

Canadian Green Shipping Corridors Preliminary Assessment

Arup
Lloyd's Register Maritime Decarbonisation Hub
Oceans North
Vancouver Maritime Centre for Climate



About



Arup

Arup is a global independent firm of more than 17,000 designers, planners, engineers, architects, consultants and technical specialists, working across every aspect of today's built environment.

Founded to be both humane and excellent, we collaborate with our clients and partners using imagination, technology and rigour to shape a better world.

For Arup, creating a better world is all about creating a more sustainable future, including for the maritime sector. We are focussed on supporting the new partnerships, technologies and infrastructure solutions required to transform maritime transport. We bring together maritime, energy and sustainability skills to support actors across the value chain of ports and shipping.



Lloyd's Register Maritime Decarbonisation Hub

Creating safe, sustainable pathways to a zero-carbon maritime industry.

The mission of the Lloyd's Register (LR) Maritime Decarbonisation Hub is to accelerate the sustainable decarbonisation of the maritime industry, by enabling the delivery and operation of safe, technically feasible and commercially viable zero-emission vessels by 2030.

The shipping industry needs leadership, collaboration and evidence-based direction to achieve its decarbonisation goals. The LR Maritime Decarbonisation Hub creates and shares evidence, insight and knowledge about the transition to a decarbonised world fleet. The Hub collaborates with a wide range of stakeholders, including shipowners, shipyards, technology providers, regulators, and industry associations, to facilitate the transition to a more sustainable maritime industry.

The LR Maritime Decarbonisation Hub is a not for profit joint venture between Lloyd's Register and the Lloyd's Register Foundation. Lloyd's Register Group is wholly owned by the Lloyd's Register Foundation, a politically and financially independent global charity that promotes safety and education.



Oceans North

Oceans North is Canadian charity with a mandate to promote the conservation of Canada's northern oceans and the resulting well-being of people and communities who rely upon its natural wealth.

As part of a holistic strategy to protect the ocean, Oceans North is working to decarbonize maritime emissions that are contributing to climate change and adversely impacting communities and the environment.

Our approach includes ongoing public education and awareness initiatives, research, as well as engagement with government, stakeholders, and Indigenous partners, to create community-driven solutions for the development and uptake of zero emissions technologies and practices.

Our work to advance Canada's zero-emissions maritime energy transition includes a focus on the creation of emission-free ports, zero-emission vessels and green shipping corridors.



Vancouver Maritime
Centre for Climate

Vancouver Maritime Centre for Climate

The Vancouver Maritime Centre for Climate is an industry led initiative dedicated to accelerating the transition to a zero emissions shipping industry in British Columbia.

The VMCC recognize that maritime operators are currently facing large regulatory hurdles to reduce emissions with no clear path forward on how to meet these objectives. It is our believe that bringing industry together helps facilitate the mobilization and implementation of green technologies that will help ship owners and the supporting land based infrastructure get to zero emissions faster. Climate-driven risks to the global and local economy are already here, and the issues are getting more urgent. We believe it is time to acknowledge the extraordinary emissions from the shipping industry and accelerate the transition towards a zero emissions industry here in British Columbia.

Introduction

International shipping emits approximately one billion tonnes of CO₂ every year. It's an industry almost entirely reliant on fossil fuels which are the greatest contributor to greenhouse gas emissions. Without intervention, these emissions are expected to continue growing which will lead to increases in global warming and the severity of the associated impacts. **An urgent transition away from fossil fuels is required.**

It's been estimated that by 2030 at least 5% of fuels used by international shipping and 15% used by domestic shipping¹ must have zero-lifecycle emissions to align decarbonisation with the 2015 Paris Agreement objectives. However, this transition incorporates a number of challenges including relatively high fuel costs, limited production capacity, and immaturity of onboard technologies.

Dozens of green shipping corridor initiatives have been announced globally. They are a vehicle to mobilise stakeholders across the shipping and fuel-supply value chains to address the barriers to zero emission fuel uptake. Initially focussing on the early stages of fuel transition, their aim is to develop supply chains while the technical and commercial readiness of the solutions progress. These initiatives will prepare the industry reach a 'tipping point' where these solutions start to scale rapidly based on market forces.

Significant investment in energy and fuel production infrastructure will be required globally to drive the transition away from fossil fuels. This represents an opportunity for countries around the world to achieve their environmental objectives while growing economic prosperity, realising social co-benefits, and protecting themselves from the impact of divestment from fossil fuel industries.

As an existing energy producer with a skilled workforce and substantial land and natural resource availability, Canada is well placed to seize the opportunity to become a producer, or even exporter, of zero emission fuels. Several corridor partnerships involving Canadian ports have already been announced and the Transport Canada has released a national Green Shipping Corridors Framework to guide and accelerate their implementation.

Oceans North commissioned Arup to undertake this preliminary assessment into the potential impact that green shipping corridors – and maritime decarbonisation more broadly – could have in Canada. The aim of the work is to highlight the opportunities that green shipping corridors present and thereby mobilise stakeholders across the government, energy and maritime sectors to accelerate their development.



