CLIMATE **2050 Roadmap**

Energy

A pathway to clean, renewable, and resilient energy in Metro Vancouver

April 2023

FRONT COVER: PANORAMIC NIGHT VIEW IN METRO VANCOUVER

Metrotower III,
4515 Central Boulevard,
Burnaby, BC, V5H 0C6
www.metrovancouver.org

March 2023

Metro Vancouver acknowledges that the region's residents live, work, and learn on the shared territories of many Indigenous peoples, including 10 local First Nations: qícəy̓ (Katzie), qʷɑ:ńƛəń (Kwantlen), kʷikʷəƛəm (Kwikwetlem), máthxwi (Matsqui), xʷməθkʷəy̓əm (Musqueam), qiqéyt (Qayqayt), se'mya'me (Semiahmoo), Sḵwx̱wú7mesh Úxwumixw (Squamish), scəẃaθən məsteyəxʷ (Tsawwassen), and sə́lílwətaʔɬ (Tsleil-Waututh).

Metro Vancouver respects the diverse and distinct histories, languages, and cultures of First Nations, Métis, and Inuit, which collectively enrich our lives and the region.

The goals and targets at the heart of Metro Vancouver's climate-related plans are based on the best available information. Reaching them is a top priority for the organization and the region. We must take bold action now to become a carbon neutral region by 2050, while recognizing that changes to our climate are already occurring, and that climate resilience must be a central consideration for the development of the region. The *Climate 2050 Energy Roadmap* was developed between 2020-2022 and introduced for stakeholder comment during the COVID-19 pandemic. Across the globe, the pandemic response has provided a glimpse of what is possible and what we can achieve with coordinated efforts and common goals in a time of crisis.

The actions in this Roadmap reflect both current policies and new directions that reflect the best ideas, approaches, and available technologies. As with all good planning, this Roadmap must be viewed as an iterative, dynamic path forward. The goals will remain clear but the Roadmap will be updated as new policies, ideas, approaches, and technologies emerge.

Metro Vancouver

Metro Vancouver is a federation of 21 municipalities, one electoral area, and one treaty First Nation that collaboratively plans for and delivers regional-scale services. Metro Vancouver's core utility services include drinking water, sewage treatment, and solid waste management, along with regional services like regional parks, affordable housing, regional land use planning, and air quality and climate action that help keep the region one of the most livable in the world.

Mission

Metro Vancouver's mission is framed around three broad roles:

1. Serve as a Regional Federation

Serve as the main political forum for discussion of significant community issues at the regional level, and facilitate the collaboration of members in delivering the services best provided at the regional level.

2. Deliver Core Services

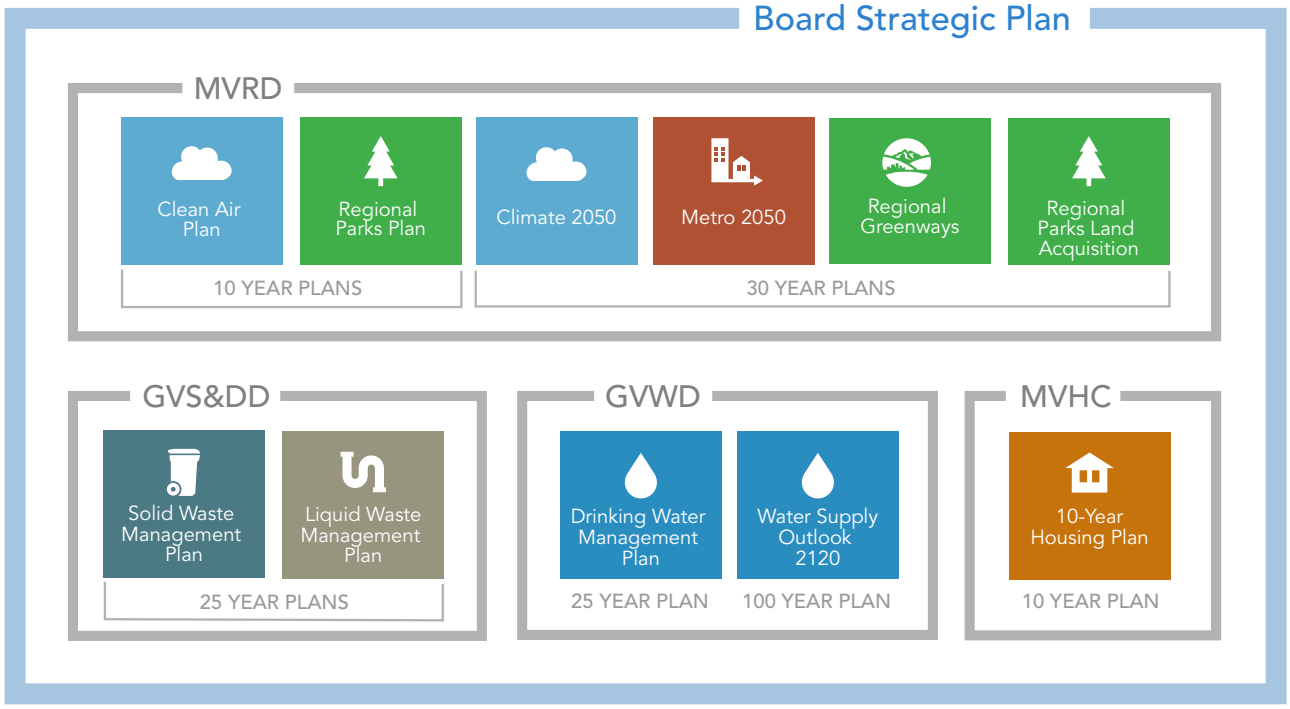
Provide regional utility services related to drinking water, liquid waste and solid waste to members. Provide regional services, including parks and affordable housing, directly to residents and act as the local government for Electoral Area A.

3. Plan for the Region

Carry out planning and regulatory responsibilities related to the three utility services as well as air quality, regional planning, regional parks, Electoral Area A, affordable housing, labour relations, regional economic prosperity, and regional emergency management.

Building a Resilient Region

Building the resilience of the region is at the heart of Metro Vancouver's work. Each of Metro Vancouver's regional plans and strategies adopts a vision, guiding principles, goals, strategies, actions and key performance measures that will support a more resilient, low carbon and equitable future. Metro Vancouver's interconnected plans and strategies are guided by the Board Strategic Plan, which provides strategic direction for each of Metro Vancouver's legislated areas of responsibility and the Long-Term Financial Plan which projects total expenditures for capital projects and operations that sustain important regional services and infrastructure. Together these documents outline Metro Vancouver's policy commitments and specific contributions to achieving a resilient region.



REGIONAL MANAGEMENT PLANS/STRATEGIES

Metro Vancouver's Roles and Responsibilities for Climate Action

The actions to achieve carbon neutrality and build a more resilient region will depend on the collaborative efforts of many players in the region as well as the federal and provincial government. However, Metro Vancouver has some unique and important roles and responsibilities for advancing climate action.

- Under the *Environmental Management Act*, Metro Vancouver has the delegated authority to provide the service of air pollution control and air quality management and may, by bylaw, prohibit, regulate and otherwise control and prevent the discharge of air contaminants, including greenhouse gases.
- Through the regional growth strategy, Metro Vancouver, with its members, plans for compact, complete communities that are foundational to enabling a carbon neutral, resilient region.
- As part of delivering its core services, Metro Vancouver also generates and uses clean, renewable energy from its facilities and is working to ensure core regional services and infrastructure are prepared for and resilient to climate change.
- Invest Vancouver is Metro Vancouver's economic development leadership service with the vision of a dynamic and resilient regional economy that delivers prosperity for all. It aims to foster greater regional collaboration on economic development issues, to advise leaders on sound economic policy and strategy, and to brand the region and its key industries to a global audience with the intention of attracting strategic investment. Invest Vancouver focuses on key export oriented industries in which the region has a productive advantage. This includes many aspects of the green economy, including clean technology, renewable energy, and clean transportation.
- In its role as a regional forum, Metro Vancouver builds and facilitates collaborative processes which engage the public and build partnerships to address significant regional issues like climate change. As part of this role, Metro Vancouver coordinates with and advocates on behalf of its member jurisdictions to other governments and partners on greenhouse gas management and climate change adaptation initiatives.

These roles are necessary but not sufficient to achieve our goals of a climate neutral, resilient region. Metro Vancouver will be looking to other orders of government, First Nations, and other regional partners to lead and collaborate in the implementation of a number of key actions in the *Climate 2050 Roadmaps*.


BURNABY

The Roadmap at a Glance

Energy is essential to our daily lives. We rely on energy every day to work, study, play, and so much more. However, human use of fossil fuels (such as gasoline, diesel, and fossil natural gas – often referred to as 'natural gas') as an energy source is associated with 90% of greenhouse gas emissions in our region. Fossil fuels have traditionally been used to heat our homes, move people and goods, and power industrial processes, but this is rapidly changing.

Transitioning to clean, renewable energy will be essential to meeting emission reduction targets and reaching a carbon neutral region by 2050. Reducing energy use and increasing energy efficiency are the first steps to reducing emissions from energy and increasing resiliency. The next step is to replace fossil fuel use with clean, renewable energy, such as electricity. In British Columbia (BC), 98% of electricity generated is low or zero carbon, derived from renewable sources such as hydro, biomass, or wind power. Many technologies that can replace fossil fuels with electricity are already commercially available, such as electric vehicles and heat pumps for heating homes and buildings. In addition to reducing greenhouse gas emissions, switching to clean, renewable electricity can improve air quality, contributing to the health of residents in the region.

As we transition to clean, renewable energy, it is critical that we develop an energy system that is resilient to the impacts of a changing climate. Impacts such as extreme heat and severe storms threaten the reliability of our energy supply. We must protect existing energy infrastructure, and build resilient energy systems, to ensure that energy supply continues to be reliable.

The goals and targets Climate 2050 Energy Roadmap are closely linked to the actions in the the other Climate 2050 Roadmaps in particular the **Transportation, Buildings and Industry & Business Roadmaps**.

Metro Vancouver, together with its member jurisdictions, has been taking action on climate change for decades. But we need to do more to achieve the deep reductions in greenhouse gas emissions required to meet our goals and to prepare for the impacts of climate change. Coordination and collaboration with other orders of government, First Nations, energy regulators, energy utilities, and other regional partners will be essential to transitioning to 100% clean, renewable, and resilient energy.

The *Energy Roadmap* lays out 36 actions for transitioning to clean, renewable energy, and increasing resiliency, organized under the following six strategic areas:

1. Plan for the Transition to Clean, Renewable, and Resilient Energy
2. Accelerate Electrification
3. Increase Sustainable Production of Low Carbon Biofuels and Hydrogen
4. Limit Expansion of Fossil Fuel Production
5. Protect Existing Energy Systems from Current and Future Climate Impacts
6. Build New Energy Systems that are Climate Resilient

WIND TURBINE

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VIEW FROM WEST VANCOUVER

Visioning Clean, Renewable, Resilient Energy in 2050

In 2050, the Metro Vancouver region has transitioned away from fossil fuels such as gasoline, diesel, and fossil natural gas (often referred to as 'natural gas'), to 100% clean, renewable energy. Society has substantially reduced its energy use through development of walkable urban centres and reliable public transport; buildings that use very little energy; a circular economy which reduces the need for energy-intensive resource extraction, manufacturing, and distribution of goods; and use of energy-efficient equipment and processes.

The remaining energy use is 100% clean, renewable. Energy supply is integrated and diverse – for example, energy is distributed through a smart electricity grid and renewable gas distribution system, but also from local, independent systems such as microgrids. Most buildings and vehicles are electrified, while some buildings, large trucks, industrial processes, marine, air, and rail applications rely on a combination of district energy systems, low carbon hydrogen, and biofuels. Use of clean energy has resulted in improved regional air quality. Energy infrastructure is resilient and reliable – energy outages are infrequent, despite increased extreme weather due to climate change, and essential services all have backup power systems in place.

