Discussion Paper

# Low-Carbon Fuels and Newfoundland and Labrador's Marine Transportation Sector

July 2026

econext
Advancing Newfoundland & Labrador's
Green Economy

# Contents

econext
Advancing Newfoundland & Labrador's
**Green Economy**

*Partially Funded by Natural Resources Canada*

*Financé partiellement par Ressources naturelles Canada*

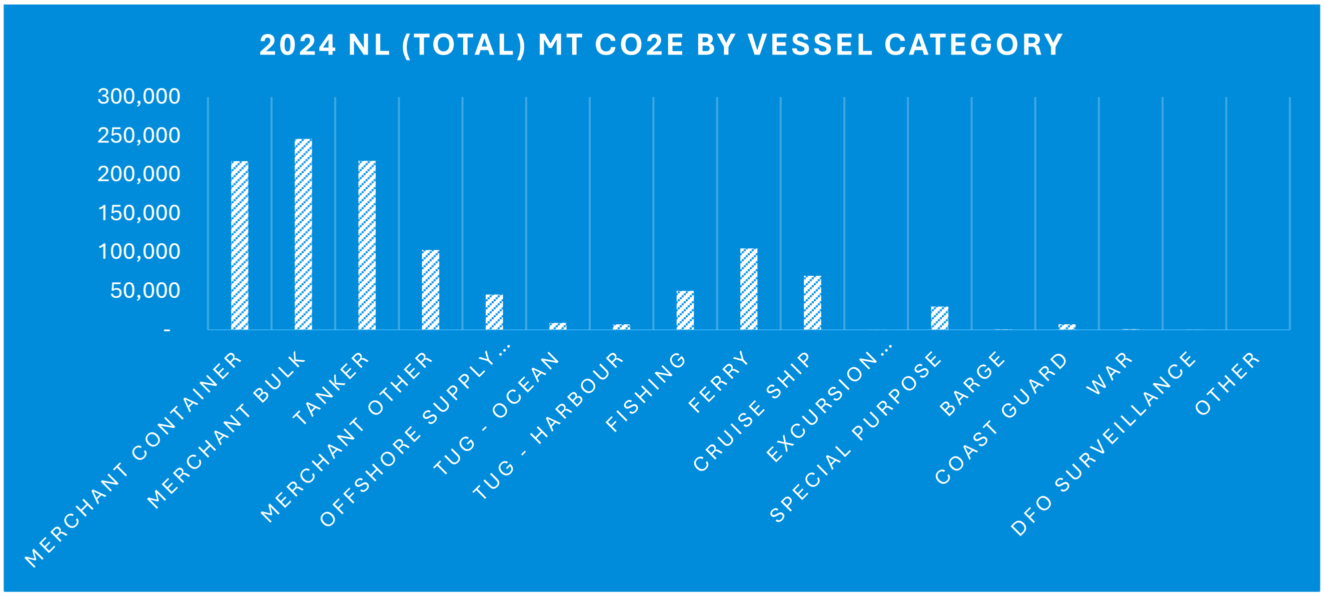
Canada

**Version 2.0 – Published July 27, 2026**

# 1. Executive Summary

This paper aims to advance the discussion on decarbonization within the marine transportation sector in Newfoundland and Labrador (NL) and support future decision-making on the supply of low-carbon fuels.

The marine transportation is responsible for almost 7% of NL's GHGs[1]. When including marine traffic that either originates and/or terminates at international ports (i.e., container ships, bulk shipments of raw materials), GHGs associated with marine transportation in NL equals 13% of the province's total emissions.




*2024 (Total) NL MT CO2e by Vessel Category (Bar)*

International marine traffic – the shipment of goods and raw materials to and from NL – represents the majority of the sector's GHGs. While fuel adoption decisions in these segments will be made by industry on an international basis, it is important for NL to be acutely aware of trends in order to ensure it can supply demanded fuels and capitalize on emerging production opportunities. In the provincial-only GHG context, ferries, supply ships, and fishing vessels factor more prominently.

There are important benefits to be realized from the adoption of low-carbon fuels in NL's marine transportation sector: (1) decreased greenhouse gas (GHG) emissions from both the electricity and waste sectors; (2) reduced air pollutants in the atmosphere; (3) increased energy security; (4) the valorization of under-utilized waste resources; and (5) economic development for communities.

[1] https://www.gov.nl.ca/eccc/files/Historical-GHG-Emissions-Summary-NL-1990-2024-April-2026.pdf

Following analysis of newly available marine transportation data and international trends, a number of key insights can be made:

- Vessels have long lifespans and most vessels on order will still use fossil fuels. Thus, biofuels and renewable fuels will play a key role in the sector for many years;
- LNG is emerging as a fuel of choice for future vessels, creating opportunities for the use of biofuels and also the blending of green hydrogen.
- Green methanol is emerging as a fuel of choice for future vessels, creating opportunities for green hydrogen and the use of captured CO2 – as these are the two key ingredients in green methanol production. This also creates new biofuels opportunities (i.e., the blending of bio-methanol, ethanol, etc.)
- Green ammonia is approaching proof of concept as a shipping fuel, with the first ammonia-powered vessels successfully piloted, engine testing near completion, and bunkering trials underway at major ports. However, the order book suggests that its adoption may not be as widespread as green methanol.
- Hydrogen appears as a potential input in many pathways (including in the production of renewable diesel).

The decarbonization of marine transportation in NL will be complex. The marine sector is deeply interwoven with rural life and livelihoods in the province, with its people culturally and commercially dependent on the ocean. Meanwhile, marine transportation in NL is diverse with many different types of vessels operating in various areas with unique operational requirements. Further, NL's geography and small and dispersed populations make infrastructure and technology deployment more complex and expensive.

NL can advance the adoption of low-carbon fuels in its marine transportation sector by:

1. Creating the enabling conditions to allow for the adoption of renewable diesel;
2. Defining best use cases for available biomass in NL and techno-economic feasibility of low-carbon fuels production;
3. Working with industrial operations in NL on sector-level marine transportation decarbonization strategies that support the use of local low-carbon fuels;
4. Ensuring future ferries procured in NL use locally produced low-carbon fuels;
5. Leveraging local hydrogen production to position NL globally as a supplier of low-carbon fuels for the marine transportation sector;
6. Investing in fuel blending/testing research and infrastructure;
7. Improving education, awareness, and skills development specific to the use of low-carbon fuels; and
8. Enabling marine transportation decarbonization through electrification infrastructure

# 2. Background and Context

## 2.1 Introduction

In 2025 econext completed a study with KPMG titled "*Opportunities for Domestic Clean Fuels Use in Newfoundland and Labrador*". This study explored potential low-carbon fuel use categorized according to sector within the province.

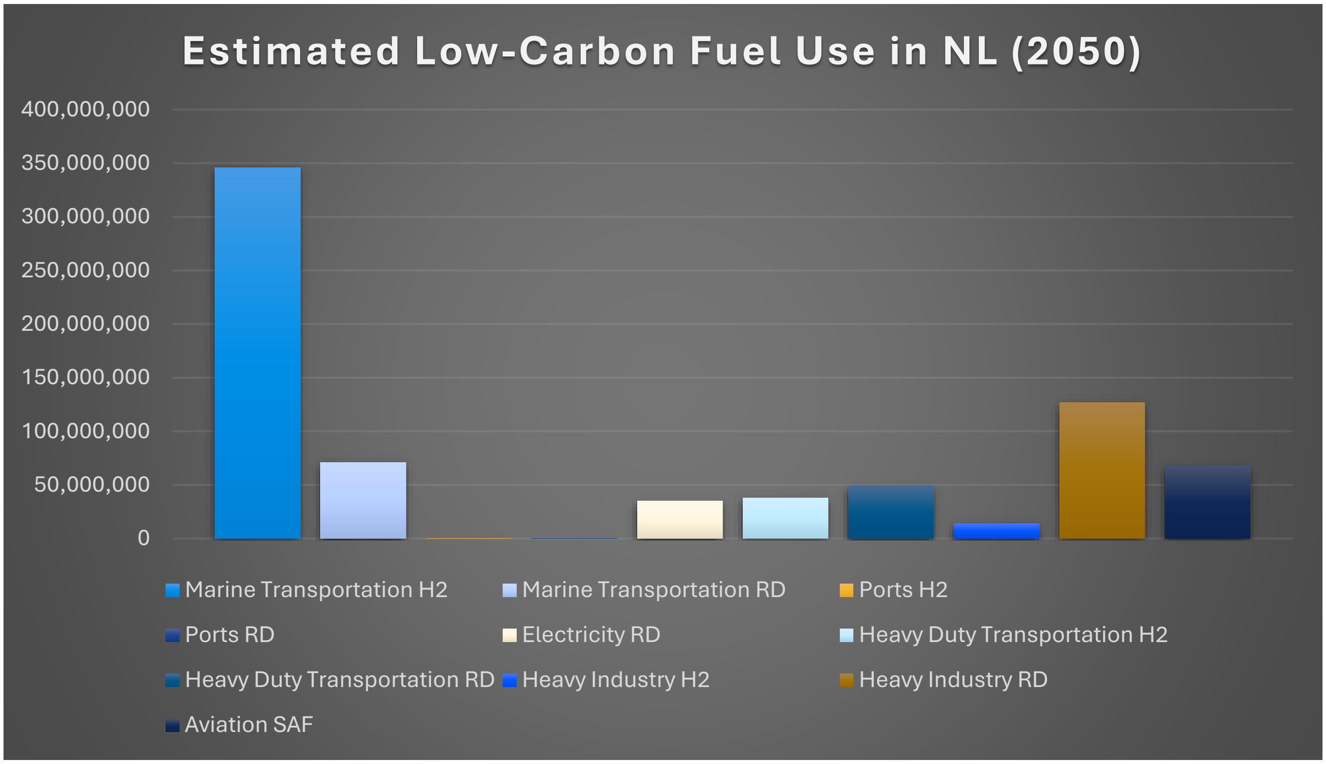



*Figure 1: Estimated Low-Carbon Fuel Use in NL in the Year 2050*
*with H2 = hydrogen and its derivatives, RD = renewable diesel, and SAF = sustainable aviation fuel*

These estimates are based on high-level assumptions using available greenhouse gas (GHG) data, International Energy Agency (IEA), and practical observations. The outlook for the future adoption of low-carbon fuels is based on many different variables and is difficult to predict – particularly within a localized geography.

However, what the research does clearly illustrate is the relative importance of marine transportation as it pertains to potential low-carbon fuel use in Newfoundland and Labrador (NL).

The decarbonization of marine transportation in NL will be complex. The marine sector is deeply interwoven with rural life and livelihoods in the province, with its people culturally and commercially dependent on the ocean. Meanwhile, marine transportation in NL is diverse with many different types of vessels operating in various areas with unique operational requirements.

Furthermore, NL's geography, low population density, and dispersed communities make infrastructure and technology deployment more complex and expensive.

Until recently, marine transportation sector in NL has not been well understood from a GHG perspective, making determinations on net zero pathways and the supply of alternative fuels difficult. New information available through Environment and Climate Change Canada (ECCC) is enabling richer analysis.

### Discussion Paper Objective

With granular data on marine transportation GHGs recently becoming available, this discussion paper aims to advance the discussion on decarbonization within the sector in NL and support future decision-making at the government, community, and industry levels on the supply of low-carbon fuels.

While every effort has been made to provide sources for information provided, this discussion paper is not an academic publication and is not intended to be. This is a document produced internally by econext staff informed by secondary research and information known to be available in the public domain.

econext welcomes all feedback that can help improve the quality and usefulness of this discussion paper. Feedback can be sent to info@econext.ca.

## 2.2 About econext

econext is a not-for-profit industry association dedicated to advancing environmentally sustainable economic growth in Newfoundland and Labrador. With a network of approximately 200 member businesses, research institutions, governments, and organizations, econext serves as a leading voice for the province's green economy.

econext has four key areas of focus:

**Member Opportunities**
We connect our members with opportunities to grow their businesses in the green economy.

**Public Policy & Advocacy**
We identify, analyze, and champion policy frameworks that support sustainable economic growth in NL.

**Capacity Building**
We equip NL's businesses, communities, and workforce with skills, experience, and knowledge needed to contribute to green economic growth.

**Innovation**
We identify emerging trends and provide insights that inform policy, investment, and innovation that advance clean growth in NL.

Together, we strengthen NL's green economy by supporting our members and help drive sustainable growth and innovation across the province. Learn more at econext.ca.

# 3. Marine Transportation in Newfoundland and Labrador

An understanding of the history of marine transportation in NL helps to establish context that is helpful in understanding present-day circumstances.

## 3.1 History and Sector Overview

NL has the longest coastline in Canada and has relied on the ocean for sustenance and economic activity since it was first populated. From the fisheries, to offshore oil and gas, to tourism, to aquaculture, to science and research, the people of NL have relied on marine transportation for their livelihoods and it is ingrained in their culture.

Most marine transportation methods in the last 150 years have involved combustion engines and the burning of fossil fuels for propulsion. Therefore, it is not surprising that marine transportation is a significant source of greenhouse gas (GHG) emissions for the province.

At 37%, transportation is the single largest contributor to GHGs in NL[2]. Marine transportation accounts for almost 20% of these emissions. At almost 7%, NL has the highest share of GHGs attributed to its marine transportation sector amongst the provinces in Canada.

---

[2] https://www.gov.nl.ca/eccc/files/GHG-Emissions-for-NL-by-Canadian-Economic-Sector-1990-2024.pdf

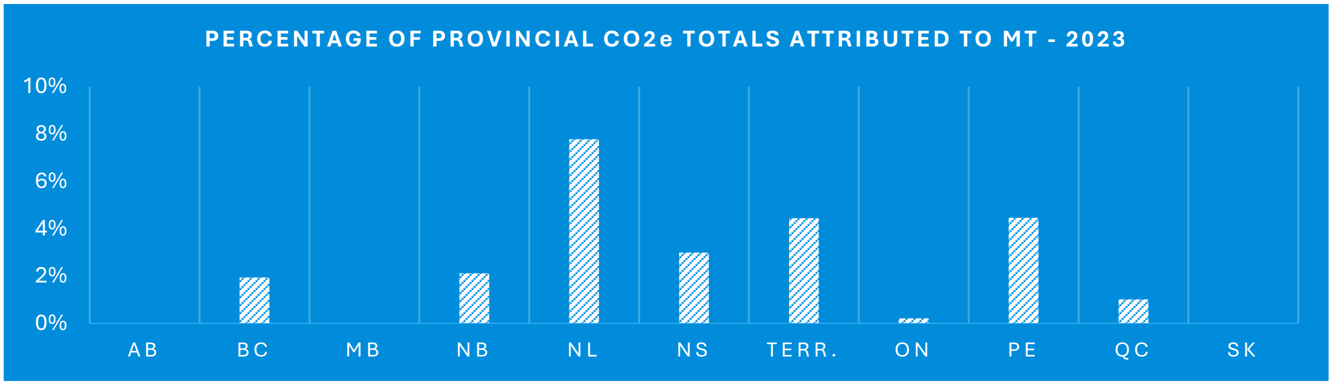


*Figure 2: % of Provincial CO2e Attributed to MT – 2023 (Data from Canada's Official GHG Inventory)*[3]

In terms of absolute emissions, NL's marine transportation sector is one of the largest emitters in Canada with British Columbia (BC) and Quebec (QC) the leaders nationally.

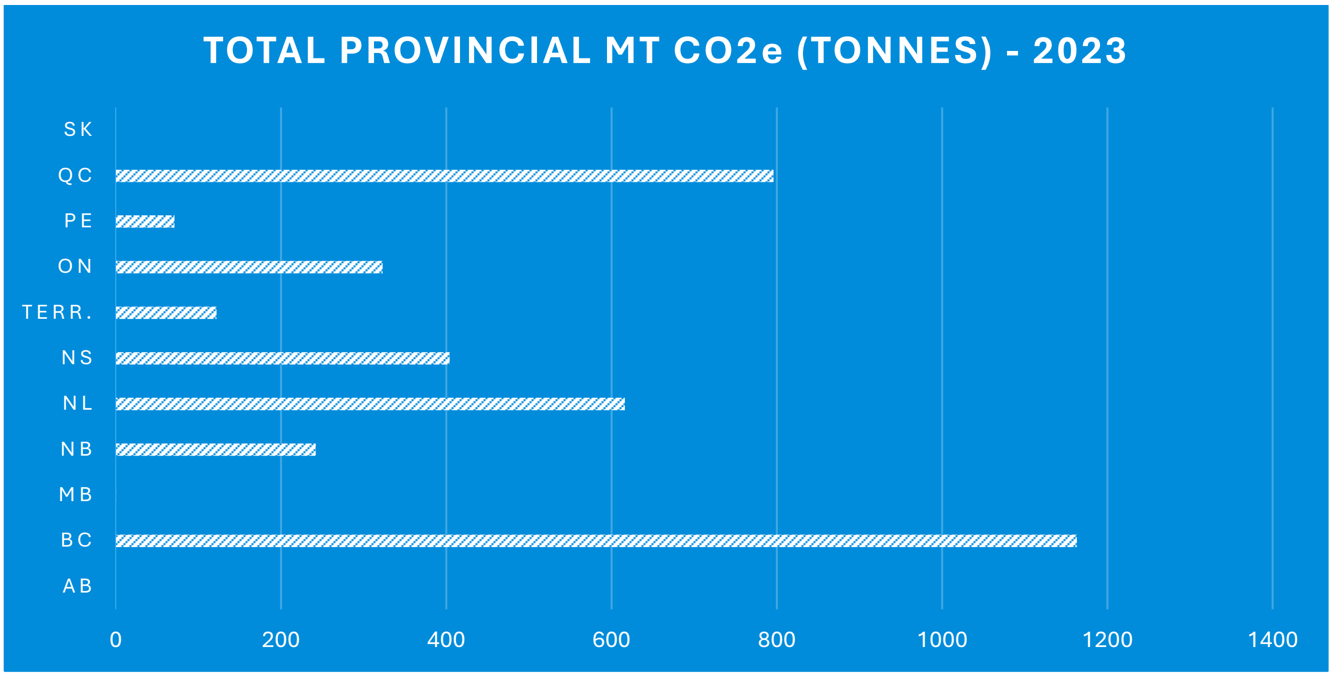


*Figure 3: Total Provincial MT CO2e – 2023 (Data from Canada's Official GHG Inventory)*4

On a proportional basis, NL has more reason to focus on marine transportation decarbonization than any other province in Canada. In totality, Canada's efforts in marine transportation decarbonization would be most impactful in BC, QC, and NL.

[3] https://data-donnees.az.ec.gc.ca/data/substances/monitor/canada-s-official-greenhouse-gas-inventory?lang=en
[4] https://data-donnees.az.ec.gc.ca/data/substances/monitor/canada-s-official-greenhouse-gas-inventory?lang=en

The sector is multi-faceted. Vessel types are designed differently, have unique applications, and have many ports of call. Therefore, the decarbonization of the sector will be complex.

