

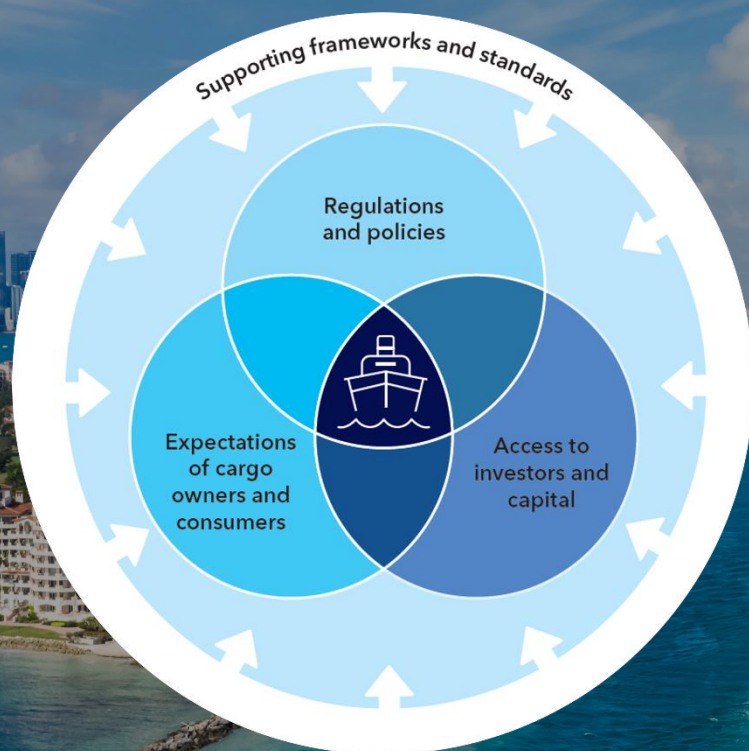
E-fuels – Powering the Future of Global Shipping

Risks & opportunities of E-fuels - Christos Chryssakis



Regulatory frameworks and new standards will drive the maritime decarbonization

5% of fuel will have to be carbon-neutral to achieve current IMO targets



IMO's ambitions will be reviewed and could be strengthened to decarbonize shipping by 2050

Lifecycle GHG emissions standards are being developed to ensure fuel sustainability

Major cargo owners expect low- and zero-emission shipping services to be in place this decade

Access to capital depends increasingly on environmental credentials

International & regional regulations are tightening



EEDI, EEXI, CII, SEEMP,...

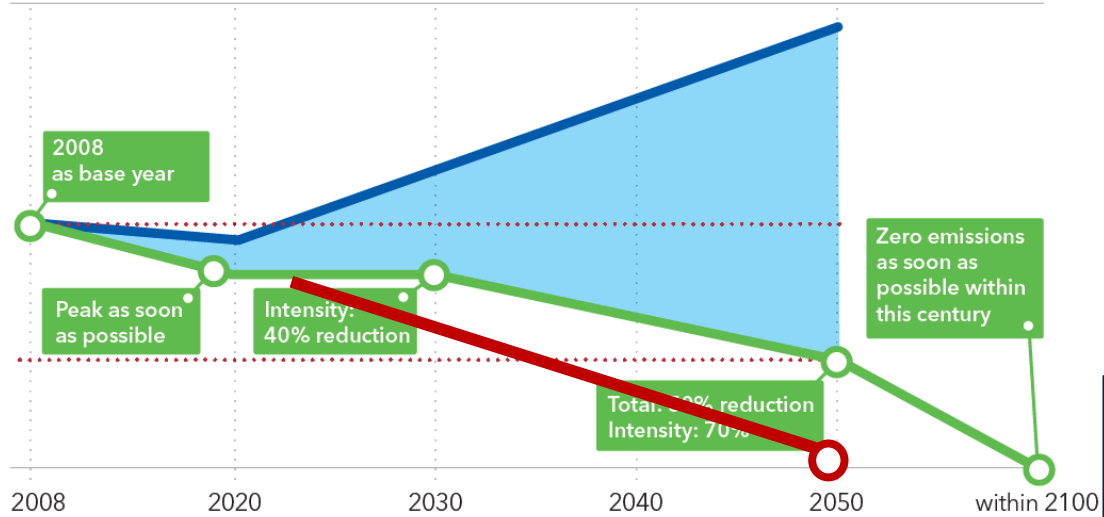
Strategy review in 2023 and higher ambitions to be expected

