The Hydrogen Economy and the Potential for Newfoundland and Labrador

A Discussion Paper

February 2021

Newfoundland and Labrador
Environmental Industry Association

Preface

The purpose of this document is to advance the discussion around opportunities associated with the hydrogen economy for Newfoundland and Labrador.

Hydrogen has long been viewed as a fuel source with great potential, and activity around it has increased substantially in recent years. This dialogue has only increased in intensity since the onset of the global pandemic and the interest by many international actors to stimulate economic recovery through clean growth initiatives.

The Newfoundland and Labrador Environmental Industry Association (NEIA) believes there may be considerable economic growth and diversification opportunities for this province through participation in the hydrogen economy.

In advance of a more fulsome and detailed stakeholder engagement towards the development a strategy for Newfoundland and Labrador, NEIA has crafted this document with the intention to create a broader awareness within the province on what the possibilities may be for the production and/or consumption of hydrogen – and what further explorations are required to narrow in on and define the real opportunities.

The exploration of Newfoundland and Labrador's hydrogen potential takes place within the context of the Canadian narrative (see: '*Hydrogen Strategy for Canada – Seizing the Opportunities for Canada*' - https://www.nrcan.gc.ca/climate-change/the-hydrogen-strategy/23080) and previous research related to the Maritime provinces (see: '*A Feasibility Study of Hydrogen Production, Storage, Distribution, and Use in the Maritimes*' - https://oera.ca/hydrogenstudy). A full reading of these strategies will provide additional insight into the discussion around Newfoundland and Labrador's opportunities.

This document leans heavily on figures acquired from the *International Energy Agency* (IEA - https://www.iea.org/reports/the-future-of-hydrogen).

If you have an interest in participating in a future discussion on Newfoundland and Labrador and its potential related to the hydrogen economy, please see the contact details at the conclusion of this document.

Hydrogen: A Brief Introduction

Hydrogen is the most abundant element in the universe, but it is rare on Earth in its natural state. It is an extremely light weight gas that would simply float beyond our atmosphere and into space.

Yet hydrogen is produced in significant amounts industrially. Approximately 70 million tonnes of hydrogen are used annually globally. Hydrogen is used as a feedstock in several important industrial processes, the most common being for the refining and upgrading of crude oil. Hydrogen-based processes help remove impurities like sulphur and help in the refinement of the material into lighter components. Hydrogen is also used in significant volumes in the production of ammonia, methanol, and steel.

There are many more potential large-scale uses of hydrogen that are now being explored, piloted, and commercialized around the world. Hydrogen can be a powerful source of energy and can be burned like gasoline to be realized. The key difference between using hydrogen and gasoline in this regard is that the by-product from burning hydrogen is water versus the greenhouse gas (GHG) emissions that result from burning fossil fuels.

This is the reasoning behind decades-long efforts to perfect its production and increase its use. Hydrogen is viewed as a promising replacement in the long-term for fossil-fuel based activities (e.g. transportation, heating, electricity production) and as a potentially significant component of the global energy transition. Its broad adoption and application can help achieve substantial GHG emissions reductions in sectors of the economy that are otherwise difficult to decarbonize.

Thus, many nations around the world – from the UK to Germany to Japan – are viewing the use of hydrogen as being a central component of their efforts to decarbonize, combat climate change, and meet their Paris Agreement and net zero objectives. Canada joined this group on December 16, 2020 with the release of its own hydrogen strategy.

But ultimately, hydrogen's capacity to achieve GHG emissions reductions lies in how it is produced.

Grey, Green, and Blue – The Production of Hydrogen

Hydrogen is an energy carrier, not an energy source. Just like electricity it must be produced from an energy source, and how it is produced can have great impact on its value from a GHG perspective. Hydrogen can be produced through a number of different processes.

Grey Hydrogen

First it can be produced with natural gas through a process called steam-methane reforming, or 'SMR'. This involves heating gas (or another methane source) to 1000 degrees or so to break up its molecules to acquire hydrogen. The downside here is that the major by-products are carbon monoxide, carbon dioxide, and other GHGs in what is a carbon-intense activity. This process has become known as "**grey**" hydrogen. There are other methods to produce hydrogen from fossil fuels, but SMR is the most common.

