

Pacific Northwest to Alaska Green Corridor Green Methanol Feasibility Study

Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping



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Executive Summary	4
Introduction.....	5
Technical Feasibility	5
Alternative Fuels Supply Chain	5
Port and Bunkering Infrastructure	6
Port of Seattle	7
Port of Vancouver.....	8
Vessel Decarbonization	9
Regulatory Feasibility	10
Alternative Fuels Supply Chain	10
Port and Bunkering Infrastructure	11
International Regulations and Guidance.....	11
Vancouver, British Columbia, Canada	11
Seattle, Washington, USA.....	12
Vessel Decarbonization	13
Emission Reduction and Environmental Performance	13
Design and Engineering (IGF/IMO Scope)	13
Fire Protection and Toxicity Controls.....	13
Crew Training and Certification	13
Bunkering Safety (Port Protocols and SIMOPS)	13
Environmental and Spill Response.....	14
Retrofit Considerations.....	14
Passenger Demand Dynamics	14
Cost Assessment.....	15
Gross Incremental Cost Gap	15
Theoretical Gross Incremental Cost Gap Per Cruise Passenger.....	16
Incremental Cost Gap	17
Optimized Financing.....	17
Proposed IMO Regulations	17
Impacts on Cost Per Cruise Passenger	19



Residual Cost Gap	20
Theoretical Cost Assessment	21
Green Premium	21
Cost Management Scenarios	22
Residual Cost Gap	23
CO ₂ e Abatement.....	25
Summary and Key Takeaways.....	25
Key Takeaways	25

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Executive Summary

The Pacific Northwest to Alaska (PNW2AK) Green Corridor project launched in May 2022 as a collaborative partnership between three multi-brand cruise line parent companies, homeports, and several ports of call in the Alaska cruise market to work together to explore low and zero- greenhouse gas (GHG) emission cruising between Washington, British Columbia, and Alaska. 'First Mover' partners in the PNW2AK include Port of Seattle (Seattle, Washington, USA), Vancouver Fraser Port Authority (Vancouver, British Columbia, Canada), Greater Victoria Harbour Authority (Victoria, British Columbia, Canada), the Alaska, USA port communities of Haines, Juneau, Skagway, and Sitka, Carnival Corporation & plc, Norwegian Cruise Line Holdings, Royal Caribbean Group, Cruise Lines International Association (CLIA), the Global Maritime Forum, Blue Sky Maritime Coalition, and Washington Maritime Blue. Partners signed a Project Charter¹ in 2023 to formalize their commitment to the project.

In 2023, First Movers engaged with the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (MMMCZCS) to scope a feasibility study and guide First Movers through their publicly available green corridor feasibility methodology². The Project Consortium, which includes Port of Seattle, Vancouver Fraser Port Authority, CLIA on behalf of the cruise lines, HY2GEN as the fuel producer, and MMMCZCS, signed the Project Commitment letter in January of 2025 to undertake a green methanol feasibility study in alignment with the following:

Vision: Accelerate the decarbonization of cruise operations between Washington, British Columbia, and Alaska

Goals: Determine the feasibility of four cruise vessels' full seasonal Alaskan Itineraries to be fuelled on green methanol by 2032

Project Evaluation Criteria:

- 4 Cruise ships fuelled by green methanol
- Bunkering available at Homeports (Port of Seattle and/or Port of Vancouver)
- First vessel operating by 2030
- All 4 vessels running on green methanol by 2032

The Consortium undertook extensive work to evaluate options and considerations for establishing a green methanol supply chain. While the project is considered technically and regulatorily feasible, the assessment revealed significant gaps in operational readiness and additional challenges that must be addressed. In particular, the regulatory landscape is rapidly evolving to ensure safe vessel operation and bunkering protocols. However, as the project evaluated a U.S.-based fuel supplier, changes to U.S. policy over the last year have introduced new regulatory uncertainties that impact the economics of U.S.-based green methanol production. Moreover, analysis shows that making the project economically viable would require closing a cost gap of exceeding \$1.4 billion (bn)³ USD to support corridor operations over a 25-year period. The additional cost of a green corridor would either require a market willing to pay green premiums for low carbon transportation that would raise costs above typical demand-based ticket prices and/or be sourced through public funding, subsidies or tax credits. Without reliable and credible indicators of a market willing to pay green premiums for such cruise itineraries, the feasibility project's cost model utilized a zero-dollar value for this variable. Additionally, initial efforts to identify other sources of funding, such as incentives or credits, were not substantial enough to offset the \$1.4bn in costs. As a result, the project continues to face challenges in achieving economic feasibility. Further exploration of cost management strategies is required to begin narrowing this gap.

¹ More detailed information can be found here: [Project Charter](#)

² More detailed information can be found here: [Feasibility Methodology](#)

³ All discussed costs in this paper are provided in USD present value

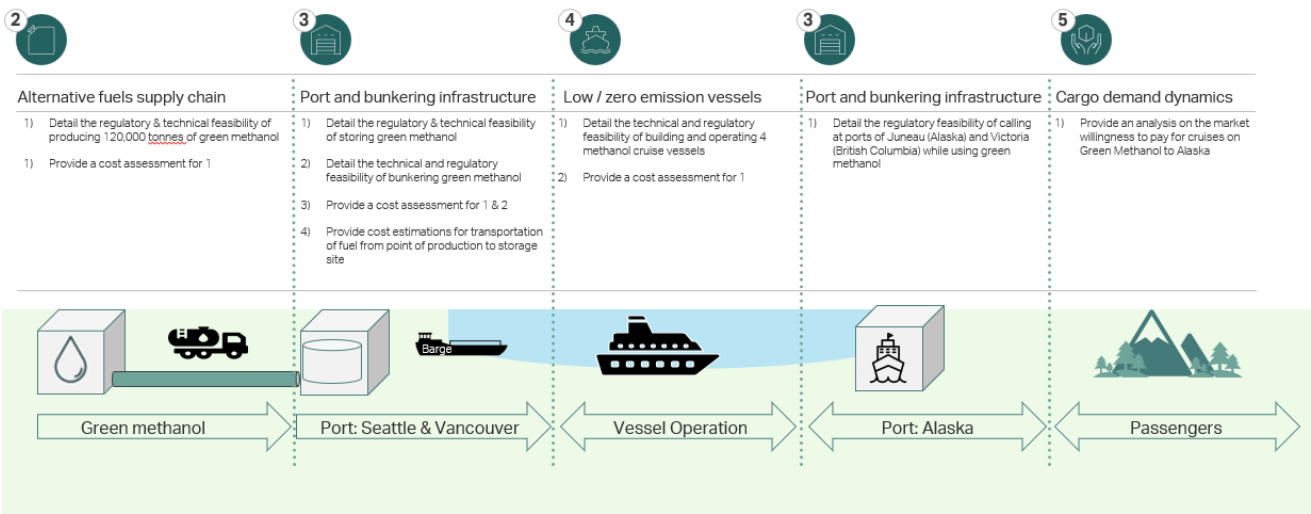
In addition to the feasibility analysis provided by the Consortium, the report outlines a theoretical pathway demonstrating how, under the MMMCZCS methodology, the incremental cost gap could be reduced to a level where public funding might assist in bridging the remaining difference.

Introduction

The PNW2AK Green Corridor project assessed the feasibility of four cruise ships operating seven-day, roundtrip itineraries from Seattle, Washington (WA) or Vancouver, British Columbia (BC) to Alaska by 2032. Based on the project requirements, which assumes each cruise ship makes twenty roundtrip calls in a season and fuel bunkering will only take place at the homeports of Seattle or Vancouver, 120,000t (tonnes) of green methanol would be required annually. If deemed feasible and implemented, the green corridor would enable an estimated 320,000 passengers to sail on low-emission cruises and ~224,000t of CO₂e to be abated each season. All emissions-related statements in this report are based on scenario modelling under defined assumptions and system boundaries. They do not represent guaranteed or realized outcomes, exclude certain lifecycle elements as specified, and should not be interpreted as consumer-facing environmental claims.

MMMCZCS’s feasibility methodology requires consortiums to investigate and confirm that each of the following workstreams are technically and regulatorily feasible for the scope of the project: Workstream 2: Alternative Fuel Supply Chain, Workstream 3: Port and Bunkering Infrastructure, and Workstream 4: Low/Zero Emission Vessels. The methodology also requires cost estimation to be provided by workstream leads to the project lead for establishing costs for all parts of the value chain. Workstream 5: Cargo Demand Dynamics, consider passenger willingness to pay for low carbon transportation. The specific scope for this project is visualized in Figure 1.

Figure 1 – Pacific Northwest to Alaska Green Corridor Scope of Work



Technical Feasibility

Based on insights from consortium members, the project is deemed feasible from a technical perspective. Below are the details for each workstream.

Alternative Fuels Supply Chain

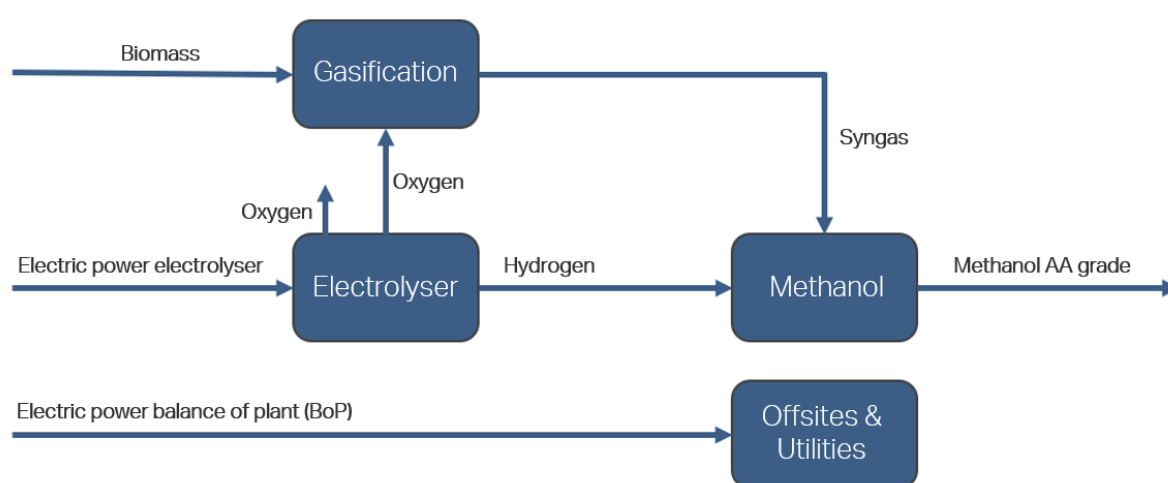
HY2GEN, a German based company producing renewable hydrogen and its derivatives globally, led the alternative fuels supply chain workstream. This workstream evaluated the technical and regulatory feasibility of producing

120,000t per year of AA Grade green methanol⁴ (MeOH) to supply four cruise ships. This study assumes the production plant is in Longview, WA, USA.

