BRITISH COLUMBIA | cleanBC GO ELECTRIC

Hydrogen Station Permitting Guidebook for BC

June 2022

Acknowledgements

The *Hydrogen Station Permitting Guidebook for BC* was prepared by HTEC and Zen and the Art of Clean Energy Solutions for the Ministry of Energy, Mines and Low Carbon Innovation. Work on the guidebook ran from January 2022 to June 2022.

This Guidebook reflects HTEC's knowledge and experience gained from developing hydrogen refuelling stations in BC. Information is specific to requirements in BC but follows the format of the Hydrogen Station Permitting Guidebook issued by the California Governor's Office of Business and Economic Development in September 2020.

Table of Contents

Executive Summary

British Columbia is committed to achieving net-zero emissions by 2050. Meeting the province's CleanBC goals requires a determined effort to increase energy efficiency, electrify the economy and switch to low-carbon fuels such as biofuels and hydrogen. Large-scale deployment of renewable and low-carbon hydrogen will play an essential role in reducing BC's emissions.

Realizing the potential of hydrogen requires all levels of government, industry and researchers to work together. As part of CleanBC, the BC 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. BC has already implemented robust policies to encourage hydrogen use in the transportation sector, including the Low Carbon Fuel Standard, Zero-Emission Vehicles Act and Regulation, and the suite of CleanBC GoElectric programming. To achieve our targets BC will require a build-out of hydrogen refuelling infrastructure across the province.

This Guidebook is intended as a comprehensive resource to support the development and permitting of hydrogen refuelling station projects. It contains six sections with a summary of each section provided below:

Overview
Provides BC's targets for reducing provincial greenhouse gas emissions and the importance of transitioning to zero-emission vehicles to achieve these goals. Background on hydrogen and fuel cell electric vehicles (FCEVs), benefits of FCEVs and their transportation applications, and regulations supporting FCEV adoption are provided. The importance of hydrogen refuelling stations (HRS) development to support FCEV adoption is highlighted along with HRS deployment status in the province.

Hydrogen and Fuel Cell Electric Vehicle Ecosystem
Provides hydrogen characteristics and a comparison with other transportation fuels. Advantages and operational details of a fuel cell vehicle are discussed, including emissions reduction benefits and comparison with battery electric technology. An overview of a typical hydrogen refuelling station is provided including description of standard components, siting considerations and layout. Finally, hydrogen production using electrolysis is discussed and gaseous and liquid hydrogen delivery methods described and compared.

Hydrogen Station Development
Provides a road map for municipal permitting, regulatory compliance, installation and operating permits, and tips on de-risking the station development in general. This section discusses strategies on how to engage with municipal planners, regulatory agencies, and utilities. It walks through the major permitting phases and discusses the three main parallel permitting paths; municipal, provincial, and utilities. The section attempts to highlight the nuances of municipal permitting, the importance of early engagement, and the overall timelines required to get all the required approvals.

Additional Topics and Considerations
Provides additional information that may be relevant to station development including importance of safety planning to gain approval from the local fire department, adherence to code requirements for FCEV repair facilities, hazardous materials regulations and environmental regulations pertaining to

development of contaminated sites. Finally, station operations and maintenance are discussed including the importance of standard operating procedures, corrective and preventative maintenance procedures, inspection schedules and file management of permit approvals.

Conclusion

Briefly concludes with key things to consider when permitting a hydrogen refuelling station, stressing the importance of early engagement with local permitting authorities to streamline the permitting process and mitigate delays.

Additional Resources

Includes reference lists of acronyms, definitions, and relevant regulations and codes to improve readability of the document, as well as a permitting checklist summary and list of site selection considerations.

1.0 Overview

1.1 Purpose of The Guidebook

This *Hydrogen Station Permitting Guidebook for BC* is intended to support hydrogen refuelling station development in BC by providing a resource for station developers, local authorities having jurisdiction (AHJs) and other stakeholders, such as regulators, equipment providers, site owners and government funding agencies, to navigate the station development and permitting process. This Guidebook will help to streamline the station development process, enabling increased access to hydrogen refuelling infrastructure to support zero-emission vehicle (ZEV) adoption in BC and achieving BC's decarbonization goals.

Regulations and permitting requirements differ between jurisdictions, and this Guidebook provides information for standardizing permitting processes, allowing municipalities to reap the environmental, economic and health benefits that hydrogen provides. Bottom-up community approaches and municipal engagement are identified as critical factors in the deployment of hydrogen refuelling technology.

The Guidebook provides comprehensive guidance on the hydrogen station development process from project inception through the development and permitting process to commissioning and final deployment. It also provides stakeholders with background on hydrogen and fuel cell electric vehicles (FCEVs), benefits of FCEVs and their transportation applications, regulations to support FCEV adoption including the Low Carbon Fuel Standard (LCFS) Part 3 Agreements, and the status of hydrogen station deployment and FCEV adoption in the province.

1.2 Summary of BC Hydrogen Fuel Cell Vehicle Market

In BC, the transportation sector is the single largest source of greenhouse gas emissions, accounting for 39% of the annual total. BC's *Climate Change Accountability Act* introduces legislated targets for reducing provincial GHG emissions below 2007 levels (40% reduction by 2030, 60% by 2040, and 80% by 2050). A transition from internal combustion engine (ICE) vehicles to ZEVs will be required to achieve these provincial decarbonization targets. In BC, ZEVs are defined as vehicles that produce zero emissions at least some of the time when operating and include battery electric vehicles (BEVs), plug-in hybrid vehicles (PHEVs) and fuel cell electric vehicles (FCEV). BEVs and PHEVs have already been deployed in large numbers in BC, and the introduction of FCEVs can complement the performance and application of BEVs and further contribute to GHG emissions reductions. Access to hydrogen refuelling infrastructure will be a critical factor in supporting FCEV adoption.

Unlike BEVs which store electricity in batteries, FCEVs use compressed gaseous hydrogen stored in on-board tanks as their fuel source. The vehicle's fuel cell module uses an electrochemical process to convert hydrogen directly into electricity which then powers an electric drivetrain. There is no combustion in the process and water vapour is the only tailpipe emission. The benefits of FCEVs include:

- **Zero emissions accompanied by easy adoption for existing drivers.** Refuelling an FCEV emulates the process for refuelling a gasoline or diesel-powered vehicle. The driver pulls the vehicle alongside a refuelling dispenser and uses a pump and nozzle to fuel a typical passenger vehicle in under 5 minutes. Hydrogen refuelling stations will be familiar to drivers and will allow for quick adoption of new FCEVs as they become more readily available.

- **Longer range and potential for industrial adoption.** FCEVs have similar travel range to gasoline and diesel engine vehicles and have the horsepower to tow larger payloads than BEVs currently on the market. The refuelling methods for FCEVs also complement existing commercial trucking options, allowing for an easier transition for large fleets which operate long hours and require fast refuelling to minimize idle time.
- **Increasing the rate of adoption of renewable energy consumption**. Hydrogen is a versatile energy carrier that can be produced from a variety of feedstocks that are abundant in our province. BC has a distinct comparative advantage because of its clean electricity which can be leveraged to produce low-cost and low-carbon hydrogen.

The number of fuel cell vehicles sold in BC is expected to increase rapidly from approximately 136 FCEVs in December 2021 to an estimated 200,000 to 350,000 FCEVs by 2040[1]. The BC *Zero-Emission Vehicles Act* supports increasing FCEV deployment by mandating that 100% of new vehicles sales in the province be zero emission by 2040[2]. Increasing FCEV adoption will also depend heavily on access and availability of hydrogen refuelling infrastructure as well as availability of FCEV supply.

BC has established itself as a leader in developing and implementing HRS infrastructure, with the first cluster of stations being developed in the BC Lower Mainland and Southern Vancouver Island. As of January 2022, there are four stations in operation: South Vancouver, North Vancouver, Burnaby and Victoria. There are also several new stations slated to open soon in BC.

Table 1: Current and Planned Stations in BC

Status	Facility Type	Address	Station Owner
Operational	Public LD refuelling Station	8686 Granville Street Vancouver, BC	HTEC
Operational	Public LD refuelling Station	2501 Westview Drive North Vancouver, BC	HTEC
Operational	Public LD refuelling Station	4505 Canada Way Burnaby, BC	HTEC
Operational	Public LD refuelling Station	4001 Quadra Street Saanich, BC	HTEC
Under construction	Public LD refuelling Station	1901 Harvey Avenue Kelowna, BC	HTEC
Planned early 2023	Public LD refuelling Station	Burnaby, BC	HTEC
Planned early 2023	Public LD refuelling Station	Victoria, BC	HTEC

[1] Zen Clean Energy Solutions. (2019). *British Columbia Hydrogen Study*. Retrieved from: https://www2.gov.bc.ca/assets/gov/government/ministries-organizations/zen-bcbn-hydrogen-study-final-v6.pdf

[2] Although 2040 is the current target for achieving 100% of new vehicle sales in the Province being zero emission, the "CleanBC Roadmap to 2030" indicates the BC Government's intention to adjust this target to 2035.

Planned early 2023	Public LD refuelling Station	Surrey, BC	HTEC
Planned mid-late 2023	Public LD/HD refuelling Station	Tsawwassen, BC	HTEC
Planned late 2022/early 2023	Public LD/HD refuelling Station	University of British Columbia Point Grey Campus Vancouver, BC	University of British Columbia

BC is recognized as a leader in the hydrogen sector with many major companies involved in developing new hydrogen technologies calling BC home. Local companies have pioneered new technologies and industry expertise in areas such as hydrogen production, components and systems testing, technology research, development and commercialization, and standards development. BC is also home to several world-class academic institutions that support the hydrogen and clean tech sectors through specialized programs and R&D.

1.3 BC's Path to 2030 Emission Reductions

BC's *Climate Change Accountability Act* (2007) legislated ambitious targets to reduce provincial greenhouse gas (GHG) emissions below 2007 levels: 40% reduction by 2030, 60% by 2040 and 80% by 2050. In 2020, BC set a near-term target of 16% reduction by 2025 to help BC remain on track to meet 2030 targets. BC has established 2030 reduction targets by sector, with targets for the transportation sector set at 27-32% reduction.[3]

There are two key pieces of legislation in BC, the *Zero-Emission Vehicles Act* and the *Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act*, that directly support ZEV adoption. These two Acts and the associated regulations are also known as BC's ZEV Mandate and Low Carbon Fuel Standard.

The Government of BC has also released several plans and studies which provide a vision and specific actions for achieving GHG emission reductions in the province in the 2030 and 2050 timeframe.

CleanBC Plan[4]

The CleanBC Plan, released by the BC Government in 2018, was developed as a plan to achieve BC's climate change targets by transitioning to clean and renewable energy sources while creating a sustainable economy with more jobs and opportunities for British Columbians. The plan provides a pathway for transitioning BC homes, businesses, industries and vehicles away from fossil fuel energy sources to renewable and cleaner energies.

Energy efficient solutions, such as heat pumps and ZEVs, are encouraged and the CleanBC Plan includes

[3] CleanBC. (2021). *Climate Change Accountability Report.* Retrieved from: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/2021_climate_change_accountability_report.pdf

[4] CleanBC. (2018). *Climate Strategy: Our Nature, Our Power, Our Future*, Retrieved from: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_2018-bc-climate-strategy.pdf

financial incentives to make low-carbon and energy efficient technologies more affordable and accessible to BC residents. Key actions in the transportation, industrial and built environment sectors are identified and quantified to eliminate an estimated 18.9 megatonnes (Mt) of GHG emissions. This represents 75% of the legislated 2030 target and the government committed to future updates of the CleanBC Plan to outline additional initiatives to meet the full 2030 target and beyond.

CleanBC: Roadmap to 2030[5]

In October 2021, BC released the CleanBC Roadmap to 2030, which is an update to the 2018 CleanBC Plan and provides new and stronger measures to accelerate emission reductions necessary to achieve the 2030 target and beyond. Use of hydrogen as a transportation fuel is highlighted as an opportunity to achieve the greatest decarbonization impact. Key actions directly impacting FCEVs and hydrogen as a transportation fuel are:

- Accelerated ZEV Act Targets: 26% ZEV by 2025, 90% by 2030, 100% by 2035
- Establishing ZEV targets for medium- and heavy-duty vehicles

BC Hydrogen Study[6]

The BC Hydrogen Study (released in 2019) focuses on the critical role hydrogen will play in enabling BC to achieve its 2030 and 2050 decarbonization targets (as outlined in the CleanBC Plan) and provides a comprehensive list of recommendations for developing a vibrant BC hydrogen economy. BC can leverage its existing resources which include a clean electrical grid, low-cost natural gas resources, and depleted gas reservoirs and saline aquifers for sequestering large volumes of CO2. The province can maintain local leadership in hydrogen and fuel cell technology by continuing to support the many high-profile BC companies involved in the sector. Adopting policies that promote and support all aspects of an emerging hydrogen economy, can position BC as a global leader in the sector and support decarbonization efforts locally as well as establish hydrogen as a valuable export resource to support decarbonization efforts globally. The study provides a vision for 2050 which includes the following:

- 15.6 Mt CO2e reduction annually
- 1.45 Mt of H2 consumption annually
- Up to 45% hydrogen injected into the natural gas grid
- 1 million FCEVs on the road
- $15 billion in export revenue

BC Light-Duty Vehicle Hydrogen Fuelling Network Study (2020)[7]

The BC Government Hydrogen Fuelling Network Study provides a plan for building a core network of light-duty hydrogen refuelling stations (HRS) across the province over the next 20 years. The study proposes

---

[5] CleanBC. (2021). *Roadmap to 2030*. Retrieved from: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_roadmap_2030.pdf

[6] Zen Clean Energy Solutions. (2019). *BC Hydrogen Study*. Retrieved from: https://www2.gov.bc.ca/assets/gov/government/ministries-organizations/zen-bcbn-hydrogen-study-final-v6.pdf

[7] Zen Clean Energy Solutions. (2020). *British Columbia Light-Duty Vehicle Hydrogen Fuelling Network Study.* Retrieved from : https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/transportation/bc_public_ld_hydrogen_fuelling_network_study_final_20200320.pdf

HRS build out of 17 stations by 2025, 55 in 2030, and 141 in 2040. When fully established, this HRS network will allow safe, convenient travel for FCEVs throughout the province's major highways and roads. Modelling of network build out considered many factors, including regional population and vehicle growth, highway traffic volumes, typical routes, and sources of electrical power and/or natural gas for hydrogen production. This study helps to inform government planning regarding funding mechanisms and support required to build out the station network in support of BC's ZEV mandate.

BC Hydrogen Strategy (2021)[8]

The BC Hydrogen Strategy was released in July 2021 and provides a blueprint of 63 key actions to realize the potential of renewable and low-carbon hydrogen for supporting BC's decarbonization goals, maintaining leadership in hydrogen technology and adoption, and building a sustainable economy. The strategy stresses the need for urgent action and the importance of policy, partnerships, innovation and infrastructure to accelerate the adoption of low-carbon hydrogen.

The strategy identifies short (2020-2025), medium (2025-2030), and long term (2030-2050) goals that provide a pathway for achieving net-zero emissions by 2050. Short term goals include scaling up production, establishing hydrogen hubs, and accelerating deployment of medium- and heavy-duty FCEV vehicles. The strategy supports diverse production methods including 'green' hydrogen production using electrolysis combined with renewable electricity as well as 'blue' hydrogen production derived from BC's abundant and low-cost natural gas resources combined with carbon capture and sequestration. Key actions include supporting regional hub development where production and end-use demand applications are co-located, supporting hydrogen use in industrial applications and hard-to-abate applications where it can most cost-effectively reduce emissions, and providing ongoing financial incentives for deployment of FCEVs and refuelling infrastructure. The strategy establishes an ambitious carbon intensity threshold for low-carbon hydrogen, 36.4 gCO2e/MJ, which aligns with the national threshold set in the Federal Hydrogen Strategy for Canada[9]. The strategy highlights the need for future policy and regulation development to ensure this threshold continually decreases over time.

