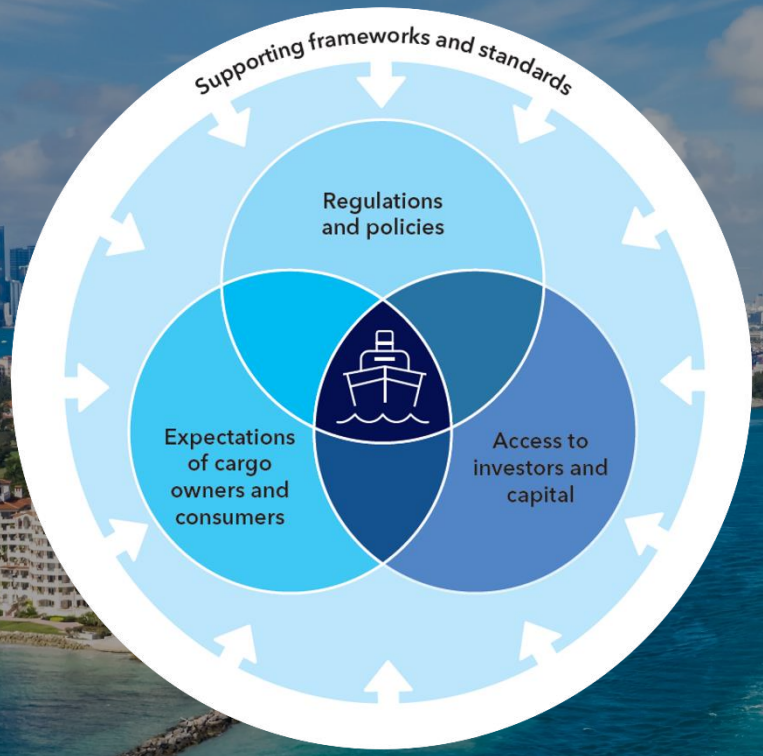
Swiss Re Institute

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

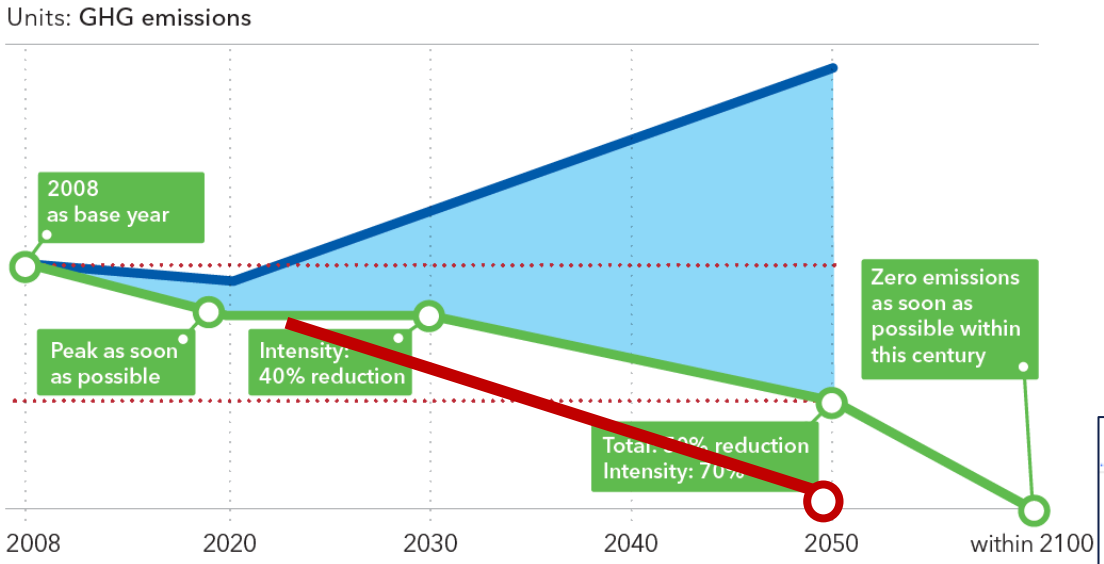
EEDI, EEXI, CII, SEEMP,…

Strategy review in 2023 and higher ambitions to be expected

Inclusion in EU Emissions Trading System (ETS)

FuelEU Maritime

Regulations becoming stricter



Total: Refers to the absolute amount of GHG emissions from international shipping.
Intensity: Carbon dioxide (CO_2) emitted per tonne-mile.

