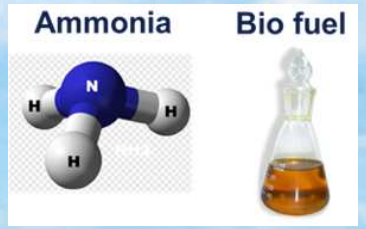
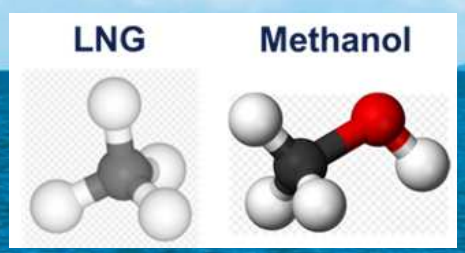
WHEN TRUST MATTERS

Institute of Chartered Shipbrokers, Singapore

Insights - future fuels in the Maritime Industry

Lukasz Luwanski, Regional Business Development Director SEA, Pacific & India, DNV Maritime





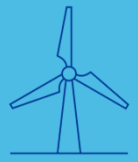
Singapore – 13th June 2022

DNV at a glance
An independent assurance and risk management company

158	~12,000	100,000	100+	5% R&D
years	employees	customers	countries	of annual revenue

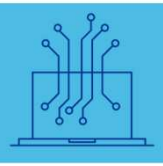
Ship and offshore classification and advisory

Energy advisory, certification, verification, inspection and monitoring



Management system certification, supply chain and product assurance

Software, platforms and digital solutions



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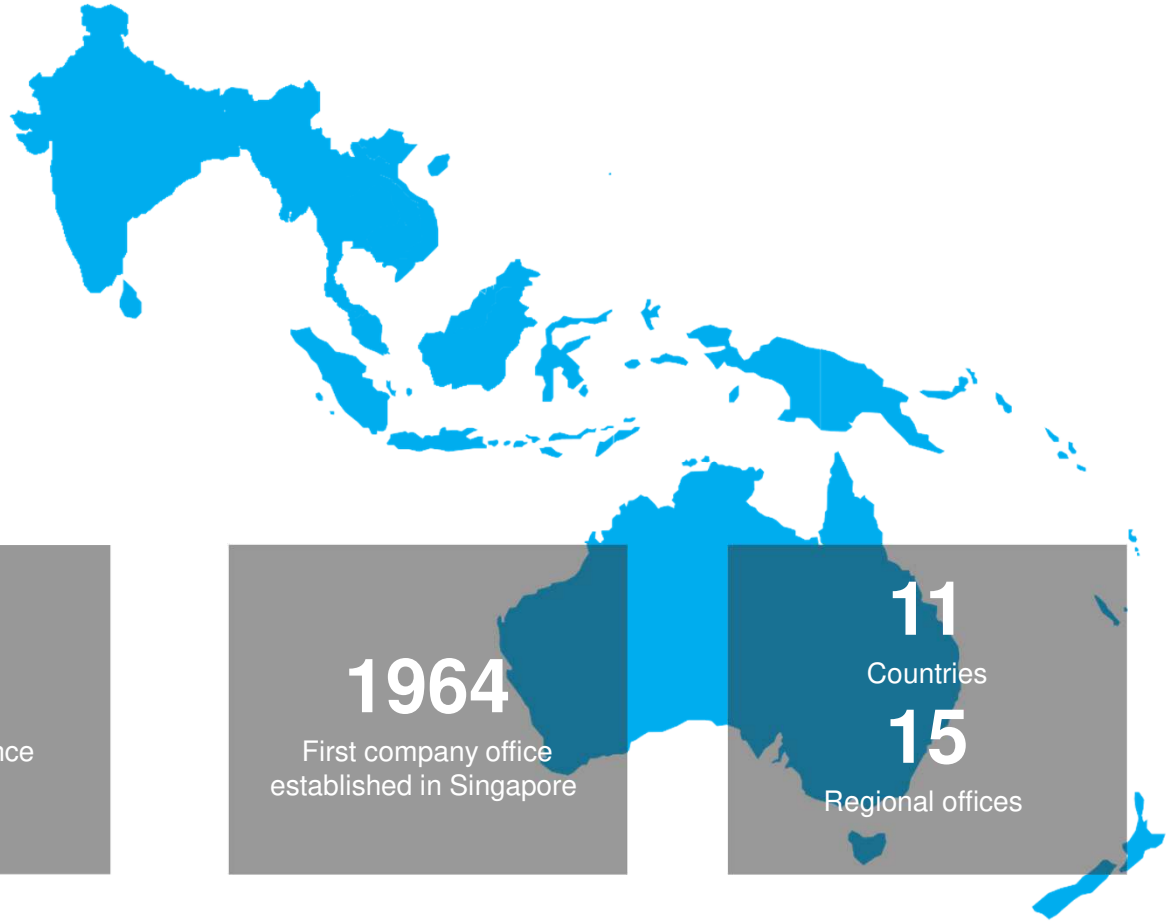
DNV Maritime in South East Asia, Pacific & India



150+
years of experience

1964
First company office established in Singapore

11
Countries

15
Regional offices

180
Maritime employees in the Region

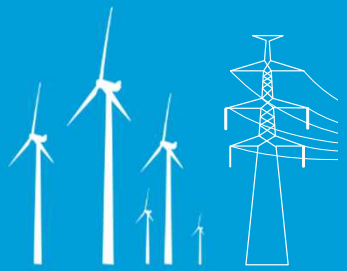
340+
staff in Singapore in total

DNV

Business areas and competences in the region

MARITIME

ENERGY SYSTEMS



BUSINESS ASSURANCE, SUPPLY CHAIN & PRODUCT ASSURANCE

DIGITAL SOLUTIONS

REGIONAL CENTRES OF EXCELLENCE FOR DECARBONIZATION AND AUTONOMY AS WELL AS FOR ADDITIVE MANUFACTURING, BOTH IN SINGAPORE

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Agenda

- Why decarbonization and International Regulations
- Common understanding of Alternative Fuels
- Case study and status of alternative fueled ships
- Conclusion

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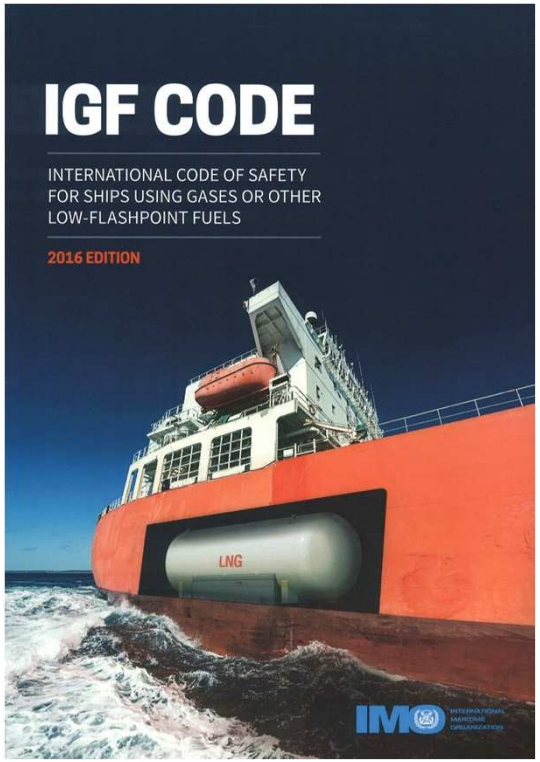
The three key elements for decarbonization of the Maritime Industry

Regional regulators, financiers and charterers push for faster progress on decarbonization

Are International Regulations to build and operate an alternative fuelled vessel established?



