Alternative Fuels – An Industry Overview

Loss Prevention Webinar – 21 May 2024

Alternative Fuels – An Industry Overview

Speakers

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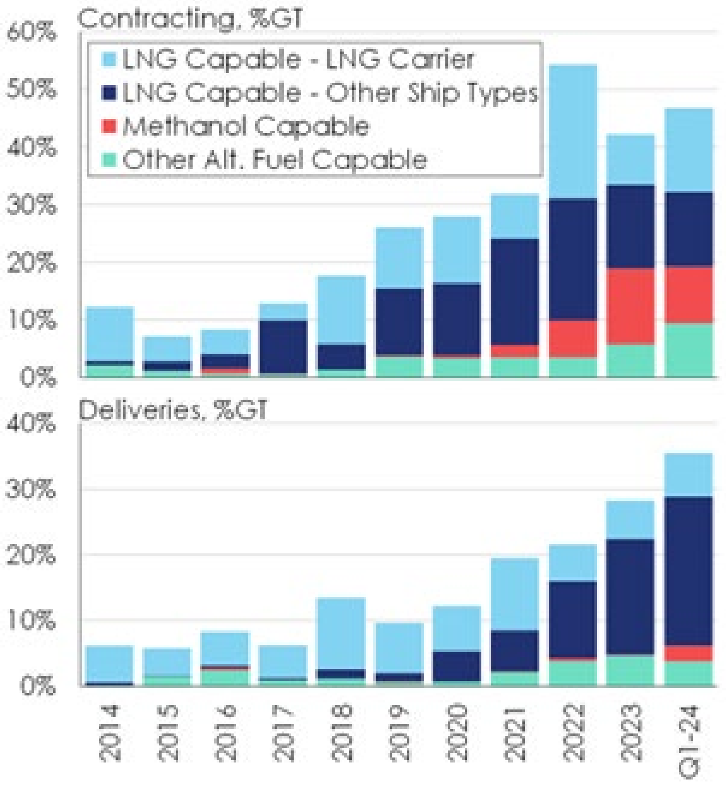
Why Alternative Fuels?

- Meeting requirements and expectations of the future:
  - UN's Paris Agreement on Climate Change to limit global mean temperature increase to well below 2°C of pre-industrial levels, while making efforts to limit warming to 1.5°C
  - IMO's revised strategy on reduction of GHG emissions, reach net-zero GHG emissions by or around 2050
  - A commitment to ensure an uptake of alternative zero and near-zero GHG fuels by 2030, as well as indicative check-points for 2030 and 2040.
- Strong emphasis by many stakeholders to reach net-zero by 2050.

Alternative Fuels

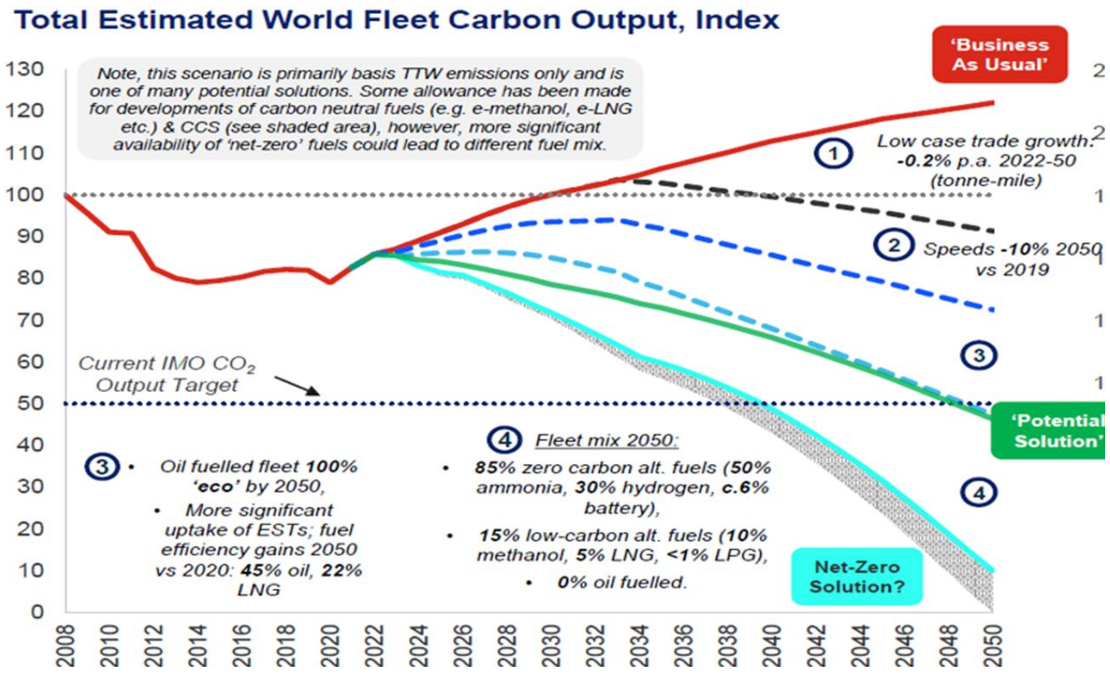
What's popular?



Source : Clarksons Research

Alternative Fuels

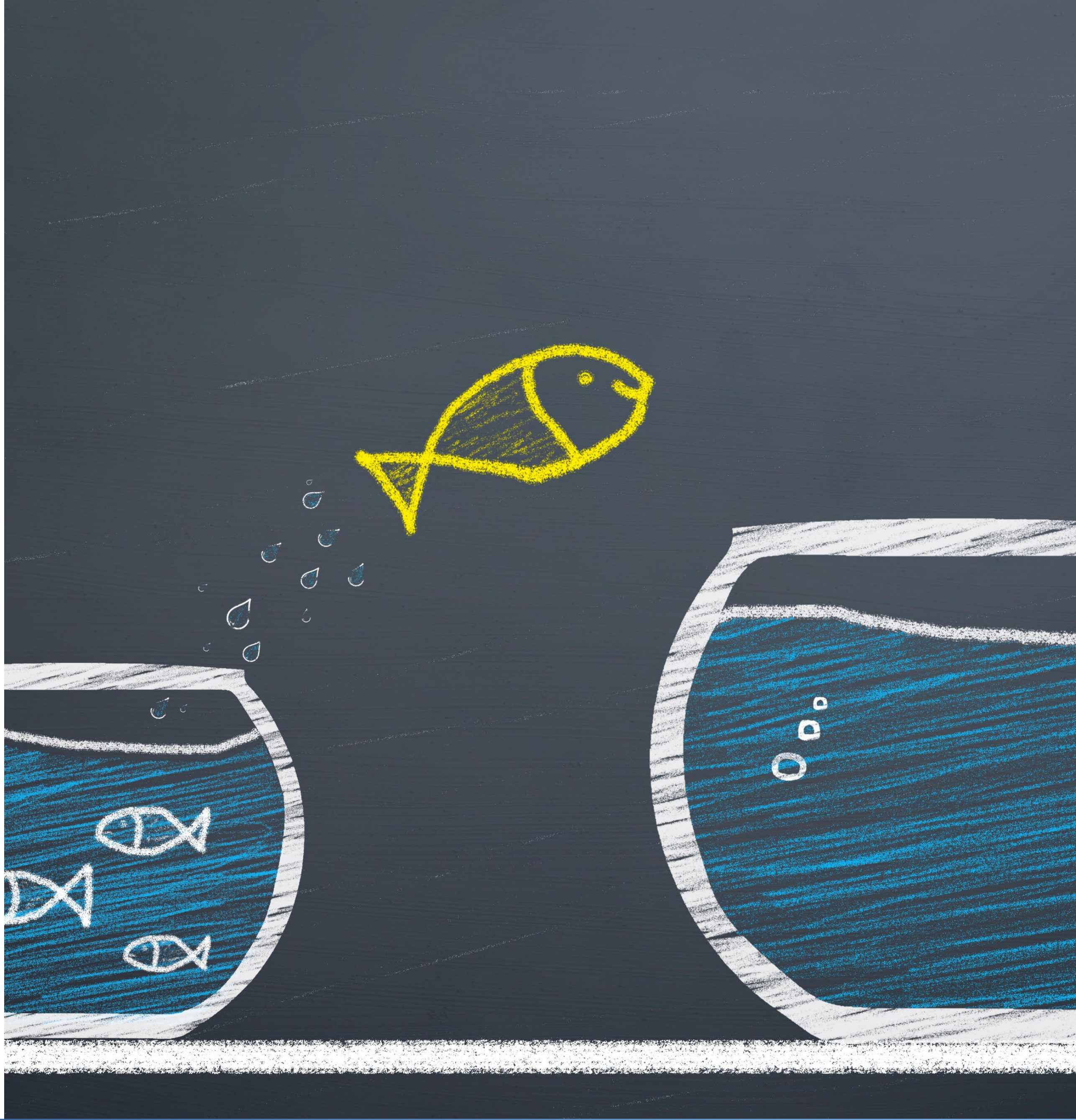
- Number of various alternative fuels
- Currently most prominent:
  - LNG
  - Methanol
  - Ammonia
  - Biofuels
- However, can these cover the demand for alternative fuels?
- What about nuclear propulsion?



Source: Clarksons Research. Based on 'Potential Net Zero' scenarios.

Transitional Risks

- Risks arising from the transition to a low-carbon economy
- Result in big shifts in asset value or higher cost of doing business
- Likely to be mitigated over time
- Becomes clearer as decarbonisation technology develops

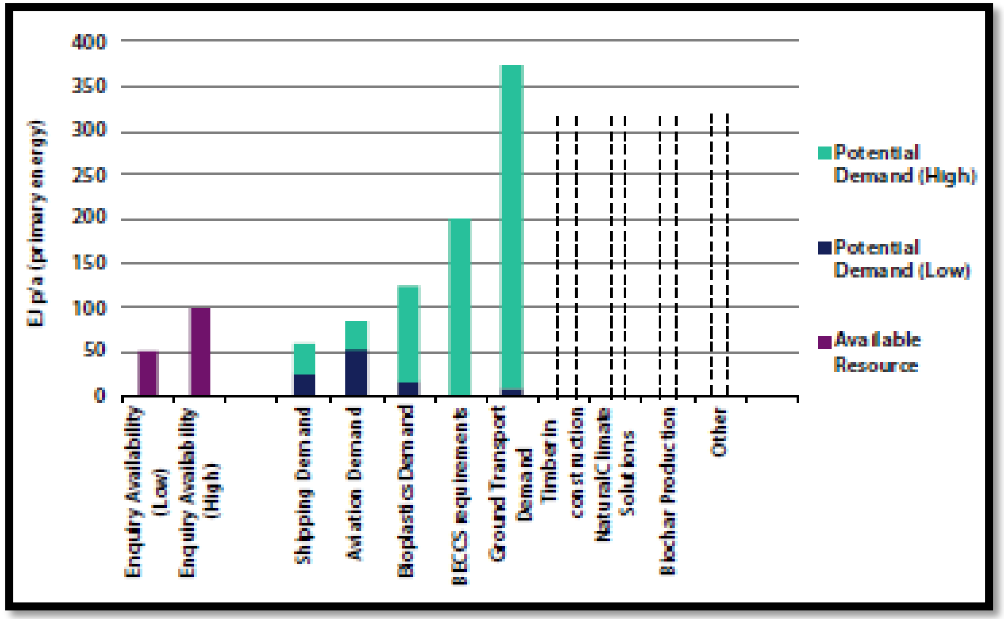


Alternative Fuels

Any Transitional Risks?

- Availability/Infrastructure – Operational disruptions
- Quality – Lack of standards
- Fuel management – Crew training
- Safety risks – Lower flash point, toxic (ammonia)
- Fuel pricing – Higher cost of doing business
- New legislation – Expensive investments

Projected availability of sustainable biofuel by mid-century:



Source: Forum for the future

Alternative Fuels Operational Challenges
LNG, Methanol, Ammonia

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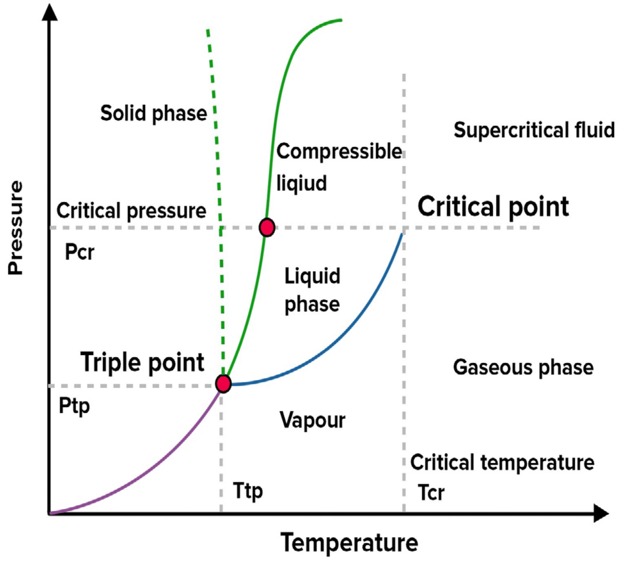
May 2024

www.waves-group.co.uk

The three Alternative fuels I am speaking about today all have one thing in common and apologies for the physics, but they all have either a boiling point or a flash point below 60 degrees C at atmospheric conditions.



Fuel	Critical point (bar) / (°C)	Flash point[2] (°C)	Boiling point (°C)
LNG	46 / -82.6	-188	-163
Ammonia	113 / 132.41	132[1]	-33
Methanol	82 / 240	11	64.7

LNG

LNG

LNG fuel has been carried in the Marine industry for many years, it has an excellent safety record and there is a burgeoning infrastructure. It is a hydrocarbon and requires stringent storage conditions .

