METHANOL AS FUEL

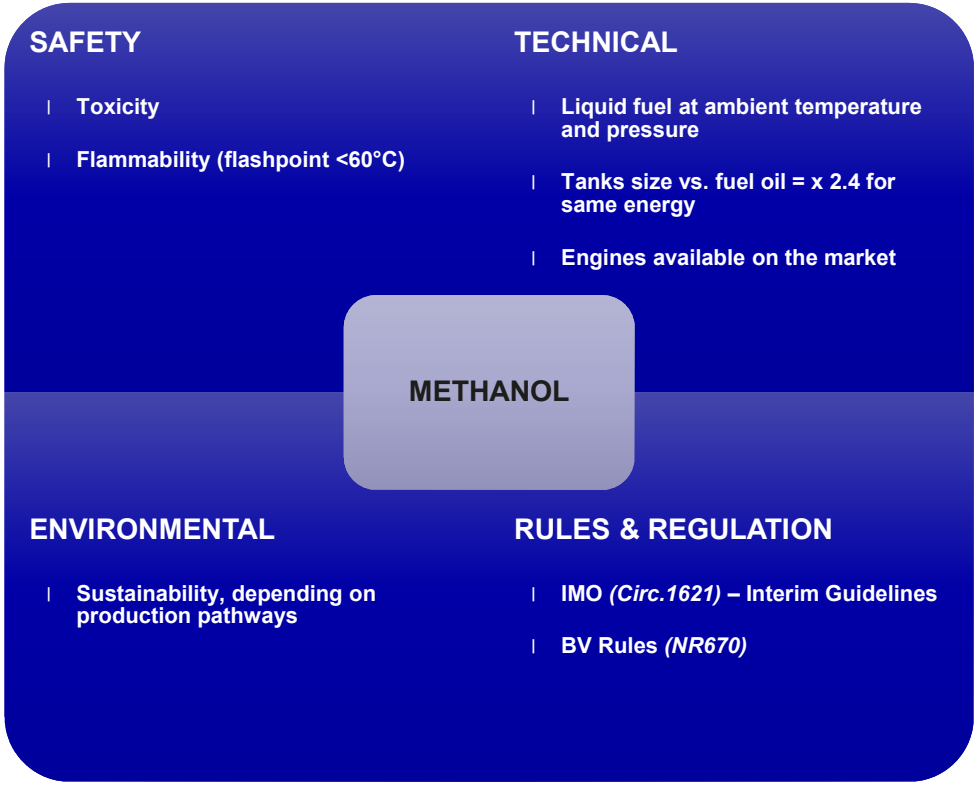
BUREAU VERITAS M&O

MARCH 2025

01

FACTS ON METHANOL

METHANOL AS FUEL



WHAT IS METHANOL ?

~100 million tons produced annually

An essential ingredient of modern life

Traditional Chemical Market

Essential ingredient used in countless industrial and consumer products

Slightly over 50% of global demand

Clean and Economic Alternative Fuel

Represents a growing demand segment for methanol

Just under 50% of global demand

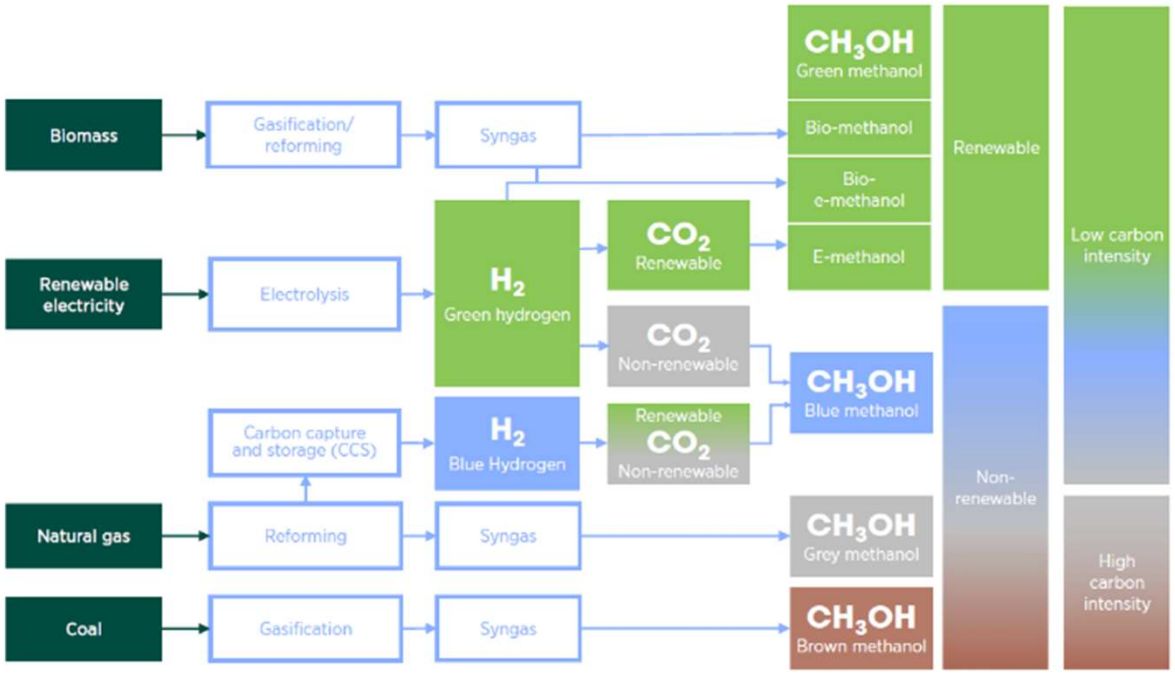
Fuel applications

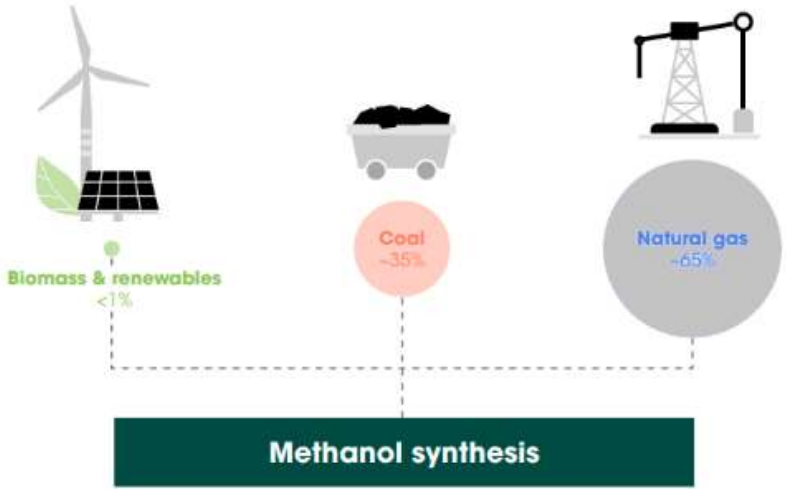
Methanol-to-olefins (MTO)

