

**Policy Options for the Integration of Hydrogen Exploration into the Provincial  
Economy**

**by**

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## **Abstract**

The hydrogen industry has grown to prominence in recent years with numerous jurisdictions releasing hydrogen strategies and promising ready incorporation into hard to decarbonize sectors. This is particularly true for British Columbia who released a hydrogen strategy in 2021 and has been making continual efforts to grow their local hydrogen economy. However, there are many difficulties when attempting to integrate hydrogen into pre-existing economic sectors, and even more issues arise when evaluating the performance of the hydrogen sector overall. The provincial government does not share the tools that other involved jurisdictions have available, namely the ready availability of federal financing. Regardless, through adjustments to administrative attention, and current financial support for the development of alternative energy technologies the province can support the scale up of their domestic industry and contribute to the development of solutions to other major barriers to hydrogens integration.

**Keywords:** Hydrogen; BC; energy; fuel cell; heating; decarbonization

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## **Executive Summary**

The British Columbia hydrogen strategy promises significant decarbonization through the incorporation of hydrogen gas; however, BC's hydrogen economy is still largely in its infancy and due to ingrained issues, it is uncertain whether it can support significant growth. To investigate these ingrained issues, I conducted interviews with industry professionals and research relating to the domestic market potential for hydrogen within the province, as well as the current state of the hydrogen industry. The most significant areas the provincial government expects to benefit from the integration of hydrogen are industrial heating and transportation, both of which face numerous unique challenges related to its integration and procurement. While the government has promised support and is currently providing economic incentives towards the green technology market at large, most hydrogen companies are having difficulty moving beyond the research and development phase. The costs associated with hydrogen procurement and integration make it difficult for hydrogen companies to capitalize upon governments financing to the degree other alternative energies are able, causing them to be regularly outcompeted by the other companies with access to the same financing.

The issue of hydrogen procurement is a problem shared unilaterally throughout the hydrogen sector, as the cost and amount available are far from conducive to the goals of the provincial economy. Other jurisdictions when faced with the issue of hydrogen procurement have invested policy attention and financial incentives towards encouraging hydrogen exploration, or the artificial production of hydrogen. The hydrogen that is currently sourced for the British Columbia economy is artificially produced, either as a byproduct in a chemical plant or converted from natural gas or water. Issues arise when attempting to scale up artificial hydrogen production due to its high cost and low efficiency, making it an unlikely candidate to significantly offset the hydrogen procurement issue. Investments towards hydrogen exploration have yielded high expectations as a low-cost source but are still defining standard practices and have yet to yield concrete results.

The mounting costs associated with hydrogen integration is inherent to the hydrogen industry at large and require significant governmental attention to address these policy

gaps. Infrastructure is one key barrier that requires the creation of policy, particularly relating to the sectors of transportation and gas heating. Filling stations are necessary features to support the growth of a small- and large-scale hydrogen transportation market and need to be strategically placed to facilitate hydrogens integration with minimal inconvenience. Modernized piping and standard practices is essential to ensuring the safe usage of hydrogen gas within pre-existing natural gas networks and is still yet to be defined the extent of which is still yet to be defined in most jurisdictions. In order for the British Columbia hydrogen industry to grow the provincial government needs to provide specialized administrative support to address the numerous policy gaps regarding the integration of hydrogen and increase the frequency of specialized financial support aimed at incentivizing the growth of key areas of the hydrogen industry.

## **Introduction**

As British Columbia attempts to achieve net zero through the incorporation of alternative technologies and the expansion of electrification, some sectors have been flagged as particularly difficult to decarbonize. The largest polluters, namely heating and heavy transportation, face significant barriers when attempting to convert to electricity. Strategies by both the federal and provincial government has centered hydrogen as a key contributor to decarbonizing these hard to abate sectors, in part due to its easy integration with internal combustion engines (ICEs) and natural gas (BC Hydrogen Strategy, 2021). I interviewed nine individuals involved in the integration of hydrogen into the provincial economy focusing on those involved in heavy transportation and the integration into gas heating. Considering the experiences and opinions of industry professionals, I argue that it is currently uncertain whether the province will be able to successfully scale up the hydrogen industry to provide the services stated by the BC government without additional policy changes and financial support. Failure to scale up is due to significant barriers relating to hydrogen procurement and to the expensive integration of hydrogen into pre-existing sectors. British Columbia does not have a readily available, inexpensive source of hydrogen gas, nor the administrative or technological framework to support its integration.

The issue of hydrogen procurement is addressed by the provincial government through financial incentives intending to scale up the production of green hydrogen, however due to technological inefficiencies and power demand there is very little confidence in its success. Other jurisdictions seeking to significantly scale up their hydrogen economies have invested in hydrogen exploration, intending to source the gas from natural deposits. This strategy is still in its preliminary phases but countries such as Australia and the USA have invested significantly in its potential success. Barriers preventing hydrogen's integration into pre-existing sectors arise due to its position as an emerging technology. Addressing these barriers requires administrative attention and governmental support—particularly in the case of infrastructure demands for fueling stations and piping networks. The provinces' ability to grow the domestic hydrogen economy hinges on its ability to address the issues of procurement and integration, both



of which need to be addressed through the provision of specialized administrative and financial support.

## **Background**

Following the federal government's release of the national hydrogen strategy in December of 2020, British Columbia became the first province to release its own strategy relaying its plans to scale up its local hydrogen economy (BC Hydrogen Strategy, 2021). BC, in relation to the other provinces, boasts 50% of all Canadian hydrogen companies and 60% of all private financing, putting it in a unique position to invest in the hydrogen economy. Through investment in hydrogen, the provincial government intends to decarbonize heating and heavy transportation, while building up the local market towards eventual exportation (BC Hydrogen Strategy, 2021). Despite the promise of governmental attention, certain hydrogen companies operating within the province are having difficulty moving beyond the research and development phase, even those that fit into the industrial sectors of heating and heavy transportation.

The prime issue preventing the scale up of the hydrogen industry is the high cost of production, causing the price of hydrogen to rise significantly above carbon intensive alternatives. The British Columbian government has promised to incentivize the growth of green hydrogen production, so it is able to provide a steady supply for the provincial economy. However, most production companies within the province operate at a lab scale, meaning they are only able to produce as much hydrogen as is needed for their research (Steiche, Interview, 2024).

The high energy demand and associated cost of green hydrogen production, although touted in both the national and provincial hydrogen strategies as an adequate solution to the hydrogen production question, make it far from economical (Barnard, 2024). On average the cost to produce green hydrogen ranges widely from between \$4.18-11.07 per kg (USD) fluctuating based on the cost of energy, while the cost of refining gasoline fluctuates generally between \$.40 and \$.70 per gallon (Marten, 2023).

Further, BC is not currently producing hydrogen on an industrial scale, and most of the hydrogen used in the province is imported from Alberta due to the lack of a domestic source. Alberta, due to preexisting demand from the oil and gas sector, produced approximately 2 million tons of hydrogen in 2022 (Gov of Alberta, 2023). In comparison one of BC's most successful producers, Chemtrade Logistics, anticipated producing 4,200 tons of hydrogen for sale in 2021 (ChemTrade, 2020). Unfortunately, both current sources of hydrogen in BC are environmentally damaging; Alberta's method of hydrogen production produces 10 kilograms of CO<sub>2</sub> for every 1 kilogram of hydrogen produced due to its lack of carbon capture, while ChemTrade logistics calculates their production of hydrogen as offsetting only around 10% of their total emissions. BC requires a significant amount of hydrogen gas to be made available for its economy to grow, but the current sources put it at odds with BC's decarbonization policy.

Hydrogen exploration has been used as a strategy in numerous jurisdictions looking to scale up domestic hydrogen production. Hydrogen exploration and extraction entails locating deposits of naturally occurring hydrogen, drilling and extracting the gas out of the subsurface, and refining the hydrogen mixture into pure hydrogen gas. Extracted natural hydrogen promises to produce at significantly higher rate and decreased cost in relation to artificial hydrogen production plants, with numerous locations, including British Columbia, identified as potential sites for deposits (Bakx 2024).

However, much like the rest of the hydrogen economy, hydrogen extraction exploration is still in its research and development phase with only one successful reported drilling and extraction site. Nevertheless, due to its promise of cheap hydrogen gas, jurisdictions such as Australia and USA have invested significant government funds in supporting the growth of this emergent industry (AHS 2023, Dept. Of Energy 2024). Further, Chapman Hydrogen and Petroleum Engineering, the company responsible for the only reported successful hydrogen well in the world, is currently active in Ontario, exploring for hydrogen deposits around the Canadian shield (Bakx 2024).

Jurisdictions such as Australia have developed robust licensing mechanisms for hydrogen exploration, mimicking those of the petroleum industry (Australian Hydrogen Strategy, 2021). Companies can apply for exploration permits, then, assuming they locate

a deposit, they may apply for drilling permits, and, assuming they are able to extract the gas, they may apply for storage permits. This creates a robust administrative framework for the industry as it grows beyond the research and development phase and into practical application. British Columbia has the capacity to support a scale up in their hydrogen economy through support of hydrogen exploration as other jurisdictions have managed, namely through the creation of licensing frameworks and related policy, so long as local companies are prepared to expand upon this opportunity.

