



**Ports & Maritime**  
Hydrogen Summit Series

## **CHARTING A COURSE FOR NET ZERO:**

Critical First Steps on a  
Hydrogen Pathway

Published October 2021



# Contents

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I. About the Authors	03
II. Acknowledgements	03
III. Executive Summary	04
IV. Introduction	07
V. Ports & Maritime Hydrogen Summit Series	09
VI. Major Themes	10
VII. Recommendations	22
VIII. Conclusion	24
IX. References	25

# About the Authors

**Oceans North** is a Canadian charity that supports marine conservation in partnership with Indigenous and coastal communities. Having worked in the Arctic and North Atlantic for more than a decade, Oceans North recognizes that the health of the climate, the ocean and coastal communities are interconnected. Climate change and its effects on the ocean is a theme throughout all our work, from developing safe Arctic shipping corridors to helping address maritime sector emissions in all three of Canada's oceans. Brent Dancey and Erin Abou-Absi lead Oceans North's work on the maritime energy transition and are the lead authors on this report.

**Zen Clean Energy Solutions** is a boutique consulting firm with over 60 years of combined experience in the clean energy sector. Zen specializes in zero-emission transportation and electrification. Zen's team has deep technical expertise in both fuel-cell electric and battery electric powertrain technologies, as well as supporting hydrogen fuelling and electric charging infrastructure.

Zen was the lead author on the Government of Canada's *Hydrogen Strategy for Canada*, the *BC Hydrogen Study*, and the recently completed *Feasibility Study of Hydrogen Production, Storage, Distribution and Use in the Maritimes* on behalf of the Offshore Energy Research Association (OERA).

**Ocean Conservancy** is working to protect the ocean from today's greatest global challenges through science-based solutions for a healthy ocean and the wildlife and the communities that depend on it.

## Acknowledgements

The authors are grateful to all of our panelists and participants who took the time to share their thoughts, experiences and expertise with us (a full list is available on p.9 and 10). We are hopeful that the connections forged during the Ports and Maritime Hydrogen Summit Series can form the basis for lasting cooperation across countries and sectors on reducing emissions and seizing the economic opportunity presented by decarbonization.

For more expert insights from our Summit Series, visit the [Summit Series YouTube channel](#), where you can watch the presentations.



# Executive Summary

**Heat waves, hurricanes, forest fires: the extreme weather that touched so many of our lives this past year gave us a visceral reminder of the urgent need to reduce carbon emissions and fight climate change. If we want to avoid the worst impacts, we need to act now, around the world and across all sectors of the economy.**

The global shipping industry—one of the world's largest emitters of greenhouse gases—has mostly remained on the periphery of discussions about reducing emissions, and the sector's current plans for decarbonization are not aligned with what is required to prevent the Earth's temperature from rising more than 1.5°C over pre-industrial levels.

Given the massive footprint of this sector, decarbonizing the shipping industry will not only lower global emissions, but also spur the development of zero-emission fuels like clean hydrogen for use in other industries. Hydrogen can be produced using only water and renewable electricity, and it emits no greenhouse gases when used to power ships and vehicles over long distances or to produce high-temperature heat for industrial use. It is estimated that hydrogen could make up 25 percent of the global energy mix by 2050.<sup>1</sup>

In addition to being an environmental imperative, reducing shipping emissions is an economic opportunity. The Global Maritime Forum forecasts that **there is a \$1.9 trillion USD market opportunity** connected to decarbonizing the shipping industry, much of which will come from investments in clean fuel production and land-based infrastructure.

As a country that is both a major energy producer and is warming at twice the global average, Canada has a large stake in the outcome of the transition to clean fuels — in the shipping sector and beyond. If we can fully seize the opportunity to become a leader in the development and use of hydrogen, it could help reduce emissions and create **more than 350,000 jobs and direct revenues of over \$50 billion a year by 2050.**

In the spring of 2021, Oceans North, Zen Clean Energy Solutions, and Ocean Conservancy convened the Ports and Maritime Hydrogen Summit Series. This first-of-its-kind event brought together decision-makers, innovators, and industry leaders on the west and east coasts to create a dialogue around the role of clean hydrogen in reducing maritime sector emissions.



Panelists and participants converged on four major themes throughout the discussion. Despite the many challenges that were identified in creating economies for new fuels, panelists agreed that **the time to act is now** and that:

- 01.** Canadian seaports are ideal for hydrogen hub development;
- 02.** Fuel-cell technology is ready for wider uptake in port-side equipment;
- 03.** Hydrogen uptake in marine vessels starts with ferries and harbour craft;
- 04.** Canada is well positioned to serve the global demand for clean hydrogen.

*Following the summit series, Oceans North and Zen Clean Energy Solutions synthesized the dialogue and developed a set of **10 recommendations** tied to the major discussion themes. They are as follows:*

## Supporting Ports as Hydrogen Hubs

- 01.** Seaports with multi-modal cargo handling operations and which serve domestic and international marine vessels should be prioritized for hydrogen hub development, with the goal of having **five hydrogen hub demonstration projects underway by 2025**. Special consideration should be given to the ports of Vancouver, Prince Rupert, Saint John, Halifax, and Montreal.
- 02.** **Seaports should have a zero-emission mandate** in line with Canada's 2030 and 2050 climate targets.

To ensure ports are tracking to meet the zero-emission mandate we recommend:

- I.** Mandatory annual reporting of carbon dioxide equivalent (CO<sub>2</sub>e) emissions and fuel consumption.
  - II.** Requiring port operators to file zero-emission equipment transition plans by 2025.
  - III.** Requiring zero-emission fuels to make up 30 percent of all fuel used at seaports by 2030 and 50 percent by 2040.
  - IV.** Prohibiting all new gasoline and diesel internal combustion engine equipment purchases post-2030.
  - V.** Requiring all ocean-going vessels to be zero emission at berth by 2030.
- 03.** A dedicated **Hydrogen Port Infrastructure Fund** should be created to advance the deployment of on-site hydrogen production, compression, storage and dispensing equipment at seaports.

This funding should include an allocation for feasibility studies to assess the technical and commercial viability of new projects and should be stackable with the Clean Fuels Fund and other federal funding programs, to a maximum of 75 percent of project costs.

Special consideration should be given to renewable-energy-to-hydrogen production projects that support hydrogen hub development at Canada's major seaports.

## Supporting Hydrogen Use in Port-Side Equipment

- 04.** A targeted **Zero-Emission Port-Side Equipment Demonstration Fund** should be created to support the uptake of zero-emission port-side handling equipment. This funding should include an allocation for feasibility studies to assess the technical and commercial viability of new projects.

Over the mid-term, this funding could transition from the design and development of new equipment to a first-come, first-serve voucher program like what exists in California for higher technology readiness level products. This approach will address the incremental capital costs of deploying zero-emission technologies.

- 05.** The government should provide **specialized manufacturing support** through tax incentives, rebates, or other public policy mechanisms to support and accelerate made-in-Canada equipment for targeted elements of the value chain for seaport or marine vessel equipment.

## Supporting Hydrogen Uptake in Marine Vessels

06. The federal government should work with provinces, municipalities, and private operators to mandate **zero-emission ferry operations** in line with the country's 2030 and 2050 climate targets. The near-term focus should be on planning and pilot development.

To ensure ferry operators are tracking to meet the zero-emission mandate, we recommend:

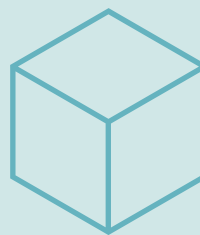
- I. Mandatory annual reporting of CO<sub>2</sub>e emissions and fuel consumption.
  - II. Requiring ferry operators to file vessel transition plans to zero-emission operations by 2025.
  - III. Requiring 30 percent of fuel use in ferries to run on zero-emission fuels or electricity by 2030.
  - IV. Prohibiting new internal combustion engine equipment purchases post-2030.
07. A **Zero-Emission Marine Vessel Fund** should be created to advance hydrogen fuel-cell electric and battery electric technologies in ferries and harbour craft. The fund should include an allocation for feasibility studies to assess the technical and commercial viability of new projects as well as support the design, assembly, and operation of the equipment for a defined period.

Special consideration should be given to local shipyards and Canadian companies in the maritime supply chain as a way of building domestic capacity and expertise in the development and implementation of zero-emission fuels and technologies.

08. The **Clean Fuels Regulation should be amended to include marine vessels and shore power at berth** to fully unlock the potential of switching to zero-emission fuels like clean hydrogen and electricity in the maritime sector.
09. The government should **prioritize the procurement of zero-emissions vessels** when constructing all non-military federal vessels, including vessels owned or operated by Crown corporations.

## Supporting Canada's Export Opportunity

10. Canadian Port Authorities should be empowered and supported to pursue **partnership agreements with international seaports** to facilitate the export of clean hydrogen and to develop green shipping corridors. These corridors must be compatible with the broader decarbonization targets that will prevent the Earth's temperature from rising more than 1.5°C. Partnership agreements would include vessel innovation, fuel bunkering, carbon intensity certification and fuel quality standardization to facilitate trade.



