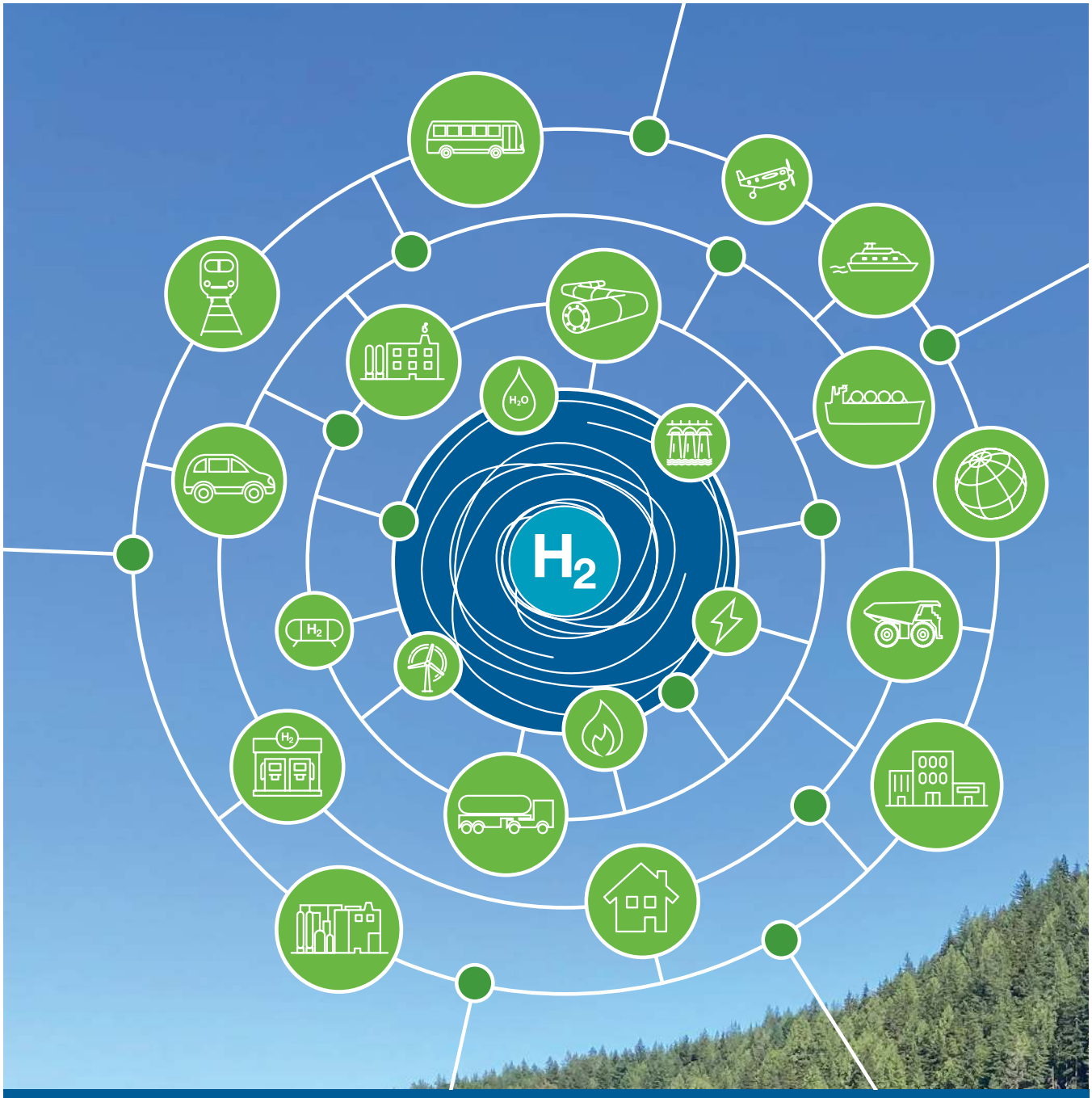


B.C. Hydrogen Strategy

A sustainable pathway for B.C.'s energy transition

BRITISH COLUMBIA

cleanBC
our nature. our power. our future.

"For British Columbia to meet its CleanBC goals, we must shift how we produce and consume energy. Renewable and low-carbon hydrogen will play a critical role in our sustainable energy future. With our clean hydroelectricity, abundant natural resources and innovative companies, B.C. can be a world leader in the growing hydrogen economy – creating new cleantech jobs and opportunities for people across the province. The B.C. Hydrogen Strategy lays out the actions we will take together to realize this vision on the path to net-zero emissions by 2050."

Honourable Bruce Ralston
Minister of Energy, Mines
and Low Carbon Innovation

H_2

Powering our transition to a lower-carbon future

"Hydrogen energy is essential to achieving carbon neutrality by 2050 and limiting global warming to less than two degrees Celsius. Canada is fortunate in that we not only have a leading fuel cell sector centred in B.C., but also leading hydrogen technology and production companies. This represents a huge opportunity for B.C. to produce the significant quantities of hydrogen that will be needed at home and abroad from our abundant, low-cost renewable power and also, when coupled with CO_2 sequestration, from our natural gas resource. Hydrogen will enable B.C. industries – from ports to trucking and mining to urban transportation – to thrive in a carbon-constrained world."

– Mark Kirby, President & CEO
Canadian Hydrogen and Fuel Cell Association

"Renewable electricity can help reduce emissions in road transport, low-temperature industrial processes and in heating buildings. However, fossil fuels have a significant advantage in applications that require high energy density, industrial processes that rely on carbon as a reactant, or where demand is seasonal. To fully decarbonize the world economy, it's likely a clean molecule will be needed and hydrogen is well placed to play this role. It is versatile, reactive, storable, transportable, clean burning and can be produced with low or zero emissions."

– BloombergNEF, *Hydrogen Economy Outlook*

"A huge step in the fight against climate change has been taken, as both governments and investors now fully grasp the role hydrogen can play in the energy transition. Now, to bring this potential to its full fruition, governments, investors and industrial companies must work together to scale up the hydrogen ecosystem around the world. Their collaboration in the coming months will allow for many of the projects around the world to become a reality and to turn hydrogen into a new, clean, abundant and competitive energy carrier,"

- Benoît Potier, Chairman and CEO of Air Liquide
and Co-Chair of the Hydrogen Council

"There is significant momentum building globally for the development and deployment of fuel cells and hydrogen at commercial scale. Numerous countries in Asia, the Americas, Europe and Africa have national hydrogen strategies or initiatives in place, some with medium- and long-term deployment targets – all with a view to addressing societal issues including energy security and resiliency, economic growth and innovation, and environmental goals."

– Tim Karlsson,
Executive Director of the
International Partnership
for Hydrogen and Fuel Cells
in the Economy

"Hydrogen can help overcome many difficult energy challenges. It can decarbonize hard-to-abate-sectors like steel, chemicals, trucks, ships and planes. Hydrogen can also enhance energy security by diversifying the fuel mix and providing flexibility to balance grids."

- Fatih Birol, Executive
Director of the International
Energy Agency

Contents

Executive summary

British Columbia is committed to achieve net-zero emissions by 2050. It is an ambitious target given that two-thirds of the energy we use for transportation, buildings and industry currently comes from fossil fuels. Meeting our CleanBC goals requires a determined effort to increase energy efficiency, electrify the economy and switch to low-carbon fuels such as biofuels and hydrogen.

When burned or used in a fuel cell, hydrogen produces no carbon emissions. Large-scale deployment of renewable and low-carbon hydrogen will play an essential role in reducing B.C.'s emissions. Independent estimates suggest that hydrogen has the potential to reduce annual emissions by 7.2 megatonnes by 2050 – equivalent to 11% of the province's 2018 emissions.[1]

Because of its versatility, hydrogen is one of the only solutions for decarbonizing sectors of the economy where direct electrification is not practical, such as heavy-duty transportation and industrial heat. Hydrogen can be used in fuel cells to produce energy for transportation and stationary power systems, especially important for industrial sites and remote communities powered by diesel. When blended into the natural gas grid, hydrogen can displace fossil fuels to heat and power our homes and buildings. Hydrogen can also be used for producing low-carbon synthetic fuels to reduce emissions in transportation and industry.

Realizing the potential of hydrogen requires government, industry and researchers to work together. As part of CleanBC, the B.C. Hydrogen Strategy outlines the Province's plan to accelerate the production and use of renewable and low-carbon hydrogen and be a world leader in the growing hydrogen economy.

The strategy includes 63 actions to undertake over the short term (2020-2025), medium term (2025-2030) and long term (2030-beyond). These include:

- incentivizing the production of renewable and low-carbon hydrogen;
- developing regional hydrogen hubs where production and demand are co-located;
- financial supports for deploying fuel cell electric vehicles and infrastructure;
- expanding the use of hydrogen across different industrial sectors and applications;
- promoting the adoption of hydrogen in areas where it is most cost-effective in terms of emission reductions;
- creating the B.C. Centre for Innovation and Clean Energy to drive the commercialization of new hydrogen technology; and
- establishing ambitious carbon-intensity targets and a regulatory framework for carbon capture and storage.

B.C. has already implemented robust policies to encourage hydrogen use in the transportation sector. B.C.'s carbon tax and low carbon fuel standard (LCFS) are reducing emissions while incentivizing the switch to renewable and low-carbon fuels. CleanBC committed to increasing the stringency of the LCFS by doubling the required reduction in carbon intensity of transportation fuels to 20% by 2030. Introduced in 2019, the *Zero-Emission Vehicles Act* requires automakers to meet an escalating annual percentage of new light-duty zero-emission vehicle sales, including hydrogen fuel cell electric vehicles. Hydrogen is expected to play a larger role for medium- and heavy-duty vehicles by supporting larger payloads and range.

[1] Zen and the Art of Clean Energy Solutions, *BC Hydrogen Study - Final Report* (2019).

The Province also recently introduced policies to support the production of hydrogen. In 2021, the Province and BC Hydro introduced the Clean Industry and Innovation Rate to offer discounted electricity for hydrogen production. In addition, recent amendments to the *Greenhouse Gas Reduction Regulation* enable utilities to produce or purchase hydrogen for displacing fossil fuels in the natural gas grid.