### **Jurisdictional Scan**

#### **USA**

Under the Biden administration, the United States has begun allocating significant financial incentives towards low emission technology and has included specific strategies to facilitate growth in their hydrogen market. This attention towards hydrogen has begun relatively recently, with the release of the Inflation Reduction Act (2022); particularly its inclusion of hydrogen tax credits and a public declaration in their confidence in its ability to “decarbonize heavy industry and heavy transportation” (Podesta 2023). This public display of support followed up in the spring when The United States Geological Survey released a series of reports that suggested the occurrence of geologic hydrogen deposits around the great lake region and encouraged future investment from both private and government stakeholders (USGS, 2023). Preceding the release of the geologic survey, the United States government, and companies currently active in oil and gas sector, have displayed an interest towards natural hydrogen exploration and extraction for the past few years (FCHEA 2021). However, like the situation in Canada and British Columbia this sector is still well within the developmental phase; no industry standard or consensus has been reached on best practices related to identifying hydrogen deposits nor safe and effective methods for its extraction.

The lack of standard practices has not gone unnoticed by the US government who empowered the Department of Energy with the goal of facilitating hydrogen’s growth. This began in late 2023 when they invested \$20 million in six separate research and development companies to work towards providing clear guidelines for exploration and extraction (Dept of Energy 2023). The Department of Energy has also received 79

applications from organizations seeking to receive funding to establish regional “hydrogen hubs” that are better capable of supporting a self-contained hydrogen economy (Office of Clean Energy Demonstrations, 2024). Recently the Great Lakes Clean Hydrogen Coalition was approved and awarded \$8 billion in financing from the Department of Energy to facilitate the growth of the local economy, centered around their nuclear-powered hydrogen production facility (Dalton, 2023). Hydrogen exploration companies have also begun gaining increased attention from private financiers, with Australian based HyTerra and Bill Gates backed Koloma exploring the possibility of drilling wells in Kansas and Nebraska (Pearce, 2024).

The United States government has displayed interest in eliciting further growth in their hydrogen industry and have placed a unique focus on hydrogen extraction. However, the billions of dollars to facilitate industry growth and millions to further research and development the success of their investment will only indicate its success or failure in the coming years (Dept of Energy 2023).

## **Australia**

Australia, in contrast to Canada and other jurisdictions has heavily invested in hydrogen since the release of their national strategy in 2019. The federal government, like other comparable jurisdictions such as the US and Canada, has reinforced potential uses of hydrogen namely the blending with natural gas, the capacity for use in fuel cells, and domestic use in the form of energy storage or chemical feedstock with the goal to eventually export to surrounding countries (Gov Au, 2019). The main aspect that separates Australia’s strategy to grow their domestic hydrogen industry from jurisdictions such as the United States, is the ongoing and significant investment from the federal government. Since 2019 the federal government has promised \$127 billion in announced hydrogen investments, a significant portion of which is being dedicated to expanding hydrogens presence domestically (Gov Au, 2024). Notable inclusions in their investment strategy are 2 billion in “Hydrogen HeadStart Programs” towards its artificial production, and \$500 million towards the development of hydrogen hubs in regional Australia that will encourage domestic use and support future export (Gov Au, 2024). As the Australian

government invests liberally in expanding hydrogen's presence in the country, they are also attempting to source future hydrogen trade partners and adjust natural gas regulation to include hydrogen specific clauses.

One central aspect of Australia's hydrogen strategy is to purposefully and systematically lower the production cost of hydrogen; as this has been identified as an area of concern for future growth. In addition to government sponsorships, the Australian government has also invested significant financial and administrative effort into their hydrogen exploration and extraction industry. The federal government has developed a robust licensing and application system for exploration companies, granting them rights to drill and test for hydrogen deposits that have been detected in the southern portion of the country. Similar to licenses related to oil and gas drilling hydrogen exploration companies apply for the right to evaluate sites and upon the discovery of a deposit have the right to perform extraction, and if they fail to discover the deposit within an allocated amount of time they forfeit their right to exploration in the area to the next bidder (Dept of Energy and Mining, 2023).

In late 2023 an Australian hydrogen exploration company confirmed the discovery of Australia's first hydrogen gas deposit, with high hydrogen concentrations levels upwards of 73.3% (Collins, 2023). Despite the high concentrations of hydrogen, upon its announcement the company was much more excited about the traces of helium, as there is a pre-established market for its procurement and sale (Collins, 2023). Although the Australian government has invested significant administrative effort into the licensing procedures related to the extraction of hydrogen, no hydrogen has been successfully extracted to date, and the demand facilitated by the federal governments significant investment into domestic usage has yet to provide a market to purchase it. The success of the Australian hydrogen economy is yet to be proved, but the government's significant investment demonstrates a commitment to the creation of a domestic market, and their administrative attention to hydrogen extraction presents a realistic solution for the issue of production cost.

## **France**

France like many of its neighbors and fellow member countries of the EU has invested a significant amount of attention towards hydrogen following the increase in natural gas prices due to the war in Ukraine (Bouacida et al, 2023). France is not as dependent on the introduction of hydrogen energy as are the US and Australia chiefly due to their heavy investment in other alternative energy technologies, namely nuclear energy. In fact, in many cases involving international hydrogen policy France has leveraged its position as the center of the international gas transportation network to loosen regulation related to nuclear energy (Bouacida et al, 2023). This strategy was successful as France is a major intersection of pipeline networks from surrounding EU states such as the Netherlands, Belgium, and Germany. Regarding France's position on the growth of the EU hydrogen economy they have adopted a position more as a facilitator, choosing to provide broad legislative support to companies looking to diversify into the hydrogen economy rather than provide direct investment (Bouacida et al, 2023).

France is also one of the few jurisdictions where hydrogen deposits have been located and in response to a recent discovery during standard natural gas exploration have amended their mining code to allow for companies to explore for and extract hydrogen (Vaissier, 2022). Despite the discovery of hydrogen deposits, and the potential to center themselves in the EU's hydrogen economy, France is more focused on letting other member states do the heavy lifting in regard to the development of hydrogen. France has adhered to a strategy of hydrogen transportation due to its geographic position relative to existing gas piping networks, rather than to capitalize on its existing hydrogen deposits. This has in part been encouraged by the discovery of large hydrogen deposits in Spain that has the capacity to significantly undercut the benefits of French hydrogen extraction. Further, countries like Germany are already offering significant investments towards hydrogen producers, companies and jurisdictions due to their high industrial demand for a natural gas alternative (Chadri, Interview, 2023). Although France has not centered hydrogen as a key alternative technology in their long-term net zero strategy, their legislative attention to the area and geographic advantage still allows them to potentially benefit from future development.

## **Research Methodology**

The primary form of conducted research has been expert semi-structured interviews, combined with a substantial document review of current British Columbian provincial policy, and Canadian federal policy aimed to facilitate the growth of the provincial hydrogen economy. The documents reviewed have all been sourced from publicly available BC and federal government reports and press releases; around 90% of which pertain to zero emission and green energy funds, in addition to available tax credits that broadly apply to the application of alternative technologies.

Nine interviews were with professionals active in the BC oil and gas industry, particularly the natural gas and heating sector. These areas were selected given their importance in the provincial strategy to leverage hydrogen in order to decarbonize local industry. These interviews were also extended to the hydrogen transportation sector, particularly heavy transportation, and the currently active hydrogen fuel cell industry. Further information was sourced from primary information gained through e-mail communication with BC's Clean Energy and Major Projects office (CEMPO), in consultation with those strongly situated in areas dealing with green energy funds and carbon tax credits.

The interviews centered on experts active in areas the government has promised to decarbonize through investment in hydrogen. Those active in these areas are not only aware of the ongoing push to integrate hydrogen but are intimately involved with the details and necessary changes involved in this transition. In regards to hydrogen's introduction to the gas heating system, one of the key areas outlined in BC hydrogen's strategy, I interviewed five gas heating specialists and alternative energy representatives from companies such as Business Energy Solutions (BES) and SlopeSide. These companies are regularly contracted by BC Hydro and Fortis BC, therefore providing me a much clearer picture of the current system of government grants and subsidies relating to alternative energy installation. It also allowed for a greater understanding of how far hydrogen has proceeded in this area and the clear shortcomings currently preventing its integration. Four interviews were conducted with experts currently participating in the

integration of hydrogen into trucking and light duty transportation through the development of hydrogen fuel cell vehicles.

The semi structured nature of the interview was conducted through in person one-on-one meetings where I asked questions related to hydrogen's integration into their industry. Participants were asked questions concerning their opinion and experiences regarding the use of hydrogen, or other alternative energy technologies, and surrounding the integration of hydrogen into other alternative technologies.