The feasibility study and role of commercial partners is informational only and does not include any business arrangements for the purchase or sale of fuels.

The plant assumes a constant power supply need with an onstream time of 8,400 hours/year. Figure 2 provides a visualization of the technical set-up HY2GEN proposes, with renewable hydrogen and oxygen. Biomass would be sourced from a local pellet supplier, and gasification technology would leverage approximately half the oxygen produced through electrolysis that converts biomass to syngas. The hydrogen and carbon monoxide from syngas would then undertake catalytic conversion to produce AA grade methanol.⁵

Figure 2 - Bio-Methanol production process



Port and Bunkering Infrastructure

The port and bunkering infrastructure workstream evaluated the technical and regulatory feasibility of transporting green methanol to the port, storage within the port, bunkering green methanol for cruise ships, and developed cost estimates for fuel transportation, along with storage and bunkering infrastructure.

While the project involves multiple ports, including the two homeports of Seattle and Vancouver, and multiple ports of call in Alaska and Victoria, BC, the feasibility study assumes bunkering will only take place at the homeports. This assumption was based on feedback from the cruise lines that vessels could fulfil a 7-day roundtrip itinerary bunkering methanol once at turnaround. The project did not assess the feasibility of bunkering in Alaska but did evaluate potential infrastructure requirements or regulatory considerations for green methanol-fuelled ships calling in Victoria, BC and Juneau, Alaska. No infrastructure changes were required for ports of call, and the regulatory considerations from Victoria or Juneau were not found to be different than other Canadian or U.S. ports.

To provide resilience to the project, it was agreed that Port of Seattle and Vancouver Fraser Port Authority would each assess the feasibility of transporting, storing and bunkering both 100% of the fuel demand from four cruise vessels

⁴ AA grade methanol refers to a high-purity specification of methanol commonly used in industrial and laboratory applications.

⁵ The renewable electricity to produce green hydrogen is assumed to be through Power Purchase Agreements.

(120,000t/year green methanol) and 50% of the fuel demand (60,000t/year green methanol). This means that three scenarios could be examined:

1. All four itineraries operating from Port of Seattle
2. All four itineraries operating from Port of Vancouver
3. Itineraries split equally between Port of Seattle and Port of Vancouver

This study highlights the different considerations each port faced, and the solutions examined. The following assumptions were used across the Workstream 3 analysis:

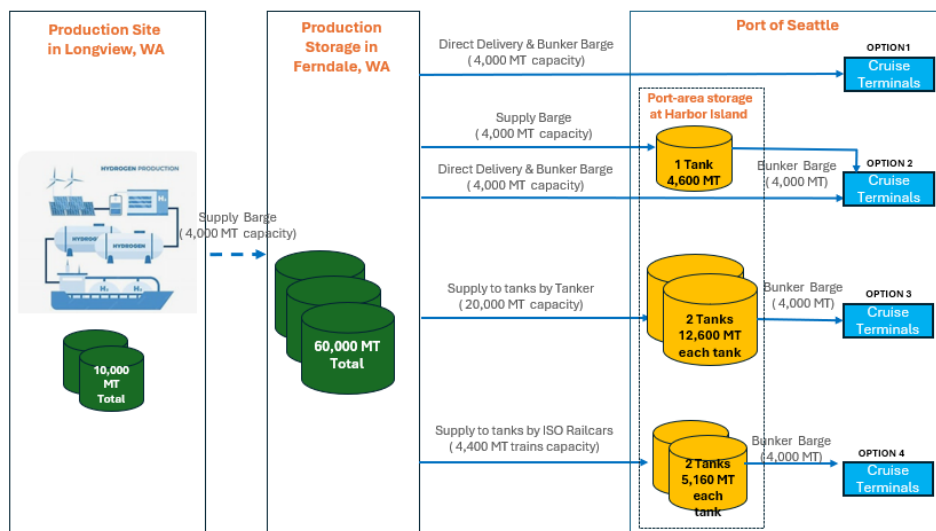
1. Infrastructure costs represent new assets; retrofitting of existing facilities was not evaluated.
2. Only one methanol cruise vessel will be bunkered at any given time, requiring a single bunkering asset and alignment with cruise itineraries.
3. The methanol will be transported from Port of Longview to the Vancouver and Seattle area using conventional fuels. The study scope did not assess the feasibility of green fuels used in fuel transportation.
4. Storage costs at the fuel production facility are factored into the fuel costs.
5. Transportation of methanol via truck and pipeline from the Port of Longview to the homeports is not considered in this study.
6. Tanks and equipment will not be repurposed for other fuels during the off-season.

The Port of Seattle and the Vancouver Fraser Port Authority each conducted independent analyses of fuel transportation, storage, and bunkering infrastructure through separate consultant-led studies. High-level cost estimates for the Cost Assessment portion of this study were derived from multiple sources, including desk research, insights from comparable projects, and discussions with industry stakeholders.

Port of Seattle

Port of Seattle examined four scenarios for end-to-end methanol transportation, storage and bunkering. Each of the scenarios possess the same starting assumptions, as shown in Figure 3, where green methanol is produced at the production plant in Longview, WA with storage capacity at the production site of up to 10,000t, and then transported via a 4,000-tonne capacity supply barge to a large-scale storage facility in Ferndale, WA with capacity up to 60,000 t.

Figure 3 - Methanol Transportation, Storage, and Bunkering Logistics Options, Port of Seattle (100% Fueling Scenario)



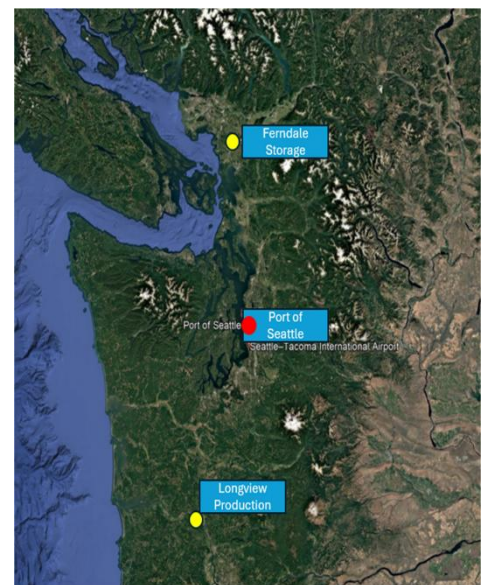
The Port of Seattle's supply chain, shown in Figure 3, incorporates a large-scale storage facility to store green methanol as it is produced year-round, but only consumed during the 6-month cruise season. Ferndale is located 110

nautical miles north of Seattle but was selected as a probable location for the feasibility study for several reasons. Siting a large-scale fuel storage facility in Seattle with access to the water would likely face space constraints. Bunker fuel for cruise is already barged from Ferndale to Seattle in the current state, and Ferndale is an existing oil-and-gas hub serving various refineries and tank farm facilities.

The Port of Seattle evaluated four scenarios for transportation from Ferndale to Seattle and the impacts on transportation costs and port-adjacent storage needs.

- 1) **Direct Barge/No Storage:** Green methanol is delivered directly from the storage facility in Ferndale to cruise ships at the port using dedicated Delivery/Bunker Barges without any port storage. This supply chain mirrors current marine fuel vessel bunkering practices at the port.
- 2) **Direct Barge/Contingency Storage:** Similar to the Direct Barge/No Storage Option, but this option adds a small contingency storage tank adjacent to Port terminals in Seattle to supplement barge deliveries when needed.
- 3) **Tanker Vessel:** Green methanol is transported from the Ferndale storage facility to storage tanks in Seattle adjacent to Port terminals using a tanker vessel then delivered to ships via bunker barge.
- 4) **Rail:** Green methanol is transported from the storage facility in Ferndale by rail to storage tanks in Seattle adjacent to Port terminals before it is delivered to ships via bunker barge.

Figure 4 - Port of Seattle Strategic Storage Locations



After reevaluating the cost, reliability, and overall feasibility of fuel logistics and bunkering services, the Port of Seattle identified the second scenario, Direct Barge/Contingency Storage, as the most practical solution. Compared to the first scenario, Direct Barge/No Storage, it is more cost-intensive but offers enhanced resilience by incorporating some storage in the Seattle harbour and adjacent to port terminals, which helps mitigate risks related to fuel supply disruptions and potential delays in bunkering operations.

Port of Vancouver

For the Port of Vancouver, the Vancouver Fraser Port Authority assessed three end-to-end scenarios based on the key assumption that the fuel production facility in Longview maintains a minimum storage buffer of one week's fuel supply to ensure continuity of operations and mitigate potential transport or production disruptions. The following scenarios outline the options for transporting methanol from Longview directly to the Port of Vancouver, as well as for its storing and bunkering at the port.

Figure 5 - Methanol Transportation, Storage, and Bunkering Logistics Options, Port of Vancouver (100% Fueling Scenario)

Scenario #1



Scenario #2



Scenario #3

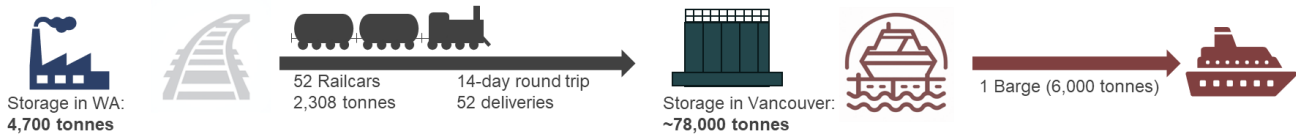


Figure 5 depicts the following scenarios:

- Transporting methanol by a 24,000-tonne supply vessel to storage facilities at the Port of Vancouver and subsequently supplying cruise vessels using a 6,000-tonne bunker barge.
- Transporting methanol by a 6,400-tonne supply barge to storage facilities at the Port of Vancouver and subsequently supplying cruise vessels using a 6,000-tonne bunker barge.
- Transporting methanol by railway tank cars to storage facilities at the Port of Vancouver and subsequently supplying cruise vessels using a 6,000-tonne bunker barge.