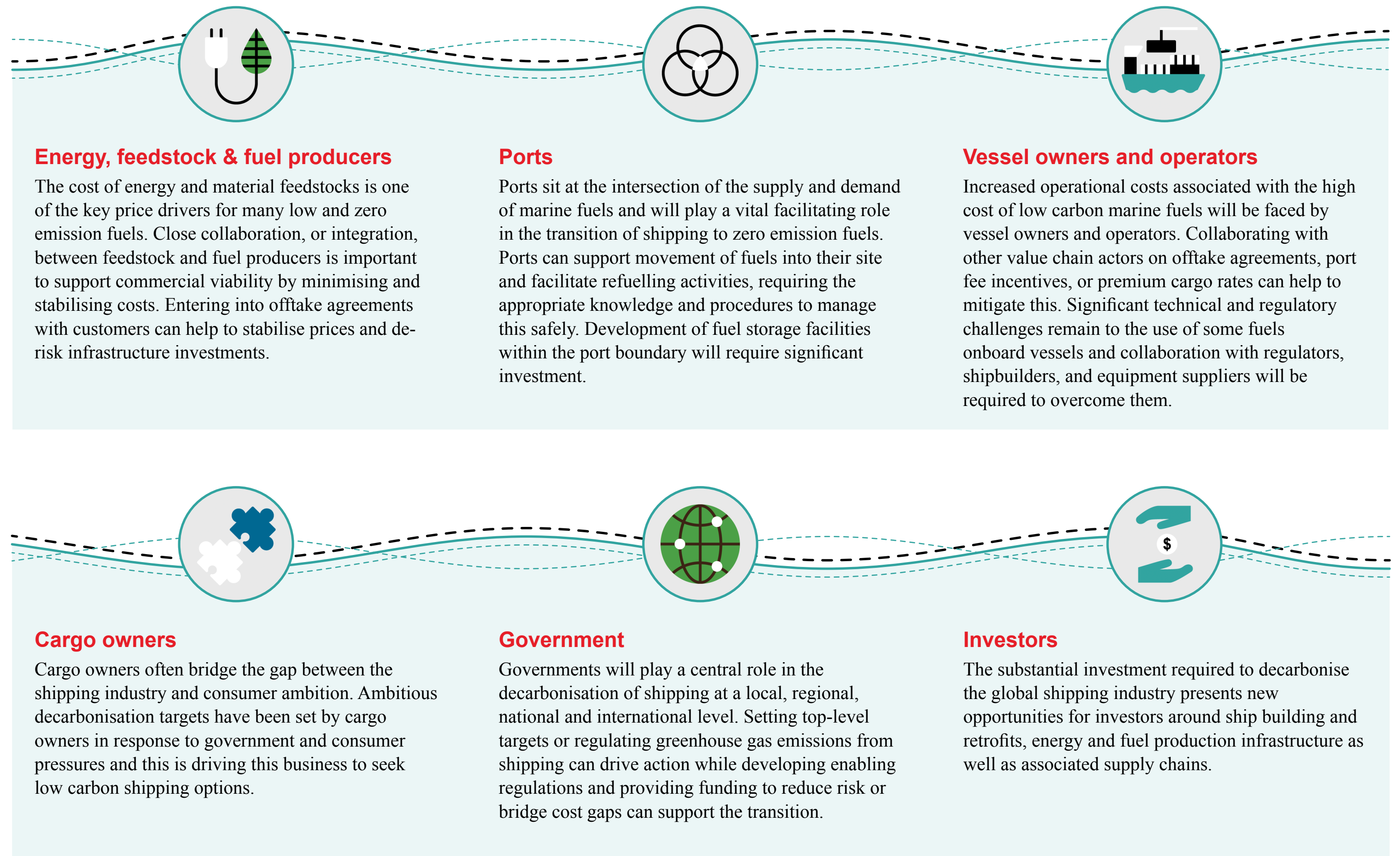
1. https://www.globalmaritimeforum.org/content/2021/03/Getting-to-Zero-Coalition_Five-percent-zero-emission-fuels-by-2030.pdf

Green shipping corridors as a vehicle for climate action

An accelerated transition away from fossil fuels is required to achieve the greenhouse gas emissions cuts needed to meet the goals of the Paris Agreement. Green shipping corridors are one way of supporting this, bringing together likeminded stakeholders to address the challenges that are holding back development and deployment of zero emission marine fuels.

The concept of green shipping corridors first emerged in 2021 and was brought into the spotlight by the Clydebank Declaration made at COP26 and now signed by 24 nations, including Canada. The declaration set out a collective aim by the signatories to establish at least six green shipping corridors by the middle of the decade, including international and domestic routes. There have been numerous corridors announced since, with a range of leadership structures, participating partners, types of route, goals, and aims. However, the common focus of these initiatives is on demonstrating the feasibility of zero emission shipping during the initial stages of the fuel transition taking place over the short-to-mid-term.

These initiatives provide opportunities for stakeholders across the zero emission marine fuel value chain to collaborate and accelerate the decarbonisation of shipping. Key stakeholders and the possible roles they could play in establishing first mover green shipping projects are described here.



Energy, feedstock & fuel producers

The cost of energy and material feedstocks is one of the key price drivers for many low and zero emission fuels. Close collaboration, or integration, between feedstock and fuel producers is important to support commercial viability by minimising and stabilising costs. Entering into offtake agreements with customers can help to stabilise prices and de-risk infrastructure investments.

Ports

Ports sit at the intersection of the supply and demand of marine fuels and will play a vital facilitating role in the transition of shipping to zero emission fuels. Ports can support movement of fuels into their site and facilitate refuelling activities, requiring the appropriate knowledge and procedures to manage this safely. Development of fuel storage facilities within the port boundary will require significant investment.

Vessel owners and operators

Increased operational costs associated with the high cost of low carbon marine fuels will be faced by vessel owners and operators. Collaborating with other value chain actors on offtake agreements, port fee incentives, or premium cargo rates can help to mitigate this. Significant technical and regulatory challenges remain to the use of some fuels onboard vessels and collaboration with regulators, shipbuilders, and equipment suppliers will be required to overcome them.

Cargo owners

Cargo owners often bridge the gap between the shipping industry and consumer ambition. Ambitious decarbonisation targets have been set by cargo owners in response to government and consumer pressures and this is driving this business to seek low carbon shipping options.