Energy density (MJ/L)
21.2

Tax Implication ($/tonne)
632.5

Availability
7

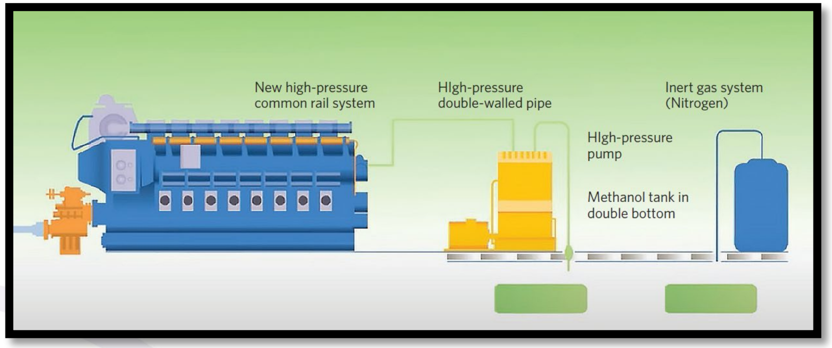
CO^2 Emissions/tonne
2.76

Tech Readiness
10

- 579 Vessel in Operation.
- 523 LNG fuelled Vessels on order.
- Global warming potential of methane is 28 times CO_2.
- High Capex cost.

What is the Impact on the Vessel

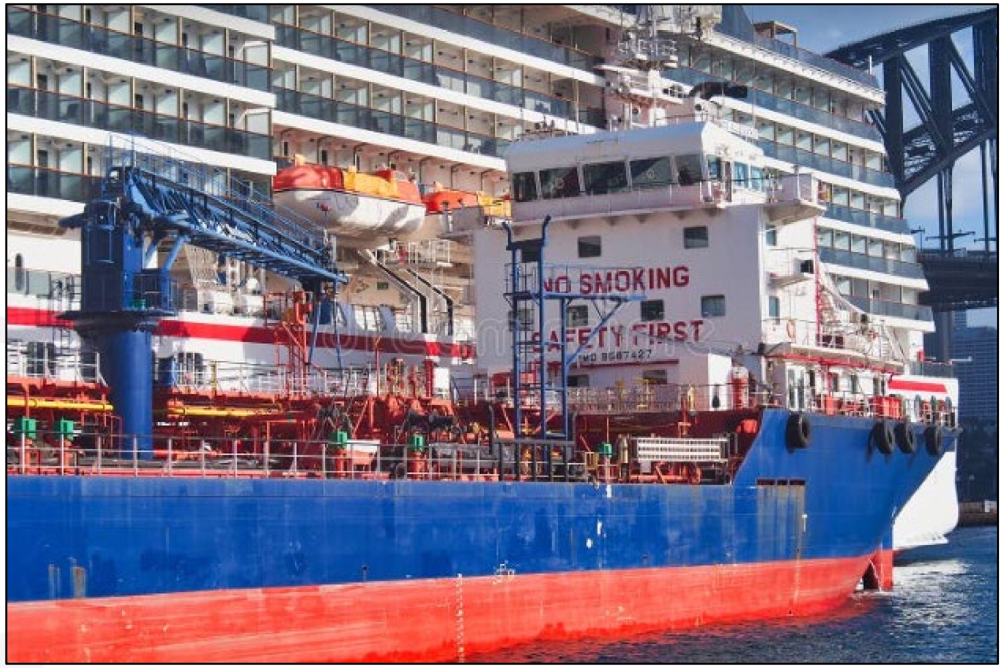
More Storage Spaces required for the new fuels.

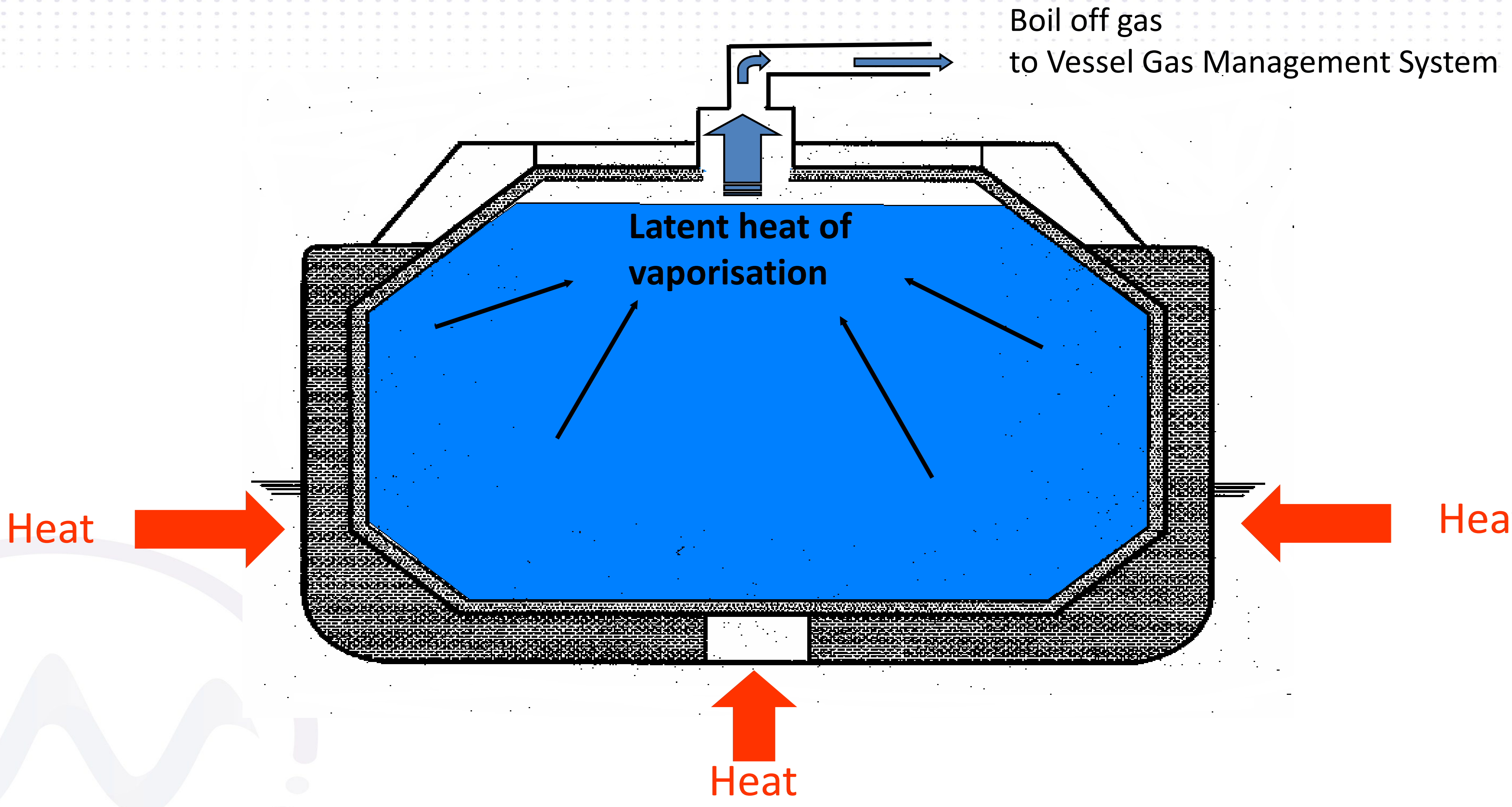


More equipment needed to process and handle the Cryogenic fuels.

What is the Impact on the Staff Attitude

- Fire Risk
- Cryogenic Liquid
- Increased maintenance
- Training requirement




Boil off gas
to Vessel Gas Management System
Latent heat of
vaporisation
Heat
Heat
Heat

Methanol

Methanol

Methanol is a hydrocarbon which is seen as a 'drop in fuel' It is easily stored and predominantly safe to operate and work with. The infrastructure is growing for this fuel but it is not readily available

Energy density (MJ/L) **15.9**

Tax Implication ($/tonne) 319

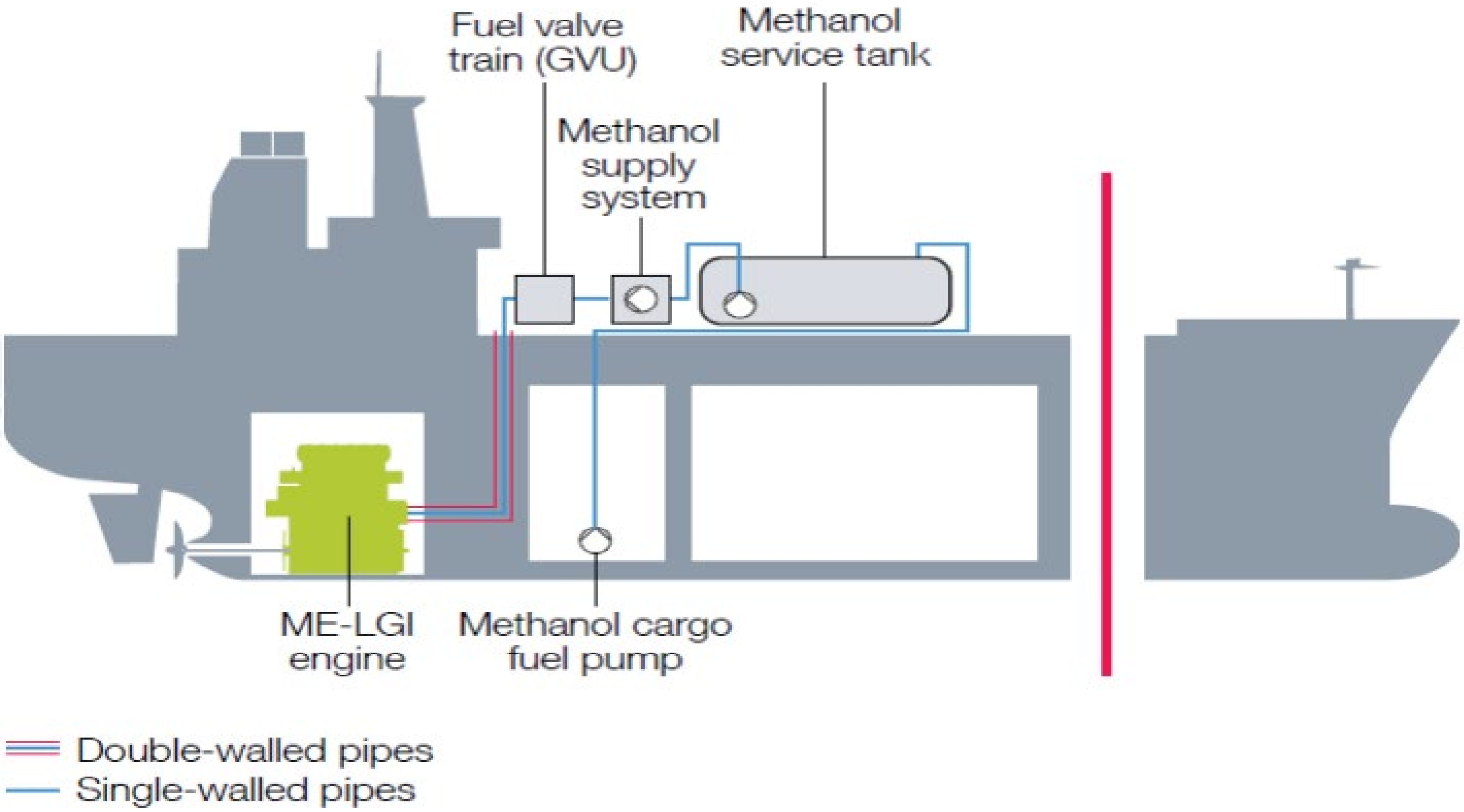
Availability **5**

CO^2 Emissions/tonne **1.39**

Tech Readiness **10**

- >29 Vessel in Operation.
- >228 Vessel on order.
- 122 ports with methanol storage so the need for green corridors may be required.
- High Capex cost.
- Nox Emissions.