Unlike most other jurisdictions, B.C. has the resources to produce both green and blue hydrogen with low carbon intensity. More than 98% of B.C.'s electricity is renewable, allowing us to leverage our clean electricity to produce green hydrogen via electrolysis. B.C. also has low-cost natural gas reserves, significant geological storage capacity and expertise in carbon capture and storage (CCS) technology, giving us the potential to produce blue hydrogen from natural gas with adequate and permanent CCS.

Not all types of hydrogen production are equal in terms of climate benefits. To reduce emissions and decarbonize the economy, the B.C. Hydrogen Strategy must focus on advancing and providing support only for renewable and low-carbon hydrogen pathways, with long-term targets for declining carbon intensity consistent with net-zero emissions by 2050. Our immediate priorities will be to:

- scale-up green hydrogen production using B.C.'s abundant supply of clean, renewable electricity; and
- establish a regulatory framework for CCS to enable blue hydrogen production while ensuring it has similar or lower emissions.

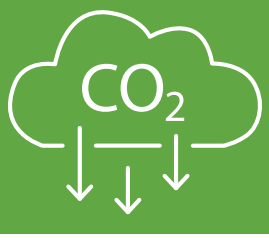
B.C. is already a world leader in hydrogen and fuel cell technology. Provincial support for innovation has led to the creation of a vibrant cluster of companies and expertise in hydrogen. More than half of Canada's companies active in the hydrogen and fuel cell sector are located in B.C. This local expertise has fuelled strong synergies between government, industry and post-secondary institutions.

B.C. is well-positioned to grow its hydrogen sector to meet the increasing demand for low-carbon solutions locally and around the world. Hydrogen is a clean energy solution for powering B.C.'s future as it presents an opportunity to reduce emissions, attract new investment and create skilled, well-paying jobs. Given our proximity to export markets, we could capture a significant portion of the global hydrogen market estimated to be greater than $305 billion by 2050.

Unlocking hydrogen's potential requires acting with urgency and working together to implement the B.C. Hydrogen Strategy. Accelerating the adoption of renewable and low-carbon hydrogen through policy, partnerships, innovation and infrastructure will help us achieve our CleanBC commitments and build a sustainable economy.

Objectives

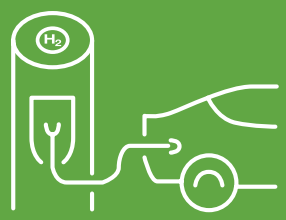
Our vision is to become a world-leading hydrogen economy by 2050.



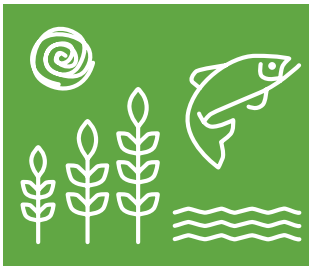
Promote innovation and investment in the production and deployment of hydrogen to achieve the energy system transformation required to meet CleanBC greenhouse gas (GHG) reduction targets

Create economic development opportunities across B.C. through increased and equitable employment in trades, cleantech and energy services

Improve air quality and reduce contamination and noise pollution in urban and remote communities



Make clean energy solutions more diverse, convenient, available and affordable for British Columbians



Fulfil our commitments under the *Declaration on the Rights of Indigenous Peoples Act*

Energy and how it's used in B.C.

Hydrogen can help us make the essential shift away from higher-carbon fuel sources in all sectors, from industrial and transportation through to residential and commercial use.

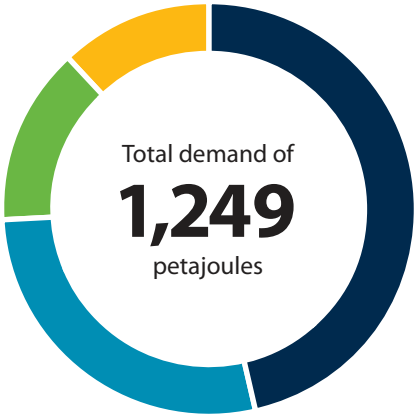
Demand for energy in B.C. is highest in the industrial sector, followed by transportation, residential and commercial use. Hydrogen can be applied to each of these sectors in B.C. and could replace a significant percentage of demand currently met by fossil fuels.

Just under 70% of B.C.'s current energy demand is met through natural gas and refined petroleum products such as gasoline and diesel.[2] Hydrogen will play an important role in helping us transition away from these higher-carbon fuels to a cleaner, low-carbon energy system.

B.C.'s electricity is over 98% clean or renewable. Electrification of the economy is key to achieving our CleanBC goals, including fuel-switching from natural gas and diesel to electricity. But for many sectors that are dependent on these fuels, such as heavy-duty transportation and high-grade industrial heating, direct electrification is not practical. In these cases, hydrogen provides an effective solution.

B.C.'s end-use energy demand by fuel (2017)

- 36% Refined petroleum
- 30% Natural gas
- 18% Electricity
- 15% Biofuels



B.C.'s end-use energy demand by sector (2017)

- 47% Industrial
- 28% Transportation
- 14% Residential
- 12% Commercial

[2] Canada Energy Regulator, Provincial and Territorial Profiles - British Columbia (2019).

B.C.'s leadership in the hydrogen economy

B.C. is a recognized world leader in fuel cell innovation and hydrogen technologies, and the Province is committed to supporting research, development and commercialization in this sector as part of the global effort to reduce emissions.

The Government of British Columbia was an early supporter of fuel cell innovation, and today the province is home to the largest hydrogen and fuel cell sector in Canada, with 51% of companies located here. Their innovations are supported by the cutting-edge research conducted at B.C.'s universities and technical institutes, which are also training the next generation of talent working in this field.

A skilled workforce will be essential for our successful shift to cleaner energy solutions and the Province and industry both have a role to play. By helping shape programs at post-secondary institutions through program advisory committees and work-integrated learning, new graduates will be prepared to enter the workforce and contribute to the growing cleantech economy, including the hydrogen and fuel cell sector.

The synergies arising from industrial, post-secondary and governmental support for hydrogen have created the province's strong hydrogen sector. Exports of B.C. fuel cell and hydrogen technology to Asia, Europe and the US have enabled industry growth and product development. But if we are to fully benefit from the innovative technologies developed in our province, they need to be put to use here in B.C. That means we need to continue to invest and innovate across the sector. Doing so will enable us to realize our GHG reduction targets, remain a world leader in fuel cell innovation and hydrogen technology, and become a leading hydrogen economy.

Hydrogen BC (HyBC)
Fuelling hydrogen innovation in B.C.

Established in 2020 as the B.C. regional branch of the Canadian Hydrogen and Fuel Cell Association, HyBC supports the province's hydrogen energy ecosystem by co-ordinating the deployment of hydrogen infrastructure and applications province-wide. In partnership with the provincial government, HyBC has an initial mandate to promote the rollout of fuel cell electric vehicles and hydrogen fuelling stations. HyBC also works to ensure the safe operation of hydrogen infrastructure by sharing best practices developed in Canada and abroad while working across the province to build demand for low-carbon hydrogen.

Institute for Integrated Energy Systems (IESVic)
A nexus of research and training

Since 1994, IESVic at the University of Victoria has charted feasible pathways to sustainable energy systems by developing technology and training the next generation of changemakers. IESVic was Canada's first major university-industry research partnership focused on fuel cells and hydrogen systems; with support from NSERC, Ballard Power Systems and others, an industrial research chair was created to focus on hydrogen storage and advanced liquefaction. IESVic faculty and students helped establish B.C. and Canada as world leaders in hydrogen and fuel cells, and IESVic continues to be an active research centre in fuel cell modelling, hybrid power trains, storage and techno-economics of the hydrogen economy.

Powertech Labs

Globally renowned for innovation

Wholly owned by BC Hydro, Powertech Labs is a world-renowned testing, consulting, and research and development organization that pioneered the design of turnkey hydrogen fuelling station packages. Powertech's Advanced Transportation group is a preferred partner for global industry leaders that bring hydrogen technologies to market. Powertech has amassed a profile of world firsts, including initiating a collaboration of leading automotive original equipment manufacturers that jumpstarted the development of hydrogen components used in all hydrogen fuel cell vehicles today, to designing and building the world's first fast-fill 70 MPa hydrogen station in Surrey, B.C., to its critical role in hydrogen fuelling protocols used around the world. Powertech will play a central role in the development of B.C.'s hydrogen economy and the successful implementation of the B.C. Hydrogen Strategy given its expertise in hydrogen equipment testing and design, the development of hydrogen codes and standards, hydrogen station and dispensing technology, hydrogen production and purification technologies, and materials testing. Powertech's relationship with BC Hydro and CleanBC will enable the company to maintain a leadership role as the deployment of hydrogen extends from the transportation to the energy sector.

Greenlight Innovation

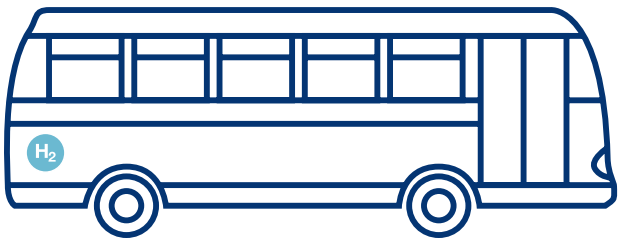
The largest installed base of fuel cell and energy storage testing solutions in the world

Located in Burnaby, Greenlight Innovation is accelerating the shift towards sustainable transport and energy consumption by producing the world's best testing and development equipment for the research and manufacture of fuel cells, electric vehicles and energy storage systems. Since 1992, Greenlight has made the tools required to commercialize alternative energy technologies, and major automotive equipment manufacturers, leading universities and research institutions rely on Greenlight's advanced testing and manufacturing equipment to provide world-class results for their programs.

Ekona Power

Producing low-cost and low-carbon hydrogen from fossil fuels

Ekona is a Vancouver-based venture that is developing a novel methane pyrolysis platform for industrial-scale hydrogen production and natural gas infrastructure that delivers low-cost hydrogen while reducing GHG emissions by over 90%. Ekona's tri-generation pyrolysis solution is a unique combination of two technologies – pulse-methane pyrolysis (PMP) and direct carbon fuel cells (DCFC). Ekona's PMP produces hydrogen at costs comparable to conventional steam methane reformers, with valuable solid carbon as the principal byproduct. Ekona's DCFC efficiently converts byproduct carbon into electricity and pure CO_2, which can be sequestered or utilized.



