Methanol: the simple facts

26 November 2020 • 11:00-11:45 GMT

Part of
Marine Fuels
Webinar Week

23-27 November 2020

marine propulsion
& auxiliary machinery

riviera

Panellist documents:

METHANOL INSTITUTE

METHANOL AS A MARINE FUEL

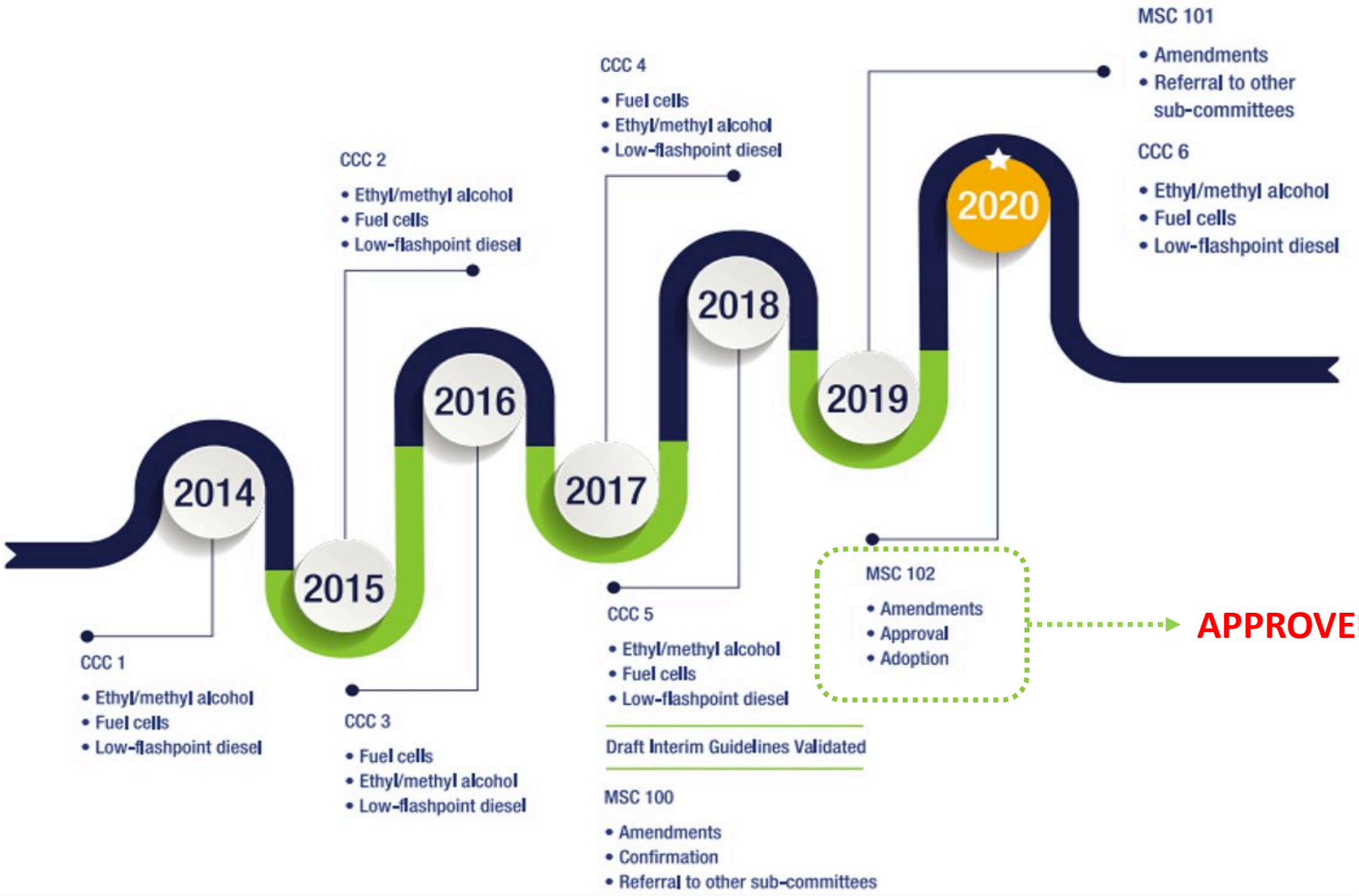
Chris Chatterton, COO

Riviera Marine Air Pollution EU, Virtual Conference 2020

November 24, 2020

Singapore | Washington | Brussels | Beijing | Delhi

IGF Code inclusion



APPROVED Nov, 2020

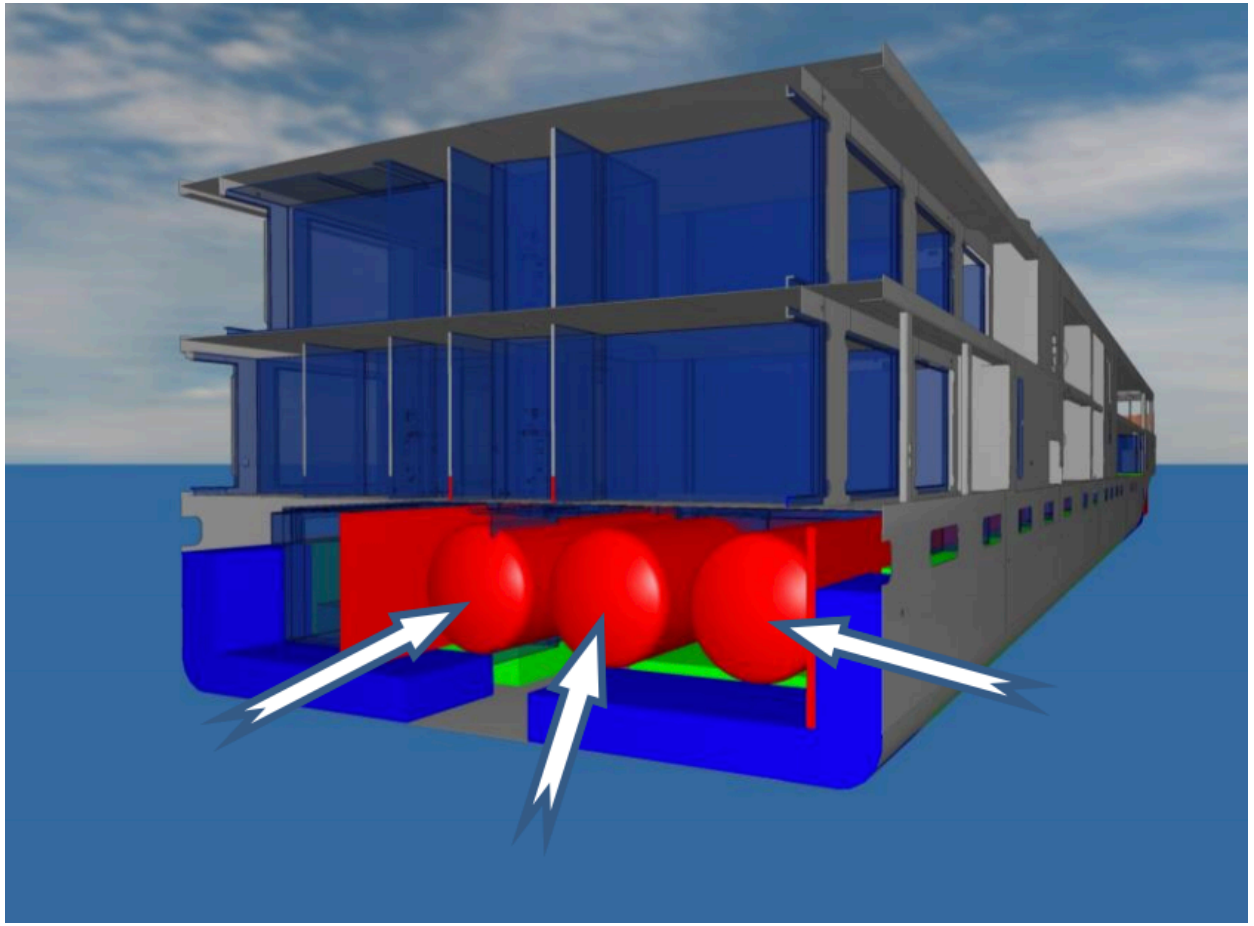
Lloyd's Register Methanol Bunkering TR

- Methanol is increasingly seen as one of the candidate fuels to be used in the decarbonisation of shipping, most resembling a **drop-in fuel**
- **Most infrastructure can be repurposed at a fraction of the cost of cryogenic fuel**
- **Single molecular structure**, irrespective of production – 99.85% puritiy!
- **Engines can be more tightly tuned** since that 'fuel flexibility' is not required
- Toxicity, together with its relatively low flash point of 12°C and material compatibility issues within the **LFSS (liquid fuel supply system) are readily managed with modern technology**
- Currently the **ISO is in the process of developing a methanol marine fuel grade specification and standard** - currently utilizing IMPCA standard