However, with a rich history in ocean industries, the private sector and research institutions are well positioned to advance initiatives to address it. This is why the province's Net Zero Advisory Council (NZAC) highlighted marine transportation as an area that NL should prioritize in its pursuit of carbon neutrality by the year 2050 and recommended that the provincial government 'develop a marine transportation decarbonization strategy by 2025 with ports and clean energy as the focus'[5].

## 3.2 Greenhouse Gas Data

Decisions in support of marine transportation decarbonization must be data and evidence driven. Fortunately, sufficiently granular data is becoming available.

The Canadian government is able to track marine traffic and make a variety of different determinations on routes, ship design, and more. Marine Communication and Traffic Services (MCTS) under the Canadian Coast Guard (CCG) leads these vessel traffic services. The MCTS undertakes its work through the exchange of information between ships and shore-based control centers. The MCTS communicates traffic information to vessels in all navigable Canadian waterways – all which must comply with Canadian marine traffic regulations.

The data that MCTS acquires includes a vessel's geospatial information (current position, origin, destination, estimated arrival time, passage times at specific points, source position, etc.), design characteristics (e.g. main engine power, length, deadweight, build year, flag, main and auxiliary engine ratings, engine stroke type, engineer RPM, scrubber information, etc.), detailed itineraries and other trip specific details (e.g. cargo information or tug/barge towing data).[6]

Collectively this information can be used to make GHG emissions calculations.

In 2025 ECCC published its updated Marine Emissions Inventory Tool (MEIT), with data updated and refined in early 2026. The tool utilizes information obtained from MCTS to provide an inventory of shipping activity, energy use, and air pollutants and GHGs from marine vessels in Canadian waters. The MEIT tool allows users to: view marine emissions

[5] https://econext.ca/wp-content/uploads/2025/07/Attachment-NZAC-Summary-of-Recommendations-2024-12-30.pdf
[6] Publication forthcoming

geospatially; filter emissions by year, region or other basic conditions; and generate emissions reports[7].

This tool provides rich information from which substantive research can be undertaken. The data provided through this tool is used in this discussion paper in detailing marine transportation and GHG emissions in NL.

## 3.3 Vessel Classes and Types

There are many forms of marine transportation in NL ranging from fishing boats, ferries, supply ships, cargo vessels, tankers, tugs, science vessels, recreational boats, and much more. To decarbonize the sector, priorities must be established and this requires an understanding of where the majority of GHGs are created.

The MEIT categorizes vessels according to ‘classes’ and ‘types’. This information is taken from MCTS which in turn is informed by vessels in Canadian waters through automated processes. Ship builders, owners, and operators are expected to align their vessel classification according to norms established by the International Maritime Organization (IMO) and classification societies such as DNV and Lloyd’s Register.

However, there are no standardized definitions of vessel classes and types that are universally used worldwide. A number of factors complicate efforts at universal classification: marine transportation often crosses national boundaries; shipbuilding involves international supply chains and customers; there are many different types of vessels and vessel use cases; and vessels can have long lifespans. The lack of a fully standardized classification scheme can create difficulties in the analysis of data.

Therefore, in interpreting the data from tools like the MEIT, assumptions must be made through an examination of vessel travel patterns, origins and destinations, etc. to gain a fulsome understanding of the vessel types being characterized. With a working knowledge of economic activity and marine transportation norms within a region, reasonable deductions can be made to produce useful definitions for analysis.

For example, an analysis of traffic in the MEIT classified as ‘tug – supply’ reveals that almost all traffic categorized in this manner applies to vessels moving back and forth between offshore oil and gas installations. Thus, this category represents vessels that are most often referred to locally as ‘offshore supply vessels’.

---

[7] https://www.canada.ca/en/environment-climate-change/services/managing-pollution/marine-emissions-inventory-tool.html

Using the MEIT, the table below outlines vessel classes and types are active in NL. The order of appearance is roughly aligned with the level of GHG emissions emitted in NL per class and type. A third column has been added which (unofficially) defines these classes and types within the NL context. These definitions allow for a productive analysis of marine transportation GHGs within the province and are used throughout the remainder of this discussion paper.

| Vessel Classes | Vessel Types | NL Descriptions |
|---|---|---|
| **Merchant Container** | | A large cargo vessel designed to transport goods in standardized intermodal containers, which are stacked both above and below deck. In NL this would include container ships that operate at ports in St. John's and Corner Brook. |
| **Merchant Bulk** | | A specialized merchant vessel designed to transport large quantities of unpackaged, dry cargo in its large cargo holds. In the NL context this would mostly involve the transportation of iron ore, nickel, etc. |
| **Tanker** | | "Tanker". A tanker ship is a vessel designed to transport liquid or gaseous cargo in bulk, such as crude oil, chemicals, and liquefied natural gas (LNG). |
| | Merchant crude | A tanker ship that moves unrefined crude oil from extraction sites to refineries or intermediary destinations. In the NL context this would mostly involve the transportation of crude from offshore oil production facilities. |
| | Merchant chemical/oil products tanker | A tanker ship that moves chemical or oil products. In the NL context this would mostly involve the distribution of refined products to and throughout ports in NL. |

| | | |
|---|---|---|
| | Merchant chemical | A tanker ship that moves chemical products. In the NL context this would mostly involve the distribution of refined products to and throughout ports in NL. |
| | Merchant (tanker) | A tanker ship that moves unrefined crude oil or refined petroleum products like gasoline and diesel. |
| | Merchant liquified gas | A specialized vessel designed to transport liquefied natural gas (LNG) or liquefied petroleum gas (LPG) at sea. |
| | Merchant ore/bulk/oil | Also known as a combination carrier, this is a versatile merchant ship built to transport wet oil or dry bulk cargoes like iron ore and coal. |
| | Merchant VLCC | "Very Large Crude Carrier" - a massive commercial oil tanker with a deadweight tonnage between 200,000 and 320,000 tonnes, built to carry up to 2 million barrels of crude oil across oceans. |
| | Merchant ULCC | "Ultra Large Crude Carrier" - the largest class of merchant oil supertanker used to transport massive volumes of crude oil with a deadweight tonnage between 320,000 and 550,000 tonnes. |
| **Merchant Passenger** | Merchant Ferry<br>Merchant Passenger | "Ferry". A commercial vessel designed primarily to transport more than 12 passengers. In the NL context this includes all ferries in the province such as those operated by Marine Atlantic, the provincial government, and contractors to the provincial government. |
| **Merchant Other** | Merchant general<br>Merchant RO/RO<br>Merchant auto | A commercial vessel transporting cargo not as containers as not as defined in 'bulk'. This would include any cargo that is not container or classified as 'bulk'. |

| | | |
|---|---|---|
| | Merchant reefer<br>Merchant coastal<br>Merchant cement<br>Merchant lash<br>Merchant ore<br>Merchant gasoline | |
| **Tug** | Tug supply | “Offshore supply ship”. In the NL context, this refers mostly to supply vessels carrying cargo (people, equipment, and other goods) to offshore oil and gas facilities. |
| | Tug ocean | A marine vessel used to tug a large payload (e.g., propelled ship, barge, etc.) by pushing or pulling them, with direct contact or a tow line, over a long distance. |
| | Tug – tug / harbour | “Tug - harbour”. A marine vessel that manoeuvres other vessels over a shorter distance by pushing or pulling them, with direct contact or a tow line, such as those found within harbours and docking wharves. |
| | Tug workboat | Same as above. |
| | Tug fire | Specialized multi-role port security and rescue vessels, often with dedicated firefighting capabilities. |
| **Fishing** | Fishing vessel | A boat or ship used for catching, harvesting, transporting, or processing fish and other aquatic life. |
| | Trawler | A commercial vessel designed to drag a large, funnel-shaped net called a trawl through the water to catch fish. |
| | Factory ship | A commercial vessel with extensive on-board facilities for processing and freezing caught fish. |

| | | |
|---|---|---|
| | Other | Other classes exist (“gillnetter”, “fishery patrol”, and “Other Fishing VSL”) however GHGs recorded in NL are close to nil and thus are not defined. |
| **Cruise** | Cruise<br>Merchant passenger | “Cruise ship”. A large ship that carries people on voyages for pleasure, typically calling at several places. In NL cruise ships dock in St. John’s, Corner Brook, and St. Anthony. |
| **Special Purpose** | Special Purpose (SP)<br>SP Cable VSL<br>SP Crane Ship<br>SP Diving<br>SP Pilot Boat<br>SP Pipe-Layer<br>SP Research VSL<br>SP Supply VSL<br>SP Survey Ship<br>SP Training VSI<br>SP Dredge | A vessel with a unique design and function, such as a research or icebreaker ship, built for specific tasks rather than general cargo. In NL can include survey ships, pilot boats, crane ships, etc. |
| **Coast Guard** | Coast guard icebreaker<br>Coast guard scientific<br>Coast guard rescue<br>Coast guard lifeboat<br>Coast guard tender | All Coast Guard vessels active in NL which could include science vessels, rescue vessels, icebreakers, lifeboats, etc. |
| **Excursion Passenger** | | A vessel used for short trips for pleasure or recreation, such as sightseeing, dinner cruises, or tours, and carries passengers for hire. In NL these would |

| | | |
|---|---|---|
| | | be vessels used within the tourism industry. |
| **War** | Warship surface<br>Warship – general<br>Warship training<br>Warship undersea | Vessels owned and operated by the Department of National Defence or militaries from other jurisdictions. |
| **DFO Fishing Surveillance Vessel** | DFO fishing surveillance vessel<br>Coast guard patrol<br>Marine security patrol CCG-RCMP | Vessels operated by both DFO and the RCMP for the purposes of surveillance, patrol, and security. |
| **Barge** | Barge Bulk Cargo<br>Barge Chemical<br>Barge General<br>Barge Miscellaneous<br>Barge Oil Drilling Rig<br>Barge Oil/Petroleum<br>Barge Self-Propelled | Barges are flat-bottomed, box-shaped or nearly box-shaped vessels with simple configurations. Barges are used for a wide variety of purposes, from general-purpose cargo carriage to heavy lifting of structures such as offshore platforms. |

*Figure 4: Ship Type and Class Definitions Situated in NL Context*

This discussion paper will use the categories described above in its subsequent analysis and conclusions.

# 4. Marine Transportation and Greenhouse Gas Emissions

This section outlines how marine transportation GHGs in NL are measured and provides an overview of NL's marine transportation GHGs in aggregate, over time, and by vessel.

## Measurement

The MEIT calculates a variety of air contaminants, pollutants, and GHGs including: nitrogen oxides (NOx); non-methane hydrocarbons (HC); particulate matter (PM, PM10, and PM2.5); sulphur oxides (SOx); carbon monoxide (CO); black carbon (BC); carbon dioxide (CO2); nitrous oxide (N2O); and methane (CH4).

The MEIT also calculates 'carbon dioxide equivalent' or CO2e. CO2e is a standardized unit (usually expressed in million metric tonnes) used to measure a greenhouse gas's impact on the basis of their global-warming potential (GWP). The unit converts amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential[8]. This allows for blended use of a number of GHGs simultaneously to understand total climate impacts. This analysis uses CO2e as the comparable metric.

**Appendix A** summarizes total marine transportation GHGs in NL from 2015-2024 in CO2e metric tonnes.

## Total Emissions vs. Accounted Emissions

The data in **Appendix A** includes international marine transportation, i.e., ships with international origins that arrive in NL or ships that depart from NL for international destinations.

For the purposes of this study, it was decided that GHGs associated with international marine transportation should be included in analysis. This is based on the fact that international marine transportation is a significant contributor of GHGs within NL's jurisdiction and the provision of locally-produced low-carbon fuels presents a variety of opportunities beyond reducing environmental impacts – including in energy security and economic development.

However, it should be noted that GHGs associated with international marine transportation are not considered 'Canadian' under internationally standardized GHG accounting practices. International marine transportation emissions are intended to be covered under possible future International IMO regulations. Therefore, the marine transportation GHG data used for analysis in the report will differ from what is officially reported Canada and its provinces. **Appendix B** summarizes total marine transportation GHGs in NL from 2025-2024 that are within the reporting jurisdictions of NL and Canada.

---

[8] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Carbon_dioxide_equivalent

The figure below shows the difference between total NL MT CO2e (including international marine traffic) versus what is accounted for and reported on in Canada (not including international marine traffic).

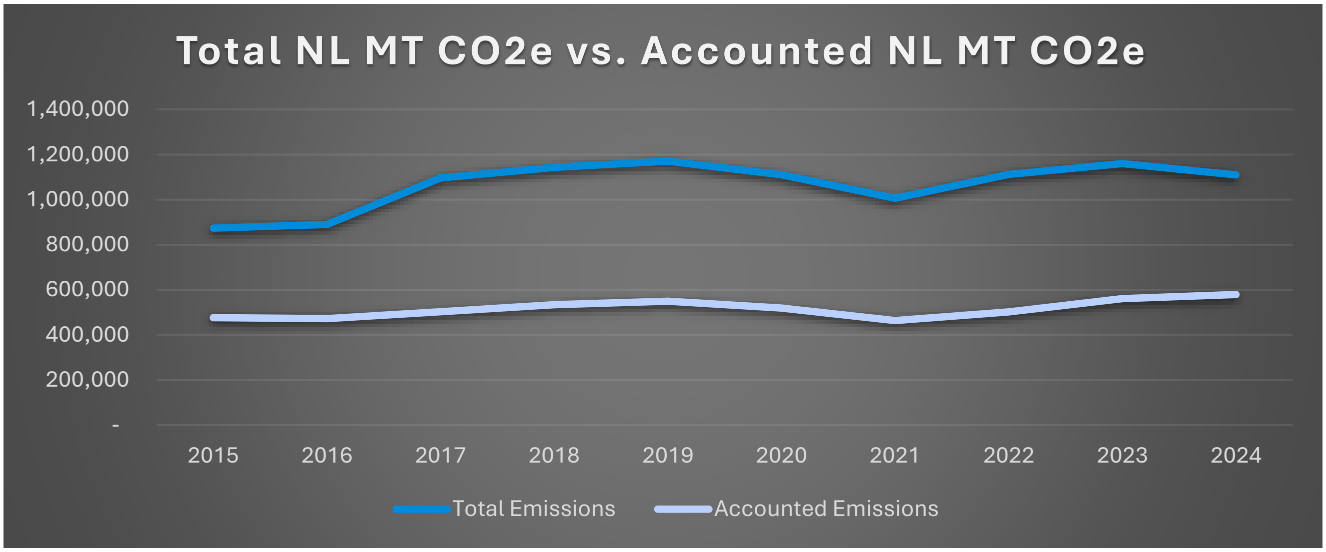



*Figure 5: Total NL MT CO2e vs. Accounted NL MT CO2e*

Note that the figures presented above and used for analysis do not include any transportation that is classified as 'innocent passage' - or marine traffic that traveled through NL waters but did not depart or arrive at an NL port.

## Emissions Over Time

Total GHGs emanating from marine transportation have grown from 873,685 CO2e in 2015 to 1,109,854 CO2e in 2024, represented a growth of almost 27%.

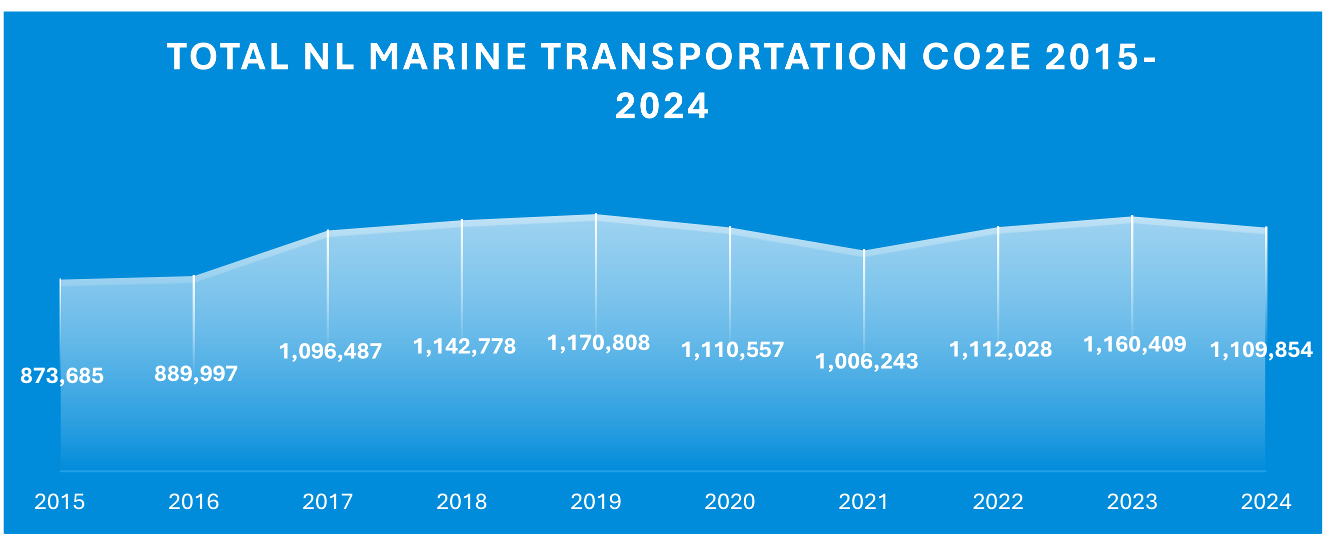



*Figure 6: TOTAL NL Marine Transportation CO2e 2015-2024*

The MEIT was updated with refined data in 2026, including updated 2024 information. Adjustments to 2024 data were material, and publications citing 2024 data from the MEIT published prior to Spring 2026 should be reviewed for accuracy. 2024 will be the base year from which the remainder of this analysis is drawn from. Note that previous versions of this discussion paper refer to 2023 data.

## CO2e by Vessel Category

Decisions around the prioritization of marine transportation decarbonization can be informed by the total GHGs associated within each vessel category. The higher the emissions in a category – the more impetus there may be to drive solutions to reduce them.