Producing hydrogen in B.C.

Hydrogen can be produced from many different feedstocks available in B.C., including both fossil fuels and renewable resources.

Hydrogen is the lightest and most abundant element in the universe and is found in compounds such as water (H_2O) and natural gas (CH_4). When hydrogen is split from water or released from organic material, it becomes a versatile energy carrier that can be used in energy systems to generate electricity and heat.

Hydrogen can be produced from fossil fuels, biomass and clean electricity, and it is also a byproduct in some industrial processes. Several hydrogen production pathways are possible in B.C. to meet domestic and/or international demand. Determining how to produce hydrogen efficiently, cost-effectively, at scale and with minimal environmental impact is critical to building supply chains within the province.

Hydrogen production pathways are often represented by colours based on the production process used.

GREEN **hydrogen** is produced from renewable sources, such as using clean electricity (e.g., hydro or wind power) to split water into hydrogen and oxygen through a process called electrolysis. Green (or *renewable*) hydrogen has a low carbon intensity when produced using clean electricity.

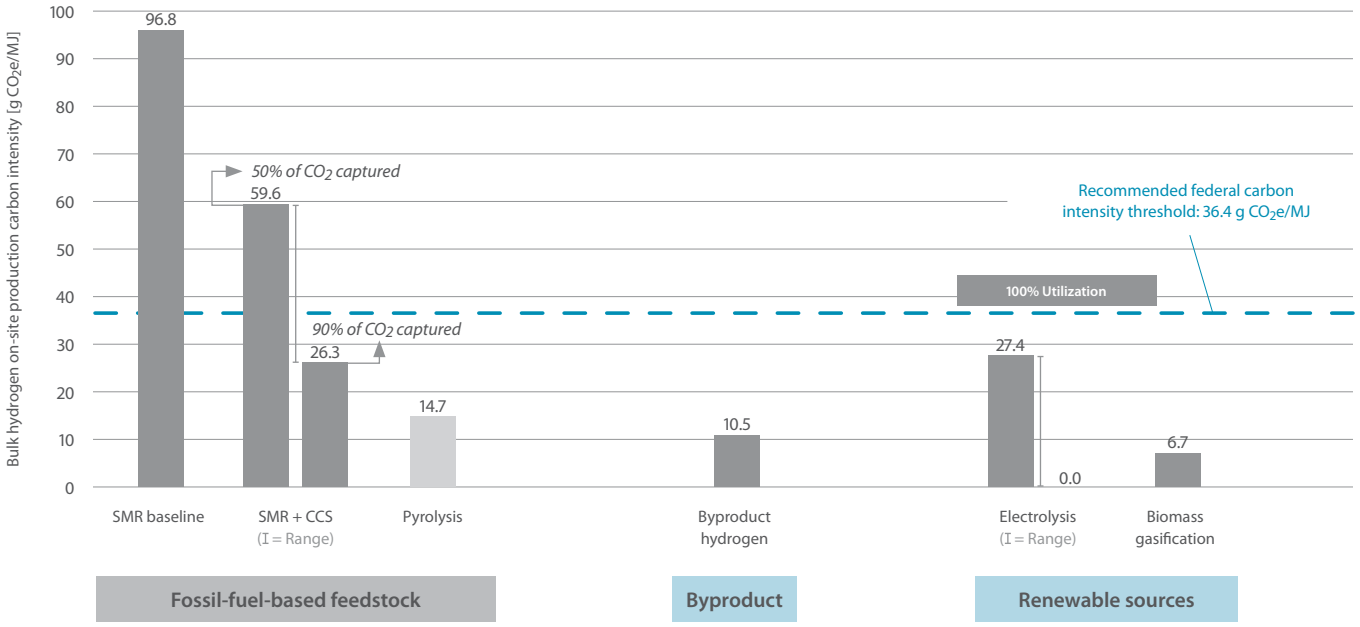
BLUE **hydrogen** is produced from non-renewable sources through steam methane reforming (SMR) with carbon capture and storage (CCS) or pyrolysis of fossil fuels, such as natural gas. With CCS, carbon dioxide is separated and sequestered underground, which reduces the carbon intensity of the produced hydrogen. With pyrolysis of natural gas, solid carbon is a byproduct. Blue hydrogen (or *hydrogen from fossil fuels with CCS*) has a low carbon intensity when produced using fossil fuel feedstock coupled with adequate and permanent CCS.

GREY **hydrogen** is produced from fossil fuel sources, but *without* CCS. Grey hydrogen does not have a low carbon intensity.

While describing hydrogen production pathways using colours is common, the terminology is not standardized and can lead to confusion around the carbon intensity of pathways and their effectiveness at reducing emissions.

In terms of climate benefits, not all hydrogen is created equal. To meet its emissions reduction targets, B.C. must focus on advancing and providing support only for renewable, low-carbon or zero-emission hydrogen pathways. The following table shows the GHG emissions intensity of different hydrogen production methods.

GHG emissions intensity of different hydrogen production methods



The carbon intensity of the production pathways shown above are modelled estimates and use a "cradle-to-gate" life-cycle analysis that includes emissions associated with feedstock production, transportation, losses, flaring, land use changes, hydrogen production and carbon capture and storage (if applicable). Data are from the B.C. low carbon fuel standard and *BC Hydrogen Study – Final Report* (2019). The actual carbon intensity of a specific hydrogen production project will depend on a number of factors.

In B.C., the carbon intensity of hydrogen will be determined using a rigorous life-cycle approach that accounts for all the emissions associated with its production. This includes emissions associated with feedstock development, transportation, hydrogen production and any CCS. The Province will work other jurisdictions to develop a common methodology for measuring and verifying the carbon intensity of hydrogen.

The federal *Hydrogen Strategy for Canada* and the European Commission recommend a carbon intensity threshold of 36.4 g CO_2e/MJ. B.C. will consider this target a starting point and will ensure that its regulatory frameworks relating to hydrogen production and use are aligned to achieve continued reductions in carbon intensity over time.

Through implementation of the B.C. Hydrogen Strategy, the Province will work to establish long-term, ambitious thresholds for declining carbon intensity consistent with ensuring that B.C. remains a world leader in hydrogen, decarbonizes the economy and achieves its goal of net-zero emissions by 2050.

Hydrogen storage and distribution

Hydrogen can be stored in either liquid or gas form for later use. It can be distributed in B.C.'s existing natural gas pipeline infrastructure or in dedicated pipelines, and it can also be compressed or liquefied for storage and distribution in tanks, convenient for delivery (generally by truck). Finally, hydrogen can also be stored in liquid chemical carriers, such as ammonia, or by bonding hydrogen to toluene, where high densities of hydrogen can be stored at lower pressures.

To overcome challenges associated with the transportation of hydrogen, B.C. is committed to reviewing hydrogen infrastructure requirements, supporting distribution trials and establishing an enabling regulatory environment for hydrogen distribution.

Hexagon Purus

Lightweight components for high-pressure vessels

Hexagon Purus is a world-leading provider of hydrogen type 4 high-pressure cylinders, complete vehicle systems and battery packs for fuel cell electric, battery electric and hybrid mobility applications. Type 4 high-pressure cylinders contain a non-metallic liner and are lightweight and cost-effective, which are important factors for high-pressure hydrogen storage across the medium- and heavy-duty commercial vehicle industry. Hexagon Purus's Global Innovation Office is in Kelowna, and the company is also investing in a new world-class engineering, prototyping and short series production factory near UBC-Okanagan for its hydrogen and battery electric products to support fuel cell vehicles, with completion planned in mid-2022.

Ionomr Innovations

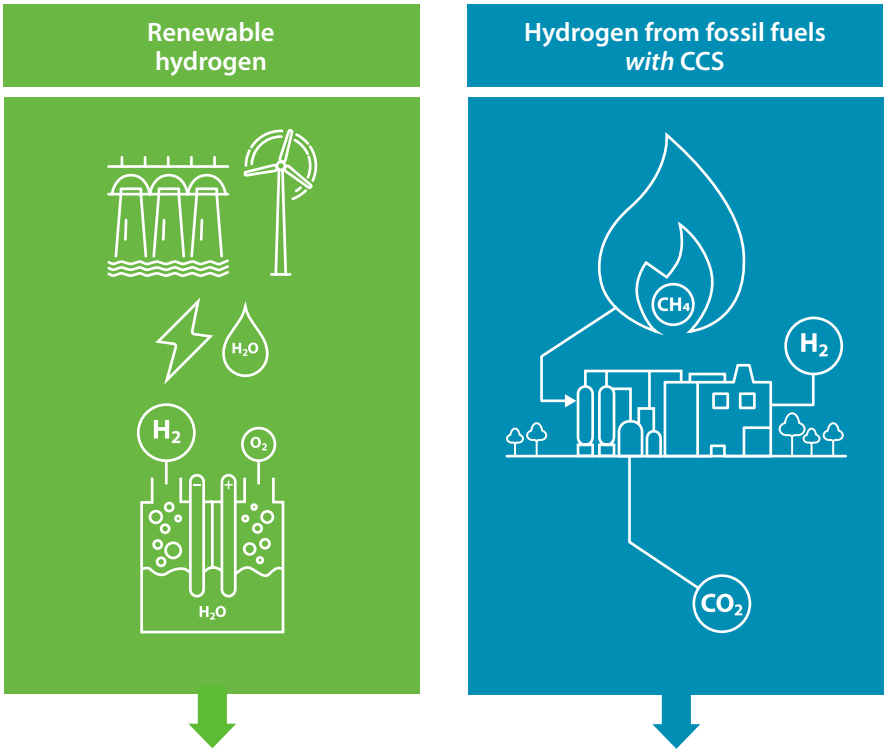
Technology that improves performance and reduces environmental impact

Ionomr's innovations are enabling the ultra-high-efficiency, lowest-cost fuel cell systems of the future. The Vancouver-based company's proton-exchange membranes (PEMs) and ionomer replace the toxic materials used in most electrochemical systems without compromising on performance or chemical durability. These materials allow existing fuel cells and PEM electrolyzers to achieve higher-efficiency targets and longer lifetimes, while minimizing the use of precious metals. Ionomr's anion-exchange materials are the first to unlock high-temperature strong alkaline systems, the largest improvement in 100 years to the alkaline electrolysis systems that form most renewable hydrogen deployments today.