For all three scenarios, the feasibility study considers fixed assets in Vancouver, including storage tanks with a pipeline to the berth, a marine berth for unloading and bunkering, and a dedicated bunkering barge.⁶

In evaluating transport, storage and bunkering scenarios, the feasibility study concluded that the optimal option depends on the required fuel volume. Rail transport is most suitable for lower volumes up to 60,000t, a medium vessel (6,400-tonne supply barge) is optimal for volumes around 120,000t, and a large vessel (24,000-tonne supply vessel) is preferred for volumes exceeding 180,000t. Given the fuel volume of 120,000t of green methanol for four cruise vessels, the medium vessel scenario was identified as the most practical and efficient mode of transport to meet the projected demand while minimizing logistical complexity and operational costs.

Vessel Decarbonization

The vessel decarbonization workstream evaluated the technical and regulatory feasibility of building or retrofitting a cruise ship to sail a 7-day itinerary to Alaska powered by green methanol. CLIA served as central consolidator of results provided by participating cruise lines. The analysis was based on several key assumptions, including the deployment of four vessels operating on green methanol by 2032. The operational window for these vessels was defined as a 20-week cruise season, spanning from mid-May to mid-October. Each vessel is expected to carry approximately 4,000 passengers, assuming full occupancy, and undertake twenty 7-day itineraries each season, thus

⁶ Under the rail scenario, the analysis accounts for the capital cost associated with one mile of new rail spur infrastructure.

providing low carbon cruises for 320,000 passengers per season. These parameters were used to model the technical and regulatory feasibility of implementing a green corridor within the defined timeframe and operational scope.

The cruise lines involved in the feasibility assessment evaluated two primary pathways for adopting methanol as a marine fuel: retrofitting existing marine diesel engines to operate as dual-fuel methanol ships, and the construction of new build vessels with dual-fuel capability.⁷ Both approaches were analysed in terms of cost implications and operational viability. Importantly, methanol technology is already considered mature within the maritime sector, with the likes of Mærsk's methanol dual-fuel ships and Stena Line's overnight passenger and car ferry, Stena Germanica, already in operation, which reduces concerns around technical feasibility of ship-based design, construction, and operations. This maturity supports confidence in the reliability and scalability of methanol-powered cruise operations should upstream infrastructure be developed and economic challenges resolved.

Regulatory Feasibility

The feasibility and consideration of development of a green methanol cruise corridor is strongly shaped by international, regional, and local regulations designed to reduce emissions, safeguard operations, and promote the adoption of alternative fuels. This section discusses the regulatory feasibility findings for green methanol fuel production, port and bunkering infrastructure, and vessel decarbonization.

Alternative Fuels Supply Chain

The PNW2AK Green Methanol Feasibility Study evaluated the feasibility of green methanol produced in the U.S; however, the regulatory landscape in the country has shifted significantly since the launch of the study in late 2024. Changes to U.S. policy in 2025 under the *Inflation Reduction Act* (IRA) and the *One Big Beautiful Bill* adversely impact the regulatory feasibility and economics of U.S.-based green methanol production projects.

Updates to Section 45V have changed tax credits for clean hydrogen production, a key upstream input for green methanol production. Section 45V now requires that eligible projects meet stricter rules for renewable power to receive tax credits. Electricity used in production must come from new sources, be physically deliverable to the facility, and time-matched. These updates add complexity and increase the costs of producing compliant hydrogen feedstock for green methanol production. As a result, the increased costs flow into the cost of green methanol production and must be reflected in project economics.

On the downstream side, updates to Section 45Z, a production tax credit for clean transportation fuels, impose stricter feedstock origin requirements (limited to the U.S., Mexico, or Canada), prohibit most fuels from claiming negative carbon intensity (CI) scores even if lifecycle modelling shows net-negative carbon emissions, and increases scrutiny of foreign ownership for facilities claiming credits. These changes introduce compliance risk and reduce the certainty of credit realization, requiring either higher input costs, reduced credit value, or a larger risk buffer.

These changes are expected to increase the levelized cost of green methanol, impacting project economics, due to the incremental cost of regulatory compliance and risk of not fully capturing tax credits. Policy updates also impact project financing. Stricter verification requirements under Sections 45V and 45Z create uncertainty around long-term credit realization, which in turn impacts debt sizing, DSCR⁸ thresholds, and loan tenors. To maintain non-recourse financing, projects must demonstrate conservative pricing assumptions, robust certification and metering protocols, and strong offtake agreements capable of absorbing variations in carbon intensity or credit value. Projects that can

⁷ Although retrofitting is technically possible, it needs to be noted that it can be limited by factors like vessel age, available space and regulatory approvals.

⁸ DSCR: Debt Service Coverage Ratio

manage these risks and demonstrate audit readiness will remain financeable; others may face higher capital costs and reduced leverage.

Port and Bunkering Infrastructure

The Port and Bunkering Workstream evaluated international, national, and regional policies for fuel transportation and bunkering protocols, as well as permitting for siting and construction of storage infrastructure.

International Regulations and Guidance

International regulations relevant to methanol transportation, storage, and bunkering include the International Maritime Organization's (IMO) International Convention for the Prevention of Pollution from Ships (MARPOL) Annex II on bulk transport of noxious liquid substances, the International Maritime Dangerous Goods Code for classification, labelling and documentation, and the 2020 Interim Guidelines for the Use of Methanol as a Marine Fuel. In addition, several industry organizations have developed complementary standards to promote consistent and safe bunkering practices worldwide. The Society for Gas as a Marine Fuel Guidelines outline best practices for all stakeholders involved in methanol bunkering, including requirements for system design, risk management, operational safety, and emergency response. Similarly, the International Association of Ports and Harbors - Clean Marine Fuels Guidance offers a harmonized framework for ports to manage bunkering operations safely and efficiently across various low-emission fuels, including methanol.

Vancouver, British Columbia, Canada

At the federal level in Canada, the Transportation of Dangerous Goods Regulations set out the rules for how methanol must be classified, contained, labelled, and documented during rail and marine transport. The *Canada Shipping Act (2001)* governs the safe operation of vessels carrying or transferring dangerous goods, while environmental protection is reinforced through the *Canadian Environmental Protection Act* and the *Fisheries Act*, which safeguard marine and coastal ecosystems. While oil spill preparedness is well established under Canada's certified Response Organizations, such as Western Canada Marine Response Corporation, response mechanisms for alternative fuels like methanol are still emerging. For fixed storage systems, the Underwriters Laboratories of Canada Standards specify methanol storage tank design, materials, and fire protection measures, while the Canadian Standards Association standards cover the construction and use of portable and highway tanks used for transporting dangerous goods.

The Vancouver Fraser Port Authority administers the Project and Environmental Review⁹ process to help fulfil its responsibilities under the *Canada Marine Act* and the *Impact Assessment Act* and ensures all developments and activities within its jurisdiction meet applicable standards and minimize environmental and community impacts. If the fuel storage infrastructure is on port land, it would fall under the port authority's Project and Environmental Review framework. Given the fuel storage infrastructure required to handle methanol at a commercial scale, such a project would likely require detailed technical studies, environmental assessments, and consultation with First Nations, stakeholders, and the public prior to approval. Depending on project specifics, additional permits or approvals may be required (e.g., *Fisheries Act* authorization, air quality permits, environmental assessment approvals etc.)

Separately, the port authority's Marine Operations department maintains the Port Information Guide, which outlines the operational procedures for safely handling, transferring, and bunkering fuels within port waters, serving as a complement to existing safety controls and regulations. The Port Information Guide reflects Transport Canada and IMO standards on safe bunkering practices, spill prevention, and emergency response while a stricter accreditation process for alternative fuels—including a risk assessment involving stakeholders such as the Canadian Coast Guard and Transport Canada—is currently being completed. Methanol-specific procedures are expected to be incorporated

⁹ [Project and Environmental Review | Vancouver Fraser Port Authority](#)

into the Port Information Guide as the fuel becomes more widely adopted, serving as a prerequisite for vessels bunkering methanol at the Port of Vancouver and ensuring that such operations are conducted safely and in full compliance with regulatory standards.

At the provincial level, additional requirements are applied to ensure safe operations and spill prevention. The BC Fire Code and BC Coastal Marine Facility and Operating Standards set detailed provisions for the design, spacing, and fire protection of facilities handling flammable liquids such as methanol.

Seattle, Washington, USA

In the U.S., the evaluation of the regulatory landscape for green methanol identified critical gaps that must be addressed to enable safe and compliant transportation and storage operations. Restrictions for simultaneous operations (SIMOPS) would prevent cruise ships from bunkering methanol while passengers are on board. However, the regulatory landscape is rapidly changing. In August 2025, the U.S. Coast Guard (USCG) released a policy letter, "Guidelines for Bunkering of Vessels using LNG and Other Alternative Marine Fuels" ¹⁰ (USCG Policy Letter CG-OES 01-25). The letter provides guidance to USCG Captains regarding bunkering of vessels using liquified natural gas (LNG) and other alternative marine fuels. It defines USCG expectations for bunkering operations not covered by existing regulations and establishes a streamlined procedure for the bunkering risk assessment process.

In Washington state, the Washington Department of Ecology (ECY) regulates the transfer of oil over state waters (RCW 88.46.160), which includes spill prevention and response. However, ECY's authority does not yet extend to non-petroleum-based fuels like methanol. The study also found gaps in spill response protocols, which prioritize containment for petroleum-based fuels, and identified the need for specialized training for emergency responders.

