WHEN TRUST MATTERS

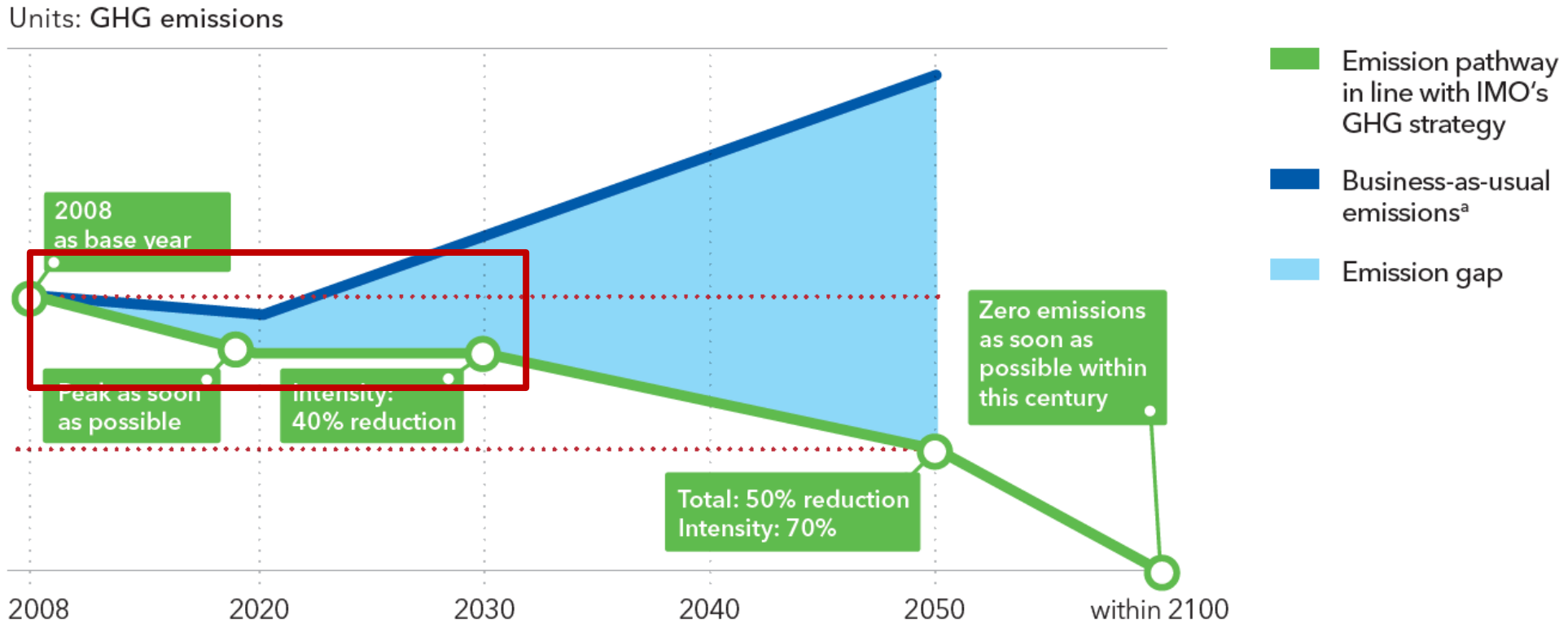
Future Marine Fuels

Ren Luft webinar

Christos Chryssakis, Business Development Manager

17 March 2021

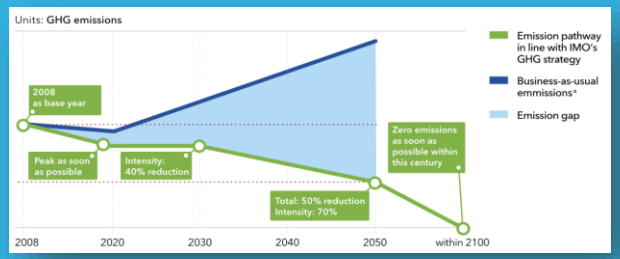
IMO strategy on GHG reductions – vision and ambitions



Total: Refers to the absolute amount of GHG emissions from international shipping.
Intensity: Carbon dioxide (CO_2) emitted per tonne-mile.
a) Note that the the business-as-usual emissions are illustrative, and not consistent with the emissions baseline used in our modelling (Chapter 6).

Attention to CO_2 emissions is intensifying – calls for transparency

IMO Ambitions



EU

Climate Initiative Bonds

Who is next?