These questions and the interview's semi-structured nature allowed targeted questions related to hydrogen integration and gave the interviewee space to state their independent opinions and experiences. Snowball sampling was also employed, with some interviewees recommending their colleagues' participation or contacting peers they believed would be congruent to the topic area. Snowball sampling allowed for additional interviews from government contractors and those involved in artificial hydrogen production and hydrogen and use applications.

A systematic document review of British Columbia and Canadian hydrogen policy was likewise conducted, hydrogen policy from relevant jurisdictions that have integrated hydrogen exploration and extraction into their domestic hydrogen strategies were also studied. Documents sourced from other jurisdictions were analyzed for specific references relating to regulation and licensing procedures not only for hydrogen extraction but also policy that applies to hydrogen's integration into pre-existing markets. Documents sourced from British Columbia or Canada were selected if they specifically referenced or outlined government promises and expectations, this includes funding allocations and proposed subsidies.

These documents were analyzed based on their relevance to hydrogen exploration, hydrogen licensing and regulation, financial support or subsidies for hydrogen and alternative technologies, as well as specific expectations for the industry at large. Documents and reports pertaining to hydrogen exploration and hydrogen licensing and regulation policy were reviewed based on their ability to adapt to a provincial setting, particularly in terms of jurisdictional scope and administrative frameworks. The review of documentation relating to financial support or subsidies for hydrogen and alternative



technologies was in turn reviewed based on feasibility, and the province's ability to expand on their current financial incentives.

Through this analysis I was intending to highlight clear barriers preventing growth in these sectors, in addition to shared successes or difficulties that would help me evaluate BC's potential progress. The separation of relevant documents into major policy groups allowed for clear comparisons across jurisdictions through clearly defined commonalities in their barriers to growth, and specified areas of investment. Hydrogen exploration policy, and hydrogen regulation maintained relative similarity across jurisdictional boundaries, while issues in relation to meeting government expectations and overcoming issues in financing held stark similarities. The systematic document analysis allowed for a clear understanding of barriers facing the hydrogen market internationally and the shared understanding related to hydrogen's potential.

## **Research Results**

### **Production**

British Columbia's lack of a consistent and nearby source of hydrogen is a major barrier to the economy's growth. The BC hydrogen strategy outlines the province's plan to accelerate the production of low carbon hydrogen and is currently in the phase of incentivizing production pathways as the province is not currently producing significant quantities of hydrogen for commercial use (CEMPO, Email communication, 2024). The British Columbia hydrogen strategy has promised power discounts to facilitate a significant increase in green hydrogen production, which entails large usage of power to turn water into hydrogen gas through electrolysis (BC Hydrogen Strategy, 2020). However, currently the majority of hydrogen production companies in BC are at a lab level, creating hydrogen for the purpose of research and development, and are having significant difficulties increasing production to the level of a plant (Iqbal, Interview, 2023). This is in part due to the drastic inefficiency of green hydrogen production, as it

requires an inordinate amount of power to produce a comparatively miniscule amount of hydrogen (Iqbal, Interview, 2023).

Quebec, which also operates on a hydroelectric power grid, recently rejected nine separate proposals for the construction of green hydrogen facilities stating that they simply did not have enough power to facilitate green hydrogen production (Fitzgibbon, Press Release, 2023). All of Quebec's currently active hydrogen production projects avoid drawing power directly from the grid, focusing instead on hydrogen production using power source from wind and solar projects (Fitzgibbon, Press Release, 2023). Further, British Columbia's power utility, BC Hydro, is beginning to encounter issues relating to power capacity and forecasts an increase in demand of power beyond what they would be able to supply and plans to issue a competitive call for power in the spring of 2024 to incentivize private power production (Iqbal, Interview, 2023). The province's plan to scale up hydrogen production through support of green hydrogen production plants, may be unable to meet future demand without significant efficiency improvements, or alternative energy sources.

Currently, the majority of hydrogen produced in BC originates from chemical plants that create the gas as a byproduct. In fact, the most recent successes in hydrogen use announced by the premier have been through connecting these chemical plants to nearby industry to offset emissions in Prince George (Eby, Press Release, 2024). The use of hydrogen from these chemical plants is relatively advantageous due to its proximity to other industries and its high safety standards inherited from pre-existing legislation (Cordero, Interview, 2024). When hydrogen is supplied from a chemical plant and connected to nearby industrial buildings, the procedures are much stricter and the safety considerations more robust, with all new infrastructure and equipment supplied for this singular installation that does not allow for widespread distribution (Cordero, Interview, 2024).

These chemical plants, however, do not create enough hydrogen to satisfy the needs of the current industry, despite the limited scale. The hydrogen supplied from these chemical plants is also less than ecological, with ChemTrade, a hydrogen producer in Prince George, estimating that their total annual hydrogen production would offset only

10% of their total emissions (ChemTrade, 2020). The majority of hydrogen used in BC is sourced from Alberta where it is used in the refining process for oil and gas (Steiche, Interview, 2024). Alberta creates hydrogen by converting it from natural gas, in an emissions intensive process commonly known as “gray hydrogen production” as it creates 10 kilograms of carbon for every 1 kilogram of hydrogen produced (Steiche, Interview, 2024). This hydrogen is then transported into the province by truck, significantly increasing the overall emissions involved with hydrogen procurement. The hydrogen currently supplying BC's market is both emission intensive and ineffective for widespread use largely hindering BC's hydrogen economy's growth.

### **Hydrogen Extraction**

Hydrogen exploration and extraction is a considerably new sector that is largely still within the research and development stage; regardless, it has attracted significant attention and concern from those involved within the British Columbia hydrogen sector. Jurisdictions such as Australia and the USA, place the cost of hydrogen extraction at between 2 and 10 times less expensive than artificially produced hydrogen (Prinzhofer et al, 2018). Natural hydrogen procured through hydrogen extraction has ability to provide significant amounts of hydrogen, at a discount when compared to other artificial production methods and has the greatest capacity to affect overall costs involved in hydrogen procurement (Jackson, Interview, 2023). However, despite its potential there is only one successful extraction site in Mali, and is yet to replicate its success in other jurisdictions.

Depending on the location of the deposit's hydrogen extraction, it can significantly decrease potential transportation costs or exacerbate them if the deposits are in remote locations. This issue presents a key concern as hydrogen transportation is difficult due to its unique molecular structure requiring specialized infrastructure, and to the transportation costs associated will Have a significant effect those involved in the hydrogen market (Jackson, Interview). As previously stated, despite hydrogen extractions optimistic properties in relation to minimizing costs, respondents tended to have more concerns due to its position as an emerging technology. In terms of its potential effect on hydrogen pricing, concerns were brought up relating to the potential cost of drilling.

Considering the difficulty associated with regular storage and transportation, the significant decrease in pricing when compared to artificially manufactured hydrogen can easily prove to be overly optimistic (Iqbal, Interview, 2023). Until industry practices are standardized, and research and development has progressed further there are no certainties that the cost of detecting, extracting, transporting, and storing natural hydrogen will be significantly less expensive than artificial production (Iqbal, Interview, 2023). Natural hydrogen extracted from deposits could provide a significant quantity of gas, but barriers relating to the cost of detection and drilling in addition to transportation and storage create uncertainty.

Skepticism was also inspired due to the current landscape of environmental protection concerns relating to mining and drilling operations. In recent years securing permits for mining and drilling operations have become increasingly difficult due to mounting environmental regulations, and even sites that have completed environmental impact assessments are subject to significant delays (Jackson, Interview, 2023). The prospect of increased hydrogen production brought about by extraction was not dismissed entirely, with respondents noting the large current and potential future demand from the hydrogen sector (Iqbal, Interview, 2023). As hydrogen extraction is still in the research and development phase, BC is unlikely to immediately benefit from its incorporation, but with significant demand for hydrogen gas from the provincial market it has the capacity to significantly assist in the ongoing plan to scale up operations.

### **Hydrogen for Heating**

Hydrogen as a resource to decarbonize heating, has been central in the provincial hydrogen strategy, and from the perspective of those involved in the push the integration of green technology one that holds considerable promise. Hydrogen itself is combustible, and due to its unique molecular structure can be integrated with other fuels such as natural gas relatively painlessly (Iqbal, Interview, 2023). Further, these fuel mixes have the capacity to offset emissions, depending on the percentage they represent in the fuel mixture (Muys, interview, 2023).

However, when addressing the practical considerations involved with its integration, issues begin to arise. Although combustible, it is not as efficient as natural gas, requiring a larger amount of the hydrogen fuel mixture to be used to accomplish similar results. The increase in fuel usage is not necessarily enough to offset the reduction in greenhouse gas (GHG) emissions caused by its integration, as the long-term effects are still under consideration, but it does require a greater supply of hydrogen to be made available to account for the losses (Muys, interview, 2023). The integration of these hydrogen fuel mixtures is also not without difficulty, as integrating any combustible substance into a system carries with it a significant degree of danger, and it will take time to develop optimal standards and practices (Cordero, Interview, 2023). Although, the majority of interviewees were not overly concerned about the potential dangers of hydrogen, with most potential negative affects seen through the expensive modernization of piping infrastructure, and potential cost increases that would be passed on to consumers.