IMO INTERNATIONAL MARITIME ORGANIZATION

- International Code for Safety for Ships using Gases or other Low-Flashpoint Fuels
- The IGF Code entered into force 1 January 2017 and focused, as a first step, on requirements for ships using **LNG as fuel.**
- Methanol, LPG, Fuel Cells and other low-flashpoint oil fuels are under development
- For Methanol, an Interim Guideline exists

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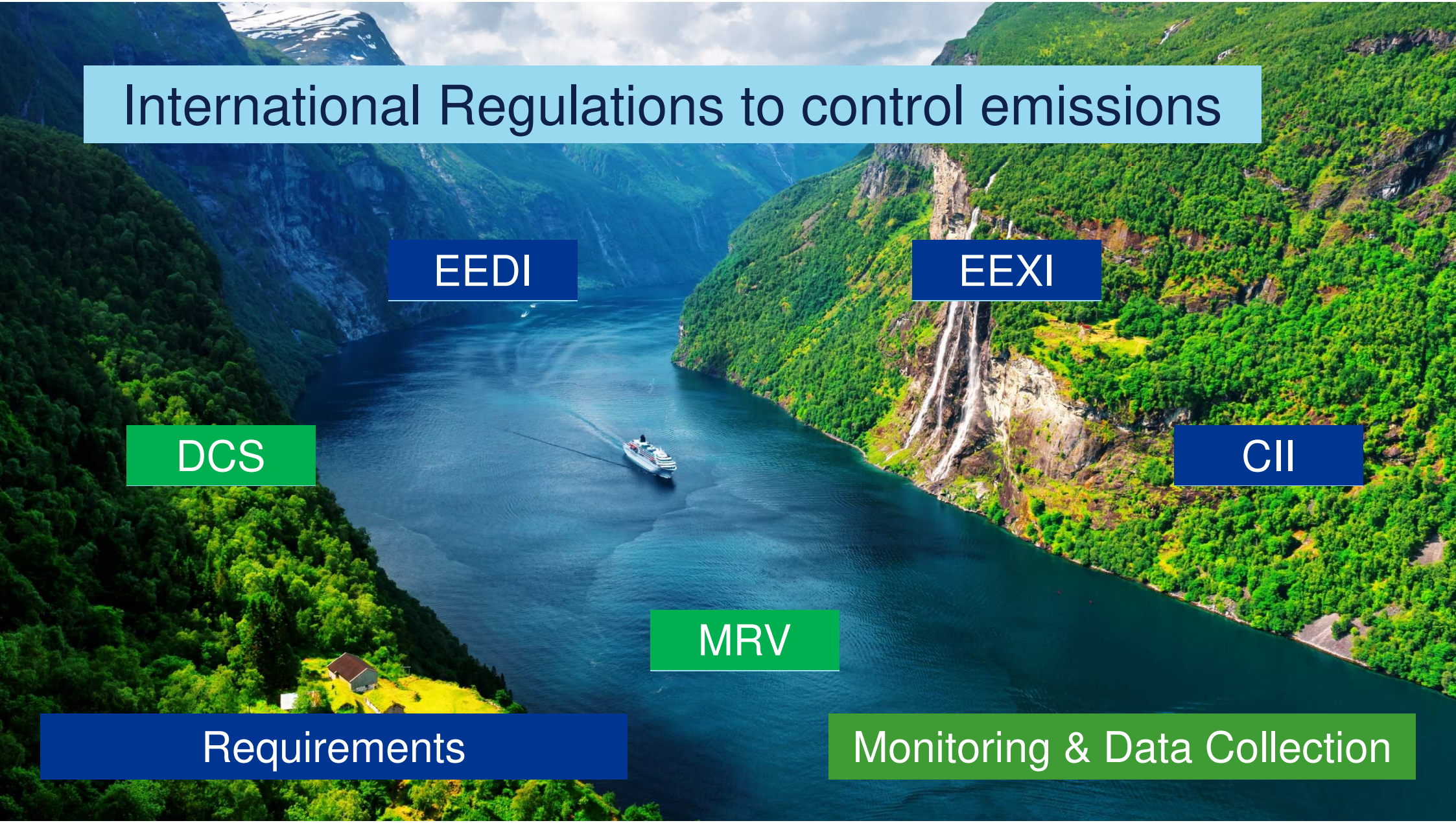

International Regulations to control emissions
EEDI
EEXI
DCS
CII
MRV
Requirements
Monitoring & Data Collection

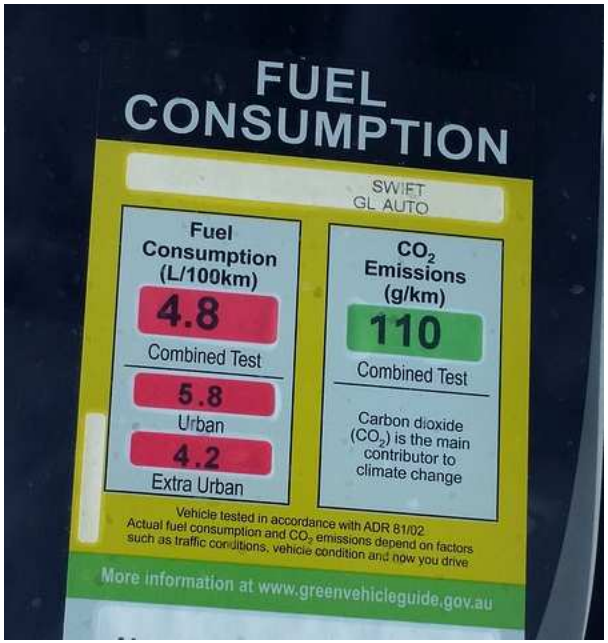
What is difference between EEDI, EEXI and CII?