methanex the power of agility

COURTESY : METHANEX

METHANOL AS LOW CARBON FUEL





Source: : IRENA and Methanol Institute

- **Brown and grey methanol production is currently around 100 Millions tons/year (Mt/y)**
- **Green methanol production is currently around 0.2 Millions tons/year (Mt/y), means 0.2%**

EVOLUTION OF REGULATIONS TOWARDS WELL-TO WAKE

IMO : **Carbon Intensity Indicator**

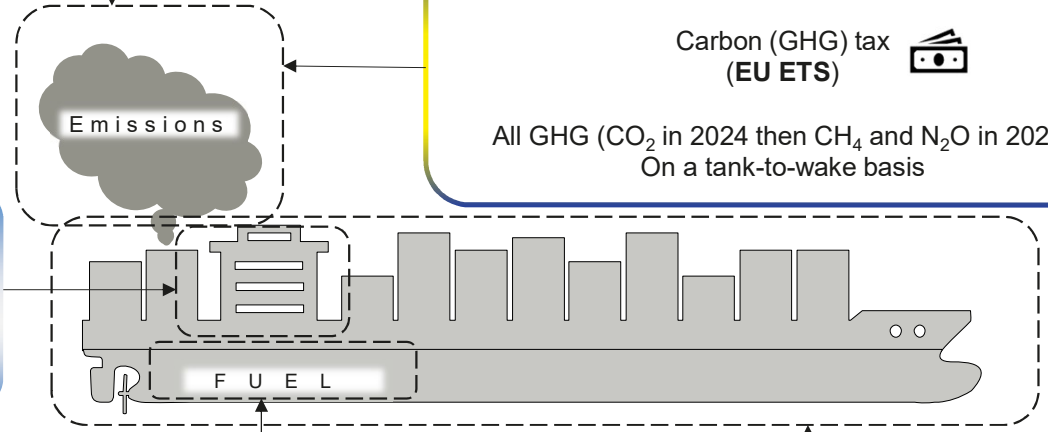
Operational requirement

Only CO_2 (CH_4 will come with LCA)
On a tank-to-wake basis

EU : **Cap-and-trade on emissions**

Carbon (GHG) tax
(**EU ETS**)

All GHG (CO_2 in 2024 then CH_4 and N_2O in 2026)
On a tank-to-wake basis



IMO : **Ship Energy Efficiency Management Plan**

Operational requirement

Continuous improvement

EU : GHG intensity of fuel
(**Fuel EU Maritime**)

Operational requirement

All GHG, on a well-to-wake basis

IMO : **Energy Efficiency Design Index (EEDI/EEXI)**

Design requirement

Evolution of regulations towards Well-to-Wake approach

METHANOL AS FUEL

IMO

- CO_2 emissions of Methanol burned onboard : 69.1 CO_2 per MJ fuel.
- On a tank-to-wake basis, Methanol yields a ~10% CO_2 reduction (for same energy) compared to conventional fuels (LNG yields a ~20% reduction as a comparison)
- Available in EEDI and EEXI calculations
- Available in SEEMP (and CII)
- IMO today : *Tank-to-Wake* CO_2 emissions
- Will evolve with the Lifecycle Assessment Guidelines (*Well-to-Wake*) and Global Fuel Standard

Methanol is in **Fuel EU maritime**

Fuel EU : *Well-to-Tank* + *Tank-to-Wake*

Well-to-Tank : 3 pathways : fossil, bio, and electrical

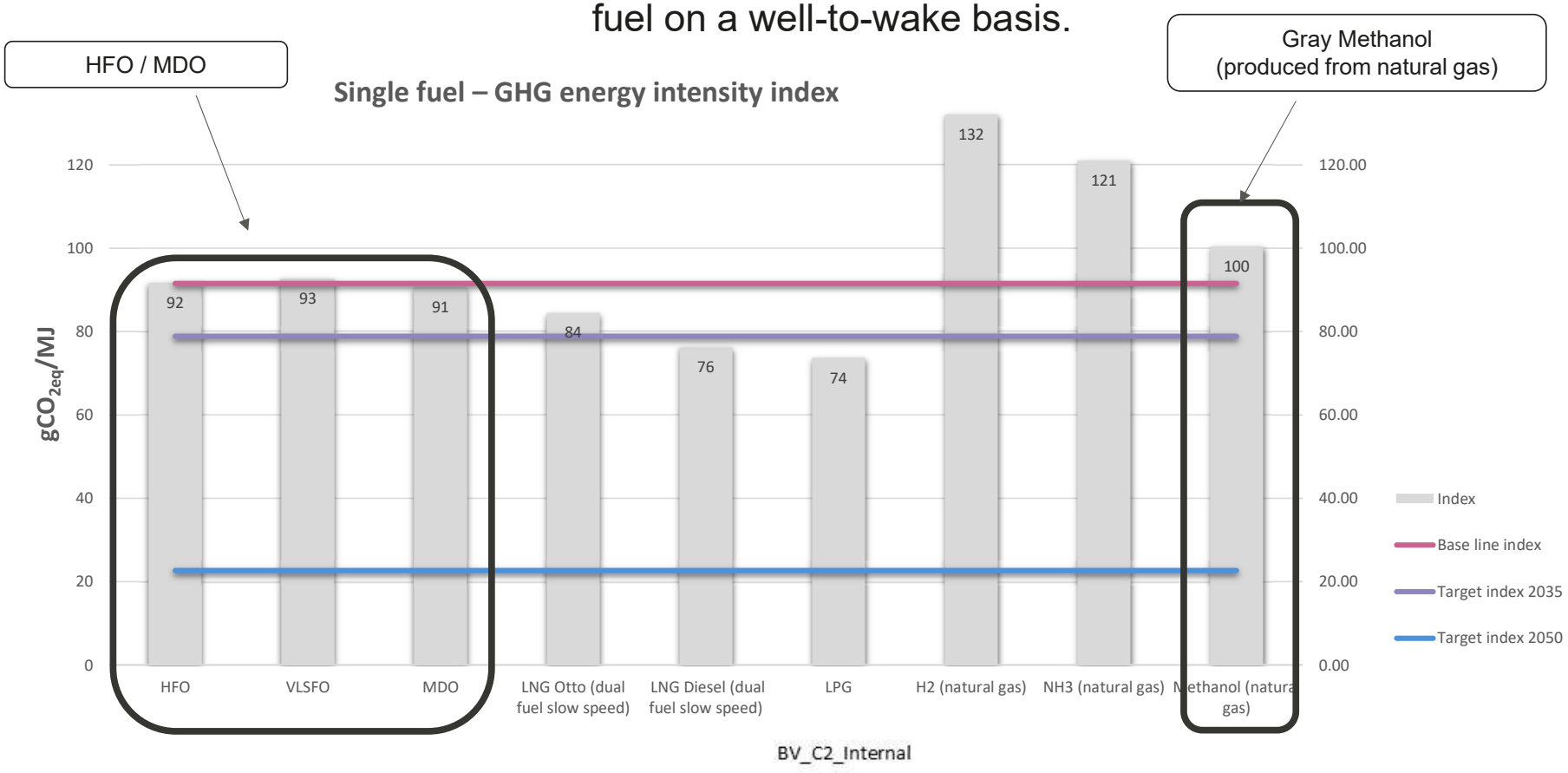
Tank-to-Wake : same as IMO (+ CH_4 and N_2O)

