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The environment & the shipping industry: Regulatory recap, goals and priorities

Stavros Hatzigrigoris

25th April 2024, Aikaterini Laskaridis Foundation

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   - Associations & Networks

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   - Hydrodynamics & Aerodynamics
   - Machinery
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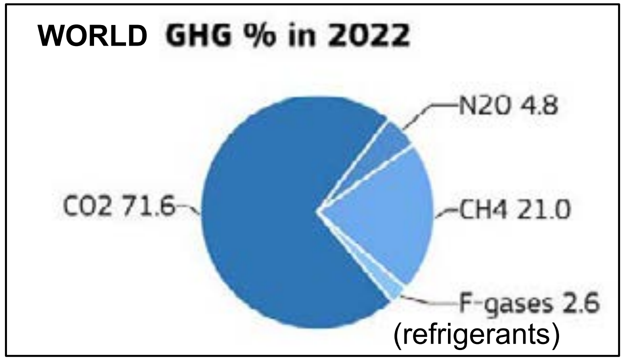
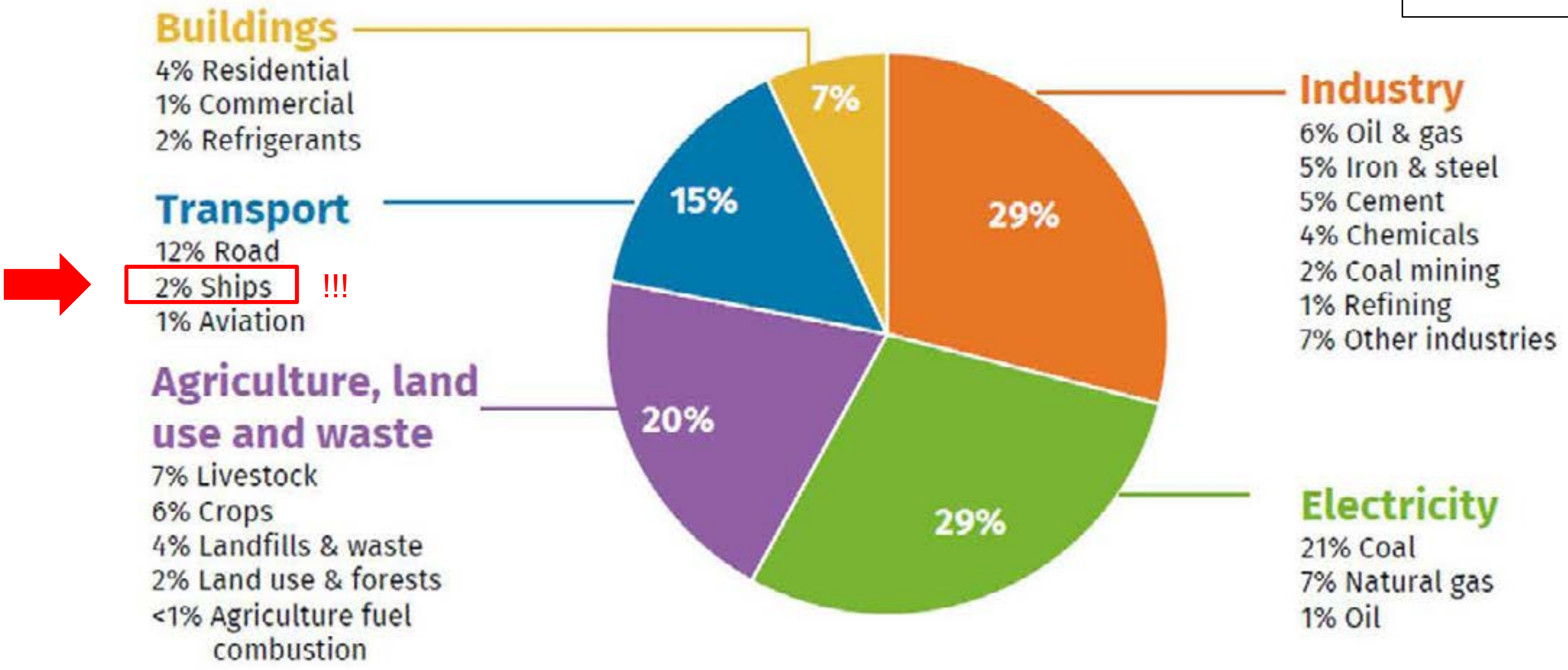
Global GHG emissions by sector

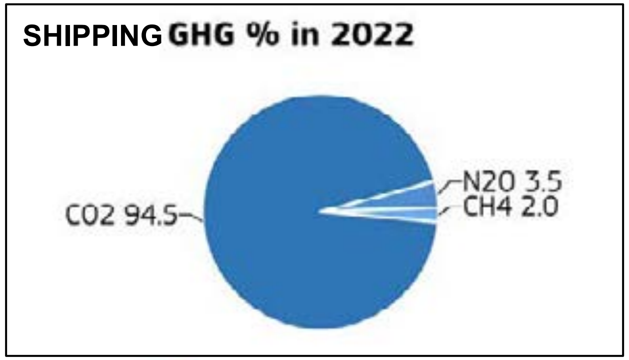


Source: JRC (Joint Research Center EU)



Source: Rhodium Group (referring to 2021)

GHGs emitted by shipping



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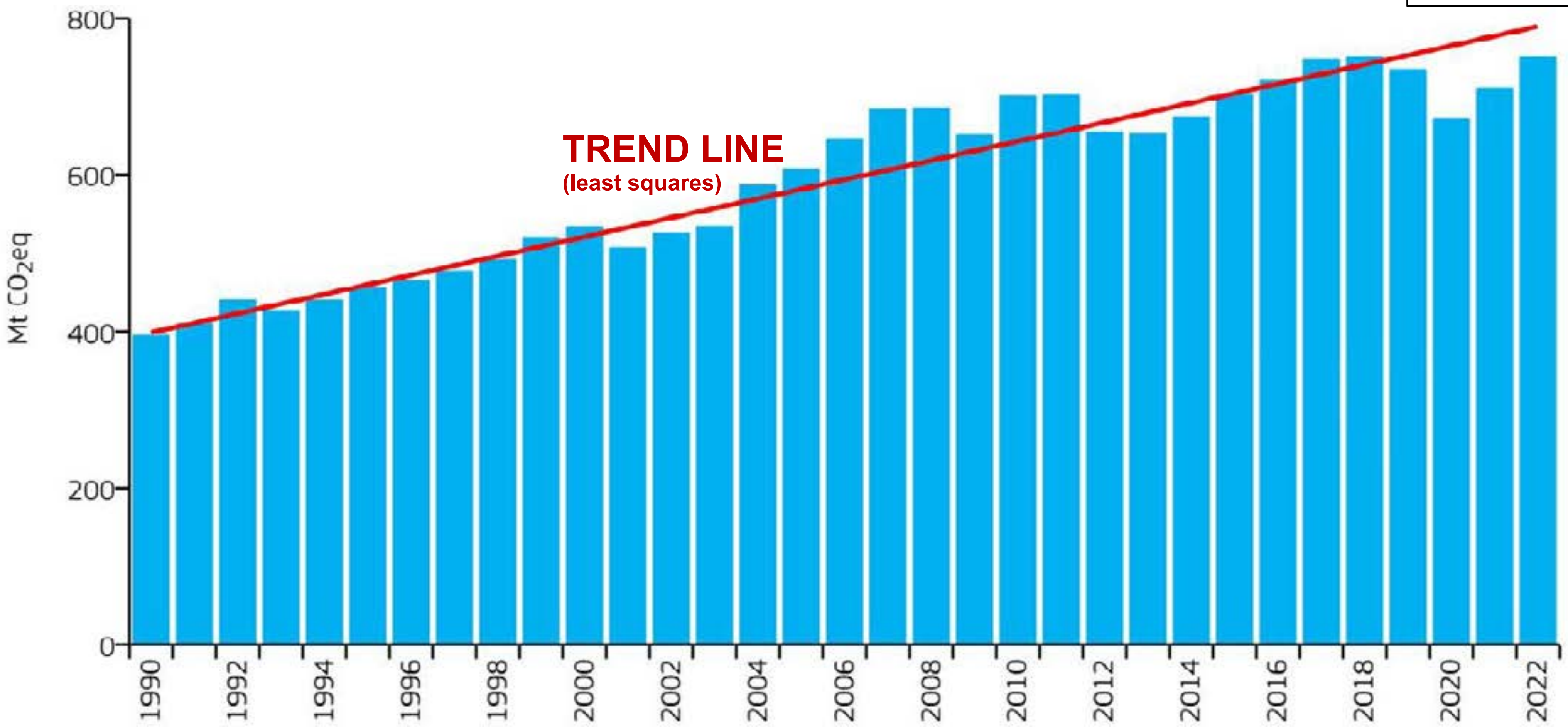

Source: JRC

Many parties are involved in regulating the maritime industry…

The United Nations

IMO

Regional Regulations

Local Regulations

CARB

Port State Control

United States Coast Guard 1790

AMSA

Asia-Pacific PSC Tokyo MOU

Paris MoU on Port State Control

Indian Ocean Memorandum of Understanding on Port State Control

China MSA

Classification Societies

IACS International Association of Classification Societies

12 members
>90% DWT

DNV

RINA

LR

ClassNK

ABS

Bureau Veritas 1828

Indian Register of Shipping

CCS China Classification Society 中國船級社

Flag States

NGOs

INTERTANKO

SIGTTO

INTERCARGO International Association of Dry Cargo Shipowners

RIGHTSHIP

OCIMF

BIMCO

WWF

GREENPEACE

Content

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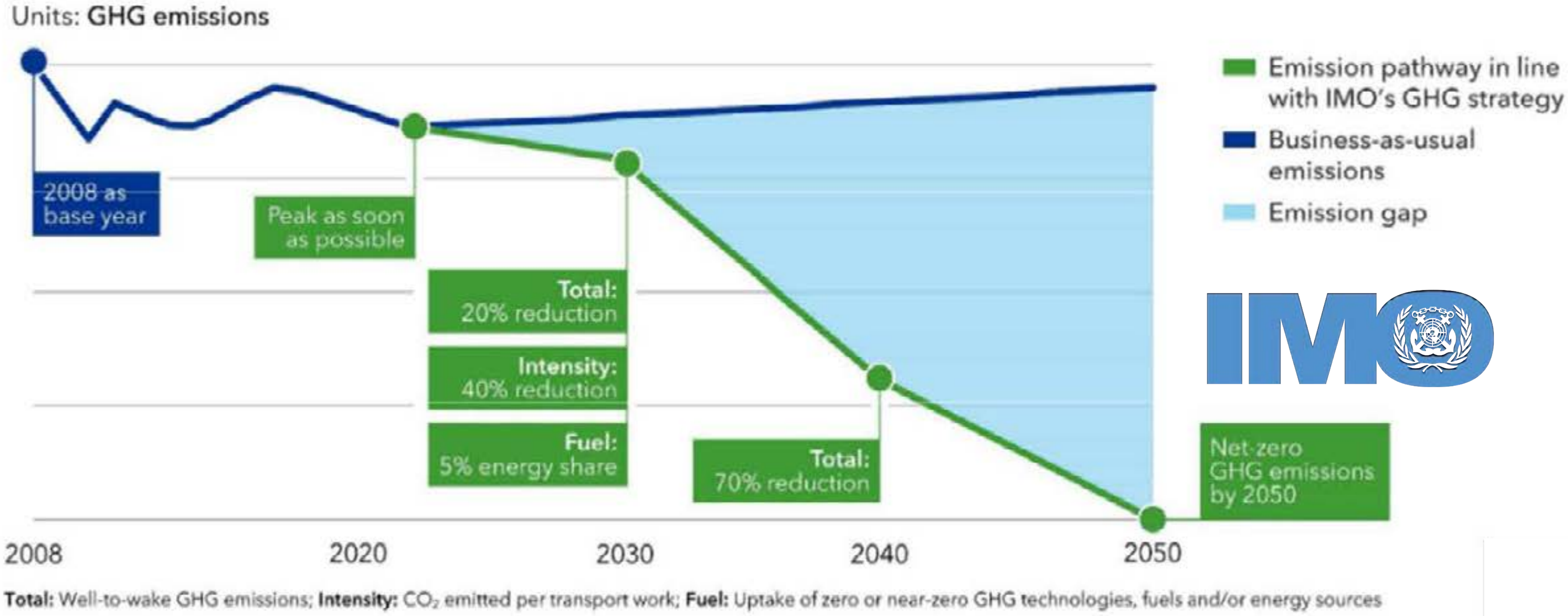
The urge to reduce GHG emissions

Climate Change ⟶ Policy Makers: Reduce GHG emissions



How does IMO regulates?