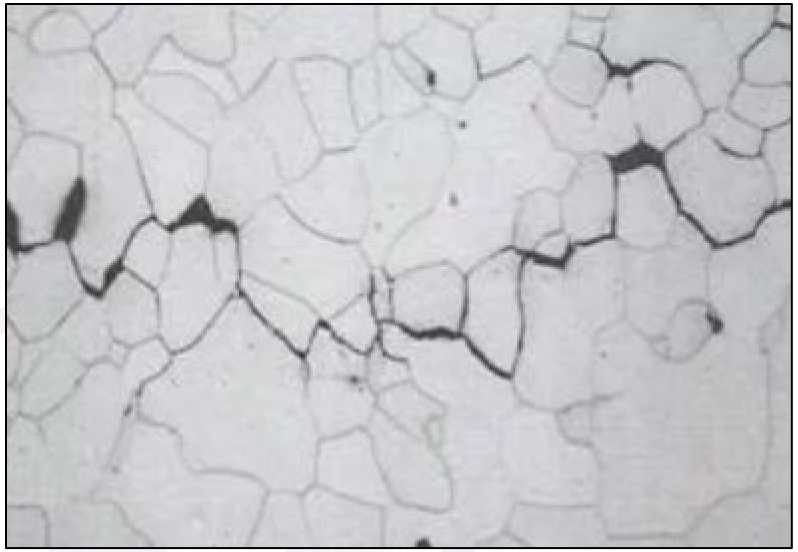
Tech On the Ship

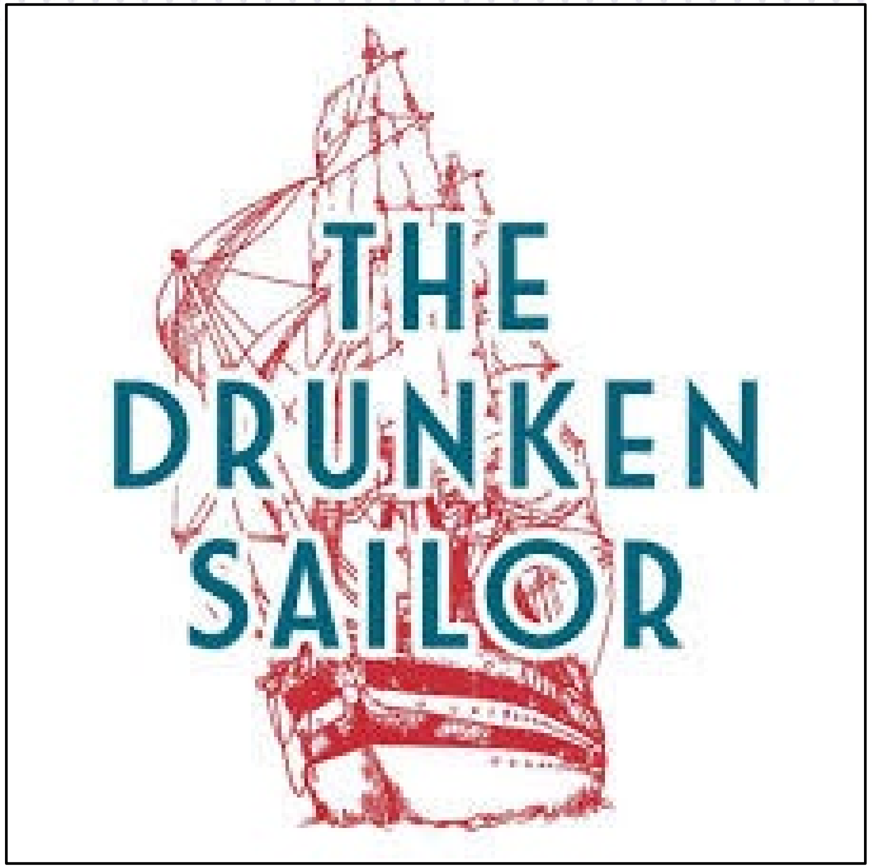


WAVES GROUP

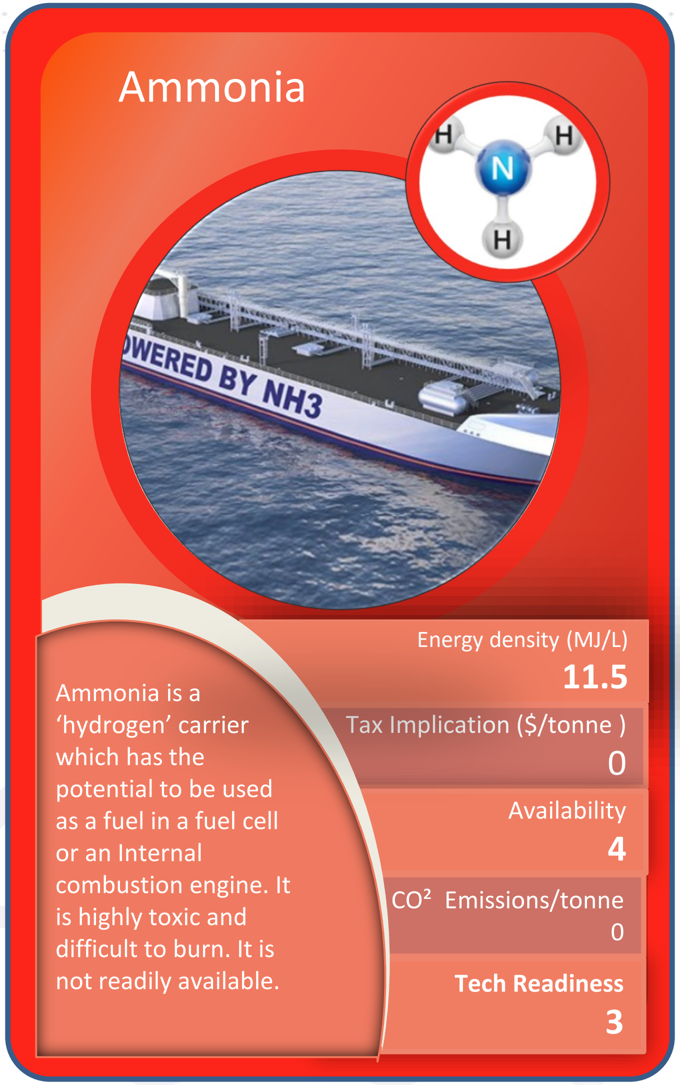
What is the Impact on the Staff

- Fire Risk
- Corrosive to Carbon steel
- Toxic
- Training requirement





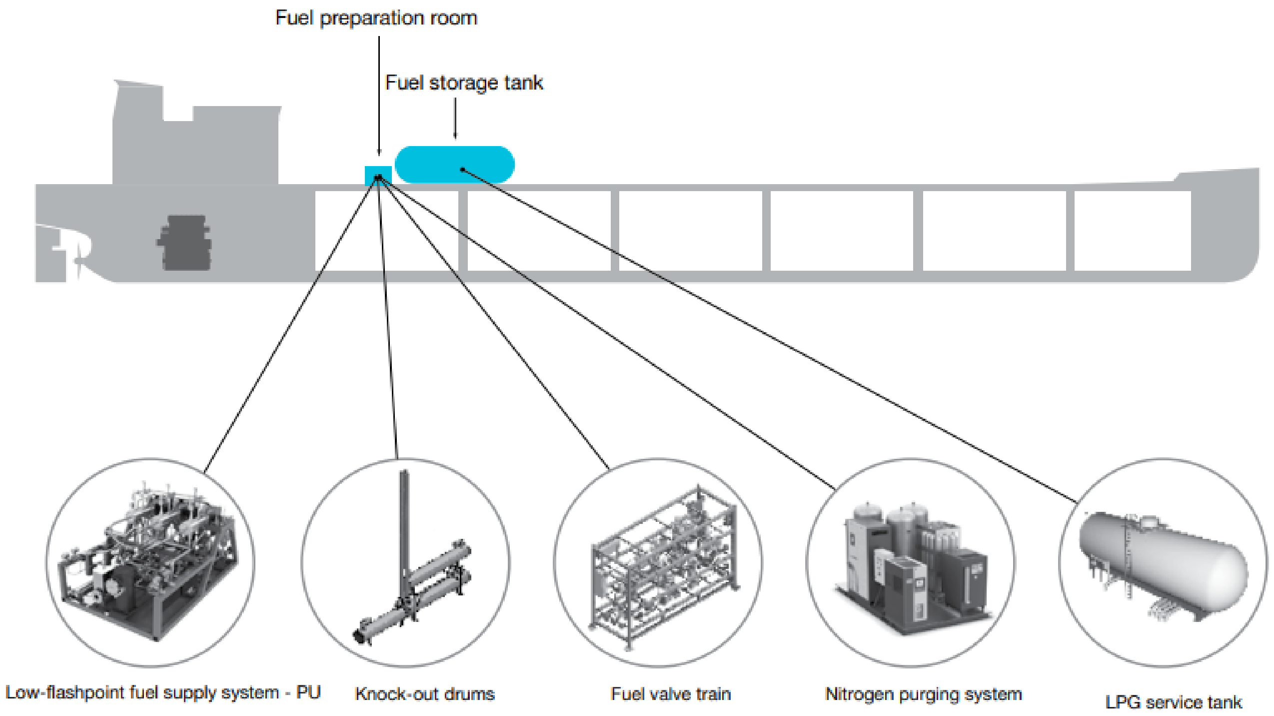
Ammonia



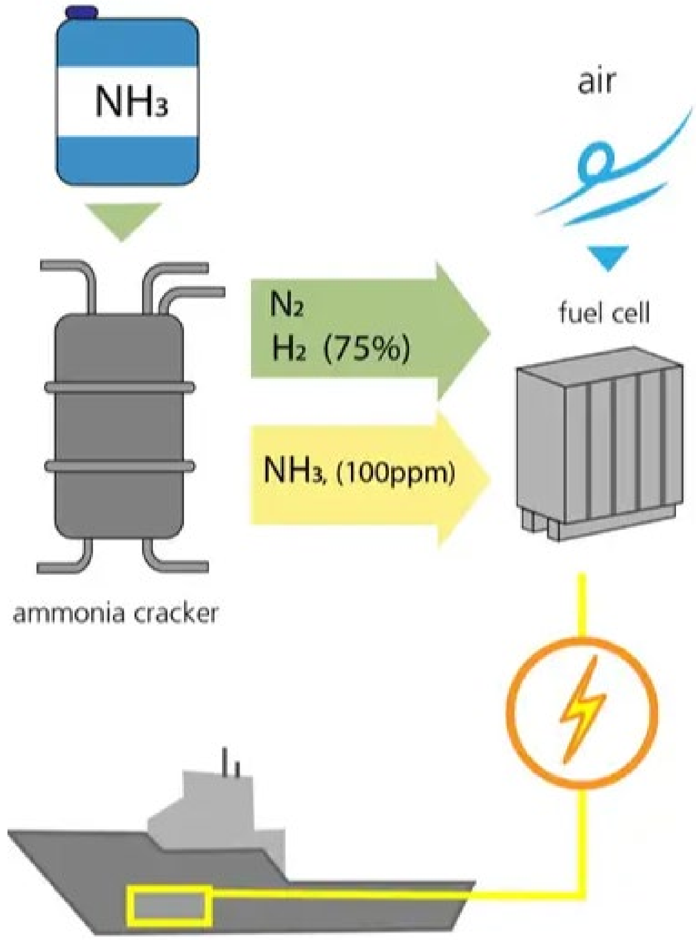
- 2 Vessels on Order to be delivered 2026.
- High Cost.
- Nox Emissions. Nox is 275 times worse than CO2
- Ammonia ready vessels being produced.