Example : Methanol in the « *gasification* » pathway is similar to LNG, in terms of total CO_2 emissions on a well-to-wake basis.

To emit less CO_2, Methanol needs to be produced in low-carbon way.

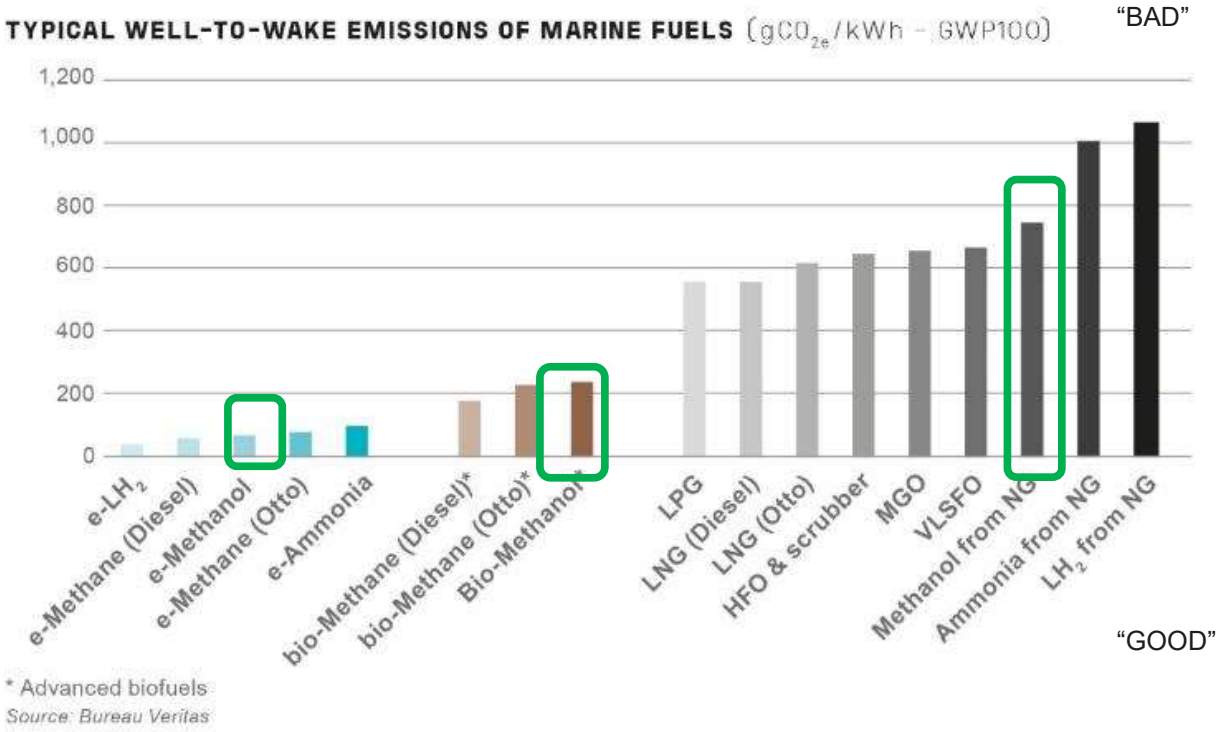
WELL-TO-WAKE EMISSIONS

Even though Methanol provide GHG emissions reduction on a tank-to-wake basis, the "gray" version of Methanol (produced from natural gas) emits more GHG than conventional fuel on a well-to-wake basis.



WELL-TO-WAKE EMISSIONS

Bio-methanol and e-methanol have better (lower) GHG emissions than “gray” methanol on a well-to-wake basis.



WELL-TO-WAKE : “GREY” METHANOL EMITS MORE THAN “GREEN” METHANOL

	Production (Well-to-Tank)	Usage (Tank-to-Wake)	Usage (Tank-to-Wake)	Total : Production and Usage
	Fuel EU	IMO and Fuel EU		
	CO_2 emissions (g CO_2 e / MJ)	CO_2 emissions (g CO_2 / MJ)	CO_2 emissions at the engine (g CO_2 / kWh)	CO_2 emissions at the engine (g CO_2 / kWh)
MGO	14	75	519	619
Methanol (produced from natural gas)	31	69	480	689
Methanol (produced from gasification (residues = bio source))	10	69	480	554
LNG	19	57	376	498

- From a Tank-to-Wake perspective, Methanol and LNG are reducing CO_2 emissions compared to Conventional Fuel (MGO)
- But from a Well-to-Wake perspective, Methanol from Natural Gas is detrimental to CO_2 emissions

With Data MAN : SGC at 75%, G80ME-C10.5, Tier III (3), EGRTC

OTHER AIR POLLUTANTS

Not forgetting other pollutants (NOx, SOx, PM), **Methanol** significantly reduces air pollution.