[8] Government of BC. (2021) *BC. Hydrogen Strategy*. Retrieved from: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/electricity/bc-hydro-review/bc_hydrogen_strategy_final.pdf

[9] NRCan. (2020). *Hydrogen Strategy for Canada*. Retrieved from: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/environment/hydrogen/NRCan_Hydrogen-Strategy-Canada-na-en-v3.pdf

BC ZEV Mandate

To support the transition to zero-emission technology, the BC Provincial government passed the *Zero-Emission Vehicles Act* (ZEV Act) in May 2019 and ZEV Regulation[10] in July 2020. The ZEV Act and Regulation establishes escalating sales targets for original equipment manufacturers (OEM), also known as vehicle suppliers, to meet for sales of all new ZEV light-duty cars and trucks from 2025 through 2040. Light-duty cars and trucks are defined as vehicles with a gross vehicle weight rating (GVWR) equal to or less than 3,856 kg. The ZEV standard is intended to encourage OEMs to supply an increased number of ZEVs at more affordable prices in BC, and help the province reach its GHG reduction targets.

Beginning with model year (MY) 2020 vehicles, automotive manufacturers are required to report on their total light-duty vehicle sales (ZEV and non-ZEV) in BC and meet annual ZEV sales targets of 10% by 2025, 30% by 2030 and 100% by 2040. Given that light-duty ZEV sales accounted for of 13% of all new light-duty vehicle sales in BC in 2021, the CleanBC Roadmap to 2030 (released in October 2021) sets out accelerated targets of 26% by 2026, 90% by 2030 and 100% by 2035, and commits to include targets for medium- and heavy-duty vehicles. It is the BC Government's intention to amend the ZEV Act and Regulation to include these new targets.

Low Carbon Fuel Standard

BC's Low Carbon Fuel Standard (LCFS) is a performance-based standard implemented in 2008 to reduce BC's reliance on non-renewable fuels and the impact of GHG emissions from transportation fuels, while also encouraging growth in BC's clean energy sector. The LCFS requires compliance by all BC fuel suppliers (manufacturers and importers) to meet carbon intensity (CI) and renewable content targets for transportation fuels they supply.

The BC LCFS uses a market-based credit trading system that allows fuel suppliers to choose how they comply with the regulation. The BC LCFS has set clear targets for CI reductions each year and suppliers generate "credits" for supplying fuels with a CI below the current annual target and incur "debits" for supplying fuel above the CI target. Suppliers must reduce the average CI of their fuels to meet the annual targets, or purchase credits from other suppliers to offset any debits they incur.

The LCFS has provided a support mechanism for developers to deploy hydrogen refuelling infrastructure in BC. Under the LCFS, fuel suppliers can obtain low carbon fuel credits by entering into an agreement (called a Part 3 agreement) with the province, to take actions that will increase the low-carbon fuel use. Credits can be approved by the province based on the projected hydrogen station capacity and the fossil fuel emissions displaced by hydrogen use. For hydrogen to be considered a Part 3 fuel, there must be reasonable belief that the hydrogen will be used in transportation applications as a substitute for gasoline or diesel fuel[11].

---

[10] BC Laws. (2020). *Zero Emission Vehicles Regulation*. Retrieved from https://www.bclaws.gov.bc.ca/civix/document/id/oic/arc_oic/0448_2020

[11] BC Ministry of Energy, Mines and Low Carbon Innovation. (2016). *Information Bulletin RLCF-009*: *Clarification for Part 3 fuel supplier in relation to Emerging Fuels*. Retrieved from: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/transportation/renewable-low-carbon-fuels/rlcf009_-_part_3_fuel_supplier.pdf

2.0 Hydrogen and Fuel Cell Electric Vehicle Ecosystem

2.1 Hydrogen as Transportation Fuel

Hydrogen Fundamentals

Hydrogen is the first element on the periodic table as it is the simplest and lightest element on earth. It is approximately fourteen times lighter than air, which means that it rises and diffuses quickly when released into the air. Hydrogen is the most abundant element in the universe, accounting for about 75% of all mass, however, is rarely found in its natural state on earth and is commonly found bonded in other compounds such as water (H_2O) and methane (CH_4). Electrolysis and steam methane reformation (SMR) are common practices used to extract hydrogen from water and methane, respectively. These processes are explained further in Section 2.5.

In its natural and gaseous state, hydrogen is invisible, odorless, tasteless, and non-toxic, making it difficult to detect. Like electricity, hydrogen is an energy carrier. It must be produced from another energy source, such as renewable wind or solar sources, and then transported elsewhere for end-use. Hydrogen has the highest energy per mass of any fuel, however, it also has very low volumetric energy density and as a result cost-effective distribution and storage is a challenge.

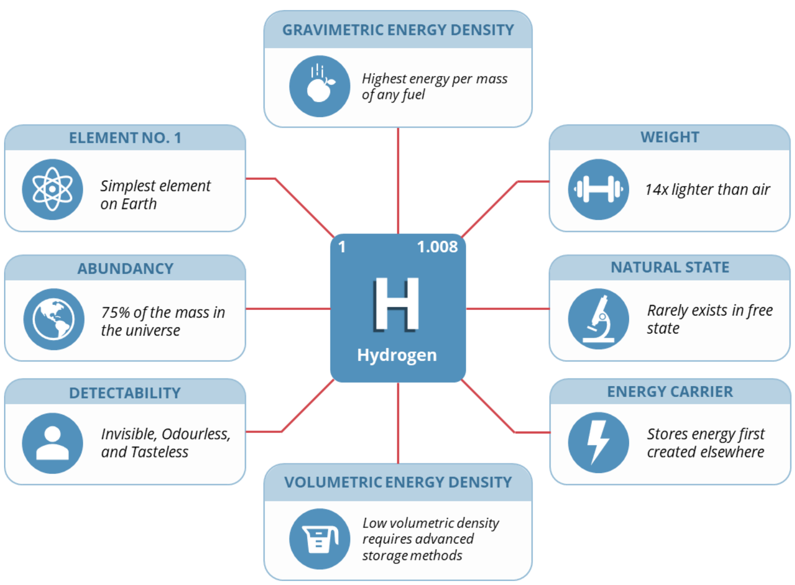

Figure 1: Hydrogen Characteristics[12]

Hydrogen's ability to produce electricity without emissions makes it a desirable alternative fuel. The chemical reaction between hydrogen and oxygen in a fuel cell produces electricity, heat, and water, with

[12] NRCan. (2020). *Hydrogen Strategy for Canada*. Retrieved from: https://www.nrcan.gc.ca/sites/nrcan/files/environment/hydrogen/NRCan_Hydrogen-Strategy-Canada-na-en-v3.pdf

no pollutants or carbon emissions released at the point of use. Hydrogen is also a clean burning fuel when combusted.

Fuel for Transportation

Hydrogen as a fuel for FCEVs is quickly becoming an attractive zero-emission alternative for transportation, especially in heavy-duty vehicles and transit buses which have long duty cycles. A fuel cell has twice the efficiency of a combustion engine while also emitting zero harmful emissions at the tailpipe.

Figure 2 provides a comparison of hydrogen fuel to gasoline and natural gas, which are other common transportation fuels. Hydrogen has much greater energy density by weight, 2.8 times denser than gasoline, but much lower energy by volume, 4 times less than gasoline[13]. As such hydrogen must be compressed for storage on a vehicle to get the range needed.

Hydrogen is colourless, odourless, and tasteless, making detection difficult. Natural gas is also odorless in its natural state, however, an odorant (mercaptan) is added to it for leak detection. Hydrogen is not odorized for two reasons: 1) the small size and mass of the H2 molecule makes it challenging to find an odorant that would bind to it and stay bound upon release, and 2) FCEVs require extremely pure hydrogen and an odorant would degrade the hydrogen purity which could reduce the performance of the fuel cell.

	Hydrogen	Natural Gas	Gasoline
Colour	No	No	Yes
Toxicity	None	Some	High
Odour	Odourless	Mercaptan	Yes
Buoyancy *Relative to Air*	14× *Lighter*	2× *Lighter*	3.75× *Heavier*
Energy *By Weight*	120 MJ/kg *2.8× > Gasoline*	~ 48 MJ/kg *~1.2× > Gasoline*	43 MJ/kg
Energy *By Volume*	4× *Less than Gasoline*	1.5× *Less than Gasoline*	120 MJ/gallon

Figure 2: Light-Duty FCEV Fuel Characteristic Comparison

[13] NRCan. (2020). *Hydrogen Strategy for Canada*. Retrieved from: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/environment/hydrogen/NRCan_Hydrogen-Strategy-Canada-na-en-v3.pdf

2.2 FCEV Technology and Emissions Reduction Potential

Fuel Cell Electric Vehicles

Fuel cell light-duty passenger vehicles are commercially available today globally, and in limited numbers in Canada. The Government of Canada has set federal targets for ZEVs to reach 20% of light-duty vehicles sales per year by 2026, 60% by 2030 and 100% by 2035. Canada considers battery electric vehicles (BEVs), fuel cell electric vehicles (FCEVs), and plug-in hybrid electric vehicles (PHEVs) as qualifying ZEVs.

Fuel cells are expected to play a significant role in medium- and heavy-duty trucks, rail, and ships that have operations with high power demand, coupled with energy intensive and long duty cycles. For example, heavy-duty trucks travelling long distances would require many heavy batteries, reducing the load capacity beyond that which would be acceptable for many operators. Long charging times could also negatively impact operations. The improved energy density and fast fill characteristics of fuel cell electric trucks will likely make them an optimal choice for certain applications.

Fuel cell electric buses (FCEBs) are commercially available, with more than 2,000 FCEBs in service worldwide, and approximately half of these deployments powered by Canadian technology.[14] The Zero-Emission Bus (ZEB) initiative underway in Canada encourages government to support school boards and municipalities in purchasing 5,000 ZEBs over the next five years.[15]

FCEVs use compressed hydrogen gas stored in on-board tanks as their fuel source. The vehicle's fuel cell modules use an electrochemical process to convert the hydrogen directly into electricity which then powers an electric drivetrain. There is no combustion in the process and water vapour is the only tailpipe emission. FCEVs also have a small battery which is used to capture energy during regenerative braking and provides additional power when accelerating, as well as smooths out power delivered from the fuel cell. In low power or idle mode, power can be provided by the battery and the fuel cell can remain off. FCEVs offer a smooth and quiet ride, and with fewer moving parts than an internal combustion vehicle they typically have lower maintenance requirements and costs.

---

[14] Ballard. (2020). *Fuel Cell Electric Buses*. Retrieved from https://www.ballard.com/docs/default-source/web-pdf's/white-paper_fuel-cell-buses-for-france_final-english-web.pdf?sfvrsn=939bc280_0

[15] Government of Canada, "*Zero Emission Transit Fund*", Retrieved from: https://www.infrastructure.gc.ca/zero-emissions-trans-zero-emissions/index-eng.html

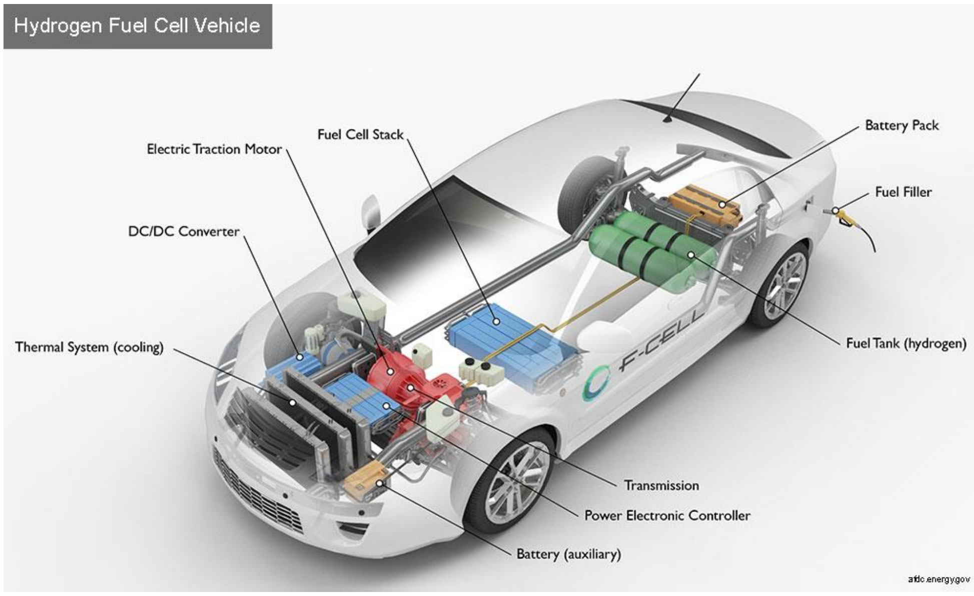

Figure 3: Fuel Cell Electric Vehicle[16]

FCEVs and BEVs emit no emissions when operating, but still have a small carbon footprint due to the contributing emissions from the vehicle manufacture, fuel production and distribution processes. These contributing emissions must be considered in establishing a total overall Well-to-Wheels vehicle emission impact.

Fuel cell light-duty passenger vehicles and transit buses are commercially available globally and deployed in limited numbers in Canada, with BC having 136 light-duty FCEVs on the road as of December 2021. Hydrogen-powered FCEVs also show strong promise in long-haul, heavy-duty trucking applications where batteries have limitations in range and payload weight.

BEVs and FCEVs are complementary technologies with each providing benefits in different applications. BEVs have already achieved widespread commercialization in the light-duty passenger vehicle market, where longer range is typically less of a concern and electricity is easily accessible for recharging. FCEVs offer greater range and faster refuelling than BEVs and are expected to have higher adoption in larger passenger vehicles, and in medium- and heavy-duty trucks and buses. FCEV commercialization is currently lagging BEV technology by about a decade, with the high vehicle price and limited hydrogen refuelling infrastructure being key barriers to adoption.

As infrastructure is rolled out and vehicle pricing reaches parity with BEVs, fuel cell vehicles are likely to be more attractive for drivers in multi-unit residential buildings (condominiums, apartments, townhouses with shared garages, etc.) where access to home charging is unavailable. This is particularly relevant for BC, where approximately 33% percent of households live in multi-unit residential buildings.[17] Once

[16] U.S Department of Energy. (n.d). *Alternative Fuels Data Center, How Do Fuel Cell Electric Vehicles Work Using Hydrogen?* Retrieved from: *https://afdc.energy.gov/vehicles/how-do-fuel-cell-electric-cars-work*

[17] Natural Resources Canada. (n.d). *Comprehensive Energy Use Database: Residential Sector – British Columbia*. Retrieved from: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/trends/comprehensive/trends_res_bc.cfm

hydrogen refuelling infrastructure is widely available, households without vehicle charging access in their parking stalls can opt for FCEVs. With availability of refuelling infrastructure, FCEVs may also be the technology of choice for fleet vehicles such as taxis that operate 24/7 where the convenience of fast refuelling will make it an attractive option. In colder climates, FCEVs can also offer better performance over battery technology, which experiences higher performance degradation in colder temperatures.

