WHEN TRUST MATTERS

Emissions Reductions in Maritime
Alternative ship fuels – Status and Outlook

Ordem dos Engenheiros – Lisbon, 26th January 2023

Jose Allona, Business Development Manager Spain

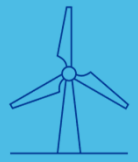
jueves, 26 de enero de 2023

An independent assurance and risk management company

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

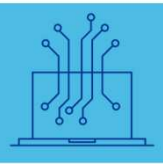
Ship and offshore classification and advisory

Energy advisory, certification, verification, inspection and monitoring



Management system certification, supply chain and product assurance

Software, platforms and digital solutions



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The world’s leading ship and offshore classification society

Global reach

Survey stations in 65+ countries and expertise in all ship and offshore segments

20%

market share of the world’s classed ships and mobile offshore units (gross tonnage)

10,563

ships + mobile offshore units in DNV Class
(286,6 mill GT, Feb 2022)

Quality

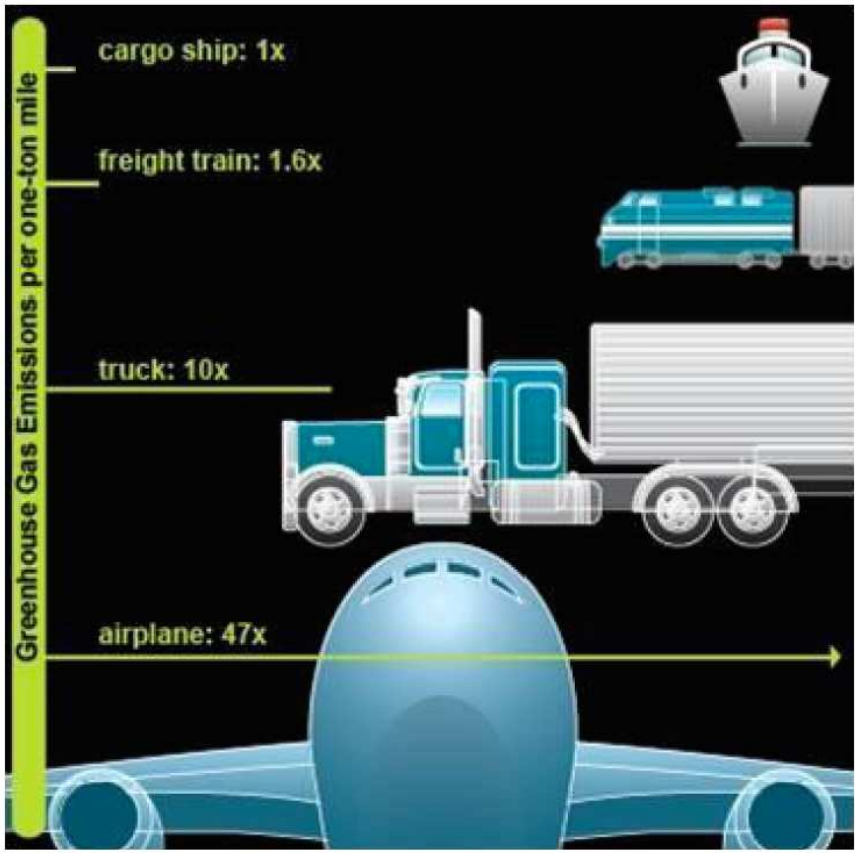
Among the top-ranking societies in Port State Control performance

DNV

DNV dominates the top 10 class society list 7 years in a row: Lloyd's List

One of the most important and widely read maritime newspapers, Lloyd's List has awarded DNV the number 1 position among class societies once again in 2022.

Comparison between different transport modes
Some figures on Maritime Transport



Graphic provided by Edgar Blanco, MIT Center for Transportation & Logistics

http://newsoffice.mit.edu/2010/corporate-greenhouse-gas-1108

- According to the International Chamber of Shipping, there are currently **more than 50,000** merchant ships operating in the oceans
- Size of world fleet, in terms of Gross Tons (GT) is aprox 1505 mGT.
- And their carrying capacity is 2200 millions DWT
- Ships transport more than 80% of world trade volume and about 70% of trade value
- The main challenge shipping is facing is the Energy Transition, Reduction of GHG emissions, and the associated energy efficiency improvement
- Shipping is by far the most efficient transport mode, and the less contaminating one

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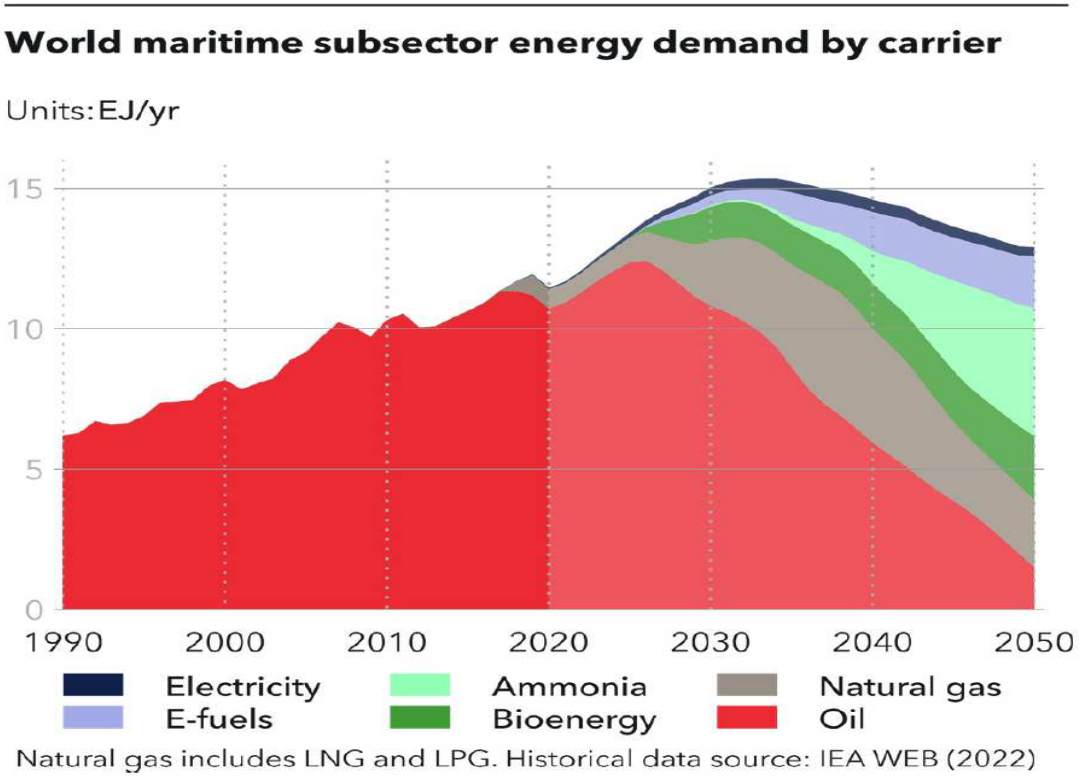
Energy Transition Outlook