EEDI = Energy Efficiency Design Index

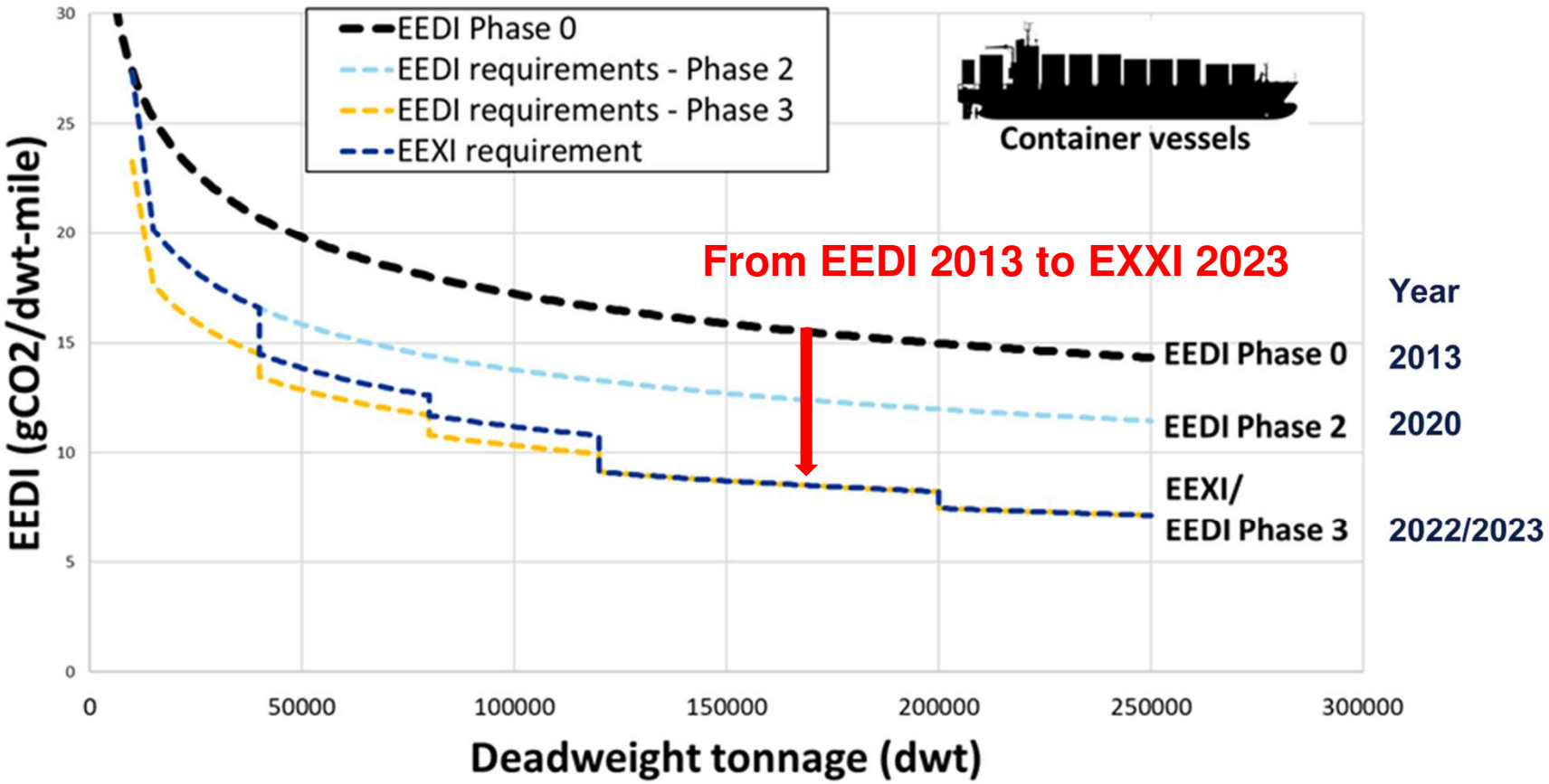
EEXI = Energy Efficiency Existing Ship Index

EEDI = a “new building” Index

EEXI = one time “existing ship” Index



What is the difference between EEDI, EEXI and CII?

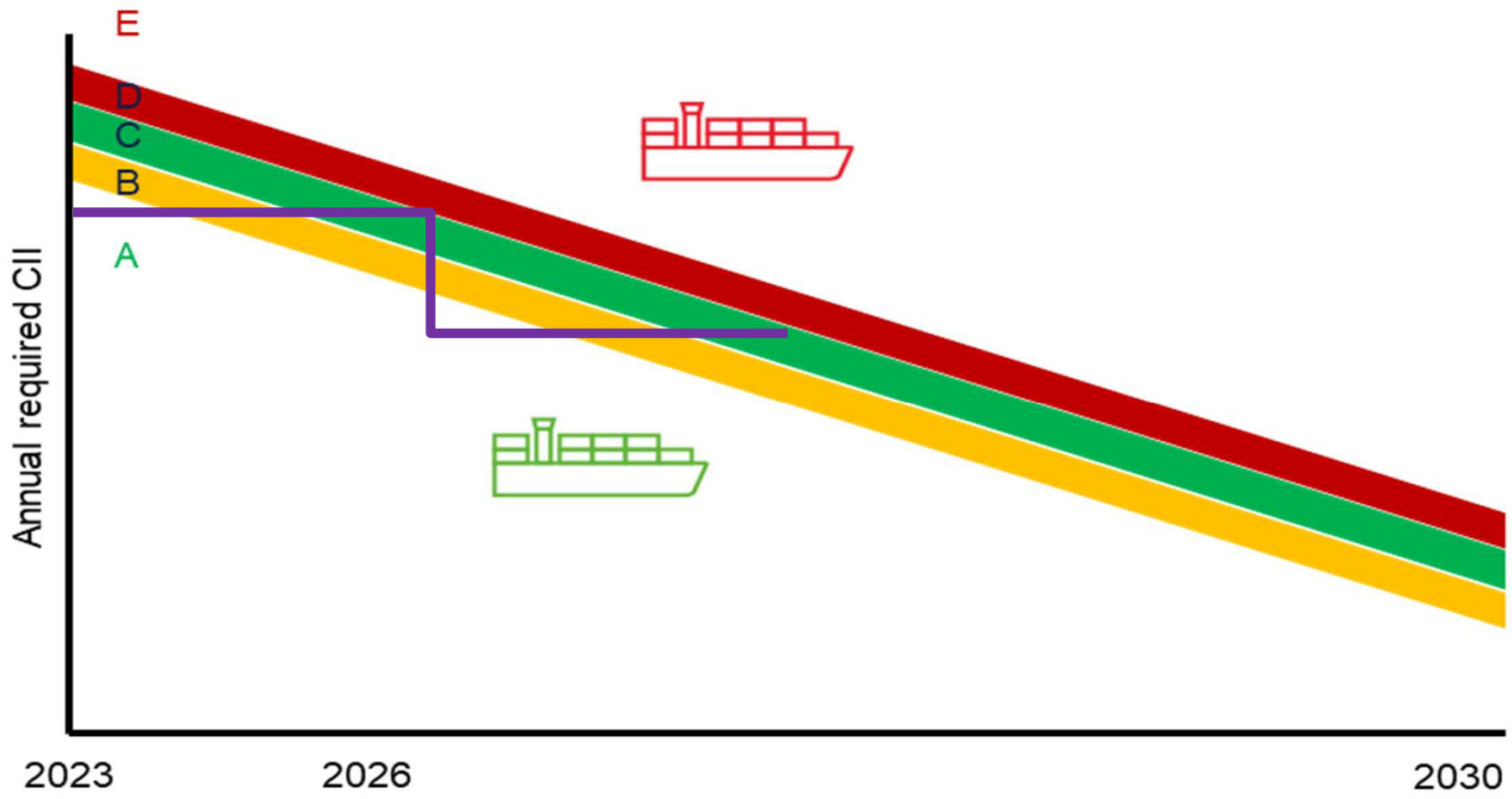


What is the difference between EEDI, EEXI and CII?

CII = Carbon Intensity Indicator

CII = an “Operational” indicator

What is the difference between EEDI, EEXI and CII?



Agenda

- Why decarbonization and International Regulations
- Common understanding of Alternative Fuels
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Grey, Blue and Green Fuels

Grey

- **Fossil fuels**, typically used today such as HFO, LNG, LPG, Methanol
- **Hydrogen (H_2), Ammonia produced from natural gas/coal** fall in this category

Blue

- Hydrogen (H_2), Ammonia produced from natural gas/coal with **Carbon Capture & Storage**
- e-fuels produced with CO_2 from **Carbon Capture** from another combustion process

Green

- **Biofuels (sustainability requirements apply)**
- Hydrogen (H_2), Ammonia produced from **carbon-free electricity**
- e-fuels produced with **CO_2 directly extracted from the atmosphere**

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Characteristics of alternative fuels compared to HFO

Emission
SO_X
NO_X
CO_2

Regulations
EEDI
EEXI
CII

Characteristic
Main engine
Generator

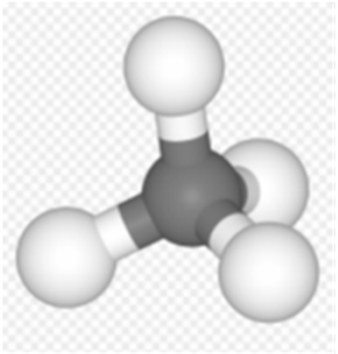
Fuel availability
Green production

Characteristics of alternative fuels compared to HFO

SO_X : minus 95 to 98%
NO_X : minus 75 to 80
(EGR/SCR)
CO_2 : minus 14 to 25%
(~70% expected for bio LNG)

