the *2013 Integrated Resource Plan* details how BC Hydro intends to meet the *Clean Energy Act* requirement that 66% of electricity demand growth by 2020 be met through energy efficiency and conservation. The *Integrated Resource Plans* also detail grid transmission line improvements and the optimization of privately owned power generation facilities (called 'independent power producers', IPPs) to make better use of existing renewable power sources. The IRP also addresses new power generation needs for the short, medium and long term, and the City's goal to move to 100% renewable energy is consistent with many aspects of the Clean Energy Strategy section of BC Hydro's 2013 IRP. In response to the *Clean Energy Act* the IRP supports the use of renewable resources. The advances that have been made in wind and solar technology provide market-ready renewable energy technologies that are cost competitive with large-hydro power. Grid-scale renewable electricity generation of the future should be brought into service as it is needed and enhance system reliability, particularly in light of a changing climate, while also maintaining affordability. There is a significant economic opportunity for new business to come to BC and be headquartered in Vancouver as renewable energy resources are developed. Current regulation allows for up to 7% of the electricity used in Vancouver to come from non-renewable sources; the City will work with its utility partners to find ways to address that non-renewable portion, but in the event that the electricity supplied to Vancouver is not 100% renewable, the City of Vancouver will investigate how to secure renewable electricity from other sources. Also, in accordance with the City's *Neighbourhood Energy Strategy*, the City intends to enable the establishment of additional neighbourhood renewable energy systems that can provide heating, limiting the need for new electrical capacity to meet heating demands.

As there are increases in both on-site electricity generation and new grid-scale generation the electrical grid will have to adapt – the electrical grid will need to become "smart" to manage these new ways of generating and distributing electricity. The "smart grid" will not only better meet customer needs but also is imperative to managing emerging technologies like energy storage, electric cars, the 'home-ecosystem', and on-site power generation distributed throughout the city. A smart-grid is more reliable, more resilient when things do go wrong, and more adaptable to the future demands on the electrical system.

Ownership and Financing

The business case for significantly reducing energy demand and moving to renewable energy sources is good when the total cost of ownership, including purchase, maintenance and operation is considered. However, there is what's known as the 'split incentive', where the person or business constructing the building is not the one who owns and operates the building. This gives the developer no incentive to spend the extra money upfront to improve the building performance, since the developer is not paying the energy costs once the building is occupied.

In some circumstances the builder and occupier are the same entity; this is often true for institutional buildings like schools, hospitals, libraries and community centres as well as commercial, rental and non-market housing developments. In these cases it is important to accelerate the pace at which building energy performance improvements are realized in order to help make energy efficiency improvements common practice and more affordable, particularly given that in these same cases the owner/operator is often more tolerant of longer payback periods for their initial investment.

In cases where the split incentive persists, there is a need to develop new financing tools and energy equipment ownership models that can support longer payback periods or reduce the need for owner financing. There is also a need to develop business models that transfer ownership of the cost savings resulting from the efficiency improvements to the person or business that financed the system improvements.

Zero-Emission Building Priorities

B.1 New buildings to be zero-emission by 2030

Vancouver's *Zero-Emission New Building Strategy*, currently under development and expected to be considered by Council within a year, will focus on a number of core actions to move residential, commercial, industrial, and institutional buildings to be zero-emission.

B.1.1 Adopt and demonstrate zero-emission standards in new City of Vancouver building construction

When new approaches and technologies are first implemented, such as those integral to zero-emission buildings, it takes time for the market to adjust. Early adoption catalyzes innovation, learning and changes in the supply chain. The City and large institutions are well placed to lead these new approaches and technologies since they do not suffer a split incentive and are tolerant of longer payback periods.

B.1.2 Ensure rezoning policy leads the transition to zero-emission buildings

The City can foster leadership through its rezoning policy. On sites where the developer is seeking higher density, the City will require demonstration of green building leadership, but is first evaluating how to evolve these requirements to better align with its zero-emission building goals. Rezoned developments help advance new practices, technology and materials in the building market. Once there is sufficient understanding of the most effective approaches to achieving higher than minimum performance requirements, these approaches should become the new baseline (see *Priority B.1.4*). This requirement will remain for a limited period after the rezoning was granted, and thereafter the regular building code will apply. The greenhouse gas intensity targets that rezoned developments will have to achieve will become progressively more stringent, increasing the market share of buildings performing to higher and higher standards, so that by 2030 all new buildings will be zero-emission.

B.1.3 Incentivize and streamline the development of exemplary buildings

The City will develop new incentives to support the development of, and increase over time the market share of, zero-emission buildings. Incentives will especially focus on detached homes since there are no rezonings for this form of development. This approach will also help advance new practices and buildings that are delivering multiple City priorities (such as affordable housing). Part of this work will identify and remove policy and permitting barriers, since this will streamline desired forms of development that will showcase and provide case-study information on how to develop an exemplary building. Support for the certification and acceptance of new technologies and materials will help stimulate supply and allow new products to enter the market.

B.1.4 Establish and enforce specific greenhouse gas intensity limits for new developments

The City will adopt performance-based building standards. The City will work with the industry and trades to ensure that buildings comply with the code. The City will establish a stretch code route to achieve zero-emission buildings by 2030 with greenhouse gas intensity limits. The stretch code increments will be stepped to be more stringent over time as the market adapts to new technology and working practices; this will realise both energy efficiency improvements and increased on-site energy generation. Buildings will be able to comply with the regulations in a number of ways, and the market will best decide the most cost-effective compliance approach. It is expected that Vancouver's Building Bylaw will require zero-emission buildings by 2030.

B.1.5 Develop innovative financing tools to help fund new zero-emission buildings

Financing mechanisms and business models are needed to overcome the split incentive and deliver the cost savings that result from efficiency improvements to those who fund the work. These tools will bring together all the key stakeholders involved in new developments and building operation including, but not limited to, the utilities, financial institutions, developers, municipal and provincial government, and other private businesses. The financial tools will aim to connect the financial benefits of reduced energy costs to investors that are interested in covering increased capital costs in exchange for a long-term secure revenue stream that is based on these savings.

B.1.6 Establish partnerships to build industry capacity

New technologies require new working approaches - trades need time to adjust to the new technologies they are installing, supply chains need time to integrate new product offerings, and building operators need to adjust to new systems. As the market for renewable energy, ultra-efficient and zero-emission building technologies grows, projects will become better planned and standardized. This process must be accelerated. There is a need to train personnel and maintain the relevant professional and trade skills to deliver high-functioning buildings, skills which in some cases are new and in other cases are easily adapted from current practice and which provide low-barrier employment opportunities.

B.1.7 Mandate building energy benchmarking and labelling requirements

In order for building improvements to be effective at both the building and city-wide scales, building energy performance data are required. The City of Vancouver will work with other levels of government and other municipal governments to ensure that buildings are required to record and report their energy use. 'Energy benchmarking' would allow for the assessment of real-world building and system performance, as well as the opportunity to provide building labels that score the energy performance of the building, and to which a dollar-value can be ascribed at the time of sale.

B.2 Retrofit existing buildings to perform like new construction

In 2014, Vancouver City Council approved the *Building Retrofit Strategy* that is now being implemented and enhanced.

B.2.1 Use the Zero-Emission New Building Strategy *to reduce the need for building retrofits*

The faster new construction can move to ultra-low energy use and zero-emission the fewer buildings there will be that require future retrofitting to use only renewable energy. In addition, the energy efficiency requirements of Vancouver's Building Bylaw for a given building element (such as furnace efficiency, or insulation amount) for new buildings will also apply to those same elements. Having Building Bylaw requirements for ultra-low energy means that many buildings will gradually move closer to zero-emission as part of the natural replacement cycle for building equipment. This is especially true for building components that have shorter lifespans, since they will need replacing after zero-emission requirements come into effect, but prior to 2050.

B.2.2 Mandate energy efficiency improvements for existing buildings

The City currently requires modest energy performance improvements that are unrelated to planned renovation work. For example, a major bathroom renovation requires that the homeowner also weather seal their house if it is exceptionally drafty. These requirements will need to evolve as energy prices change and new technologies are developed, so that cost effective energy savings can be maximized. The requirement for energy improvements at the time of permit will remain and the city will also investigate additional upgrade triggers such as mandating the regular recommissioning of large residential and commercial buildings, or requiring improvement at the time of rental or ownership transfer.

B.2.3 Provide flexibility to achieve energy efficiency requirements through the support of on-site generation or neighbourhood energy system connection

In some cases it will be difficult to meet the energy efficiency requirements of Vancouver's Building Bylaw when undertaking a renovation – either due to physical restrictions because of the existing building design and form, or due to high equipment replacement costs. Under these circumstances the City will allow connection to a neighbourhood renewable energy system or the installation of on-site renewable energy systems that result in energy savings equivalent to those which would have been achieved by retrofitting the building to achieve the standard of Vancouver's Building Bylaw.

B.2.4 Facilitate modest retrofits through incentives and financial support mechanisms

To enhance the impact of energy utility programs and to fill gaps in program offerings, the City is investigating how to offer financial incentives and fund technical support programs to facilitate retrofits. These incentives and programs could be timed to allow industry capacity building ahead of regulatory requirements or to ease the burden of regulation for specific sub-groups or building types.

B.2.5 Increase renewable energy use by large energy consumers

There are already market-ready renewable energy options for large energy users such as industrial sites and high-rise buildings. These technologies cannot currently meet all of the buildings' energy demands at reasonable cost, but the City will investigate increasing the proportion of energy required to be met through renewable sources and the rate at which that proportion will change.

B.3 Expand existing and develop new Neighbourhood Renewable Energy Systems

In 2012, Vancouver City Council approved the *Neighbourhood Energy Strategy* and *Energy Centre Guidelines* that are now being used to guide the development of neighbourhood renewable energy systems in the city.

B.3.1 Expand existing Neighbourhood Renewable Energy Systems

Southeast False Creek Neighbourhood Energy Utility (SEFC NEU): The SEFC NEU, established in 2010, is the first system of its kind in North America that recovers waste heat from sewage. This system is growing rapidly, delivering low carbon energy at a neighbourhood scale, and is financially self-sufficient with cost competitive and stable customer rates. The lessons learned from this system have helped to inform the City-wide neighbourhood renewable energy systems approach, benefit other jurisdictions that are developing similar projects, and demonstrate the first neighbourhood renewable energy system in Vancouver.

In 2012 Vancouver City Council approved expansion of the Southeast False Creek Neighbourhood Energy Utility service area to include the Great Northern Way Campus Lands in the False Creek Flats area. Expansion work is now underway, with the relocated Emily Carr University to be connected to the system in 2016. The systems will also serve student housing, and residential and commercial buildings in this area will also be served by the system. The system is also well positioned to grow to serve new and existing buildings in the Mount Pleasant and False Creek South areas, and adjacent lands in the False Creek Flats.

River District: In 2012 a private neighbourhood renewable energy systems was established to service the River District neighbourhood. This system, which is currently using a temporary natural gas boiler, will establish a low carbon energy supply once there are sufficient customer buildings to establish a revenue base sufficient for the investment in a pipeline to recover waste heat from the existing Metro Vancouver Waste to Energy Facility located in Burnaby.

B.3.2 Enable the conversion the Downtown and Hospital Steam Systems from natural gas to renewable energy.

Downtown steam system: The privately owned downtown steam system serves more than 210 buildings and provides the single largest carbon emission reduction opportunity in the city. The City is working with the system owner to plan the conversion to renewable energy source. The conversion also has the potential to supply renewable energy to other neighbourhoods in Downtown, including Northeast False Creek, South Downtown, West End, Downtown Eastside and False Creek Flats via new low-temperature hot water networks.

Children's and Women's Hospital and Vancouver General Hospital campus steam systems: These systems are interconnected via an unused steam line. Reactivation of this steam line, and establishment of a new low carbon energy centre at Children's and Women's Hospital provides a significant opportunity to increase renewable energy supply to the hospitals. The system also has the potential to expand to serve new developments and existing natural gas heated buildings in the Cambie Corridor and Central Broadway areas.

B.3.3 Enable the development of new neighbourhood renewable energy systems for downtown and the Cambie corridor

There is significant work already underway to establish new neighbourhood renewable energy systems in high density areas of the city:

Northeast False Creek: Implementation is underway for a new neighbourhood renewable energy system to serve new developments in the Northeast False Creek area, via a low-carbon hot water expansion of the downtown steam system

South Downtown: Planning activities are underway to establish a new neighbourhood renewable energy system to serve to serve new developments in the area of the Granville Street Bridge.
West End, Downtown East Side, False Creek Flats: New high density development and existing natural gas heated buildings in these areas yield significant opportunities for new neighbourhood renewable energy systems, with further feasibility analysis and planning work to take place in 2016.
Cambie Corridor: This area has a number of large development sites, including Oakridge, Dogwood Pearson Lands, TransLink Bus Barns, RCMP site and Langara Gardens. Planning work is underway to establish an neighbourhood renewable energy systems to serve these areas

B.3.4 Continue to enforce and update as required, building and renewable energy supply policies that support neighbourhood renewable energy systems.

To ensure the viability of significant capital investments in neighbourhood renewable energy systems, it is important that there are sufficient buildings connected to the system. In 2007, the City established a bylaw compelling new developments in Southeast False Creek to connect to the Neighbourhood Energy Utility. Since then, as part of the neighbourhood planning processes the City has established connection rezoning policy for a number of areas, including the Cambie Corridor, Downtown Eastside and West End to name but a few. In 2015, Council approved but has not enacted the Neighbourhood Energy Bylaw, which provides greater clarity to developers in the Northeast False Creek and Chinatown areas. It is anticipated that, as systems are established in new areas, this bylaw will be expanded to secure the necessary customer base to facilitate capital investments in neighbourhood renewable energy systems and secure neighbourhood-scale low carbon outcomes.

Metro Vancouver, as the regional authority that controls liquid waste, in consultation with member municipalities (including the City of Vancouver), has developed a policy framework to enable the recovery of waste heat from its sewage system. The City will continue to apply the framework.