# Introduction.



This past summer, Canadians witnessed the devastating and immediate impacts of climate change like never before. The world watched as temperatures climbed to a record 49.6°C in Lytton, B.C., smoke from wildfires blanketed our cities from coast to coast, and hundreds of sudden deaths occurred due to the sweltering heat. In the United States, a devastating hurricane swept through Louisiana once again before inundating New York City, flooding the subway and drowning people in their homes. Transitioning away from fossil fuels is an immediate imperative if we are to offer a hopeful future for the next generation.

Canada is warming at twice the global average, with northern areas warming almost three times faster.<sup>2</sup> If we are to succeed in staving off the worst impacts of climate change, we must lower our own emissions and aggressively push for greater ambition among countries and from major polluting industries like international shipping and aviation, which are the fastest growing sources of transportation emissions.<sup>3</sup>

We can support greater action by marshalling our vast energy resources and expertise to accelerate the production and uptake of zero-emission fuels such as electrolysis-produced hydrogen and other hydrogen-derived fuels such as ammonia or methanol. These fuels hold the answer to decarbonizing heavy industrial processes that require high temperatures as well as long-range transportation such as international shipping. Leadership in the development of zero-emission fuels will provide Canada with an opportunity to remain a top energy producer in a net-zero economy while doing our part to fight climate change.

Addressing emissions from the maritime sector is both a necessity and an opportunity for Canada. The shipping industry carries 80 percent of world trade by volume and generates more than one billion tonnes of greenhouse gas (GHG) emissions per year—more than all but the top-five emitting countries. Yet the bulk of GHG emissions from shipping are generated outside national borders and are not explicitly included in the Paris Agreement. Over the last two decades, emissions from international shipping have increased by 32 percent and are still growing.<sup>4</sup> The International Maritime Organization (IMO), a specialized agency of the United Nations charged with regulating shipping,

projects that CO<sub>2</sub> emissions from international shipping will grow by as much as 130 percent by 2050 from 2018 levels.<sup>5</sup> To keep the rise in global temperatures below 1.5°C, wealthy nations such as Canada must step up, count shipping industry emissions as their own, and regulate them accordingly, as is being done by the European Union.<sup>6</sup>

Cutting shipping emissions globally will require investments in the fuels and infrastructure required to make zero-emissions shipping a reality. So far, more than 30 countries have released hydrogen roadmaps, with over 200 hydrogen projects announced and public funding of more than \$70 billion USD. For Canada, the movement towards clean hydrogen in the maritime sector also presents a unique economic opportunity. By 2050, hydrogen-based fuels are expected to make up more than 60 percent of total fuel consumption in shipping.<sup>7</sup> In Canada, hydrogen powered ferries, tugs and fishing vessels have been identified as focus areas in building domestic hydrogen demand and advancing zero-emission technologies.<sup>8</sup>

## Maritime sector emissions in Canada

Canada's 2019 National Emissions Inventory reports that GHG emissions from domestic and international navigation in Canadian territorial waters were the equivalent of 13 megatonnes (Mt) of CO<sub>2</sub>, with domestic shipping emissions making up 4.4 Mt CO<sub>2</sub> of the total.

Port-based emissions – emissions associated with administration, cargo handling equipment, on-road vehicles, marine and rail – are not presented as a distinct category in the National Emission Inventory and are therefore more difficult to know. In the early 2000s, Transport Canada developed a Port Emission Inventory Tool that port authorities can use to undertake emissions inventories and calculate future emission estimates based on growth in trade. In most instances these emission inventories are not publicly reported.

The Vancouver Fraser Port Authority, a leader in the field of environmental stewardship and reporting among its peers, has published port emission inventories for 2010 and 2015 and is currently finalizing the 2020 inventory. The 2015 report projects that port-based emissions will continue to grow in line with cargo throughput, growing from approximately 1.1 Mt CO<sub>2</sub> in 2015 to more than 1.4 Mt CO<sub>2</sub> in 2030.

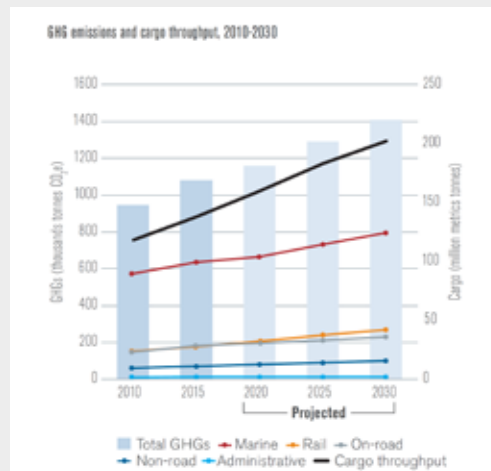


Figure 1. Credit: Vancouver Fraser Port Authority

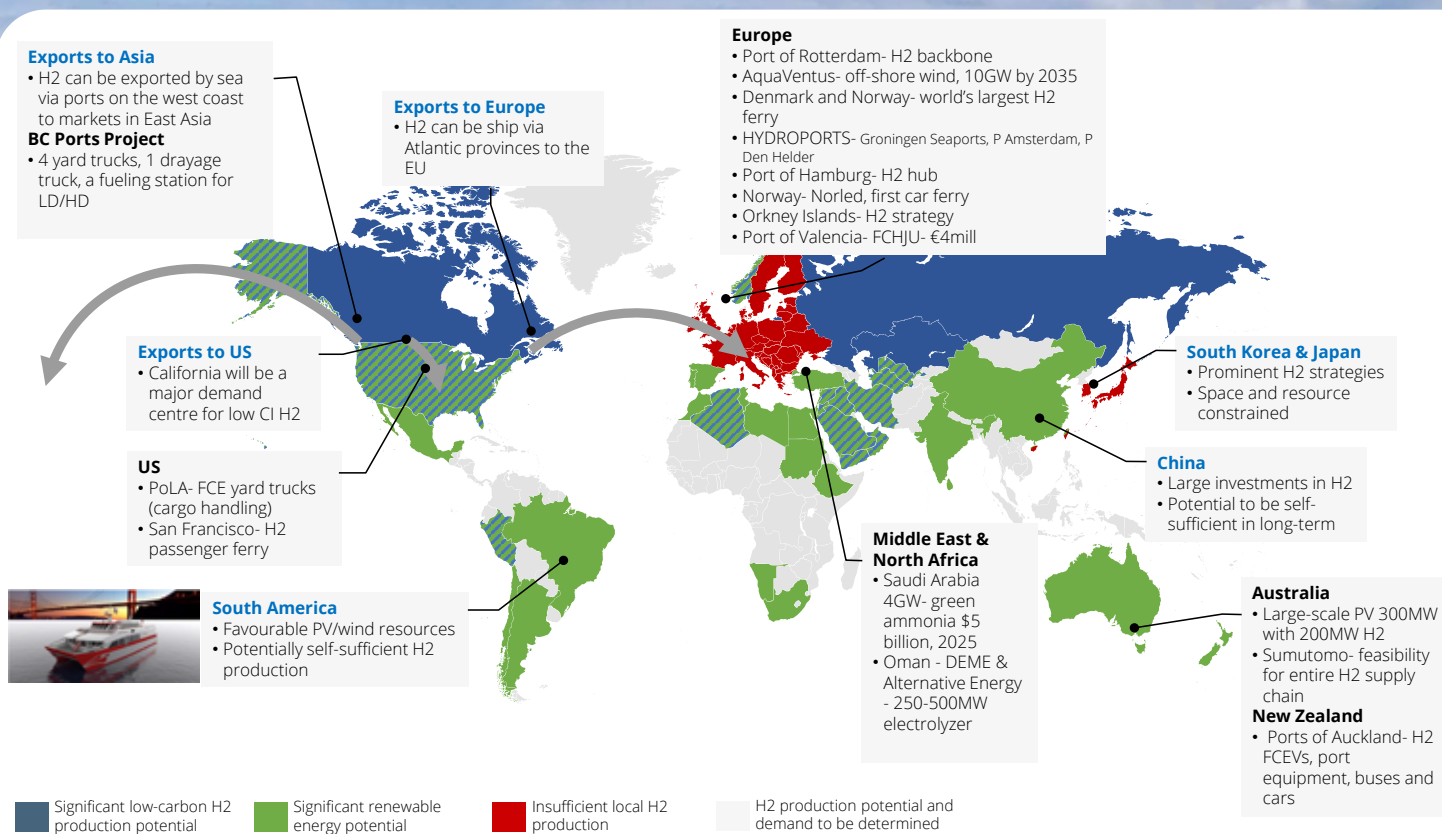


Figure 2. Canada is well positioned to provide clean hydrogen to global markets. Credit: Zen Clean Energy Solutions.

