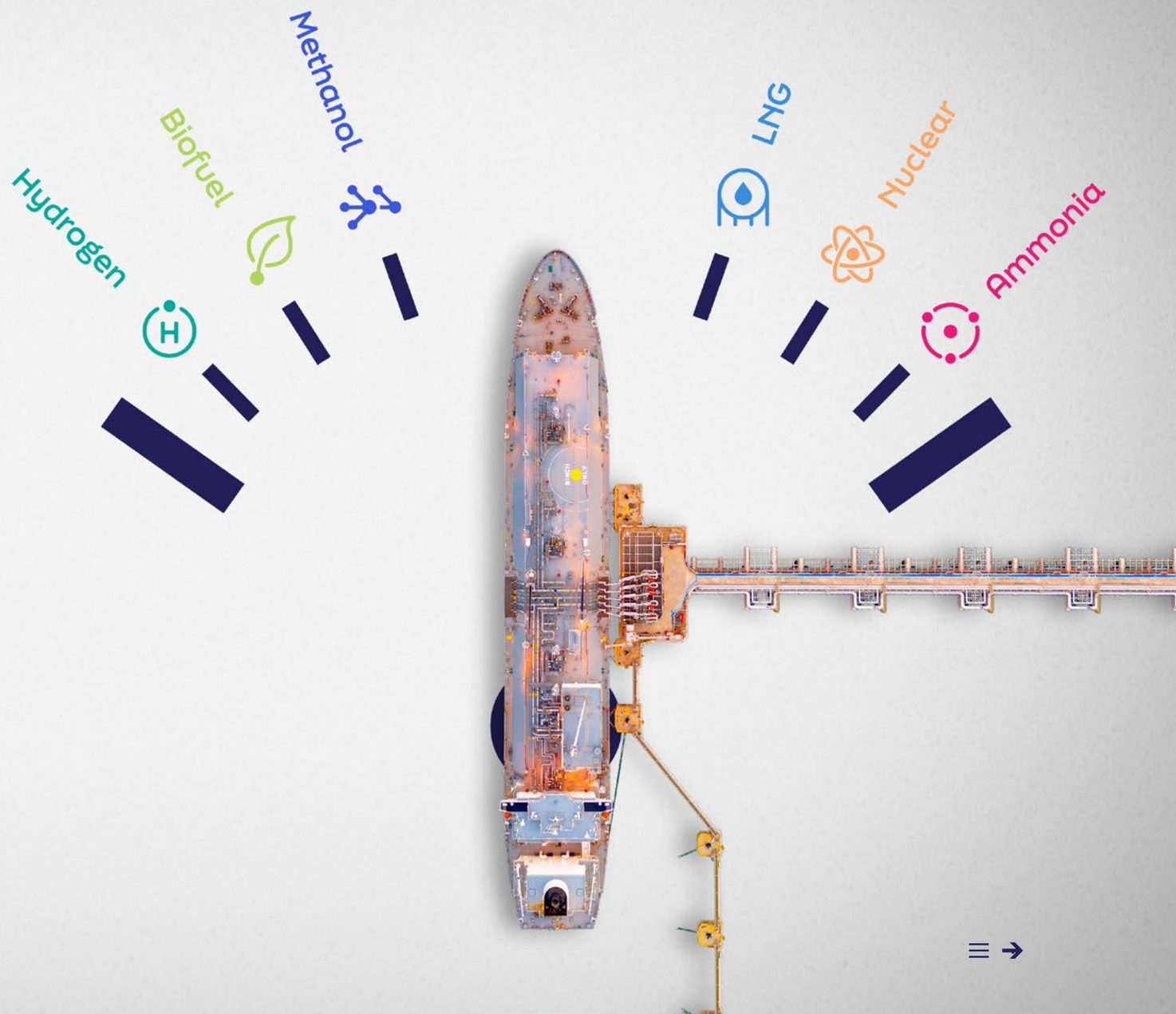
Fuel for thought

Ports

Expert insights into the future of alternative fuels

Your trusted adviser in alternative and low carbon maritime fuel



Contents

Introduction

Foreword 3
Executive Summary 4

1 The Port Challenge

1.1 Maritime decarbonisation and the role of ports 7
1.2 Why fuel transition is different from previous shipping transitions 7
1.3 The investment dilemma: risks of waiting versus risks of acting 8

2 Understanding Future Fuel Demand

2.1 Alternative fuel pathways 10
2.2 Which fuels are likely to be adopted first? 17
2.3 Regional differences in fuel demand 17
2.4 Vessel segments and fuel preferences 17

3 Port Infrastructure Readiness

3.1 Existing infrastructure capabilities 18
3.2 Storage requirements 35
3.3 Bunkering infrastructure 35
3.4 Utility and energy requirements 35
3.5 Future-proofing investments 35

4 Safety and Risk Management

4.1 New fuel hazards 36
4.2 Port emergency preparedness 37
4.3 Occupational health and workforce impacts 37
4.4 Incident response planning 38
4.5 Safety culture for multi-fuel operations 38
4.6 Insurance, liability and classification 39

5 Regulation and Compliance

5.1 IMO developments 43
5.2 National and regional regulations 45
5.3 Port authority responsibilities 46
5.4 Emerging fuel standards 46
5.5 Future regulatory outlook 46

6 Supply Chains and Energy Ecosystems

6.1 Fuel production trends 47
6.2 Import and export considerations 47
6.3 Fuel availability risks 47
6.4 Port energy hubs 48
6.5 Strategic partnerships 49

7 The Port Business Case

7.1 Investment models 50
7.2 Funding and finance 50
7.3 Revenue opportunities 51
7.4 Competitive positioning 51
7.5 Lessons from early movers 51

8 Digitalisation and Operational Readiness

8.1 Digital fuel monitoring 52
8.2 Traffic and bunker scheduling 53
8.3 Data-driven decision making 53
8.4 Port community systems 54
8.5 Digital twins and scenario planning 54

9 Port Readiness Framework

9.1 Assess 56
9.2 Prioritise 56
9.3 Invest 57
9.4 Implement 57
9.5 Scale 57

Conclusion

Key takeaways 58
Critical decisions for the next decade 60
Port readiness checklist 60

Appendices and References

Ports and regions not covered 61
Glossary of key terms 61
References 62

Foreword

The move to new alternative fuels in shipping is underway. With a wider roll-out depending both on the demand from vessels and supply chain availability, ports have become pivotal in this transition.

Shipowners are committing capital at pace. By January 2026, 1,942 alternative-fuel-capable vessels were on order, and alternative-fuel ships accounted for nearly half of orderbook tonnage. Port readiness has not kept up. In January 2026, LNG bunkering was available at 222 ports. Methanol was actively offered at just 25. Commercial ammonia bunkering had taken place at only one port.

That gap creates both risk and opportunity. Ports that wait for certainty risk falling behind competitors that are already building safety frameworks, licensing regimes and partnerships. Ports that invest too early risk assets that are never fully used. Getting the balance right is one of the defining strategic decisions facing port leaders this decade.

This edition of Fuel for Thought is written for those leaders. It sets out what each fuel pathway means for a port, from biofuels and LNG to methanol, ammonia, hydrogen and nuclear. It covers the infrastructure, safety, regulatory, workforce, digital and financial foundations that readiness depends on. And it draws on the experience of ports around the world that have moved from strategy to operation.

One lesson stands out. Readiness is built long before the first ship arrives. Every successful operation described in this report rested on careful risk assessment, clear regulation, trained people and close cooperation between port authorities, fuel suppliers, shipowners, emergency services and classification societies.

Lloyd's Register has worked alongside the maritime industry through every major transition in its history. That experience includes LR's involvement in ammonia bunkering studies, the development of IMO guidelines for ammonia as fuel, and early work on nuclear port readiness. Safety must remain the foundation on which every new fuel is introduced.

No port needs to prepare for every fuel at once. Every port does need a plan. This report is intended to help port leaders build one.



Kamran Ul Haq
Senior Vice President
LR Ports Advisory



Executive Summary



At a glance

1,942

alternative-fuel-capable ships on order

Lloyd's Register / Clarksons, Jan 2026

222

ports offering LNG bunkering, with 62 more planned

SEA-LNG, Jan 2026

8,016 t

largest single biomethanol bunkering, Shanghai

CMA CGM, Aug 2026

1 port

with commercial ammonia bunkering: Ulsan

Ulsan Port Authority, Apr 2026

61.8 Mt

announced low-carbon methanol pipeline by 2031, against 6–12 Mt expected operational

GENA Solutions, Jun 2026

3.4%

alternative fuels' share of Singapore's 2025 bunker sales (1.95 of 56.77 Mt)

MPA data, Jan 2026

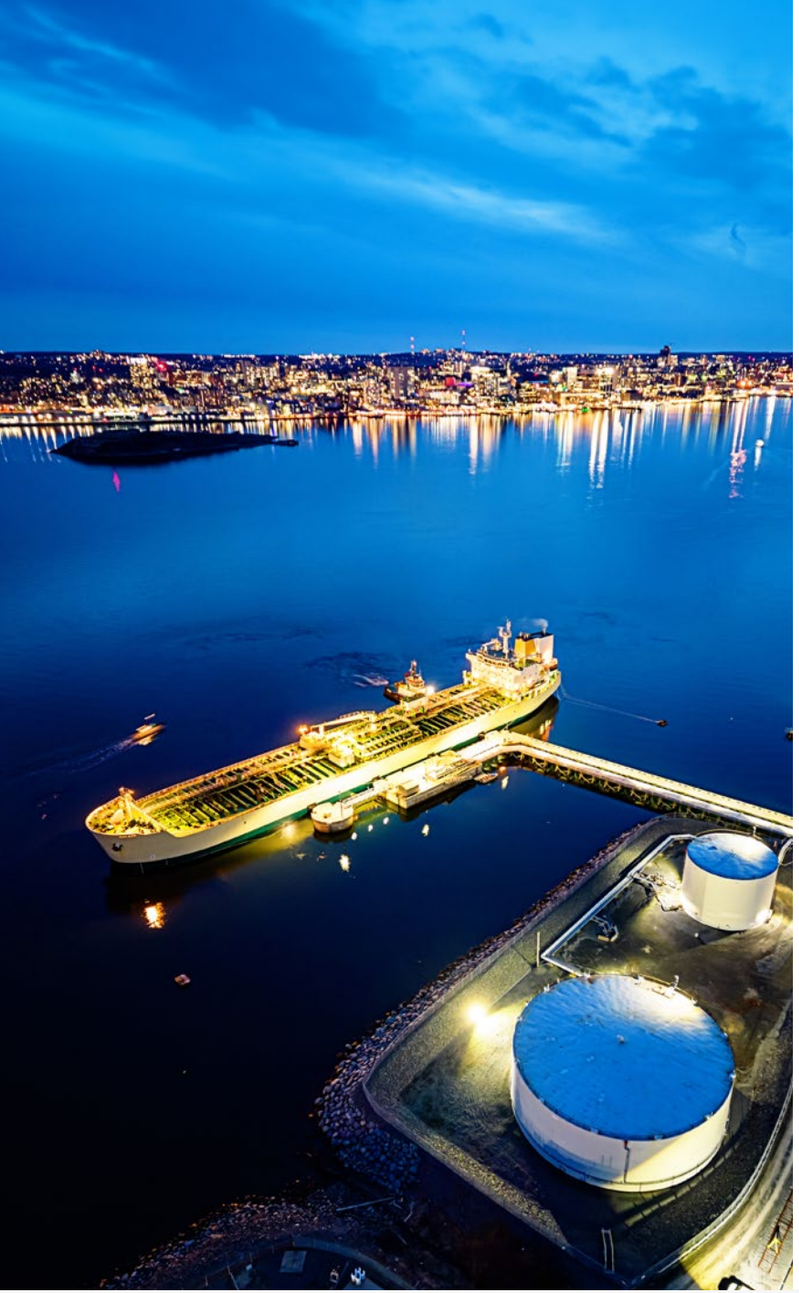
Key messages for ports

What fuels will call at your port? LNG and biofuel blends already move through established networks. Methanol is commercially available at a small number of leading hubs, ammonia has been bunkered commercially at only one port, hydrogen remains a short-sea and demonstration fuel, and nuclear raises port-access rather than bunkering questions.

How do you manage safety and regulation? The IGF Code stops at the ship's bunkering connection, so ports and national authorities set the shore-side rules. Licensing, gas dispersion modelling, emergency planning and trained people are the common foundations, against IMO guidelines that are still interim.

How should infrastructure be planned? Vessel ordering is running ahead of port investment. Investment tied to named vessel programmes, green corridors and credible demand carries less risk than speculative capacity.

What are the safety and risk priorities? Ammonia's toxicity, new workforce competencies and gaps in the international liability regime all need to be addressed before routine operation.



The world's major bunkering ports are moving from feasibility studies to operational trials for alternative marine fuels. They are doing so at markedly different speeds, and the gap between the candidate fuels is widening.

LNG already has a mature, near-global bunkering network. Industry coalition SEA-LNG reported in January 2026 that LNG bunkering was available in 222 ports, with a further 62 ports planning to offer it.

Vessel ordering is running ahead of port investment. Clarksons Research counted 25 ports actively offering methanol bunkering in January 2026, against 222 for LNG, while alternative-fuel-capable ships made up 47 per cent of orderbook tonnage.

Methanol has crossed into commercial bunkering. Singapore began licensing methanol suppliers on 1 January 2026, and a single biomethanol transfer at Shanghai reached 8,016 tonnes in August 2026. ISO 22120:2026, published in August 2026, is the first international specification for bunkering methanol-fuelled vessels.

Ammonia has moved from ship-to-ship demonstrations to the first commercial bunkering operation, completed at Ulsan in South Korea on 23 April 2026. Most other major hubs remain at the trial-authorisation, pilot or safety-framework stage.

Hydrogen bunkering for deep-sea shipping remains at an early, largely experimental stage. The IMO approved interim safety guidelines for hydrogen-fuelled ships in May 2026, but port-side bunkering capability lags well behind.

Biofuel blends are the most port-ready option, because they move largely through existing bunker barge and storage infrastructure.

Across all of these fuels, the harder problem is often not whether a port can offer a fuel but the 'last mile' between supply and ship.

Bunker vessels, berth time, licensing and emergency cover have to be paid for whether or not ships call, and there is often no natural owner for that step. Its economics are driven by utilisation rather than capital cost, so low early volumes mean high unit costs.

Shore power shows the same pattern. Portsmouth International Port completed its shore power system in late 2025, but it went unused until a deal on electricity costs was agreed with Brittany Ferries in summer 2026.

Nuclear power sits apart. It raises no bunkering question, but a port-access, licensing and liability question that two US ports began formally working through in mid-2026.

This report sets out, port by port and region by region, examples where infrastructure, safety procedures and regulatory groundwork stand for these six fuel pathways. It covers more than twenty-five ports and port authorities across Europe, Asia, the Middle East, North America, South America and Australia.

It also examines the gap between vessel ordering and port readiness, workforce and skills, and the financing of port infrastructure, and closes with practical implications for shipowners, operators and charterers and an overall conclusion.

The vessel side of the transition is further advanced than the shore side. LR's analysis of Clarksons Research data, published in January 2026, put the alternative-fuel-capable orderbook at 1,942 vessels.

By fuel, LR counted 1,259 LNG-capable ships, 385 methanol, 139 LPG, 55 ethane, 53 hydrogen, 45 ammonia, 22 biofuel and 4 nuclear.*

Some of these ships are gas carriers, able to burn their own cargo rather than resort to bunkered fuel. Where gas carriers are included, the counts overstate the number of ships that will need alternative fuel from a port, particularly for LPG and ethane.

Owners ordered 590 alternative-fuel-capable vessels in 2025, totalling 45.5 million gross tonnes. Methanol accounted for 134 of those orders, ammonia for six and hydrogen for 13.

Including tonnage already in service, LR put the combined alternative-fuel-capable fleet and orderbook at 4,542 vessels, equivalent to 2.1 per cent of global fleet and orderbook tonnage.

This shapes how the port findings should be read. An owner ordering a methanol dual-fuel ship is one of hundreds. An owner ordering an ammonia- or hydrogen-capable ship is one of a much smaller cohort, and the shore-side gap is most acute for exactly those two fuels.

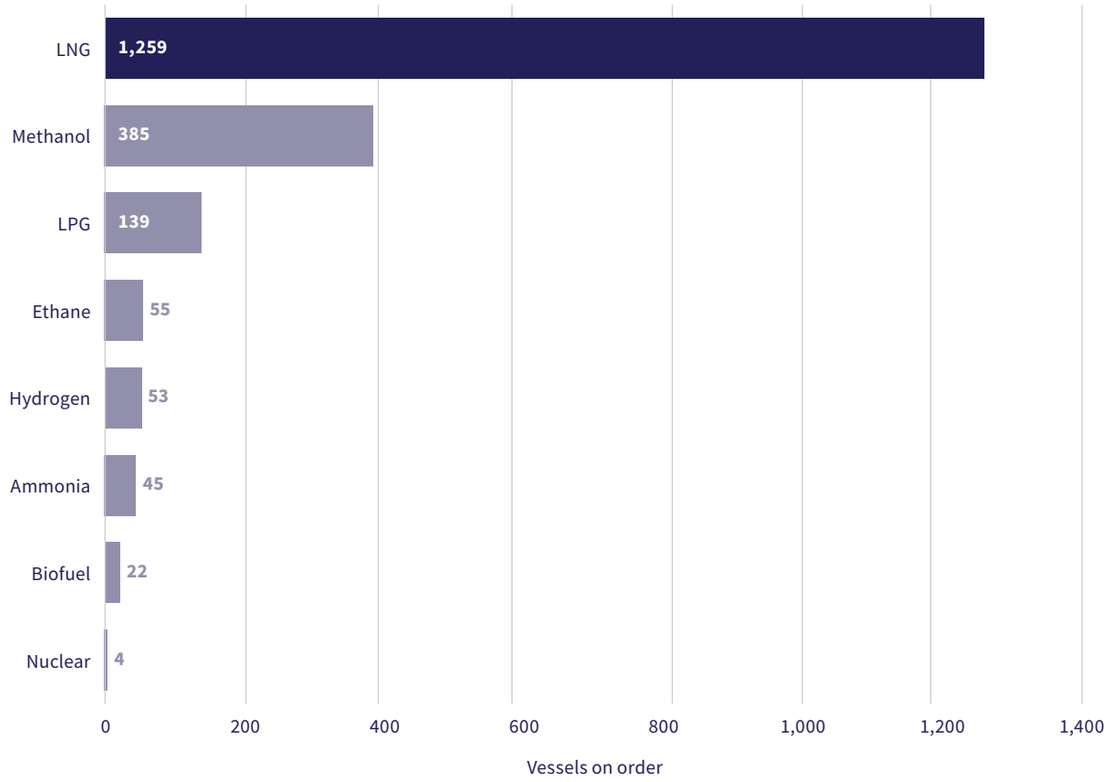
Findings draw on port authority statements, classification society and IMO documents, survey data, and specialist maritime and energy trade press to September 2026. Where a claim rests on a port's or company's own account, that is stated.

A port is not described as commercially ready for a fuel merely because it has announced a strategy, signed a memorandum, completed a feasibility study or carried out a one-off transfer. Where an organisation describes its own milestone as a world first, that description is reported as the organisation's claim.

Every figure here is a snapshot of a fast-moving picture, and the evidence cut-off for this report is 28 September 2026. The IMO Net-Zero Framework session was due to reconvene in October 2026, after that cut-off, and several timelines described in this report may have moved by the time of reading.

Figure 1. Alternative-fuel-capable orderbook by fuel type

January 2026



Source: Lloyd's Register analysis of Clarksons Research data.
*Categories sum to 1,962 against LR's stated total of 1,942, due to <1% of the fleet being capable for more than one fuel.

Chapter 1: The Port Challenge

1.1

Maritime decarbonisation and the role of ports

Ports sit at the point where the shipping industry's decarbonisation plans meet physical infrastructure, local safety regulation and energy supply. Shipowners can order alternative-fuel vessels, but those ships depend on ports to supply the fuel, approve the operation and manage the risk.

The chapters that follow show how far that port-side preparation has progressed. The vessel side, as Chapter 2 sets out, is already well ahead.

1.2

Why fuel transition is different from previous shipping transitions

Previous changes in marine fuel, such as tighter sulphur limits, largely changed the specification of oil-based fuels moving through existing supply chains. Storage, bunker barges, transfer procedures and crew competencies stayed broadly the same.

This transition is different. Ports face six pathways at once, each with a different physical state, hazard profile and supply chain: cryogenic LNG, ambient-temperature but toxic methanol, refrigerated and highly toxic ammonia, liquid hydrogen at around minus 253 degrees Celsius, drop-in biofuels and nuclear power, which raises no bunkering question at all.

No single fuel is certain to dominate, so ports must plan for several in parallel, often on the same berths, and with regulation that is still interim for most of them.



1.3

The investment dilemma: risks of waiting versus risks of acting

The demand versus readiness gap

Many ports may be technically capable of bunkering methanol or ammonia, but access to green methanol and green ammonia remains constrained. Investment in alternative-fuel vessels remains strong, while the port infrastructure needed to supply them is significantly less developed.

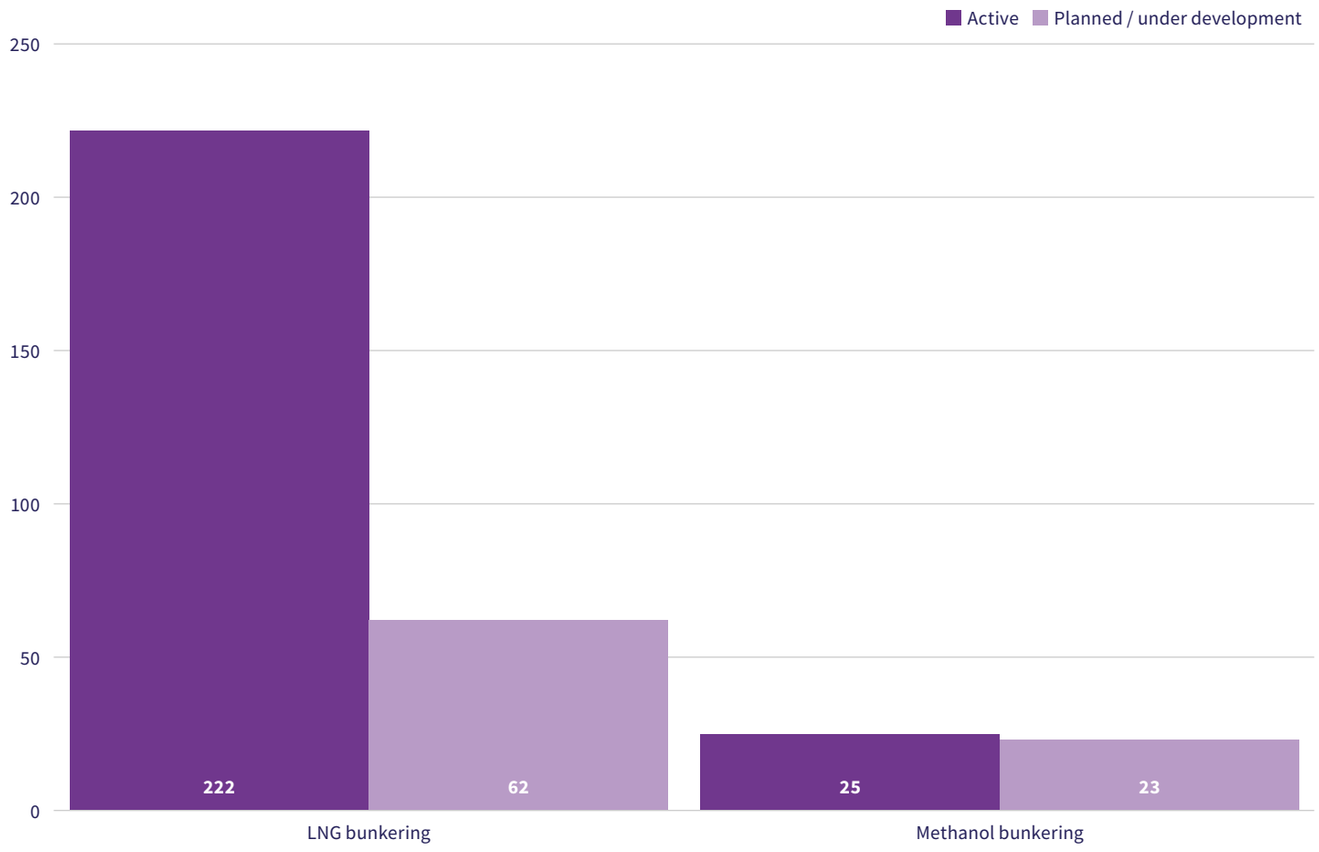
LR analysis of Clarksons Research data identified 1,942 alternative-fuel-capable vessels on order as of January 2026. Clarksons' own Green Technology Tracker, which counts on a slightly different basis, put the alternative-fuel orderbook at 2,036 ships, equivalent to 26 per cent of vessels on order by number and 47 per cent by gross tonnage.

Bunkering availability, by contrast, is highly concentrated by fuel type. Clarksons reported in January 2026 that 222 ports had LNG bunkering available, with 62 more planned, compared with only 25 ports actively offering methanol bunkering and a further 23 methanol projects under development.

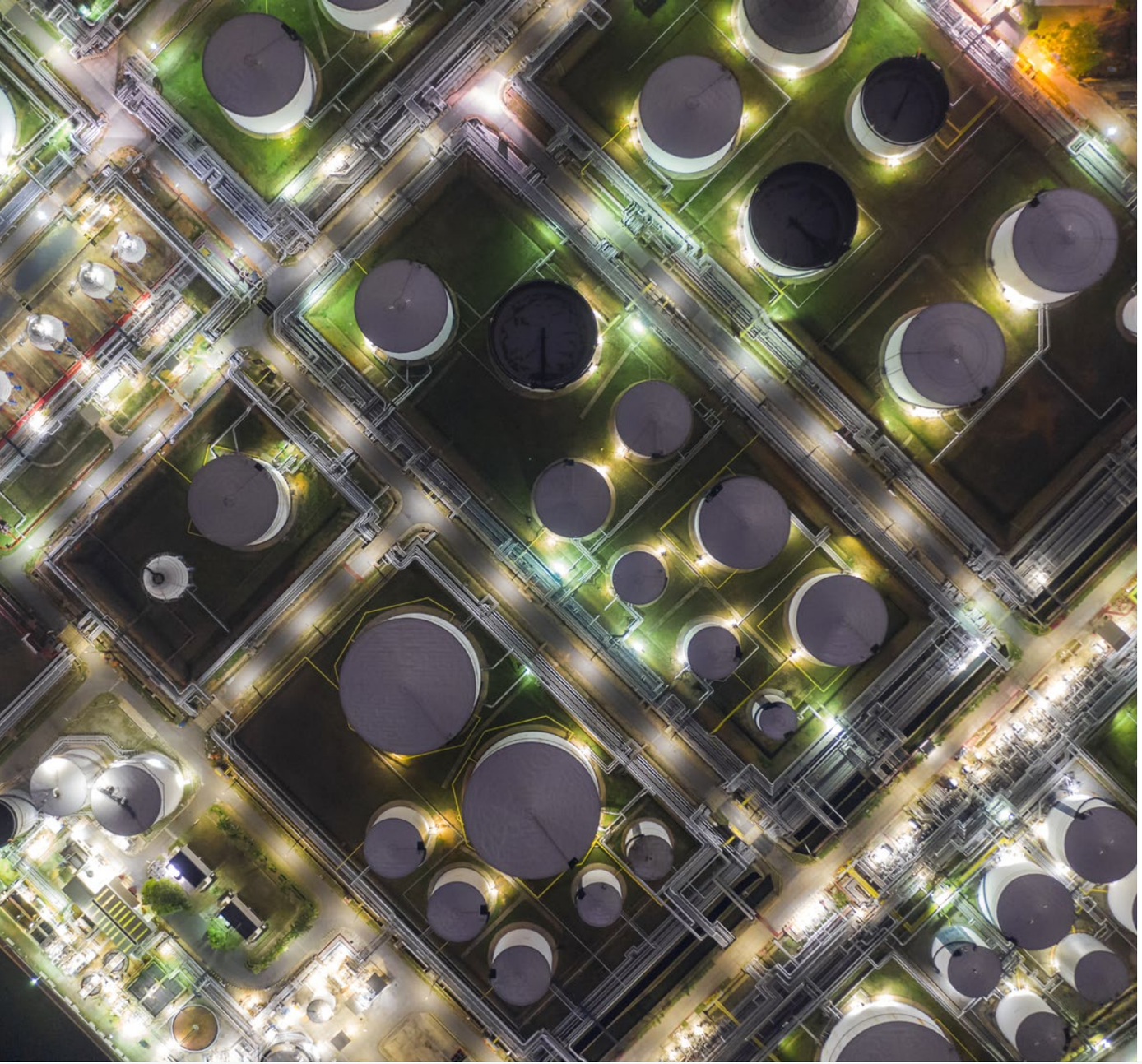
For ammonia the gap is wider still. This report identified only one port, Ulsan, with commercial ammonia bunkering, against 45 ammonia-capable vessels on order. Clarksons has pointed to ongoing concerns around the availability and bunkering infrastructure of fuels such as green methanol and ammonia.