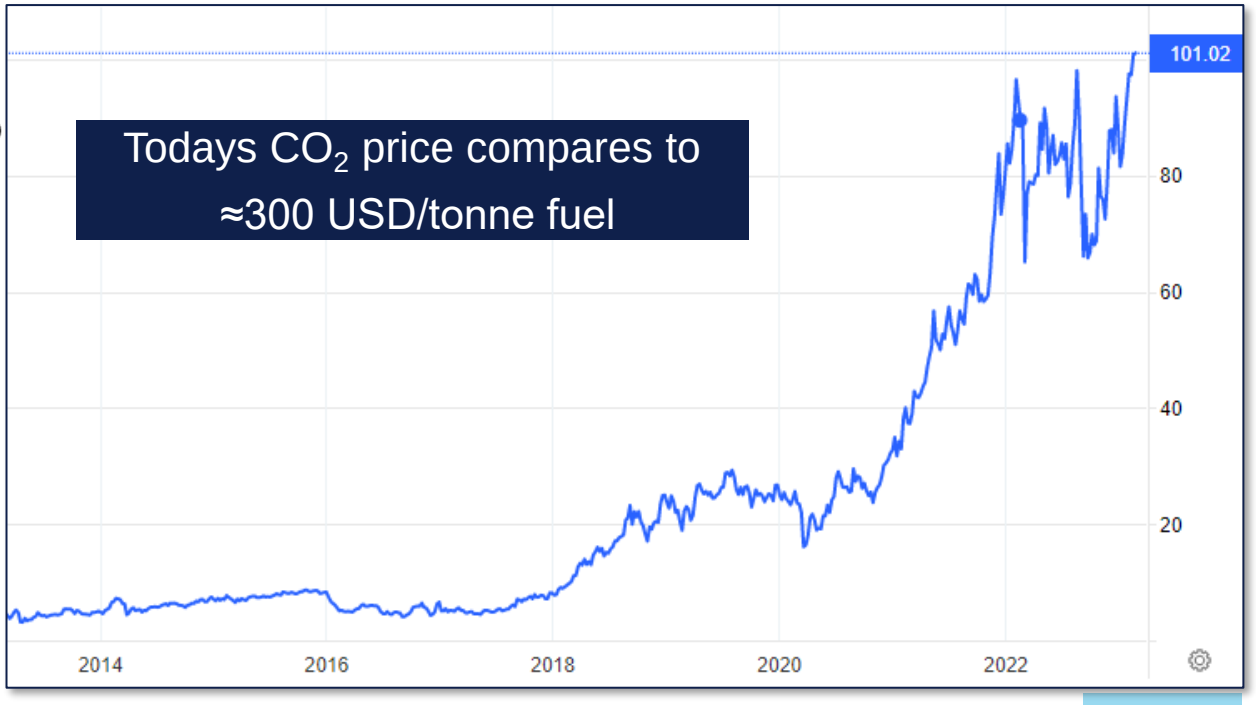
Revision in 2023:
100% decarbonisation by 2050? Net-zero?