Banks assessments

POSEIDON PRINCIPLES

Some of the Signatories

BNP PARIBAS The bank for a changing world

CRÉDIT AGRICOLE CORPORATE & INVESTMENT BANK

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CREDIT SUISSE

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Nordea

DNB

Danske Bank

Charterer requirements

SEA CARGO CHARTER

Some of the Signatories

TRAFIGURA

DOW

TOTAL

equinor

GUNVOR

LDC. Louis Dreyfus Company

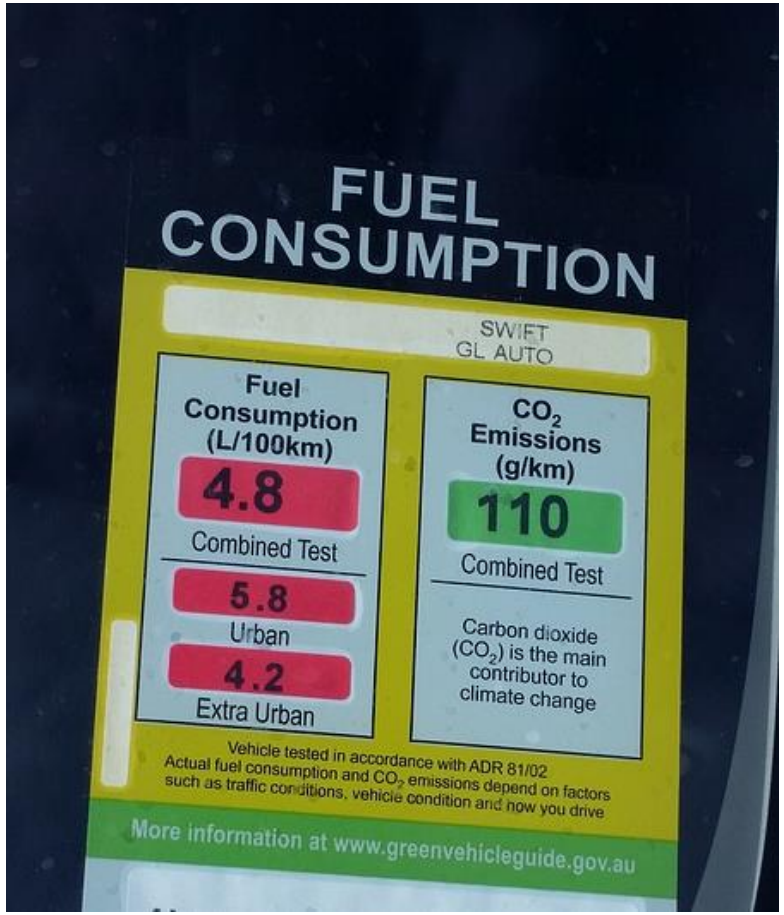
Cargill

AngloAmerican

DNV

IMO Short term measures: EEXI and CII

EEXI: Design indicator

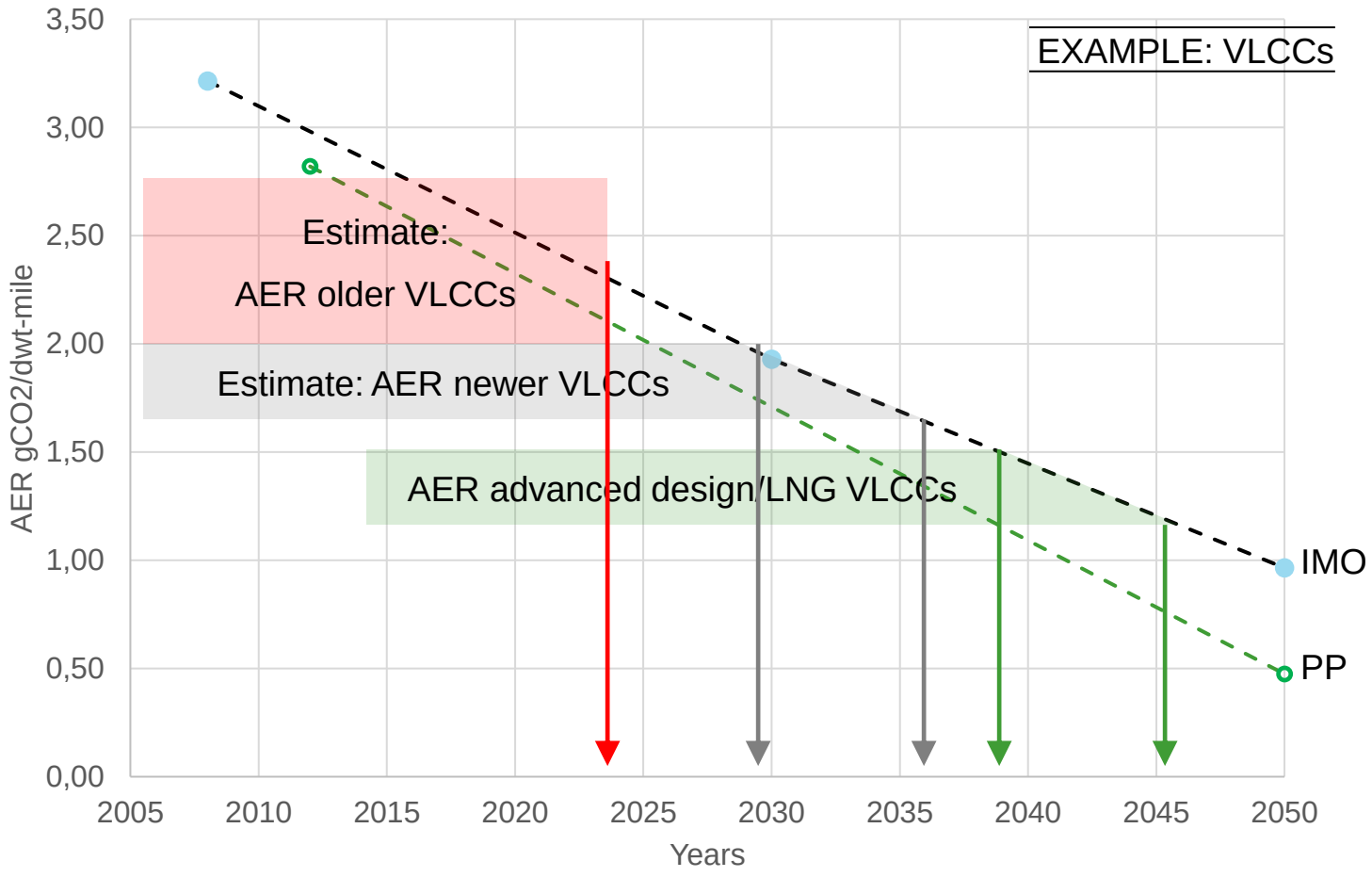


CII: Operational indicator

	EEXI	CII
Limits/reduction rates	Agreed	Work in progress
Calculation guidelines	Work in progress	Work in progress

Impact of the CII for newbuildings

Carbon Intensity Indicator (CII), e.g. Annual Efficiency Ratio (AER)