## **Fortis BC**

As the provincial gas utilities company, Fortis BC has found itself in a difficult position in relation to BC's recent push towards green energy. Legislation from both the federal and provincial governments are now steadily being enacted to assist in the transition away from traditional carbon emitting fuels; in BC this has been going on for several years with several recent policy changes targeting gas heating, including a total ban of the installation of gas heaters by 2030 (Gov BC, 2024). These legislative actions have signaled to Fortis BC that they need to rapidly decarbonize and as such have enacted new efficiency measures and integrated low emission technologies (Chadri, Interview, 2023).

These policies have been reinforced by green energy funds, and financial assistance from the provincial government, allowing Fortis BC, in some cases, to pay upwards of 80% of expenses for the installation of high efficiency or electric heat pumps (Chadri, Interview, 2023). However, in January of 2024 Fortis BC ceased all financial incentives and projects for the installation of alternative technologies that do not involve

the use of natural gas (O'Rourke, Interview, 2024). The increasing difficulties brought about by these evolving legislative conditions, has created a semi-contentious relationship between Fortis BC and BC Hydro, as they were becoming competitors in a market previously dominated by Fortis BC (O'Rourke, Interview, 2024). If Fortis BC cannot integrate hydrogen, they will face increased pressure due to electrification as BC Hydro continues to supplement the transition costs of switching to electrical heat pumps (Wolfe, Interview, 2024). Further, many of the alternative technologies benefiting from government financing such as wind and solar support the push towards electrification and are currently outpacing their competitors in the hydrogen market (Wolfe, Interview, 2024). Regardless of any potential future issues, those involved with Fortis BC's transition are not worried for the near future and are more than confident that they will be able to maintain relevance due to the current extent of BC's power capacity (Iqbal, Interview, 2023).

## **Hydrogen For Transportation**

Using Hydrogens used in transportation was another key consideration outlined in the BC hydrogen strategy and has received continued attention from the provincial government. As heavy transportation emissions represent a fair portion of BC's total GHG emissions, the provincial government has been promoting transitions to hydrogen powered vehicles alongside electric vehicle incentives (CEMPO, Email Communication, 2024). As stated in the BC hydrogen strategy the province is committed to expanding supporting infrastructure for hydrogen transportation and has provided financial incentives for companies such as HTEC to expand their current fueling station network (CEMPO, Email Communication, 2024). However, despite the targeted financial incentives the hydrogen transportation industry has lagged significantly behind the electric car industry, and the supporting infrastructure is still extremely isolated.

Hydrogen fuel cell cars require less materials to make than electric vehicles allowing for slightly less expensive production and, when compared in terms of fuel efficiency and range, are no less effective (Meinke, Interview, 2023). In terms of heavy transportation trucks burning hydrogen in internal combustion engines (ICE) can haul

larger quantities of hydrogen allowing them to potentially operate over longer ranges when compared to electrically powered alternatives (Meinke, Interview, 2023). Hydrogen's ability to decarbonize heavy transportation, and its advantages has been a well-used talking point to justify investment in hydrogen fuel cells, and hydrogen powered trucks, but the current reality of the situation in BC is less than idyllic. While technological advancements relating to hydrogen trucks have been progressing steadily in recent years, due to significant upsets in the hydrogen trucking industry, securing private financing has become increasingly difficult (Steiche, Interview, 2024). This largely pertains to the recent difficulties facing the Nicola hydrogen trucking company who recently begun losing hundreds of millions of dollars after their CEO was charged with fraud for misleading investors on the current state of their hydrogen trucking technology (Steiche, Interview, 2024). Further, government investment is not readily available for activities outside of research and development, and many companies currently active in the hydrogen trucking market are not applicable for financing through the existing net zero or green energy funds (Steiche, Interview, 2024).

### **Transportation of Hydrogen**

The transportation of hydrogen was brought up numerous times as a barrier that negatively affects the growth of the hydrogen industry both internationally and in BC. Due to its unique molecular structure, Hydrogen does not work well in pre-established gas piping networks nor gas pipelines, forcing transportation to be handled under very strict requirements. As previously stated, it is possible to transport hydrogen through pre-existing piping infrastructure, but it would cause many issues related to leaks and embrittlement (Muys, Interview, 2023).

Hydrogen is extremely small in comparison to other elements causing it to leak in places where normal gas molecules such as methane or natural gas would not. Despite the concerning implications of this, it is not outright a safety concern as the gas is lighter than air and tends to dissipate (Muys, Interview, 2023). The tendency of hydrogen to leak would only be dangerous to infrastructure or human well-being if it gathered in a confined space such as a pump house, instead this creates greater concerns related to fuel

usage (Muys, Interview, 2023). The higher the concentration of hydrogen in the fuel mixture the greater the chance of leaks, causing a not insignificant amount of hydrogen to dissipate before it is used, requiring more hydrogen gas overall (Muys, Interview, 2023). These concerns only become a significant issue when higher percentages of hydrogen are used in the fuel mixtures and is not an issue in newer polyethylene coated pipes (Muys, Interview, 2023). However, as the BC government outlined a significant incorporation of hydrogen into the provincial gas heating utility, this may become an issue in the future, and the solution to modernize the pre-existing piping infrastructure would be extremely expensive as only a limited minority of pipes within the current network are polyethylene coated.

Embrittlement also contributes significantly to difficulties in transportation, as pipes used to transport hydrogen will erode over time. The erosion of these pipes creates numerous issues, as after a certain point the unbridled pipes cannot even be used to transport the natural gases originally designed for without risking leakage (Muys, Interview, 2023).

The ongoing embrittlement of these pipes also increases the amount of lost hydrogen through pre-existing and new leaks. This means that the longer hydrogen is used in the old gas piping system the more expensive maintaining operations will be; as the consumption of more hydrogen creates a cycle of embrittlement and leakage. If this cycle of embrittlement and leaking is not addressed through modernization of piping infrastructure it could be made unusable.

The introduction of polyethylene coated pipes allows most of these problems to be avoided, requiring the expensive replacement of most of the existing network (Muys, Interview, 2023). This embrittlement also does not happen uniformly and instead it is focused most around areas that are already leaking hydrogen, which would be in transfer stations or major junctions, increasing the possibility of hydrogen gathering in an enclosed space, and interrupting the delivery of natural gas to between sectors (Muys, Interview, 2023).

While the embrittlement of pipes has the greatest effect on heating infrastructure due to its large scale, similar problems are found when transporting through natural gas



pipelines, except embrittled areas and leaks would be harder to detect due to the vast distance it covers, increasing the possibility of losing larger amounts of hydrogen when transported over long distances. The embrittlement of pipes exacerbates preexisting issues relating to the use of hydrogen, requiring more overall use of hydrogen gas and increasing the overall cost due to loss of infrastructure.

### **Government Assistance**

Government assistance for British Columbia's hydrogen industry is not exclusive, nor is it in ready supply. The BC and federal governments tend to supply financing through generalized net zero or green energy funds, this way a large pool of applicants can draw money to fund their projects (Jackson, Interview, 2023). In the case of more popular and well-known alternative energy projects, such as solar and wind power, individual federal provincial grants are readily available, as is assistance fund financing from provincial agencies such as BC Hydro (Jackson, Interview, 2023). This has led to a significant focus over the past several decades on solar and wind-based projects, who have their own infrastructure and technological issues accompanying them (Wolfe, Interview, 2024). Hydrogen projects have not received this same kind of attention, relying on provincial grants to specific organizations (CEMPO, 2024). In the case of production, although small scale hydrogen producers are granted power discounts, these would only have a significant effect once production had scaled up and does little to support their immediate needs (BC Hydrogen Strategy, 2021). In the case of transportation, the majority of grants and discounts are aimed at the production of electric vehicles and has no available grants for low emission vehicles where many hydrogen trucking projects fall under (Steiche, Interview, 2024). Hydrogen projects can still receive funding under green energy and net-0 funds but cannot stand out as competitive compared to alternative technologies. Without significant policy attention hydrogen technology will remain more expensive than other emission abatement technologies and may remain unable to significantly scale up (Jackson, Interview, 2023).

## **Policy Criteria and Measures Defined**

### **Cost**

Cost in relation to both the government and industry stakeholders is a key criterion to evaluate the viability of each policy option. The British Columbia hydrogen strategy has already made promises of increased financial support, so some increases in cost to the government is expected. However, neither the government nor industry stakeholders should be overly burdened with the cost of growing the hydrogen industry as both parties have pre-established commitments to see its growth. Cost also would define whether industry stakeholders could stay in business or if the government strategy to promote the hydrogen industry would succeed.