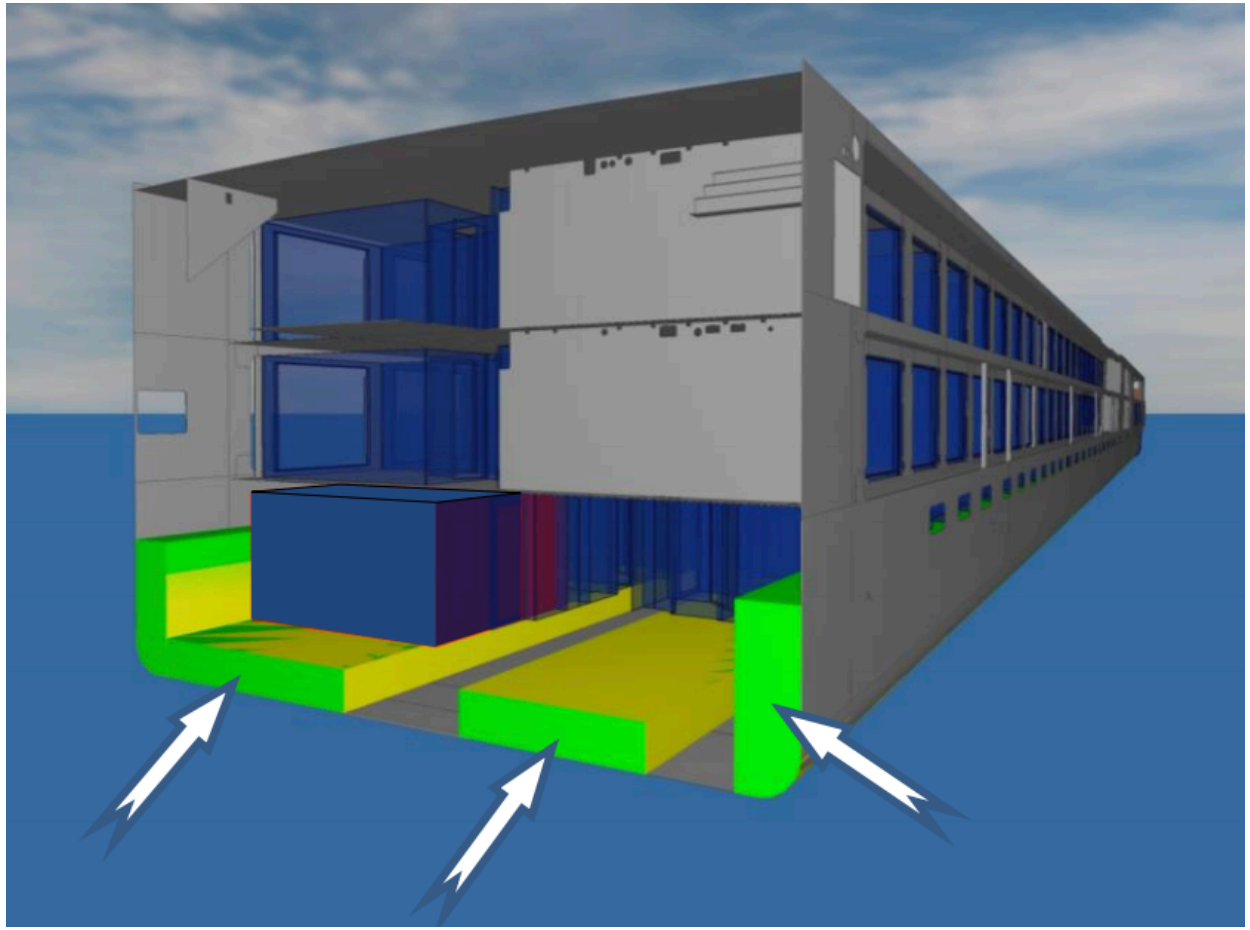
https://www.lr.org/en/latest-news/lr-methanol-institute-guidance-on-methanol-bunkering/

On board energy spacing

LNG: -162C



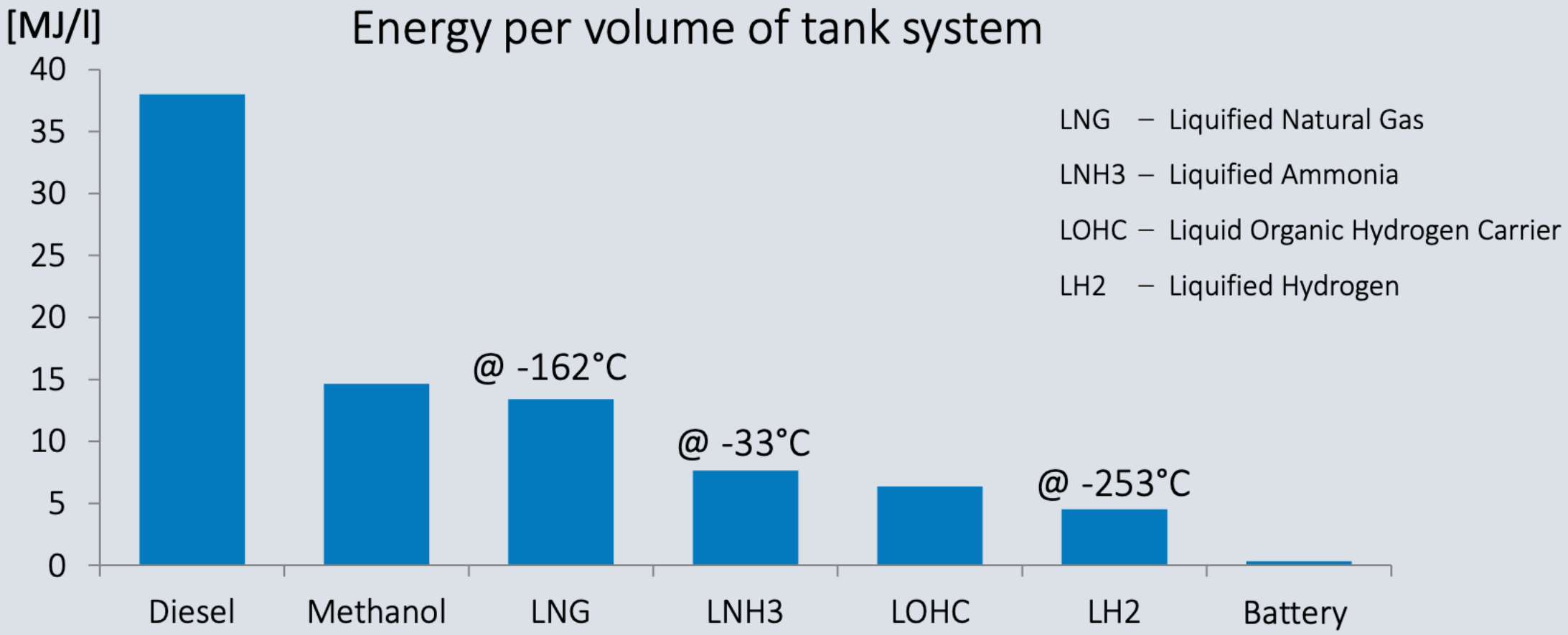
Methanol



Methanol allows for nearly random tank arrangement

Source: Meyer Werft

Fuel storage



Source: Meyer Werft

Battery, H2, LOHC and LNH3 may not be suitable for long distances

Indicative cost of renewable methanol

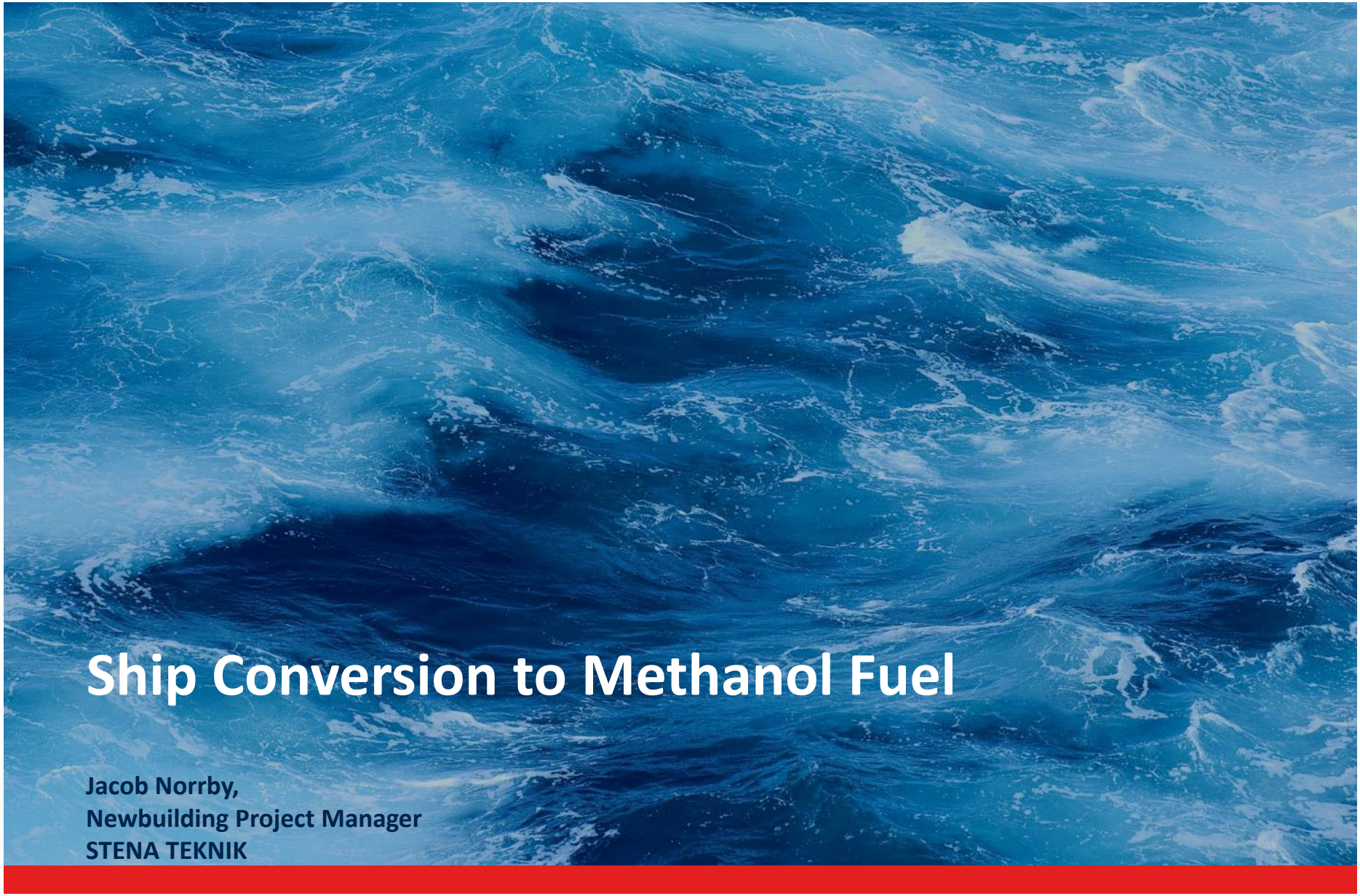
		Estimated Costs in USD		
		2015 – 2018	2030	2050
Cost of green H_2 ($/t H_2) [a]		4000 – 8000	1800 – 3200	900 – 2000
Cost of CO_2 ($/t CO_2) [c]		50 – 100	50 – 100	50 – 100
Cost of Methanol ($/t MeOH) [b]	No Carbon Credit	870 – 1690	460 – 790	290 – 560
	Carbon Credit of $50/t CO_2 [d]	780 – 1610	370 – 700	200 – 480
	Carbon Credit of $100/t CO_2 [d]	700 – 1520	290 – 620	120 – 390

(a) Source: (IRENA, 2020)

(b) assuming $50 per ton synthesis cost for e-methanol once the raw material, H_2 and CO_2 are provided

(c) Origin of the CO_2 will change over time as volumes increase

(d) The carbon credit per ton of e-methanol is based on the difference between the average CO_2eq emissions from methanol production from natural gas (95.2 gCO_2eq/MJ) and average CO_2eq emissions from e-methanol production from renewable CO_2 and H_2 (8.645 gCO_2eq/MJ). Considering a LHV of 19.9 MJ/kg for methanol, this corresponds to a 1.72 tCO_2eq of emission avoided per ton of e-methanol, compared to traditional natural gas based methanol.