Good to know: CII and SEEMP

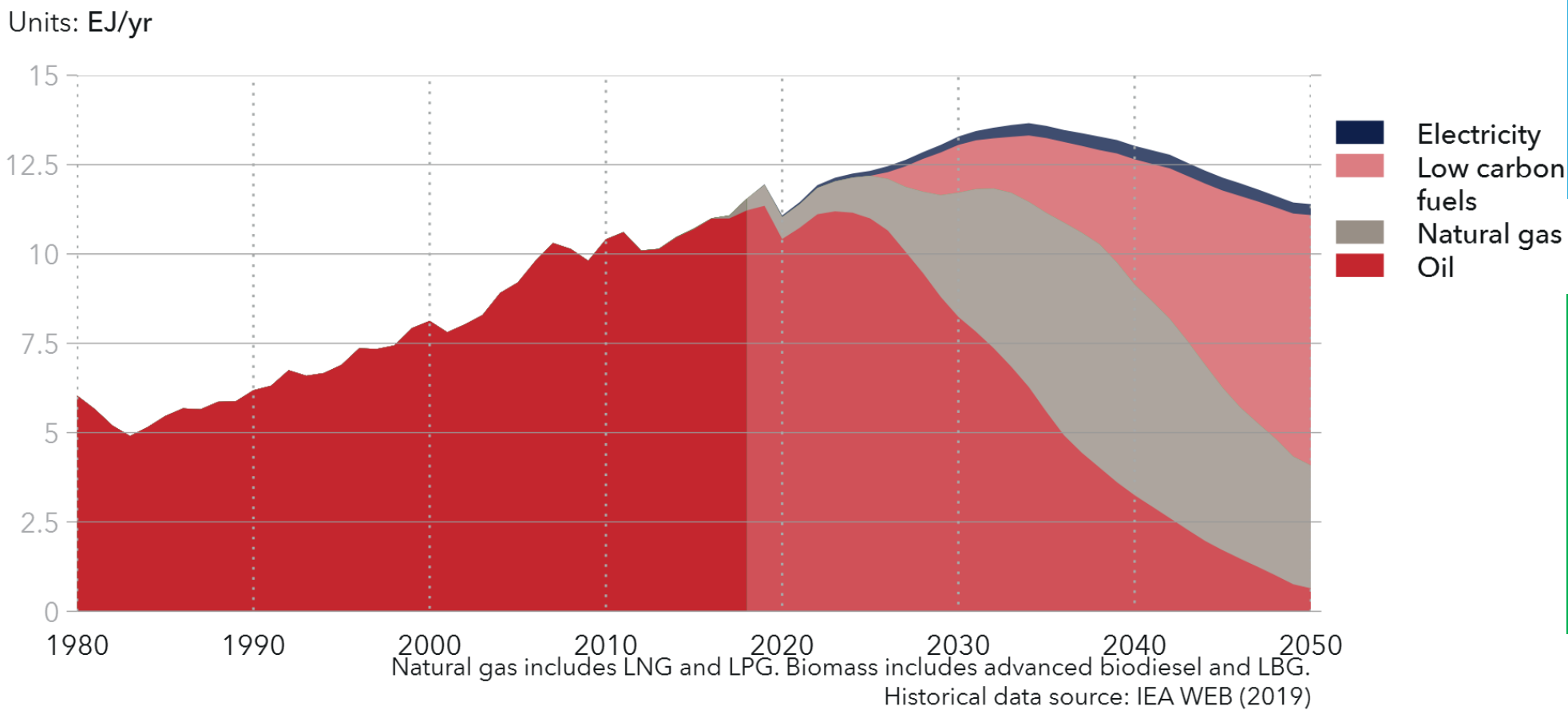
- In force as of 1.1.2023 – but details yet unclear, subject to MEPC 76
- Most likely, **many ship owners** will have to **implement operational measures + update SEEMP** to remain compliant

Questions

- (When) Are our ships running into non-compliance?
- Which measures are most cost efficient to keep them commercially viable?
- How do we ensure my SEEMP remains compliant?

The maritime fuel mix will change dramatically

World maritime subsector energy demand by carrier



Key assumptions

- Population growth
- Economic growth
- Regulations for decarbonization

Low Carbon Fuels

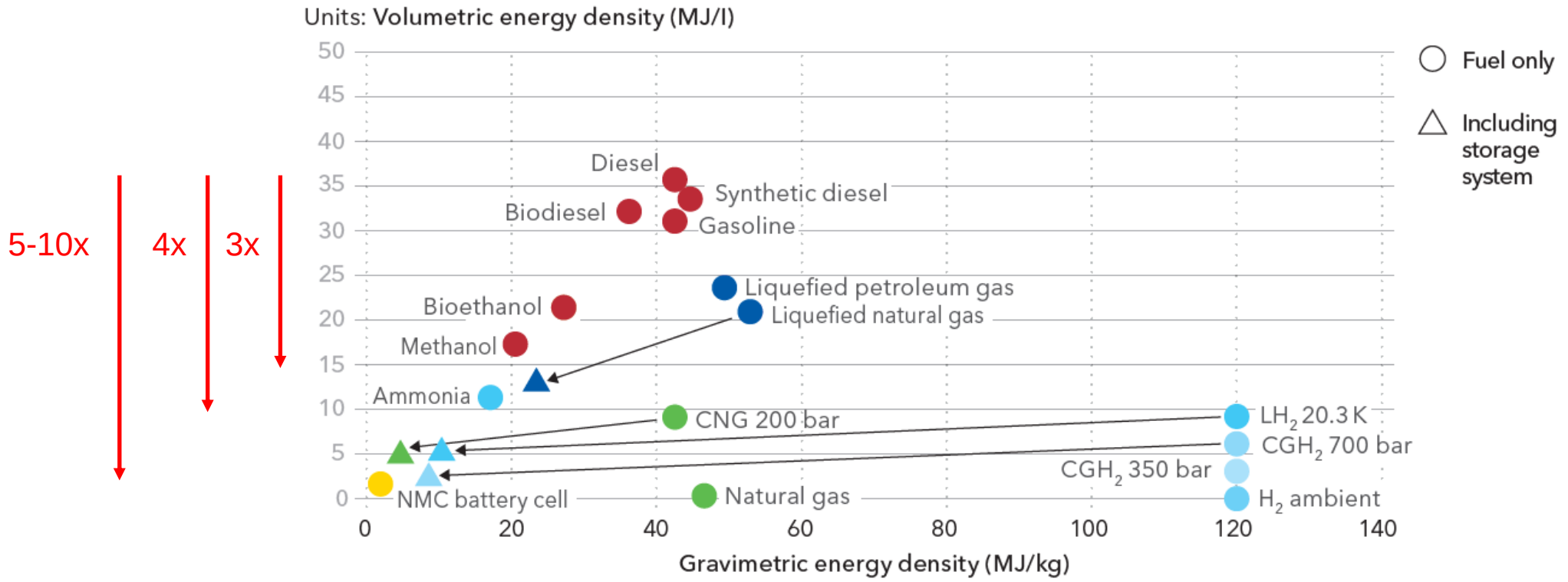
- biofuels
- e-fuels
- methanol
- ammonia
- hydrogen

What is the best fuel option?

	Availability	Infrastructure & Storage	Maturity of technology	Energy density	Price	Green credentials
VLSFO/MGO						
LNG						
LPG						
Methanol						
Biofuels						
Hydrogen						
Ammonia						