The disparity shows that vessel ordering decisions are in many cases outpacing port investment decisions. The risk is that future alternative-fuel vessels will be capable of using fuels that remain unavailable across large parts of the global port network.

Figure 2. Ports with LNG and methanol bunkering
January 2026



Source: Clarksons Research, Green Technology Tracker (January 2026), as reported by Riviera Maritime Media and Cyprus Shipping News.



Risks, uncertainties and what could change this picture

Every milestone in this report sits on assumptions that could yet be disrupted.

Feedstock and production timing is the most immediate risk. GENA's June 2026 data shows 61.8 million tonnes of announced low-carbon methanol capacity, but GENA's estimate of operational renewable capacity by the end of 2031 is only 6 to 12 million tonnes.

Renewable ammonia faces a similar dependency on electrolyser capacity and offtake agreements. A port that builds bunkering infrastructure ahead of confirmed fuel supply carries a real risk of under-used assets if production slips.

Regulatory finality is the second risk. The IMO's ammonia guidelines are explicitly interim, as per the standard IMO process, and subject to revision. The hydrogen guidelines are high-level and intended for experimental projects, and the methanol guidelines are themselves under revision.

A port or owner investing against today's interim framework should expect further amendments.

Geographic concentration is the third risk. Almost every commercial or near-commercial milestone recorded here sits within a small cluster of North Asian, Northern European and Singaporean ports, plus Houston.

Large parts of Africa, South Asia, Latin America and the Pacific are largely absent from the alternative fuel bunkering map in this research. That raises the prospect of a two-tier network in which some routes are decarbonisation-ready and others are not.

Demand risk cuts both ways. Owners ordering methanol or ammonia tonnage ahead of confirmed bunkering are committing capital against a network that does not yet exist at scale in the places their ships will call. Conversely, a slowdown in newbuild ordering would reduce the pressure on ports to invest.

Chapter 2:
Understanding Future Fuel Demand

2.1

Alternative fuel pathways

The profiles below summarise the technical and safety characteristics of each fuel pathway, the state of vessel and supply markets, and the main milestones to date.

Biofuels

In maritime usage, ‘biofuel’ generally means liquid drop-in bio-oils that can replace or blend with conventional residual and distillate fuels. LR’s Guidance Notes for Class and Statutory Approval and Use of Marine Biofuels use this definition and exclude bio-methane and methyl or ethyl alcohol fuels, which fall under the IGF Code. This report follows the same approach.

Within that family, hydrotreated vegetable oil is chemically closest to a drop-in hydrocarbon fuel.

Fatty acid methyl ester (FAME) blends, the basis of most B24 and B30 products now moving through the ports in this report, are broadly compatible with existing tanks and pipework. They can still raise questions of oxidation stability, cold flow, water affinity and microbial growth. Some of these issues also arise with conventional fuels, given the variability of blend stocks used worldwide, but FAME content adds its own. The fossil fuel blended with the bio-component also varies by product, from VLSFO to marine gas oil.

None of this changes the headline conclusion that biofuels need far less new port infrastructure than ammonia, hydrogen or even methanol. No new safety case of the kind ammonia or hydrogen require is needed. Their constraints are feedstock availability, certification integrity and price.

A traded market now exists. Platts has published market-based assessments of Singapore-delivered B24 bio-bunkers since August 2024, and added B30 assessments in October 2025 after the MPA raised the allowable biofuel blend carriage limit on conventional bunker tankers from 25 to 30 per cent from 7 March 2025.

Supply is broad. In Singapore alone, 14 suppliers were delivering biofuel blends by 2023. LR’s FOBAS Global Fuel Finder now includes biofuel availability and quality data by port and supplier.



LR FOBAS: biofuel activity across the ports in this report

FOBAS, the Fuel Oil Bunker Analysis and Advisory Service, is LR's fuel testing and advisory arm. Its Global Fuel Finder includes biofuel availability and quality data by port and supplier.

Over the previous 12 months, FOBAS data show 90 ports around the world delivering drop-in biofuels, residual and distillate, to ships. The 13 leading ports accounted for 77.5 per cent of biofuel bunker quantities and the remaining 77 ports for 22.5 per cent.

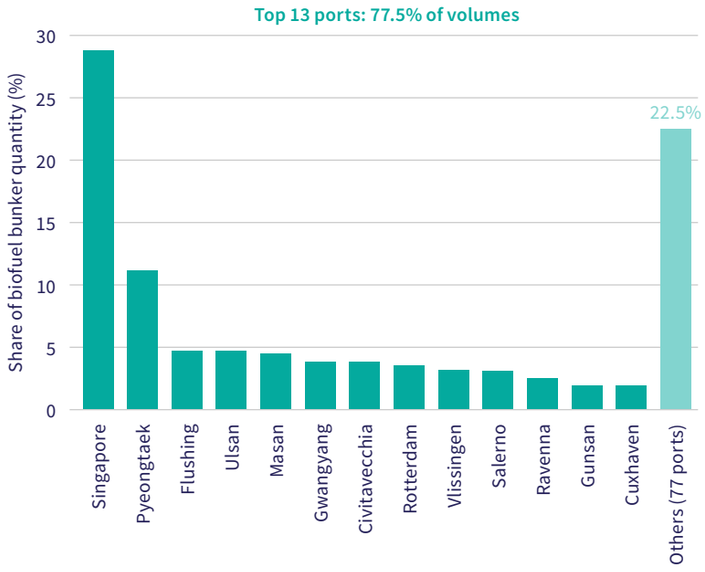
Singapore alone accounted for more than a quarter of volumes, followed by Pyeongtaek. South Korean ports, including Ulsan, Masan, Gwangyang and Gunsan, feature strongly, alongside Italian ports such as Civitavecchia, Salerno and Ravenna, and Rotterdam, Vlissingen and Cuxhaven in northern Europe.

Among the port clusters profiled in this report, FOBAS records biofuel bunkering activity at 11 of 16. No biofuel activity was recorded at Charleston, Houston and the US Gulf Coast, Kandla, Los Angeles and Long Beach, or the Pilbara.

Supply is broad. In Singapore alone, 14 suppliers were delivering biofuel blends by 2023. LR FOBAS Global Fuel Finder now includes biofuel availability and quality data by port and supplier.

Figure 3. Share of drop-in biofuel bunker quantities delivered by port

Previous 12 months



Source: Lloyd's Register FOBAS data (residual and distillate biofuels combined). 'Others' comprises 77 ports.

Table 1. Biofuel bunkering activity at the ports profiled in this report

Port	Biofuel activity (FOBAS data)
Antwerp-Bruges, Belgium	Yes
Charleston, United States	No
Fujairah, United Arab Emirates	Yes
Gibraltar (British Overseas Territory) and Algeciras, Spain	Yes
Hamburg, Germany	Yes
Houston and the US Gulf Coast, United States	No
Kandla, India	No
Los Angeles and Long Beach, United States	No
North Sea Port (Vlissingen, Terneuzen and Ghent), Netherlands and Belgium	Yes
Pilbara Ports (Dampier and Port Hedland), Australia	No
Rotterdam, Netherlands	Yes
Shanghai and Ningbo-Zhoushan, China	Yes
Singapore	Yes
Ulsan and Busan, South Korea	Yes
Ports of the United Kingdom	Yes
Yokohama, Kobe and Nagoya, Japan	Yes

Source: Lloyd's Register FOBAS data.

In the Amsterdam-Rotterdam-Antwerp region, FincoEnergies has supplied drop-in biofuels under its GoodFuels brand since 2015, Glencore completed the acquisition of a majority stake in the company in July 2026. In South Korea, S-Oil began supplying B30 VLSFO in July 2026 through an integrated operation in the Ulsan region.

Examples in this report include Vopak's B24 supply at Fujairah in March 2025 and the 1,375 tonnes of B100 delivered alongside methanol to Ane Maersk at Antwerp-Bruges in April 2024.

LNG, bio-LNG and e-methane

LNG is not a future or green fuel in the sense the others in this report are. It is the only alternative marine fuel with a mature global bunkering network, and much of the rest of the infrastructure story builds on it.

SEA-LNG's January 2026 review counted 222 ports offering LNG bunkering and 62 more planning to do so. By mid-2026 it reported 67 LNG bunker vessels in operation and 42 on order.

LNG continues to dominate the orderbook. LR's analysis of Clarksons Research data counted 1,259 LNG-capable ships on order in January 2026, around two thirds of all alternative-fuel-capable newbuildings.

LNG's hazard profile, understood after two decades of commercial bunkering, centres on cryogenic burns, boil-off gas management and a flammable but non-toxic vapour cloud. That is materially simpler than ammonia's toxicity or hydrogen's ignition characteristics.

Bio-LNG and synthetic e-methane can in principle move through the same cryogenic storage, bunker vessel and transfer infrastructure as fossil LNG, because the molecule is identical. Uptake is growing: almost 16 per cent of LNG supplied at Algeciras in 2025 was bio-LNG, and Rotterdam recorded a more than six-fold increase in bio-LNG blend bunkering in 2025.

Volumes at the leading hubs are now substantial. In 2025 Singapore sold 571,400 tonnes of LNG bunkers, Shanghai roughly 320,000 tonnes and Antwerp-Bruges 235,000 tonnes. Rotterdam and Algeciras report in volume terms: more than one million cubic metres and 333,833 cubic metres respectively.

The caveat, as with every bio- or e-prefixed fuel in this report, is that the climate benefit depends on production pathway and methane slip, not on port infrastructure.

Figure 4. The LNG bunkering network

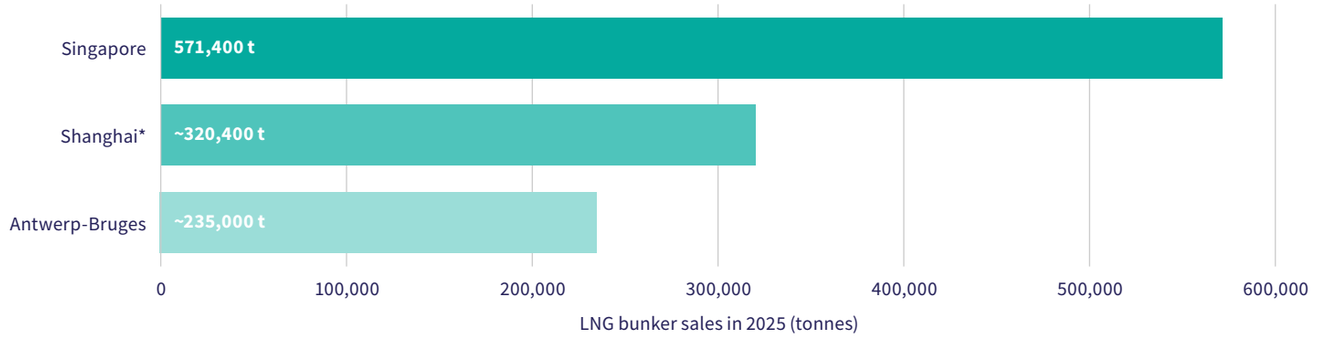
2026



Source: SEA-LNG: ports as at January 2026, bunker vessels as at mid-2026, as reported by ENGINE and gCaptain.

Figure 5. LNG bunker sales in 2025

Ports reporting in tonnes



Source: MPA via Hydrocarbon Processing (Singapore); Shanghai Customs via Ship & Bunker, converted from 712,000 m^3 (*approximate); Port of Antwerp-Bruges via ENGINE.

Methyl and ethyl alcohol (methanol and ethanol)

Methanol's advantage is largely logistical. It is liquid at ambient temperature and sulphur-free, and can move through barges, pipework and coated tanks similar to those used for existing liquid cargoes.

Bunkering still requires its own risk assessments, licensing and crew training, given methanol's toxicity and flammability. But it does not demand the wholesale reinvention of port infrastructure that ammonia and hydrogen do.

Supply is the constraint. GENA Solutions, working with the Methanol Institute, tracked 284 renewable and low-carbon methanol projects at the end of June 2026, representing 61.8 million tonnes of announced capacity by 2031.

That comprised 24.7 million tonnes of e-methanol, 25.9 million tonnes of biomethanol and 11.2 million tonnes of low-carbon methanol. GENA's August 2026 release restated 61.8 million tonnes against a 2032 horizon.

GENA's own estimate of operational renewable methanol capacity is far lower: 6 to 12 million tonnes by the end of 2031.

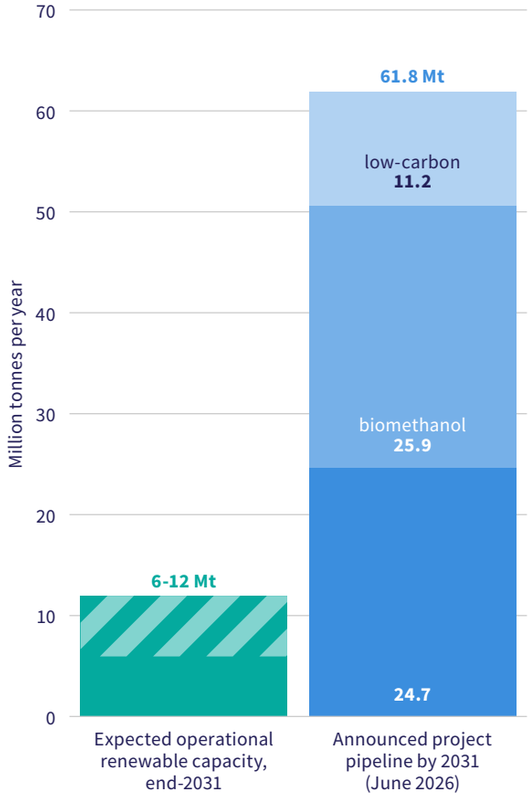
Bunkering transfer technology is maturing quickly, and ports can bunker fossil methanol through existing chemical infrastructure. Producing enough low-GHG bio- or e-methanol to match the newbuild orderbook is a separate and as yet unsolved problem.

Actual methanol bunker volumes remain small. In 2025 Rotterdam bunkered 11,819 tonnes of biomethanol, Shanghai about 10,000 tonnes of green methanol and Singapore about 3,000 tonnes, while Antwerp-Bruges recorded no methanol sales after the third quarter of 2024. Set against 385 methanol-capable ships on order, those figures show how far methanol bunkering remains from routine.

Ethanol, the other alcohol fuel covered by the same IMO interim guidelines, emerged as a bunkering option in July 2026. On 12 July, CMA CGM Iron took on around 500,000 litres, approximately 395 tonnes, of sugarcane-derived bioethanol at Santos, supplied by Copersucar and delivered by Bunker One. Bunker One described it as Latin America's first bioethanol bunkering of an ocean-going containership.

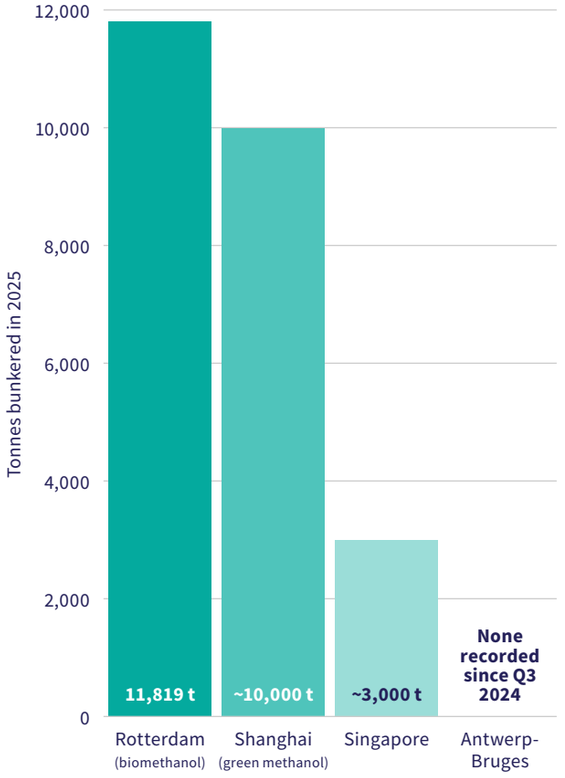
Three days later, the Port of Barcelona announced its first bioethanol bunkering, in which Repsol supplied 2,800 tonnes to Maersk's Antonia Maersk. Ethanol remains far behind methanol in adoption, but two ports within a week puts it firmly on the watchlist.

Figure 6. Announced low-carbon methanol pipeline against expected operational capacity



Source: GENA Solutions / Methanol Institute, June 2026. The low-carbon component is classed by GENA as blue methanol.

Figure 7. Methanol bunker sales in 2025 at selected ports



Source: Port of Rotterdam via Manifold Times; Shanghai Municipal Office of Port Services and MPA via ENGINE and Ship & Bunker; Port of Antwerp-Bruges via Ship & Bunker.



Ammonia

Ammonia is widely regarded as a leading carbon-free candidate for large ocean-going vessels. It liquefies at -33 degrees Celsius, and the chemical industry already produces, stores, transports and distributes it worldwide.

Its principal hazard is toxicity. Industry bodies also highlight the potential for explosive atmospheres and material compatibility challenges. Any accidental release poses an immediate danger to port workers and nearby populations that fire-focused LNG safety cases were never designed to address.

Port-side safety work therefore centres on gas dispersion modelling to define exclusion zones, detection and rapid shutdown, and emergency planning coordinated with local fire and environmental authorities.

The fleet is small but growing. LR counted 45 ammonia-capable vessels on order in January 2026, against 385 methanol-capable vessels.

Production pathway matters directly for port planning. Grey, blue and green ammonia are chemically identical at the point of bunkering but represent very different supply chains and, in most frameworks, very different eligibility for emissions credit.

Rotterdam's April 2025 pilot used grey ammonia as a chemical proxy. Ulsan's April 2026 commercial bunkering used green ammonia produced from renewable power in Inner Mongolia by Envision and imported by Lotte Fine Chemical.

A bunkering jetty does not distinguish between pathways. Emissions readiness is a question about what sits behind the jetty, not the jetty itself.

Hydrogen

For ports and ships alike, the binding constraint is volume rather than mass. Hydrogen's low volumetric energy density, whether stored as compressed gas or as cryogenic liquid, means it currently suits short-sea, ferry and harbour-craft applications better than deep-sea shipping, where bunker tank volume is at a premium.

The clearest large-scale demonstration of liquid hydrogen shipping is the Japan-Australia Hydrogen Energy Supply Chain project. Its carrier, Suiso Frontier, has a 1,250 cubic metre tank holding liquid hydrogen at -253 degrees Celsius.

The vessel carried the world's first cargo of liquefied hydrogen from Hastings in Victoria to the Hy touch Kobe receiving terminal in Japan, arriving in February 2022. The route is roughly 9,000 kilometres each way.

Because dedicated hydrogen bunkering remains so scarce, one transitional option is to generate hydrogen on board from methanol or ammonia, allowing a vessel to run fuel cells without shore-side hydrogen supply.

Port-side hydrogen infrastructure also needs to be distinguished from ship bunkering, because press coverage often blurs the two. The Immingham Green Energy Terminal, for example, is designed to import ammonia and convert it into hydrogen for onward road transport, not to bunker ships.

A port can therefore be advancing on hydrogen while having no capacity yet to refuel an ocean-going hydrogen-fuelled vessel. This report preserves that distinction throughout.

Nuclear power

Nuclear is structurally different from every other fuel in this report, because a merchant nuclear ship does not need to visit a port to bunker in any conventional sense.

The relevant port questions are access, insurance, liability, security and regulatory licensing for a vessel carrying an operating reactor.

A merchant nuclear ship may still carry auxiliary or back-up generators running on conventional or bio-based fuel, so some bunkering may be needed, though on a much smaller scale.

Refuelling, defuelling and the handling of radioactive material and waste will need to take place only at specifically licensed, approved and certified locations. Those activities carry a different safety and security profile from normal cargo operations and are outside the scope of this report.

Nuclear security and safeguards are likely to be new territory for most ports. They will need to be established in coordination with nuclear regulators and emergency responders.

Regulation is developing internationally. The International Atomic Energy Agency launched its Atomic Technologies Licensed for Applications at Sea (ATLAS) initiative at a ministerial event in Washington on 26 and 27 August 2026, backed by a joint statement from more than two dozen member states including the United Kingdom and the United States.

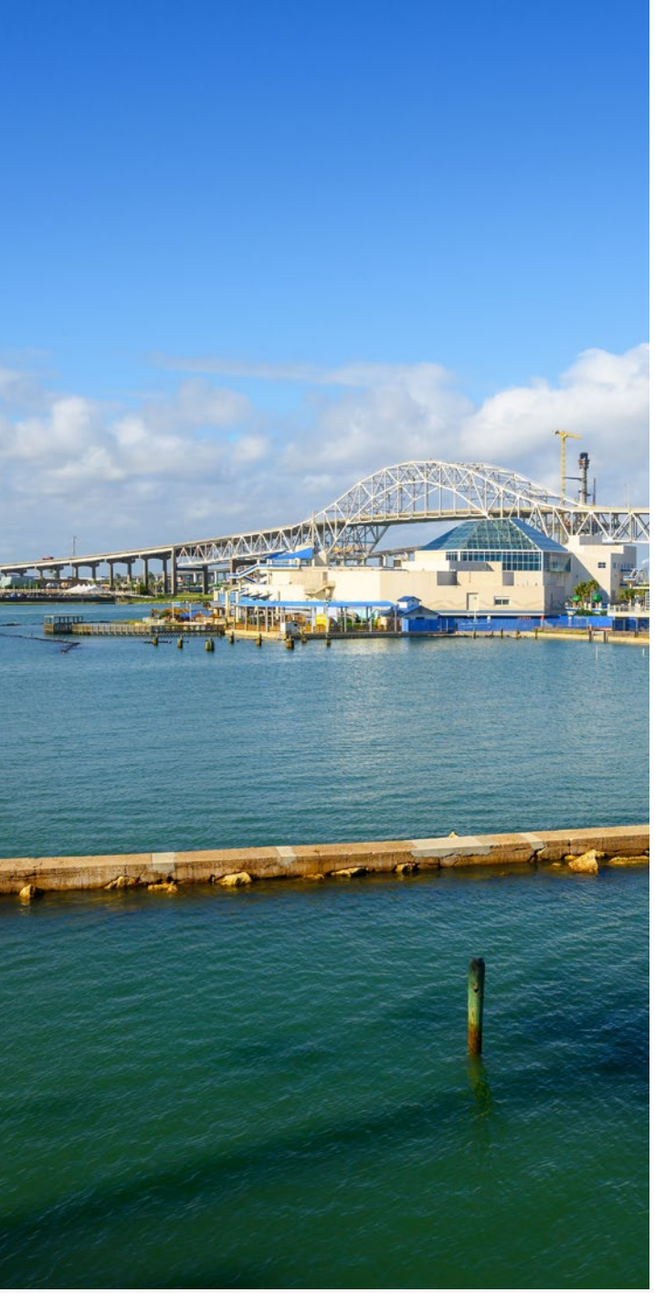
ATLAS will work with the IMO towards an international framework for the safe, secure and safeguarded use of nuclear technology at sea, covering both nuclear-powered ships and floating nuclear power plants.

In the United Kingdom, the Maritime Nuclear Consortium (MarNuc), convened by LR and launched in January 2026 with Rolls-Royce, Babcock, Global Nuclear Security Partners, Stephenson Harwood, NorthStandard and Nuclear Risk Insurers (NRI), aims to drive development of a class certification framework, a security and safeguards architecture and insurability pathways for nuclear-powered vessels.

In the United States, the Maritime Administration (MARAD) issued a request for information in May 2026 seeking industry input on developing small modular reactors for commercial maritime use, as part of an initiative launched by the Transportation Secretary.

Commercial activity is following. In August 2026, Hornbeck Offshore signed a memorandum of understanding with, and invested in, Deployable Energy, developer of the 1 MWe Unity Nuclear Battery microreactor. The National Reactor Innovation Center has since selected Deployable Energy for a maritime demonstration with Hornbeck Offshore, alongside a full-power demonstration at Idaho National Laboratory.





Nuclear port readiness

Two US ports moved this from a theoretical question to an active one in mid-2026.

On 22 July 2026, the Port of Long Beach signed a non-binding memorandum of cooperation with MARAD, becoming the first US seaport to formalise such a partnership on nuclear-powered commercial vessels. It followed MARAD's request for information of 7 May 2026.

The Long Beach framework envisages coordination with the US Coast Guard, the Department of Energy and the Nuclear Regulatory Commission on safety standards, inspections and operating protocols. The port separately signed a lease with Bluecore to allow the company to develop and carry out unfuelled testing of a barge-mounted nuclear power unit.

On 19 August 2026, the Port of Corpus Christi, the largest US port for petroleum exports, signed its own memorandum of cooperation with MARAD. It covers small modular reactors, port microgrids, shoreside power, infrastructure for emerging nuclear-powered concepts and workforce development.

Corpus Christi also signed a memorandum of collaboration with Core Power for a site-specific readiness study. It will examine the port as a potential location for a floating nuclear power plant and its readiness for calls by nuclear-powered commercial ships.

All of these agreements are exploratory. They do not authorise construction of nuclear-powered ships or commit the government or ports to a particular reactor design, and Core Power has described its study as preliminary.

Two different uses of nuclear technology at a port need to be kept apart. Long Beach's lease with Bluecore, for the development and unfuelled testing of a barge-mounted nuclear power unit, and Corpus Christi's study of the port as a potential location for a floating nuclear power plant both concern floating power units rather than ships. These raise different questions from a nuclear-powered ship calling at a port.

The only operating floating nuclear power plant is Russia's Akademik Lomonosov, which has supplied electricity to the Arctic port town of Pevek since December 2019. Rosatom is building a second-generation series for Arctic use and marketing export versions.

Europe is approaching the same questions through studies rather than port agreements. A desktop joint development project by LR, the Port of Rotterdam Authority, Core Power and Maersk, published in June 2026, used Rotterdam as a case study.

It found that existing port safety and risk-management frameworks could provide a credible starting point for assessing calls by nuclear-powered commercial ships. The main barriers identified were regulatory alignment, governance, integration with port risk management and public acceptance, with further work needed on emergency preparedness, security, liability and public engagement.

On 2 September 2026, LR, A.P. Moller-Maersk, the Port of Felixstowe and South Carolina Ports announced the Pink Corridor project. Centred on a conceptual nuclear-powered container ship trading between Charleston and Felixstowe, its initial phase focuses on the security and safeguards requirements for port access. Areas of study include ship security, safeguards, cyber resilience, emergency response, insurance regimes and the alignment of maritime and nuclear regulation. Its findings will inform the scope of a possible second phase covering engineering, regulatory, legislative, security and safeguards frameworks for nuclear merchant ships.

What has changed is that ports are now working through, in concrete institutional settings, the questions a nuclear Port Readiness Level would need to answer. Most of the port system profiled here has not yet started this work.

2.2

Which fuels are likely to be adopted first?

On the evidence to date, the order of adoption is reasonably clear, even if the pace is not. LNG already has a near-global bunkering network and dominates the orderbook. Biofuel blends are the most immediately deployable, moving through existing bunker infrastructure. Methanol is commercial at a small number of leading hubs, but supply of low-carbon methanol is the binding constraint.