The Global Maritime Forum forecasts that there is a \$1.9 trillion USD market opportunity connected to cleaning up the international shipping industry; almost 90 percent of that amount will come from investments in clean fuel production and land-based storage and bunkering infrastructure.<sup>9, 10</sup>

As a major energy producer with abundant renewable energy resources and energy expertise, Canada is well positioned to utilize clean hydrogen as a means of both decarbonizing our economy and generating wealth. The *Hydrogen Strategy for Canada*, released in December 2020, highlights Canada's unique starting point and assesses the environmental and economic benefits of deploying hydrogen across the full value chain. Given Canada's rich feedstock reserves, skilled labour force, strategic energy infrastructure assets, and technological innovations, the country could become one of the top three producers of clean hydrogen globally.<sup>11</sup> If Canada can fully seize the opportunity presented by hydrogen it could lead to more than 350,000 jobs and direct revenues of over \$50 billion a year by 2050.<sup>12</sup>

Investments in hydrogen infrastructure for ports and shipping can help kickstart this broader transition. While the use of hydrogen in the maritime sector has not received as much attention as other potential applications, both the *Hydrogen Strategy for Canada* and the International Energy Agency have identified commercial ports as ideal settings for scaling up hydrogen supply chains and driving economy-wide emission reductions.<sup>13, 14</sup>

## What is the difference between Green, Blue & Grey Hydrogen?

Hydrogen is a versatile energy carrier that can be produced from a wide range of sources and used to power vehicles or produce the high-temperature heat needed for industrial processes. Some hydrogen fuel production methods emit greenhouse gases, while others do not. In all cases, hydrogen fuel emits only water when burned. All hydrogen is clear and can be stored in gaseous or liquid forms. The terms 'green', 'blue' and 'grey' hydrogen are commonly used to describe the way the hydrogen was produced, which determines the amount of carbon dioxide emitted to create the fuel.

### Green Hydrogen:

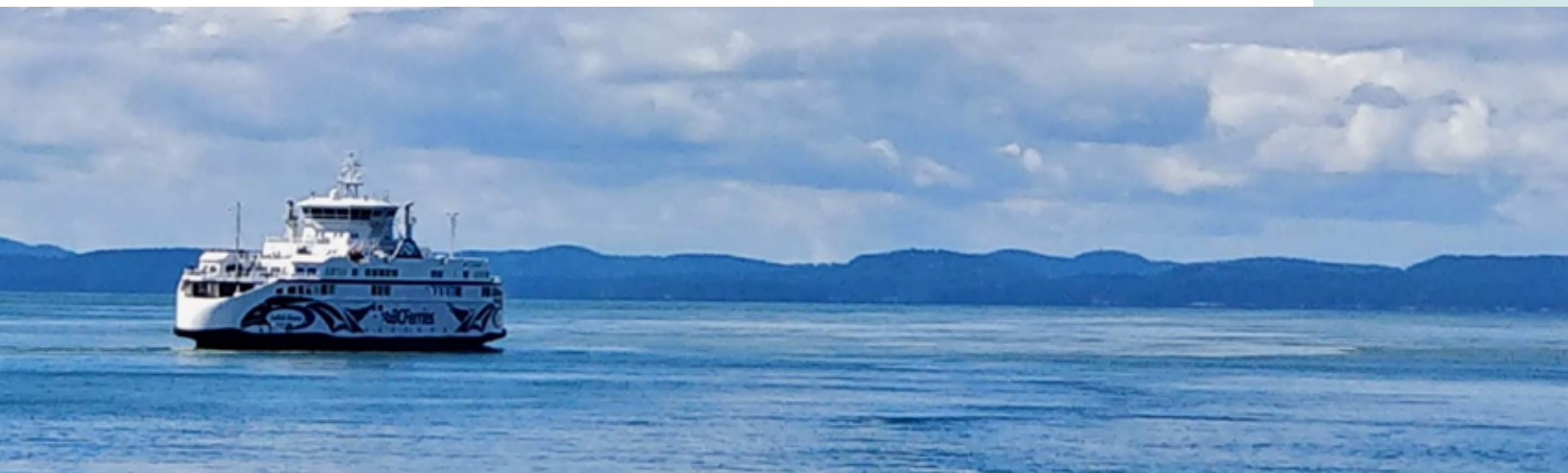
Water molecules are split into hydrogen (H<sub>2</sub>) and oxygen (O<sub>2</sub>) by the process of electrolysis. This process uses electricity as the energy source to drive the conversion. When renewable energy such as wind or solar is used to power the electrolysis process, no carbon dioxide is emitted, making it the cleanest option.

### Blue and Grey Hydrogen:

Natural gas is used to create hydrogen in a process called 'reforming'. This involves splitting methane molecules (CH<sub>4</sub>) using steam and purifying them into two streams of gas: hydrogen (H<sub>2</sub>) and carbon dioxide (CO<sub>2</sub>). In 'grey' hydrogen the carbon dioxide is released into the atmosphere, contributing to climate change, while in 'blue' hydrogen the carbon dioxide is captured through a Carbon Capture and Storage System (CCS). Blue hydrogen is considered low carbon, but not zero emission, as CCS is not able to capture and store 100 percent of the carbon emissions.

In this report, we use the term 'clean hydrogen' to be inclusive of both 'green' and 'blue' hydrogen sources, acknowledging the role blue hydrogen may play as a bridge fuel until zero-emission green hydrogen becomes cost-competitive and widely available. When evaluating both 'blue' and 'green' hydrogen fuel production, it is important that a full well-to-wake/well-to-wheel lifecycle assessment considers the potential greenhouse gas emissions at every step of production and combustion of the fuel.





However, capturing the benefit of port-based hydrogen deployments will not be possible without broad cross-sector collaboration and government leadership. To initiate this critical dialogue in Canada, Oceans North partnered with Zen Clean Energy Solutions and Ocean Conservancy to host the first-ever Ports and Maritime Hydrogen Summit Series.

The summit aimed to increase visibility and dialogue around the role of clean hydrogen in the maritime sector and the need to develop seaport hydrogen hubs in Canada. We brought together thought leaders, innovators, and industry experts from the West Coast and Atlantic regions to participate in two half-day sessions that featured expert panelist presentations, break-out sessions on key themes and dialogue with key federal decision-makers on how to best move forward.

This report has two main sections. The first section explores the four major themes that emerged during our conversations, along with “expert insights” from some of our participants.

The second section provides a set of 10 recommendations for decision-makers to consider as they continue to develop decarbonization pathways for the entire economy. The recommendations were developed by Oceans North and Zen Clean Energy Solutions independently of the Summit Series but are connected to the major themes.

# Ports and Maritime Hydrogen Summit Series.

The Ports and Maritime Hydrogen Summit Series was organized as two half-day sessions: a West Coast session on March 31, 2021, and an Atlantic session on April 1, 2021.

## West Coast

The West Coast event included the Honourable Jonathan Wilkinson, Minister of Environment and Climate Change, who engaged the panelists and participants in a conversation on how to build a maritime hydrogen economy. The plenary discussion was introduced by Sabina Russell, Principal, Zen Clean Energy Solutions. The panelists included Colin Armstrong, the CEO of HTEC, which owns and operates hydrogen fueling station equipment; Hansi Liu-Atkinson, Energy Manager, BC Ferries; Ronan Chester, Manager Strategic Environmental Initiatives, Port of Vancouver; and Nicolas Pocard, Vice-President of Marketing and Strategic Partnerships at Ballard Power Systems, a manufacturer of fuel-cell engines.



## Atlantic

The Atlantic Canada event included opening remarks from the Honourable Seamus O'Regan, Minister of Natural Resources. Andy Filmore, Parliamentary Secretary to the Minister of Transportation and Communities, facilitated a conversation regarding what a maritime hydrogen economy might look like in Atlantic Canada. Panelists included Monica Swanson, Business Manager of International Hydrogen Projects at the Port of Rotterdam; Chris Norris, the Director of Business Development – Green Hydrogen with Siemens Energy; Joel Werner, the Director of Engineering & Projects at DP World Canada, which operates container terminals; and Capt. Allan Gray, President & CEO, Port of Halifax.



## Major Themes.

Panelists and participants converged on four major themes throughout the discussion. Despite the many challenges in creating economies for new fuels, panelists agreed that the time to act is now and that:

- 01.** Canadian seaports are ideal for hydrogen hub development;
- 02.** Fuel-cell technology is ready for wider uptake in port-side equipment;
- 03.** Hydrogen uptake in marine vessels starts with ferries and harbour craft;
- 04.** Canada is well positioned to serve the global demand for clean hydrogen.

The following section describes the key topics of discussion that took place under each theme and provides expert insights from our panelists that offer deeper, sector-specific perspectives on the challenges and opportunities ahead.





## Theme 01: Canadian seaports are ideal for hydrogen hub development

Canadian seaports have been identified as opportune places to develop hydrogen hubs. In ports, multiple modes of transportation converge on shared fueling infrastructure. They also offer other supporting infrastructure, access to a highly skilled workforce, a high volume of end-use applications and a gateway to global export markets.

### Expert Insight: Ports are living labs and strategic gateways for trade

Capt. Allan Gray, President & CEO of the Halifax Port Authority, spoke of his experience in supporting port-based bunkering and use of liquified natural gas (LNG) in Australia, an analogous process where many of the same hurdles facing hydrogen today had to be overcome.