Climate 2050 Energy Roadmap

A pathway to clean, renewable, resilient energy in Metro Vancouver

The Challenge

Energy is critical to our daily lives – energy heats and cools our homes, fuels our vehicles, and powers our society. However, the majority of the energy we use today is derived from fossil fuels, a major source of greenhouse gases and health-harming air contaminants (such as fine particulate matter). Fossil fuels, primarily gasoline, diesel, and fossil natural gas, are responsible for 90% of the region's greenhouse gas emissions. Transitioning to clean, renewable energy is critical to reaching climate targets for both 2030 and 2050. However, this will require a large-scale transformation in how we generate, distribute, and use energy. We need to plan for what a future energy system will look like, and accelerate the transition towards 100% clean, renewable, and resilient energy.

A carbon neutral region is the best option for future generations to maintain a good quality of life beyond 2050. We have to make some difficult decisions and investments today to avoid passing on the full burden and responsibility of climate action to future generations at higher cost and consequence. Metro Vancouver and many of its member jurisdictions have committed to ambitious, science-based targets and bold leadership in action to respond to the climate crisis. This plan responds to the global challenge to come together, think big, and act now.

What is a Carbon Neutral Region?

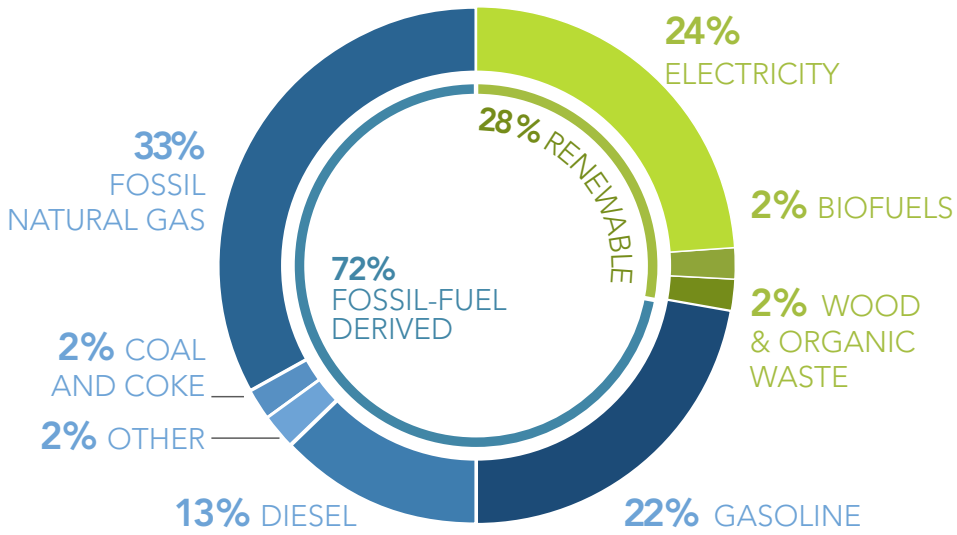
A carbon neutral region means that we have achieved the deepest greenhouse gas emission reductions possible across all economic sectors, and any emissions left are balanced out by the carbon dioxide removed from the atmosphere by the plants, trees, and soil in the region, as well as by potential carbon capture technologies that are currently under development.

Emissions from Energy in Metro Vancouver

Energy plays a vital role in powering the region's economy and our daily lives. Clean, renewable energy is energy derived from sources with low or zero emissions, and is replenished over days and years. In Metro Vancouver, 28% of the energy we use is clean, renewable energy (Figure 2), of which 24% is from clean, renewable electricity. The major energy sources used within each regional sector are as follows:

- **Buildings** – fossil natural gas, electricity, and district energy systems are used to heat and cool our homes, and electricity is used to power appliances and other devices.
- **Transportation** – diesel and gasoline fuel the movement of people, goods, and services, whether by car, truck, train, plane, or boat; electricity and biofuels power a small but increasing part of this sector.
- **Industry** – many different sources of energy are used in industrial processes including fossil natural gas, electricity, biomass, coal, and petroleum coke.
- **Non-road engines** – diesel and gasoline fuel non-road equipment such as backhoes and excavators.
- **Agriculture** – fossil natural gas provides most of the energy for greenhouses and diesel fuels farm vehicles and equipment.

FIGURE 2: SOURCES OF ENERGY WITHIN METRO VANCOUVER (2015)



Fossil fuels make up approximately three-quarters of the energy used in the Metro Vancouver region, but are associated with 90% of the region's greenhouse gas emissions [1]. Non-energy emissions are primarily related to greenhouse gases produced during natural and industrial chemical processes. Reducing the use of fossil fuels while increasing the use of clean, renewable energy is a key emissions reduction opportunity.

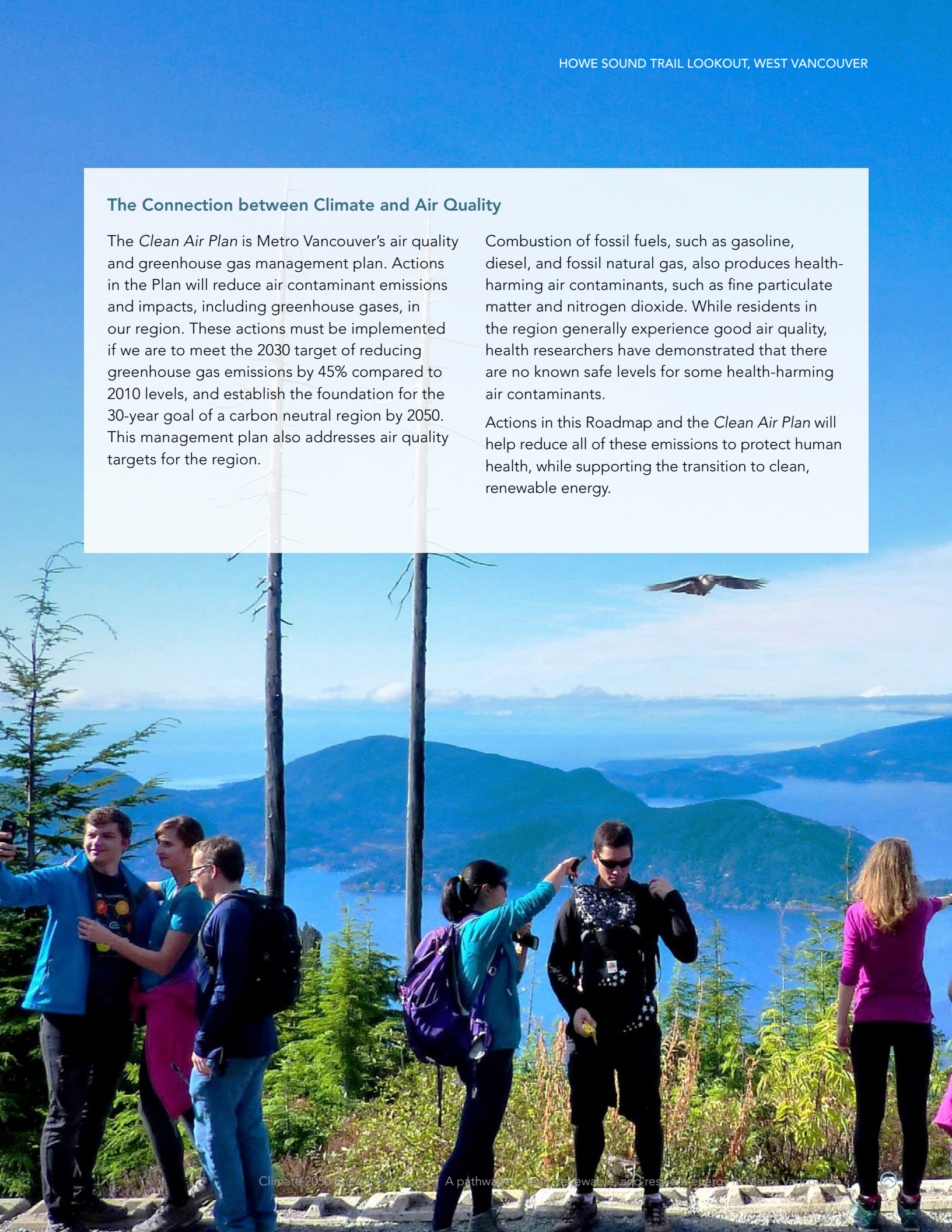
1 Electricity does not produce appreciable emissions within our region. As BC's electricity is primarily produced from clean, renewable sources, there is a small amount of emissions related to out-of-region electricity generation.

Is Natural Gas a Fossil Fuel?

Fossil natural gas, often referred to as 'natural gas', is a fossil fuel. Fossil natural gas was formed millions of years ago from the pressurized and heated remains of organic material and is mostly composed of methane, about 95% by volume. Methane is a potent greenhouse gas, with a global warming potential of approximately 25 times that of carbon dioxide over a 100-year timeframe or 85 times over a 25-year timeframe. In BC, fossil natural gas is primarily produced through hydraulic fracturing, a process which uses significant amounts of water to fracture rock and extract natural gas. Fossil natural gas production is also associated with fugitive methane (released to the atmosphere from accidental release or leaks) and vented methane. Within the Metro Vancouver region, combustion of fossil natural gas is responsible for 32% of regional greenhouse gas emissions.

For the energy that is used in the region, greenhouse gases are emitted during production and transport, as well as during end-use. Lifecycle greenhouse gas emissions include emissions associated with all stages of energy production and use, from extraction, processing, distribution, through to end-use, and includes fugitive emissions, such as methane. While Metro Vancouver and its member jurisdictions have limited authority over emissions that occur outside of the region, Metro Vancouver can take action to increase use of energy sources that have lower lifecycle greenhouse gas emissions, such as electricity.

Some infrastructure associated with fossil fuel production and transport is located within the region. Large amounts of solid and liquid fossil fuels are exported through port terminals overseen by the Vancouver Fraser Port Authority (Port of Vancouver). These terminals export thermal and metallurgical coal, crude oil, and liquefied natural gas. Some companies have plans to expand fossil fuel exports. While Metro Vancouver and its member jurisdictions have minimal jurisdiction over energy exports, the region is home to a sizeable fossil fuel export network, which contributes to the lifecycle emissions of many fossil fuels used outside of the region.



HOWE SOUND TRAIL LOOKOUT, WEST VANCOUVER

The Connection between Climate and Air Quality

The *Clean Air Plan* is Metro Vancouver's air quality and greenhouse gas management plan. Actions in the Plan will reduce air contaminant emissions and impacts, including greenhouse gases, in our region. These actions must be implemented if we are to meet the 2030 target of reducing greenhouse gas emissions by 45% compared to 2010 levels, and establish the foundation for the 30-year goal of a carbon neutral region by 2050. This management plan also addresses air quality targets for the region.