Government

Governments will play a central role in the decarbonisation of shipping at a local, regional, national and international level. Setting top-level targets or regulating greenhouse gas emissions from shipping can drive action while developing enabling regulations and providing funding to reduce risk or bridge cost gaps can support the transition.

Investors

The substantial investment required to decarbonise the global shipping industry presents new opportunities for investors around ship building and retrofits, energy and fuel production infrastructure as well as associated supply chains.

Fuels for green shipping corridors

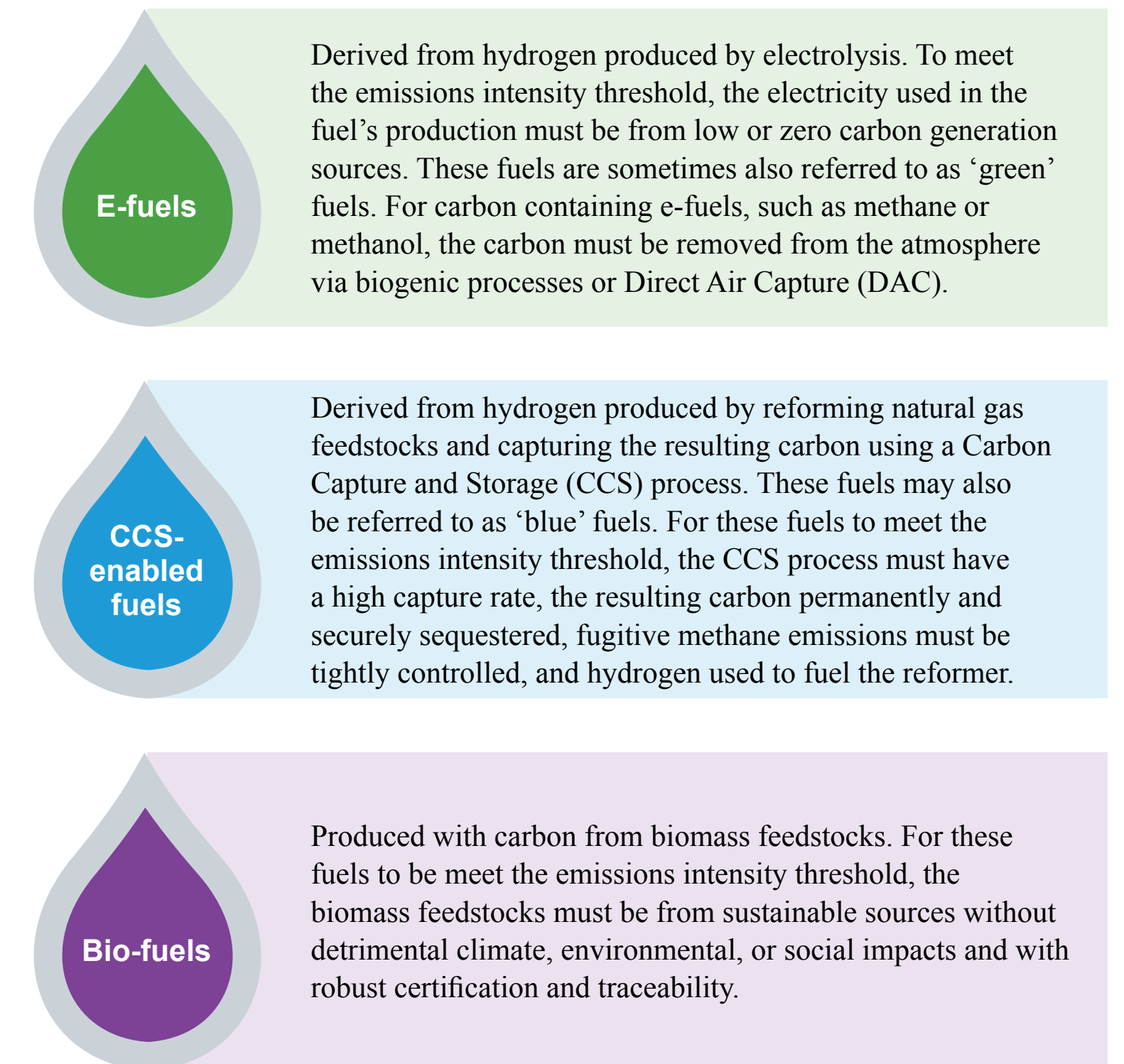
There are numerous fuel options to be considered for the fuel transition, with no one solution applicable across all shipping applications. However, the industry is coalescing around a few core fuels expected to make up the majority of the future fuel mix for deep sea shipping: methanol, ammonia, methane and drop-in fuel oils from renewable sources. To reflect their true climate impact, the full lifecycle greenhouse gas emissions generated during the feedstock generation, fuel production, and distribution must also be considered.

Green shipping corridors are an opportunity for high-ambition partners to drive the uptake of low and zero emission fuels in the next few years. This study focusses on fuel production pathways that could offer significant reductions in lifecycle greenhouse emissions compared to conventional fuels thereby supporting the decarbonisation of shipping on a trajectory aligned with the Paris Agreement.

There are a number of ways to define what constitutes low emissions, with various government and industry standards defining thresholds for the lifecycle emissions of hydrogen and other fuels. These are a key measure to ensuring that government support and investment are directed towards projects that can effectively contribute to greenhouse gas emissions reduction. The Canadian Hydrogen Strategy recommended alignment with the European Union's CertifHy scheme's threshold for low emission hydrogen. This is currently set at 60% below the carbon intensity of hydrogen produced from natural gas without CCS. This report uses the term 'low emission fuel' to refer to fuels with lifecycle greenhouse gas intensity of 20gCO₂e/MJ or lower, which is approximately 80% lower than for conventional shipping fuel oils.