He stated that seaports can be used as a living lab for testing and implementing new technologies because they provide multiple opportunities to replace diesel use, from forklifts to harbour craft. Ports will play a strategic role, he said, in both bunkering clean fuels for use on ships and as gateways to global markets. He described four fundamental roles that ports can play to facilitate growth in the hydrogen sector:

- 01. End-use:** Hydrogen fuel cells could replace diesel engines in port-side cargo handling equipment and harbour craft like tugboats. Hydrogen fuel-cell generators could also power ships at berth.
- 02. Innovation:** Ports will play an important role in innovation because they allow industry to test new hydrogen technologies. They also provide a forum for regulatory development, enabling first movers to get ahead of the competition.
- 03. Bunkering:** To decarbonize large, ocean-going vessels, there will need to be hydrogen bunkering at a network of ports built along specific trade corridors.
- 04. Facilitate export:** Ports will need to understand the demand for hydrogen export and develop infrastructure plans that consider storage needs and the types of vessels that will be calling at the port to move hydrogen to market.

## Matching hydrogen supply and demand

A constant theme throughout each session was the way in which ports provide a concentrated centre where hydrogen supply and demand can be matched and where the value chain can be built out from production to end use.

Ports are attractive places for hub development because of the potential to replace vast quantities of diesel fuel with clean hydrogen across a variety of port-based applications, from mobility (forklifts, rubber-tired gantry cranes, and drayage trucks) to stationary (power plants and refrigerated containers) to marine vessels (ferries and tugs). The convergence of multiple end uses provides the scale to drive down the per-unit cost of hydrogen fuel.

### Expert Insight: Aggregated demand for hydrogen lowers project costs

Speaking as a provider of hydrogen fueling infrastructure for light and heavy-duty hydrogen applications, Colin Armstrong, CEO of HTEC, stated that “ports provide the ability to aggregate demand and that is what is going to drive costs down.”

## Local production required

While ports provide multiple end-use applications for hydrogen, it was made clear that the availability of commercial volumes of locally produced low-carbon hydrogen will be an essential component of seaport hydrogen hub deployment. We heard from numerous project developers that limited supply of locally produced hydrogen and lack of fuelling infrastructure are impediments to moving forward with commercial-scale hydrogen deployments. The current cost of shipping clean hydrogen from other jurisdictions is expensive and unsustainable.

### Expert Insight: Local hydrogen production is an essential component of hydrogen hub development

“Without affordable green hydrogen produced locally, we’re not going to go anywhere,” said Nicolas Pocard, Ballard Power System’s VP of Marketing and Strategic Partnerships, when talking about the need to advance fleet-sized demonstration projects.

## Seaport hydrogen hubs to address climbing CO<sub>2</sub> emissions

Regarding port-based emissions, we heard that Canadian ports are attractive candidates for hydrogen hub development because of the challenges ports are facing to reduce CO<sub>2</sub> emissions. There was an acknowledgment that Canadian port authorities have been largely overlooked in Canada’s national climate plan and that growing port emissions could undermine Canada’s 2030 and 2050 climate goals.



Figure 3. Depiction of seaport hydrogen hub in Rotterdam. Credit: Port of Rotterdam.

## Expert Insight: Seaports are going the wrong way in terms of CO<sub>2</sub> emissions

While other sectors have had some success in combatting carbon emissions from their operations, CO<sub>2</sub>e emissions are rising year over year at Canadian ports (Figure 1) and are not on track to align with Canada's 2030 and 2050 climate commitments.

The Port of Vancouver—the largest port on the west coast and third largest in North America— estimates that by 2030, their emissions will have grown by close to 50 percent from what they were in 2010.

Ronan Chester, Manager of Strategic Environmental Initiatives at the port, spoke directly to the challenge of emissions growing on pace with trade and economic activity. *"We have this predicament,"* he said, *"in that the greenhouse gas emissions associated with Canada's largest port are growing, not decreasing, and this is a problem."* In the last 10 years, the port has grown by 40 million

tonnes of throughput annually, with a forecast predicting growth will increase to 200 million tonnes in the future. He further noted that *"while we have full confidence in the Government of Canada's climate action plan for the nation to meet its targets at a national level, we can see that the largest port in Canada is not on track to conform with these goals."*

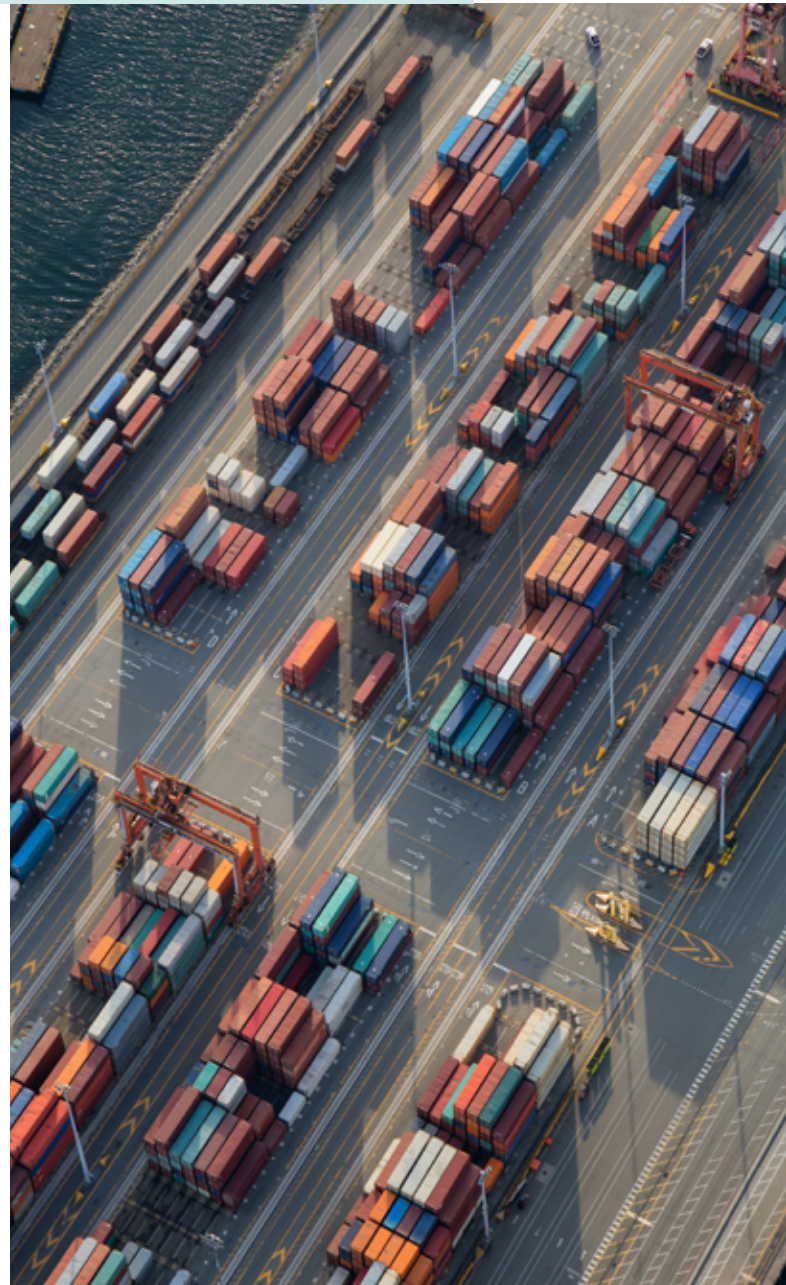
Chester also spoke about the need to decarbonize ports and build zero-emission infrastructure to remain competitive in a net-zero economy. *"If we don't get this right,"* he said, *"if we don't get at it early, and if we don't do it together, there's a good chance we're going to miss the boat, and we will not have the opportunity to develop the energy infrastructure and systems that we need."*

## Summary

The summit dialogue highlighted the fact that Canadian seaports are well positioned to become hydrogen hubs and that a scaled build-out of the full hydrogen value chain at ports on the east and west coasts is a logical next step in implementing Canada's national hydrogen strategy.

Ports have enough commonality in terms of equipment and operations that a template of safety systems and protocols, codes and standards, and operational best practices for hydrogen hubs could be created and replicated throughout Canadian ports on both coasts.

It was made clear that government support is necessary to create momentum at this early stage of development. The federal government has already put in place some of the key programs and policies to spur port hub development, such as the Clean Fuel Fund and the proposed Clean Fuel Regulations, but a more targeted approach is needed. Mandatory public reporting of port emissions and regulatory tools such as emission targets will provide a framework that will support the uptake and use of zero-emission fuels at port.





## Theme 02: Fuel-cell technology is ready for wider uptake in port-side equipment

One of the key messages from panelists and participants at the summits was that, despite some industry and government hesitancy, hydrogen fuel-cell technology is well developed and ready for many key port-based commercial applications.

### Expert Insight: Fuel-cell technology is working; systems level demonstrations are needed

Pocard, VP of Strategic Marketing at Ballard Power Systems, spoke to the commercial readiness of fuel-cell technology and emphasized the need for fleet-level integration and user demonstrations. *"The technology is working,"* he said. *"When I use 'demonstration,' it's not from the sense of technology demonstration—there are thousands of fuel-cell trucks in operation worldwide. Where we need demonstrations is in the sense of the user who is new to the technology and needs to understand how to integrate it into their operations."*

Pocard's presentation highlighted some of Ballard's key global implementation numbers, which illustrate that the technology is ready to meet the demands of the transportation sector. Ballard's fuel-cell technology is already powering 2,200 trucks and 1,000 transit buses worldwide and has supplied 850 megawatts of fuel-cell power.