Cost in relation to the government is in the form of not just investments and proposed subsidies, but also in terms of jurisdictional or administrative expansion. Currently, the government is significantly involved in incentivizing transition to green technologies and supporting research and development of carbon neutral technologies. Additional support to companies involved in the hydrogen industry could result in increased strain on government resources, and in some cases with little potential return. Alternatively, if investment or additional support in some areas could result in the government ultimately saving money or receiving additional income because of the expanded industry; the effect would be a lowered cost.

Industry stakeholders' considerations of cost are also taken into perspective due to the necessary role they play in expanding the hydrogen economy. Inefficient government support, or a lack of administrative attention could significantly affect industry stakeholders' ability to remain viable. Further, even small government actions in favor of administrative support, or inclusion in certain green energy funds could significantly improve the market viability of certain hydrogen companies by affecting costs overall.

### **Administrative complexity**

Administrative complexity is a criterion that can only be examined from the government perspective, as the expansion of jurisdictional considerations and administrative support is firmly a governmental burden. Policy options requiring the expansion of pre-existing agencies, or the duties faced by current regulators, would cause this administrative complexity to increase. Should administrative complexity expand beyond the reasonable expectations of what the government is capable of could cause the ultimate failure of the policy. However, as industries expand and government involvement grows, increases in administration are not unexpected, and thus this criterion is essential when considering the government's capacity to accommodate the hydrogen industries growth.

### **Stakeholder acceptance**

The criteria of stakeholder acceptance can be perceived not only from the perspective of industry stakeholders, but also those involved in the government side of operations who are pushing for the expansion of the hydrogen economy. Major changes to government policy or currently available financing mechanisms could cause unnecessary disruption in the private sector, especially if priorities are shifted away from areas the government previously promised to support. Further, government sector stakeholders who are supporting the growth of green technology within the province could view changes in attention and financing for alternative green energy technologies in favor of hydrogen negatively, especially if they have established interest in other sectors. Low degrees of stakeholder acceptance from both the government and stakeholder perspective could lead to policy failure.

Private sector stakeholders represent companies involved in the growth of the hydrogen industry, or who are looking to benefit from the hydrogen industry's growth. For many operating within this sector any additional attention to hydrogen would be received gratefully but they may become more concerned with the addition of government regulation, or the expansion of preexisting administrative bodies aiming at evaluating their practices. Companies currently operating within the hydrogen industry who see decreased attention towards their sector but overall, more attention to the

hydrogen sector would have low to minimal degrees of acceptance for these policies as they negatively affect their business.

Government stakeholders involved in BC's push towards green energy, and carbon neutral alternative technologies also have a diverse range of opinions when it comes to the financing of hydrogen. Significant stakeholder attention has already been granted to more well-known alternative technologies, should this attention shift or cause disruption to these pre-established sectors it can be assumed that government stakeholders with professional stakes in these ventures would be concerned. Attention and financing that is no longer exclusively shared by more popular alternative technologies that in the past have been favored with government attention may become concerned if these opportunities are extended to the hydrogen sector. Further, certain government stakeholders may have preexisting interest and motivation towards the incorporation of certain aspects of the hydrogen industry that they would prefer to see supported over others. Stakeholder acceptance from government representatives is a key consideration as to whether the policy will succeed, as without their administrative support failure is inevitable.

## **Effectiveness**

Effectiveness has a broad definition in relation to the other criteria but is no less important as it defines the potential effect the policy has on the hydrogen industry's viability. There are numerous strategies and government support that can be applied to the hydrogen industry that would have little overall effect. There are also many administrative supports that can be provided to the hydrogen industry that would have a great effect on its ability to scale up. The effectiveness of the policy will be measured by its impact on the hydrogen industry, with a particular focus on the sectors it is impacting. Greater consideration will be given to the transportation and heating sectors as these have been highlighted in the BC hydrogen strategy as particularly salient areas for decarbonization. Government policy that has little to no effect on the introduction of hydrogen into heating or transportation sectors will have a low degree of effectiveness on the viability of the industry at large.

## **Industry capacity**

The criteria of industry capacity refer to the hydrogen industry's ability to act on proposed government policy, from the perspective of private enterprises. Administrative support and access to government financing can greatly impact the viability of the hydrogen industry, but only if the companies involved in the market can take advantage of this support. The provision of government financing or support outside of key areas of the hydrogen industry would garner little advantage to the current industry, similarly the addition of green energy or net zero funds that are only partly aimed at the hydrogen industry would have little positive effect. Government support aimed to affect future development rather than provide timely support will see a negative effect in relation to industry capacity as they are unable to readily benefit from this support. The current hydrogen industry is mostly in its research and development phase, and thus needs targeted support from the government to make it marketable in relation to other alternative technologies.

## **Economic Sustainability**

Economic sustainability refers to the provincial government's ability to maintain the policy in the long term. Financing and administrative support that only has a short-term effect or is only applied for a short amount of time would result in higher degrees of economic sustainability due to the low long-term cost. Support aimed at scaling up the hydrogen industry that does not have the capacity to expand upon it or does not have a future without significant technological advancement will also score poorly in terms of economic sustainability. Support aimed at improving research and development, or aimed at sectors that are unlikely to move beyond the research and development sector without significant technological development will be scored as low due to the costs associated with long-term investment without significant returns. Economic sustainability will evaluate hydrogen industry's ability to maintain long-term growth and will score poorly in sectors unlikely to succeed and apply for an indeterminate period.

## **Environmental Sustainability**

Environmental sustainability will evaluate the capacity of the policy option to support hydrogen's ability to offset emissions and decarbonize key sectors. The key justification for hydrogen's integration into major facets of BC's economy is its ability to offset emissions in hard to abate areas such as heating and transportation. Policy options that do not allow for the ready integration of hydrogen as a decarbonizing agent will score poorly in environmental sustainability. Further, policy options that encourage the growth of hydrogen industry in a manner that encourages increased emissions, such as in support of gray hydrogen production, or increasing its production as a byproduct in chemical plants will score poorly in terms of environmental sustainability. Policy options that are unable to reasonably abate emissions can be deduced as poor environmental policy, and if they're unable to positively affect the hydrogen industry's ability to abate emissions then they undermine the government's promises to do so.

## **Policy Options and Evaluation**

### **Specialized Financial Support**

Specialized financial support indicates a strategy in which the government adapts a series of specialized funds and subsidies to facilitate the growth of the hydrogen market and incentivize research and development into hydrogen extraction. This option has in part already been promised by the government through the British Columbia hydrogen strategy, however, has not seen large scale adoption (BC Hydrogen Strategy, 2021). The currently available funds and subsidies are broadly available to a range of green energy and alternative technology and are largely used to facilitate the growth of solar and wind energy projects. One of British Columbia's largest commitments to the clean energy transition was in the form of a \$35 million grant to establish the Center for Innovation and Clean Energy (CICE), an investment that was made the same year the provincial hydrogen strategy was released. As of January 3rd, 2024, CICE Total investment in low carbon hydrogen was just under 8% of their total investments, with the remainder

allocated to other alternative energy projects (CICE, 2024). Although some companies active in the hydrogen industry are able to benefit from these green energy funds, they are highly targeted towards research and development and they're not overly beneficial to scaling up market operations (Steiche, interview, 2024). In the case of hydrogen extraction investments into research and development are notably beneficial as this is where the majority of participating companies are operating in, but in order to facilitate the growth of hydrogen extraction existing funds would need to be extended to cover research in this area. Other specialized financial support should appear in the form of either an expansion of pre-existing green energy funds to allow greater penetration in the hydrogen market, or the provision of specific funds towards hydrogen energy projects. To allow hydrogen to establish a foundation in BC's alternative technology economy specialized funds and government subsidies are needed to make it competitive.

### **Specialized Administrative Support**

Another policy option that does not require immediate government funds is to expand administrative support and regulation that would facilitate the hydrogen economy's growth and evaluate its shortcomings. This is an additional policy that was promised in the British Columbia hydrogen strategy that is yet to see full application and can work to facilitate government cooperation in addition to managing safety concerns. Following the release of the British Columbia hydrogen strategy the BC government added the regulation of hydrogen gas to the duties performed by the BC oil and gas regulator, this served both to signal government support for hydrogens use in heating and assigned responsibility for its monitoring to a government department.

Increasing regulatory oversight would require the gradual expansion of several government offices and departments to facilitate monitoring and cooperation in key sectors of the hydrogen market. The BC oil and gas regulators would need to see a notable increase in administrative volume, and other departments such as the BC clean energy and major projects office would be granted a greater degree of responsibility for outreach. This policy option does not allow for the quick dispersal of financing, but it does allow for additional government cooperation, and a greater understanding of the

evolving hydrogen market that will assist government decision makers as they work to facilitate hydrogen's growth. This policy option could entail the creation of a new regulatory and administrative body where they can work through the issues that may arise and creating a more streamlined and direct approach to supporting emerging industries such as hydrogen exploration. A new regulatory body will make it easier to address issues and facilitate growth in target areas necessary for the hydrogen industry's growth.