Ship Conversion to Methanol Fuel

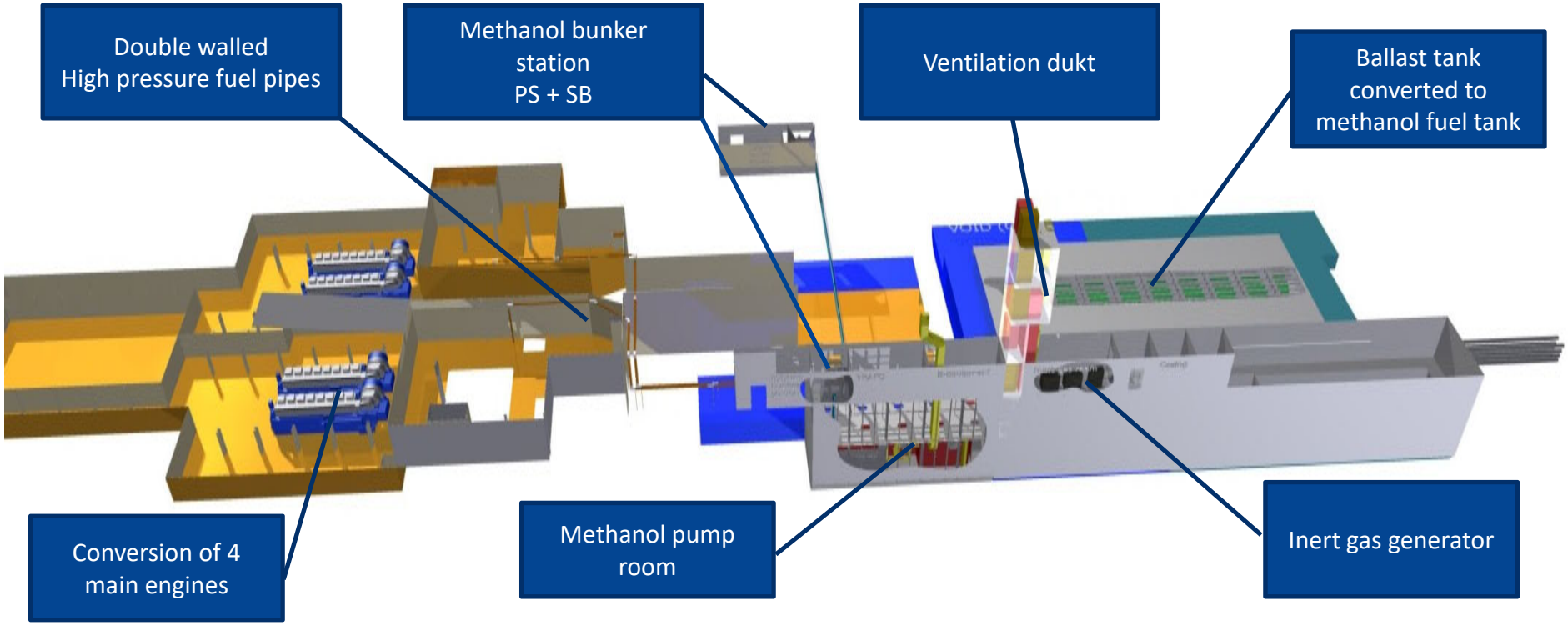
Jacob Norrby,
Newbuilding Project Manager
STENA TEKNIK

Stena Teknik
CARE, INNOVATION & PERFORMANCE

STENA GERMANICA

- Converted 2015 for Methanol
- Bunkering
- Storage Tanks
- Supply System
- Retrofit four 4-stroke ME:s
- Safety System

Stena Teknik
CARE, INNOVATION & PERFORMANCE



Stena Teknik
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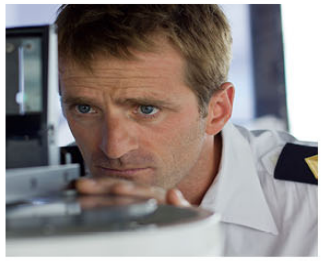
Experiences

- Pipe connections
- Vibrations in HP piping
- More than 10,000 hrs running
- Methanol well suited marine fuel

Stena Teknik
CARE, INNOVATION & PERFORMANCE

WE CARE



WE INNOVATE

WE PERFORM

Stena Teknik

CARE, INNOVATION & PERFORMANCE

Marine Fuel Webinar Week

‘Methanol: the simple facts’

26th November 2020

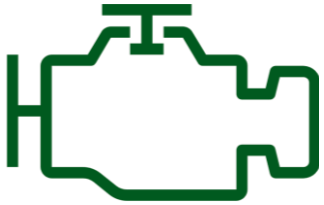
Proman Stena Bulk JV – Dual-fuel vessels to be in service by 2022

- Owner: Proman Stena Bulk Limited
- Engine: Methanol Dual Fuel (MAN B&W 6G50ME-C9.6 MW Tier III)
- IMO II – 18 Cargo Tanks
- Methanol consumption: ~ 40-46 MT/Day
- Size (DWT): 49,900 MT
- Delivery – 2022
- **Prosperous to be the first methanol dual-fuel ship available for trade to non-methanol producers, from 2022**

What needs to be done to increase the pace of market development?

Regulatory

Technical Development



Bunkering Availability

Pricing

Proman Focus

Pricing & Availability Considerations

Pricing

Producers / marketers need to be flexible and creative on pricing structures, and this is a focus for Proman

Flexibility on Price Indices

- Fuel Oil
- Henry Hub
- Others

Flexibility on Contract Tenors

- Short Term
- Mid Term
- Long Term

All-in Solution

Ensure fuel bunkering and availability is in place

Bunkering

Methanol is available in 120+ ports and handled safely in existing infrastructure

Required work

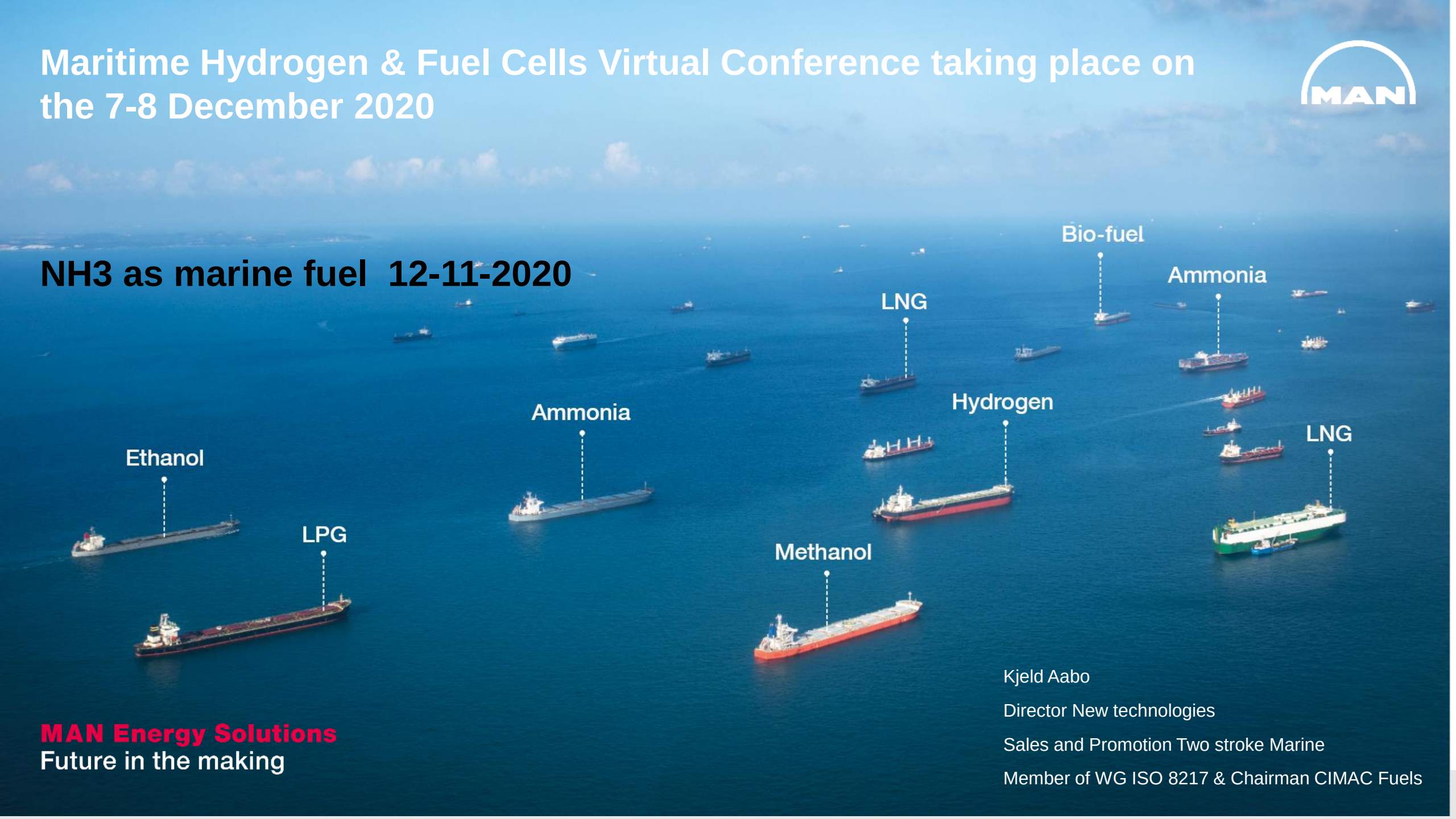
- Work with port authorities and address safety check-list and procedural aspects
- Work with customers to understand and address their needs
- Work with bunkering companies on terminal fuel availability

Proman Focus!