- NOx : reduced between 30% to 60%, two-stroke low-pressure engines are Tier III-compliant, but high-pressure engines will need abatement technologies like SCR or EGR to achieve compliance.
- SOx : reduced over 90%, Methanol does not contain Sulphur, notwithstanding possible pollution from pilot fuel (1.5% to 5%).
- Particulate Matters : reduction over 85%

AIR POLLUTION LEVELS FOR LNG, LPG AND METHANOL

Air pollutant	Emissions reduction compared to conventional HFO engine [%]		
	LNG	LPG	Methanol
NOx	Up to 40% for 2S Diesel cycle Up to 90% for 2S Otto cycle	Up to 20% for 2S Diesel cycle	30%-60% (Tier II compliant)
SOx	Over 90%	Over 90%	Over 90%
PM	Over 85%	Over 85%	Over 85%

Source: Bureau Veritas

PHYSICAL PROPERTIES

- Methanol remains a carbon fuel :

$$2\ CH_3OH + 3\ O_2 \rightarrow 2\ CO_2 + 4\ H_2O$$

- Methanol (CH_3OH) is a liquid at ambient temperature and pressure.
- Methanol is colourless
- Methanol is a low flashpoint liquid, with a flashpoint of 11ºC
- Methanol has toxic and corrosive properties

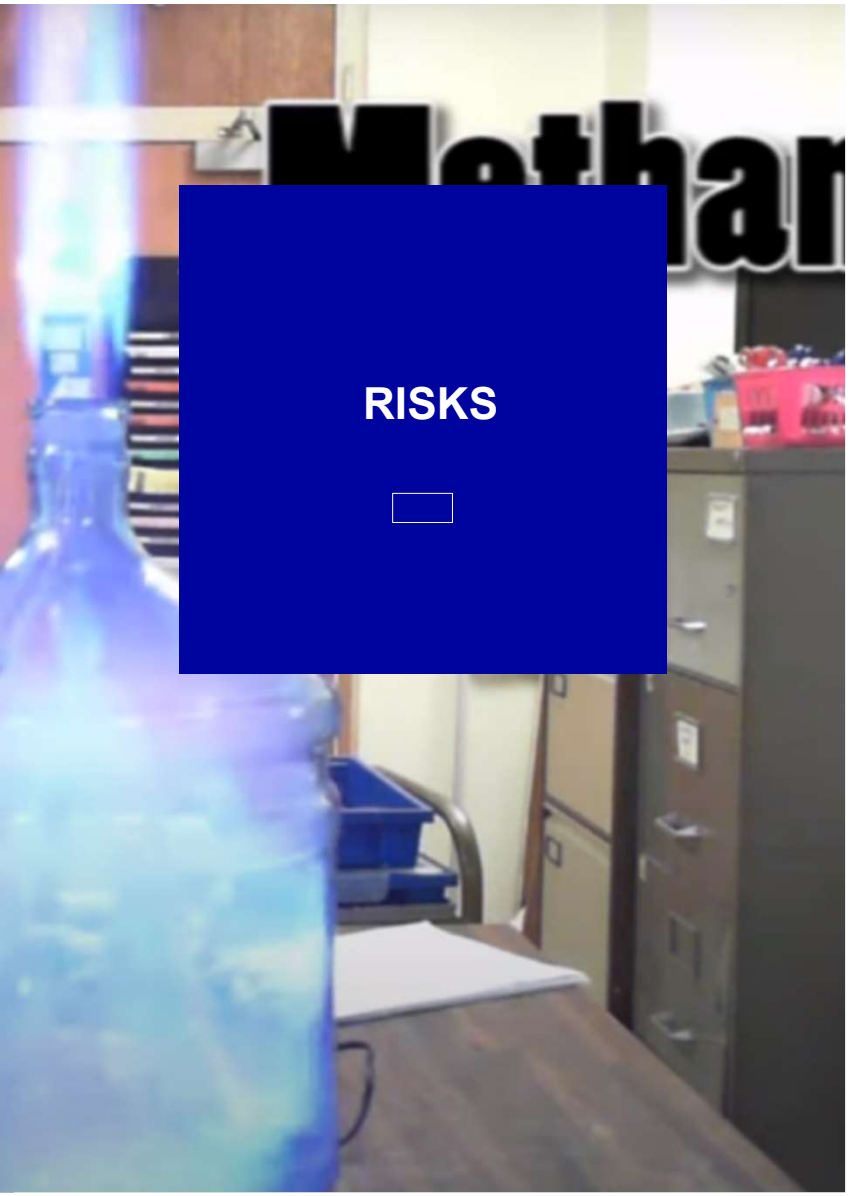
METHANOL PROPERTIES WILL IMPACT SHIP DESIGN

	MGO	Methanol	Methane	Impact
Combustion	$C_nH_m + O_2 \rightarrow n\ CO_2$	$CH_3OH + 3/2\ O_2 \rightarrow CO_2 + 2\ H_2O$	$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$	Explains the good emission coefficient factor as Methanol is closer to CO_2 molecule in terms of weight compared to hydrocarbons.
Energy per mass (LHV) (MJ/kg)	43	20	50	Low energy density impact the quantity in mass of bunker
Energy per volume (LHV) (GJ/m3)	37	16	23	Low energy density impact the Tank size (2.3 x MDO)
Liquid density (at storage temperature)	0.84	0.79	0.42	Heavier than LNG
Flash point	Above 60 °C	10-16 °C	-188 °C	Safety aspects and flammability
Boiling point @ atm	Above 150 °C to 390 °C	64 °C	-162 °C	Venting : methanol cloud will tend to drop down as methanol condenses
Auto-ignition temperature	> 240 °C	455 °C	540 °C	Need pilot fuel to ignite
Flammability range	~ 1 - ~6 vol%air	6 - 44 vol%air	5 - 15 vol%air	
Solubility in water at 20°C	insoluble	Totally miscible (1000 g/L)	2.3 g/L	Possible to venting in water : to be discussed
Toxicity : Absorption by skin. (Time Weighted Average) (mg/m3, 8 hours)	100	260	-	Methanol is less toxic than MGO by absorption
Toxicity : Inhalation. (1=very toxic)	Cat.4	Cat.3	low	Methanol is more toxic than MGO by inhalation

WHAT IS METHANOL ?