- **Conventions** ex. SOLAS, MARPOL, STCW,
- **Resolutions**: Each committee brings resolutions to amend part of International convention

XYZ . 123 (34)

- XYZ → Which Committee passed the resolution?
  Ex. **MSC** (Safety), A (Assembly), **MEPC** (Pollution), C (Council), FAL (Facilitation), LEG (legal)
- 123 → Resolution number (Chronological order)
- (34) → No. of Committee's Session in which it was adopted

- **Circulars**: clarification, interpretation or guidance on its various codes and conventions

XYZ . 1 / Circ . 34

- XYZ → Which Committee passed the resolution?
- 1 → Which subject does it concerns?
  Ex. MEPC.1 General on pollution
  MEPC.2 Provisional categorization of liquid substances
  MEPC.3 Oily wastes port facilities
  etc.
- 34 → Circular number (Chronological order)

SOLAS

Chapter I – General Provisions

Surveying the various types of ships and certifying that they meet the requirements of the convention.

Chapter II-1 – Construction – Subdivision and stability, machinery and electrical installations

The subdivision of passenger ships into watertight compartments so that after damage to its hull, a vessel will remain afloat and stable. This includes compliance with the International Code on Intact Stability

Chapter II-2 – Fire protection, fire detection and fire extinction

Fire safety provisions for all ships with detailed measures for passenger ships, cargo ships and tankers under the FSS Code and requirements for the carriage of gas as a fuel under the IGF Code

Chapter III – Life-saving appliances and arrangements

Life-saving appliances and arrangements, including requirements for life boats, rescue boats and life jackets according to type of ship. The specific technical requirements are given in the International Life-Saving Appliance (LSA) Code.

Chapter IV – Radiocommunications

The Global Maritime Distress Safety System (GMDSS) requires passenger and cargo ships on international voyages to carry radio equipment, including satellite Emergency Position Indicating Radio Beacons (EPIRBs) and Search and Rescue Transponders (SARTs).

Chapter V – Safety of navigation

This chapter requires governments to ensure that all vessels are sufficiently and efficiently manned from a safety point of view. It places requirements on all vessels regarding voyage and passage planning, expecting a careful assessment of any proposed voyages by all who put to sea. Every mariner must take account of all potential dangers to navigation, weather forecasts, tidal predictions, the competence of the crew, and all other relevant factors. It also adds an obligation for all vessels' masters to offer assistance to those in distress and controls the use of lifesaving signals with specific requirements regarding danger and distress messages. It is different from the other chapters, which apply to certain classes of commercial shipping, in that these requirements apply to all vessels and their crews, including yachts and private craft, on all voyages and trips including local ones.

Chapter VI – Carriage of Cargoes

Requirements for the stowage and securing of all types of cargo and cargo containers except liquids and gases in bulk. Including compliance with the Code of Safe Practice for Ships Carrying Timber Deck Cargoes

SOLAS

Chapter VII – Carriage of dangerous goods

Requires the carriage of all kinds of dangerous goods to be in compliance with the International Bulk Chemical Code (IBC Code), The International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) and the International Maritime Dangerous Goods Code (IMDG Code).

Chapter VIII – Nuclear ships

Nuclear powered ships are required, particularly concerning radiation hazards, to conform to the Code of Safety for Nuclear Merchant Ships.

Chapter IX – Management for the Safe Operation of Ships

Requires every shipowner and any person or company that has assumed responsibility for a ship to comply with the International Safety Management Code (ISM).

Chapter X – Safety measures for high-speed craft

Makes mandatory the International Code of Safety for High-speed craft (HSC Code).

Chapter XI-1 – Special measures to enhance maritime Safety

Requirements relating to organizations responsible for carrying out surveys and inspections, enhanced surveys, the ship identification number scheme, and operational requirements.

Chapter XI-2 – Special measures to enhance maritime security

Includes the International Ship and Port Facility Security Code (ISPS Code). Confirms that the role of the Master in maintaining the security of the ship is not, and cannot be, constrained by the Company, the charterer or any other person. Port facilities must carry out security assessments and develop, implement and review port facility security plans. Controls the delay, detention, restriction, or expulsion of a ship from a port. Requires that ships must have a ship security alert system, as well as detailing other measures and requirements.

Chapter XII – Additional safety measures for bulk carriers

Specific structural requirements for bulk carriers over 150 metres in length.

Chapter XIII - Verification of compliance

Makes mandatory from 1 January 2016 the IMO Member State Audit Scheme.

Chapter XIV - Safety measures for ships operating in polar waters

The chapter makes mandatory, from 1 January 2017, the Introduction and part I-A of the International Code for Ships Operating in Polar Waters (the Polar Code).

SOLAS ex. Inert Gas System (ChII-2, Reg)

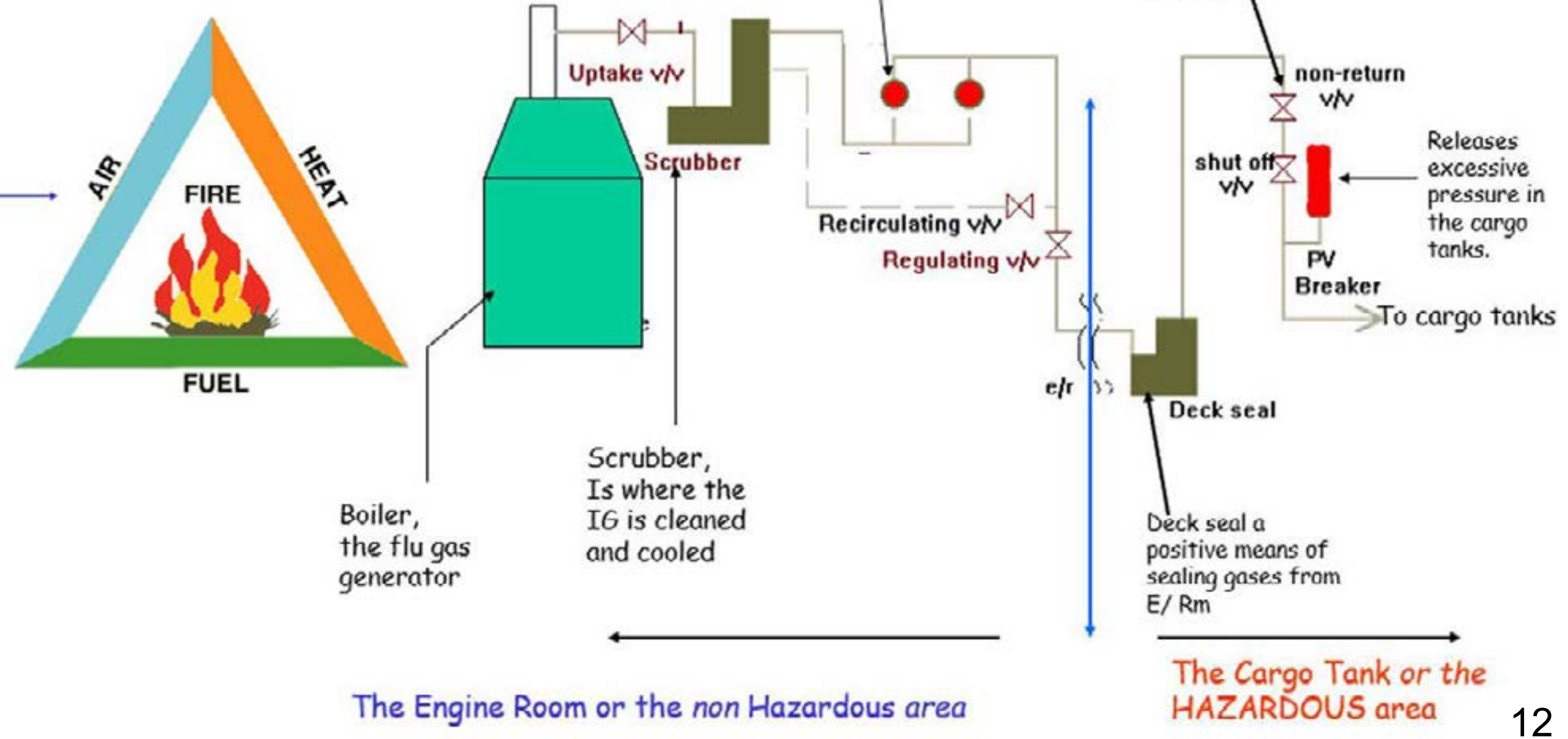
What is a Fire Triangle

It describes the three different factors required for ignition of a fire.