Tech On the Ship

I. C. E

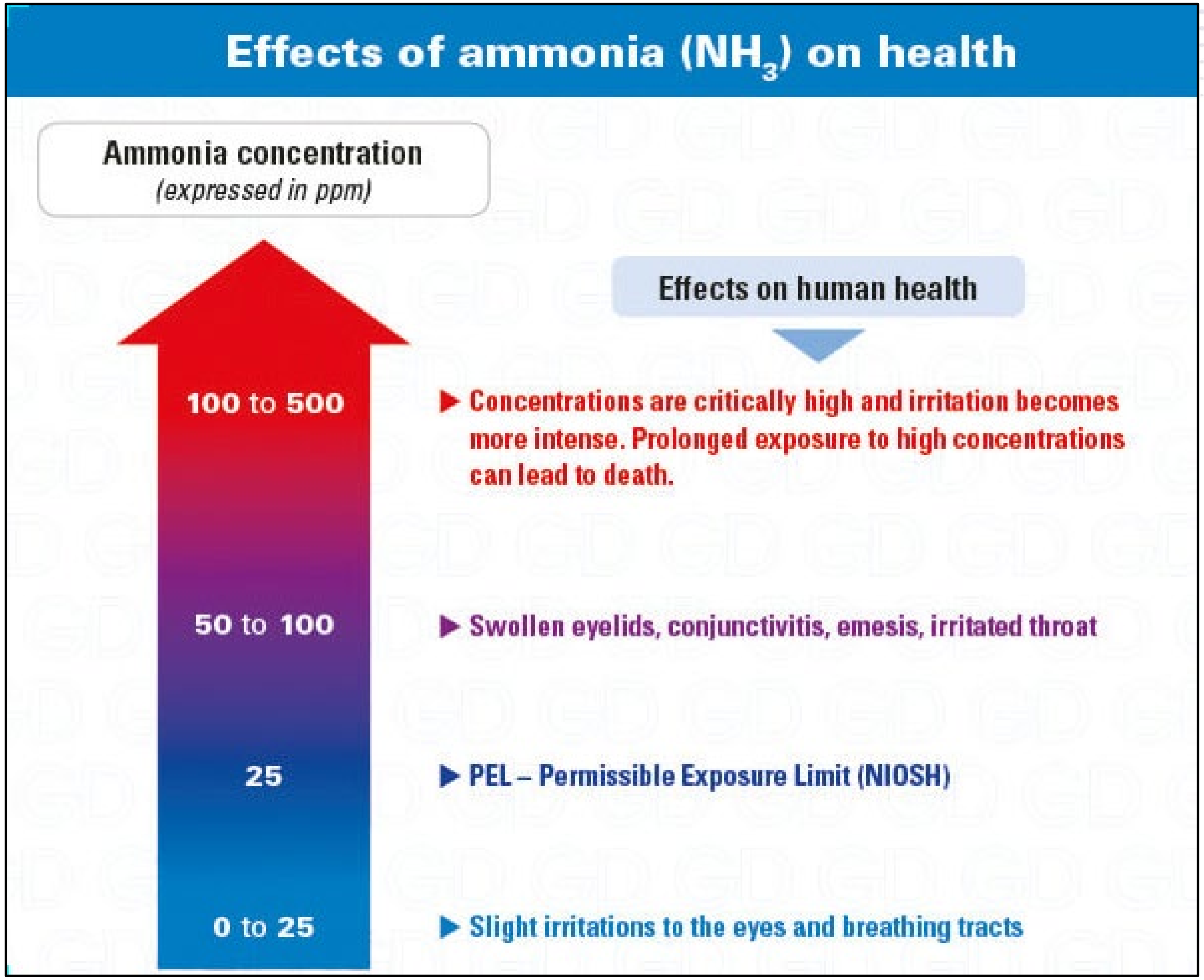


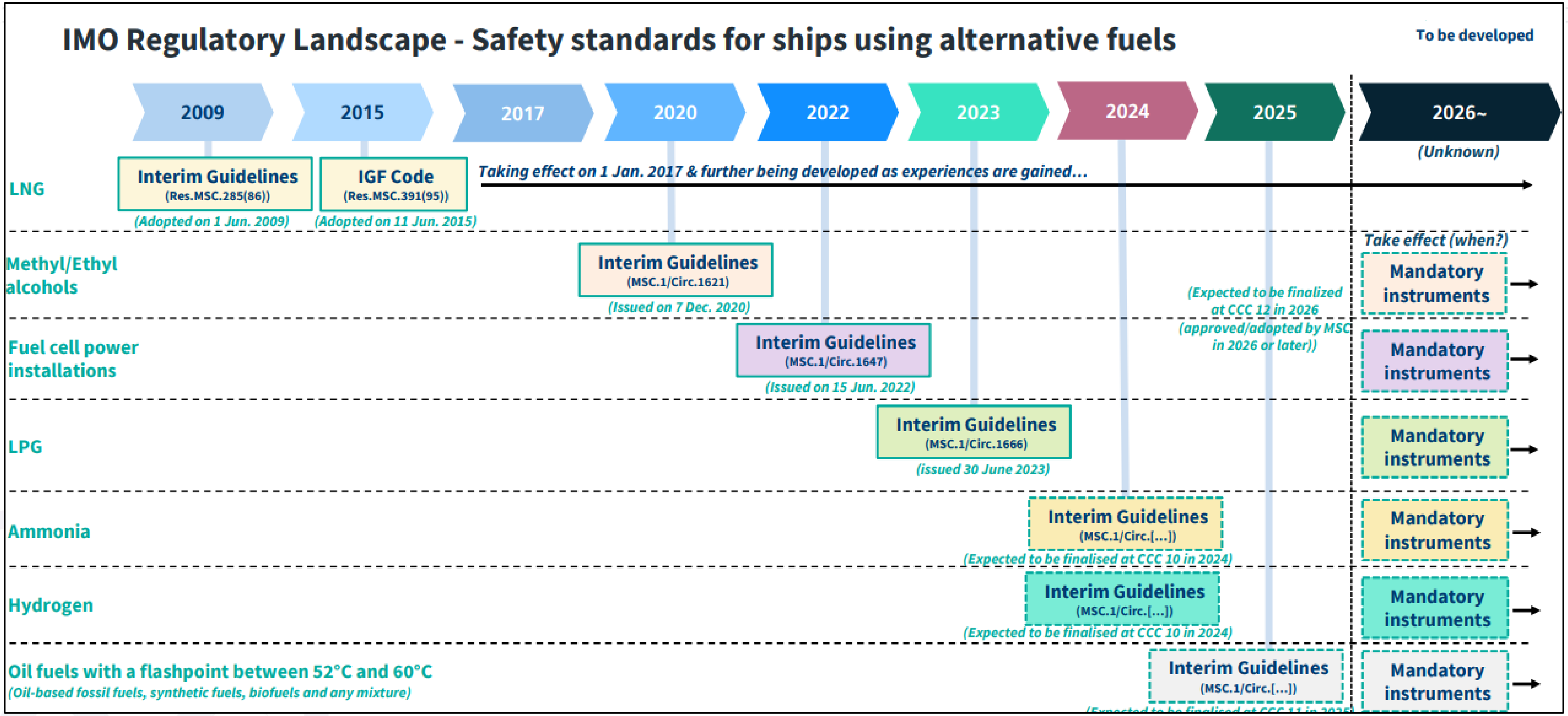
Fuel Cell



What is the challenge on the Staff

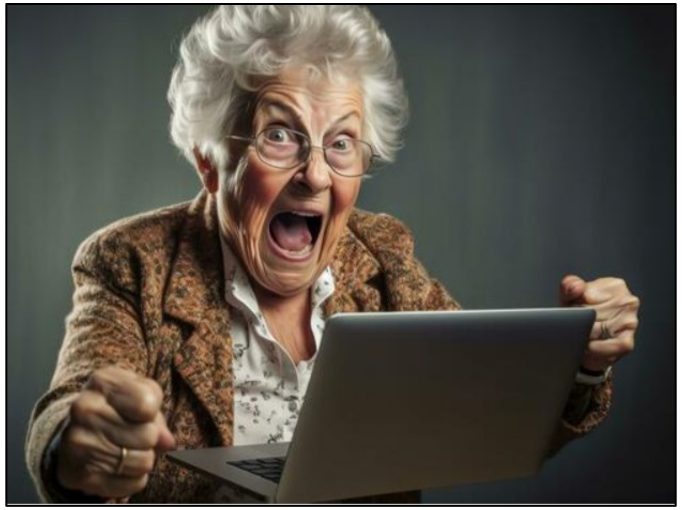
- Toxic
- Low temperature Storage
- Training requirement.



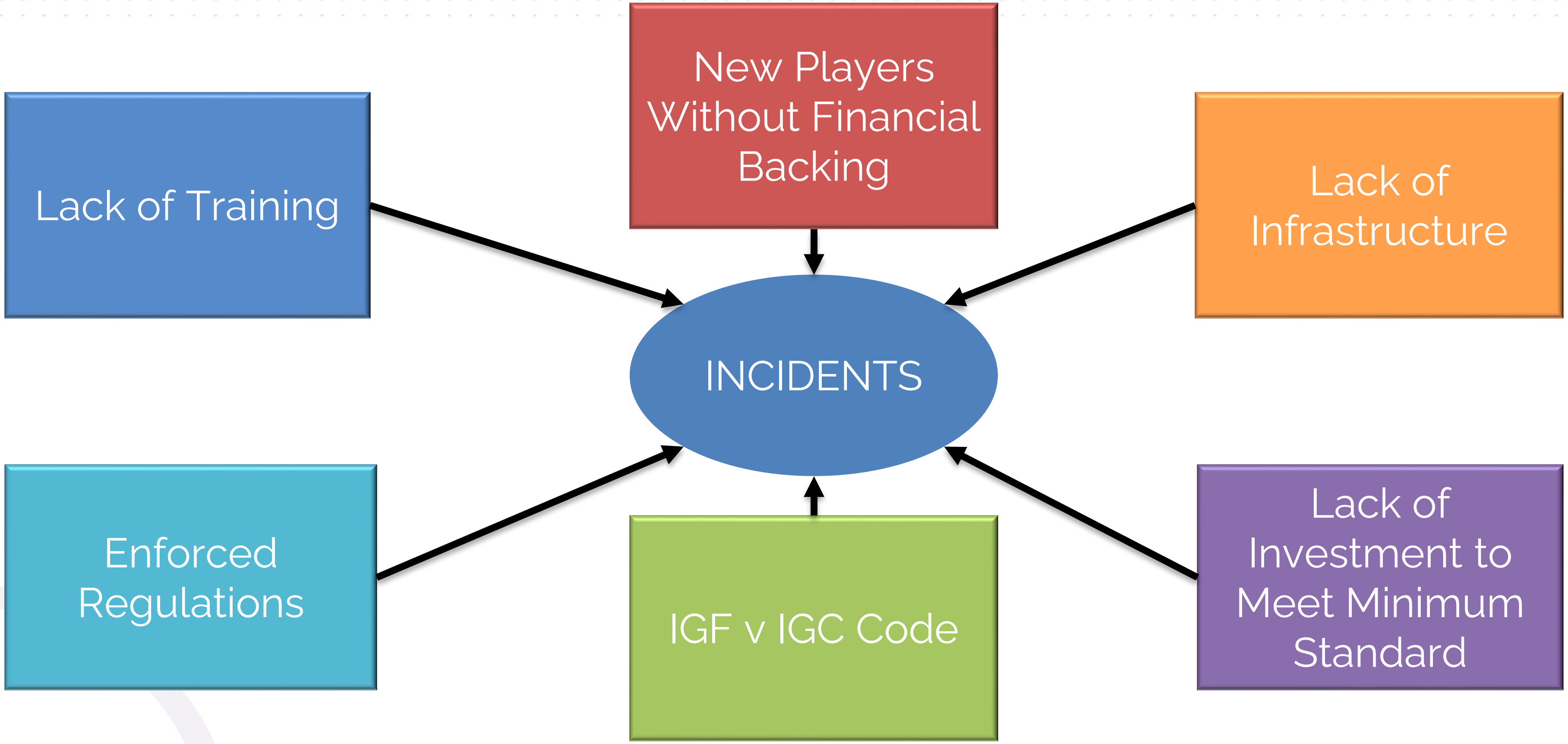

IMO Regulatory Landscape - Safety standards for ships using alternative fuels
To be developed
2009
2015
2017
2020
2022
2023
2024
2025
2026~
(Unknown)
LNG
Interim Guidelines
(Res.MSC.285(86))
(Adopted on 1 Jun. 2009)
IGF Code
(Res.MSC.391(95))
(Adopted on 11 Jun. 2015)
Taking effect on 1 Jan. 2017 & further being developed as experiences are gained…
Methyl/Ethyl alcohols
Interim Guidelines
(MSC.1/Circ.1621)
(Issued on 7 Dec. 2020)
Take effect (when?)
Mandatory instruments
(Expected to be finalized at CCC 12 in 2026 (approved/adopted by MSC in 2026 or later))
Fuel cell power installations
Interim Guidelines
(MSC.1/Circ.1647)
(Issued on 15 Jun. 2022)
Mandatory instruments
LPG
Interim Guidelines
(MSC.1/Circ.1666)
(issued 30 June 2023)
Mandatory instruments
Ammonia
Interim Guidelines
(MSC.1/Circ.[…])
(Expected to be finalised at CCC 10 in 2024)
Mandatory instruments
Hydrogen
Interim Guidelines
(MSC.1/Circ.[…])
(Expected to be finalised at CCC 10 in 2024)
Mandatory instruments
Oil fuels with a flashpoint between 52°C and 60°C
(Oil-based fossil fuels, synthetic fuels, biofuels and any mixture)
Interim Guidelines
(MSC.1/Circ.[…])
Mandatory instruments

What will be needed

- Different fuels require different training
- More training
- Different training



Future issues arising



Thank You!!

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Moving Forward

Leading the way for sustainable solutions

VPS

Alternative Fuels – focus on Biofuels

Britannia P&I Club

Singapore 21st May 2024

Capt. Rahul Choudhuri
President, Strategic Partnerships

VPS | Global reach & local speech

Accelerated by legislative changes, disruptive technologies and new fuels, the maritime industry is **moving forward towards a low-carbon future.**

Industry actors are expected to commit to making their operations less carbon-intensive and more sustainable.

VPS helps its customers to **identify pathways towards more sustainable operations.** We do this **by providing insights, digital tools and advice along the entire marine fuels and emissions value chain.**

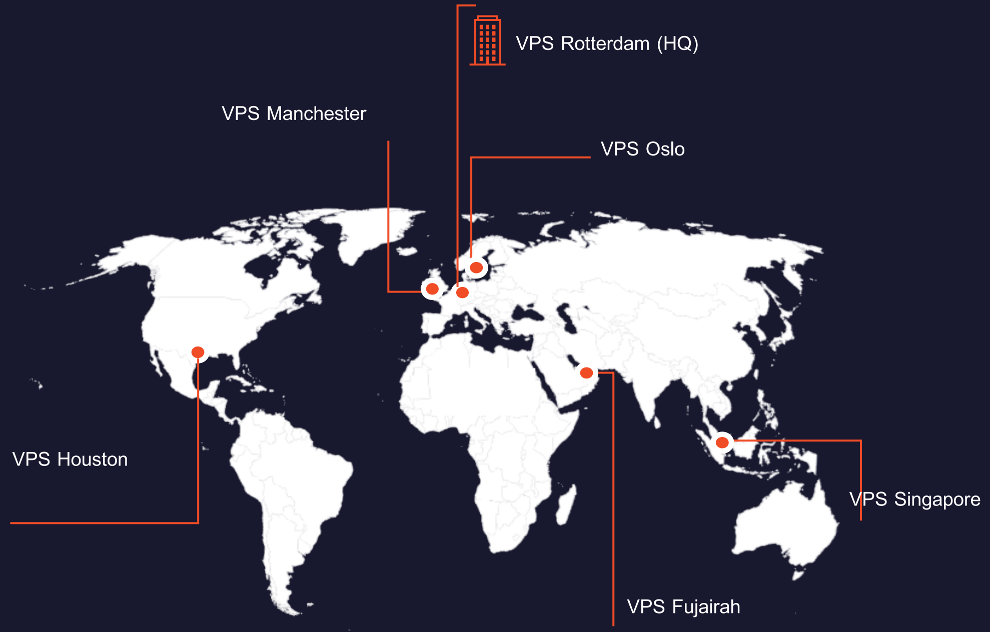
VPS is uniquely positioned to assist with this transition, thanks to

1. Over 40 years of experience testing marine fuels
2. Expertise in optimising marine operations
3. The most robust & reliable emission monitoring tech in the market
4. Integrated software portfolio powered by market-leading fuel quality database
5. Our holistic view on decarbonising the marine fuels and emissions value chain