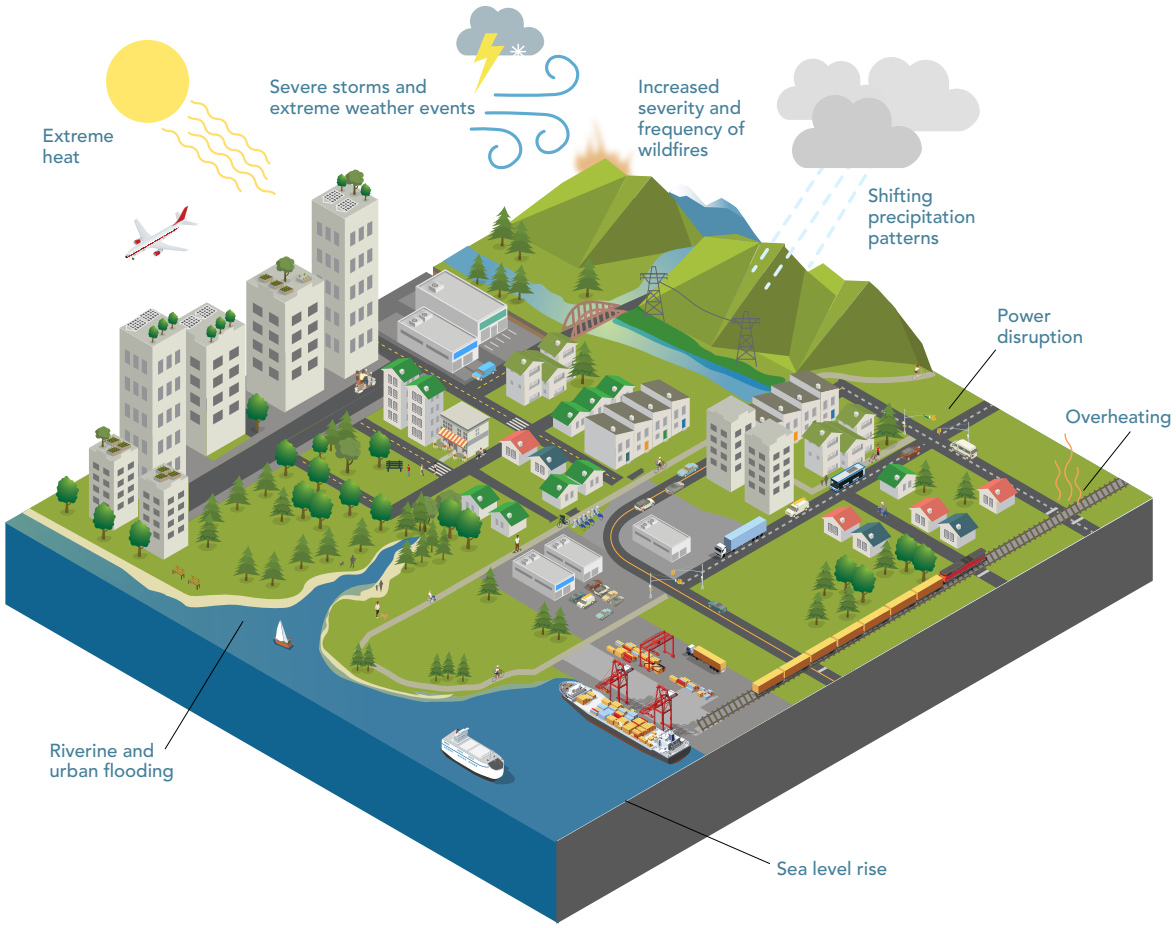
Combustion of fossil fuels, such as gasoline, diesel, and fossil natural gas, also produces health-harming air contaminants, such as fine particulate matter and nitrogen dioxide. While residents in the region generally experience good air quality, health researchers have demonstrated that there are no known safe levels for some health-harming air contaminants.

Actions in this Roadmap and the *Clean Air Plan* will help reduce all of these emissions to protect human health, while supporting the transition to clean, renewable energy.

Climate Change Impacts on Energy

The energy system that serves Metro Vancouver is made up of a complex and interconnected network of energy infrastructure including but not limited to oil and gas pipelines, natural gas compressor stations, gasoline and diesel fueling stations, high-voltage electricity power lines, electrical substations, and voltage transformers. Energy infrastructure lasts for decades and has not always been designed to accommodate the impacts of climate change. Protecting energy infrastructure from the current and future impacts of climate change will be essential to building a resilient region.

EXPECTED CLIMATE CHANGE IMPACTS



Based on climate projections to the 2050s we can expect the following changes and impacts in the Metro Vancouver region:

Climate Changes

Hotter temperatures and extreme heat events, with higher daytime and nighttime temperatures and more hot summer days. This will lead to increased frequency and severity of heatwaves, wildfires, and droughts.

Shifting precipitation patterns, including more rainfall in every season except the summer, and less precipitation falling as snow.

Severe storms and extreme weather events, including high winds and heavy rainfall, which can lead to overland flooding and landslides.

Sea level rise, with 0.5 metres expected by 2050, will impact coastal communities in the region.

Impacts Felt

Power and fuel supply disruption due to shock events that can cause damage to energy infrastructure (i.e., extreme rainfall, landslides, ice storms, windstorms, and wildfires), or due to increased strain on the energy system from extreme weather. This is especially a high risk to service continuity of essential services, such as hospitals and community centers.

Riverine and urban flooding, from periods of extreme rainfall and sea level rise, which can cause near-term and long-term damage to critical energy infrastructure at low elevations or in floodplains, such as electrical substations, underground infrastructure, or district energy systems.

Changes to seasonal water levels, as a result of reduced snowpack and hotter, drier summers, can impact hydroelectric generation and electricity supply to the region.

Clean, Renewable, and Resilient Energy

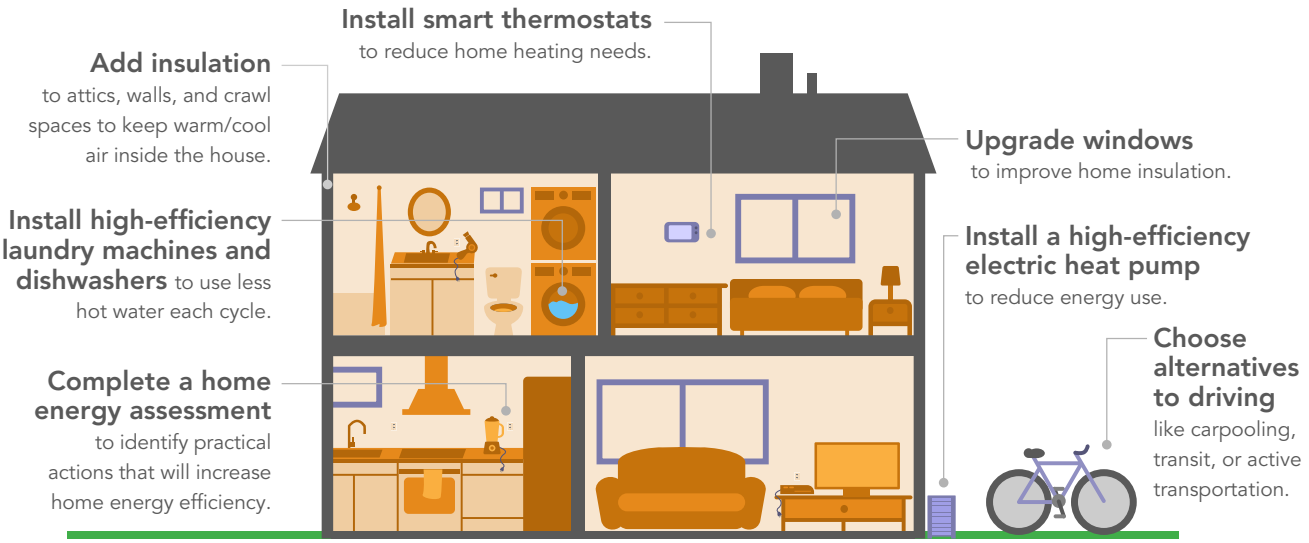
Reducing the amount of energy used in the region and transitioning to clean, renewable energy is crucial to achieving deep emission reductions. However, this will require massive shifts in the way energy is used and supplied. At the community scale, residents and businesses need to take steps to reduce energy use, as well as switch to technologies that use clean, renewable energy. At the system scale, sufficient clean, renewable energy needs to be available to meet societal demand, while ensuring that energy costs remain affordable.

As the region transitions to using clean, renewable energy, there is also an opportunity to address climate adaptation. New infrastructure associated with the supply of clean, renewable energy presents an opportunity to build back better, specifically to build new infrastructure that is resilient to the impacts of climate change and to upgrade existing infrastructure. Ultimately, the transition to clean, renewable, and resilient energy needs to be designed to ensure that it reduces regional emissions, improves the health of residents, distributes costs in an equitable manner, and increases resiliency of the energy system.

Reducing Energy Use

One of the first steps to reducing greenhouse gas emissions and other environmental impacts (i.e., land and water impacts) associated with energy production is to reduce the total amount of energy used. There are many ways that residents and businesses can directly reduce energy usage. In buildings, this could mean using a programmable thermostat or taking shorter showers to reduce fossil natural gas and electricity use. For personal transportation, this could mean shifting modes of transportation to walking, rolling, cycling, taking transit, or carpooling to reduce use of gasoline and diesel.

Another way to reduce energy use is by improving energy efficiency, which in this context, means using less energy to accomplish the same task. Technology is getting progressively more energy efficient and investing in new technology could reduce the amount of energy used. For example, hybrid vehicles are more fuel efficient than gasoline-powered cars and electric vehicles are even more efficient than hybrid vehicles. Reducing energy loss will also improve the energy efficiency of buildings, technologies and processes. For example, improving the insulating properties of the building envelope (i.e., walls, windows, foundation, and roof) to keep warm or cool air inside, in addition to heat recovery systems, will all help reduce energy use. In industrial settings, using advanced control systems to optimize equipment operation or insulating pipes to reduce heat loss can also improve energy efficiency. By using less energy, we can reduce reliance on energy, which will result in less disruption to residents and businesses during interruptions to energy supply, such as power outages.



Reducing energy usage is instrumental to reducing emissions associated with energy use and can help improve resiliency in events where energy supply is interrupted. Actions specifically related to reducing energy use in the buildings, transportation, and industry sectors can be found in the **Buildings Roadmap, Transportation Roadmap, and Industry and Business Roadmap**.

Types of Clean, Renewable Energy

Low and zero emission energy sources are critical to transitioning to clean, renewable energy. Major types of clean, renewable energy that will be important in reaching our emission reduction targets include electricity, hydrogen, and biofuels.

Electricity

In BC, 98% of the electricity generated is from renewable sources, such as hydro, biomass, or wind power. The generation, transmission, and use of electricity in BC is associated with very low emissions over its lifecycle, in comparison to the production, transport, and combustion of fossil fuels. However, there can be other land and water impacts associated with electricity generation, which need to be minimized as new clean, renewable generation is added to the electrical grid. Electricity also does not generate air contaminants at point of use, which eliminates emissions of health-harming contaminants that are produced when fuels are combusted (e.g., fine particulate matter and nitrogen oxides), thereby improving air quality and health of residents. Electricity is also used to power mechanical cooling, which will be critical for resident health and safety during extreme heat events.

Many electric technology solutions, such as electric vehicles and high efficiency heat pumps for home heating and cooling, are already commercially available. There are also significant co-benefits to using clean, renewable electricity.

- Buildings – Electric heat pumps provide both heating during the winter and cooling during the summer, making buildings more resilient to the longer, hotter, drier summers that are predicted for the region as a result of climate change. Heat

pumps may also help filter indoor air, a feature that is especially important during wildfire smoke events that are becoming increasingly common during the summer months.

- Vehicles and Non-Road Engines –The use of electric vehicles and non-road engines (e.g., construction equipment, generators) in the urban environment can reduce the impact of health-harming air contaminants on nearby populations because they produce no tailpipe emissions. Another benefit is a reduction in noise pollution.

Transitioning to use of electricity is an essential strategy to reducing emissions and reaching the region's 2030 target of 45% reduction in emissions from 2010 levels. Strategies and actions related to electrification in major sectors can be found in the **Buildings, Transportation, Industry and Business, and Agriculture Roadmaps**.

Hydrogen

Most of the hydrogen produced world-wide today is from fossil natural gas and hydrogen is mostly used as a feedstock in emission-intensive industrial sectors, such as oil refining. However, hydrogen produced from electricity can be clean and renewable, and depending on how it is used, zero emissions.

Though the technology to produce, distribute and use hydrogen energy is still developing, hydrogen could be a viable solution to decarbonize hard-to-electrify sectors, such as heavy-duty transportation and industrial applications. When powering fuel cells, hydrogen can be used as zero emission energy for the transportation sector when produced using clean, renewable energy. Strategies and actions supporting uptake of zero emission vehicles can be found in the **Transportation Roadmap**.

Hydrogen can also be blended into the gas distribution system, which can support decarbonization of the buildings and industrial sectors. Depending on the point of injection and pipeline capacity, hydrogen by volume between 5% and 15% can be blended into the existing gas distribution system, with minimal impact on boilers and similar appliances. However, hydrogen combined with methane gas at mixes greater than 15% by volume would require some changes to gas pipelines and end use equipment, such as household appliances. Also, all combustion processes produce health-harming air contaminant emissions; even combustion of pure hydrogen produces nitrogen oxides.