Emission Reduction Potential

Achieving emission reductions in the transportation sector will require a transition to zero-emission technology, which includes both BEVs and FCEVs. The *British Columbia Hydrogen Study*[18] (2019) provides projections for FCEV deployments, and the resulting hydrogen demand and emissions reductions, for the 2030 and 2050 timeframes. Projections for the 2030 timeframe range from 19,000 to 41,000 FCEVs providing an estimate of the opportunity that light-duty and heavy-duty FCEV deployments (light-duty passenger vehicles, medium- and heavy-duty trucks, public transit and private coach buses), can provide in reducing emissions in the province. (Note: actual deployments were lower than projected in the 3 years since publishing the report, so projection will be on the high side).

The study estimated 2030 emission reductions will range from 0.12-0.49 Mt CO2e annually and increase to 5.5-9.4 Mt CO2e annually in 2050. Light-duty FCEVs provide the greatest opportunity for emission reductions, driven by the large light-duty vehicle population. Achieving these emission estimates and the vehicle deployments that support them depends heavily on access to an established refuelling infrastructure network.

More detailed information on the projections and modelling can be found in the BC Hydrogen Study.

2.3 Hydrogen Stations

Station Components

All hydrogen refuelling stations consist of similar components: storage tanks, compression equipment and dispensers, collectively referred to as compression, storage and dispensing equipment. Stations are typically classified by the types of vehicles they serve (light-duty or heavy-duty) and the hydrogen supply source (liquid or gaseous hydrogen deliveries or on-site hydrogen generation). Cooling the hydrogen gas before dispensing is required to meet Society of Automotive Engineers (SAE) Standards to prevent overheating of the vehicle's on-board tanks during refuelling. The three standards for fuel cell vehicles are:

- SAE J2601 "Fuelling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles"
- SAE J2061-2 "Fueling Protocol for Gaseous Hydrogen Powered Heavy Duty Vehicles"
- SAE J2601-3 "Fueling Protocol for Gaseous Hydrogen Powered Industrial Trucks"

Hydrogen refuelling stations can be integrated into existing gas stations or built as stand-alone stations to serve a specific mobility fleet such as heavy-duty trucks, transit buses, or forklifts. Regardless, the

[18] Government of BC. (2021) *BC. Hydrogen Strategy*. Retrieved from: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/electricity/bc-hydro-review/bc_hydrogen_strategy_final.pdf

refuelling experience is similar to gasoline or diesel refuelling in terms of fill time, dispenser operation, payment and convenient access in local neighbourhoods and along transportation corridors. While the dispenser may look and operate like a gasoline or diesel dispenser, the supporting storage, compression, and dispensing equipment must be designed for specific use with hydrogen.

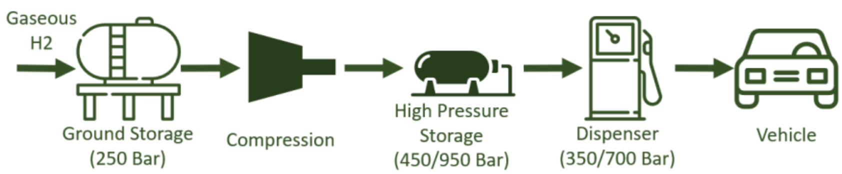

Figure 4. Gaseous H2 Refuelling Station Compression, Storage, and Dispensing Equipment Chain

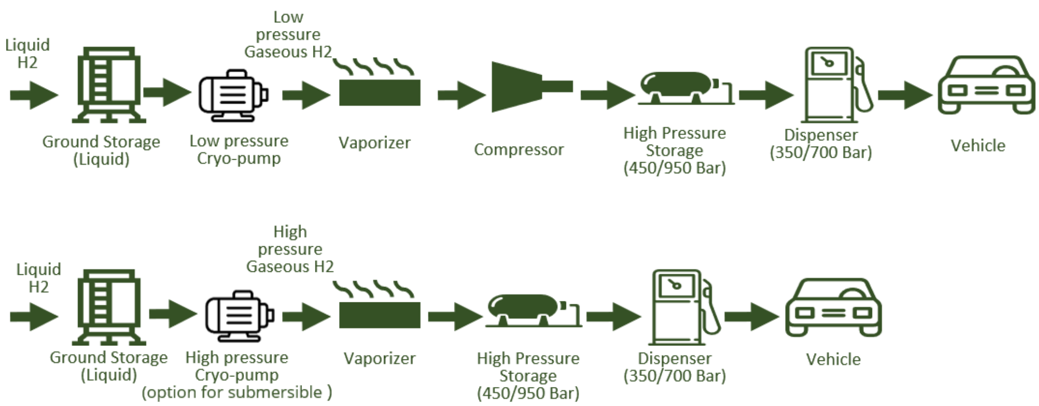

Figure 5: Liquid H2 Refuelling Station Compression, Storage, and Dispensing Equipment Chain (top with compressor, bottom without)

Storage

<u>Ground Storage</u>

Ground storage refers to tanks that store delivered hydrogen, which can be delivered as either liquid or gas from an industrial supplier or produced as a gas from on-site generation.

Gaseous hydrogen (GH2) ground storage tanks typically store GH2 at pressures of 200-450 bar (approximately 2900-6500 psi). The gaseous ground storage tanks can be permanent or removeable. Permanent tanks are filled from a high-pressure tube trailer accessing the site. Removeable or 'swappable' storage operations involve removing the empty tanks and replacing them with full ones.

Figure 6: Example of ground storage tank

In BC, all of the hydrogen refuelling stations currently receive gaseous hydrogen deliveries. Liquid deliveries have not been considered as the setback requirements associated with liquid hydrogen equipment are far greater than those for gaseous hydrogen and are challenging to accommodate in the confined footprint of an urban refuelling station. However, in California, as hydrogen demand and station capacity have increased, liquid hydrogen deliveries are becoming the standard, and ultimately, station design and deliveries in BC will involve liquid hydrogen as well.

Larger capacity stations (>1000 kg/day demand) typically receive liquid hydrogen deliveries as it is more economical to transport large quantities of hydrogen in liquid form, while smaller capacity stations typically receive gaseous deliveries. Liquid hydrogen (LH2) must be stored at cryogenic temperatures, below -252.8°C, the boiling point of LH2 at 1 atm pressure. LH2 ground storage tanks are typically double-walled, vacuum-insulated cryogenic tanks, that store LH2 at pressures between 2-7 bar (30-100 psi).

High-Pressure Gaseous Storage

All hydrogen stations also feature a high-pressure gaseous storage tank for buffer storage and direct dispensing into the vehicles. The gas is stored at a pressure above the required dispensing pressure, at approximately 950 bar (13,800 psi) for light-duty refuelling at 700 bar (10000 psi).

All hydrogen storage vessels are made from hydrogen compatible materials and have built in safety features including temperature and pressure relief valves and appropriate safe venting. Current stations have a combination of 950-1000 bar storage and 450-500 bar ground storage, depending on compressor type and cascading strategy.

Compression

Compression is required to convert low-pressure liquid or gaseous hydrogen contained in the ground storage, to a high-pressure gas appropriate for dispensing into fuel cell vehicles. The compression equipment differs depending on the liquid or gaseous state of the hydrogen in the ground storage.

<u>Gaseous</u>
With gaseous storage, the low-pressure hydrogen must flow through a high-pressure compressor to reduce the volume and increase the pressure of the hydrogen gas to 350 bar (5000 psi) for heavy-duty vehicle refuelling, or 700 bar (10,000 psi) for light-duty vehicles.

<u>Liquid</u>

With liquid storage, multiple configurations involving combinations of cryo-pumps, vaporizers, and compressors can be deployed to convert the stored LH2 into high-pressure GH2 appropriate for dispensing into a fuel cell vehicle. These include:

- Pump-vaporizer-compressor: a low-pressure cryo-pump transfers LH2 from the storage tank to a vaporizer, and then a compressor further compresses the hydrogen gas to reach dispensing pressure.
- Pump-vaporizer: high-pressure cryo-pumps transfer the liquid hydrogen to the vaporizer, achieving 450 bar pressure, and eliminating the need for a compressor. This is only appropriate for heavy-duty refuelling which occurs at 350 bar.
- Submersible pump-vaporizer: High-flow submerged liquid hydrogen pumps are an emerging technology capable of instant start, high storage tank utilization, and unlimited back-to-back fills (subject to tank capacity). A submersible LH2 pump is mounted to the LH2 ground storage tank through an integrated pump socket and controlled by an external dedicated hydraulic drive unit. The LH2 flows from the pump to a vaporizer which can produce gaseous hydrogen at required dispensing pressure (450 bar or 700 bar) without additional compression.

Cooling

After compression and prior to dispensing, the hydrogen typically enters a closed-loop cooling system to chill the gas to a temperature appropriate for the refuelling protocol used at the station. This cooling compensates for the heat of expansion preventing the vehicle's on-board fuel tanks from overheating during refuelling and enables faster filling times. In a light-duty station, the hydrogen gas is usually chilled to -40°C prior to dispensing.

Dispenser

Hydrogen dispensers are designed to look and operate similar to gasoline and diesel dispensers. A single dispenser can have one or two nozzles and often two dispensers are placed on a single island to provide multiple refuelling positions. To refuel, the driver places the dispensing nozzle in the vehicle receptacle and squeezes the trigger which locks the nozzle into place and signals the dispenser to begin refuelling. When complete, the driver removes the nozzle and returns it to the holster on the dispenser.

Dispensers include control systems that adhere to fuelling protocols, such as SAE J2601 for light-duty vehicle refuelling, to determine when the refuelling process is complete. The dispenser ends the refuelling process when a state-of-charge (SOC) above 95% is reached. All light-duty 700 bar dispensers include infrared communication to enable 'communicated fills' (vehicle to station communication) which uses temperature and pressure information from the FCEV compressed hydrogen storage tank to calculate SOC. If communication is unavailable, refuelling relies on ambient temperature and rated vehicle tank capacity to determine SOC.

Every station also requires real-time monitoring controls and safety equipment including fire detection and hydrogen pressure relief systems.

Figure 7: Light-Duty Station Refuelling; Hydrogen Dispenser

2.4 Hydrogen Delivery

There are several commercially viable methods for delivery of liquid and gaseous hydrogen. The following section details hydrogen transportation via tube trailer, drop and swap, pipeline, and cryogenic tanker.

Gaseous Hydrogen

Tube trailer delivery

Specially designed hydrogen tube trailers haul compressed high-pressure gaseous hydrogen in a series of cylinders (or tubes) on a trailer. The tube trailer is brought to the station site, where a driver connects the hydrogen tubes to the station, refilling the on-site ground storage. Fuel transfer typically occurs via "cascade filling" whereby the higher-pressure hydrogen in the tube trailer flows into the lower pressure on-site ground storage tank without the use of a compressor. Tube trailers typically deliver GH2 in steel tubes at pressures up to 250 bar. There are emerging trailer designs using composite materials for tank construction which allow for 450 bar storage pressure and reduces overall weight. This improvement significantly increases the carrying capacity, which decreases overall transportation costs and GHG emissions.

Figure 8: Example hydrogen tube trailer (Source: Air Products)

Drop and swap delivery

Drop and Swap delivery utilizes portable GH2 storage systems which consist of a matrix of high-pressure

GH2 storage tanks manifolded together. HTEC's PowerCube, shown in Figure 9, has 5 compressed hydrogen tanks bundled together and is an example of a temporary storage matrix. When the on-site storage level decreases below the threshold required to refuel FCEVs, the tanks will be taken off-site for refilling and full tanks will be delivered to the site to replace them.

Figure 9: 4 HTEC PowerCubes stacked for on-site storage at the Port of LA (left)[19], view of single HTEC PowerCube (right)

Figure 10: Schematic of Truck delivering PowerCube units to site

Pipeline

Gaseous hydrogen can also be delivered by pipeline in situations where nearby pipeline access is available. Pipelines usually supply hydrogen for industrial processes, which typically do not require high purity hydrogen. For refuelling stations, hydrogen requires a purification process to ensure the gaseous hydrogen meets the hydrogen purity requirements for FCEVs as specified in Hydrogen Fuel Quality

[19] HTEC photo of fuelling equipment installed at Port of LA as part of ZECAP project. *ZECAP is part of **California Climate Investments** (http://www.caclimateinvestments.ca.gov), a statewide program that puts billions of cap-and-trade dollars to work reducing greenhouse gas emissions, strengthening the economy and improving public health and the environment — particularly in disadvantaged communities. ZECAP is funded through the California Air Resources Board's ZANZEFF program.*

standard SAE J2719 "Hydrogen Fuel Quality for Fuel Cell Vehicles."

Liquid Hydrogen

LH2 is delivered in super-insulated, cryogenic tanker trucks. Over long distances, LH2 is more economical to transport because liquid tankers can carry much larger quantities of hydrogen than gaseous tankers. In this scenario, the LH2 tanker truck will arrive on site where a trained operator will connect a hose from the tanker truck to a designated valve on the on-site LH2 storage tank to offload the hydrogen.

2.5 Hydrogen Generation

There are several commercially viable hydrogen production pathways that can be used to produce hydrogen, with the most common being SMR and electrolysis technology. Globally, most hydrogen is currently produced via SMR, a process where natural gas is converted to hydrogen and carbon dioxide. If the SMR process involves renewable natural gas (RNG) or is combined with carbon capture technology, low carbon hydrogen can be achieved. Electrolysis is a process that uses electricity to split water molecules into hydrogen and oxygen. When using electricity from renewable sources (wind, solar, hydro), the resulting hydrogen can have a very low-carbon intensity

This report will focus only on the production of green hydrogen in BC, which is hydrogen derived from renewable resources and renewable energy sources. As shown in Figure 11, BC has a distinct comparative advantage with its low-carbon intensity electricity grid, where 91%[20] of the electricity is generated through hydroelectric sources. BC is home to over 15,955 MW of hydroelectric capacity, with an additional 1,100 MW slated to come online after completion of the Peace River Site C dam in 2025.[21]

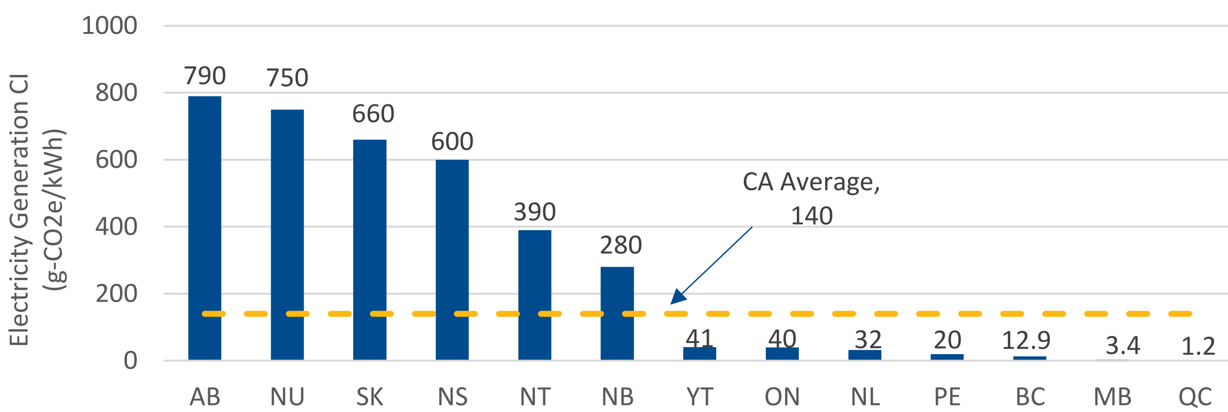

Figure 11: Carbon Intensity of Provincial Electricity Generation Sources[22]

---

[20] Canada Energy Regulator. (2022). *Provincial and Territorial Energy Profiles – British Columbia*. Retrieved from: https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-british-columbia.html

[21] Canada Energy Regulator. (2022). *Provincial and Territorial Energy Profiles - British Columbia.* Retrieved from: https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-british-columbia.html

[22] NRCan. (2020). *Hydrogen Strategy for Canada.* Retrieved from: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/environment/hydrogen/NRCan_Hydrogen-Strategy-Canada-na-en-v3.pdf

Centralized production of low-carbon intensity hydrogen in BC is critical for the province to meet its decarbonization targets. Procuring green hydrogen locally will reduce GHG emissions associated with delivery and reduce transportation costs compared with procurement from hydrogen production facilities located in California and Quebec. The most economical and viable pathway for large scale green hydrogen production in BC is water electrolysis. Figure 12 shows a schematic of centralized hydrogen production using electrolysis combined with BC's low-carbon hydroelectricity and other renewable sources. The production facility can include liquefaction to serve larger hydrogen demand and delivery distance.