Blue Hydrogen

Second, GHG-emitting approaches to hydrogen production through the use of fossil fuels can be augmented by carbon capture and storage (CCS) technologies. Deploying CCS can mitigate the negative environmental impacts of SMR or fossil-fuel based electrolysis, and is known as "**blue**" hydrogen. Blue hydrogen has significant prospects in traditional hydrogen production facilities through retrofitting, and in oil and gas producing jurisdictions due to the availability of natural gas, the synergies associated with the carbon capture and storage technologies required, and because the operators, infrastructure, and supply chains are well-positioned to participate in the energy transition in this manner. Blue hydrogen offers a pathway to leverage fossil fuel resources in a low carbon way which can speed decarbonization of the energy sector.

Green Hydrogen

Third, hydrogen can be produced through a process called electrolysis. This is a process that splits hydrogen from water using an electric current. Any source of electricity can be used for electrolysis, but of course the most desirable approach from an environmental perspective would be to use clean electricity as the result would be a zero-emissions fuel from production to consumption. Creating hydrogen using a renewable energy source is known as "**green**" hydrogen. Green

hydrogen is viewed as being a potentially game-changing advancement in the fight against climate change due to the emissions-reduction impact it can have on both upstream and downstream energy systems.

Beyond grey, blue, and green hydrogen, there are also several other pathways for hydrogen production which no colour is clearly defined, but which are fully viable. One such approach is through **biomass conversion** – using either gasification or anaerobic digestion to produce hydrogen. This can be considered both a renewable and carbon-neutral method of hydrogen production. Hydrogen can also be produced via nuclear power (electrolysis) and by capturing and purifying industrial by-products.

Approximately 70 million tonnes of hydrogen is used annually around the world, and the IEA estimates that more than 99% of it is produced using fossil fuels or by-products in GHG intense processes like SMR. This represents substantial growth opportunities for both blue and green hydrogen production.

Blue and green hydrogen production is more expensive, in part, because the technologies are newer. However, it is expected that the costs associated with these methods will decrease substantially in the decades to come as technology advances and economies of scale are achieved. It has recently been predicted that green hydrogen production methods can reach cost parity with grey hydrogen by as soon as the year 2030.

Significant global emissions reductions can be achieved by displacing the existing use of hydrogen with blue or green production methods. But the excitement around hydrogen is not just around for what the element is used for today, but for what it can be used for in the years ahead.

The Emerging Hydrogen Economy

Hydrogen is a versatile resource that is particularly useful where high-intensity or prolonged energy is required. In the pursuit of economy-wide decarbonization, hydrogen is viewed as a fuel that has great potential where electrification is not entirely practical for technical or financial reasons.

Transportation

Hydrogen can be used directly in fuel cell electrical vehicles (FCEVs) which can have two times the efficiency of combustion engines. Light-duty passenger vehicles and transit busses are

commercially available, with heavy-duty and long-haul trucks showing particular promise due to the necessary duration and ranges of travel. These opportunities extend into other areas of transportation, including trains, marine vessels such as ferries, cargo vessels, cruise ships, etc., off-road vehicles, and even aircraft. These applications may seem futuristic, but the technologies have existed for some time. Fuel cell bus fleets have been deployed in a number of international jurisdictions as early as the 2000s. Norway's first hydrogen-powered ferry set sail in 2019. In 2020 Airbus unveiled a hydrogen-powered concept airliner.

Heating

Hydrogen is suitable in applications where high-grade heat is needed and where electric heating is not technically or economically viable, e.g. industrial heating and space-heating for homes and buildings. Hydrogen is versatile in that it can be burned directly or as a blend with natural gas. In many cases hydrogen can be blended with natural gas for use within existing natural gas heating applications, presenting an opportunity for rapid adoption and immediate GHG emissions reductions.