Fuel storage limitations

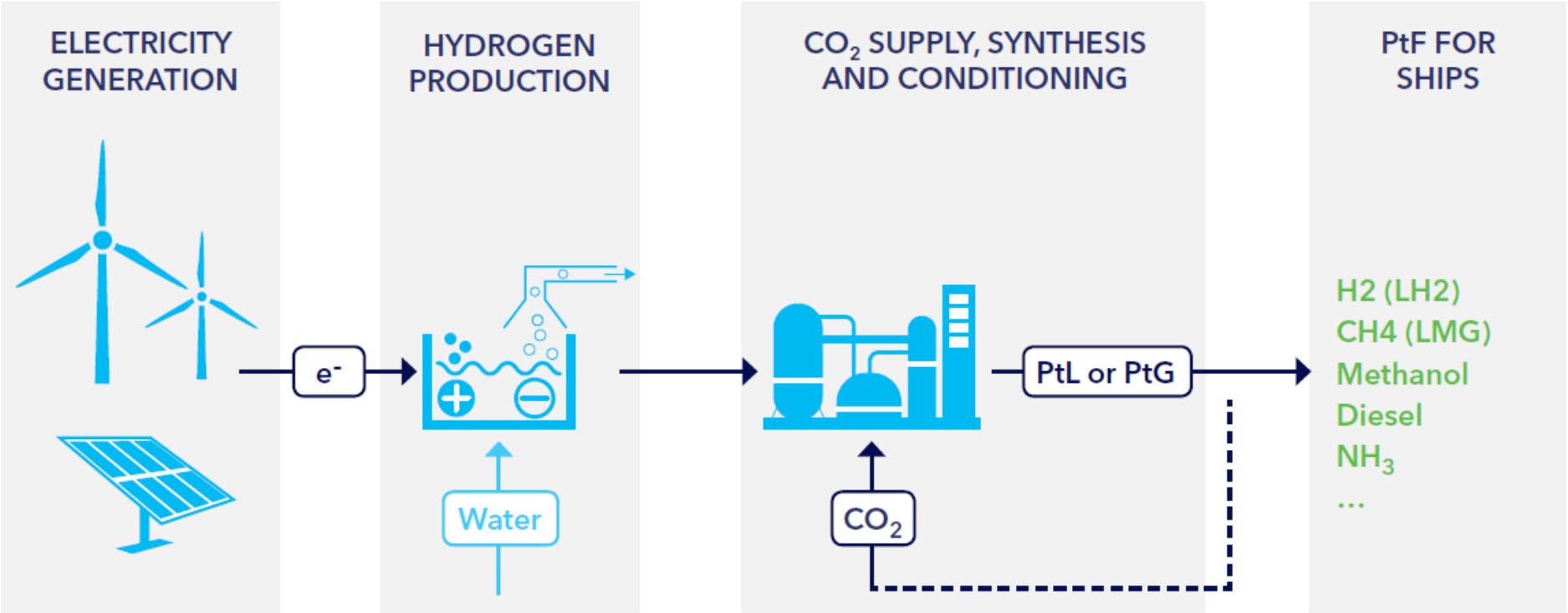
Comparison of gravimetric and volumetric storage density for fuels



Note: Arrows show shifts in energy density when storage is required.
Key: CGH_2, compressed gaseous hydrogen; CNG, compressed natural gas; H_2 ambient, hydrogen at ambient temperature; LH_2 20.3 K, liquefied hydrogen at 20.3 kelvin; NMC, lithium nickel manganese cobalt oxide

Source: Inspired by Shell (2017) and MariGreen (2018)

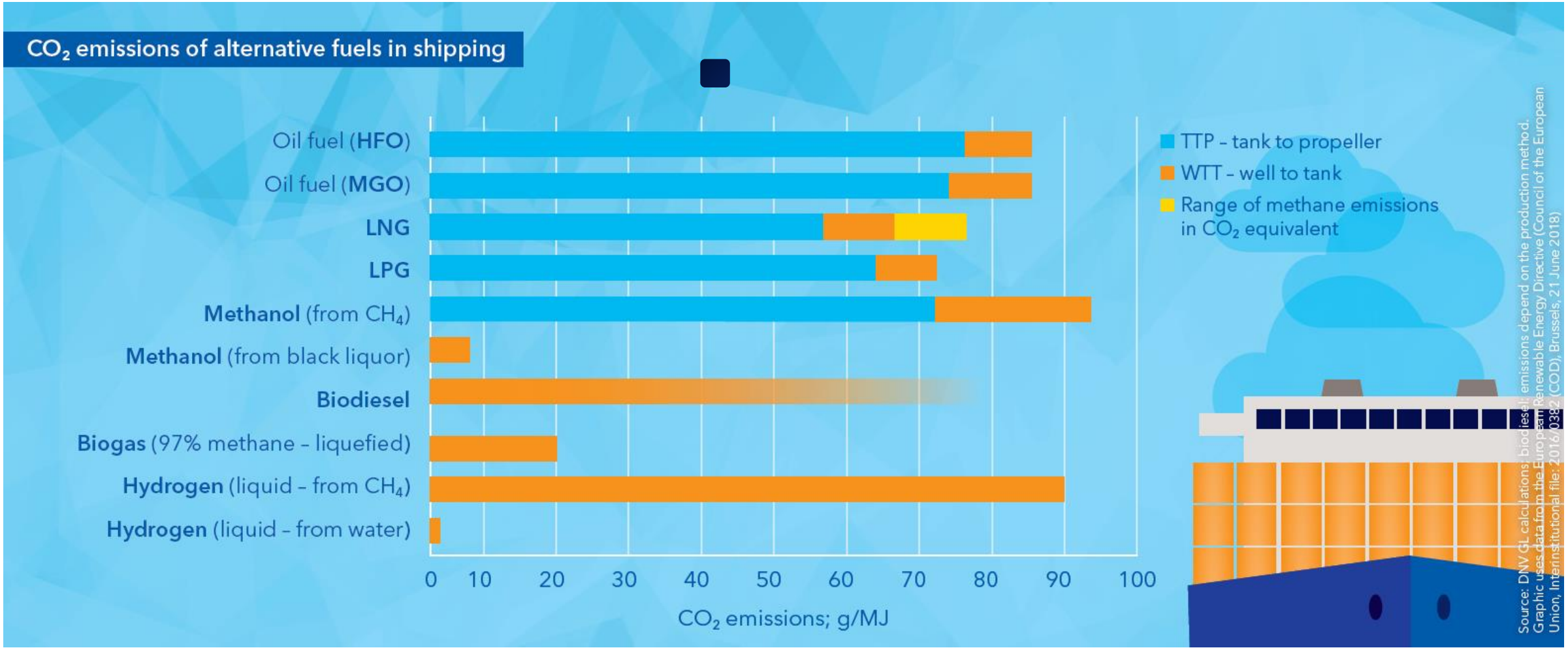
How will e-fuels be produced in the future?