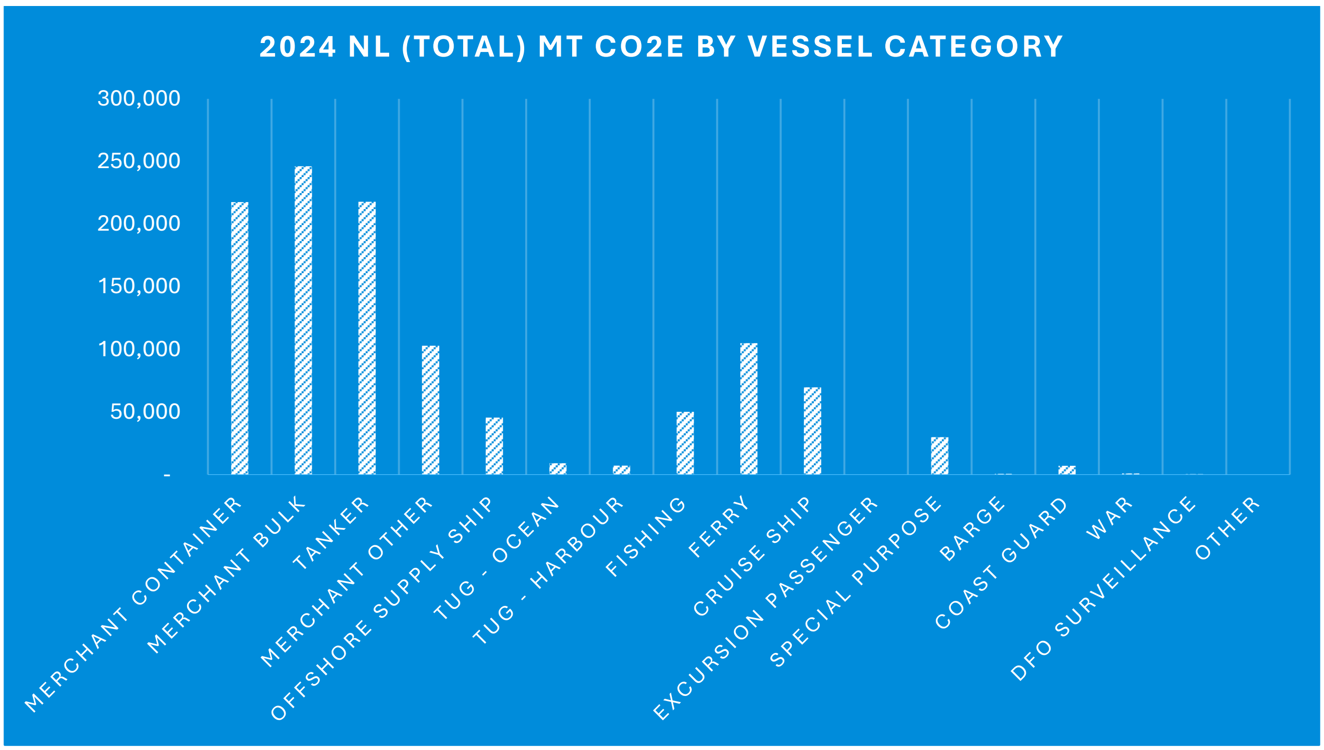



*Figure 7: 2024 (Total) NL MT CO2e by Vessel Category (Bar)*

Overall 2024 marine transportation GHGs in NL rise from 579,242 tonnes of CO2e to 1,109,854 tonnes of CO2e when including traffic with either an international origin or destination.

As would be expected, 'tanker', 'merchant container', 'merchant bulk', and 'merchant other' vessel types account for significantly more GHGs when including transportation to and from international destinations.

It is worthwhile comparing marine transportation GHG totals in NL against those that would be accounted for with the purpose of provincial and federal reporting as the results may impact the decarbonization priorities of industry versus governments.

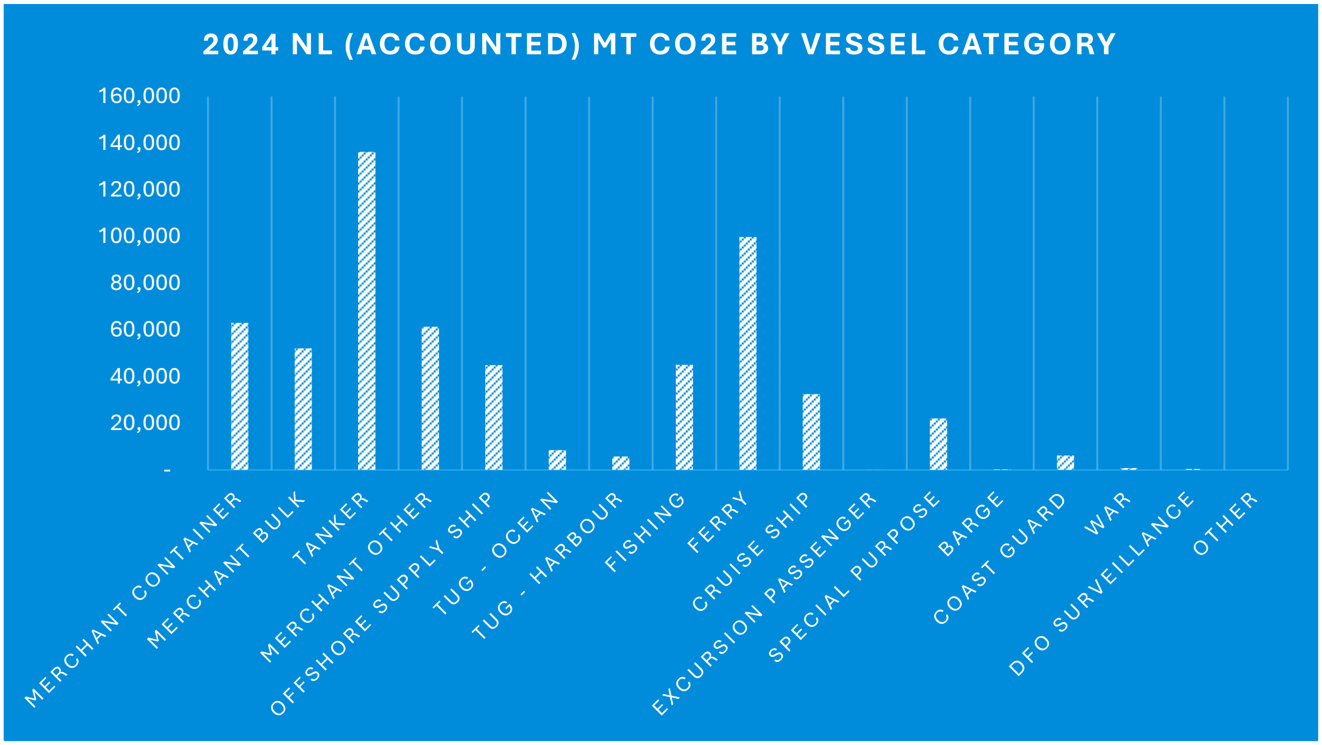



*Figure 8: 2024 (Accounted) NL MT CO2e by Vessel Category (Bar)*

Of particular interest when comparing these data sets is the prevalence of merchant container, merchant bulk, and tanker vessel categories when including all GHG data. This is unsurprising as there is a significant amount of goods and services that arrives in NL from international origins via container shipping. Additionally, markets for NL's primary natural resource exports (crude oil, iron ore, nickel, etc.) are international and would be represented by bulk and tanker traffic.

Notable when considering the accounted GHGs (official figures that would be reported federally/provincially) is the increased share that ferry and tanker traffic have relative to other emissions sources.

Examining each vessel category in greater detail – including a high-level overview of decarbonization pathways for each in NL – will help to inform training and workforce development considerations. However, in advance of this examination it is important to have a general understanding of the technologies that can be deployed to assist in and drive emissions reductions within maritime transportation.

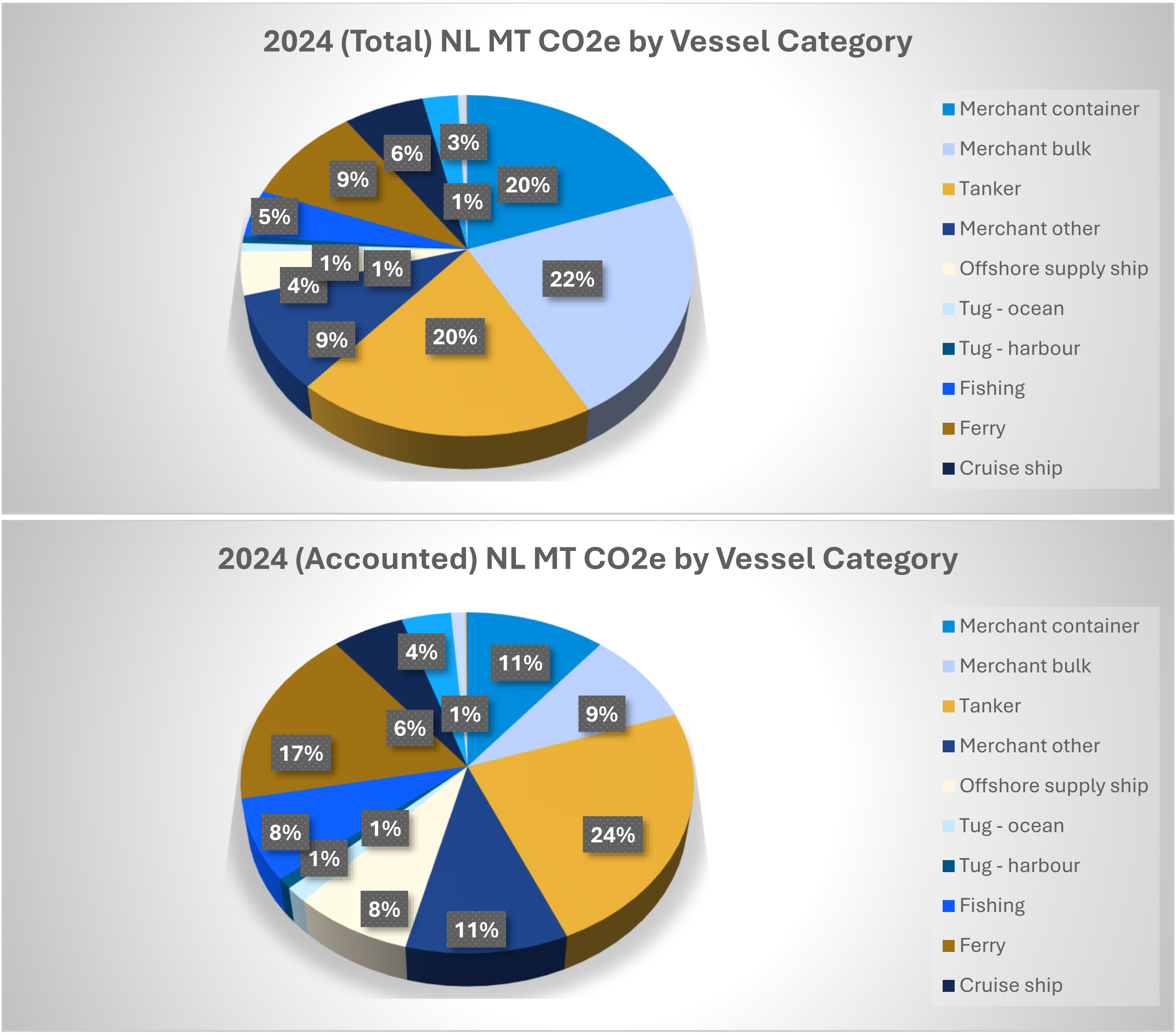



*Figure 9: 2024 (Total vs. Accounted) NL MT CO2e by Vessel Category (Pie)*

# 5. Marine Transportation Decarbonization in NL

Approaches to reducing GHGs in marine transportation range from the optimization of vessel equipment and operations, electrification, and the adoption of low-carbon fuels. In addition, there are a number of regulations that have been (or are in the process of being) implemented which are accelerating the adoption of decarbonization methods.

As marine transportation is structurally an international sector, trends and drivers internationally affect what is taking place in NL. Below is a high-level summary of technologies and policy mechanisms that are being developed and deployed internationally in support of marine transportation decarbonization.

## 5.1 Marine Transportation Decarbonization Technologies

### Vessel Optimization

In the same way that changes in habits and energy efficiency measures in a home or building can reduce GHGs, the optimization of marine vessel operations can yield emissions reductions. Energy efficiency measures on ships can be classified as follows[9]:

- *Energy consumers* – improvement in energy efficiency of onboard consumers such as lighting equipment and cargo handling systems.
- *Energy harvesting* – measures that capture energy from the surroundings, converting it to propulsion power or electricity (e.g. sails and solar panels).
- *Propulsion and hull* – measures that improve the hydrodynamical performance of the vessel.
- *Machinery* – measures that relate to the machinery on board the vessel, including main engines, auxiliary engines, and related systems.
- *Operational* – measures that relate to the way in which the ship is maintained and operated (i.e., route optimization) and the cargo is handled.

It is estimated that operational and technical energy-efficiency measures can reduce fuel consumption in the maritime industry by 4% to 16% by 2030[10]. The effect of each energy efficiency measure varies depending upon a range of factors such as vessel type, size, age, location, and route[11]. As optimization can achieve both emissions reductions and cost savings, this is the first best place for vessel owners / operators to start in their decarbonization journey.

### Electrification

Batteries on ships allow stored electrical energy to be used for propulsion and other onboard systems instead of the burning of fuel. Fully battery-powered ships produce zero direct emissions of GHGs and harmful pollutants during operation. As with electric vehicles on our roads, it should be remembered that the overall GHG reduction potential of electrification in marine transportation is dependent on the GHG intensity of the electricity used to charge the battery.

---

[9] https://brandcentral.dnv.com/original/gallery/10651/files/original/216954a7-8cc8-49b6-b99e-37e76a41410a.pdf
[10] https://www.dnv.com/expert-story/maritime-impact/strategies-for-meeting-upcoming-decarbonization-targets/
[11] https://www.dnv.com/maritime/insights/topics/ship-energy-efficiency/solutions/

Electric propulsion systems powered by batteries are significantly quieter than traditional engines, reducing noise pollution in marine environments. Batteries can provide quick and precise power adjustments for better control and manoeuvrability and can provide power to smooth peak loads in the ship network. Fewer energy conversions are required than when using fuel, and therefore fewer energy losses. Additionally, electric motors are more efficient than combustion engines.

*Shore power at the Port of Hamburg (BBC[12])*

There are some challenges associated with fully electric ships. First, they have a limited range compared to ships using liquid fuels. The recharging of batteries takes longer than conventional refuelling of ships, impacting scheduling and operational efficiencies. Electrified ships also require significant infrastructure port-side to enable their charging. On board batteries also present a risk of uncontrolled exothermic chemical reactions which are not present on conventional ships[13].

The presence of batteries (and associated equipment) on vessels presents the potential for different types of chemical reactions which previously did not need to be considered by crew and maintenance workers. Therefore, electrification in marine settings requires specialised training.

---

[12] https://www.bbc.com/news/uk-england-hampshire-67339269
[13] https://www.lr.org/en/knowledge/research/zcfm/electrification/

Electric vessels are not expected to be suitable for long-distance shipping but are ideal for powering short-sea ferries and small vessels[14]. Battery-powered vessels are particularly appropriate for relatively short routes (recognizing the limitations of battery ranges) and/or routes with consistent ports of call (recognizing challenges associated with providing charging infrastructure shoreside).

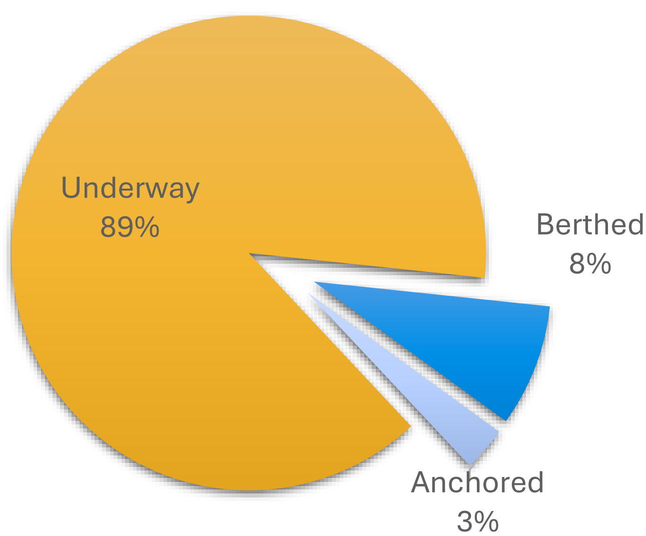
Over the last decade the maritime industry has started to embrace hybrid and electric technology – particularly in smaller vessels such as workboats, pleasure craft and ferries[15]. This is because electric ships are most ideal for shorter routes due to limitations in range and charging infrastructure[16]. Short voyages allow frequent battery-charging and for batteries to cover a substantial amount of a ship's annual energy needs[17].

### *Hybrid Electric*

The use of batteries in hybrid power systems (i.e. in combination with other higher energy density technologies) increases potential applications. A hybrid vessel is one where a battery is supplemented by a more conventional ship engine that runs on fuel. The battery can be charged through shoreside power or the ship's engine itself. To achieve greater decarbonization, hybrid vessels can be built to use alternative fuels when the propulsion shifts to using the engine.

### *Shore Power*

The use of shoreside electricity when berthed is an additional GHG reduction opportunity. Most vessels run at all times, even with docked, burning fuel in the process. This is also referred to as 'hotelling'. The MEIT calculates 'berthed' emissions in 2024 in NL as being 87,552 CO2e or being responsible for 8% of all marine transportation GHGs in the province.




[14] https://globalmaritimeforum.org/news/zero-emission-shipping-fuels-methanol-and-ammonia/
[15] https://www.idtechex.com/en/research-report/electric-boats-and-ships/948
[16] https://brandcentral.dnv.com/original/gallery/10651/files/original/216954a7-8cc8-49b6-b99e-37e76a41410a.pdf
[17] https://www.dnv.com/expert-story/maritime-impact/strategies-for-meeting-upcoming-decarbonization-targets/

Retrofitting ships with the capability to 'plug in' to access shoreside electricity – and providing the enabling infrastructure at the port – can result in meaningful GHG reductions. This is particularly true when vessels are able to access clean electricity.

There are barriers to the broad use of shore power – namely the presence of infrastructure portside required to facilitate it, limitations on infrastructure or power supply portside, and/or the configuration of portside power sources / adapters and their compatibility with the vessels needing to access them.

The provision of shore-power for hotelling vessels is applicable to all almost all vessel categories.

### Clean and Low-Carbon Fuels

'Clean' and 'low-carbon fuels' is a catch-all term which refers to fuels that have a lower carbon intensity than their conventional alternatives. Conventional fuels in the marine transportation sector typically include fuels such as heavy fuel oil (HFO), marine diesel oil (MDO), etc.

Clean or low-carbon fuels can be used in conjunction with conventional fuels, as a replacement for them using existing equipment, or as a replacement through the adoption of new technology. There is a wide variety of different low-carbon fuels relevant to marine transportation, each with their own characteristics to consider.

Clean and low-carbon fuels relevant to the marine transportation sector are discussed in detail in Section 6 of this discussion paper.

### Dual-Fuel Engines

Vessel owners, operators, and builders are increasingly looking to ships which can run on more than one fuel – or are 'dual-fuel'. Dual-fuel engines can seamlessly transition between fuels without any interruption in power output.

While more costly, having the capability to run on multiple fuels helps mitigate risks for vessel operators. These risks can be regulatory (i.e., moving from one jurisdiction with less stringent GHG rules to one with more stringent rules) or supply-related (i.e., traveling in areas where the availability of one fuel may be limited, un-reliable, or non-existent). Dual-fuel engines allow for vessel owners and operators to de-risk the energy transition for their business – giving them long-term options in the face of long-term uncertainty.