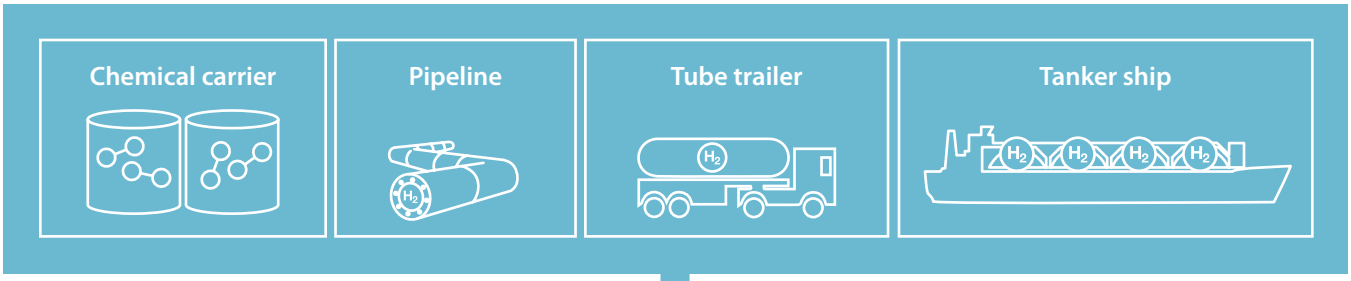
"Ionomr's revolutionary ion-exchange materials enable the proliferation of hydrogen to its rightful leadership position in the future of abundant renewable and sustainable energy."

– Bill Haberlin, CEO
Ionomr Innovations

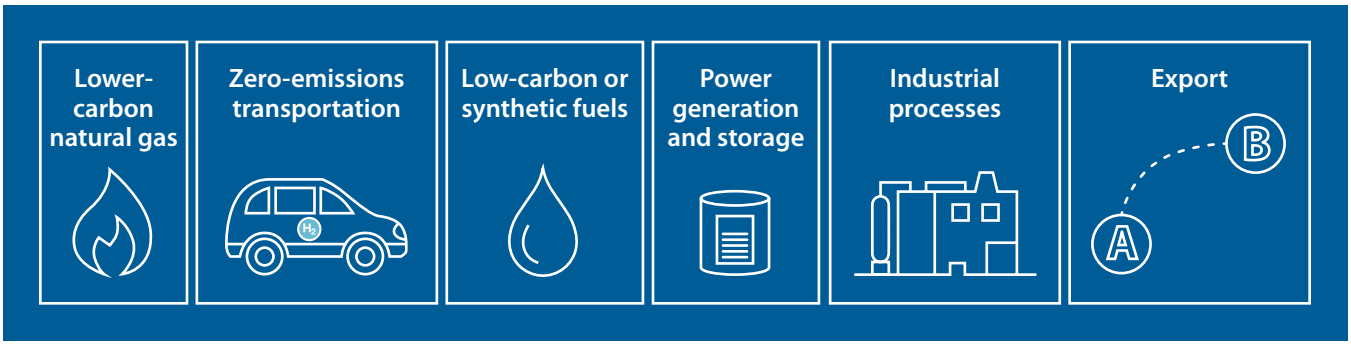
LOW-CARBON HYDROGEN PRODUCTION PATHWAYS



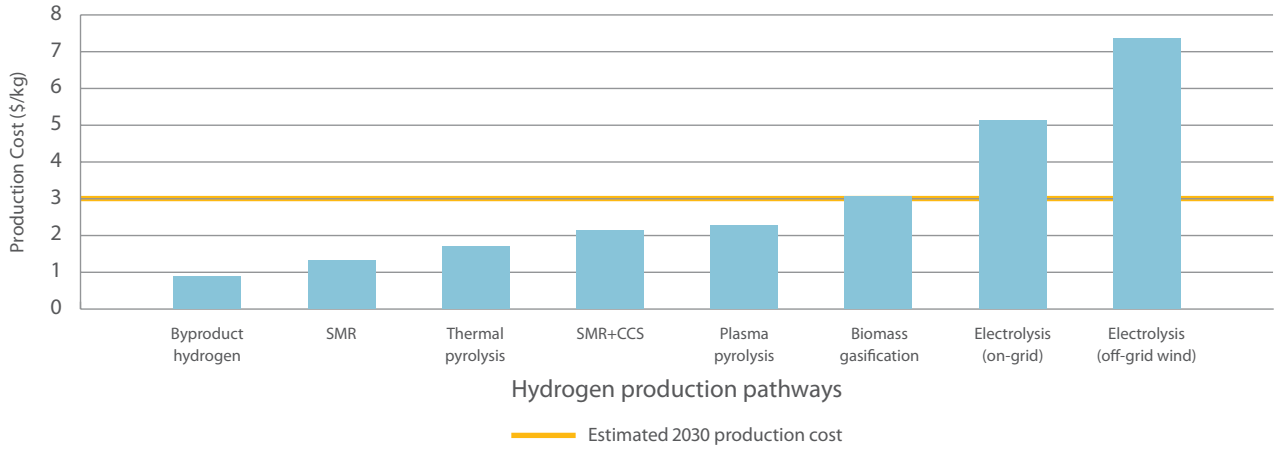
STORAGE / DISTRIBUTION



END USES



Cost of hydrogen production



Cost of bulk on-site hydrogen production by pathway in B.C. in 2020

Production costs are normalized to production scale of 100 tonnes per day.[3]

Grey hydrogen production methods, such as SMR, are currently the most cost-effective ways to produce hydrogen at scale and are the most commercially advanced technologies; however, SMR produces significant carbon emissions. CCS is one way to reduce the carbon emissions from this pathway.

Production costs for all pathways are heavily dependent on the price of inputs, such as natural gas and electricity. While B.C. has one of the lowest cost and cleanest electricity grids in North America, renewable hydrogen production at scale via electrolysis will require electricity rates in the range of $40/MWh. There is also a growing interest in dedicated electricity generation for hydrogen production using intermittent energy resources such as wind. It is expected that as the cost of these renewable electricity resources decline, so too will the cost of low-carbon hydrogen production. Building electrolyzers at locations with access to high-voltage electricity and transportation infrastructure will be necessary for renewable hydrogen production. BloombergNEF expects the levelized cost of hydrogen from large renewable-energy-powered projects will be cost-competitive with low-carbon hydrogen from natural gas via SMR + CCS by 2030.[4]

While modelling shows the costs of different hydrogen production pathways, the costs of delivered hydrogen will vary greatly depending on the location of the facility, method of production, transportation and storage requirements, and the state of the hydrogen (liquid or gaseous). The Province targets cost-parity or lower with the wholesale price of incumbent fuels for hydrogen production, such as gasoline or diesel for transportation or delivered diesel for remote communities. It is estimated that to be globally competitive, the price of hydrogen produced (excluding storage and transportation) would need to be less than $3/kg by 2030. Ensuring that hydrogen is widely available for domestic use and for export will depend on our ability to scale up the technology, keep the costs of inputs competitive within the industry, reduce transportation costs and ensure access to robust and efficient supply chains.

[3] Government of Canada, *Hydrogen Strategy for Canada* (2020).
[4] BloombergNEF, *Hydrogen Economy Outlook* (March 20, 2020).

Making electrolysis more affordable

In January 2021, the Province and BC Hydro announced the Clean Industry and Innovation Rate to help support and attract new innovative industries, such as hydrogen production, to B.C. by making it more affordable to connect into BC Hydro's grid. The Clean Industry and Innovation Rate is a seven-year discount from BC Hydro's standard industrial rate (20% discount for the first five years, 13% discount in year six and 7% discount in year seven) and is available to new customer plants that use a process to remove GHGs from the atmosphere or produce a renewable or low-carbon fuel. The Province continues to explore ways to make B.C. more competitive with lower-cost jurisdictions by analyzing additional rate structures that will make electrolysis more affordable and, in turn, reduce the cost of low-carbon hydrogen for consumers in B.C.

How we'll grow hydrogen production

2020-2025

- Stimulate hydrogen production through direct support and incentives
- Continue to provide policy support for increasing hydrogen demand certainty and de-risking the development of hydrogen production infrastructure
- Provide policy support to utilities who choose to produce or purchase hydrogen
- Advocate for increased production and consumption of hydrogen in B.C.
- Work with industry partners to establish hydrogen deployment hubs in B.C.

2025-2030

- Consider introducing alternative electricity rate designs to support hydrogen production
- Promote hydrogen production at scale to meet domestic and/or international demand
- Determine if brownfield sites can be used for industrial parks that include hydrogen production

2030-beyond

- Support long-term self-sufficiency in hydrogen supply and with it introduce new opportunities for economic development
- Support the development of hydrogen liquefaction, distribution and transmission infrastructure

Codes and standards

Existing agencies will play an important role in regulating the hydrogen industry and ensuring the safe production and responsible use of our natural resources, such as water and natural gas. We also need to make sure that regulations and permitting requirements are clear and consistent across sectors and jurisdictions to enable sector-coupling and ensure B.C. is set up for seamless trade opportunities, both regionally and abroad.

Hydrogen projects may need to be regulated based on the specific production pathway or end use. For example, hydrogen produced by SMR has parallels with oil and gas activities due to the use of natural gas, and there may be overlap with the regulatory approval processes in place for the oil and gas industry as determined by the BC Oil and Gas Commission.

Hydrogen projects require a clear path forward, and the Province will work to remove roadblocks and harmonize regulation and permitting in B.C. Many organizations have valuable expertise to share, including the CSA Group, Canada Energy Regulator, Canadian Hydrogen and Fuel Cell Association, Measurement Canada, FortisBC, Pacific Northern Gas, Enbridge, Technical Safety BC, the BC Oil and Gas Commission and the British Columbia Utilities Commission.