1. Air (Oxygen)
2. Heat (External Spark)
3. Fuel (Cargo)

The Inert Gas is used to cut of the Air or the Oxygen side of the triangle

A Typical Block Diagram of Inert Gas System



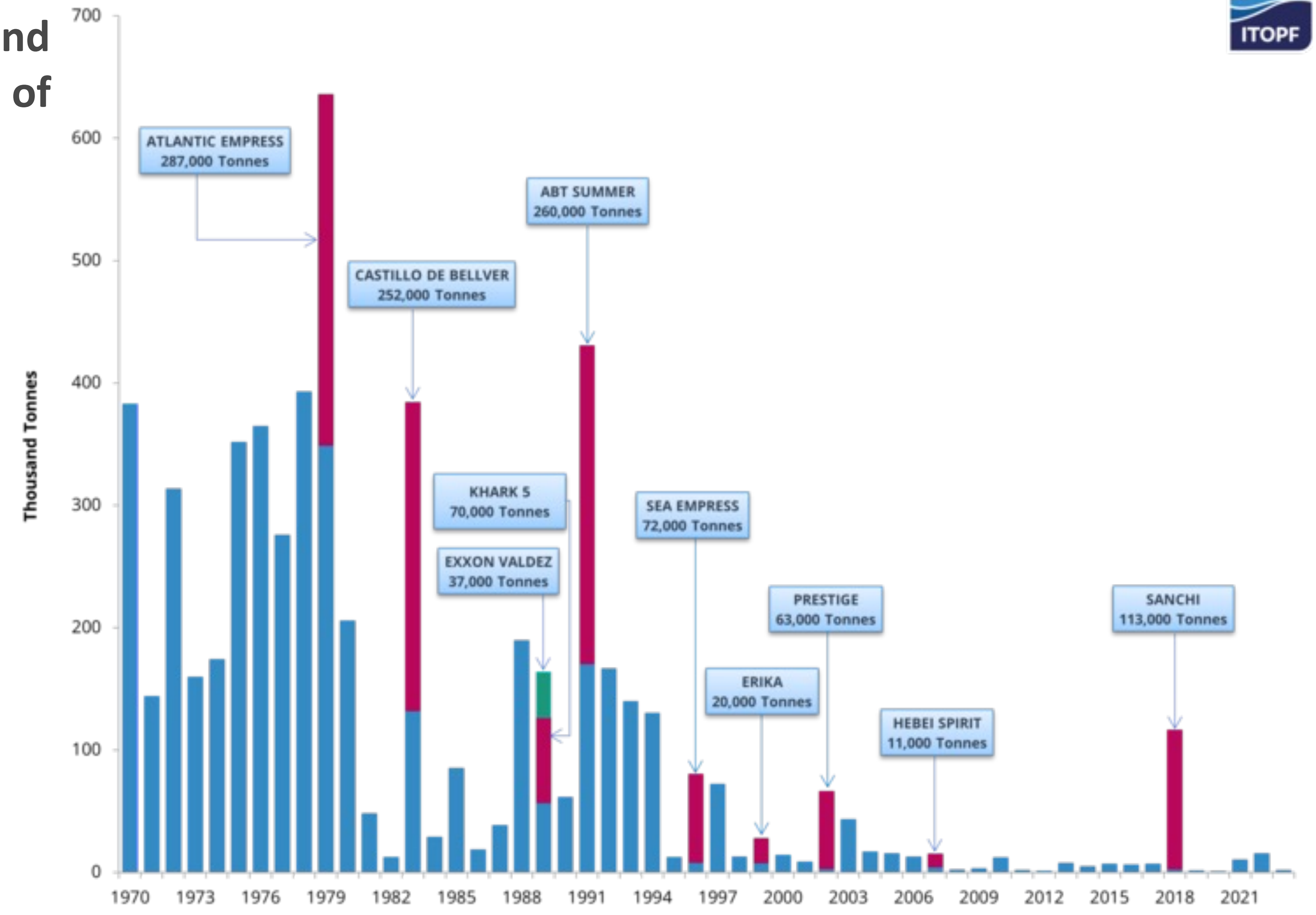
MARPOL

Annex	Title	Entry into force
Annex I	Prevention of pollution by oil & oily water	2 October 1983
Annex II	Control of pollution by noxious liquid substances in bulk	6 April 1987
Annex III	Prevention of pollution by harmful substances carried by sea in packaged form	1 July 1992
Annex IV	Pollution by sewage from ships	27 September 2003
Annex V	Pollution by garbage from ships	31 December 1988
Annex VI	Prevention of air pollution from ships	19 May 2005

THE EXXON VALDEZ OIL SPILL

NBCNEWS.com

Thousand Tonnes of spilt oil



MARPOL Annex I

Chapter	Regulations	Topics
1	1-5	General: Definitions and Applications
2	6-11	Surveys and certification: Flag administration and Port State Control (PSC)
3	12-17	Machinery Space: Construction, discharge control and equipment (all ship types)
4	18-36	Cargo Areas: Construction, discharge control and equipment (oil tankers)
5	37	Shipboard oil pollution emergency plan (SOPEP)
6	38	Reception facilities
7	39	FPSOs and FSUs

Definitions (Reg 1), Applications (Reg 2), Exemptions and waivers (Reg 3), Exceptions (Reg 4), Equivalents (Reg 5)

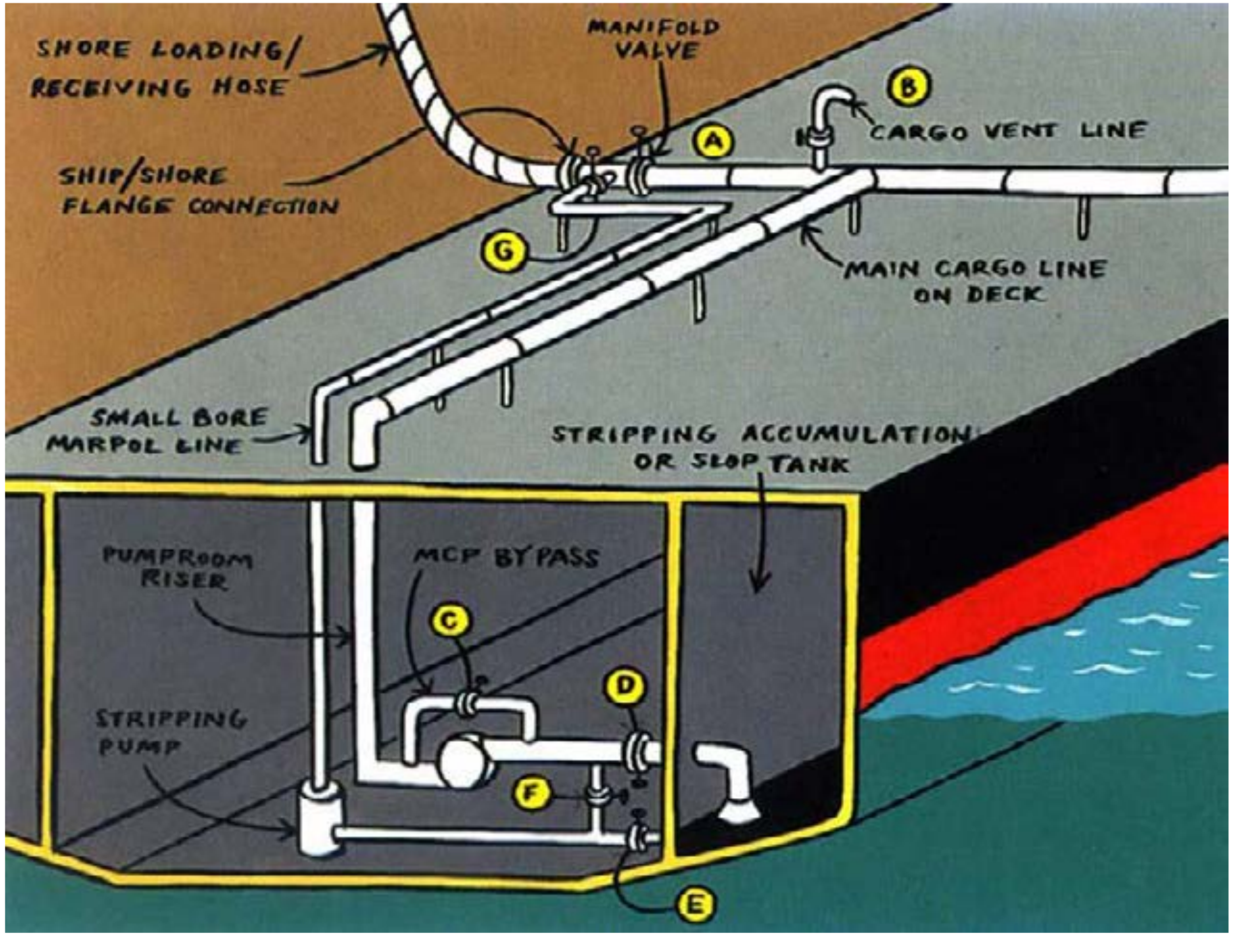
LIST

- Surveys (for Certificate)
- IOPP (International Oil Pollution Prevention Certificate) (Reg 7,8)
- Form, duration & validity of certificate (Reg 9,10)
- The role of the flag and PSC in accordance to the (Reg 11)