Emission pathway in line with IMO's GHG strategy

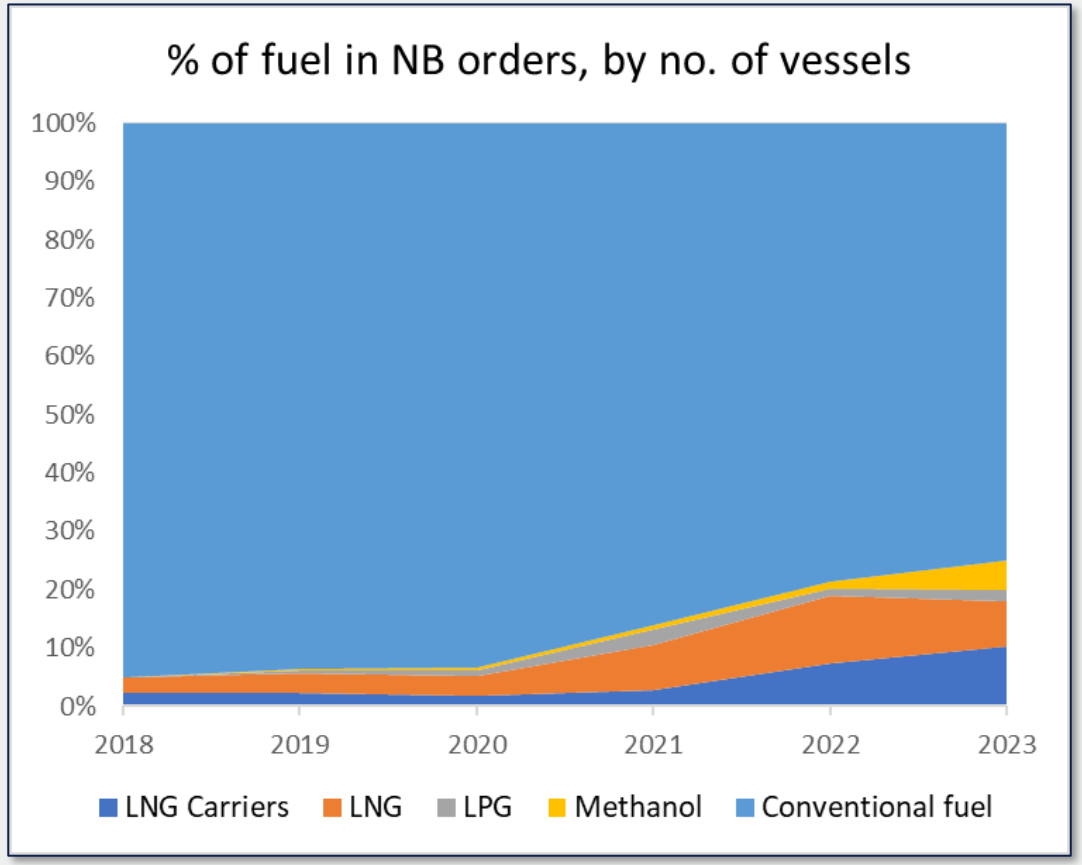
Business-as-usual emissions[a]

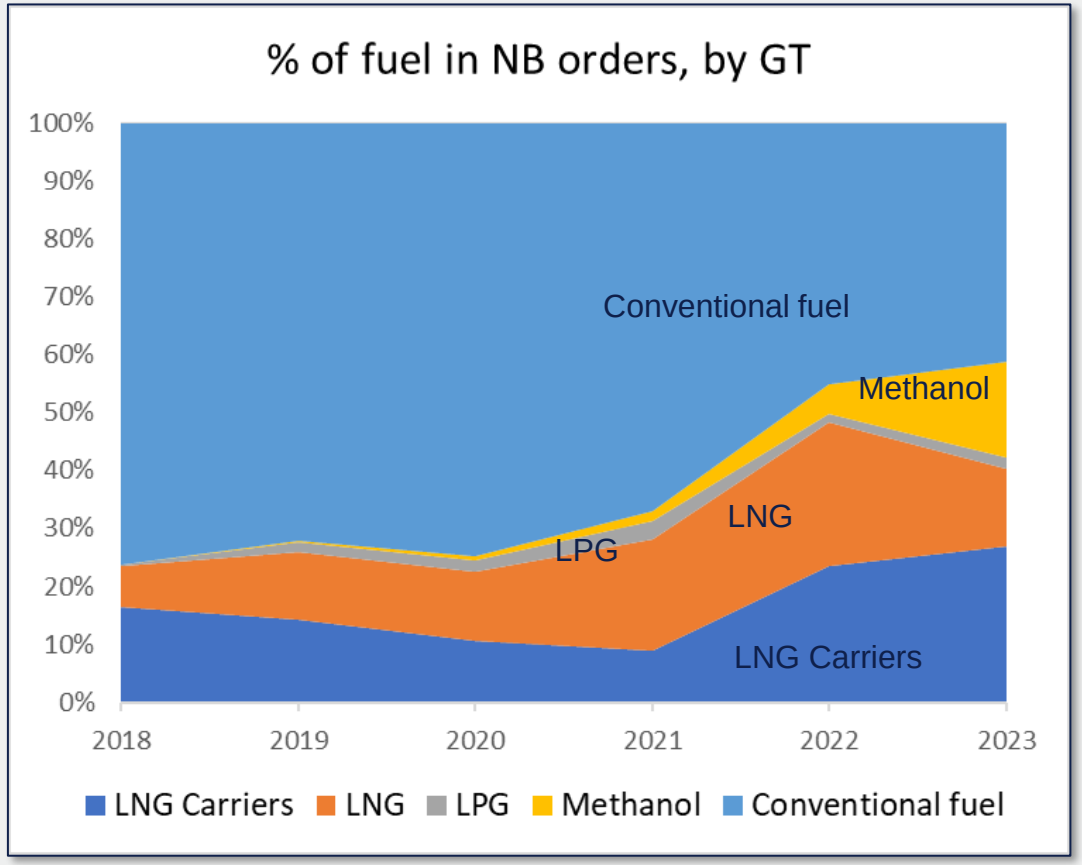
Emission gap

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 11ºC
- 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.