Energy density [MJ/kg] : +19%
Tank volume: +100%
Main engine & Generator:
available, built and in operation

LNG



Regulations:
available and enforced

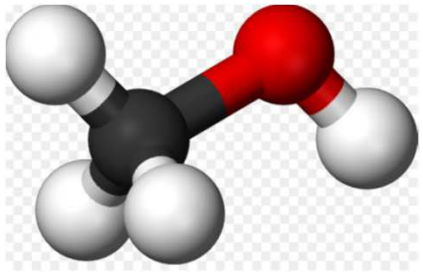
EEDI, EEXI and CII:
positive impact

Fuel availability:
Rotterdam, Singapore,
Shanghai, Marseille and fast ++
Green production:
bio available / synthetic ~7 years

Characteristics of alternative fuels compared to HFO

SO_X : minus 95 to 98%
NO_X : minus 80% (EGR/SCR)
CO_2 : minus 5 to 10%
(min -90% expected for green methanol)

Methanol



Regulations:
interim guideline available and enforced
EEDI, EEXI and CII:
positive impact

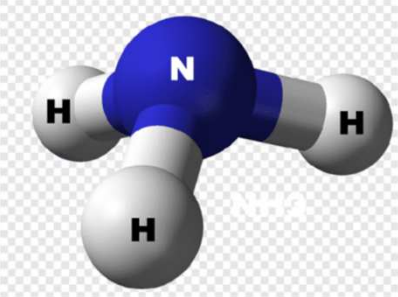
Energy density [MJ/kg]: minus 50%
Tank volume: +150%
Main engine & Generator:
available, operation and further development ongoing

Fuel availability:
not for deep sea shipping
Green production:
technology & production small scale exist

Characteristics of alternative fuels compared to HFO

SO_X : minus 95 to 98%
NO_X : uncertain (EGR/SCR)
CO_2 : minus 80 to 90%
(due to pilot fuel 100% not achievable yet)

Ammonia



Regulations:
alternative design approach

EEDI, EEXI and CII:
positive impact

Energy density [MJ/kg]: minus 50%
Tank volume: +280%
Main engine & Generator:
not available, development ongoing with timeline 2025-26

Fuel availability:
not developed
Green production:
technology & production small scale exist

Characteristics of alternative fuels compared to HFO

SO_X : minus 95%
NO_X : minus 10 to 20% or
plus 10 to 15%
CO_2 : minus up to 70%
achievable

Energy density [MJ/kg]: minus 5%
Tank volume: + 3~5%
Main engine & Generator:
available, built and in operation

Bio fuel

Regulations:
in progress

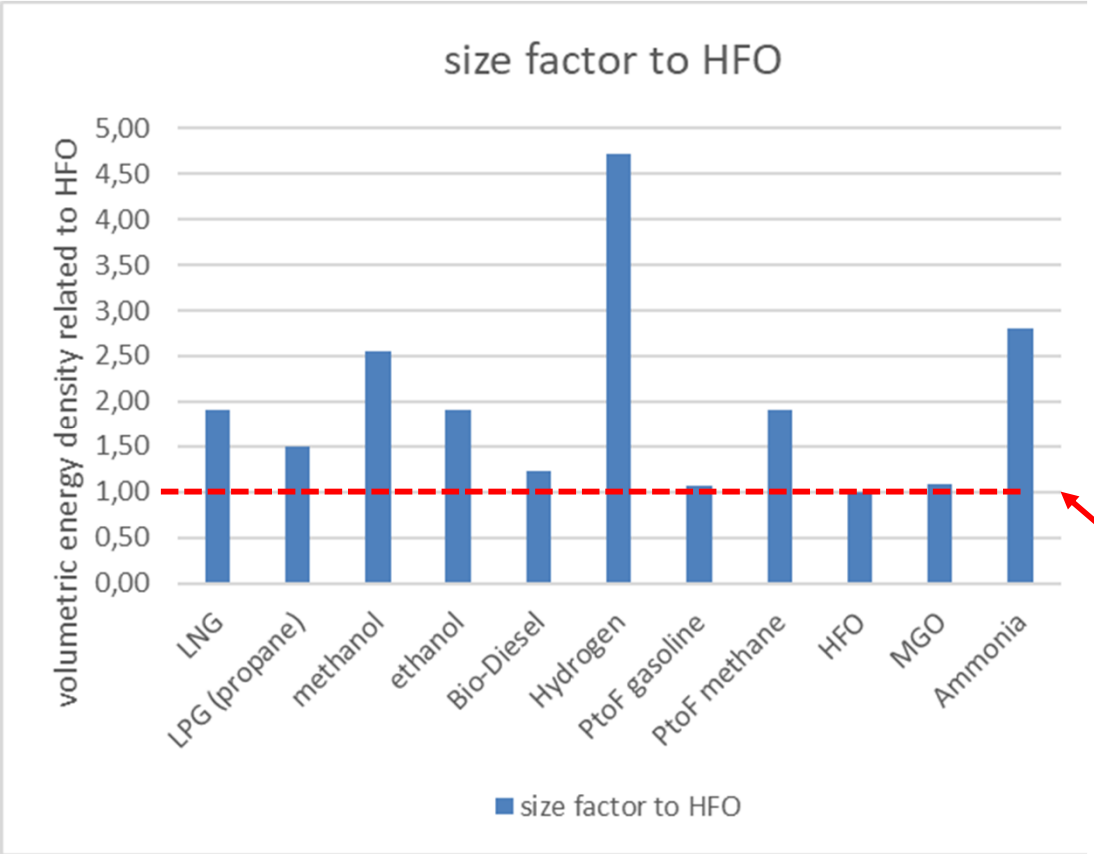
EEDI, EEXI and CII:
if decided on CII only