Ammonia has crossed into commercial bunkering at only one port so far, with others at pilot or trial stage. Hydrogen remains a short-sea and demonstration fuel, and nuclear is at the stage of port-access studies and agreements rather than operation.

2.3

Regional differences in fuel demand

Readiness and demand differ sharply by region, and within regions. Europe's leading hubs run broad multi-fuel programmes driven in part by FuelEU Maritime; North Asian ports lead on ammonia and methanol operations; Singapore dominates biofuel and LNG volumes; and large parts of Africa, South Asia, Latin America and the Pacific are largely absent from the alternative-fuel bunkering map.

Volumes reflect those choices. In 2025 Singapore sold 1.95 million tonnes of alternative fuels, mostly biofuel blends and LNG, while Shanghai bunkered more green methanol than Singapore and Rotterdam recorded the highest share of alternative fuels among major hubs. The regional picture is set out in Chapter 3.

2.4

Vessel segments and fuel preferences

Fuel choices differ by vessel type, and the milestones in this report show the pattern. Container lines have led on methanol, from Ane Maersk at Antwerp-Bruges to CMA CGM Osmium at Shanghai, and on ethanol with CMA CGM Iron at Santos. Cruise ships and car carriers have favoured LNG, as with Icon of the Seas at Algeciras and simultaneous LNG bunkering of car carriers at Ulsan.

Ammonia's early adopters are gas carriers and bulk carriers. Exmar's gas carrier Antwerpen took the first commercial ammonia bunkering at Ulsan, and Fortescue's chartered Newcastlemax bulk carriers will trade on short, well-defined iron ore routes from the Pilbara. Gas carriers able to burn their own cargo may not need to bunker alternative fuels at all.

Smaller vessels are testing the newer fuels: the ammonia-fuelled tug Sakigake at Yokohama, the ammonia-fuelled offshore vessel Fortescue Green Pioneer, and planned methanol-fuelled RoPax ferries on the Tyne-IJmuiden route. Nuclear interest is concentrated on large container ships, through the Pink Corridor study, and on offshore and power applications.



Chapter 3:
Port Infrastructure Readiness

3.1

Existing infrastructure capabilities

The Port Readiness Level, or PRL, is a self-assessment tool developed by the World Ports Climate Action Programme with the International Association of Ports and Harbors. It gives ports a common language for benchmarking preparedness for a given fuel.

The scale runs from 1 to 9. Levels 1 to 3 cover analysis, 4 to 6 development, and 7 to 9 implementation.

It is cited explicitly by several ports in this report. Rotterdam reached PRL 7 for ammonia after its April 2025 pilot, and Kandla was rated PRL 6 for methanol following an independent assessment in 2026.

Rules and procedures for safe bunkering were operational for LNG in 33 per cent of responding ports and for biofuels in 24 per cent. Ammonia and hydrogen remained in the early stages of adoption.

Some 53 per cent of responding ports had publicly declared a target of carbon neutrality before 2050. Read alongside the port-by-port detail, the Tracker makes clear that the leading hubs profiled here sit well ahead of the median IAPH member port.

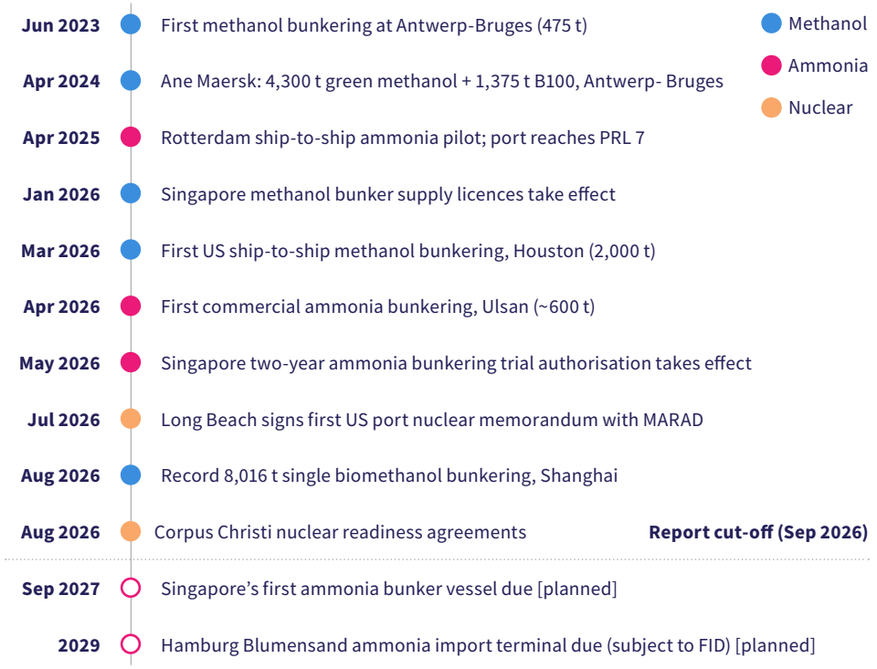
How the ports in this report were selected

The ports profiled in this report were chosen to show the full range of readinessacross six fuel pathways. They are not a ranking and do not form a complete list. They fall into three groups: the largest bunkering hubs; ports that have recorded a notable first or milestone for an alternative fuel; and ports included because of significant work on a single fuel, such as nuclear port access or ammonia export. Some therefore show little or no activity in several fuels. Further ports of strategic importance to shipowners are summarised more briefly. The absence of a port should be read as a gap in coverage, not as evidence that the port itself is unprepared.

Port-by-port assessment

The port evidence below is grouped by region and then arranged alphabetically. The timeline sets the main milestones in sequence.

Figure 8. Key alternative fuel bunkering and port-readiness milestones
2023 to 2029



Source: Port authorities, operators and regulators as cited in the port profiles and References.



Europe

1 Antwerp-Bruges, Belgium

Antwerp-Bruges describes itself as the world's fifth-largest bunkering port and aims to become a multi-fuel port across both its sites.

Its first methanol bunkering took place on 1 June 2023, when 475 tonnes were supplied to the tanker Stena Pro Marine, named in 2023 reports as Proman Stena Marine.

On 1 April 2024, Ane Maersk, the first large methanol-powered deep-sea vessel, took on 4,300 tonnes of green methanol and 1,375 tonnes of B100 biodiesel at the MPET terminal, simultaneously with cargo operations.

Demand for LNG is growing quickly, with bunker sales reaching a record 235,000 tonnes in 2025, more than three times the 68,000 tonnes supplied in 2024. Bio-blended bunker sales were about 21,000 tonnes in the first quarter of 2026.

The port has conducted risk assessments for all fuel types and is implementing a licensing system for bunker operators. Methanol has not become routine: port data show no methanol bunker sales recorded after the third quarter of 2024. No ammonia bunkering operation at Antwerp-Bruges was identified in this research.

2 Gibraltar (British Overseas Territory) and Algeciras, Spain

The Strait of Gibraltar is a major bunkering location serving transatlantic, Europe-Asia and Mediterranean-Africa routes. Its alternative fuel picture is led by LNG.

Algeciras supplied 333,833 m^3 of LNG through 78 ship-to-ship operations in 2025. That placed it in Europe's top three for LNG bunkering behind Rotterdam and Marseille Fos, according to the port authority, and almost 16 per cent of the volume was bio-LNG.

Peninsula began LNG bunkering at Algeciras in January 2024, supplying Icon of the Seas. In August 2025, Axpo delivered more than 4,000 cubic metres of bio-LNG to CMA CGM Fort Bourbon at the port.

On ammonia, ITOCHU and Peninsula signed a memorandum in 2023 on jointly developing ammonia bunkering in Algeciras. No methanol or ammonia bunkering operation at the strait was identified in this research.

The Gibraltar-San Roque refinery on the bay is operated by Moeve, the name Cepsa adopted in October 2024.

3 Ports of Greece

Greece's alternative-fuel bunkering is led by biofuels. The country's first biofuel bunkering took place at Lavrio in April 2025, when Coral Marine and Motor Oil Refinery supplied the cruise ship Celestyal Discovery with a used cooking oil-based blend meeting ISO 8217:2024.

In May 2025 Cosco Shipping announced that biofuel bunkering was available at Piraeus Container Terminal. In October 2025 Coral Marine completed its first biofuel delivery by barge in Greece, supplying a B24 blend to the container ship Xin Lian Yun Gang at the terminal.

Greece has had a legal framework for LNG bunkering since 2019, but no LNG bunkering of a ship in Greece has been recorded.

LNG bunkering has not progressed beyond planning. In January 2020 the European Investment Bank agreed up to €20 million towards an LNG bunker vessel for DEPA, to be based at Piraeus and supplied from the Revithoussa terminal.

In 2022 DEPA Commercial said it was building a 4,000 m^3 vessel, but no order, delivery or operation has since been reported.

A small-scale LNG loading facility at Revithoussa, redesigned as a floating platform for ships of 1,000 to 30,000 m^3, was put out to tender in August 2026 on a 19-month contract.

Shore power is the most active strand. Studies are complete for five ferry and four cruise connection points at Piraeus, and Greek authorities aim to complete Piraeus and Thessaloniki by the end of the decade.

Preparation for other fuels is at the safety-framework stage. Piraeus Port Authority is a partner in SUPERALFUEL (Interreg IPA ADRION, July 2024 to June 2027), which is developing harmonised safety and risk assessment guidelines for hydrogen, ammonia and methanol and will apply its method to hydrogen and methanol bunkering at Piraeus.

4 Hamburg, Germany

Hamburg has taken one of the most methodical, publicly documented approaches in this survey, under its Sustainable Energy Hub initiative, and publishes a port bunker map showing which locations are ready for which fuel.

Cruise Center Steinwerder has been equipped for LNG bunkering since 2019 and for methanol since 2024. In August 2025, the Hamburg Port Authority approved ship-to-ship LNG and methanol bunkering at the Burchardkai and Predöhlkai container terminals, following a risk assessment with RWE Supply & Trading.

The HPA does not act as a bunker supplier. It sets the safety framework, and independent companies deliver the fuel.

On 21 July 2026, the HPA and MB Energy announced a completed risk analysis and safety concept for ship-to-ship ammonia bunkering, with a focus on container ships, cruise ships and RoRo and ConRo vessels. The HPA's bunker map targets portwide readiness for LNG, methanol and ammonia by the end of 2026.

Physical supply will follow later. MB Energy received a permit in April 2026 for an ammonia import terminal at Blumensand, with planned throughput of around 600,000 tonnes a year and commercial operation expected from 2029, subject to a final investment decision.

An ammonia bunker barge is being considered as a possible addition. This sequencing, safety framework first and physical import infrastructure years later, is a useful corrective to any assumption that a port declaring itself ammonia-ready has also solved fuel supply.



5 Ports of Italy

Italy has moved from one-off LNG bunkering to regular supply. Edison carried out the first ship-to-ship LNG bunkering in the Adriatic at Trieste in July 2024, supplying the cruise ship Silver Ray from the 30,000 m^3 Ravenna Knutsen under a harbour master ordinance covering LNG and bio-LNG.

In November 2025 Edison and CMA CGM completed Italy's first ship-to-ship LNG bunkering of a container ship, CMA CGM Salamanque, at Trieste, under a revised ordinance that allows bunkering at any hour. At Genoa, Axpo began supplying GNV's ro-pax ferry GNV Virgo on 4 December 2025 with a six-hour ship-to-ship transfer of 500 m^3 of bio-LNG, Italy's first. Axpo has since refuelled the vessel roughly every two days, and its sister ship GNV Aurora was first bunkered there in March 2026.

The service has since spread south. Axpo and Carnival carried out the first LNG refuelling of a cruise ship at Naples, Sun Princess, on 24 May 2026.

In August 2026 Axpo and Vitol completed the first LNG bunkering at Civitavecchia, Italy's largest cruise port, using the 7,500 m^3 bunker vessel Green Pearl. Supply is underpinned by the 20,000 m^3 Ravenna small-scale depot, owned by Depositi Italiani GNL (PIR, Edison and Scale Gas) and supplied by Edison since 2021.

Drop-in biofuel is commercially available. Enilive has supplied unblended HVO100 by barge at Genoa and Ravenna since October 2025, and at Venice since early 2026.

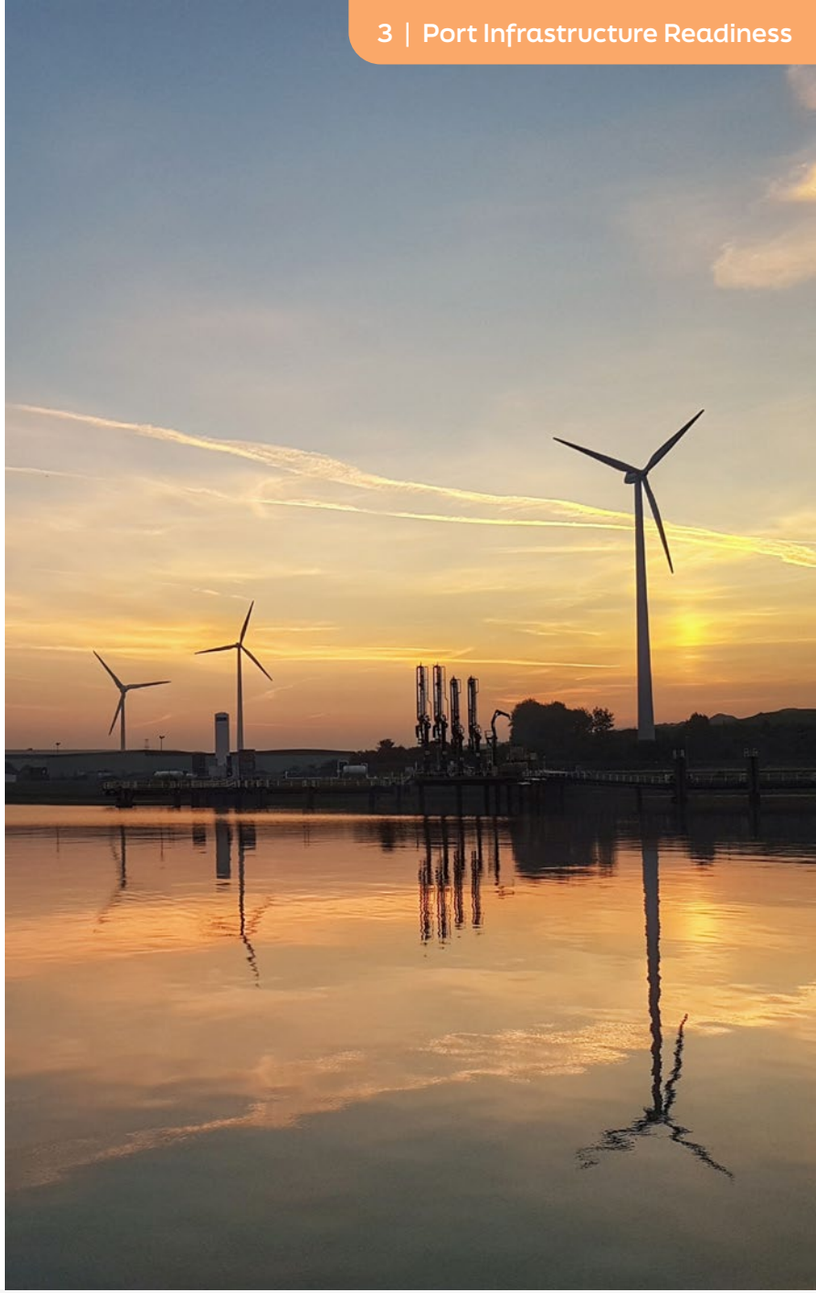
LR FOBAS data confirm the scale of Italian activity: Civitavecchia, Salerno and Ravenna together accounted for about 9.5 per cent of global drop-in biofuel bunker volumes between 1 October 2025 and 30 September 2026. Shore power is being rolled out with more than €800 million of national and EU recovery funding across 52 projects, but no Italian port had confirmed routine commercial service by October 2026. Methanol bunkering is not yet established in Italy and hydrogen is at a proof-of-concept transfer stage to a vessel at La Spezia at time of writing.

6 North Sea Port (Vlissingen, Terneuzen and Ghent), Netherlands and Belgium

North Sea Port offers one of the more methodologically interesting case studies. Rather than pursuing one fuel at a time, it commissioned an independent risk analysis covering all berths across Vlissingen, Terneuzen and Ghent for LNG, hydrogen, methanol and ammonia.

Published in February 2026, the study assessed truck-to-ship and ship-to-ship bunkering for seagoing and inland vessels, and reviewed surrounding infrastructure as well as nautical risk.

Chief executive Cas König said it showed all four fuels could be refuelled safely throughout the port area. Controlled bunkering trials are to follow, each reviewed with the emergency services before wider roll-out.



7 Rotterdam, Netherlands

Rotterdam is the world's second-largest bunker port and has positioned itself as a multi-fuel hub. The port authority states that it has fully implemented the Port Readiness Level method for LNG and, to a large degree, for methanol.

Port data show that in 2025 vessels bunkered more than one million m^3 of LNG in Rotterdam for the first time, including 17,644 cubic metres of bio-LNG, more than six times the 2024 volume. Biomethanol bunkering rose to 11,819 tonnes from 3,946 tonnes a year earlier, and in total 9.8 million tonnes of marine fuel were bunkered at the port.

Alternative fuels already make up a larger share of sales in Rotterdam than at other major bunker ports. In the third quarter of 2025 the port sold 2.45 million tonnes of marine fuel, of which 13.2 per cent was alternatives to conventional oil-based fuels, the highest share among major bunkering hubs. Biofuel deliveries, mainly biodiesel-fuel oil blends, reached 201,319 tonnes in that quarter and fossil LNG 121,614 tonnes.

Infrastructure is expanding to match. A new 180,000 cubic metre LNG storage tank and additional regasification capacity at the Gate terminal were due to be operational in the second half of 2026. The port's chief operating officer has said the aim is to increase biofuel volumes, develop bunkering facilities for new fuels and work on import, export and bunkering strategies for hydrogen, ammonia and methanol.

Rotterdam's market position is not static. In the first quarter of 2026 its bunker sales fell 25 per cent on the previous quarter, which the port authority attributed partly to the Netherlands' implementation of the third Renewable Energy Directive, and Antwerp-Bruges' sales overtook Rotterdam's for the quarter. Rotterdam's LNG bunker volumes nevertheless rose 39 per cent on the quarter to 120,000 tonnes.

On 12 April 2025, Trammo, OCI and James Fisher Fendercare conducted an ammonia ship-to-ship bunkering pilot at the Maasvlakte 2 APM terminal. Some 800 cubic metres of liquid ammonia at minus 33 degrees Celsius were transferred in about two and a half hours, without release.

The pilot was overseen by the DCMR Environmental Protection Agency, the Rijnmond Safety Region and the Joint Fire Service, and formed part of the EU-funded MAGPIE programme. It concluded PRL 6 and raised Rotterdam's ammonia readiness to PRL 7, with safety procedures in place for bunkering on a project basis.

The port has said the first ammonia-capable ships are expected in 2026 or 2027. No commercial ammonia bunkering at Rotterdam was identified in this research.

The next phase of ammonia bunkering at Rotterdam will be governed by a validated safety framework, a licensing system and an ammonia bunker map defining suitable locations.

Rotterdam also anchors one of the most developed green corridors. The Rotterdam-Singapore Green and Digital Shipping Corridor, established in August 2022, had 28 partners across the container shipping value chain by March 2025 and aims to cut greenhouse gas emissions from large container vessels on the route by 20 to 30 per cent by 2030. Its pilots include the first bunkering of mass-balanced liquefied bio-methane at Rotterdam, and it has working groups on bio- and e-variants of ammonia, methanol and methane.

The port was also the case study for the June 2026 joint development project on nuclear-powered ship port calls led by LR, described in the nuclear section.





8 Ports of the United Kingdom

The United Kingdom does not have a Rotterdam- or Singapore-style multi-fuel bunker hub. Its national Maritime Decarbonisation Strategy, published in March 2025, set goals of at least a 30 per cent reduction in fuel lifecycle greenhouse gas emissions by 2030 and 80 per cent by 2040, against 2008, and its ports are building a set of regional capabilities.

The Port of Tyne's Green North Sea Shipping Corridor with IJmuiden, launched in November 2024, is the most concrete near-term pathway to commercial alternative-fuel bunkering, because it is tied to DFDS's planned methanol-fuelled RoPax vessels, due between 2029 and 2030. A Ricardo study published in December 2025 found methanol could cut emissions on the route by around 70 per cent, with onshore power adding a further 10 per cent to 15 per cent.

Elsewhere, activity is at demonstrator or import scale. The Immingham Green Energy Terminal, consented in February 2025, is designed to import ammonia and convert it into hydrogen for road transport rather than to bunker ships. Milford Haven plans a hydrogen fuelling demonstrator for vessels, and the HI-FIVED consortium at Aberdeen received UK Government funding in 2023 to demonstrate liquid hydrogen bunkering for an autonomous vessel. Its delivery status has not been verified for this report.

Southampton hosted the ammonia-fuelled Fortescue Green Pioneer for Port State Control inspections in March 2025, it then visited the Port of London, a useful regulatory precedent but not a bunkering service. On nuclear, the Port of Felixstowe is the UK end of the Pink Corridor project with Charleston.

With the UK Emissions Trading Scheme now covering domestic maritime, UK ports have a pricing driver comparable to, if narrower than, FuelEU Maritime in the EU. The UK has relevant capability but not yet an integrated bunkering network.



Asia

1 Pilbara Ports (Dampier and Port Hedland), Australia

The Pilbara is not principally a bunkering hub for passing trade but a major bulk export region. Its vessel traffic is dominated by bulk carriers on a small number of well-defined routes to Asia, which simplifies infrastructure planning relative to a diversified hub.

A feasibility study commissioned by Yara Clean Ammonia and Pilbara Ports and undertaken by LR, published in November 2023, found ship-to-ship ammonia bunkering could be performed within acceptable risk levels at anchorages in Dampier and Port Hedland.

It found existing infrastructure, including Yara's Karratha plant and the Bulk Liquids Berth at Dampier, could be leveraged to begin bunkering in the near term. It estimated potential demand for ammonia fuel in the iron ore trade at 1 to 1.5 million tonnes in 2035.

Commercial commitments followed in 2026. On 22 June, Fortescue agreed to charter 12 Newcastlemax bulk carriers from CMB.TECH's Bocimar. Up to three will be delivered with dual-fuel ammonia engines and are expected in service by the end of 2026; the other nine will be ammonia-ready.

Pilbara Ports has confirmed plans for its first ammonia refuelling trial at Port Hedland later in 2026.

2 Kandla, India

India's programme is at an earlier stage than China's or South Korea's. Kandla, operated by the Deendayal Port Authority, already handles methanol as cargo and has storage tanks, pipelines and jetties.

Following an assessment, the port was rated PRL 6 for methanol bunkering. On 2 April 2026, it carried out India's first shore-to-ship methanol bunkering trial, with Stolt Tankers, J M Baxi, Aegis Vopak and Indian Oil Corporation.

The port is working towards availability of around 500,000 tonnes a year of RFNBO-compliant e-methanol by 2028 to 2029, aimed at dual-fuel vessels on the Asia-Europe route. Ship-to-ship methanol bunkering is planned as the next phase.

3 Shanghai, Ningbo-Zhoushan and Tianjin, China

On 10 February 2026, ten national ministries and commissions, including the Ministry of Transport and the National Development and Reform Commission, issued a plan for Shanghai to become an international centre for green shipping fuel bunkering and trading by 2030.

The plan targets bonded LNG bunkering capacity of one million cubic metres and one million tonnes of methanol and biofuel bunkering capacity by 2030. It concentrates infrastructure on the chemical industry park, Hengsha Island, the Yangtze estuary and Yangshan Port. The plan covers LNG, green methanol and biofuels, and does not include ammonia.

Shanghai already bunkers LNG at scale. It completed China's first ship-to-ship bonded LNG bunkering of an international vessel in March 2022, and bonded LNG bunkering rose 54 per cent in 2025 to 712,000 cubic metres, or roughly 320,000 tonnes. The port also supplied about 10,000 tonnes of domestically produced green methanol in 2025, its first recorded year of green methanol bunkering and more than Singapore's roughly 3,000 tonnes.

In March 2026, CMA CGM Osmium took on 3,643 tonnes of biomethanol at Yangshan using a simultaneous loading and bunkering model. In August 2026, the same vessel took on 8,016 tonnes, reported as the world's largest single biomethanol bunkering, supplied from Shanghai Electric's Taonan plant.

Sources differ slightly on the date of the August operation, between 15 and 17 August. One outlet names the vessel CMA CGM Osiris; the owner names it CMA CGM Osmium.

Ningbo-Zhoushan completed its first ship-to-ship green methanol bunkering on 22 April 2026, transferring around 503 tonnes to COSCO Shipping Libra. On 23 August 2026, the same vessel took on around 5,500 tonnes, a provincial record.

The Zhoushan area issued its first licence to supply methanol to international ships on 24 December 2025. Its July 2025 pilot guidelines extended permitted bunkering fuels to include LNG, LPG and ammonia, and the port now offers ship-to-ship bunkering across LNG, biofuels and methanol.

Tianjin carried out China's first green methanol bunkering of a ro-ro ship on 22–23 September 2025. Sinopec supplied about 300 tonnes of green methanol, shore to ship, to China Merchants' new methanol dual-fuel car carrier CM Hong Kong (Chinese name Gang Rong) at the Tianjin Port Global Ro-Ro Terminal.

Tianjin also exports green methanol for bunkering elsewhere: in July 2025, 5,000 tonnes were loaded at Vopak's Dagu terminal for delivery to Singapore.

Seagoing LNG bunkering at Tianjin remains at the licensing and storage stage. CNOOC Tianjin New Energy received North China's first bonded LNG bunkering pilot qualification in September 2024, and a 200,000 m^3 bonded LNG storage facility opened at Nangang in July 2025.

No completed LNG bunkering of a seagoing ship could be verified. However, shore power is well established: Tianjin Port Group projected more than 380 ship connections in 2024, up 88 per cent.

Elsewhere in northern China, Qingdao carried out the region's first biofuel bunkering, B24, in June 2025, and Dalian its first green methanol ship-to-ship bunkering in July 2025.

No ammonia or hydrogen bunkering has been identified at Tianjin to date.



4 Singapore

Singapore is the world's largest bunker port, which makes its fuel transition programme disproportionately influential for the rest of the industry.

On methanol, the MPA launched a call for applications in March 2025 and selected three licensees from 13 applicants: Global Energy Trading, Golden Island and PetroChina International (Singapore). The licences run for five years from 1 January 2026.

On ammonia, the Fortescue Green Pioneer took on ammonia fuel during harbour trials in Singapore in March 2024.

On 27 April 2026, the MPA issued its first ammonia bunkering trial authorisation, to ZETA Bunkering, a subsidiary of Japan's ITOCHU. It took effect on 15 May 2026 for up to two years and is intended to verify technical readiness, operational protocols, infrastructure and technologies.

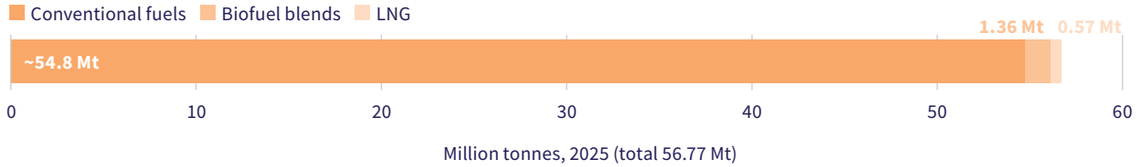
ITOCHU's first ammonia bunker vessel, of around 5,000 cubic metres, is under construction at Sasaki Shipbuilding for delivery in September 2027. Demonstration bunkering is planned for late 2027.

Singapore's LNG and biofuel markets are established and growing. MPA data show record total bunker sales of 56.77 million tonnes in 2025. Alternative fuels accounted for 1.95 million tonnes, including 1.36 million tonnes of biofuel blends and 571,400 tonnes of LNG. Around 3,000 tonnes of methanol was bunkered in the year, before the new supply licences took effect. The MPA opened applications for additional LNG bunker supply licences in January 2026.