Inclusion in EU Emissions Trading System (ETS)

FuelEU Maritime

Regulations becoming stricter

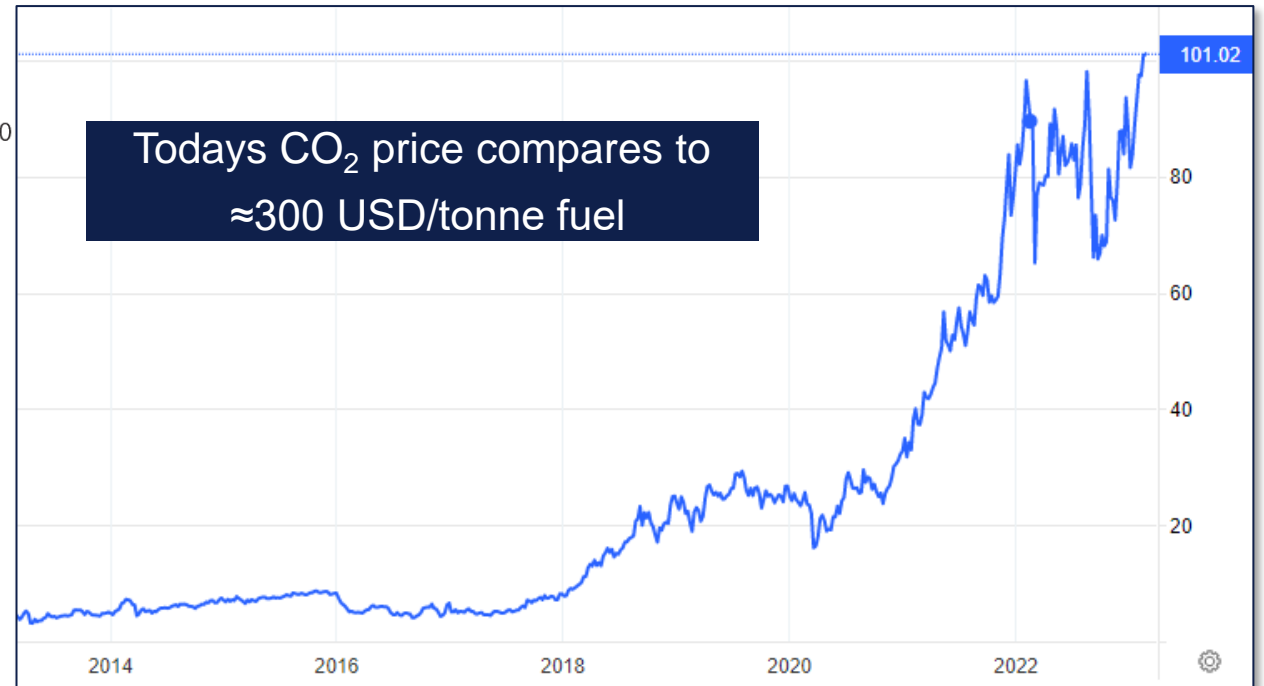
Units: GHG emissions



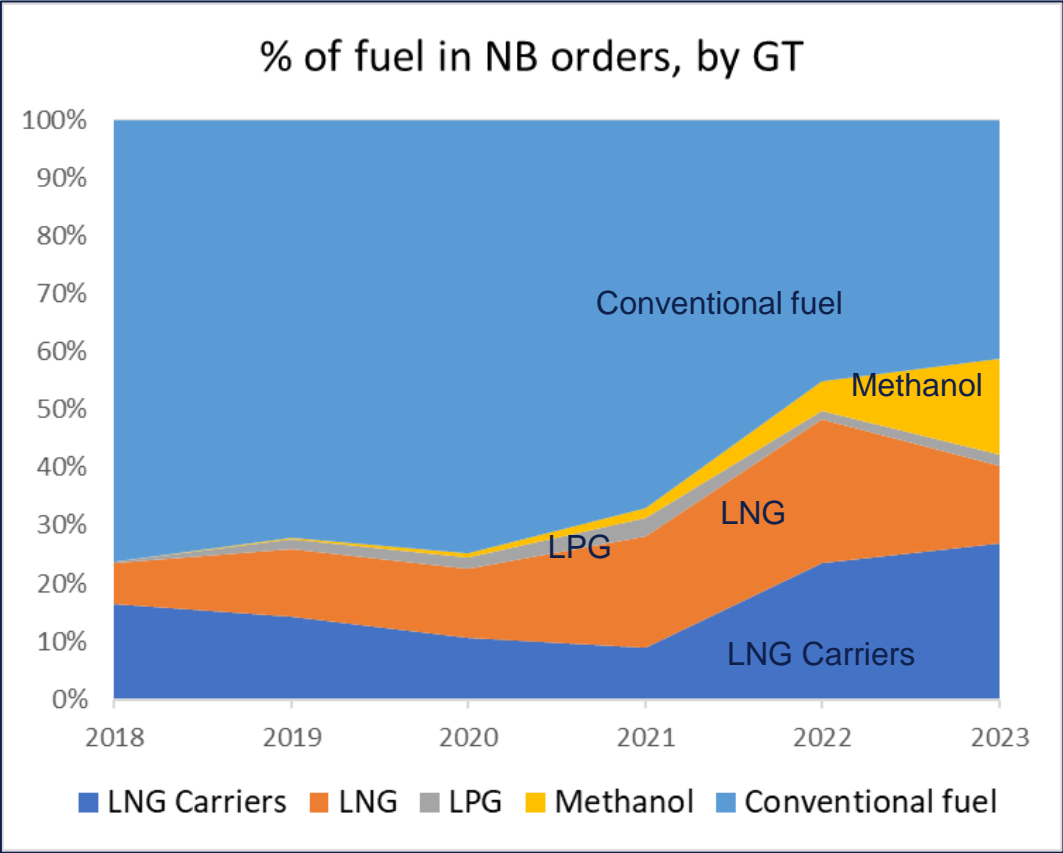