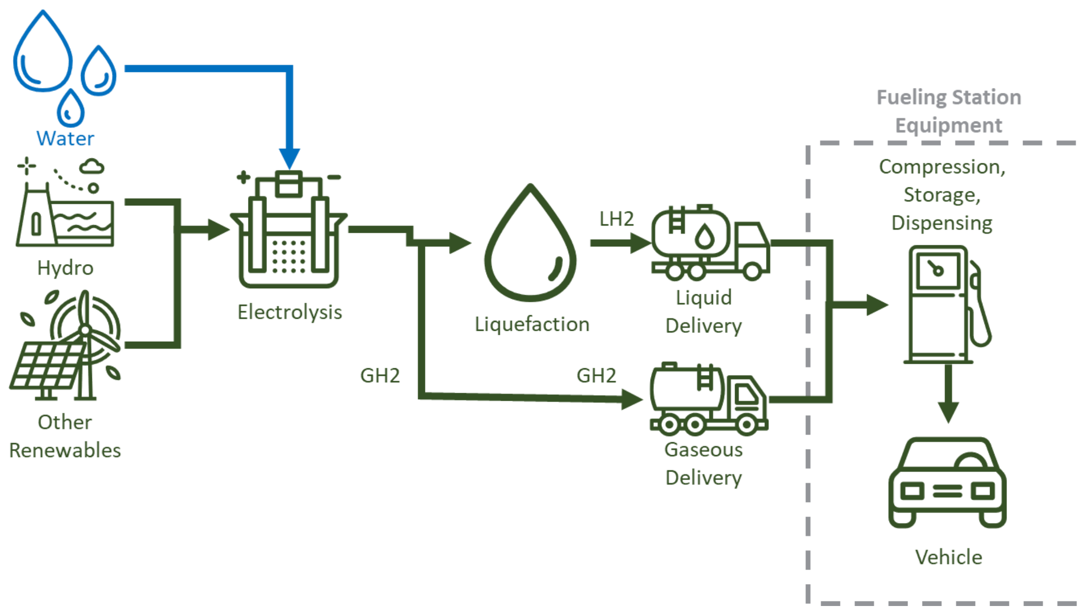

Figure 12: Centralized Green Hydrogen Production via Electrolysis

Electrolysis is the process of using electricity to split water into hydrogen and oxygen. Figure 13 shows a simple electrolyzer cell with 2 electrodes separated by a membrane. When a direct current is applied to the electrodes, water reacts at the anode to form oxygen and protons (positively charged hydrogen ions). The protons pass selectively through the membrane to the cathode where they combine with electrons to form hydrogen gas. About 18 litres of freshwater is required to produce 1 kg of hydrogen and 8 kg of oxygen. The resulting hydrogen is very pure and can be used directly in transportation and other end-uses after drying. The oxygen, while often vented, can also be captured and used in medical or industrial applications.

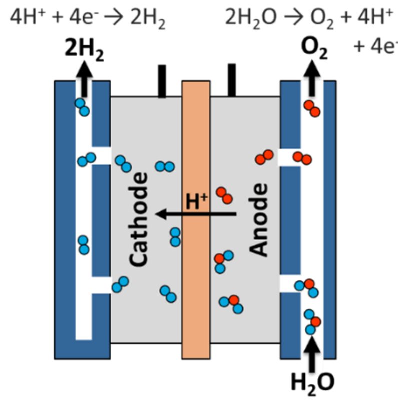

Figure 13: Simplified version of an Electrolyzer Cell[23]

As shown in Figure 14, the core components of a green hydrogen production facility are the electrolyzer, compressor or liquefaction equipment, on-site hydrogen storage, and distribution.

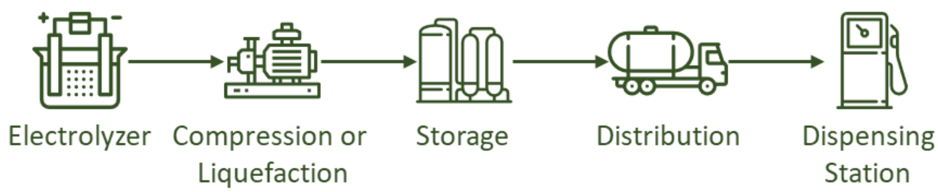

Figure 14: Major Unit Operations of Hydrogen Production via Electrolysis

Gaseous Hydrogen Production

Currently, there are two commercially viable electrolyzer technologies: proton exchange embrane (PEM) and alkaline electrolysis. Depending on the chosen technology, the gaseous hydrogen produced from the electrolyzer system ranges from 1-40 bar. As outlined in Section 2.4, gaseous hydrogen is typically delivered at either 250 bar or 450 bar pressures. For gaseous hydrogen delivery, a compressor is required to increase the pressure of the hydrogen to the required delivery pressure. On-site gaseous storage is typically installed to provide a buffer supply to mitigate against process disruptions or unplanned downtime of equipment.

Liquid Hydrogen Production

Analysis performed as part of the BC Hydrogen Study (2019) projected liquid hydrogen delivery becoming more economical than gaseous delivery for facilities producing more than 10 tonnes of hydrogen per day[24]. Liquefaction plants have a large footprint, high capital costs, and are energy intensive, which makes it economically unviable at smaller scale. The volumetric density of liquid hydrogen is 71 kg/m^3, which is 3.4 times the density of gaseous hydrogen at 350 bar. For high volume hydrogen production facilities, supplying liquid hydrogen significantly decreases transportation and delivery costs. Figure 15 shows a

[23] Office of Energy Efficiency & Renewable Energy. (2022) *Hydrogen Production: Electrolysis. Retrieved from: https://www.energy.gov/eere/fuelcells/hydrogen-production-electrolysis*

[24] Government of BC. (2021) *BC. Hydrogen Strategy*. Retrieved from: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/electricity/bc-hydro-review/bc_hydrogen_strategy_final.pdf

comparison of gaseous and liquid hydrogen delivery as a function of distance. LH2 delivery is lower cost on a per kg basis, however, installing the equipment to enable liquid hydrogen delivery is not necessarily cost effective for customers with low hydrogen demand or located in close proximity to a local hydrogen supply. Therefore, these customers will continue to rely on gaseous delivery.

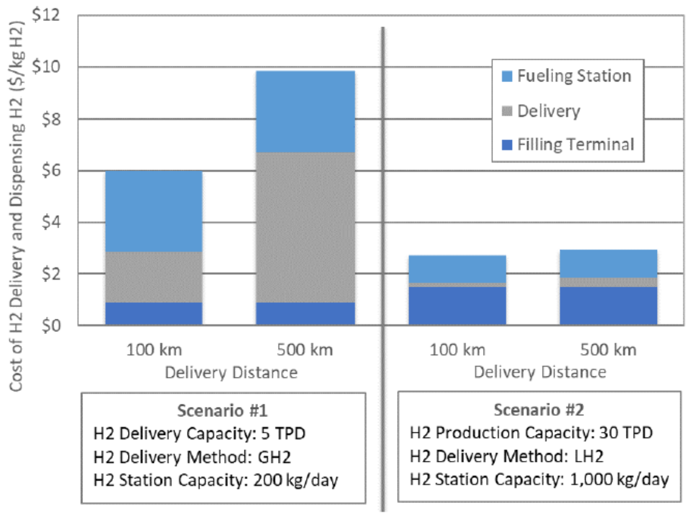

Figure 15: Cost analysis of hydrogen as a compressed gas and cryogenic liquid[25]

The process of producing liquid hydrogen involves three key steps:

- Compression
- Cooling
- Expansion

Gaseous hydrogen is first compressed then sent to a cold box where it undergoes a two-step cooling process to decrease the temperature to -193°C and then -233°C. The cooled hydrogen gas is then expanded through a throttling valve, which further cools the hydrogen to -253°C where it becomes a liquid state. Hydrogen liquefaction is an energy intensive process, consuming more than 30% of the energy content of the hydrogen, approximately 10-20 kWh/kg-H2.[26] Like a gaseous hydrogen production facility, an on-site liquid storage tank is typically installed to provide buffer storage to ensure consistent supply to end-users relying on the hydrogen fuel.

Small-scale On-site Generation

On-site production via small-scale electrolysis is an option for refuelling stations located in remote areas that have access to electricity.[27] Small-scale PEM electrolyzers are available in containerized designs, which include key components such as water treatment, cooling systems, and vent systems. Figure 16

[25] Government of BC. (2021) *BC. Hydrogen Strategy (p.54)*. Retrieved from: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/electricity/bc-hydro-review/bc_hydrogen_strategy_final.pdf

[26] US Department of Energy. (2019). *Current Status of Hydrogen Liquefaction Costs.* Retrieved from: https://www.hydrogen.energy.gov/pdfs/19001_hydrogen_liquefaction_costs.pdf

[27] Zen Clean Energy Solutions. (2020). *British Columbia Light-Duty Vehicle Hydrogen Fuelling Network Study.* Retrieved from : https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/transportation/bc_public_ld_hydrogen_fuelling_network_study_final_20200320.pdf

shows two examples of containerized PEM electrolyzer systems, each capable of producing approximately 1,000 kg-H2/day and integrated into two standard 40-foot shipping containers, which allows for ease of shipping to remote areas by truck. Figure 17 shows an overhead layout of a facility utilizing a containerized electrolyzer system to produce 500 kg-H2/day for the mobility sector.

Figure 16: Containerized Electrolyzer Systems[28][29]

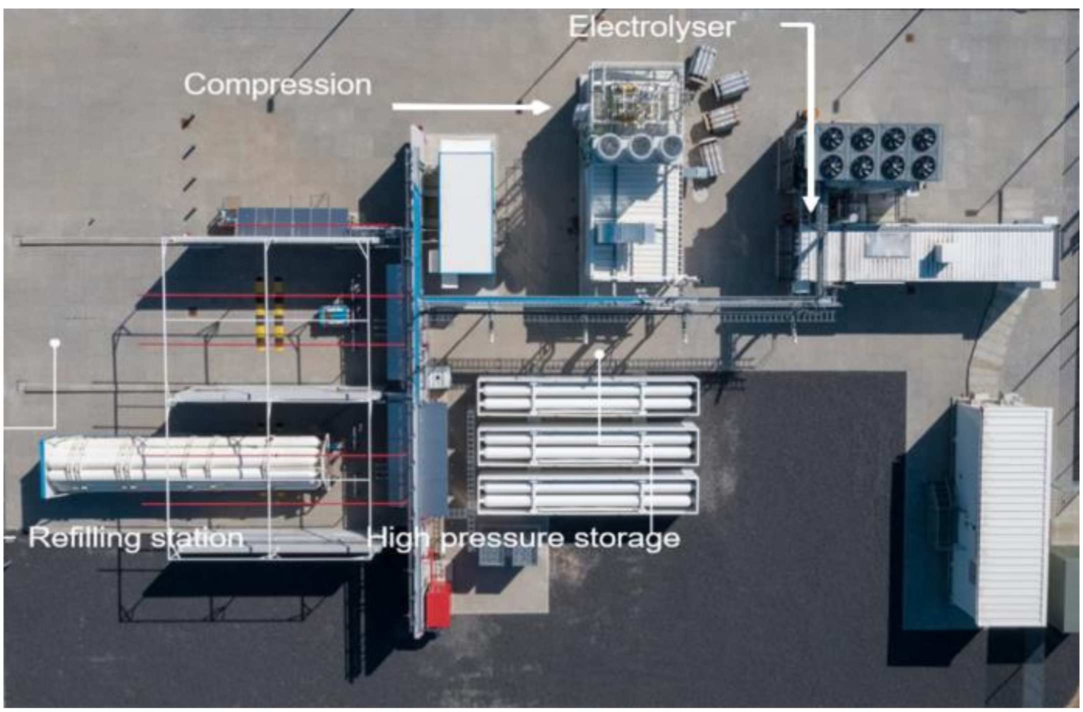

Figure 17: Example of on-site Electrolyzer System Integrated with compression, storage, and refilling station[30]

[28] NEL ASA. (2022) Containerized PEM Electrolyzer. Retrieved from: https://nelhydrogen.com/product/m-series-containerized

[29] Cummins. (2020). Power to Hydrogen to Power Solution. Retrieved from: https://flexnconfu.eu/wp-content/uploads/2020/11/Webinar-FLEXnCONFU_Cummins_D_Thomas.pdf

[30] Cummins. (2020). *MW-scale PEM electroly*sis. Retrieved from: https://hybalance.eu/wp-content/uploads/2020/09/20200924_HyBalance_Hydrogenics_vFINAL.pdf

2.6 Hydrogen Market and Pricing in BC

Hydrogen Pricing

Hydrogen as a fuel in BC is still in the early stages of development and the cost to the end-user will vary based on factors such as production source, carbon intensity, transportation cost, and price of labour. Retail hydrogen refuelling station operators in BC aim to provide a hydrogen price at the fuel pump equivalent to the price of gasoline for the end-user. This will encourage fuel cell adoption by individuals and fleet operators. It is important to note that hydrogen is sold to the public in units of kilograms rather than litres, as is the case for gasoline or diesel, so the pump price cannot be directly compared.

2.7 Station Types and Considerations

Figure 18. Light-Duty Station

Light-Duty Stations

Generally, station developers will work with existing fuel purveyors interested in offering a new fuel such as hydrogen. Existing fuel stations are set up to handle vehicle queuing (or stacking) and offer an intuitive flow for vehicle traffic. In most cases the hydrogen dispenser will be located under the existing canopy between traditional fuel dispensers.

The routing of utility connections between the hydrogen storage and compression equipment to the island-based dispenser needs careful consideration. Active retail fuel stations will have significant sub surface infrastructure that will complicate equipment siting and installation. Trenching and potential interference need to be de-risked with careful study of the existing sub surface infrastructure. This information can come from studying existing drawings and performing site-specific utility locate exercises.

Forecourt considerations will include car stacking, general vehicle traffic, slab grounding, weather protection and general hazardous zone considerations for siting of the dispenser. In most cases stakeholders will want to see an auto turn and traffic analysis done to understand the impact of the hydrogen equipment on current activities in the forecourt area.

In many cases the site will have additional business units sharing the property including car washes and drive through vendors. The business units will be sensitive to interruption of their revenue stream. Careful construction planning will help mitigate some of these concerns.