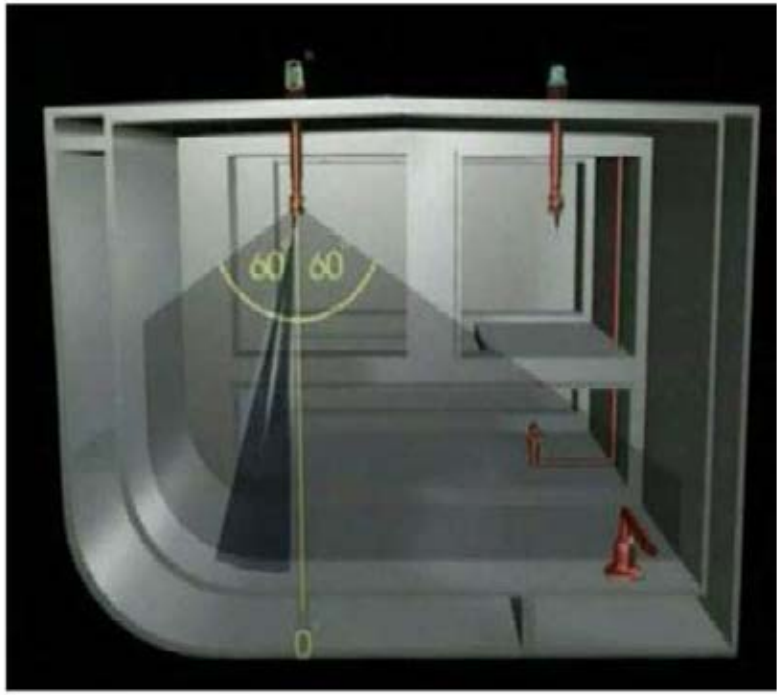
Examples following…

MARPOL Annex I: Examples

Regulation 30: Marpol line

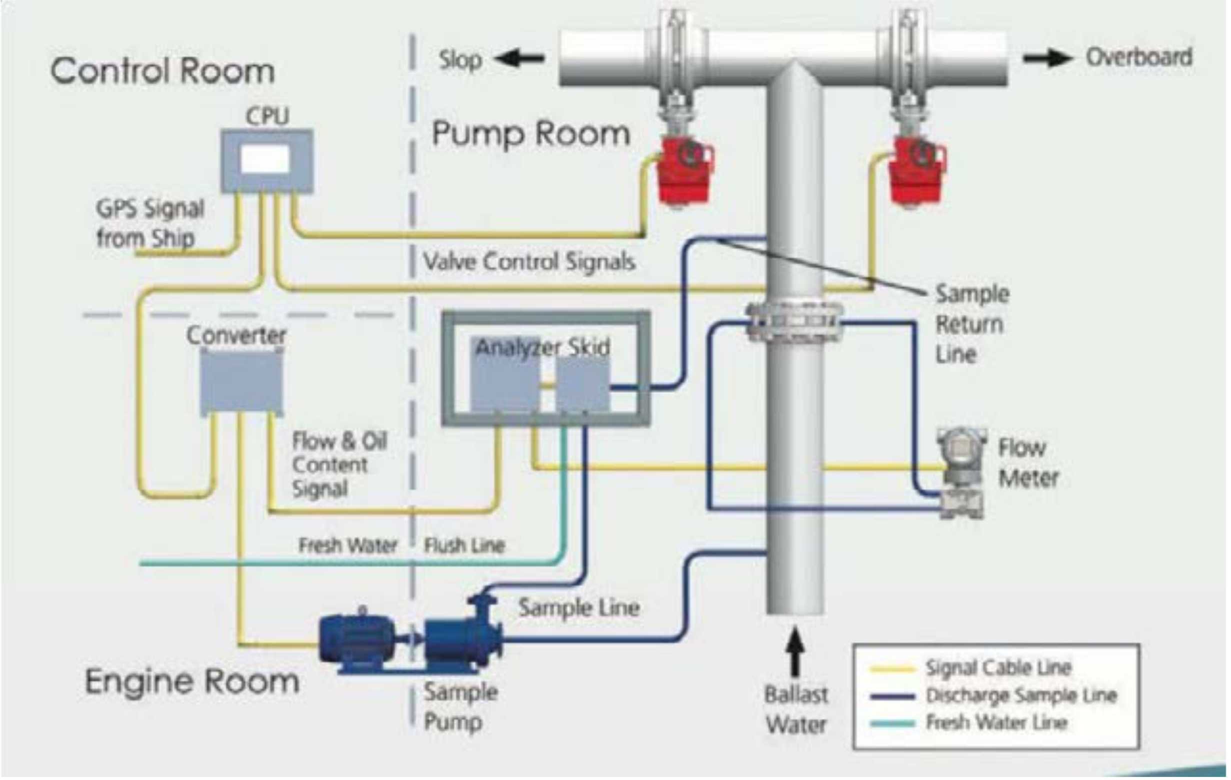


Regulation 33,35: COW

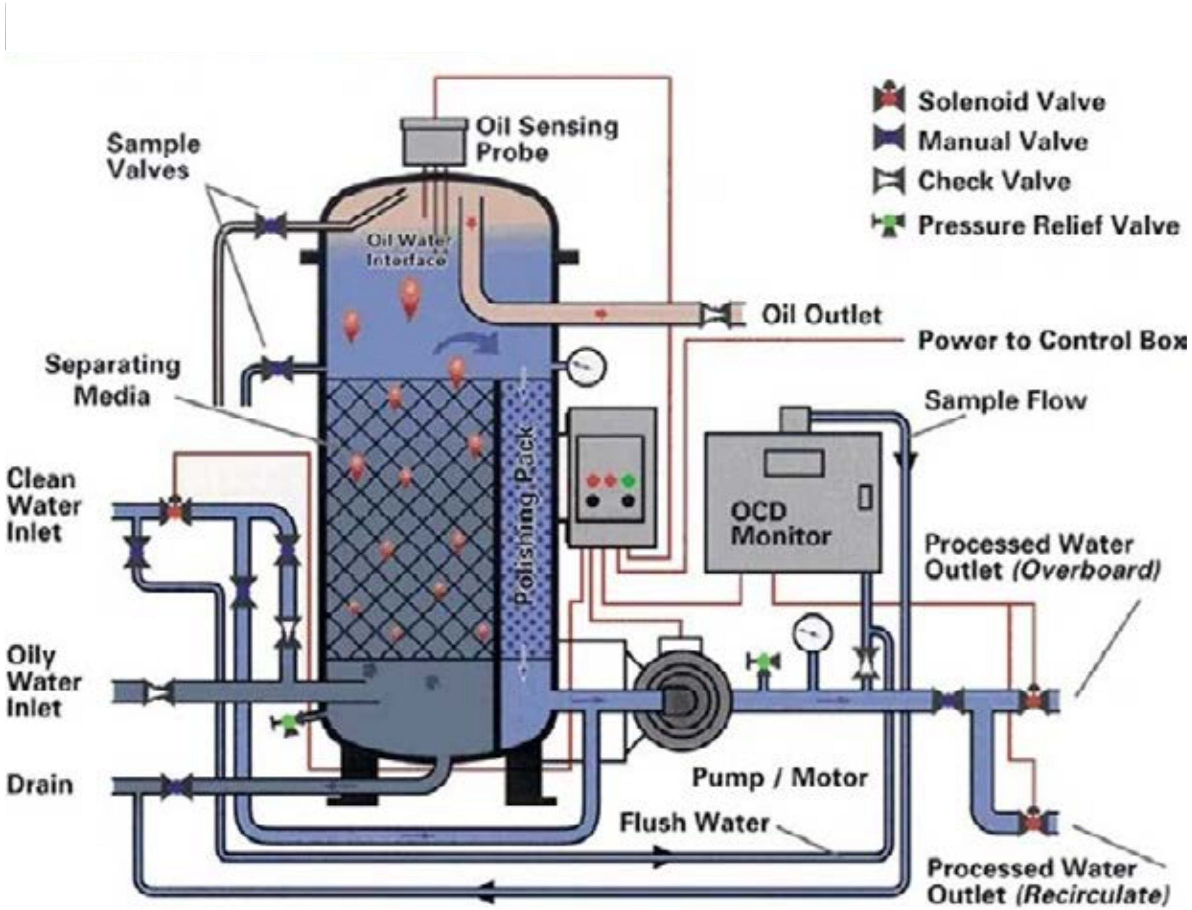


MARPOL Annex I: Examples

Regulation 15,31: Discharge of oil, O.D.M.E.



Regulation 14: Filtering of oil (OW Separators)



MARPOL Annex II

Control of pollution by noxious liquid substances in bulk

- It details the **discharge criteria** for the elimination of pollution by noxious liquid substances carried in large quantities.
- It **divides substances** into categories and introduces detailed operational standards and measures.
- The discharge of pollutants is allowed only to **reception facilities** with certain concentrations.
- No matter what, no discharge of residues containing pollutants is permitted within **12 nautical miles** of the nearest land.
- Stricter restrictions apply to **"special areas".**
- Annex II covers the International Bulk Chemical Code (**IBC Code**) in conjunction with Chapter 7 of the SOLAS Convention.

MARPOL Annex III

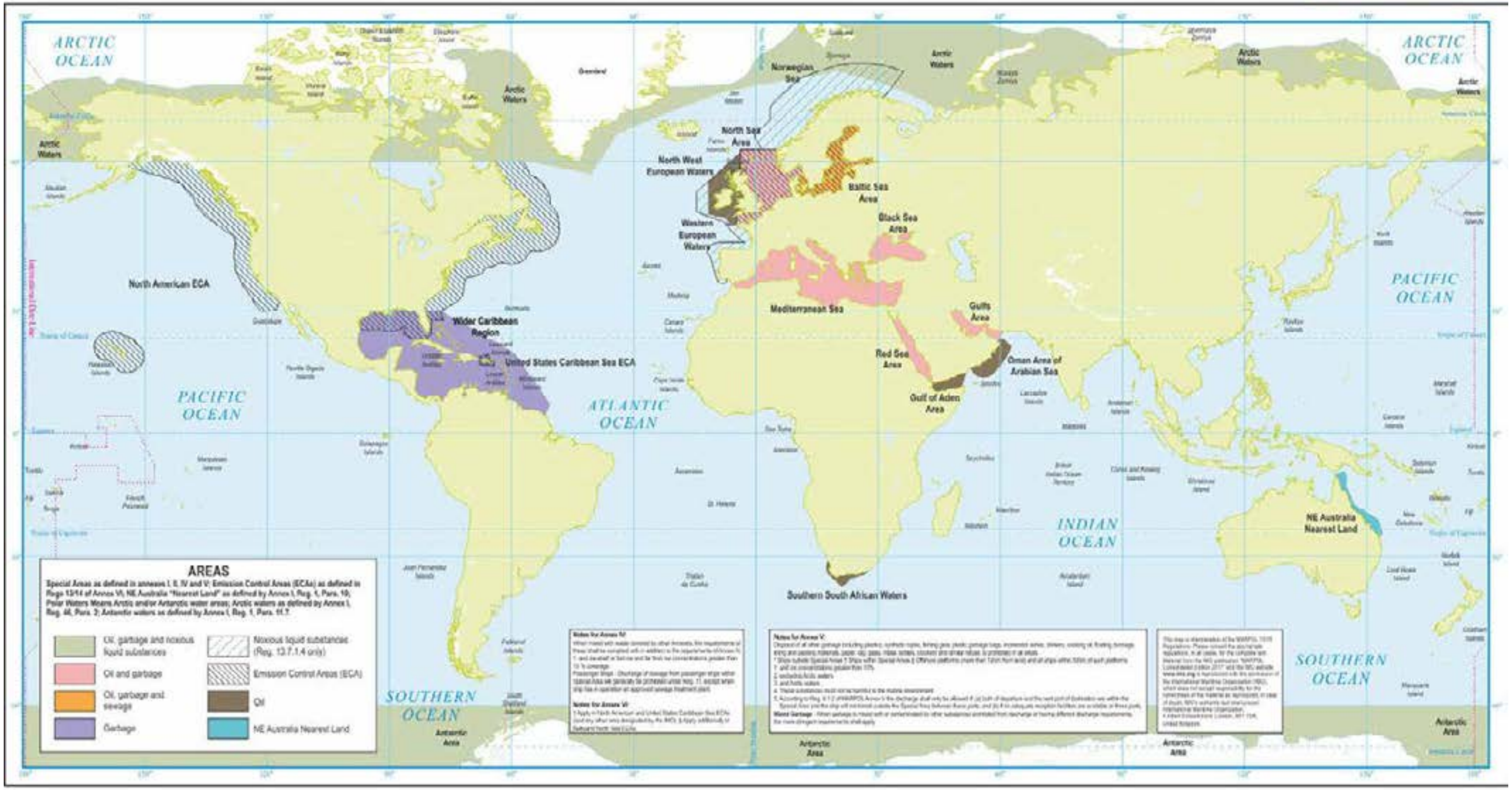
Prevention of pollution by harmful substances carried by sea in packaged form

- It contains general requirements for the standards on **packing**, **marking**, **labeling**, **documentation**, **stowage**, **quantity subtraction**, **division** and **notifications** for preventing pollution by **harmful substances**.
- In line with the International Maritime Dangerous Goods **(IMDG) Code**, which has been expanded to include marine pollutants

22-0131 Marpol 73/78 (01/2023)

MARPOL Special Areas Map

MARINE LITE PRINTING S.A.



DISCHARGE OF OIL/OILY MIXTURES - Machinery spaces, all ships (Annex I)

Regulation 15: All areas except Polar Waters (ships ≥ 400gt). Permitted: when en route; the oily mixture is processed through oil filtering equipment (Reg. 14); the oil content of the effluent without dilution is ≤ 15 ppm; the oily mixture does not originate from cargo pump-room bilges on oil tankers; the oily mixture, in case of oil tankers, is not mixed with oil cargo residue.
All areas except Polar Waters (ships < 400gt). Permitted: when en route; the oily mixture is processed through approved equipment; the oil content of the effluent without dilution is ≤ 15ppm; the oily mixture does not originate from cargo pump-room bilges on oil tankers; the oily mixture, in case of oil tankers, is not mixed with oil cargo residue.
Polar Waters. No discharge permitted.

DISCHARGE OF OIL/OILY MIXTURES - Cargo spaces, oil tankers (Annex I)

Regulation 34. Outside Special Areas except Arctic Waters. Permitted: when > 50nm from the nearest land, proceeding en route; rate of discharge ≤ 30l/nm; total quantity of oil discharged into the sea ≤ 1/15,000 (tankers delivered on or before 31 December 1979) or ≤ 1/30,000 (tankers delivered after 31 December 1979) total quantity previous cargo; slop tank arrangement and equipment as per Annex I Regs 29 and 31 respectively. Discharge of clean or segregated ballast permitted.
Inside Special Area. Not permitted; discharge of clean or segregated ballast permitted.

DISCHARGE OF NOXIOUS LIQUID SUBSTANCES (Annex II)

Noxious liquid substances discharged into the sea from tanks or deballasting operations are broadly categorised as follows: X: major hazard; Y: hazard; Z: minor hazard. For further information on these categories see Reg. 6.3 and Appendix 1 of Annex II. Discharge to sea of cargo residues or residue/water mixtures containing Categories X, Y, Z, ballast water, tank washings or other mixtures containing such substances is prohibited unless in compliance with Annex II. All effluent to be discharged below waterline through approved underwater discharge outlet (except Category Z from pre-2007 vessels); ≥ 12nm from land; in depth ≥ 25m; min. speed of vessel 7 knots if self-propelled, 4 knots otherwise.
Polar waters: discharge prohibited.