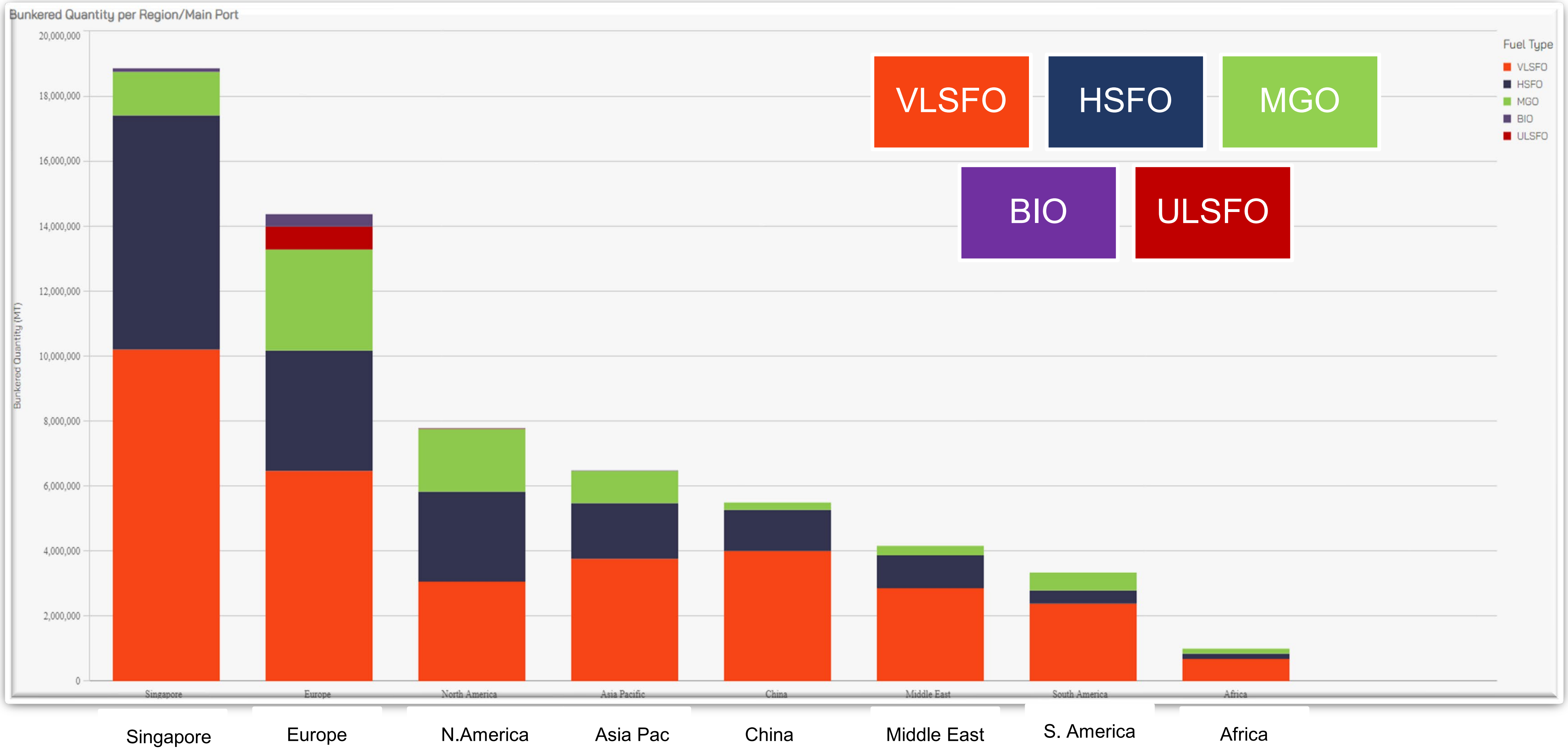
By choosing VPS, shipowners and operators can accurately monitor, report and reduce their fleet's emissions, while **improving operational performance and mitigating risk**.

270+ staff of which **30** dedicated to decarbonisation

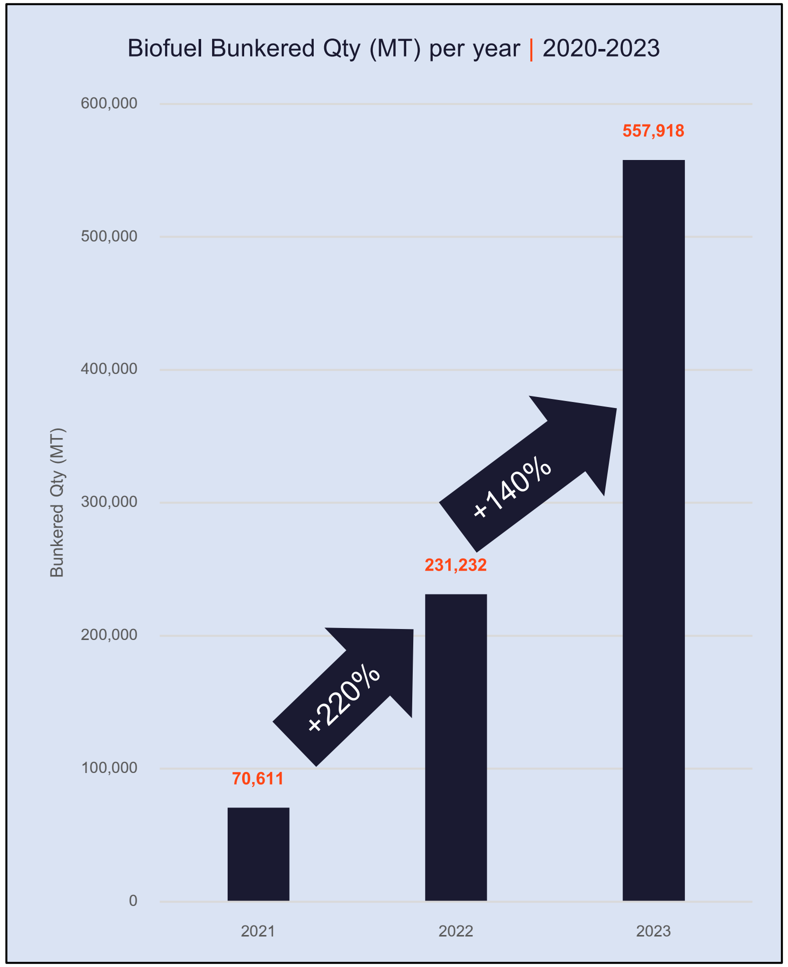
Global presence through **6** strategic locations

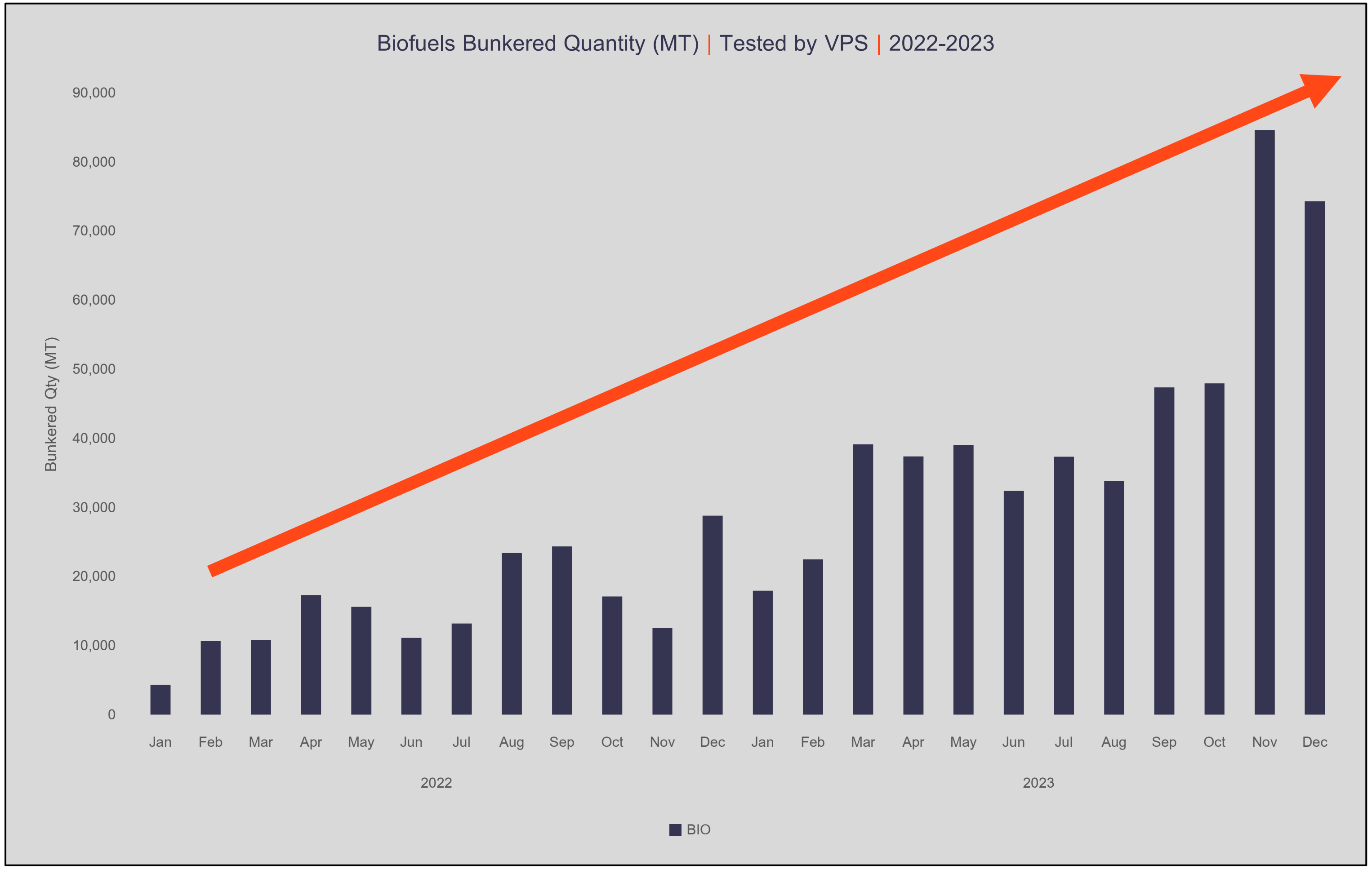


Bunkered Quantity (MT) by Region 2023



Biofuels Bunkered Quantity increase





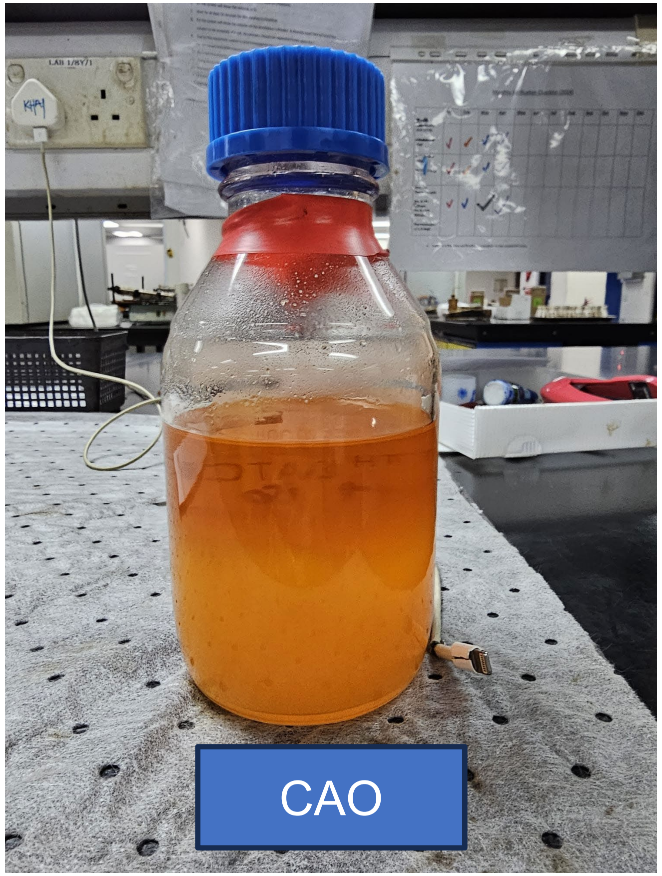
Biofuels – as part of Sustainability Reporting

SUSTAINABLE FUELS _NfR		
TARGETS	**MEASURES**	**STATUS 2023**
Expanding the procurement of biofuels	Ensuring the supply of liquid biofuel through contracts with suppliers	Around 213,000 tonnes of bunkered biofuel blend (previous year: around 120,500 tonnes)
Ensuring access to selected alternative fuels at competitive prices in the medium to long term	Dialogue with potential suppliers	Continued dialogue with potential and existing suppliers

SUSTAINABLE PRODUCTS _NfR		
TARGETS	**MEASURES**	**STATUS 2023**
Offering customers more sustainable, climate-friendly transport options through the use of biofuels	Further improvements to the Ship Green product	Launch of Ship Green, a product for the low-carbon transportation of goods
Providing our customers with greater transparency in regard to our CO_2e emissions	Development of a central IT solution to perform carbon calculations for various use cases	Initial functions in the emissions database have already been developed

Courtesy of Hapag-Lloyd Sustainability Report 2023

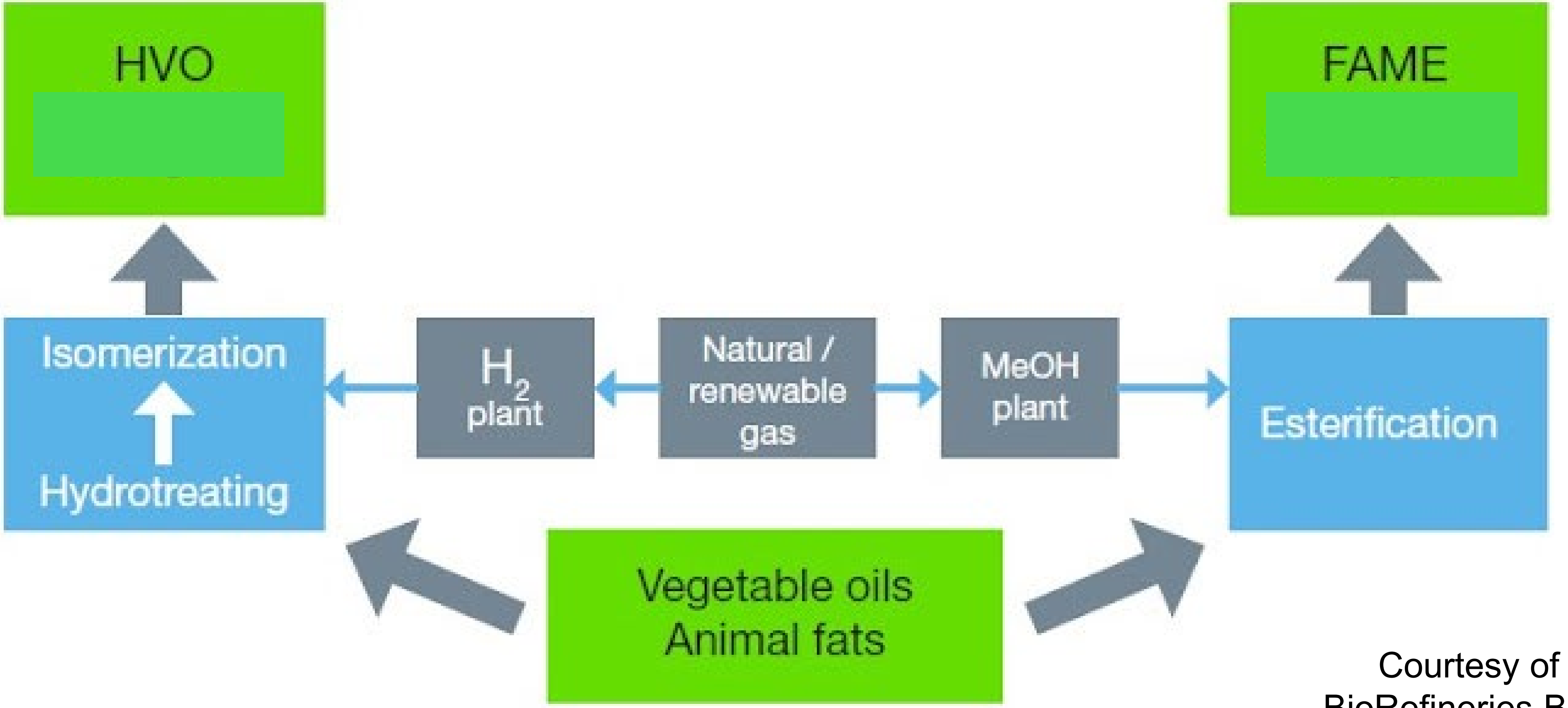
Biofuels – what we see



Quality Parameters: MGO vs FAME vs HVO

PARAMETERS	UNIT	DMA typical	100% FAME Vs HVO
Kinematic viscosity @ 40 °C	mm^2/s	3.0	5.0 / 3.0
Density @ 15 °C	kg/m^3	830 - 850	880 / 780
Sulfur	mg/kg (ppm)	0 - 300	0 – 15 / <0.03
Flash point	°C	>70	100 – 140 / >70
Acid number	mg KOH/g	0.2	0.5 / <0.01
Water	% (v/v)	<0.01	0.05 / <0.01
Fatty Acid Methyl Ester (FAME)	% (m/m)	<0.1	95 – 100 / <0.01
Net calorific value	MJ/kg	43	37 / 44
Cetane number	-	45-55	55 / >74
Oxidation Stability @110°C	hours	>24	>8 / >48
Total sediment	% (m/m)	<0.01	<0.01
Oxygen	% (m/m)	0.9	10.5 / <0.02