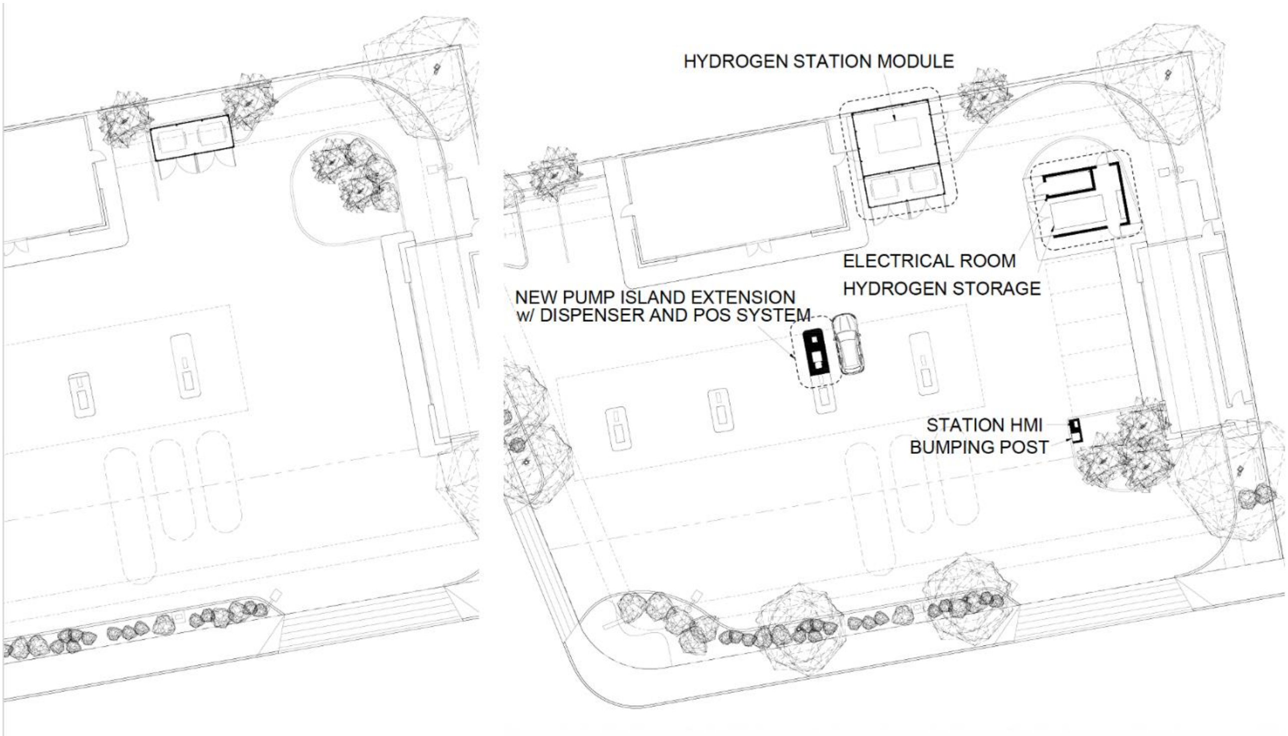

Figure 19: Siting example at a busy urban fuel station, before and after

Heavy-Duty Stations

In addition to the consideration for a light-duty station, additional considerations need to be taken into account with respect to heavy-duty stations. Generally, the biggest concerns are related to the vast amount of space required for large vehicles to manoeuvre into and out of the stations. An auto turn analysis and setback review will reveal the buildable area on the site. While heavy-duty station footprints may appear large, siting opportunities can be as challenging as dense urban light-duty stations.

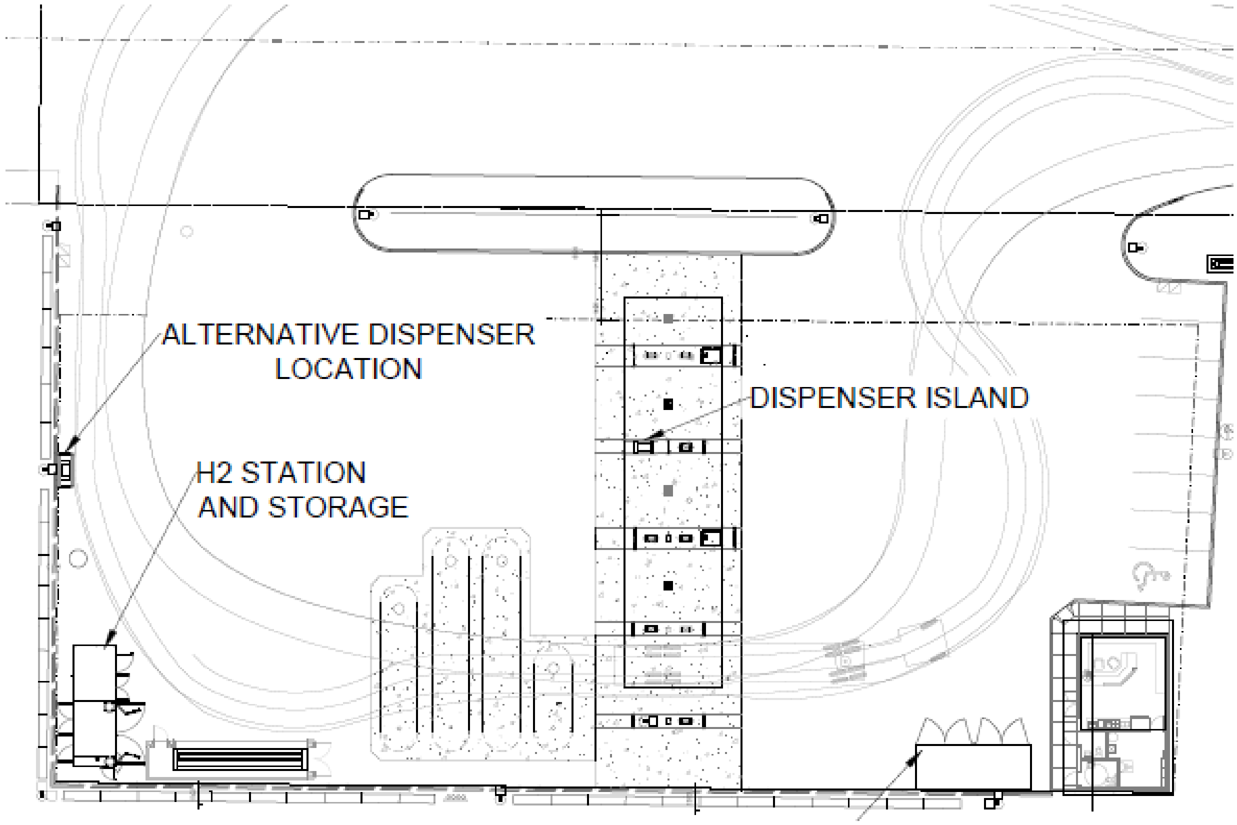

Figure 20: Typical heavy-duty fuel station forecourt traffic

3.0 Hydrogen Station Development

Developing a hydrogen refuelling station in BC is a resource and time intensive exercise, particularly for the first station in a community. Permitting requirements will differ from one station project to another depending on the site characteristics, station specifications, the municipal permitting process, public engagement requirements, and local building bylaws.

In BC, municipalities issue the required development, building, and occupancy permits.

In addition to the municipal permits, each station project and associated equipment will also require a site design and equipment registration, as well as installation and operating permits from the provincial authority having jurisdiction. In BC, the Authority Having Jurisdiction (AHJ) for gas systems and equipment, including hydrogen, pressure vessels, pressure piping and refrigeration systems, as well as electrical systems is Technical Safety BC.

This section of the Guidebook is designed to minimize the research required to permit a station from the AHJs, municipality, and station developer perspective, offering insight and tools from past projects and general recommendations for de-risking the permitting process.

A major part of the station permitting process is dedicated to ensuring stations are built to meet current codes and standards. The following sections provide references to BC codes and guidance, which can be amended by local jurisdictions in certain circumstances. The local municipal planning department will have the final authority on the code interpretation in their jurisdiction. Previous experiences have shown that code requests can vary with different interpretations from one municipality to another. Given this reality, the British Columbia Building Code (BCBC), can generally be used to plan a permit strategy that is applicable across the province. However, as discussed in Pre-Application Outreach in Section 3.3 below, it is important for station developers to meet early in the process with the municipal planners to ensure projects are designed in compliance with local interpretations of codes and standards.

Before proceeding through the detailed information in this section, the reader should be aware that there are numerous opportunities to flood or overwhelm the hydrogen station development process with information. A complex permit application may attempt to address any question that could arise, but also greatly increases the amount of time required to review and approve a package. Each municipality is different, but as a rule of thumb, the best permit applications are concise but complete, including enough information to make each department's review as simple and straightforward as possible.

3.1 Provincial Hydrogen Code Requirements

Installation Permits and Codes

The BC Gas Safety Regulation (BC Reg. 103/2004) includes various requirements for hydrogen refuelling stations. This includes the following (Section 25):

"An applicant for an installation permit for a gas system or proposed gas system must, if required by a provincial safety manager, provide drawings in support of the application and pay any required fees."

In BC, Technical Safety BC fulfills the role of the provincial safety manager. Stations require equipment registration, site design registration, installation, and operating permits from Technical Safety BC. Some guidance on obtaining these approvals is included in Section 3.3.

The main objective of the site design registration is to demonstrate compliance with CAN/BNQ 1784-000 Canadian Hydrogen Installation Code (CHIC), which will be adopted in the BC Gas Safety Regulation on October 1, 2022[31]. This includes many detailed requirements, and it is beyond the scope of this document to discuss all of these. However, TSBC is likely to require the following:

- A statement of compliance
- All drawings, specifications, calculations and instructions necessary to construct, install, operate and maintain the equipment
- A detailed site-specific risk assessment and demonstration of the management systems employed to control process hazards may be required (CAN/CSA Z767 Process Safety Management from the Canadian Standards Association is considered a best practice document).

Documentation must be signed and sealed by a professional engineer who is registered with the Association of Professional Engineers and Geoscientists of BC and has a firm understanding of hydrogen systems and the associated risks and liabilities.

[31] Regulation of the Attorney General and Minister Responsible for Housing. (2022). Ministerial Order No. M191. Retrieved from: https://www.bclaws.gov.bc.ca/civix/document/id/mo/mo/m0191_2022

Once TSBC has issued a site design registration the installation work can start. An appropriately licenced contractor will need to pull TSBC installation permits.

No regulated work should be performed prior to obtaining the applicable installation permits. Please refer to Section 6.4 for full list of codes and standards relevant for BC and Canada.

Operating Permits and Codes

For operating a station, there are additional requirements. The BC Gas Safety Regulation (Section 28) states that:

"(1) The owner of any of the following must apply to a provincial safety manager for an operating permit:

... (c) an establishment for filling containers with gas"

As with the equipment and site registrations, it is necessary to receive a "Class 8 – Special Type" operating permit from Technical Safety BC before operations begin. Some guidance on operating and maintenance considerations is provided in Section 4.6.

Differences between Light-, Medium- and Heavy-duty Stations

The overall regulatory framework is similar for light-, medium- and heavy-duty stations, however there are some differences in the code details that apply. These are discussed below.

Light-Duty Stations (700 bar)

For light-duty stations, CHIC makes reference to Standard CSA/ANSI HGV 4.3 ("Test methods for hydrogen fuelling parameter evaluation"). This document verifies the requirements of SAE J2601 ("Fuelling protocols for light-duty gaseous hydrogen surface vehicles"), which establishes the protocol and process limits for hydrogen refuelling of light-duty vehicles.

Medium- and Heavy-Duty Stations (350 and 700 bar)

For non-light-duty stations, CHIC requires that there are two means to authorize refuelling. SAE J2601-2 is a performance-based protocol document that provides performance requirements for hydrogen-dispensing systems used for refuelling 350 bar heavy-duty hydrogen transit buses and vehicles, while SAE J2601-3 fulfills a similar purpose for industrial trucks. Neither of these documents are explicitly referred to in CHIC but compliance is likely to be important in the process of obtaining a design registration from Technical Safety BC.

3.2 Local Bylaws

Municipalities in BC are required to follow the British Columbia Building Code (BCBC). However, municipalities typically adopt local laws (also called "bylaws") to supplement these provincial and federal building codes to address local considerations. These local considerations are captured in what municipalities call development permit areas (DPAs), zoning, and land use designation. DPAs can cover local considerations and range from climate considerations and aesthetics, to geohazards. DPAs are specific to the municipality. Zoning and land use designation typically dictate the kind of structures and activity that can take place on a particular parcel of land. It is important for developers to understand the implications of these municipal bylaws.

A municipality may have local building bylaws that supplement or add to the provisions of the BCBC for any section that impacts hydrogen stations. In many cases these local bylaws are available online and an experienced architect can help interpret these and how they will inform the site layout.

3.3 Station Development Process

Several permits from both municipal and provincial AHJs will be required at different times throughout the project. Technical Safety BC Operating permits are to be in place prior to the facility going into operation and are ongoing throughout the life of the facility. They are in place to provide oversight of the continued operation, maintenance, and lifecycle planning for the facility.

The overall local permitting process, Technical Safety BC permitting process, and power utility permitting process are summarized in the figure below and described in greater detail in following section:

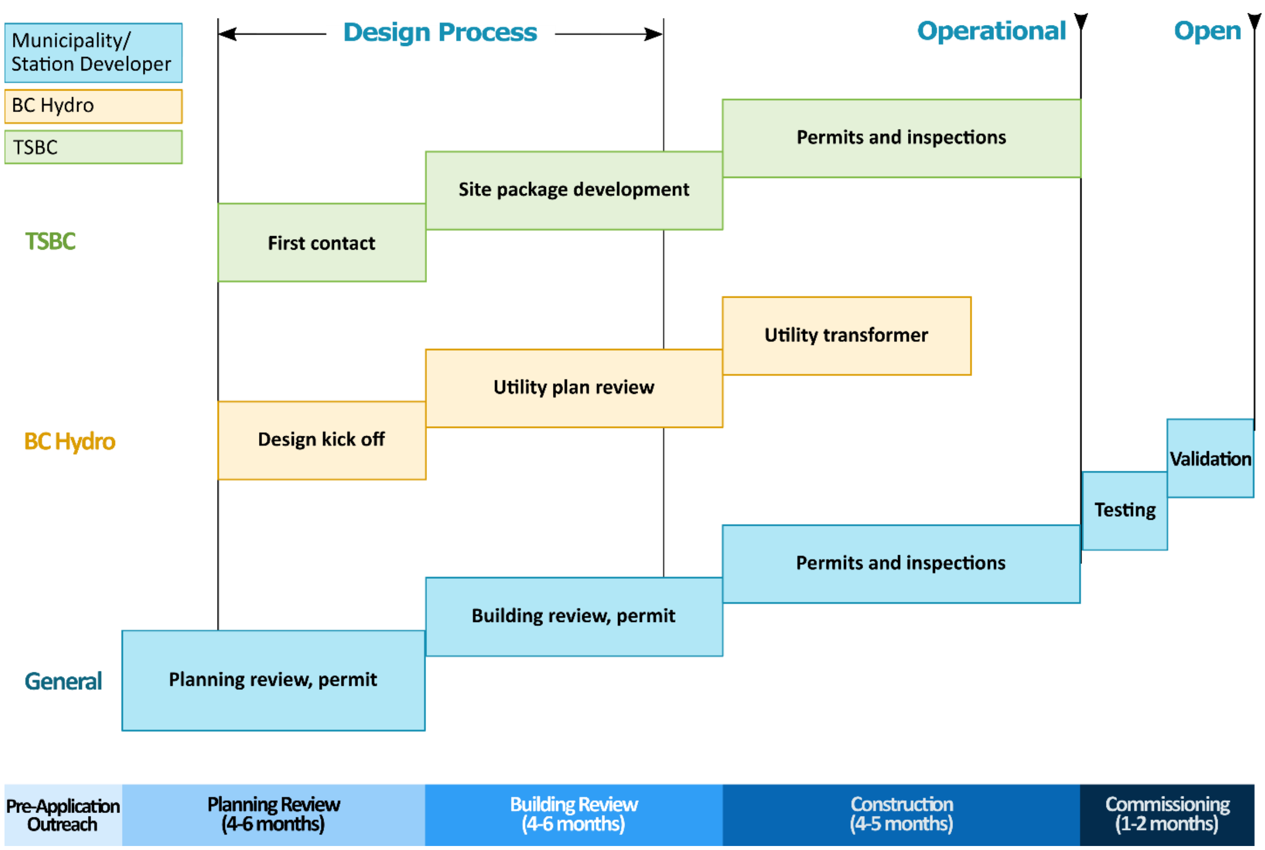

Figure 21: Typical Hydrogen Station Development Process

It is important to remember that the design and permitting processes are interrelated, and multiple permits and approvals may be required in different stages of the process. The "Hydrogen Station Development Process" diagram shown in Figure 21 outlines the processes involved and includes a range of estimated timelines. Note: a more detailed version of Figure 24 is included in Appendix A.