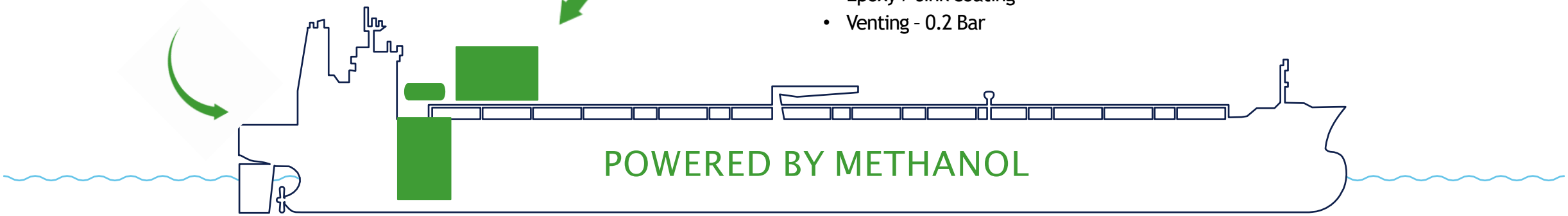
Technical challenges with methanol. Case: methanol as fuel for tankers - some issues…

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

Source: JDP partners

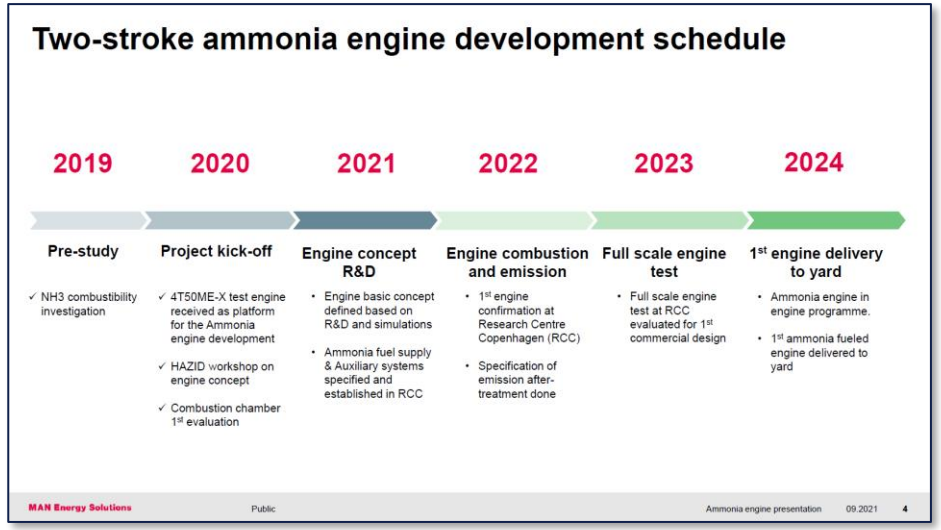
DNV Rules

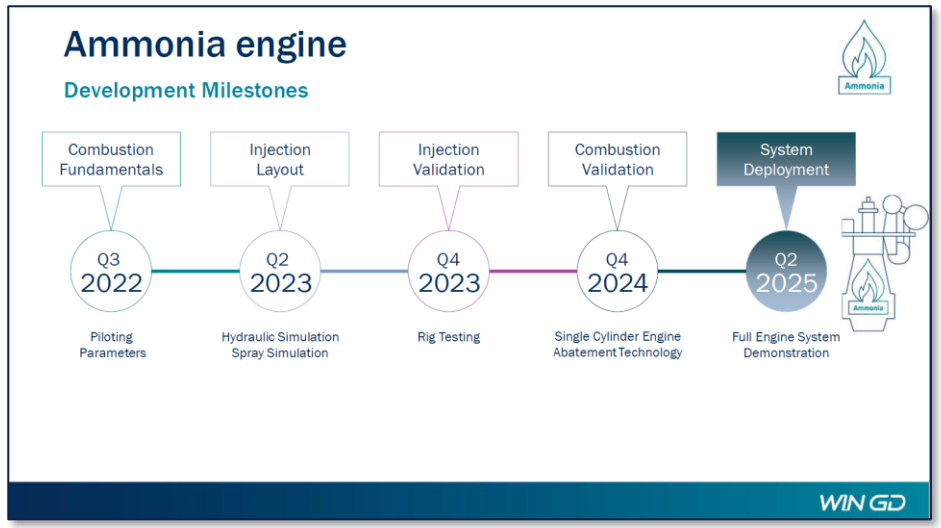
- DNV was first out with our Rules in 2013 for Low Flashpoint Liquid Fuelled Engines
- LFL Ready notations available