B.4 Ensure grid supplied electricity is 100% renewable

B.4.1 Partner with utilities to increase the supply of renewable energy

The City will work with its utility partners to increase the supply of renewable energy that is affordable and reliable and that increases the resiliency of the energy supply networks to Vancouver. The City of Vancouver will work with utilities to help develop their *Integrated Resource Plans* as required by legislation, and advocate for the inclusion of new renewable energy resources that maximize the renewable energy provisions in the *Clean Energy Act,* develop economic opportunity, and better meet the city's future energy needs. The City will work to ensure that existing renewable energy opportunities such as customer-based generation, net metering and BC Hydro's standing offer on clean electricity generation are maximized, as well as working to better understand the changes in electrical demand that will result from a transition to 100% renewable electricity.

B.4.2 Partner with utilities to implement a smart grid that meets Vancouver's energy needs

The City will partner with electrical utilities to implement improvements to the distribution systems within Vancouver, improve power quality and develop a smart grid that better meets customers' needs, optimizes electrical distribution to increase system efficiency, and improves reliability. The City will work to ensure that its role in distributed energy generation compliments utility efforts and initiatives to increase renewable energy supply. The City will also work with its partners to ensure that energy storage and smart devices seamlessly connect utility grids with future buildings and transportation needs.

A Vision of Vancouver's Building Energy Use in 2050

Modelling the supply of and demand for energy in Vancouver, as well as some select anticipated technological changes allows a feasible vision for the city's stationary energy use in 2050 to be developed. Below in shown how the strategic approach of reducing demand, increasing renewable energy use and increasing renewable energy supply can meet Vancouver's building energy needs in 2050.

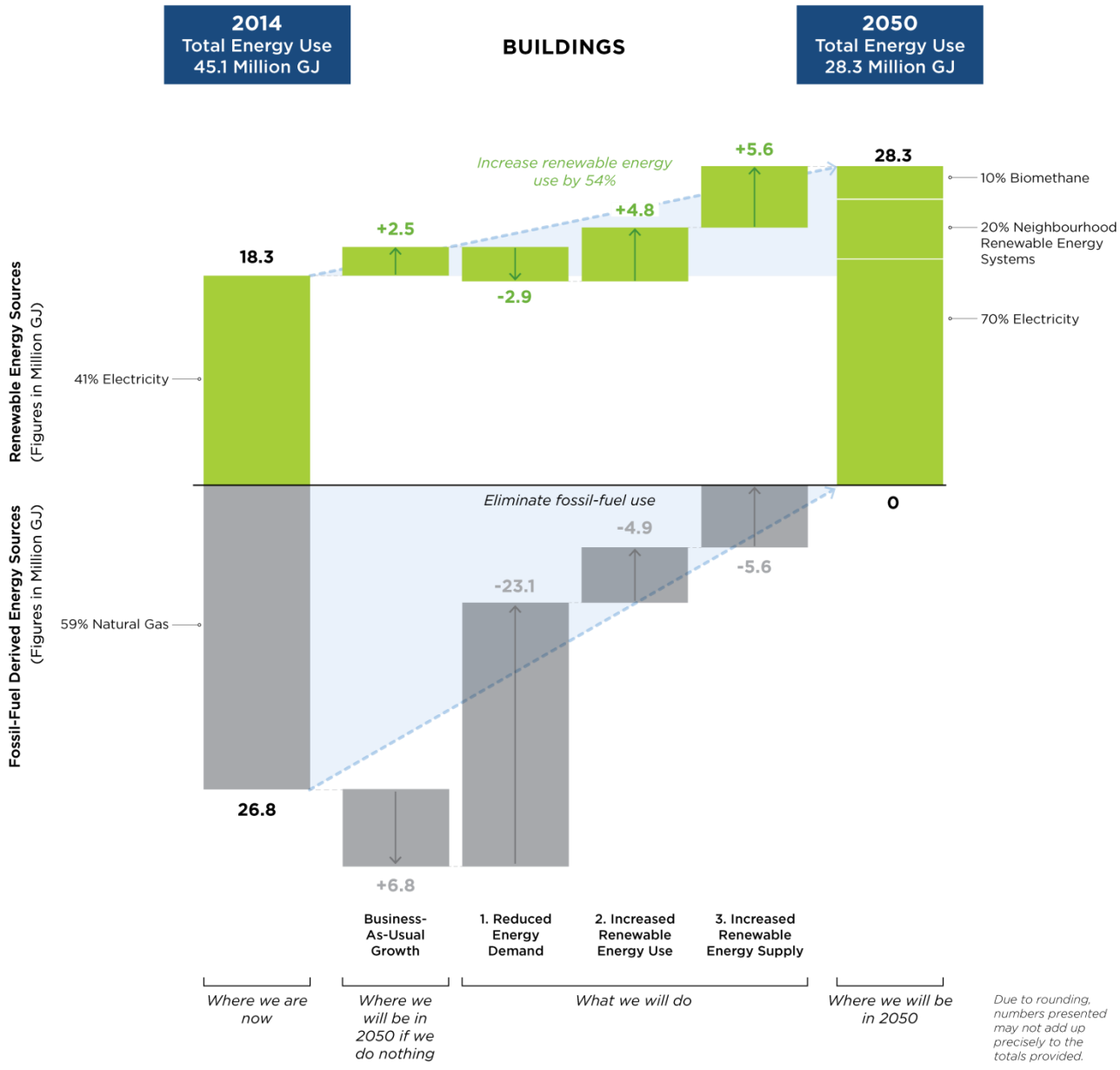


Figure 7 **– Building Energy Use Transformation 2014-2050**

The building energy priorities outlined above will feasibly allow Vancouver to grow and eliminate its dependence on fossil fuels. Improvements in building and appliance energy efficiency will allow the city to grow without dramatically increasing electricity demand by 2050. Vancouver has an active property development market compared to many cities. If historical

trends continue, by 2050 about 40% of total floor space in Vancouver will have been built after 2020 and be zero-emission; about 30% of the floor space will have been built to current or upcoming building standards, while the remaining 30% will have been built prior to 2010. The implications are that almost half of the floor space in Vancouver will be zero-emission buildings, while the remaining half will have undergone a retrofit to bring them up to a similar standard.

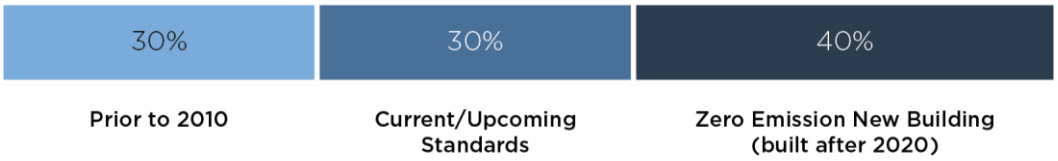


Figure 8 **– Anticipated City-wide Building Stock Age in 2050**

Of that total floor area, about 10% can reasonably be expected to use electrical resistance (baseboard) heat and hot water since come buildings aren't large enough to merit the efficiency advantages of a heat pump. About 20% of the floor area in the city will be serviced by neighbourhood renewable energy systems. The remaining portion will have heat and hot water provided through heat-pump technology, both air-source and geoexchange; local site design will determine to what extent these needs are met by on-site generation or by renewable grid electricity.

City-wide building energy demand could be reduced by over a third compared to 2014 levels through: adopting zero-emission buildings; requiring that buildings that undergo retrofit attain a similar level of performance; and connecting buildings to neighbourhood renewable energy systems. Of that energy demand which does remain, about 70% can be met through renewable electricity (both on-site and grid supplied) which constitutes about a 10-15% increase in building related electrical demand compared to today; about 20% of total building energy demand will be met through the city's neighbourhood renewable energy systems, and 10% through biomethane. Biomethane is currently a limited resource, and is likely to remain so as demand for it increases. As such, biomethane for space heat is not the best long-term use of the resource, and it is expected that biomethane will be used most extensively in the commercial freight sector for its high energy content and easy of transport. However, in the short-to-medium term biomethane affords a ready opportunity to decarbonize building space heat and hot water for those that are currently using natural gas.

As building performance improves there will be a change in the building energy end uses that demand the most energy. Across the city as a whole, accounting for population growth to 2050, home appliance energy use can be expected to stay constant, with LEDs expected to cut residential lighting needs by as much as 80%, while air conditioning load will have increased by about 75%. There are two areas of significant load growth, although significant for different reasons. Plug loads like TVs, smartphones, microwaves and so on are expected to more than double, increasing the share of total residential building energy demand associated with plug loads from 16% to 36%. The need to charge electric vehicles is significant in that is it a 'new' electrical demand for buildings, but the scale of the demand increase is itself small accounting for only about 5% of total building energy demand across the city. This value may at first seem low, but given that a with current vehicle batteries a full charge allows a vehicle to travel about 150*km*, and daily commutes are 10-30*km*, the energy demanded to fully recharge the battery each day is small.

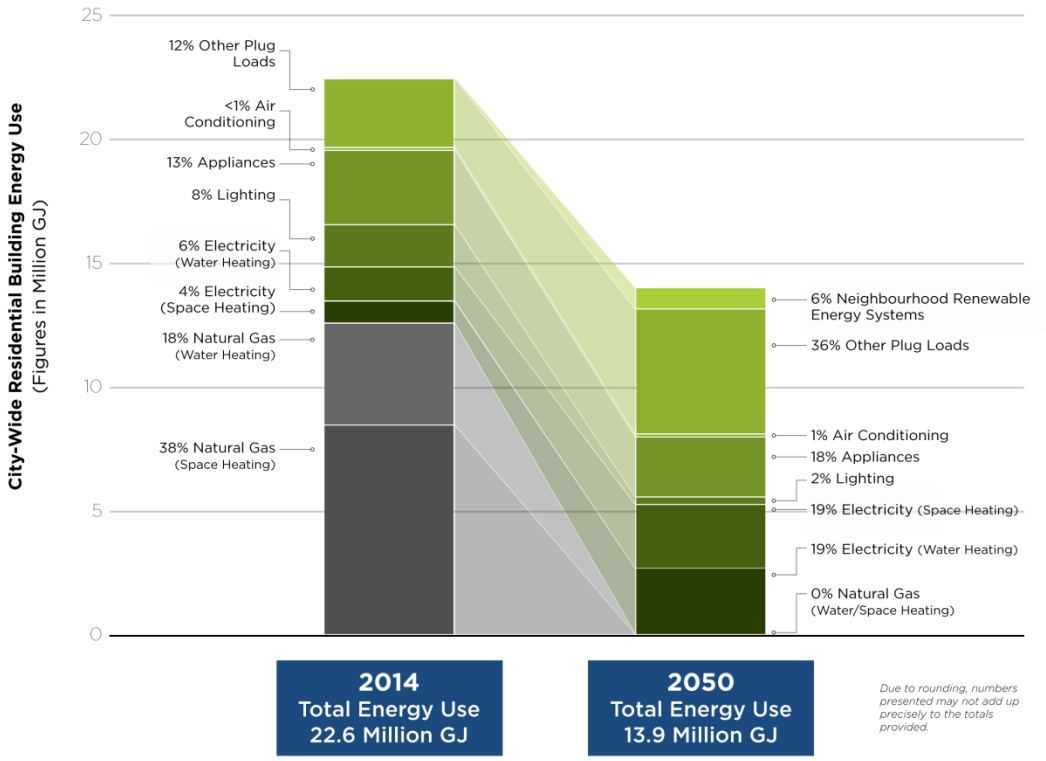


Figure 9 **– Vancouver Residential Building Energy Use by End-Use 2014 and 2050**

The large reduction in building energy use will also lead to a growing importance for the embedded carbon and embedded energy associated with building construction. As the implementation of the *Renewable City Strategy* progresses, a move toward full life-cycle building considerations will be inevitable.

Industrial, institutional and commercial buildings will see plug and equipment loads increase by about 20%, and a reduction in lighting energy demand of about one-third through the use of LEDs. The most significant energy savings can be expected from HVAC systems that will, in aggregate by 2050, use about half the energy than they did in 2014. Non-residential connections to the city neighbourhood renewable energy systems will displace significant amounts of space heat and hot water needs that would otherwise have been met through biomethane. Direct biomethane use is expected to account for about 10% of industrial energy use, while the neighbourhood renewable energy systems may also use biomethane to produce heat. In total, industrial, institutional and commercial buildings, systems and equipment improvements can be expected to cut city-wide energy use for the sector by about 35%.