Electricity Grid

Hydrogen can be used as a fuel for power production through either hydrogen combustion in turbines or for use in stationary fuel cell power plants. In addition, it is an excellent storage medium, meaning that it can assist in helping balance electricity supply and demand. In this regard, it can be a valuable tool in load management to mitigate the challenges that some renewable sources have with respect to generating intermittent electricity (e.g. wind). Or it can assist in balancing seasonal energy variations (e.g. storing excess electricity produced in the Summer months to use in the Winter months when demand may exceed supply). Hydrogen can also provide stability for off-grid renewables based power solutions in remote communities and remote industrial sites such as mines. Hydrogen can also add value to existing electricity networks; where excess electricity is wasted or sold at a loss, it can be converted to a new commodity in the form of hydrogen that bypasses electricity transmission and market constraints.

Industrial Applications

Related to transportation, heating, and power generation, hydrogen has particular opportunity within industrial settings. Often viewed as sectors that are 'hard to abate' or decarbonize, there are

multiple promising applications for hydrogen within heavy industry that require energy at a high intensity, over a long duration, or in remote and/or hard-to-access environments. A remote mine is an excellent example where operations and equipment are often all fossil fuel-based and electrification is not practical or feasible.

The sectors listed here are among the most challenging to address from a GHG emissions reduction perspective. A widespread adoption of zero-emissions fuel, created from clean electricity, would represent a remarkable step in the fight against climate change.

The Future Demand for Hydrogen

The demand for hydrogen, which has grown more than threefold since 1975, continues to rise to meet the requirements associated with its traditional uses in chemicals and refining. This demand is met almost entirely via grey hydrogen, with 6% of global natural gas and 2% of global coal going to hydrogen production.

As a consequence, production of hydrogen is responsible for approximately 830 million tonnes of CO2 per year, equivalent to the GHG emissions of the United Kingdom and Indonesia combined. The displacement of grey hydrogen with either blue or green represents a significant opportunity for clean growth.

However, this in and of itself does not impact the overall demand for hydrogen.

There are many variables associated with hydrogen adoption in each of its potential applications, making demand predictions challenging. It is difficult to predict the degree to which hydrogen solutions will be deployed versus battery solutions, the pace at which solutions in general will be adopted, and the speed of the technological advances that are required to make such adoption economic.

With this said, the IEA records that since 2010 the global demand for hydrogen has grown by 28%. The IEA anticipates that hydrogen has the potential to meet between 18% and 24% of total global energy demand by 2050. This would represent enormous growth.

Uncertainties have not impeded recent large-scale investments in blue and green hydrogen, or the development national hydrogen strategies. In its own recently released hydrogen strategy the Government of Canada contends that the demand for hydrogen in global energy systems is dramatically increasing – with projections indicating at least a tenfold increase in demand in the coming decades.

There is risk associated with being a new entrant into the world of mass hydrogen production, and this is why many strategies are focusing on creating domestic demand (where it does not yet exist) for domestic production as a first step. Yet the reward for early movers may be significant.

The Opportunities for Newfoundland and Labrador

While the hydrogen economy may be a relatively new concept within Newfoundland and Labrador, it is important to understand that Canada is already in a position of leadership.

Canada is among the top ten hydrogen producers in the world today, and is recognized as a global leader in the hydrogen and fuel cell sector. It is home to the largest clean hydrogen production facility in the world where hydrogen is produced from natural gas with carbon capture and storage.

A Canadian strategy has been released, as has a strategy for the Maritime provinces. But what is the hydrogen economy opportunity for Newfoundland and Labrador?

Starting the Discussion

The purpose of this document is to advance Newfoundland and Labrador's collective understanding around the opportunities associated with the hydrogen economy. The following suggestions are meant only to incite thought and discussion, and stimulate new thinking. Some of the ideas and questions posed may be easily refuted or answered by subject matter experts. Other components may require further investigation to either validate or invalidate their potential. The intention of this discussion paper is to help stakeholders establish what we know and what we do not know so that the most prospective opportunities can be focused on.

Production vs. Consumption

Many jurisdictions are looking inwards in their approach to hydrogen planning, with a key driver being emissions reductions within their economies. For Newfoundland and Labrador, the domestic opportunities may not be substantial enough to demand domestic production. Yet the production opportunities in and of themselves may be significant. The province might view its place in the hydrogen economy along the same lines of its participation in other natural resource industries like oil and gas and mining – an opportunity for export into a global market.