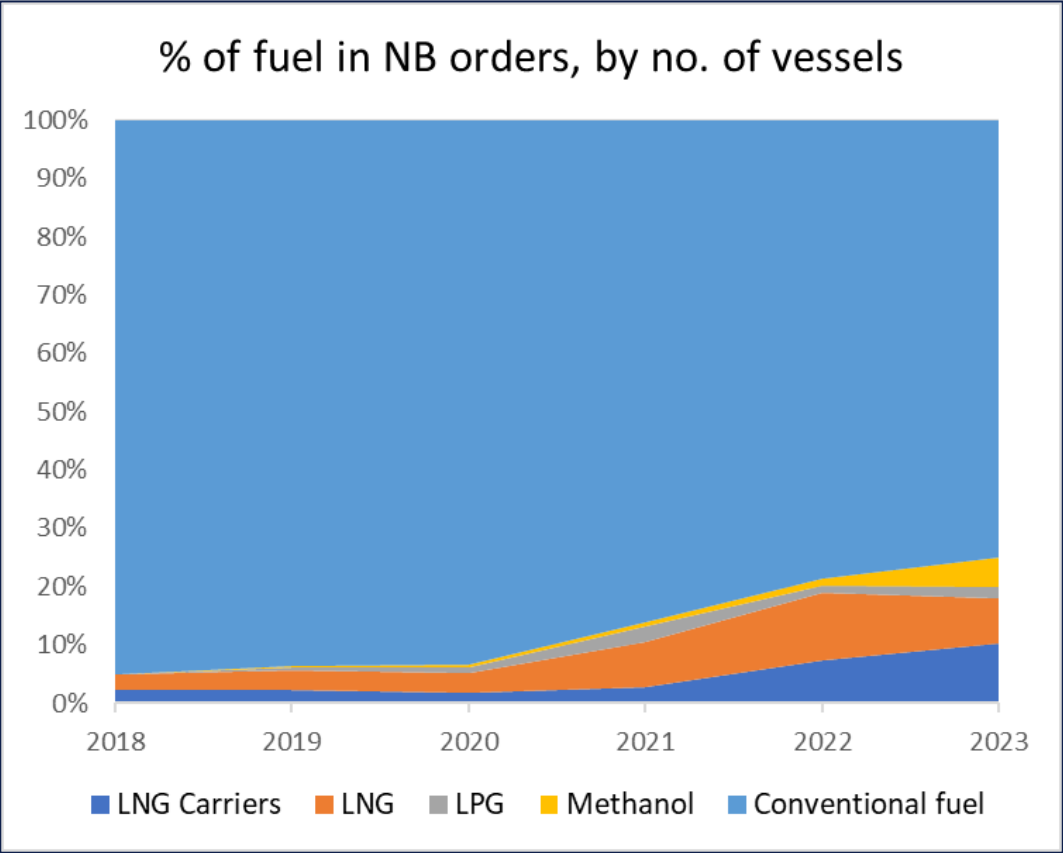
Total: Refers to the absolute amount of GHG emissions from international shipping.
Intensity: Carbon dioxide (CO₂) emitted per tonne-mile.