	MGO	Methanol	Methane	Impact
Combustion	$C_nH_m + O_2 \rightarrow n\ CO_2$	$CH_3OH + 3/2\ O_2 \rightarrow CO_2 + 2\ H_2O$	$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$	
Molecular weight	-	32 g / mol	16 g / mol	
Energy per mass (LHV) (MJ/kg)	43	20	50	
Energy per volume (LHV) (GJ/m3)	37	16	23	Tank size
Liquid density (at storage temperature)	0.84	0.79	0.42	Fuel weight
Flash point	Above 60 °C	10-16 °C	-188 °C	Safety
Boiling point @ atm	Above 150 °C to 390 °C	64 °C	-162 °C	Venting
Auto-ignition temperature	> 240 °C	455 °C	540 °C	Pilot fuel
Flammability range	~ 1 - ~6 vol%air	6 - 44 vol%air	5 - 15 vol%air	
Solubility in water at 20°C	insoluble	Totally miscible (1000 g/L)	2.3 g/L	"Venting"
Toxicity : Absorption by skin. (Time Weighted Average) (mg/m3, 8 hours)	100	260	-	Safety
Toxicity : Inhalation. (1=very toxic)	Cat.4	Cat.3	low	Safety

Methanol properties will impact on : Venting arrangement, Cloud dispersion, Tank arrangement, CO_2 emission conversion factor,..



RISKS

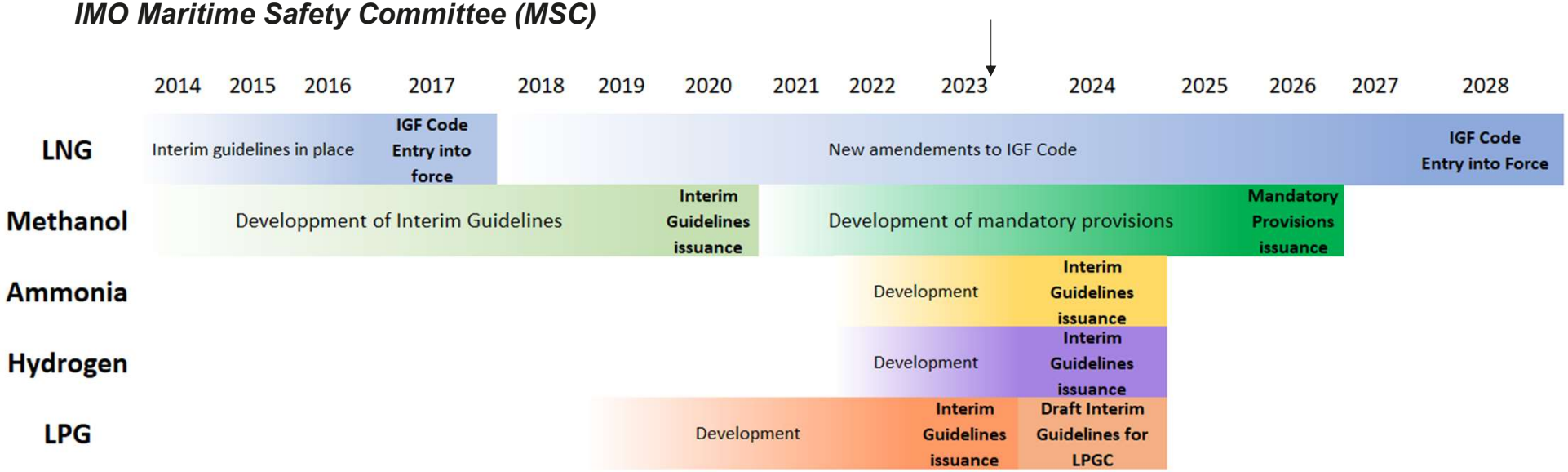
- Fire risk : invisible flames
- Explosion risk
- Toxicity to human : inhalation, skin contact, eye contact, ingestion

02

REGULATORY

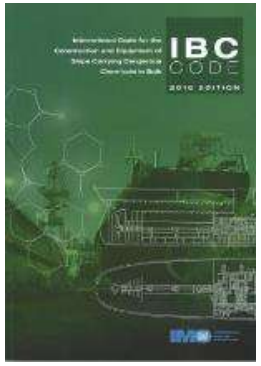
IMO – ALTERNATIVE FUELS

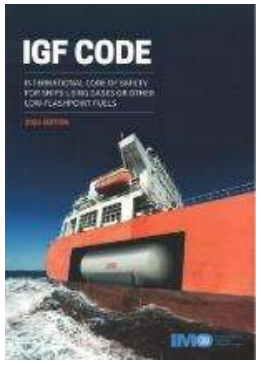
IMO Sub-Committee on Carriage of Cargoes and Containers ("CCC") ***(caretaker of IGF and IGC Codes)***
IMO Maritime Safety Committee (MSC)



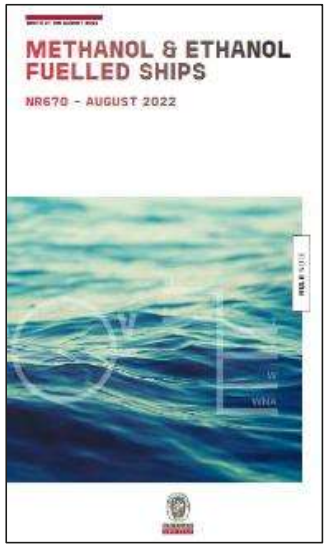
TODAY, all new fuels
(LPG, Methanol, Hydrogen, Ammonia), except LNG,
are under "Alternative Design" scheme of IGF Code,
Before "Interim" becomes "Mandatory"
Meaning "Flag" will matter !