Fossil-derived Liquefied Natural Gas (LNG) fuel has not been considered in this report as it is able to offer only limited carbon emission reductions compared to liquid fossil fuels on a lifecycle basis and in some cases can result in higher greenhouse gas emissions. It cannot therefore be considered as low emissions based on the requirements above. Moreover, the purpose of green shipping corridor initiatives is to accelerate development of supply chains for low and zero emission fuels that are currently immature.

The fuels considered in this study can be grouped and defined as follows:



Canadian context

Canada has a legislated commitment to achieve net zero emissions by 2050. Through the 2030 Emissions Reduction Plan, the country is developing a national action plan to align emissions reductions in the marine sector to this trajectory while taking direct action to reduce emissions from government operated vessels.

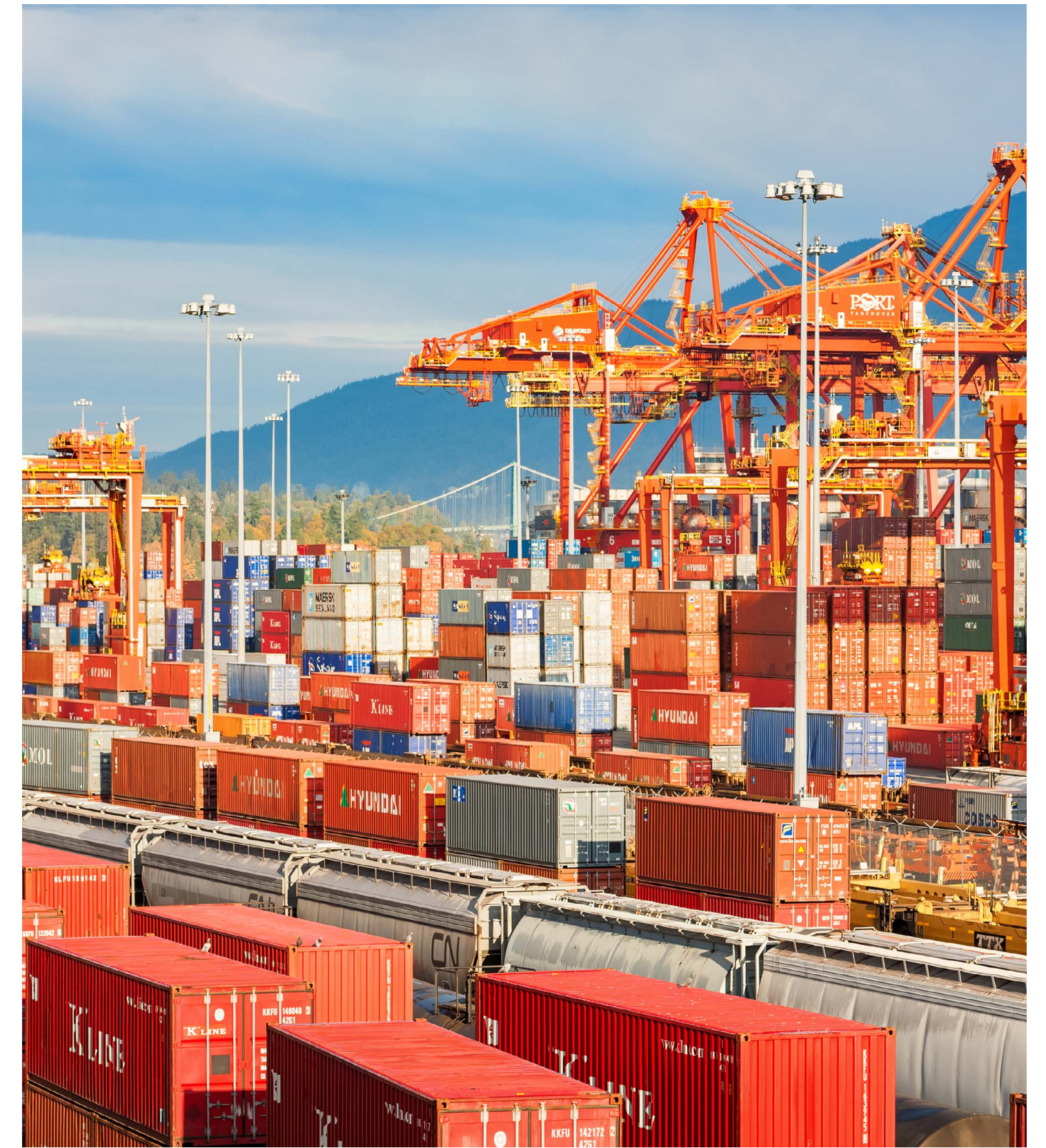
The government's commitments are supported by strong policies and frameworks, including the 'Canadian Green Shipping Corridors Framework' published in 2022 to help guide the development of corridor initiatives. At an international level, Canada co-sponsored a proposal to the International Maritime Organization to increase the level of ambition in its revised greenhouse gas reduction strategy to align with Paris Agreement's objectives.

Canada has one of the cleanest electricity systems in the world, with more than 83% of output coming from non-emitting sources. The government has committed to supporting clean energy projects to further reduce emissions from power generation. The country has a wealth of financial resources, infrastructure, energy expertise, and a skilled workforce as a result of its historical strength in the oil and gas sector. This could be leveraged to develop zero emission fuel pathways. These factors make Canada well placed to become a supplier of zero emission fuels, supporting green shipping corridor projects involving the country's ports and potentially others further afield.