	Ship construction date	Categories	Residue (litres)
After unloading, residues in cargo tanks and associated piping shall not exceed the following:	Before 1 July 1986	X, Y	≤ 300
		Z	≤ 900
	From 1 July 1986 to 31 December 2006	X, Y	≤ 100
		Z	≤ 300
	After 31 December 2006	X, Y, Z	≤ 75

Discharge of ballast permitted into sea if clean and segregated or if containing < 1 ppm substance previously carried and ≥ 12nm from nearest land and in water depth ≥ 25m.

DISCHARGE OF SEWAGE (Annex IV)

	Distance from nearest land (nm): ≤ 3	≥ 3	> 12
Sewage which is not comminuted or disinfected, meeting requirements of Reg. 9	✗	✗	✓
From an approved system for comminuting and disinfecting, meeting requirements of Reg. 9	✗	✓	✓
From an approved sewage treatment plant certified to meet requirements of Reg. 9	✓	✓	✓

DISCHARGE OF GARBAGE (Annex V)

	Distance from nearest land (nm): [illegible]	[illegible]	[illegible]
Food waste comminuted or ground	✓ ≥3	✓ ≥12	✓ >12
Food waste not comminuted or ground	✓ ≥12	✗	✗
Cargo residues not contained in wash water	✓ ≥12	✗	✗
Cargo residues contained in wash water	✓ ≥12	✓ ≥12	✗
Cleaning agents and additives contained in cargo hold wash water	✓	✓ ≥12	✗
Cleaning agents and additives in deck and external surfaces wash water	✓	✓	✗
Carcasses of animals carried on board as cargo and which died during the voyage	✓	✗	✗

AIR POLLUTION (Annex VI)

Regulation 13. NOx emission limits are set for diesel engines depending on the engine rated speed (crankshaft revolutions per minute) (n, rpm) and the construction date of the vessel. Tier I and Tier II limits are global, while the Tier III standards apply only in Emission Control Areas. The operation of such marine diesel engine is prohibited, except when the emission of nitrogen oxides (calculated as the total weighted emission of NO_2) from the engine is within the following limits:

Tier	Vessel Construction Date	NOx Limit (g/kWh): n < 130	130 ≤ n < 2000	n ≥ 2000
	≥ 1 January 2000	17.0	$45 \cdot n^{-0.2}$	9.8
I	≥ 1 January 2000	17.0	$45 \cdot n^{-0.2}$	9.8
II	≥ 1 January 2011	14.4	$44 \cdot n^{-0.23}$	7.7
III	≥ 1 January 2016	3.4	$9 \cdot n^{-0.2}$	2.0
III	≥ 1 January 2021	3.4	$9 \cdot n^{-0.2}$	2.0

Regulation 14. The general requirements regarding sulphur oxides (SOx) and particulate matter are:
a) the sulphur content of any fuel oil used on board ships shall not exceed 3.50% m/m, and 0.50% m/m on or after 1 January 2020
b) for ships operating within an Emission Control Area, the sulphur content of fuel oil used on board ships shall not exceed 0.10% m/m.

MARPOL Annex IV: Sewage

- **Prohibition of Sewage Discharge**:

Sewage discharge into the sea is strictly prohibited, except under specific conditions.

- **Approved Treatment Plants**:

Ships must have an approved sewage treatment plant in operation. Discharge of comminuted and disinfected sewage is allowed at a distance of over three nautical miles from land.

- **Untreated Sewage Discharge only when**:

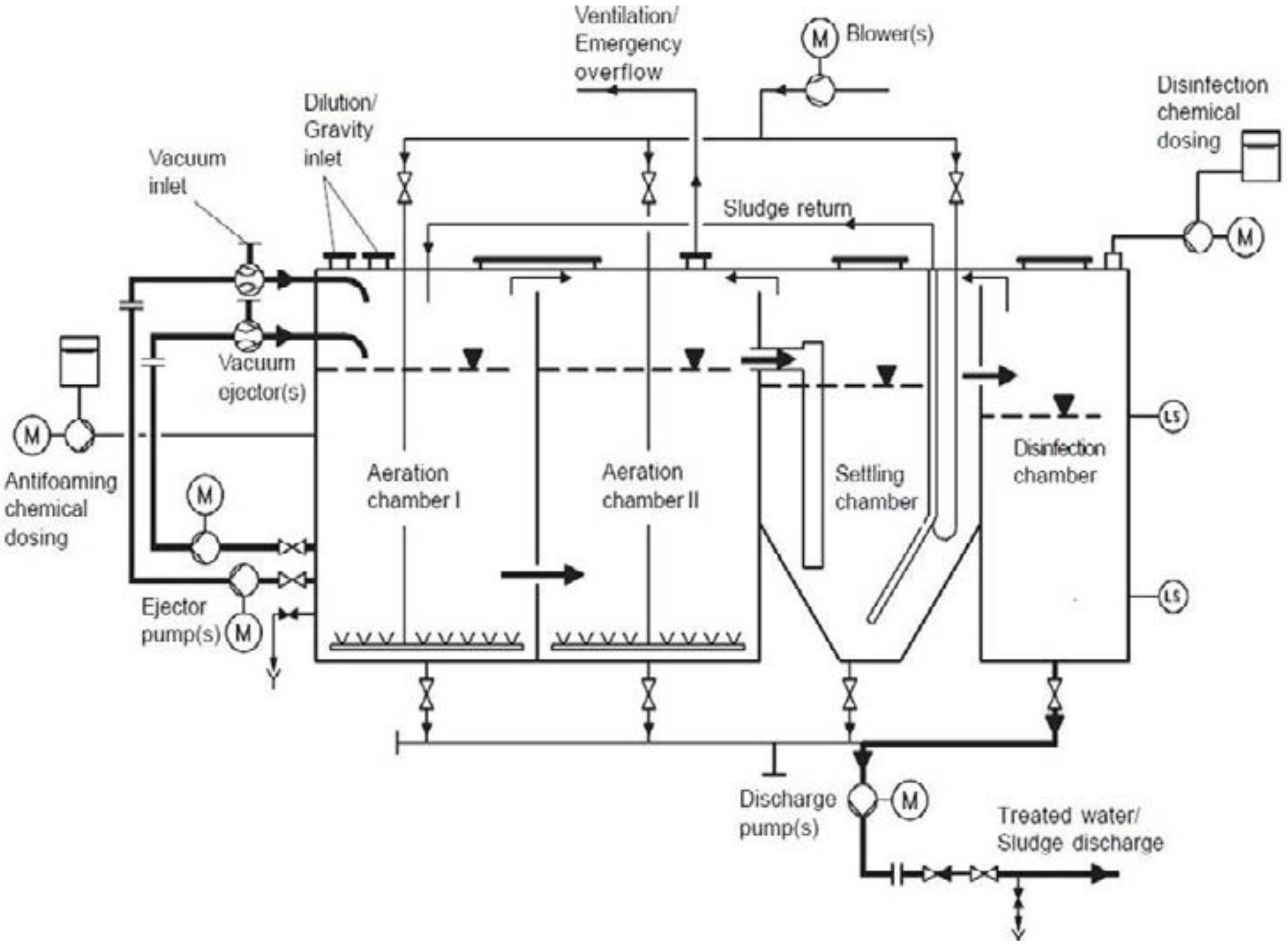
At a distance exceeding 12 nautical miles from land, with ship speed at least 4 knots, and discharge rate should be approved by the Administration.

- **Special Area Regulations**:

Discharge from passenger ships within Special Areas is generally prohibited, except with an approved sewage treatment plant certified by the Administration.

- **Additional Requirements**:

Sewage treatment plants on passenger ships must meet nitrogen and phosphorus removal standards in Special Areas. Compliance with regulations outlined in resolutions MEPC.227(64) and MEPC.227(64), section 4.2.



MARPOL Annex V: Garbage

Years ago it was normal practice to throw ship's garbage over the side. The past years the disposal of ship's garbage become increasingly regulated.

Information included in Annex V

- Distance from shore for food waste. Special areas more strict (12nm)
- Prohibit discharging cleaning agents or additives that considered harmful
- Prohibit discharging Cargo residues that considered harmful
- Special Areas stricter for cargo residues
- Exemptions: securing safety, life at sea, fishing gear
- Placards on board, Garbage management plan, Garbage Record Book
- Polar code: Antarctica transit: Sufficient space for garbage storage and prohibit discharge of unsterilized pulry.

Garbage type[1]	All ships except platforms[4]	
	Regulation 4 Outside special areas and Arctic waters (Distances are from the nearest land)	Regulation 6 Within special areas and Arctic waters (Distances are from nearest land, nearest ice-shelf or nearest fast ice)
Food waste comminuted or ground[2]	≥3 nm, en route and as far as practicable	≥12 nm, en route and as far as practicable[3]
Food waste not comminuted or ground	≥12 nm, en route and as far as practicable	Discharge prohibited
Cargo residues[5, 6] not contained in washwater	≥ 12 nm, en route and as far as practicable	Discharge prohibited
Cargo residues[5, 6] contained in washwater		≥ 12 nm, en route and as far as practicable (subject to conditions in regulation 6.1.2 and paragraph 5.2.1.5 of part II-A of the Polar Code)
Cleaning agents and additives[6] contained in cargo hold washwater	Discharge permitted	≥ 12 nm, en route and as far as practicable (subject to conditions in regulation 6.1.2 and paragraph 5.2.1.5 of part II-A of the Polar Code)
Cleaning agents and additives[6] in deck and external surfaces washwater		Discharge permitted
Animal Carcasses (should be split or otherwise treated to ensure the carcasses will sink immediately)	Must be en route and as far from the nearest land as possible. Should be >100 nm and maximum water depth	Discharge prohibited
All other garbage including plastics, synthetic ropes, fishing gear, plastic garbage bags, incinerator ashes, clinkers, cooking oil, floating dunnage, lining and packing materials, paper, rags, glass, metal, bottles, crockery and similar refuse	Discharge prohibited	Discharge prohibited

1. When garbage is mixed with or contaminated by other harmful substances prohibited from discharge or having different discharge requirements, the more stringent requirements shall apply.
2. Comminuted or ground food wastes must be able to pass through a screen with mesh no larger than 25 mm.
3. The discharge of introduced avian products in the Antarctic area is not permitted unless incinerated, autoclaved or otherwise treated to be made sterile. In polar waters, discharge shall be made as far as practicable from areas of ice concentration exceeding 1/10; in any case food wastes shall not be discharged onto the ice.
4. Offshore platforms located 12 nautical miles from nearest land and associated ships include all fixed or floating platforms engaged in exploration or exploitation or associated processing of seabed mineral resources, and all ships alongside or within 500 m of such platforms.
5. Cargo residues means only those cargo residues that cannot be recovered using commonly available methods for unloading.
6. These substances must not be harmful to the marine environment.