The MPA is party to corridors with Rotterdam, with six Japanese ports and with Los Angeles and Long Beach.

Figure 9. Singapore bunker sales by fuel type

2025



Source: MPA data via Hydrocarbon Processing and Ship & Bunker, January 2026. Conventional figure derived from reported totals.



5 Ulsan and Busan, South Korea

South Korea has produced the single most significant milestone in this survey. On 23 April 2026, at Pier 2 of Ulsan Main Port, Lotte Fine Chemical supplied approximately 600 tonnes of green ammonia by port-to-ship transfer to the gas carrier Antwerpen, built by HD Hyundai Heavy Industries for Belgian owner Exmar.

The Ulsan Port Authority and the regional oceans and fisheries office describe it as the world's first commercial ammonia bunkering. Independent trade reporting describes earlier ammonia bunkering as demonstrations only.

Under a January 2024 memorandum of understanding, the Ulsan Port Authority worked with Lotte Fine Chemical, HD Hyundai Heavy Industries and HMM on regulation, infrastructure, vessel readiness and fuel supply. The Ministry of Oceans and Fisheries, the regional office and the Ulsan Fire Department were involved in safety oversight.

The fuel was used for the vessel's sea trials ahead of delivery.

Ulsan also reports the world's first methanol bunkering demonstrations for container ships, in 2023 and 2024. In September 2025 it completed South Korea's first ship-to-ship green methanol bunkering of a bulk carrier, Green Future, and it has carried out simultaneous LNG bunkering for car carriers.

Busan, South Korea's largest container port, is pursuing a longer-dated programme. The Busan Port Authority plans 520,000 cubic metres of storage at Busan New Port by 2032, comprising 370,000 cubic metres for LNG and 150,000 cubic metres for green methanol, with berths for bunker vessels.

6 Yokohama, Kobe and Nagoya, Japan

Japan's approach has been driven as much by national energy policy as by shipping demand. Yokohama, Kobe and Nagoya are among the six ports in the Singapore-Japan corridor, all of which are pursuing initiatives under the national Carbon Neutral Port plan.

On 17 July 2024, NYK supplied ammonia by truck-to-ship transfer to the tugboat Sakigake at Honmoku Wharf in Yokohama. NYK described it as the world's first truck-to-ship ammonia bunkering of an ammonia-fuelled tug. The ammonia was produced by Resonac, with later supply from JERA.

Kobe hosts Hy touch Kobe, the liquefied hydrogen receiving terminal that took the first Suiso Frontier cargo in 2022. That is hydrogen import infrastructure rather than ship bunkering capability.





Middle East and the Suez Canal

1 Fujairah, United Arab Emirates

Fujairah, on the UAE's east coast outside the Strait of Hormuz, is the world's third-largest bunkering hub. It supplied almost 7.5 million tonnes of shipping fuel in 2024 and has more than 100 million barrels of crude and product storage.

A UAE energy ministry official told the 2025 Fujairah bunkering forum that the port is enhancing its capabilities across LNG, methanol, ammonia and biofuels.

Concrete milestones so far are in biofuels. The first B24 bunker deliveries in the UAE took place at Fujairah in December 2023. Vopak Horizon Fujairah completed its own first bio-bunker supply, of B24, in March 2025.

Bahrain-based Mercantile & Maritime has proposed a biofuels plant at the port. Bunker industry professionals quoted in March 2025 described demand for alternative bunker fuels at Fujairah as minimal.

2 Dubai, Abu Dhabi and Qatar

The UAE's first LNG bunkering took place at Dubai Harbour on 4 January 2025. Monjasa's 5,000 m^3 bunker vessel Green Zeebrugge delivered about 3,000 m^3 of LNG to the cruise ship Costa Smeralda, with an LNG carrier chartered from ADNOC Logistics & Services serving as floating storage.

Dubai Ports Authority said a fuel bunkering regulation was being developed for port operators and LNG suppliers. Abu Dhabi followed in April 2025, when AD Ports Group hosted its first ship-to-ship LNG bunkering at Khalifa Port, supplying the container ship MSC Thais. Biofuel blends are available in the wider UAE market: a 200-tonne B24 delivery was made at Khor Fakkan in January 2024.

At Jebel Ali, PIL and DP World signed an MoU in December 2023 covering planned biofuel bunkering trials, with e-LNG, methanol and ammonia to be explored later, although no completed bunkering has been reported.

Methanol remains at study stage. AD Ports, Masdar, Advario and CMA CGM are assessing an e-methanol bunkering and export facility at Khalifa Port, and DP World's green corridor agreement between Jebel Ali and Ningbo-Zhoushan covers cooperation on LNG, methanol and shore power.

Qatar is the world's leading LNG exporter, yet no LNG bunkering at Qatari ports could be verified for this report. Conventional fuel-oil bunkering began at Ras Laffan anchorage and Hamad Port in 2017, and in 2019 Qatar Petroleum and Shell agreed a joint venture to develop LNG bunkering at strategic locations worldwide, without a Qatari supply point being confirmed.

QAFCO's blue ammonia plant at Mesaieed, designed for 1.2 million tonnes a year, is a production and export project. It had been targeted for the second quarter of 2026, initially as grey ammonia while its carbon capture unit was completed, but no start of production had been confirmed by October 2026.

3 Oman

Oman's most advanced project is LNG at Sohar. Marsa LNG, owned 80 per cent by TotalEnergies and 20 per cent by OQEP, is building a one million tonne a year liquefaction plant with 165,000 m^3 of storage, intended to become the Middle East's first onshore LNG bunkering centre. Construction had passed 55 per cent by the end of June 2026, and start-up is targeted for the first quarter of 2028.

Sohar has also introduced biofuel, extending a B20 blend from a trial on one tug to its whole tug fleet in 2024, and signed a shore power agreement for its container terminal in September 2025.

It has experience of ammonia handling: in January 2026 Exmar's gas carrier Kortrijk completed a full-cargo ship-to-ship ammonia transfer there, a cargo operation rather than bunkering.

Duqm and Salalah are the focus for future fuels. In June 2026 Oman signed agreements for further phases of ACME's green hydrogen and ammonia project at Duqm, each designed for 400,000 tonnes a year of green ammonia, with commercial operation expected in 2030 and 2033.

Asyad, OQ Alternative Energy and Sumitomo agreed in September 2024 to study turning existing Salalah and Duqm bunkering sites into low-carbon fuel bunkering hubs.

At Salalah, a HIF Global-led consortium signed an MoU in November 2025 for e-methanol production and a bunkering hub, Yamna has named the port as one of five potential ammonia bunkering hubs, and the port signed a lease for a biofuel storage hub in October 2025.

HyDuqm, another hydrogen concession, targets 1.2 million tonnes a year of green ammonia, with an investment decision expected in 2027.

None of these has yet delivered alternative-fuel bunkering.

4 Suez canal ports, Egypt

East Port Said hosted the region's first methanol bunkering in August 2023, when the barge Lara S delivered about 500 tonnes of green methanol to a Maersk container ship in around six hours.

No further methanol bunkering in Egyptian ports was identified for this report.

Supply plans are extensive but largely uncommitted. Scatec's December 2023 memorandum with the Suez Canal Economic Zone (SCZONE) envisages about 100,000 tonnes a year of green methanol for bunkering at East Port Said, at an estimated US$1.1 billion.

In August 2025 SCZONE, ITOCHU and Orascom Construction agreed to design, develop and operate ammonia bunkering facilities at Ain Sokhna and East Port Said.

Production is closest at Ain Sokhna, where the Egypt Green Hydrogen project holds a €397 million H2Global contract to supply up to 397,000 tonnes of renewable ammonia to Europe between 2027 and 2033.

In November 2025 the Ministry of Petroleum and the Suez Canal Authority agreed to develop an LNG station at Port Said, initially for canal tugs and ferries, although a December 2025 CEDIGAZ analysis found no evidence of tenders, financing or licensing.

Egypt has also assessed five ports for alternative-fuel readiness under the IMO GreenVoyage2050 programme.





Americas

1 Brazil

Brazil's most advanced activity is in drop-in biofuels. Petrobras made its first sale of B24 bunker fuel, blended at Rio Grande, in July 2024.

In February 2026 it agreed to supply Odfjell with up to 12,000 tonnes of B24 during the year from its Rio Grande terminal, building on the Brazil–Norway green corridor agreed in 2025.

Petrobras also bunkered B24 into three Transpetro tankers at São Sebastião in November 2025, and plans a R$3.3 billion expansion at Santos that would allow B24 sales in São Paulo, with no start date yet given.

Brazil's longer-term potential has been assessed independently. A May 2025 ICCT study scored six ports as candidate hubs for renewable hydrogen, ammonia and methanol bunkering: Santos, Rio Grande, Itaqui, Pecém, Navegantes and Porto do Açu. Santos and Rio Grande scored highest, at 4.4 out of 5.

Santos has also hosted Latin America's first bioethanol bunkering of an ocean-going container ship, CMA CGM Iron, on 12 July 2026, already described in Section 2.1.

CMA CGM described it as a first demonstration, and no further ethanol bunkering at Santos had been announced by October 2026.

Owner interest is widening: Vale and Shandong Shipping have agreed a charter for ethanol-fuelled ore carriers, with deliveries from 2029.

The policy framework is still forming. A resolution creating a national sustainable marine fuel programme was withdrawn from the National Energy Policy Council's September 2026 agenda.

Methanol, ammonia and hydrogen remain at planning stage, including a licensed e-methanol plant project at Suape and green ammonia projects at Açu.

No LNG bunkering in Brazil was identified. Santos has supplied shore power to tugs since November 2024, but not yet to seagoing ships.

2 Charleston, United States

The Port of Charleston, operated by South Carolina Ports, is the US end of the Pink Corridor project announced on 2 September 2026 by LR, A.P. Moller-Maersk, South Carolina Ports and the Port of Felixstowe.

Centred on a conceptual nuclear-powered container ship trading between Charleston and Felixstowe, the project's initial phase examines the security and safeguards requirements for port access, along with cyber resilience, emergency response, insurance regimes and the alignment of maritime and nuclear regulation. Its findings will inform the scope of a possible second phase covering engineering, regulatory and legislative frameworks for nuclear merchant ships.

That makes Charleston one of only a handful of ports worldwide formally working through the port-side requirements for nuclear-powered merchant ships. No alternative fuel bunkering milestones at Charleston were identified in this research.

3 Houston and the US Gulf Coast, United States

Houston achieved the first ship-to-ship methanol bunkering in the United States on 30 March 2026. Maersk's dual-fuel Tangier Maersk received 2,000 tonnes of methanol, supplied by Methanex, from the tank barge Kirby 29067.

The operation followed four months of meetings, risk assessments and design reviews involving the US Coast Guard, its Liquefied Gas Carrier National Center of Expertise, Maersk Line Limited and Kirby Marine.

Kirby Marine, the largest tanker barge operator in the United States, brought existing experience of handling methanol as a cargo. That is a useful illustration of how much bunkering capability can be built on an existing chemical-handling base.

Elsewhere on the Gulf Coast, Corpus Christi's nuclear readiness agreements are described under nuclear port readiness in Chapter 2. On the US East Coast, the Port of Charleston is the US partner in the Pink Corridor project, profiled above.

4 Los Angeles and Long Beach, United States

The San Pedro Bay port complex, the largest container gateway in the United States, is at an earlier stage for ship bunkering than the leading Asian and European hubs.

Long Beach did host the first LNG bunkering of a container ship on the US West Coast, when Pasha Hawaii's George III refuelled there in August 2022.

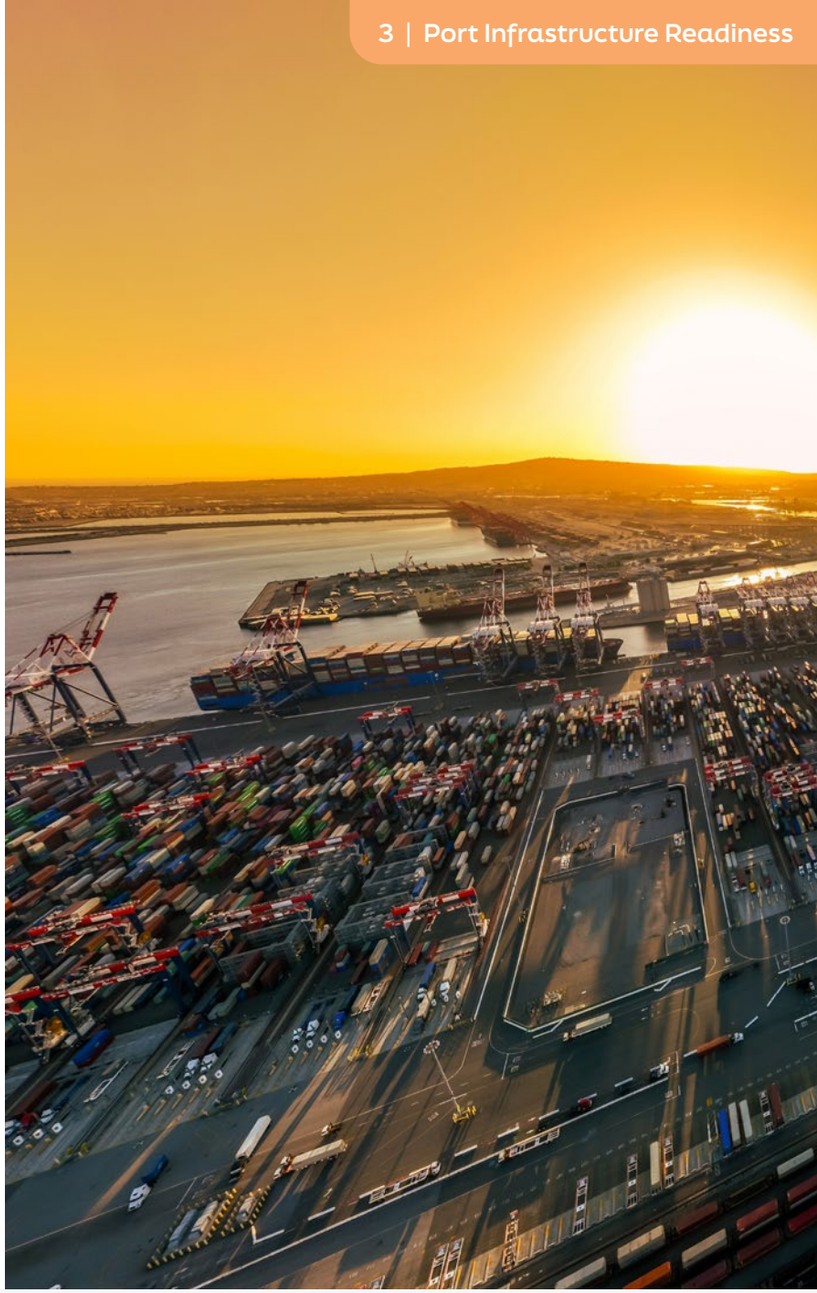
In September 2025, the ports, with C40 Cities and consultancy ICF, issued a request for information to help design a pilot-scale methanol bunkering project. It sought input on feasibility, permitting with the US Coast Guard and fire services, safety, logistics and risk-sharing.

Under their renewed corridor agreement with Singapore, the two ports have said they are preparing for a methanol pilot in 2026.

A Long Beach executive said in 2024 that the port had facilities that could be converted to store methanol but lacked bunkering facilities for supplying it to ships.

Both ports are partners in a green and digital shipping corridor with Singapore agreed in 2023, and Long Beach joined the Shanghai-Los Angeles green shipping corridor in 2022.

On nuclear, the two ports have diverged. Long Beach's agreement with MARAD is described in the nuclear section above; no equivalent agreement by the Port of Los Angeles was identified in this research.





5 Panama and South America

Panama is one of the world's largest bunkering locations, but its published sales remain almost entirely conventional. Panama Maritime Authority figures show 444,042 tonnes sold in February 2026, with no separate category for LNG or biofuels.

In October 2025 the authority reinstated licensing for fuel supply by barge, lifting restrictions in place since 2019.

Drop-in biofuels are already offered in Panama. In January 2025 Monjasa became the first biofuel bunker supplier in Panama, offering B30 by barge at Cristóbal and Balboa. Its first delivery, 900 tonnes of B30 to the car carrier Hestia Leader at Cristóbal, followed on 2 February 2025.

LNG bunkering, however, has not moved beyond announcements. Crowley planned Pacific-side ship-to-ship operations under the first LNG bunkering permit issued in Panama, and AES and Seaspan Energy targeted Atlantic-side operations from March 2025.

No completed LNG bunkering in Panama could be verified.

The Panama Canal Authority is using transit access as an incentive instead. Since November 2025 its NetZero Slot has reserved one Neopanamax slot a week for dual-fuel ships able to burn a fuel of 75 gCO_2e/MJ or less on a well-to-wake basis, such as LNG, methanol or ammonia, with a guaranteed 24-hour transit.

Hydrogen-based fuels remain at strategy and study stage. Panama's 2023 national green hydrogen strategy aims for clean hydrogen and derivatives to supply 5 per cent of national bunkering by 2030, and an EU-funded Panama to Algeciras green corridor study is under way. In Chile, Enaex is studying ammonia bunkering at Mejillones under a 2024 memorandum of understanding, and the 620,000 tonne a year Volta renewable ammonia project at Mejillones received environmental approval in December 2025.

5 Vancouver, Canada

Vancouver has moved from LNG fuelling of domestic ferries to ship-to-ship bunkering of deep-sea vessels. In November 2024 the Vancouver Fraser Port Authority gave Seaspan Energy its first LNG bunkering accreditation, making LNG the first alternative fuel approved for bunkering at the port.

Seaspan announced Canada's first ship-to-ship LNG bunkering, to a tanker in the Upper Harbour, on 3 February 2025.

On 9 March 2025 Seaspan Garibaldi bunkered the 7,900 TEU CMA CGM Pointe du Piton, and in May 2025 Silver Nova became the first cruise ship to bunker LNG at Vancouver.

Seaspan now operates three LNG bunker vessels and had completed more than 150 ship-to-ship operations by July 2026.

Supply is set to grow. The LNG comes from FortisBC's Tilbury facility; FortisBC completed its 10,000th marine LNG refuelling in April 2026, ten years after it began LNG bunkering in 2016.

In July 2026 British Columbia cleared the way for a Tilbury expansion costing more than C$2 billion, with commercial operation targeted for 2031, subject to further permits.

Vancouver is also looking beyond LNG. The port authority describes planning for methanol and ammonia as being at an early stage.

A November 2025 study by Oceans North and Arup set out a concept for e-methanol production at the port, noting that fuels for the two green corridors involving Vancouver, Pacific Northwest to Alaska for cruise and the North Pacific Green Corridor for bulk, had yet to be decided.

On the east coast, the Port of Montreal reports more than 200 LNG bunkering operations in seven years.

Vancouver was the first Canadian port to offer shore power, at Canada Place in 2009, and extended it to the Deltaport and Centerm container terminals in 2015.

Federal funding of up to C$6.6 million will expand the Canada Place system.

The port's EcoAction programme offers up to 75 per cent off harbour dues for ships using LNG, methanol or hydrogen, or connecting to shore power.

Comparative summary

Read together, the ports surveyed are at materially different stages of readiness, and readiness differs by fuel within the same port. Rather than a single ranking, the evidence is grouped here by the type of milestone each port has demonstrated.

Commercial or licensed alternative-fuel bunkering in more than one fuel, combined with an advanced ammonia position: Ulsan, which has reported a commercial ammonia bunkering; Rotterdam, which has completed a large ammonia transfer pilot and reached ammonia PRL 7; Singapore, which licenses methanol bunkering and has an active ammonia trial authorisation; and Hamburg, which has an approved ammonia safety concept and a portwide readiness target for the end of 2026 but no physical ammonia supply before 2029.

Commercial bunkering in LNG, methanol or both, without a validated ammonia pathway at the port: Antwerp-Bruges, Shanghai, Ningbo-Zhoushan, Algeciras and Houston, whose fuel mix and maturity differ. Yokohama has demonstrated truck-to-ship ammonia supply to the ammonia-fuelled tug Sakigake.

Principally feasibility work, trials, planned projects or capability in selected fuels only: Charleston, whose work to date is on nuclear port access, Los Angeles and Long Beach, Busan, Kandla, Fujairah beyond biofuels, the Pilbara, North Sea Port pending its controlled trials, and the UK clusters.

These groupings are this report's own assessment. Each port should still be assessed fuel by fuel rather than by a single overall position.

North Sea Port stands somewhat apart, because its risk analysis assessed all four fuels across its entire berth estate at once. That gives it a comparative internal picture most other ports do not yet have.

Figure 10. Alternative fuel bunkering readiness by port and fuel

Port / cluster	LNG	Methanol / ethanol	Ammonia	Hydrogen	Biofuel*	Nuclear (port access)
Antwerp-Bruges	Commercial / recurring	First operations / trial	Framework, study or plan	Not reported	Commercial / recurring	Not reported
Brazilian ports (Santos, Rio Grande)	Not reported	First operations / trial	Framework, study or plan	Framework, study or plan	Commercial / recurring	Not reported
Busan	Framework, study or plan	Framework, study or plan	Not reported	Not reported	Commercial / recurring	Not reported
Charleston	Commercial / recurring	Not reported	Not reported	Not reported	Not reported	Framework, study or plan
Cyprus (Limassol)	Framework, study or plan	Not reported	Not reported	Not reported	Not reported	Not reported
Dubai / Abu Dhabi	First operations / trial	Framework, study or plan	Not reported	Not reported	Not reported	Not reported
Fujairah	Framework, study or plan	Framework, study or plan	Framework, study or plan	Not reported	Commercial / recurring	Not reported
Gibraltar / Algeciras	Commercial / recurring	Not reported	Framework, study or plan	Not reported	Commercial / recurring	Not reported
Greek ports	Framework, study or plan	Framework, study or plan	Framework, study or plan	Framework, study or plan	Commercial / recurring	Not reported
Hamburg	Commercial / recurring	Commercial / recurring	Framework, study or plan	Not reported	Commercial / recurring	Not reported
Houston / US Gulf	Commercial / recurring	First operations / trial	Not reported	Not reported	Not reported	Framework, study or plan
Istanbul, Türkiye	Framework, study or plan	Not reported	Not reported	Not reported	Commercial / recurring	Not reported
Italian ports	Commercial / recurring	Not reported	Not reported	First operations / trial	Commercial / recurring	Not reported
Kandla	Not reported	First operations / trial	Not reported	Not reported	Not reported	Not reported
Los Angeles / Long Beach	First operations / trial	Framework, study or plan	Not reported	Not reported	Not reported	Framework, study or plan
Ningbo-Zhoushan	Commercial / recurring	Commercial / recurring	Framework, study or plan	Not reported	Commercial / recurring	Not reported
North Sea Port	Framework, study or plan	Framework, study or plan	Framework, study or plan	Framework, study or plan	Commercial / recurring	Not reported
Omani ports	Framework, study or plan	Framework, study or plan	Framework, study or plan	Not reported	First operations / trial	Not reported
Panama	Framework, study or plan	Not reported	Not reported	Framework, study or plan	Commercial / recurring	Not reported
Pilbara Ports	Not reported	Not reported	Framework, study or plan	Not reported	Not reported	Not reported
Qatar	Framework, study or plan	Not reported	Not reported	Not reported	Not reported	Not reported
Rotterdam	Commercial / recurring	Commercial / recurring	First operations / trial	Not reported	Commercial / recurring	Framework, study or plan
Shanghai	Commercial / recurring	Commercial / recurring	Not reported	Not reported	Commercial / recurring	Not reported
Singapore	Commercial / recurring	Commercial / recurring	First operations / trial	Not reported	Commercial / recurring	Not reported
Suez Canal ports	Framework, study or plan	First operations / trial	Framework, study or plan	Not reported	Not reported	Not reported
Tianjin	Framework, study or plan	First operations / trial	Not reported	Not reported	Not reported	Not reported
UK ports	Not reported	Framework, study or plan	Not reported	Framework, study or plan	Commercial / recurring	Framework, study or plan
Ulsan	Commercial / recurring	Commercial / recurring	First operations / trial	Not reported	Commercial / recurring	Not reported
Vancouver	Commercial / recurring	Framework, study or plan	Framework, study or plan	Not reported	First operations / trial	Not reported
Yokohama / Kobe / Nagoya	Commercial / recurring	Not reported	First operations / trial	Not reported	Commercial / recurring	Not reported

Classification is this report's own, based on the milestones documented in this report; it is not an official IAPH Port Readiness Level. 'Commercial / recurring' means commercial supply or repeated operations; 'First operations / trial' means a pilot, demonstration, trial authorisation or first operation; 'Framework, study or plan' means a safety framework, study, licence framework, memorandum or stated plan. 'Not reported' means no milestone was identified in this research, not that none exists. *Biofuel reflects bunkering activity recorded in Lloyd's Register FOBAS data for the ports in Table 1 ('Commercial / recurring' where activity is recorded) and publicly reported deliveries for the other ports; Omani biofuel reflects harbour tug use only and Vancouver reflects domestic ferry trials only. Bio-LNG is counted under LNG. Production projects not linked to bunkering are not counted. Nuclear refers to port-access readiness, not bunkering.

3.2

Storage requirements

Each fuel places different demands on storage. LNG requires cryogenic tanks and boil-off management; ammonia is stored refrigerated at around minus 33 degrees Celsius or under pressure; liquid hydrogen needs storage at around minus 253 degrees Celsius; methanol and biofuels can use ambient-temperature tanks similar to those for existing liquid cargoes.

Where ports already handle a fuel as cargo, storage can often be adapted. Kandla already had methanol tanks, pipelines and jetties, and a Long Beach executive said in 2024 that existing facilities could be converted to store methanol. Elsewhere, new capacity is being built: a 180,000 cubic metre LNG tank at Rotterdam's Gate terminal, 520,000 cubic metres of LNG and methanol storage planned at Busan New Port by 2032, and an ammonia import terminal at Hamburg's Blumensand from 2029, subject to investment decision.

3.3

Bunkering infrastructure

Three transfer methods dominate: ship-to-ship from a bunker vessel, truck-to-ship from a road tanker, and port- or pipe-to-ship from fixed shore pipework. Each is in use for the newer fuels: ship-to-ship ammonia at Rotterdam, truck-to-ship ammonia to a tug at Yokohama, and port-to-ship ammonia from the pier at Ulsan.

Bunker vessels are the critical enabler for scale. SEA-LNG reported 67 LNG bunker vessels in operation and 42 on order by mid-2026; Singapore's first ammonia bunker vessel is due in September 2027, and Hamburg is considering an ammonia bunker barge. Single methanol transfers have already scaled more than sixteen-fold, as the Conclusion shows.

3.4

Utility and energy requirements

Alternative fuels and shore power both increase demand on port utilities. Onshore power supply requires grid connection capacity, substations and berth-side equipment, and EU regulation will require container and passenger ships to use it at core ports from 2030, as Chapter 5 describes. The Ricardo study of the Tyne-IJmuiden corridor found shore power could add a further 10 to 15 per cent emissions reduction to methanol on that route.

Grid capacity is a wider constraint. Chapter 7 sets out the scale of global grid investment required, and Chapter 6 describes how floating or land-based nuclear power units could in future supply ports directly.

3.5

Future-proofing investments

Because no single fuel is certain to dominate, ports are favouring investments that keep options open. Hamburg's approach of putting a safety framework in place first and physical import infrastructure later, and North Sea Port's assessment of four fuels across all its berths at once, both reduce the risk of committing to the wrong fuel too early.

Linking infrastructure to named vessel programmes is another safeguard: the Tyne-IJmuiden corridor is tied to DFDS's planned methanol RoPax vessels. Infrastructure that can serve several fuels, such as LNG facilities that bio-LNG and e-methane can later use, also reduces the risk of stranded assets.



Chapter 4:
Safety and Risk Management

Behind the headline milestones lies a common set of physical and procedural infrastructure that has to be in place before an alternative fuel transfer can take place. Across the ports profiled here, it is this infrastructure and the safety governance around it, rather than vessel orders, that most often sets the pace.

4.1

New fuel hazards

Each new fuel brings a different hazard profile, summarised in the fuel profiles in Chapter 2: ammonia's toxicity, hydrogen's very low ignition energy, methanol's toxicity and flammability, and LNG's cryogenic and flammability risks. Port-side controls begin with understanding how a release would behave at each berth.