Demonstrating the opportunity for Canada

The study features three Canadian ports – Vancouver, Prince Rupert and Halifax – to explore the infrastructure required to meet the developing demand for zero emission shipping fuels (see case studies at end of this document).

Arup has developed an illustrative fuel supply typology for the three ports, considering a suitable fuel production pathway in each case based on the regional energy and policy context. Based on analysis from the Lloyd's Register Maritime Decarbonisation Hub, that estimated the potential development of low and zero emission fuel uptake under different scenarios, we have approximated the size, type and capital cost of energy and fuel production infrastructure required to meet the estimated demand and have explored the challenges and opportunities faced in delivering it.



Canadian context

Several green shipping corridors have already been announced in Canada

At least four green shipping corridor announcements involving Canadian ports have been made, demonstrating the strength of industry support for maritime decarbonisation. There is an opportunity to build on this early progress and establish Canada as a leader in maritime decarbonisation.



1

A pledge by the Port of Antwerp and the Port of Montreal to create a trans-Atlantic green shipping corridor.

2

A memorandum of understanding signed between the Halifax Port Authority and the Hamburg Port Authority.

3

The Pacific Northwest to Alaska Green Corridor Project, which is exploring a green corridor between Alaska, British Columbia, and Washington.

4

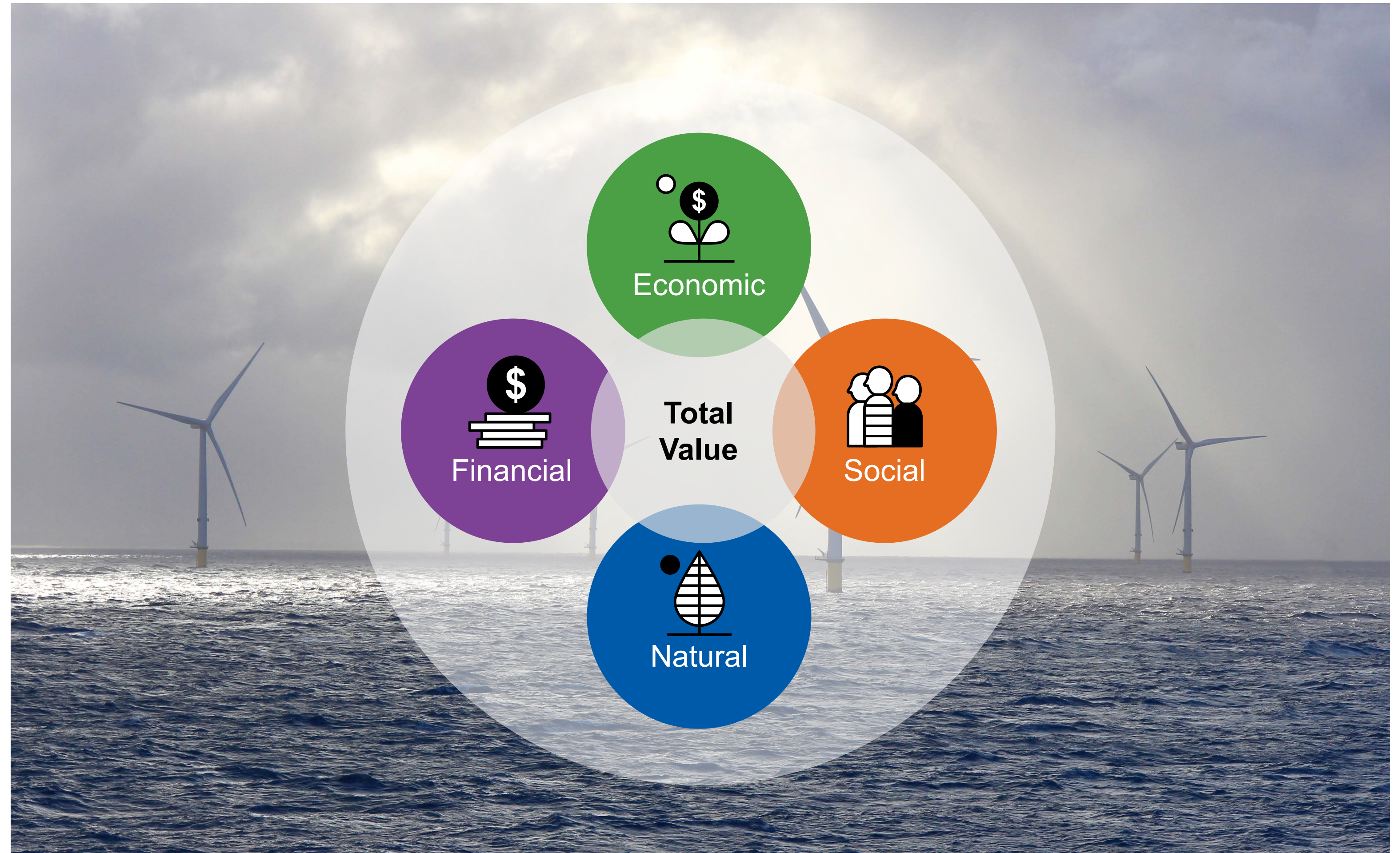
An announcement that Canada's Chamber of Marine Commerce (CMC) is exploring the potential for a green shipping corridor on the Great Lakes and St. Lawrence Seaway.

Realising the Total Value of Green Shipping Corridors for Canada

The new infrastructure required to supply low and zero emission fuels to first mover green shipping corridors will attract significant investment.

These projects will have positive impacts on Canada's economy, at national and local levels, as well as on the natural environment and communities living nearby if developed responsibly. Considering the 'total value' case for green shipping corridors – incorporating natural, economic, financial and social value – and supporting fuel supply projects can help to shape, capture, and leverage their wider value and therefore improve their investment case.