Most energy needed to produce large hydrocarbons

Most effective production for H_2, ammonia, methanol, LNG

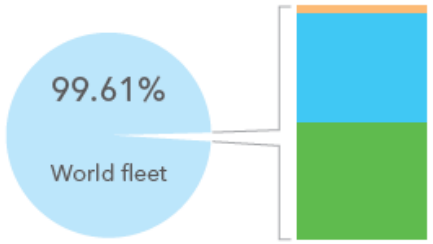
Environmental performance



Alternative fuel uptake

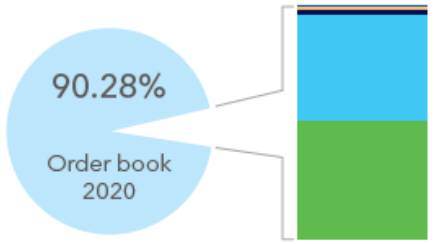
Alternative fuel uptake (percentage of ships)

Ships in operation



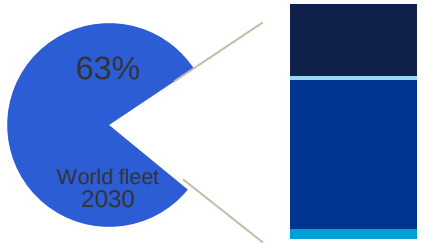
Methanol	0.01%
LNG	0.16%
Battery	0.22%
Sum	**0.39%**

Ships on order



Ammonia	0.02%
Hydrogen	0.06%
Methanol	0.47%
LPG	0.67%
LNG	4.52%
Battery	3.99%
Sum	**9.74%**

2030 IMO compliance scenario

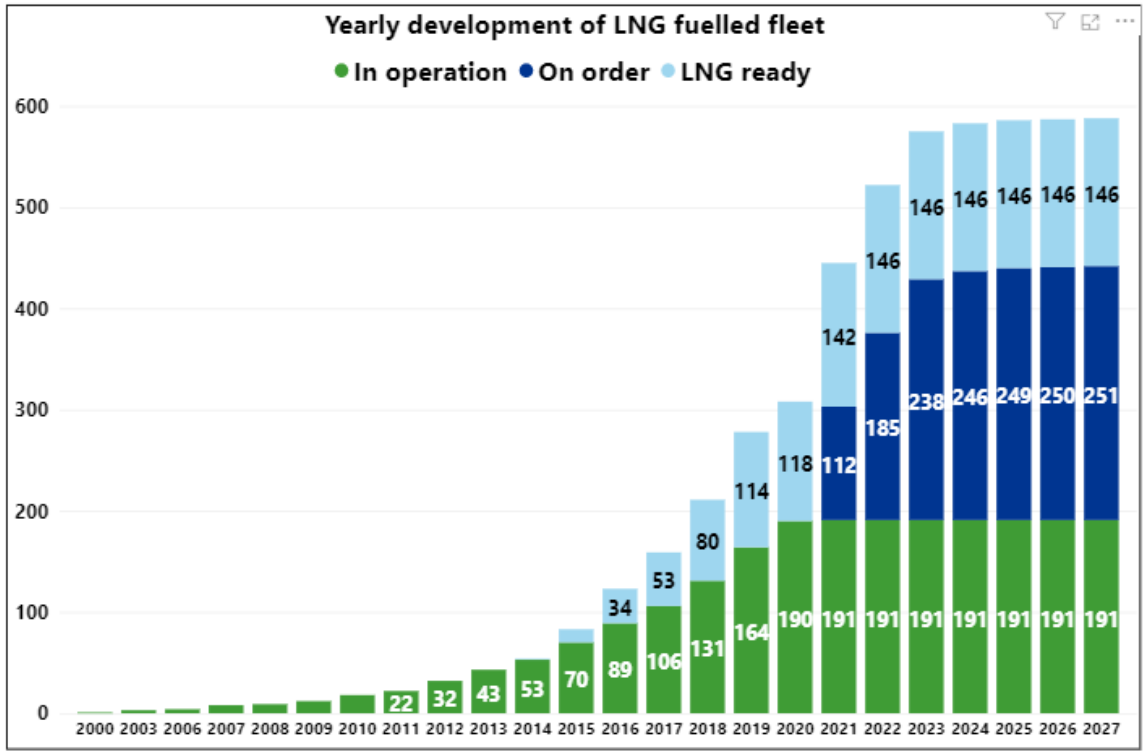


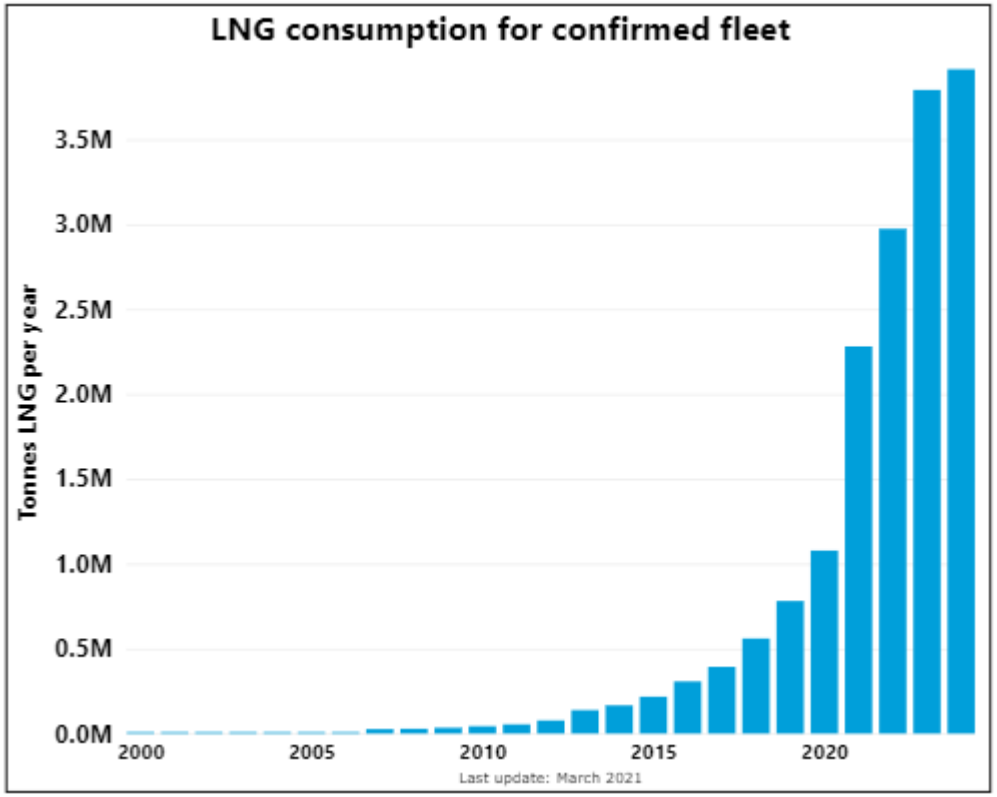
Biofuels	11%
Zero-carbon fuels	< 1%
Alternative fossil fuels	24%
Grid electricity	2%
Sum	**~37%**