Phase 1: Pre-Application Outreach

The municipal planning department is often the most effective place to first engage a local authority. Ultimately, the planning department will ensure a project meets zoning requirements and fits within the municipality's official community plan and development permit area requirements. This includes considering impacts to parking, aesthetics, on-site circulation, trees, and traffic flow. Planning departments will connect applicants with other relevant departments as appropriate. During this phase, community consultation may also be required.

Community engagement will be more crucial in some areas than others, and it is important for station developers to understand community dynamics when developing an outreach plan. Planning departments can often provide insight into the associated community's expected willingness for or resistance to development, as well as other potential concerns specific to the communities they represent.

Above all else, two of the most important steps in the hydrogen station development process occur during the pre-application outreach phase, before a permit application is submitted. These steps involve site license agreements and establishing a permitting pathway and are described in more detail below.

Step 1: Site licence agreements

Seamless communication between the station developer, site owner, and site operator is vital in securing the station site. Site owners and operators must be fully committed to the proposed station arrangement and remain part of the process to enable any necessary changes along the way. Understanding site ownership structures is key.

In many cases, sites are leased and the station developer enters into a sublease with their operating partners. There are potential legal pitfalls if the site owner, the entity registered on the land title as the owner, is not aware of the proposed development.

A land title may be encumbered with loans or other restrictions which may introduce risk to the project. It is key to fully understand the land ownership structure.

Step 2: Establish communication and a permitting pathway

Most municipal planning departments welcome pre-application meetings with the applicant, and key municipal staff. These meetings can help the applicant ensure their application provides all the information that the planners need to approve the development permit, saving time and resources for both the developer and planning staff. Pre-application meetings can uncover potential issues upfront and will go a long way to de-risking the success of the project. They provide an excellent opportunity to bring municipalities up to speed with the broader effort to deploy hydrogen-powered FCEVs.

These early meetings can open a dialogue about items that could delay the permitting process or lead to the denial of an application, such as:

- Problems with the proposed site—parking, circulation, right-of-way, or clearances.
- Specific municipal requirements that the project must meet to achieve approval, such as aesthetics or local bylaws, and ways to streamline the approval process.

- Community contribution agreements (CCAs) may be required by some municipalities. CCAs can range from greenspace dedications to cash contributions for community assets.
- Issues with similar projects in the jurisdiction.
- Neighbourhood concerns.

The pre-application meeting can take place any time before the permit package is submitted, but earlier in the process is typically better, even if a very rough general arrangement document or aerial photo of the site are the only design documents available. During the pre-application meeting, the applicant should lay out the plan, describe the proposed path forward, learn what permits or approvals will be required to complete the project, and gain a clear understanding of the level of detail each department would like to see in the permit application submittal package.

Phase 2: Planning Review (Development Permit Application)

Planning Review is a required part of the permitting process which ensures that a proposed station fits within a municipality's zoning and land use designation, development permit area, and overall aesthetics. Experience has shown that gaining planning approval can be the most time-consuming aspect of the permitting process, underscoring the importance of early engagement with the planning department. Depending on the community and proposed project site, the planning process may be as simple as checking a box if the chosen location is zoned to accept more refuelling infrastructure. However, most municipalities don't have bylaws that include hydrogen as a fuel so a more complex development permit area review, coupled with planning advisory committee reviews and public consultation, is to be expected.

If an item needs to be heard by council, agenda requests should be made as early as possible, as some municipalities may have protracted processes and a back-log of actions that require a public meeting.

The involvement of the municipal planning department will vary by jurisdiction and station location. In the simplest case, a proposed station will fit within the parameters designated by a municipality's zoning bylaws and Official Community Plan, and not displace any parking spaces, or trigger the need to upgrade facilities to comply with additional provincial or federal requirements. However, many sites are geographically constrained and require special consideration from the municipal planning department.

The Planning Review process typically does not require detailed engineering drawings. However, any required general arrangement or architectural drawings should take code compliance into account.

Interpretation of codes can vary by jurisdiction, underscoring the importance of early fire and building department engagement. For example, if a fire wall will be required as a mitigation measure, it needs to be included for Planning Review to avoid needing to backtrack through the process.

Planning review can be broken down into 4 main activities:

1. Zoning review to make sure land use aligns with the proposed activity
2. Architectural review to ensure the plans are bylaw compliant
3. Fire department engagement to ensure the fire department understands the project and hazards
4. Utility engagement to ensure adequate utilities are available at the proposed location.

Step 1: Zoning

A municipality cannot permit a hydrogen refuelling station without proper zoning approval. In BC, local jurisdictions are responsible for writing or adopting their own zoning bylaws. As such, the rules that govern the siting and construction of hydrogen stations may differ substantially from one jurisdiction to another.

For example, jurisdictions may have specific language that covers hydrogen stations in an industrial zone, but not in a commercial zone. Others may simply group hydrogen in with all motor vehicle fuels and, therefore, may allow it in commercial zones. Some jurisdictions may require design reviews or specific discretionary approvals to proceed, while in others, hydrogen dispensers may be installed in existing refuelling stations by right or entitlement.

Applicants should refer to a community's Official Community Plan to help make an initial zoning compatibility assessment. In some cases, a location may be covered by a Development Permit Area (DPA), which provides a more nuanced and detailed land use description.

Section 219 covenants and variances

In the simplest case, the selected project site will already be zoned for vehicle refuelling and allowed to add additional fuel, which is one reason why most hydrogen stations are proposed at existing gasoline facilities. However, in some cases the station developer or property owner will need to obtain conditional approval in the form of a Section 219 covenant or variance before pursuing approval to build. Section 219 of the *Land Title Act* of BC allows a municipality to register a covenant on a land title. A Section 219 covenant defines how a site can be used and may impose certain limitations.

A variance is a request for a deviation from local zoning bylaws (e.g., eliminating parking spots, building height). Consideration of a conditional approval or variance is a discretionary act of the municipality, and if approved, is generally subject to pertinent conditions of approval and mitigation requirements. Conditional approvals and variances typically involve a public meeting by a zoning board, the planning commission, or a zoning administrator.

Rezoning

In some cases, a site may need to be rezoned by the relevant municipality. This process requires public meetings by the local planning advisory committee, or city council. The council is not obligated to approve requests for rezoning and must deny such requests when the proposed zone conflicts with the Official Community Plan.

Step 2: Architectural Review

Some municipalities have design review bodies chartered to review and approve the aesthetics of development plans. These committees play a crucial role in project approval, and approval often needs to occur prior to a project being heard by a planning advisory committee. Generally, an architectural or design review board works to ensure that projects fit the local form and character DPA. They may ask for unique roofing, landscaping, or painting to help a station blend in or make a visual statement. These requests can lead to negotiations between the board and project proponents—leading to a mutually agreeable solution.

At times, aesthetic-driven requests conflict with codes and standards—in this case, it often falls to the project proponent to articulate why suggested changes cannot be implemented. Local building department staff can often also help identify and support a path forward.

Step 3: Fire department reviews

The timing of a fire department's review of a project varies by municipality and project. Some fire departments will engage early in the process (in parallel with planning review), while others will begin their review once a project has Planning Approval. As with all permitting, early engagement is critical, especially if the project is likely to require mitigation measures, as these measures (e.g., a fire wall) can impact the Planning Review.

Hydrogen station designs need to comply with the BC Building Code and associated fire code requirements as well as the Canadian Hydrogen Installation code (CHIC). CHIC ensures proper setback distances, equipment and mitigation measures for refuelling, infrastructure and storage. Any hydrogen station design must demonstrate code and standards compliance through plans, notes, and calculations. These notes and calculations should clearly identify the specific codes the project will be designed to and demonstrate how the project proposes to meet these codes. The primary means of resolving any questions relating to code compliance is through the plan-check process.

In some cases, it will make sense to have an application requirement meeting prior to submitting the application. If a municipality offers such a meeting, station developers should be prepared to give a complete description of each code section the proposed project addresses and how the project will meet or exceed all code requirements.

Step 4: Utility power considerations during development permit application

The level of utility involvement in a station development is site and design specific. In the simplest case, the utility company can pull power from adjacent power lines that have excess capacity for the station. Project timelines and complexity increase with wider power demand and expansion requirements, which might entail an upgrade to the distribution infrastructure near the project area. Generally, a station power demand will require a power upgrade to the site in the form of a larger transformer or an additional transformer. In many cases, the site owner will require separate metering to keep the utility costs for the hydrogen station separate from other power demands on the site. This requirement will depend on the arrangement made with the site owner.

Obtaining Electrical Utility Approval

An electrical service connection typically begins with an online application for a new electrical service. It is the applicant's responsibility to provide the basic electrical requirements and site information on the application. Once the application is submitted to the power utility, an electrical designer will be assigned to the project and will require the following:

- Power requirements
- Single line diagram (SLD)
- General layout of the station or project
- Application fee (the amount will be dependent on the size of the service required)

After the information above has been provided to the utility, the designer will work with the applicant's lead electrical engineer to develop a plan to bring the service to site. Depending on the existing infrastructure at site, the power provider may need to upgrade the existing equipment or install new equipment to provide the necessary service.

Once the electrical utility designer and applicant's electrical engineer agree on the power service details, the designer is required to have the construction drawings approved by the city/municipality. Once approved, the applicant will receive a quote letter that confirms the power service and required fee. Once the fee is paid, the application process is complete and the remaining work is handled by the applicant's electrical contractor during construction, which includes coordination with the utility provider to complete the connection and energize the site.

The electrical contractor must meet regulatory requirements of the Electrical Safety Regulation in BC and the installation must conform with the Canadian Electrical code. Technical Safety BC is also the Authority having jurisdiction for electrical equipment and systems in BC.

Development Permit Fees

Fees are generally based on project value and clearly laid out in the respective municipalities fee bylaw. A simple fee bylaw search will reveal permit fees associated with the project.

Planning Approval Tips

<u>Early engagement</u>

Early municipal, fire department, and Technical Safety BC engagement can have tremendous benefits, saving both developers and reviewing bodies considerable time. A preliminary site plan can help guide this initial discussion and subsequent path forward. This general arrangement can facilitate a discussion about key constraints on most sites, such as parking spaces and traffic flow. It can also provide clarity on design expectations or requirements, such as specific landscaping or building aesthetics, that can help minimize rounds of feedback and revisions in the permitting process. It is also important for station developers to give careful consideration to, and be open about, potential issues such as local bylaws, sound impacts, or space constraints, that might arise and delay the project, or result in project cancellation down the road.

<u>Parking</u>

Parking is a particularly contentious issue with municipalities and neighbourhood associations. Generally, residents are concerned about any additional parking burden placed on their streets and municipalities have become resistant to any reduction in parking spaces due to development. In most cases your site plan will need to accommodate for any displaced parking spaces.

Parking spaces fall into a number of categories: general parking, loading areas, and disabled access parking. All are important for the local planning process and can impact station design. All parking requirements are typically governed by the municipality's bylaw and zoning requirements and planners are often very concerned with the preservation of parking spots. Developers should incorporate parking requirements into the station design as early as possible and engage the municipality for their input.

Traffic flow and site circulation

Traffic flow and circulation is a critical element of the station siting and fundamental to gaining planning approval as well as site host approval. Demonstrating a detailed understanding of the site dynamics and user behaviour will help guide discussions with the municipal planning department. Planners will be particularly supportive of station designs that improve the on-site traffic flow. Developers should demonstrate an understanding of how flow and circulation will change with increased vehicles accessing the station and size the station capacity and dispensing positions appropriately to minimize long refuelling lines.

Traffic flow during construction will be a concern for the site host and any ongoing revenue-generating activities including car washes and drive-throughs. Sit host will be sensitive to any revenue losses during construction. Detailed construction planning and traffic management will go a long way to gaining project approvals.

Hydrogen supply strategy

For stations receiving hydrogen deliveries, the schedule and dynamics of the hydrogen delivery needs to be considered early in the station design. Delivery schedules will be governed by site dynamics, property-owner constraints and local bylaws which may limit or restrict deliveries during certain times. Challenges with delivery schedules or delivery vehicle access need to be understood early in the process and mitigated in the station design. A detailed auto turn analysis of the hydrogen delivery vehicle should be performed.

Form and character

Stations must be compliant with the local building bylaws but should also be designed to fit the local visual landscape as much as possible. Visual aesthetics can contribute to gaining community support and will save time and money in the long run through a quicker approval process.

A local architect, familiar with the local form and character requirements, can assist the developer in creating a plan that integrates the station into the existing visual landscape and complies with any form and character DPA in the community. Demonstrating a willingness to work with the municipality on design and local preferences will minimize potential back and forth between the developer and municipality and streamline the overall approval process.

Understanding site ownership

Developers should take the time to fully understand the ownership structure, lot lines, easements, encumbrances, and any title restrictions affecting the proposed property. This information is critical to the permitting process and having the information upfront will save time throughout the permitting process and prevent any pitfalls down the road. If the site has multiple owners, all owners should be consulted on the proposed development plans. Station owners often lease the space to host their station and may not be aware of title restrictions on the property and it may fall to the developer to educate the station owner on any title concerns. Investing the time to research the property title early in the process can save time overall.

Fire approval tips

Engaging the local fire department as a stakeholder in the project is highly recommended. The fire department can help identify a pathway to fire approval, and their support is vitally important in the permitting process. This is especially true for municipalities new to hydrogen refuelling equipment. Engaging the local fire official early on, and gaining their support for the project, can provide the municipal planning department with the confidence they need to approve the proposed station. Fire approval will require an emergency response plan and it is recommended that the developer engage an experienced risk engineer, with a clear understanding of hydrogen-related hazards, to assist in developing this plan.

Electrical utility connection tips

Early engagement with local utility is highly recommended to ensure that the utility is able to provide a new service and deliver any additional power requirements to the site, in a timely manner. This early engagement ensures that required utility specifications are provided on all site drawings and will minimize any revisions during in the permitting process.

The type and size of any upgrades will be dependent on the available power at a nearby connection or transformer. Developers should engage with the local utility early to understand power availability so that sites can be accurately assessed during the site selection process for meeting the developer's requirements.