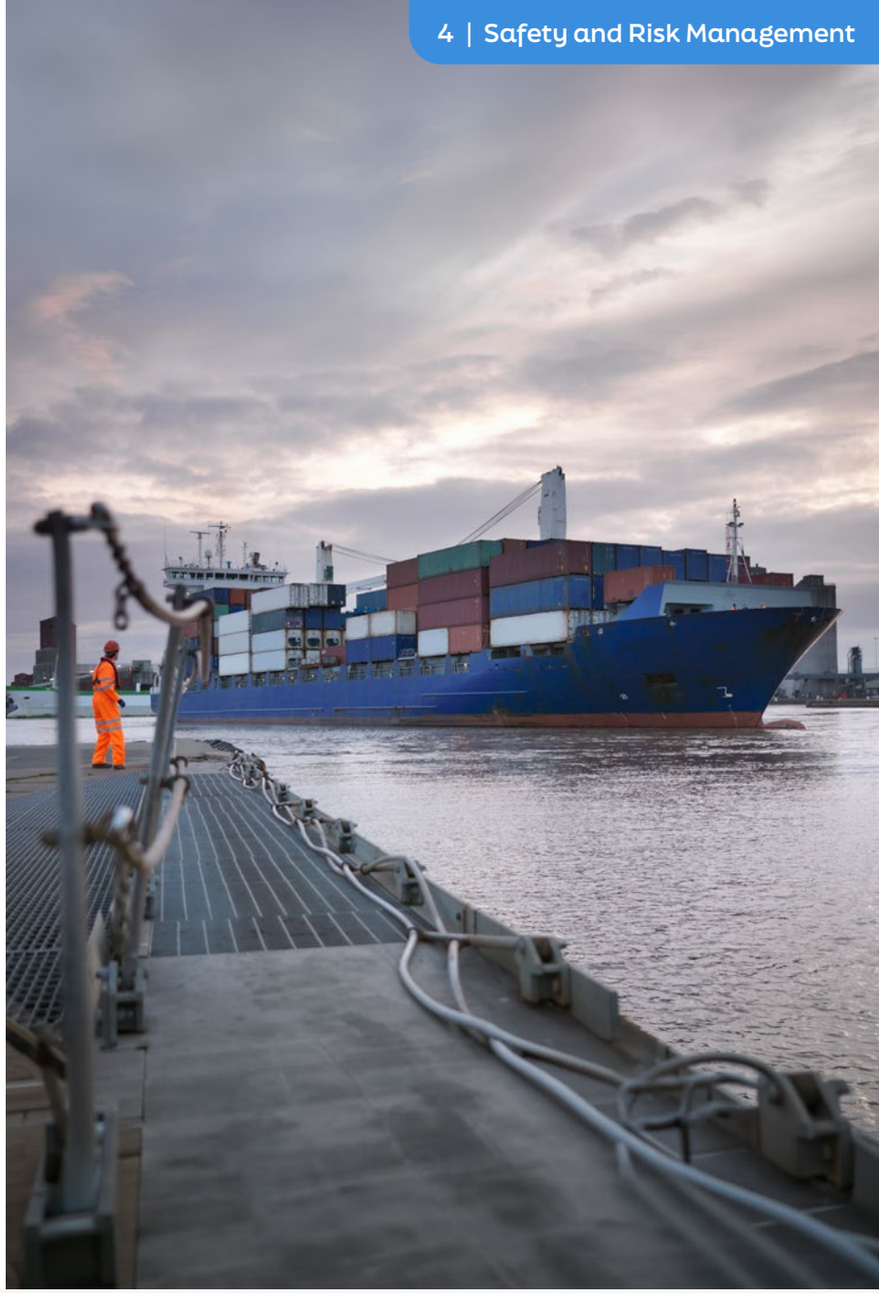
Exclusion zones and gas dispersion modelling

For ammonia and hydrogen in particular, gas dispersion (ammonia) and fire and explosion and cryogenic risk assessment (Hydrogen) specific to each berth is required to establish the boundary within which a release would pose a hazard, taking account of wind, nearby structures, transport links and population.

North Sea Port's risk analysis, published in February 2026, is the clearest public illustration of how far this now extends. It assessed all berths across Vlissingen, Terneuzen and Ghent, and looked beyond nautical risk to roads, wind turbines, high-voltage lines and nearby Seveso-regulated sites.

The output of such modelling determines exclusion zone size, which in turn constrains which berths can realistically be converted without wider land-use change.

On the ship side, Lloyd's Register's Guidance Notes on Gas Dispersion and Explosion Analysis for Alternative Fuelled Ships set out best practice for carrying out these analyses. Best practices provided in this guidance note are also applicable for port assessments.



4.2

Port emergency preparedness

Emergency preparedness for the newer fuels has to be built jointly with fire services, environmental agencies and maritime authorities. Rotterdam's ammonia pilot was overseen by the environmental agency, the regional safety authority and the joint fire service, and North Sea Port will review each controlled trial with the emergency services before wider roll-out.

Security measures

Port facility security arrangements apply to every fuel, but the newer fuels add requirements. Toxic or flammable releases call for designated zones for incident management and safe refuge, and for restrictions on nearby activities during bunkering.

Nuclear goes further. Security and safeguards measures will need to be established with nuclear regulators and emergency responders, potentially including designated berths or safe-harbour areas and restrictions on port activities set by the ship's nuclear safety case. Both the Rotterdam nuclear study and the Pink Corridor project identify security as an area needing further work.

Security, weather and operational constraints

Some factors sit outside a purely technical readiness assessment but affect practical readiness.

Fujairah's position just outside the Strait of Hormuz means its investment case has to be read alongside the security and insurance environment affecting Gulf shipping. Conflict in the Middle East from March 2026 disrupted oil and gas flows through the Strait, and Platts reported on 11 March 2026 that operations at the port of Fujairah remained suspended. The current position should be checked before relying on any Gulf bunkering assumption.

In the Strait of Gibraltar, bunkering is exposed to weather-related disruption, a reminder that alternative fuel investment does not remove the operational fragility of ship-to-ship transfer in an exposed anchorage.

4.3

Occupational health and workforce impacts

Infrastructure readiness alone will not determine whether alternative marine fuels are adopted successfully. Ports will also need significant investment in workforce capability to handle, store and transfer new fuels safely.

The challenge is most acute for ammonia and hydrogen. Pilots, harbour masters, terminal operators, bunker crews, emergency responders and local authorities may all need new operational procedures and safety competencies, from toxic-release response and specialist protective equipment to gas detection, exclusion-zone management and joint emergency exercises. Because ammonia bunkering has so far been carried out at only a small number of ports, practical experience of it remains scarce.

Industry bodies are beginning to address the gap. The UK Chamber of Shipping's Safety of Alternative Fuels Working Group has recommended specialised training, ammonia-specific protective equipment and dedicated port emergency response playbooks for ammonia bunkering.

LR's Maritime Decarbonisation Hub recently developed The Ammonia Competency and Training Practitioner Handbooks providing a practical framework for developing the skills and capabilities needed to safely operate and support ammonia-fuelled vessels. Developed through the joint Fuel Safety Frameworks: Ammonia initiative by Lloyd's Register Maritime Decarbonisation Hub and Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, the handbooks translate real-world operational scenarios into clear, role-based training requirements for shipboard crews, fleet managers, terminal personnel, shore support teams, emergency responders and training providers. They cover three critical areas: emergency response, maintenance, and leak detection, management, isolation and repair, helping organisations establish consistent competency standards across both onboard and shore-based operations. Built on extensive industry collaboration, the handbooks use a shared competency framework and scenario-based guidance to strengthen safety, preparedness and coordination throughout the ammonia fuel value chain find out more at www.thedecarbhub.org.

Demand for specialist knowledge is also growing. UNCTAD's TrainForTrade programme launched an online course on Energy Transition in Ports in 2026; its first edition, delivered in Spanish between April and June 2026, brought together 544 participants from 31 countries. The course sits within TrainForTrade's Port Management Programme, which has trained more than 13,500 port professionals across 183 countries and territories since 1996.

Workforce readiness is therefore becoming a differentiator between ports that can move alternative-fuel projects from planning to operation and those that remain at the feasibility stage. Safety frameworks, emergency preparedness plans and operational training may prove as important as investment in physical infrastructure.



4.4

Incident response planning

Leak detection, containment and emergency shutdown

Typical requirements include continuous gas or vapour detection at the berth and along hose runs, secondary containment beneath pipework, and automated emergency shutdown able to isolate a transfer quickly after a detected leak.

For ammonia, the IMO's interim guidelines add toxic-area classification and a tiered alarm structure on board. For hydrogen, very low ignition energy places particular demands on gas and flame detection.

Incident response plans also need to reflect what a release of a new fuel looks like. A spill of ammonia or hydrogen may leave no oil on the water to recover, creating instead a toxic, flammable or explosive gas cloud, so the response shifts from environmental clean-up to containment, detection and protecting people.

4.5

Safety culture for multi-fuel operations

Simultaneous operations and turnaround

A recurring commercial pressure is the desire to bunker alongside cargo operations rather than requiring a dedicated stop, known as simultaneous operations or SIMOPS.

Antwerp-Bruges' bunkering of Ane Maersk in April 2024 was carried out alongside cargo handling. Shanghai's March 2026 biomethanol bunkering of CMA CGM Osmium used a simultaneous loading and bunkering model, and Ulsan has carried out simultaneous LNG bunkering for car carriers.

SIMOPS raises the safety bar rather than lowering it. A bunkering exclusion zone must coexist with active crane, lashing and stevedoring operations, which makes SIMOPS a useful indicator of operational maturity.

Licensing, crew training and classification oversight

Every commercial or near-commercial operation described here involved licensing or formal authorisation, classification society involvement, and in most cases direct oversight by maritime and fire authorities.

Singapore selected three methanol licensees from 13 applicants. Antwerp-Bruges has conducted risk assessments for all fuel types and is implementing a licensing system for bunker operators.

Ulsan's ammonia operation was overseen by the regional oceans and fisheries office under a hazardous materials self-safety management plan. Houston's methanol bunkering followed four months of preparation between the US Coast Guard, Maersk and Kirby Marine.

North Sea Port has said that each controlled trial will be reviewed with the emergency services before wider roll-out.

4.6

Insurance, liability and classification

The move to alternative fuels changes not only what a port handles but who carries the risk when something goes wrong. Insurers, brokers and P&I clubs have been more consistent than any other group in warning that the liability framework has not kept pace with the fuels themselves.

This section sets out who insures which part of a bunkering operation, where the legal gaps lie, how insurers are responding, and what ports can do now.

Who insures what

A bunkering incident at a berth can touch three separate layers of insurance.

The first is port and terminal liability. The specialist mutual in this market is TT Club, which tailors cover for port authorities and terminal operators, including port liability and combined commercial and environmental risks. Ports also buy cover in the commercial market through brokers.

The second is the ship's own third-party liability cover. The International Group of P&I Clubs, a group of 12 mutuals, provides liability cover for around 90 per cent of the world's ocean-going tonnage. An incident during bunkering is likely to engage this cover first.

The third is the bunker supplier's cover, which sits with the barge or terminal operator delivering the fuel.

Which layer responds depends on where the incident occurs, who caused it and what the contracts between port, supplier and shipowner say. That allocation is becoming more important as the fuels become more hazardous.

The liability gap

The international compensation regime for ship-source pollution was built around oil. The Bunkers Convention provides compulsory insurance, channels liability and allows limitation of liability for a bunker spill, but it applies only to bunker oil, defined as hydrocarbon mineral oil.

Most alternative fuels therefore fall outside it. The marine insurers' association IUMI has pointed out that an ammonia fuel spill would not fall under the Bunkers Convention, and that the victims of an oil spill may, perversely, be better protected than the victims of an alternative-fuel spill.

Writing in February 2026, the West of England P&I Club set out the practical consequence. Where a fuel falls outside the conventions, the benefits of strict liability, compulsory insurance and direct action against insurers fall away, and compensation depends on local law, with outcomes varying widely between jurisdictions.

The club also noted that a release of an alternative fuel may leave no oil on the water to recover. Instead it may create a toxic, flammable or explosive gas cloud, shifting the response from environmental clean-up to containment, detection and human safety. That is precisely the kind of incident a port's emergency services would face.

UK P&I has made the same point for gaseous fuels including LNG, ammonia and hydrogen, describing a noticeable gap in the liability and compensation regime for damage they cause.

IMO factors

The IMO Legal Committee has agreed to examine whether its liability and compensation regimes suit alternative fuels such as ammonia, hydrogen and methanol. It will carry out a gap analysis to decide whether new instruments or amendments to existing ones are needed, with a target completion year of 2027.

Separately, the 2010 HNS Convention will enter into force on 29 November 2027, after its entry-into-force conditions were met on 29 May 2026. It covers loss of life, injury, property damage, clean-up costs and environmental damage from more than 2,000 hazardous substances, including LNG, LPG and alcohols, backed by an HNS Fund financed by cargo receivers.

Two limits matter for ports. HNS applies to these substances when carried as cargo, not when held in a ship's own fuel tanks, so it does not close the gap for bunkering. And as at May 2026 its 12 contracting states did not include the United Kingdom.

The International Group of P&I Clubs has an Alternative Fuels Working Group that is raising awareness of the gap in the international regime, with the aim that states at the IMO will address it.

How insurers are responding

Insurers have been open that they lack loss data. Allianz Commercial has noted that there is little historical data on alternative fuels in marine applications, and its Safety and Shipping Review 2026 warned that regulatory and liability frameworks for LNG, methanol and ammonia continue to lag behind adoption.

Allianz has also flagged operational risks relevant to port approaches. Dual-fuel ships can be more prone to machinery claims where crews are unfamiliar with procedures, and switching fuels near the coast can cause brief electrical failures and loss of manoeuvrability in congested waters.

Marsh has said that insurers may manage their exposure through policy warranties, sub-limits and exclusions for alternative-fuel risks. This was written in 2024 as a description of likely market behaviour. No published evidence was found of specific exclusions or premium loadings already being applied to port liability policies, and ports should check their own wordings.

NorthStandard has argued that existing conventions such as the CLC are not appropriate for the new fuels, and that the central challenge for insurers is how to price the risk before a large number of fuels are in use.

TT Club's published work on the energy transition has focused on onshore power supply. In January 2026 it warned that OPS requires careful planning, thorough risk assessment and early stakeholder engagement, and it identified stranded assets as a commercial risk if technology shifts. No TT Club guidance specific to ammonia, methanol or hydrogen bunkering was found.

Different fuel exposures

Broker WTW, writing in February 2026, stressed that each new fuel presents different operational risks, so the safety, liability and insurance implications for ports, suppliers and customers vary considerably.

LNG is the best understood, with its main risk being flammability when vaporised. Methanol's fire risks are well understood and manageable with standard measures, and because it mixes with water a spill disperses quickly, but it is toxic to people. Ammonia presents the most severe profile: it is highly toxic even at low concentrations, and a serious spill forms ammonium hydroxide, which is highly toxic to marine life. Hydrogen's very low ignition energy makes leak management critical.

WTW also made a structural point that matters for port insurance. As landlords, port authorities are partly shielded because concession holders usually make the investment, and fuel suppliers will bear most of the investment and running costs, including cryogenic storage and additional fire protection. Port authorities often co-fund projects as public bodies, however, which can bring exposure back to them.

WTW also noted that ports have no single global regulator and rely on national rules and industry associations for guidance, which adds to the uncertainty insurers face.





Contracts, standards and regulators

In the absence of a convention, much of the risk is being allocated through contracts, standards and local permitting.

BIMCO published its Biofuel Clause for Time Charter Parties 2026 in June 2026. It allocates responsibilities, risks and costs between owners and charterers where biofuels are used, including fuel specification against ISO 8217, sampling and testing, and liability for non-compliant fuel. A P&I club representative took part in its drafting.

In the United States, the Coast Guard's Policy Letter 01-25, issued in July 2025, sets a risk-based framework for bunkering LNG and alternative fuels including methanol, ammonia, hydrogen and LPG. A bunkering proposal and risk assessment must be submitted for review by the Captain of the Port before any operation, and the Captain of the Port can halt operations that deviate from the approved plan.

Port-level frameworks serve the same purpose. Rotterdam's next phase of ammonia bunkering will be governed by a validated safety framework, a licensing system and an ammonia bunker map defining suitable locations. Singapore's Technical Reference TR 129 sets custody transfer, operational and safety requirements for methanol bunkering. Hamburg's port authority does not act as a bunker supplier but sets the safety framework within which independent suppliers operate.

The UK Chamber of Shipping's Safety of Alternative Fuels Working Group, whose 52 member organisations include insurers and port authorities, published preliminary risk assessments in August 2026. It identified toxic release as the main safety concern for ammonia bunkering and recommended dedicated port emergency response playbooks, ammonia-specific protective equipment, specialised training and pilot port acceptance frameworks.

For insurers, frameworks of this kind are likely to become the evidence of good risk management on which cover and terms are based.

Nuclear: insurability

For nuclear-powered ships, insurance is being treated as a design question from the outset. The UK Maritime Nuclear Consortium (MarNuc), convened by Lloyd's Register with NorthStandard and Nuclear Risk Insurers among its members, includes establishing insurability pathways for nuclear-powered vessels in its first programme.

The underlying legal gap is long-standing: the 1962 Brussels Convention on the liability of operators of nuclear ships never entered into force. Ports cannot make confident admission, leasing or investment decisions without knowing how liability would be allocated, so insurance and liability need to be addressed early in any nuclear project rather than left until a live proposal is negotiated.

The Pink Corridor project between Charleston and Felixstowe includes insurance regimes among its areas of study, alongside security, safeguards and emergency response. The Rotterdam nuclear port-call study identified liability as one of the areas needing further work before routine operation could be contemplated.

War risk and location

Location also affects insurability. Allianz's Safety and Shipping Review 2026 described the closure of the Strait of Hormuz as more impactful than many expected, setting a dangerous precedent for other maritime chokepoints. Bunkering hubs near chokepoints, such as Fujairah just outside the Strait, need their alternative-fuel investment case read against war-risk cover and its cost. This situation may have changed since publication and should be checked.

Practical implications for port authorities

The following points follow from the evidence above.

Allocate the risk in writing. With no convention cap or fund for most alternative fuels at the berth, liability will be decided under local law. Bunkering licences, supplier agreements and concession terms should state clearly who carries alternative-fuel risk and require suppliers to hold adequate cover.

Review policy wordings now. Ports should check whether their liability cover responds to toxic gas release as well as fire and pollution, and whether any fuel-specific exclusions, sub-limits or warranties apply.

Build the evidence insurers will ask for. Validated safety frameworks, gas dispersion studies, licensing systems, emergency response plans and training records are likely to shape the terms on which cover is offered.

Watch the concession boundary. Landlord ports are partly shielded, but co-funding infrastructure or operating shared emergency services can bring exposure back to the port authority.

Track the IMO and HNS timetable. The Legal Committee's gap analysis is due in 2027 and HNS enters into force in November 2027. Neither yet covers alternative fuels held as bunkers, and the United Kingdom is not a party to HNS.

Classification and carbon accounting

No port's safety framework is built in isolation from the classification societies that assess vessel systems and bunkering arrangements.

Classification oversight appears repeatedly in the milestones described here. Lloyd's Register undertook the Pilbara ammonia bunkering study, worked with Belgium's FPS Mobility and EXMAR on the IMO guidelines for ammonia cargo as fuel on gas carriers, and is involved in both the Rotterdam nuclear port-call study and the Pink Corridor project.

That pattern is itself a proxy for how much bespoke engineering assurance the newer fuels currently require.

On the financial side, Verra published VM0053, Alternative Low-Carbon Fuels for Shipping, on 16 June 2026. Verra describes it as the first structured, independent accounting framework for quantifying emission reductions in maritime transport.

VM0053 applies to fuels such as hydrogen from water electrolysis, green ammonia and e-fuels including e-methanol and e-LNG, used on new or existing ships of any size. It was developed by Iino Kaiun Kaisha with Grütter Consulting and Verra.

It matters for port investment because it gives producers and owners a potential basis for monetising emission reductions through carbon credits, which could improve the economics of exactly the green production projects whose timing is the leading supply-side risk.

Evidence limits

Public positions from insurers are mostly general. No published alternative-fuel positions were found from port liability underwriters such as Allianz, AXA XL or Lloyd's syndicates specific to port operations, and no evidence was found of premium loadings or exclusions already applied to port policies. Findings reflect published sources to September 2026, and the IMO work described here is ongoing.



Chapter 5:
Regulation and Compliance

Before considering any individual port, it is worth setting out the regulatory scaffolding within which port investment is taking place. It shapes what a port can lawfully do and what a credible safety case looks like.

5.1

IMO developments

Net-Zero Framework

Globally, the IMO's Net Zero Framework, combining a global fuel standard with an emissions pricing mechanism, was approved at MEPC 83 in April 2025.

An extraordinary session of the MEPC held in October 2025 did not adopt the framework due to concerns about its potential economic impact on shipping and trade. Discussions continue to find a suitable model for the framework that can be supported globally. If adopted, and depending on what type of framework is adopted, an IMO global fuel standard could encourage operators to use both alternative fuels supplied through ports and Onshore Power Supply (OPS) connections to reduce emissions while in port. Whether an OPS connection will be part of any mandatory IMO measure remains to be seen. The entry into force on an IMO Net Zero Framework remains unclear given the ongoing political uncertainty around the negotiations.

The uncertainty itself is an investment risk for ports and fuel producers deciding how quickly to commit capital.

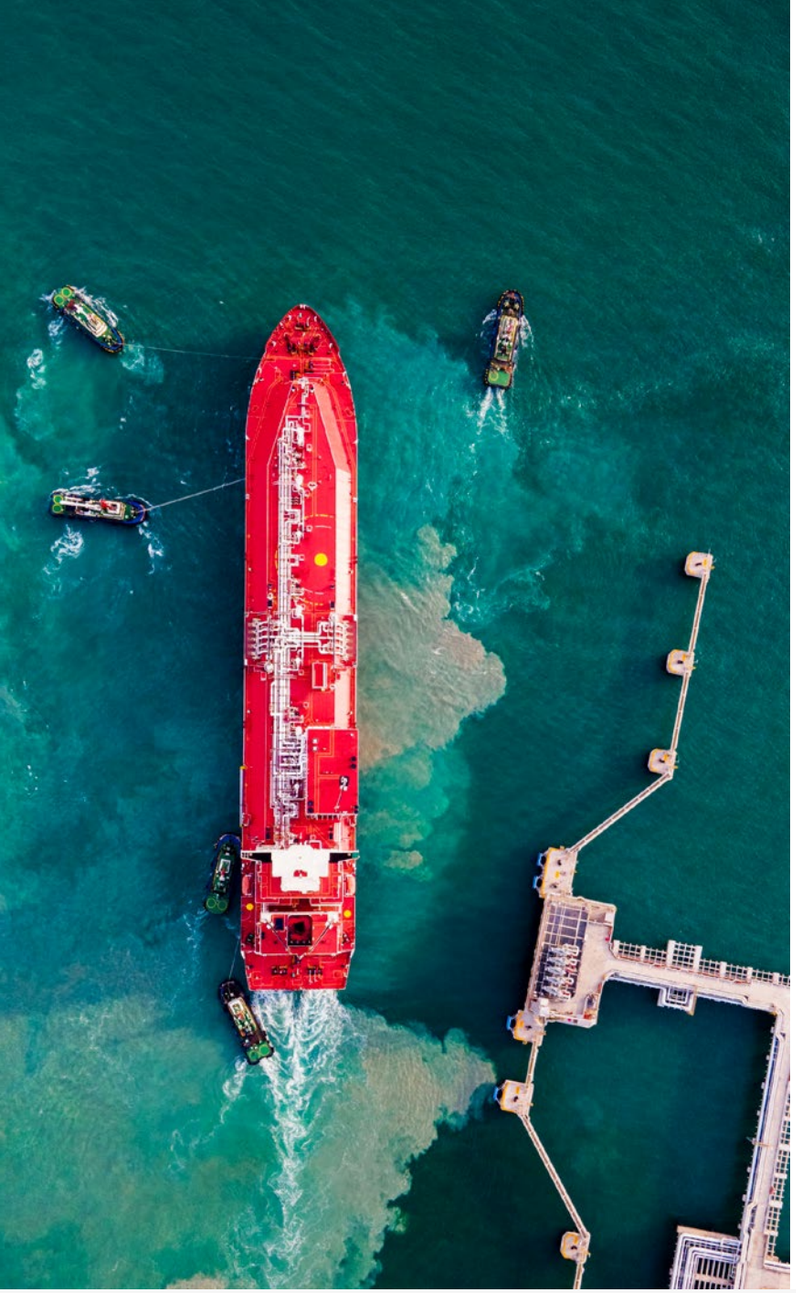
The IGF Code

The International Code of Safety for Ships using Gases or other Low-flashpoint Fuels, the IGF Code, has been the foundational safety instrument for LNG-fuelled shipping since it entered into force in 2017. It sets goal-based requirements for fuel containment, machinery spaces, bunkering arrangements, fire safety and gas detection.

Ammonia, hydrogen and methanol have each required their own interim guidelines, because none behaves like LNG. The IGF Code's detail was written with a flammable, non-toxic gas in mind.

The IGF Code applies to the ship, up to its bunkering connection. It does not regulate the port or the bunker supplier, so shore-side bunkering procedures are set nationally or by individual ports.

Singapore, for example, published Technical Reference TR 129 on methanol bunkering in March 2025. It covers custody transfer, operational and safety requirements and a framework for crew competency. Rotterdam's ammonia bunkering will be governed by the port's own safety framework, licensing system and ammonia bunker map.



At international level, ISO 22120:2026, published in August 2026, sets requirements for methanol bunkering transfer systems, operational procedures, risk assessment, safety protection and personnel training.

For ammonia, the Maritime Safety Committee approved interim guidelines at MSC 109 in December 2024. They were published as MSC.1/Circ.1687 on 26 February 2025.

The guidelines are goal-based and non-mandatory. They can be used as part of an Alternative Design and Arrangement to the IGF Code. They cover ship design, equipment, operations, bunkering, toxicity mitigation and crew protection, and are intended to provide at least the same level of safety as conventional oil-fuelled machinery.

They introduce toxicity-specific concepts with little precedent in LNG regulation, including the classification of toxic areas and a tiered alarm system. Thresholds have been reported at 25 ppm for localised alarms, 110 ppm for global alarms and 220 ppm for system shutdown.

The IMO has stressed the provisional nature of the guidelines and expects to revise them as operational experience is gained, particularly on toxicity controls and emergency systems.

Separately, amendments to paragraph 16.9.2 of the IGC Code, adopted at MSC 109, entered into force on 1 July 2026. They allow an Administration to accept certain toxic cargoes, including ammonia, as fuel on gas carriers. MSC 111 in May 2026 approved companion interim guidelines on the use of ammonia cargo as fuel.

The ammonia-cargo-as-fuel guidelines approved at MSC 111 were developed by members of an IMO working group supported by a collaboration between Belgium's Federal Public Service Mobility and Transport, gas carrier operator EXMAR and Lloyd's Register, drawing on operational experience of carrying ammonia.

For hydrogen, MSC 111, held from 13 to 22 May 2026, approved interim guidelines for the safety of ships using hydrogen as fuel. They establish a goal-based framework aligned with the IGF Code, with provisions for the arrangement, installation, control and monitoring of machinery, equipment and systems using hydrogen. This was published as MSC.1/Circ.1701 on 7 July 2026.

The guidelines are deliberately high-level, focusing on goals and functional requirements to support experimental projects, and are expected to be developed further as experience is gained. They are a starting point rather than a complete code.

The engineering challenge is severe. Liquid hydrogen is stored at around minus 253 degrees Celsius, and hydrogen's very low ignition energy and wide flammability range demand a different order of containment and detection engineering from LNG or ammonia.

Hydrogen's regulatory foundation is therefore now ahead of its commercial bunkering readiness, not the other way around.

Methanol and ethanol are governed by interim guidelines for methyl and ethyl alcohol fuels, MSC.1/Circ.1621, which the IMO is revising with approval expected in 2027.