Expected energy demand by carrier – DNV ETO 2050 outlook

Emissions of GHG by the different transport modes

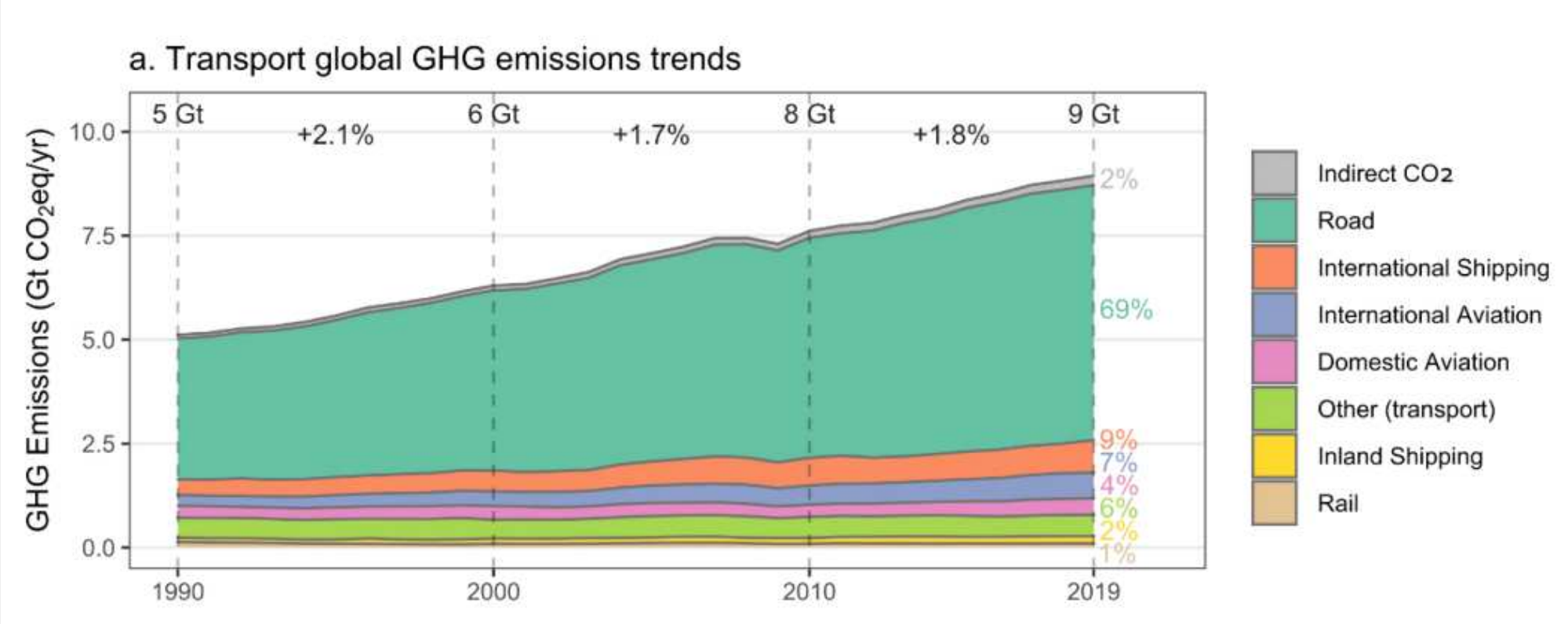


image and numbers extracted from the IPCC AR6 report, published in 2022, using 2019 data

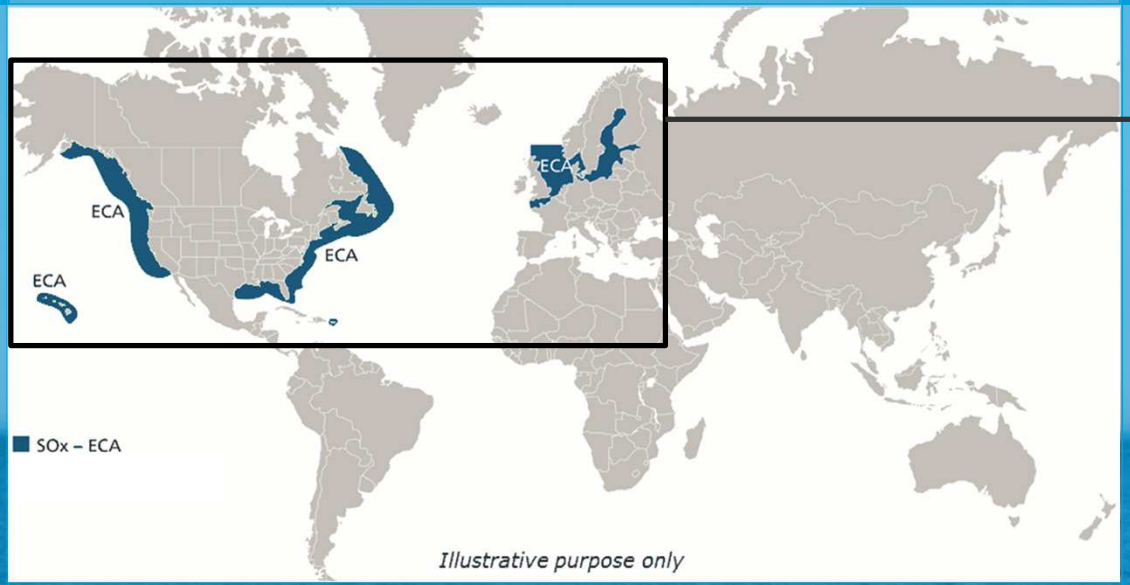
Regulatory framework

Emission to Air

NOx

1st January 2015. SOx Emission Controal Areas (SECA) introduced in North America and Europe