In Seattle, achieving regulatory feasibility will require additional engagement with regulatory stakeholders to address policy gaps and develop safe methanol bunkering protocols, along with training for emergency responders. Engagement with industry and regulatory stakeholders must also be paired with Tribal consultation and community outreach efforts. Hosting informational sessions and engaging with environmental advocacy groups early on could help build support for the transition to green methanol and address concerns regarding the safety and environmental impacts of using green methanol as a maritime fuel. Steps are already underway to initiate engagement and protocol development outside of the PNW2AK Green Corridor project. Port of Seattle, in partnership with the American Bureau of Shipping, will convene agencies and key stakeholders to develop a methanol bunkering desktop exercise by 2027.

Storage development in Washington state may require a Shoreline Substantial Development Permit, State Environmental Policy Action (SEPA) or National Environmental Policy Act (NEPA) review, as well as air quality, land use, fire code, and building permits. Lead times vary but could take 18 to 36 months for permitting and at least two years for construction. With that lead time, initial engagement and pre-permitting conferences need to begin about five years out of the intended operation date. The permitting timelines would make it unlikely that the first methanol cruise vessel could be in the water by 2030 based on the project evaluation criteria. Washington state developed a streamlined permitting process for clean energy facilities that offers promise for streamlined permitting (the Clean Energy Coordinated Permit Process), but it does not currently include marine fuels like methanol. The Port of Seattle, in collaboration with key stakeholders, will need to work to clarify and streamline the permitting process for new methanol storage infrastructure and could advocate for the inclusion of methanol within the Clean Energy Coordinated Permit Process.

In addition to bunkering and permitting regulations, certain laws also influence the economic feasibility for Port of Seattle. A key example is the *Jones Act* (Section 27 of the Merchant Marine Act of 1920), which governs domestic

¹⁰ Source: https://www.dco.uscg.mil/Portals/9/DCO%20Documents/5p/5ps/Operating%20and%20Environmental%20Standards/OES-2/LNG%20Fuel%20STS%20Xfr/OES_PolicyLetter_01-25_24Jul2025.pdf?ver=Lsd6Y1cEeZ28tXNj-ldr4w%3d%3d

maritime trade. This legislation mandates that any vessel loading and transporting goods – including fuels – between two U.S. ports or places, be crewed predominantly by Americans, built in the U.S. and registered under the U.S. flag. These requirements can significantly impact the cost and availability of vessels for domestic fuel transport, shaping the economic feasibility of bunkering operations.

Vessel Decarbonization

Emission Reduction and Environmental Performance

At the international level, the IMO is considering adopting mid-term GHG reduction measures. These measures could possibly include a global fuel standard and a GHG pricing mechanism. If adopted, they would act as key drivers for the green corridor by incentivizing the uptake of low and zero-emission fuels and creating consistency across global maritime operations. Complementary IMO frameworks under development, including safety requirements for alternative fuels, seafarer training, and finalized Life Cycle Assessment (LCA) guidelines, provide essential safeguards while creating standardized metrics for environmental performance. In addition, compliance with measures such as the Carbon Intensity Indicator (CII), the Maritime Labour Convention, and ESG-aligned procurement practices ensure that the transition remains safe, equitable, and socially responsible.

Design and Engineering (IGF¹¹/IMO Scope)

Ships using methanol are treated as “low-flashpoint fuel” vessels under the IMO’s Safety of Life at Sea Convention (SOLAS) via the International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels (IGF Code), with methanol-specific requirements set out in IMO MSC.1/Circ.1621 (Interim Guidelines for methyl/ethyl alcohol fuels). That framework dictates fuel storage location and segregation, cofferdams, double-walled or ducted fuel lines with leak detection, mechanical ventilation and gas detection in fuel preparation/consumer spaces, emergency shutdown (ESD) and control philosophy, and materials compatibility throughout the fuel system.

Fire Protection and Toxicity Controls

Because methanol is a low-flashpoint, water-miscible alcohol (and toxic by ingestion/inhalation), the methanol guidance requires alcohol-resistant foam (and water spray) capabilities, enhanced detection, and ventilation interlocks; it also drives hazardous-area classification for electrical/equipment in fuel spaces and arrangements to manage vapors during maintenance or leaks. Class guides and the IMO circular highlight these protections and their functional goals.

Crew Training and Certification

Personnel serving in low-flashpoint-fuel ships must meet the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW¹²)/IGF training standards (basic/advanced endorsements), with company procedures and drills aligned to the fuel’s properties (e.g., spill response with water dilution and toxic exposure precautions). The U.S. Coast Guard has issued policy guidance on IGF endorsements that operators should factor into manning and training plans.

Bunkering Safety (Port Protocols and SIMOPS)

Bunkering methanol requires specific transfer procedures (hoses/quick-connects and materials compatible with alcohols), nitrogen purging/inerting as applicable, defined safety/exclusion zones, and a SIMOPS risk assessment when conducting parallel cargo/passenger operations.

Recent national/port standards (e.g., Singapore) checklists, roles, emergency communications, metering, sampling, and simultaneous-operations controls can serve as a template for other ports. In U.S. waters, USCG Policy Letter CG-

¹¹ International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels

¹² The [International Convention on Standards of Training, Certification and Watchkeeping for Seafarers](#)

OES 01-25 provides Captains of the Port with updated guidance for bunkering LNG and alternative fuels (including methanol).

Environmental and Spill Response

Methanol mixes readily with water and, therefore, spill plans need to emphasize rapid containment at the source, water flushing/dilution where directed by the authority, toxic exposure monitoring, and fire protection readiness rather than traditional floating-boom recovery alone. It needs to be ensured that Safety Data Sheets (SDS) availability, Personal Protective Equipment (PPE), and port-approved methods are embedded in the shipboard oil pollution emergency plan (SOPEP)/vessel response plan (VRP) annexes and bunkering checklists.

Retrofit Considerations

From a regulatory standpoint, the requirements for retrofitting conventional diesel-powered vessels to methanol dual-fuel operation are broadly consistent with those for new builds, though technical and operational complexity differs. For conversions, added space and weight for fuel tanks (lower volumetric energy density vs. marine gas oil (or MGO)), cofferdams/vent trunks, and ESD¹³-valve access; re-routing of ventilation and hazardous-area boundaries; and possible relocation/shielding near accommodation spaces can be expected. Class society rules and guides provide prescriptive details and acceptable equivalencies under the IGF goal-based framework—these should be referenced in the conversion specification and Hazard Identification (HAZID) and Hazard and Operability Study (HAZOP¹⁴).

Overall, the regulatory environment is evolving to provide both incentives and structured safeguards that should enable the adoption of green methanol; however, success will ultimately depend on coordinated implementation, infrastructure readiness, and financial support mechanisms such as subsidies to offset higher fuel and retrofit costs.

Passenger Demand Dynamics

CLIA examined the extent to which potential cruise passengers are willing to pay a premium beyond the standard ticket price for low and zero-GHG emission cruising. The output of this work highlighted significant challenges.

Like other sectors of travel and tourism, the cruise industry follows a dynamic, tiered pricing model subject to market demands and a wide range of variables including the timing of purchase (e.g., months or years ahead of sailing), the cruise product being offered, and the type of cabin purchased, among other factors). Accordingly, cruise ticket prices are not a reflection of the operational costs of a specific ship and/or itinerary. CLIA also raised concerns about relying on survey responses or other non-attributable statements by potential travellers reflecting well-intentioned hypothetical willingness to pay a green premium above typical ticket prices. There is often a significant gap between what consumers may aspire to and their actual behaviour, in practice, at the point of purchase. This view was informed, in part, by the low uptake of airline passengers in voluntary contribution programs for carbon footprint mitigation.

As a result of their investigation, CLIA concluded that for the purpose of cost modelling, the project should utilize a zero-dollar value in any assumptions related to passenger willingness to pay a green premium for zero or near-zero emission cruises.

¹³ Electrostatic discharge

¹⁴ HAZID; Hazard Identification; HAZOP: Hazard and Operability Study

Cost Assessment

Gross Incremental Cost Gap

The adoption of green fuels in the maritime industry faces significant challenges due to their higher cost compared to fossil fuels, and critically, the fuels remain unavailable at scale. Fossil fuels remain cheaper to produce, benefit from established infrastructure for transport, storage, and bunkering, and operate within a mature, highly commercialized market—making access low-risk. In contrast, green fuels require substantial upfront investment in production and supporting infrastructure, as a precondition to their availability. This cost gap, particularly for green methanol, often prevents projects from advancing beyond the feasibility stage. Public funding can help bridge this gap. The feasibility study analyzes capital expenditures (CAPEX) and operational expenditures (OPEX) across all workstreams to determine the additional expense of operating a green corridor versus a conventional fossil-fuel corridor under business-as-usual conditions.

Consortium members analyzed their corresponding segments of the value chain to calculate the CAPEX and OPEX over a 25-year period. HY2GEN provided both CAPEX and OPEX for the construction and operation of the green methanol production facility. Port of Seattle and Vancouver Fraser Port Authority provided CAPEX and OPEX for storage infrastructure and bunkering barges from their respective consultant-led studies. Costs of transporting methanol from point of production in Longview to the respective ports was assumed to be an operational cost also derived by the Port of Seattle and Vancouver Fraser Port Authority. CLIA, anonymizing and aggregating insights for the three cruise lines, provided the CAPEX for both conventional and dual-fuel vessels, as well as the incremental OPEX costs for dual-fuel vessels. While costs for retrofitting vessels were also provided, only new build vessels (fossil fueled ships and green methanol fueled ships) were considered to simplify modelling and comparison to an equivalent fossil corridor. The model uses the current market price of marine gas oil (MGO) to model equivalent fuel costs on the fossil corridor.

The gross incremental cost displayed in Figures 6 and 7 is the difference between the total corridor costs over a 25-year period for the Port of Seattle and Port of Vancouver respectively. The values in these figures have been derived through Consortium’s input to the MMCZCS Green Corridor Cost and CO₂e calculation Model¹⁵, which accounts for the cost of financing and discounting over the corridor lifetime to provide an output in Net Present Value. All costs referenced in this study are in USD (present dollar value).