METHANOL AS FUEL



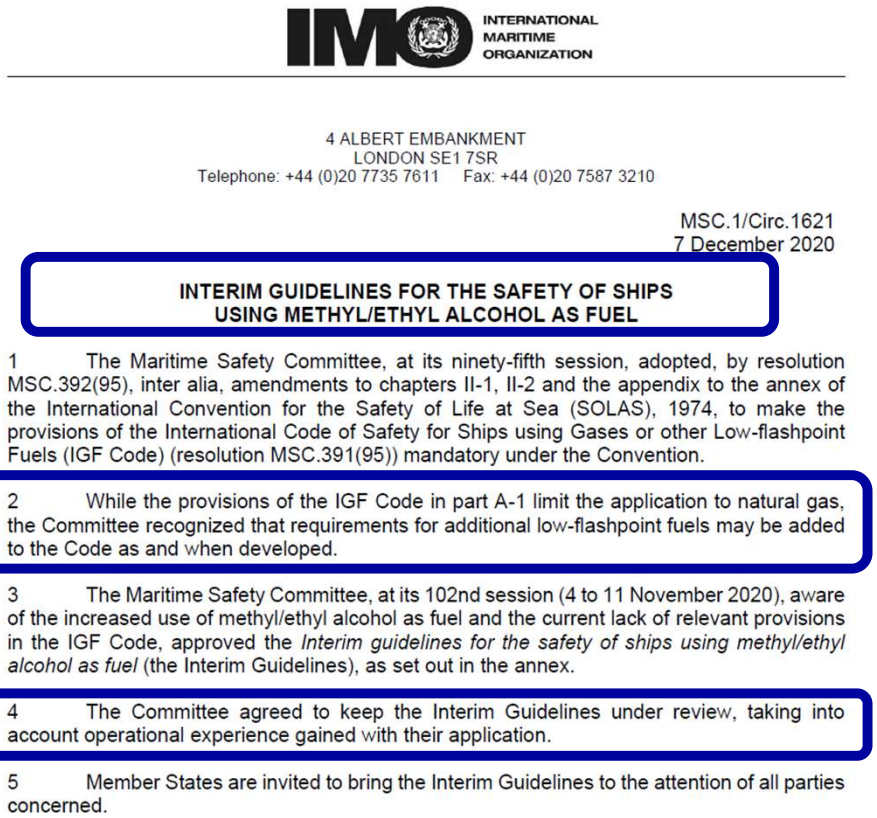


IMO Interim guidelines
Circ. 1621



BV Rules (NR 670)

METHANOL AS FUEL



INTERNATIONAL MARITIME ORGANIZATION

4 ALBERT EMBANKMENT
LONDON SE1 7SR
Telephone: +44 (0)20 7735 7611 Fax: +44 (0)20 7587 3210

MSC.1/Circ.1621
7 December 2020

INTERIM GUIDELINES FOR THE SAFETY OF SHIPS USING METHYL/ETHYL ALCOHOL AS FUEL

1 The Maritime Safety Committee, at its ninety-fifth session, adopted, by resolution MSC.392(95), inter alia, amendments to chapters II-1, II-2 and the appendix to the annex of the International Convention for the Safety of Life at Sea (SOLAS), 1974, to make the provisions of the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code) (resolution MSC.391(95)) mandatory under the Convention.

2 While the provisions of the IGF Code in part A-1 limit the application to natural gas, the Committee recognized that requirements for additional low-flashpoint fuels may be added to the Code as and when developed.

3 The Maritime Safety Committee, at its 102nd session (4 to 11 November 2020), aware of the increased use of methyl/ethyl alcohol as fuel and the current lack of relevant provisions in the IGF Code, approved the *Interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel* (the Interim Guidelines), as set out in the annex.

4 The Committee agreed to keep the Interim Guidelines under review, taking into account operational experience gained with their application.

5 Member States are invited to bring the Interim Guidelines to the attention of all parties concerned.

IGF Code is limited to natural gas as fuel (liquefied or gaseous state).

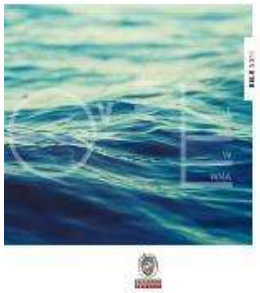
For other low-flashpoint fuels, compliance with the functional requirements of this Code must be demonstrated through alternative design.

The Methanol/Ethanol as fuel guidelines will be updated as operational experience is gained.

Methanol as marine fuel

Bureau Veritas (*NR 670*) Methyl / Ethyl Alcohol Fuelled Ships

	Fire	Pressure	Toxic	Corrosion	Cryogeny
Methanol	**X**		**X**		
LNG	X	X			X
LPG	X				X
Compressed Hydrogen	X	X		X	
Liquid Hydrogen	X			X	X
Ammonia	X		X	X	



Application

Ships within the scope of SOLAS Convention: compliance with the requirements of **IMO IGF Code** and **Flag Administration** as applicable.

BV Rules incorporates requirements of the **IMO Circular on Methanol as Fuel** *(Circ.1621 - Interim guidelines for the safety of ships using methyl/ethyl Alcohol as fuel)*

Risk assessment

› A risk assessment is to be conducted to ensure that risks arising from the use of low-flashpoint fuels affecting persons on board, the environment, the structural strength or the integrity of the ship are addressed.