Fuel availability:
available

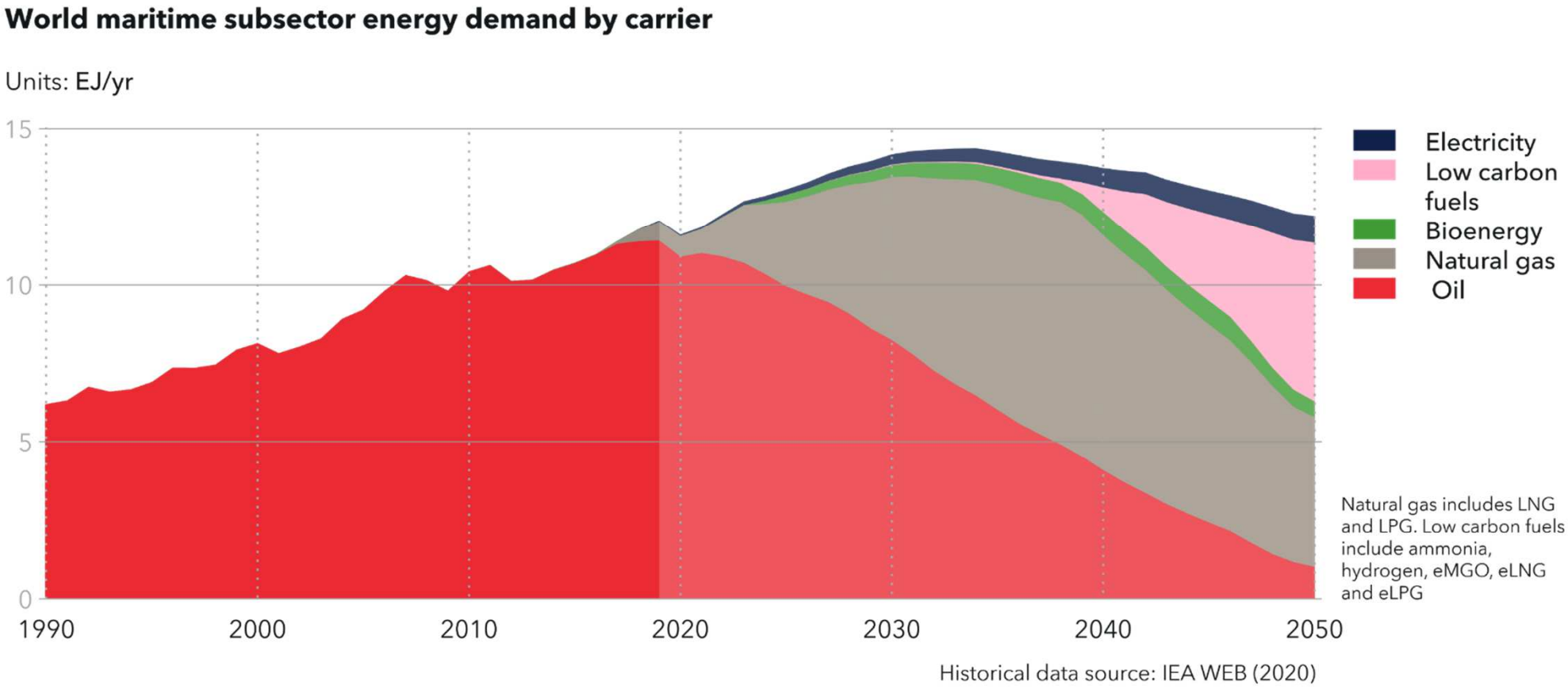
Green production:
available

Fuel volume: How much space future fuels will need?

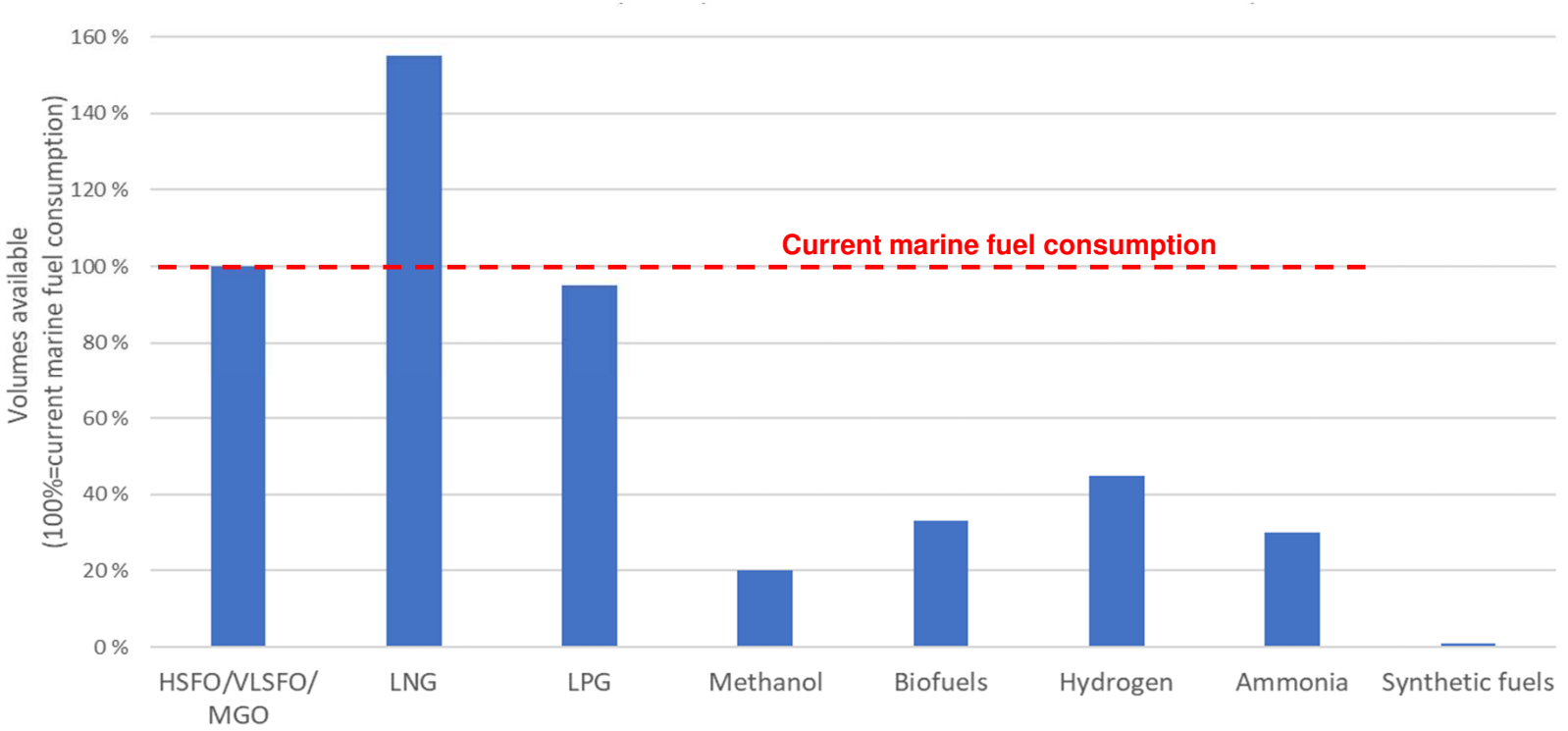
- HFO has the highest volumetric energy density
- Hydrogen needs more than 4,5 times the volume of oil based fuel. It may not be suitable for deep sea shipping
- Other fuel alternatives are acceptable for deep sea shipping with regard to required volume, though introduce new storage challenges / bunkering intervals



The maritime fuel mix will change over the next years



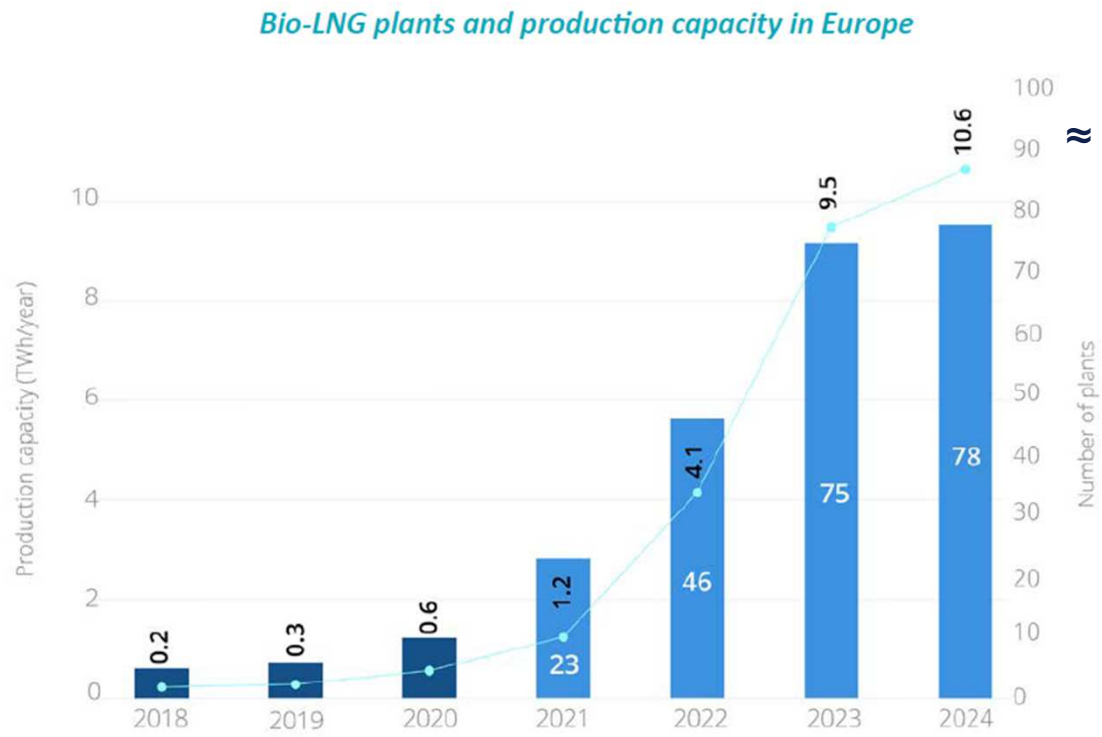
Alternative fuels availability compared to marine fuel consumption - relative energy content