Methanol is liquid at ambient temperature and pressure. Its bunkering and handling profile is therefore far closer to conventional fuel logistics than any gaseous or cryogenic alternative, which is the main reason ports have been able to reuse existing tank, barge and jetty assets for it.

5.2

National and regional regulations

Regulatory drivers: FuelEU Maritime and UK ETS

FuelEU Maritime, in effect since January 2025, establishes a fuel standard that progressively tightens greenhouse gas intensity limits on the energy used by ships in EU and EEA waters, as well as international voyages to/from the EU /EEA. Each year, companies in scope must submit a FuelEU report to their verifier by 31 January, verified compliance balances are recorded in the FuelEU database by the end of April, and by 30 June any penalty must be paid before a FuelEU Document of Compliance is issued.

The increasingly stringent greenhouse gas intensity targets will drive an escalating cost of non-compliance. That is a direct commercial reason why European ports such as Rotterdam, Antwerp-Bruges, Hamburg and North Sea Port have moved faster and more publicly than many counterparts elsewhere to provide alternative fuel and energy sources.

Onshore power supply (OPS) is part of the same picture. AFIR (2023/1804) primarily requires ports to provide OPS infrastructure. FuelEU Maritime (2023/1805) requires eligible ships to use that infrastructure once available. Regarding ships that are connecting to OPS, FuelEU maritime will only require cargo and passenger ships >5,000GT to comply. From 2035 the requirement extends to any EU port where OPS is installed.

National and regional carbon pricing is also spreading beyond the EU. The UK extended its Emissions Trading Scheme to domestic maritime activity from 1 July 2026 for ships of 5,000 gross tonnage and above, covering emissions on domestic voyages and within UK ports, and has consulted on covering 50 per cent of emissions from international voyages to and from the UK from 2028. That proposal remains subject to a final policy decision and to UK-EU negotiations.

Other national frameworks are emerging for specific fuels: the US Coast Guard’s Policy Letter 01-25 requires a bunkering proposal and risk assessment for alternative fuels, Singapore regulates methanol bunkering through licensing and Technical Reference TR 129, and national approaches to nuclear-powered shipping diverge, as described in Chapter 6.





5.3

Port authority responsibilities

Because the IGF Code stops at the ship's bunkering connection, port authorities and national administrations carry much of the responsibility for shore-side bunkering safety. Approaches differ: some, such as the Hamburg Port Authority, set the safety framework and leave supply to independent companies; others license bunker suppliers directly, as in Singapore and Antwerp-Bruges.

Port state control and the compliance backstop

Behind voluntary readiness programmes sits the flag and port state control regime, which applies regardless of how far a port's alternative fuel programme has progressed.

The UK Maritime and Coastguard Agency's Port State Control inspection of the ammonia-fuelled Fortescue Green Pioneer at Southampton in March 2025 shows these regimes beginning to engage with ammonia-fuelled tonnage. The experience of LNG suggests inspection practice will need to mature alongside uptake of the newer fuels.

No concentrated inspection campaign focused on the IGF Code was identified in the research for this report.

5.4

Emerging fuel standards

Standards are filling gaps the IMO framework leaves open. ISO 22120:2026 sets international requirements for methanol bunkering, Singapore's TR 129 covers methanol bunkering procedures, BIMCO's 2026 biofuel clause ties biofuel specification to ISO 8217 in time charters, and Verra's VM0053 methodology provides a basis for crediting emission reductions from low-carbon fuels. Each is described in more detail elsewhere in this report.

5.5

Future regulatory outlook

Several milestones fall in 2027: the expected revision of the IMO methanol guidelines, the completion target for the IMO Legal Committee's review of liability for alternative fuels, and the entry into force of the HNS Convention in November. The IMO's ammonia and hydrogen guidelines are interim, and the timetable for the IMO Net-Zero Framework remains uncertain.

Chapter 6
Supply Chains and Energy Ecosystems

6.1

Fuel production trends

Production of low-carbon fuels is the main constraint on the transition. Announced renewable and low-carbon methanol capacity reached 61.8 million tonnes by 2031 in GENA Solutions' June 2026 data, but GENA expects only 6 to 12 million tonnes of operational renewable capacity by the end of 2031. Renewable ammonia faces a similar dependency on electrolyser capacity and offtake agreements, while bio-LNG supply is growing from a small base. The methanol and LNG profiles in Chapter 2 set out the detail.

6.2

Import and export considerations

For many ports, readiness depends on import infrastructure as much as on bunkering. Hamburg's planned Blumensand terminal and the Immingham Green Energy Terminal are designed to import ammonia, Kobe's Hy touch Kobe terminal receives liquefied hydrogen, and the Suiso Frontier voyage from Australia showed what long-distance hydrogen shipping involves.

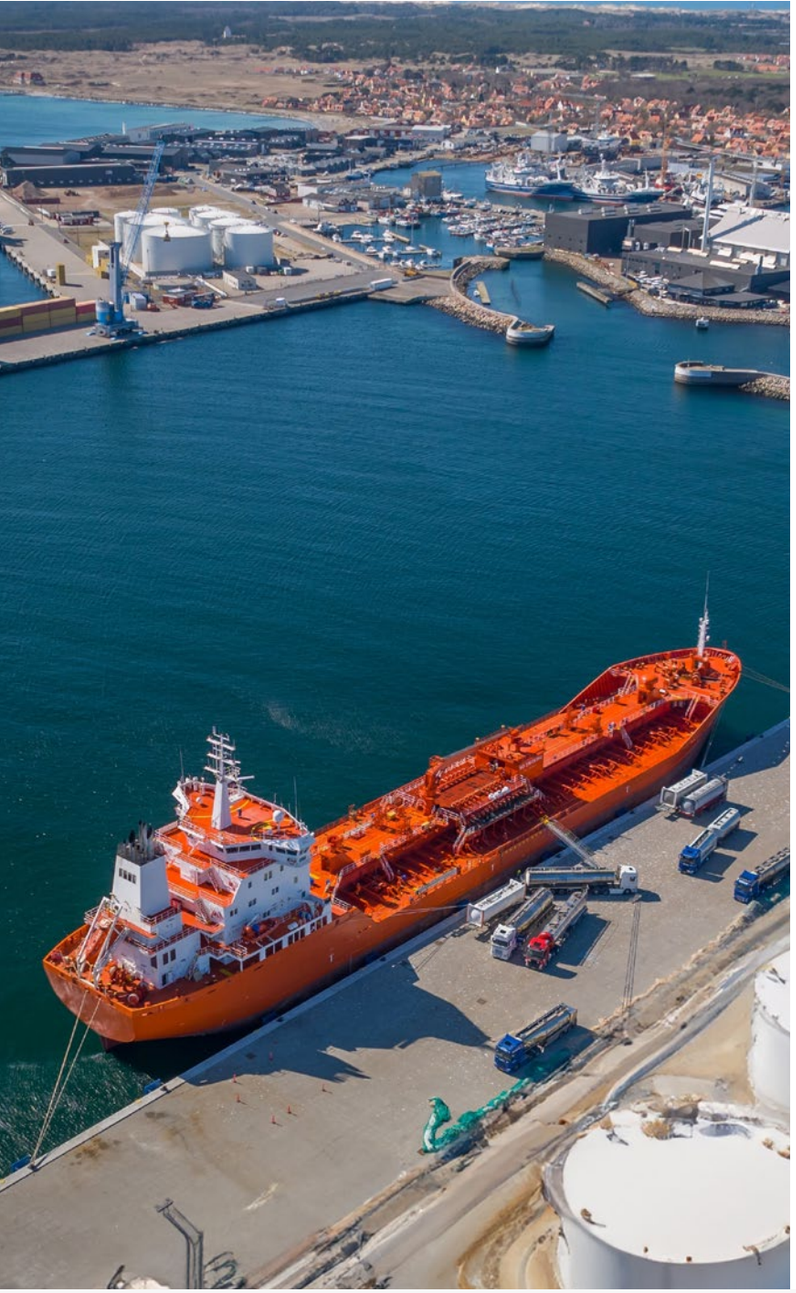
Others draw on domestic production. Shanghai's 2025 green methanol supply was domestically produced, and the green ammonia bunkered at Ulsan was produced from renewable power in Inner Mongolia. Export regions such as the Pilbara could become both producers and bunkering locations for ammonia.

6.3

Fuel availability risks

Availability risks come from production timing, geopolitics, weather and market behaviour. Feedstock and production timing are discussed in Chapter 1, and security and weather constraints, including disruption around the Strait of Hormuz, in Chapter 4. Availability can also fade after early milestones: Antwerp-Bruges, an early leader in methanol bunkering, recorded no methanol sales after the third quarter of 2024.





6.4

Port energy hubs

Preparing ports for nuclear

A forthcoming joint briefing for port leaders from Lloyd's Register and the British Ports Association argues that ports should treat advanced nuclear as a long-term infrastructure and operating-model question, not simply as a new fuel.

It identifies three broad use cases, each with different regulatory, commercial and operational obligations: nuclear-powered vessels calling at a port; floating or transportable nearshore power units supplying electricity, heat or fuels; and land-based small modular reactors or microreactors on or near port land. The opportunity for ports is therefore wider than receiving ships, extending to baseload power, shore power, industrial heat, hydrogen and synthetic fuel production, resilient microgrids and specialist technical services.

For a nuclear-powered vessel, the port call itself remains recognisable, but the assurance, evidence and coordination requirements increase across pre-arrival, approach, berthing, port operations and departure. The briefing's central principle is that nuclear-specific controls should be embedded in a port's existing marine safety-management system, not run as a parallel regime, alongside layered arrangements for radiation monitoring, security, safeguards and integrated emergency response.

The international framework predates modern reactor designs. SOLAS Chapter VIII and the IMO Code of Safety for Nuclear Merchant Ships, adopted in 1981 as resolution A.491(XII), were written for vessels such as NS Savannah and Otto Hahn, and the Code is now under review. The 1962 Brussels Convention on the liability of operators of nuclear ships never entered into force, leaving liability and insurance uncertain.

National approaches also diverge. The briefing notes that the UK has emphasised insurability and regulatory leadership, South Korea is linking nuclear-powered shipping to its shipbuilding strategy, Russia continues to operate nuclear icebreakers and floating nuclear power, and the United States is developing pathways for advanced reactors and microreactors. Ports seeking to move early will need to engage with national rules in parallel with slower international harmonisation.

To support proportionate planning, the briefing proposes a tiered model of readiness: a nuclear-aware port that can assess an exceptional enquiry with specialist support; a nuclear-ready port that has identified berths or sites, trained teams and exercised scenarios; a nuclear-enabled port able to support recurring visits or provide specialist services; and a nuclear energy hub integrating floating, transportable or land-based generation. It sets out no-regret actions, including setting the ambition, mapping stakeholders, building the evidence base, reviewing existing safety systems, engaging regulators early and preparing plain-English communications, within a staged pathway from orientation and assessment to development and delivery.

6.5

Strategic partnerships

Green corridors

A number of readiness gains are being pursued jointly under green shipping corridors, in which ports at either end of a trade lane coordinate fuel availability and regulation so that an owner can commit to alternative-fuel tonnage with confidence.

Rotterdam and Singapore are developing a green and digital shipping corridor that includes an ammonia working group and planned bunkering pilots. Singapore signed a corridor agreement with Japan in December 2023 covering six Japanese ports, and another with Los Angeles and Long Beach in 2023.

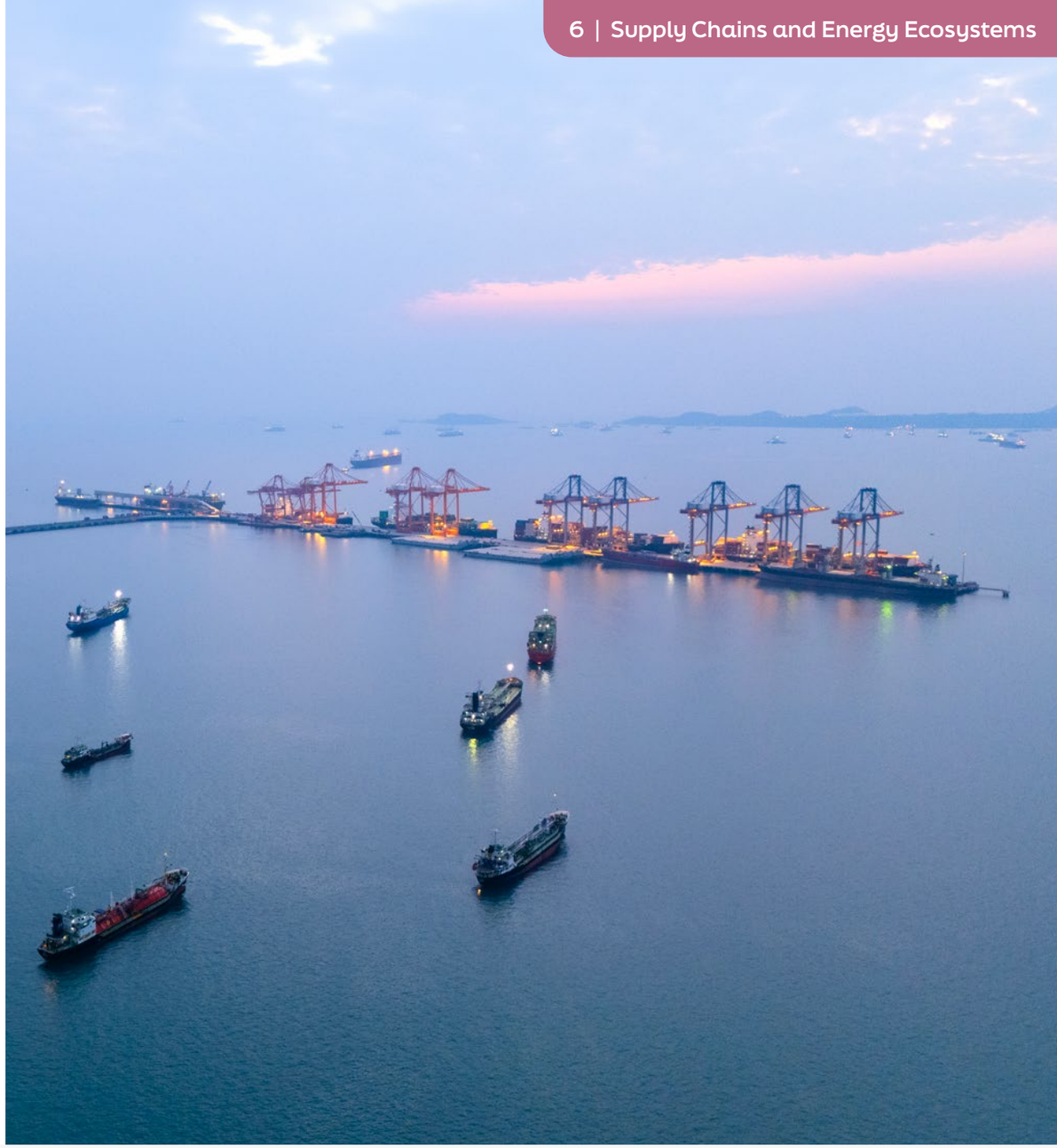
The Port of Tyne and the Port of IJmuiden are developing a corridor to prepare for DFDS's planned methanol-fuelled RoPax vessels.

The corridor model is increasingly how readiness gains at one port become commercially usable fuel availability. A single ready port with no matching capability at the other end of a route is of limited value to an owner.

A parallel 'pink corridor' concept, named after the colour used to denote nuclear energy, applies the same end-to-end logic to nuclear-powered shipping. Its emphasis is on regulatory readiness, security, safeguards, emergency preparedness and mutual recognition rather than bunkering infrastructure.

Ports and energy company partnerships

Partnerships between ports and energy companies underpin most milestones in this report: the Hamburg Port Authority with MB Energy, the Ulsan Port Authority with Lotte Fine Chemical, ITOCHU with Peninsula at Algeciras, Maersk, Kirby Marine and Methanex at Houston, and Yara Clean Ammonia with Pilbara Ports. Nuclear studies have brought together Lloyd's Register, ports, shipowners and technology developers.



Chapter 7
The Port Business Case

7.1

Investment models

Several investment models appear in this report: public funding of shore power, as at Portsmouth; national strategic plans, as for Shanghai; consortium-funded corridors, such as Tyne-IJmuiden; supplier-led bunkering, as with Kirby Marine and Methanex at Houston; and port authorities that set the safety framework while independent companies invest in supply, as at Hamburg.

The model matters for risk as well as funding. As section 4.6 notes, landlord port authorities are partly shielded where concession holders and fuel suppliers make the investment, but co-funding can bring exposure back to the port.

7.2

Funding and finance

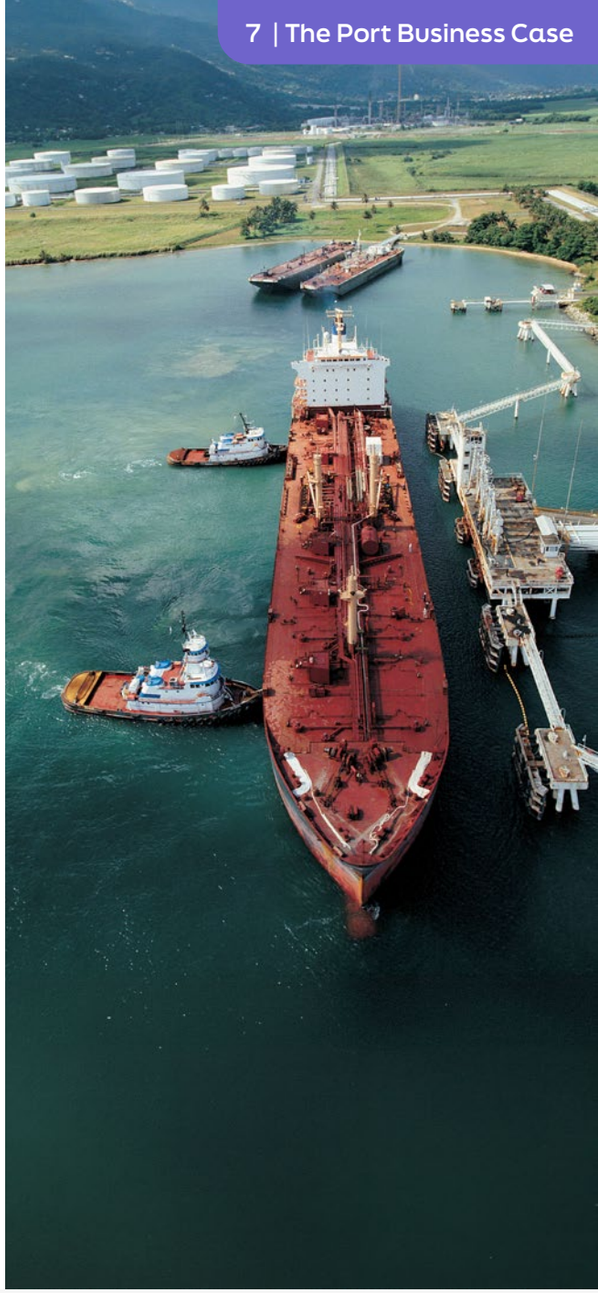
For many ports, the greatest barrier to alternative-fuel readiness may be capital rather than technology. Bunkering infrastructure, energy storage, grid upgrades, shore power and safety systems all require substantial upfront investment, while future fuel demand remains uncertain.

The wider energy transition shows the scale of the challenge. The International Energy Agency's Electricity 2026 report estimates that meeting forecast electricity demand through 2030 would require annual global grid investment to rise by roughly 50 per cent from today's US$400 billion, to around US$600 billion. Ports are also weighing decarbonisation against competing priorities, from digitalisation and resilience to capacity expansion.

Public funding already underpins several projects in this report. Portsmouth's shore power system was funded with £19.8 million from the UK Department for Transport and £4.6 million from Portsmouth City Council, and the UK Government contributed £1.5 million to the £9 million Tyne-IJmuiden green corridor. The IEA has also noted that many countries will not be able to fund grid expansion from public budgets alone, making private investment and multilateral development bank support essential.

Access to public funding, blended finance, development-bank support and private capital is therefore becoming part of port readiness. Carbon-credit methodologies such as Verra's VM0053, described below, may also improve the economics of low-carbon fuel production.

The ports that move fastest may not be those with the strongest technical case, but those able to secure financing early and present bankable investment propositions, supported by credible demand forecasts, regulatory certainty and long-term infrastructure strategies.



7.3

Revenue opportunities

Alternative fuels can bring new revenue as well as cost. Antwerp-Bruges' LNG bunker sales more than tripled in 2025, and alternative fuels made up 13.2 per cent of Rotterdam's sales in the third quarter of 2025.

In the longer term, ports may earn revenue from energy services as well as fuel: shore power, industrial heat, hydrogen and synthetic fuel production and, potentially, nuclear-generated power, as Chapter 6 describes.

7.4

Competitive positioning

Readiness is already shifting competitive positions. Shanghai bunkered more green methanol than Singapore in 2025, and Antwerp-Bruges' bunker sales overtook Rotterdam's in the first quarter of 2026. Green corridor membership is emerging as a further signal of where reliable supply will be available first.

7.5

Lessons from early movers

Early movers point to consistent lessons. Ulsan's commercial ammonia bunkering followed more than two years of structured preparation under a 2024 memorandum of understanding. Singapore's methanol licences took around ten months from call for applications to entry into force, while its ammonia programme will take considerably longer. Portsmouth's shore power system went unused until a commercial deal on electricity costs was agreed, and Antwerp-Bruges' early methanol lead has not yet turned into regular sales.



Chapter 8
Digitalisation and Operational Readiness

Physical infrastructure is only part of readiness. Ports handling several fuels also need reliable data on what is delivered, when and where, and systems that let port authorities, terminals, bunker suppliers and shipowners plan around each other. The leading hubs in this report are already building that digital layer, mostly for conventional fuels so far, and it is likely to matter even more as alternative fuels add exclusion zones, licensing checks and tighter operating windows.

8.1

Digital fuel monitoring

Accurate measurement of what is bunkered is the foundation. Singapore has required mass flow meters for bunker deliveries since 2017. Rotterdam and Antwerp-Bruges followed on 1 January 2026, when certified mass flow meter systems became mandatory on bunker vessels delivering residual fuels, distillates and biofuels.

The two ports acted after independent research found recurring quantity issues in their bunker markets. Mass flow meters measure the actual mass delivered in real time, giving both parties the same data and greatly reducing quantity disputes. The Rotterdam and Antwerp-Bruges systems must meet the international ISO 22192 standard.

Documentation is going digital too. The IMO approved the use of electronic bunker delivery notes at MEPC 80, and Singapore launched the first port initiative for them in November 2023. Since 1 April 2025, Singapore's bunker suppliers have been required to provide digital bunkering services and issue electronic bunker delivery notes by default; by August 2025 all of them had done so.

Singapore supported the change with new standards: SS 709, a specification for digital bunkering supply chain documentation published in November 2024, and a revised SS 648 code of practice for bunker mass flow metering that adds data integrity and transmission requirements. Stakeholders can verify electronic delivery notes against the information transmitted to the MPA.

These systems were built for conventional fuels and biofuel blends. Extending the same metering, documentation and data integrity to LNG, methanol and ammonia, where custody transfer and safety data are more complex, is one of the next steps; Singapore's TR 129 already covers custody transfer for methanol bunkering. Fuel quality monitoring is part of the same picture: Lloyd's Register's FOBAS service tests bunker samples and records fuel availability and quality data by port and supplier.



8.2

Traffic and bunker scheduling

Alternative-fuel bunkering adds constraints to port scheduling. Exclusion zones, simultaneous operations, a small number of specialised bunker vessels and the need for emergency cover all make it more important that bunkering is planned around the rest of the port call, not squeezed into it.

Singapore's Just-in-Time Planning and Coordination Platform, part of the digitalPORT@SG system, provides advance and real-time vessel schedule information so that ships can adjust their speed and reduce waiting time at anchorage. Marine service providers can use the same information to plan pilotage, towage and bunker tankers. The MPA began extending the platform to tankers at energy terminals and to vessels at anchorages from January 2024.

Rotterdam developed a comparable tool, now PortXchange Synchronizer, which gives all parties in a port call a shared real-time view of schedules. In a pilot with Maersk aimed at cutting the share of its vessels delayed by bunkering from 19 per cent to 10 per cent, the port reported eliminating those delays altogether. The port authority spun PortXchange off as a separate company in 2019, and the platform has since been used at other ports including Felixstowe, Houston and Algeciras.

In Rotterdam, all bunker activities must also be reported and registered in advance through the port community system, Portbase, giving the port authority oversight of who is bunkering, where and when.

8.3

Data-driven decision making

Readiness decisions are only as good as the data behind them. This report draws on several data sources that ports can also use directly: the World Ports Tracker for benchmarking against peers, Lloyd's Register's analysis of Clarksons Research orderbook data for vessel demand, GENA Solutions' project tracker for low-carbon methanol supply, port authority bunker statistics for actual volumes, and Lloyd's Register's FOBAS data for biofuel activity and fuel quality.

Operational data is becoming an asset in its own right. Mass flow meter readings and electronic delivery notes create a verifiable record of every delivery, and Singapore's digital bunkering initiative was expected to save the industry close to 40,000 man-days a year. Shared scheduling data in platforms such as Singapore's and Rotterdam's allows ports to see where berths, bunker vessels and service providers are constrained.

For alternative fuels, the most useful data will often be specific to each port: berth-by-berth gas dispersion results, the vessels and fuels expected to call, and the capacity of bunker suppliers. Ports that collect and share that data early will be better placed to make investment decisions, satisfy regulators and insurers, and demonstrate readiness to shipowners.

8.4

Port community systems

A port community system is a neutral, open electronic platform that allows public and private stakeholders in a port to exchange information securely through a single submission of data. Europe has a long tradition of such systems: Portbase in the Netherlands, DAKOSY in Hamburg and Portic in Barcelona are among the established examples.

Portbase, established by the Port of Rotterdam Authority and the Port of Amsterdam, describes itself as Europe's largest port community, with more than 6,000 companies and 15,000 users. It is also the channel through which bunker activities in Rotterdam are notified in advance.

Regulation has reinforced the model. Since 1 January 2024, the IMO's Facilitation Convention has required public authorities to establish, maintain and use maritime single window systems for the electronic exchange of information on ships' arrival, stay and departure. Singapore's digitalPORT@SG serves as its maritime single window, bringing together up to 16 regulatory applications previously submitted through three separate portals, and also hosts bunker licensing services.

As alternative fuels arrive, these platforms are a natural home for the additional information ports will need: bunker supplier licences, pre-bunkering notifications, safety checklists and confirmation that exclusion zones and emergency arrangements are in place.

8.5

Digital twins and scenario planning

Digital twins, virtual models of a port fed with live operational data, allow ports to test changes before making them. Singapore launched its first Maritime Digital Twin on 24 March 2025, developed by the MPA with the Government Technology Agency. It integrates real-time data from vessels, port operations and environmental sensors and uses artificial intelligence and predictive analytics to optimise operations, improve energy efficiency and reduce emissions.

The MPA describes the twin as a sandbox in which companies and researchers can develop and test new operating concepts before deploying them, with pilot testing from the second half of 2025. In June 2025 the MPA agreed with Yinson GreenTech to extend its capabilities for more precise modelling and scenario testing, including electric harbour craft and charging.