MARPOL Annex VI: Incineration

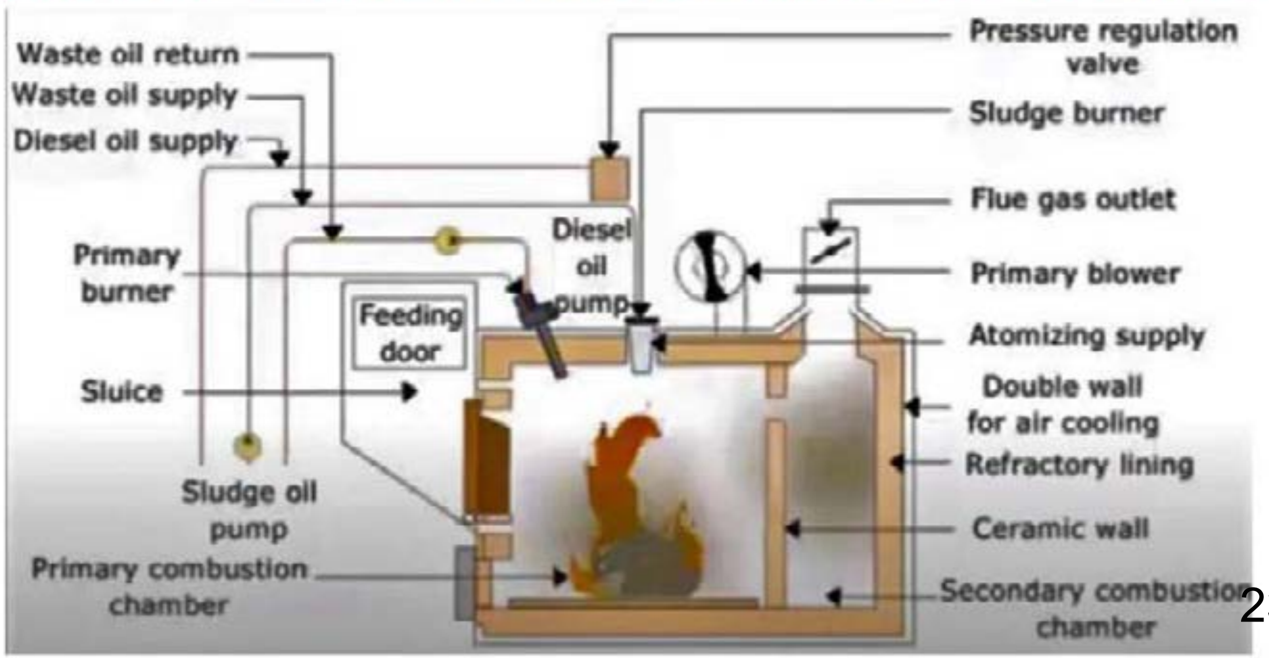
Permits incineration of:

• PVC – plastics (where type approved to do so) (Reg.16.3)
• Sewage sludge and sludge oil (generated during normal operation of engines and boilers). This is not permitted in ports, harbours and estuaries (Reg.16.4)

Prohibits incineration of (Reg.16.2):

• MARPOL Annex I, II & III cargoes,
• Polychlorinated biphenyls (PCB),
• Garbage containing heavy metals,
• Refined petroleum products containing halogens,
• Sewage and sludge oil not generated on board,

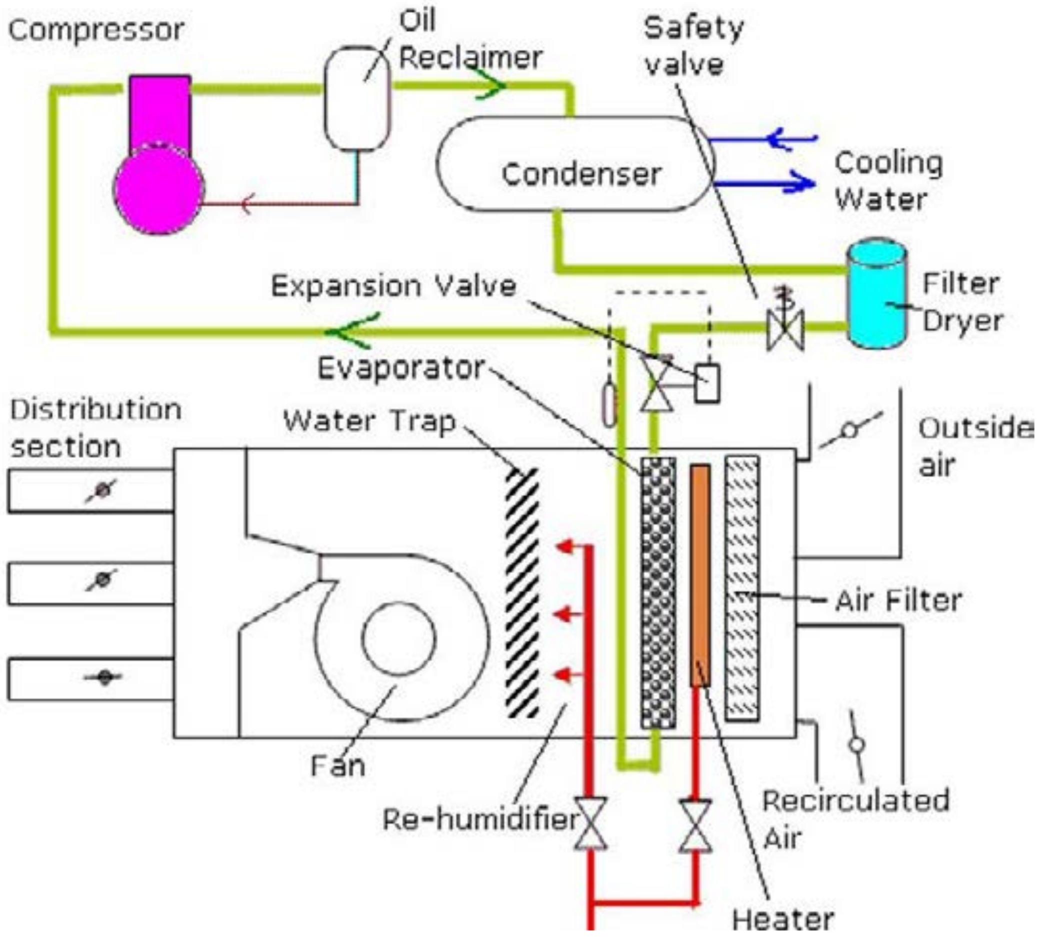
➢ Certificate needed for all incinerators installed from 1 January 2000.
Certification according to: "**2014 Standard Specification for Shipboard Incinerators"** (Reg. 16.6.1)
➢ Incinerator shall be provided with a manufacturer's operating manual which is to be retained
➢ Personnel to be trained in use (Reg. 16.7 – 16.8).
➢ All incinerators should have a combustion flue gas outlet temperature monitoring system.



MARPOL Annex VI: ODS

Ozone Depleting Substances (ODS)

- MARPOL Annex VI: Not applicable for EDG and lifeboats
- Parties are obliged to provide facilities without causing delay for (Reg.17):
  - Reception of ODS in ship repair yards
  - Reception of Exhaust Gas Cleaning System residues
- Supplement to IAPP Certificate, ODS Record Book
- Does not apply to permanently sealed units (Reg.12.1) with no refrigerant charging connections …
- Any deliberate emissions prohibited (Reg.12.2)
- Other than Hydrochloroflurocarbon (HCFC) all other ODS banned in new ships from 19 May 2005 (Reg.12.3.1)
- HCFC banned in new ships from 1 January 2020 (Reg.12.3.2). Delivery to reception facilities following removal (Reg.12.4)



MARPOL Annex VI: VOC

Volatile Organic Compounds (VOC) are light components of crude oil, which evaporate during loading operations or during the carriage of high-volatility crude oil cargoes. Under regulation 15:

- VOC management plant
- Reception facilities
- VAPOUR Line in ship's manifold for return of VOC to reception facilities

What are Vapor Connections ?

Some ports do not allow cargo vapors to be vented to atmosphere during loading . Hence they have to be sent back to the terminal for treatment through these vapor connections at the manifold.

MARPOL Annex VI: EEDI/EEXI (CO2/t*nm)

Main engine | Aux. engine | Shaft motor | Energy efficient technology (electrical) | Energy efficient technology (mechanical)

$$\frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} P_{MEi}\cdot C_{FMEi}\cdot SFC_{MEi}\right) + \left(P_{AE}\cdot C_{FAE}\cdot SFC_{AE}*\right) + \left(\left(\prod_{j=1}^{M} f_j\cdot\sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)}\cdot P_{AEeff(i)}\right) C_{FAE}\cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)}\cdot P_{eff(i)}\cdot C_{FME}\cdot SFC_{ME}\right)}{f_i\cdot f_c\cdot f_l\cdot f_w\cdot Capacity\cdot V_{ref}}$$

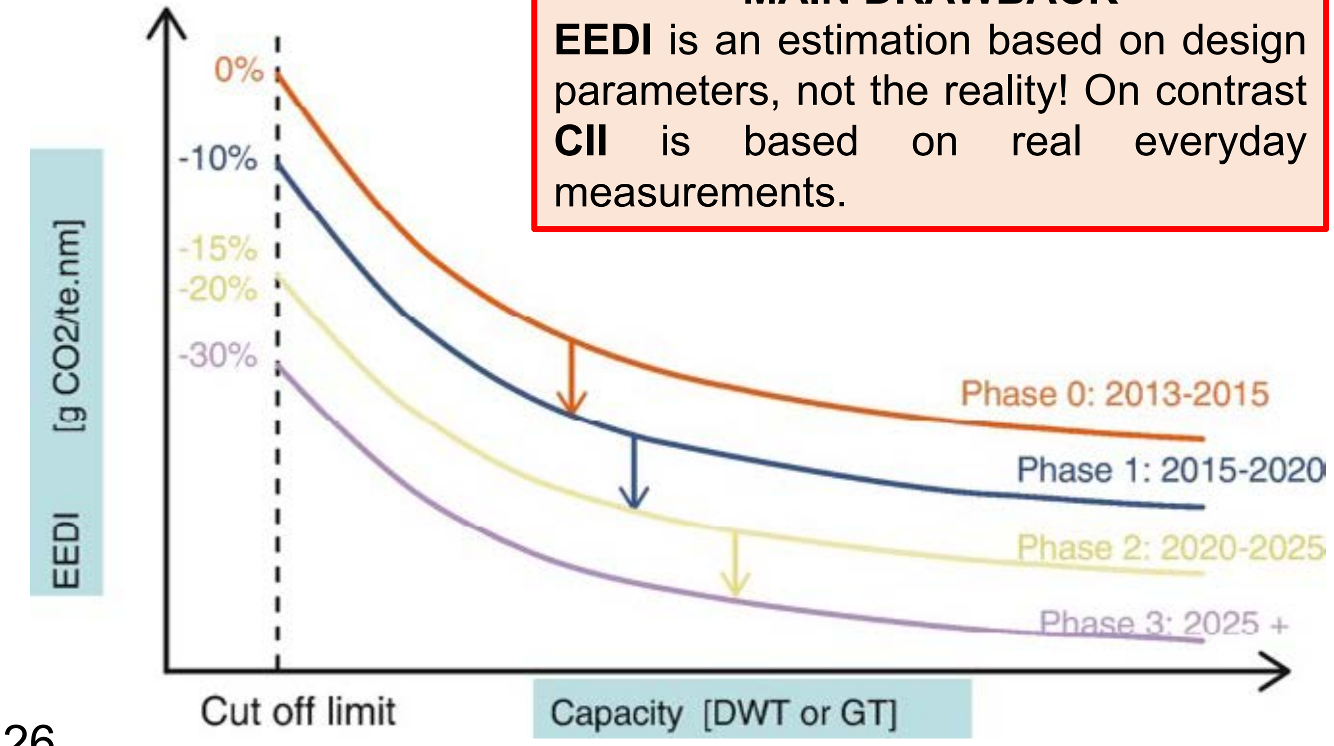
Correction factors

Transport work

- Energy Efficiency Design Index **(EEDI)**
- Energy Efficiency Existing Index **(EEXI)**
- **International Energy Efficiency (IEE) Certificate** will be issued for a ship whose compliance with the regulation is verified.