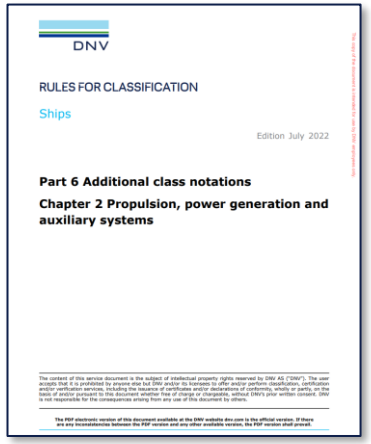
IMO

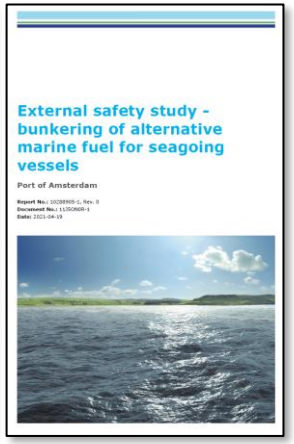
- **IGF Code** – Part A (2.3) - Alternative design approach for ships using low flashpoint fuels
- **MSC.1/Circ.1621** - Interim Guidelines for the Safety of Ships Using Methyl/Ethyl Alcohol as Fuel (December 2020) may be used in lieu of the Alternative Design Approach subject to agreement with the Flag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