HFO,MGO	LNG	LPG	Methanol	Bio-fuel	H2	Synthetic Fuel
assumed consumption 2020 (330 Mio t/a)	approx. 10% of natural gas production end 2018	production in 2015	production capacity 2016	production 2016 (Bio Diesel and straight vegetable oil)	production 2016	PtoF = Power to Liquid and Power to Gas: CO_2+H_2 → fuel

Bio-LNG plants in Europe

1 https://www.europeanbiogas.eu/eba-statistical-report-2021/



≈ 1 million toe

Figure 8: Current and future develoment of the number of bio-LNG plants and local bio-LNG production capacity in Europe (TWh/year) from 2018 t 2024.

Source: European Biogas Association

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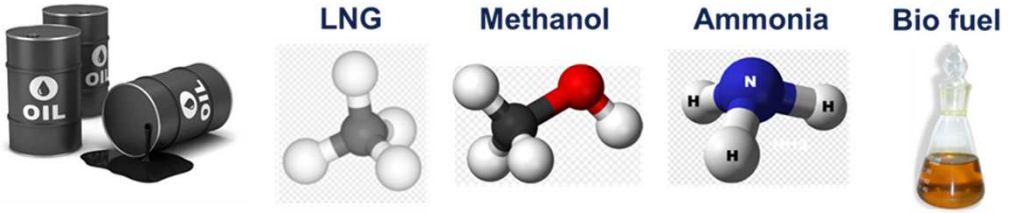
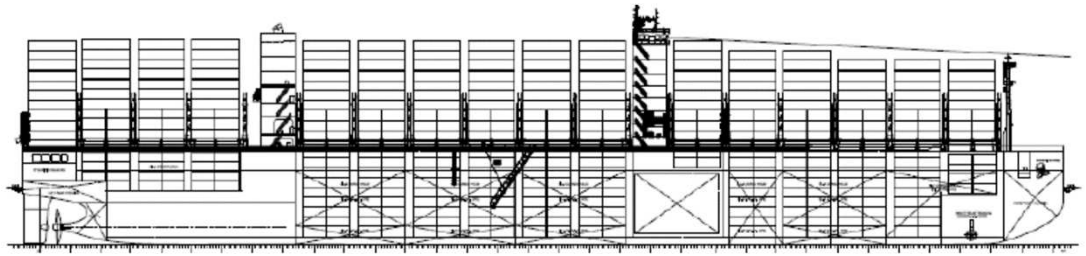
CII case study for a 7.400 TEU Container Ship

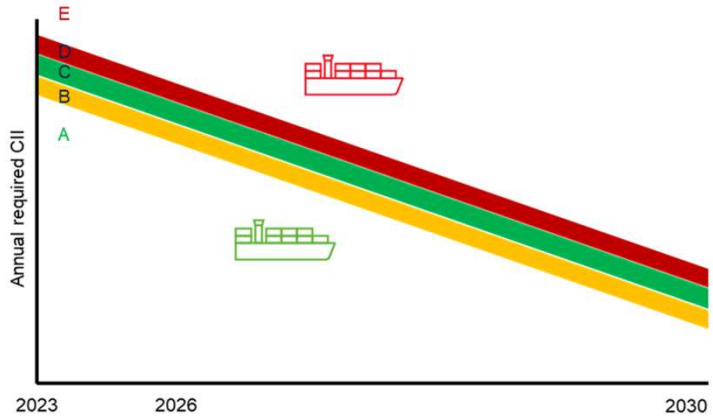
What have we discussed till now?

- Each fuel has a different CO_2 emission

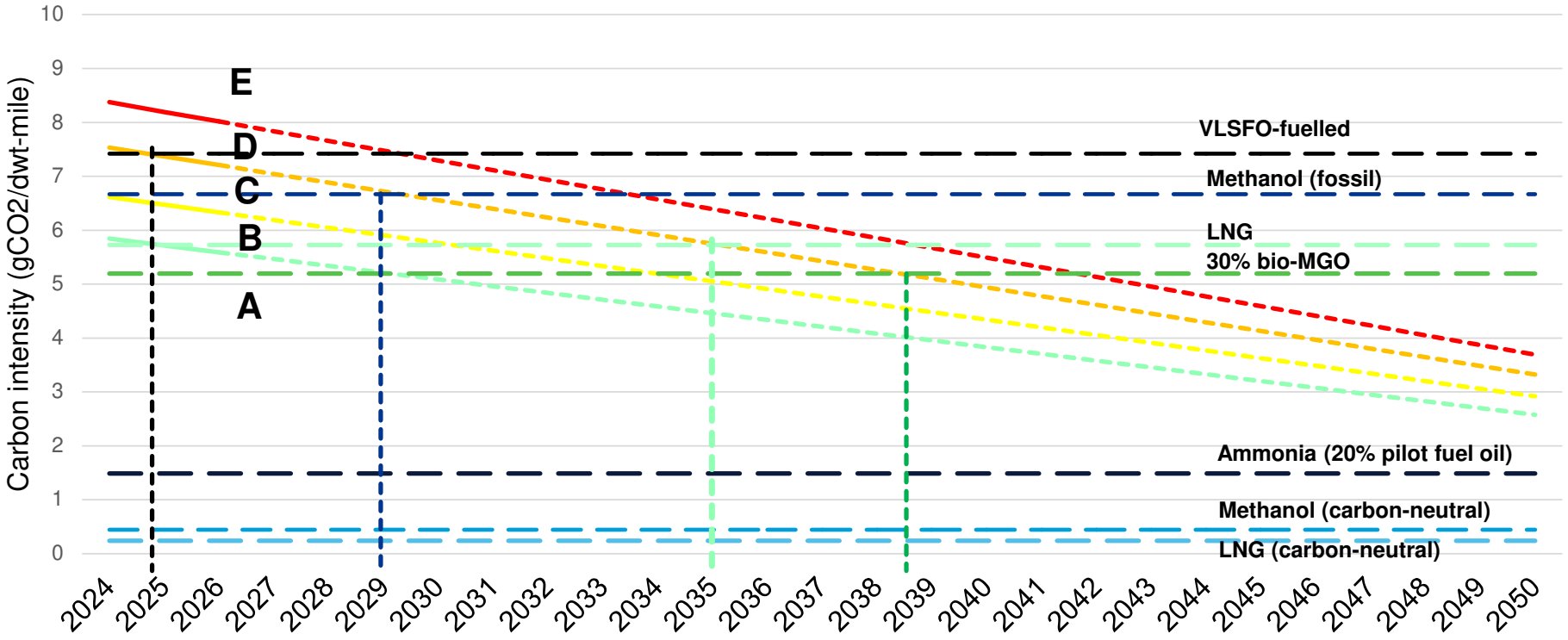


- Main aspect of CII:
  - Verification of vessel performance according to CO_2 emission
  - Different zones to judge the ranking of a vessel from A to E with middle zone C