SOx



2015
SECA
0.1%S

Applicable for all ships trading in the SECA's

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Regulatory framework

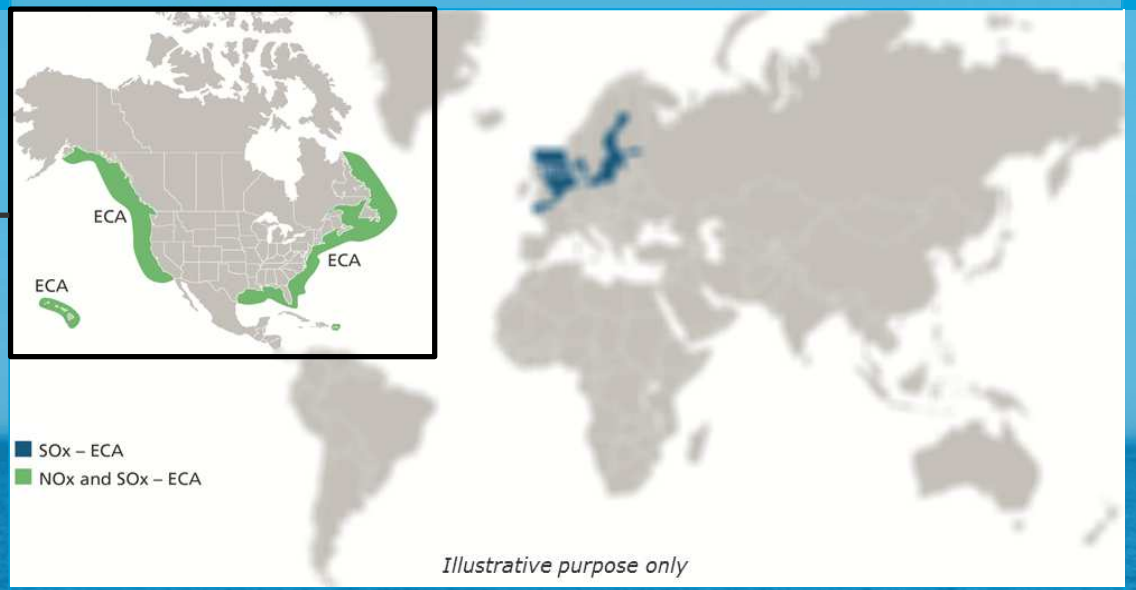
Emission to Air

NOx

1st of January 2016. NOx Emission Control Areas (NECA) introduced in North America and Caribbean waters

SOx

2016
NECA
Tier III



2015
SECA
0.1%S

Applicable for all ships trading in NECA in Americas, keel laid after 1st of January 2016

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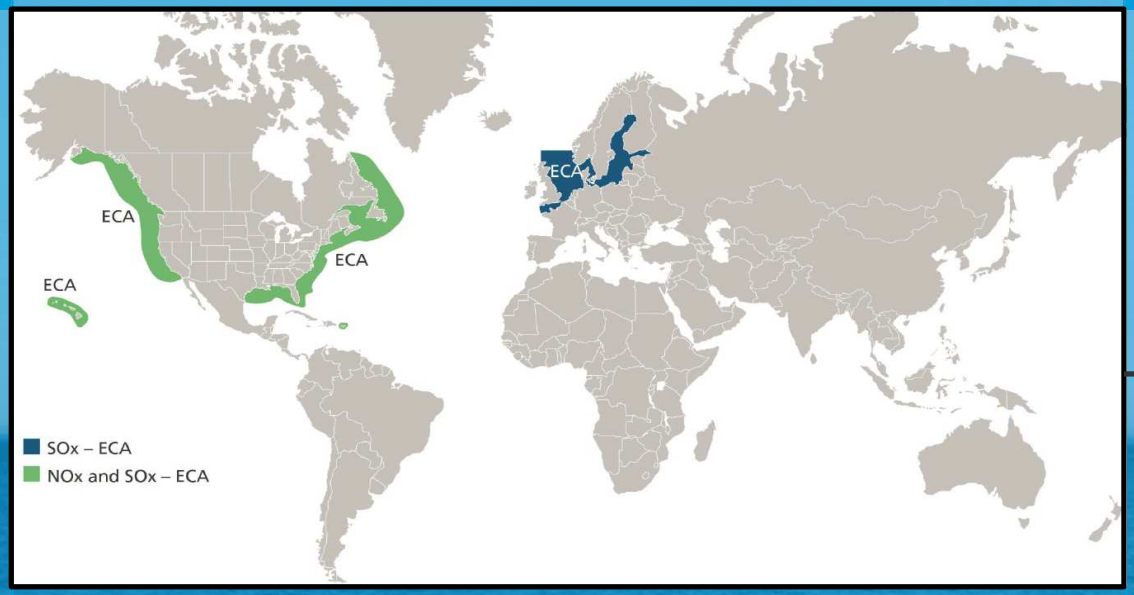
Emission to Air