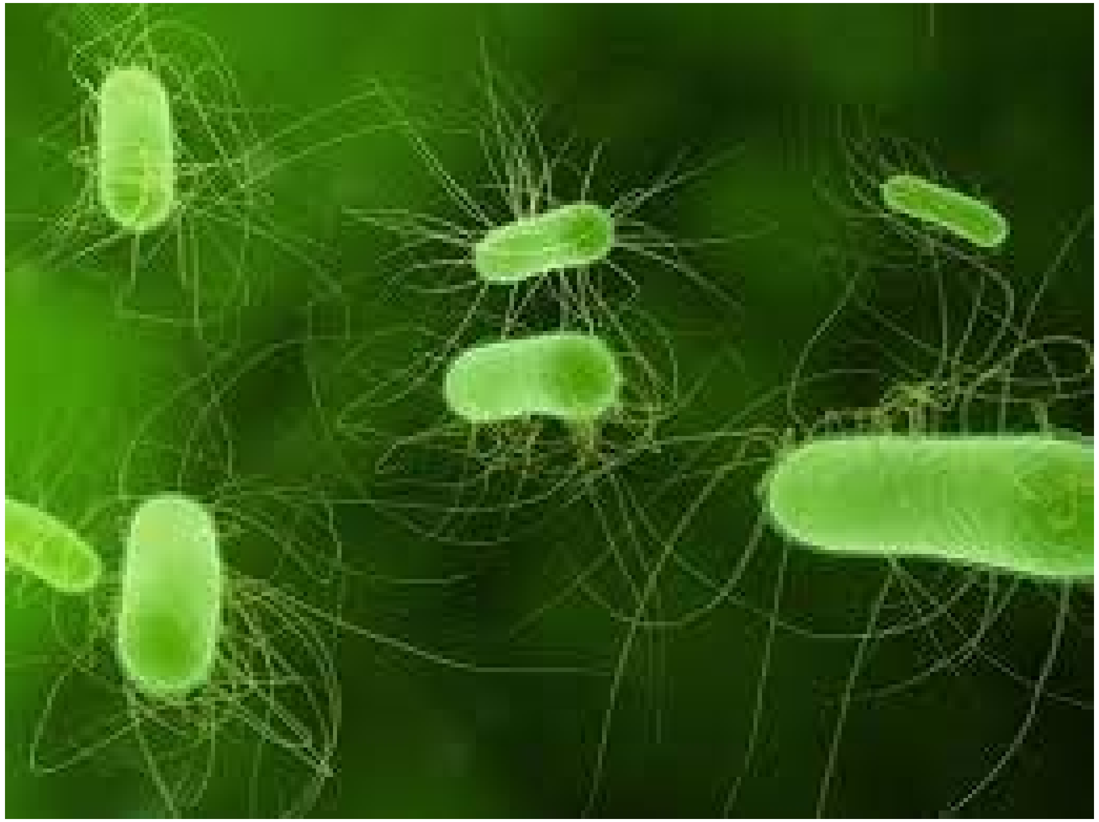
FAME & HVO production



Courtesy of
BioRefineries Blog

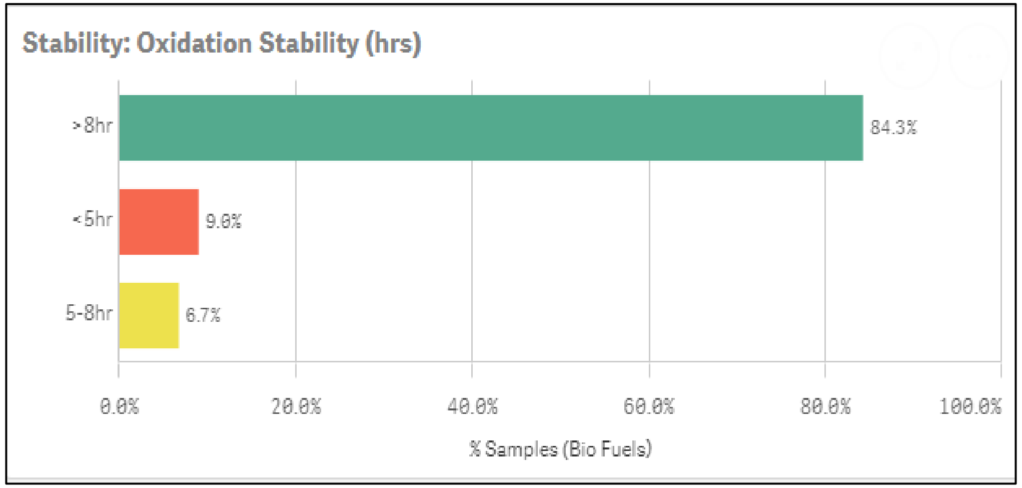
Biofuel - FAME Characteristics

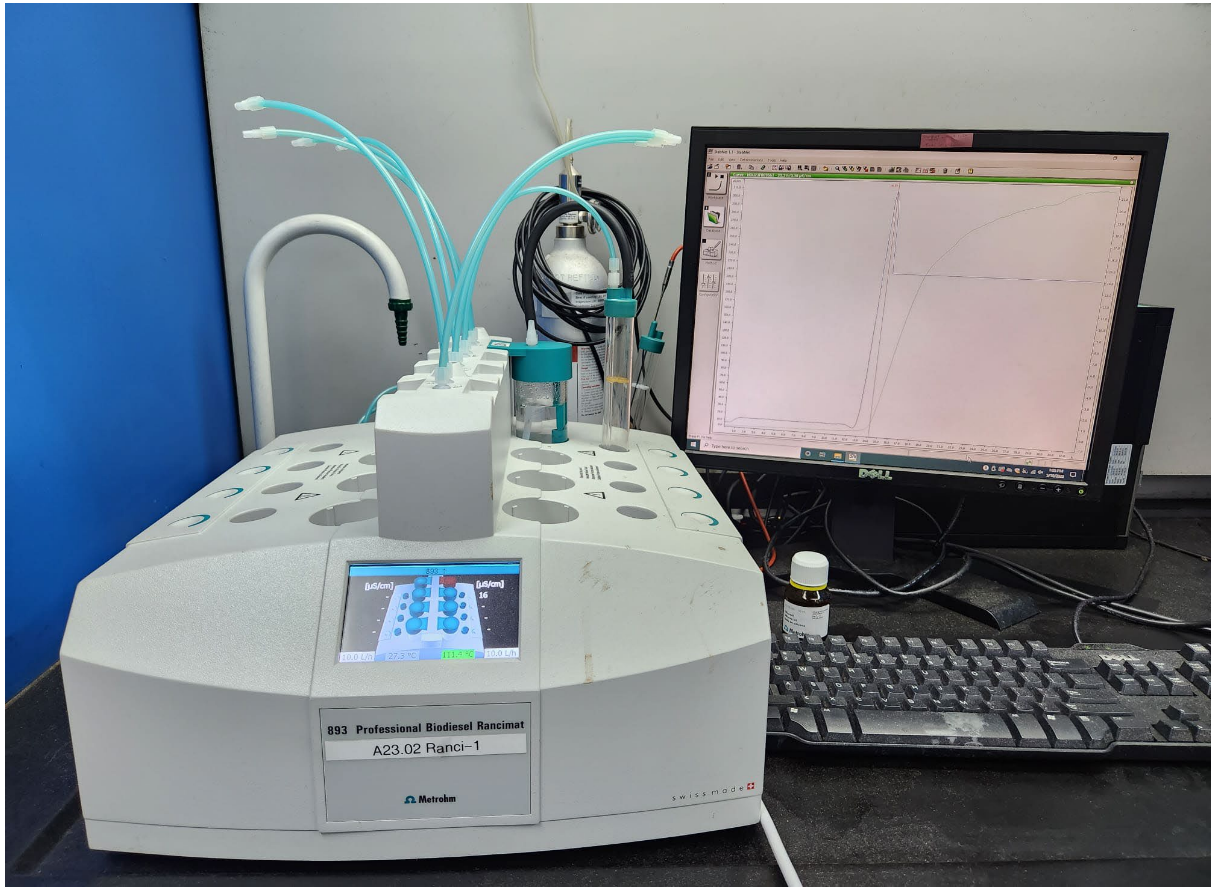
- Greater affinity towards water
- Poor cold flow property
- Long-term stability
- Material compatibility