- **Less than 1% of the existing fleet is running on alternative fuels**
- **10% of current orderbook with alternative fuels**
- **20% of vessels ordered in 2020 with alternative fuels (mainly LNG, LPG)**

Source: Alternative Fuels Insight: afi.dnvgl.com and *DNV GL's Maritime Forecast to 2050*

LNG uptake


Yearly development of LNG fuelled fleet
In operation
On order
LNG ready
600
500
400
300
200
100
0
2000 2003 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027
22 32 43 53 70 89 106 131 164 190 191 191 191 191 191 191 191 191
34 53 80 114 118 112 185 238 246 249 250 251
142 146 146 146 146 146 146


LNG consumption for confirmed fleet
Tonnes LNG per year
3.5M
3.0M
2.5M
2.0M
1.5M
1.0M
0.5M
0.0M
2000
2005
2010
2015
2020
Last update: March 2021

Some of the LNG Fuel Considerations…

…it all boils down to safety, flexibility and cost…

Operational profile

- Trading area
- Bunkering locations
- Local and global regulatory compliance
- Primary fuel

LNG Fuel tanks

- Size and type
- Maker
- Material
- Design Pressure
- Filling limit
- PU foam (BOR) and application
- Cost

Engines

- ME (LP / HP)
- Aux. E
- SCR / EGR
- Aux. Boilers
- Exh. Gas Boiler
- Safety/Operation
- Maintenance
- Cost

BOG Handing

- Holding time
- BOG handling system
- Cost

LNG systems

- Piping
- Bunkering
- N2 capacity
- Cryogenic protection
- Safety and control systems

DNV

Other fuel options

LPG

- 2017: no activity
- 2019:
  - 12 LPG carriers -retrofits
  - 42 new LPG carriers ordered
- GHG: -17%

DNV class rules for LPG as a fuel

Methanol

- 1 passenger vessel
- 9 methanol tankers
- 15 new methanol tankers orderd
- Main challenge: Fuel cost
- Easy to produce as bio-/synthetic-methanol
- GHG:
  - -10% onboard-fossil methanol
  - -80% biomethanol

DNV low flashpoint liquid fuel rules address methanol

Hydrogen

- 2 Passenger ferries ordered
- Main challenges:
  - CapEx
  - Fuel cost
  - Storage space
- Mainly for short-sea shipping
- GHG:
  - H_2 from NG: same as oil
  - Renewable H_2: -100%

DNV is working with industry partners to develop requirements for hydrogen

Ammonia

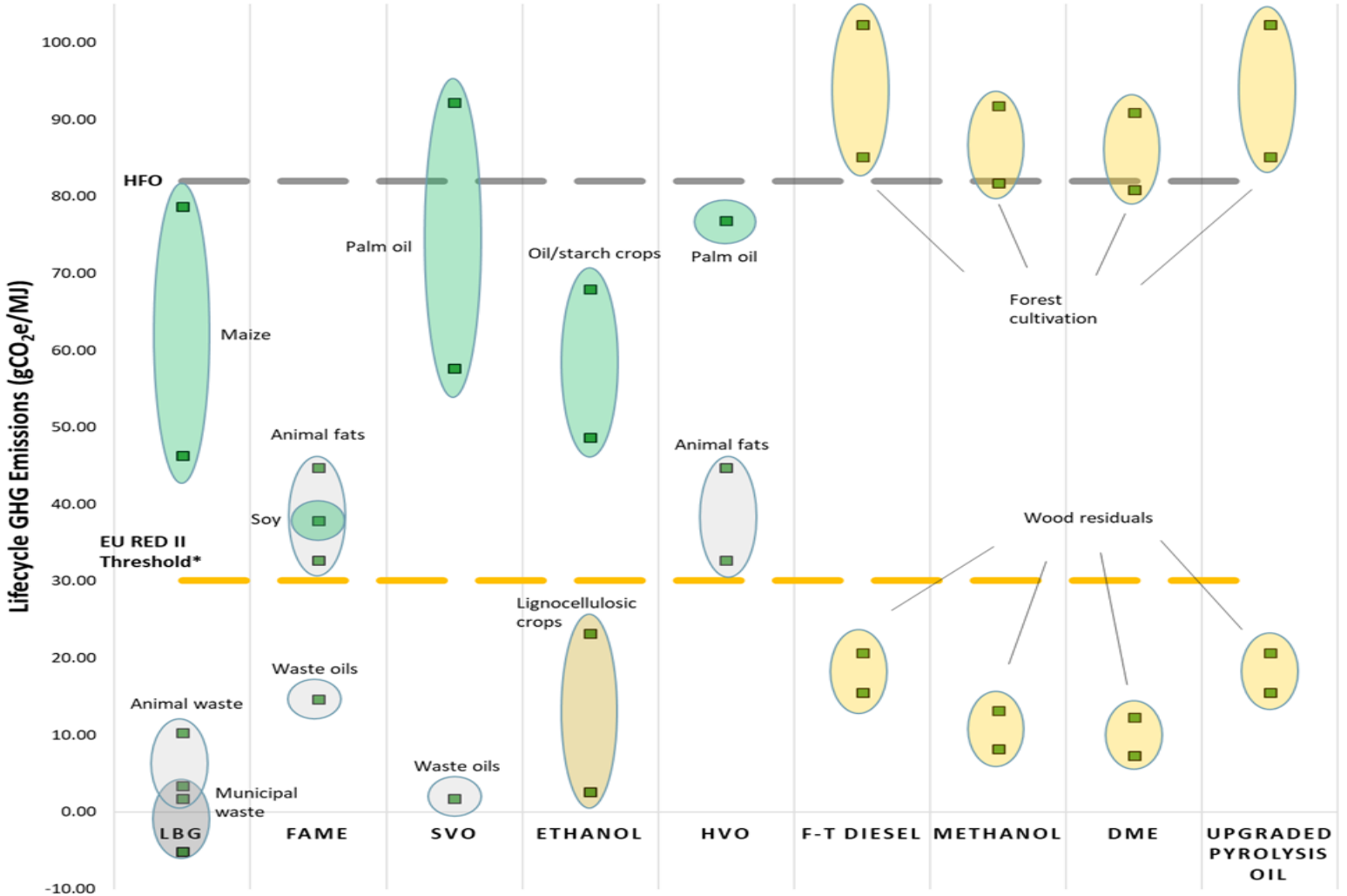
- First engines available in 2023-2024
- Suitable for deep-sea shipping
- Easy to store
- Main challenge: Toxic and corrosive
- Ammonia Ready notations already offered