## Hydrogen fuel-cell technology meets the requirements for port-side operations

We heard from port operators that hydrogen fuel-cell technology can provide a viable alternative to diesel-operated cargo handling equipment when looking for zero-emission solutions. We were told that hydrogen fuel cells are an attractive option because they can meet the unique requirements of port operations, which include handling large payloads and operating for long periods without stopping to refuel.

### Battery Electric versus Fuel-Cell Electric Engines for Specialized Applications

Rapid increases in the use of both battery electric and fuel-cell electric engines will be critical in our transition away from fossil fuels. In specialized port equipment and marine vessels, which technology to choose comes down to the specifics of the application and the work being done.

#### Batteries are:

- ✓ more energy efficient over shorter distances, and
- ✓ less expensive, and
- ✓ benefit from greater availability of infrastructure than hydrogen fuel-cell technology.

#### Fuel cells are:

- ✓ lighter and more efficient over longer distances, and
- ✓ offer quick refuelling, analogous to conventional fuels, and
- ✓ are modular, so can be phased in as part of a larger retrofit.

## Financial support for systems-level demonstrations

Despite the readiness of the technology and the obvious decarbonization benefits of replacing diesel-powered cargo handling equipment with hydrogen-powered alternatives, we heard that port operators are unable to make the transition on their own. The need for targeted financial support for demonstrations or regional hub implementation projects was a major theme that ran throughout the Ports & Maritime Hydrogen Summits, whether it was for system-level demonstration of commercially ready technology or to advance new technologies to a level of commercial readiness.

We heard that demonstration projects allow operators to pilot equipment at a scale appropriate for the maturity of the technology, train staff, and plan for a scaled deployment. Through this type of support, the marine supply chain could develop innovative hydrogen-fueled equipment where there are currently few options and foster competition where there are existing products.

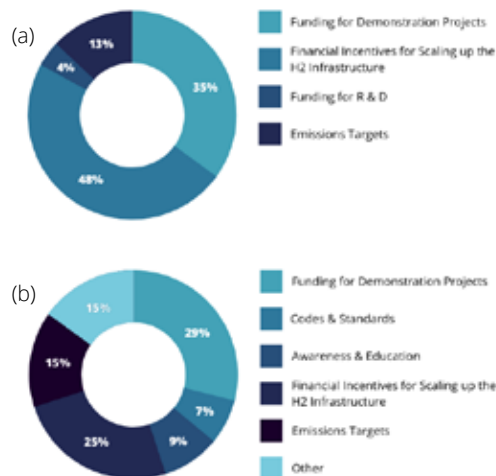


Figure 4. Poll Results from (a) West Coast summit (b) and Atlantic Canada

### Expert Insight: There are not enough zero-emission equipment choices for port operators

Joel Werner, Director of Engineering & Projects at DP World Canada, explained the challenges faced by manufacturers of zero-emission port-side handling equipment. Machines such as the container stacker are specialized and require a lot of energy to operate: *“This machine lifts a 40-tonne container 20 to 30 times an hour in and out of the stack, so there are constant requirements for peak loading, and it does this 24 hours a day. We are working with original equipment manufacturers and suppliers, but they are still developing the technologies to help us move to electrification or hydrogen.”*

### CASE STUDY: BCH2 Ports Project supports the development of Canada’s first seaport hydrogen hub

The BCH2 Ports Project is a collaboration between the public and private sectors that showcases made-in-B.C., port-based hydrogen technology in support of the province’s decarbonization targets. The project consists of:

- four fuel-cell electric hybrid yard trucks and one drayage truck, operating at the BC Ferries terminal and the Tidewater warehouse container examination facility; and
- a commercial hydrogen fuelling station capable of fuelling fuel-cell electric trucks and other equipment.

The project has been developed by a world-leading consortium of technology providers, systems integrators, original equipment manufacturers, equipment operators and project managers. It will be Canada’s first port-based hydrogen infrastructure project and will enable project partners to validate the commercial viability of zero-emission fuels for port-side handling vehicles. It will also set the stage for the use of hydrogen for onboard marine applications in B.C.

The hydrogen fuel for the project will be generated from a centralized hydrogen production facility that will use B.C.’s clean electrical grid. The carbon emissions from the project vehicles will be reduced by more than 90 percent on a well-to-wheel basis compared to conventional diesel-powered yard trucks and gasoline-powered passenger vehicles.

### Collaboration needed to connect fuel-cell technology to end users

Despite the readiness and advantages of fuel-cell technology, we heard that deeper engagement with original equipment manufacturers (OEMs) is needed to develop specialized cargo handling equipment that meets the commercial cost targets of the port operators.

Systems integrators like Hexagon Purus and BAE Systems are overcoming the current lack of available OEM options by sourcing conventional platforms and actively retrofitting the equipment for fuel-cell electric propulsion, such as the yard trucks under the BCH2 Ports Project (see box on left). The fuel-cell electric yard trucks are being designed and assembled locally in Kelowna, B.C., which is creating economic growth and jobs in the region.

### Summary

The summit dialogue highlighted that hydrogen fuel-cell technology is well-suited for port-based cargo handling equipment and ready for greater uptake at Canadian ports. Government support for demonstrations projects and enabling regulations are needed to drive innovation and competition among cargo handling equipment manufacturers.

Greater uptake of zero-emission cargo handling equipment will create the incentive to produce more clean hydrogen, an important dynamic in seaport hydrogen hub development. Current demonstrations underway highlight the opportunity for local companies to play a role developing the specialized equipment which creates jobs and supports made-in-Canada manufacturing.



## Theme 03: Hydrogen uptake in marine vessels starts with ferries and harbour craft

Panelists and participants agreed that clean hydrogen and other hydrogen-derived fuels like ammonia and methanol will have a critical role in reducing shipping emissions in the decades leading up to 2050, pointing to recent examples around the world where hydrogen fuel-cell technology is being developed and tested on marine vessels.

At the same time, participants acknowledged that further small-scale demonstration projects are needed to advance hydrogen fuel-cell technology for marine vessels. Unlike fuel-cell electric buses, where the technology is sufficiently mature to compete commercially with diesel, hydrogen-powered vessels require more research, development and deployment (RD&D) to advance the technology to a point where fleet operators can confidently include hydrogen-fueled propulsion in their long-term capital plans.

These demonstration projects represent critical first steps towards reducing emissions from this sector. Unlike a forklift or passenger vehicle, the lifespan of a marine vessel can stretch for over 30 years. Vessels built today will likely still be operating in 2050. It has been estimated that, for international fleets to achieve net-zero by 2050, 30 percent of fuels used in domestic fleets need to be zero emissions by 2030.<sup>15</sup> This further underscores the importance of near-term domestic demonstration projects.



### Expert Insight: There is growing demand for fuel-cell electric marine vessels

Pocard of Ballard indicated that *"two years ago, no one was talking about fuel-cell power for marine vessels."* Since then, Ballard has become a key partner in multiple projects in the European Union, ranging from ferries and barges to push boats, tugs and for auxiliary power on cruise ships.

In 2019, Ballard established a Marine Centre of Excellence in Hobro, Denmark, to serve the marine market with zero-emission solutions.



## 'Maritime shipping's moon-shot ambition': the Getting to Zero Coalition

The Getting to Zero Coalition is an alliance of more than 150 companies within the maritime, infrastructure and finance sectors across the world. Understanding that the maritime sector must begin decarbonizing as soon as possible, they have committed to the goal of getting "commercially viable deep sea zero emissions vessels powered by zero emissions fuels into operation by 2030." Their Call to Action for governments has three components, which are also aligned with the recommendations of this report:

01. Commit to decarbonizing international shipping by 2050
02. Support industrial scale zero emission shipping projects through national action
03. Deliver policy measures that will make zero emission shipping the default choice by 2030

## Financial support required to advance fuel-cell technology in short sea vessels

When asked about where government support would be most important to advance hydrogen technology in marine vessels, participants agreed funding for demonstrations was a top priority along with financial incentives for scaling up hydrogen infrastructure.

Panelists agreed that pilot projects demonstrating hydrogen technology in short sea vessels like ferries and tugs would be a logical starting point because of their relatively short voyages and consistent refuelling locations.

We also heard from fleet operators that one of the main challenges they face when making decisions on future low-carbon fuels is how to test feasibility without compromising safety and service delivery. Financial support at this early stage would allow operators to develop and test hydrogen vessels in parallel with their existing commercial activities, where costs and reliability in a competitive setting are the priority. This support will be essential over the coming years as fleet operators make investment decisions regarding which alternative fuel to use in a low-carbon future.

## Expert Insight: Ferry operators need experience in the field for hydrogen to become part of future fleet expansion plans

Hansi Liu-Atkinson, Energy Manager at BC Ferries, expects that low-carbon hydrogen could help BC Ferries reach its target of net-zero emission operations by 2050, and emphasized the importance of testing and evaluation.