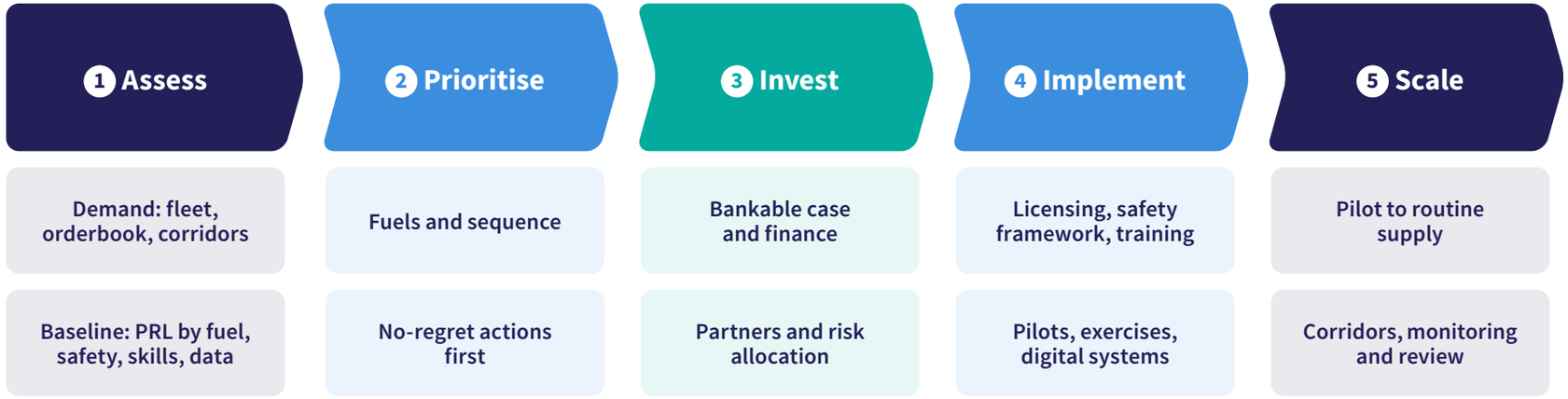
For alternative fuels, scenario planning is already central to readiness. Berth-specific gas dispersion modelling, such as North Sea Port's analysis of all its berths for four fuels, is a form of scenario testing, and the nuclear readiness work described in Chapter 6 calls for scenarios to be exercised before a port is considered nuclear-ready. Combining these analyses with live operational data in a digital twin could let ports test bunkering locations, simultaneous operations and emergency responses for new fuels before they are needed.



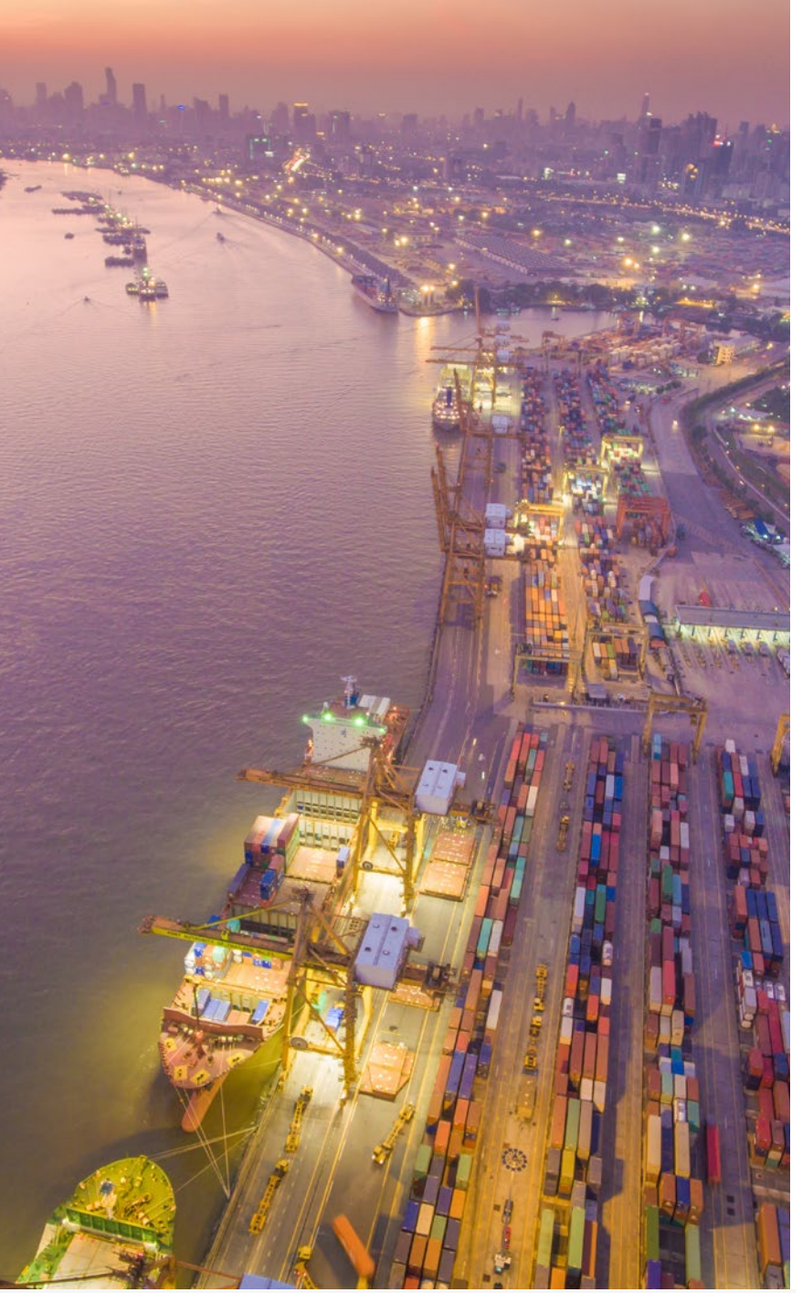
Chapter 9
Port Readiness Framework

The evidence in this report points to a common sequence that ports can follow, whatever their size or starting point. The framework below draws that evidence together in five stages: assess, prioritise, invest, implement and scale. It is designed to be proportionate: a port need not move every fuel through every stage at once, and different fuels will sit at different stages at the same port.

Figure 11. A five-stage approach to port readiness for alternative fuels



Source: Drawn from the evidence in this report.



9.1

Assess

Readiness starts with an honest picture of where a port stands and where its demand is likely to come from. That means understanding the fleet that calls today, the vessels on order that are likely to call in future, and the corridors and trade lanes the port serves.

Demand is highly concentrated. A May 2026 study by Lloyd's Register's Maritime Decarbonisation Hub found that around 19 ports account for about half of estimated global bunkering volumes, with Singapore alone representing around a quarter. It concluded that early adoption of sustainable fuels is most likely at high-throughput, tightly regulated bunkering hubs that can add new fuels while maintaining delivery assurance and safety, and it identified at least 127 e-fuel projects worldwide that could supply shipping, most still before a final investment decision.

Against that picture, ports can benchmark themselves fuel by fuel. The IAPH Port Readiness Level tool provides a common scale; alongside it, a baseline should cover existing storage and berths, safety studies and emergency arrangements, licensing, workforce skills, digital systems and the regulatory position. The data sources described in Chapter 8 support this stage.

9.2

Prioritise

No port can prepare for every fuel at once. Prioritisation means choosing which fuels to pursue, in what order and to what level, based on demand, local supply, regulation and risk appetite.

The evidence suggests a broad pattern. Biofuel blends and LNG can often be supported through existing or established infrastructure. Methanol suits ports with chemical-handling experience and a clear customer base. Ammonia calls for safety frameworks and licensing well before physical supply, as Hamburg's sequencing shows, and hydrogen bunkering remains a demonstration-scale decision for most ports.

Some actions make sense whatever the fuel choice. Drawing on the staged approach set out for nuclear in Chapter 6, these no-regret actions include setting a clear ambition, mapping stakeholders, building the evidence base, reviewing existing safety systems, engaging regulators early and preparing clear communications for the local community.

9.3

Invest

Investment decisions turn priorities into infrastructure. The strongest cases in this report are tied to named vessel programmes or corridors, such as the Tyne-IJmuiden corridor and DFDS's planned methanol ferries, rather than to speculative capacity.

A bankable case needs credible demand forecasts, regulatory certainty and an investment model that allocates cost and risk sensibly between the port authority, concession holders, fuel suppliers and shipowners. Chapter 7 sets out the models and sources of finance available, and section 4.6 the insurance and liability questions that should be settled in contracts before infrastructure is built. Investment that can serve more than one fuel reduces the risk of stranded assets.

9.4

Implement

Implementation is where most of the practical work lies. Every commercial or near-commercial operation in this report depended on a safety framework, berth-specific gas dispersion modelling, licensing or formal authorisation, coordination with emergency services and trained people.

Pilots are the usual route. Rotterdam's ammonia pilot was overseen by environmental, safety and fire authorities and raised the port to PRL 7; Singapore's ammonia programme began with a trial authorisation; North Sea Port will review each controlled trial with the emergency services before wider roll-out. Exercising emergency scenarios, training pilots, harbour masters, terminal staff and responders, and putting digital notification, metering and documentation in place are all part of this stage.

9.5

Scale

Scaling means moving from first operations to routine, reliable supply. Singapore took around ten months to move from its call for applications to licensed methanol supply, while its ammonia programme will take considerably longer. Rotterdam's next phase of ammonia bunkering will move from project-based pilots to a licensing system and an ammonia bunker map.

Scale also depends on partners at the other end of the route. Green corridors, such as Rotterdam-Singapore, turn readiness at one port into usable fuel availability for shipowners. Ports that keep monitoring demand, safety performance and regulation, and revisit their priorities as the market moves, will be best placed to expand capability as volumes grow.



Conclusion

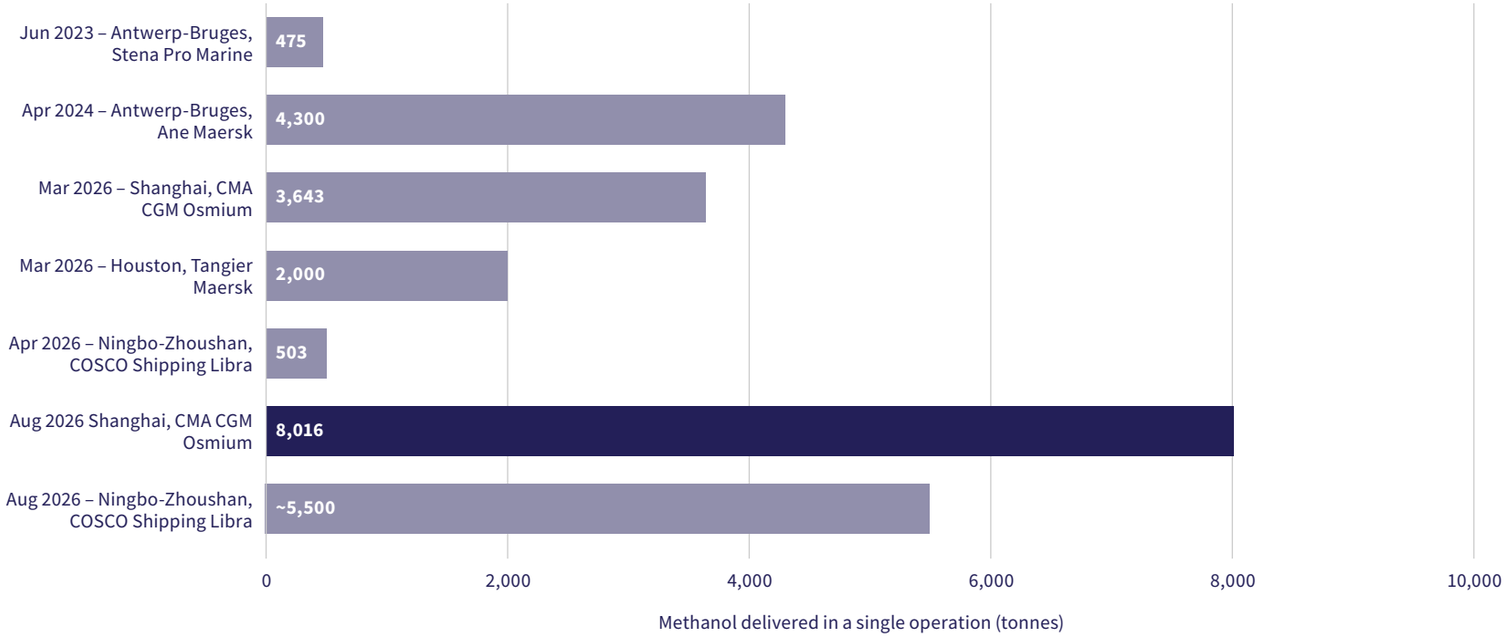
Key takeaways

The question for the world's ports is no longer whether they will build alternative fuel bunkering, but which fuel, at which port, and on what timeline. The evidence in this report points to a differentiated picture rather than a single verdict.

Readiness diverges within regions, not just between them. Within Europe, Rotterdam, Antwerp-Bruges and Hamburg run broad multi-fuel programmes, while the Strait of Gibraltar has built a strong LNG and bio-LNG position without methanol or ammonia bunkering to date. Within North Asia, Ulsan's commercial ammonia milestone sits alongside a Shanghai plan that covers LNG, methanol and biofuels but not ammonia. Individual port authorities' strategic choices, not simply geography, do most of the explanatory work.

LNG already has the network, and bio-LNG and e-methane can largely inherit it. Methanol has separated itself from ammonia and hydrogen in commercial maturity, because its liquid, ambient-temperature handling lets ports repurpose existing storage, barge and pipeline infrastructure. Single transfers have scaled from 475 tonnes at Antwerp-Bruges in 2023 to 8,016 tonnes at Shanghai in 2026, and the binding constraint has shifted from bunkering capability to the supply of low-carbon methanol.

Figure 12. Largest single methanol bunkering transfers cited in this report



Source: Port of Antwerp-Bruges; Seatrade Maritime; US Coast Guard via Ship & Bunker; S&P Global; CMA CGM via Manifold Times; Manifold Times.

Ammonia has crossed from demonstration to commercial reality, but only at Ulsan so far. Rotterdam, at PRL 7, and Singapore, early in a two-year trial, remain a step behind; Pilbara's first trial is planned for late 2026, and Hamburg's physical ammonia supply is not expected before 2029. Across every ammonia-active port in this survey, safety governance has been the most visible pacing item, though fuel cost and the scale of low-carbon production may prove just as decisive.

Hydrogen remains, realistically, a short-sea and harbour-craft fuel for the foreseeable future, even as its regulatory foundation advances. Biofuel blends, unglamorous but immediately deployable, are the quiet workhorse: biofuel bunkering rules have been found to be operational in nearly a quarter of responding ports, second only to LNG, and any assessment of a port's actual readiness today should weight biofuel availability accordingly.

Nuclear needs no bunkering at all, but it needs a licensing, security and port-access regime. Long Beach and Corpus Christi have begun to explore that through agreements with MARAD, and Rotterdam, Charleston and Felixstowe through studies with Lloyd's Register and industry partners. Not every port needs the same capability: a staged approach, from nuclear-aware to nuclear-ready and beyond, lets ports prepare proportionately before any vessel or power unit is proposed.

For shipowners, operators and charterers, the practical consequence is that fuel choice and trade route are now inseparable. Newbuild and conversion decisions should be tested against the specific ports a vessel will call at, green corridors offer the clearest signal of where supply will become reliable first, and biofuel blends remain the lowest-risk option for owners who need to act now.

For ports, the evidence points to the same discipline: build the safety framework, licensing, emergency response capability and trained workforce that insurers and regulators will expect, secure financing early on the basis of credible demand, and allocate the new risks clearly in contracts. Any assessment of an individual port should be built fuel by fuel, rather than on a single verdict of whether a port is or is not ready.



Critical decisions for the next decade

Fuel choice and trade route are now inseparable. Rotterdam, Singapore, Shanghai, Ningbo-Zhoushan and Hamburg offer methanol bunkering, and Houston and Ulsan have completed operations. Antwerp-Bruges, an early leader, recorded no methanol sales after the third quarter of 2024, a reminder that capability and routine supply are not the same thing. A vessel trading mainly through regions without verified methanol supply cannot count on it.

Ammonia narrows this further. As of September 2026, only Ulsan has carried out commercial ammonia bunkering. Rotterdam, Singapore, Hamburg and the Pilbara are at various pilot, trial or framework stages, and no ammonia bunkering was identified elsewhere in this research, the UK included.

Any newbuild or conversion decision should be stress-tested against the specific ports a vessel will call at, not against the industry's aggregate progress.

The Singapore precedents indicate how long regulatory steps can take. For methanol, around ten months elapsed between the call for applications in March 2025 and licences taking effect on 1 January 2026.

For ammonia, the trial authorisation took effect in May 2026, but demonstration bunkering is not planned until late 2027, once a dedicated bunker vessel is delivered. Owners should not assume ammonia will follow the faster methanol timeline.

Biofuel blends remain the lowest-risk, highest-availability compliance option for owners who need to act now, since they move through existing bunker supply chains. A traded premium for B24 and B30 is now assessed in Singapore.

Green corridor participation is emerging as a signal of where bunkering reliability will land first. Chartering or newbuild decisions anchored to a named corridor carry less infrastructure risk than decisions based on a single port's readiness.

Port readiness checklist

Ten questions for port leaders

- **Fuels:** which fuels are vessels calling at, or planning to call at, your port likely to need, and on what timeline?
- **Benchmark:** where does your port stand on the IAPH Port Readiness Level scale for each fuel?
- **Safety:** are berth-specific gas dispersion studies, exclusion zones and emergency plans in place for the newer fuels?
- **Licensing:** is there a licensing or authorisation framework for alternative-fuel bunker suppliers?
- **People:** are pilots, harbour masters, terminal staff and emergency responders trained for the fuels you expect?
- **Infrastructure:** what storage, transfer, grid and shore power capacity is needed, and can it serve more than one fuel?
- **Digital:** are bunker scheduling, metering and documentation digital, and can your systems handle notifications and safety data for new fuels?
- **Partnerships:** which fuel suppliers, shipowners and corridor partners will share the investment and the demand risk?
- **Risk and insurance:** who carries alternative-fuel liability in your contracts, and does your insurance respond to toxic gas release?
- **Finance:** is there a bankable case, supported by credible demand forecasts and available public or blended finance?

Appendices

Ports and regions not covered

This report examines more than twenty-five ports and port authorities, but that still leaves much of the world's bunkering map untouched.

Latin America appears only through Santos. Panama and Brazil, the Caribbean and South America's other ports are absent. Sub-Saharan Africa has no entry.

Southeast Asia beyond Singapore is thin: Port Klang and Tanjung Pelepas, both competitors to Singapore on the Malacca Strait, are not assessed. Mainland China is represented by Shanghai and Ningbo-Zhoushan and Tianjin, leaving out Qingdao and Hong Kong.

North America's East Coast is represented only by Charleston and Houston, whose profile covers nuclear port-access work; New York and New Jersey would be natural additions. India is represented by Kandla alone.

A reader using this report to plan a global bunkering strategy should treat the absence of a port as a research gap, not a finding that the port is unprepared.

Glossary of key terms

IGF Code: the IMO's goal-based safety code for ships using gases or other low-flashpoint fuels, in force since 2017.

IGC Code: the IMO code for gas carriers. Amendments in force from 1 July 2026 allow an Administration to accept certain toxic cargoes, including ammonia, as fuel.

MSC.1/Circ.1687: the IMO circular publishing the interim guidelines for the safety of ships using ammonia as fuel, dated 26 February 2025.

Port Readiness Level (PRL): a nine-level self-assessment scale for a port's preparedness to bunker a given fuel, developed under the World Ports Climate Action Programme with IAPH.

SIMOPS: simultaneous operations, in which a vessel bunkers while cargo operations continue.

Ship-to-ship (STS), truck-to-ship (TTS) and port- or pipe-to-ship (PTS): the three principal transfer methods, distinguished by whether fuel comes from a bunker vessel, a road tanker or fixed shore pipework.

Green corridor: an arrangement between ports, typically at either end of a trade lane, to coordinate alternative fuel availability and regulatory alignment.

B24 and B30: blends of 24 and 30 per cent biofuel, typically fatty acid methyl ester, with conventional fuel oil such as VLSFO.

RFNBO: renewable fuel of non-biological origin, such as e-methanol made from renewable hydrogen and captured carbon.

FuelEU Maritime: the EU regulation, in effect since January 2025, tightening greenhouse gas intensity limits on fuels used by ships in EU and EEA waters.

UK ETS: the UK Emissions Trading Scheme, extended to maritime from 1 July 2026.

IMO Net-Zero Framework: the IMO's proposed global fuel standard and emissions pricing mechanism, approved in principle in April 2025, with adoption adjourned in October 2025 for one year.

Grey, blue and green ammonia or hydrogen: production pathway classifications for fossil-derived production without carbon capture, fossil-derived production with carbon capture, and production from renewable electricity. The three are chemically identical at the point of bunkering.

References

1. AJOT, Ulsan Port completes world's first ammonia port-to-ship bunkering for commercial vessels (April 2026): https://www.ajot.com/news/ulsan-port-completes-worlds-first-ammonia-port-to-ship-bunkering-for-commercial-vessels
2. Allianz Commercial, Decarbonization and sustainability in shipping: https://commercial.allianz.com/news-and-insights/expert-risk-articles/decarbonization-sustainability-shipping.html
3. Allianz Commercial, Safety and Shipping Review 2026: https://commercial.allianz.com/news-and-insights/reports/shipping-safety.html
4. Ammonia Energy Association, IMO moves forward with interim guidelines for ammonia fuel use: https://ammoniaenergy.org/articles/imo-moves-forward-with-interim-guidelines-for-ammonia-fuel-use
5. Ammonia Energy Association, Lotte: completing the ammonia bunker fuel value chain: https://ammoniaenergy.org/articles/lotte-completing-the-ammonia-bunker-fuel-value-chain
6. Ammonia Energy Association, Practical lessons, safety framework emerge from Rotterdam bunker demonstration (June 2026): https://ammoniaenergy.org/articles/practical-lessons-safety-framework-emerge-from-rotterdam-bunker-demonstration/
7. ANS Nuclear Newswire, Long Beach is first port to partner with MARAD on maritime reactors (July 2026): https://www.ans.org/news/article-8250/long-beach-is-first-port-to-partner-with-marad-on-maritime-reactors/
8. Argus Media, Singapore, Rotterdam advance 'green' shipping corridor (April 2024): https://www.argusmedia.com/en/news-and-insights/latest-market-news/2557588-singapore-rotterdam-advance-green-shipping-corridor
9. Argus Media, UAE's Fujairah port allocates land for biofuel plant (includes Singapore biofuel supplier count, 2023): https://argusmedia.com/ja/news-and-insights/latest-market-news/2590267-uae-s-fujairah-port-allocates-land-for-biofuel-plant
10. Axpo, Axpo completes Spain's first ship-to-ship Bio-LNG bunkering operation (August 2025): https://www.axpo.com/es/en/newsroom/media-releases/2025/axpo-completes-spain-s-first-ship-to-ship-bio-lng-bunkering-oper.html
11. BIMCO, Biofuel Clause for Time Charter Parties 2026: https://www.bimco.org/news-insights/bimco-news/2026/07/13-biofuel/
12. BIMCO, IMO Legal Committee addresses key maritime issues at the 112th session: https://www.bimco.org/news-insights/bimco-news/2025/04/01-imo-legal-committee/
13. Britannia P&I, MPA implements Just in Time Planning and Coordination Platform (November 2023): https://britanniapandi.com/2023/11/mpa-implements-just-in-time-planning-and-coordination-platform/
14. Brookes Bell, Port of Houston completes first ship-to-ship methanol bunkering in the United States: https://www.brookesbell.com/news-and-knowledge/port-of-houston-completes-first-ship-to-ship-methanol-bunkering-in-the-united-states
15. C40 Cities, Request for Information: San Pedro Bay Ports methanol bunkering pilot: https://www.c40.org/wp-content/uploads/2025/09/Request-for-Information_Methanol-bunkering-at-SPBP.pdf
16. Clean Shipping International, Brittany Ferries begins electric operations (August 2026): https://www.cleanshippinginternational.com/brittany-ferries-begins-electric-operations/
17. Clean Shipping International, IACS revisits ammonia fuel safety requirement (November 2024): https://cleanshippinginternational.com/?p=13353
18. Clean Shipping International, Methanol-fuelled Newcastle–IJmuiden green corridor could cut GHG by 80%: https://www.cleanshippinginternational.com/?p=17662
19. Cyprus Shipping News, Shipping's Green Technology Tracker: 2025 Review by Clarksons Research (January 2026): https://cyprusshippingnews.com/2026/01/07/shippings-green-technology-tracker-2025-review-by-clarksons-research/
20. edie, IEA: Annual electricity grid investments must double to keep 1.5C alive: https://www.edie.net/iea-annual-electricity-grid-investments-must-double-to-keep-1-5c-alive/
21. ENGINE, Antwerp-Bruges bunker sales overtake Rotterdam (April 2026): https://engine.online/news/antwerp-bruges-bunker-sales-overtake-rotterdam-7a96
22. ENGINE, Antwerp-Bruges' LNG bunker sales hit record highs in 2025 (February 2026): https://engine.online/news/antwerp-bruges-lng-bunker-sales-hit-record-highs-in-2025-777f
23. ENGINE, Bunker One completes first bioethanol bunkering in Latin America (July 2026): https://engine.online/news/bunker-one-completes-first-bioethanol-bunkering-in-latin-america-7e45
24. ENGINE, LNG bunkers offered at 222 ports: Sea-LNG (January 2026): https://engine.online/news/lng-bunkers-offered-at-222-ports-sea-lng-7696
25. ENGINE, Major bunker ports poised to lead green fuel transition – LR study (May 2026): https://www.engine.online/news/major-bunker-ports-poised-to-lead-green-fuel-transition-lr-study-7c11
26. ENGINE, Shanghai bunker sales rise, methanol tops Singapore (January 2026): https://engine.online/news/shanghai-bunker-sales-rise-methanol-tops-singapore-76d8
27. ENGINE, UK shipping body calls for stronger ammonia, hydrogen safeguards (August 2026): https://engine.online/news/uk-shipping-body-calls-for-stronger-ammonia-hydrogen-safeguards-7f5b
28. Gard, Shipowners' P&I (International Group coverage): https://www.gard.no/products-and-services/products/shipowners/shipowners-p-and-i/
29. gCaptain, Hornbeck Offshore backs maritime nuclear push with Deployable Energy (August 2026): https://gcaptain.com/hornbeck-offshore-backs-maritime-nuclear-push-with-deployable-energy/
30. gCaptain, Port of Long Beach, MARAD launch first U.S. partnership on nuclear-powered shipping (22 July 2026): https://gcaptain.com/port-of-long-beach-marad-launch-first-u-s-partnership-on-nuclear-powered-shipping/
31. Global Maritime Forum, Negotiations at IMO adjourn without a decision on the Net-Zero Framework: https://globalmaritimeforum.org/press/negotiations-at-IMO-adjourn-without-a-decision-on-NZF/
32. H2 International, Hamburg port becomes bunker-ready for ammonia: https://www.h2-international.com/mobility/mobility-hamburg-port-becomes-bunker-ready-ammonia
33. Hamburg Port Authority, Port Bunker Map: https://www.hamburg-port-authority.de/fileadmin/user_upload/seh/Port_Bunker_Map.pdf
34. Hellenic Shipping News (source: Port of Long Beach), Singapore, Long Beach, L.A. ports to establish green, digital shipping corridor: https://www.hellenicshippingnews.com/singapore-long-beach-l-a-ports-to-establish-green-digital-shipping-corridor/
35. Hellenic Shipping News (source: Ulsan Port Authority), Ulsan Port achieves Korea's first green methanol STS bunkering for bulk carrier (September 2025): https://www.hellenicshippingnews.com/ulsan-port-achieves-koreas-first-green-methanol-sts-bunkering-for-bulk-carrier/
36. Hellenic Shipping News, Lloyd's Register expands Global Fuel Finder with new biofuels capability: https://www.hellenicshippingnews.com/?p=1086317
37. Hill Dickinson, IMO's Net-Zero Framework: adoption adjourned, and consensus building continues: https://www.hilldickinson.com/insights/articles/imos-net-zero-framework-adoption-adjourned-and-consensus-building-continues
38. Hydrocarbon Processing, Cepsa becomes Moeve (October 2024): https://hydrocarbonprocessing.com/news/2024/10-1/cepsa-becomes-moeve/