There is a broad range of positive value outcomes that could be delivered for Canada through green shipping corridors and longer-term decarbonisation of the maritime sector. The type of value that can be delivered – and the benefactors of it – depend as much on the approach taken to implementing the capital projects as it does on the infrastructure itself. It is vital to actively engage with relevant stakeholders and ensure that evidence-based knowledge of local needs and context feeds into decision-making processes within the project to maximise potential for sustainable and equitable long-term value creation. Identifying the key value outcomes from the early stages of a project and embedding them in its delivery can help to align stakeholders and create broad-based support.



Realising the Total Value of Green Shipping Corridors for Canada

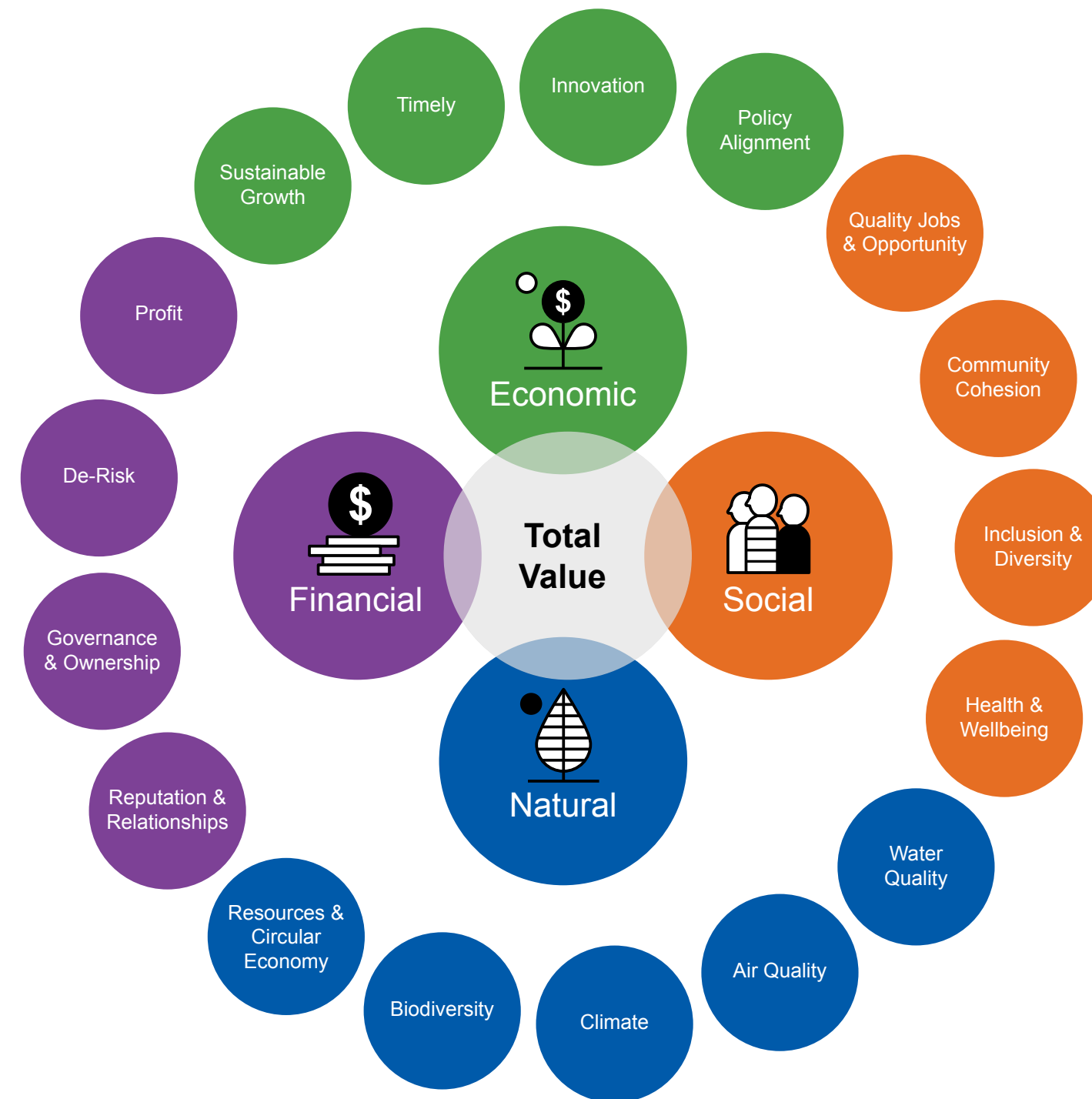
Financial value

Green shipping corridors can help attract investment in land side energy and fuel production infrastructure to Canada where natural resources, a skilled workforce and land can be leveraged to produce cost competitive zero emission shipping fuels. The development of this infrastructure creates opportunities to explore how its financial benefit can be distributed among a broader range of stakeholders, such as local communities and indigenous groups, to help deliver a just and equitable transition.

Natural value

Vessels operating in Canadian waters produce significant emissions (more than 13 million tonnes of CO₂ in 2019) and thousands of tonnes of air pollutants that impact the health of port and coastal communities, pollute oceans and can themselves have a significant climate impact. There are also risks associated with accidental fuel oil spills as well as ongoing habitat loss and natural resource depletion.

Although zero emission fuels present their own environmental risks if not properly managed, green shipping corridors are an opportunity to collaborate across the energy, fuel and shipping value chains to address these while exploring opportunities to deliver net benefits to biodiversity and support the development of circular economy principles in any new projects.