NOx

1st of January 2020 IMO enforces a global sulphur cap of 0.5%

SOx

2016
NECA
Tier III



2015
SECA
0.1%S

2020
IMO
0.5%S

Applicable world wide for all ships

DNV

Regulatory framework

Emission to Air

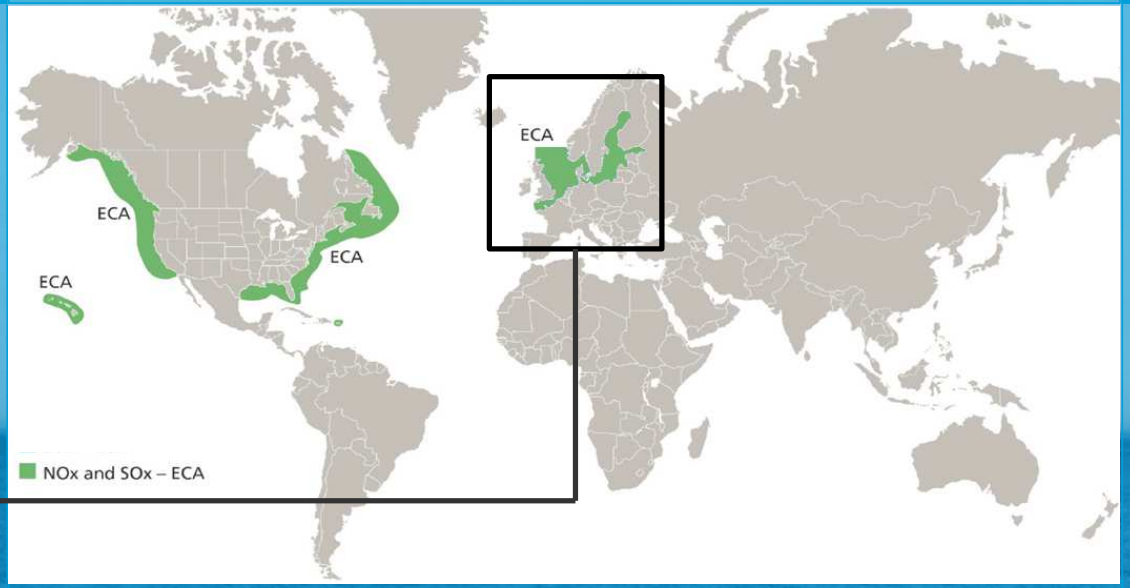
NOx

1st of January 2021. NOx Emission Control Areas (NECA) will be introduced in Baltic Sea, North Sea and English Channel

SOx

2016
NECA
Tier III

2021
NECA
Tier III



2015
SECA
0.1%S

2020
IMO
0.5%S

Applicable for all ships trading in NECA in Europe, keel laid after 1st of January 2021

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2018 - IMO strategy on GHG reductions

- Vision:

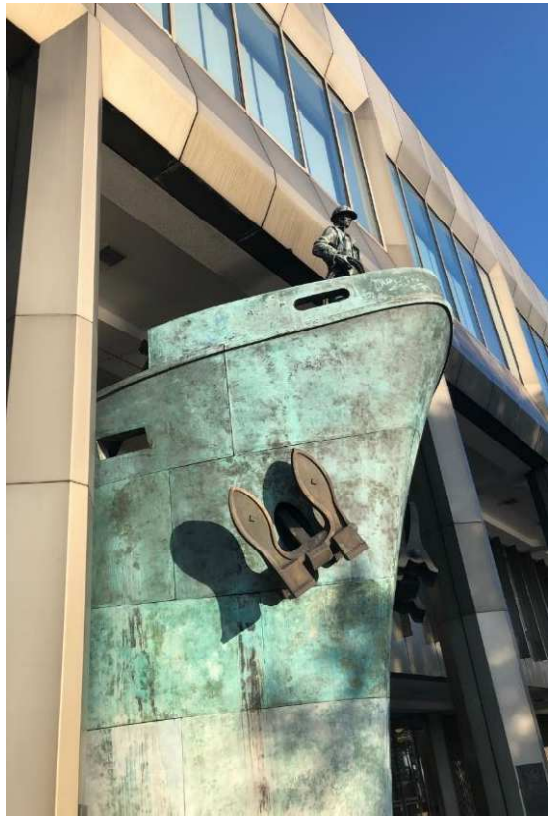
"IMO remains committed to reducing GHG emissions from international shipping and, as a matter of urgency, aims to phase them out as soon as possible in this century"

- Ambitions:
  - Review EEDI with the aim to strengthen requirements
  - **Reduce the average carbon intensity (CO2 emissions per transport work) by 40% in 2030** and by 70% in 2050, compared to 2008
  - Reduce total GHG emissions from shipping by at least **50% in 2050** compared to 2008
- Strategy review in **2023, higher ambitions** to be expected

IMO – GHG at a glance

Adopted regulations:

- EEDI for Existing Ships (EEXI):
  retroactive one-off requirement applied to existing ships
- Carbon Intensity Indicator (CII) / Enhanced SEEMP :
  mandatory annual reduction targets for operational emissions
- Entry into force: Nov. 1st 2022 – **effective as of Jan. 1st 2023**



Work on additional measures, ramping up:

- Guidelines on fuel well-to-wake GHG footprint – **completion in 2022**
- GHG strategy review – **decision by 2023**
- Workplan for mid- and long-term measures – **decision by 2023**
- Increasingly challenging discussions on **market based measures**
- Measures to catalyse a **fuel transition**, including a **potential GHG footprint requirement** for fuels

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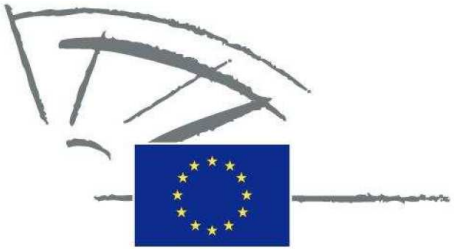
EU Green Deal – a climate neutral Europe by 2050