Speaking of the BCH2 Ports Project in Delta, B.C. (see case study on page 15), Liu-Atkinson said it is "allowing us to do some critical testing before we make significant fleet decisions and bridge that gap between our push for innovation and providing our customers with a safe and reliable service."

The main challenge ahead for BC Ferries is to transition their ferry fleet to cleaner fuels — the fleet represents approximately 98 percent of their emissions footprint.

*"A new construction offers the greatest potential to achieve the most substantial reductions in greenhouse gas emissions," she said. Looking ahead, there are five new major vessels in BC Ferries' capital plan, with the first one anticipated in about five years.*

BC Ferries recognizes the potential of adopting hydrogen as a marine fuel but needs government support to further evaluate feasibility. *"It's important to have enabling policies and programs on a sector-specific basis," she said, "to bridge the gap between ambitious regulatory targets and on the ground application [...] If Canada is going net-zero by 2050, the provinces have to be aligned and all headed in that direction."*



## Regulation and financial incentives drive uptake of zero-emission solutions for marine vessels

Financial support for demonstrations alone is not enough to incentivize the uptake of zero-emission technologies in the marine sector. The approaches that are being taken in Europe and the United States, where there is a combination of regulation, government procurement and financial incentives, are helping to advance hydrogen-powered marine vessels and were seen as a model to follow here in Canada.

The California Air Resource Board put forward a number of amendments this year to the Commercial Harbour Craft Regulation intended to bring that sector in line with the state's ambitious goal to be net zero by 2045.<sup>16</sup> The regulatory push for zero-emission ferries combined with project funding collected from the state's cap and trade regime is driving innovation. Similarly, Norway's target to halve domestic shipping emissions by 2030, its decision to ban emissions from all water traffic in west Norwegian fjords by 2026, and funding allocated through the European Parliament's Research and Innovation Program are creating

the conditions required to move hydrogen fuel-cell technology in ferries to the next level.<sup>17</sup>

Government procurement of zero-emission technologies is another important policy lever that can support the uptake of hydrogen-powered ferries and harbour craft. Given the fact that the first zero-emission marine vessels must be in operation by 2030 to achieve the goals of the Paris Agreement,<sup>18</sup> governments should use their purchasing power to incentivize zero-emission ferries and government vessels. Federal Crown corporations such as Marine Atlantic Inc. and other federal departments that own and operate marine vessels should be a particular focus of the Greening Government Strategy, which aims to reduce the emissions and environmental impacts of the Canadian government's operations.

## Retrofits provide options to replace auxiliary power

Given the capital costs, lifecycles, and operational economics of marine vessels, replacing whole fleets with zero-emission vessels will take more than 30 years.<sup>19</sup>

This means special attention should be given to retrofitting existing vessels with fuel-cell systems. Fuel cells are modular, meaning that they can be implemented strategically to match available infrastructure constraints. For example, fuel cells can first be used to replace auxiliary power before they are used to replace main engines. Doing so provides a near-term opportunity to integrate hydrogen fuel-cell technology onto existing diesel-powered ferries and harbour craft. In Canada and elsewhere, passenger ships are some of the heaviest emitters and offer an opportunity to pilot fuel-cell technology for auxiliary engines as a starting point.<sup>20</sup>



## Summary

We heard from panelists that the push to develop and deploy hydrogen-powered marine vessels is gaining momentum. We also heard from fleet operators that financial incentives for demonstration projects—along with regulations that provide clear guidelines for reducing emissions in line with Canada's net-zero targets—are needed to support the uptake of zero-emissions fuels and help operators make important investment decisions about fleet renewal.

Given the long lifespan of marine vessels, decisions made now will affect Canada's ability to meet its net-zero by 2050 targets. If Canada is to meet its commitments, it must invest in near-term vessel demonstration projects that will allow fleets to begin the broader transition to zero-emission fuels. These critical projects will enable scaling up of the technology so that ocean-going vessels commissioned in the 2030s will be able to integrate zero-emissions technologies and so that the necessary infrastructure and skilled labour will already be in place.





## Theme 04: Canada is well positioned to serve the global demand for clean hydrogen

Finally, we heard firsthand about opportunities for Canada to become a major exporter of clean hydrogen to countries looking to decarbonize their energy systems. Port-based hydrogen hubs could play a strategic role in facilitating trade.

### Hydrogen export opportunity

From the *Hydrogen Study for Canada*, we know that hydrogen could make up a significant portion of Canada's energy export revenues over the coming decades, representing an estimated \$50 billion by 2050.<sup>21</sup>

Participants at the Atlantic Summit heard Monica Swanson, Business Manager of International Hydrogen Projects at the Port of Rotterdam,<sup>22</sup> describe the port's plan to become an international hub for clean hydrogen production and import to other northwest European countries.

Currently, 13 percent of all energy consumed and 40 percent of industrial energy comes into Europe through the Port of Rotterdam.

The plan would see Rotterdam become a key entry point for the anticipated 60 million tonnes of hydrogen that will serve the European market on an annual basis by 2050.

Swanson told panelists and participants that the European Union views Canada as a likely supplier of clean, electrolysis-produced hydrogen because of our abundant renewable energy resources, inexpensive electricity, and deep seaports near European ports.

### Expert Insight: Major European demand for hydrogen will come sooner than many think; importer looking to Canada for supply

Monica Swanson, Business Manager of International Hydrogen Projects at the Port of Rotterdam, emphasized the speed with which the global energy transition is unfolding and how nations are racing to make plans for a new energy mix in which hydrogen will feature prominently.

Swanson estimates 20 Mt of green hydrogen will flow through the Rotterdam Port by 2050. Canada has an opportunity to become a major supplier: *"We're looking at Canada to see where hydrogen can be produced cheaply to meet huge demand expected because of the Green Deal in Europe. In Europe, the development of a hydrogen economy is not a fantasy, it is going to happen, and it's being pushed with the greatest amount of energy and policies and all kinds of taxation."*



Figure 4. Strong growth in hydrogen flow projected through Port of Rotterdam post-2030. Credit: Port of Rotterdam



## Expert Insight: The future wants green hydrogen

Speaking of the European demand for hydrogen fuel, Swanson of the Port of Rotterdam made the important distinction between electrolysis-produced hydrogen and hydrogen produced from natural gas: *"We are looking at energy flow from countries where renewables are abundant, where electricity can be produced cheaply, so that as a result the hydrogen can be produced cheaply. When you produce hydrogen from renewable energy, it is green hydrogen—that is what we are looking for in the EU, specifically."* (See box on p.8 for more on the different ways of producing hydrogen).

## Export opportunities flow from the development of a robust domestic hydrogen economy

The Rotterdam example demonstrates how the development of broader hydrogen economies are built from a foundation of domestic hydrogen supply and use. Local hydrogen production coupled with renewable energy generation and conversion of on-land transportation networks to hydrogen are prominent features of the Rotterdam hub as it prepares to become a major importer of hydrogen by 2030.

Sabina Russell, Principal at Zen Clean Energy Solutions, echoed the importance of this staged approach. She said that Canada must focus on creating domestic port-based hydrogen hubs that can eventually be scaled up to meet global demand post-2030. The infrastructure required to transport and store hydrogen at ports and the development of regulatory and safety protocols must begin now so that Canadian ports will be positioned to move hydrogen to market.

Canadian seaport hydrogen hubs will be an essential link to hydrogen demand centres in the EU and Asia Pacific region. The export market will provide the economies of scale to maximize the role of hydrogen in the transformation of our domestic energy systems.

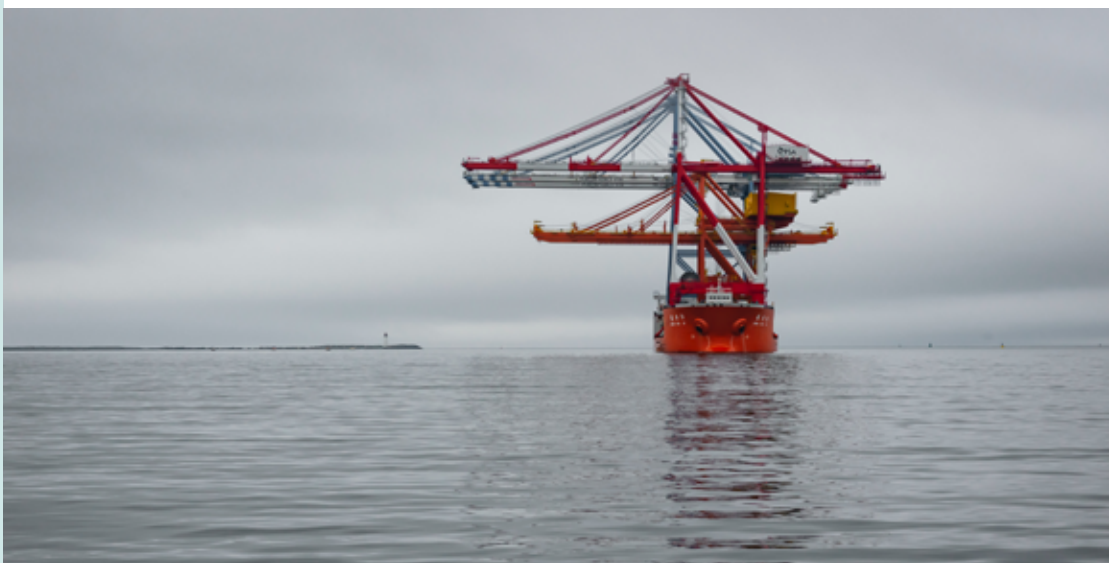
## Renewable hydrogen preferred in pathway to net zero

The message participants heard from Swanson regarding the preference for green hydrogen is based on the European Commission's *Hydrogen Strategy for a Climate-Neutral Europe*, released in July 2020.<sup>23</sup> The strategy lays out a vision to promote hydrogen derived entirely from renewable electricity sources such as wind and solar power. Similar to Canada's projections, the EU predicts that clean hydrogen could meet 24 percent of the world's energy demand.