DNV draft rules for ammonia as fuel and ammonia ready –to be published July 2021

Biofuels: Lifecycle GHG Emissions

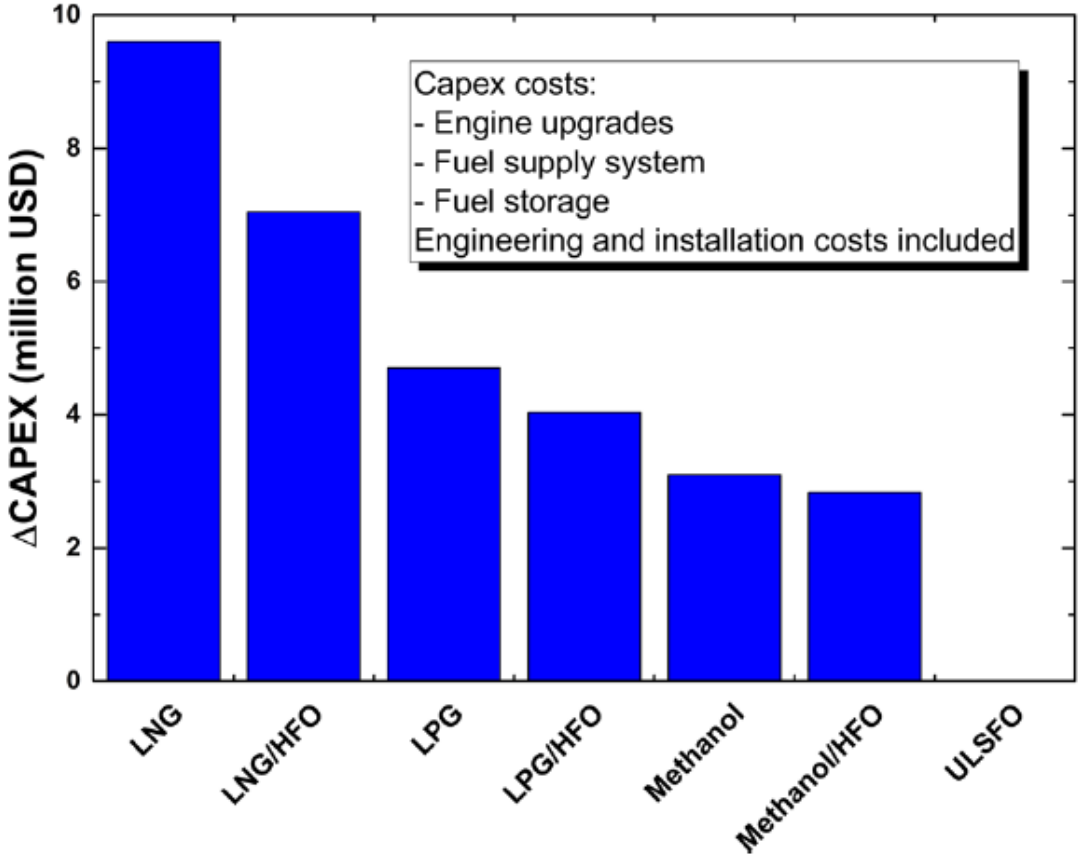
GHG emissions depend on source of biomass

Advanced biofuels have lower emissions than *conventional*

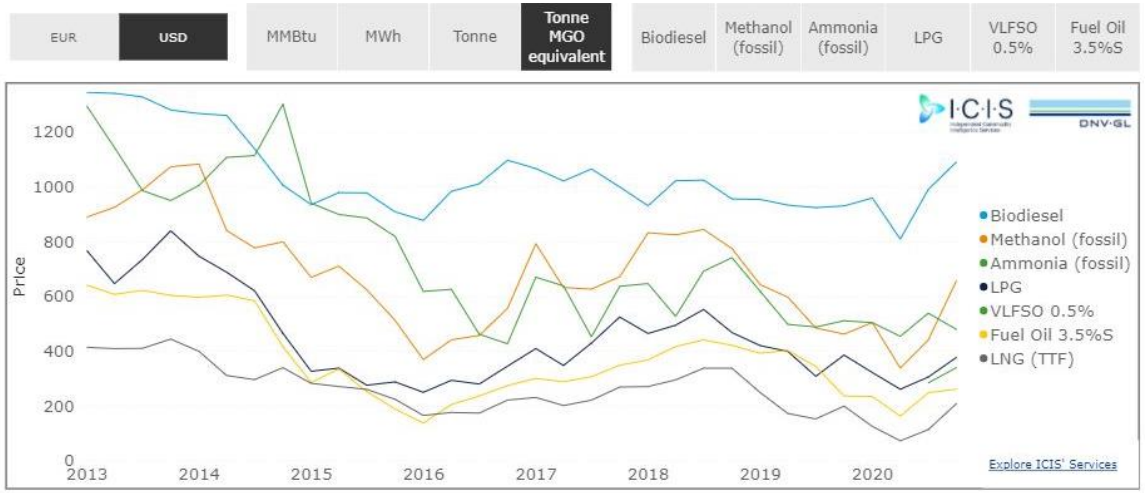


Based on data from various sources

What is the business case?