Ballard Power Systems

A world leader in hydrogen fuel cells

Burnaby-based Ballard is a leading global provider of innovative hydrogen fuel cell products and services that have the Power to Change the World.® Over its 40-year history, Ballard has invested more than $1 billion in research and development to advance fuel cell technology and has produced over 850 megawatts of proton-exchange membrane fuel cell products. Today, Ballard's 900+ employees design, manufacture and sell fuel cell products that power zero-emission transit buses, trucks, trains, marine vessels and forklifts and contribute to CO_2 emission reductions. Its heavy-duty fuel cell power modules lead the industry in performance, durability and overall road experience, having operated more than 50 million kilometres, and there are currently more than 3,000 hydrogen fuel cell electric buses and trucks powered by Ballard in operation globally.

"At Ballard, we are convinced that hydrogen can offer economically viable, financially attractive and socially beneficial solutions. We believe that hydrogen is needed to achieve deep decarbonization of our economy and meet Canada's emission reduction targets. With its natural resources and a local hydrogen and fuel cell technology cluster, British Columbia is facing a unique opportunity. A comprehensive hydrogen strategy for the Province will send a strong signal to investors, boosting economic growth and local jobs while positioning B.C. as a leader in the hydrogen economy."

– Randy MacEwen, President and CEO
Ballard Power Systems

How we'll regulate hydrogen production

2020-2025

- Review provincial, federal and international codes, standards and regulations for hydrogen production and establish a compatible regulatory framework
- Amend regulations to allow the BC Oil and Gas Commission to regulate hydrogen production, storage and transportation if produced from fossil fuels
- Amend *Water Sustainability Act* related regulations to include hydrogen production as an authorized industrial water use purpose and set new water fees and rentals
- Enable hydrogen as a pathway for natural gas utilities to reduce emissions
- Ensure regulatory frameworks relating to hydrogen production and use are aligned to encourage continued reductions in carbon intensity over time
- Establish carbon-intensity targets for hydrogen production pathways
- Provide support only for renewable or low-carbon hydrogen pathways
- Establish a working group made up of representatives from the hydrogen industry, regulatory agencies and government to implement B.C. Hydrogen Strategy actions

2025-2030

- Continue to implement the Low Carbon Fuel Standard Part 3 Agreements to advance hydrogen production, fuelling infrastructure, operation and maintenance projects
- Review sectoral opportunities for hydrogen offtake
- Develop carbon management frameworks to encourage at-scale production of low-carbon hydrogen and transition policy incentives from direct support to market-based mechanisms

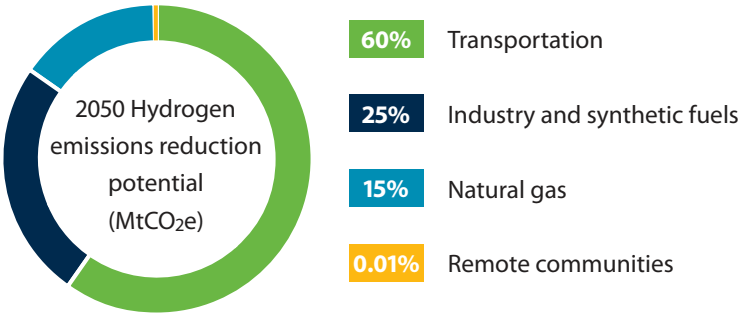
2030-beyond

- Achieve a clear and supportive regulatory environment for hydrogen production in B.C.
- Require a phased reduction in the carbon intensity of hydrogen produced and used in B.C.
- Explore policy framework mechanisms for long-duration energy storage using hydrogen

Using hydrogen in B.C.

Hydrogen will play a critical role in hard-to-decarbonize sectors where direct electrification is not practical, such as heating and power, transportation and industrial processes. The Province is committed to promoting the most cost-effective applications that result in the greatest climate benefit.

By 2050, hydrogen has the potential to reduce the province's emissions by 7.2 megatonnes of carbon dioxide equivalent (CO_2e) per year,[5] equal to 11% of B.C.'s 2018 emissions.[6] Hydrogen deployment in transportation applications is expected to account for 60% of these reductions as hydrogen fuel cells, often used in vehicles, offer greater efficiency than burning hydrogen. Applications in industry and synthetic fuels (25%) and natural gas (15%) make up the remainder of the potential reductions from hydrogen.



Blending hydrogen with natural gas to decarbonize heating and power

B.C. has an extensive network of natural gas pipelines that can be used to help meet our GHG reduction targets and grow the province's hydrogen economy. Natural gas represents the greatest source of carbon emissions in the built environment, where it is most commonly used for space and water heating in residential and commercial buildings, large multi-unit buildings, hospitals and schools. Industrial sites such as mines, pulp and paper mills, and refineries also rely on natural gas for direct heating and feedstocks.

One way to reduce emissions associated with natural gas use is by injecting hydrogen into the natural gas grid. When natural gas is blended with hydrogen, its emissions from combustion are reduced, providing a cleaner energy source. While the volume of hydrogen that can be directly injected into B.C.'s extensive pipeline distribution network depends on the point of injection and pipeline capacity, studies have shown that hydrogen by volume up to 5%-15% can be tolerated in the pipeline network with minimal disruption to appliances in homes and businesses.[7]

Blending hydrogen with natural gas is an innovative solution for natural gas utilities to meet environmental standards, including the CleanBC requirement that 15% of natural gas consumption must come from renewable gas by 2030.

It would also reduce some of the emissions associated with burning natural gas in appliances, power-generating equipment and industrial processes. More work will be done to understand the implications across the entire natural gas system. Since 80% of the natural gas produced in British Columbia is sold in the export market, injecting hydrogen in the high-pressure transmission system could have implications for downstream customers. Depending on the point of injection and volume of hydrogen injected, the Canada Energy Regulator, the BC Oil and Gas Commission or Technical Safety BC will be engaged to review the pipeline network for integrity and safety.

[5] Zen and the Art of Clean Energy Solutions, *BC Hydrogen Study - Final Report* (2019).
[6] Government of British Columbia, *Provincial Greenhouse Gas Emissions Inventory* (2020).
[7] Zen and the Art of Clean Energy Solutions, *BC Hydrogen Study – Final Report* (2019).

Power-to-Gas: Integrating our electricity grid and gas infrastructure

Power-to-Gas (P2G) converts electricity into hydrogen through electrolysis, and the resulting hydrogen can then be injected into the natural gas distribution network for use in buildings, transportation or seasonal storage. P2G projects also allow utilities or communities to store surplus energy generated from intermittent renewable power, such as wind. Hydrogen can be stored in dedicated tanks for days, weeks and even months to be used when demand changes across the seasons. This stored hydrogen can also be injected into the natural gas distribution system or be used in a stationary fuel cell for electricity production when needed. P2G could be a powerful way for B.C. to integrate our clean electricity grid and our existing natural gas infrastructure to achieve our GHG reduction targets, improve system resiliency and increase energy storage.

FortisBC

Exploring how to incorporate hydrogen into the gas distribution network

An integrated gas and electric utility, FortisBC serves over 1.2 million customers across 135 communities and 57 Indigenous communities. To achieve its target of a 30% reduction in its customers' GHG emissions by 2030, FortisBC is exploring ways to increase the content of renewable and low-carbon gases like hydrogen in the gas supplied to its customers. The utility is currently progressing to pre-feasibility planning and technical analyses for introducing hydrogen into its gas distribution network and is evaluating large-scale projects for the centralized production of renewable hydrogen. Through its Clean Growth Pathway to 2050, FortisBC also plans to make significant investments in low- and zero-carbon vehicles and infrastructure and to grow renewable gas supply to achieve 15% of all gas it delivers by 2030.

How we'll support blending hydrogen with natural gas

2020-2025

- Establish a regulatory framework for injecting hydrogen into the natural gas and propane distribution systems
- Include hydrogen as a prescribed undertaking under the *Greenhouse Gas Reduction Regulation*
- Partner with a utility to review the infrastructure requirements to accommodate up to 100% hydrogen in the distribution system
- Support hydrogen injection trials into natural gas and/or propane distribution systems

2025-2030

- Mandate that new or modified natural gas or propane pipelines be hydrogen compatible
- Support the introduction of hydrogen-tolerant equipment
- Explore the role of hydrogen in meeting the CleanBC 15% renewable gas target

2030-beyond

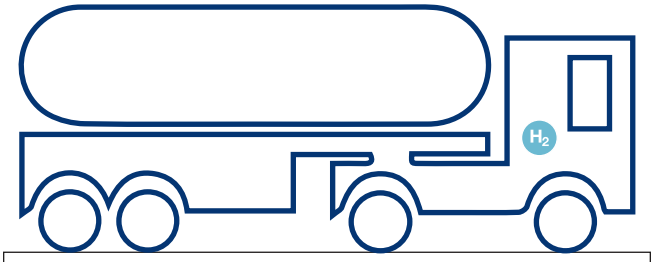
- Support large-scale hydrogen injection into the natural gas and propane distribution systems

Fuelling our transportation sector

Transportation in B.C. emits over 25 million tonnes of CO_2e annually, accounting for approximately 41% of the province's total GHG emissions.[8] Meeting our emissions reduction goals will require a substantive change in how we choose to get around, the kilometres we travel, the vehicles we drive and how we fuel our transportation choices.

Hydrogen fuel cell electric light-duty vehicles are already being adopted by fleets in B.C., and in the near term greater opportunities for hydrogen vehicle deployment are opening up in the medium-, heavy-duty and off-road vehicle sectors. Medium- and heavy-duty hydrogen fuel cell electric vehicles are suitable for heavy payloads and can benefit from short refuelling times and greater operability range. Fuel cell vehicles can also operate in temperatures as low as -30°C with minimal impacts to engine efficiency, and the excess heat generated from the fuel cell stack keeps the engine and cabin warm.

There are currently few low-carbon solutions for planes, trains and ships that require energy-dense fuel. Here, the rapid innovation in hydrogen-powered transportation provides a promising pathway for increased hydrogen adoption in these transportation modes, which are hard to electrify. Hydrogen rail and ferry pilot projects are currently taking place in Europe with great success.