Thank you

Maritime Hydrogen & Fuel Cells Virtual Conference taking place on the 7-8 December 2020

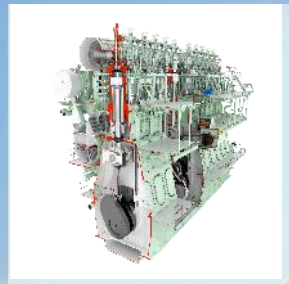
NH3 as marine fuel 12-11-2020



MAN Energy Solutions
Future in the making

Kjeld Aabo
Director New technologies
Sales and Promotion Two stroke Marine
Member of WG ISO 8217 & Chairman CIMAC Fuels

The world’s leading designer of two-stroke Diesel engines



Design of
two-stroke engines

Production of
spare parts

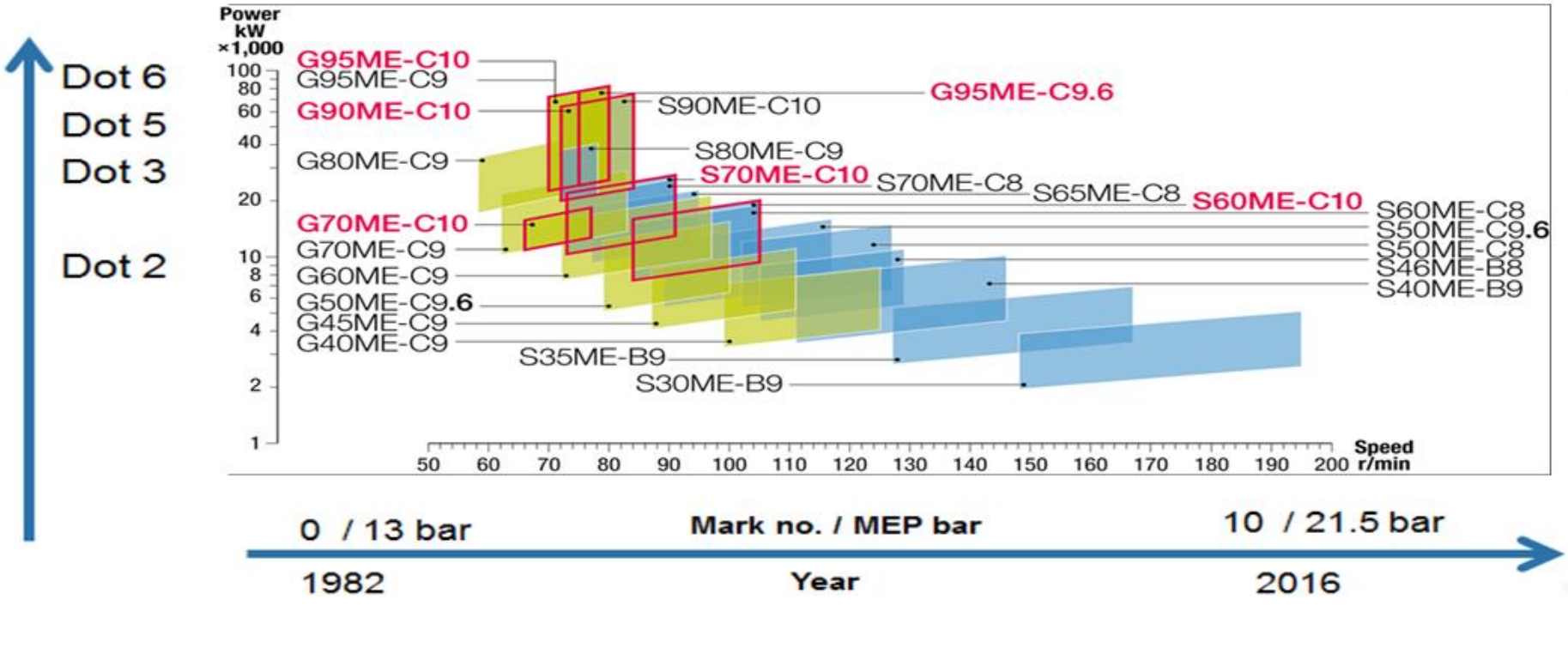
PrimeServ Academy

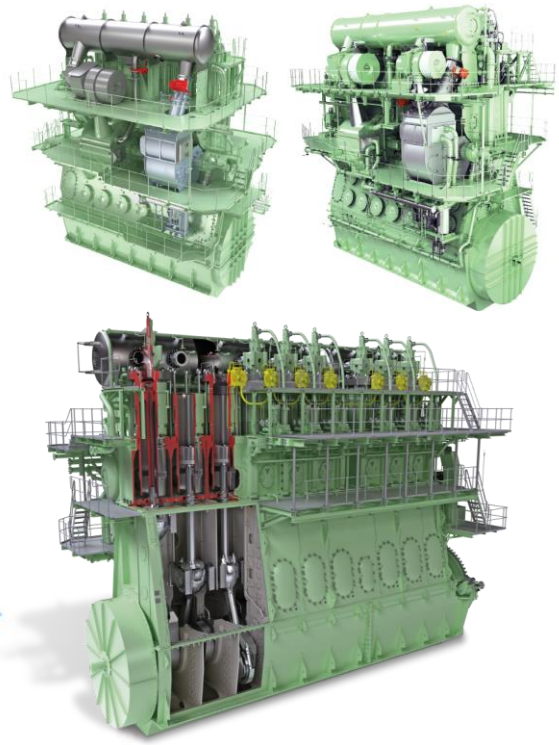
R&D Centre

Diesel House

The test engine no. 2 arriving at Copenhagen

Engine Programme Development

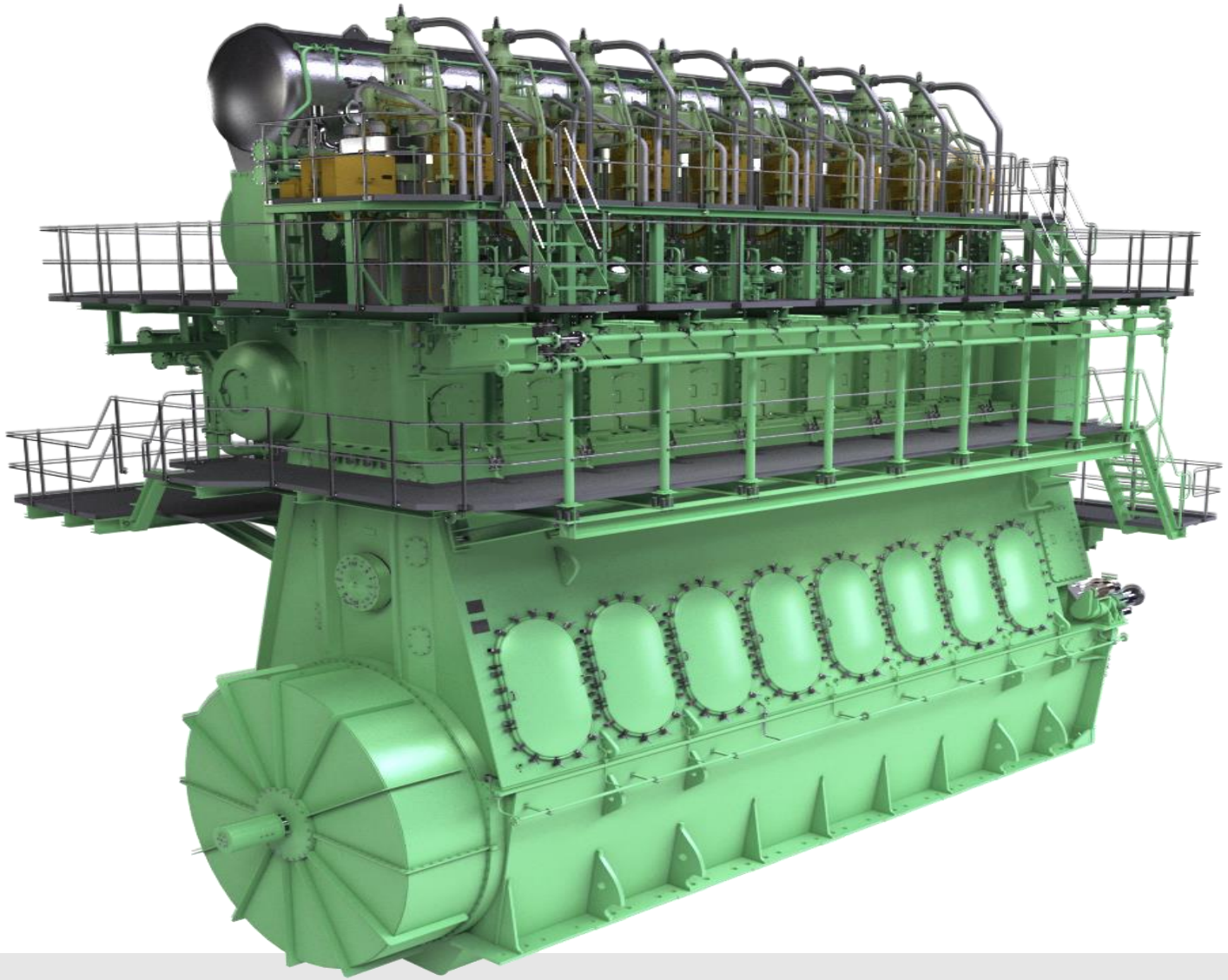




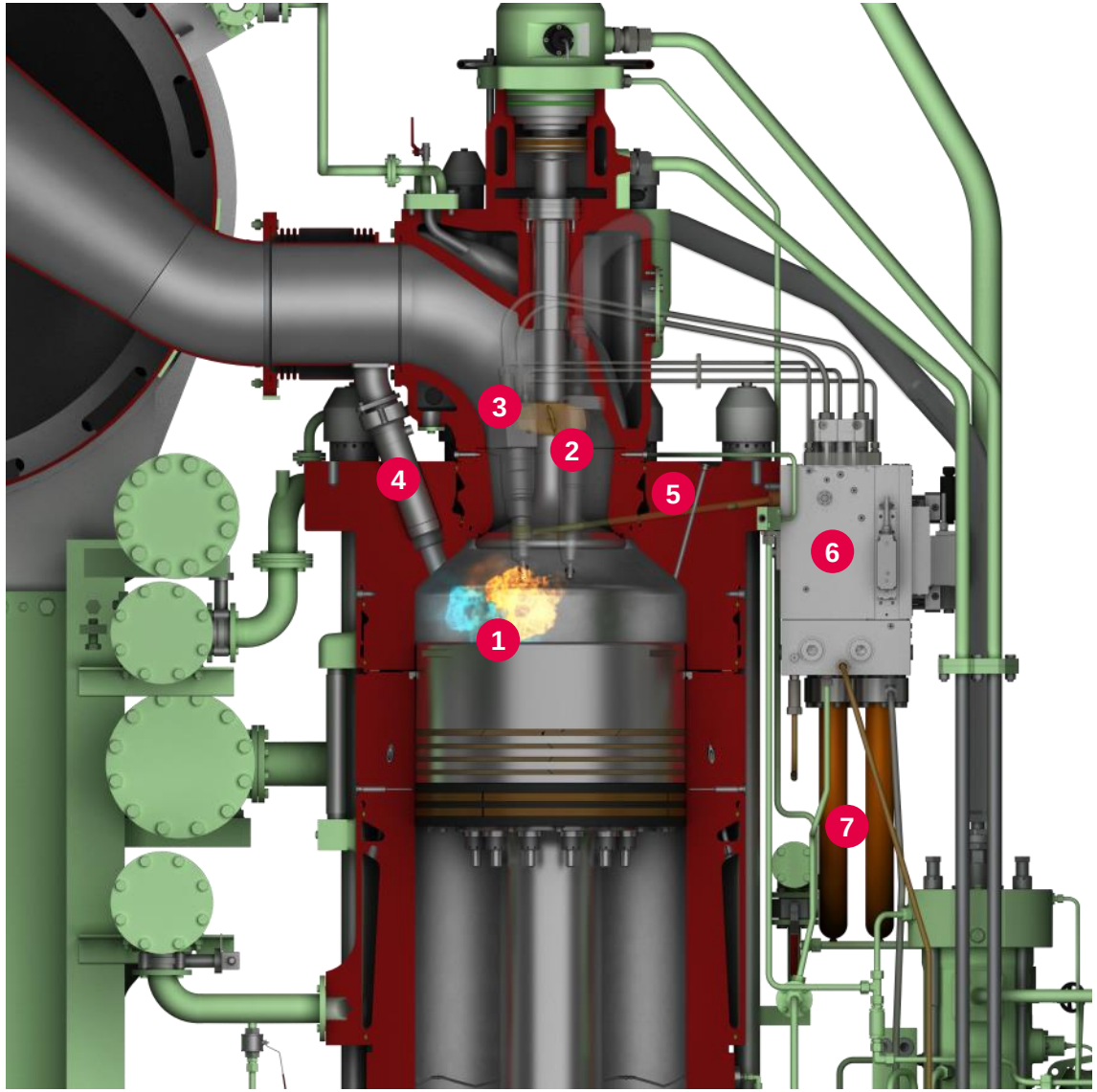
Mission: Meet any combination of propeller power and speed the naval architects will need

ME-GI engine

GI components



Combustion Principle - diesel cycle



1. From actual footage (colorized)
   Yellow = pilot oil (0.5 to 5%* @100% load)
   Blue = fuel gas
2. Conventional slide fuel valve
3. Gas fuel valve
4. High pressure safety valve
5. Gas distribution channel (yellow)
6. Gas distributor block
7. Gas chain link double-walled pipes

*) based on main fuel selection

MAN B&W engines for new marine fuels

LNG		Ethane	Methanol	LPG	Ammonia
ME-GI	ME-GA	ME-GIE	ME-LGIM	ME-LGIP	→ 2024

Dual fuel reference list