The BC Government has developed the **BC Hydrogen Strategy**, which helps guide the transition to hydrogen as a clean, renewable form of energy and highlights key policy actions that the BC Government will take to overcome barriers in hydrogen production, transportation, and end-use. One of the key actions in this strategy is to establish regional hydrogen hubs, which would co-locate low carbon hydrogen production and end-use applications to spur and grow hydrogen supply and demand.

A Metro Vancouver hydrogen hub could remove bottlenecks for growth of this sector based on the competitive advantage created by the collective talent of firms in the region working on hydrogen production, storage, transportation, membranes, fuel cells, testing, and consulting. The Government of Canada has developed the **Hydrogen Strategy for Canada**, which lays out a framework to position Canada as a world-leading producer, user, and exporter of clean hydrogen and associated technologies. Hydrogen will be an important part of the energy system that enables the region to reach carbon neutrality by 2050.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Hydrogen: A Form of Low Carbon Energy?

Hydrogen can be produced in several ways, and each is associated with different levels of greenhouse gas emissions. The most prominent methods have been denoted by the industry using different colours, and are outlined below, though there are other production pathways that are rapidly developing.

- **Green hydrogen** is produced using electricity, and can be zero emission and zero carbon energy if the electricity used is generated from clean, renewable sources.
- **Waste hydrogen** is produced by a commercial process in which the primary purpose is not the production of hydrogen. Waste hydrogen is considered clean, renewable energy.
- **Blue hydrogen** is produced using fossil natural gas, with capture and storage of the greenhouse gas emissions created during production. Blue hydrogen is not renewable and maintains reliance on fossil fuels.
- **Grey hydrogen** is also produced using fossil natural gas, but creates significant greenhouse emissions during production, which is released to the atmosphere. Grey hydrogen is not renewable and maintains reliance on fossil fuels.

The Government of Canada has recommended a threshold for the carbon intensity of low carbon hydrogen. Based on that threshold, green hydrogen, waste hydrogen, and blue hydrogen with at least 90% carbon capture are considered low carbon.

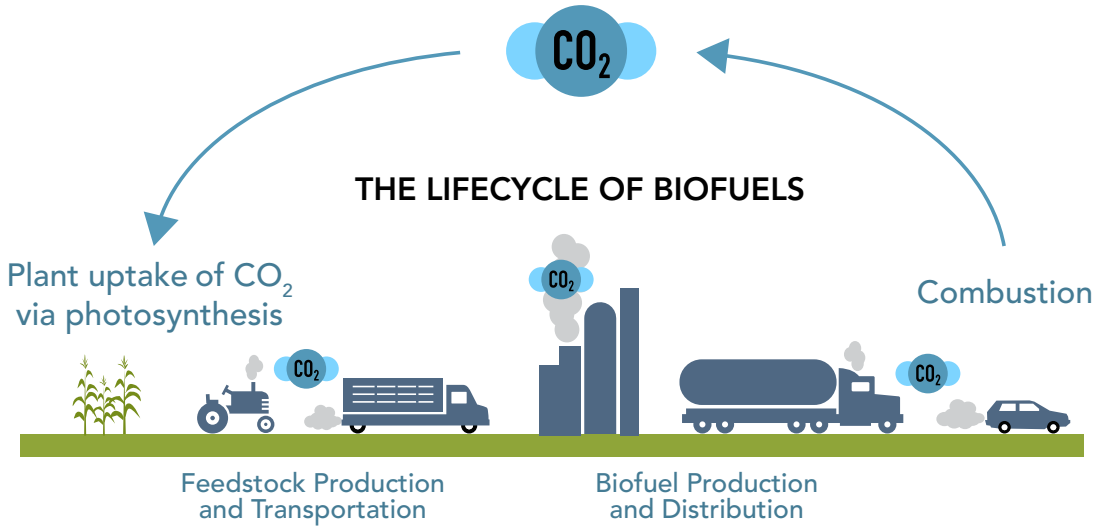
Low Carbon Biofuels

Biofuels are produced using organic matter derived from biomass such as plants. Biofuels are considered low carbon because the plants used to make biofuels absorb carbon dioxide as they grow, offsetting the carbon dioxide emitted during combustion. Biofuels have been associated with higher lifecycle emissions than other types of renewable energy due to greenhouse gas emissions associated with changes to land use, use of fossil fuel-based fertilizers, and distribution of fuel. The feedstock for most biofuel production today is edible crops, such as soy and corn, which can impact food prices as well as having adverse land-use impacts, such as deforestation. Sustainability of feedstock must be prioritized if biofuel consumption increases in the region.

The upcoming federal *Clean Fuel Standard* aims to establish sustainability criteria for biofuels and their feedstock, which are designed to exclude feedstock with high indirect land-use change risk, feedstock from land with a high biodiversity value or high carbon value, and forest biomass feedstock that is not managed sustainably. Also, while biofuels can have lower lifecycle carbon emissions compared to traditional fossil fuels, they still produce health-harming air contaminants when combusted, which can have negative impacts for public health and the environment.

Some common liquid biofuels are listed below:

- **Biodiesel** is made from vegetable oils (such as canola) and waste animal fats. It can be blended in fossil diesel in amounts up to 20% and used in conventional diesel engines.
- **Renewable diesel** is also made from vegetable oils and animal fats, but using a different process that makes the end fuel almost identical to regular diesel. It can be used directly in conventional diesel engines without requiring engine modifications.
- **Ethanol** is the most common renewable alternative to gasoline. Made from plants such as corn or sugar cane, it can be blended up to 10% in regular gasoline used in conventional gasoline engines. Flex fuel vehicles that can accommodate gasoline blends with up to 85% ethanol have become increasingly common in North America.
- There are specialized types of liquid biofuels for aircraft and marine vessels, such as sustainable aviation fuel, to support decarbonization of those sectors.



Other types of non-liquid biofuels include the following:

- **Renewable natural gas** (RNG) is a gaseous biofuel that is mostly composed of methane. It is produced primarily from anaerobic digestion of organic feedstock (such as food, agricultural, and forestry waste). Since it is primarily composed of methane, it can be substituted directly in natural gas-burning equipment as a renewable, low carbon alternative to fossil natural gas.
- **Firewood** and **wood pellets** are another common biofuel used in the region. Combustion of solid biofuels can emit significant amounts of fine particulate matter and other health-harming air contaminants when combusted, which can impact air quality and public health. Several regulations exist in the region to minimize the air quality impacts of solid biofuels, such as the *Metro Vancouver Regional District Residential Indoor Wood Burning Emission Regulation Bylaw 1303* and *Greater Vancouver Regional District Boilers and Process Heaters Emission Regulation Bylaw 1087*.

If used strategically, biofuels have the potential to displace the use of fossil fuels in difficult to decarbonize sectors such as difficult-to-electrify buildings, heavy duty vehicles, and marine, air, rail and industrial processes, especially in the short term while new zero emission technologies are developed.

Industrial Processes and Clean, Renewable Energy

Switching to clean, renewable energy is also an important strategy for reducing greenhouse gas emissions from industrial processes, such as cement manufacturing, chemical and wood products processing, and many others. In cases where electrification is not feasible due to technological challenges or high thermal process needs, (e.g., cement production), switching to low carbon, renewable energy sources other than electricity provides an alternative solution in reducing greenhouse gas emissions. Examples include switching from high carbon fuels, such as coal and coke, to biofuels such as wood or renewable natural gas.

If used strategically, biofuels have the potential to displace some of the fossil fuels used in light and heavy-industrial operations. Fuel switching can be a viable strategy for decarbonization, while also acknowledging the need for industries in the region to remain competitive.

Transitioning to Clean, Renewable and Resilient Energy

Strengthen Climate Policy

Accelerating adoption of technologies that use clean, renewable energy will require strong climate policy, ranging from comprehensive regulation to deep financial incentives for residents and businesses. While some policies already exist to enable residents and businesses to switch to clean, renewable energy, stronger policies are required from all levels of government to accelerate the transition to 100% clean, renewable energy by 2050.

Key Climate Policies

Strong climate policy is essential to driving the transition to 100% clean, renewable energy by 2050. In the absence of strong policy, emissions reductions are often incremental and insufficient to achieve goals and targets. Recent climate policy announcements have set the direction for stronger action on climate, but it will be the implementation of these policies that drive deep emission reductions. Some of the key existing and upcoming climate policies that will drive adoption of clean, renewable energy in the region are listed below.

Province-wide:

- Carbon tax increasing to $170/tonne carbon dioxide by 2030 (***CleanBC Roadmap to 2030***)
- Cap of 6 million tonnes CO2e/year for natural gas utilities (*CleanBC Roadmap to 2030*)

Buildings:

- Greenhouse gas performance requirements for new construction (province-wide implementation by 2030 as per *CleanBC Roadmap to 2030*; also, some member jurisdictions have implemented low carbon energy system requirements complementary to the BC Energy Step Code)
- Requirements for all new space and water heating equipment sold in BC to have a rated efficiency equal or greater than 100% by 2030 (*CleanBC Roadmap to 2030*)
- Greenhouse gas performance requirements for existing homes and buildings (*Climate 2050 Buildings Roadmap*)

Transportation:

- 100% sales target for zero emission light duty vehicles by 2035 (*CleanBC Roadmap to 2030*)
- Sales targets for zero emission medium and heavy duty vehicles (*CleanBC Roadmap to 2030*)
- Federal vehicle efficiency standards (Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations, and Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations)
- Reduction in average carbon intensity for gasoline and diesel of 30% by 2030, inclusive of aviation and marine fuels (Renewable & Low Carbon Fuel Requirements Regulation, *CleanBC Roadmap to 2030*)

Industry:

- New industrial facilities must have a plan to be net-zero (carbon neutral) by 2050 (*CleanBC Roadmap to 2030*)
- Integrate greenhouse gas reduction requirements into emission regulations and permits (*Clean Air Plan*)

Transform the Electrical Grid

Electricity will play a major role in the transition to clean, renewable energy. A number of organizations, including Metro Vancouver, are directly working on actions to accelerate electrification. BC Hydro's **Electrification Plan** will accelerate the transition from fossil fuels to electricity through enhanced programs and incentives. To accommodate the higher demand for electricity, the way electricity is generated and distributed will need to grow and transform to support a carbon neutral region. The key challenge will be to ensure that there is sufficient clean, renewable energy to meet demand. Within their **2021 Integrated Resource Plan**, BC Hydro has developed a plan to continue meeting the electricity needs of BC for the next 20 years, including a range of enhanced demand-side measures such as demand response programs and time-of-use rates; transmission upgrades; and development of wind and solar power.

To ensure that the electrical grid is responsive to future needs, such as integrating new sources of clean, renewable energy and increasing resiliency, there is a need to invest now in modernizing the grid to allow integration of new technologies. For example, investments in smart-charging technology will enable electric vehicles to be charged during periods of low electrical demand, and potentially supply electricity back into the grid when needed, which will support BC Hydro in managing electrical demand. Emerging energy storage technologies such as batteries and hydrogen energy storage (when hydrogen production is strategically added onto parts of the electrical grid as a form of energy storage), can help increase the penetration of renewables, such as wind and solar energy, which will help support increased power demand from electrification of buildings and some industrial processes.

As more electricity generation, transmission, and distribution infrastructure is built, there is a need to ensure that new infrastructure, along with existing infrastructure, is resilient to the impacts of climate change. Key risk management activities that BC Hydro is pursuing include: siting new infrastructure in areas that are less susceptible to climate impacts such as wildfires or riverine flooding, updating design standards and codes to ensure that they reflect future climate projections, selecting resilient material for transmission infrastructure, and ensuring existing infrastructure is regularly maintained.