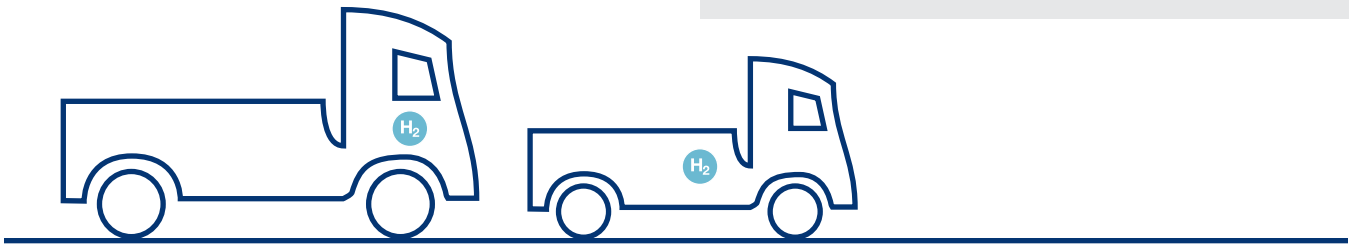
How does a fuel cell electric vehicle work?

Hydrogen fuel cell electric vehicles use hydrogen gas to power an electric motor. Hydrogen and oxygen are combined in the fuel cell to produce electricity, and the only byproducts are water and heat. These vehicles do not produce any tailpipe emissions when driven and are more efficient than conventional internal combustion engines.

Hydra Energy

Using waste hydrogen to displace diesel consumption in heavy-duty trucks

Delta-based Hydra Energy is removing barriers for hydrogen adoption in transportation and accelerating the commercial-scale deployment of hydrogen-fuelled heavy-duty vehicles. Hydra combines unprecedented innovation in hydrogen engine technology with a supply of low-carbon-intensity hydrogen fuel sourced from waste. Its Hydrogen as a Service™ model provides retrofits and fuelling infrastructure at no upfront cost to the fleet operator in exchange for an exclusive hydrogen fuel supply agreement. Heavy-duty diesel trucks can be retrofitted with Hydra technology to operate as dual-fuel, hydrogen-diesel vehicles without power, torque, range or payload loss while cutting GHG emissions and local air contaminants by 30-50%.



[8] CleanBC, *2020 Climate Change Accountability Report* (2020).

Zero-Emission Vehicles Act

The *Zero-Emission Vehicles Act* requires automakers to meet an escalating annual percentage of new light-duty zero-emission vehicle (ZEV) sales: 10% by 2025, 30% by 2030 and 100% by 2040. Although the targets start with light-duty vehicles, the legislation provides options to expand to other vehicle classes, including medium- and heavy-duty vehicles. The legislation aims to meet provincial GHG reduction targets and ensure British Columbians can benefit from a greater availability of ZEVs at more affordable prices.

B.C.'s ZEV and FCEV Programs

The Province strives to remove barriers to adopting ZEVs, including hydrogen fuel cell electric vehicles (FCEVs). Through a comprehensive market transformation approach, the ZEV Act and Regulation, and the Go Electric program, support both the supply and demand for ZEVs in B.C. The Go Electric program provides financial support for the deployment of FCEVs, hydrogen fuelling stations and other hydrogen-powered technology and equipment through the Hydrogen Fuelling and Fleet program, Advanced Research and Commercialization program, the Commercial Vehicle Pilot program and the Speciality-Use Vehicle Incentive program. StrongerBC: BC's Economic Recovery Plan committed $30 million for a new Commercial Vehicle Innovation Challenge that will include supporting FCEV development. Additionally, the Go Electric Vehicle Rebate program supports the adoption of passenger FCEVs in B.C.

Loop Energy

More power, fewer materials

Burnaby-based Loop Energy develops world-leading zero-emission hydrogen fuel cell engines and fuel cell stacks for medium-to heavy-duty bus and truck applications. While fuel cell electric solutions have proven performance, cost remains an impediment to widespread adoption. Together with its partners, Loop Energy is commercializing zero-emission solutions that provide more power in a smaller system – with fewer materials and without compromising performance, range or economics.

Building out hydrogen fuelling infrastructure

In 2018, B.C. led the way when Canada's first retail hydrogen fuelling station opened in Vancouver with provincial government support. Since then, three more stations have been opened, two in Metro Vancouver and one in Greater Victoria. Vehicle manufacturers have targeted B.C. as a key market for the rollout of fuel cell electric vehicles in Canada thanks to the province's leadership in the fuel cell sector and the provincial government's commitment to expanding the hydrogen fuelling network as outlined in CleanBC. The Government of Canada is also supporting hydrogen fuelling stations across the country, and in 2019 Quebec's first retail hydrogen station opened for business with equipment designed and manufactured by B.C.'s Powertech Labs and Hydrogen Technology & Energy Corporation.

Hydrogen Technology & Energy Corporation (HTEC)
Experts in hydrogen fuelling infrastructure

HTEC builds, owns and operates hydrogen production facilities, distribution systems, and fuelling stations in B.C., Quebec, Alberta and California. The company began in 2005 and operates in North Vancouver. In collaboration with the Province and other partners, HTEC has opened four retail hydrogen fuelling stations in B.C., the largest network in Canada. Further, HTEC draws upon its deep industry experience, know-how and technologies to provide customized engineering services and packaged hydrogen production, processing, distribution and vehicle-fuelling solutions for its infrastructure platform and clients.

"Government policy will facilitate hydrogen's role in decarbonizing our world. Policies such as B.C.'s Zero-Emission Vehicles Act and low carbon fuel standard make it possible for fuel suppliers to deliver low-carbon-intensity fuels and give consumers the choice to drive hydrogen electric vehicles. HTEC couldn't lead the rollout of Canada's first network of hydrogen fuelling stations without the support of the Province and our other partners; we thank all for their shared commitment to fuelling the drive to hydrogen."

– Colin Armstrong, President & CEO
Hydrogen Technology & Energy Corporation

How we'll encourage the growth of hydrogen in transportation

2020-2025

- Pilot the use of hydrogen fuel cells in medium- and heavy-duty vehicles, marine, rail, aviation, off-road and other commercial transportation applications
- Continue to leverage the Part 3 Agreement program to expand the public hydrogen fuelling station network across the province
- Explore the roles FCEVs can play in supporting achievement of CleanBC commitments to make 10% of the BC government light-duty fleet ZEVs and reduce its emissions by 40% by 2030
- Provide monetary and non-monetary incentives for fuelling infrastructure and vehicle purchase
- Allow medium- and heavy-duty vehicle sales to generate credits under the ZEV Act
- Explore ZEV Act compliance targets for medium- and heavy-duty vehicle classes
- ZEVs reach 10% of new light-duty vehicle sales by 2025

2025-2030

- Review and expand the pilot demonstration use of hydrogen fuel cells in medium- and heavy-duty vehicles, marine, rail, aviation, off-road and other commercial transportation applications
- Include targets for medium- and heavy-duty vehicles in the ZEV Act
- Support the development of hydrogen production and liquefaction infrastructure
- ZEVs reach 30% of new light-duty vehicle sales by 2030

2030-beyond

- Continue to support the widespread use of hydrogen in medium- and heavy-duty vehicles, marine, rail, aviation, off-road and other commercial transportation applications
- ZEVs reach 100% of new light-duty vehicle sales by 2040

Producing low-carbon and synthetic fuels

Using hydrogen to produce low-carbon and synthetic fuels is an opportunity to reduce emissions in B.C.'s transportation and refining sectors.

To increase the supply of cleaner fuels, CleanBC set out a target to ramp up production of renewable fuel in B.C. to 650 million litres by 2030. The B.C. low carbon fuel standard (LCFS) also requires fuel suppliers to progressively decrease the average carbon intensity of their fuels to achieve a 20% reduction in 2030 relative to 2010. This can be achieved by increasing the volume of biofuels blended with conventional fossil fuels or by supplying lower-carbon fuels such as hydrogen and electricity. Fuel suppliers generate credits by supplying fuels with a carbon intensity below the prescribed target. These credits can be used to comply with the LCFS or sold in the credit market to generate additional revenue. The LCFS encourages suppliers to offer lower-carbon fuels, such as hydrogen, in the B.C. fuel market.

In addition to setting annual carbon-intensity reduction requirements, the LCFS spurs growth in the clean fuels industry through the Part 3 Agreement Program. Under this program, fuel suppliers can obtain credits for undertaking projects that increase the use of low-carbon fuels sooner than would otherwise happen. The Province will continue to use existing policy mechanisms, such as the LCFS and the Part 3 Agreement Program to promote innovation while reducing GHG emissions resulting from the use of lower-carbon fuels. Since 2019, 23 projects have awarded over 800,000 credits and committed to investing over $450 million in emissions reductions in the B.C. fuels industry and the Part 3 Agreement Program to accelerate market transformation.

In the fossil fuel sector, hydrogen is used to refine crude oil into products that include gasoline, diesel and jet fuel. Since much of this hydrogen is currently produced from fossil fuels without CCS, finding ways to reduce the emissions from hydrogen production at refineries will also reduce the life-cycle emissions of these products. Hydrogen is also used in large quantities when making renewable fuels, such as co-processing biocrudes from renewable sources like canola oil or oil derived from animal fats (tallow). The Province is focusing efforts to deploy hydrogen use in low-carbon and synthetic fuel production, as these fuels can be used to decarbonize hard-to-abate sectors such as long-distance trucking, marine and aviation.

Carbon Engineering

Capturing carbon dioxide to make clean fuel

A licensed partner of Squamish-based Carbon Engineering Ltd., Huron Clean Energy is developing multiple clean fuel synthesis plants, beginning in B.C. and then deploying across Canada. Carbon Engineering's breakthrough Direct Air Capture and AIR TO FUELS™ technologies are used to create clean fuel out of air. When carbon dioxide captured from the atmosphere is combined with renewably generated hydrogen, clean fuel is produced. This clean, near-carbon-neutral fuel can be used in all existing transportation infrastructure as a replacement fuel or blended with current fuels such as gasoline, diesel or aviation Jet A to lower the carbon intensity of those fuels. Access to large quantities of low-carbon hydrogen produced in B.C. will be key in enabling these plants to deliver industrial quantities of clean fuels for the aviation and diesel markets.

Decarbonizing industrial processes

In addition to reducing the carbon intensity of fossil fuels used in hard-to-abate transportation sectors, low-carbon hydrogen can also be used to decarbonize industrial processes that are not practical to electrify or that require hydrogen as a feedstock. For example, many industrial processes require natural gas to produce process heat at temperatures that cannot be achieved through electrification. Additionally, the largest current use for hydrogen in Canada and internationally is as an essential feedstock in emissions-intensive industrial processes.