### **Direct Government Intervention**

The final policy option of direct government intervention is the largest scale and most expensive of the three options, as it requires the government to take a direct hands-on approach to facilitate the growth of the hydrogen economy. According to the British Columbia hydrogen strategy, the province expects not only significant progress but also a significant decarbonizing impact in the near future beyond what the market is currently able to provide. Direct government intervention would entail significant involvement from the provincial government in the hydrogen industry. This would require government financing and administrative attention relative to other large scale energy projects, causing a significant increase in government expenditure. To facilitate rapid decarbonization, relative to the expectations outlined in the BC hydrogen strategy, the government would need to radically increase investments in key sectors such as hydrogen production and hydrogen infrastructure. This option has the capacity to rapidly facilitate growth and incentivize technological advancements beneficial to hydrogen's integration; however, considering that the majority of the market is in the research and development phase there is no guarantee this would significantly stimulate growth. This approach is similar to that of the Australian government who wishes not only to create a robust domestic hydrogen economy but also facilitate the exportation of hydrogen in the near future. To accomplish these goals the Australian federal government has invested billions of dollars in the domestic production and exploration of hydrogen gas in addition to incentives and subsidies for hydrogen companies, however, unlike Australia the BC government does not have unabridged access to federal financing.



## **Multi-Criteria Analysis**

### **Low, Medium, And High**

#### **Low**

If a policy option were to score low, it would mean it has a limited degree of compatibility with the associated criteria. A higher degree of compatibility with the associated criteria is preferable in all cases except for cost to government, cost to industry, and administrative complexity. In the case of the cost to government, and cost to industry, criterion a low degree of compatibility is preferred as it would be associated with lower costs. In the case of the criterion of administrative complexity a low compatibility is preferred as it would indicate a lower degree of administrative complexity.

#### **High**

If a policy option is scored high in its associated criterion, this suggests high compatibility. In nearly all cases a high degree of compatibility is preferable, as it suggests a positive association with the related criterion. This differs in the case of the three criteria: cost to government, cost to industry, and administrative complexity. In the case of these three-criterion having a high degree of compatibility would not be preferable as it would be associated with a higher cost and a higher administrative complexity.

#### **Medium**

When a policy option is scored medium, it means the policy option has neither a high nor low degree of compatibility with the associated criteria. The score of medium is generally preferable in relation to a score of low, except in regard to the three criteria: cost to government, cost to industry, and administrative complexity. In the case of these three criteria the score of medium would be preferable to a score of high, as it would be associated with a slightly lower degree of cost and administrative complexity.

**Table 1:**

	<b>Direct Government Intervention</b>	<b>Specialized Administrative Support</b>	<b>Specialized Financial Support</b>
<b>Cost to Government</b>	High	Medium	High
<b>Cost to Industry</b>	Low	Medium	Low
<b>Effectiveness</b>	Medium	Medium	High
<b>Administrative complexity</b>	High	Medium	Medium
<b>Industry capacity</b>	Medium	High	Medium
<b>Stakeholder acceptance Government</b>	Low	High	Medium
<b>Stakeholder acceptance Industry</b>	Low	Medium	High
<b>Economic Sustainability</b>	Low	High	Medium
<b>Environmental Sustainability</b>	High	Low	Medium

## **Direct Government Intervention**

### **Cost to Government**

These policy options score high in terms of cost to government as it requires a significant investment in infrastructure, administration, and financing. The government would be required to finance the growth of the hydrogen economy nearly independent of private financing. Considering the significant development necessary this approach could allow the government to illicit growth with high costs. They would be responsible for all major aspects involved in facilitating large scale growth and introducing hydrogen as a decarbonization method. Australia is a jurisdiction that has adopted this approach has allocated billions of dollars to facilitate domestic growth and increase hydrogen production (Australian Hydrogen Strategy, 2023).

### **Cost to Industry**

This policy option entails one of the lower costs to industry, due to the heavy burden placed on the government in financing the growth of the hydrogen market. Companies active in BC would be still subject to greater financial costs due to the increased government oversight and regulation but would also be able to access greater financing and benefit from government partnerships. Companies that otherwise would flounder without private investment or have difficulty growing past the research and development phase would be able to lean heavily on government investment.

### **Effectiveness**

This policy option scores medium in terms of effectiveness, as although the government has high control over the hydrogen industry's activities, there's no certainty they could facilitate its growth. Oversight over hydrogen operations does allow the government a greater degree of awareness and responsiveness, but it does not guarantee control over the successes and failures. Weaker areas in the hydrogen economy will be noticed sooner, and government attention can be focused towards areas with greater chances of success but ultimately the outcome is dependent on the market.

### **Administrative Complexity**

This policy option requires a significant degree of administrative complexity and thus scores high in this category. Enacting a heavy degree of government involvement, as seen in jurisdictions such as Australia, requires a significant amount of oversight and targeted financing. The duties and responsibilities of several major departments and offices within the province would need to be retrofitted and their capacities significantly increased. This expansion in provincial administrative capacity is most likely beyond what British Columbia is currently capable of providing without federal assistance and could be comparable to the creation of a major government agency.

### **Industry Capacity**

This policy option only elicits a medium score due to its potential effect on the current provincial hydrogen industry. As previously stated much of the current hydrogen industry is in the research and development phase and would require significant government attention in order to scale up to meet the promises outlined in the BC hydrogen strategy. Should the government adopt a direct approach to intervention the industry would still require a significant amount of government financing and attention to scale up in a short amount of time. Further, many active hydrogen projects, and companies that would not be considered readably commercially viable, could be sidelined in the overall government strategy, causing them to fail without direct support. The industry's capacity to respond and benefit from direct government intervention is middling due to it requiring heavy government investment.

### **Government Stakeholder Acceptance**

This policy option scores low in terms of government stakeholder acceptance due to the significant necessary changes in the current green energy strategy. To enact a strategy of direct government investment, financing and administrative attention currently aimed at other alternative energy projects, such as solar, wind, and hydropower will have to be directed towards the burgeoning hydrogen economy. This reallocation of funds would cause disruptions towards the ongoing work of numerous government administrators and stakeholders. In addition, major projects currently undertaken by provincial departments and offices would need to be canceled or reworked in favor of the large governmental push towards hydrogen. Overall, despite the significant increase in

governmental oversight due to the switch from pre-established alternative energy projects this policy option scores low in terms of government stakeholder acceptance.

### **Industry Stakeholder Acceptance**

This policy option also scores low in terms of industry stakeholder acceptance due to the significant increase in government oversight and regulation. Despite potential increases in government cooperation and financing companies involved in the hydrogen industry would be subject to a significant degree of scrutiny over their current business practices and would be subject to the whims of the government bureaucracy. In some cases, government administrators may determine certain sectors the hydrogen economy to be non-viable and will not provide financing in certain areas, causing these companies to lose financing that they would have otherwise been able to collect through research and development funds. Although companies active in the hydrogen industry desire an additional degree of policy attention to facilitate growth, an increased degree of oversight and regulation there's never considered desirable in a private market (Jackson, Interview, 2023).

### **Economic Sustainability**

Despite this option's ability to facilitate significant potential growth from the hydrogen industry, it scores low in terms of economic sustainability. As previously mentioned, the provincial government does not have the resources available to jurisdictions such as Australia that have employed this policy of increased government intervention. Further, as the provincial hydrogen economy is largely in the research and development phase it's unlikely to significantly grow in the short term, requiring extended government attention, and costs, through the long term. Without significant help from the federal government, the provincial government would be unable to provide significant government intervention long-term due to cost issues.

### **Environmental Sustainability**

Direct government intervention due to its ability to rapidly decarbonize major sectors within their jurisdiction allows for a higher degree of environmental sustainability. Direct government oversight allows for fast incorporation of new

technologies into government-controlled sectors such as heating and transportation. This oversight also allows for the fast adoption of best practices and technological advancements that would assist hydrogens integration and allow for decarbonization in a shorter time frame.

## **Specialized Administrative Support**

### **Cost to Government**

Specialized administrative support scores medium in terms of cost to government. This policy option requires the expansion of certain government offices and departments but does not require large scale financing. The administrative support provided by the government does not necessarily have to be to an extreme degree as seen in direct government involvement but can exist to provide necessary support and regulation. Growing certain government bodies requires increased government investment, but not overwhelmingly.

### **Cost to Industry**

This policy option is scored medium in terms of cost to industry, as it does not place the financial burden solely on the government or on hydrogen companies. This is due to the lack of specialized government financing towards companies active in the province, requiring these industries to source financing from private sources. Unlike the other two policy options this option still requires some degree of financial stability from the hydrogen industry, while still leaving room for government support and cooperation.

### **Effectiveness**

This policy option also scores medium in terms of effectiveness, due to the limited effect of government assistance without direct financial support. Administrative support is still beneficial towards the hydrogen industry as it allows for the provision of subsidies and governmental cooperation in certain projects. This can be seen through the government's targeted support of certain hydrogen transportation companies, and recent

regulatory amendments that allow for hydrogens use in the heating of some industrial buildings. However, without direct government financing the effect of this support will be limited.