A Pathway for Renewable Energy Development

From wind, to offshore wind, to solar, to water – Newfoundland and Labrador is rich in renewable resources. The challenge is that the province has already met its domestic electricity needs with clean energy, and the prospect of developing renewable energy resources for the primary purpose of export is significantly challenged by transmission infrastructure and regulatory constraints. The prospect of developing renewable resources for the purposes of producing green hydrogen – as is now being done elsewhere in the world – may present opportunities for substantial economic growth and diversification while sidestepping transmission challenges.

A Use for Excess Clean Electricity

The changing state of energy markets has challenged the revenue potential associated with the sale of excess Muskrat Falls electricity. This excess electricity is most abundant during the Summer months when domestic demand is low. Could this energy be more profitable if converted into another commodity – green hydrogen? Or could making some of this excess electricity available for the purposes of stimulating research and development activity around hydrogen production as an investment attraction strategy pay off over the longer term?

Balancing Domestic Demand and Supply

Related to the above issue around the seasonality of electricity supply and demand, can hydrogen be used as a storage medium and balancing mechanism for Newfoundland and Labrador's electricity grid? Can the production of hydrogen in the Summer months and its subsequent availability for use for electricity generation in the Winter months negate the need for fossil-fuel based backup capacity (e.g. the Holyrood Generating Station)? Could the availability of hydrogen on the island increase the resiliency of the grid at-large?

Remote Communities

Scaling the above opportunity down, can hydrogen be used in rural and remote communities to decarbonize electricity systems? At present these communities generate electricity through diesel turbines. Even with the introduction of renewable energy technologies, it is expected that these turbines run at approximately 30% capacity to maintain operational efficiency and reliability. By shifting away from diesel and using hydrogen instead, a number of advantages can be realized. GHG emissions can be reduced to

zero. Issues with the intermittent nature of renewable systems can be mitigated. Presuming much of the hydrogen supply can be produced locally, further cost and emissions reductions can be achieved by reducing transportation and logistics challenges associated with diesel. Newfoundland and Labrador can leverage the lessons learned from a hybrid wind and hydrogen system installed in Ramea in a research initiative between 2007-2011.

2041 and the Upper Churchill

In 2041 Newfoundland and Labrador will acquire control of the Upper Churchill Falls hydroelectric facility. With green hydrogen production expected to become cost competitive with grey by 2030, it is possible that large scale hydrogen production from this resource could be highly profitable for Newfoundland and Labrador – while avoiding the complexities of trying to export electricity through multiple jurisdictions. What steps can Newfoundland and Labrador take today to prepare itself for this opportunity? In addition, if the province is in a position to produce cheap hydrogen – could it also gain a competitive advantage in downstream opportunities (e.g. ammonia, methanol, etc.)?

Natural Gas and the Offshore Industry

The oil-producing reservoirs offshore Newfoundland and Labrador have some quantities of natural gas, but perhaps not enough to be deemed profitable for development and export by operators. Today this gas is used in diesel turbines to generate electricity for offshore operations, for re-injection into the reservoirs to enhance oil recovery, and is flared in certain circumstances. With pressures to reduce the use of gas for electricity and the amount of flaring, changing operations may mean changing economics for gas. It is also a possibility that future discoveries have much higher concentrations of gas. Given the connections between gas, the increasing importance of carbon capture and storage, and the relationship of both to blue hydrogen, it is worth understanding what potential exists for hydrogen as it relates to Newfoundland and Labrador's offshore oil and gas industry.

The Come by Chance Refinery

The Come By Chance refinery is a crude oil refinery just beyond the Avalon Peninsula portion of Newfoundland. Although there is a great deal of uncertainty surrounding the future of the refinery due to the economic impacts of COVID-19, it may be worth exploring to what degree (if any) blue or green hydrogen can play in its future. If hydrogen is used in the same manner as it is in other refineries around

the world, Come By Chance may represent one of the largest potential ‘customers’ of locally produced hydrogen.

Other Industrial Adopters

There may be opportunities worth exploring for hydrogen production and/or consumption related to some of the province’s major industrial facilities – e.g. mining, sawmills, etc.