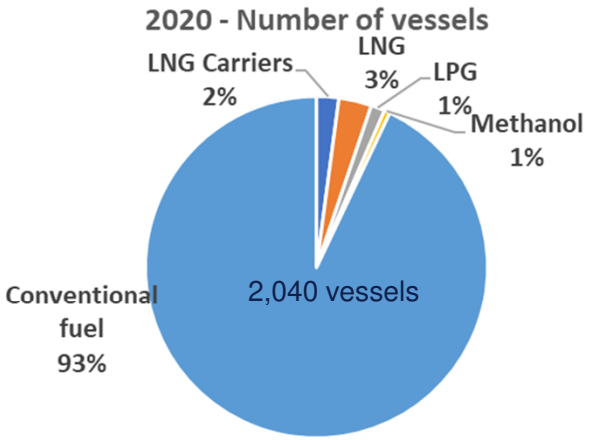


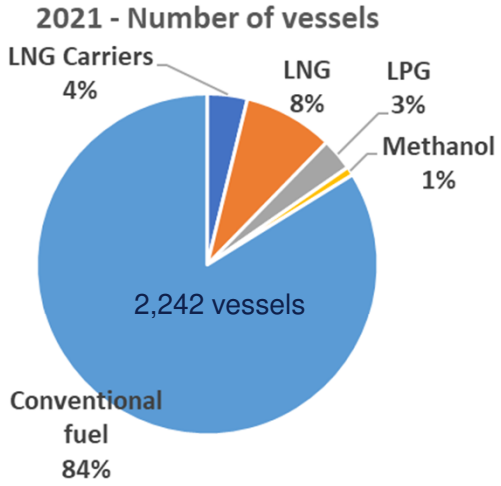
Estimated operational carbon intensity for 7.400 TEU Container Ship

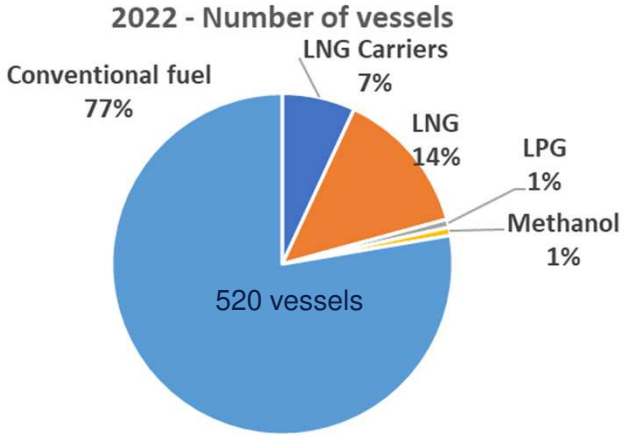


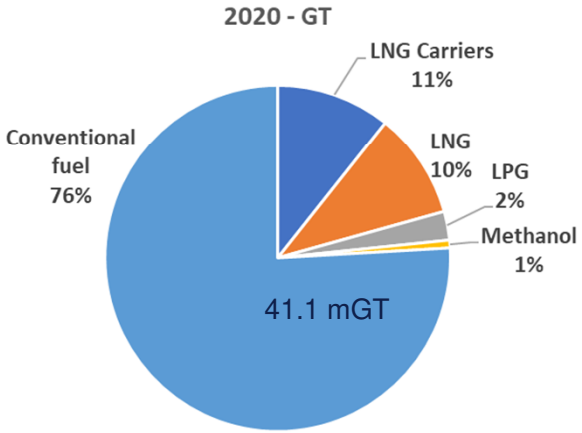
Note:
Guidelines for lifecycle GHG emission factors for marine fuels have still not been developed by the IMO and in the above figure, emissions factors for methanol (carbon-neutral), ammonia, bio-MGO, and LNG (carbon-neutral) is set to zero. Emission factors for VLSFO, methanol (fossil-based), and LNG have been set to 3.114, 1.375, and 2.75 respectively, in terms of tonnes CO_2/tonne fuel, covering tank-to-propeller CO_2 emissions. CII correctional factors have not been decided and could potentially change the results. The indicated operational carbon intensity of the newbuild is based on CO_2-emissions data from modern comparable vessels in 2019. CII rating requirements and reduction factors have only been adopted up until 2026, however, in the above figure CII rating requirements are linearly extended towards 2050 to indicate future possible reduction requirements.

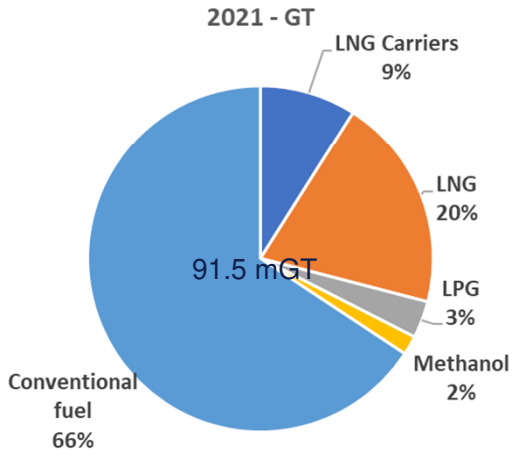
Newbuilding orders with alternative fuels