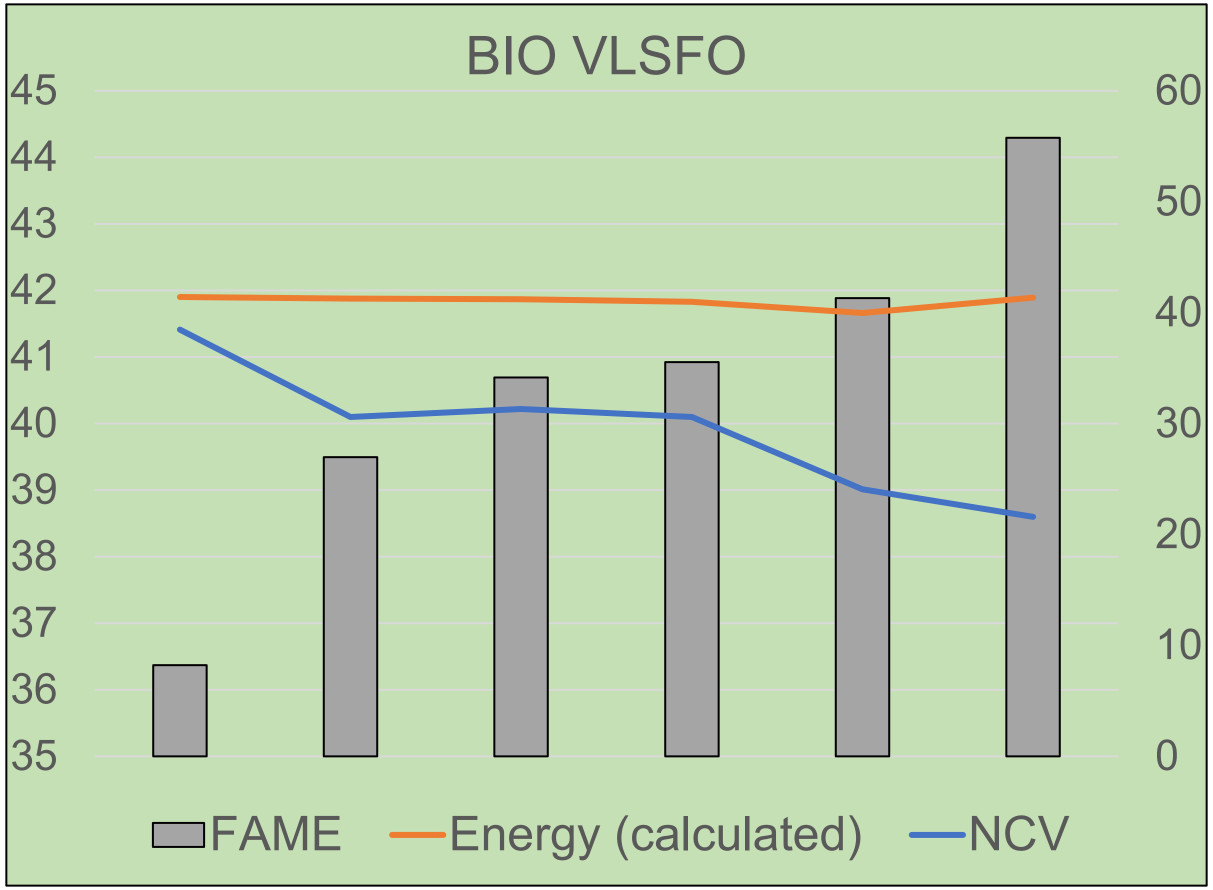
Biofuel - Stability

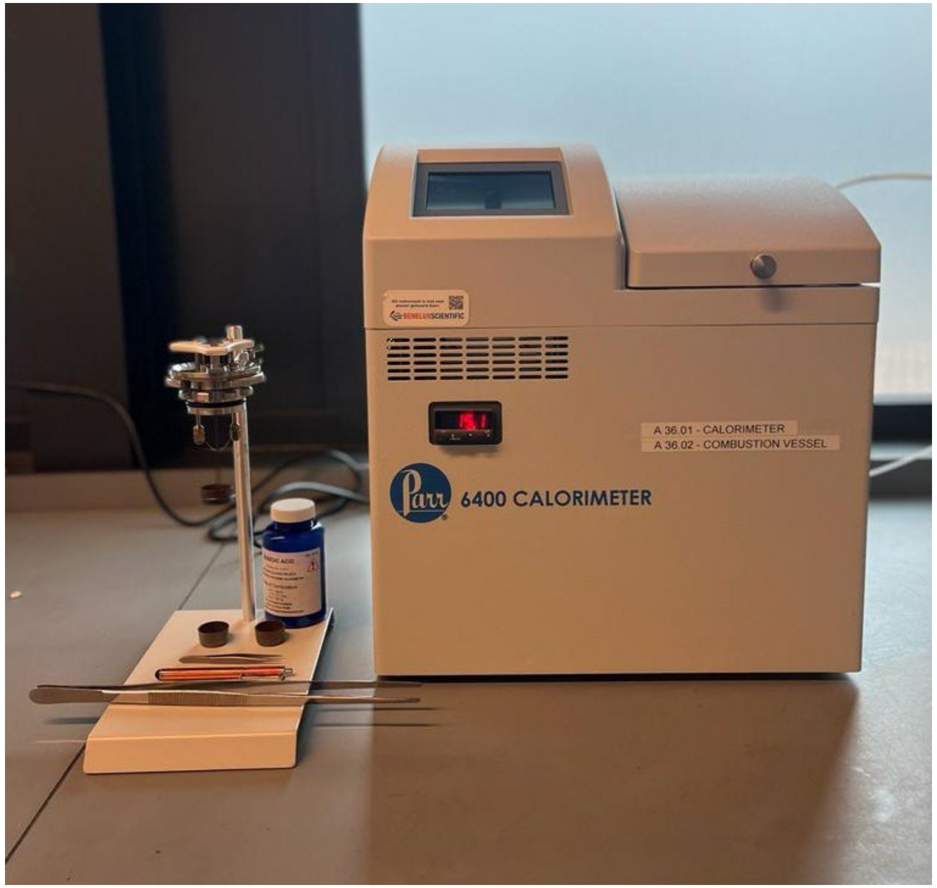
- Less stable
- Unsaturated content
- Oxidation





Biofuel – Energy Content





Bio-APS for Bio-MGO Blends

Parameter	Spec Limit	Test Method	Purpose of Test
ISO 8217 Test Slate	various	As specified in ISO8217 standard	Ensure fuel is fit for use as bunker fuel
FAME content	N/A	ASTM D7371/EN 14078 modified	Accurate measure of renewable C content
Net Calorific Value	N/A	ASTM D240	Accurate measure of CV (usual calculation method does not work for biofuels)
CP Cloud Point	N/A	EN ISO2015 modified (LP1305)	Cold-flow property
Bacteria, Yeast Fungi	N/A	LP2301	Microbiological activity
Cetane Index	min 40	ASTM D4264	Combustion property
Oxidation stability (at 110 °C) - Rancimat	min 8.0 hr	EN 15751	Stability of the biofuel
Iodine value	max 120g I/100g	EN 14111	Susceptibility to oxidise
TAN / Acid Value	max 0.5 mg KOH/g	ASTM D664	Corrosivity
Sulfur content (ppm)	N/A	ASTM D4294	Understand level of lubricity in the fuel
Lubricity (HFRR)	Max 520	EN ISO12156-1	Poor lubricity due to low S levels

Bio-APS for Bio-VLSFO & Bio-HFO Blends

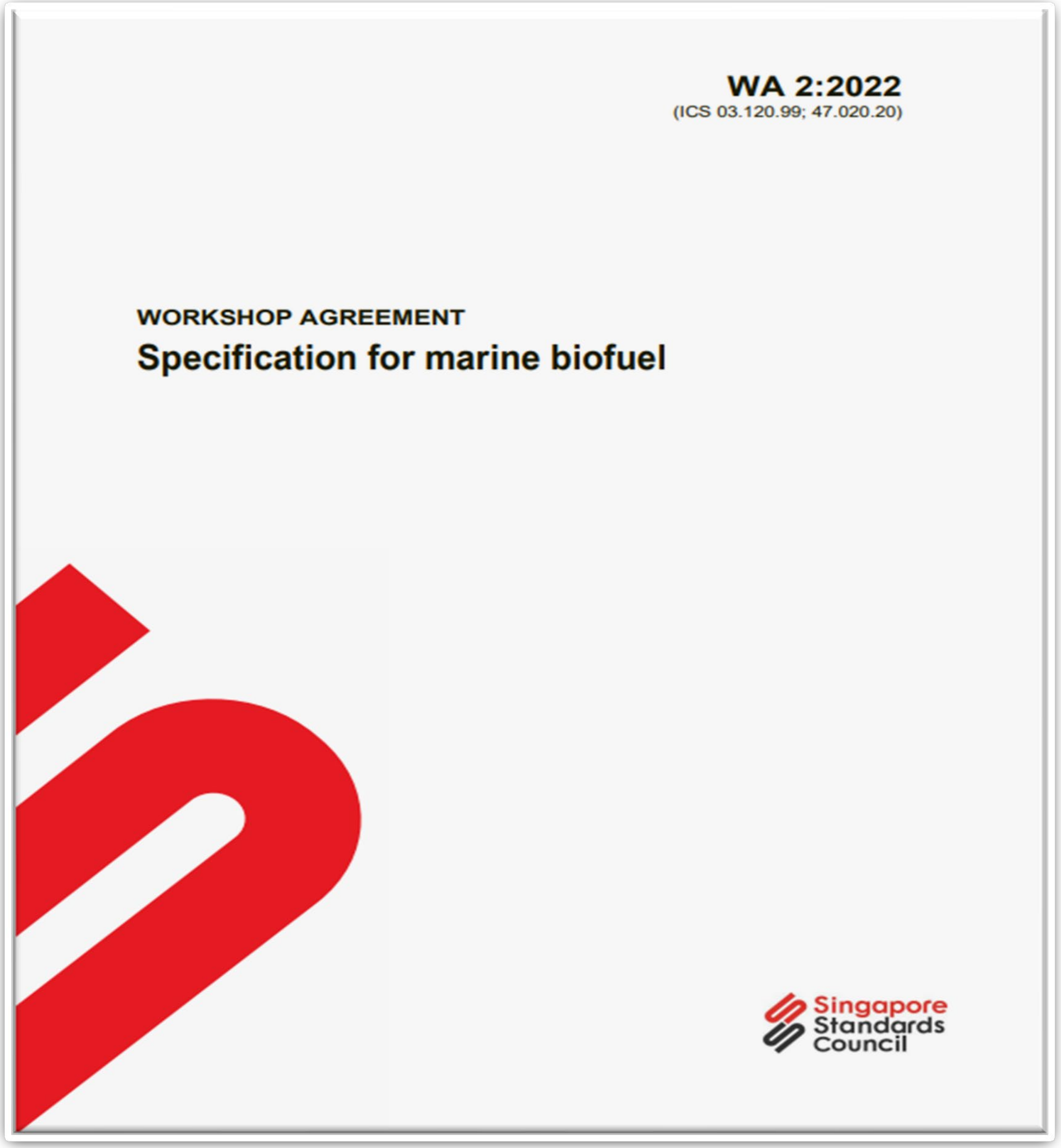
Parameter	Spec Limit	Test Method	Purpose of Test
ISO 8217 Test Slate	various	As specified in ISO8217 standard	Ensure fuel is fit for use as bunker fuel
FAME content	N/A	ASTM D7371/EN 14078 modified	Accurate measure of renewable C content
Net Calorific Value	N/A	ASTM D240	Accurate measure of CV (usual calculation method does not work for biofuels)
WAT/WDT	N/A	LP1307	Cold-flow property (WAT needed due to dark colour of oil)
Bacteria, Yeast Fungi	N/A	LP2301	Microbiological activity
Oxidation stability (at 110 °C) - Rancimat	min 8.0 hr	EN 15751	Stability
Iodine value	max 120g I/100g	EN 14111	Susceptibility to oxidise
TAN / Acid Value	max 0.5 mg KOH/g	ASTM D664	Corrosivity

100% FAME – ISO14214

Parameter	Test Method	Spec Limit min	Spec Limit max	Analytical Technique
FAME content	EN14103	96.5%		GC
Density at 15 °C	EN ISO 12185	860	900	
Viscosity at 40 °C	EN ISO 3104	3.50	5.00	
Net Calorific Value	ASTM D240	N/A		Calorimeter
Flash point	EN ISO 2719	101°C		
Cetane Index	ASTM D4264	51.0		
Copper strip corrosion (3 h at 50, 100, 150°C)	ASTM D130	Class 1		
Steel corrosion @ 20,60, 120°C	LP2902	N/A		
Oxidation stability (at 110 °C)	EN 15751	8.0 hr		Rancimat
TAN / Acid value	ASTM D664		0.5 mg KOH/g	Autotitrator
Iodine value	EN 14111		120g I/100g	Manual Titration
Water content	ASTM D6304		0.05%	Karl Fischer
Sulfated ash content	ASTM D874		0.02%	
Sulfur content (ppm)	ASTM D4294		10ppm	
Group I metals (Na+K)	IP501		5.0ppm	ICP
Group II metals (Ca+Mg)	IP501		5.0ppm	ICP
Phosphorus content	IP501		4.0ppm	ICP
Linolenic acid methyl ester	EN 14103		12.0%	GC
Methanol content	EN 14110		0.20%	GC
Monoglyceride, Diglyceride, Triglyceride content	EN 14105		0.7%, 0.2%, 0.2%	GC
Free glycerol	EN 14105		0.02%	GC
Total glycerol	EN 14105		0.25%	GC

Biofuels – Standards development

- Awareness
- Understanding Biofuel characteristic
- Setting robust quality control


WA 2:2022
(ICS 03.120.99; 47.020.20)

WORKSHOP AGREEMENT
Specification for marine biofuel

Singapore Standards Council

Biofuels – GCMD

GCMD and NYK Line team up to address concerns of long-term, continuous biofuels use on vessel operation

Published on
9 May 2024

PRESS RELEASE

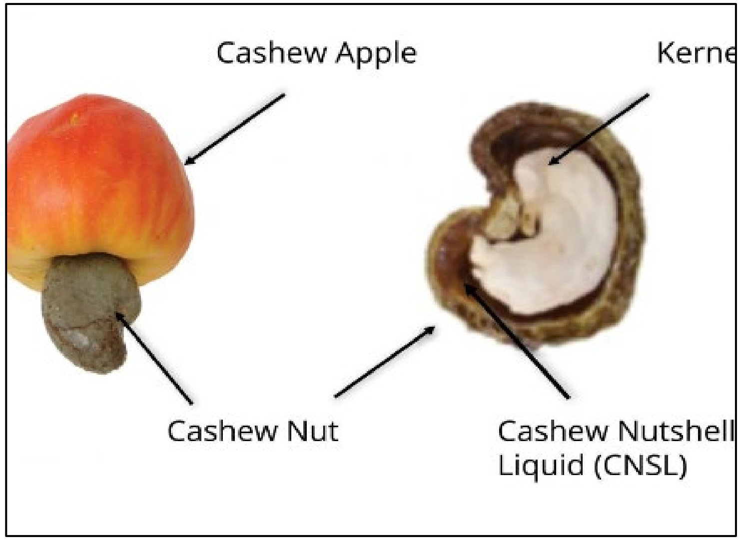
GCMD and NYK Line team up to address concerns of long-term, continuous biofuels use on vessel operations

- The consortium will launch a six-month trial of biofuels use to understand their impact on engine performance and onboard systems operations.

Singapore / Tokyo: 9 May 2024 – The **Global Centre for Maritime Decarbonisation** (GCMD) has teamed up with NYK Line to launch **Project LOTUS** (long-term impact of continuous use of biofuels on vessel operations). This six-month project will trial the continuous use of a biofuels blend comprising of

Cashew Nut Shell Liquid (CNSL)

- Natural resin from shell
- Renewable & sustainable, valuable by-product
- Primarily made up of Anacardic acid, Cardols & Cardanols – basically Phenols
- Production - 1 M mtons / year ~
- Used on Friction materials like brake lining, paint coatings
- Industrial use since early 1900's
- Structure allows direct blend as a Biofuel.



CNSL-Blended Fuels Experience

- CNSL-blended fuels with MGO, VLSFO or HSFO have shown mixed reactions to vessel operations.
- Some CNSL-blends have been stored and burnt without issue.
- Some CNSL-blends have given rise to operational problems such as:
    - Fuel sludging
    - Fuel injector failure
    - Corrosion of engine parts
    - Filter clogging
    - Fuel system deposits
    - Corrosion of turbocharger nozzle rings
    - Damage to Selective Catalytic Reactor (SCR) units.

- CNSL contains reactive phenolic compounds making them prone to polymerization forming gums and fuel deposits

Handling and Use of CNSL & CNSL-Blends

- Do not use 100% CNSL as a marine fuel.
- Traditional marine fuels blended with CNSL, may reduce the high acid number, reactivity and potassium levels of 100% CNSL, but increase energy content, sulphur, cold-flow and sediment potential issues.
- Check with the OEM regarding the compatibility of CNSL-based biodiesel blended products.
- When CNSL is heated above 200°C it will polymerise.
- Avoid storage period over three months, if extended storage is unavoidable carry out periodic sampling and testing every 2-3 months to test for acid number, iodine value, plus ISO8217.
- The absence of sulphur in CNSL will require marine engine lubrication oils with low TBN and high detergency in order to provide efficient engine lubrication and prevent scuffing.
- Material compatibility – CNSL is highly reactive and therefore could have compatibility issues when in contact with certain materials.
- The use of CNSL blends can significantly reduce HC, CO/CO_2 and smoke emissions, although they raise NOx emissions slightly.