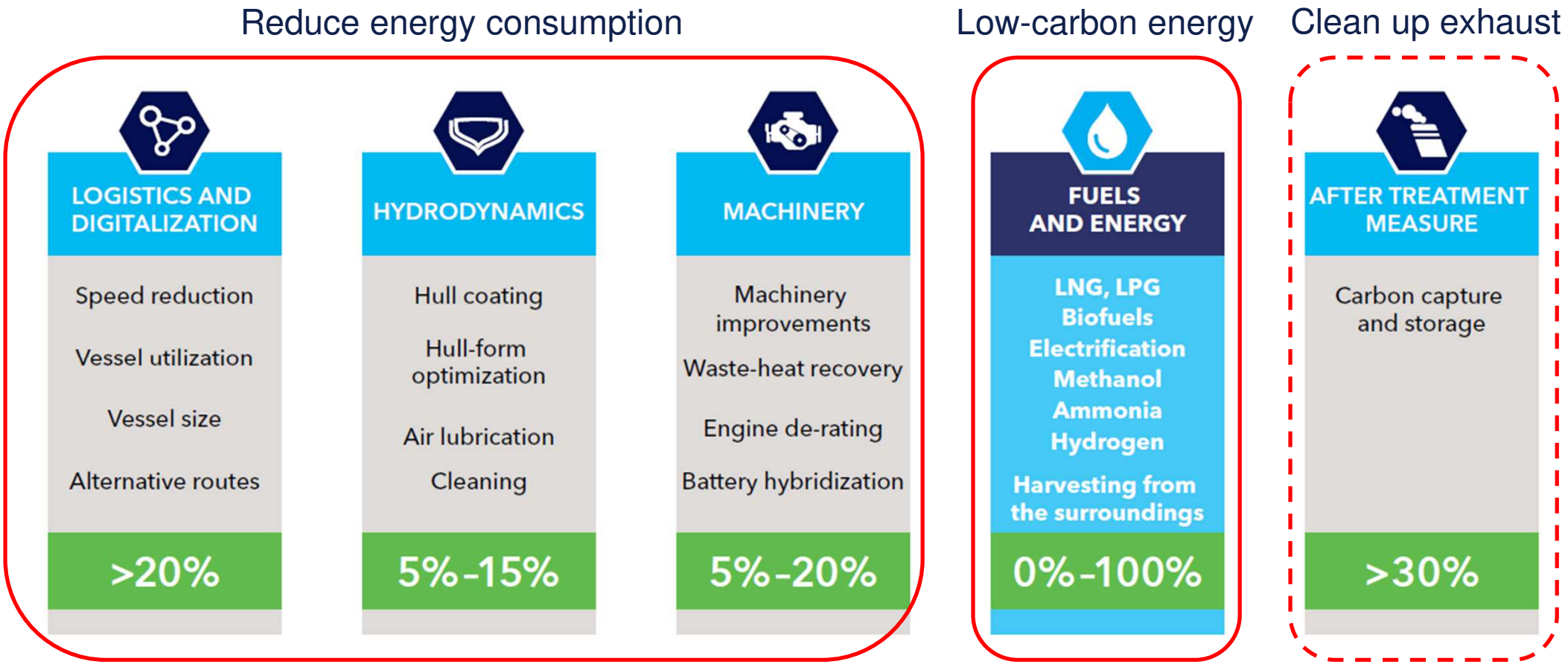
- **Objectives**
  - **Climate neutral Europe by 2050**, including shipping.
  - Estimated **90% reduction in maritime transport emissions relative to 1990 needed by 2050**
  - **European Climate Law** - key vehicle for future actions
  - New overarching EU target for 2030; **original 40% reduction relative to 1990 increased to 55%**



- **Fit for 55 package proposed by Commission on 14 July 2021**
  - Inclusion of shipping in **European Trading Scheme Directive**
  - **Fuel EU Maritime Regulation**, part of strategy for sustainable and smart mobility: New policy measures to drive shift to low carbon fuels
  - Revision of **Alternative Fuels Infrastructure Regulation**: Shore-side electricity and LNG in TEN-T core network ports by 2030 (electricity) and 2025 (LNG)
  - Revision of **Energy Taxation Directive**: Ending tax exemptions for marine fuels

- **Other Green Deal regulations**
  - **Taxonomy Regulation and Delegated Acts**: Sets conditions that an economic activity has to meet in order to qualify as sustainable, with implications for financing. This is undergoing expansion.
  - **Zero Pollution action plan for water, air and soil**. Portfolio of pollution control measures to be put forward. No harmful pollution by 2050.

What are our options?



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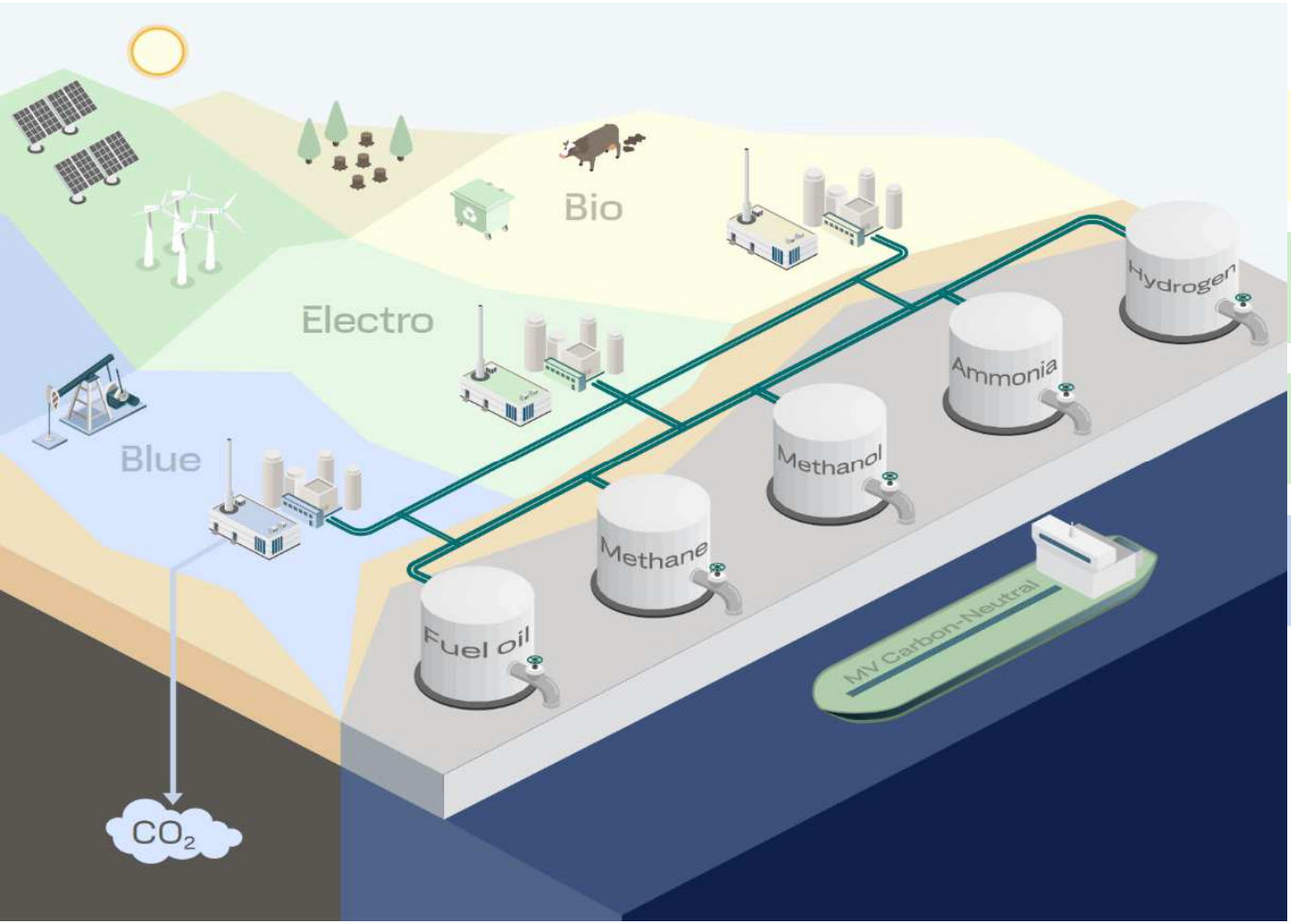
The maritime industry needs to change to carbon neutral fuels



Biomass sustainable for biofuels

Renewable electricity for electrofuels

Sustainable carbon for carbon based electrofuels

CCS at large scale

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Which is the best alternative fuel option?