Figure 7 - PNW2AK, Port of Seattle, Gross Incremental Cost Gap (USDm)

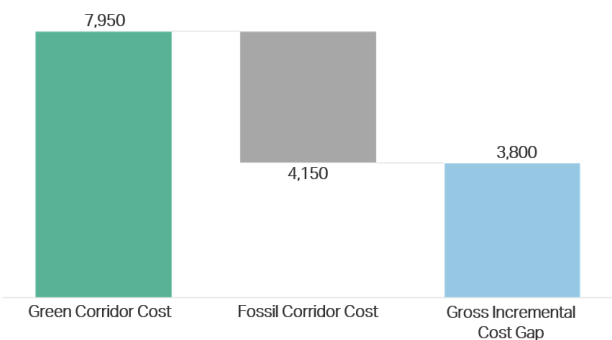
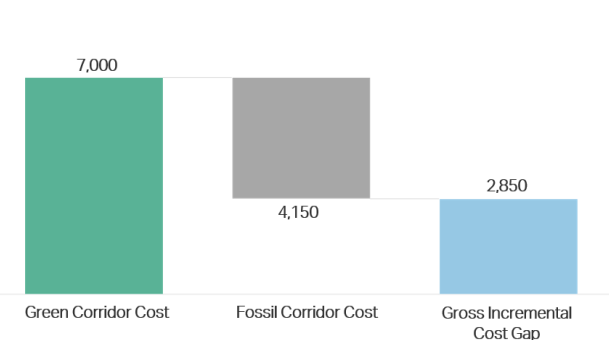


Figure 6 - PNW2AK, Port of Vancouver, Gross Incremental Cost Gap (USDm)



¹⁵ [MMCZCS Green Corridor Cost and CO₂e calculation Model](#)

The gross incremental cost gap has thus been calculated to be \$3.8bn for the Port of Seattle and \$2.85bn for the Port of Vancouver. Costs for equivalent fossil corridors remain constant for each homeport as the costs for construction and operation of vessels, as well as the price of MGO, is assumed to be the same.

The scenario with the Port of Seattle as a homeport is approximately \$950m more expensive than that of Port of Vancouver. This difference in cost is attributed to differences in how each port evaluated the transportation and infrastructure requirements in the fuel delivery supply chain. In particular, the Port of Seattle scenario reflects higher barge costs associated with *Jones Act*-compliant barges in the U.S. and a more complex fuel delivery and storage system. Port of Seattle's fuel delivery supply chain involves a large-scale storage facility outside of Seattle and a smaller scale contingency facility in the port. While this supply chain increases resilience for the future growth of methanol offtake within the port, it makes the initial project more expensive as compared to current bunkering arrangements which do not include local storage at the port. Since the study assumes green methanol is produced and stored in Washington, delivery also requires a barge constructed in the U.S. Estimates for a *Jones Act*-compliant barge for bunkering in Seattle were three times that of the Port of Vancouver for a similar vessel. Costs pertaining to methanol production, and construction and operation of dual fuel vessels remain constant across the two scenarios.

The study also assessed the gross incremental cost gap for a scenario where both the Port of Seattle and the Port of Vancouver serve as homeports with two green methanol cruise vessels calling at each. The cost assessment for this scenario resulted in an estimated total green corridor cost of approximately \$8bn. This scenario is not analyzed further because its total cost, and thus the cost gap, is sufficiently similar to the scenario involving four cruise vessels calling at a single port, meaning additional analysis would offer little additional insight.

Theoretical Gross Incremental Cost Gap Per Cruise Passenger

The MMMCZCS analysis examined the theoretical maximum added cost per passenger per cruise, if all of the increased costs for a green corridor—including fuel supply, infrastructure, and methanol-capable vessels—were solely absorbed by passengers on the PNW2AK cruise itineraries using green methanol. The reality is that no one entity within the value chain can carry the gross incremental of a green corridor cost alone. Therefore, an array of levers is required to close the gap, including, for example, optimized financing and regulations, green premiums, cost management strategies, and public funding. Understanding the gross incremental cost gap per passenger provides context to the size of the cost gap if no other levers are realized to help close it.

Four 4,000-passenger cruise vessels, each operating 20 roundtrip voyages per season, would transport an estimated 8 million passengers over a 25-year period. If the cost of operating a fossil corridor over 25 years is \$4.15bn dividing this cost of a fossil corridor across 8 million passengers results in an average cost of approximately \$520 per passenger. Using the same cost allocation approach for the green corridor results in an estimated cost of \$1,000 per passenger in Seattle (\$7.95bn divided by 8m passengers) and \$880 per passenger in Vancouver (\$7bn divided by 8m passengers).

This means, in a scenario with no measures to lower the gross incremental cost gap (e.g., no regulatory support, no optimized financing or other measures) closing the gross incremental cost gap would require a market willing to pay a green premium of \$360-\$480 per cruise passenger on a green methanol cruise¹⁶. It's important to note that this figure does not represent the final ticket price; rather, it reflects a theoretical allocation of corridor-related expenses per passenger for analytical purposes and excludes any revenue earned by the cruise lines.

¹⁶ When considering a 7-day cruise itinerary.

Incremental Cost Gap

The incremental cost gap of a green corridor represents the difference between the gross incremental cost and the combined effect of optimized financing and regulatory impacts. The following sections detail these two mitigating factors and their influence on reducing the net additional cost.

Optimized Financing

With the project entailing large CAPEX costs, there is a significant level of financial cost considered. This financial cost could be reduced if the project accessed loans at a lower rate of interest. Base case financing terms vary across the value chain, but the cost reduction modelled is derived through replacing the base case interest rate with a one equal to the value of the U.S. 10-year government bond yield (4.2%¹⁷). A comparison of the interest rates is displayed in

Table 1. This determines a reduction in costs of \$600m in the Port of Seattle scenario, and \$400m in the Port of Vancouver scenario. The difference in the reduction in costs as a result of optimized financing for Seattle and Vancouver is due to the difference in the CAPEX costs for infrastructure at each port, as noted previously.

Table 1 Interest Rate Comparison Base Case and Optimized Financing

Workstream	Base Case	Optimized
Alternative Fuel Supply Chain	8%	4.2%
Port and Bunkering Infrastructure	7%	4.2%
Zero Emission Vessel	5%	4.2%

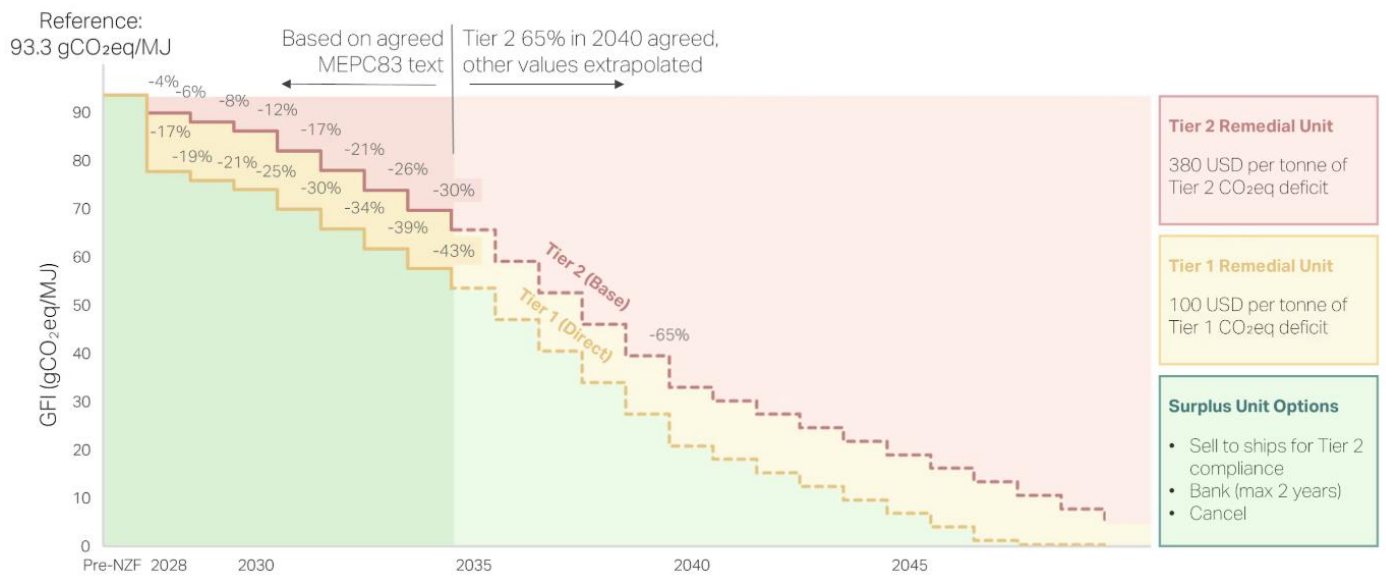
Proposed IMO Regulations

The IMO proposed Net-Zero Framework (NZF) remains under consideration. If adopted, the NZF would establish a GHG Fuel Intensity (GFI) target requiring ships to meet a reduction in GHG emission intensity on a well-to-wake basis. If successfully implemented, this would provide a positive cost benefit for vessels sailing on low carbon fuels, while also increasing the cost for vessels sailing on fossil fuels.

Figure 8, developed by MMMCZCS, visualizes how the proposed GFI becomes increasingly strict over time. Vessels consuming fossil fuels, such as cruise vessels considered in the equivalent fossil corridor, would incur additional costs of compliance stemming from both Tier 1 and Tier 2 remedial units under the current NZF proposal. The positive impact considered on the green corridor is generated from over compliance with the GFI, which, as proposed, would provide surplus units. These surplus units can be used by a vessel owner to create Tier 2 compliance within their wider fleet which consumes fossil fuels or can be sold to other vessel owners to provide Tier 2 compliance for their vessels. Over time, as the value of the GFI decreases, the use of the fossil fuels generates more remedial units, thus increasing the cost of compliance for the fossil corridor, while at the same time decreasing the surplus units generated from the use of green methanol or other low carbon fuels, which in turn lower the annual cost benefit for the green corridor.

¹⁷ Value used in cost model September 2025.