Classification notations

Additional service feature : **methanolfuel**

Additional class notation : **methanolfuel-prepared**

Methanol as marine fuel

BV Rules

Safety assessment at the core of the process

- Under IGF Code: risk analysis is to be performed. NR670 asks for:
  - HAZID: ship including fuel & bunkering spaces and zones where vents lines and discharge lines are led.
  - HAZOP: very **high pressure** fuel installation (type approved equipment not to be included)
  - FMECA for **high pressure** equipment (pumps, compressors, diesel engines, electrical generation and distribution systems as settled in IEC 60812)

Gas dispersion analysis

- when arrangement of vents outlets not satisfiying due to size limits

Explosion analysis

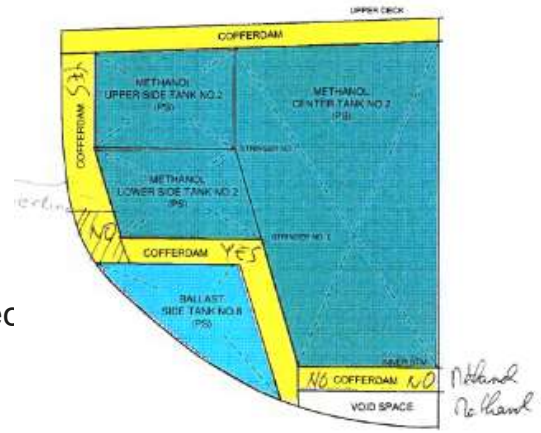
- in any space containing any potential sources of release and potential ignition sources
- for gas hazardous spaces, the maximum pressure built up in case of explosion not to exceed the design pressure of the space

METHANOL AS MARINE
BV RULES

General arrangement – some features

- Cofferdams are required around the methanol tanks
- Fuel tanks may be at the ship side below waterline
- All fuel tanks should be inerted at all times during normal operation
- Hazardous areas, based on IEC 60092-502 approach, extended to 6m (zone1) + 4m (zone2) around tank PV valves outlets [vs 3m +1.5 m for IGF code]

Transversal section – tanks in front engine room



Materials compatibility constraints

Prevention of leakage & explosion

- Prevent flammable or explosive atmosphere: double wall piping + tank inerting
- Ventilation of hazardous areas, fuel preparation spaces, bunkering station not on open dec
- Limit ignition sources (certification/shut-off)

04

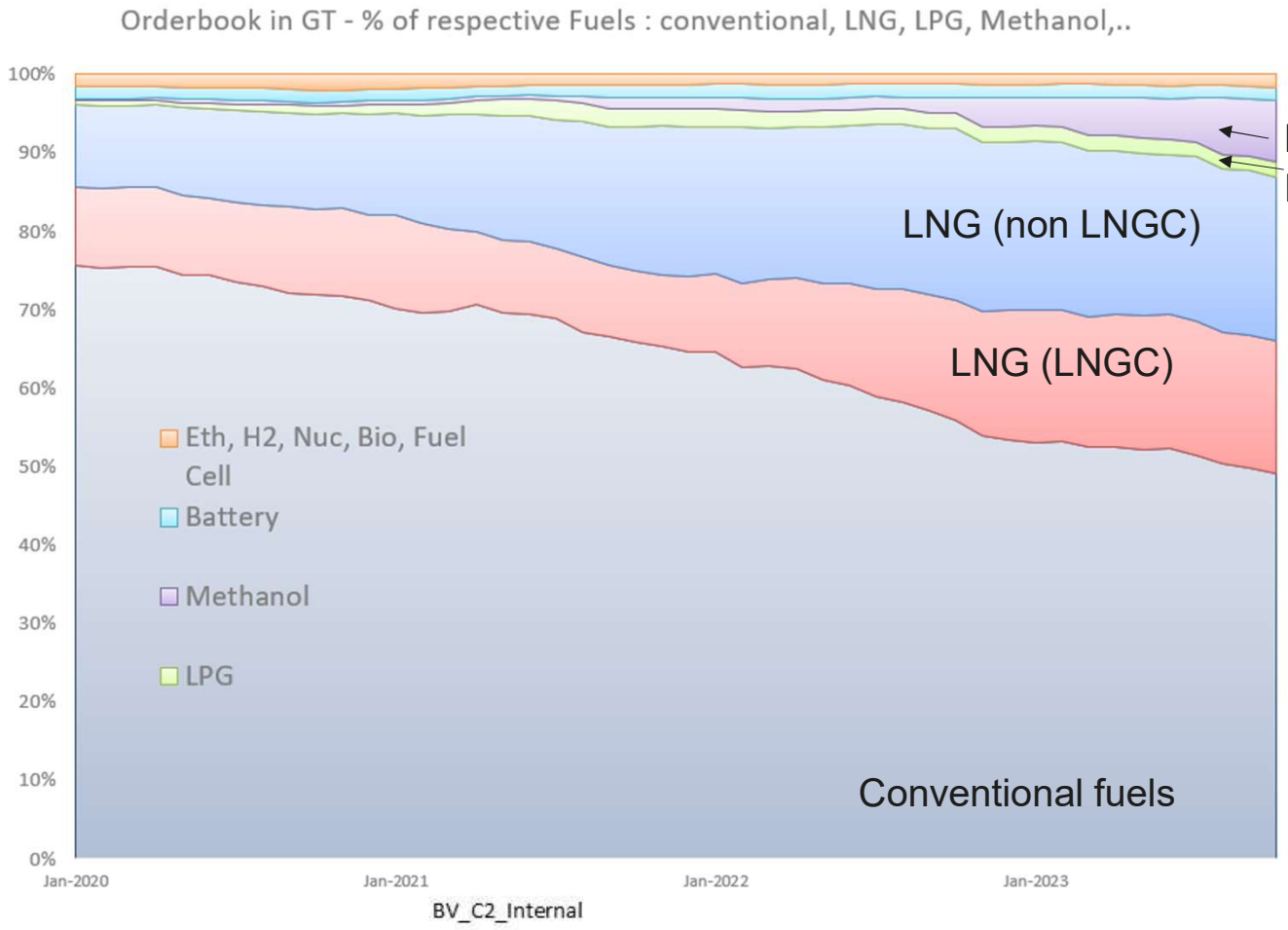
MARKET

MARKET REVIEW - ORDER BOOK AND % OF FUEL

OCTOBER 2023

Alternative fuels amount to 51% of the orderbook (in GT)

- Strong uptake of **Methanol as fuel** Continued interest in **LNG as fuel**
- **LPG as fuel** only for LPGC (100% of in service and 100% of on order)