Economic value

Shipping has been estimated to directly contribute CAD\$3 billion to Canada's gross domestic product² while the energy sector makes up a further 9% of the economy³ (approx. CAD\$175 billion). Both sectors will undergo significant change in the coming decades as the world transitions to a net zero economy, so continuing with business-as-usual will not be an option. Green shipping corridors present opportunities to address risks associated with this transition, realise first mover advantages, create green jobs, and support sustained economic growth while delivering on policy ambitions.

Social value

While maritime industries can bring significant benefits to port and coastal communities in terms of employment and economic growth, these same communities also often experience the worst of the negative impacts of shipping such as air, water and noise pollution. Maritime activity can have a particularly acute impact on low-income communities, who may live in the most polluted areas, as well as indigenous people who have a strong ancestral connection to the sea and coastal lands.

Green shipping corridors, and the longer-term decarbonisation of shipping presents an opportunity to reduce pollution and pursue broader social benefits. These may include the generation of new employment opportunities for local communities, skills development for existing workers, improved health and wellbeing, enhanced community cohesion, and increased inclusion of indigenous groups.

2. Council of Canadian Academies, "The Value of Commercial Marine Shipping to Canada," 2018

3. Canada Energy Regulator, "Energy in Canada," accessed 2023: <https://www.cer-rec.gc.ca/en/about/publications-reports/annual-report/2018/energy-in-canada.html>

Exploring the impact of green shipping corridors in Canada

Case studies



Case study 1

British Columbia, the Port of Vancouver and the Port of Prince Rupert

British Columbia has one of the lowest carbon intensity grids in the world, with hydropower being the main source of electricity.

There is currently an energy and capacity surplus which is forecast to persist until around 2030. This presents the opportunity to produce low carbon fuels such as hydrogen and its derivatives. The region's geology provides significant natural gas resources as well as potential for development of a carbon sequestration market, both of which may be leveraged to develop CCS-enabled fuel production. These opportunities are identified in the B.C. Hydrogen Strategy that supports the province's aim of reaching net zero emissions by 2050 and its ambition to become a world leading hydrogen economy.

As the largest port in Canada, there is potential for a substantial zero emission fuel demand to develop in Vancouver over the coming decades. This provides an opportunity to facilitate the decarbonisation of ships operating throughout the region. Although smaller than Vancouver, Prince Rupert is located at a strategic point with strong container shipping links to east Asian ports, giving it potential to be a key player in first mover green shipping corridors.

Case study 2

Nova Scotia and the Port of Halifax

Nova Scotia has significant renewable potential and some of the most ambitious greenhouse gas reductions targets in the country that are expected to be met through development of significant offshore wind energy capacity.

Historically Nova Scotia has been a producer and exporter of fossil fuels from the Sable Offshore Energy Project but production stopped in 2018. The province has now committed to delivery of at least 500MW of new renewable energy by 2026 and to leasing 5GW of offshore wind sites by 2030. A number of major hydrogen and ammonia projects are now planned in the province which intend to make use of this ample renewable energy to produce low or zero emissions fuels, predominantly for export.

The Lloyd's Register Maritime Decarbonisation Hub analysis identified 239 vessels that called in the Port of Halifax during 2021 and, due to their international operations, are expected to generate limited zero emission fuel demand at the port which may not warrant a dedicated marine fuel production facility. The Port of Halifax's position as Canada's Atlantic Gateway, strategically located on key established service routes from major shipping lines, make it well placed to initiate collaboration discussions with first-mover stakeholders and support building up of fuel demand at the port. This may be particularly compelling given the anticipated availability of significant quantities of zero emission fuel in the region.

British Columbia, the Port of Vancouver and the Port of Prince Rupert

Case study #1

Production of e-methanol in Port of Vancouver

Illustrative typology

An illustrative fuel supply typology has been shaped for the Port of Vancouver, based on the production of e-methanol. The production of e-methanol is well suited to the province of British Columbia and Vancouver area specifically due to the surplus low carbon renewable energy generation capacity, predominantly from hydro-dams in the region. It also represents an opportunity to develop and demonstrate emergent direct air capture (DAC) technologies as a source of carbon dioxide required to produce methanol.

A 200ktpa capacity green methanol plant would be capable of meeting the lower end of the 2040 demand projected by Lloyd's Register Maritime Decarbonisation Hub.

This plant would:

Require approximately 370MW of renewable power to operate at full capacity and be equipped with 400MW of electrolysis capacity. The typology assumes that the energy is taken from surplus hydroelectric generation capacity in the region.

Consume 320,000 tonnes of CO₂ feedstock per year, produced from a dedicated and co-located DAC plant.

Occupy a waterfront location, with a footprint in the of approximately 70 acres, and supply the fuel directly to bunker barges.

Require capital investment of CAD\$3-4 billion.



British Columbia, the Port of Vancouver and the Port of Prince Rupert

Case study #1

Supply of CCS-enabled ammonia to Port of Prince Rupert

Illustrative typology

An illustrative fuel supply typology has been shaped for the Port of Prince Rupert, based on CCS-enabled ammonia. This typology leverages the natural gas reserves of northern British Columbia and makes use of the carbon sequestration opportunity presented by the Western Sedimentary Basin.

An ammonia plant with capacity of 225 ktpa would be capable of meeting the lower end of the 2040 demand projected by Lloyd’s Register Maritime Decarbonisation Hub for both Vancouver and Prince Rupert.

This plant would:

Be located near natural gas production and carbon sequestration opportunities in northern British Columbia. The fuel would be delivered to the Port of Prince Rupert via existing rail links.

Produce around 400,000 tonnes of CO2 per year that would be permanently sequestered.

Consume more than a million tonnes of natural gas per year, which is equivalent to approximately one day of British Columbia’s natural gas production.

Require capital investment of CAD\$0.75-1 billion.