There are other benefits to fuel-fuel engines; they can help to optimize fuel consumption and ensure operational flexibility in different maritime conditions.

### Retrofits

New builds can be constructed to be 'fuel-ready' for alternative fuels, ensuring long-term flexibility and regulatory alignment. The retrofit of existing vessels is also an option. Retrofitting existing vessels enables shipowners to extend the operational life of their assets while adapting to a decarbonizing market. Through targeted upgrades – such as engine modifications, fuel system conversions, and energy-saving technologies – retrofitted ships can meet evolving regulatory requirements and reduce their carbon footprints without the need for full replacement. Extensive techno-economic feasibility assessments would need to be undertaken in advance of vessel retrofitting. However, given the long lifespan of vessels retrofitting is an important consideration.

### Other Technologies

The decarbonization of marine transportation is a pursuit attracting global interest and is a focus of research, development, and innovation. While there are other technologies relevant to marine transportation decarbonization that exist or are in development (such as nuclear propulsion and on-board carbon capture and storage systems), the above highlighted solutions provide the context necessary for this paper.

## 5.2 Policy and Regulations Driving Marine Transportation Decarbonization

The regulation of marine transportation emissions is challenging and complex because of the global nature of the sector – many vessels crossing many international borders at all times. However, international, regional, and national policies are emerging.

### IMO Net Zero Framework

Marine traffic with international origins or destinations are not included in federal or provincial GHG reporting, and this is consistent with internationally standardized methodology. GHGs that result from international marine transportation are envisioned to be regulated under the IMO.

In 2023, the IMO adopted a revised GHG strategy targeting net zero by or around 2050. To ensure that shipping reaches these ambitions, the IMO planned to implement a collection of measures consisting of both technical and economic elements.

The IMO Net-Zero Framework (IMO NZF) has two main parts, which are linked:

1. A global fuel standard that requires ships to gradually reduce how polluting its ship fuel can be (i.e. how much greenhouse gas is emitted for each unit of energy used, across a fuel's life cycle); and
2. A pricing mechanism with set prices on the GHG ships emit, to encourage the industry to lower emissions to comply with the global fuel standard[18].

The draft legal text of the IMO NZF was approved by its member states (including Canada) in April 2025. The scheme has become an issue of contention with the current American President's administration, which has been pressuring for its abolishment[19]. While the adoption of the IMO NZF has been delayed as a result, a May 1, 2026 meeting indicated that the majority of IMO member states continued to be in support of the initiative with hopes to adopt it in December 2026[20].

## European Union Regulation

Regulation of marine transportation emissions does not hinge on the IMO. For example, carbon pricing and fuel standards enacted in the EU will have a significant impact on the global marine transportation sector given the amount of goods that enter and exit European ports.

### *European Union Emissions Trading System*

The European Union Emissions Trading System (ETS) was extended in 2024 to cover marine transportation and CO2 emissions from all large ships entering EU ports.

The ETS is a carbon pricing system which covers 50% of emissions from voyages starting or ending outside of the EU and 100% of emissions that occur between two EU ports and when ships are within EU ports. There is an overall ETS emissions cap and restrictions on emissions individual companies can produce. Shipping GHGs are being phased into

[18] https://www.imo.org/en/mediacentre/hottopics/pages/faqs-the-imo-net-zero-framework.aspx
[19] https://www.bbc.com/news/articles/c3vnl0yxg53o
[20] https://cleanshipping.org/news/shipping-imos-net-zero-framework-progresses-but-engos-slam-unnecessary-delay/

inclusion, but quickly – from 40% of reported emission in 2024 to 100% in 2027 and subsequent years[21].

### *FuelEU Maritime Regulation*

Meanwhile, the FuelEU Maritime Regulation came into effect in 2025 and promotes the use of renewable, low-carbon fuels and clean energy technologies for ships, essential to support decarbonisation in the sector.

This is a fuel standard which sets maximum limits for the yearly average GHG intensity of the energy used by ships above 5,000 gross tonnage calling at European ports, regardless of their flag. Targets will ensure that the greenhouse gas intensity of fuels used in the sector will gradually decrease over time, starting with a 2% decrease by 2025 and reaching up to an 80% reduction by 2050. In addition, passenger and container ships at berth or moored at the quayside must use on-shore power supply (OPS) or alternative zero-emission technologies from 1 January 2030[22].

The UK plans to mirror the EU's work, with a commitment to incorporating ships over 5,000 GT into the UK Emissions Trading Scheme starting in 2026[23].

## Canadian Policy and Regulations

Canada's policy and regulations pertaining to marine transportation GHGs are less advanced than those being implemented in the EU, but the trajectory is clear.

### *Clean Fuel Regulations*

Canada's Clean Fuel Regulations (CFRs) came into effect in 2023 and create incentives for the development and adoption of clean fuels, technologies and processes[24].

The stated goal of the CFRs is to significantly reduce pollution by making the fuels Canadians use every day cleaner over time. The CFRs require liquid fossil fuel (gasoline and diesel) suppliers to gradually reduce the carbon intensity – or the amount of pollution

---

[21] https://climate.ec.europa.eu/eu-action/transport-decarbonisation/reducing-emissions-shipping-sector_en
[22] https://transport.ec.europa.eu/transport-modes/maritime/decarbonising-maritime-transport-fueleu-maritime_en
[23] https://brandcentral.dnv.com/original/gallery/10651/files/original/216954a7-8cc8-49b6-b99e-37e76a41410a.pdf
[24] Government of Canada: What are the Clean Fuels Regulations? - https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-regulations/about.html

– from the fuels they produce and sell for use in Canada over time, leading to a decrease of approximately 15% (below 2016 levels) in the carbon intensity of gasoline and diesel used in Canada by 2030.

There are a number of methods for regulated industry to be compliant with the CFR.

The first approach is the creation of compliance credits. There are three compliance categories, with the first two being relevant in the context of low-carbon fuels:

**Compliance Category 1:** Undertaking projects that reduce the lifecycle carbon intensity of liquid fossil fuels (e.g., carbon capture and storage, on-site renewable electricity, co-processing). This includes the blending of fuels with lower carbon GHG intensity with conventional fuels.

**Compliance Category 2:** Supplying low carbon intensity fuels (e.g., biodiesel, hydrogen, e-methanol, etc.)[25].

There is, therefore, an incentive structure that exists for the production and supply of low-carbon fuels to customers like those found within the electricity sector – including when those fuels are blended.

*econext's emissions reduction fund is a mode of compliance under the CFR (www.nlerf.ca)*

The second approach to compliance is for regulated industry to contribute to an Emissions Reduction Fund (ERF) authorized by the Minister of Environment and Climate

[25] https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-regulations/compliance.html

Change Canada (ECCC). econext's [Newfoundland and Labrador Emissions Reduction Fund] is one of a select few organizations in Canada with a registered ERF approved as a compliance mechanism under the CFR.

ERF funded projects could also conceivably involve partnerships between low-carbon fuel producers, distributors, and users – users such as vessel owners and operators.

While the CFR does not specifically regulate marine transportation emissions, the framework does create incentives for fuel producers and distributors in the country to provide lower-carbon fuels to customers – and the marine transportation sector is a significant fuel customer.

### *Other Federal and Provincial Commitments*

Canada has a legislated commitment to reach net zero by the year 2050[26], and Newfoundland and Labrador has committed to do the same[27] (albeit this is not legislated). Net zero (and related GHG reduction commitments) are not possible without addressing emissions in the marine transportation sector.

As part of its 2030 Emissions Reduction Plan, Canada committed to the development of a national action plan to help the marine sector to reduce emissions[28]. Specifically, the plan committed to:

1. Developing a national action plan to enable the marine sector to reduce its emissions, which could include engagement with stakeholders on energy efficiency/carbon intensity requirements for domestic vessels in-line with requirements for international vessels.
2. Working with international partners to develop measures to reduce black carbon in the Arctic from international shipping.

---

[26] https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html
[27] https://natural-resources.canada.ca/climate-change/regional-energy-resource-tables/newfoundland-labrador-regional-energy-resource-table-framework-collaboration-path-net-zero
[28] https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030/plan.html

Canada signed the 'Declaration on Zero Emission Shipping by 2050' in 2022[29], and has placed a priority on the development of 'Green Shipping Corridors'[30], or zero-emission maritime routes between two (or more) ports.

While a national plan to reduce emissions in the sector has not yet emerged, Canada's trajectory on this subject is clear through its support of international initiatives. Provincially, on the advice of its Net Zero Advisory Council (NZAC)[31], the Government of NL committed in its 2025-2030 Climate Change Mitigation Action Plan to working with the Federal Government and industry to develop a marine decarbonization initiative[32].

## Industry Leadership

Regardless of the speed at which policies and regulations are implemented internationally, industry continues to move towards decarbonization.

Cargo owners are increasingly facing customer and investor expectations to decarbonize their operations across the entire supply chain. In some industry segments, there is a clear green premium for low- or zero-emission products[33].

In response, many have announced their own GHG reduction targets – some even ahead of regulatory requirements – and are integrating these goals into their business strategies.

For example, global shipping giant Maersk has announced plans to achieve net zero GHGs by the year 2040[34]. The company's plan is bolstered by a commitment to making dual fuel engines the standard for all newbuilt Maersk vessels.

Significant uncertainty remains as to the speed at which marine transportation decarbonization will occur and what technologies that will be adopted in support. However, it is clear that the aim to reduce GHG emissions in the sector is a long-term and resilient trend. The adoption of low-carbon fuels will play an important role in achieving GHG emissions reductions, and the remainder of this discussion paper will focus on what opportunities this presents for marine transportation in NL.

---

[29] https://sdgs.un.org/partnerships/canada-joined-zero-emission-shipping-2050-initiative
[30] https://tc.canada.ca/en/marine-transportation/marine-pollution-environmental-response/green-shipping-corridors/framework
[31] https://www.gov.nl.ca/eccc/files/Attachment-NZAC-Summary-of-Recommendations-2024-12-30.pdf
[32] https://www.gov.nl.ca/eccc/files/25207-Climate-Change-Mitigation-Plan-June-27-.pdf
[33] https://brandcentral.dnv.com/original/gallery/10651/files/original/216954a7-8cc8-49b6-b99e-37e76a41410a.pdf
[34] https://www.maersk.com/sustainability/all-the-way-to-net-zero

# 6. About Low-Carbon Fuels

Clean fuels, or 'low-carbon' fuels are fuels that produce much lower GHGs than traditional fuels on a life-cycle basis[35]. As, by definition, low-carbon fuels have a lower carbon intensity than conventional fuels. Their increased production and use is viewed as being vital in the world's fight against climate change and the pursuit of net zero.

Before exploring the opportunities for low-carbon fuels within NL's marine transportation, it is important to have general understanding of the relevant types of fuels and how they are generally produced and used.

## 6.1 Categorizing Low-Carbon Fuels

There are many types of low-carbon fuels.

Low-carbon fuels can be produced from a variety of feedstocks, such as agricultural and forest biomass, waste materials, electricity, and fossil fuels with carbon capture and storage[36].

Some low-carbon fuels can be used to supplement conventional fuels; some can be used as a direct replacement for conventional fuels within existing equipment and infrastructure; while others are replacements that require new equipment and infrastructure.

It is helpful to categorize low-carbon fuels into three categories that acknowledge these important differences: (1) biofuels; (2) renewable biofuels; and (3) e-fuels.

### Biofuels

Biofuels are fuels made from recently living organic matter (biomass) like plants, agricultural waste, or animal fats, offering alternatives to fossil fuels. There are a wide variety of biofuels depending on the type of biomass used and the processes used in their creation. Biomass can be converted to fuels through different processes including direct combustion, thermochemical and chemical conversion, and biological conversion. A biofuel can be produced with much lower GHGs than their fossil fuel-based counterparts, and when 'burned' can also be less harmful. However, as they are not chemically identical

[35] https://natural-resources.canada.ca/energy-sources/clean-fuels/clean-fuels-fueling-future
[36] https://natural-resources.canada.ca/energy-sources/clean-fuels/clean-fuels-fueling-future

to their conventional fuel counterpart (i.e., biodiesel vs. diesel), most often biofuels cannot directly replace fuels at a 1:1 ratio without causing harm to equipment. To achieve environmental benefits, biofuels are most often blended with petroleum-based products to reduce the GHG intensity of their use. 'First generation' biofuels are those made from sugar, starch, or vegetable oil. Their feedstocks are those that might have an impact on food supply if used in large quantities. 'Second generation' biofuels are those made from sustainable feedstocks as defined by the feedstock's availability, its impact from a GHG perspective, and land use[37].

## Renewable Biofuels

Produced through a different method ('catalytic pyrolysis'), 'renewable' biofuels are chemically identical to their petroleum-based counterparts (i.e., diesel and renewable diesel).

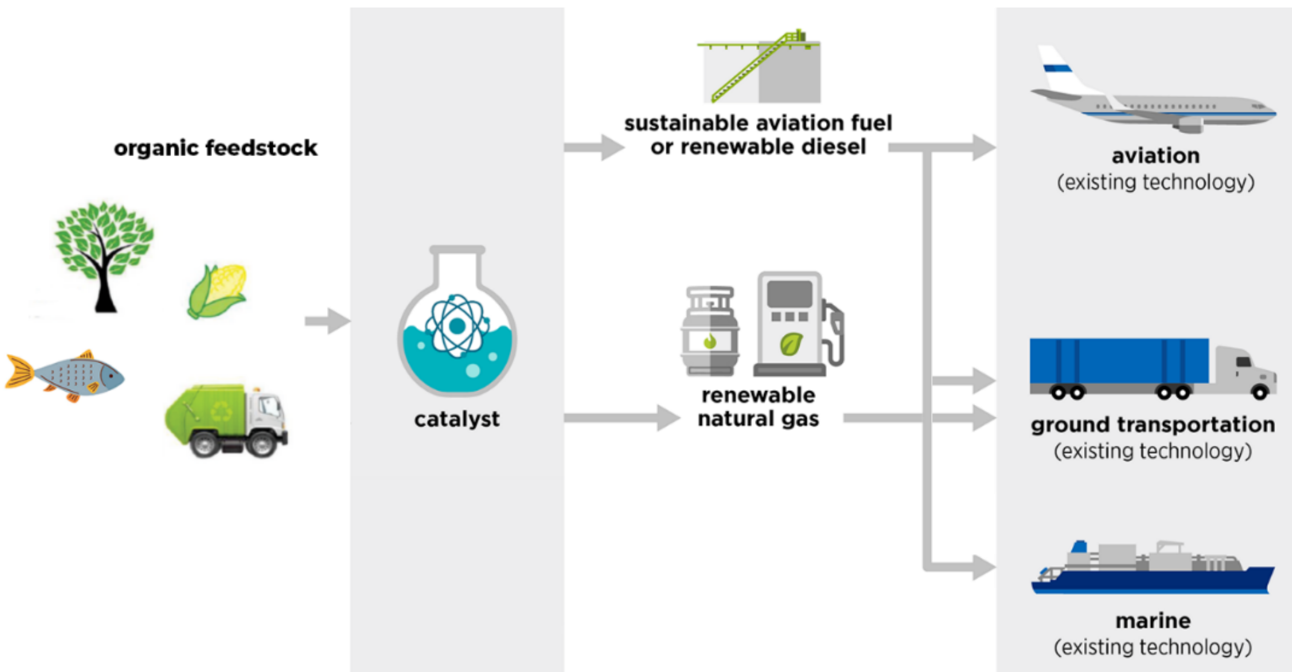



*Figure 10: Examples of renewable biofuel pathways*

This means that renewable biofuels can potentially be used as a direct replacement (i.e., as a 'drop-in') for conventional fuels in existing technology (i.e., combustion turbines, car/truck/ship engines, other heavy equipment) if not a heavy additive in blending. The concept of blending is defined explored in detail further in the report. This also means that existing transportation, storage, and refueling infrastructure can be used – simplifying the logistics of decarbonization.

---

[37] https://econext.ca/wp-content/uploads/2025/06/Biomass-Energy-Potential-NL-Version-1.0-2025-06-11.pdf

### E-Fuels

E-fuels (electro-fuels) are synthetic fuels produced through electrolysis, which splits water molecules into hydrogen and oxygen using renewable electricity[38]. The most commonly discussed e-fuel is hydrogen, but the category includes fuels that have hydrogen as one of the key components. E-fuels are viewed as being instrumental in the fight against climate change and the global pursuit of net zero as they generally emit significantly less GHGs than fossil fuel alternatives, and their main component – hydrogen – can be produced using clean energy sources.

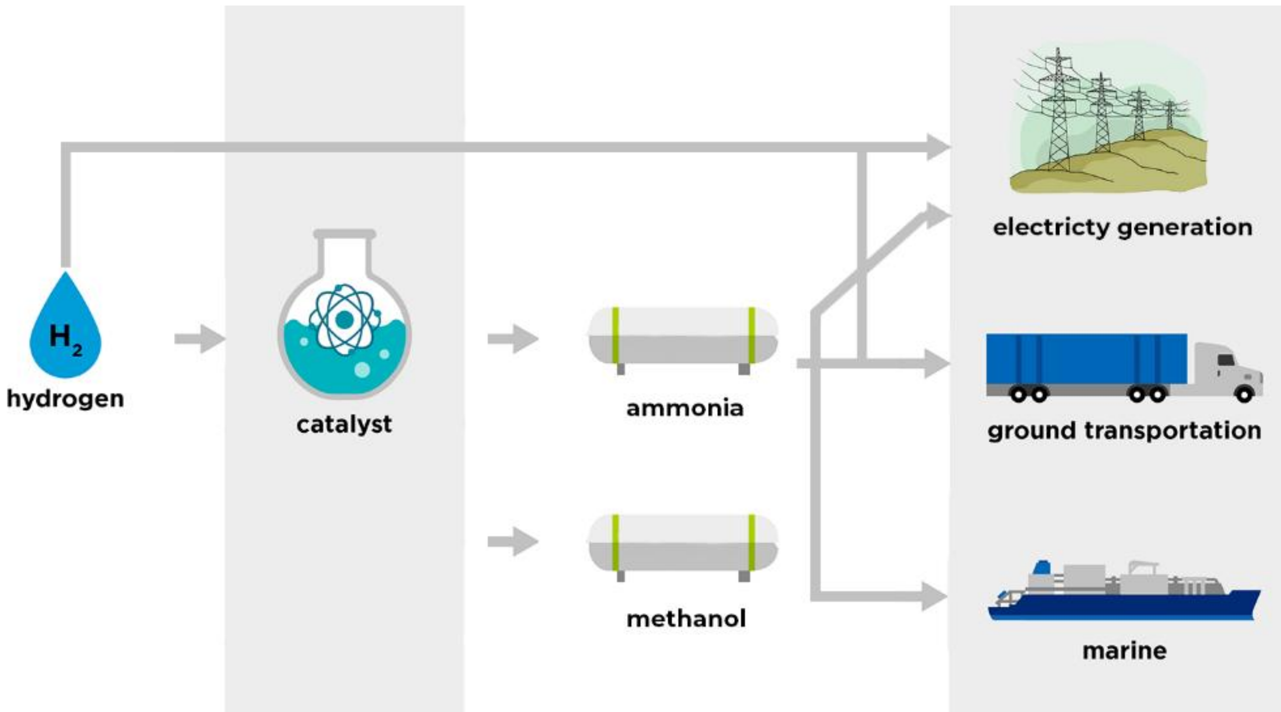



*Figure 11: Examples of e-fuel pathways*

There are a number of different terms that are being used to describe fuels with a lower carbon intensity that conventional fuels, often used interchangeably and sometimes incorrectly. However, in econext's experience, using these three terms (biofuels, renewable biofuels, and e-fuels) has proven to be the most effective approach to categorizing and communicating these fuels.