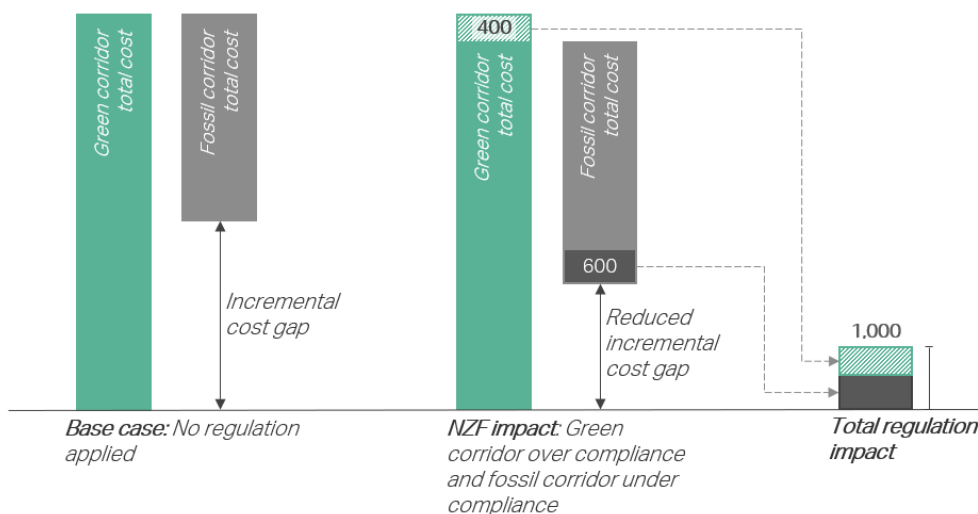
Figure 8 - Proposed IMO Net Zero Framework



Over the 25-year lifetime of the corridor, it has been calculated that the IMO NZF, if adopted, would increase the costs of a fossil corridor by \$600m and provide a cost benefit to the green corridor of \$400m (not including any rewards). This means that, as proposed, the regulation would have a total impact on the incremental cost gap of approximately \$1bn as shown in Figure 9. As the regulation is impacting the use of fuels, and the same quantities of fuels are considered for both the Port of Seattle and Port of Vancouver scenarios of the corridor, these values remain constant across both sets of analysis.

The proposed IMO NZF also seeks to include a "Reward Mechanism" to further incentivize the uptake of zero and near-zero emission fuels. At the time of writing the value, accessibility, and mechanics of this reward are yet to be determined and thus were not factored into the impact of the proposed regulation on the cost gap.

Figure 9 - Impact of the Proposed IMO Net Zero Framework (USDm)



Impacts on Cost Per Cruise Passenger

When optimized financing and the proposed IMO NZF regulations are factored into the cost assessment, the cost per cruise passenger decreases, lowering the green premium from \$480 per passenger to \$280 per passenger for the Port of Seattle scenario, and from \$360 per passenger to \$185 per passenger for the Port of Vancouver scenario. Figure 10 and Figure 11 show how these costs impact the end cost per passenger for both homeport scenarios.

Figure 10 - Costs Visualized Per Passenger; Port of Seattle

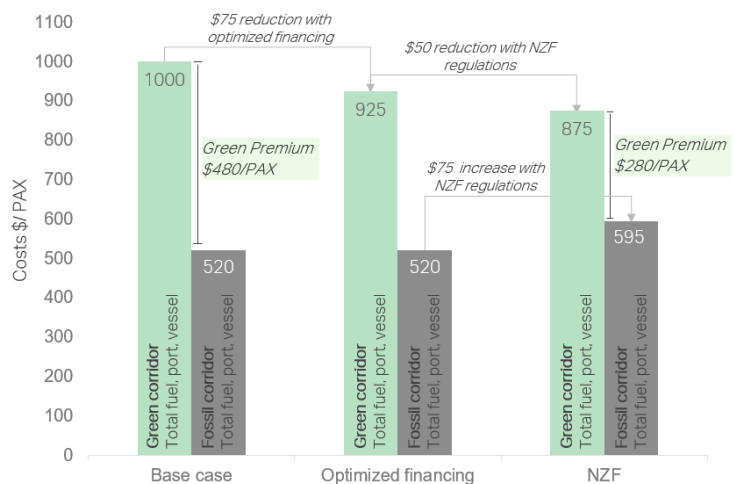
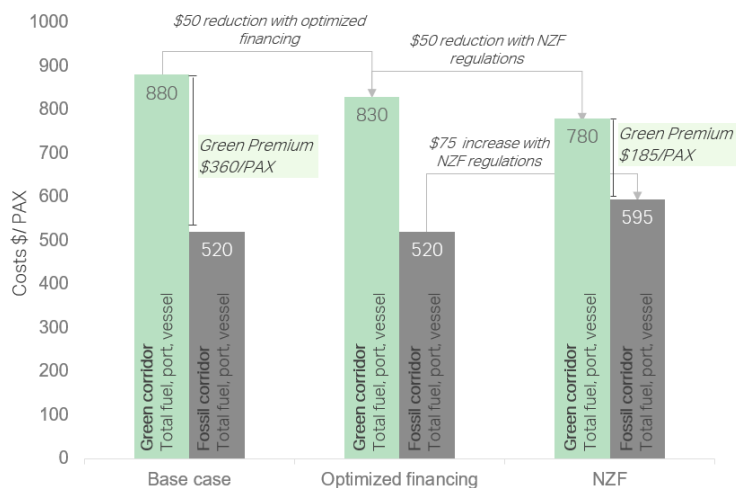


Figure 11 - Costs Visualized Per Passenger; Port of Vancouver



Given larger CAPEX requirements, the Port of Seattle scenario benefits more from optimized financing, reducing the starting cost of the green corridor by \$75 per passenger as opposed to \$50 per passenger in the Port of Vancouver scenario.

Under both scenarios, the cost per passenger of a fossil cruise increases by an estimated \$75 due to regulatory costs associated with sailing on fossil fuels under the proposed IMO NZF, while the per-passenger cost of a green-fuelled cruise decreases by an estimated \$50 due to regulatory incentives for a total net impact of approximately \$125 per passenger. It should be noted that these impacts are based upon the NZF as proposed in October 2025, which has

not yet been adopted by IMO. At the time of writing, without adoption of the NZF, no significant regulatory induced cost reduction would be seen on this corridor.

Residual Cost Gap

Figure 12 and Figure 13 illustrate the final output of the Cost Assessment for the Port of Seattle and the Port of Vancouver, including the incremental cost gap after accounting for optimized financing and the proposed IMO regulation. The figures also show the residual cost gap, which accounts for any additional impact of green premiums or other cost management mechanisms to further decrease the cost of green corridor compared to a fossil corridor.

If a portion of the incremental costs could be recovered from passengers willing to pay green premiums for zero or near-zero emission cruise itineraries at the time of purchase, combined with other cost management measures and public funding, the project could theoretically be economically feasible. However, as discussed in the ‘Passenger Demand Dynamics’ analysis, the lack of reliable data on passengers’ willingness to pay and the dynamics of cruise pricing led the study to apply a zero-dollar value to the green premium for modeling purposes. This does not imply that green premiums should be excluded in practice; rather, it highlights that without at least some contribution from passengers, the resulting total residual cost gap—which remains at \$2.2bn for the Port of Seattle scenario and \$1.45bn for the Port of Vancouver scenario—would be difficult to cover through cost management and public funding alone.

Figure 10 - Visualization of Total Incremental and Residual Cost Gap, Port of Seattle (USDm)

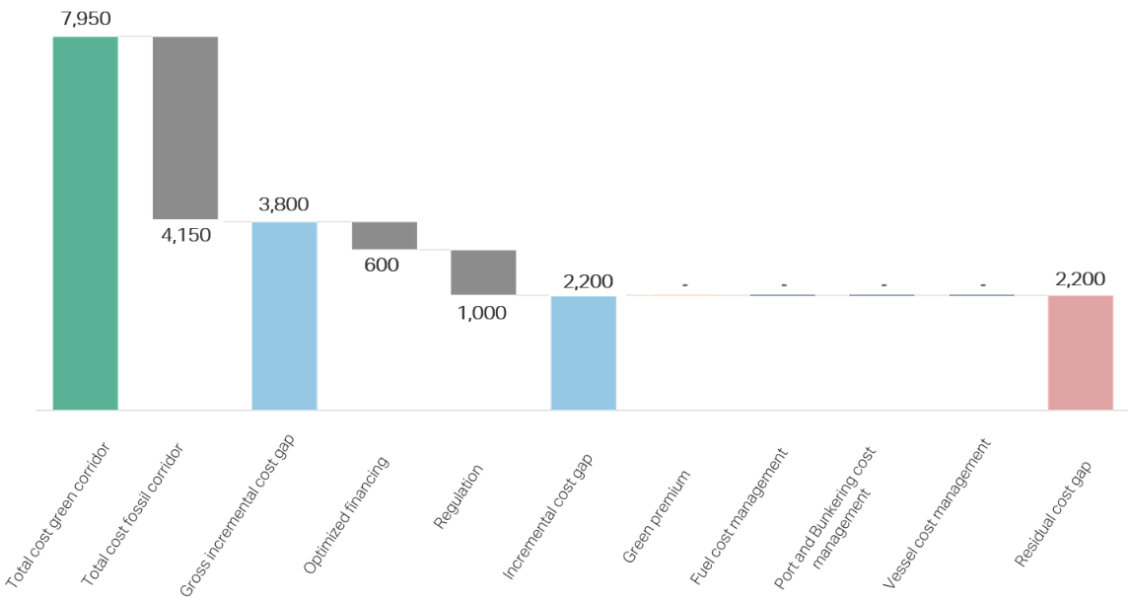
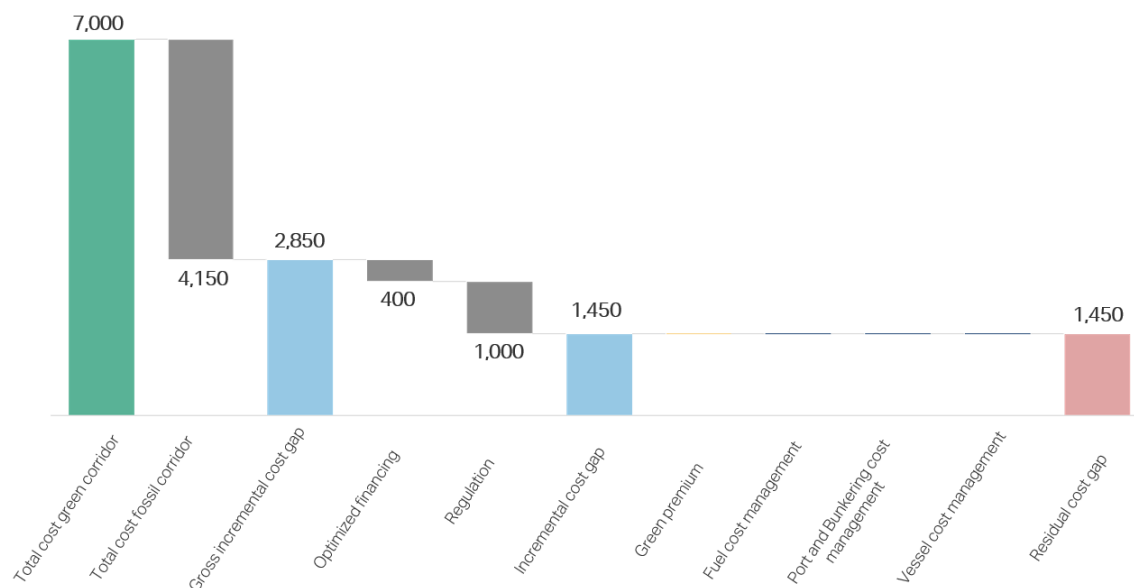