Nova Scotia and the Port of Halifax

Case study #2

Vessels in the Port of Halifax as a secondary offtaker of e-ammonia

Illustrative typology

An illustrative typology has been shaped for the Port of Halifax, in which vessels using the port become a secondary off taker from the large ammonia production facilities elsewhere in Nova Scotia.

This typology would see the port develop a zero emission fuels hub with the potential to supply port equipment and users in other transport and industrial sectors.

This plant would:

Delivery of ammonia fuel from the production plant to the port is via a gas carrier loaded at the production facility's marine loading jetty.

As demand increases and bunkering become more frequent, in-port storage facilities may be required to ensure more consistent fuel availability. The size of the storage tanks would depend on the demand evolution, however is likely to be matched to the size of typical shuttle tanker capacities in the region of 40,000 to 60,000m³.

In the shorter term, while the uptake of ammonia fuel scales up, the relatively infrequent bunkering activities could be met by a bunker vessel that acts as in-port storage as well as delivering the fuel directly to the receiving ships.

An estimated \$250-500million of capital investment would be required for an ammonia bunkering vessel, fuel storage facility and loading jetty, excluding any marine civil works such as breakwaters or dredging.



The next steps

This report explores the opportunity to Canada presented by the maritime fuel transition and the broad natural, economic, financial and societal value that it could deliver.

Stakeholders from across the shipping and energy sectors must work together to identify opportunities for first mover green shipping corridors, harnessing the high levels of ambition that exist to demonstrate the technical, commercial, and regulatory feasibility of zero emission shipping in the country.

With supportive government policies and frameworks, these projects can catalyse the urgent action required to transition the maritime sector away from fossil fuels.

[Download the full report here](#)

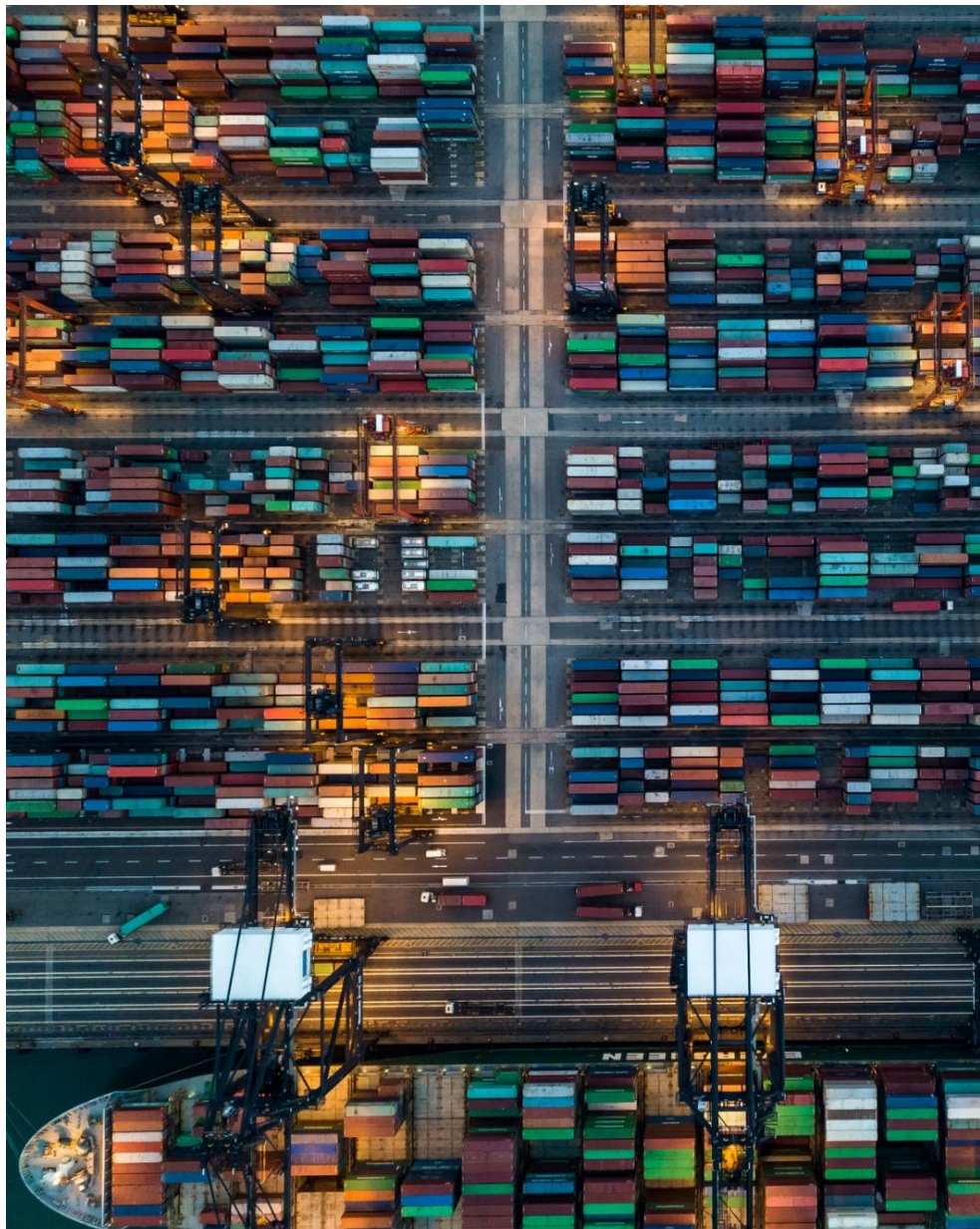
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Oceans North Conservation Society

Canadian Green Shipping Corridors Preliminary Assessment

Final Report

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This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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