	Availability	Infrastructure & Storage	Technology Maturity	Energy density	Price	Green
VLSFO/MGO						
LNG						
LPG						
Methanol						
Bio-/e-fuels						
Hidrogen						
Amonia						

Aprox. status in 2022

DNV

Which is the best alternative fuel option?

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VLSFO/MGO						
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Methanol						
Bio-/e-fuels						
Hidrogen						
Amonia						

Status by 2035

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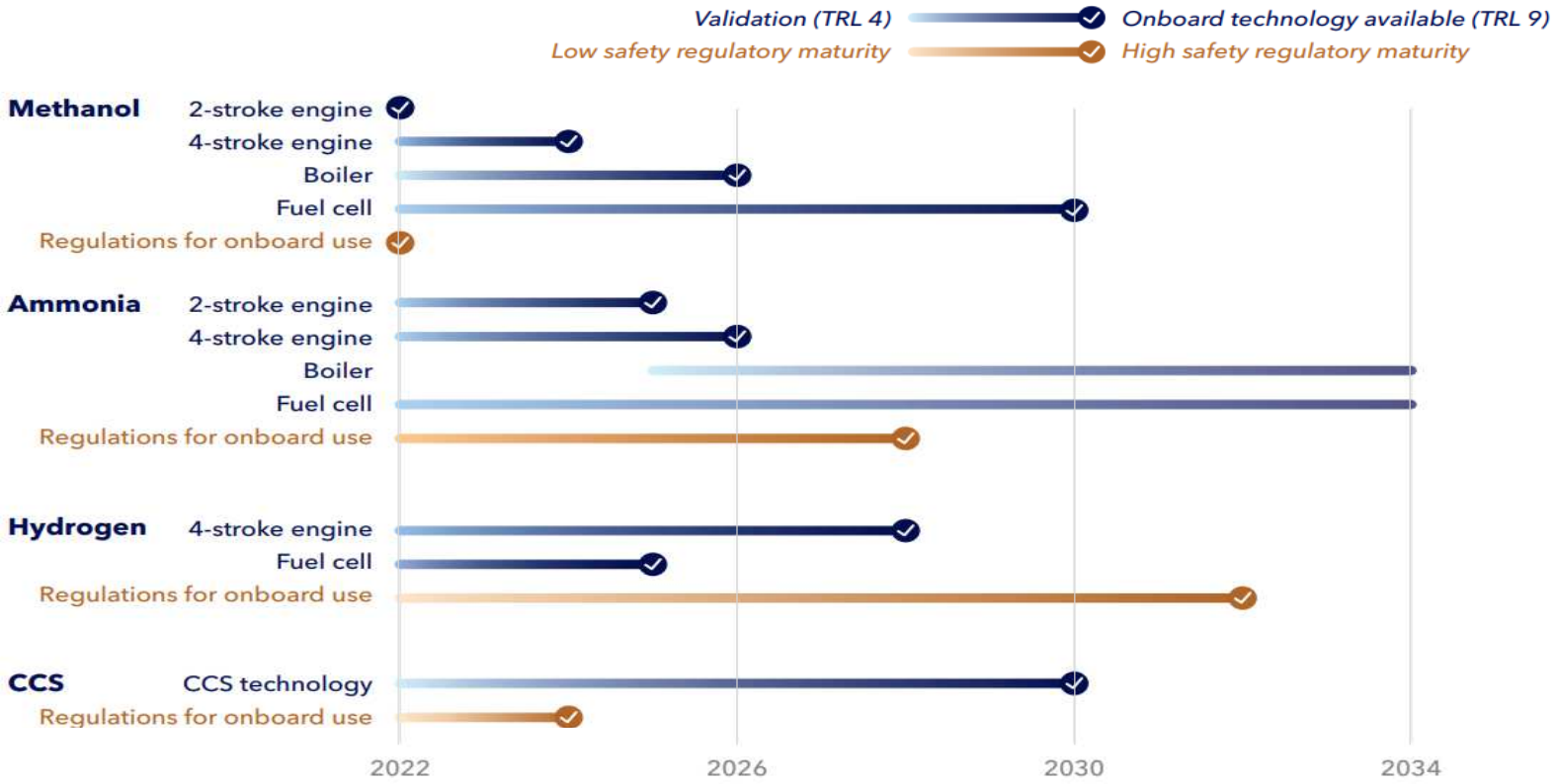
The Technology for the use of alternative fuels will be available for use in 3-8 years



Potential and challenges of alternative fuel options

Liquified Natural Gas (LNG)

LNG is considered a mature alternative fuel option. However, there are some technology choices that need to be made depending on specific vessel design and operational requirements.

Benefits of LNG as marine fuel

- LNG-fuelled vessels **can reduce a vessel's EEDI rating by 20 percent** and the corresponding Carbon Intensity Indicator rating by approximately the same amount.
- At the same time, improved vessel design and engine technologies **can reduce GHGs by up to 25 per cent**. And with more bunkering options now available and others planned, LNG represents a good, medium term option to reach compliance.
- An LNG fuelled vessel can **use lower/zero carbon fuel options like SNG, or biogas with minimal conversion** – offering a potential path to decarbonized operations.

Technical considerations

- Because LNG has a lower volumetric energy density than fuel oil, onboard gas storage requires **larger tanks** than conventional fuel oil storage to provide the same operational range.
- And due to the **low temperature of LNG**, the **tank insulation and required gas handling systems** additional space and equipment is required.
- Depending on their preferences and priorities, owners can choose between **two main types of engine technologies** with different characteristics that are **now available to the market**.