Understand electrical load requirements

Load requirements can differ significantly between station designs. Stations with on-site hydrogen generation (through electrolysis) typically consume much more electricity than stations receiving delivered hydrogen. Stations with delivered gaseous hydrogen will have lower energy requirements over stations receiving liquid hydrogen. The local building department may have different review strategies depending on the load requirement. There are 10 municipalities in BC which regulate electrical systems within their municipality, Technical Safety BC is the AHJ for the rest of the Province.[32]

Consider establishing separate electrical service

If a station is being installed at an existing refuelling site, the site operator may want to keep the electrical costs separate. In most BC municipalities a separate meter is a common and straightforward request of the utility.

Phase 3: Building Review

In most BC jurisdictions, the building department within the local government serves as the central clearinghouse for project approval. The building department conducts a building plan check once a project has been cleared by the planning department. Then the building department will review complete, fully detailed plans to ensure that projects comply with applicable requirements of the BC Building Code and local bylaws. These detailed plans typically include architectural, structural, civil, mechanical, and electrical information.

[32] Technical Safety BC (2022). Jurisdiction. Retrieved from: https://www.technicalsafetybc.ca/about-us/jurisdiction

The building department will use its interpretation of the BC Building Code to ensure a project is set up for safe installation and operation, with a focus on safety, structural design, and layout. It may issue separate permits for demolition, site grading, and construction. Final construction plans must incorporate all the planning department's conditions of approval. When the project is approved, the municipality will issue the building permit.

As the municipality reviews the application, it will often provide feedback in the form of questions, comments or a definition of changes needed for approval. Station developers should expect to receive full and complete comments from all building departments. Adjustments in the permit application may be required based on staff input. Applicants should clearly and succinctly address all issues raised by the building department and resubmit a modified package as soon as possible. It is important to provide full and complete responses when addressing feedback and revisions.

Phase 4: Construction

After the municipality issues the building permit, construction can begin. During and at the completion of construction, the station will be subject to inspections and final approval by the building inspectors. The purpose of these inspections is to ensure that project developers build their projects in compliance with the specifications agreed upon in previous phases of the process. Work in progress inspections are strongly recommended to help avoid potentially costly interpretation misunderstandings and to help ensure a station opens on time. When construction is complete, the station developer will file a notice of completion and begin commissioning the station.

Timely construction tips and best practices

Inspection processes can vary from jurisdiction to jurisdiction. The local process should be fully understood before commencing construction. Many jurisdictions will require multiple inspections, others a single inspection upon project completion. Either way, inspections should be worked into the project plan and scheduled as soon as possible to avoid long lead times.

Phase 5: Commissioning

Once a station has been fully constructed and an application for occupancy by the station developer has been submitted, final commissioning begins. Once commissioning is completed, the station can be opened to the public. An "open" retail station can accept any FCEV driver with valid payment methods.

Currently, final retail station commissioning involves four key parties: the station developer, local AHJ, main equipment supplier, and automotive manufacturers.

The following steps are general milestones and not meant to serve as a complete commissioning checklist.

The station developer is responsible for constructing the station in accordance with the plans and specifications approved by the AHJ. Commissioning plans can vary from project to project depending on the level of complexity, customization, and vendor selection. Generally commissioning involves four main phases, installation verification, operational verification, clearance to introduce hydrogen, and performance verification. The developer needs to ensure all required inspections have been performed and required permissions are in place by the AHJ prior to placing the equipment into operation.

The installation verification work involves a thorough field review of the complete installation to ensure the equipment in the field is consistent with the equipment specified in the design. Once the complete installation has been confirmed, operational checks can begin.

The operational verification work will focus on individual unit operations of the equipment and a thorough functional test of the safety systems. It is critical that all functional elements and the critical safety systems function fully prior to hydrogen introduction.

In order to introduce hydrogen to the system, the station developer and associated stakeholders must agree to clear the system for hydrogen introduction. Station construction and documentation shall be completed with no deficiencies, prior to the introduction of hydrogen into the system. The clearance to introduce hydrogen should involve a thorough audit by the station developers of the site, equipment, documentation, safety procedures, operating procedures, and confirmation that required training has been completed. This audit should satisfy all associated stakeholders prior to allowing hydrogen on site. Safety cannot be overstated.

The final phase of commissioning generally follows CSA/ANSI HGV 4.3 and involves a number of test fills into a test tank prior to filling an actual FCEV. This phase is intended to validate the performance of the station as a whole. The performance validation will include hydrogen fuel quality testing and confirmation of the fuelling protocol.

Hydrogen Fuel Quality Testing

The hydrogen station, including the dispenser, must be tested to ensure it complies with the hydrogen quality requirements in SAE J2719 “Hydrogen Fuel Quality for Fuel Cell Vehicles.”

This step is required prior to introducing fuel into a vehicle.

Fuelling Protocol Confirmation

Currently, station developers and Hydrogen Station Equipment Performance (HyStEP) testing team work together to ensure new stations fill FCEVs according to industry agreed upon fuelling protocols such the SAE Protocols. Once successful testing (ANSI/CSA HGV 4.3 test matrix) is complete, automotive manufacturers perform final test fills to confirm that the station fills according to their satisfaction.

4.0 Additional Topics and Considerations

4.1 Transportation of Hydrogen via Marine Vessels

Hydrogen transport is challenging as hydrogen exists as a gas at normal temperature and pressure, taking up enormous volume. As such, hydrogen must be compressed (typically to approximately 200-450 bar) for transport via tanker truck or pipeline. For longer distance transport, hydrogen is typically liquified by reducing its temperature to -253°C and reducing its volume to 1/800th of its gaseous state volume.

Shipping hydrogen by marine vessel is in its infancy and currently being evaluated by many organizations to understand the technical challenges and economics of long-distance transport. Ocean transport requires dedicated tanker vessels capable of maintaining liquid hydrogen at cryogenic temperatures. The energy to liquify the hydrogen and maintain it at cryogenic temperatures adds enormous cost and brings the economic viability of transporting pure hydrogen into question. However, there are no significant environmental concerns as liquid hydrogen will quickly evaporate in the event of spill.

Hydrogen can also be stored and transported using chemical compound carriers, which are compounds that contain large amounts of hydrogen by volume and can be handled relatively easily. Common chemical carriers include ammonia, methanol and methylcyclohexane, all common industrial compounds with established guidelines for safe and secure transport. All of these compounds can be transported at much higher temperatures than liquid hydrogen, which simplifies and lowers the cost of transportation.

From an environmental perspective, ammonia is a gas at atmospheric pressure, but is highly soluble, so it is likely that a significant proportion may react with the seawater, forming ammonium hydroxide. This is highly toxic to sea life in the short term, but concentrations will reduce quickly as diffusion occurs and it will not linger in the same way an oil spill would.

Methanol will quickly dissolve in the water. Although it is toxic to aquatic life, it will also quickly disperse.

In 2021, a number of hydrogen export projects were announced, where low-carbon hydrogen will be produced in Alberta and converted to either ammonia or methanol, then transported by rail to the Port of Prince Rupert on BC’s West Coast for shipping to Asian markets. Bulk export terminals at the Port of Prince Rupert are eager to participate in these low-carbon energy export projects and contribute to a global shift away from fossil fuel exports.

4.2 Safety Planning

As discussed above, stations require equipment registration and operating permits from Technical Safety BC. Before issuing a permit, Technical Safety BC must receive acceptance documentation from the local government where the facility is to be located, as well as from the fire department responsible for the area. To assist in obtaining these approvals, it may be necessary to educate and inform the local community, including officials, businesses, and residents who may not be familiar with the concept of hydrogen as a transportation fuel.

Common misconceptions include the belief that hydrogen is inherently more dangerous than gasoline. While there are certainly aspects that increase the risk, such as the typically high storage pressure and low ignition energies, this is counterbalanced by many other elements that reduce the risk, such as:

- Rapid dispersion—no pooling, unlike gasoline
- Sealed connection and regular leak testing, decreasing risk of loss of containment events
- Leak and flame detection and automatic isolation

Highlighting these factors to the local community can be helpful in gaining local government acceptance of the technology.

Approval from the fire department often requires a more technical approach in order to ensure the station design adequately addresses the risks associated with hydrogen. One approach for addressing these risks, is to develop a "safety case," a document that provides a structured argument demonstrating that all hydrogen-related risks have been identified and appropriately mitigated. This document is likely to include references to design concept and site selection, standards compliance, safety studies performed (including hazard identification and assessment), and a summary of the emergency response plan. Significant issues identified in the safety studies may be highlighted and the resolutions documented.

The fire department will be particularly interested in the properties of hydrogen following a loss of containment or fire scenario, and the immediate actions required by site staff and fire department staff to manage such an incident. A clear emergency response plan, developed in collaboration with the fire department is critical to ensuring the safety of site staff, fire department representatives, and the surrounding community.

4.3 FCEV Repair Facilities

Various codes and standards apply to repair garages and compliance with these will help support the application for the required permits.

- CAN/BNQ 1784-000 Canadian Hydrogen Installation Code (CHIC) requires that "maintenance facilities for compressed hydrogen-fueled vehicles shall comply with the same requirements as vehicles using compressed natural gas as per the document CAN/CSA B401."
- CSA B401 includes various requirements depending on whether the repair facility is classified as minor or major.
    - A **major repair** includes "ac*tivities carried out on vehicles that need extensive work such as engine overhaul, paint curing, body work, welding, grinding, and other hot work and all repairs to the high-pressure side of the... fuel system.*"
    - A **minor repair** includes "*lubrication, inspection, and minor maintenance such as engine tune-ups; parts replacement including those on the low-pressure side of the natural gas fuel system; replacement or addition of oil, brake fluid, antifreeze, transmission fluid, and air-conditioning refrigerants; brake system repairs; tire rotation, repair, or replacement; painting and other similar routine maintenance. Repairs, service, or maintenance to a completely defuelled and purged system, or portion of system, are considered a minor repair."* Similarly, NFPA 2 breaks repair facilities into two broad categories:

- A **minor repair garage** is defined as a *"building or portions of a building used for lubrication, inspection, and minor automotive maintenance work, such as engine tune-ups, replacement of parts, fluid changes (e.g., brake fluid, air-conditioning refrigerants), brake system repairs, tire rotation and similar routine maintenance work."*
- A **major repair garage** is defined as a *"building or portions of a building for major repairs, such as work on the hydrogen storage system, the fuel system, repairs that require defuelling of the hydrogen fuel cell vehicle, and maintenance or repairs that require open-flame cutting or welding."*
- Minor repair facilities for hydrogen motor vehicles must comply with NFPA 30A (Fuel Dispensing Facilities), while major repair facilities must comply with requirements in NFPA 2, along with NFPA 30A if the facility also repairs vehicles power by flammable and combustible liquids.

Even for minor repair facilities, both codes have requirements on gas detection and ventilation – existing garages for internal combustion engine vehicles may not comply. It is therefore important to review the codes to confirm, as modifications may be required. Requirements for major repairs are more stringent and may require a more specialized facility.

There may also be manufacturer-specific requirements. For example, Toyota currently has 12 dealerships in BC that are authorized to service the Toyota Mirai. All are located in the Lower Mainland and Victoria. To be authorized, dealers had to participate in both sales and service training specific to the Mirai.

Table 2: List of FCEV Certified Dealerships

City	Dealership
Burnaby	Destination Toyota
Chilliwack	Valley Toyota
Maple Ridge/ Pitt Meadows	West Coast Toyota
New Westminster	Westminster Toyota
North Vancouver	Jim Pattison Toyota North Vancouver
Port Moody	OpenRoad Toyota – Port Moody
Richmond	OpenRoad Toyota – Richmond OpenRoad Hyundai - Richmond
Surrey	Jim Pattison Toyota Surrey
Vancouver (Downtown)	Jim Pattison Toyota Downtown
Vancouver (South)	Granville Toyota
Victoria	Jim Pattison Toyota Victoria
White Rock	OpenRoad Toyota – Peach Arch

4.4 Relevant Hazardous Materials Regulations

The concept of stored hydrogen and hydrogen stations located within our communities is a new concept to many, and understanding the associated hazards and risk is key to the success of any station development project. The following list of regulations will help to guide the continuous growth of hydrogen stations within the province as well as the transport of hydrogen on the road.

1) Hydrogen is NOT classified as an "extremely hazardous material" based on the guidelines within the BC Hazardous Waste Legislation:
   https://www.bclaws.ca/civix/document/id/complete/statreg/63_88_00
2) Hazardous Product Regulations
   https://laws-lois.justice.gc.ca/eng/regulations/sor-2015-17/FullText.html
3) *Transportation of Dangerous Goods Act* for transporting high pressured gas applicable within Canada
   https://laws-lois.justice.gc.ca/eng/acts/t-19.01/
4) Work Safe BC regulations of working within hydrogen and the risk of exposure to any individual
   https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-23-oil-and-gas

4.5 Station Operation and Maintenance Considerations

Operations Procedures

Hydrogen stations require qualified operators and licenced technicians. Technical Safety BC issued operating permits stipulate operations competencies as outline in the *Safety Standards Act* – Gas Safety Regulation. It is key the operator familiarize themselves with their legal obligations under this regulation.

Hydrogen systems require ongoing and periodic maintenance and ongoing customer support.

In order to facilitate safe and reliable operation, standard operating and maintenance procedures need to be developed in cooperation with the equipment suppliers, safety personnel, and operations staff. An asset management plan, customer service plan, fuel supply strategy, and fully staffed operations team will be required to meet the demands of a hydrogen refuelling station.

Maintenance Procedures

Key equipment must be replaced or recertified in accordance with CSA Boiler, pressure vessel, and pressure piping code B51-15, or by manufacturer recommendation, depending on which is the more stringent regulated servicing interval. Typical key equipment includes hydrogen storage vessels, pressure safety valves, hoses, and dispensing components.

Pressure Safety devices installed in British Columbia that have a maximum servicing interval as defined in CSA document B51-14 *Boiler, pressure vessel, and pressure piping code*, Update No. 1 (December 2014). "*Reclosing pressure relief devices shall be serviced periodically in accordance with the requirements of Clauses 12.7.2 to 12.7.5 and Table 5.*"

Inspection must be performed by an agency approved by the regulatory authority and in accordance with the inspection procedures specified in ISO 19078, and follow the manufacturer's specifications.

Tests and inspections must be conducted according to local laws and mandatory regulations. Moreover, lists and inspections of CSE must be conducted according to the manufacturer's recommendations and requirements by the AHJs.

Inspection results are used as inputs to preventative maintenance planning and further refinement of the equipment maintenance plan.

Control and calibration of measuring and test equipment must ensure accurate performance of the equipment instrumentation. All calibration records should be accessible for future audits and regulatory compliance.

As mentioned in section 3.1 of this document, a "Class 8 – Special Type" operating permit must be issued from Technical Safety BC, before the station can begin operations.

CAN/BNQ 1784-000 Canadian Hydrogen Installation Code (CHIC) includes various requirements for operation and maintenance of any hydrogen system.

- The installer must train the system operator on the proper and safe use of all hydrogen equipment and provide copies of the manufacturer's instructions to the system operator.
- The operator must implement a Process Safety Management System in accordance with CAN/CSA Z767, or an equivalent standard.
- Operating instructions must be available, along with as-built process and instrumentation drawings.
- Employee training records must be signed by the employee and kept with the project files.
- Maintenance must be performed by qualified personnel only.
- Maintenance records must be kept for at least four years.