While there is ongoing debate in the EU about the role of LNG-derived hydrogen as a bridge fuel and the EU's ongoing reliance on energy imports, the Netherlands, Belgium, Spain and Germany have all signalled their intention to champion the import of green hydrogen from countries with capacity to produce it in large quantities.<sup>24</sup> The group of EU states seeking to increase hydrogen imports also have some of the continent's busiest ports.

Over the last year, numerous EU countries and consortiums have announced agreements to secure green hydrogen imports. In January 2021, for example, the Port of Antwerp announced the formation of a consortium that aims to establish a full renewable hydrogen import value chain in Belgium by the end of the decade.<sup>25</sup> A similar consortium focused on the import of green hydrogen formed around the Port of Rotterdam in March 2021.

Earlier this year, Canada and Germany signed a memorandum of understanding to explore the joint development of green hydrogen from Canadian hydroelectric power for export to Germany. While the cost of green hydrogen is significantly greater than blue hydrogen at this point, this will change as electrolyzer technology becomes more prevalent and renewable energy supply grows.<sup>26</sup> Germany has already committed €2 billion to the development of hydrogen technologies in "partner countries."<sup>27</sup>





## Green shipping corridors

We heard that one of the major hurdles facing the shipping industry as it develops multiple low-carbon fuel sources is that there may be uncertainty about which fuel sources are available on key trade routes. When looking at clean hydrogen or ammonia for ocean-going vessels, ship owners will need to know there is a reliable supply of fuel and the opportunity to bunker at the ports they call on. The development of green shipping corridors that phase in zero-emission fuels and propulsion technologies will help overcome this challenge. International coordination and the creation of green shipping corridors that connect a network of seaport hydrogen hubs would provide shippers with certainty of fuel supply. These corridors must be compatible with the broader decarbonization targets that will prevent the Earth's temperature from rising more than 1.5°C.

Developing these green shipping corridors will require harmonized international regulations, a bunkering strategy and specialized vessels, but the potential benefits are immense. The new generation of zero-emission fuels for maritime transport has the potential to disrupt traditional supply chains and provide an investment opportunity for nimble and well-positioned ports to become key fuel suppliers to ocean-going vessels.

### Summary

Through dialogue and presentations, summit participants gained a clear understanding of the economic opportunities for Canada to become an exporter of clean hydrogen. We heard that seaport hydrogen hubs will play a strategic role in the global hydrogen economy and that a strong domestic hydrogen economy is an essential building block in preparing Canada to realize potential opportunities. Green shipping corridors linking international seaport hydrogen hubs are necessary to create certainty regarding the supply of zero-emission shipping fuels. Producing and supplying zero-emission fuels to a global fleet offers a major opportunity for economic development along Canadian coasts.

### Expert Insight: Zero-emission fuels required at both ends of voyage for green shipping

Capt. Gray, President and CEO of the Halifax Port Authority, used the example of LNG export from Australia to demonstrate the importance of developing zero-emission fuel infrastructure along key trade corridors to facilitate the trade of low-carbon hydrogen: *"Where there was a pathway where LNG was supplied at both ends, where the round trip voyage would allow them to get back to an LNG-producing port, the transition to LNG was an easy path."*



# Recommendations.

Following the summit, Oceans North and Zen Clean Energy Solutions worked together to develop recommendations for advancing the use of hydrogen in Canada's ports and maritime sector. Although the recommendations were developed independently of the summit meetings, each set of recommendations addresses one of the major themes.

## Supporting Ports as Hydrogen Hubs

- 01.** Seaports with multi-modal cargo handling operations and which serve domestic and international marine vessels should be prioritized for hydrogen hub development, with the goal of having five hydrogen hub demonstration projects underway by 2025. Special consideration should be given to the ports of Vancouver, Prince Rupert, Saint John, Halifax, and Montreal.
- 02.** Seaports should have a zero-emission mandate in line with Canada's 2030 and 2050 climate targets.

To ensure ports are tracking to meet the zero-emission mandate we recommend:

- I.** Mandatory annual reporting of CO<sub>2</sub>e emissions and fuel consumption.
  - II.** Requiring port operators to file zero-emission equipment transition plans by 2025.
  - III.** Requiring zero-emission fuels to make up 30 percent of all fuel used at seaports by 2030 and 50 percent by 2040.
  - IV.** Prohibiting all new gasoline and diesel internal combustion engine equipment purchases post-2030.
  - V.** Requiring all ocean-going vessels to be zero emission at berth by 2030.
- 03.** A dedicated Hydrogen Port Infrastructure Fund should be created to advance the deployment of on-site hydrogen production, compression, storage and dispensing equipment at seaports.

This funding should include an allocation for feasibility studies to assess the technical and commercial viability of new projects and should be stackable with the Clean Fuels Fund and other federal funding programs, to a maximum of 75 percent of project costs.

Special consideration should be given to renewable-energy-to-hydrogen production projects that support hydrogen hub development at Canada's major seaports.

## Supporting Hydrogen Use in Port-Side Equipment

- 04.** A targeted Zero-Emission Port-Side Equipment Demonstration Fund should be created to support the uptake of zero-emission port-side handling equipment. This funding should include an allocation for feasibility studies to assess the technical and commercial viability of new projects.

Over the mid-term, this funding could transition from the design and development of new equipment to a first-come, first-serve voucher program like what exists in California for higher technology readiness level products. This approach will address the incremental capital costs of deploying zero-emission technologies.

- 05.** The government should provide specialized manufacturing support through tax incentives, rebates, or other public policy mechanisms to support and accelerate made-in-Canada equipment for targeted elements of the value chain for seaport or marine vessel equipment.



## Supporting Hydrogen Uptake in Marine Vessels

- 06.** The federal government should work with provinces, municipalities, and private operators to mandate zero-emission ferry operations in line with the country's 2030 and 2050 climate targets. The near-term focus should be on planning and pilot development.

To ensure ferry operators are tracking to meet the zero-emission mandate, we recommend:

- I.** Mandatory annual reporting of CO<sub>2</sub>e emissions and fuel consumption.
  - II.** Requiring ferry operators to file vessel transition plans to zero-emission operations by 2025.
  - III.** Requiring 30 percent of fuel use in ferries to run on zero-emission fuels or electricity by 2030.
  - IV.** Prohibiting new internal combustion engine equipment purchases post-2030.
- 07.** A Zero-Emission Marine Vessel Fund should be created to advance hydrogen fuel-cell electric and battery electric technologies in ferries, harbour craft and fishing vessels. The fund should include an allocation for feasibility studies to assess the technical and commercial viability of new projects as well as support the design, assembly, and operation of the equipment for a defined period.

Special consideration should be given to local shipyards and Canadian companies in the maritime supply chain as a way of building domestic capacity and expertise in the development and implementation of zero-emission fuels and technologies.

- 08.** The Clean Fuels Regulation should be amended to include marine vessels and shore power at berth to fully unlock the potential of fuel-switching to zero-emission fuels like clean hydrogen and electricity in the maritime sector.
- 09.** The government should prioritize the procurement of zero-emissions vessels when constructing all non-military federal vessels, including vessels owned or operated by Crown corporations.

## Supporting Canada's Export Opportunity

- 10.** Canadian Port Authorities should be empowered and supported to pursue partnership agreements with international seaports to facilitate the export of clean hydrogen and to develop green shipping corridors. These corridors must be compatible with the broader decarbonization targets that will prevent the Earth's temperature from rising more than 1.5°C. Partnership agreements would include vessel innovation, fuel bunkering, carbon intensity certification and fuel quality standardization to facilitate trade.



# Conclusion.



Over the last few years, the discussion around climate change has shifted in Canada. There is now political consensus around the fact that greenhouse gases from human activities are the cause of climate change, and there is a growing sense of urgency to find solutions as communities struggle in the face of increasingly unpredictable and extreme weather events such as floods, forest fires and droughts.