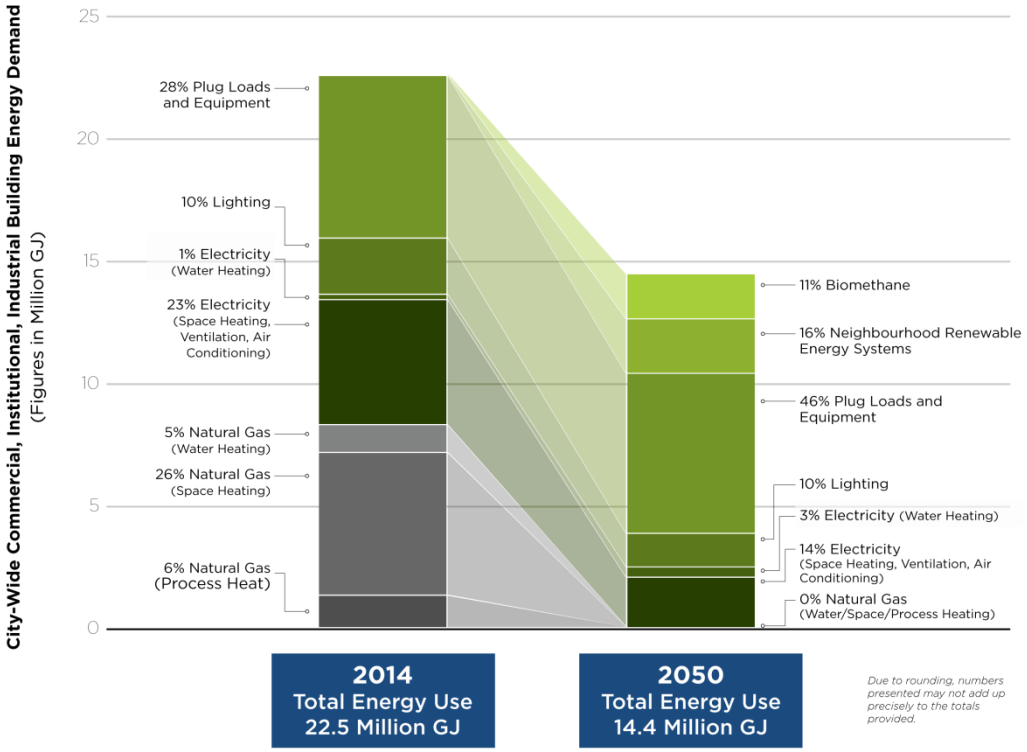


Figure 10 **– Vancouver Industrial, Institutional and Commercial Building Energy Use by End Use 2014 and 2050**

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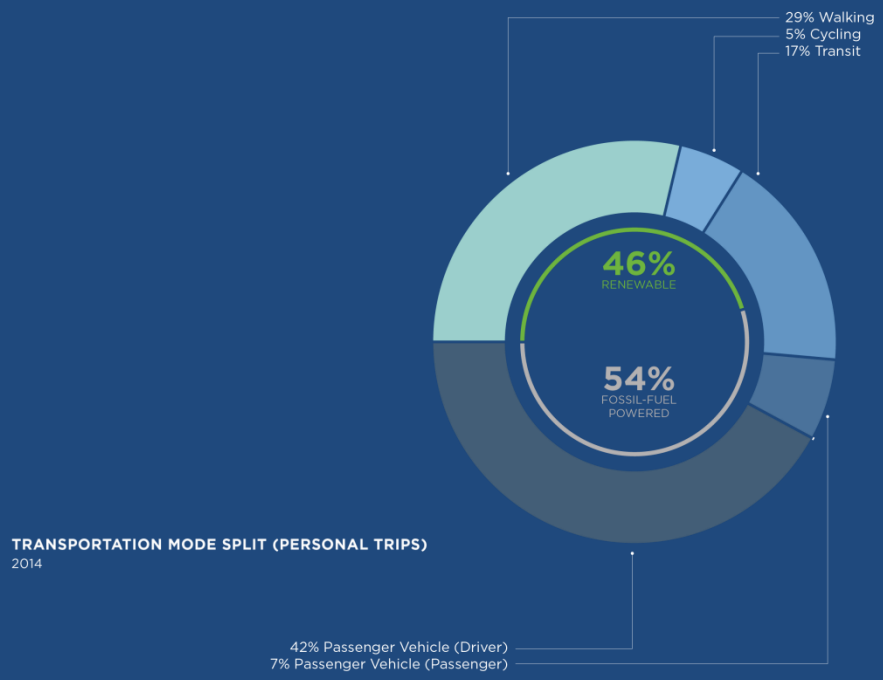
Summary :: Achieving Renewable Transportation in Vancouver

Imagine a city where the transportation system is efficient, supports a thriving economy while increasing affordability, provides citizens the opportunity to be healthy and mobile, and which is powered by renewable energy.



Renewably Powered Transportation Priorities

To increase the proportion of renewably powered trips from that shown in the pie-chart above for 2014 Vancouver will:

T.1 Use land-use and zoning policies to develop complete compact communities and complete streets that encourage active transportation and transit

- T.1.1 Foster land use as a tool to improve transportation consistent with the direction established in *Transportation 2040*
- T.1.2 Enhance and accelerate the development of complete streets and green infrastructure
- T.1.3 Enhance the pedestrian network according to the direction established in *Transportation 2040*
- T.1.4 Enhance cycling infrastructure and encourage more bike trips according to the direction set in *Transportation 2040*
- T.1.5 Use parking policies to support sustainable transportation choices and efficient use of our street network.
- T.1.6 Optimize the road network to manage congestion, improve safety, and prioritize green transportation.

T.2 Improve transit services as set out in *Transportation 2040*

- T.2.1 Extend the Millennium Line in a tunnel under Broadway
- T.2.2 Improve frequency, reliability, and capacity across the transit network
- T.2.3 Develop a transit supportive public realm with improved multimodal integration and comfortable waiting areas
- T.2.4 Work with the transit authority and other partners to transition fossil fuel powered transit vehicles to renewable energy

T.3 Transition light-duty vehicles (cars and light trucks) to be predominantly electric, plug-in hybrid or sustainable biofuel powered

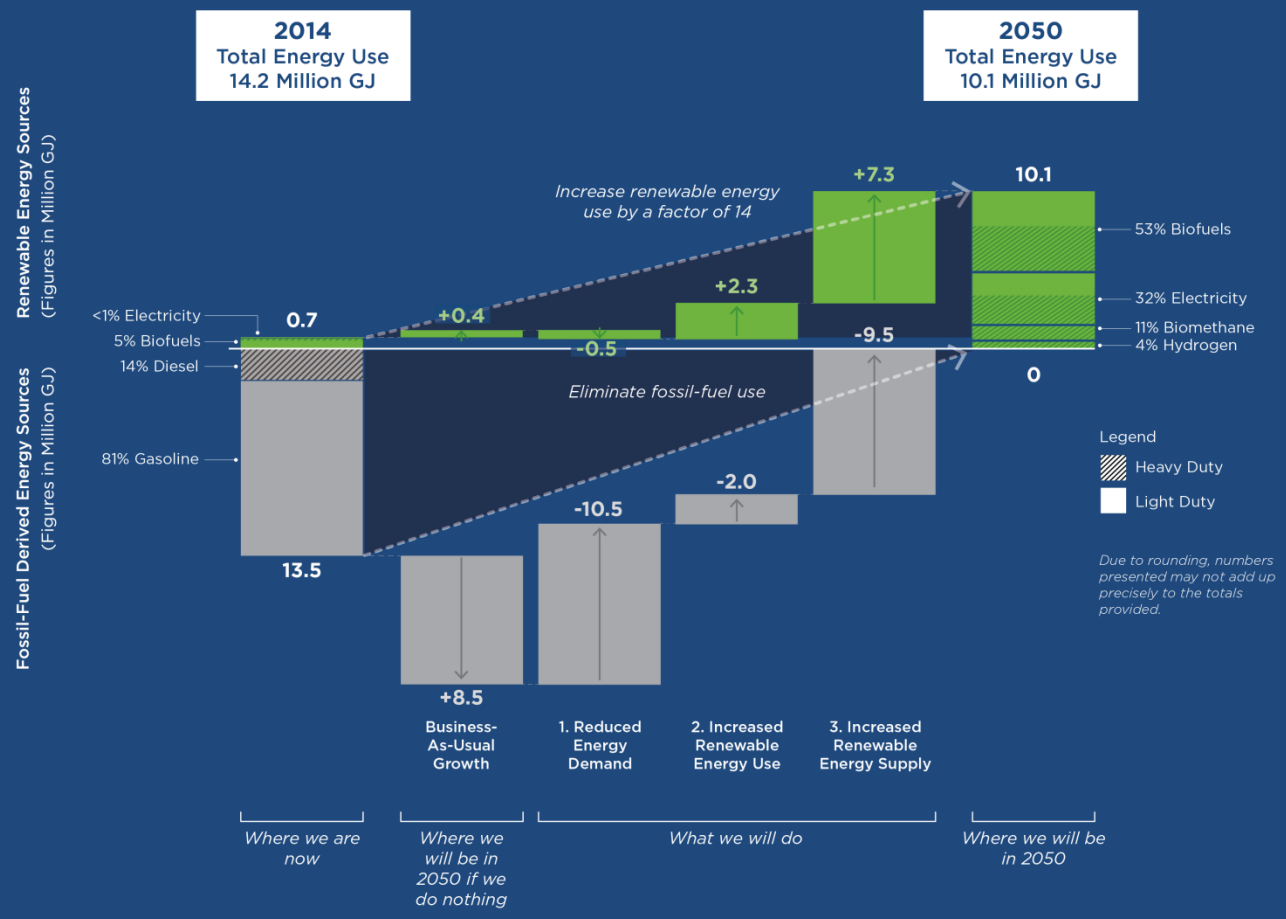
- T.3.1 Develop vehicle and fuel standards to support renewably powered vehicles
- T.3.2 Develop supporting infrastructure that meets the needs of renewably powered vehicles

T.4 Develop car-sharing and regional mobility pricing to encourage rational journey choice

- T.4.1 Support increased car-sharing and the uptake of renewably powered vehicles in car-sharing fleets.
- T.4.2 Advocate for comprehensive regional mobility pricing

T.5 Better manage commercial vehicle journeys and transition heavy-duty (commercial) vehicles to sustainable biofuels, biomethane, hydrogen and electricity

- T.5.1 Improve the delivery of commercial freight, goods, and services according the direction set in *Transportation 2040*
- T.5.2 Work with fleet operators and contractors to transition to renewably powered vehicles



A Vision for Vancouver's Transportation System in 2050

Vancouver will continue its efforts to build a city that is compact and complete, allowing most people to meet their daily needs through walking, cycling, and transit. Longer journeys will be made on transit that is predominantly electrified, complemented by renewable fuels like sustainable biofuel, biomethane, or hydrogen. The number of people living and working in the city will grow significantly by 2050, and while the number of private vehicles per person could decline by as much as 15%, the total number is expected to increase by 15%. Even with this growth, the actions outlined in the *Renewable City Strategy* - including thoughtful land use planning and infrastructure investments that improve green transportation options - could reduce total annual vehicle kilometres travelled by 20% over 2014.

The *Renewable City Strategy* priorities will help transition private vehicles to using only renewable energy sources. By 2050 about 25% of Vancouver's personal vehicles would be electric using renewably generated electricity, 45% plug-in hybrids using renewable electricity and sustainable biofuels, and the remainder conventional hybrid vehicles running on sustainable biofuels. The compact nature of Vancouver means daily commutes are short enough to allow the vast majority of plug-in hybrid journeys to use only the vehicle's battery. Given the anticipated growth in both electric and plug-in hybrid vehicles, it will be critical to provide charging infrastructure at home, work, and on-the-go locations. The effect of autonomous cars on our transportation system is expected to be marked, although it is unclear if the effect will in aggregate be positive or negative.

As fewer people drive for personal trips, the proportion of transportation energy attributable to commercial vehicles will increase. Less important than the number of commercial vehicles is the distance they travel and the weight of goods they haul. Improving how goods, freight, and services are provided will be paramount, although it is as yet unclear if electrification, biofuels, biomethane or hydrogen will dominate heavy-duty vehicle types.

TRANSPORTATION :: Making Transportation Renewable

Imagine a city where the transportation system is efficient, supports a thriving economy while improving affordability, provides citizens the opportunity to be healthy and mobile, and which is powered by renewable energy.

How Vancouver Moves

As a community our transportation choices shape our city and ourselves. The ease with which we can move around determines how we spend our time each day, where we can go, who we can see, and what we can do. Our transportation choices impact our health and well-being as well as the quality of our air. Vancouver is a multi-modal city where most citizens use a combination of walking, cycling, transit, and motor vehicles to get around and meet their needs.

Our transportation system moves more than people - it also moves goods and services that are essential to a thriving local economy and high quality of life, requiring efficient local networks and connections to the larger road, rail, air, and marine networks.

Transportation and land use are inextricably linked - how we design our communities affects our mode choices and how much we travel. Those travel needs in turn influence how we use land. *Transportation 2040*, the City's strategic transportation plan, establishes a clear hierarchy of transportation modes that are consistent with the strategic approach of reducing the need for motorized transport, and prioritizing walking, cycling, and transit as the city's top transportation choices.

Vancouver continues to be a sustainable transportation leader in North America, building on past successes and pioneering emerging concepts to enhance green mobility and accessibility. Vancouver has already reached its 2020 mode share target that at least 50% of all trips originating in the city being on foot, bike, and/or transit, climbing from 40% in 2008. Over the same time period the number of daily bike trips doubled from 50,000 to 100,000 per day.

Numerous projects have contributed to this success. In particular, the opening of the Canada Line rapid transit line in 2009 resulted in a large increase in transit use. Land use and urban design play an important part. We continue to build mixed-use, walkable communities that are well served by transit. The City has also taken a new approach to cycling with an increased focus on low-stress bike facilities that feel comfortable for people of all ages and abilities.

Additionally, Vancouverites have embraced car sharing more than any other city in North America, with services rapidly expanding and now including one-way services. Car sharing makes it easier for people to embrace a multi-modal "car-light" lifestyle that doesn't require owning a car.

To continue to make progress on these achievements, the City needs support from outside agencies. One million people will be added to the Metro Vancouver region in the next 30 years, or about 35,000 people per year. The transit system is largely at capacity and requires significant support and funding from higher levels of government in order to meet increasing demand. The regional Mayors' Council *Transportation and Transit Plan* details the projects necessary to reach our mode share targets, but stable, long-term funding sources are required to deliver them.

Automobiles, while declining in terms of mode share, will continue to play an important role in our transportation system for the foreseeable future. Autonomous vehicles, in particular, could radically change how we get around, and at the moment their future effect, both positive and negative, is unclear. To meet our long-term air quality and emissions targets, it is important to support the shift to renewably powered vehicles.

Adapting to a Changing Transportation System

Road transport accounted for about 37% of Vancouver's total emissions in 2014 and that's because the way we use and think of transport has been established over a century. That car-centric mindset is slowly changing but not without challenges. Many key actions—to improve the pedestrian realm, build a complete and attractive cycling network, improve transit capacity and reliability, and create vibrant public spaces—will require further road space reallocation from the private automobile. The emergence of information technology and systems to manage our journeys and make them easier has already begun, and can be expected to grow even more. The actions laid out in *Transportation 2040* and the direction set by the *Renewable City Strategy* outline the steps needed to ensure a smooth transition away from auto dependency.