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Liquefied Petroleum Gas (LPG)

LPG, which is any mixture of propane and butane in liquid form, is a widely available fuel that has recently been introduced as a marine fuel.

Benefits of LPG as marine fuel

- Liquified Petroleum Gas combustion results in **CO2 emissions that are approximately 15 per cent lower** than those of Fuel Oil FO.
- When accounting for the complete life cycle, including fuel production, the **CO2 savings amount to roughly 17 per cent**.
- The **cost of installing LPG** systems on board a vessel **is roughly half that of an LNG system**. This is because there is no need for special materials for handling cryogenic temperatures.

Technical considerations

- Currently **only two-stroke diesel engines are commercially available for using LPG as a ship fuel**.
- Four-stroke engines have also been developed but so far are only used for power generation on shore, not for marine applications.
- LPG fuelled vessels often install **shaft generators** to take advantage of **LPG for auxiliary engines**.
- LPG can be stored under pressure or refrigerated, but bunkering options may not always be available in the temperature and pressure range a ship can handle. Therefore, **pressurized tanks are typically selected**.
- The bunkering source and the ship must carry the necessary equipment and installations for safe bunkering.
- **LPG tanks can also be suitable for ammonia**, so long as their pressure rating is appropriate. Engine technology is also quite similar, making LPG designs the **easiest to retrofit to utilise ammonia** as fuel at a later stage.

Methanol

Methanol is the simplest alcohol with the lowest carbon content and highest hydrogen content of any liquid fuel. Methanol can be made available through existing infrastructure in more than 100 ports globally

Benefits of methanol as ship fuel

- Methanol combustion in an internal combustion engine **reduces CO2 emissions by approximately 10 per cent** compared to FO.
- When considering the complete life cycle, including the production of the fuel from natural gas, the total CO2 emissions are equivalent to or slightly higher (ca. 5%) than the corresponding emissions of petroleum-based fuels.
- In the future, **“green methanol”** is likely to become available, with the potential for significantly lower GHG emissions.

Technical considerations

- There are **two main options for using methanol as fuel in conventional ship engines**: A two-stroke diesel-cycle engine or in a four-stroke, lean-burn Otto-cycle engine.
- Methanol is a liquid fuel and **can be stored in standard fuel tanks**, but modifications are required to accommodate its **low-flashpoint** properties to comply with the IMO’s IGF Code.

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Ammonia

Green ammonia (produced by electrolysis powered by renewables), or blue ammonia, (produced from byproducts of current fossil fuel production) are promising sources of zero-carbon fuel but will require significant investments in production capacity from renewables and bunkering infrastructure to replace FO.

Benefits of ammonia as fuel:

- Apart from being a potential **zero-carbon fuel**, ammonia is **cheaper** that batteries **and easier to store** than hydrogen or LNG, and is nearly identical to LPG at low pressure under ambient conditions.

Technical considerations

- Ammonia is a **toxic and corrosive** substance, and **emissions** from combusted ammonia may contain a high amount **of nitrous oxide** (N_2O), a powerful greenhouse gas.
- At present, the **technology** to clean ammonia exhaust **is still being refined** and the use of this fuel on existing ships will require engine modifications and the installation of new fuel tanks and safety systems. Such engines are expected to be commercially available in 2024.
- However, some owners are already building ships that are **"ammonia ready",** equipped with stainless steel tanks to manage corrosion and engines that can handle ammonia as a 'drop in' fuel.
- It should also be noted that ammonia-fuelled engines will require a certain amount conventional **pilot fuel**.
- Moreover, due to the low volumetric energy of ammonia, it may be more practical in many cases to use a **combination of ammonia and fuel oil.**

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Hydrogen

- Hydrogen from electrolysis and renewable energy is the basic building block for a range of fuels. Hydrogen can be used directly as compressed or liquefied gas. Other technologies for storing hydrogen are also being developed.

Benefits of hydrogen as fuel:

- If produced using renewable energy, hydrogen does not result in **any CO2 emissions**, making it one of the cleanest alternative fuel options.
- While **fuel cells** are considered the key technology for hydrogen, other applications are being studied such as **internal combustion engines** that have promising marine applications.

Technical considerations:

- **Storage of hydrogen requires approximately six to ten times more space** than conventional FO, depending on the technology selected.
- Liquefied hydrogen is at the lower end of this range, at the expense of **very low temperatures (-253oC)**, which requires appropriate materials.
- **Cost of the storage systems** is another limiting factor, combined with the **lack of infrastructure for supplying hydrogen to shipping.**
- Therefore, in the short- to medium-term future, hydrogen is mainly a viable option for **coastal vessels** that can secure local fuel supply, especially if supported by government financing.

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Nuclear power

Technical Developments

Extensive experience with nuclear propulsion in naval vessels

- Not commercially feasible
- Safety and security risks

Molten Salt Reactors (MSR)

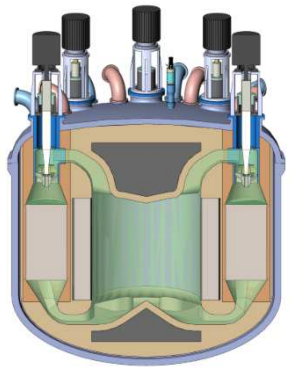
- Inherently safe technology
- Demonstrator expected by 2024 (100kW-1 MW)
- First marinized reactor by 2028-2030
- Leasing scheme to make cost competitive