MAIN DRAWBACK

EEDI is an estimation based on design parameters, not the reality! On contrast **CII** is based on real everyday measurements.

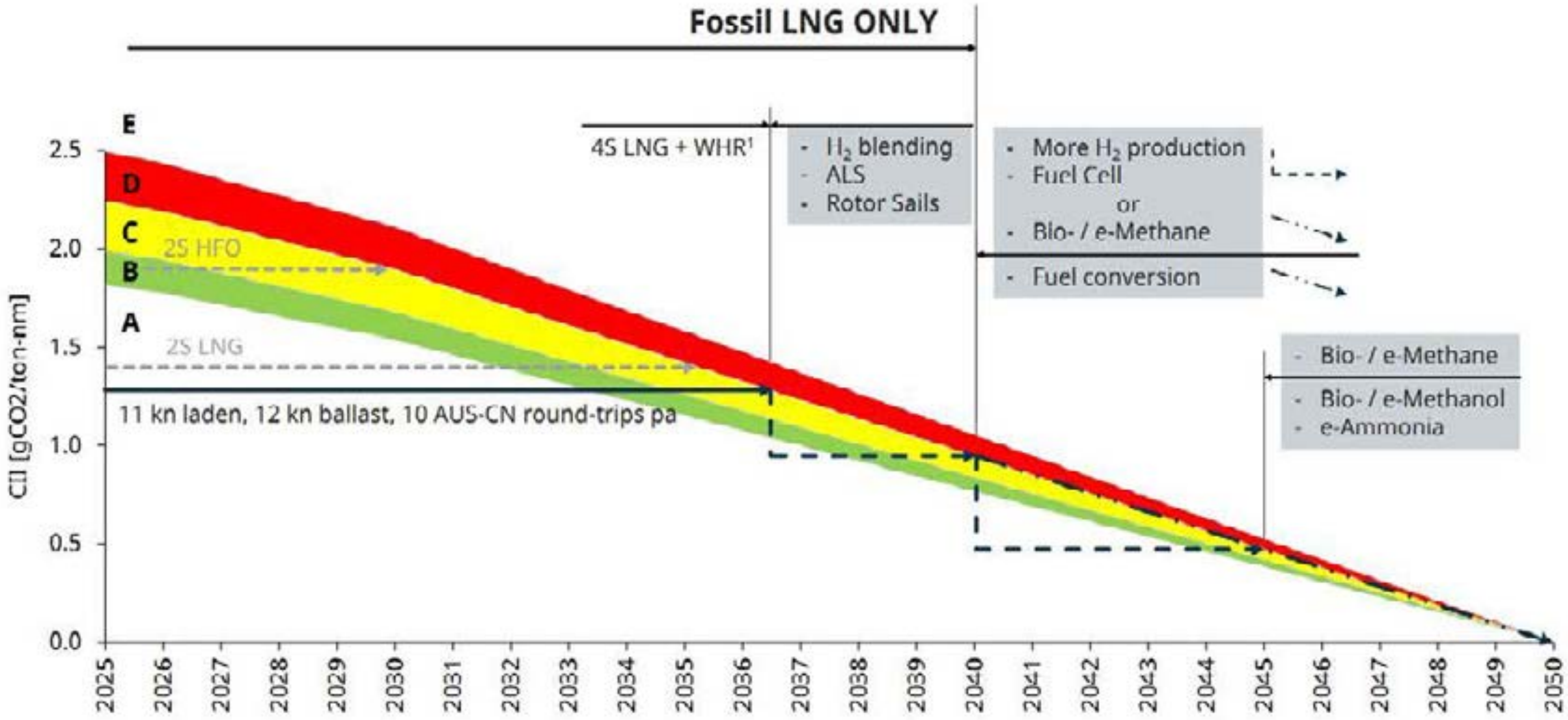


MARPOL Annex VI: CO2

Starting in 2024, the **CII** must be calculated and reported to IMO. The attained annual operational CII and the environmental rating (A to E) will be noted on the Statement of Compliance (SoC), which will be required to be kept on board for five years.

In case of a **D rating** for three consecutive years or one **E rating**, a corrective action plan must be submitted and verified before the SoC can be issued.

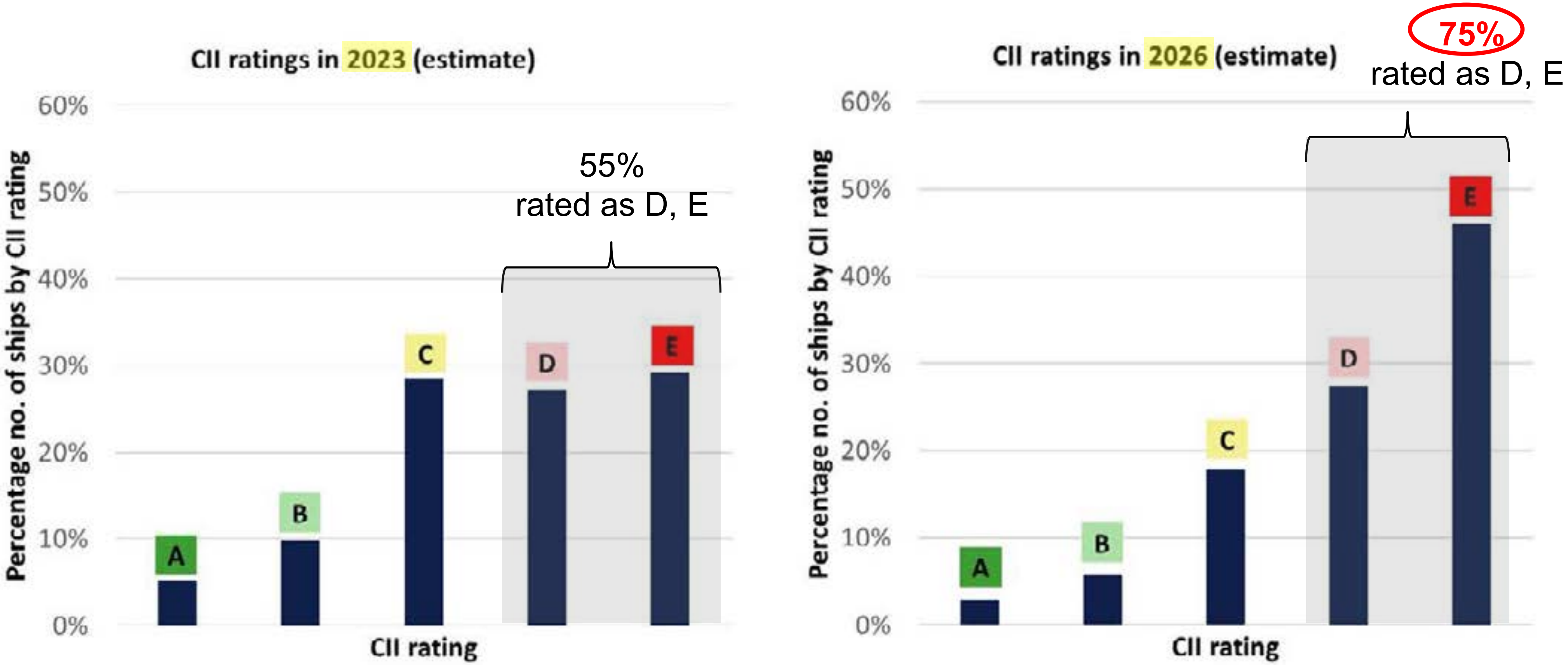
$$\text{CII} = \frac{\textit{Annual fuel consumption} \times \textit{Fuel factor}}{\textit{Annual distance travelled} \times \textit{Capacity}} \times \textit{Correction factors}$$



MARPOL Annex VI: CO_2

If the shipowners take no action, it is estimated that most of the ships will acquire a rating lower than C. The number of ships rated as D or E will increase through the years. For example:

*The CII Impact on the **container** vessel fleet:*



Source: DNV

NOx CAP "IMO 2020"

WORLD: ***Tier II*** (constr. ≥ 2000) → **<u>100%</u> Tier I** (<130rpm ⇒ 17g/kWh)

WORLD: ***Tier II*** (constr. ≥ 2011) → **<u>80%</u> Tier I** (<130rpm ⇒ 14.4g/kWh)

NECA: ***Tier III*** (USA constr. ≥ 2016) → **<u>20%</u> Tier I** (Baltic & North constr. ≥ 2021) (<130rpm ⇒ 3.4g/kWh)

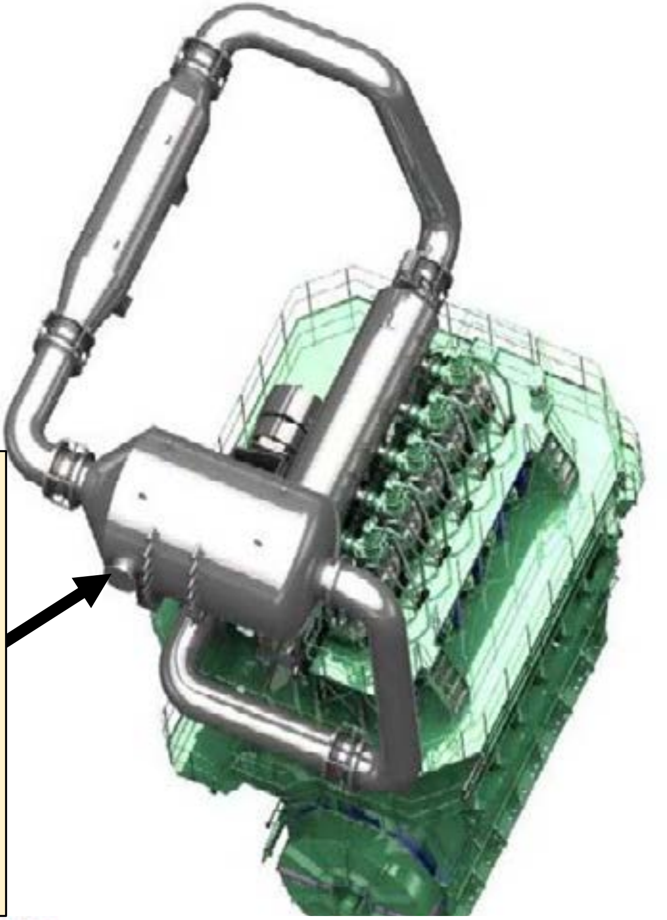
MARPOL Annex VI: NOX

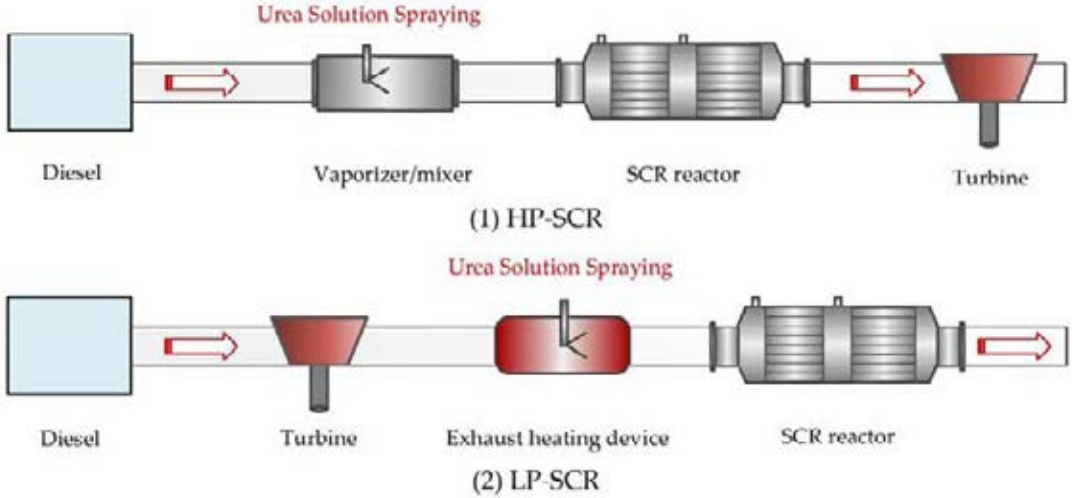
- Test bed exhaust emission measurement according to <u>NOx Technical Code (NTC)</u>: To demonstrate that NOx is below the IMO Tier.
- NOx Technical File: Information on performance and emissions tests + components, settings, operating values & adjustments to be observed
- Issue of Engine International Air Pollution Prevention (EIAPP) Certificate or statement of compliance for an engine:
  - a) Issued for each engine
  - b) Valid for the engines life (unless major conversion)
- If there are NOx reductions technologies, specific certification rules applies.