Vancouver has to date, through a clear transportation vision, been successful in ensuring that people, goods, and service can travel efficiently. The City's success has come from comprehensive partnerships, regional planning, and close cooperation between different municipal departments. Reimagining what road space is used for has led to development of "complete streets" that provide mobility and public space options for a wide variety of street users, changing how we move, alleviating congestion, and allowing Vancouverites to take important steps to improve their health. The transportation system that Vancouver is aiming for is not one where freedoms are given up at the expense of environmental benefit, but one where people make sustainable choices because they are the most rational, comfortable, convenient, safe, and enjoyable ways of getting around.

Preferential Parking Quick Start: **Support the uptake of renewably powered vehicles through preferential parking provision**

Parking provision and management is an important determinant of how we use our vehicles. Through the provision of preferential parking for clean vehicles it is possible to catalyze the uptake of clean vehicles as people see tangible benefits to ownership. As the transition becomes more complete there will be a need to reassess how preferential parking is managed.

Reduce Motorized Transportation Demand

Land Use and Urban Design as Renewable Energy Tools

Focusing on the factors that affect Vancouver's transportation choices promotes the design of communities that facilitate the transportation hierarchy. *Transportation 2040*'s "5D's" of the built environment- destinations, distance, density, diversity and design are core considerations in ensuring our communities are complete and well connected. Our transportation choices depend on a variety of factors, including travel time and reliability, marginal cost, how far we have to go and how flexible we need that journey to be. For example, do we have things to carry, are we in a rush, are we meeting people, is parking available close to the destination, and will we have to pay for it?

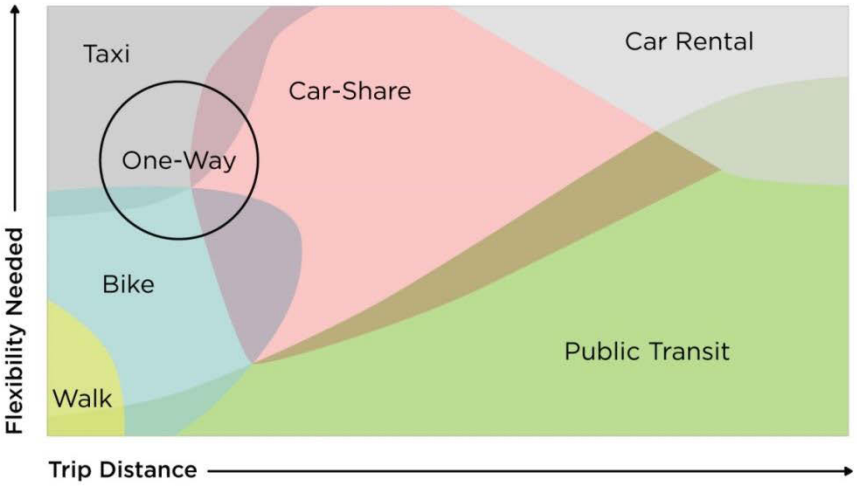


***Figure 11* – Journey Mode Choice According to Distance and Required Flexibility**

Several principles underlie the *Regional Growth Strategy* and the City's own *Regional Context Statement*, including:

- Ensuring that Vancouver has a compact urban area to promote energy conservation and efficiency;
- Delivering a sustainable economy that is both local and international and not bound to fossil fuels;
- Effectively protecting the environment and responding to climate change through use of only renewable energy sources; and
- Developing complete communities that rely less on personal motorized transport.

Vancouver is an urban planning success story that has fostered livable densification, first in the downtown and now throughout the city. Vancouver is a city of unique neighbourhoods, which, although diverse, are working toward a set of common goals that underpin what a 100% renewable energy city can achieve:

1. Creation of an urban form that is environmentally sustainable;
2. Development of a range of affordable housing options to meet a diverse set of needs;
3. Contributing to a robust and diversified economy, which as a result is resilient;
4. Support for communities that enhance culture, heritage, and creativity;
5. Development of sustainable transportation options that are not just viable but preferable;
6. Enhancement of public open spaces, parks, and green linkages;
7. Promotion of resilient, sustainable, safe, and healthy communities.

In delivering these goals, the City is committed to upholding the highest standards of urban design that makes our streets and cityscape attractive, functional, memorable and safe. Through the integration of parks, open spaces, sidewalks,

walkways, bodies of water, trees, landscaping and lighting the city can match the urban fabric of the city to the needs of a renewable transportation system.

Underway Now: **Replace the Georgia and Dunsmuir viaducts for better at grade services and public space**

Removing the two elevated roadways that connect the False Creek Flats to Downtown will repair a major gap in the Vancouver's urban fabric, improve walking and cycling, create new open space and increase land for housing including affordable housing. The City has already completed initial feasibility and design work based on public input and continues to work on the Northeast False Creek Conceptual Plan and Northeast False Creek: Directions for the Future.

Increase Walking

Walking will continue to be the City's top transportation priority. Almost every journey has a walking component to it at some point. For short trips, walking is the best option for people and the environment, and businesses benefit from passing customers. Vancouver's grid network, good urban planning and pleasing urban design mean walking trips are often direct, convenient and interesting. There is still more that the City can do to make walking more appealing and safer. As part of its *Transportation 2040* efforts, the City is taking a comprehensive approach to address gaps in the walking network, improve sidewalk connectivity, create more temporary and permanent public spaces, and maximize accessibility for those with visual or mobility impairments.

Underway Now: **Improve the False Creek bridges to support active transport**

The False Creek Bridges are currently unpleasant to cross on foot or by bike. City staff are working on conceptual designs to reallocate vehicle road space to walking and biking following steadily reducing vehicle numbers on the bridges. City staff are currently developing conceptual designs that will be considered by Council once complete.

Increase Cycling

Cycling creates no emissions, is inexpensive, improves health and allows easy access to much of Vancouver. It is often the fastest way to get around for short-to-medium length trips, with many destinations accessible by bike within 20 minutes. There is also increasing evidence suggesting that cycling, similar to walking, is good for local businesses.

While cycling is growing in popularity, many people are discouraged from riding because it seems dangerous or impractical. To reach a wider audience, the City is focusing on building a direct, intuitive network of routes that efficiently connect destinations and are comfortable for everyone, including families with children, the elderly, and novice riders. Providing more secure, convenient, and abundant parking and end-of-trip facilities like showers and change rooms is also important, as is promotion and education to encourage cycling as an everyday, normal activity.

Underway Now: **Implement a public bike-share system**

The City of Vancouver is committed to implementing a public bike-share system. The City has made efforts to implement a financially prudent and viable bike-share system and is committed to working with its private sector partners to deliver a bike-sharing service by 2016.

Increase the Use of Renewable Transportation Options

Increase Transit Use

The city's compact urban form is complemented by our comprehensive public transit system. TransLink is the local transit authority, and has a shared responsibility with the local municipalities and regional government to deliver multi-modal transportation options including management of the major road network and regional cycling infrastructure. A large portion of the transit service in Vancouver is already electrified through the use of SkyTrain (electrified light rail) and trolley buses, but there are still diesel bus services on many of the routes that either do not have trolley infrastructure or need to have the ability to pass other buses (trolley buses cannot pass one another without additional infrastructure). Meeting the City's 100% renewable energy goals will require expanding the trolley network and/or converting these non-electric routes to other fuel sources. This will not only reduce carbon emissions but significantly improve local air quality and protect our health.

Increase Shared Vehicle Journeys

Car sharing is a membership based service that gives access to a fleet of cars which can be rented. Fees are typically charged on a distance- or time-based rate, sometimes with nominal fixed membership fees. This fee structure typically allows people to go 'car light' or even 'car-free' and save money compared to owning their own vehicle, yet still maintain the flexibility of car ownership. Car-share companies have varying service models; some allow the user to pick up and drop off the car anywhere within the city, called one-way car-share; others require the vehicle to be picked up and dropped off at the same place, called return-to-base car-share. Some companies have a range of vehicle models, while others use only a single type. These differences encourage people to have multiple memberships to meet their exact journey needs. A single car-share vehicle can replace up to 11 personally owned vehicles, freeing up road space for other uses. The already-significant ability of car-sharing to cut energy demand from transportation is further enhanced through the potential of using renewably powered cars in car-sharing fleets.

Increase Renewably Powered Personal Vehicle Choice

Personal vehicles will continue be an important part of the city's transportation mix, and even with significant gains in active transportation, it is critical to support increased vehicle efficiency. With the exception of the electrified SkyTrain and trolley buses in Vancouver, today's transportation system is almost exclusively based on the combustion of gasoline and diesel. The transportation system of the future will have a greater range of energy sources and vehicle types than are common today. The various vehicle types will meet different transportation needs, from those of the individual passenger to light commercial and long-distance freight.

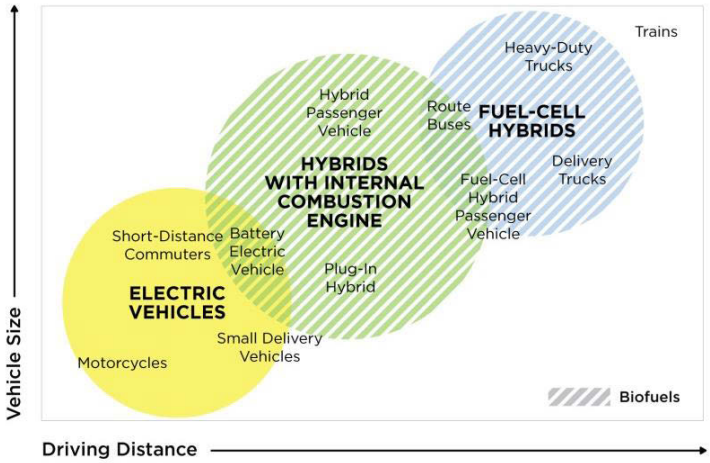


Figure 12 **– Vehicle Suitability for Different Journey Needs**

The transport system is expected to evolve so that, most short-distance and local journeys will be made on foot or bike, most longer trips by transit, and those remaining using electric vehicles of various types, depending on the needs of the journey. Electric vehicles already have ranges that are ample enough for peoples' everyday use. If drivers need to make longer journeys that cannot be served by the range of battery technology or where battery technologies are not cost efficient, alternatives like hydrogen and biofuels will need to be considered. Vehicles already available today called plug-in hybrid electric vehicles combine a battery and regular engine, so that for short distances the car acts like an electric vehicle, and when the battery runs flat a regular engine takes over. For those people who regularly travel long distances, renewable fuel solutions will come from liquid biofuels and renewable hydrogen fuel cell vehicles. Similar solutions can also be expected for larger vehicles like buses and trucks.

Based on uptake for hybrid vehicle technology, the last big change in vehicle technologies before the current boom in electric vehicle sales, it will take between 15 and 20 years to see significant changes in automobile fleets, and about the same amount of time again for technologies to be adopted into the early core market. This means that although vehicles tend to be replaced every seven to ten years, the longer time needed for widespread changes means action must start now, particularly to support technologies that are becoming commercially viable.

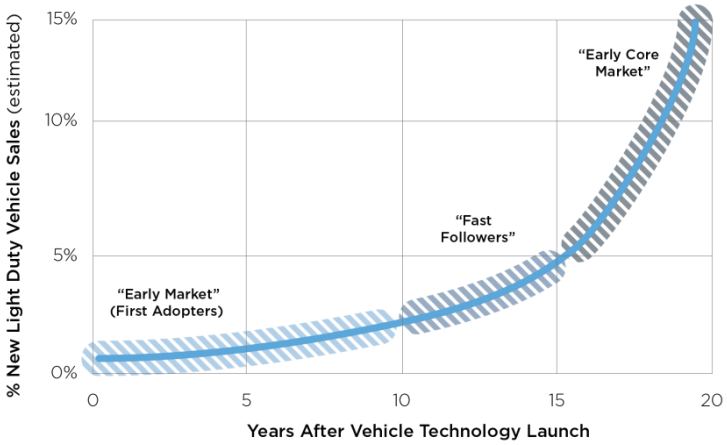


Figure 13 **– New Vehicle Technology Uptake Times**[2]

[2] Adapted from hybrid electric vehicle launch trend graph, California Environmental Protection Agency

Battery Electric Vehicles

Battery electric vehicles, often just called electric vehicles, have an on-board battery that is charged up to drive an electric motor which moves the car. Electric vehicles have started to become widely available in the last few years, and with lower maintenance and fuel costs than regular vehicles their sales are growing steadily. Electric drive systems are also being demonstrated for light-trucks. Current battery technology allows a moderately priced electric vehicle to travel about 150*km* on a single charge, although some more expensive models can reach more than 400*km*, and this is expected to become much more widely available as battery technology matures and battery prices decline. That maturity is making batteries smaller, cheaper and able to store more power; but it's unlikely that batteries will ever be able to complete with liquid fuels for long journeys. electric vehicles make ideal urban vehicles, and given time to develop will suit some light-truck needs also. The time to charge the cars' battery is still significant, but new technologies are reducing that charge time.

Electric Vehicle Infrastructure Quick Start: **Develop and implement an electric vehicle infrastructure strategy to accelerate electric vehicle uptake**

The City will develop a comprehensive electric vehicle infrastructure strategy to support the development of electrical infrastructure to charge electric vehicles and accelerate their uptake. The electrification of personal transport will require new infrastructure to support the charging of electric vehicles and plug-in hybrids. That infrastructure will mostly be required at home, but will also be needed to support workplace charging and charging while out and about. The strategy will address how to expand the provision of charging infrastructure in both new and existing buildings where there are clear routes to doing so, while also identifying strategic partnerships to solve challenges where no immediate solution is apparent.

Plug-in Hybrid Electric Vehicles

Plug-in hybrid electric vehicles have a battery *and* a combustion engine. The battery is charged by plugging in the car, just as you would for an electric vehicle, and the car can then be driven using only the battery. When the battery runs flat, the regular engine starts and the vehicle uses that to get around. If the regular engine is fuelled using biofuels (see below) and the battery charged using renewable electricity, plug-in hybrids are a renewable way to get around. Plug-in hybrid electric vehicle technology is currently suited to cars of all sizes, but can be expected to diffuse into light trucks also. Plug-in hybrid cars are just becoming available in Canada but have seen huge growth in Europe where they have been available for longer. Through the combined use of the battery and engine, the vehicles have a range the same as today's cars.