Transportation

Transportation is an area of particular opportunity for hydrogen use, and in the Newfoundland and Labrador context this takes shape in the marine environment. Ferries, fishing vessels, tugboats, and other marine vessels all may have the potential for hybrid or hydrogen-based propulsion. With significant marine traffic in and out of its ports, should the province’s ports be preparing to provide hydrogen fuel to national and international carriers to play their part in enabling the hydrogen economy? On land, with the absence of rail infrastructure, inter and intra-provincial transportation of goods is facilitated by heavy duty trucks. Displacing emissions associated with these activities via hydrogen-powered trucks could create a reasonable demand for fuel and significantly reduce the province’s GHG emissions.

Biomass Conversion

Hydrogen produced through biomass conversion is considered both renewable and carbon-neutral, and may present interesting opportunities for small scale production and innovation within a number of key industries for Newfoundland and Labrador. The province’s forestry, fishery, and aquaculture industries – and even its municipal sector – produce biomass wastes that may have the potential to be repurposed. This would have a number of advantages including the diversion of organic wastes from landfills, creating value from waste, and the renewable sourcing of a potentially cheap feedstock.

Home Oil Heating

There is no natural gas heating infrastructure in Newfoundland and Labrador, as heat is provided predominantly via electricity from the grid or through oil. While the relationship between natural gas systems and hydrogen is well known, are there opportunities for innovation and technology development to facilitate hydrogen use in situations where homes are heated by oil?

Additional Considerations

In evaluating the opportunities for Newfoundland and Labrador and the hydrogen economy, there are a number of considerations the must be taken into account.

Hydrogen vs. Electrification

Where should electrification end and hydrogen begin use in the Newfoundland and Labrador context? Increasing the demand for electricity is an important priority for this province as it contributes to the mitigation of electricity rates and/or the costs of the Muskrat Falls project. Careful consideration should be given to what fuel switching initiatives are earmarked for hydrogen as to not jeopardize electrification objectives.

Regulatory Frameworks

A review of regulatory frameworks should be considered to proactively identify challenges with respect to hydrogen production, use, and experimentation in the province. Advance work in this regard can help ensure future investors and developers are not frustrated or become entangled with immature regulation. Certainty can be a competitive advantage in a world where the deployment of technology is still quite new and competition intense. Better yet, regulations can be positioned to incentivize hydrogen activity.

Competitive Advantages

In the long-term, will world demand for hydrogen be competitive enough to allow for a jurisdiction like Newfoundland and Labrador to produce and transport it worldwide? As competition is likely to be fierce, are there advantages the province has in terms of its abundance of clean energy resources, port infrastructure, geography, etc. that will allow it to compete in the market?

Conclusion

The purpose of this paper is to stimulate interest in and discussion around the opportunity for Newfoundland and Labrador to participate in the hydrogen economy.

While the hydrogen economy may be a relatively new concept within Newfoundland and Labrador, it is an industry that is rapidly evolving internationally. Other provinces within Canada have established hydrogen strategies. And Canada is but one of many countries around the world pursuing the industry aggressively. Other nations have developed strategies to inform optimal supply pathways and end-use applications for hydrogen, as well as to define export strategies.

The opportunities may be vast, but the window is closing for Newfoundland and Labrador to be an early entrant into the hydrogen economy.

NEIA believes that further investigation of the ideas presented is warranted. Newfoundland and Labrador can become a global leader in the energy transition, and hydrogen may play a significant role. The opportunities to grow and diversify the province's economy in the process may be substantial.

In the coming months NEIA will be helping to inform research and stakeholder engagement towards the development of a hydrogen strategy for Newfoundland and Labrador.

Some of the ideas and questions posed here may be easily refuted or answered by subject matter experts. If you are a subject matter expert in Newfoundland and Labrador and would like to weigh in on any of the topics explored, we would be interested in hearing from you. Similarly, if you would like to be engaged and contribute as NEIA works to better define the province's hydrogen opportunity, we would welcome your input and support.

To engage with us on this topic, please contact NEIA's Executive Director Kieran Hanley at kieran@neia.org by February 15, 2021.