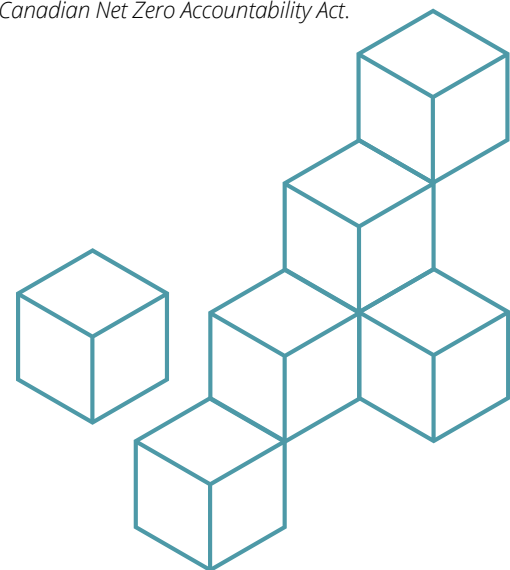
How we deal with the challenge of climate change is deeply connected to post-pandemic economic recovery and growth. The choices Canada makes now could be transformational, both economically and environmentally.

Significant steps have already been taken to address climate change at a national level. Policies and programs contained in the Pan-Canadian Framework on Clean Growth and Climate Change as well as the new strengthened climate plan have started to bend the curve on rising emissions. However, many challenges remain as the government works to develop zero-emission pathways across all sectors of the economy. Canada's maritime sector, for example, has not received the same level of attention as other sectors in Canada's national climate plans.

Canada's future prosperity will depend in part on our ability to leverage our natural assets and expertise as a major global energy exporter to become a leading provider of zero-emission technologies and clean fuels such as hydrogen. The Summit dialogue underscored the outsized role that seaport hydrogen hubs can play in preparing Canada to take advantage of the growing demand for clean hydrogen around the world. We heard throughout the Ports and Maritime Hydrogen Summit-Series that the sector is eager to do its part to align with Canada's climate goals and position their businesses to succeed in the future net-zero economy.

Clean hydrogen is just one of many solutions required in the transition to net zero—electrification, biofuels, and increased efficiency all have a role to play. But the production, export and bunkering of clean hydrogen in Canada has the potential to magnify our country's impact on climate change by reducing emissions beyond our borders and by helping to address global shipping emissions, a large and growing source of emissions that must be taken seriously.

Despite the many challenges that were identified in creating economies for new fuels, panelists and participants at the Ports and Maritime Hydrogen Summit agreed that the time to act is now and that early action would bring economic benefits. The recommendations contained in this report provide a framework that will support the development of seaport hydrogen hubs in Canada and help close the gap between Canada's ambitions and the actions required to meet our 2030 targets and the legal obligations of the *Canadian Net Zero Accountability Act*.





# References.

1. Natural Resources Canada. (2020). *Hydrogen Strategy for Canada*. Retrieved from: <https://www.nrcan.gc.ca/climate-change/the-hydrogen-strategy/23080>
2. Bush, E. and Lemmen, D.S., Eds. (2019). *Canada's Changing Climate Report*. Government of Canada. Retrieved from: [https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/Climate-change/pdf/CCCR\\_FULL-REPORT-EN-FINAL.pdf](https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/Climate-change/pdf/CCCR_FULL-REPORT-EN-FINAL.pdf)
3. European Parliament. (2021). Emissions from planes and ships: facts and figures (infographic). Retrieved from: <https://www.europarl.europa.eu/news/en/headlines/society/20191129STO67756/emissions-from-planes-and-ships-facts-and-figures-infographic>
4. Ibid.
5. International Maritime Organization. (2020). *Fourth IMO Greenhouse Gas Study*. Retrieved from: <https://wwwcdn.imo.org/localresources/en/MediaCentre/Documents/Fourth%20IMO%20GHG%20Study%202020%20Executive%20Summary.pdf>
6. European Commission (n.d.). Reducing emissions from the shipping sector. Retrieved from: [https://ec.europa.eu/clima/policies/transport/shipping\\_en](https://ec.europa.eu/clima/policies/transport/shipping_en)
7. International Energy Agency. (2021). *Net Zero by 2050: A Roadmap for the Global Energy Sector*. Retrieved from: [https://iea.blob.core.windows.net/assets/beceb956-0dcf-4d73-89fe-1310e3046d68/NetZeroBy2050-ARoadmapfortheGlobalEnergySector\\_CORR.pdf](https://iea.blob.core.windows.net/assets/beceb956-0dcf-4d73-89fe-1310e3046d68/NetZeroBy2050-ARoadmapfortheGlobalEnergySector_CORR.pdf)
8. Zen Clean Energy Solutions, Dunsy Energy Consulting and Redrock Power Systems. (2020.) *A Feasibility Study of Hydrogen Production, Storage, Distribution and Use in the Maritimes*. Offshore Energy Research Association. Retrieved from: <https://oera.ca/sites/default/files/2020-11/A%20Feasibility%20Study%20of%20Hydrogen%20Production%20Storage%20Distribution%20and%20Use%20in%20the%20Maritimes.pdf>
9. Krantz, R., Sogaard, K. and Smith, T. (2020). The scale of investment needed to decarbonize global shipping. The Getting to Zero Coalition. Retrieved from: [https://www.globalmaritimeforum.org/content/2020/01/Getting-to-Zero-Coalition\\_Insight-brief\\_Scale-of-investment.pdf](https://www.globalmaritimeforum.org/content/2020/01/Getting-to-Zero-Coalition_Insight-brief_Scale-of-investment.pdf)
10. Christensen, J. (2020). How decarbonizing shipping could start a global energy transition. World Economic Forum. Retrieved from: <https://www.weforum.org/agenda/2020/01/decarbonizing-shipping-global-energy-transition>
11. Natural Resources Canada, *Hydrogen Strategy*.
12. Ibid.
13. Ibid.
14. IEA, *Net Zero by 2050*.
15. Osterkamp, P., Smith, T., Sogaard, K. (2021). Five percent zero emission fuels by 2030 needed for Paris-aligned shipping decarbonization. The Getting to Zero Coalition. Retrieved from: [https://www.globalmaritimeforum.org/content/2021/03/Getting-to-Zero-Coalition\\_Five-percent-zero-emission-fuels-by-2030.pdf](https://www.globalmaritimeforum.org/content/2021/03/Getting-to-Zero-Coalition_Five-percent-zero-emission-fuels-by-2030.pdf)
16. California Air Resources Board. (2021). Proposed Amendments to the Commercial Harbor Craft Regulation. Retrieved from: <https://ww2.arb.ca.gov/sites/default/files/2021-09/CHC%20Fact%20Sheet%203SEP2021.pdf>
17. Norwegian Shipowners' Association. (2020). *Zero Emissions in 2050*. Retrieved from: <https://rederi.no/globalassets/dokumenter/alle/rapporter/2020--klimarapport-engelsk.pdf>
18. Getting to Zero Coalition (n.d.) The Getting to Zero Coalition. Global Maritime Forum. Retrieved from: <https://www.globalmaritimeforum.org/getting-to-zero-coalition>
19. Golden, F. (2018). Where do old cruise ships go to die? Bloomberg News. Retrieved from: <https://www.bloomberg.com/news/articles/2018-05-31/where-do-old-cruise-ships-go-to-die>
20. DNV GL AS Maritime. (2020). *Alternative Fuels for Canada: Pointing the Direction towards Low/zero-emission Shipping*. WWF-Canada. Retrieved from: <https://www.wwf.ca/wp-content/uploads/2021/04/Alternative-Fuels-for-Canada-Pointing-the-direction-towards-low-zero-emission-shipping.pdf>
21. Layzell, DB., Young, C., Lof, J., Leary, J. and Sit S. (2020). *Towards Net-Zero Energy Systems in Canada: A Key Role for Hydrogen*. Transition Accelerator Reports: Vol 2, Issue 3. <https://transitionaccelerator.ca/towards-net-zero-energy-systems-in-canada-a-key-role-for-hydrogen>
22. Port of Rotterdam. (2021). Cooperation Uniper and Port of Rotterdam Authority in production green hydrogen. Retrieved from: <https://www.portofrotterdam.com/en/news-and-press-releases/cooperation-uniper-and-port-of-rotterdam-authority-in-production-green>
23. European Commission. (2020). *A Hydrogen Strategy for a Climate-neutral Europe*. Retrieved from: [https://ec.europa.eu/energy/sites/ener/files/hydrogen\\_strategy.pdf](https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf)
24. Kurmayer, N. (2021). EU countries clash over scale of future hydrogen imports. Euractiv. Retrieved from: <https://www.euractiv.com/section/energy-environment/news/eu-countries-clash-over-scale-of-future-hydrogen-imports/>
25. Simon, F. (2021). Belgian port lays out plans for 'massive' imports of green hydrogen. Euractiv. Retrieved from: <https://www.euractiv.com/section/energy-environment/news/belgian-port-lays-out-plans-for-massive-imports-of-green-hydrogen/>
26. Hulst, N. (2019). The clean hydrogen future has already begun. International Energy Agency. Retrieved from: <https://www.iea.org/commentaries/the-clean-hydrogen-future-has-already-begun>
27. Government of Germany. (2020). *The National Hydrogen Strategy*. Federal Ministry of Economic Affairs and Energy. Retrieved from: <https://www.bmwi.de/Redaktion/EN/Publikationen/Energie/the-national-hydrogen-strategy.html>



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