Other aspects

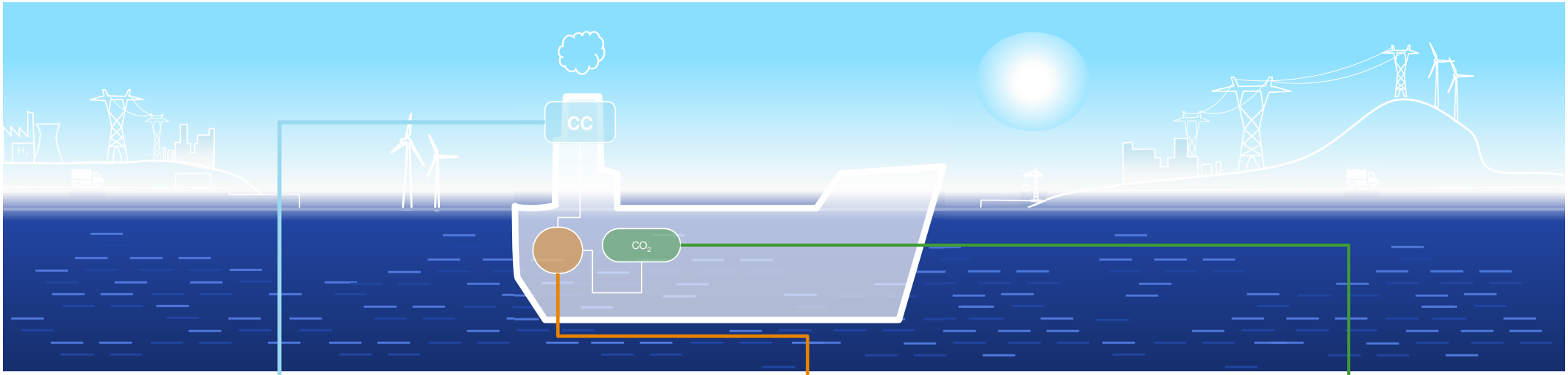
International regulations: SOLAS has to be modernized and updated

Public perception

Commercial uptake not before 2035



A maritime CCS system



Carbon capture system:

Post-combustion CO_2 separation

Clean gas leaves to air

CO_2 is captured into an agent or as pure stream

Treatment system:

CO_2 by-product is treated and

- converted to storage conditions or
- disposed to the environment*

*Regulatory perspective ???

Storage:

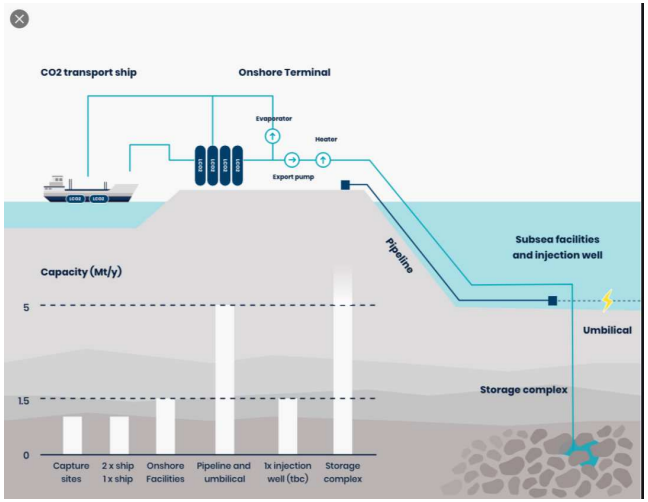
- Solid (adsorption)
- Gas (compressed, e.g. for small routes)
- **Liquefied** (typical CO_2 transport conditions)

CCS is easier to apply on LNG and LPG fueled systems

Expected development of CO_2 shipping / Northern Lights

- The Northern Lights project is part of the Norwegian CCS demonstration project with capture of CO_2 from industrial sources in the Oslofjord region, shipping of liquid CO_2 from capture sites to an onshore terminal on the Norwegian west coast, and pipeline transport from onshore to an offshore storage complex in the North Sea.
- For this project, a specification for 7500 m^3 multigas carrier (LPG and CO_2) has been developed and distributed to selected shipyards as part of a tendering process. The design is based on the *medium pressure* concept.
- ✠1A Tanker for Liquefied Gas (incl. CO_2), Ship type 2G (-35 deg.C, 19barg, 1100 kg/m3) Ice (C), Winterized, F(A, M), E0, Gas Fueled, Clean Design, Comf. (V2, C2), BWT-T, NAUT(AW), TMON, COAT-PSPC(B), RP (1, 20), Shore Power, BIS,

Source: Equinor/Northern Lights Project Concept report



1st of a kind CO_2 Ships in Present CCS Projects

- **Current ships @ 7,500 m^3** capacity
- 2 x **type-C cargo in-line tanks**
- **Baseline is Fully Pressurised LPGC modified for CO_2**
- **Proven concept** (scaled up beverage industry ships)
- Operating Condition: **15barg -26°C** (design 19barg, c.-35°C)
- Operating range 13-18barg at equilibrium temperature

- **For NL High tensile 50mm steel** to maximise tank diameter - verified by DNV and Norwegian Authorities
  - ❑ **Approval in Principle** (AiP) **complete**
  - ❑ **General Approval for Ship Application** (GASA) ***Complete***

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DNV resources on decarbonization (selection)

Alternative Fuels Insight

www.dnv.com/afi

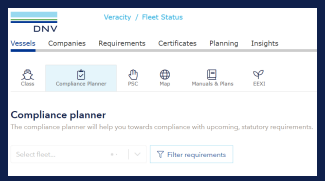
Emissions Insights

incl. preliminary CII rating (customer portal)

www.dnv.com/dcs

Compliance Planner

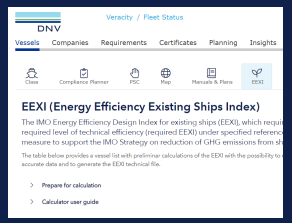
(Customer portal)



www.dnv.com/compliance

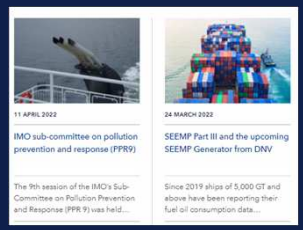
EEXI Calculator

(Customer portal)



www.dnv.com/eexi

Technical & Regulatory News



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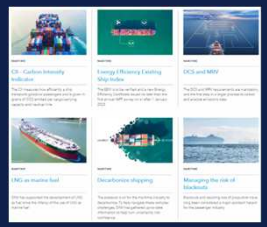
Decarbonization hub

www.dnv.com/decarb

Topic pages

MRV/DCS, EEXI, CII, etc.



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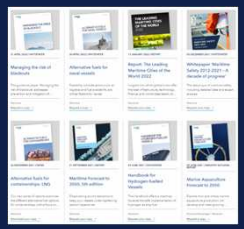
Publications

Alternative fuels, Ammonia as fuel, etc.



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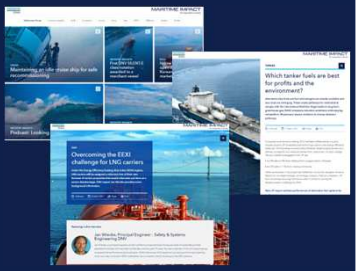
Maritime Impact



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Thank you!

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