Hydrogen Fuel Cell Vehicles

Hydrogen fuel cell vehicles use a fuel cell to convert hydrogen into electricity, which then drives an electric motor. Unlike an electric vehicle or plug-in hybrid electric vehicle, the car does not have a battery; the hydrogen itself is stored in the car and converted into electricity when it's needed. The first commercially available fuel cell vehicles are starting to become enter the market, particularly in California, although they are not yet widely available in Canada. Hydrogen fuel-cell technology is well suited to medium-to-large cars and light-duty trucks. Since hydrogen is a gas it must be compressed and stored in a high-pressure tank. This means the car's fuel system is a little more complex, but results in a range and refueling time similar to today's cars.

Increase Commercial Vehicle Technology Options

Commercial vehicles cover a large range of vehicle types from light trucks to buses, garbage haulers to large articulated trucks. For each particular vehicle type the technologies listed below could be used, although the larger the vehicle the less suited to complete electrification it is likely to be.

Biofuel Powered Commercial Vehicles

Biofuels are liquid fuels that can be used in combustion engines much like those in cars and trucks of today and can replace gasoline and diesel. Currently most biofuels are typically blended with regular diesel and gasoline since engines have not been optimized to use pure biofuels, although pure biofuels are being used more extensively as an unblended direct replacement for diesel in modern engines. Some biofuels are almost identical to diesel and can be used as a direct replacement today, although they are more expensive. Biofuels are suited to large vehicles like buses and trucks but can be used in any size engine. The amount of energy stored in biofuels is more than that of hydrogen and biomethane which means that biofuels are particularly good for long distance freight vehicles.

Civic Renewable Transport Fuel Quick Start: **Accelerate the integration of renewable fuels into the City of Vancouver fleet**

The City will accelerate the transition to alternative fuels such as higher biodiesel blends, biomethane, hybrids, hydrogen, and electric. The City of Vancouver fleet has about 1,800 vehicles and equipment, with a fuel blend of 5% biodiesel and 95% regular diesel as the majority fuel used by the fleet. Moving the City fleet to renewable fuels demonstrates clear leadership, and the viability of alternative fuels and supports broader market uptake.

Biomethane Powered Commercial Vehicles

Biomethane is methane produced by natural processes, is a high-grade energy source and can be used as a direct replacement for natural gas. Methane is the major component of natural gas and biomethane is the same chemical, except made from biological processes rather than natural gas. There has been a significant effort by engine manufacturers to develop compressed natural gas (CNG) and liquefied natural gas (LNG) engines for buses and trucks, aimed at replacing diesel. These technologies are starting to become more widely available and the same technology, if fuelled using biomethane, can rapidly transform commercial freight to be renewable. Like hydrogen, biomethane is a gas, and to store enough to give a vehicle a useful range requires the biomethane to be compressed or liquefied, which has a cost premium associated with both the process and the vehicle fuel system complexity.

Hydrogen Powered Commercial Vehicles

The technology needed to power commercial freight and other large vehicles with hydrogen is almost identical to that for personal vehicles; it is simply larger and more powerful. In many ways hydrogen is more favourable for larger vehicles since the more complex fuelling systems take up less relative space and can more easily be integrated into trucks or buses.

Electric and Hybrid Commercial Vehicles

Although unlikely to be suitable for long distances, electric powertrain technologies may develop to support urban commercial use. Overhead power cables, much like those used for trolley buses could be adapted for heavy commercial vehicles – particularly those on fixed route, like to and from the port. Improved battery and charging technologies may also allow vehicles like buses to charge rapidly at their depots or at the end of their routes, while operating only on the battery along the route. Hybrid heavy-duty vehicles that use a battery to get moving or help acceleration, then switch to a combustion engine for cruising are under development and are very well suited to stop-start applications like garbage and delivery trucks.

Increase Supply of Renewable Transportation Fuels

The "hierarchy of fuels" establishes the ease with which new renewable fuels can be adopted. For mobile uses liquid fuels are preferable since they are transported easily and more easily handled during refuelling. However, with improvements in battery and charging technology, electrification is becoming an option for more vehicles, although the ease with which electric power trains can be used decreases as vehicles get larger. Cars, commercial freight and local goods and service delivery dominate motorized transportation in Vancouver. The diagram below illustrates the range of transport fuel uses and their suitability to be electrified.

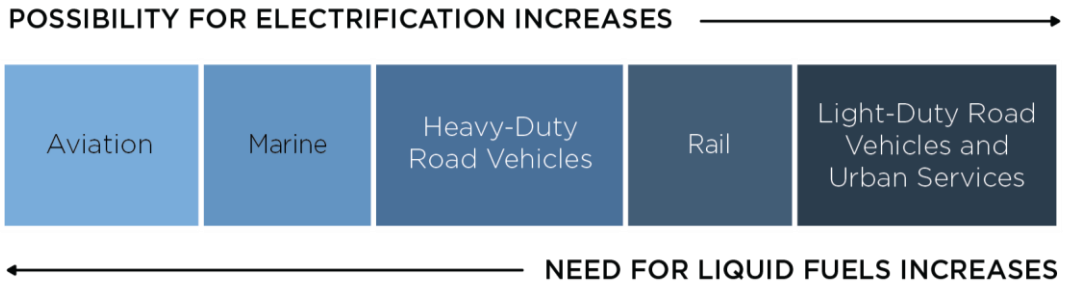


Figure 14 **– Suitability of Liquid Transportation Fuels and the Ability to Electrify Transportation**

Electricity Supply

Electricity generation in BC is legislated to be at least 93% clean and a move to 100% renewable electricity would secure its environmental benefits. Current and anticipated future electrical generating capacity in BC is able to meet the increased demand that electrification of the transport system would create; but ensuring that local electrical systems within the city are able to meet the needs of electrified transport is important. Even when that electrical capacity is supplied there will be a need to ensure that the vehicle-charging infrastructure is available for people to recharge their vehicles, particularly personal home and workplace charging.

Plug-in hybrid electric vehicles will mostly use only electricity when driving in the city, and electric vehicles will only use electricity. There is still a need to develop charging infrastructure to recharge the cars, and ensure that a network of fuelling stations exists for drivers to top up with biofuel when needed. This diversity leads to shared infrastructure needs and increased resilience so the vehicles are not tied to a single fuel source.

Biofuel Supply

Biofuels can be produced from a wide variety of feedstocks such as wood, grass, plants, and even algae, with the technologies to do so at various stages of development. There is the potential to develop significant biofuel production throughout the Pacific Northwest and central Canada. It is important to ensure that the feedstocks used to make the biofuels are grown responsibly, most preferably from what is currently considered the waste stream (*eg.* agricultural waste). The supply of biofuel feedstocks, typically canola in Western Canada, is more than sufficient to meet near-term local requirements since much of the current production is exported. The diversity of feedstocks and agricultural methods that can be used to produce biofuels limits any potential impacts to food supplies and pricing, since with the right regulation biofuel production should not compete with food production. Some relatively easy changes to the fuel supply and distribution network in the region would allow for higher amounts of renewable fuels to be blended into traditional transportation fuels, while setting the stage for a more complete long-term shift to biofuels.

Biomethane Supply

Technology such as anaerobic digestion produces biomethane from food scraps and the material left over from that process is used in the production of compost and fertilizer. Biomethane is currently in limited supply in BC since there are few sites producing it. However, as the need to replace natural gas grows there is expected to be an increase in demand. This increase in demand, and therefore production, will likely be met by landfills (which produce methane as their waste decomposes), anaerobic digesters (which take organic waste like kitchen scraps and yard trimmings to make biomethane), and waste water/sewage treatment plants. As waste diversion programs take effect and better ways to use the waste stream are implemented, biomethane production from landfills is expected to decline while anaerobic digesters will increase production volumes. The technology to distribute biomethane already exists – it is today's natural gas network.

Underway Now: **Expand the beneficial use of biomethane produced by the Vancouver Landfill**

The City will work with industry and business partners to expand the beneficial use of biomethane produced by the Vancouver Landfill beyond the current levels. The Vancouver Landfill in Delta is undergoing significant infrastructure improvements to optimize the capture of landfill gas at the site. With this optimized system in place, the opportunity exists to put more of the biomethane in the landfill gas to beneficial use by introducing it to the natural gas system or using it to fuel biomethane powered vehicles.

Hydrogen Supply

Hydrogen is in plentiful supply since it is the major constituent of water. However, the majority of hydrogen used today comes from natural gas, but using renewable electricity to electrolyze water could produce clean hydrogen in the quantities needed. A move to increase hydrogen use will require new fuelling-station infrastructure, which would be similar to the gas stations of today.

Renewably Powered Transportation Priorities

T.1 Use land-use and zoning policies to develop complete compact communities and complete streets that encourage active transportation and transit

T.1.1 Foster land use as a tool to improve transportation consistent with the direction established in Transportation 2040.

Transportation 2040 established three core land use directions, all of which are integral to expanding walk, bike and transit journey, while reducing personal auto vehicle journeys. The directions are:

- Prioritize and encourage a dense and diverse mix of services, amenities, jobs, and housing types in areas well-served by frequent, high-capacity transit;
- Locate major trip generators near rapid transit stations or along transit corridors; and
- Design buildings to contribute to a public realm that feels interesting and safe.

T.1.2 Enhance and accelerate the development of complete streets and green infrastructure.

Complete streets are streets that meet the needs of multiple different users from pedestrians and cyclists, to car drivers and those delivering goods. A complete street allows for improved safety for all its users, improvements in public health, and increased economic activity. Green infrastructure incorporates urban forests and vegetation into the street scape as well as better managing rainwater, and providing flood control and pollution reduction. These complementary approaches to urban design serve to reduce reliance on cars and foster more renewable transportation choices.

T.1.3 Enhance the pedestrian network according to the direction established in Transportation 2040

Transportation 2040 establishes a comprehensive approach to improving Vancouver's pedestrian network. Almost all aspects of an enhanced pedestrian network will contribute to reducing our dependence on fossil fuel derived transport, but of most note are enhancements that make it easier and more comfortable for people to walk to their destination. Attractive green spaces and green corridors promote walking and are consistent with the city's goals for its urban forest. Improving the pedestrian network will include:

- Addressing gaps in the city's pedestrian network;
- Improving accessibility and safety for people of all ability levels;
- The provision of generous, unobstructed walking environments; and
- The creation of more pedestrian-priority streets and spaces.

T.1.4 Enhance cycling infrastructure and encourage more bike trips according to the direction set in Transportation 2040

Transportation 2040 has established a clear direction upon which the city's bike network will be enhanced and expanded to increase the number of people cycling. As with improvements to the pedestrian network, all enhancements to cycling infrastructure will positively impact the transition to renewable energy. The most significant changes to encourage enhanced bike use will focus on:

- Making it easier to combine cycling with other forms of transportation.
- Upgrading and expanding the cycling network with direct, low-stress routes that are safe for people of all ages and abilities; and.
- Providing secure, convenient, accessible, and abundant bike parking throughout the city, including at home, work, shopping areas, transit stations, and other busy destinations.

T.1.5 Use parking policies to support sustainable transportation choices and efficient use of our street network.

Parking is a major transportation and land use lever, shaping the way our communities look and feel and how people get around. In accordance with Transportation 2040, the City will continue to advance parking policies to:

- Support local businesses and reduce congestion by making it easier for customers, delivery drivers, and visitors to find available spaces;
- Improve neighbourhood livability and enable other street uses by better managing on-street parking and spillover, especially where use of the street is in high demand;
- Reduce parking demand and make it easier to drive less by encouraging or requiring demand-management strategies in new development;
- Increase housing affordability and choice by separating out parking costs so people only pay for what they need; and
- Design spaces to be safe, flexible, and adaptable for a resilient city that can accommodate changing needs over time.

T.1.6 Optimize the road network to manage congestion, improve safety, and prioritize green transportation.

Vancouver's road and parking infrastructure is at capacity, with no room to expand. *Transportation 2040* sets a direction that, through optimizing the road system and managing parking as a district resource, can reduce the energy used by the vehicles in the system. The effect of the expected growth in autonomous vehicles is unclear, with both positive and negative consequences on energy and road use anticipated. To improve the network efficiency the City will:

- Ensure that the road network is optimized to manage congestion impacts;
- Consider the impacts to all road users when reallocating road space;
- Continue to support transportation demand programs that empower employers, institutions and districts to reduce driving;
- Explore technologies to better manage on-street parking;
- Where appropriate, reallocate road space to support green transportation, more vibrant public spaces, and improved safety.

***T.2 Improve transit services as set out in* Transportation 2040**

T.2.1 Extend the Millennium Line in a tunnel under Broadway

Central Broadway is the largest employment centre in the entire province after downtown Vancouver, and home to the busiest bus route in North America. Overcrowded buses pass thousands of waiting passengers each day, despite buses running every two minutes during peak periods. Many more people choose not to take transit because it is overcrowded or not convenient enough. An underground Millennium Line extension to Arbutus Street is anticipated to carry over 160,000 passengers on opening day, roughly three times as many passengers as the 99 B-Line today, and equivalent to about 24 lanes of single occupancy vehicle motor traffic. Travel times between Commercial Drive and Arbutus Street would be reduced by more than 50%, providing significantly improved access to Broadway's jobs and services for residents throughout the region.

T.2.2 Improve frequency, reliability, and capacity across the transit network

A successful transit system has a range of services. Fast, frequent, reliable, high-capacity *rapid transit* is essential to attract new riders and meet mode-share targets. Encouraging more people to shift away from the private automobile requires transit that competes favourably with driving in terms of speed, convenience, comfort, and reliability. *Local transit* is also an important part of the service spectrum, particularly for people with mobility challenges who require stops close to their destination.