Engine type	Number of engines		Stroke	Bore	Total engines	Engines in service
ME-GI	235	6	S	90	333	120
		19	G	90		
		3	S	80		
		4	S	70		
		179	G	70		
		5	L	70		
		3	G	60		
		2	S	60		
		9	S	50		
		1	G	50		
		4	G	45		
ME-LGIM	26	23	G	50		
		3	S	50		
ME-GIE	28	21	G	60		
		3	G	50		
		4	S	50		
ME-LGIP	42	33	G	60		
		2	S	60		
		2	G	50		
		5	S	35		

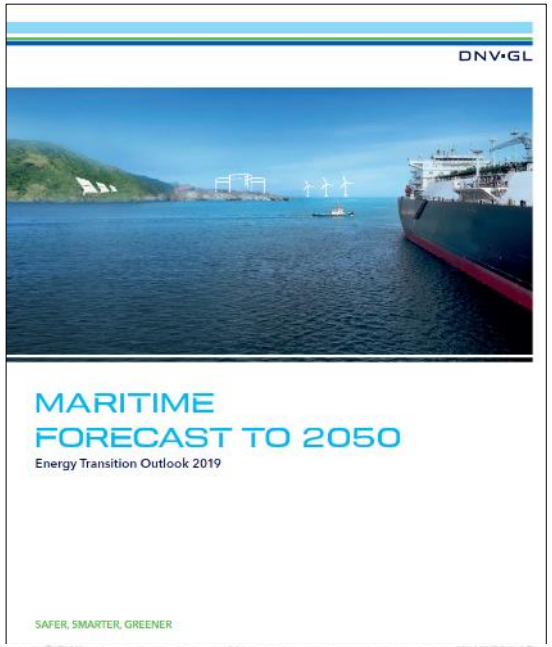
Modular design enables extensive retrofit options

By ensuring **full fuel flexibility and extensive retrofit capabilities with a proven record,**
MAN Energy Solutions **future proof** your investment

Fuel types	MC	ME-B	ME-C	ME-GI	ME-GA	ME-GIE	ME-LGIM	ME-LGIP
0-0.50% S VLSFO	Design	Design	Design	Design	Design	Design	Design	Design
HFO	Design	Design	Design	Design	Design	Design	Design	Design
Biofuels	Design	Design	Design	Design	Design	Design	Design	Design
LNG	-	-	Retrofit	Design	Design	Retrofit	Retrofit	Retrofit
LEG (Ethane)	-	-	Retrofit	Retrofit	-	Design	Retrofit	Retrofit
Methanol / Ethanol	-	-	Retrofit	Retrofit	-	Retrofit	Design	Retrofit
LPG	-	-	Retrofit	Retrofit	-	Retrofit	Retrofit	Design
Ammonia****	-	-	Retrofit	Retrofit	-	Retrofit	Retrofit	Retrofit

Estimates of ammonia uptake

DNV-GL predict new ships to be fueled by green ammonia by the 2030's.



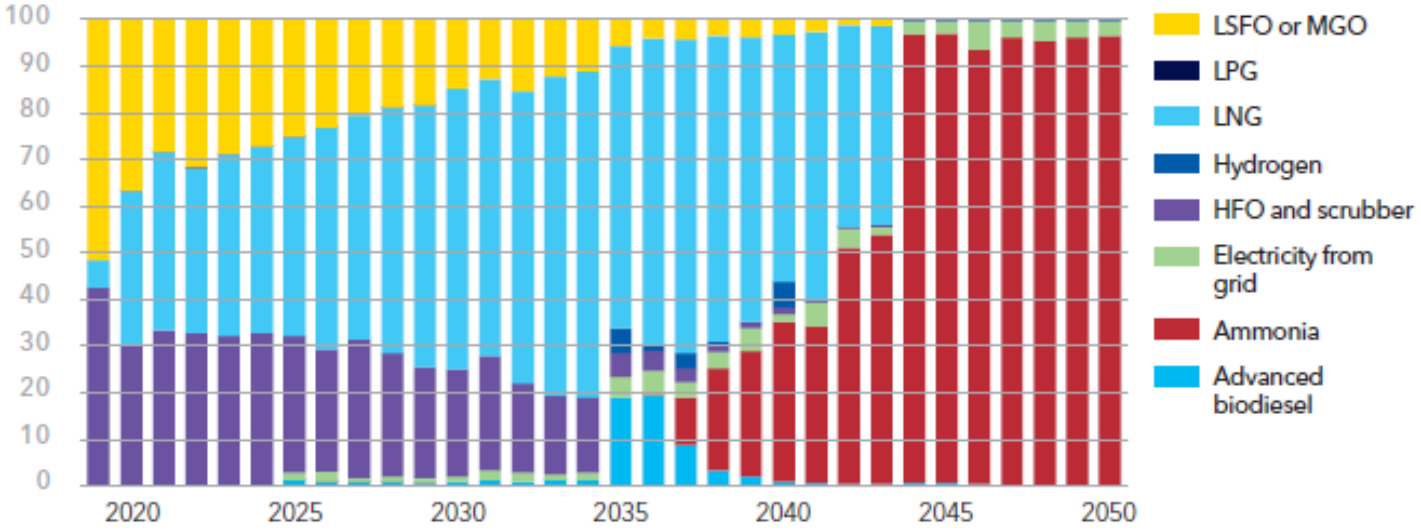
"Ammonia is the most promising carbon-neutral fuel option for newbuildings."