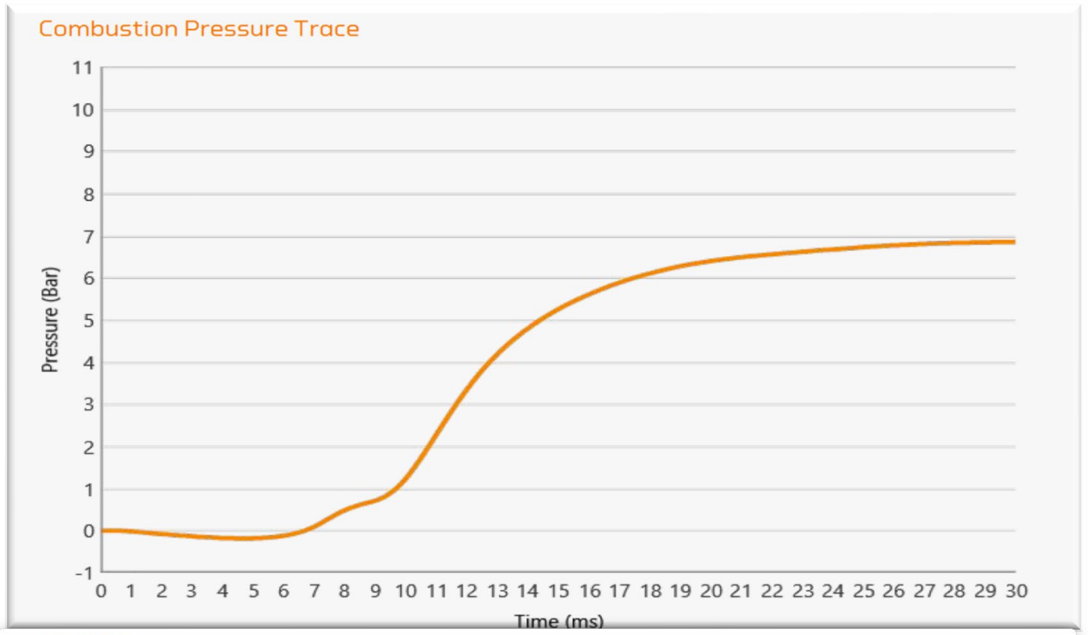
Tyre Pyrolysis Oil (TPO)

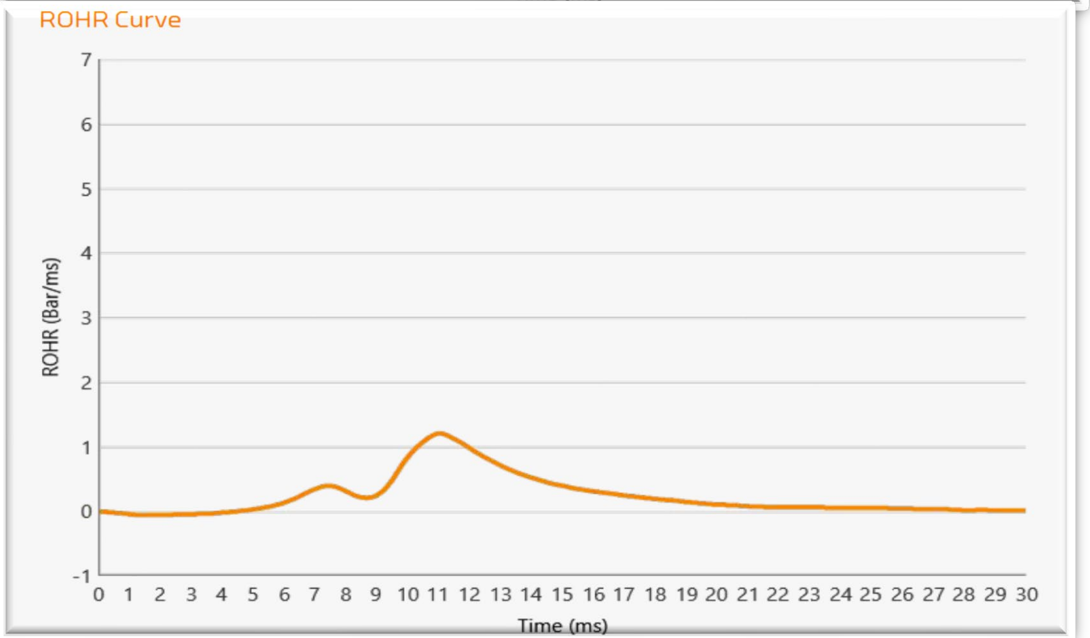
- Waste tyre disposal concerns 1970's, renewable resource
- Commercialised early 2000
- Composition complex – primarily Aromatic(e.g. Benzene) & Oxygenate(e.g. Phenols) compounds
- Used in industrial boilers, asphalt binder in road construction
- Needs esterification before use as Biofuel blend – improve fuel property(e.g. ignition quality), reduce contaminant(e.g. phenols), enhance stability.

Fuel Combustion Analysis – HSFO (80%)/TPO (20%)

Fuel Ignition & combustion test results - IP 541/06

Description	Parameter	Value	Unit
Estimated Cetane Number	ECN	11.8	-
Ignition Delay	ID	6.95	ms
Main Combustion Delay	MCD	8.95	ms
End of Main Combustion	EMC	18.80	ms
End of Combustion	EC	29.97	ms
Pre-Combustion Period	PCP	2.00	ms
Main Combustion Period	MCP	9.85	ms
After Burning Period	ABP	11.17	ms
Max ROHR Level	MRL	1.20	bar/ms
Position of Max ROHR	PMR	11.11	ms
Accumulatied ROHR	AR	6.80	Bar
Max Pressure Increase	MaxP	6.94	Bar





Fuel Combustion Analysis – HSFO (100%)

VPS

Fuel Parameters

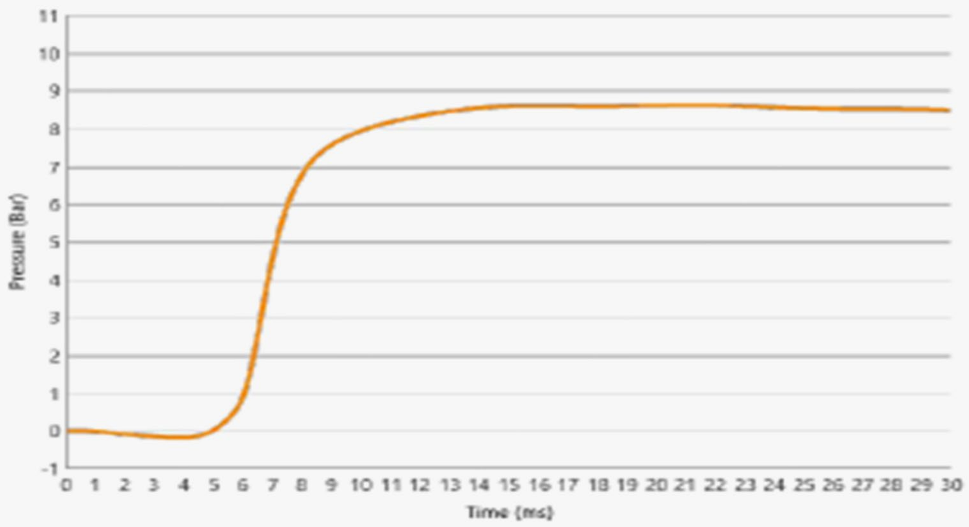
Density @ 15°C	961.6 kg/m3
Viscosity @ 50°C	153.2 mm2/s
Sulfur	1.70 %m/m
CCAI (Ignition Quality)*	833 -

*Calculated value

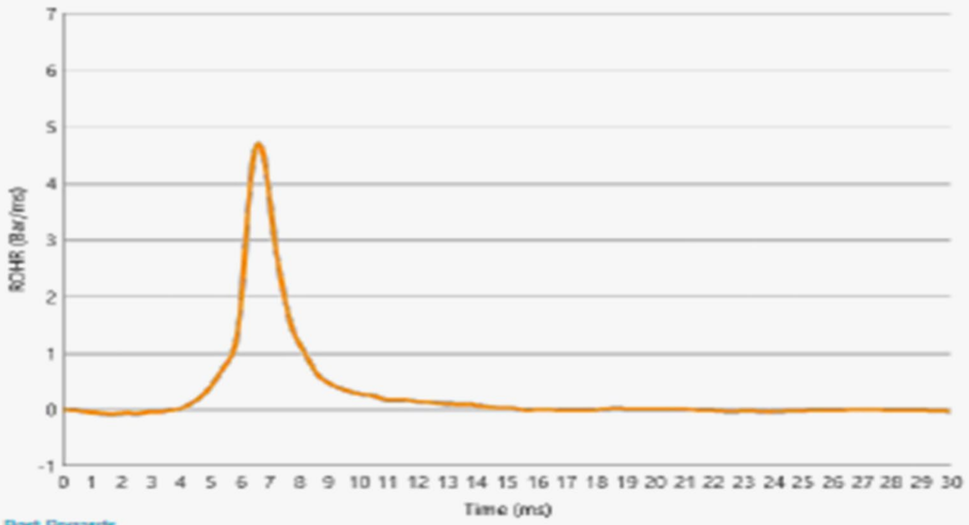
Fuel Ignition & combustion test results - IP 541/06

Description	Parameter	Value	Unit
Estimated Cetane Number	ECN	27.2	-
Ignition Delay	ID	5.21	ms
Main Combustion Delay	MCD	6.05	ms
End of Main Combustion	EMC	9.46	ms
End of Combustion	EC	14.16	ms
Pre-Combustion Period	PCP	0.84	ms
Main Combustion Period	MCP	3.42	ms
After Burning Period	ABP	4.69	ms
Max ROHR Level	MRL	4.70	bar/ms
Position of Max ROHR	PMR	6.65	ms
Accumulated ROHR	AR	8.47	Bar
Max Pressure Increase	MaxP	8.64	Bar

Combustion Pressure Trace



ROHR Curve



Best Regards,
On behalf of Veritas Petroleum Services BV

Methanol as fuel

VPS – First Methanol Bunkering

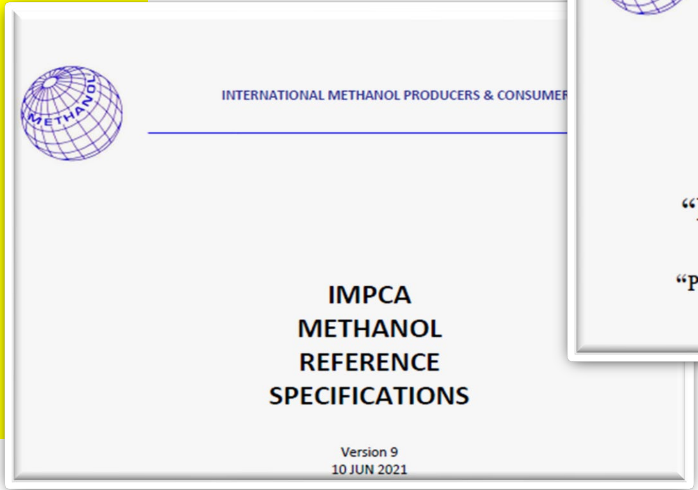
- VPS engaged by Maersk to survey, sample and test the first methanol bunkering in Singapore July 2023, for the Laura Maersk.
- Bunkering practices required heightened H&S procedures, e.g. tank cleaning, closed sampling device, glass sample bottles.
- Biofuel used as the Pilot-Fuel.
- Samples dispatched for testing under IATA regulations.
- Samples tested to the International Methanol Producers and Consumers Association (IMPCA) standard were a close match to the COQ.
- Further surveys and quality testing took place in Port Said and Rotterdam during the vessels eastbound voyage to Denmark.

Methanol – Testing Considerations

Methanol key testing considerations:

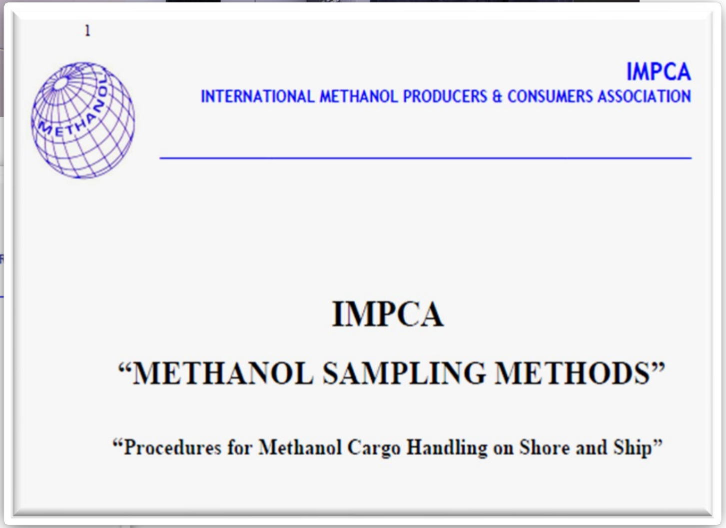
- Calorific Value
- Methanol content
- Ethanol content
- Water
- Acetone
- Chloride
- Acidity (Acetic Acid)
- Sulphur
- Appearance
- Purity & Impurities

- IMPCA Quality Specifications & ISO 6583(DIS)


INTERNATIONAL METHANOL PRODUCERS & CONSUMER

IMPCA
METHANOL
REFERENCE
SPECIFICATIONS

Version 9
10 JUN 2021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IMPCA
INTERNATIONAL METHANOL PRODUCERS & CONSUMERS ASSOCIATION

IMPCA
"METHANOL SAMPLING METHODS"

"Procedures for Methanol Cargo Handling on Shore and Ship"

Thank You

EXPERIENCE ▶ INNOVATION ▶ SUSTAINABILITY

Q&A

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