T.2.3 Develop a transit supportive public realm with improved multimodal integration and comfortable waiting areas

The City will work with Translink to provide comfortable waiting areas across the transit network, and to improve connections between services and across modes. Great transit complements walking and cycling, extending the range a person can travel and connecting walking- and biking-oriented neighbourhoods together. Improved transit access supports more affordable, equitable communities by providing better access to jobs and other destinations throughout the region, and by making it easier to live car-light or car-free.

T.2.4 Work with the transit authority and other partners to transition fossil fuel powered transit vehicles to renewable energy

Much of the transit network in Vancouver already runs on renewable electricity. For the portion of the network that is not currently renewably powered the City will work with all relevant partners to transition to the use of only renewable energy sources – the focus of which will be the displacement of diesel fuel.

T.3 Transition light-duty vehicles (cars and light trucks) to be predominantly electric, plug-in hybrid or sustainable biofuel powered

T.3.1. Develop vehicle and fuel standards to support renewably powered vehicles

Advocate for a low- and zero-emission vehicle standard: The Provincial Government has the authority to establish and implement low-emission and zero-emission vehicle standards. Both standards limit tailpipe emissions from vehicles to the point where emissions are either very low or zero. Alternative fuels such as biofuels, biomethane, hydrogen, and electricity are able to meet the exacting requirement of a low-emission standard, and are the only way to directly meet zero-emission standards. By enacting this type of regulation the Provincial Government ensures that the vehicle manufacturers make cleaner vehicles, and that they are available to buy in BC.

Advocate for continued strengthening the Renewable and Low Carbon Fuel Requirements Regulation: BC already has a renewable and low carbon fuel regulation that requires the carbon intensity of fuels to be 10% lower in 2020 than they were in 2008. This regulation is imperative to moving fuel suppliers to provide low carbon and renewable fuels like biofuels, biomethane, hydrogen and electricity. Supply side regulations – regulations that affect product suppliers - like this have been shown to be more effective in reducing emissions than those policies encouraging consumers to buy clean vehicles - demand side regulation - although both are needed. The Provincial low-carbon and renewable fuel regulation should be accelerated to rapidly reduce the carbon intensity of transportation fuels and support a move to wholly renewable fuels, while letting the markets decide which fuels best meet that need.

Advocate for increased commercial vehicle efficiency and transition to renewable fuels: The Federal Government needs to set higher performance standards for heavy-duty trucks. Heavy-duty truck engine efficiencies have improved more slowly than those for personal vehicles, and there are few signs that this pace will accelerate. That needs to change. Commercial vehicle lifetimes are long, so action must be taken now to begin the transition to renewable fuels. By changing to renewable fuel options commercial operators can be protected from fuel price increases and volatility in the long run, but ways must be found to overcome the initial additional expense of renewably fuelled vehicles. The steps required to support operators to make a more renewable fuel choice include:

- The Federal Government increasing engine efficiency requirements and supporting vehicle manufacturers to warranty engines for higher biofuel blends (beyond the current industry standard 20% biofuel limit);
- The provision of Provincial and Federal purchase incentives, for both fleet and individual operators; and
- Provincial niche market regulation – a regulatory approach that mandates a small, but growing, portion of total sales to be of new technologies – of heavy-duty vehicles.

Strengthening the requirements of the low carbon and renewable fuel regulation, will have a large impact on which technologies are adopted by the commercial sector. Biofuels and biomethane are most likely to be adopted in the short-to-medium term, with hydrogen coming to market later.

Advocate for the development of financial incentives to support the growth of renewably fuelled vehicles: The Provincial and Federal Governments must provide financial incentives for the purchases of renewably fuelled vehicles. The incentive structure could be a direct purchase incentive (as BC has a limited number of at present), tax break, tax rebate or similar. The initial purchase price of renewably fuelled vehicles is still higher than that for

a regular combustion engine vehicle and incentives are an effective way to support consumers to make the cleaner choice.

T.3.2 Develop supporting infrastructure that meets the needs of renewably powered vehicles

Support the expansion of renewable fuel infrastructure for personal vehicles: The diversity of renewable fuels used in the future requires new infrastructure, including enhancements to the electrical grid to supply battery electric and plug-in hybrid vehicles, as well as hydrogen fuelling stations for private and commercial vehicles. The existing natural gas and fossil fuel infrastructure can be repurposed to supply biomethane and biofuels. All these changes will require investment that must be harmonized across senior levels of government. The City is already supporting these developments where it can through *Transportation 2040*.

Enact regulation that supports the use of electricity as a transportation fuel: The Provincial Government needs to regulate electricity as a transportation fuel as well as for conventional stationary use. Electricity has not traditionally been a transportation fuel, it has been the preserve of stationary power needs. Because of this the regulation of electrical utilities and its consumers – building occupants – means that the transition to adopting electric vehicles has been hindered. Specifically, the City will urge the Provincial Government to:

- Amend the Strata Property Act to support renewably powered vehicles;
- Deregulate the sale of electricity for use as a transportation fuel;
- Introduce electrical rate tariff changes such as allowing time-of-use charging that encourages the use; and of electricity for transport and to better manage the electrical grid.

Support the expansion of renewable fuel infrastructure for commercial vehicles: As with personal vehicle fuelling infrastructure, there is a need and opportunity to increase the amount of renewable fuel infrastructure that can meet the diverse needs of the future commercial fleet. The focus of the expansion should be to:

- Explore options for increasing the use of existing alternative fueling infrastructure, particularly biofuels, biomethane and electricity; and
- Investigate options for, and the potential impacts of, developing centralized alternative fueling infrastructure in industrial areas.

Maximize the beneficial use of compostable materials: Food scraps and yard waste can form the mainstay of biomethane production. The Provincial Government has in place the BC Bioenergy Strategy, and the City wishes to see its implementation accelerated and the strategy enhanced to consider the highest and best use of food scraps. The City will review new opportunities and support the expanded use of biomethane from solid waste materials.

Use City authority over local waste management to support the use and development of renewable energy: The City will undertake a policy review to see how, under its existing authority, it can enhance the role it plays with its partners in the waste management and recovery system to support the expansion of renewable energy. The City will also continue to work with partners and other levels of government to increase the effectiveness, scope and scale of extended producer responsibility programs.

T.4 Develop car-sharing and regional mobility pricing to encourage rational journey choice

T.4.1 Support increased car-sharing and the uptake of renewably powered vehicles in car-sharing fleets.

Increasing the extent to which car-sharing services are available improves the efficiency with which roads and parking space are used, supports the emergent circular economy, has immediate environmental benefits and can help catalyze a transformation in vehicle technologies.

- Expand car-sharing services in Vancouver
- Work with car-share operators to increase the use of renewably powered vehicles in their fleets

T.4.2 Advocate for comprehensive regional mobility pricing

Pricing the transportation system to reflect the service it provides is a fundamental way to optimize performance, while encouraging sustainable choices and rational travel behaviour. Mobility pricing should:

- Support regional road or congestion pricing to encourage journey choice that accurately reflects true journey cost, better fund sustainable transport options like walking, biking and transit, and support clean vehicles where motor vehicles journey cannot be avoided; and
- Support vehicle insurance rates that reward drivers for driving less or driving a renewably powered vehicle.

T.5 Better manage commercial vehicle journeys and transition heavy-duty (commercial) vehicles to sustainable biofuels, biomethane, hydrogen and electricity

T.5.1 Improve the delivery of commercial freight, goods and services according the direction set in Transportation 2040

Support efficient goods and services movement and delivery while minimizing environmental and community impacts: *Transportation 2040* includes policies addressing a wide range of goods and services movement and delivery, for local to regional and beyond. At the local scale, the City can encourage low-impact and appropriately sized vehicles, provide for efficient deliveries and pickups, maintain an efficient truck network, and support local production and distribution to reduce the need for large-scale transport. For larger-scale movements, the City can support improved rail capacity and reliability, and Port Metro Vancouver efforts to improve environmental performance and efficiency.

Enhance local goods and service movement logistics: The goods and services transportation system will be optimized through improved logistics. This will reduce vehicle journeys, maximize vehicle utility, and minimize the extent to which loads are transferred from one vehicle to another. Efficient loading and unloading areas are an integral part of a well-functioning system in which local production and distribution reduce the need for large-scale transportation.

T.5.2 Work with fleet operators and contractors to transition to renewably powered vehicles

Engage commercial vehicle fleets to transition to renewably powered vehicles: Fleets provide an opportunity to change a large number of vehicles through shifting the thinking of just one person or business. Fleets are also very cost conscious and eager to avoid the price and volatility increases expected of gasoline and diesel. Fleet partnerships will be established to:

- Utilize local expertise to develop driver training programs for fleet managers;
- Identify technologies with the lowest uptake barriers and promote the types of fleets for which they are most effective;
- Undertake targeted outreach to educate fleet owners and managers on the potential impact and cost savings associated with renewable and smart fleet technologies; and
- Promote uptake of existing tools, such as alternative fuel apps and websites.

Partner with Port Metro Vancouver to accelerate the transition to renewably fuelled freight transport: The City will support Port Metro Vancouver in advancing port-related emissions reductions through increased energy efficiency and the expanded use of renewable energy. Port Metro Vancouver works in collaboration with industry and various government agencies and organizations to advance emissions reductions and the sustainability of the port. Vancouver will support Port Metro Vancouver in advancing emissions reduction initiatives across port operations, including, for example, increasing use of shore power (cold-ironing) for ocean-going vessels, exploring short-sea shipping opportunities, and increasing the use of clean technologies and renewable energy in trucking, rail, and cargo-handling activities. The City will also continue to support Port Metro Vancouver in advancing port sustainability and preparation for the anticipated future outlined in the Port 2050 scenario planning process, in particular the “Great Transition” scenario, which entails a rapid transition toward a low-carbon future.

Encourage movement of goods by renewably powered rail when goods must be shipped over longer distances: Rail is the most efficient method, and has the least environmental impact, when goods and people must be transported for long over-land distances. The rail system also provides the largest potential for a rapid move to renewable energy since there are only a few operators and a significant amount of infrastructure already in place that could be leveraged to speed the transition. *Transportation 2040* lays out a number of strategies to increase both freight and passenger rail service levels in Vancouver, including:

- The development and implementation of long-term rail corridor strategies; and
- Advocating for improvements to the regional rail network to address major bottlenecks.

The City will work with the Provincial Government and Metro Vancouver to require non-road engines/equipment to operate on renewable energy: The technology already exists to enable non-road engines, such as those found in construction and landscaping equipment, to operate on renewable energy. Non-road equipment powered by biofuels or electricity are starting to come to market, and through tighter regulation of greenhouse gases and air pollutants it is possible to accelerate the move towards these technologies. Regulatory approaches to increase the use and supply of electricity to construction sites will also be investigated.

A Vision of Vancouver's Renewably Powered Transportation System in 2050

Modelling the transportation demand and the ways in which it may be met through viable technological changes allows the development of a feasible vision for city's transportation energy use in 2050. Below is shown how the strategic approach of reducing demand, increasing renewable energy use and increasing renewable energy supply can meet Vancouver's transportation energy needs in 2050.

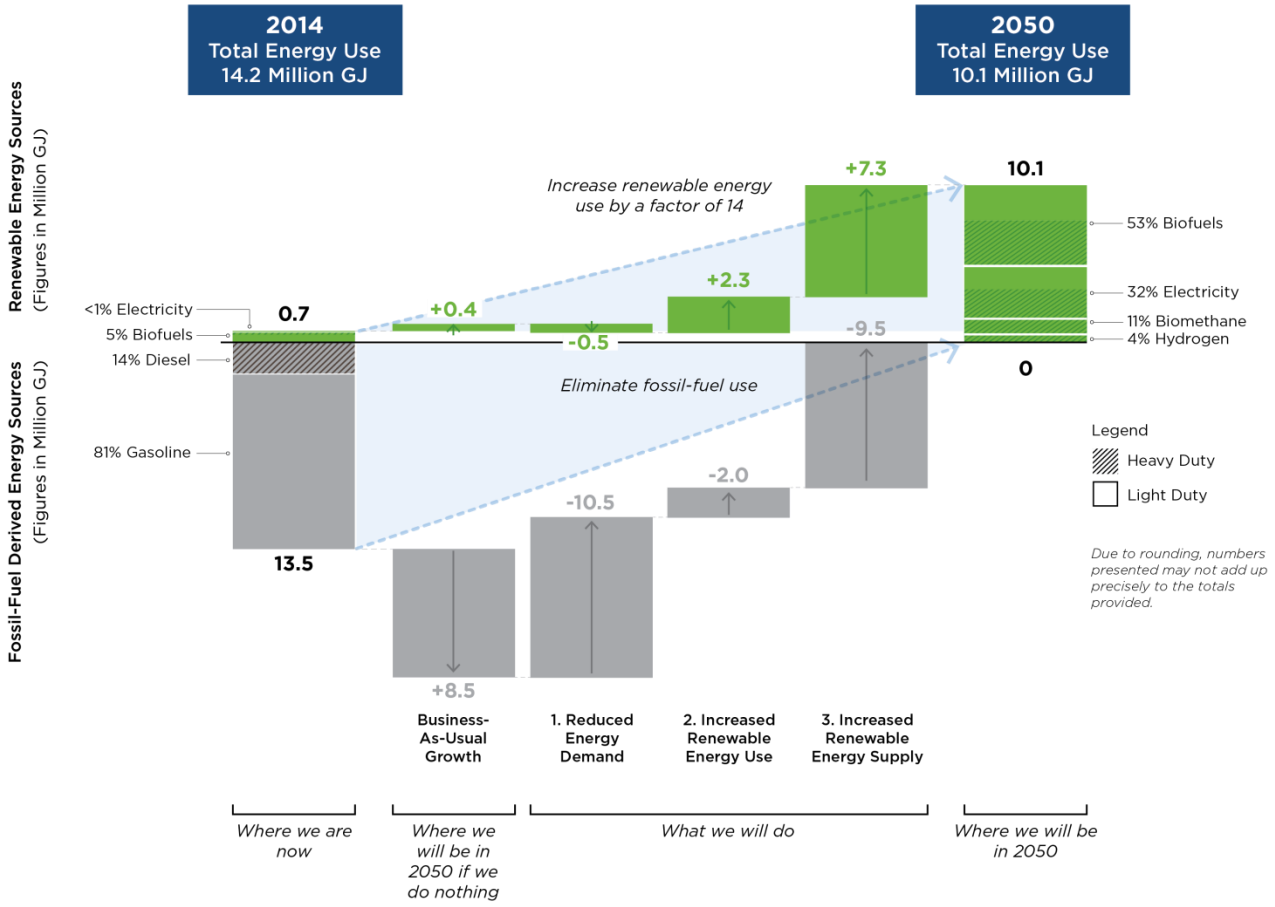


Figure 15 **– Transportation Energy Use Transformation 2014-2050**

The current passenger vehicle sector is dominated by gasoline use. With anticipated population increases the number of vehicles in the city is expected to grow by about 15%. Vehicle growth is expected to be below long-term historic growth because of improvements made to the city's walking, biking and transit infrastructure (this trend is already starting to be observed). Analysis has shown that these same measures could reduce annual vehicle kilometers travelled per car by about 20% and per person by about 40%, while at the same time reducing cars per person by about 15%. Since Vancouver is such a compact city, with short commutes, it is well suited to the use of electric vehicles and plug-in hybrid vehicles. When driving around the city the vehicles will have been charged using renewable electricity. Plug-in hybrids powered by biofuels will still allow people to make longer journeys, and use their vehicles much as they do today; but when, driving around the city will predominantly use electric propulsion. Electric vehicles and plug-in hybrid vehicles, will not suit everyone's vehicle needs, so conventional hybrid cars like today's will still be used, but be powered by biofuels. The proportion of each type of vehicle, including any conventionally fuelled vehicles that remain in 2050 will be driven by the structure of Provincial fuel and vehicle regulations and economics, as well as the extent to which home and workplace charging are developed for electric vehicles and plug-in hybrid vehicles, although by 2050 45% of vehicles could be plug-in hybrids (with biofuel combustion) and 25% fully electric with the remainder being conventional hybrids using biofuels.