Revision in 2023:
100% decarbonisation by 2050? Net-zero?

EU emissions allowances – ETS spot and futures prices (€/t)



Newbuilding orders with alternative fuels



Updated: March 2023

The main safety challenges



Segregation

Protect gas fuel installation from external events

Double barriers

Protect the ship against leakages

Leakage detection

Give warning and enable automatic safety actions

Automatic isolation of leakages

Reduce consequences of a leakage

Physical properties

- Methanol (CH_3OH) is the simplest alcohol with the lowest carbon content and highest hydrogen content of any liquid fuel
- Methanol is a colourless liquid at ambient temperature and pressure
- Methanol is a **low flashpoint liquid**, with a flashpoint of 11°C
- Methanol has **toxic and corrosive** properties
- Methanol has lower energy density than VLSFO



Methanol spills or leaks

- Significantly less impact than conventional hydrocarbon fuels.
- Dissolves readily in water.
- Only very high concentrations create lethal conditions or any changing effect on the local marine life.



- **A methanol spill results in limited damage to the environment** except for the release of carbon into the marine ecosystem.
- Methanol in the ocean is common, produced naturally by phytoplankton, and is readily consumed by bacteria microbes, thus entering, and supporting the food chain.



Methanol and safety risks



Toxicity to humans:

- Methanol is toxic and poisonous to the central nervous system
 - may cause blindness, coma, and death if ingested in large quantities
 - to be handled carefully if spilled or leaked in confined spaces or on deck
- Since its vapor is heavier than air, it increases the risk of inhaling the vapor by the onboard crew.
- At high vapor concentrations, methanol can also cause asphyxiation.



Explosion risk:

- Fuel vapours in tanks and enclosed spaces after a spill
- Air in ullage spaces
- Sparks, static discharge, lightning, tank entry, etc.



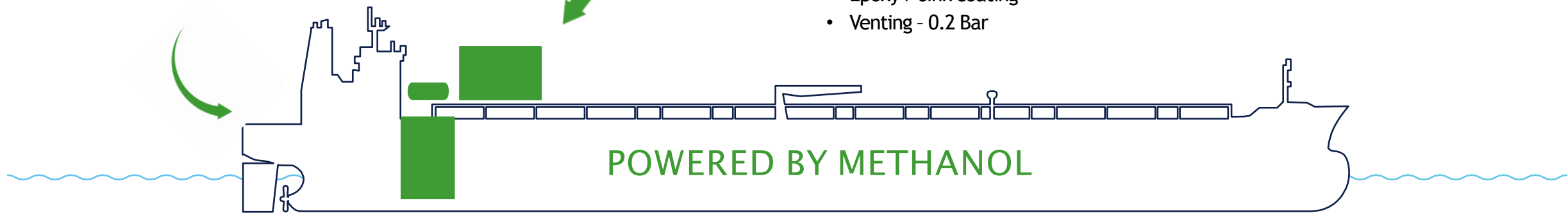
Technical challenges with methanol. Case: methanol as fuel for tankers - some issues...