CHIC includes guidance on topics that must be addressed in the training sessions. CHIC also includes a table of mandatory maintenance items, and mandates that the maintenance program must present for approval to the AHJ upon request. This is not an exhaustive list, and it is recommended that the applicant refers to CHIC for the detailed requirements.

4.6 Environmental Acts, Regulations, and Site Disclosure Statements

In BC, the process for identifying contaminated sites is established in the BC *Environmental Management Act* (EMA)[33] and the Contaminated Sites Regulation (CSR)[34]. These provincial regulations work together to:

- Identify potentially contaminated sites

[33] BC Laws. (2021). *Environmental Act*. Retrieved from: https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/03053_00

[34] BC Laws. (2021). *Environmental Act, Contaminated Sites Regulation*. Retrieved from: https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/375_96_04

- Remediate contaminated sites prior to redevelopment
- Collect basic site information through the Site Registry

Properties planned for development, which have a history of commercial or industrial use, may be affected by the contaminated sites identification process. This is most notably the case for historical or existing gasoline/diesel refuelling station sites. Schedule 2 of the CSR provides a list of site uses, organized by category, that have the potential to cause contamination at a property. Schedule 2 should be reviewed to determine if the proposed hydrogen refuelling station site has ever been used for any of the industrial or commercial uses listed in Schedule 2.

If a site has exhibited Schedule 2 activities, a site disclosure statement will be required at certain trigger points during the project development. A site disclosure statement is a form[35] that provides available information to the province about the past and present Schedule 2 uses of a site. Activities that trigger a site disclosure statement include, but are not limited to, the following:

- Decommissioning or ceasing operations
- Applying for municipal approvals or permits
- Selling a property

It is important to note that once the site disclosure process is triggered, an approving officer for municipality zoning, development or building permit applications cannot approve any permit applications until the applicant submits to the approving authority confirmation that the site disclosure process has been completed. In many cases, a site disclosure statement triggers requirements in the EMA and the CSR to complete site investigations.

To ensure that the site disclosure process does not impact project schedules, a review of legislated environmental requirements should be completed early in the planning process.

---

[35] BC Government. (2022). *Site Disclosure Form.* Retrieved from: https://chefs.nrs.gov.bc.ca/app/form/submit?f=32a95812-f9db-4fd2-99eb-7e362b0253b1

5.0 Conclusion

By setting ambitious ZEV targets, the province of British Columbia has firmly committed to transitioning to a zero-emission future. Achievement of these targets requires a diversified and complementary set of low-carbon transportation solutions, including hydrogen FCEVs and hydrogen refuelling infrastructure to support adoption. BC has already established itself as a leader in developing and employing hydrogen refuelling station infrastructure in North America. There are, however, still many barriers facing the hydrogen industry that are hindering widespread adoption, with permitting being a major obstacle. Tackling these challenges requires multi-level coordination and planning around general permitting principles for the staged development of hydrogen refuelling stations. Municipalities hold the key to addressing these uncertainties and creating momentum at a community level that will lead to wider scale adoption.

The guidelines and 'tips' provided in this Guidebook are intended to support a more efficient station development process. However, projects invariably have site-specific nuances that can complicate the permitting process. It is critical to begin consultation with project stakeholders as early as possible in the development process and use conservative timeline estimates that allow for permitting delays without compromising the overall project schedule.

To succeed at permitting a hydrogen refuelling station, the developer needs to understand the municipal and regulatory framework. Treat the municipality and provincial regulator as a stakeholder in your project: engage early and understand their mandate and your obligations to them.

On the municipal permitting front, developers will inevitably run into a lack of language that addresses hydrogen in local building and zoning bylaws, particularly at urban retail refuelling stations. This will present itself as the biggest challenge because the developer will need to help educate the municipal planners, local fire departments, and possibly the public, to gain support at the development permit level. This process is time consuming with no guarantee of a successful development permit application.

Understanding the municipality culture and its position on climate change will be a key factor. Some municipalities have a strong climate action mandate and enable planning staff to make decisions on projects that fall outside established bylaws. Some municipalities may require public consultation or an audience with council. In some cases, particularly in smaller municipalities, staff will not be resourced to support projects that fall outside of established bylaws, and a presentation to council may help staff free up resources to work on these kinds of projects.

To succeed at the regulatory level, the station developer will need to be a hydrogen expert. Understanding the obligations under the Gas Safety Regulation and the Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation is fundamental. Only qualified locally registered professional engineers can produce the required design and regulatory submissions. The developer must understand hydrogen design considerations in detail, including critical safety infrastructure, risk assessment tools, code requirements, and the need for a complete operational strategy that always ensures public safety.

6.0 Additional Resources

6.1 Acronyms

AHJ	Authority Having Jurisdiction
BC	British Columbia
BEV	battery electric vehicle
°C	degrees Celsius
CHIC	Canadian Hydrogen Installation Code
CI	carbon intensity
CO2	carbon dioxide
CO2e	carbon dioxide equivalent
CSE	critical safety equipment
DPA	development permit area
FCEV	fuel cell electric vehicle
FCEB	fuel cell electric bus
GHG	greenhouse gases
GH2	gaseous hydrogen
GVWR	gross vehicle weight rating
H2	hydrogen
HD	heavy-duty
HRS	hydrogen refuelling station
HTEC	HTEC - Hydrogen Technology and Energy Corporation
HyRAM	Hydrogen Risk Assessment Model
HyStEP	hydrogen station equipment performance
ICE	internal combustion engine
kg	kilogram
LCFS	low carbon fuel standard regulation
LD	light-duty
LH2	liquid hydrogen
LNG	liquified natural gas
MJ	megajoule; one million joules of energy
Mt	megatonne; one million metric tonnes
MY	model year
NFPA	National Fire Protection Association
NFPA 2	NFPA 2 Hydrogen Technologies Code
NOx	oxides of nitrogen
OEM	original equipment manufacturer
PHEV	plug in hybrid electric vehicle

SMR	steam methane reformation
SOC	state-of-charge
SOx	oxides of sulphur
TPD	tonnes per day
ZEV	zero-emission vehicle

6.2 Definitions

green hydrogen	Hydrogen which is produced from water by electrolysis using renewable energy such as hydroelectricity, wind, or solar.
blue hydrogen	Hydrogen which is produced from fossil fuels by steam methane reformation, pyrolysis or other processes with carbon capture and sequestration.
well-to-wheel	Refers to the GHG emissions related to fuel extraction, processing, distribution and use.

6.3 Hydrogen Station Permitting Checklist

Task Description	**Response:**	
Initial Assessment	**YES**	**NO**
Pre-Application Outreach	**-**	**-**
Secure site control**.** Establish lines of communication between station developer, site owner, and site operators. Are all parties fully committed to the project?		
Planning Review	-	-
Prepare general arrangement or architectural drawings displaying code compliance.	-	-
Zoning	-	-
Complete a zoning compatibility assessment to ensure property zoning details will allow for a hydrogen refuelling station. Is the proposed site properly zoned for hydrogen refuelling?		
During the pre-application meeting, request a zoning variance if the proposed refuelling station will deviate from local zoning codes (e.g., eliminating parking spots, building height).	-	-
During the pre-application meeting, request rezoning of the site. If the site zoning details do not allow for a hydrogen refuelling station, the site will need to be rezoned by the municipality. The municipal council is not obligated to approve requests for rezoning. As well, rezoning often includes lengthy public consultation processes.	-	-

Do any local bylaws impact the ability to add hydrogen to the property?		
Architectural Review		
Some communities have design review bodies to review and approve the form and character of development plans. Sometimes these boards will request specific requirements to help a station blend in to fit the local aesthetics. Are all requests compliant with codes and standards and feasible for the project scope?		
Incorporate these requests into the design.	-	-
Reject any aesthetic-driven requests that conflict with codes and standards and provide a reason to the requesting body. Or, if impractical, negotiate on these requests to come to an agreeable solution.	-	-
Environmental Assessment	-	-
Infrequently, an Environmental Assessment review is required in some jurisdictions. This requirement should be determined as soon as possible as these assessments can be time consuming. Is there potential for Environmental Assessment related concerns to develop?		
Determine if similar projects have been completed in British Columbia. If so, during the pre-application meeting, share how projects complied with the Environmental Assessment or the municipal planning department. Seek guidance from the municipal planning department.	-	-
Fire Department	-	-
Can refuelling equipment fit on-site and accommodate relevant setback distances in NFPA 2, CHIC or any other relevant code?		
Can mitigation measures reduce required setback distances?		
Establish a project review with the local fire department, either through development review process or independently.	-	-
Pre-application Meeting	-	-
Establish communication and permitting pathway: Meet with key municipal staff and site owner to ensure application has all information a jurisdiction needs to approve the station.	-	-
Pre-Application Questions from Station Developer	-	-
Are there any site issues the station developer should be aware of?	-	-

How should a permit application be structured to make it as easy as possible for each department? What level of detail is expected?	-	-
Should an application intake meeting be requested with all relevant departments?	-	-
Are there any steps that can be taken to reduce the permitting timeline? What can the station developer do to help streamline review efforts?	-	-
Is the location in an aesthetically sensitive area? If not, the station developer should focus on the engineering package, but keep in mind visual appeal, which is often crucial to planning approval. If yes, the station developer should consider hiring a local architect to help ensure the project reflects the local form and character.	-	-
How does the construction inspection process work? Is there anything we (the station developer) can do to get ahead of typical issues that may arise during inspections?	-	-
Pre-Application Meeting Questions from stakeholders	-	-
How will the station be supplied with hydrogen?	-	-
How do you expect traffic to flow through the site?	-	-
What codes and standards do you plan to design to?	-	-
How do you plan to meet relevant setback distances?	-	-
What do you expect the station to look like?	-	-
Have you engaged the local utility?	-	-
Application Checklist		
Is the application appropriately tailored to each department?		
Avoid providing unnecessary information which will inundate the plan-check process. The ideal permit application demonstrates department specific compliance with all relevant codes – nothing less and nothing more.	-	-
Does the application clearly spell out the codes and standards it has been designed to meet?		
Does the application address relevant ordinance and zoning constraints?		
Have all pre-application meeting questions been answered?		
Has the station's safety plan been clearly articulated?		
The hydrogen station operator should develop a project safety plan to address potential risks and impacts to personnel, equipment, and the environment. The plan should describe how project safety is communicated and made available to the	-	-

operating staff, neighbouring occupants, and local emergency response officials.		

6.4 Regulations, Codes, and Standards

The following list is focused on specific codes and standards relevant for BC and Canada, but also includes some international standards. It is intended to be used for informative purposes, and covers a large selection of applicable codes, but does not list every regulation, code, and standard that may be used.

ITEM TYPE	CODES & STANDARDS
Hydrogen Specific	
Vent Stack and Vent Systems	CGA G-5.5 - Standard for Hydrogen Vent Systems CSA B51 - Boiler, Pressure Vessel & Pressure Piping Code
Hydrogen Piping	ASME B31.12 - Standard on Hydrogen Piping and Pipelines CSA B51 Parts 1, 2 & 3 - Boiler, Pressure Vessel & Pressure Piping Code CGA G-5.4 - Standard for Hydrogen Piping Systems at Consumer Locations CAN/BNQ 1784-000 Canadian Hydrogen Installation Code (CHIC)
Fuelling	ISO 17268 - Gaseous Hydrogen Land Vehicle Refuelling Connection Devices SAE J2600 - Compressed Hydrogen Surface Vehicle Fuelling Connection Devices SAE J2601 - Fuelling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles SAE J2601-2 - Fuelling Protocol for Gaseous Hydrogen Powered Heavy Duty Vehicles SAE J2601-3 - Fuelling Protocol for Gaseous Hydrogen Powered Industrial Trucks SAE J2799 - Hydrogen Surface Vehicle to Station Communications Hardware and Software SAE J2719 - Hydrogen Fuel Quality for Fuel Cell Vehicles CSA/ANSI HGV 4.1 - Hydrogen-Dispensing Systems CSA/ANSI HGV 4.3 - Test Methods for Hydrogen Fuelling Parameter Evaluation CSA/ANSI HGV 4.9 - Hydrogen Fuelling Stations CGA H-5: Standard for Bulk Hydrogen Supply Systems
Safety	NFPA 2 - Hydrogen Technologies Code D 1784-000-8 - Canadian Hydrogen Installation Code (CHIC) ISO 19880 - Gaseous hydrogen — Fuelling stations
Vessels	
Pressure Vessel	CSA B51 Parts 1, 2 & 3 - Boiler, Pressure Vessel & Pressure Piping Code ASME Boiler & Pressure Vessel Code – Section VIII, Div 1 ASME Boiler & Pressure Vessel Code – Section VIII, Div 2 ASME Boiler & Pressure Vessel Code – Section VIII, Div 3
Piping	
Piping System	ASME B31.1 - Power Piping

	ASME B31.3 - Process Piping
Valves	CSA/ANSI HGV 4.4 - Gaseous Hydrogen - Fuelling Stations – Valves
Fittings	CSA/ANSI HGV 4.10 - Standard for fittings for use in compressed gaseous hydrogen refuelling station
Hoses	CSA/ANSI HGV 4.2 - Hoses for compressed hydrogen fuel stations, dispensers and vehicle fuel systems
Electrical	
Electrical Installations	C22.1-18 - Canadian Electrical Code
Hazardous Area Classification	API RP505 - Classification of Locations for Electrical Installations IEC 60079 - Explosive Atmospheres NFPA 2 - Hydrogen Technologies Code
Site	
Design	BC Building Code (2018) BC Fire Code (2018) CAN/BNQ 1784-000 Canadian Hydrogen Installation Code (CHIC)

6.5 Site Selection Considerations

Typically, use of the setback distances provided in CAN/BNQ 1784-000 Canadian Hydrogen Installation Code (CHIC) allows a determination of whether a particular site can contain a hydrogen refuelling station. The 2022 edition of CHIC has reduced some setback distances, potentially allowing stations to fit on smaller sites.

The default CHIC setback distances are based on the total hydrogen storage and define clearance distances from the storage system itself and any associated unloading connections. This includes distances to:

- Buildings
- Wall openings
- Flammable and combustible liquids and gases above and below ground
- Oxygen storage
- Fast and slow-burning solids
- Open flames and welding
- Air compressor intakes, or inlets to ventilating or air-conditioning equipment
- Exposed persons (other than technical personnel)
- Public streets, alleys, ways and parked vehicles
- Line of adjoining property that can be built upon
- Encroachment by overhead utilities[36]

None of the default CHIC setback distances exceed 5 metres for gaseous hydrogen storage. However, for liquid hydrogen, setback distances can be over 30 metres, which can result in significant siting challenges. Many of these setback distances can be reduced or eliminated by including a 2-hour rated fire barrier. As

[36] Examples: overhead electrical wires or piping containing other hazardous materials

an alternative, CHIC also allows the distances to be calculated based on piping diameter and pressure using tables in NFPA 55 and NFPA 2, or through validated risk assessment toolkits such as HyRAM, if approved.

Development plans in the area must also be considered. If a building permit has been issued for the area around a proposed station installation, the details of this building permit need to be taken into consideration in the design and application for registration of the station installation.

Station siting is often a flexible process that involves local officials along with neighbouring businesses and residents in the decision-making process. Some site constraints can be addressed through mitigation measures such as obtaining setback credit from adjacent sites or alternative designs. It should also be noted that CHIC does have a “flexible compliance” option. Therefore, risk assessment techniques can be used to justify alternative approaches to safety that achieve an equal or better level of safety to the prescriptive requirements.

6.6 Hydrogen Station Development Process