'Low-carbon fuels' is a catch-all term describing any fuel with a lower carbon intensity than the status quo fuel.

---

[38] https://spectra.mhi.com/energy-transition/what-are-e-fuels-and-can-they-help-decarbonization

## 6.2 Low-Carbon Fuels Relevant to Marine Transportation

There is a wide range of fuels with distinct characteristics and use cases that are relevant in the context of marine transportation.

### Liquified Natural Gas (LNG)

LNG is natural gas in its liquid form. LNG is produced by purifying natural gas and super-cooling it to -260°F to turn it into a liquid[39]. LNG is more expensive than natural gas due to higher production and storage costs but is valuable in transportation applications that require longer ranges due to its higher density[40] – including marine transportation. While still a fossil fuel, the use of LNG as a marine fuel offers several benefits, including reduced emissions: LNG combustion produces lower levels of sulphur oxides (SOx), nitrogen oxides (NOx), particulate matter, and carbon dioxide ($CO_2$) compared to heavy fuel oil (HFO). LNG is being embraced in the marine transportation sector as a potential transitional fuel as the industry looks towards a carbon-neutral future that includes non-fossil fuels[41].

### Biomethane / Renewable Natural Gas (RNG, Bio-LNG)

Biogas is a renewable source of methane gas produced when organic matter breaks down without oxygen[42]. Biogas can come from a variety of sources, including municipal solid waste landfills, anaerobic digester plants at water resource recovery facilities (wastewater treatment plants), livestock farms, food production facilities, and organic waste management operations[43] for use in place of (or in tandem with) fossil natural gas. The biological matter that's used to produce biogas will naturally decay anyway, so capturing the gases produced by this decay, and using them as an energy source, causes less harm to the environment than allowing them to escape into the atmosphere[44].

Biomethane – or 'Renewable Natural Gas (RNG)' – refers to biogas that has also been cleaned and conditioned to remove or reduce non-methane elements allowing it to be used as a replacement for (or supplement to) traditional natural gas or LNG[45]. Bio-LNG is interchangeable with conventional natural gas; bio-LNG can be mixed with conventional

---

[39] https://afdc.energy.gov/fuels/natural-gas-basics
[40] https://afdc.energy.gov/fuels/natural-gas-basics
[41] https://www.lr.org/en/knowledge/research/fuel-for-thought/lng/
[42] https://biogasassociation.ca/biogas_101/
[43] https://afdc.energy.gov/fuels/natural-gas-renewable
[44] https://www.nationalgrid.com/stories/energy-explained/what-is-biogas
[45] https://afdc.energy.gov/fuels/natural-gas-renewable

LNG or fully replace it. Because of this, RNG has the same potential as a fuel within the marine transportation sector.

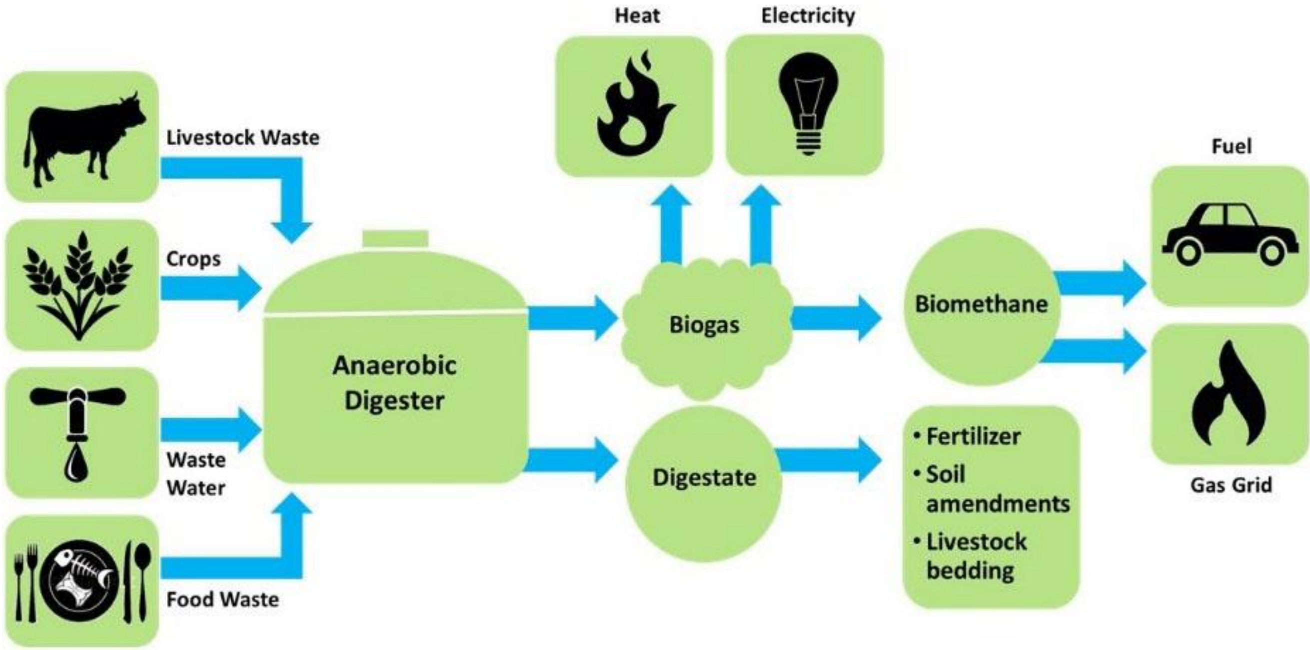



*Figure 12: Examples of biomethane pathways*[46]

## BioLPG

Propane and liquid petroleum gas (LPG) is relied on in many parts of the world for the powering of appliances, grills, heating systems, and even refrigerators. BioLPG is a renewable fuel that is chemically identical to propane and LPG. BioLPG is made from sustainable resources, such as crop residue, vegetable oils, and municipal waste with the most common production process is hydrotreating (also called hydrogenation)[47]. Propane, LPG, and BioLPG can be blended together or used interchangeably without the need for any modification from the end-user, creating opportunities for increased production and use of BioLPG worldwide. From a marine transportation perspective, large vessels which carry and transport LGP are increasingly able to burn the LPG it carries as a fuel[48], however at present the technology is not scalable to other vessel types. There are safety challenges to consider in the use of BioLPG. LPG mixed with air is a fire and explosion hazard if it is used and stored incorrectly. It is also toxic to inhale at high concentrations. Lastly, LPG in its liquid form could cause cold burns if the skin is not properly insulated[49].

---

[46] https://www.eesi.org/papers/view/fact-sheet-biogasconverting-waste-to-energy
[47] https://www.ferrellgas.com/tank-talk/blog-articles/what-is-biolpg/
[48] https://www.argusmedia.com/en/news-and-insights/latest-market-news/2580101-barriers-impede-lpg-as-a-marine-fuel-study
[49] https://www.argusmedia.com/en/news-and-insights/latest-market-news/2580101-barriers-impede-lpg-as-a-marine-fuel-study

## Biohydrogen

Biohydrogen refers to hydrogen obtained from biogenic sources (for example, biogases and biomass) using a variety of technologies including biological, thermochemical, and bioelectrochemical processes[50]. For example, the vast majority of hydrogen used today is produced via natural gas through a process called 'steam methane reforming' (SMR). Consider that RNG is chemically identical to natural gas; a low-carbon hydrogen can be produced with biomass as the original feedstock via SMR using RNG. While biohydrogen itself is not expected to be used in large quantities in NL, it is mentioned here because of the potential uses of green hydrogen and the potential for biohydrogen as a supplement.

## Bio-methanol

Biogas can also be refined to produce bio-methanol. Whereas RNG is gaseous, the compound can be further refined into a liquid alcohol (bio-methanol)[51]. Methanol is a light, versatile, colourless and flammable alcohol. Methanol is used as a solvent for lacquers, paints, varnishes, cements, inks, dyes, plastics and various industrial coatings. It is also used in the production of pharmaceuticals, formaldehyde and other chemical products. Methanol appears as an ingredient in many products, from industrial solvents to windshield-washer fluid and nail-polish remover. It can also be used as a fuel and is a viable option for various applications with increasing interest in its use in power generation and adoption within the marine transportation sector. In an internal combustion engine, methanol reacts with the oxygen in the air to create energy with carbon dioxide and water as the residuals.

## Ethanol

Ethanol is a renewable, alcohol-based fuel made primarily from the fermentation of plant materials like corn, sugarcane, wheat, wood fibres, or other biomass feedstocks – potentially even wood waste from the construction and demolition industry. Ethanol is commonly blended with gasoline and blending is required in most jurisdictions in North America. With a higher octane value than gasoline, ethanol improves the effectiveness of the fuel by preventing engine knocking. Typically, gasoline contains E10 (10% ethanol, 90% gasoline), which reduces air pollution[52]. Quebec has recently introduced legislation which

---

[50] https://www.europeanbiogas.eu/wp-content/uploads/2025/06/Decarbonising-Europes-hydrogen-production-with-biohydrogen.pdf
[51] https://methanol.org/wp-content/uploads/2020/04/IRENA_Innovation_Renewable_Methanol_2021.pdf
[52] https://afdc.energy.gov/fuels/ethanol-fuel-basics

will require a 12% ethanol blend by 2026 and 15% by 2030[53], with other provinces already having made these commitments. NL has a permanent exemption from requirements in Canada for ethanol blending, but its use on a voluntary basis presents opportunity for the decarbonization of the surface transportation sector.[54] Ethanol is gaining traction as a future marine transportation fuel due to the fact it mixes easily with methanol.

### Biodiesel

Biodiesel is a diesel fuel substitute made from renewable materials such as: plant oils (canola, soy, flax, etc.), waste cooking oil (yellow or tap grease), other oils (tall, fish, and algae), animal fats (beef or sheep tallow, pork lard, or poultry fat); and potentially from cellulosic feedstock consisting of agriculture and forest biomass.

The process to create biodiesel is called 'transesterification.' Made from renewable resources biodiesel has the potential to reduce GHG emissions by over 80% on a lifecycle basis.[55] Biodiesel is most often used blended with conventional diesel (see 'Blending Fuels' above). As such, biodiesel has applications in NL that mirror those of conventional diesel – including use in the marine transportation sector as diesel is a very common fuel.

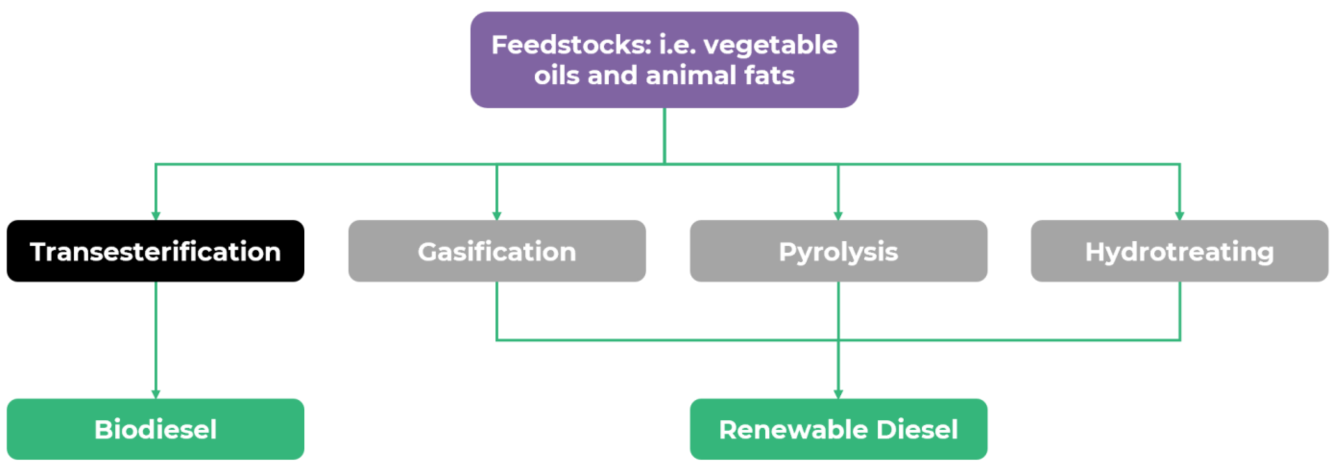



*Figure 13: Example of Biodiesel and Renewable Diesel production pathways*

[53] https://www.ctvnews.ca/montreal/article/quebec-rolling-out-higher-ethanol-blend-in-gasoline-starting-this-week/
[54] Biofuel Technologies: Lessons Learned and Pathways to Decarbonization - https://onlinelibrary.wiley.com/doi/10.1111/gcbb.13091
[55] https://natural-resources.canada.ca/energy-efficiency/transportation-energy-efficiency/biodiesel

## Renewable Diesel

Similar to biodiesel in terms of feedstock, renewable diesel is a fuel made from fats and oils, such as soybean oil or canola oil – however the process utilized in fuel production is different. Produced most often by hydrotreating, and also via gasification, pyrolysis, and other biochemical and thermochemical technologies, the resulting fuel is chemically identical to conventional diesel[56] but has a much lower lifecycle carbon footprint. This means that renewable diesel can be used as a direct replacement for conventional diesel (i.e., as a 'drop-in'), if not a heavy additive in blending.

While renewable diesel has a similar chemical structure to diesel, it has been shown to produce equal or lower levels of NOx and PM emissions when burned. In addition, traditional diesel contains aromatic compounds present in distillates that contribute to toxicity, whereas renewable diesel does not contain such compounds and as a result, has a decreased environmental toxicity and a higher degradation rate. As such, in the case of a spill, renewable diesel has less short and long-term environmental effects compared to conventional fossil fuels[57].

Renewable diesel is produced in NL; Braya Renewable Fuels has converted the Come by Chance refinery to produce up to 18,000 barrels per day of renewable diesel[58]. Renewable diesel has applications in NL that mirror those of conventional diesel – including use in the marine transportation sector. Renewable diesel production requires hydrogen.

## Green Hydrogen

Hydrogen is the most abundant element in the universe. When burned, hydrogen produces only water vapour, resulting in zero GHG emissions which makes it an attractive fuel source. Hydrogen has been a widely used input in a variety of industries for many years and can be produced through a variety of methods[59]. The vast majority of hydrogen used today is produced via natural gas through a process called 'steam methane reforming' ('grey hydrogen'). This process can be paired with carbon capture and storage (CCS) to produce hydrogen with much fewer resulting GHGs ('blue hydrogen').

---

[56] https://afdc.energy.gov/fuels/renewable-diesel
[57] https://econext.ca/discussion-paper-opportunities-for-domestic-clean-fuels-use-in-newfoundland-and-labrador/
[58] https://brayafuels.com/
[59] https://www.siemens-energy.com/global/en/home/products-services/solutions-usecase/sustainable-fuels.html#Hydrogen-tab-0

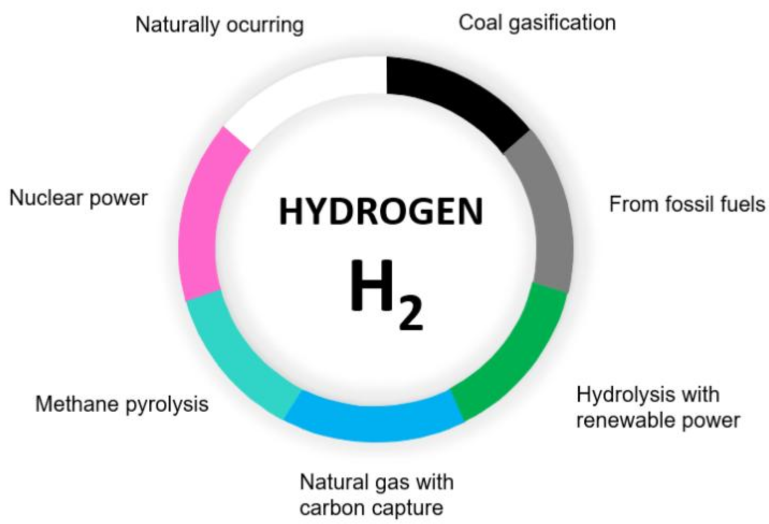



*Figure 14: Hydrogen production pathways and colour associations*[60]

'Green hydrogen' is when hydrogen is produced through a process called 'electrolysis' utilizing renewable energy. Green hydrogen can be produced with zero GHGs and be 'burned' resulting in zero GHGs – positioning it strongly as an important contributor in the fight against climate change. Green hydrogen is expected to be produced in NL in the early 2030s with a focus on export markets. Hydrogen's low energy density compared to conventional fuels necessitates larger storage tanks, impacting ship design and cargo capacity. While pure hydrogen might struggle with long-distance journeys, it could be suitable for short-sea shipping or powering port equipment[61]. Hydrogen's role in shipping, however, is seen to be significant overall as it is a key input into other low-carbon fuels with significant adoption potential.

## Liquid Organic Hydrogen Carrier (LOHC)

Hydrogen is light gas with low energy density, making storage and transportation costly. For this reason, a number of different fuels which feature hydrogen as one of the primary elements are being considered as 'hydrogen carriers' as they have more favourable characteristics for transport and storage. LOHC is one of these 'hydrogen derivative' fuels and allows hydrogen to be chemically bonded to a liquid carrier making it safer and more efficient to handle. LOHCs can be transported easily using existing diesel infrastructure, with the organic compound removed near the point where hydrogen is to be used. These organic compounds are capable of reversible hydrogenation – binding and releasing hydrogen through chemical reactions[62]. Much of the organic compound can be 'recycled'

[60] https://jpt.spe.org/twa/the-color-palette-of-the-colorless-hydrogen
[61] https://www.lr.org/en/knowledge/research/fuel-for-thought/hydrogen/
[62] https://www.deassociation.ca/newsfeed/what-is-lohc-liquid-organic-hydrogen-carrier

and bonded with hydrogen again many times. Given the potential LOHC has as a hydrogen carrier and the fact it may be produced within NL by the early 2030s[63], it presents opportunities for hydrogen use within the province that are not practical if transporting and storing hydrogen in its pure state. Moreover, innovation relating to all-electric marine vessels that utilize LOHC technology is advancing[64].