However, there is still some risk posed by reliance on centralized energy systems, since a catastrophic event such as a major earthquake or atmospheric river event, could cause major systems to fail. Currently, much of the region relies on diesel generators to supply backup power in case of power outages, but diesel supply could also be impacted in the situation of a catastrophic extreme weather event (e.g., flooding and landslides that damage road and rail infrastructure). One way to increase resilience is to explore local, independent energy systems, such as microgrids. A microgrid is a system composed of electrical loads, such as electric buildings and electric vehicle chargers, and distributed energy generation resources, such as solar or wind generation, that are interconnected through an electrical grid. Most importantly, microgrids have the ability to operate independently from the central electrical grid, so can remain operating during regional power outages. While still an emerging approach, microgrids could help increase the resiliency of the electrical grid.

Home Based Solar Power

Home based solar power, such as rooftop solar panels, is one source of clean, renewable electricity. While home based solar, as a whole, is more expensive than utility scale solar and wind in BC, home based solar is one way that residents can help contribute to clean, renewable electricity supply and reduce their energy costs. As technology advances and home batteries become more abundant, home based solar power could also add resiliency to the grid. While home based solar panel is likely to make up a small portion of future electricity generation, the region will need access to any and all sources of clean, renewable electricity to meet its 2030 and 2050 targets.

Decarbonize the Fossil Natural Gas System

Decarbonization of the current fossil natural gas system will be critical to achieving carbon neutrality by 2050. Currently, the region relies heavily on the gas distribution system, which transports primarily fossil natural gas for use in heating and hot water within homes, as well as heating in some industrial processes and greenhouses. Some renewable gases, such as renewable natural gas (RNG), are drop-in replacements for fossil natural gas (since both are primarily composed of methane). Some renewable gases, such as green hydrogen, will require new gas distribution infrastructure or upgrades to existing gas distribution infrastructure. As such, the existing gas distribution network could be leveraged to deliver renewable gas.

The *CleanBC Roadmap to 2030* includes a greenhouse gas emissions cap for natural gas utilities of 6 million tonnes CO2e for 2030, which is approximately 47% lower than 2007 emission levels, and specifies that renewable gas (green hydrogen, waste hydrogen, and RNG) must make up a minimum of 15% of B.C.'s natural gas by 2030. While renewable gas currently makes up less than 1% of FortisBC's total gas supply, FortisBC has developed a **10-year forecast** for sourcing sufficient renewable gas to meet the province-wide 15% renewable gas target by 2030.

Production of renewable gas will need to scale up significantly to fully decarbonize the gas system. An expert report commissioned by the British Columbia Utilities Commission notes that RNG demand will likely outpace RNG supply in the medium- to long-term, and that without significant technological breakthroughs, RNG supply is unlikely to meet the growing demand for RNG. It should also be noted that there are considerable double-counting risks associated with RNG, particularly RNG sourced from out-of-province. Robust accounting, tracking, verification, and reporting requirements need to be implemented in order to guarantee the integrity of the emission reductions from RNG and to mitigate the risks of double-counting.

As there are limited amounts of renewable gas available to achieve the targets within *CleanBC* and the *Climate 2050 Roadmaps*, use of renewable gas should be prioritized in difficult-to-electrify sectors, such as industrial applications with high temperatures or requiring combustion for process requirements. Electrification should be prioritized in sectors where electric technologies are commercially available, such as buildings and light duty vehicles, to maximize the use of available clean, renewable energy. Additionally, until production of renewable gas increases sufficiently to fully decarbonize the current gas supply, there may be a need to right-size the gas system in the interim in order to reduce the risk of stranded gas assets and avoid excessive cost impacts to ratepayers.

As the gas system decarbonizes, new infrastructure as well as existing gas infrastructure needs to be resilient to the impacts of climate change. Upgrading existing infrastructure and ensuring that new infrastructure is designed to withstand the impacts of future climate projections, such as flooding and landslides, will be essential to increasing resiliency of the gas system. Currently, most of the fossil natural gas supplied to the Metro Vancouver region is supplied from Northeastern BC through one major pipeline. Failure of this pipeline will result in severe restrictions to gas supply to the region. Diversifying gas supply, such as integrating different sources of renewable gas, could increase resiliency of the gas system.

Increase Sustainable Liquid Biofuel Production

While provincial legislation is driving a transition to zero emission vehicles, liquid biofuels will be an important near-term strategy to decarbonize the transportation sector, as well as a longer-term solution for difficult-to-electrify sectors such as marine, air, and rail. The BC *Low Carbon Fuel Standard* provides a strong policy framework for increasing biofuel production and ensuring sustainability of feedstock. The *CleanBC Roadmap to 2030* includes a target to double the quantity of renewable fuels produced in BC annually to 1.3 billion litres by 2030. For comparison, approximately 7.4 billion litres of gasoline and diesel was consumed in BC in 2020. Notably, there are opportunities to directly produce liquid biofuels in the Metro Vancouver region.

Metro Vancouver is currently engaged in a hydrothermal processing pilot that will convert wastewater biomass into biocrude that can be refined into low carbon biofuels. If the challenges of scale-up can be overcome to achieve robust operations, hydrothermal processing could produce over 2 million litres of biocrude annually by 2035. Supporting sustainable liquid biofuel production will be crucial to ensuring that there is sufficient biofuel to achieve the region's emission reduction goals in difficult-to-electrify sectors.

Limit Expansion of Fossil Fuel Production

In addition to accelerating the transition to clean, renewable energy, expansion of fossil fuel production must be simultaneously limited on a global scale. Both the International Energy Agency and the United Nations Environment Programme have noted that new production of fossil fuels is incompatible with limiting global warming to 1.5 degrees Celsius. New fossil fuel infrastructure can have an asset lifetime upwards of 30 years and could become stranded assets as the global demand for fossil fuel decreases. Thus, to ensure that global warming can be limited to 1.5 degrees Celsius and to minimize the risk of stranded assets, we need to limit expansion of fossil fuel production and explore how to repurpose existing infrastructure for supply of clean, renewable energy. Within the region, this means working with the British Columbia Oil and Gas Commission (BCOGC), which regulates oil and gas operations, refineries, and geothermal development in BC, to limit expansion of fossil fuel production. Existing infrastructure also needs to be repurposed as much as possible; renewable natural gas should be distributed within the existing gas distribution system and renewable diesel should be distributed through existing diesel distribution networks.

Transitioning to clean, renewable energy will also impact workers and communities currently relying on the fossil fuel industry. Governments, businesses, and industry should evaluate how the shifts in the global, national, and local economy will impact workers and communities and take the appropriate steps to minimize these impacts. For example, as the world transitions away from coal, workers in the coal mining industry may be adversely impacted. Government programs, such as income support and education and skills building programs, will help minimize impacts of the energy transition on workers and communities.

Plan for the Transition to 100% Clean, Renewable, and Resilient Energy

Given the complexities and interconnectedness of the energy system, transitioning to 100% clean, renewable, and resilient energy by 2050 will require careful planning today. In 2015, electricity and fossil natural gas made up more than 50% of the energy use within Metro Vancouver. Electricity and natural gas are mostly supplied by provincially regulated utilities, BC Hydro and FortisBC. It will be essential to work with the energy utilities and their regulator, the British Columbia Utilities Commission (BCUC), to plan for the transition to 100% clean, renewable, and resilient energy.

Under the *Utilities Commission Act*, the BCUC and energy utilities are required to consider **BC's energy objectives**, which include BC's greenhouse gas emission reduction targets. While the BCUC is required to consider BC's energy objectives when approving utility rates, programs and projects, the *Utilities Commission Act* is not explicit on how greenhouse gas objectives are considered and balanced with other objectives, such as affordability and reliability. It is critical that BC's energy objectives align with the targets outlined in this Roadmap and the *CleanBC Roadmap to 2030*, while explicitly outlining how greenhouse gas reduction is considered and balanced with other government priorities.

It will be important to conduct similar planning exercises to ensure that supply of other emerging sources of clean, renewable energy can be scaled up to match the demand needed to achieve BC's greenhouse gas reduction targets and the goals and targets within this Roadmap. The BC Hydrogen Strategy outlines a pathway to accelerate the production and use of renewable and low-carbon hydrogen. Scaling up of emerging sources of clean, renewable energy will require coordinated action from multiple stakeholders, including Metro Vancouver.

Social Equity

Social equity (as used in this Roadmap) refers to the promotion of fairness, justice, and the removal of structural barriers that may cause or aggravate disparities experienced by different groups of people. Metro Vancouver's efforts to move towards clean, renewable, and resilient energy will continue to incorporate the voices and needs of a range of communities to ensure that fairness and equity are of the highest priority, and that no one is left behind in this transition. Additional supports will need to be provided to vulnerable groups to support an equitable transition. Organizations responsible for energy-related climate policies must consider whether inequity is created or magnified, and address these inequities to ensure a just transition. Actions that reduce emissions must also support an equitable distribution of benefits, such as improved air quality and jobs related to clean, renewable energy, and avoid an inequitable distribution of costs, such as unaffordable energy costs for homes and businesses.

Integrating equity into Metro Vancouver's climate change programs is a work in progress. Metro Vancouver is developing a strategic approach to assessing equity during implementation of the *Clean Air Plan* and the *Climate 2050 Roadmaps*. This will include community input, health impact assessments, and other equity evaluation tools.

The Journey to Clean, Renewable, and Resilient Energy

The *Energy Roadmap* is focussed on the systemic changes required of our energy system to support a transition to clean, renewable energy. However, transformation of the energy system will not only require strategies and dedicated actions within this Roadmap, but also within the other *Climate 2050 Roadmaps*.

Linkages to other *Climate 2050 Roadmaps*

There are many linkages between energy and other Climate 2050 issue areas.

Buildings – conserve energy, install more efficient equipment, and switch to heating and cooling systems that use clean, renewable energy.

Transportation – switch to low energy modes of personal transportation (e.g., walking, biking, public transit), improve efficiency of engines, switch to more efficient freight transportation methods, switch to zero emission vehicles, increase zero emission refueling infrastructure, and increase use of low carbon, renewable biofuels.

Industry and Business – increase energy efficiency of industrial processes and explore equipment that can use clean, renewable energy.

Infrastructure – improve process efficiencies to reduce energy use and utilize water and wastewater infrastructure to generate clean, renewable energy.

Waste – reduce energy use and emissions associated with waste collection and disposal and consider circular economy principles within energy generation, including how waste can be used to generate clean, renewable energy.

Agriculture – increase energy efficiency of agricultural processes, explore equipment that can use clean, renewable energy, and explore viability of using agricultural waste to generate clean, renewable energy.

Land Use and Growth Management – direct higher density forms of residential and commercial growth to urban centres and locations with good transit to encourage walking, biking and transit, and to allow people to live without a car; facilitate more multi-unit residential housing which uses fewer resources and less energy per unit.

Nature and Ecosystems – nature and ecosystems cool urban areas, reducing the need for air conditioning and decreasing overall energy use.

Goals and Targets

Metro Vancouver's *Climate 2050 Strategic Framework* has set the following regional vision to guide the region's response to climate change:

- Metro Vancouver is a carbon neutral region by 2050
- Infrastructure, ecosystems, and communities are resilient to the impacts of climate change

Metro Vancouver has also set an interim target of 45% reduction in greenhouse gas emissions from 2010 levels, by 2030.