Figure 13 - Visualization of Total Incremental and Residual Cost Gap, Port of Vancouver (USDm)



Theoretical Cost Assessment

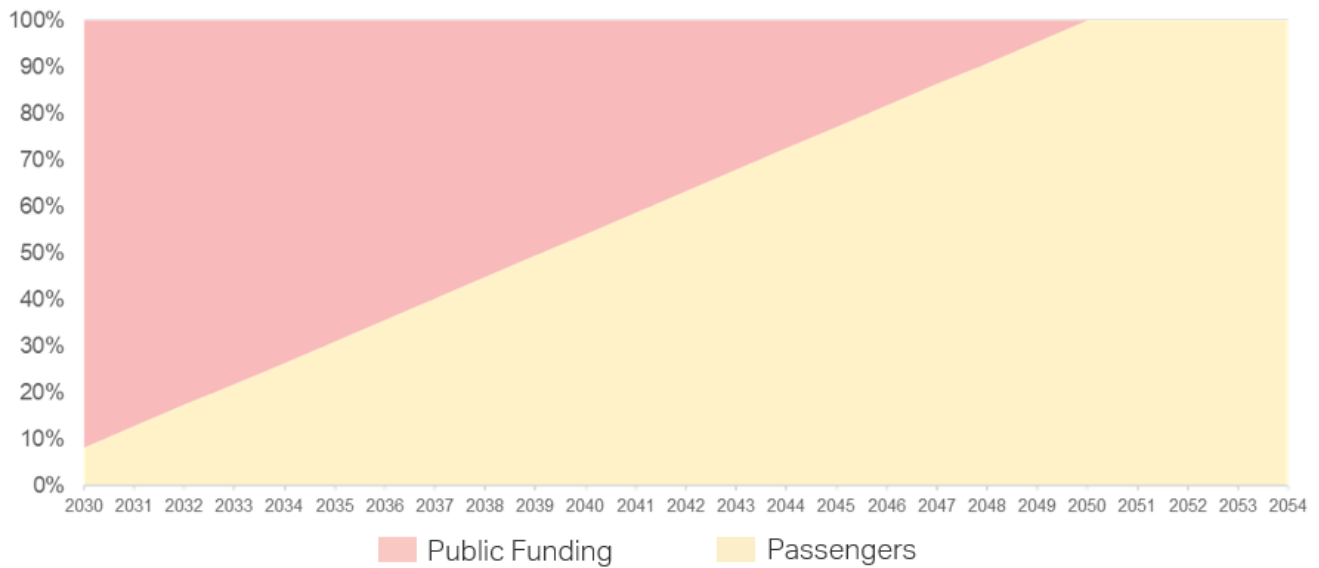
This chapter is based on generic assumptions from MMMCZCS and not representative of this Consortium's commitments. The theoretical cost assessment demonstrates how, according to the MMMCZCS methodology, the incremental cost gap could be further reduced to a point where targeted public funding may be able to close the cost gap.

Green Premium

A 2022 article from McKinsey related to cargo shipping, stated that, "A group of front-running shippers indicated in interviews that they are willing to pay a premium of between 5 and 10 percent for sustainable logistics services"¹⁸. While public research in other maritime segments suggests that some customers may accept some form of price increases for sustainable services, comparable data for the cruise market is not yet available. Accordingly, as shown in Figure 14, the model adopts a simplified assumption for the purpose of the study, applying a linear increase in the willingness to pay by passenger, in order to illustrate a situation where public funding is not required indefinitely.

¹⁸ [Driving Decarbonization: Accelerating zero-emission freight transport](#), McKinsey, 2022

Figure 11 - Illustrative Share of Incremental Cost Covered by Passenger's vs Required by Public Funding



Green premiums may increase at a faster or slower rate, or in periodical steps, but to ensure the corridor is not reliant on subsidies indefinitely this theoretical exercise assumes that the market would at some point carry the cost of the full premium. In Figure 14, this entails the model output illustrates a willingness to pay of \$25 per passenger in 2030, linearly increasing to the full incremental cost in 2050.

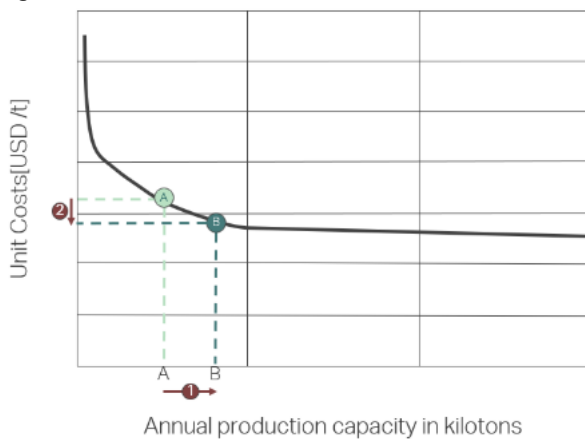
By assuming a gradual increase in the passengers' willingness to pay, the MMMCZCS methodology calculates the cost gap can be reduced by \$1.35bn in the Port of Seattle scenario and by \$950m in the Port of Vancouver scenario. This scenario is based on the current assumptions from the feasibility study that formed the gross incremental cost gap. If these assumptions change—such as a reduction in methanol price—the scenario would need to be adjusted accordingly.

Cost Management Scenarios

Consortium members can also investigate external synergies that have the potential to reduce the cost to the green corridor. The following cost management scenarios are provided across each area of the value chain:

- Alternative Fuel Production:** If additional demand for green methanol was found, either within or external to the maritime industry, production scale could be leveraged to reduce the levelized cost of methanol production as depicted in Figure 15. In the figure, reference point 1 indicates the increase in annual production capacity from A to B, while reference point 2 illustrates how unit costs change in response to the increase in annual capacity. Calculations utilizing scaling equations provided by HY2GEN indicate that by doubling the annual production of green methanol to 240,000t, the cost of a green corridor could be reduced by \$150m over the 25-year lifetime.

Figure 12 - Unit Cost as a Function of Plant Size



- **Port storage and bunkering infrastructure:** With both homeports actively investigating other green corridor initiatives, there is also potential to distribute CAPEX costs for storage and bunkering infrastructure to other initiatives that would use these investments. In the model, this cost management strategy assumes 50% of the CAPEX costs of storage and bunkering facilities (Port of Seattle ~ \$400m; Port of Vancouver ~ \$50m) can be distributed to these other initiatives to reflect how this infrastructure would be shared.
- **Discounts on port fees:** Discounts on port fees were not incorporated into the cost analysis due to limited impact to narrow the cost gap. However, ports can promote green corridors through incentive mechanisms, such as fee reductions (e.g., Port of Vancouver's EcoAction Program), and explore opportunities to leverage fees and other incentives could be an area of further study.
- **Vessel Decarbonization:** Due to the seasonality of the Alaskan cruise season, cruise vessels are only utilized in the region for half of the year. This theoretical example assumes that rather than this corridor carrying the entire incremental CAPEX pertaining to the investment in a new build, dual-fuel vessel, only 50% (~\$200m) of that investment would be applied to the cost of the Pacific Northwest to Alaska corridor. The remaining investment costs would be covered by other markets the vessels operate in during the rest of the year.

Residual Cost Gap

Using these assumptions, cost management and synergies can reduce the incremental cost gap by \$750m for Port of Seattle and \$400m for Port of Vancouver. When combined with an assumed willingness by the market to pay some theoretical level of green premiums this provides a residual cost gap \$100m for both green corridor scenarios, as shown in Figure 16 and Figure 17.