Fuel gas supply system (FGSS)

- Inerted Service tank & fuel tanks
- Fuel preparation room
- N2 purging of fuel lines
- Full separation of cargo and fuel system

Tank system

- 2-2.5 times the volume as MGO
- Integrated tanks aft of cargo area - or independent tanks on deck
- Cofferdam might be required for the integrated tanks
- Epoxy / sink coating
- Venting - 0.2 Bar



Generators and boilers

- Under development by several companies

Main engine

- ME-LGIM
- Under development by other companies as well.

EEDI

- Projects today comply with Phase 3
- Focus should be on Cargo Capacity

General issues:

- Fuel capacity
- Cofferdam dimensions
- Gas zones
- Volume of existing engine technology
- Operational experience

DNV Rules

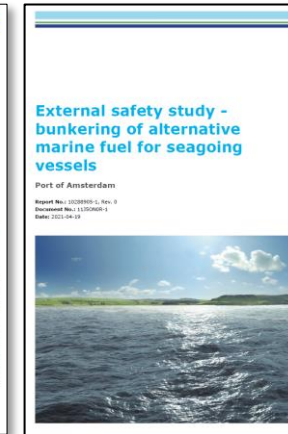
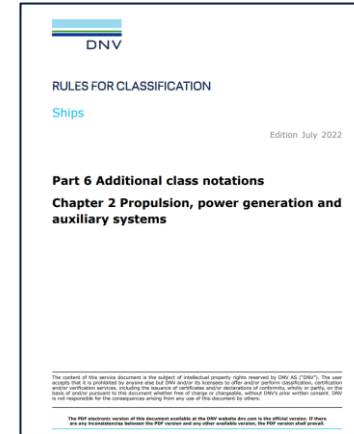
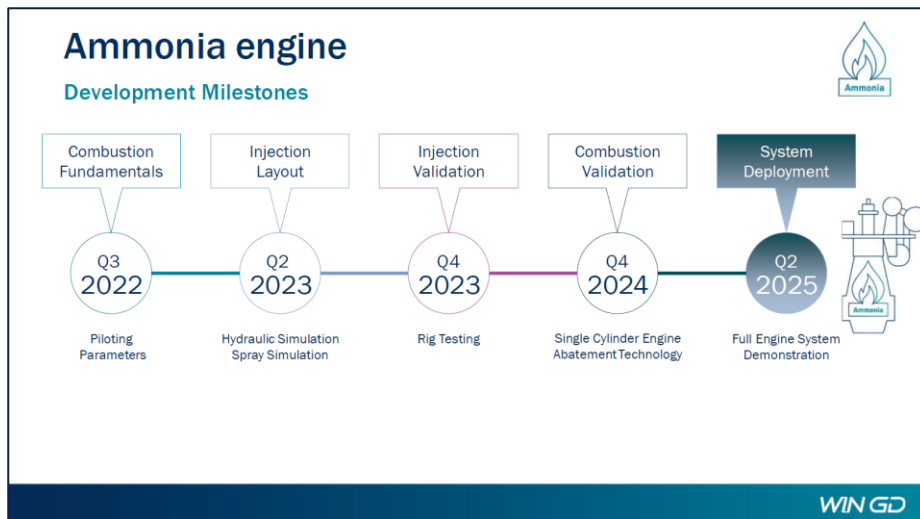
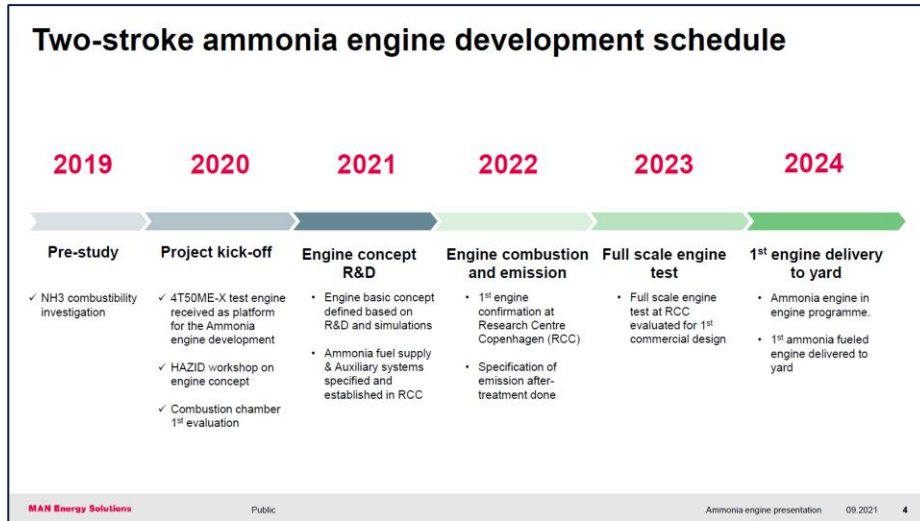
- DNV was first out with our Rules in 2013 for Low Flashpoint Liquid Fuelled Engines
- LFL Ready notations available