### **Administrative Complexity**

Increased administrative support scores medium in terms of administrative complexity, as although it requires the expansion of certain government offices and departments it does not require a large-scale overhaul of the existing system. It is normal for government administration to naturally grow, especially regarding the regulation or support of burgeoning and important industries. This policy option does not require the creation of a new regulatory agency or governing body but rather encourages the expansion of administrative and regulatory bodies to meet the needs of a growing industry. The expansion of administrative capacity can also take place over a longer time period, allowing the government time to adjust.

### **Industry Capacity**

This policy option scores high in terms of industry capacity, due to the many policy gaps needed to be addressed in the hydrogen industry. Currently, many companies feel overlooked or are uncertain of the support they are likely to receive from the government. In some cases, this concern also applies to missing regulation and safety measures. By granting administrative oversight over this new industry many of these questions can be answered and support garnered in key areas. In terms of hydrogen in heating, many regulatory questions still need to be answered, particularly in relation to safety and best practices if companies like Fortis BC are to move forward with their integration plans. Those involved in the hydrogen industry are interested in receiving additional administrative attention from the government and are likely to experience this support long term due to the longevity of this policy option.

### **Government Stakeholder Acceptance**

Government stakeholder acceptance of providing specialized administrative support is high due to its low cost and limited interruption of pre-existing operations. The expansion of administration designed to assist in the hydrogen industry would increase

the size and powers associated with certain government offices and departments but would not require any shift in attention from pre-established alternative energy operations. The growth of administrative departments and offices involved in the oversight of the hydrogen industry would also experience a positive increase to their current scope and responsibilities that would allow them a greater impact beyond what they are currently capable.

### **Industry Stakeholder Acceptance**

Industry stakeholder acceptance in terms of the provision of increased governmental administrative support is ranked as medium, due to the increased regulation and oversight. Although many companies involved in the integration of hydrogen into key sectors would benefit greatly from addressing regulatory and policy gaps that are preventing their growth, the prospect of increased regulation is unpopular. Many companies are currently struggling to receive government funding and procure private financing, the addition of governmental oversight and new regulation can be seen as demoralizing despite its necessity. This policy option also represents a limited action by the government to support the industry, opting instead to create a governmental framework that can assist the slow growth of the industry without direct financial investment.

### **Economic Sustainability**

Economic sustainability is ranked high in terms of specialized administrative support, due to its low cost and ability to maintain itself long term. The expansion of administrative and regulatory bodies allows for specialized government support well into the future, and due to its low cost is relatively easy to maintain. By addressing the policy gaps in certain key areas, the expansion of hydrogen into these areas is expedited, allowing for economic growth despite the lack of direct financial investment. In addition, as the majority of companies involved in BC's hydrogen industry are in the research and development phase this policy option has the capacity to support this area until significant technological advancements are procured, or federal financing is made available.



## **Environmental Sustainability**

Specialized administrative support scores low in terms of environmental sustainability due to its long-term approach to integrating hydrogen for decarbonization. While specialized administrative support can address policy gaps and expediate the development of technology in the research and development phase, it does not allow for quick integration of hydrogen for decarbonization. Instead, this policy option aims to facilitate the growth of the hydrogen economy over the longer term, or Intel technological advancement and federal financing can be procured.

## **Specialized Financial Support**

### **Cost to Government**

In order to provide specialized financial support, the government would be required to shoulder a significant cost and thus this policy option scores high in terms of cost. Creating hydrogen-specific green energy funds or providing sector specific subsidies would require a significant amount of government resources to finance, possibly more than the provincial government can provide. Even with the cooperation of the federal government for the provision of these finances would still incur a significant cost as government financing is provided to an area that is not readily able to access pre-existing funds.

### **Cost to Industry**

In industry cost, providing specialized financial support from the government would incur a low cost from the industry as the government bears most of the burden in scaling up. Companies involved in BC's hydrogen industry could apply and receive financing from the government for research and development, which is currently available, and for expansions in commercial markets. This option overall would limit BC hydrogen companies' reliance on private financing, which in some cases is not readily available, but as a result would be more reliant on government funds.

## **Effectiveness**

In terms of effectiveness this policy option ranks high as it provides financial support to an industry with immediate need. Many of the companies involved in BC's hydrogen industry are having difficulties growing due to the lack of government and private financing, in sectors areas, such as heavy transportation private financing is notably sparse. With the introduction of government funds many companies involved in BC's hydrogen industry would quickly be able to benefit from the stimulus either to improve current research and development, or insist in larger scale growth, either would indicate a high degree of effectiveness in terms of the provision of specialized government financing.

## **Administrative Complexity**

The provision of specialized financial support ranks medium in terms of administrative complexity. This policy option would involve the creation of certain government run funds and targeted subsidies that would require a certain degree of administrative oversight. While some government offices and departments may require minimal expansion to accommodate applicants and manage subsidies, this would not entail a wide-scale overhaul of government institutions. Some administrative expansion is necessary to accommodate the specialized financial support, but not significantly.

## **Industry Capacity**

The industry's capacity to respond to specialized financial support is ranked as medium. Despite this policy option achieving a high rank in terms of effectiveness, due to its ability to improve the hydrogen industries viability, without government oversight to dictate the movement of financial resources there is no guarantee the industry would be able to maintain its growth and solve its own debilitating issues. The industry can receive government financing and augment current research and development funds, but there is no guarantee and scene will find its way to critical sectors without specialized administrative support. In regard to addressing the problem of production, much of the financing could find its way to improving green hydrogen electrolysis or scaling up lab level green hydrogen production; which is unlikely to provide significant returns without

technological improvement (Iqbal, Interview, 2023). Further, hydrogen exploration companies who are operating in the research and development space currently Could be applicable for financing through these specialized funds but whether these gains in information will be used within the province, or whether future surveys will take place is uncertain.

### **Government Stakeholder Acceptance**

Government stakeholder acceptance in terms of specialized financial support is also ranked as medium, the financing would need to be reallocated from other alternative energy projects. if the federal government does not provide assistance in financing BC's growing hydrogen industry the provincial government would need to foot the bill. In addition, as attention shifts away from more popular alternative technologies such as solar and wind, future targeted financing be made available to the hydrogen industry to the detriment of other pre-established projects. Nevertheless, this does not require a significant shift away from pre-established alternative energy projects, only requiring a appropriate degree of attention towards the hydrogen industry and thus would cause less disruption as more involved options such as direct government intervention.

### **Industry Stakeholder Acceptance**

Industry stakeholder acceptance in terms of specialized financial support is high, as domestic companies will receive considerable amounts of government financing. Industry participants conducting research and development, or trying to grow operations, would greatly benefit from additional financial resources. The increase in government financial support would also allow industries to rely less on private financing, which in many cases is difficult to procure. This financial support would apply broadly to a greater number of industries stakeholders and would assist in offsetting some of the higher cost barriers such as infrastructure development. Industry stakeholders would have a high degree of acceptance towards receiving specialized government financing as it puts the least amount of burden on the industry for scaling up operations.

### **Economic Sustainability**

Specialized financial support scores medium in terms of economic sustainability, as it requires the government to foot a significant amount of the bill for scaling up the hydrogen industry. In addition, without specialized government oversight there is no guarantee that the money government is providing will align with government goals or expectations. The government has limited control over the finances they are providing to the hydrogen industry and has no guarantees as to the effects it will provide, regardless the provision of funds to an industry that very much desires it will have some positive successes in terms of economic returns.

### **Environmental Sustainability**

This policy option also scores medium in terms of environmental sustainability, as there is no guarantee the financing will result in rapid decarbonization. The provision of these funds may positively affect research and development, and application of hydrogen into certain high emitting sectors, and thus would have some positive effect on environmental sustainability. However, without government oversight there is no guarantee the funds will be allocated in such a way to readily offset emissions. The financing will help the development of environmentally conscious technologies and would further the progress towards integrating hydrogen into high emitting sectors, but without government support there is no guarantees that this will occur within a set time frame.

### **Policy Recommendation**

The policy I would recommend for the purposes of facilitating hydrogen exploration, and encouraging the growth of the provincial hydrogen industry, would be a combination of specialized administrative support and specialized financial support. This option would balance and expansion of administrative departments and offices within the provincial government, coupled with the increase in financial incentives through targeted subsidies and expanded availability of existing funds.

Administrative expansion is necessary to grow the hydrogen industry as the current market is experiencing many issues and policy gaps that require government

attention. Financial support is also required, as hydrogen is yet to establish itself in major sectors of BC's industry, however without the government attention garnered through administrative expansion there is no guarantee this financial support would be successful.