Figure 13 - Visualization of Theoretical Cost Assessment Residual Cost Gap, Port of Seattle, USDm

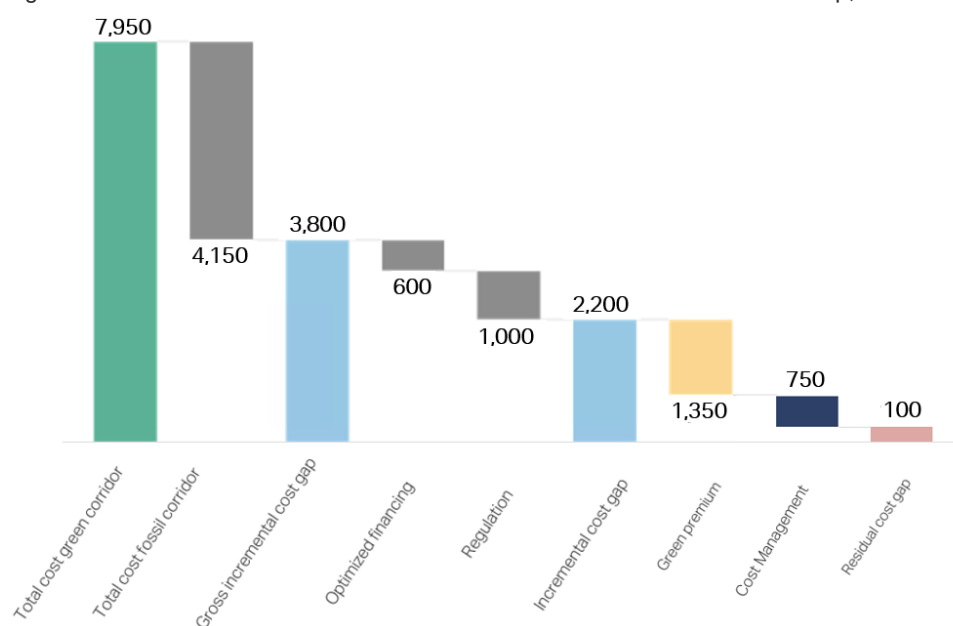
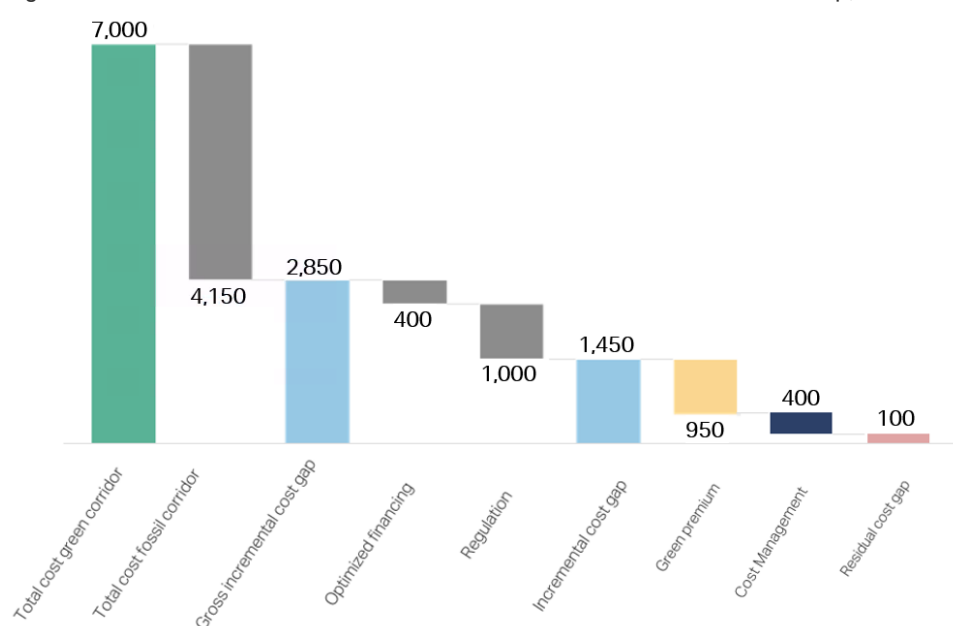


Figure 14 - Visualization of Theoretical Cost Assessment Residual Cost Gap, Port of Vancouver, USDm



Early green corridor projects will likely need some level of public support because low-emission fuels are expensive and require new supply chains. In the first few years, these supply chains will be underused, adding extra costs for First Movers. The residual cost gap of over \$1.4bn¹⁹ is assumed to be insurmountable for public or philanthropic funding; however, \$100m in the theoretical example is more feasible. In Canada, programs like the Clean Fuels Fund, Strategic Response Fund, and Canada Growth Fund could be explored, while in the U.S., the Breakthrough Energy Catalyst Fund may be worth considering if this scenario moves forward. The amount of public funding needed depends largely on the market's willingness to pay green premiums—how much of the incremental cost that may be absorbed by the

¹⁹ Lowest incremental cost gap scenario (Port of Vancouver) without considering cost management and green premiums. See chapter Impacts on Cost .

market—and, how much can be managed across different stakeholders in the value chain. Therefore, in addition to providing funding, governments and agencies should also consider regulations that require the use of low-GHG fuels.

CO₂e Abatement

Over the 25-year lifetime of the corridor, 5.6 million tonnes of CO₂e would be abated in total from the four cruise vessels operating their Alaskan itineraries on green methanol rather than conventional fuel (assume MGO). This means that before financing and regulation are considered, the cost of abatement of the green corridor is \$680/tonne CO₂e in the Port of Seattle scenario, and \$515/tonne CO₂e in the Port of Vancouver scenario.²⁰ The total CO₂e abatement, when attributed to passengers, represents a reduction of nearly 733kg of CO₂e per passenger per cruise²¹. While there is still 37kg of CO₂e attributed to each passenger from pilot fuel, which is assumed to be fossil, this marks a 95% reduction in CO₂e emissions across the four ships each season. CO₂e emissions associated with transportation and bunkering of the fuel were not included in the scope of the study.

Summary and Key Takeaways

The Pacific Northwest to Alaska Green Corridor project is technically and regulatorily feasible, though it faces some challenges. To be economically feasible at this stage would require identifying additional sources of funding to close the incremental cost gap of more than \$1.45bn through regulatory support, cost management, optimized financing, public funding including grants and incentives, as well as potential green premiums.

The study determined for the purpose of the analysis that overcoming the economic feasibility solely through a market willing to pay green premiums would require between an additional \$360-\$480 per passenger per cruise. This premium could be reduced to between \$185-\$280 if optimized financing was secured and if the proposed IMO NZF regulations were to be adopted. If the assumption becomes that IMO NZF is not in place, and only optimized financing is considered, the estimated green premium for passengers would range between \$310 and \$405. The feasibility study identified potential challenges in passing additional costs to passengers within existing dynamic pricing models.

In the view of the MMMCZCS, to mature the project to a point where economic feasibility can be achieved, the project would need passengers to be willing to pay at least some proportion of increased costs as envisioned by the theoretical approach considered herein to maintain credibility and to offset the reliance on external sources of funding. Thus, increasing clarity and confidence on how much the market is willing to pay to pay in green premiums, assessing costs pertaining to accessing green methanol produced in other regions, and a deeper evaluation on port and bunkering infrastructure—including retrofits when accounting for increased utilization—stand as both logical and urgent next steps to understanding if the cost gap can be overcome in the near future.

Key Takeaways

The feasibility study revealed several key insights relevant to ports, cruise lines, and fuel providers, which highlight opportunities and challenges for implementing green methanol in the region.

Methanol-capable cruise ships are technically feasible. The feasibility assessment confirms that both newbuild and retrofit options for methanol-capable cruise vessels are technically viable, although strong safety measures and training are still essential to successful implementation. However, cost, vessel age, space constraints, and deployment timing remain key determinants of pathway selection.

Storage and bunkering of green methanol for four cruise ships is technically feasible, but land and waterfront access constraints complicate siting for new infrastructure. Limited availability of industrial land with suitable tideland access in the Port of Seattle and the Port of Vancouver significantly influences the feasibility of green methanol storage and

²⁰ Cost of CO₂e abatement = [(total cost of green corridor – total cost of fossil corridor)/(CO₂e emissions of fossil corridor – CO₂e emission green corridor)]

²¹ Total CO₂e emissions generated in fossil corridor over 25 years (5.86 million tonnes) divided by total number of passengers (8 million)

bunkering infrastructure in the two homeports. Additional evaluation and engagement with industry is needed to identify optimal storage locations and understand associated supply chain risks. Feasibility to date focuses on new infrastructure, while repurposing existing facilities could be further explored. Additionally, given their geographic proximity, additional options for centralized, shared bunkering and storage infrastructure among the Ports of Seattle and Vancouver could be explored to further reduce infrastructure costs. Retrofitted storage and barge infrastructure may also reduce CAPEX costs.

Safety and accreditation frameworks must mature for methanol operations. While international guidance exists, port-level safety standards and accreditation for alternative fuels are still evolving. Emergency response programs built for petroleum need updated plans, training, and multi-agency coordination to address methanol-specific risks.

Seasonal cruise market creates utilization challenges that could be helped by other green corridor projects. The seasonal nature of the Alaska cruise market limits year-round utilization of port storage and bunkering infrastructure, underscoring the value of identifying off-season demand or shared-use infrastructure to improve overall project economics. The PNW2AK project is one of several green corridor initiatives in the Pacific Northwest region, including the North Pacific Green Corridor and two cargo-focused routes between Seattle-Tacoma and the Republic of Korea.

Green methanol supply remains a gap in the Pacific Northwest and regulatory uncertainty complicates U.S.-based fuel production. Despite HY2GEN's involvement in the feasibility study to provide input on green methanol production, there is currently no established supplier delivering green methanol at scale for marine use in the Pacific Northwest region. This gap highlights the early-stage nature of the market and the reliance on future investment decisions by fuel producers. Since the project started, U.S. policy has changed to adversely impact the regulatory feasibility for U.S. based-fuel production. As a result, HY2GEN indicated they will not advance development activities in the U.S. until regulatory clarity and long-term policy stability is restored. The decision to evaluate green methanol production in the U.S. had other ramifications on the project economics. Notably, compliance with the *Jones Act* increase infrastructure and bunkering costs for Seattle compared to Vancouver as *Jones Act*-compliant barges would be needed to deliver fuel between two U.S. ports. Further engagement with fuel producers is needed to understand how different variables, including production location and supply chain, would impact the feasibility and incremental cost of the green corridor.

Dynamic cruise pricing complicates cost recovery options. Cruise pricing models present challenges for consumer-based cost recovery. Cruise fares are driven by dynamic pricing models reflecting consumer demand, booking timing, and broader market conditions, among others, rather than the direct operating costs of individual voyages. As a result, this pricing structure does not support predictable or reliable estimates of potential green fuel premiums that consumers may be willing to pay above typical market costs. This uncertainty limits the ability to project-incremental cost recovery for decarbonization costs and increases reliance on alternative funding mechanisms and incentive-based approaches.

Risk-sharing frameworks are essential to unlock investment. Clear frameworks for how regulatory, market, and investment risks are shared among fuel producers, ports, infrastructure owners, and cruise operators are needed to enable stakeholders to commit capital and advance projects beyond the feasibility stage.

Public funding is critical for implementation. Given current cost differentials between green methanol and fossil fuels, even with maximizing other cost levers, green corridor projects are likely to require a degree of public funding, incentives, or concessional financing to proceed. Such support is particularly important to offset First Mover risks and underutilized infrastructure.