IMO

- **IGF Code** – Part A (2.3) - Alternative design approach for ships using low flashpoint fuels
- **MSC.1/Circ.1621** - Interim Guidelines for the Safety of Ships Using Methyl/Ethyl Alcohol as Fuel (December 2020) may be used in lieu of the Alternative Design Approach subject to agreement with the Flag Administration
- Earliest adoption of **LFL Fuels in IGF code** is 2028

Ammonia developments



Home | Projects | Media centre | Contact us

GCMD awards ammonia bunkering safety study to DNV-led consortium

Singapore, 26 January 2022 - The Global Centre for Maritime Decarbonisation (GCMD) is pleased to award its ammonia bunkering safety study to a DNV-led consortium. DNV, a globally established class

2025-2030: Testing of ammonia technology & operations

Ammonia: engine development challenges

- Several **challenges** to overcome
 - Ammonia difficult to ignite and burn \Rightarrow pilot fuel injection required
 - Increased NO_x emissions \Rightarrow SCR aftertreatment system
 - Potential for small amounts of unburned NH_3 : very unpleasant odour
 - Very dangerous for humans
 - Potential for N_2O emissions \Rightarrow very potent GHG
 - Availability of green ammonia?
- Internal Combustion Engines under development:
 - **2-stroke dual-fuel**, MAN-ES
 - **4-stroke dual-fuel**, Wärtsilä
 - WinGD
- Fuel cell development (2 MW)