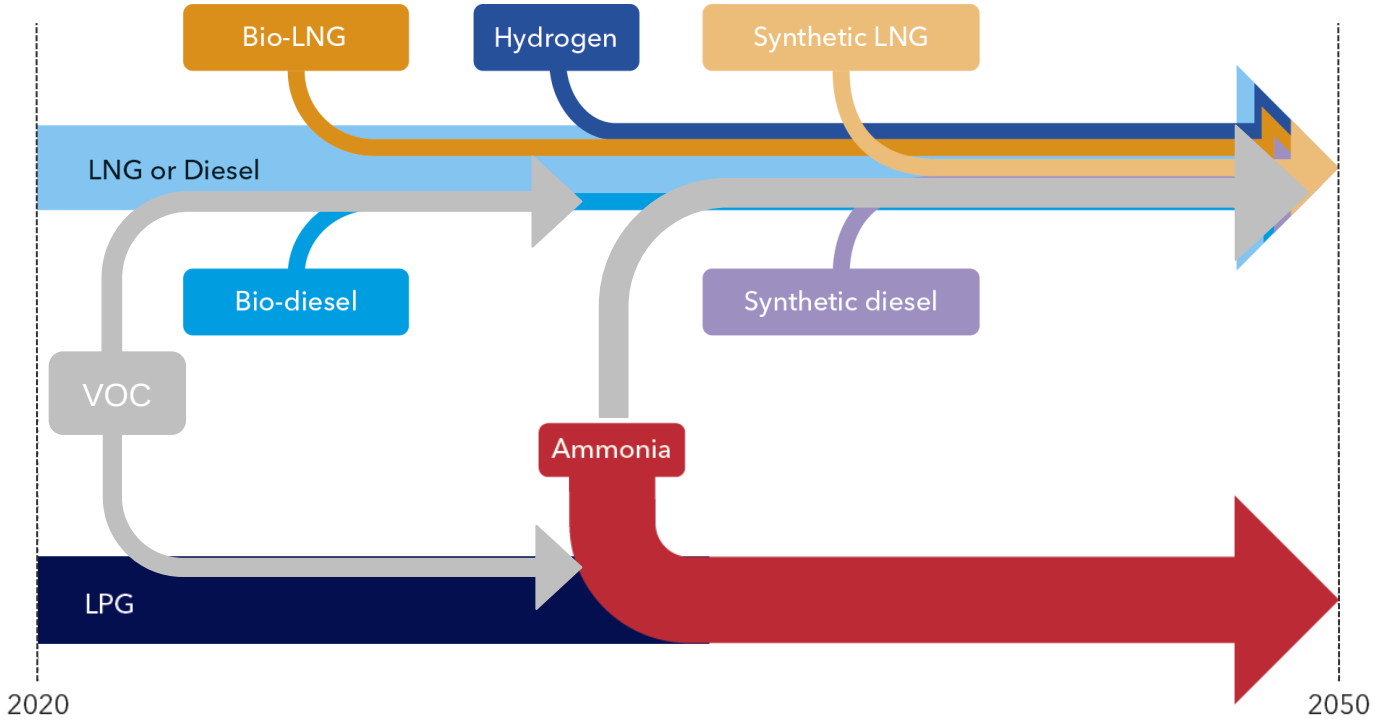


Example vessel: LR1 Tanker, 10.4 MW Main engine



Fuel flexibility and bridging technologies - the three pillars

Bridging technologies can facilitate the transition from traditional fuels, via fuels with lower-carbon footprints, to carbon-neutral fuels



Nuclear propulsion

Technical Developments

Extensive experience with nuclear propulsion in naval vessels

- Currently not commercially feasible
- Safety and security risks

Molten Salt Reactors (MSR)

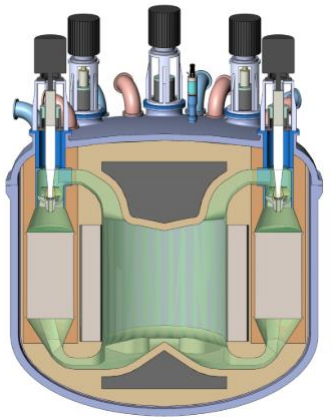
- Inherently safe technology
- Demonstrator expected by 2024 (100kW-1 MW)
- First marinized reactor by 2028-2030
- Leasing scheme to make cost competitive

Other aspects

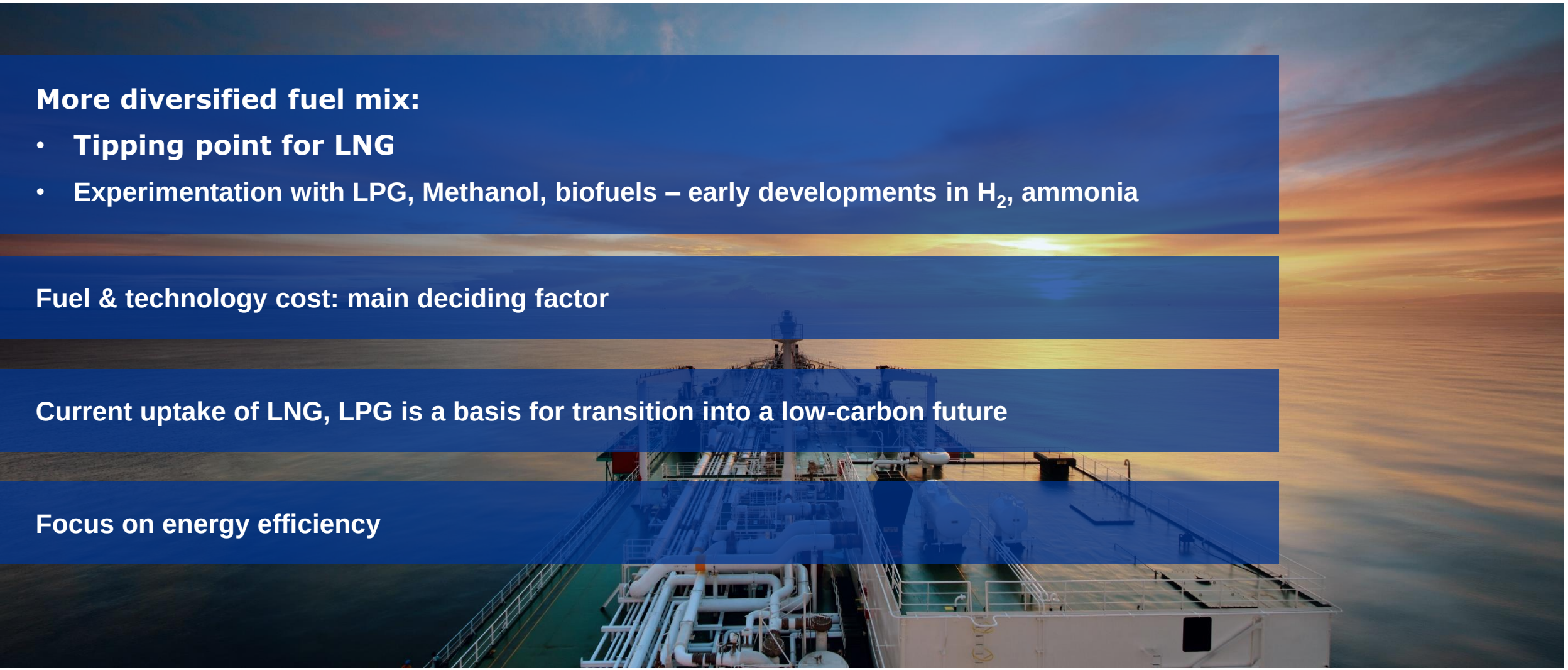
International regulations: SOLAS has to be modernized and updated

Public perception

Commercial widespread uptake not before 2035



Key takeaways



More diversified fuel mix:

- **Tipping point for LNG**
- **Experimentation with LPG, Methanol, biofuels – early developments in H_2, ammonia**

Fuel & technology cost: main deciding factor

Current uptake of LNG, LPG is a basis for transition into a low-carbon future

Focus on energy efficiency

Future Marine Fuels

Ren Luft webinar

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