Hydrogen's decarbonization benefits and heating attributes mean that it can be used to displace natural gas and reduce the emissions from many high heat industrial processes. Industrial processes that require large amounts of high-grade heat include upstream fossil fuel extraction and downstream refining, cement manufacturing, pulp and paper processing, and other steam reliant processes.[9]

The demand for hydrogen today is driven by industries that require it as a feedstock, primarily in oil refining, ammonia production, methanol production and steel production.[10] As the vast majority of hydrogen used in these industries is produced from fossil fuels without CCS, low-carbon hydrogen presents an alternative that can reduce the carbon intensity of final products.

How we'll support industry to increase hydrogen use
2020-2025
• Evaluate the use of hydrogen across different heavy industries, such as at pulp and paper mills, cement plants, petroleum refineries and aluminum smelters to reduce emissions and create economic development • Support pilots for the use of low-carbon hydrogen for synthetic fuel production • Explore carbon-intensity targets under the low carbon fuel standard
2025-2030
• Review the success of pilot projects across B.C.'s industries • Support the use of hydrogen across industries in B.C., including refining biocrude and producing synthetic fuels • Support the use of hydrogen in small and medium-size industrial businesses • Support hydrogen's contribution to the CleanBC targets of producing 650 million litres of renewable or low-carbon fuels per year and the low carbon fuel standard reaching 20% reduction in carbon intensity by 2030
2030-beyond
• Where appropriate, support the use of low-carbon hydrogen in industrial processes, such as in pulp and paper mills, petroleum refining and aluminum smelting

[9] Government of Canada, *Hydrogen Strategy for Canada* (2020).
[10] International Energy Agency, *The Future of Hydrogen: Seizing Today's Opportunities* (2019).

Hydrogen hubs

One of the challenges facing hydrogen development in B.C., and around the world, is matching supply and demand. Regional hydrogen hubs overcome this challenge by co-locating hydrogen production and end-use applications. Through co-location, hydrogen hubs generate early and focussed opportunities for domestic hydrogen production and use in areas otherwise heavily dependent on fossil fuels by spurring and growing supply and demand, lowering costs and strengthening local hydrogen proficiency.

The concept of hydrogen hubs fits well with B.C.'s abundance of clean electricity and natural gas resources, established local hydrogen companies and variety of end-use applications. Supporting hydrogen hubs in B.C. is critical to accelerating domestic hydrogen supply and demand, while also realizing the significant economic opportunities in developing B.C.'s hydrogen export market. The Province is committed to identifying regions that can support and realize the greatest decarbonization benefits of hydrogen hubs, such as seaports, industrial sites and urban locations like UBC's city-scale hydrogen testbed.

Fuelling economic development

Hydrogen is both a clean energy solution and an economic development opportunity for B.C.

Hydrogen's key contribution to B.C.'s net-zero economy

Hydrogen is not only key in B.C.'s path to net-zero emissions by 2050, but also to building a prosperous low-carbon economy with new clean energy jobs. Home to Canada's largest cluster of hydrogen companies, B.C. has the unique opportunity to leverage an already successful local hydrogen sector to grow its hydrogen economy. Low-carbon hydrogen's decarbonization attributes present an opportunity for B.C. to reduce emissions and support the scale-up of B.C.-based hydrogen companies with expertise in low-carbon technologies and innovation. All of this will be in high demand as B.C. and many countries around the world pursue net-zero targets.

In April 2021, the Province committed $35 million to establish the Centre for Innovation and Clean Energy (CICE) as part of StrongerBC. The CICE will bring together innovators, companies, government and researchers to accelerate the commercialization of clean energy technology and products, including low-carbon hydrogen.

Zero-emission vehicles call for technicians with new skills

As zero-emission cars gain in popularity, there's a growing need for technicians and mechanics who can service these vehicles. The Province provided $325,000 in funding to the British Columbia Institute of Technology to develop a first-of its-kind training course for certified Red Seal automotive service technicians to upgrade their skills for zero-emission vehicles. The curriculum was designed in partnership with the City of Vancouver's green-fleet technicians and includes course modules for servicing battery electric, plug-in hybrid and fuel cell electric vehicles. The course will be offered throughout the province in Kelowna, Prince George and Victoria.

UBC's Hydrogen Hub
A city-scale testbed

With support from the Ministry of Energy, Mines and Low Carbon Innovation, the University of British Columbia has broken ground on a project that brings the production, distribution and end use of hydrogen together on one city block at the corner of Wesbrook Mall and Thunderbird Boulevard in Vancouver. The Integrated Energy Test Bed uses a solar array to charge electric vehicles and power a water electrolyzer. The produced hydrogen feeds a refuelling station for light- and heavy-duty fuel cell vehicles.

Hydrogen in Indigenous and remote communities

There are up to 50 remote communities in B.C. that are not connected to the natural gas or electricity distribution systems, and as a result experience energy-related challenges and opportunities that are very different from grid-connected communities. Numerous remote communities rely on diesel-powered generators to meet their power needs, and as part of CleanBC, the Province has set a target of reducing diesel generation of electricity province-wide by 80% by 2030.

Many Indigenous Nations are interested in adopting clean energy solutions that will reduce their carbon footprint, strengthen community resilience, achieve energy self-sufficiency and increase economic opportunities for their communities. Hydrogen is a potential energy resource to achieve each of these objectives, either from cleaner back-up power, fuel cell electric vehicles or increased economic activity. The Province will engage with interested Indigenous Nations to explore whether there are opportunities to be involved in developing, owning and operating hydrogen infrastructure and services.

Hydrogen-powered microgrids, which can deliver combined heat and power, have the potential to stimulate economic development opportunities. This may come in the form of employment, investment and potential for joint ownership with industry. Hydrogen-powered microgrids may also benefit communities by shifting reliance away from high-carbon-emitting generation technologies, lowering GHG emissions, improving air quality, reducing noise pollution and eliminating diesel spills.

Communities may consider building out hydrogen fuelling infrastructure to promote the uptake of fuel cell electric vehicles, which maintain high performance even during extreme cold or heat. Diesel-reliant communities may also be interested in integrating hydrogen with renewable resources to power their communities. For example, in areas where electricity can be generated from wind resources, communities could store energy using hydrogen for later use, thereby minimizing the impacts of intermittency.

There are several potential applications for hydrogen in remote communities. The Province recognizes that a one-size-fits-all approach for hydrogen is not possible, as each community differs in size, climate, geography and energy requirements. Furthermore, production, storage and distribution costs may be a challenge depending on scale, technology and site location. The Province will look to understand the potential opportunities of hydrogen with interested communities and explore what options exist for capacity building and clean energy planning.

Declaration on the Rights of Indigenous Peoples Act

The Government of B.C. is committed to advancing reconciliation with Indigenous peoples through the implementation of the *Declaration on the Rights of Indigenous Peoples Act*. Consistent with this legislation, the Province acknowledges the need to consult and co-operate with Indigenous Nations early and in good faith to obtain their free, prior and informed consent relating to adopting and implementing hydrogen-related legislative or administrative measures that may affect them.

How we'll advance hydrogen as a source of clean energy in communities

2020-2025

Commission a comprehensive study for hydrogen in communities, including:

- Education and engagement on the potential for hydrogen
- Novel applications of hydrogen (e.g., phasing out propane)
- Capacity-building tools for community clean energy and hydrogen projects
- A case study with a small to medium-sized fossil-fuel-reliant community to investigate the feasibility of moving to 100% renewable energy with a hydrogen component

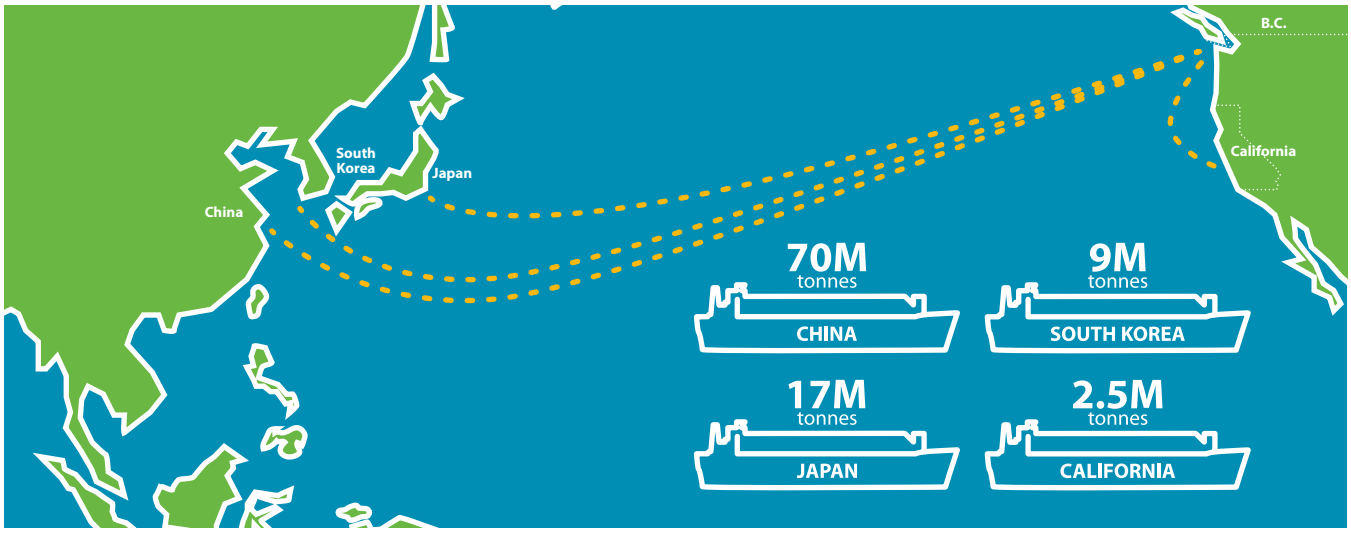
2025-2030

- Implement findings and results from the community feasibility study
- Introduce capacity-building tools for community clean energy and hydrogen projects

2030-beyond

- Support the conversion of a small to medium-sized fossil-fuel-reliant community to hydrogen
- Promote the installation of hydrogen to power communities

Exporting hydrogen



Demand projections by jurisdiction in 2050

Jurisdictions around the world are seeking ways to meet emissions reduction goals and are recognizing the role that hydrogen can play to help them meet ambitious targets. The global market for hydrogen is expected to reach more than 230 million tonnes in 2050. B.C. is well-positioned to meet a portion of this demand due to our extensive low-cost natural gas reserves, clean electricity, proximity to key trading partners and existing natural gas infrastructure that can be leveraged for exporting hydrogen.