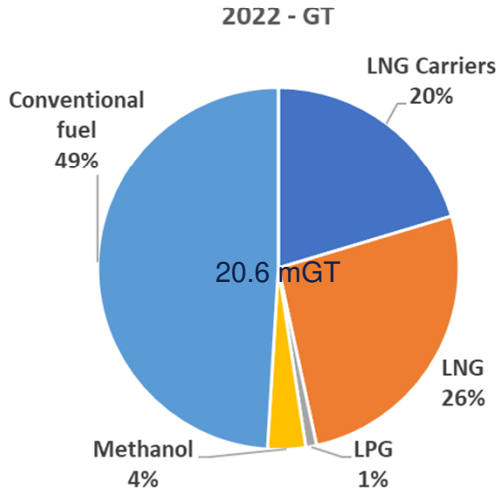












Updated: May 2022

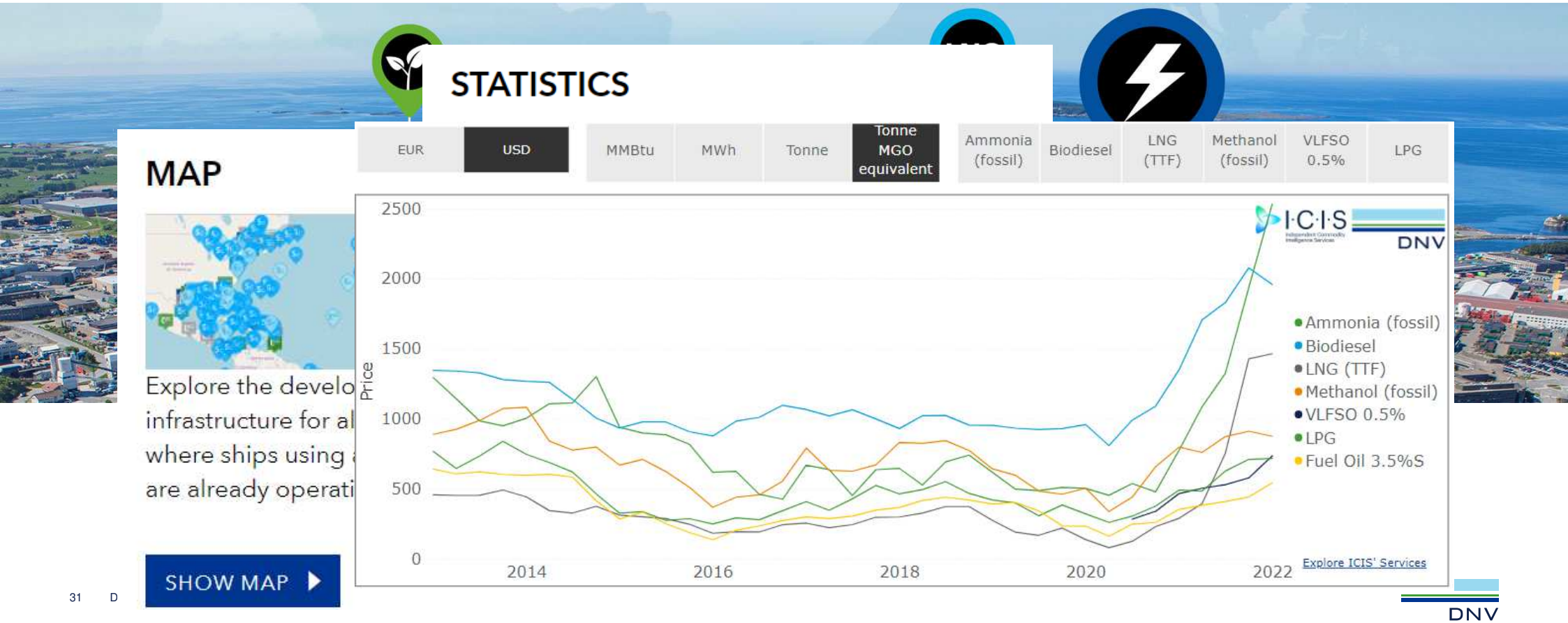
Three key trends

SHARE OF ALTERNATIVE FUELS INCREASING FAST

LARGE VESSELS DRIVING THE CHANGE

MORE DIVERSE FUEL MIX

DNV Alternative Fuels Insight
infrastructure, statistics, prices



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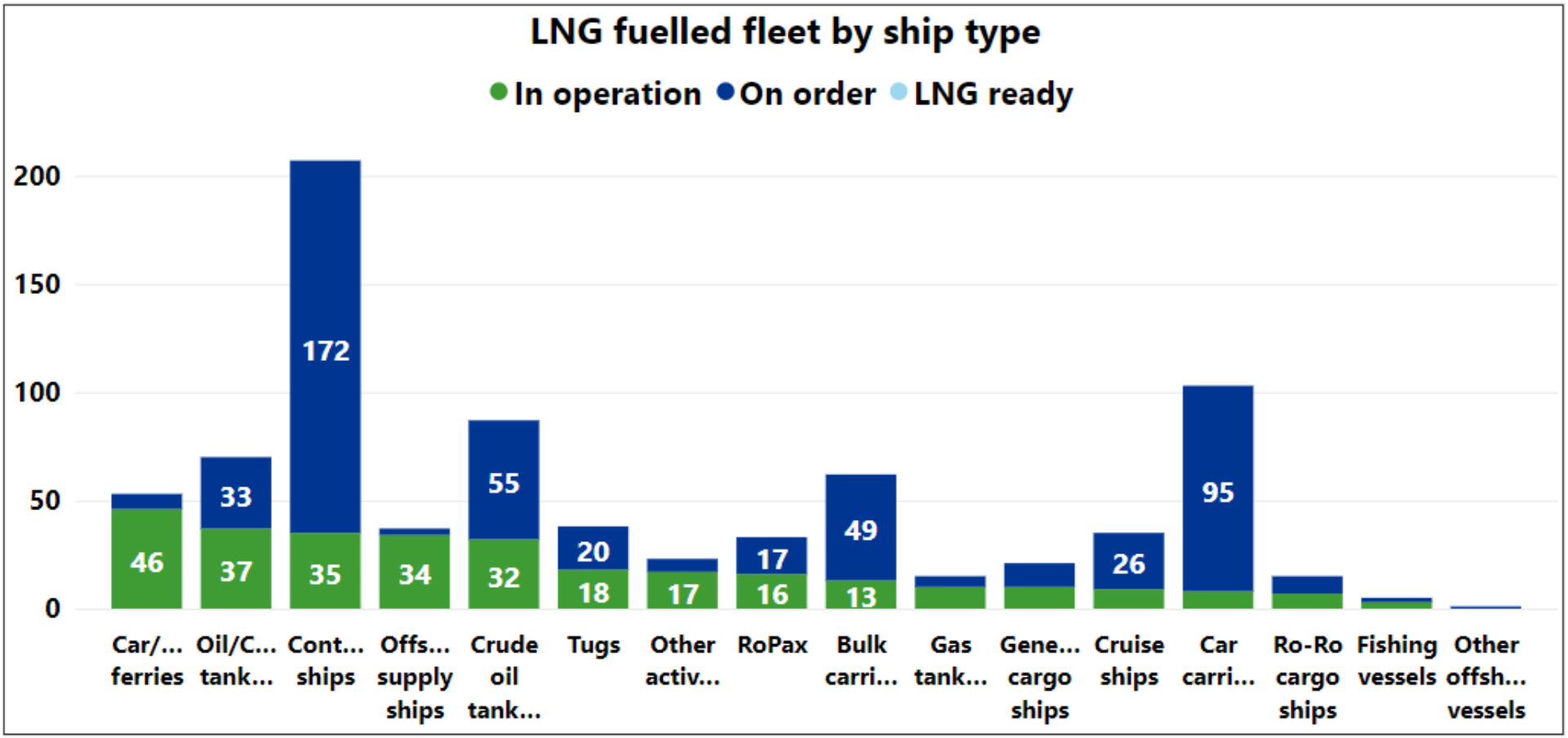
805 confirmed LNG fuelled vessels by fleet type



Updated: May 2022

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The three key boundary elements for decarbonization at the Maritime Industry

- All three elements are needed for a decarbonisation pathway
- Green fuels will be the only solution on long-term
- Each ship segment as well as trading area will likely have their fuel solution

WHEN TRUST MATTERS

Institute of Chartered Shipbrokers, Singapore

Insights - future fuels in the Maritime Industry

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Appendix - Definitions

Short cut	Description
SO_X	Sulphur oxides
NO_X	Nitrogen oxides
CO_2	Carbon dioxide
GHG	Green House Gas
LNG	Liquefied Natural Gas
CH_4	Methane
LPG	Liquefied Petroleum Gas
CH_3OH	Methanol
NH_3	Ammonia
H_2	Hydrogen

Short cut	Description
FAME	Fatty acid methyl ester
PtoF	Power to Fuel (Synthetic Fuels)
EEDI	**E**nergy **E**fficiency **D**esign **I**ndex
EEXI	**E**nergy **E**fficiency E**x**isting Ship **I**ndex
CII	Carbon Intensity Indicator
EPL	Engine Power Limit
AER	Annual Efficiency Ratio
MRV	EU **M**onitoring, **R**eporting and **V**erification of CO_2 emissions
DCS	IMO fuel oil **D**ata **C**ollection **S**ystem