(DNV-GL, 2019, p. 15)

FIGURE 6.6

Share of fuels (% of energy bunkered) for newbuildings for the IMO ambitions DR pathway (2018-2050) with main focus on design requirements

Units: Percentage (%)



LSFO, low-sulphur fuel oil; MGO, marine gas oil; LPG, liquefied petroleum gas; LNG, liquefied natural gas; HFO, heavy fuel oil
Advanced biodiesel, produced by advanced processes from non-food feedstocks

Alternative fuels

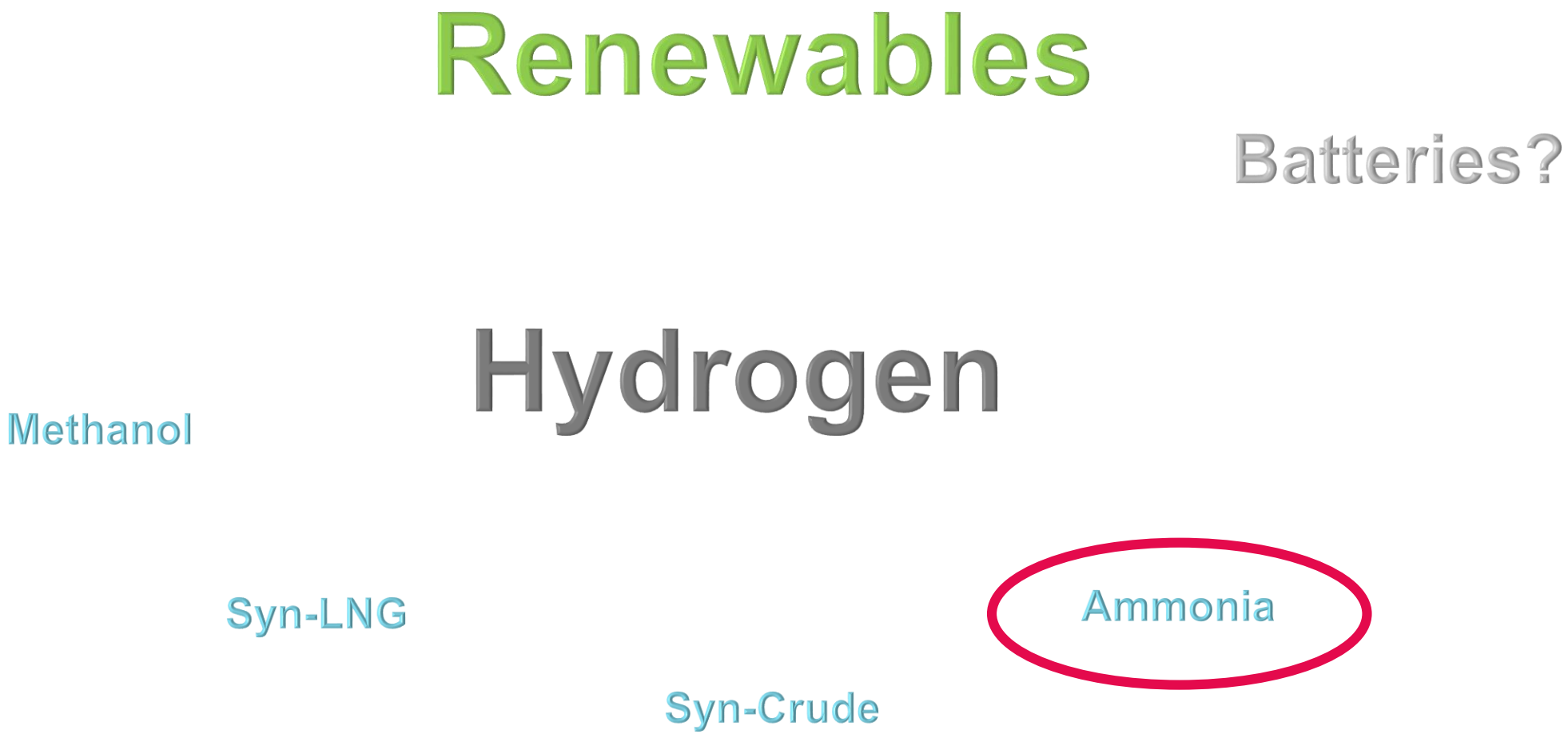
Properties

Energy storage type	Specific Energy MJ/kg	Energy Density MJ/L	Required Tank Volume m^3. [1]	Supply pressure bar	Estimated PtX efficiency	Injection pressure bar	Emission Reduction Compared To HFO Tier II			
MGO	42,7	35,9	1000	7-8		950	SO_x	NO_x	CO2	PM
Liquefied natural gas (LNG -162 °C)	50.0	22,4	1602	300	0,56	300	90-99%	20-30%	24%	90%
Liquid ethane gas (LEG -88 °C)	47,5	17,1	2099	380		380	90-97%	30-50%	15%	90%
liquefied petroleum gas (LPG -42,4 °C)	46,4	23,5	1527	50		600-700	90-100%	10-15%	13-18%	90%
Methanol	19.9	15,8	2272	10	0,54	500	90-97%	30-50%	5%	90%
Ethanol	26	21,2	1693	10		500				
Ammonia (liquid -33 °C)	18,6	11,5	3121	70	0,65	600-700	100%	Compliant with regulation	>95%	>90%
Hydrogen (liquid -253 °C)	120	8.5	4223		0,68					
Marine battery market leader, Corvus, battery rack	0,29	0,33	108.787							
Tesla model 3 battery Cell 2170*. [2]	0,8	2.5	14360							

- *1: Given a 1000 m^3 tank for MGO. Additional space for insulation is not calculated for in above diagram. All pressure values given a high pressure Diesel injection principle.*
- *2: Values for Tesla battery doesn't contain energy/mass obtained for cooling/safety/classification .*

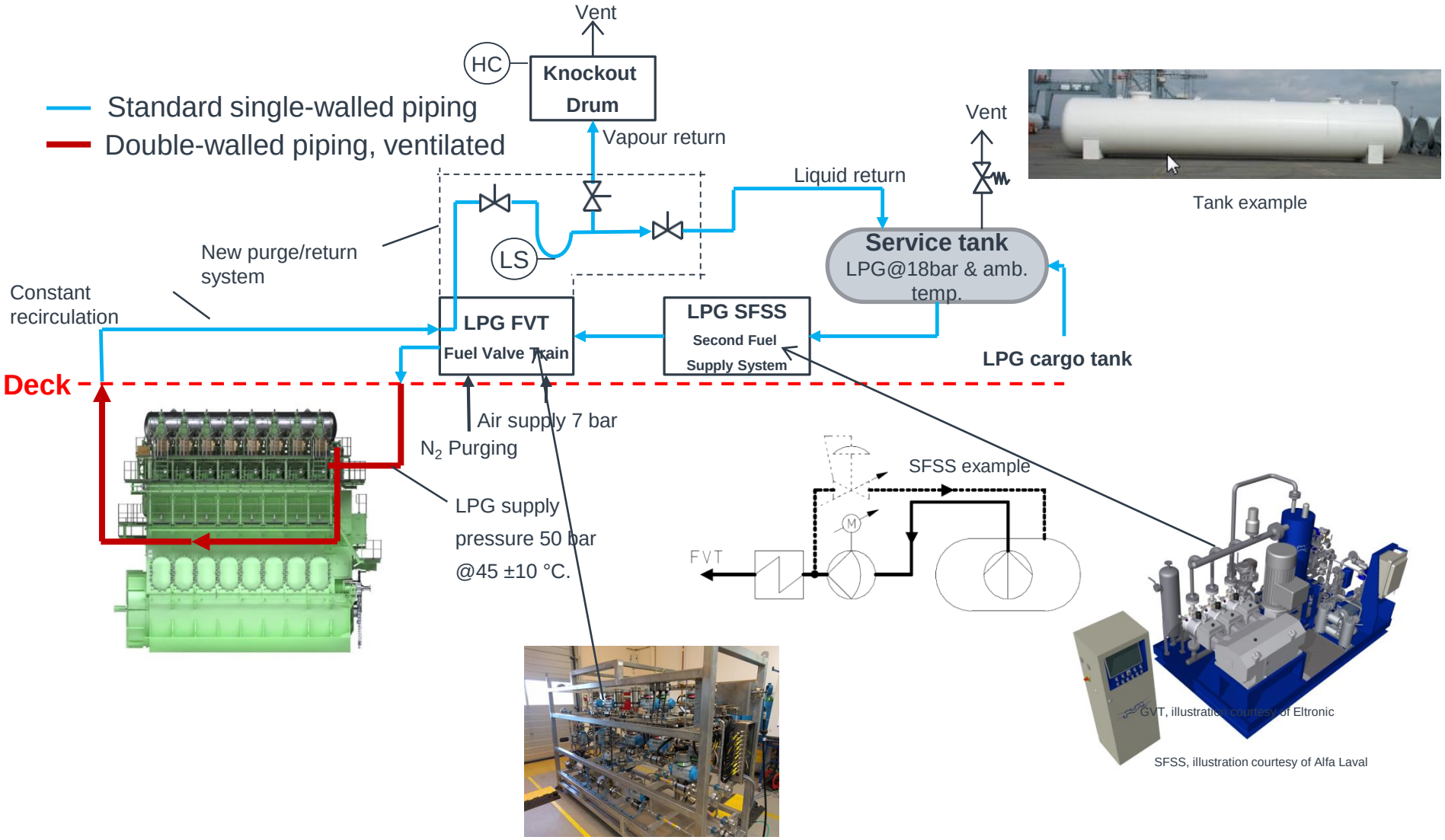
Green Ammonia as a fuel in shipping

Why



ME-LGIP Gas Technologies - LPG

ME-LGIP: LPG system layout – simplified

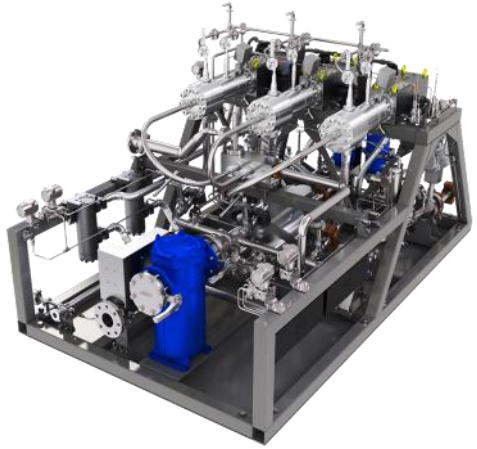


World’s first conversion of a VLCV

Hapag Lloyd 15.000 TEU VLCV

GI components

Pump Vaporizer Unit (PVU)



LNG Tank & FGSS

Retrofit Conversion Reference List

In Service	In process
ME-GIE: 1	ME-GI incl. FGSS & PVU: 1
ME-GI: 2	ME-LGIP: 12 (1 completed)

Two-Stroke Ammonia Engine Development Schedule

2019

Pre-study

- ✓ NH3 combustibility investigation.