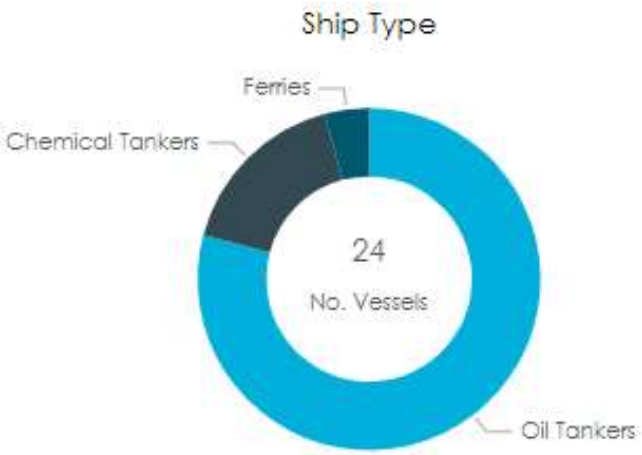
Alternative fuels = LNG (LNGC and non-LNGC), LPG, methanol, Battery, Ethane, Hydrogen, Nuclear, Biofuels

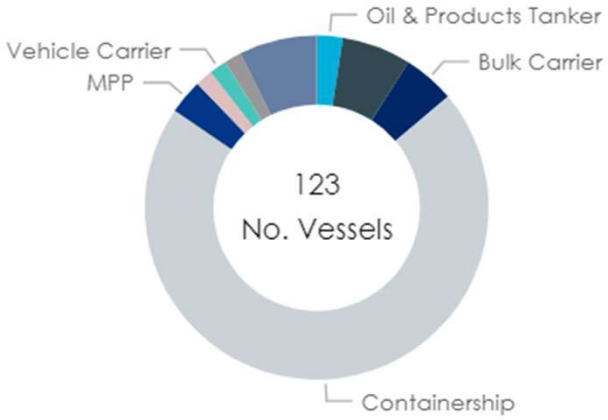
Clarksons Oct 2023

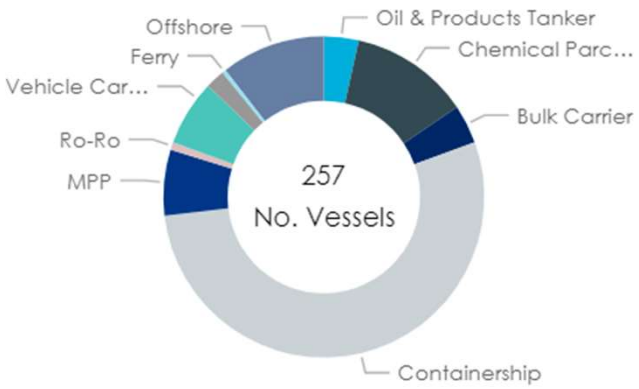
MARKET REVIEW - METHANOL AS FUEL

… A “BOOMING” FUEL : STRONG WITH CONTAINERSHIPS …

JUNE 2023







Clarksons
June 2023

MARKET REVIEW - METHANOL AS FUEL

2013
Concept Design -
Engine Development

2016
WFS 1° generation
vessels launched (7)

2020
WFS 3rd generation
vessels ordered (+8)

2020
IMO methanol
guidelines approved

Fastwater
(2020-24)

Leanships, SUMMETH, Green Pilot,
MoT China Fishing Boat (2015-19)

2015
Stena Germanica Conversion
1° methanol ferry

Powered by four Wärtsilä
4-stroke engines

2019
WFS 2° generation
vessels launched
(+4) 100,000+
running hrs

2020/2021
Major industry
players support
methanol as a
marine fuel

Number of methanol vessels to date:

WATERFRONT Shipping Limited	19
Stena	1
Stena Proman	6
MAERSK	1 + 8
Total	35

COURTESY : METHANEX

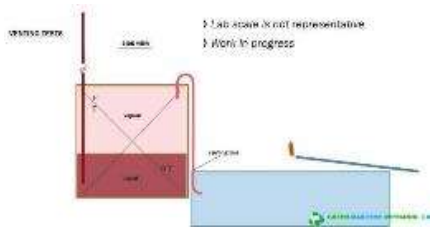
BUREAU VERITAS

METHANOL AS FUEL PROJECTS

- 6 x 15,600 TEU, CMA-CGM, Dalian
- 1 x general cargo, Portugal
- 1 x special service, Spain
- 2 x oil chemical, China
- 6 x 15,000 TEU, CMA-CGM, Jiangnan
- 1 x offshore construction, Jan de Nul
- 2 x containership, Turkey
- + 11 Methanolfuel-Prepared

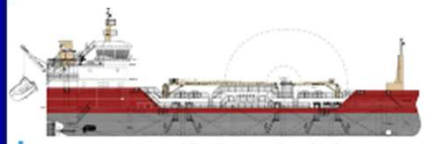
Selection other projects

- Green Maritime Methanol 2.0 (GMM) (~25 stakeholders)
- P1: 31m Tug boat - conversion - inland navigation (ES-TRIN applicable)
- P2: 169m Hopper Dredger - new construction
- P3: 19m special service boat - conversion (ES-TRIN)
- P4: 150m special service ship (rock installation ship) – conversion
- P5: 54m survey vessel – conversion
- P6: 113m container ship – conversion



BUREAU VERITAS

METHANOL & OIL BUNKERING SHIPS



Stena and OljOla to build methanol bunkering vessel for North Europe

BV Reg : 42301G. Yard Turkey.
DWT = 2,000 T

November 03, 2022 | Engines & Fuel, News

Global Energy Group to add 4,000 DWT methanol bunkering ship to its Singapore fleet

BV reg : 43615K (1+1 ships total. See VPM)
DWT = 4,000 T

Industry partners to deliver Singapore's first hybrid electric bunker tankers

BV Reg : 43813A (1+4 ships total, see VPM)
Not methanol bunkering ship, although could carry MeOH
Novelty = first oil bunker with Hybrid Electric
DWT = 7,990 T

Spain: Mureloil SAU orders its first hybrid bunker tanker from Murueta Shipyard

BV Reg : 39459S (1 ship)
DWT = 8,400 T

Thank you

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@bureauveritas_marine

jose.chong@bureauveritas.com

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Our insight into **what will fuel the maritime energy transition.**
Here's what to expect:

Context, challenges and fuel characteristics

Reaching net-zero requires ambitious objectives and collaborative actions. A variety of factors will influence fuel choices.

Supply, availability and scalability

What quantity are available ?

Regulatory and market considerations

How to encourage alternative fuels ?