## Green Methane

Methane has been used as a fuel and, later, a chemical feedstock since it was discovered and isolated in the 18th century. It is four parts hydrogen and one part carbon. Methane is a key component of natural gas (90%) and historically has been taken either directly from natural gas fields or as a by-product of other fossil fuel extraction[65]. However, methane can be synthetically created through the combination of hydrogen and carbon dioxide. When green hydrogen is used in this process (along with sustainably sourced carbon dioxide), the resulting fuel is green methane (or 'e-methane'). Similar to biomethane, green methane is chemically identical to conventional methane and thus can be used as a heavy blend (or replacement for) natural gas. Green methane production has been commercialized at a relatively small scale, with most projects tied to existing biogas/biomethane plants; supplying green hydrogen in addition to anaerobic digestion can reportedly increase methane output by 60% compared to typical biogas upgrading[66]. As natural gas is primarily methane, and methane is primarily hydrogen, green hydrogen can be used in the decarbonization of natural gas / LNG / RNG and their applications.

## Green Methanol

Methanol is one part carbon, three parts hydrogen, one part oxygen, and one part methyl group ($CH_3OH$). Methanol as a fuel has several potential benefits, including low emissions, low cost, and excellent energy density. Methanol is water-soluble and readily biodegradable. With hydrogen being a primary component, the use of green hydrogen in methanol production results in 'green methanol' or 'e-methanol'. Liquid methanol has a higher energy density than gaseous hydrogen, making it practical for transport and storage. Low-carbon methanol (including bio-methanol and green methanol) is increasingly being viewed as a fuel of choice within the international marine transportation sector. Methanol as a fuel has several potential benefits, including low

---

[63] https://www.greenenergyhub.ca/
[64] https://www.lr.org/en/knowledge/press-room/press-listing/press-release/2018/developing-standards-for-all-electric-ships-with-lohc-technology/
[65] https://enapter.com/en/blog/the-promise-of-green-methane/
[66] https://www.idtechex.com/en/research-article/e-fuels-explained-methanol-methane-diesel-and-saf/34444

emissions, low cost, and excellent energy density. It is biodegradable and miscible in water – reducing the environmental impacts of a potential spill. However, methanol does have corrosive characteristics which requires specific storage and handling arrangements. It has a low flashpoint and toxicity, requiring increased safety systems[67].

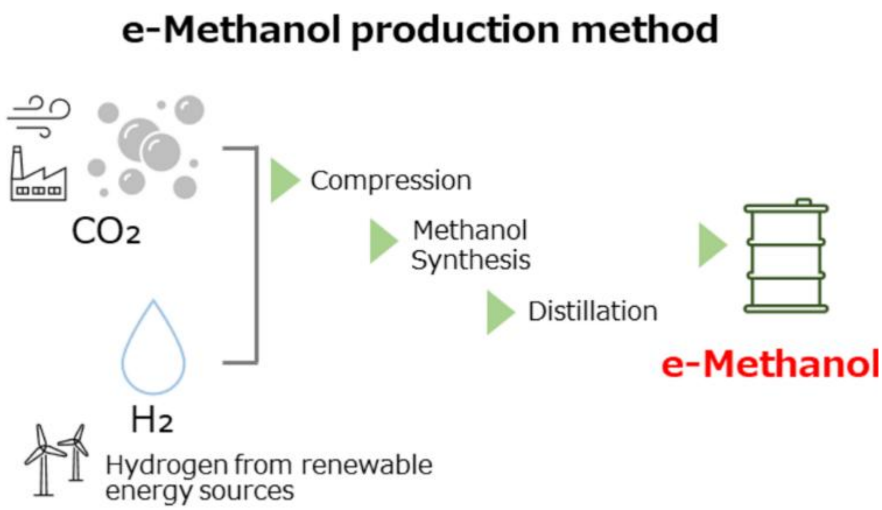



*Figure 15: e-methanol production method[68]*

## Green Ammonia

Ammonia is one part nitrogen and three parts hydrogen ($NH_3$). Similar to green methanol, ammonia can be produced using green hydrogen resulting in a clean fuel that is commonly referred to as 'green ammonia' or 'e-ammonia'. Ammonia can be used in a variety of applications with an international focus on chemical processing, fertilizer production, marine transportation, and some early work in electricity generation. Its high energy density and low viscosity make it a suitable option as a 'hydrogen carrier' or as a method to transport hydrogen long distances.

Unlike traditional marine fuels, ammonia is virtually free of sulphur oxide (SOx) and particulate matter (PM) emissions, contributing to cleaner air quality. Ammonia can be used in a variety of marine engines, including dual-fuel engines that can switch between ammonia and conventional fuels. Its high energy density and low viscosity make it a suitable option for long-range shipping operations. Challenges such as its toxicity, storage, and handling safety need to be addressed when discussing ammonia's suitability as a marine fuel[69]. Notably, a final investment decision is expected to be made on a large green

---

[67] https://www.lr.org/en/knowledge/research/fuel-for-thought/methanol/
[68] https://www.idemitsu.com/en/business/oil/lowcarbon/e-methanol_future.html
[69] https://www.lr.org/en/knowledge/research/fuel-for-thought/ammonia/

ammonia production in NL before 2030[70] with production being export-focused for international markets.

Low-carbon fuel adoption trends – which will help dictate NL's marine transportation decarbonization strategies – are explored in Section 7.

## 6.3 Benefits of Low-Carbon Fuels

There are a number of benefits to the adoption of low-carbon fuels that should be considered in decision-making.

**Decreased GHGs:** The use of low-carbon fuels allows for lifecycle GHG reductions. These reductions will either be associated with the direct use of the fuel (e.g., a clean fuel will produce far fewer GHGs) and/or the displacement of conventional fossil fuels. The amount of GHGs replaced will depend on the low-carbon fuel used and what is displacing.

**Reduced air pollutants:** The use of low-carbon fuels is often associated with the reduction of other air pollutants such as particulates (tiny particles of solid matter that lodge in the lungs and deposit on buildings), carbon monoxide, sulfur dioxide, hydrocarbon, and other air toxins[71]. Each low-carbon fuel and the process used in their deployment will result in unique reductions. The amount of air pollutants reduced will depend on the low-carbon fuel used and what it is displacing.

**Energy security:** Many low-carbon fuels can be produced using local renewable resources (i.e., biomass, electricity, etc.) Even when locally produced fuels are blended with conventional fuels, this: (1) displaces the volume of fuel that must be imported; (2) protects against supply and supply chain disruptions caused by geopolitical events; (3) protects against price volatility of globally traded commodities; and (4) provides for domestic fuel production and supply capabilities that can be called on when needed in an emergency. For example, a diesel fuel blended with 30% locally produced biodiesel and renewable diesel displaces 30% of the required diesel to be imported and the geopolitical impacts on that import which are out of the user's control.

**Valorization of wasted resources:** Oftentimes organic waste material (e.g., household organic waste, forestry residues, fishing and aquaculture discards, agricultural waste) are sent to landfill. This 'waste' is actually a resource which has value and can be considered as feedstock for low-carbon fuels production. Morevoer, the diversion of these waste streams

---

[70] https://evrec.ca/project/

[71] https://advancedbiofuels.ca/net-zero

away from landfills reduces the harmful GHGs that are caused by the decomposition of biomass.

**Economic development and growth:** The production and distribution of low-carbon fuels (including the diversion of biomass from landfills) creates jobs, wealth, and improved environmental outcomes for communities. Many low-carbon fuels have value and opportunity domestically, while also are tradeable commodities on a regional, national, and global scale. As various biomass-derived fuels are interoperable with their e-fuel counterparts, there are opportunities for the scaling of production utilizing electricity as an additional feedstock.

## 6.4 Blending Fuels

Fuel types do not necessarily need to be homogeneous or used exclusively. As alluded to earlier throughout this paper, fuels can be used in conjunction with one another through blending.

### Purpose of Blending

Blending allows for the realization – even if in part – of the benefits to low-carbon fuel use as described above. While the blending of fuels does not provide the environmental benefits that the wholesale adoption of low-carbon fuels might, given the long lifespans of equipment and low turnover rate, blending presents an immediate opportunity to achieve GHG emissions reductions.

Blending can be done on an incremental basis, allowing for its users to become comfortable with the use of low-carbon fuels over time, ensure minimal disruption with existing equipment, and also to grow alongside with the available supply.

Fuel blending is likely to become more important over time as (a) pressures continue to mount worldwide to lower the carbon intensity of fuels produced and consumed, while (b) the availability of low-carbon fuels to meet this demand is likely to be in short supply.

### Blending of Different Fuels

In some cases, the degree to which fuels can be blended is limited.

This is specifically the case for biodiesel. As biodiesel is not chemically identical to conventional diesel, it is most often an additive in a blend with conventional diesel. A blend classified as B2, for example, is 98% petroleum diesel and 2% biodiesel. B20 is a blend of 80% petroleum diesel and 20% biodiesel. Blending of biodiesel with diesel has become commonplace; the majority of North American engine manufacturers now endorse up to a B5 biodiesel blend[72]. Generally, B20 and lower-level blends can be used in current engines without modifications. In fact, many diesel engine original equipment manufacturers (OEMs) approve the use of B20[73]. Blending potential is specific to the equipment, its manufacturer, and warranty coverage.

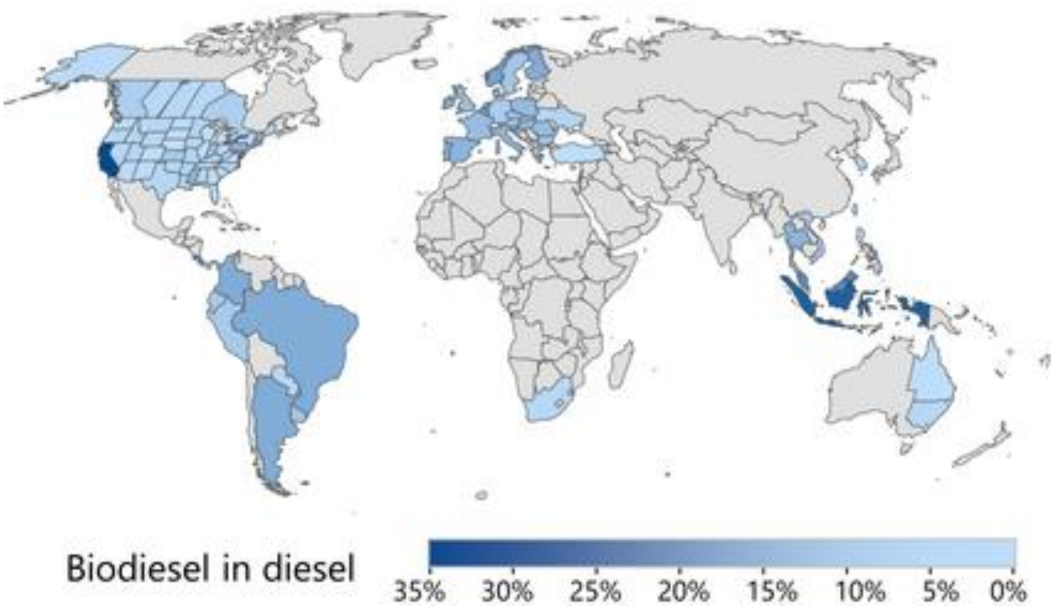



*Figure 15: Global Biodiesel Blending Mandates[54]*

Another similar case is the potential to blend low-carbon methane with natural gas. While a significant amount of low-carbon methane can be blended due to having the same chemical makeup as the methane component of natural gas, methane totals 90% of the makeup of natural gas so 100% replacement is not possible.

Similarly, there is the potential to blend low-carbon hydrogen with natural gas. Hydrogen can be blended with natural gas and delivered through its existing infrastructure for end-use appliances such as stoves, water heaters, generators, etc[74]. Existing natural gas equipment can typically handle a blend of up to 15% hydrogen without compromising performance or safety[75].

---

[72] https://natural-resources.canada.ca/energy-efficiency/transportation-energy-efficiency/biodiesel
[73] https://afdc.energy.gov/fuels/biodiesel-blends
[74] https://www.cga.ca/natural-gas-101/hydrogen-a-lower-emitting-and-versatile-fuel
[75] https://www.csagroup.org/article/research/appliance-and-equipment-performance-with-hydrogen-enriched-natural-gases

### Blending of Same Fuels

In other cases, the low-carbon fuel is chemically identical to its fossil fuel counterpart and can be blended at any ratio at it will not change the composition or characteristics of the original or resulting fuel. This is the case with diesel and renewable diesel.

### Multi-Fuel Blends

Blending does not necessarily need to be limited to two fuels. For example, the Canadian Coast Guard is testing fuel blends composed of 10% biodiesel, 40% renewable diesel, and 50% conventional diesel[76] in its ships[77].

Fuel blending can be done in many different existing engine types and does not require expensive vessel retrofits. There are many different possible fuel blends with optimizations unique to engine types and their uses indicating a need to focus on R&D that meet the needs of particular regions and the nature of marine transportation within them.

# 7. Low-Carbon Fuel Adoption Opportunities in NL's Marine Transportation Sector

Before considering low-carbon fuel adoption opportunities in NL, a brief overview of international adoption trends is instructive as this will impact localized strategies.

## 7.1 International Low-Carbon Fuels Adoption Trends

### Biofuels and Renewable Fuels

Overall, biofuels are considered technologically ready for deep-sea shipping, as they can be used as drop-ins or blends with minor modifications to existing engines, machinery, and storage systems. This simplifies the transition from existing fossil-derived fuels.[78].

---

[76] https://www.ccg-gcc.gc.ca/corporation-information-organisation/greening-initiatives-ecologisation-eng.html
[77] https://www.canada.ca/en/canadian-coast-guard/corporate/about-us/greening-initiatives.html
[78] https://www.lr.org/en/knowledge/research/fuel-for-thought/biofuel/

This is creating surging demand from the marine transportation sector for biofuels worldwide. For example, in a scenario where there are no supply constraints, it is estimated that global demand for biodiesel in shipping could go well past 140 million tonnes of fuel oil by 2028. This is compared to total biofuel production capacity expectations of peaking – in best-case circumstances – at around 120 million tonnes in the same time period.

Total supply could drop sharply to just 40 million tonnes when sustainability criteria—prioritizing cleaner, second-generation biofuels—are applied[79]. One of the solutions to the supply issue is the incorporation of additional feedstocks into biofuels productions – especially urban waste and forest product processing residues fuels[80].

Considering that biofuels are in high demand in other sectors (i.e., electricity, surface transportation), when production risks, actual output levels, and competition from other sectors are taken into account, the volume of biofuels realistically available for the marine transportation industry dwindles even further.

Despite their drop-in compatibility with current ships, biofuels are not expected to be as scalable as e-fuels and life cycle emissions can vary significantly depending on feedstock and production process[81]. However, the potential for biofuels to reduce GHGs in the near term through blending should not be ignored, nor should its potential to continue to factor into the energy mix in the long term – albeit at a smaller scale. By 2050, biodiesel and bio-LNG are predicted to continue to be used widely[82].

The above means that biofuels and renewable fuels will be in significant demand and have an important role to play in the decarbonization of the marine transportation sector worldwide in the near and medium terms. Yet this role is limited based on expected supply difficulties. Therefore, in the longer term the marine transportation sector will be looking to other types of fuels.

[79] https://www.offshore-energy.biz/report-surging-shipping-demand-points-to-looming-biofuel-supply-crunch/
[80] https://www.ieabioenergy.com/wp-content/uploads/2025/04/IEA-Bioenergy-TCP-Task-39-T3-Maritime-Biofuel-Hinders-Report-revised.pdf
[81] https://globalmaritimeforum.org/news/zero-emission-shipping-fuels-methanol-and-ammonia/
[82] https://maritime.lr.org/l/941163/2023-09-04/86cyj/941163/1693881339KV19NyGO/LR_Fuel_Mix_Report_v1.pdf

## Vessels on Order

When projecting long-term demand in the marine transportation sector for e-fuels (i.e., low-carbon fuels beyond biofuels and renewable fuels), statistics on vessels on order – or 'in the order book' – can provide important insights.

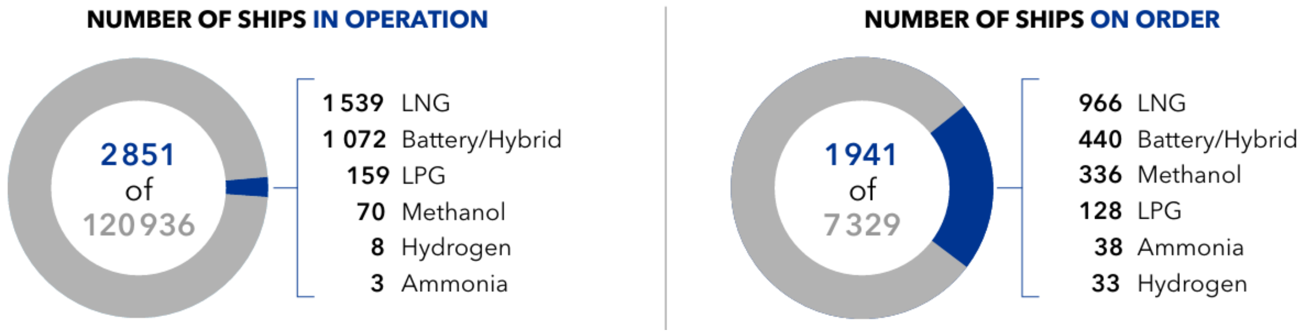



*Figure 16: Alternative fuel technology uptake in the world fleet in the number of ships[83]*

As of August 2025, the increasing trend of ordering larger ships with dual-fuel propulsion capabilities continues, with a similar share of the gross tonnage on order being alternative fuel-capable. The uptake of LNG vessels is dominating, followed by methanol-capable vessels. The containership segment continues to have the highest number of methanol-fuelled ships on order[84].

Interviews and analysis of planned investments suggest that over 60% of future vessel purchases are focused on low-carbon methanol and ammonia, although most remain at an early stage. Analysis shows that the container segment has seen the greatest increase in demand for green shipping solutions, while decisions around bulk are made closely with those that are shipping specific cargo[85].

While these insights have great value, the number of vessels currently in operation and the typically long lifespans of vessels must be factored into decision-making. While over 25% of vessels on the order book are alternative fuel capable, this still means that just under 75% of orders are being made with conventional fuels in mind. Thus. the importance of decarbonizing marine transportation fuels currently in use (i.e., through blending) will be significant.

[83] https://www.dnv.com/maritime/maritime-forecast/
[84] https://www.dnv.com/maritime/maritime-forecast/
[85] https://www.shell.com/business-customers/marine/decarbonising/_jcr_content/root/main/section_945430094/promo_copy_copy_1424/links/item0.stream/1685556533872/b8cfc522e207d5e92a19b9f5943f9eb1f73a9d10/all-hands-on-deck-digital-thirty-first-may.pdf

### Future Fuel Demand Implications

The above suggests a number of key findings which are important when considering the potential for low-carbon fuel adoption within NL's marine transportation sector.