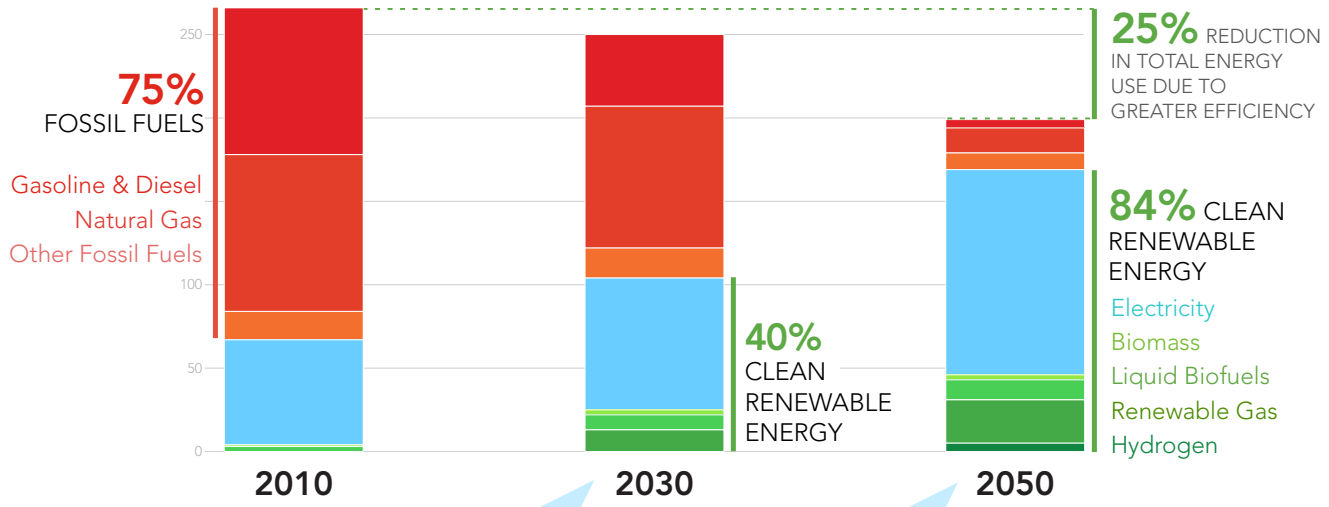
Achieving this vision means setting goals in each of the *Climate 2050 Roadmaps*, organized by sectors in the region, that contribute towards getting to a carbon neutral, resilient region.

Metro Vancouver has set the following climate goals for energy, to help visualize the region we will live in and to track progress out to 2030 and 2050.

GOAL	TARGETS
All of the energy used in Metro Vancouver is derived from clean, renewable sources	By 2030: • 60% of the energy used in the region is derived from clean, renewable sources By 2050: • 100% of the energy used in the region is derived from clean, renewable sources
All regional energy infrastructure is reliable and resilient to the current and future impacts of climate change.	By 2030: • All energy providers have identified known, unmitigated climate hazards that could impact energy infrastructure. • All new energy infrastructure is protected from known, unmitigated climate hazards. By 2050: • The energy system is protected from the current and future impacts of climate change.

The diagram below shows the possible impacts of the strategies and actions described in this Roadmap and the other *Climate 2050 Roadmaps* on reducing total energy use and increasing the use of clean, renewable energy, within an aggressive and achievable scenario.

POTENTIAL IMPACT OF THE STRATEGIES AND ACTIONS DESCRIBED IN THE CLIMATE 2050 ROADMAPS



2030

- Expanded active transportation infrastructure and transit service
- All new passenger vehicles sold in the region are electric
- Medium-duty/heavy-duty zero emissions vehicle mandate
- Increased stringency of the BC Low Carbon Fuel Standard
- Almost all new buildings are electric
- GHG limits for large existing buildings

2050

- Almost all passenger vehicles are zero emissions
- Most medium-duty/heavy-duty vehicles are either zero emissions or using low carbon biofuels
- The majority of buildings in the region are zero emissions or using low carbon energy
- Increased uptake of renewable natural gas by industrial users
- Progressive electrification of non-road equipment
- Significant decrease in overall driving as more trips are made on transit, active modes, and through shared mobility options.

The actions in this Roadmap reflect both current policies and new directions that reflect the best ideas, approaches, and available technologies. While these strategies and actions are significant in increasing uptake of clean, renewable energy, achieving approximately 40% by 2030, this still falls short of meeting the 2030 and 2050 targets in this Roadmap. Metro Vancouver and its partners will continue to explore opportunities to further accelerate uptake of clean, renewable energy during the detailed planning and implementation of the actions. Thus, the Roadmap should be viewed as an iterative, dynamic path forward – as new policies, ideas, approaches, and technologies emerge, Metro Vancouver will update this Roadmap, and the other *Climate 2050 Roadmaps*, to enable further progression towards the established goal and targets.

Reaching these ambitious goals will also require extensive collaboration between Metro Vancouver and key partners. Many of the actions identified in this Roadmap will be led by other governments and agencies (e.g., national, provincial, local), First Nations, energy utilities, and industry. Fortunately, many of the organizations needed to make this transition are already actively working toward similar goals, beginning with Metro Vancouver member jurisdictions and their community and corporate plans, the Government of BC and its *CleanBC Roadmap to 2030* plan, the Government of Canada and its 2030 Emissions Reduction plan, as well as First Nations, energy utilities, and, increasingly, industry associations.

Clean, Renewable Energy Strategies

Strategy 1: Plan for the Transition to Clean, Renewable, and Resilient Energy

Achieving a carbon neutral region by 2050 will require that the region transitions to clean, renewable, and resilient sources of energy. Having a comprehensive plan will help ensure that the transition is successful, fair, and equitable. As energy regulators, the BC Utilities Commission and the BC Oil and Gas Commission can ensure that energy utilities are planning to meet *CleanBC* and *Climate 2050* objectives. The BC Government will also play an instrumental role in developing the regulatory framework that enables the utilities to plan for the energy transition.

1.1 Align British Columbia's Energy Objectives with Strong Climate Action.

BIG Move

Work with the BC Government, member jurisdictions, First Nations, and the BCUC, on updating BC's energy objectives within the *Clean Energy Act* to reflect strong action on climate change, in alignment with the goals and targets outlined in this Roadmap and the *CleanBC Roadmap to 2030*. This could include: greenhouse gas reduction requirements for all utilities, such as the natural gas utilities emission cap announced in the *CleanBC Roadmap to 2030*; targets for energy efficiency and conservation for all utilities; increases to the amount of electricity in BC sourced from clean or renewable resources; changes to the definition of affordable rates; and changes to how utilities can recover costs.

1.2 Strong Climate Mandate for Energy Utilities.

BIG Move

Advocate to the BC Government to update the *Utilities Commission Act* to ensure that that the BCUC regulates public utilities in a manner that ensures their compliance with, and appropriate contribution to achieving, the updated energy objectives in the *Clean Energy Act*, as per Action 1.1.

1.3 Revise Utility Regulation to Align with Strong Climate Action.

Advocate to the BC Government to revise and in some cases, repeal, outstanding regulations and directions applying to public utilities and regulators, to ensure that they align clearly and directly with the updated energy objectives as per Action 1.1.

BIG Move **Big Moves** are foundational to achieving the 2030 and 2050 targets, and should lead to the most significant greenhouse gas reductions and/or climate resilience.

Corporate LEADERSHIP **Corporate Leadership** actions are ones Metro Vancouver will implement in its corporate operations to demonstrate leadership and support regional actions.

CAP **Clean Air Plan** actions are ones adopted within Metro Vancouver's Clean Air Plan.

1.4 Long-term Planning Scenarios for the Transition to 100% Clean, Renewable Energy.

Advocate to the BC Government, the BCUC, and the energy utilities, to include multiple, coordinated long-term planning scenarios within their long-term resource plans, including a scenario with accelerated electrification and declining gas demand. The plans should include strategies to mitigate rate impacts and reduce risk of stranded assets.

1.5 Regional Climate Action in Energy Utility Regulatory Processes.

Work with member jurisdictions and First Nations to provide input to relevant BCUC and BCOGC proceedings related to regional and/or municipal climate policy. Input would focus on evaluating the impact of projects, programs, and rates proposed by regulated entities and assess whether they align with regional climate and municipal climate policy and the updated energy objectives as per Action 1.1.

1.6 Implement Tracking, Verification, and Reporting Requirements for Renewable Natural Gas Supply.

Advocate to the BC Government to implement tracking, verification, and reporting requirements for renewable gas supply, in line with systems that have been implemented in leading jurisdictions such as California. Tracking, verification, and reporting requirements will guarantee integrity of the environmental attributes associated with renewable natural gas supply, and mitigate risks of double-counting.

1.7 Reduce Energy Poverty.

Work with the BC Government, the BCUC, energy utilities, member jurisdictions, and First Nations, on reducing the number of households in energy poverty, particularly racialized, recent immigrant, and Indigenous households, through equitable policy design, targeted programs and incentives, and inclusive engagement.

1.8 Transition Corporate Energy Use to 100% Clean, Renewable Energy.

Corporate LEADERSHIP

Transition Metro Vancouver's corporate energy use to 100% clean, renewable energy between 2035 and 2040, such as energy use from buildings, on-road fleet, non-road fleet, and industrial facilities.

Strategy 2: Accelerate Electrification

Electrification is a key decarbonization strategy to meet emission reduction targets. Technologies that use electricity can have critical co-benefits such as improved air quality, cooling benefits, and reduced noise pollution – making it a priority pathway for achieving significant greenhouse gas reductions. While electricity is currently widely used, there may be infrastructure constraints for electricity supply that need to be resolved as large parts of the region electrify. To address these constraints, BC Hydro is exploring a number of programs that will support electrification and reduce demand on the electrical grid, such as time-of-use electricity rates and related demand response programs. Success of these programs will require adoption of smart technologies by BC Hydro, residents, and businesses.

2.1 Electrification Rates.

Advocate to BC Hydro, the BC Government, and the BCUC to enable rate structures that support electrification in alignment with BC Hydro's Electrification Plan, including discounted rates for customers who adopt heat pumps and discounted rates for households that struggle with meeting home energy needs, particularly Indigenous households. These rates should be combined with additional funding to promote electrification, as outlined in Action 2.1 in the *Climate 2050 Buildings Roadmap* and Actions 2.3, 2.6, 3.5 and 3.8 in the *Climate 2050 Transportation Roadmap*.

2.2 Time-of-Use Rates, Demand Response Programs, and Electric Vehicle Peak Reduction Programs.

Advocate to BC Hydro and the BC Government to implement time-of-use rates, demand response programs, and electric vehicle peak reduction programs, as outlined in BC Hydro's 2021 Integrated Resource Plan. This will help reduce the amount of new electrical generation required in BC and help some customers save on their energy bills. This would be supported by increasing public awareness of these programs, as outlined in Action 2.7 in the *Climate 2050 Buildings Roadmap* and Action 2.7 in the *Climate 2050 Transportation Roadmap*.

2.3 Modernizing the Electrical Grid.

Work with BC Hydro on modernizing their grid to support accelerated electrification and resiliency. Grid modernization will enhance the BC Hydro's ability to support electrification initiatives and enable the grid to be more resilient, flexible, and reliable.

2.4 Regional Grid Constraints.

Work with BC Hydro, member jurisdictions, and First Nations to address areas of the electrical grid in Metro Vancouver where grid capacity would limit current and future electrification, thus requiring substantial costs for upgrades. Overcoming regional grid constraints will support accelerated electrification.

2.5 High Performance Heating and Cooling Equipment Import and Sale Standards.

Advocate to the Government of Canada and the BC Government to establish energy efficiency standards for new and imported heating and cooling equipment that has a rated energy performance of 100% or more and minimum greenhouse gas requirements for refrigerants, by 2030. This would ensure that buildings are conserving energy while reducing emissions.

2.6 Minimize Air, Land, and Water Impacts.

Work with the BC Government, member jurisdictions, and First Nations to ensure that land and water impacts are minimized in new clean, renewable electricity generation, transmission, and distribution. This would include impacts on biodiversity and agriculture.

Strategy 3: Increase Sustainable Production of Low Carbon Biofuels and Hydrogen

Biofuels and hydrogen can help decarbonize difficult-to-electrify sectors, such as industrial processes and goods movement. However, there is currently a limited supply of sustainable biofuels and hydrogen, and thus a need to increase production while avoiding unintended impacts. There are opportunities within the region to sustainably produce biofuels from organic waste feedstock (i.e., liquid waste, solid waste, and agricultural waste). Increasing biofuel production from these sustainable sources will greatly support the transition to clean, renewable energy.

3.1 More Stringent Low Carbon Fuel Standards.

Advocate to the BC Government to further increase the stringency of the BC *Low Carbon Fuel Standard* to reduce the carbon intensity of transportation fuels, primarily through increasing use of renewable diesel and ethanol. Advocate to the Government of Canada to further tighten the federal *Clean Fuel Standard* to include more stringent carbon intensity targets for all transportation fuels.