Ammonia developments









2025-2030: Testing of ammonia technology & operations

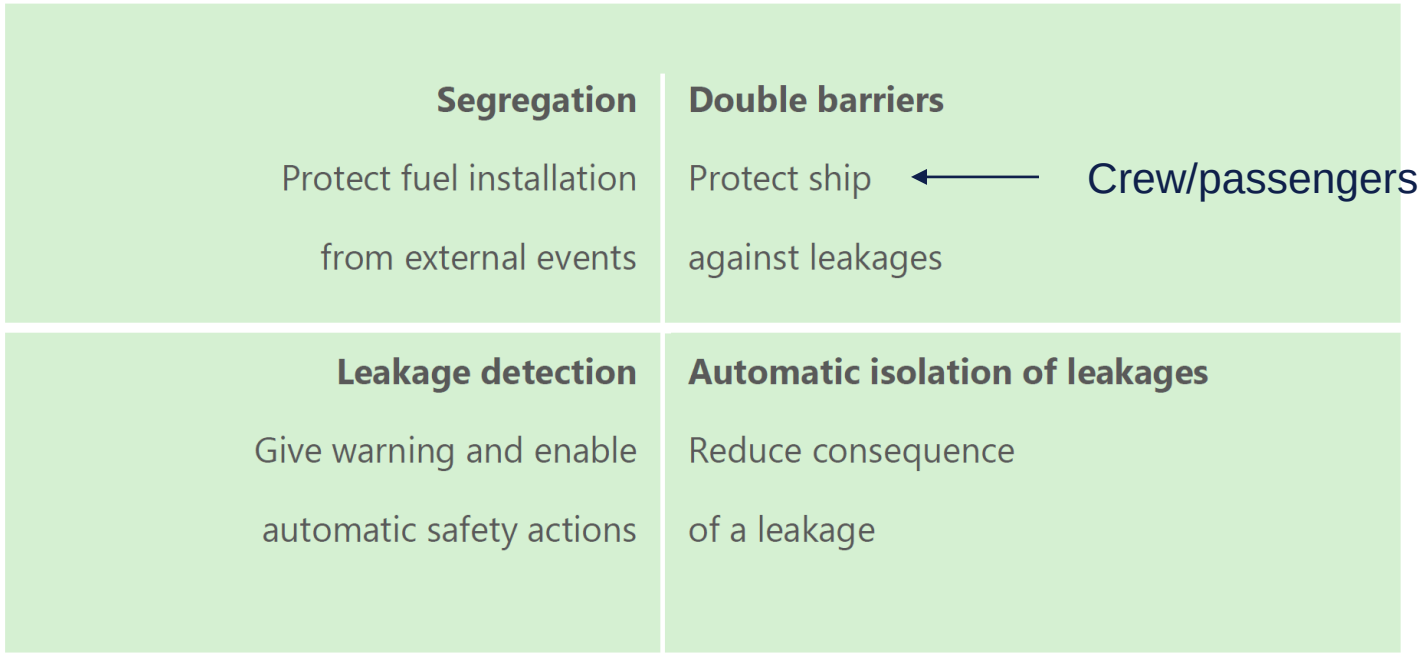
Ammonia: engine development challenges

- Several **challenges** to overcome
  - Ammonia difficult to ignite and burn ⇒ pilot fuel injection required
  - Increased NO_x emissions ⇒ SCR aftertreatment system
  - Potential for small amounts of unburned NH_3: very unpleasant odour
    - Very dangerous for humans
  - Potential for N_2O emissions ⇒ 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

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

effecting 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 m^3, 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: 200m^3/hour