Policy gaps related to the expansion of hydrogen into gas heating, and governmental support for the construction of supporting infrastructure are necessary facets to encourage growth in the hydrogen industry that require administrative support. This option seeks to balance the advantages of financial and administrative support while avoiding the detriments of direct government intervention. Rather than attempting to shape the hydrogen industry into a robust domestic market, this option expands administrative support and provides financial incentive while giving the industry room to grow and expand out of their research and development phase. Government departments and offices such as the BC oil and gas regulator and the Clean Energy and Major Projects office will need to expand existing personnel and duties, while existing green energy and alternative technology funds should be expanded to include a greater range of hydrogen projects. Current financing allocated within plans such as StrongerBC and CleanBC, will need to adopt a more hydrogen focused strategy. This would entail specialized requirements for investments in hydrogen companies or additional oversight regarding industry focused financing, necessitating greater contributions from projects such as the Center for Innovation and Clean Energy (CICE). This expanded government and financial attention towards the hydrogen economy has the greatest chance of facilitated steady growth in the long term and allows for further adjustment by the provincial government should the federal government provide future support as they have claimed.

## Multi-Criteria Analysis

Table 2:

	Policy Recommendation: Specialized Administrative and Financial Support
Cost to Government	High
Cost to Industry	Medium
Effectiveness	High
Administrative Complexity	Medium
Industry Capacity	High
Government Stakeholder Acceptance	Medium
Industry Stakeholder Acceptance	Medium
Economic Sustainability	High
Environmental Sustainability	Medium

## **Cost to Government**

Specialized Administrative and Financial Support is scored high in terms of cost to government, due to the significant financial burden of scaling up administrative and financial support. Although this option works to balance the advantages of financial and administrative support, it cannot avoid the costs of direct government intervention. This option is able to provide administrative oversight that could limit unnecessary investment in non-viable sectors but cannot guarantee a significant decrease in costs as a result. This option does place a significant burden on the government to manage the growth of their hydrogen industry, Due to the financial cost associated with increasing administrative duties and providing financial incentives.

## **Cost to Industry**

The policy recommendation also scores medium in terms of cost to industry, as they still bear some of the burden for growing the hydrogen industry, rather than being totally reliant on government or private financing. In this policy option the government and private companies bear equal responsibilities for growing the hydrogen industry, with the government providing additional attention and financing. While the additional administrative oversight will come with regulation, it will also allow for targeted subsidies and government cooperation. Further, although financing from the government is limited in comparison to specialized financial support or direct government involvement, financing will still be made available at a rate greater than what is currently available.

## **Effectiveness**

This policy option is rated as highly effective due to its ability to provide targeted administrative and financial support. The viability of the provincial hydrogen industry will be greatly increased by the addition of governmental support and financing. Policy gaps that are significantly affecting the growth of key hydrogen sectors could be addressed in financing provided to specialized areas. This policy option avoids the shortfalls of specialized financial support by including additional administrative attention, while garnering the government and industry additional resources to tackle more specific

issues relating to scaling up. Overall, this policy option provides the administrative framework for a growing industry and the financial investment to incentivize its growth.

### **Administrative Complexity**

Administrative complexity is ranked medium when evaluating the policy recommendation. Comments on this is due to the requirements on government offices and departments to expand existing duty and staff, not only to increase policy attention towards the hydrogen industry but also to specialize financing. The administrative complexity involved in expanding key government departments is not overbearing as it is targeted to pre-existing areas and does not constitute a large-scale overhaul of government departments. The administrative expansion that is required is notably limited when compared to more involved policy options such as direct government intervention and only demands growth in key support in areas that would be required for a scaled-up hydrogen economy.

### **Industry Capacity**

Industry capacity is also rated high for this option as they can benefit from government attention and receive targeted financial support. As the hydrogen industry in BC is still attempting to grow and is still largely in the research and development phase, both aspects are necessary to facilitate its scale up in the long term. Additional administrative attention allows for the government to address key policy areas and define standards in areas such as safety. The targeted financial support also allows the government to scale up key areas before others, and broadly allows the industry to benefit from the new government policy and standards. Through administrative and financial support, the industry now has the capacity to grow, without being subject to overt government oversight or overly reliant on private financing.

### **Government Stakeholder Acceptance**

This policy recommendation is ranked medium in terms of government stakeholder acceptance, as due to the shift away from pre-established alternative energy projects. This policy option allows for the expansion of powers and personnel in key government departments aimed at the hydrogen industry, but also requires the shifting of



attention away from more popular alternative energy projects such as solar and wind. This largely is due to the financial support as it requires existing green energy funds to expand applicable applicants to include more companies involved in the hydrogen sector. Additional administrative attention from offices such as the Clean Energy and Major Project Office may draw resources and personnel from non-hydrogen alternative energy projects and cause disruptions to the work of government stakeholders. The additional financial support will at least in part be provided through increased access to pre-existing alternative energy funds that may cause a decrease in available financial support for other green energy companies. These kinds of adjustments can cause contention from government stakeholders currently invested in the success of these alternative technologies.

### **Industry Stakeholder Acceptance**

Industry stakeholder acceptance is also ranked as medium in terms of the policy recommendation. Although industry stakeholders would be glad to receive financial incentives and have concerns relating to policy gaps put to rest, the addition of government oversight and regulation will cause contention. As government administration expands to cover key areas of the hydrogen economy viable and unviable sectors will become clearer, particularly when targeted financing is put in place. Further, regulation and practice standards will apply to everyone, demanding uniform compliance from companies that previously operated with limited oversight. While the hydrogen industry can broadly benefit from these changes menace, many current stakeholders will end up on the wrong side, and all will be subject to new regulations and standards of practice.

### **Economic Sustainability**

This policy recommendation ranks high in terms of economic sustainability, as it does not place an overt burden of cost on either the government or industry. This policy option is relatively low cost for the government as although it requires growth in certain administrative departments it does not demand overt government involvement in the hydrogen sector. This policy option is notably viable for the long-term taking a light-handed approach to applying financing and policy, with the expectation of future

technological advancement or federal investment. The BC hydrogen industry would be subject to modern regulation and financing allowing growth from industry without being overly stifled by government involvement. Further, the government can realistically manage and support this industry's growth without bearing most of the financial burden or incurring costs from large-scale involvement.

### **Environmental Sustainability**

In terms of environmental sustainability this policy recommendation is ranked medium. Although these policies will allow the long-term growth of the hydrogen industry, while the government adjusts regulations and policies, it does not allow for the ready incorporation of hydrogen into key carbon emitting sectors. This policy recommendation is aimed more towards long term stability, then rapid incorporation and decarbonization. This policy option could overtime facilitate the integration of hydrogen into key emitting sectors, but only after significant growth and technological advancement has taken place because of the government's change in policy. In the short term, this policy option does little to offset emissions, heating and transportation and only supports the growth of hydrogen industry and related technologies.

### **Conclusion**

British Columbia needs to make a significant number of policy adjustments in order to facilitate the transition of hydrogen as a decarbonizing factor into the provincial economy. The promises and expectations outlined in the provinces 2021 hydrogen strategy are extremely ambitious and intend to enact significant change and several targeted sectors that is beyond what the market is currently able to provide. In order for the BC hydrogen industry to scale-up and contribute towards the decarbonization goals outlined in the hydrogen strategy, issues of scarcity and industry capacity need to be addressed.

Currently, hydrogen is extremely expensive and plans to scale up artificial production have seen little progress. This is due to the state of hydrogen production and exploration maintaining itself solidly in the research and development phase but has

begun attracting significant governmental attention. Other jurisdictions have begun making significant investments towards the development of artificial hydrogen production, and the possibility of hydrogen extraction; centering these two facets in their strategy to grow their hydrogen economies and avoid the procurement issue.

Additional problems arise in the provincial hydrogen economy as many companies struggle to procure private and governmental financing stunting their growth and trapping them in the research and development phase. Should a significant portion of hydrogen gas become available for the provinces to use it is not guaranteed that the hydrogen economy would be in a place to exploit it.

While British Columbia is unique in its approach to growing its hydrogen economy due to its subnational position and lack of ready access to federal financing, the province can still situate itself as a leader in hydrogen technology making use of its available resources. Targeted financing and administrative support even on a subnational level can incentivize growth, and further assist development of new technologies. Issues of hydrogen procurement can only be solved through advancements in hydrogen technology and the specialized policy approach allows the province to contribute to its development and take advantage of any potential advancements from out of province sources. The specialized financial administrative attention from government also allows steady growth within the provincial industry, allowing it a solid foundation on which to take advantage of future changes in the industry. With these specialized policy instruments BC can manage and grow its hydrogen economy until the introduction of federal financing or technological advancement allows for greater advancement in the industry.

## **Interviews**

(Patrick Steiche, Interview, 2024)

(Jonjo O'Rourke, Interview, 2024)

(Douglas Cordero, Interview, 2024)

(Simon Wolfe, Interview, 2024)

(Mehmud Iqbal, Interview, 2023)

(Akash Chaudri, Interview, 2023)

(Landon Jackson, Interview, 2023)

(Connor Meinke, Interview, 2023)

(Ceclia Muys, Interview, 2023)

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