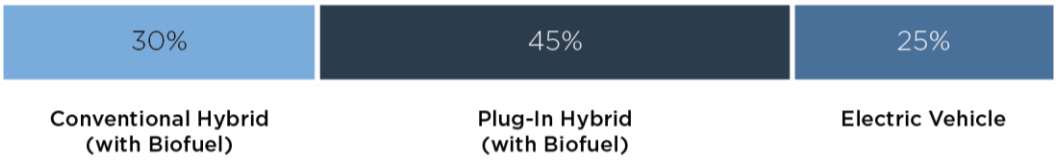


Figure 16 **– Passenger Vehicle Count by Vehicle Type 2014 and 2050**

Given Vancouver's short commutes the electrical demand required by electric vehicles and plug-in hybrid electric vehicles should not be difficult to meet; the challenge is the timing of that demand. People are likely to plug in when they get to work and then again when they get home, which also coincides with current peak demand as people prepare dinner and switch on their TV or computer, plug in their phone, and so on. There will have to be extensive load management of the electrical grid to control charging at these peak times, further demonstrating the need for the electrical grid to become "smart". There will also be a role to play for hydrogen in the personal vehicle market, although it is expected to be small.

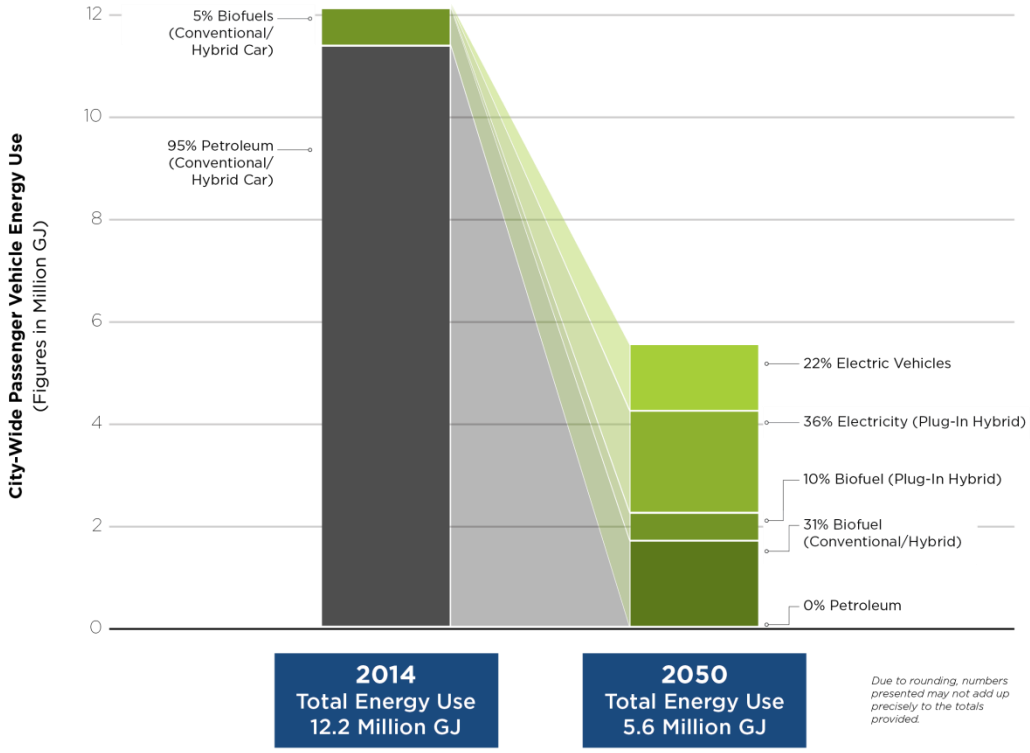


Figure 17 **– Passenger Vehicle Energy Use by Fuel Source 2014 and 2050**

The energy use by the light-to-medium commercial transport sector is driven not so much by the number of vehicles, but by the distance they travel. For heavy freight it is both the distance travelled and the weight transported by the large vehicle fleet that matters. For smaller commercial vehicles there is likely to be significant electrification with the remainder powered by biofuels or hydrogen, where the split will be determined by fuel cost economics. The use of electricity within Vancouver's transportation system will remain high because of the city's existing trolley bus system. What is less clear is the transformation to be expected in large commercial vehicles. The technology that comes to dominate will almost wholly be determined by the vehicle market's response to Provincial fuel regulations and the infrastructure that those regulations catalyze. Currently, trends in technology suggests about a one-fifth market share for hydrogen and four-fifths for biofuels and biomethane, although these proportions are very sensitive to fuel supply and purchase economics. Similarly, fuel economics are expected to significantly influence the portion of the transit system that is not electrified, but it is currently

unclear whether biofuels, biomethane or hydrogen will dominate, or whether they may share equal portions. Economic growth is still expected to lead to an increase in commercial vehicle trips, which results in commercial vehicle travel staring to dominate the energy used by the transportation sector as a whole in 2050. Switching to renewable fuels will dominate changes in the commercial freight sector since, compared to personal trips, the City has less influence over how commercial trips are made. The predominance of fuel switching over trip reduction in their sector is amplified since commercial vehicles also tend to be larger and use more energy per vehicle kilometre travelled. In aggregate the trends that reduce personal transport use, but increase commercial transport need, significantly increase the importance of renewable energy for the commercial sector in overall city-wide transportation energy use.

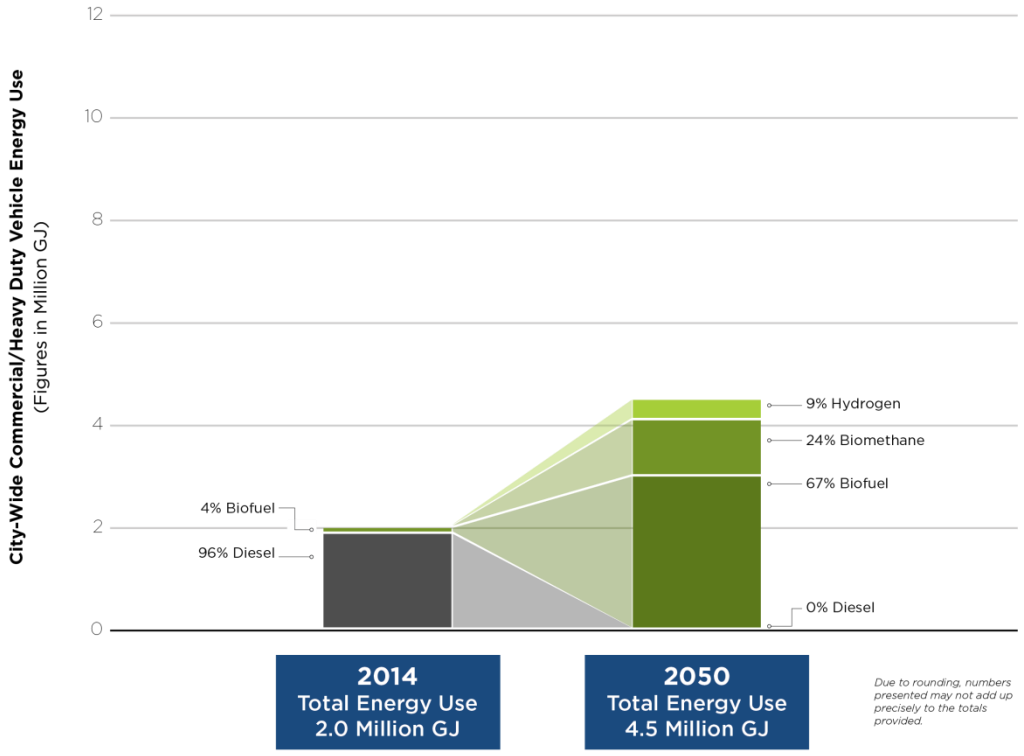


Figure 18 **– Commercial Vehicle Energy Use by Fuel Source 2014 and 2050**

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Renewable City Action Team, Delegates and Support Staff *

Gregor Robertson *(Co-Chair)*, Mayor, *City of Vancouver*
David Boyd *(Co-Chair)*, Adjunct Professor School of Resource and Environmental Management, *Simon Fraser University*
Alex Lau, Vice President, *Golden Properties Ltd.*
Allan Neilson, General Manager Policy Planning and Environment, *Metro Vancouver*
Brent Gilmour, Executive Director, *Quality Urban Energy Systems of Tomorrow (QUEST)*
Cara Pike, Executive Director, *Climate Access*
David Porte, Chair, *Urban Development Institute*
Ian MacKay, CEO, *Vancouver Economic Commission*
James Tansey, Executive Director Centre of Social Innovation and Impact Investing, *University of British Columbia*
Joanna Sofield, General Manager PowerSmart, *BC Hydro*
Marc Lee, Senior Economist, *Canadian Centre for Policy Alternatives*
Mark Jaccard, Director School of Resource and Environmental Management, *Simon Fraser University*
Merran Smith, Executive Director, *Clean Energy Canada*
Peter Robinson, CEO, *David Suzuki Foundation*
Ross Beaty, Executive Chairman, *Alterra Power Corporation*
Susanna Laaksonen-Craig, Head Climate Action Secretariat, *Government of BC*
Tom Pedersen, Executive Director, *Pacific Institute of Climate Solutions*
TransLink, *Transportation Planning and Policy*
Wal Van Lierop, President and CEO, *Chrysalix Venture Capital*

Delegates and Advisory to RCAT Members

Jeremy Mourhouse, *Clean Energy Canada*
Jim Nelson, BC Hydro
Robyn Wark, BC Hydro
Ben Finkelsteain, Climate Action Secretariat, *Government of BC*

* Representation on the *Renewable City Action Team* does not explicitly or implicitly represent endorsement of the *Renewable City Strategy* by the individual or organization presented.

Strategic Development

Conor Reynolds - Metro Vancouver
Derek Jennejohn - Metro Vancouver
Marcel Pitre - Metro Vancouver
Raymond Kan - Metro Vancouver
Ronan Chester - Port Metro Vancouver
Dom Repta - TransLink
Fearghal King - TransLink
Jacob Fox - TransLink
Bryan Buggey - Vancouver Economic Commission
John McPherson - Vancouver Economic Commission
Juvarya Veltkamp - Vancouver Economic Commission
Alec Tsang - BC Hydro
Alex Tu – BC Hydro
Kunle Adeleye – BC Hydro
Tina Lau – BC Hydro
Dina Matterson - BC Hydro
Kristin Hanlon - BC Hydro
Maria Furberg - BC Hydro
Randy Reimann - BC Hydro
Sanjaya De Zoysa - BC Hydro
Jorge Marques – BC Hydro
Brian Moghadam - Powerex

Technical Advisory

Andreas Truckenbrodt - Canadian Hydrogen Fuel Cell Association
Craig Louie - SysEne Consulting
Doug Hooper - Canadian Western Biofuels Association
Fred Ghatala - Canadian Western Biofuels Association
Ian Thomson - Canadian Western Biofuels Association
Ian Baillie - CanWEA
Ruben Arellano - Geoexchange BC
David Cookson - Geoexchange BC

Community Energy Advisory

Ali Grovue - BC Sustainable Energy Association
Thomas Hackney - BC Sustainable Energy Association
Dale Littlejohn - Community Energy Association

Microconference Attendees

Michael Pullinger - BC Sustainable Energy Association
Lauren Archibald - Bullfrog Power
Emilie Adin - City of North Vancouver
Patricia Bell - Community Energy Association
Andrew Grant - Conversations for Responsible Development (CRED)
Michael Rodgers - Cooperative Housing Federation of BC
Arnold Sang - Co-operative Housing Federation of British Columbia
Charlotte Argue - Fraser Basin Council
Bob Purdy - Fraser Basin Council
Byron Smith - Greenhouse PhotoGraphix Inc.
Nicole Ford - HUB Cycling
Laura Jane - HUB Cycling
Eoghan Hayes - Ions Engineering Ltd
Bryn Davidson - Lanefab Design/Build
Morgan McDonald - Ledcor
Chris Bruntlett - Modacity
Christopher Hakes - Offsetters Climate Solutions
Gord Kukec - BC Sustainable Energy Association
Eesmyal Santos - Recollective
Ruth Briggs - SPEC
Rola Nasreddine - SPEC
Suzanne Fairley - Vancouver Electric Vehicle Association
Amanda Ross - Wensley Architecture