Port of Oslo – key results

LSIR Contours

Concept 1

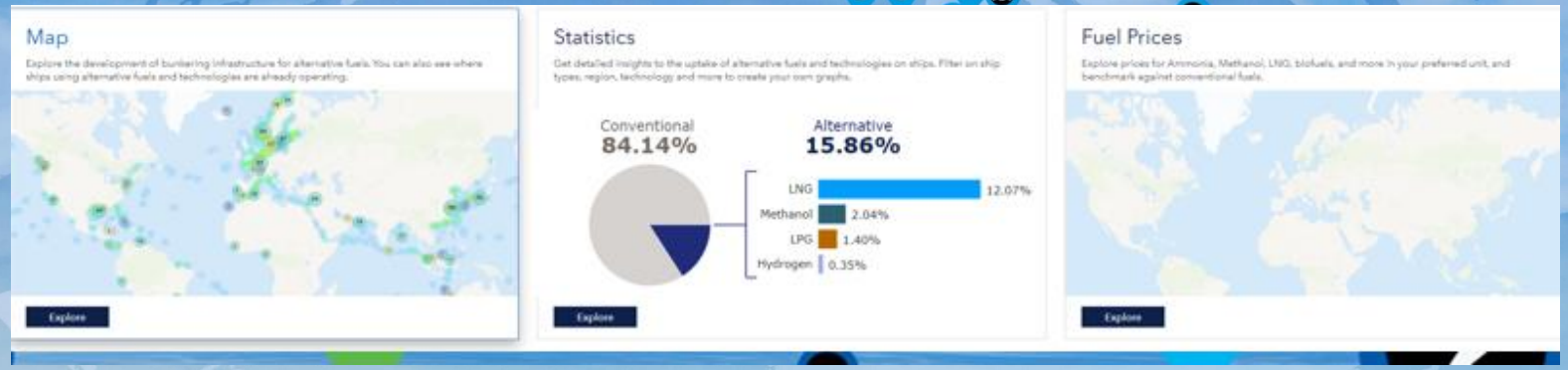
Concept 2

Red: 10^{-6}/year

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

AFI – Alternative Fuels Insight

www.dnv.com/afi



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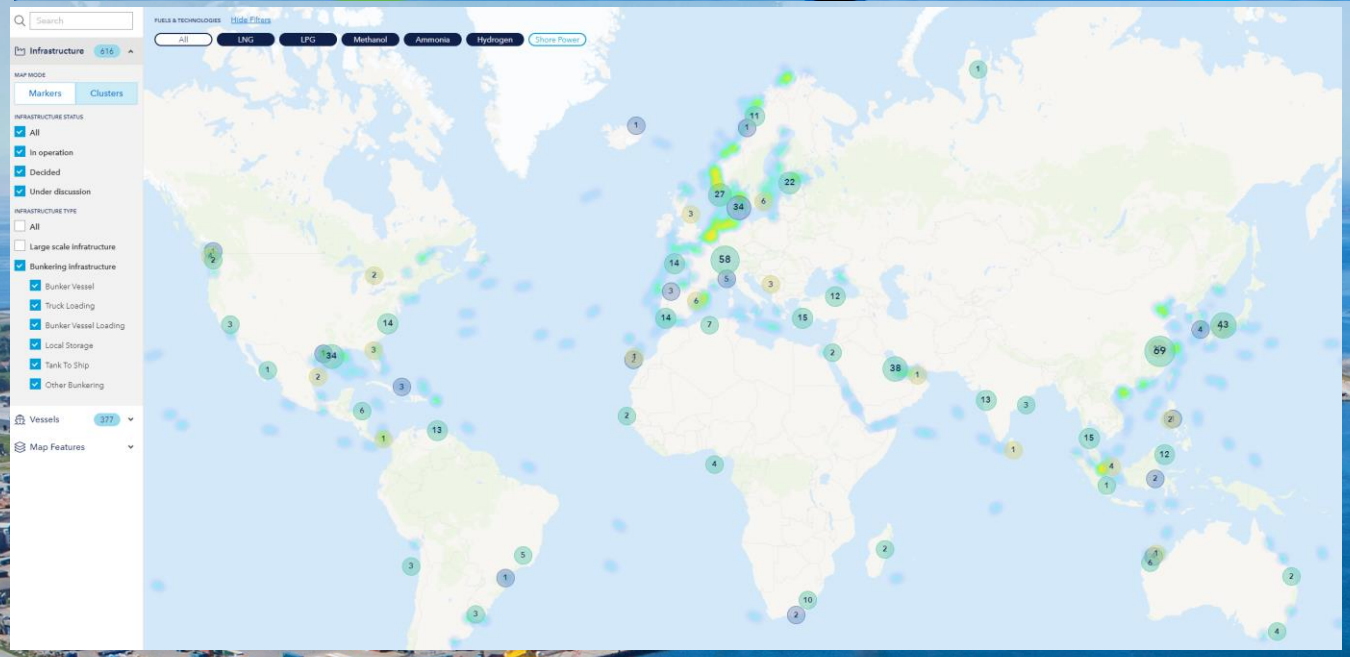

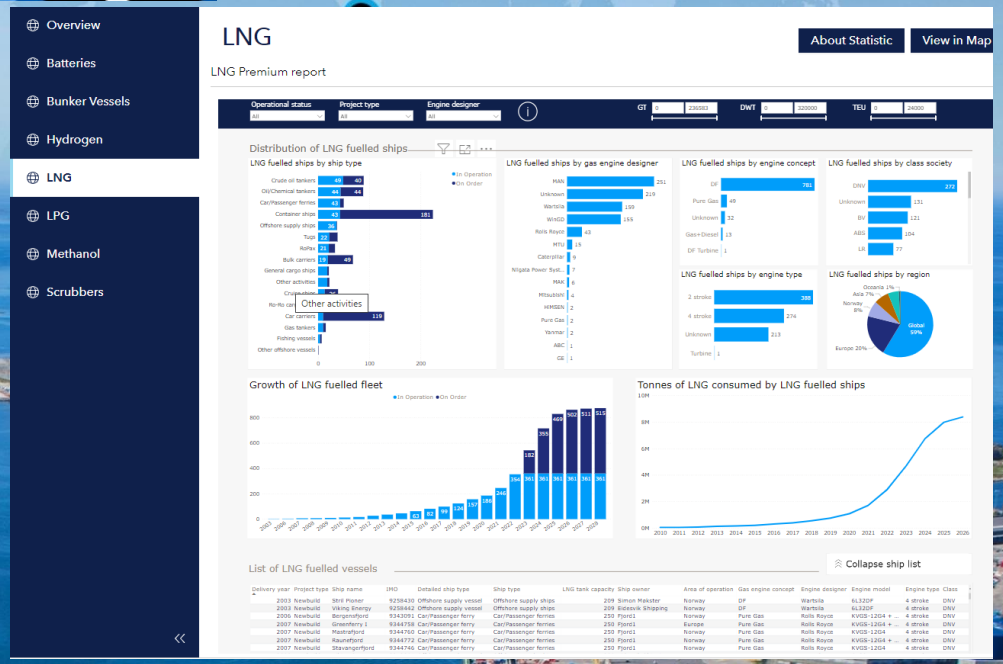

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