The top export markets of China, Japan, South Korea and California are predicted to account for almost 50% of total global demand for hydrogen by 2050 with a combined market size of $305 billion.[11] If B.C. can capture even a fraction of this export market, it will result in significant export revenue for the province. Our proximity to these markets and their advanced plans for the adoption of hydrogen at scale further strengthens B.C.'s export potential.[12]

The *BC Hydrogen Study* estimates that B.C.'s potential production capacity could be over 2.2 million tonnes annually. Our experience and proven capabilities in producing and exporting natural resources makes for a potentially smooth transition to exporting hydrogen. This demand for hydrogen could be met through various production pathways, with transportation choices based on geography, volume, distance and end-use. The Province will continue to engage with industry stakeholders and our international partners to create export supply chains and foster support for hydrogen.

[11] Zen and the Art of Clean Energy Solutions, *BC Hydrogen Study - Final Report* (2019).
[12] ITM Power, Chiyoda Corporation, Mitsui & Co. and G&S Budd Consulting, *Centralized Renewable Hydrogen Production in BC - Final Report* (2019).

How we'll develop B.C.'s export market for hydrogen
2020-2025
• Collaborate with industry stakeholders and international partners regarding export opportunities • Promote B.C. internationally as an attractive jurisdiction for investment in hydrogen production for domestic supply and export • Continue to promote B.C.'s fuel cell technology abroad and promote the province as a supplier of low-carbon hydrogen to global markets
2025-2030
• Attract domestic and international investment for the development of supply chains to export hydrogen
2030-beyond
• Enable the construction of dedicated infrastructure for hydrogen export

Measuring our success

These Measures of Success will guide us as we continue to grow our vibrant and innovative hydrogen and fuel cell sector in B.C.

Measures of Success	
Jobs and prosperity	• B.C. maintains its position as a leader in fuel cell development with a diverse talent pool of highly qualified personnel • B.C. experiences job growth in trades as a result of a hydrogen production industry • Indigenous communities are supported in identifying possible pathways for partnerships and participation in the growing hydrogen sector
Competitive	• B.C. develops multiple hydrogen hubs that accelerate the growth of the local hydrogen economy • B.C. produces hydrogen that is a cost-effective energy resource for British Columbians • B.C. maintains its competitive position regarding the commercialization of hydrogen and fuel cell technology
Innovation	• B.C. continues to have a highly innovative hydrogen and fuel cell technology sector • B.C. has world-class hydrogen production supply chains as well as a supportive research and development environment
Clean	• The carbon intensity of hydrogen produced in B.C. declines over time • The hydrogen industry uses water sustainably and continues to look for innovative ways to maximize efficient water usage
Communities	• Benefits flow back to Indigenous and non-Indigenous communities where hydrogen production facilities are located • Hydrogen is a cost-effective option for diesel-reliant Indigenous and non-Indigenous communities to achieve their climate objectives
Hydrogen exports	• B.C. exports hydrogen to key markets and meets a portion of international demand • Hydrogen exports provide a net benefit to British Columbians • B.C. is seen as an attractive jurisdiction for domestic and international investment in hydrogen

Summary of policy actions

As outlined throughout this Strategy, the Government of British Columbia is committed to providing the policy, regulatory and infrastructure support needed to realize hydrogen's potential to help us meet our emissions reduction goals. The following actions for the next 10 years and beyond will enable us to achieve our vision to be a world-leading hydrogen economy by 2050.

How we'll grow hydrogen production

2020-2025

- Stimulate hydrogen production through direct support and incentives
- Continue to provide policy support for increasing hydrogen demand certainty and de-risking the development of hydrogen production infrastructure
- Provide policy support to utilities who choose to produce or purchase hydrogen
- Advocate for increased production and consumption of hydrogen in B.C.
- Work with industry partners to establish hydrogen deployment hubs in B.C.

2025-2030

- Consider introducing alternative electricity rate designs to support hydrogen production
- Promote hydrogen production at scale to meet domestic and/or international demand
- Determine if brownfield sites can be used for industrial parks that include hydrogen production

2030-beyond

- Support long-term self-sufficiency in hydrogen supply and with it introduce new opportunities for economic development
- Support the development of hydrogen liquefaction, distribution and transmission infrastructure

How we'll regulate hydrogen production

2020-2025

- Review provincial, federal and international codes, standards and regulations for hydrogen production and establish a compatible regulatory framework
- Amend regulations to allow the BC Oil and Gas Commission to regulate hydrogen production, storage and transportation if produced from fossil fuels
- Amend *Water Sustainability Act* related regulations to include hydrogen production as an authorized industrial water use purpose and set new water fees and rentals
- Enable hydrogen as a pathway for natural gas utilities to reduce emissions
- Ensure regulatory frameworks relating to hydrogen production and use are aligned to encourage continued reductions in carbon intensity over time
- Establish carbon-intensity targets for hydrogen production pathways
- Provide support only for renewable or low-carbon hydrogen pathways
- Establish a working group made up of representatives from the hydrogen industry, regulatory agencies and government to implement B.C. Hydrogen Strategy actions

2025-2030

- Continue to implement the Low Carbon Fuel Standard Part 3 Agreements to advance hydrogen production, fuelling infrastructure, operation and maintenance projects
- Review sectoral opportunities for hydrogen offtake
- Develop carbon management frameworks to encourage at-scale production of low-carbon hydrogen and transition policy incentives from direct support to market-based mechanisms

2030-beyond

- Achieve a clear and supportive regulatory environment for hydrogen production in B.C.
- Require a phased reduction in the carbon intensity of hydrogen produced and used in B.C.
- Explore policy framework mechanisms for long-duration energy storage using hydrogen

How we'll support blending hydrogen with natural gas

2020-2025

- Establish a regulatory framework for injecting hydrogen into the natural gas and propane distribution systems
- Include hydrogen as a prescribed undertaking under the *Greenhouse Gas Reduction Regulation*
- Partner with a utility to review the infrastructure requirements to accommodate up to 100% hydrogen in the distribution system
- Support hydrogen injection trials into natural gas and/or propane distribution systems

2025-2030

- Mandate that new or modified natural gas or propane pipelines be hydrogen compatible
- Support the introduction of hydrogen-tolerant equipment
- Explore the role of hydrogen in meeting the CleanBC 15% renewable gas target

2030-beyond

- Support large-scale hydrogen injection into the natural gas and propane distribution systems

How we'll encourage the growth of hydrogen in transportation

2020-2025

- Pilot the use of hydrogen fuel cells in medium- and heavy-duty vehicles, marine, rail, aviation, off-road and other commercial transportation applications
- Continue to leverage the Part 3 Agreement program to expand the public hydrogen fuelling station network across the province
- Explore the roles FCEVs can play in supporting achievement of CleanBC commitments to make 10% of the BC government light-duty fleet ZEVs and reduce its emissions by 40% by 2030
- Provide monetary and non-monetary incentives for fuelling infrastructure and vehicle purchase
- Allow medium- and heavy-duty vehicle sales to generate credits under the ZEV Act
- Explore ZEV Act compliance targets for medium- and heavy-duty vehicle classes
- ZEVs reach 10% of new light-duty vehicle sales by 2025

2025-2030

- Review and expand the pilot demonstration use of hydrogen fuel cells in medium- and heavy-duty vehicles, marine, rail, aviation, off-road and other commercial transportation applications
- Include targets for medium- and heavy-duty vehicles in the ZEV Act
- Support the development of hydrogen production and liquefaction infrastructure
- ZEVs reach 30% of new light-duty vehicle sales by 2030

2030-beyond

- Continue to support the widespread use of hydrogen in medium- and heavy-duty vehicles, marine, rail, aviation, off-road and other commercial transportation applications
- ZEVs reach 100% of new light-duty vehicle sales by 2040

How we'll support industry to increase hydrogen use

2020-2025

- Evaluate the use of hydrogen across different heavy industries, such as at pulp and paper mills, cement plants, petroleum refineries and aluminum smelters to reduce emissions and create economic development
- Support pilots for the use of low-carbon hydrogen for synthetic fuel production
- Explore carbon-intensity targets under the low carbon fuel standard

2025-2030

- Review the success of pilot projects across B.C.'s industries
- Support the use of hydrogen across industries in B.C., including refining biocrude and producing synthetic fuels
- Support the use of hydrogen in small and medium-size industrial businesses
- Support hydrogen's contribution to the CleanBC targets of producing 650 million litres of renewable or low-carbon fuels per year and the low carbon fuel standard reaching 20% reduction in carbon intensity by 2030

2030-beyond

- Where appropriate, support the use of low-carbon hydrogen in industrial processes, such as in pulp and paper mills, petroleum refining and aluminum smelting

How we'll advance hydrogen as a source of clean energy in communities

2020-2025

Commission a comprehensive study for hydrogen in communities, including:

- Education and engagement on the potential for hydrogen
- Novel applications of hydrogen (e.g., phasing out propane)
- Capacity-building tools for community clean energy and hydrogen projects
- A case study with a small to medium-sized fossil-fuel-reliant community to investigate the feasibility of moving to 100% renewable energy with a hydrogen component

2025-2030

- Implement findings and results from the community feasibility study
- Introduce capacity-building tools for community clean energy and hydrogen projects

2030-beyond

- Support the conversion of a small to medium-sized fossil-fuel-reliant community to hydrogen
- Promote the installation of hydrogen to power communities

How we'll develop B.C.'s export market for hydrogen

2020-2025

- Collaborate with industry stakeholders and international partners regarding export opportunities
- Promote B.C. internationally as an attractive jurisdiction for investment in hydrogen production for domestic supply and export
- Continue to promote B.C.'s fuel cell technology abroad and promote the province as a supplier of low-carbon hydrogen to global markets

2025-2030

- Attract domestic and international investment for the development of supply chains to export hydrogen

2030-beyond

- Enable the construction of dedicated infrastructure for hydrogen export

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