Commercially available: 2024-2025

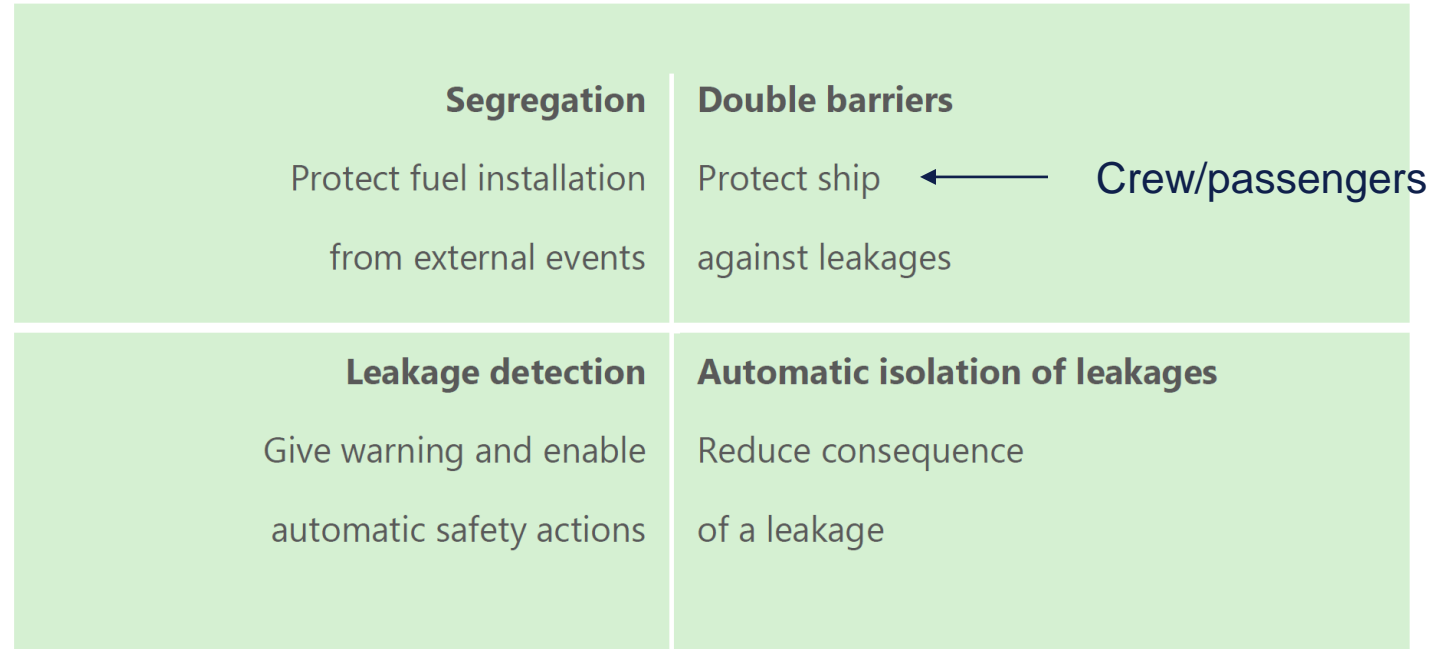


Fuel-flexible
energy
converters



Safety concept for ammonia

- Same basic safety concept as applied for LNG fuel in rules and in the IGF code
- Ammonia: The need for robust double barriers, detection and shut down systems are more due to crew/passenger exposure risks, than the explosion risks
- Experience also taken from IGC Code and Class rules for ammonia used as a refrigerant



Key differences in safety concept for ammonia vs. LNG

affecting the vessel arrangements and systems

1. Normal operation venting of ammonia to atmosphere not allowed in concentrations exceeding 30ppm
 - Catching system, ARMS, required;
 - ↪ “ammonia release mitigation system”
 - E.g. scrubber, gas combustion unit
 - Note: release concentration proposed increased to 300ppm in 2023 rule edition!
2. Leaks or emergency venting is led to dedicated “toxic zones”
 - Ventilation inlets and outlets, openings to enclosed spaces and lifeboats, mustering stations or lifesaving appliances prohibited within toxic zones
 - Toxic zones for ammonia fuel are much larger than hazardous zones for LNG fuel



Source: Spadeadam Research and Testing

Port of Oslo – Two concepts

- **Concept 1**

Bunkering from a pressurized storage tank onshore to a passenger ship

- Storage tank: 1000 m³, filled either by:
 - pressurized ammonia from 2 trucks every day or
 - refrigerated ammonia by bunker ship every 4th day
- Worst case scenario: rupture leak on the inlet connection line to the storage tank with pressurized ammonia (continuous leak at high rate)

- **Concept 2**

Bunkering from a bunker ship to a passenger ship

- Refrigerated ammonia transferred from the bunker ship using hose
- Flow rate: 200m³/hour

Port of Oslo – key results

LSIR Contours

Concept 1

Concept 2



1000 m



250 m

Red: 10^{-6} /year

Yellow: 10^{-7} /year = Maximum distance

AFI – Alternative Fuels Insight

www.dnv.com/afi

Map

Explore the development of bunkering infrastructure for alternative fuels. You can also see where ships using alternative fuels and technologies are already operating.

Explore

Statistics

Get detailed insights to the uptake of alternative fuels and technologies on ships. Filter on ship types, region, technology and more to create your own graphs.