City of Vancouver Staff Developers and Advisors

Sustainability Group

Malcolm Shield – Climate Policy Manager

Sean Pander - Green Buildings Program Manager

Lloyd Lee - Monitoring and Reporting Planner

Ian Neville – Climate Policy Analyst

Doug Smith - Assistant Director

Amanda Pitre-Hayes - Director

Lisa Brideau - Sustainability Specialist

Transportation

Steve Brown - Manager, Traffic and Data Management

Paul Krueger - Senior Planner, Transportation Plan

Eric Mital – Manager, Neighbourhood Parking and Transportation

Neal Peacock - Senior Engineer, Strategic Transportation Planning Branch

Paul Storer – Manager, Transportation 2040 Plan Team

Dale Bracewell - Manager, Active Transportation

Mike Zipf - Senior Active Transportation Engineering Assistant

Neighbourhood Energy Utility Branch

Chris Baber - Utility Manager

Kieran McConnell - Systems Engineer

Waste Management and Resource Recovery Division

Chris Underwood - Manager, Solid Waste Strategy

Brian Beck - Strategic Projects Engineer

Monica Kosmak - Project Manager - Multi Material BC

Don Darrach - Landfill Gas Technician

Planning

Anita Molaro - Assistant Director - Urban Design

Sailen Black - Senior Development Planner

Michelle McGuire - Senior Planner – Vancouver-South

Financial Planning and Analysis

Grace Cheng - Senior Manager, Long-term Financial Planning

Rob Evans – Senior Financial Analyst

Sean Martinez - Senior Financial Analyst

Law

Kelly Oehlschlager - Assistant Director - Construction, Procurement and Technology

Supply Chain Management

Rachael Carroll - Category Manager

Community Services

Keltie Craig – Senior Social Planner

Facilities and Real Estate Management

Danica Djurkovic - Director of Facilities Planning and Development

Craig Edwards - Manager, Energy and Utilities

Permits and Licensing

Sarah Hicks - Deputy Chief Licence Inspector/Licence Office Manager

Equipment Services

Amy Sidwell – Equipment Management Engineer

GLOSSARY

Renewable energy is energy that is naturally replenished as it is used

Term	Definition
Anaerobic digestion	A collection of processes by 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 to produce fuels.
Biofuel	A fuel (as wood or ethanol) composed of or produced from biological raw materials
Biomethane	A mixture of methane and carbon dioxide produced by bacterial degradation of organic matter and used as a fuel.
Cleantech	Clean Technology is a diverse range of products, services, and processes that harness renewable materials and energy sources, dramatically reduce the use of natural resources, and cut or eliminate emissions and wastes.
Climate resilience	The capacity for a city, organization or other system absorb stresses and maintain function in the face of external stresses imposed upon it by climate change and to adapt, reorganize, and evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared for future climate change impacts.
CO_2	Carbon dioxide, the primary greenhouse gas in the Earth's atmosphere.
CO_2e	Carbon dioxide equivalent: a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of CO2 that would have the same global warming potential (GWP), when measured over a specified timescale (generally, 100 years). For example, methane (CH4) has a global warming potential that is 25 times greater than carbon dioxide, giving 1 tonne CH4 = 25 t CO2e.
Electric vehicle	A generic term that usually includes any vehicle that plugs into an external electrical source, including both Battery Electric Vehicles that use only electricity; and, Plug-In Hybrid Electric Vehicles, that primarily use a battery but have an on-board gasoline engine to extend range. 'EV' does not usually refer to more traditional 'hybrid' vehicles that do not obtain electric power from an external source.
Electrolysis	Chemical decomposition produced by passing an electric current through a liquid or solution containing ions
Embedded carbon/ Embedded 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 source. This may be calculated from cradle to (factory) gate, cradle to (installation) site, or (ideally) from cradle to grave.
Embedded energy	Embedded energy - also known as embodied energy - is the sum of all the energy required to produce any goods or services, considered as if that energy was incorporated or 'embodied' in the product itself. It is an accounting method that can be useful in determining the effectiveness of energy-producing or energy-saving devices, or the "real" replacement cost of a building. One fundamental purpose for measuring this quantity is to compare the amount of energy produced or saved by the product in question to the amount of energy consumed in producing it.
Feedstock	A raw material that supplies or fuels an industrial process or a machine.

Term	Definition
Fuel cell	An electrochemical cell in which the energy of a reaction between a fuel, such as liquid hydrogen, and an oxidant, such as liquid oxygen, is converted directly and continuously into electrical energy. Fuel cells are different from batteries in that they require a continuous source of fuel and oxygen or air to sustain the chemical reaction. Fuel cells can produce electricity continuously for as long as these inputs are supplied.
Fuel switch	The substitution of one fuel for another. In the context of greenhouse gas emissions, fuel switching implies the switch from a high carbon fuel to a low carbon fuel.
Gasification	Gasification is a chemical process whereby a carbon source such as coal, natural gas or biomass, is broken down into carbon monoxide (CO) and hydrogen (H_2), plus carbon dioxide (CO_2) and possibly hydrocarbon molecules such as methane (CH_4).
Geothermal/ geoexchange	Energy systems that obtain heat from the earth and/or use the ground for cooling.
Greenhouse gas	A gas that contributes to the greenhouse effect by absorbing infrared radiation, such as carbon dioxide or methane
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").
Hydrogen	A chemical element that can be burnt or used in fuel cells and which doesn't release any greenhouse gases. Hydrogen can be made from natural gas (when it is not considered renewable) or through the electrolysis of water, which if using clean electricity is renewable.
Hydrogen fuel cell vehicle	A vehicle that uses hydrogen to produce an electric current, with the only by-product being water. Often seen as an alternative to EVs, HFCVs can be fuelled similarly to traditional internal combustion engine vehicles.
Large hydro	Hydroelectric power stations that generate more than 10MW of electricity.
LED	A light-emitting diode (LED) is a semiconductor device that emits visible light when an electric current passes through it. Modern LEDs can emit a variety of colours, and have the advantage of a very long life and low power requirements.
Major roads network	Also known as arterial roads, are major through roads expected to carry the largest volumes of traffic.
Neighbourhood Renewable Energy System	Neighbourhood renewable energy systems are local energy networks that have 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	The term passive house (Passivhaus in German) refers to a rigorous design philosophy that allows ultra-low energy use.
Plug load	The energy used by products that are powered by means of an ordinary outlet. This term excludes building energy that is attributed to major end uses (HVAC, lighting, water heating, etc.)
Photovoltaic	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

Term	Definition
Residuals	Residuals are waste materials that remain after reusable, recyclable and compostable materials have been removed from a waste stream.
Sewer heat	Wastewater, which consists of what gets flushed down toilets but is 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—typically about 60°F (15.6° C), though this varies by geography and season.
Small hydro	Hydroelectric plants that capture energy in flowing water, including run-of-river projects. Small hydro are considered to be projects that generate between 2MW and 10MW of power.
Solar thermal / solar heat	Heat radiation from the sun collected by heat- absorbing panels through which water iscirculated: used for domestic hot water, central heating, and h eating swimming pools
Solar power	The use of the sun's energy to generate electricity through solar photovoltaic systems.
Southeast False Creek Neighbourhood Energy Utility	The Neighbourhood Energy Utility (NEU) is a self-funded facility that uses waste thermal energy captured from sewage to provide space heating and hot water to new buildings in Southeast False Creek (SEFC). This captured energy eliminates more than 60% of the global warming pollution associated with heating buildings.
Split incentive	It is often the case that a building developer is not the building owner or occupant. There is therefore little incentive for a developer to pay higher up-front costs to reduce operating costs – the incentive for a better performing building is split between the developer and the owner/occupant.
tCO_2e	Metric tonnes (equal to 1,000kg) of carbon dioxide equivalent

QUICK REFERENCE :: Priorities, Actions Underway and Quick Starts

Zero-Emissions Building Priorities

B.1 New buildings to be zero-emission by 2030

- B.1.1 Adopt and demonstrate zero-emission standards in new City of Vancouver building construction
- B.1.2 Ensure rezoning policy leads the transition to zero-emission buildings
- B.1.3 Incentivize and streamline the development of exemplary buildings
- B.1.4 Establish and enforce specific greenhouse gas intensity limits for new developments
- B.1.5 Develop innovative financing tools to help fund new zero-emission buildings
- B.1.6 Establish partnerships to build industry capacity
- B.1.7 Mandate building energy benchmarking and labelling requirements

B.2 Retrofit existing buildings to perform like new construction

- B.2.1 Use the Zero-emission New Building Strategy to reduce the need for building retrofits
- B.2.2 Mandate energy efficiency improvements for existing buildings
- B.2.3 Provide flexibility to achieve energy efficiency requirements through the support of on-site generation or neighbourhood energy system connection
- B.2.4 Facilitate modest retrofits through structured guidance and the provision of incentives
- B.2.5 Increase renewable energy use by large energy consumers

B.3 Expand existing and develop new Neighbourhood Renewable Energy Systems

- B.3.1 Expand existing Neighbourhood Renewable Energy Systems
- B.3.2 Enable the conversion of the downtown and hospital steam systems from natural gas to renewable energy
- B.3.3 Enable the development of new neighbourhood renewable energy systems for downtown and the Cambie corridor
- B.3.4 Continue to enforce, and update as required, building and renewable energy supply policies that support neighbourhood renewable energy systems

B.4 Ensure grid supplied electricity is 100% renewable

- B.4.1 Partner with utilities to increase the supply of renewable energy
- B.4.2 Partner with utilities to implement a smart grid

Zero-Emission Building Quick Starts

Civic Passive House Quick Start: The City will support a Passive House or ultra-low thermal demand design philosophy for City buildings

Retrofit Incentive Program Quick Start: The City will develop and implement a home retrofit incentive program

Civic Renewable Generation Quick Start: The City will support new renewable energy technologies for City buildings

Solar Quick Start: The City will streamline the process for the installation of rooftop solar systems

Renewably Powered Transportation Priorities

T.1 Use land-use and zoning policies to develop complete compact communities and complete streets that encourage active transportation and transit

T.1.1 Foster land-use as a tool to improve transportation consistent with the direction established in *Transportation 2040*
T.1.2 Enhance and accelerate the development of complete streets and green infrastructure
T.1.3 Enhance the pedestrian network according to the direction established in *Transportation 2040*
T.1.4 Enhance cycling infrastructure and encourage more bike trips according to the direction set in *Transportation 2040*
T.1.5 Use parking policies to support sustainable transportation choices and efficient use of our street network
T.1.6 Optimize the road network to manage congestion, improve safety, and prioritize green transportation

T.2 Improve transit services as set out in *Transportation 2040*

T.2.1 Extend the Millennium Line in a tunnel under Broadway
T.2.2 Improve frequency, reliability, and capacity across the transit network
T.2.3 Develop a transit supportive public realm with improved multimodal integration and comfortable waiting areas
T.2.4 Work with the transit authority and other partners to transition fossil fuel powered transit vehicles to renewable energy

T.3 Transition light-duty vehicles (cars and light trucks) to be predominantly electric, plug-in hybrid or sustainable biofuel powered

T.3.1 Develop vehicle and fuel standards to support renewably powered vehicles
T.3.2 Develop supporting infrastructure that meets the needs of renewably powered vehicles

T.4 Develop car-sharing and regional mobility pricing to encourage rational journey choice

T.4.1 Support increased car-sharing and the uptake of renewably powered vehicles in car-sharing fleets.
T.4.2 Advocate for comprehensive regional mobility pricing

T.5 Better manage commercial vehicle journeys and transition heavy-duty (commercial) vehicles to sustainable biofuels, biomethane, hydrogen and electricity

T.5.1 Improve the delivery of commercial freight, goods, and services according the direction set in *Transportation 2040*
T.5.2 Work with fleet operators and contractors to transition to renewably powered vehicles

Transportation Quick Starts and Actions Underway

Preferential Parking Quick Start: Support the uptake of renewably powered vehicles through preferential parking provision

Civic Renewable Transport Fuel Quick Start: Accelerate the integration of renewable fuels into the City of Vancouver fleet

Underway Now: Replace the Georgia and Dunsmuir viaducts for better at grade services and public space

Underway Now: Implement a public bike-share system

Underway Now: Improve the False Creek bridges to support active transport

Underway Now: Develop and implement an electric vehicle infrastructure strategy to accelerate electric vehicle uptake

Underway Now: Expand the beneficial use of biomethane produced by the Vancouver Landfill

City Services Renewable Energy Priorities

S.1 The City will adopt a comprehensive approach to the consideration of climate change as part of its service planning

S.2 The City will adopt a comprehensive approach to pricing carbon emissions for municipal operations

S.3 The City will develop a framework to assess how City enabling tools may be used to support the transition to 100% renewable energy

S.4 The City commits to keep abreast of financing mechanisms available that enable the delivery of renewable energy technology and other green infrastructure

City Service Quick Starts

Licensing Powers Quick Start: The City of Vancouver will investigate how best to use its licensing and permitting powers to accelerate the adoption of renewable energy

Purchasing Power Quick Start: The City of Vancouver will investigate how best to use its purchasing power to accelerate the adoption of renewable energy

Economic Opportunity Priorities

E.1 Support innovators through business and technology research, incubation, acceleration, and demonstration.

E.2 Actively work with businesses to increase the use of renewable energy

E.3 Target key events and organizations that represent cleantech and renewable energy to strengthen Vancouver's economy

E.4 Attract 'green capital' and enable more innovative financing mechanisms for clean and renewable businesses

Economic Opportunity Quick Starts

Underway Now: Expand and accelerate the Green and Digital Demonstration Program

Business Emissions Quick Start: Use the Vancouver Business Energy and Emissions Profile to develop a targeted business energy use reduction and fuel switching strategy