2020

Project kick-off

- ✓ 4T50ME-X test engine received as platform for the Ammonia engine development.
- ✓ HAZID workshop on engine concept.

2021

1st engine test

- 1st engine confirmation at Research Centre Copenhagen (RCC).
- Engine basic concept defined based on engine tests.
- Ammonia supply & Auxiliary systems specified

2022

Emission specification

- Specification of emission after-treatment done.

2023

Full scale engine test

- Full scale engine test at RCC completed.

2024

1st engine delivery to yard

- Ammonia engine in engine programme.
- 1st ammonia burning engine to be installed at yard.

Solutions for retrofitting to alternative fuels

Future Proof Engine Technology

- MAN B&W ME-C engines are Future Proof and can be retrofitted to use LNG, LPG, Ethane and Methanol as fuel
- MAN Energy Solutions extensive Dual Fuel portfolio is now being supplemented with the development of an engine type using Ammonia (NH3) as fuel.

Retrofit to use of Ammonia as fuel:

- MAN Energy Solutions is working diligently towards being able to offer retrofit conversion of 2-stroke engines to use Ammonia (NH3) as fuel, preferable meeting vessels 5 year docking schedules after Q1 2025.

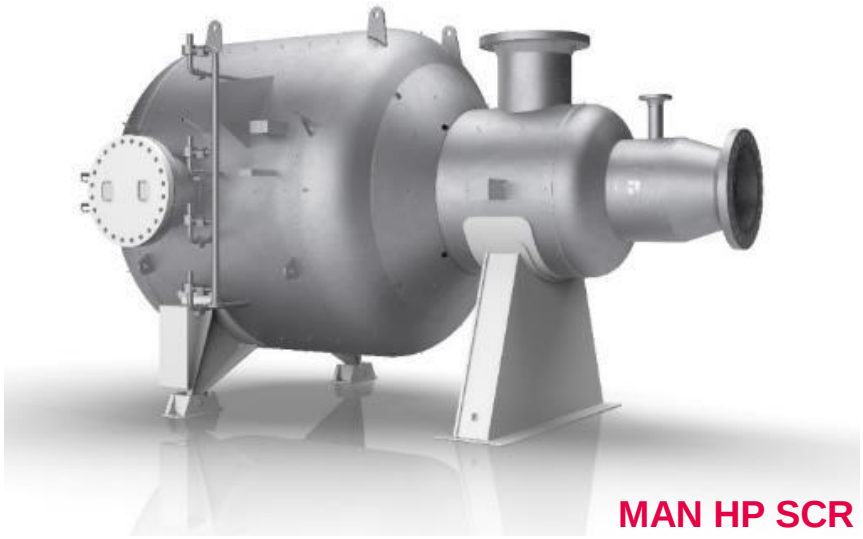
Ammonia engine developments

Engine Technology

- Ammonia in an internal combustion engine has been proven difficult in the past, however very little literature on the matter exists
- A long stroke slow speed engine is unchartered territory when it comes to ammonia
- Our two stroke slow speed engines have proven to be very robust even with the most difficult fuels, simply because there is ample pressure and time available for the combustion process

Emissions

- Unburned ammonia must be eliminated
- NO will be formed even at low temperatures
- N_2O emission, a potent green house gas, is a concern
- SCR systems, sized similarly to today TIII systems is the obvious proven choice to deal with some of these emissions



MAN HP SCR

All data provided in this document is non-binding.
This data serves informational purposes only and is especially not guaranteed in any way.
Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.

Methanol

A Clean, Cost-Effective Marine Fuel Solution

GREEN MARINE PARTNER

Methanol – Marine Fuels Webinar Week

26 November 2020

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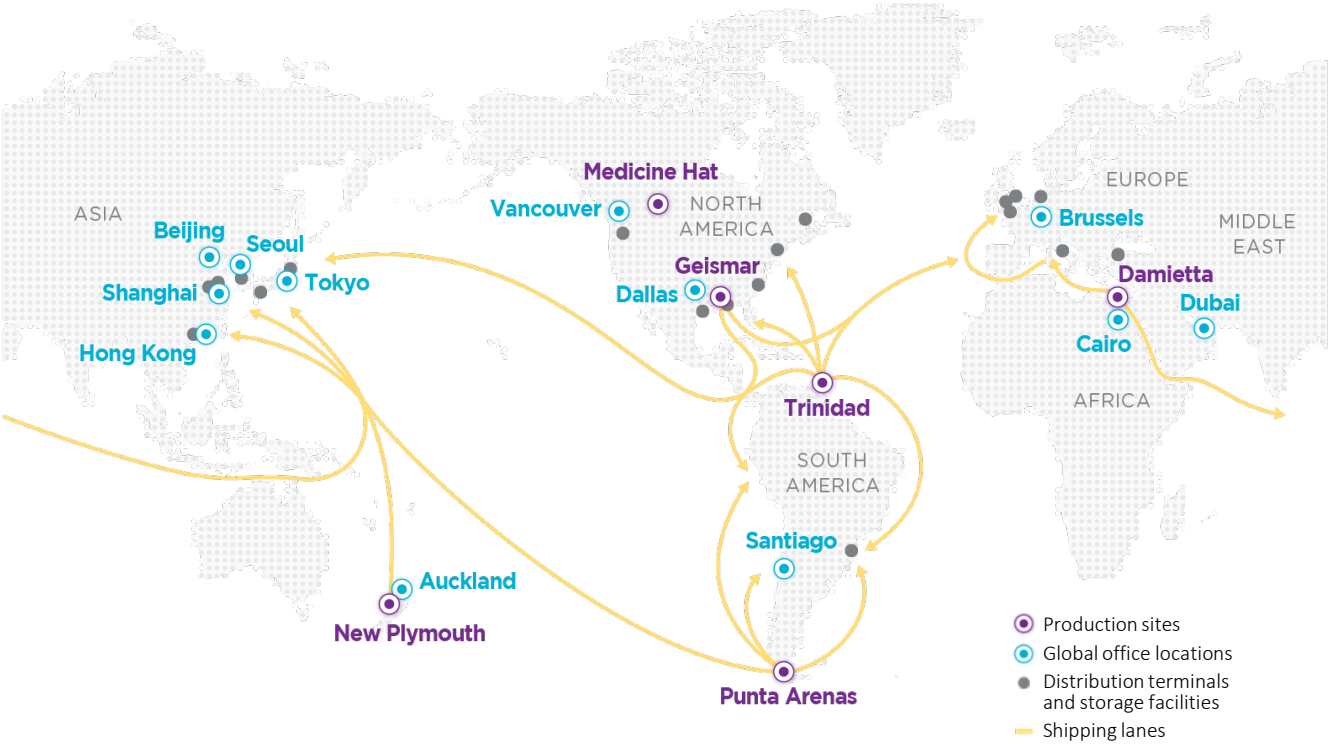
Methanex

The world's largest producer and supplier of methanol to major international markets



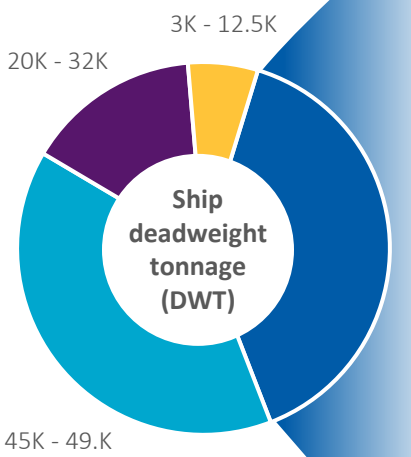
Headquartered in Vancouver, Canada, Methanex operates production sites in Canada, Chile, Egypt, New Zealand, the United States and Trinidad and Tobago.

Our global operations are supported by:

- an extensive global supply chain of terminals
- storage facilities and
- the world's largest dedicated fleet of methanol ocean tankers.