39. Hydrocarbon Processing, Marine fuel sales in Singapore bunker hub scale fresh highs in 2025 (January 2026): https://hydrocarbonprocessing.com/news/2026/01/marine-fuel-sales-in-singapore-bunker-hub-scale-fresh-highs-in-2025/
40. Hydrogen Energy Supply Chain project, The Suiso Frontier: https://www.hydrogenenergysupplychain.com/supply-chain/the-suiso-frontier/
41. IAEA, IAEA to launch ATLAS: pioneering nuclear solutions for shipping and offshore energy: https://www.iaea.org/newscenter/pressreleases/iaea-to-launch-atlas-pioneering-nuclear-solutions-for-shipping-and-offshore-energy-washington-august-26-27-2026
42. IAEA, Joint Statement, ATLAS Ministerial Launch Event (August 2026): https://www.iaea.org/newscenter/pressreleases/joint-statement-atlas-ministerial-launch-event
43. IAPH World Ports Tracker 2026 (via World Ports Sustainability Programme): https://world-ports-sustainability-programme.storychief.io/iaph-world-ports-tracker-2026-reveals-state-of-global-port-sustainability
44. IAPH, London announced as venue of IAPH2026 conference: https://www.iaphworldports.org/?p=20630
45. IMO, FAL Convention: https://www.imo.org/en/ourwork/facilitation/pages/falconvention-default.aspx
46. IMO, IMO treaty on hazardous and noxious cargo to enter into force in 2027: https://www.imo.org/en/mediacentre/pressbriefings/pages/imo-hns-treaty-to-enter-into-force-in-2027-.aspx
47. IMO, Maritime Single Window: https://www.imo.org/en/ourwork/facilitation/pages/maritimesinglewindow-default.aspx
48. IMO, MSC.1/Circ.1687, Interim Guidelines for the Safety of Ships Using Ammonia as Fuel (26 February 2025), via US Coast Guard: https://www.dco.uscg.mil/Portals/9/DCO Documents/5p/LGCNCOE/docs/IMO MSC_1-Circ_1687 – Interim Guidelines for the Safety of Ship Using Ammonia as Fuel.pdf
49. IMO, The IMO Net-Zero Framework – FAQs: https://www.imo.org/en/mediacentre/hottopics/pages/faqs-the-imo-net-zero-framework.aspx
50. Inter-American Development Bank, International case studies and good practices for implementing Port Community Systems: https://publications.iadb.org/publications/english/document/International_Case_Studies_and_Good_Practices_for_Implementing_Port_Community_Systems.pdf
51. International Energy Agency, Electricity 2026: Executive summary: https://www.iea.org/reports/electricity-2026/executive-summary
52. International Group of P&I Clubs, The Group's Strategic Roadmap: https://www.igpandi.org/article/the-groups-strategic-roadmap/
53. IPCSA, Port Community Systems: General: https://ipcsa.international/pcs/pcs-general/
54. ISO, ISO 22120:2026 Ships and marine technology, Specification for bunkering of methanol fuelled vessels: https://www.iso.org/es/contents/data/standard/08/69/86958.html
55. ITOCHU, Authorisation by MPA for ammonia bunkering trials in Singapore: https://www.itochu.co.jp/en/news/news/2026/260520.html
56. ITV News, Ferries to start plugging in to Portsmouth port's electricity supply during turnarounds (August 2026): https://www.itv.com/news/meridian/2026-08-03/ferries-to-start-plugging-in-to-ports-electricity-supply-during-turnarounds
57. IUMI, How can liability and compensation regimes adapt to alternative fuels and cargoes?: https://iumi.com/newsletter-june-2024/how-can-liability-and-compensation-regimes-adapt-to-alternative-fuels-and-cargoes/
58. Lin-gang Special Area, Shanghai Port tops 2 million cubic meters in bonded LNG bunkering: https://en.lingang.gov.cn/html/website/lg/English/News1630758253379031042/Updates/2082390917161975810.html
59. LISCR, CCC 11 meeting summary: https://www.liscr.com/marketing/liscr/media/liscr/online library/maritime/ccc-11-meeting-summary.pdf
60. Lloyd's Register FOBAS, biofuel bunkering activity data by port (supplied by Lloyd's Register, 2026)
61. Lloyd's Register, Alternative-fuelled ship orders remain significant in 2025 (January 2026): https://www.lr.org/en/knowledge/insights-articles/alternative-fuelled-ship-orders-remain-significant-in-2025/
62. Lloyd's Register, CCC 11 Summary Report (September 2025): https://www.lr.org/en/knowledge/regulatory-updates/imo-meetings-and-future-legislation/ccc-11-summary-report/
63. Lloyd's Register, FuelEU Regulation: timetable for compliance: https://www.lr.org/en/expertise/maritime-energy-transition/fueleu-regulation/timetable-for-compliance
64. Lloyd's Register, Guidance Notes for Class and Statutory Approval and Use of Marine Biofuels: https://www.lr.org/en/knowledge/lloyds-register-rules/guidance-notes/guidance-notes-for-class-and-statutory-approval-and-use-of-marine-biofuels/
65. Lloyd's Register, Guidance Notes on Gas Dispersion and Explosion Analysis for Alternative Fuelled Ships: https://www.lr.org/en/knowledge/lloyds-register-rules/guidance-notes/guidance-notes-on-gas-dispersion-and-explosion-analysis-for-alternative-fuelled-ships/
66. Lloyd's Register, Pink Corridor project to explore safety requirements of nuclear-powered transatlantic container shipping route (2026): https://www.lr.org/en/knowledge/press-room/press-listing/press-release/2026/pink-corridor-project-to-explore-safety-requirements-of-nuclear-powered-transatlantic-container-shipping-route/
67. Lloyd's Register, Rotterdam study sets out pathway for nuclear-powered commercial ship port calls (June 2026): https://www.lr.org/en/knowledge/press-room/press-listing/press-release/2026/rotterdam-study-sets-out-pathway-for-nuclear-powered-commercial-ship-port-calls/
68. Lloyd's Register, UK-led maritime consortium sets out plan for nuclear-powered fleet (January 2026): https://www.lr.org/en/knowledge/press-room/press-listing/press-release/2026/uk-led-maritime-consortium-sets-out-plan-for-nuclear-powered-fleet/
69. Manifold Times, Algeciras claims third place in Europe's LNG bunkering league: https://www.manifoldtimes.com/news/spains-algeciras-claims-third-place-in-europes-lng-bunkering-league/
70. Manifold Times, CMA CGM boxship takes on record 8,016 mt of biomethanol in Shanghai: https://www.manifoldtimes.com/news/cma-cgm-boxship-takes-on-record-8016-mt-of-biomethanol-bunker-fuel-in-shanghai
71. Manifold Times, digitalPORT@SG: MPA implementing JIT Platform for Port of Singapore (includes 2025 digital bunkering adoption): https://www.manifoldtimes.com/news/digitalportsg-mpa-implementing-jit-platform-for-port-of-singapore/
72. Manifold Times, GENA Solutions methanol project pipeline, August 2026 release: https://www.manifoldtimes.com/news/gena-solutions-total-renewable-and-low-carbon-methanol-project-pipeline-decreases-from-62-3-to-61-8-mt-by-2032
73. Manifold Times, GENA Solutions methanol project pipeline, June 2026 release: https://www.manifoldtimes.com/news/gena-solutions-total-renewable-and-low-carbon-methanol-project-pipeline-rises-from-61-6-to-61-8-mt-by-2031/
74. Manifold Times, Glencore backs FincoEnergies' biofuel growth with majority stake acquisition (July 2026): https://www.manifoldtimes.com/?p=77807
75. Manifold Times, HPA and MB Energy develop safety concept for STS ammonia bunkering: https://www.manifoldtimes.com/news/hpa-and-mb-energy-develop-safety-concept-for-sts-ammonia-bunkering/
76. Manifold Times, Ningbo-Zhoushan Port completes Zhejiang's largest single-ship green methanol bunkering operation (August 2026): https://www.manifoldtimes.com/news/ningbo-zhoushan-port-completes-zhejiangs-largest-single-ship-green-methanol-bunkering-op
77. Manifold Times, PetroChina Fuel Oil subsidiary secures Zhoushan's first methanol bunkering licence (January 2026): https://www.manifoldtimes.com/news/petrochina-fuel-oil-subsidiary-secures-zhoushans-first-methanol-bunkering-licence/
78. Manifold Times, Repsol and Maersk wrap up first bioethanol bunkering operation in Port of Barcelona (July 2026): https://www.manifoldtimes.com/?p=76411
79. Manifold Times, Rotterdam bio-LNG bunker sales surges sixfold in 2025 as bio-blended fuels drops (February 2026): https://www.manifoldtimes.com/news/rotterdam-bio-lng-bunker-sales-surges-sixfold-in-2025-as-bio-blended-fuels-drops/
80. Manifold Times, Singapore, LA and Long Beach ink MoU to establish green and digital shipping corridor (April 2023): https://www.manifoldtimes.com/?p=56124
81. Manifold Times, South Korea: S-Oil launches B30-VLSFO bio bunker fuel supply (July 2026): https://www.manifoldtimes.com/?p=78145
82. MARAD, Transportation Secretary and Port of Corpus Christi sign agreement (August 2026): https://www.maritime.dot.gov/newsroom/trumps-transportation-secretary-sean-p-duffy-and-port-corpus-christi-sign-agreement
83. Marine Insight, India conducts first shore-to-ship methanol bunkering at Kandla Port: https://www.marineinsight.com/india-conducts-first-shore-to-ship-methanol-bunkering-at-kandla-port

84. Marine Link, Fortescue charters up to 12 ammonia-capable bulkers from CMB.TECH: https://www.marinelink.com/news/fortescue-charters-ammoniacapable-bulkers-540502
85. Marine Link, IMO approves new guidelines for ammonia-fueled vessels (May 2026): https://www.marinelink.com/news/imo-approves-new-guidelines-ammoniafueled-539598
86. Marine Link, Singapore Maritime Week underway (March 2025): https://www.marinelink.com/news/singapore-maritime-week-underway-523848
87. Marine Log, Deployable Energy set for INL, Hornbeck demonstrations: https://marinelog.com/news/deployable-energy-set-for-inl-hornbeck-demonstrations
88. Maritime Professional, By the Numbers: Maritime Safety in 2026 (summary of Allianz review): http://www.maritimeprofessional.com/news/numbers-maritime-safety-2026-fewer-420550
89. Marsh, The future of maritime fuels (January 2024): https://www.marsh.com/en/industries/marine/insights/future-maritime-fuels.html
90. MPA, Digital Bunkering: https://www.mpa.gov.sg/port-marine-ops/marine-services/bunkering/digital-bunkering
91. MPA, digitalPORT@SG: About: https://digitalport.mpa.gov.sg/about
92. MPA, Factsheet: Singapore–Japan Green and Digital Shipping Corridor (December 2023): https://mpa.gov.sg/docs/mpalibraries/media-releases/mpa-media-factsheet_singapore-japan-green-and-digital-shipping-corridor
93. MPA, Media Factsheet: Charting Singapore Forward as a Hub Port and International Maritime Centre: https://www.mpa.gov.sg/media-centre/details/media-factsheet-charting-singapore-forward-as-a-hub-port-and-international-maritime-centre
94. MPA, MPA to launch Digital Bunkering for Enhanced Efficiency (October 2023): https://www.mpa.gov.sg/media-centre/details/mpa-to-launch-digital-bunkering-for-enhanced-efficiency
95. MPA, Rotterdam and Singapore strengthen collaboration on Green and Digital Shipping Corridor (March 2025): https://mpa.gov.sg/media-centre/details/rotterdam-and-singapore-strengthen-collaboration-on-green-and-digital-shipping-corridor
96. MPA, Singapore advances maritime innovation with geospatial partnerships and launches Maritime Digital Twin (March 2025): https://www.mpa.gov.sg/media-centre/details/singapore-advances-maritime-innovation-with-geospatial-partnerships-and-launches-maritime-digital-twin
97. MPA, Singapore to award licences for methanol bunkering (24 November 2025): https://www.mpa.gov.sg/media-centre/details/singapore-to-award-licences-for-methanol-bunkering
98. NorthStandard, Risk assessments required for alternative fuel bunkering in the US (August 2025): https://north-standard.com/insights-and-resources/resources/news/risk-assessments-required-for-alternative-fuel-bunkering-in-the-us
99. NYK, Truck-to-ship ammonia bunkering of ammonia-fuelled tugboat (July 2024): https://nyk.com/english/news/2024/20240717_01.html
100. Offshore Energy, MPA and Yinson GreenTech to elevate Singapore's maritime digital twin (June 2025): https://www.offshore-energy.biz/mpa-and-yinson-greentech-to-elevate-singapores-maritime-digital-twin/
101. Offshore Energy, Port of Antwerp-Bruges sees its very first methanol bunkering (June 2023): https://www.offshore-energy.biz/port-of-antwerp-bruges-sees-its-very-first-methanol-bunkering/
102. ORE Catapult, Port of Milford Haven spearheads plans for the UK's clean maritime future (March 2025): https://ore.catapult.org.uk/resource-hub/blog/port-of-milford-haven-spearheads-plans-for-the-uks-clean-maritime-future-hypr
103. Port of Aberdeen, UK government funding for liquid hydrogen autonomous vessel project: https://www.portofaberdeen.co.uk/news/port-of-aberdeen-welcomes-uk-government-funding-for-worlds-first-liquid-hydrogen-autonomous-vessel-project
104. Port of Antwerp-Bruges, First methanol bunkering with deepsea vessel Ane Maersk: https://newsroom.portofantwerpbruges.com/en/press-releases/first-methanol-bunkering-with-deepsea-vessel-ane-maersk-at-port-of-antwerp-bruges
105. Port of Hamburg, Waltershof Hafen is bunker-ready for methanol and LNG (August 2025): https://www.hafen-hamburg.de/en/press1/news/waltershofer-hafen-ist-bunker-ready-fuer-methanol-und-lng-meilenstein-fuer-alternative-schiffskraftstoffe-in-hamburg/
106. Port of Rotterdam, ammonia bunkering pilot (April 2025): https://www.portofrotterdam.com/en/news-and-press-releases/port-rotterdam-takes-important-step-making-shipping-more-sustainable-pilot
107. Port of Rotterdam, Bunkering in Rotterdam: https://www.portofrotterdam.com/en/sea-shipping/bunkering-in-rotterdam
108. Port Technology International, Rotterdam and Maersk Partner for Port Call Optimization: https://www.porttechnology.org/rotterdam-and-maersk-partner-for-port-call-optimization/
109. Portbase, Community Solutions: https://www.portbase.com/en/community-solutions/
110. PortNews, Busan Port Authority targets 2032 start-up for LNG and green methanol bunkering hub: https://en.portnews.ru/news/391400/
111. PortXchange, Port of Rotterdam Authority launches new company PortXchange (2019): https://port-xchange.com/port-of-rotterdam-authority-launches-new-company-portxchange/
112. Professional Mariner, Long Beach, LA, Singapore renew green shipping directive: https://professionalmariner.com/long-beach-la-singapore-renew-green-shipping-directive/
113. Riviera Maritime Media, Orderbook low-carbon readiness outpaced in-service fleet uptake (January 2026): https://www.rivieramm.com/news-content-hub/orderbook-low-carbon-readiness-outpaced-in-service-fleet-uptake-87293
114. S&P Global, Fujairah biofuel developments (March 2025): https://www.spglobal.com/energy/en/news-research/latest-news/agriculture/031925-fujairah-port-to-expand-biofuel-footprint-with-major-saf-plant-bio-bunker-milestone
115. S&P Global, Interview: Port of Long Beach to expand bunkering capabilities for green shipping corridors (April 2024): https://www.spglobal.com/energy/en/news-research/latest-news/shipping/041924-interview-port-of-long-beach-to-expand-bunkering-capabilities-for-green-shipping-corridors
116. S&P Global, Interview: Rotterdam expands green bunker capacity, worried over IMO delay (November 2025): https://www.spglobal.com/energy/en/news-research/latest-news/refined-products/112425-interview-rotterdam-expands-green-bunker-capacity-worried-over-imo-delay
117. S&P Global, Ningbo-Zhoushan completes first bonded green methanol STS bunkering: https://www.spglobal.com/energy/en/news-research/latest-news/agriculture/042426-ningbo-zhoushan-port-completes-first-bonded-green-methanol-sts-bunkering
118. S&P Global, Platts Bunkerwire, 11 March 2026: https://www.spglobal.com/content/dam/spglobal/s1/en/documents/general/west-africa/Bunkerwire_11Mar2026.pdf
119. S&P Global, Platts launches B30 Singapore biobunker assessments (October 2025): https://www.spglobal.com/energy/en/pricing-benchmarks/our-methodology/subscriber-notes/100125-platts-launches-b30-singapore-biobunker-assessments-updates-b24-lsfo-volume
120. S&P Global, Platts to launch B30 Singapore biobunker assessments (September 2025): https://www.spglobal.com/energy/en/pricing-benchmarks/our-methodology/subscriber-notes/090325-platts-to-launch-b30-singapore-biobunker-assessments-update-b24-lsfo-volume
121. S&P Global, Platts to launch new Singapore bio-bunkers market-based assessments (July 2024): https://www.spglobal.com/energy/en/pricing-benchmarks/our-methodology/subscriber-notes/070324-platts-to-launch-new-singapore-bio-bunkers-market-based-assessments
122. SAFETY4SEA, Clarksons Research: LNG remains the top alternative fuel (January 2026): https://safety4sea.com/clarksons-research-lng-remains-the-top-alternative-fuel/
123. SAFETY4SEA, IMO CCC 10 key outcomes: https://safety4sea.com/imo-ccc-10-key-outcomes
124. SAFETY4SEA, New report finds that bunkering demand is concentrated around 19 ports (2026): https://safety4sea.com/new-report-finds-that-bunkering-demand-is-concentrated-around-19-ports/
125. SAFETY4SEA, Port of Rotterdam & Port of Antwerp-Bruges mandate the use of MFM (July 2025): https://safety4sea.com/port-of-rotterdam-port-of-antwerp-bruges-mandate-the-use-of-mfm/
126. SAFETY4SEA, Singapore launches new standard on methanol bunkering (TR 129, March 2025): https://safety4sea.com/singapore-launches-new-standard-on-methanol-bunkering
127. SEA-LNG 2026 Mid-Year Market Review (via gCaptain): https://gcaptain.com/sea-lng-says-lng-continues-to-lead-alternative-fuel-orders-as-biomethane-supply-expands/
128. Seatrade Maritime, World's largest green methanol bunkering in Shanghai port (March 2026): https://www.seatrade-maritime.com/bunkering/world-s-largest-green-methanol-bunkering-in-shanghai-port

129. Shanghai Municipal Government, Shanghai eyes global green shipping fuel bunkering and trading hubs by 2030: https://english.shanghai.gov.cn/en-GreenShipping-ShippingCenter/20260212/921f9710bf0d4caf893e80d334aad0d1.html
130. Shanghai Municipal Government, Shanghai sets new record for ship refueling in 2025 (January 2026): https://english.shanghai.gov.cn/en-GreenShipping-ShippingCenter/20260121/3fea967bf748466799d5a7791cf1d3c9.html
131. Ship & Bunker, Alt Fuels to Require Separate Conventions, Says P&I Insurer (February 2024): https://shipandbunker.com/news/emea/389451-alt-fuels-to-require-separate-conventions-says-pi-insurer
132. Ship & Bunker, BIMCO Releases Biofuel Clause for Time Charter Parties: https://shipandbunker.com/news/world/919687-bimco-releases-biofuel-clause-for-time-charter-parties
133. Ship & Bunker, Hamburg opens Waltershof terminals to methanol and LNG bunkering: https://shipandbunker.com/news/emea/401683-hamburg-opens-waltershof-terminals-to-methanol-and-lng-bunkering
134. Ship & Bunker, MB Energy wins government permit for Hamburg ammonia import terminal: https://shipandbunker.com/news/emea/866198-mb-energy-wins-government-permit-for-hamburg-ammonia-import-terminal
135. Ship & Bunker, Ningbo-Zhoushan Port sees first ship-to-ship green methanol bunkering (April 2026): https://shipandbunker.com/news/apac/768872-ningbo-zhoushan-port-sees-first-ship-to-ship-green-methanol-bunkering
136. Ship & Bunker, North Sea Port ready for alternative fuel bunkering following risk analysis: https://shipandbunker.com/news/emea/221244-north-sea-port-ready-for-alternative-fuel-bunkering-following-risk-analysis
137. Ship & Bunker, Port of Antwerp-Bruges Q2 bunker volumes up 5.5% year-on-year (2026): https://shipandbunker.com/news/emea/663266-port-of-antwerp-bruges-q2-bunker-volumes-up-55-year-on-year
138. Ship & Bunker, Port of Houston conducts first US ship-to-ship methanol bunkering: https://shipandbunker.com/news/am/226938-port-of-houston-conducts-first-us-ship-to-ship-methanol-bunkering
139. Ship & Bunker, Rotterdam and Antwerp-Bruges Mass Flow Meter Mandate Enters into Force (January 2026): https://shipandbunker.com/news/emea/691269-rotterdam-and-antwerp-bruges-mass-flow-meter-mandate-enters-into-force
140. Ship & Bunker, Shanghai outpaced Singapore in methanol bunker sales in 2025 (January 2026): https://shipandbunker.com/news/apac/938720-shanghai-outpaced-singapore-in-methanol-bunker-sales-in-2025
141. Ship & Bunker, Singapore to issue additional LNG bunkering licences (January 2026): https://shipandbunker.com/news/apac/595529-singapore-to-issue-additional-lng-bunkering-licences
142. Skuld, UK Emission Trading Scheme for maritime entering into force on 1 July 2026: https://cms12.skuld.com/topics/environment/air-pollution/europe/uk-emission-trading-scheme-for-maritime-entering-into-force-on-1-july-2026/
143. Smart Maritime Network, MPA Singapore announces deadline date for move to digital bunkering (October 2024): https://smartmaritimenetwork.com/2024/10/09/mpa-singapore-announces-deadline-date-for-move-to-digital-bunkering/
144. SYBAss, Recap: IMO MSC 111: https://sybass.org/news/recap-imo-msc-111-2/
145. Tank Storage, Port of Rotterdam, Port of Antwerp-Bruges introduce bunkering change (ISO 22192): https://tankstorage.com/all-news/technical-news/port-of-rotterdam-port-of-antwerp-bruges-introduce-bunkering-change/
146. Techfinitive, How the world's largest ports are using AI to keep the global supply chain humming: https://www.techfinitive.com/features/how-the-worlds-largest-ports-are-using-ai-to-keep-the-global-supply-chain-humming/
147. The Maritime Executive, First commercial bunkering of ammonia completed on Exmar ship in Ulsan: https://maritime-executive.com/article/first-commercial-bunkering-of-ammonia-completed-on-exmar-ship-in-ulsan
148. The Maritime Executive, Fortescue brings ammonia-powered PSV to UK ahead of IMO meetings (March 2025): https://maritime-executive.com/article/fortescue-brings-ammonia-powered-psv-to-uk-ahead-of-imo-meetings
149. The Maritime Executive, IMO finalizes interim safety guidelines for ammonia fuel ahead of MEPC 82 (September 2024): https://maritime-executive.com/article/imo-finalizes-interim-safety-guidelines-for-ammonia-fuel-ahead-of-mepc-82
150. The Maritime Executive, Itochu proposes an ammonia bunkering facility at Algeciras (September 2023): https://maritime-executive.com/article/itochu-proposes-an-ammonia-bunkering-facility-at-algeciras
151. The Maritime Executive, Peninsula supplies first LNG bunkering at Port of Algeciras (January 2024): https://maritime-executive.com/corporate/peninsula-supplies-first-lng-bunkering-at-port-of-algeciras
152. The Maritime Executive, Pink Corridor to explore nuclear-powered transatlantic container shipping (3 September 2026): https://maritime-executive.com/article/pink-corridor-to-explore-nuclear-powered-transatlantic-container-shipping
153. TT Club, Ports and terminals insurance: https://www.ttclub.com/our-cover/ports-and-terminals/
154. TT Club, TT Club warns cold ironing needs careful planning as ports race to cut emissions (January 2026): https://www.ttclub.com/news-and-resources/news/article/tt-club-warns-cold-ironing-needs-careful-planning-as-ports-race-to-cut-emissions/
155. UK Government, Immingham Green Energy Terminal development consent decision announced (6 February 2025): https://gov.uk/government/news/immingham-green-energy-terminal-development-consent-decision-announced
156. UK Government, Maritime decarbonisation strategy (25 March 2025): https://www.gov.uk/government/publications/maritime-decarbonisation-strategy
157. UK Government, UK ETS scope expansion: emissions from international maritime voyages (consultation): https://www.gov.uk/government/consultations/uk-ets-scope-expansion-emissions-from-international-maritime-voyages/uk-ets-scope-expansion-emissions-from-international-maritime-voyages-consultation-accessible-webpage
158. UK Government, World's first dual-fuel ammonia-powered vessel arrives in the UK (March 2025): https://www.gov.uk/government/news/worlds-first-dual-fuel-ammonia-powered-vessel-arrives-in-the-uk
159. UK P&I, Navigating the Alternative Fuel Transition (June 2025): https://www.ukpandi.com/news-and-resources/news/article/navigating-the-alternative-fuel-transition/
160. UNCTAD TrainForTrade, Energy transition in ports (course): https://tft.unctad.org/thematic-areas/port-management/energy-transition-in-ports/
161. UNCTAD, Accelerating the energy transition in ports (August 2026): https://unctad.org/news/accelerating-energy-transition-ports
162. Upply, The four key points in Allianz's Safety and Shipping Review 2026: https://market-insights.upply.com/en/the-four-key-points-in-allianz-safety-and-shipping-review-2026
163. Verra, VM0053 Alternative Low-Carbon Fuels for Shipping v1.0: https://verra.org/methodologies/vm0053-alternative-low-carbon-fuels-for-shipping-v1-0/
164. West of England P&I Club (Erin Walton), Alternative fuels are here, but liability frameworks are not, Splash247 (February 2026): https://splash247.com/alternative-fuels-are-here-but-liability-frameworks-are-not/
165. World Nuclear News, First port signs up to US initiative on maritime SMRs (July 2026): https://www.world-nuclear-news.org/articles/first-port-signs-up-to-us-initiative-on-maritime-smrs
166. World Nuclear News, Project to consider trans-Atlantic nuclear-powered cargo ships: https://www.world-nuclear-news.org/articles/project-to-consider-trans-atlantic-nuclear-powered-cargo-ships
167. World Nuclear News, Russia's floating plant heads for final destination: https://world-nuclear-news.org/Articles/Russias-floating-plant-heads-for-final-destination
168. World Nuclear News, Second US port to explore nuclear maritime technologies: https://www.world-nuclear-news.org/articles/second-us-port-to-explore-nuclear-maritime-technologies
169. WTW, Regulatory uncertainty: Why port readiness for alternative fuels is stalling (February 2026): https://www.wtwco.com/en-be/insights/2026/02/regulatory-uncertainty-why-port-readiness-for-alternative-fuels-is-stalling
170. Yara, Study reveals Pilbara potential for ammonia as a clean shipping fuel (November 2023): https://yara.com/news-and-media/news/archive/2023/study-reveals-pilbara-potential-for-ammonia-as-a-clean-shipping-fuel

FUEL FOR THOUGHT

An alternative fuel report series from Lloyd's Register

Discover more

visit lr.org/fuelforthought



Important Notice and Disclaimer

In this notice, LR means Lloyd's Register Group Limited, its subsidiaries and affiliates, and their respective officers, employees and agents. Report means Fuel for Thought: Ports.

This Report is provided for general information only and does not constitute legal, technical, regulatory, financial or other professional advice. Readers should not rely on it as a substitute for professional advice tailored to their particular circumstances.

Nothing in this Report constitutes or replaces any classification, certification, verification, statutory approval or regulatory compliance determination by LR or any other authority.

This Report is based on information available as at 28 September 2026, including information obtained from third parties. LR has not independently verified all such information and makes no representation or warranty as to its accuracy, completeness or currency. The Report may contain statements regarding future developments which are subject to risks and uncertainties and should not be relied upon as guarantees of future outcomes.

References to organisations, ports, companies, products or projects are included for information purposes only and do not constitute endorsement by LR. Where LR provides services to, or participates in projects with, organisations referred to in this Report, any views, assessments or classifications expressed are LR's own and do not constitute certification, approval or a formal LR rating.

To the fullest extent permitted by law, LR accepts no liability for any loss arising from reliance on this Report or its contents. Where information or advice is provided under a separate contract with an LR entity, liability shall be governed exclusively by the terms of that contract.

© Lloyd's Register Group Limited 2026. All rights reserved. Third-party materials remain the property of their respective owners.