3.2 Implement Renewable Gas Content Requirements.

Advocate to the BC Government to establish content requirements for renewable gas, in line with targets in the provincial *CleanBC* plan. Renewable gas includes renewable natural gas, which has a lower carbon intensity than natural gas from fossil fuels.

3.3 Prioritize Sustainability in Biofuel Feedstock.

Work with the BC Government and the Government of Canada to ensure that feedstock for biofuel production is sourced sustainably and responsibly. This would include impacts on biodiversity and agriculture.

3.4 Regional Hydrogen Hub.

Work with the BC Government, Canadian Hydrogen Fuel Cell Association, B.C. Centre for Innovation and Clean Energy, member jurisdictions, First Nations, and other regional partners on the development of a regional hydrogen hub in Metro Vancouver, in alignment with the *BC Hydrogen Strategy*. A regional hydrogen hub would co-locate low carbon hydrogen production and end-use applications, such as industrial users, to spur and grow hydrogen supply and demand.

3.5 Regional Sources of Liquid Biofuels.

Explore opportunities and air quality impacts for regional production of liquid biofuels, such as renewable diesel, from organic feedstock.

3.6 Develop Local Sources of Sustainable Aviation Fuel.

Support airlines at the Vancouver International Airport and other regional partners in increasing local availability of sustainable aviation fuel.

3.7 Streamline Emission Requirements for Anaerobic Digestion Facilities.

Develop an emission regulation for anaerobic digestion of manure, other agricultural waste, and commercial food waste. The regulation would maintain equivalent protections for regional air quality and human health as the existing permit process, and would provide a simpler path to regulatory compliance.

3.8 Expand Anaerobic Digestion of Agricultural Waste.

CAP

Advocate to the BC Government, the Government of Canada, energy utilities, member jurisdictions, and First Nations to expand development of anaerobic digestion facilities to process manure, other agricultural waste, and commercial food waste. This could include funding (e.g., incentives, tax credits, loans) and removal of barriers in existing regulations. Any expansion should avoid the loss of agricultural land in Metro Vancouver.

3.9 Phase Down Use of Thermal Coal and Petroleum Coke.

Develop regulatory requirements for industrial facilities to phase down the usage of thermal coal and petroleum coke in the region by 2030. This could support industrial facilities in transitioning to low carbon energy sources, such as biofuels, to meet greenhouse gas reduction requirements, as outlined in Action 3.1.2 within the *Clean Air Plan*.

3.10 Metro Vancouver as a Regional Clean, Renewable Energy Provider.

Corporate LEADERSHIP

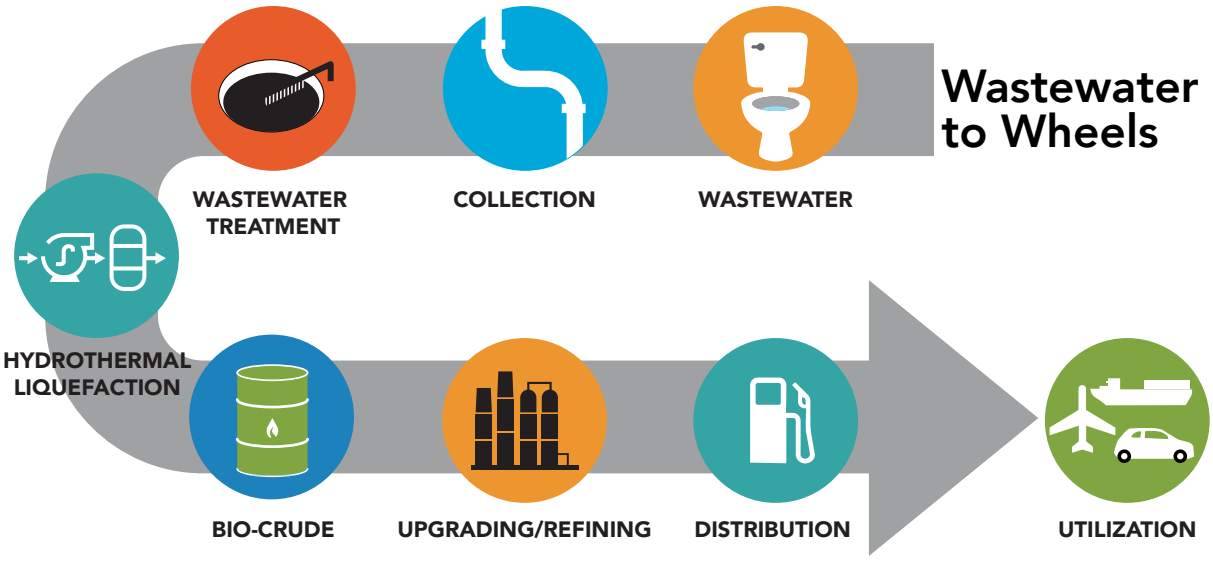
Increase provision of clean, renewable energy, such as waste heat, electricity, biofuels, and hydrogen, to the region. Metro Vancouver manages various waste streams, such as liquid waste, organic food waste, and construction and demolition waste, that can be used to produce clean, renewable energy, while adhering to the concepts of a circular economy.

3.11 Innovative Research on Optimizing Energy Recovery from Waste Streams.

Corporate LEADERSHIP

Conduct innovative research on optimizing energy recovery from waste streams to advance technical knowledge and commercial availability of potentially industry-changing technologies.

DESCRIPTION OF THE HYDROTHERMAL LIQUEFACTION PROCESS THAT METRO VANCOUVER IS PILOTING



Strategy 4: Limit Expansion of Fossil Fuel Production

To limit global warming to 1.5 degrees Celsius, the world will need to limit expansion of fossil fuels as well as accelerate the transition to clean, renewable energy. Limiting expansion of fossil fuel production will support global climate action as well as reduce the potential of stranded assets in a carbon neutral future.

4.1 Account for the Full Climate Impact of Fossil Fuel Production and Export Projects.

Advocate to the BC Government and the Government of Canada to acknowledge through a policy statement that any new fossil fuel production and export projects (coal, oil, natural gas, liquefied natural gas), or expansions to fossil fuel production and export sites are likely to cause unacceptable environmental effects, such as climate change. This policy statement will help inform provincial and federal ministers in determining whether these types of projects are in the public interest and whether they hinder or contribute to BC's and Canada's ability to meet its commitments in respect of climate change, as required under the federal *Impact Assessment Act* and BC *Environmental Assessment Act*. This will also support Metro Vancouver in assessing the full climate impact of projects located within the region, which can include impact on regional and global emissions.

4.2 Eliminate Subsidies and Public Financing for Fossil Fuels.

Advocate to the Government of Canada to eliminate fossil fuel subsidies by 2023, develop a plan to phase out public financing of the fossil fuel sector, and eliminate flow-through shares for oil, gas and coal projects, as announced in the Deputy Prime Minister and Minister of Finance's 2022 **Mandate Letter**.

4.3 Just Transition Plan for Workers and Communities Engaged in the Fossil Fuel Industry.

Advocate to the BC Government to develop a Just Transition Plan with extensive stakeholder input, that will complement the *CleanBC Roadmap to 2030* and *Climate 2050 Roadmaps* to develop actionable recommendations that ensure that workers and communities engaged in the fossil fuel industry are not left behind in the transition to clean, renewable energy.

Resilient Energy Strategies

Strategy 5: Protect Existing Energy Systems from Current and Future Climate Impacts

While reducing regional emissions will contribute to the global effort against climate change, some impacts from a changing climate are locked in and are likely to occur even with deep emission reductions. Rising sea levels, increased frequency and severity of riverine flooding, and more frequent and intense heatwaves, wildfires, and droughts are already impacting our energy system, and are likely to continue to impact regional energy networks. Much of our critical energy infrastructure will remain standing for decades, but has not been designed to withstand impacts from changing climate hazards. Identifying current and future climate impacts, and protecting and upgrading existing energy infrastructure from the hazards posed by these impacts, is essential to maintaining a resilient energy system. Reducing vulnerability of critical regional infrastructure, such as improving backup power systems, can limit impacts caused by disruption to the energy system.

5.1 Comprehensive Climate Risk and Vulnerability Assessment.

BIG Move

Work with the BC Government, member jurisdictions, First Nations, and energy utilities in the region to complete a comprehensive regional climate risk and vulnerability assessment that would support a more coordinated approach to climate adaptation in the region. This could complement or include other regional vulnerability assessments, such as those outlined in Action 6.4 in the *Climate 2050 Buildings Roadmap* and Action 6.5 in the *Climate 2050 Transportation Roadmap*.

5.2 Prepare for Regional Disruption due to Extreme Weather Events.

Work with the BC Government, member municipalities, First Nations, energy utilities, and other regional partners responsible for emergency management and response, to develop and maintain climate change adaptation plans that establish protocols to respond to, and rapidly recover from, disruption to the regional energy system due to severe climate-related weather events.

5.3 Protect and Increase Resilience of Existing Regional Energy Generation Infrastructure.

Work with member jurisdictions, First Nations, local businesses, and energy utilities to increase the resilience of generation infrastructure, such as cogeneration facilities and district energy systems, and ensure they are protected from current and future climate impacts.

5.4 Protect and Increase Resilience of Existing Energy Distribution Infrastructure.

Work with the BC Government, member jurisdictions, First Nations, and energy utilities to ensure that regional energy distribution infrastructure, such as electrical substations, power lines and pipelines, are protected from current and future climate impacts.

5.5 Ensure Critical Regional Infrastructure has Backup Power.

Work with member jurisdictions, First Nations, and energy utilities to ensure that critical regional infrastructure have access to backup power, ideally low-carbon, to minimize interruptions to essential services during climate-related weather events.

Strategy 6: Build New Energy Systems that are Climate Resilient

In addition to protecting critical energy infrastructure and networks, steps must also be taken proactively to build a more resilient energy system. Climate change adaptation needs to be considered during the location, construction, maintenance, and operation of new energy infrastructure to avoid creating vulnerabilities that make adaptation more difficult and expensive in the future. Design standards with updated climate projections should be employed to ensure resiliency is integrated into the design of new energy infrastructure. Proactive work should be undertaken to foster innovation and develop technologies that support a climate resilient energy system.

6.1 Design for Climate Resilient Energy Infrastructure.

Work with the BC Government, member jurisdictions, First Nations, and energy utilities and their regulatory bodies to ensure that all newly constructed and retrofitted energy infrastructure, including generation, transmission, and distribution infrastructure, are designed to be resilient to current and future impacts of climate change.

6.2 Pilot Innovative Renewable Energy + Storage Systems to Improve Resiliency.

Work with member jurisdictions, First Nations, and energy utilities in piloting innovative renewable energy + storage systems to improve resiliency, such as home solar plus battery systems or using excess grid electricity to produce hydrogen.

6.3 Vehicle-to-Grid Technologies.

Corporate LEADERSHIP

Work with BC Hydro and other interested electric vehicle infrastructure owners to pilot test the viability and utility of bi-directional vehicle chargers with zero-emission vehicles. Using electric vehicles as decentralized batteries could help reduce the need for new electricity generation and increase resiliency in the electrical grid during periods of increased demand or system disruption.

PORT MOODY

ALDERGROVE REGIONAL PARK

Setting the Path Ahead

The "Setting the Path Ahead" section will eventually be found on Metro Vancouver's Climate 2050 webpages under "Energy," and will serve as a companion to the *Energy Roadmap*. This will allow Metro Vancouver to track progress towards targets, and add and adjust strategies and actions in response to performance measurement.

Electricity is one of the most important sources of clean, renewable energy for significant early reductions of greenhouse gases in the region, particularly for buildings and personal transportation. Electric air-source heat pumps and electric vehicles are becoming readily available and deployable on a large scale. It is critical that the actions identified in this Roadmap support both faster uptake of electric technologies and support BC Hydro in scaling up electricity supply and modernizing the grid. Taking early action to reduce emissions can also help improve air quality and enhance resilience in energy systems, which will ensure that energy supply is resilient to changing climate conditions and increased prevalence of extreme weather events.