Waterfront Shipping fleet

Approximately 40% of our long-term fleet is powered by methanol



49,999 DWT Methanol Dual Fuel Engine


Cajun Sun


Manchac Sun


Lindanger


Taranaki Sun


Mari Jone


Leikanger


Mari Boyle


Creole Sun


Mari Couva


Mari Kokako


Takaroa Sun

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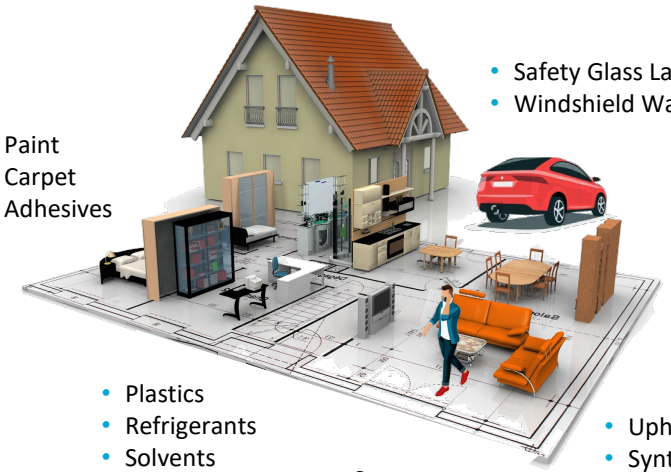
Methanol

An essential ingredient of modern life

Traditional Chemical Market

Essential ingredient used in countless industrial and consumer products

Slightly over 50% of global demand



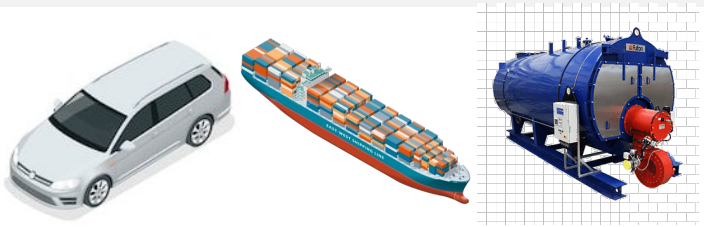
- Paint
- Carpet
- Adhesives
- Safety Glass Laminate
- Windshield Washer Fluid
- Plastics
- Refrigerants
- Solvents
- Sportswear
- Fleece Fabrics
- Upholstery
- Synthetic fibres

Clean and Economic Alternative Fuel

Represents a growing demand segment for methanol

Just under 50% of global demand

Fuel applications

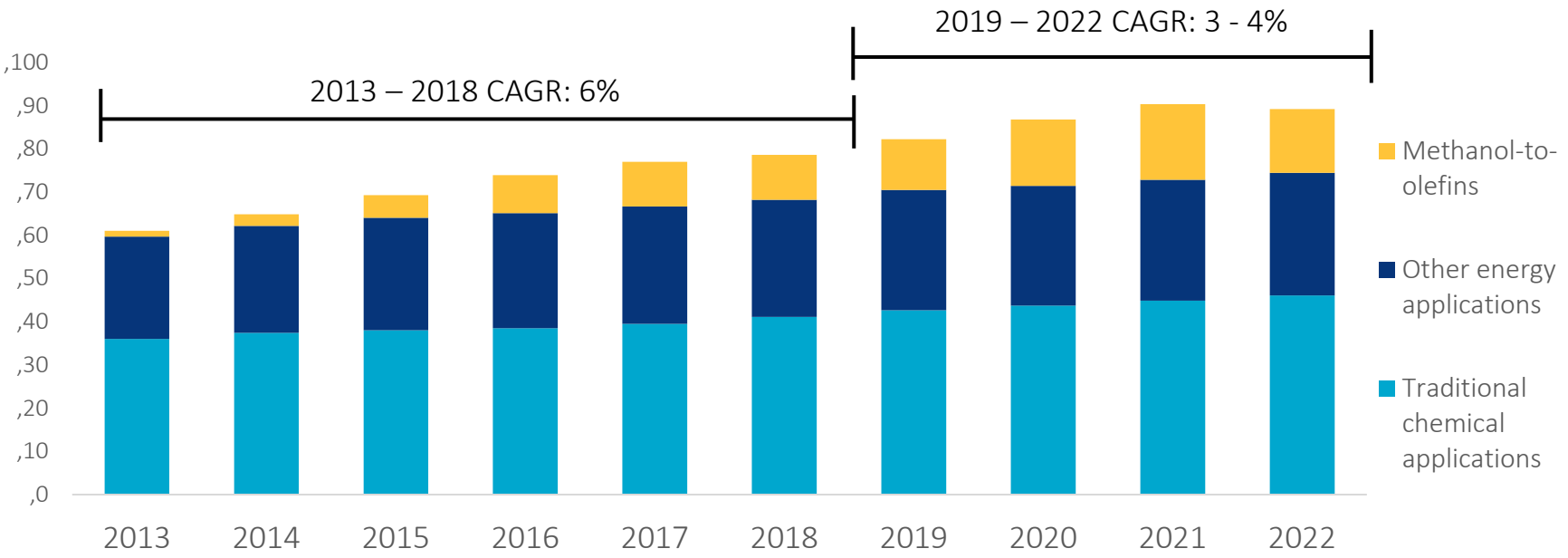


Methanol-to-olefins (MTO)

methanex
the power of agility

Strong market growth driven by demand

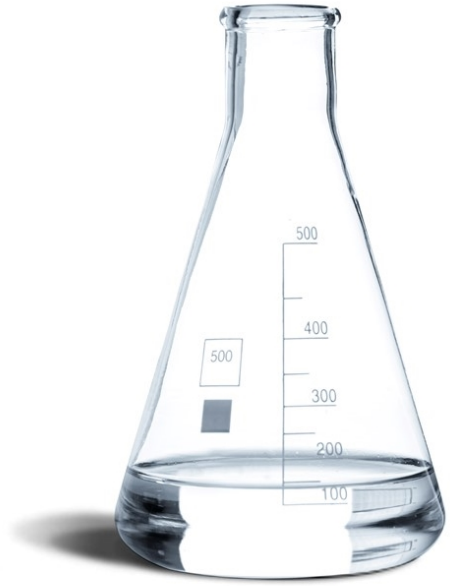
Projected 3-4% CAGR with steady growth across various applications



Source : IHS Chemical Supply and Demand Fall 2019 Update. Excludes demand from integrated coal-to-olefins (CTO) facilities.

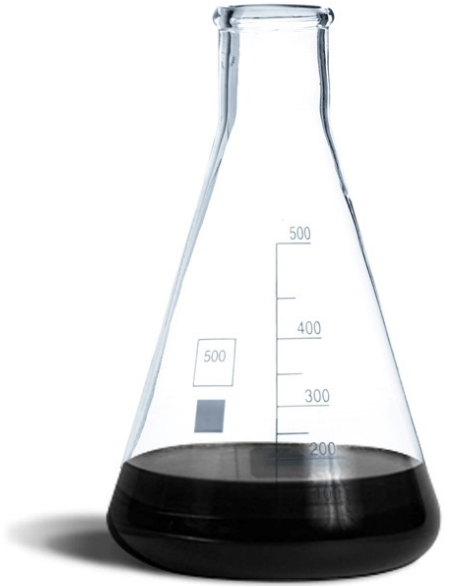
Methanol as a marine fuel

Methanol is an innovative alternative fuel solution with many benefits



Methanol

Environmental	• Low emissions • Safe, environmentally friendly • Bio-degrades rapidly in water
Available	• Available globally • Long history of safe handling • Straightforward bunkering with existing infrastructure
Affordable	• Low incremental investment • Competitive fuel costs • Liquid fuel flexibility
Proven	• Successfully in use today • Commercialization activity expanding



Diesel bunker fuel

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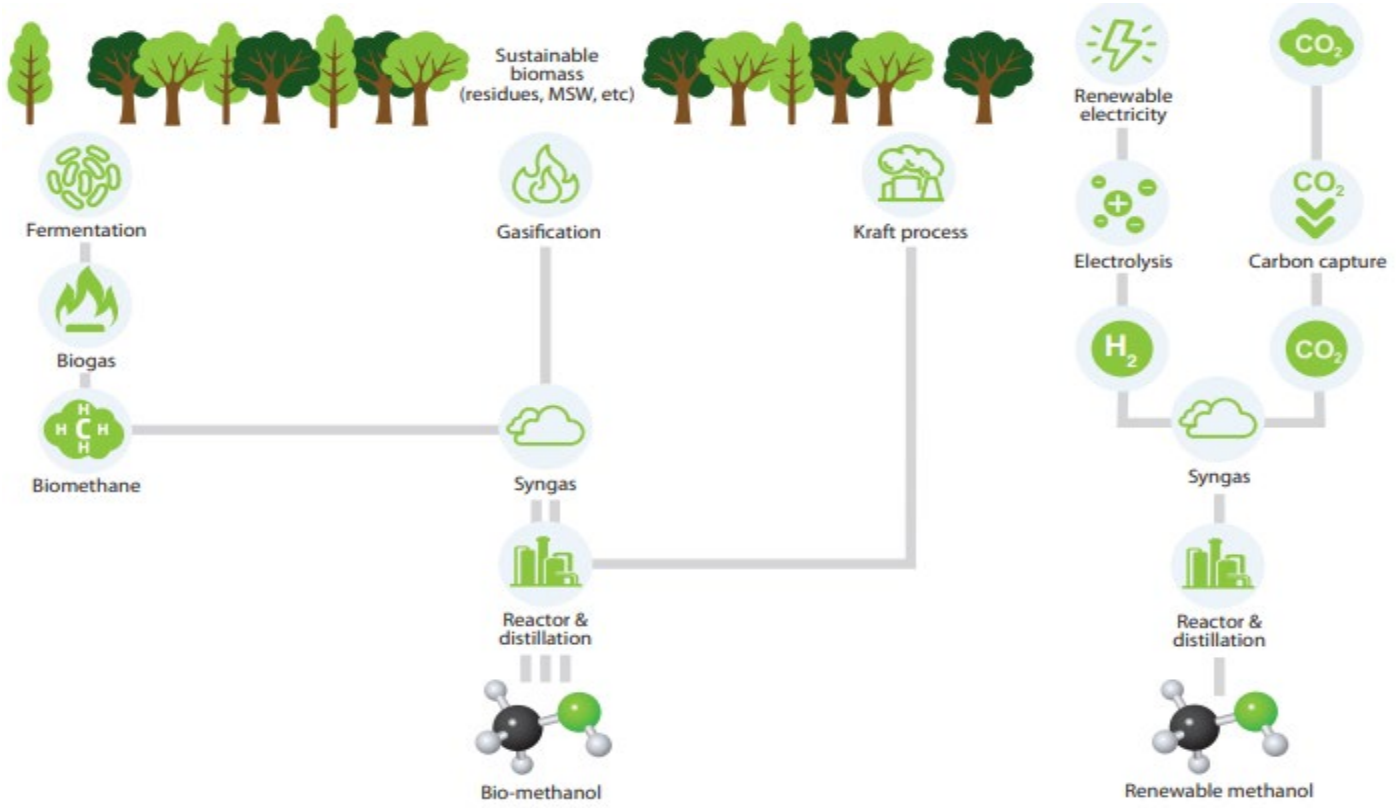
CO_2 Reduction Pathway to Meet IMO 2050 Goals



Source: The Methanol Institute and QAFAQ

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Thank you

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