1. Given the long lifespan of vessels and the fact that 75% of vessels on the order book will use conventional fuels, **biofuels and renewable fuels** will play an important role for many years to come (either as primary fuels or within blends).
2. **LNG** is emerging as a fuel of choice for future vessels which creates opportunities for the use of **RNG**. This also creates opportunities for green hydrogen blending, as many marine engines can safely run on a mixture that includes 25% **hydrogen**[86]. Innovators will push these limits over time.
3. **Green methanol** is emerging as a fuel of choice for future vessels. This creates opportunities for green **hydrogen** and the use of captured **CO2** – as these are the two key ingredients in green methanol production. This also creates new **biofuels** opportunities – with bio-methanol and ethanol having the potential to be blended in mixtures.
4. **Green ammonia** is approaching proof of concept as a shipping fuel, with the first ammonia-powered vessels successfully piloted, engine testing near completion, and bunkering trials underway at major ports[87]. However, the order book suggests that its adoption may not be as widespread as green methanol.
5. **Hydrogen** appears as a potential input in many pathways (including in the production of renewable diesel).

## 7.2 Likely Low-Carbon Fuels Adoption Scenarios in NL

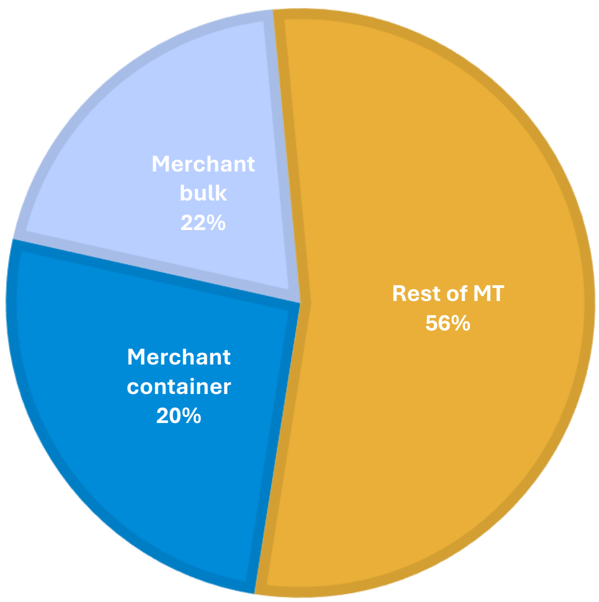
With an understanding of the technologies being deployed to support marine transportation decarbonization and international marine low-carbon fuels policy and technology trends, a more in-depth examination of sectoral GHG sources in NL's marine transportation sector can yield important insights that will help inform decision-making relating to the decarbonization of the sector within the province. Unless otherwise indicated, the incumbent fuel for marine transportation segments in NL is diesel.

---

[86] https://www.wartsila.com/insights/article/hydrogen-fuel-for-thought-in-our-q-a

[87] https://globalmaritimeforum.org/news/zero-emission-shipping-fuels-methanol-and-ammonia/

## Shipping (Merchant Container, Merchant Bulk)




In 2024, 'merchant container' was responsible for 20% of NL's marine transportation GHGs, while 'merchant bulk' was responsible for 22%. These categories both involve the movement of goods and most often to or from international ports. Therefore, for a significant portion of NL's marine transportation GHGs (42%), a high degree of international collaboration is required between vessel owner / operators, ports, fuel suppliers, etc. in decarbonization.

NL is likely not in a position to influence the trajectory of low-carbon fuels adoption for this highly international sector, however it can act to ensure that it is providing the fuels that the sector needs. This will protect existing trade routes for the province – and potentially open up new ones.

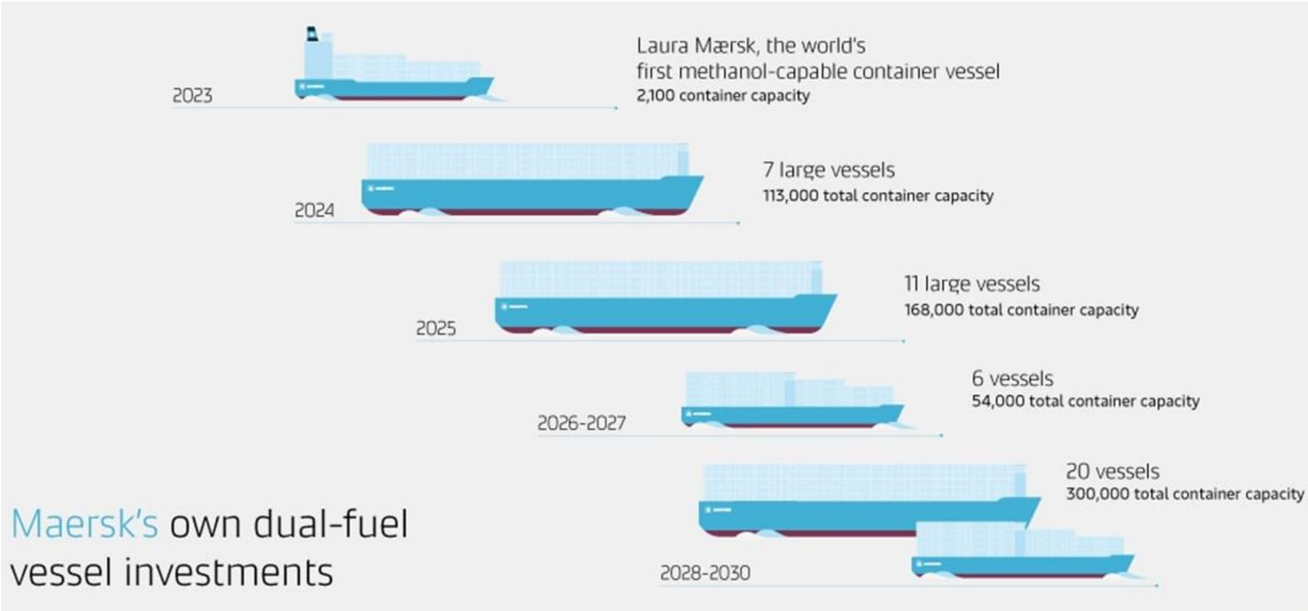
A significant majority of this traffic arrives at the Port of St. John's, with further analysis required to fully delineate points of origin and destinations involving NL.

International shipping will be the driver for the adoption of low-carbon fuels. NL should be aware of the technology pathways key owners/operators (that have a port of call in in the province) are choosing to ensure that ports are in a position to provide supply. For example, Maersk planned to add 19 dual-fuel container ships capable of running on methanol between 2023-25[88].

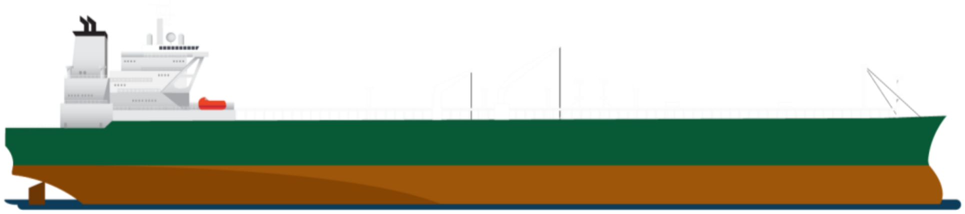
As decisions around merchant bulk are made closely with those that are shipping specific bulk cargo (i.e., iron ore, nickel), NL should maintain close dialogue with relevant industrial

[88] https://www.reuters.com/business/sustainable-business/maersk-agrees-project-with-spain-make-e-methanol-its-fleet-2022-11-03/

operators. For example, in 2026 Vale announced the pioneering of a vessel that would run primarily on ethanol, resulting in GHG reductions of 90% compared to the alternative[89].

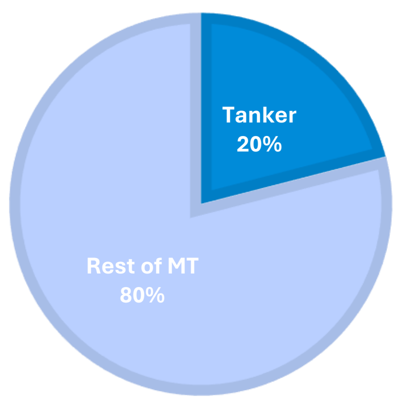



*Maersk dual-fuel vessel investments[90]*



## Tanker

In 2024, 'tanker' traffic was responsible for 20% of NL's marine transportation GHGs. At least 70% of tanker traffic is the transport of crude oil, with the vast majority being between Whiffen Head / Come by Chance and offshore oil and gas facilities like Hebron, Hibernia, White Rose, and Terra Nova.

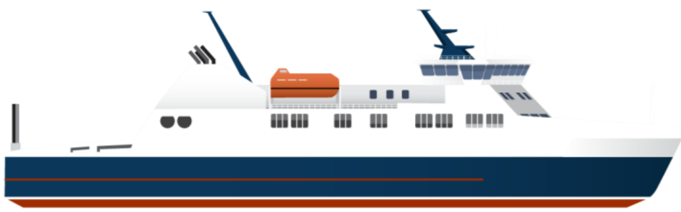


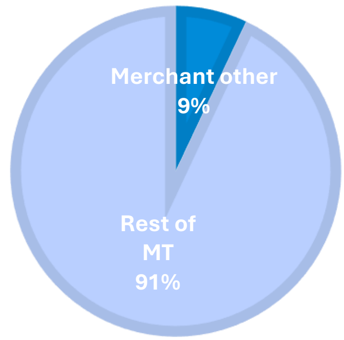

---

[89] https://vale.com/w/vale-announces-the-worlds-1st-ethanol-powered-ocean-going-vessel-carbon-emission-reduction-can-reach-90

[90] https://www.maersk.com/sustainability/all-the-way-to-net-zero

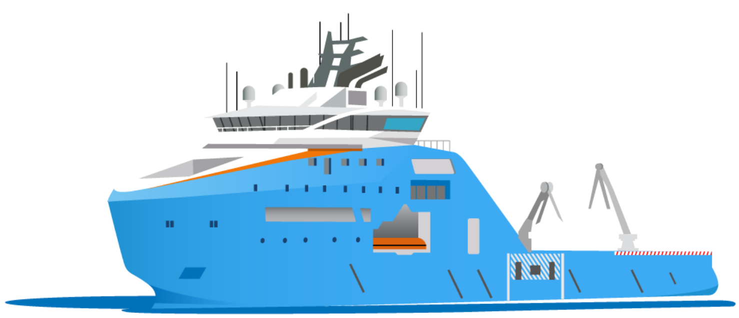
Tankers are similar to large container and bulk ships in terms of their potential for low-carbon fuels adoption. This means biofuels and renewable fuels (for blending) in the near and medium term, and the potential for adoption of e-fuels in the longer term. One distinction is that tankers have more routes with both NL departures and arrivals; 60% of tanker traffic has both a Canadian origin and destination. These factors suggest that there is more of an opportunity to influence the speed and type of technology adoption in the tanker category (versus container and bulk) as much of the marine traffic is within national jurisdiction.

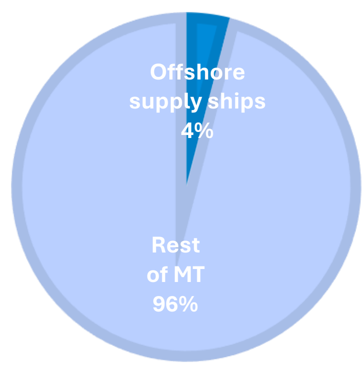





## Domestic Shipping (Merchant Other)

In 2024, 'Merchant other' was responsible for 9% of NL's marine transportation GHGs. This category typically involves the movement of goods that are not containerized or classified as 'bulk'. More work is required to fully characterize this activity in NL, but vessels within this segment typically share the characteristics of shorter routes. Low-carbon fuels are highly relevant to this segment, but there may be more electrification opportunities to be realized than in other categories[91].






## Offshore Supply Vessels

In 2024, offshore supply ships were responsible for 4% of NL's total marine transportation GHGs, a percentage that rises to 8% if viewing through the lens of Canadian GHG

[91] https://www.shell.com/business-customers/marine/decarbonising/_jcr_content/root/main/section_945430094/promo_copy_copy_1424/links/item0.stream/1685556533872/b8cfc522e207d5e92a19b9f5943f9eb1f73a9d10/all-hands-on-deck-digital-thirty-first-may.pdf

accounting and reporting. The vast majority of offshore supply traffic is between offshore oil and gas installations (Hebron, Hibernia, White Rose, Terra Nova) and the Port of St. John's with some traffic to the Port of Long Pond, Bull Arm, and Bay Bulls. Fuel blending presents a significant decarbonization opportunity for offshore supply vessels. Due to their relatively short transit routes, they are also a candidate for increased electrification or hybrid propulsion systems.

For example, in 2021 Atlantic Towing began working to retrofit one of their four offshore supply ships, the Atlantic Shrike, with electric battery technology. Following the retrofit, the Atlantic Shrike has delivered strong and measurable results: 11% fuel savings across all operations; 362 tonnes of $CO_2$ reductions in 2024, verified by operational data; reduced engine noise, improving crew comfort; and lower engine running hours, extending maintenance intervals and enhancing working conditions in the engine room[92].

With approximately 18% of NL's marine transportation emissions directly related to the support of the offshore oil and gas industry, there may be an opportunity for collaboration to further advance the industry's low-carbon credentials as compared to other oil producing jurisdictions.

### Fishing

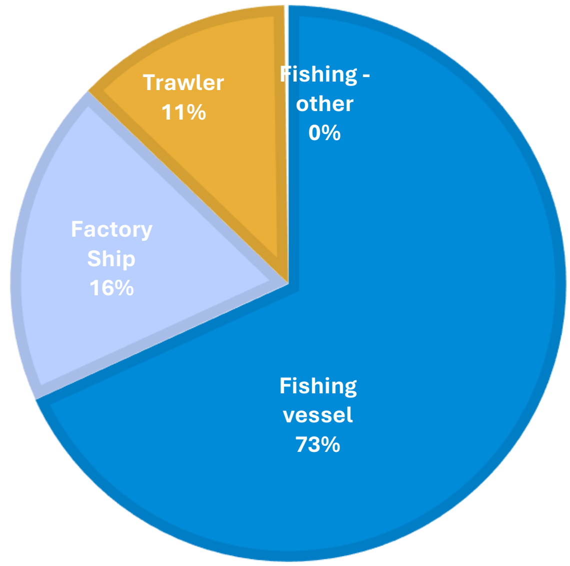
In 2024, fishing vessels were responsible for 5% of NL's total marine transportation GHGs, a percentage that rises to 8% if viewing through the lens of Canadian GHG accounting and reporting. There are many fishing vessels in NL, many of which are small, and most of which are independently owned and operated.

The MEIT differentiates this segment between 'fishing vessels' (73% of fishing GHGs), 'trawlers' (11% of fishing GHGs), 'factory ships' (a large ocean-going vessel with extensive on-board facilities for processing and freezing – 16% of fishing GHGs), and 'other' (close to 0% of fishing GHGs). More research is required to better characterize vessels in the province's fishery.

---

[92] https://www.vard.com/articles/atlantic-shrike-achieves-11-fuel-reduction-with-seaq-energy-storage-system

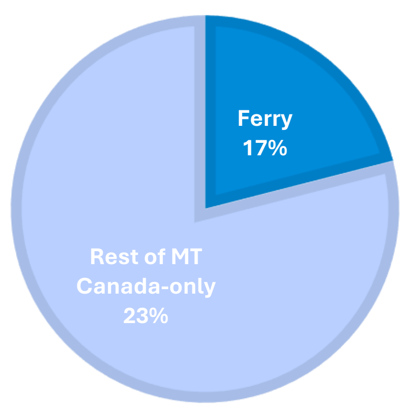
With so many variables to consider in fishing, and the fact each trip is often so important to its owner's livelihood, propulsion needs to be highly reliable and easy to use. Decarbonization solutions must meet the needs of the vessel owners and operators; these needs vary significantly between the sub-categories listed – with many being small boats with small crews.




These factors challenge the adoption of low-carbon fuels which would require new and different safety protocols.[93] To ease the transition towards new fuels those which are more similar to fossil marine diesels should be used. This suggests that the most direct decarbonization opportunity in the near term is fuel blending. Electrification may be suitable for fishing vessels which are typically have shorter routes. This is less true of larger fishing vessels like trawlers operated by larger companies. These companies have the capacity to progress more quickly towards electrification and the adoption of clean fuels.

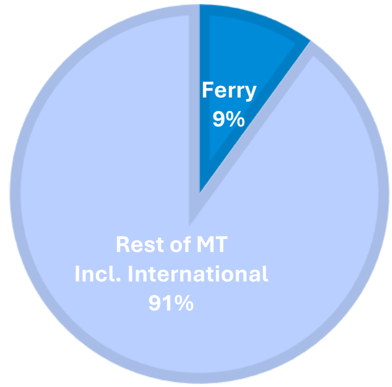
## Ferries

In 2024, ferries were responsible for 9% of NL's total marine transportation GHGs, a percentage that rises to 17% if viewing through the lens of Canadian GHG accounting and reporting. Some travel categorized in the MEIT under "Merchant other" ("Merchant RO/RO") appears to be ferry activity based on the ports of departure and destination. Further analysis is suggested as the resulting GHG increase attributed to ferries may not be immaterial. As such, it is likely that ferries are in fact responsible for more than 17% of NL's marine transportation GHGs.




[93] https://www.tandfonline.com/doi/full/10.1080/1059924X.2025.2453056?src=exp-la

NL's provincial government is directly responsible for 14 ferry routes as either the owner/operator of vessels or the contracting party for ferry services. Meanwhile, a federal crown corporation (Marine Atlantic) is responsible for ferry traffic between NL and NS. The ferry service between Fortune, NL and Saint-Pierre and Miquelon is owned and operated by the French territorial government.




While more research is needed to confirm the analysis, 44,984 tonnes of CO2e of ferry traffic in 2024 can be attributed to Marine Atlantic routes between Sydney and Port aux Basques and Argentia. This represents 48% of all ferry emissions.

Meanwhile the remainder can be attributed to routes operated (or contracted) by the provincial government[94]:

- Bell Island – Portugal Cove
- St. Brendan's – Burnside
- Fogo Island – Change Islands – Farewell
- Long Island – Pilley's Island
- Charlottetown – Norman's Bay
- Goose Bay – Rigolet – Ports North to Nain
- Goose Bay – Cartwright – Black Tickle
- Blanc Sablon – St. Barbe (Strait of Belle Isle Area)
- La Poile – Rose Blanche
- Ramea – Grey River – Burgeo
- Francois – Grey River – Burgeo
- Gaultois – McCallum – Hermitage
- Rencontre East – Bay L'Argent – Pool's Cove
- South East Bight – Petite Forte

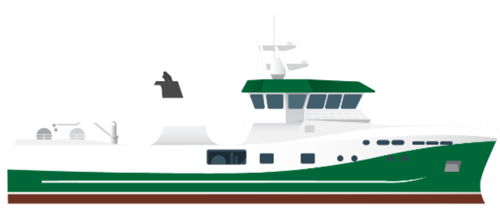
More research is required to estimate the GHG emissions that are associated with specific ferry routes. Ferries are the perfect segment for electrification and battery power. Short, regular routes between the same ports makes it easier to charge regularly and reduces the need for large batteries[95]. Hybrid systems provide similar opportunity in situations where there is increased risk averseness.