As large parts of the economy electrify, there will be some sectors that will be difficult-to-electrify, such as some existing buildings, industrial processes, and goods movement. Action that supports rapid development and scale-up of zero emission and low carbon options for these sectors is needed to ensure that the energy system can transition to 100% clean, renewable energy by 2050.

The timeline below includes all of the actions included in this Roadmap. Although there is much work to be done, there are some critical actions that, if started over the next few years, will make a major difference to accelerating the region's transition to clean, renewable, and resilient energy.

CLIMATE 2050 ENERGY ROADMAP ACTION TIMELINE

STRATEGY	2022-2024	2025-2029	2030-BEYOND
Plan for the Transition to Clean, Renewable, and Resilient Energy	Align British Columbia's Energy Objectives with Strong Climate Action		
	Strong Climate Mandate for Energy Utilities		
	Revise Utility Regulation to Align with Strong Climate Action		
	Long-term Planning Scenarios for the Transition to 100% Clean, Renewable Energy		
	Regional Climate Action in Energy Utility Regulatory Processes		
	Implement Tracking, Verification, and Reporting Requirements for Renewable Natural Gas Supply		
	Reduce Energy Poverty		
	Transition Corporate Energy Use to 100% Clean, Renewable Energy		
Accelerate Electrification	Electrification Rates		
	Time-of-use Rates, Demand Response, and Electric Vehicle Peak Reduction Programs		
		Modernizing the Electrical Grid	
	Regional Grid Constraints		
	High Performance Heating and Cooling Equipment Import/Sale Standards		
	Minimize Air, Land, and Water Impacts		
Increase Sustainable Production of Low Carbon Biofuels and Hydrogen		More Stringent Low Carbon Fuel Standards	
	Implement Renewable Gas Content Requirements		
	Prioritize Sustainability in Biofuel Feedstock		
	Regional Hydrogen Hub		
		Regional Sources of Liquid Biofuels	
	Develop Local Sources of Sustainable Aviation Fuel		
		Streamline Emission Requirements for Anaerobic Digestion Facilities	
	Expand Anaerobic Digestion of Agricultural Waste		
	Phase Down Use of Thermal Coke and Petroleum Coke		
	Metro Vancouver as a Regional Clean, Renewable Energy Provider		
	Innovative Research on Maximizing Energy Recovery from Waste Streams		
Limit Expansion of Fossil Fuel Production	Account for the Full Climate Impact of New Fossil Fuel Production and Export Projects		
	Eliminate Subsidies and Public Financing for Fossil Fuels		
	Just Transition Plan for Workers and Communities Engaged in the Fossil Fuel Industry		
Protect Existing Energy Systems from Current and Future Climate Impacts	Comprehensive Climate Risk and Vulnerability Assessment		
	Prepare for Regional Disruption due to Extreme Weather Events		
	Protect and Increase Resilience of Existing Regional Energy Generation Infrastructure		
	Protect and Increase Resilience of Existing Energy Distribution Infrastructure		
	Ensure Critical Regional Infrastructure has Backup Power		
Build New Energy Systems that are Climate Resilient	Design for Climate Resilient Energy Infrastructure		
		Pilot Innovative Renewable Energy + Storage Systems to Improve Resiliency	
		Vehicle-to-grid Technologies	

Measuring our Progress

The table below lists examples of some of the performance indicators that could be used to help Metro Vancouver measure regional progress towards meeting the targets set out for this purpose. The performance indicators used will depend, to some extent, on the availability of this information from other organizations.

Because the *Energy Roadmap* is calling for actions from many different partners and stakeholders, data sharing will be foundational to understanding the pace of progress towards our common goals, and will help governments to continue to shape equitable and cost-effective pathways to a carbon neutral future. While much of the data needed to measure progress in on-road transportation are already collected, there are significant data gaps for rail, marine, and air transportation. Additional work is underway to understand what key performance indicators and data effectively measure progress towards regional resilience (noted in the table below as "TBD").

ROADMAP ELEMENT	KEY PERFORMANCE INDICATOR	DATA SOURCE	DATA IS CURRENTLY COLLECTED
Regional Clean, Renewable Energy Use	Percentage of clean, renewable energy used	Regional GHG inventory	Yes
	tCO2e from regional energy use	Regional GHG inventory	Yes
	Energy use by type (GJ)	Metro Vancouver BC Hydro FortisBC BC Government	Partial
Plan for the Transition	tCO2e from regional electricity use	BC Hydro Local & BC Governments	Partial
	tCO2e from regional gas use	FortisBC	Yes
	Thermal coal and petroleum coke use in industrial processes (GJ)	Regional GHG Inventory	Yes
	Renewable energy supplied by MV	Metro Vancouver	Yes
Accelerate Electrification	Number of high-efficiency electric equipment installed	Shelf/Industry surveys	No
	Number of new buildings with low carbon energy systems	Local government building permits	Yes
	Regional vehicle fleet make up by engine type: internal combustion, electric, hybrid, hydrogen (number of vehicles, % of total regional vehicle stock)	ICBC Metro Vancouver TransLink	Yes
	Number of electric vehicle chargers	Municipalities BC Government Charging service providers	Yes
	Regional equipment registration by model year, engine tier and fuel type (GJ)	Metro Vancouver – Non Road Diesel Engine Emission Regulation Port of Vancouver	Partial

ROADMAP ELEMENT	KEY PERFORMANCE INDICATOR	DATA SOURCE	DATA IS CURRENTLY COLLECTED
Sustainable Production of Low Carbon Biofuels and Hydrogen	Biofuels used in-region (GJ)	Regional GHG Inventory	Partial
	Sustainable feedstock used, associated with biofuel consumption in region (tonnes)	BC Government Government of Canada Market research firms	No
	Kilometres travelled by aircraft using zero or low emission fuels (km, % of total km travelled)	Transport Canada Regional airports Airlines	No
	Number of in-region anaerobic digestion facilities	Metro Vancouver	Yes
	Biofuel production from Metro Vancouver facilities (GJ)	Metro Vancouver	Yes
Limit Expansion of Fossil Fuel Production	Number of new, in-region, completed projects related to new or expanded fossil fuel production and export	Metro Vancouver Industry Surveys	Partial
Protect Existing Energy Systems	TBD	TBD	TBD
	TBD	TBD	TBD
	TBD	TBD	TBD
Build New Climate Resilient Energy Systems	TBD	TBD	TBD
	TBD	TBD	TBD

Glossary

Biodiesel is made from vegetable oils (such as canola) and waste animal fats. It can be blended in fossil diesel in amounts up to 20% and used in conventional diesel engines.

Biofuels are produced using organic matter derived from biomass such as plants. Biofuels can be gaseous, liquid, or solid. Common biofuels include biodiesel, renewable diesel, ethanol, renewable natural gas, firewood, and wood pellets.

Carbon neutral region is a region that has achieved the deepest greenhouse gas emissions reductions possible across all economic sectors and removes or captures sufficient carbon dioxide to balance any remaining regional greenhouse gas emissions.

Clean, renewable energy is derived from sources with low or zero emissions or from sources that can be replenished over days or years.

Climate change adaptation means anticipating, planning for, and responding to the adverse effects of climate change and taking appropriate action to prevent or minimize the damage it can cause, or taking advantage of opportunities that may arise. It has been shown that well-planned, early adaptation action saves money and lives later.

Climate resilience describes the capacity of ecosystems, economies, infrastructure, and communities to absorb the impacts of climate change while maintaining essential services and functions needed to support health and well-being. In some cases, climate resilience involves changing services and functions so they are more sustainable.

Combustion refers to the process of burning a fuel to make energy.

Common air contaminants are air contaminants that can harm public health and reduce residents' quality of life and life expectancy by causing heart and lung diseases, cancer, asthma, and other impacts. Common air contaminants include fine and coarse particulate matter, ground-level ozone, nitrogen dioxide, and sulphur dioxide.

Electrical grid is the network through which electricity is generated, transmitted, and distributed to the end user. The electrical grid includes electrical generation infrastructure, such as hydroelectric dams, and transmission and distribution infrastructure, such as transformers, substations, and power lines.

Ethanol is the most common renewable alternative to gasoline. Made from plants such as corn or sugar cane, it can be blended up to 10% in regular gasoline used in conventional gasoline engines.

Fine particulate matter ($PM_{2.5}$) is made up of tiny solid or liquid particles that float in the air and can penetrate deep into the lungs and even into the bloodstream. Fine particulate matter can damage people's health by aggravating existing lung and heart diseases, increasing the risk of cancer and reducing life expectancy.

Fossil natural gas, sometimes called natural gas, is a fossil fuel composed of mostly methane, about 95% by volume. Combustion of fossil natural gas generates greenhouse gas emissions.

Fugitive emissions are unintended discharges to the atmosphere resulting from accidental release or leaks.

Greenhouse gases are air contaminants that trap heat and are the cause of climate change. Greenhouse gases include carbon dioxide and nitrous oxide as well as short-lived climate forcers such as methane, halocarbons, black carbon, and ozone. Limiting or preventing greenhouse gas emissions and removing these gases from the atmosphere is critical to avoiding catastrophic climate change (sometimes referred to as climate change mitigation).

Ground-level ozone (O_3) can have harmful impacts on everyone, especially children, seniors, and people with lung and heart conditions. It is primarily formed when nitrogen oxides and volatile organic compounds react in the air on hot and sunny days.

Hazard refers to a dangerous phenomenon, substance, human activity, or condition. In this context, hazards are caused or made worse by climate change. Examples include rainstorms, extreme weather, wildfires, storm surges, landslides, and floods.

Impacts refers to the consequences of realized risks on ecosystems, economies, infrastructure and communities. Impacts may be referred to as consequences or outcomes, and can be adverse or beneficial.

Lifecycle greenhouse gas emissions refers to all greenhouse emissions associated with the production, distribution, and use of a particular energy source, from feedstock extraction, processing, transportation, to end-use. For example, lifecycle emissions of gasoline would span all associated emissions, from extraction of oil from the ground until combustion in a vehicle.

Microgrids refers to systems composed of electrical loads and distributed energy generation resources, that are interconnected through an electrical grid. Microgrids have the ability to operate independently from the central electrical grid, so can remain operating during regional power outages.

Natural gas, referred to as fossil natural gas in this Roadmap, is a fossil fuel composed of mostly methane, about 95% by volume. Combustion of natural gas generates greenhouse gas emissions.

Nitrogen dioxide (NO_2) can damage people's health by aggravating existing lung diseases like asthma and bronchitis and reducing immunity to lung infections. It is formed during high-temperature fuel combustion.

Renewable diesel is also made from vegetable oils and animal fats, but using a different process that makes the end fuel nearly identical to regular diesel. It can be used directly in conventional diesel engines without requiring engine modifications.

Renewable gas is gas produced from renewable resources. This primarily includes green hydrogen, waste hydrogen, and renewable natural gas.

Renewable natural gas is a gaseous biofuel that is mostly composed of methane; it is produced primarily from anaerobic digestion of organic feedstock (such as food, agricultural, and forestry waste).

Social Equity is the promotion of fairness, justice, and the removal of structural barriers that may cause or aggravate disparities experienced by different groups of people.

Stranded assets are assets that have suffered from unanticipated or premature write-downs, devaluation, or conversion to liabilities.

Vulnerability is the degree to which ecosystems, economies, infrastructure, and communities are susceptible to, or unable to cope with, the adverse effects of climate change. Vulnerability varies based on exposure, sensitivity, and adaptive capacity. Geographic location, socio-economic conditions, and other factors can impact susceptibility to harm and adaptive capacity.

Vulnerability assessments identify areas or populations most likely to be impacted by projected changes in climate and build an understanding of why these areas are vulnerable, including the interaction between climate change, non-climatic stressors, and cumulative impacts. Assessments evaluate the effectiveness of previous coping strategies and target potential adaptation measures.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