Conventional

84.14%

Alternative

15.86%

- LNG 12.07%
- Methanol 2.04%
- LPG 1.40%
- Hydrogen 0.35%

Explore

Fuel Prices

Explore prices for Ammonia, Methanol, LNG, biofuels, and more in your preferred unit, and benchmark against conventional fuels.

Explore

11,800 AFI subscribers

Partners:



Search

Infrastructure 516

Map Mode

Markers Clusters

Infrastructure status

- All
- In operation
- Decided
- Under discussion

Infrastructure type

- All
- Large scale infrastructure
- Bunkering infrastructure
- Bunker Vessel
- Truck Loading
- Bunker Vessel Loading
- Local Storage
- Tank To Ship
- Other Bunkering

Vessels 377

Map Features

Fuels & technologies: **LNG** | LPG | Methanol | Ammonia | Hydrogen | Shore Power

- Overview
- Batteries
- Bunker Vessels
- Hydrogen
- LNG**
- LPG
- Methanol
- Scrubbers

LNG

LNG Premium report

Operational status: In Operation On Order

Project type: Offshore supply vessel Offshore supply ship Car/Passenger ferry

Engine designer: Wärtsilä MAN MTU Caterpillar

GT:

DWT:

TEU:

About Statistic View in Map

LNG fuelled ships by ship type

Crude oil tanker	47	10
Oil/Chemical tanker	13	14
Container ship	12	181
Offshore supply ship	24	1
Truck	2	1
Rohrta	1	1
Ball carrier	1	1
General cargo ship	1	1
Other activities	1	1
Crane barge	1	1
Gas tanker	1	1
Other offshore vessels	1	1

LNG fuelled ships by gas engine designer

MAN	251
Unknown	219
Wärtsilä	155
MAN	15
MTU	15
Nippon Power Syst.	1
Caterpillar	1
Mitsubishi	1
MAN	1
Pure Gas	1
Wärtsilä	1
ABC	1
CE	1

LNG fuelled ships by engine concept

Pure Gas	185
Unknown	121
Gas+Diesel	18
DF Turbine	1

LNG fuelled ships by class society

DNV	214
Unknown	131
BV	121
ABS	104
LR	97

LNG fuelled ships by engine type

2 stroke	198
4 stroke	274
Unknown	213
Turbine	1

LNG fuelled ships by region

Asia 7%
Europe 20%
Other 73%

Growth of LNG fuelled fleet

Tonnes of LNG consumed by LNG fuelled ships

List of LNG fuelled vessels

Delivery year	Project type	Ship name	IMO	Detailed ship type	Ship type	LNG tank capacity	Ship owner	Area of operation	Gas engine concept	Engine designer	Engine model	Engine type	Class
2003	Newbuild	Shel Fisher	929420	Offshore supply vessel	Offshore supply ship	200	Simon Møller	Norway	DF	Wärtsilä	6L20P	4 stroke	DNV
2003	Newbuild	Wiking Energy	929842	Offshore supply vessel	Offshore supply ship	200	Spank Shipping	Norway	DF	Wärtsilä	6L20P	4 stroke	DNV
2006	Newbuild	Bergsøfjord	934293	Car/Passenger ferry	Car/Passenger ferry	200	Fjord	Norway	Pure Gas	Mitsubishi	KV50-1204	4 stroke	DNV
2007	Newbuild	Gjøstern 1	934708	Car/Passenger ferry	Car/Passenger ferry	200	Fjord	Norway	Pure Gas	Mitsubishi	KV50-1204	4 stroke	DNV
2007	Newbuild	Mælstrand	934730	Car/Passenger ferry	Car/Passenger ferry	200	Fjord	Norway	Pure Gas	Mitsubishi	KV50-1204	4 stroke	DNV
2007	Newbuild	Rausjøfjord	934772	Car/Passenger ferry	Car/Passenger ferry	200	Fjord	Norway	Pure Gas	Mitsubishi	KV50-1204	4 stroke	DNV
2007	Newbuild	Stavangerfjord	934746	Car/Passenger ferry	Car/Passenger ferry	200	Fjord	Norway	Pure Gas	Mitsubishi	KV50-1204	4 stroke	DNV

Thank you for your attention!





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