For In the near term the most direct decarbonization opportunity is fuel blending. It is important to note that Marine Atlantic's newest vessel, the *Ala'suinu*, incorporates dual

[94] https://www.gov.nl.ca/ti/ferryservices/schedules/
[95] https://www.dnv.com/expert-story/maritime-impact/showcasing-innovations-in-the-ferry-industry/

fuel technology and is equipped with batteries to further reduce its carbon footprint. The ship runs on diesel (as with the rest of its fleet) but has LNG capability. This presents various future opportunities for emissions reductions in NL – ranging from the supply of LNG, the supply of RNG, to the blending of hydrogen.

As provincial and federal governments make decisions on the futures of their ferry fleets, they should be mindful about how these decisions can affect the environment while supporting economic development and energy security.



### Tug - Harbour

Tugboats escort vessels from the open ocean into ports to provide extra layers of safety in case the ship loses power, or its rudder fails. These tasks require tugs to be powerful and maneuverable. Despite the relatively small size of tugboats, their powerful propulsion systems allow them to exert enormous force – a necessity given the important role that they play.

Tugs used for short distances (such as for ports or small harbours) are prime for full electrification with backup generators and can provide quicker and more powerful tugging. Tugs used for longer hauls would typically be more suited for hybrid electric configurations[96]. In the near term the most direct decarbonization opportunity is fuel blending.

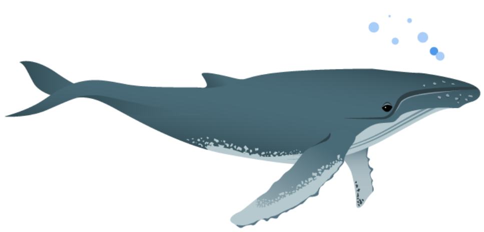
Harbour tugs represented 1% of NL's marine transportation GHGs in 2024, with 'tug-ocean' representing just over 0.8%. While these are not significant contributions on a provincial level, the decarbonization of these vessels may be more meaningful to the ports that industries that they serve.

[96] https://clearseas.org/insights/why-make-tugs-electric/

## Cruise Ships

Cruise ships can vary significant in size, which would influence their movement towards either low-carbon fuels adoption or battery electrification. More than 15% of the vessels set to launch over the next five years will be fully equipped to integrate fuel cells or batteries and 85% of CLIA-member vessels coming online between now and 2028 will be able to plug into shoreside electricity[97].

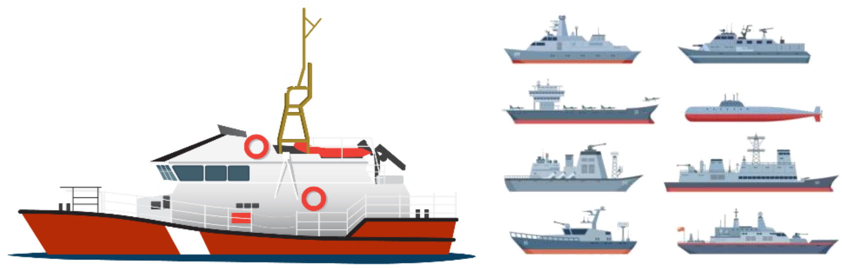
Most cruise ships arriving in NL are relatively large. Shoreside power connectivity is particularly important to the cruise industry as it improves air quality for its passengers when docked. Therefore, from an environmental and business development perspective, the provision of electricity infrastructure in ports like St. John's, Corner Brook, and St. Anthony should be considered, Meanwhile, cruise companies are actively testing the use of low-carbon fuels in their fleet. In the near term the most direct decarbonization opportunity is fuel blending.



## Excursion passenger

This type of vessel is similar to ferries in that the voyages of tourism boats in NL are typically short and regular between the same ports. Therefore, this segment is ideal for electrification and battery power as inventory turns over. In the near term the most direct decarbonization opportunity is fuel blending.

[97] https://porthole.com/cruise-industry-commits-to-pursue-net-zero-carbon-for-global-cruising-by-2050/



### Other (Special purpose, Coast guard, War, DFO Fishing Surveillance Vessell)

The types of vessels can vary significantly in these categories. In most cases these vessels travel great distances and spend significant time offshore. Electrification will not likely be the most practical decarbonization solution. Owners of these vessels are typically more risk averse (i.e., governments, contractors on strict timelines conducting complex tasks and maneuvers) therefore it is likely these segments will not be the first movers in adopting new fuel technologies. In the near term the most direct decarbonization opportunity is fuel blending.

# 8. Recommendations

Low-carbon fuels adoption pathways for marine transportation are difficult to predict. Approaches are likely to diverge from one another depending on the sector in question. In some of the segments of marine transportation, NL has little control over decarbonization pathways that are chosen. Yet, in other segments, NL does have a degree of control.

This analysis of low-carbon fuels adoption possibilities within NL's marine transportation sector reveals a number of next steps which should be taken in order for environmental, economic, and energy security benefits to be realized.

## 8.1 Create the enabling conditions to allow for the adoption of renewable diesel in NL's marine transportation sector

Renewable diesel is produced in NL and it is a fuel which is expected to play a significant role in the decarbonization of the marine transportation sector worldwide. Increased use of renewable diesel within the sector domestically within NL will result in reduced GHGs while also creating economic growth and development opportunities for local industry. To realize these opportunities, collaboration will be required between fuel producers, end users, logistics and service providers, and ports.

## 8.2 Define best use cases for available biomass in NL and techno-economic feasibility of low-carbon fuels production

From RNG to ethanol, there are multiple fuel production pathways using locally available biomass that are relevant in the marine transportation sector context. Moreover, there are multiple different sources of biomass that each has their own characteristics influencing how they would be best used in fuel production. Lastly, there are other fuel demands that are expected to arise over time within the province – particularly in support of the electricity and surface transportation sectors. A techno-economic analysis is required to determine the best end uses at a provincial level for each of these organic waste materials (in addition to landfill gas) and the feasibility of low-carbon fuel production and adoption business cases. This study should include research identifying the best available commercial technologies that align with best use cases and the NL context, as well as consideration for the various supports and frameworks (i.e., ITCs, CRF, CER, waste diversion, etc.) that can impact economics.

## 8.3 Work with industrial operations in NL on sector-level marine transportation decarbonization strategies that support the use of local low-carbon fuels

There are a small number of large-scale industrial operations in NL which require the dedicated use of vessels in the transportation (export) of raw materials. Substantive marine transportation GHG emissions are associated with the oil and gas industry ('tanker', 'supply vessel') and the mining industry ('merchant bulk'). Collaboration with these industries to advance GHG reduction strategies that incorporate the use of locally produced low-carbon fuels has the potential to yield significant environmental, economic, and energy security benefits for the province.

## 8.4 Ensure future ferries procured in NL use locally produced low-carbon fuels

Ferries contribute 17% of all domestic marine transportation GHGs in NL. Federal and provincial governments are owners, operators, and/or contractors of these services. Therefore, there is a direct opportunity for Canada and NL to make independent decisions on technologies to be adopted. Ferries that use locally produced low-carbon fuels will result in reduced environmental impacts, greater energy security, and the economies of communities and the province at-large.

## 8.5 Leverage local hydrogen production to position NL globally as a supplier of low-carbon fuels for the marine transportation sector

Final investment decisions are expected to be made in 2027 on hydrogen and ammonia production projects in NL. Green hydrogen is an important input for a variety of different low-carbon fuels important to the marine transportation sector – from renewable diesel and LNG to green methanol. The presence of domestic green hydrogen production opens the door to many possibilities including the expansion of international trade routes that incorporate NL ports of call and the establishment of green shipping corridors.

## 8.6 Invest in fuel blending/testing research and infrastructure

While different decarbonization pathways exist for each vessel type, the potential for fuel blending is a common factor. More focus needs to be placed on testing and trialing fuel blends in NL. To overcome industry risk aversion with the adoption of new technologies, adequate research and development capabilities in terms of equipment and personnel is required. These capabilities must be relevant to the NL context and accessible. Blending and testing capabilities are understood to be few and difficult to access in Canada, presenting an opportunity for the province to create facilities that would be in-demand and attract interest and investment. The testing of biodiesel and renewable diesel blends in real-world NL scenarios should be an immediate priority, followed by hydrogen and relevant derivates.

## 8.7 Improve education, awareness, and skills development specific to the use of low-carbon fuels

As the marine transportation sector is so intricately tied with the culture and livelihoods of NLers, it is important to consider what decarbonization pathways will mean for people, workers, and communities. Efforts in the near term to demystify new technologies and processes will pay off in the medium and long term.

## 8.8 Enable marine transportation decarbonization through electrification infrastructure

While not specific to low-carbon fuels, a low-hanging fruit in marine transportation decarbonization in NL is reducing 'berthed' or hoteling GHGs – which were estimated to be 8% of all sector GHGs in NL in 2024. NL is an ideal location for shorepower given its 90%+ clean electricity grid. Shoreside infrastructure is a key enabler of marine transportation decarbonization and is within NL's direct control to provide. More search is required to better understand the demand and supply particulars in vessel electrification.

# 9. Conclusion

There are important benefits to be realized from the adoption of low-carbon fuels in NL's marine transportation sector: decreased GHGs; reduced air pollutants; increased energy security; the valorization of wasted biomass resources; and economic development and growth within NL.

While adoption pathways are difficult to predict with precision, there is enough evidence to suggest that a focus on biofuels, renewable diesel, and hydrogen and its derivatives has the potential to greatly benefit the province.

# Appendix A

The table below summarizes total marine transportation GHG's in NL from 2025-2014 in CO2e metric tonnes – including traffic to and from international ports.

| Category | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Merchant container** | 172,353 | 169,842 | 253,008 | 272,946 | 271,533 | 246,772 | 230,270 | 270,057 | 269,108 | 217,540 |
| **Merchant bulk** | 142,772 | 160,038 | 218,549 | 212,254 | 211,223 | 243,813 | 232,608 | 245,855 | 231,877 | 246,196 |
| **Tanker** | 207,440 | 228,265 | 249,163 | 277,594 | 281,784 | 317,266 | 246,794 | 247,907 | 295,352 | 217,846 |
| **Merchant other** | 78,500 | 70,091 | 85,299 | 81,064 | 86,657 | 76,414 | 80,765 | 71,422 | 79,369 | 102,868 |
| **Offshore supply ship** | 71,777 | 53,352 | 58,495 | 55,500 | 72,205 | 41,210 | 34,671 | 43,661 | 42,324 | 45,471 |
| **Tug - ocean** | 27,590 | 23,231 | 30,746 | 32,776 | 26,265 | 10,684 | 5,448 | 2,905 | 2,212 | 9,021 |
| **Tug - harbour** | 7,201 | 9,621 | 9,881 | 11,057 | 10,194 | 11,039 | 7,696 | 7,283 | 7,897 | 7,110 |
| **Fishing** | 30,543 | 33,043 | 36,597 | 46,638 | 37,986 | 35,776 | 51,467 | 42,698 | 41,042 | 50,160 |
| **Ferry** | 87,634 | 97,025 | 86,185 | 84,080 | 91,908 | 80,009 | 85,279 | 99,896 | 98,491 | 104,963 |
| **Cruise ship** | 16,864 | 16,347 | 25,894 | 26,100 | 34,397 | 216 | - | 41,916 | 57,393 | 69,720 |
| **Excursion passenger** | 40 | 226 | 166 | 93 | 48 | - | 79 | 96 | 31 | 13 |
| **Special purpose** | 14,392 | 19,253 | 30,691 | 32,317 | 37,748 | 30,955 | 23,177 | 27,649 | 28,639 | 29,939 |
| **Barge** | 688 | 73 | 2,838 | 624 | 463 | 7,046 | 861 | 798 | 295 | 628 |
| **Coast guard** | 13,176 | 7,514 | 7,689 | 7,975 | 6,989 | 7,789 | 5,985 | 8,714 | 5,647 | 7,064 |
| **War** | 478 | 696 | 183 | 577 | 308 | 785 | 286 | 266 | 174 | 909 |
| **DFO Surveillance** | 2,238 | 1,379 | 1,101 | 1,184 | 1,101 | 784 | 858 | 904 | 559 | 406 |
| **TOTAL** | 873,685 | 889,997 | 1,096,487 | 1,142,778 | 1,170,808 | 1,110,557 | 1,006,243 | 1,112,028 | 1,160,409 | 1,109,854 |

The source for this information is Environment and Climate Change Canada's Marine Emissions Inventory Tool (MEIT - https://ec-meit.ca).

For all data: (1) CO2eq was selected as the measurement; (2) NL is selected as the exclusive "Prov/Terr"; and (3) innocent passage was excluded by selecting "Canadian O/D-Only".

# Appendix B

The table below summarizes total marine transportation GHG's in NL from 2025-2014 in CO2e metric tonnes – excluding traffic to and from international ports. It is these figures which factor into provincial and national GHG reporting.

| Category | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Merchant container** | 172,353 | 169,842 | 253,008 | 272,946 | 271,533 | 246,772 | 230,270 | 270,057 | 269,108 | 217,540 |
| **Merchant bulk** | 142,772 | 160,038 | 218,549 | 212,254 | 211,223 | 243,813 | 232,608 | 245,855 | 231,877 | 246,196 |
| **Tanker** | 207,440 | 228,265 | 249,163 | 277,594 | 281,784 | 317,266 | 246,794 | 247,907 | 295,352 | 217,846 |
| **Merchant other** | 78,500 | 70,091 | 85,299 | 81,064 | 86,657 | 76,414 | 80,765 | 71,422 | 79,369 | 102,868 |
| **Offshore supply ship** | 71,777 | 53,352 | 58,495 | 55,500 | 72,205 | 41,210 | 34,671 | 43,661 | 42,324 | 45,471 |
| **Tug - ocean** | 27,590 | 23,231 | 30,746 | 32,776 | 26,265 | 10,684 | 5,448 | 2,905 | 2,212 | 9,021 |
| **Tug - harbour** | 7,201 | 9,621 | 9,881 | 11,057 | 10,194 | 11,039 | 7,696 | 7,283 | 7,897 | 7,110 |
| **Fishing** | 30,543 | 33,043 | 36,597 | 46,638 | 37,986 | 35,776 | 51,467 | 42,698 | 41,042 | 50,160 |
| **Ferry** | 87,634 | 97,025 | 86,185 | 84,080 | 91,908 | 80,009 | 85,279 | 99,896 | 98,491 | 104,963 |
| **Cruise ship** | 16,864 | 16,347 | 25,894 | 26,100 | 34,397 | 216 | - | 41,916 | 57,393 | 69,720 |
| **Excursion passenger** | 40 | 226 | 166 | 93 | 48 | - | 79 | 96 | 31 | 13 |
| **Special purpose** | 14,392 | 19,253 | 30,691 | 32,317 | 37,748 | 30,955 | 23,177 | 27,649 | 28,639 | 29,939 |
| **Barge** | 688 | 73 | 2,838 | 624 | 463 | 7,046 | 861 | 798 | 295 | 628 |
| **Coast guard** | 13,176 | 7,514 | 7,689 | 7,975 | 6,989 | 7,789 | 5,985 | 8,714 | 5,647 | 7,064 |
| **War** | 478 | 696 | 183 | 577 | 308 | 785 | 286 | 266 | 174 | 909 |
| **DFO Surveillance** | 2,238 | 1,379 | 1,101 | 1,184 | 1,101 | 784 | 858 | 904 | 559 | 406 |
| **TOTAL** | 873,685 | 889,997 | 1,096,487 | 1,142,778 | 1,170,808 | 1,110,557 | 1,006,243 | 1,112,028 | 1,160,409 | 1,109,854 |

The source for this information is Environment and Climate Change Canada's Marine Emissions Inventory Tool (MEIT - https://ec-meit.ca).

For all data: (1) CO2eq was selected as the measurement; (2) NL is selected as the exclusive "Prov/Terr"; and (3) innocent passage was excluded by selecting "Canadian O/D-Only". Canada is selected for both "Country of Origin" and "Country Destination" toggles.

# Appendix C

The list below summarizes the makeup of each vessel category presented in this report according to vessel types and classes used by Environment and Climate Change Canada's Marine Emissions Inventory Tool (MIET – https://ec-meit.ca).

**Merchant Container**
**Merchant Bulk**
**Tanker**
- Tanker - Merchant Crude
- Tanker - Merchant Chemical/Oil Products Tanker
- Tanker - Merchant Chemical
- Tanker - Merchant (Tanker)
- Tanker - Merchant Liquified Gas
- Tanker - Merchant Ore/Bulk/Oil
- Tanker - Merchant VLCC
- Tanker - Merchant ULCC

**Merchant - Other**
- Merchant Auto
- Merchant Cement
- Merchant Coastal
- Merchant Gasoline
- Merchant General
- Merchant Lash
- Merchant Ore
- Merchant Reefer
- Merchant RO/RO

**Offshore Supply Ship ("Tug Supply")**
**Tug Ocean**
**Tug - Harbour**
- Tug Fire
- Tug Workboat
- Tug Harbour
- Tug

**Fishing**
- Fishing - Factory Ship
- Fishing - Fishery Patrol
- Fishing - Fishing Vessel
- Fishing - Gilnetter
- Fishing - Longliner
- Fishing - Trawler
- Fishing - Other Fishing VSL (Open Boat)

**Note:**

Some travel categorized in the MEIT under "Merchant other" ("Merchant RO/RO") appears to be ferry activity based on the ports of departure and destination.

Further analysis is suggested as the resulting GHG increase attributed to ferries may not be immaterial.

**Ferry**
- Merchant Ferry
- Merchant Passenger ("Ferries")

**Cruise Ship**

**Excursion Passenger**

**Special Purpose**
- Special Purpose
- Special Purpose Cable VSL
- Special Purpose Crane Ship
- Special Purpose Diving
- Special Purpose Pilot Boat
- Special Purpose Pipe-Layer
- Special Purpose Research VSL
- Special Purpose Supply VSL
- Special Purpose Survey Ship
- Special Purpose Training VSI
- Special Purposes - Dredge

**Barge**
- Barge Bulk Cargo
- Barge Chemical
- Barge General
- Barge Miscellaneous
- Barge Oil Drilling Rig
- Barge Oil/Petroleum
- Barge Self-Propelled

**Coast Guard**
- Coast Guard Icebreaker
- Coast Guard Lifeboat
- Coast Guard Rescue
- Coast Guard Scientific
- Coast Guard Tender

**War**
- Warship - General
- Warship Surface
- Warship Training
- Warship Undersea

**DFO Fishing Surveillance Vessel**
- DFO Fishering Surveillance Vessel
- Coast Guard Patrol
- Marine Security Patrol CCG-RCMP