There are options for ship-board measurement, verification and certification but not practiced due to complexity of measurements.

TIER III technologies

Selective Catalytic Reduction (SCR) and Exhaust Gas Recirculation (EGR)





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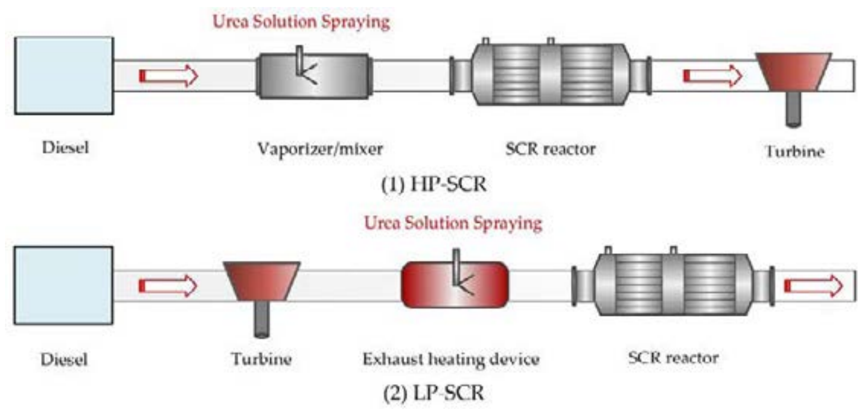
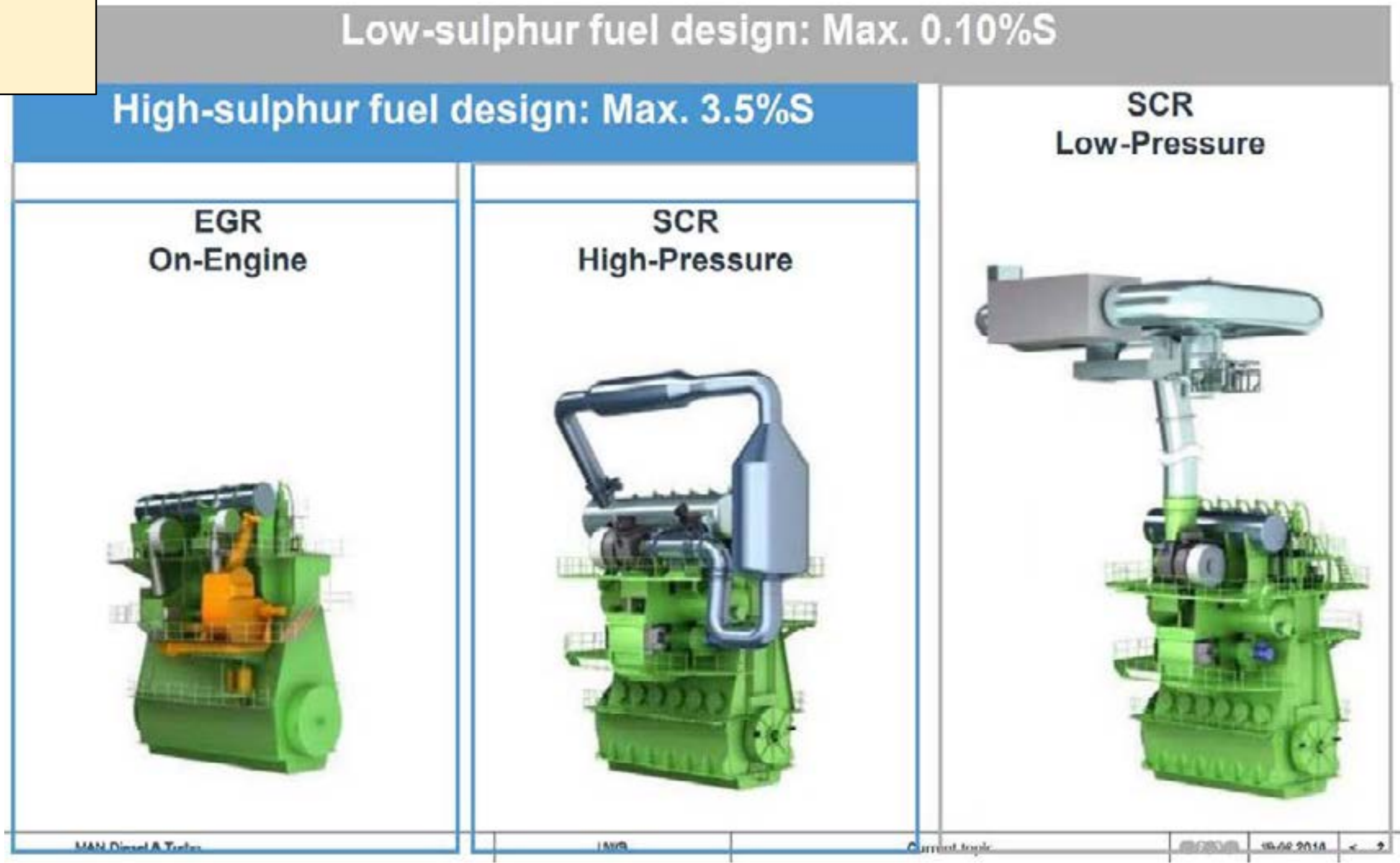
TIER III technologies

SCR and EGR





NOx & SOx MAP

SULFUR CAP "IMO 2020"

WORLD: [S] < ***0.50%*** *m/m*

SECA: [S] < ***0.10%*** *m/m*

For all ships, no matter age!

NOx CAP "IMO 2020"

WORLD: ***Tier II*** (constr. ≥ 2000) → **<u>100%</u> Tier I** (<130rpm ⇒ 17g/kWh)

WORLD: ***Tier II*** (constr. ≥ 2011) → **<u>80%</u> Tier I** (<130rpm ⇒ 14.4g/kWh)

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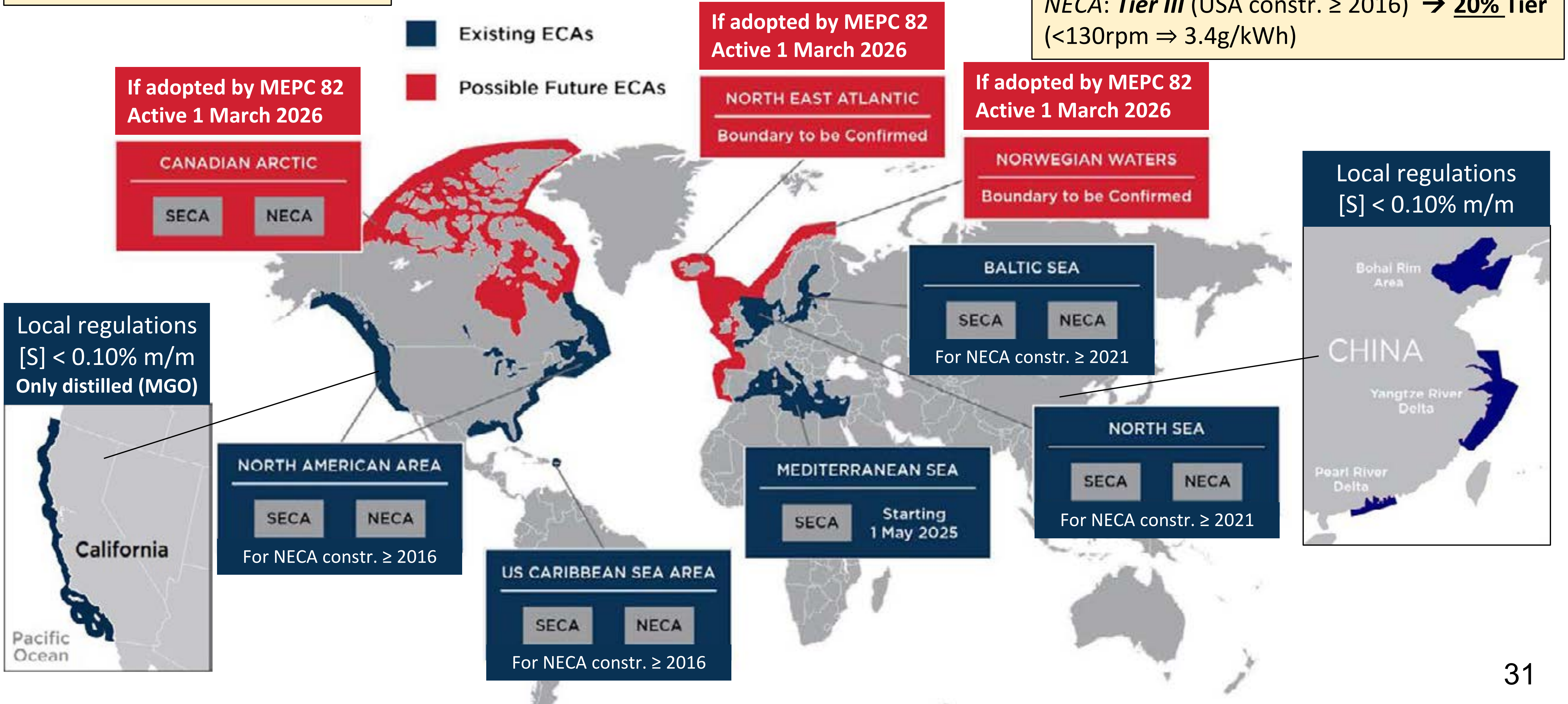


Locally Sulfur regulations & compliance

CARB

California

Local regulations
[S] < 0.10% m/m
Only distilled (MGO)
All vessels!

SOx Solutions	WORLD	SECA & Locally China	CARB
MGO ([S]< 0.10%m/m)	✓	✓	✓
VLSFO ([S]< 0.50%m/m)	✓	✗	✗
ULSFO ([S]< 0.10%m/m)	✓	✓	✗
EGCS (scrubber) & HFO ([S]> 0.5%m/m)	✓	✓	✗
LNG (has no Sulfur)	✓	✓	✓
Alternative fuels	**TtW zero [S], regulations under development**		

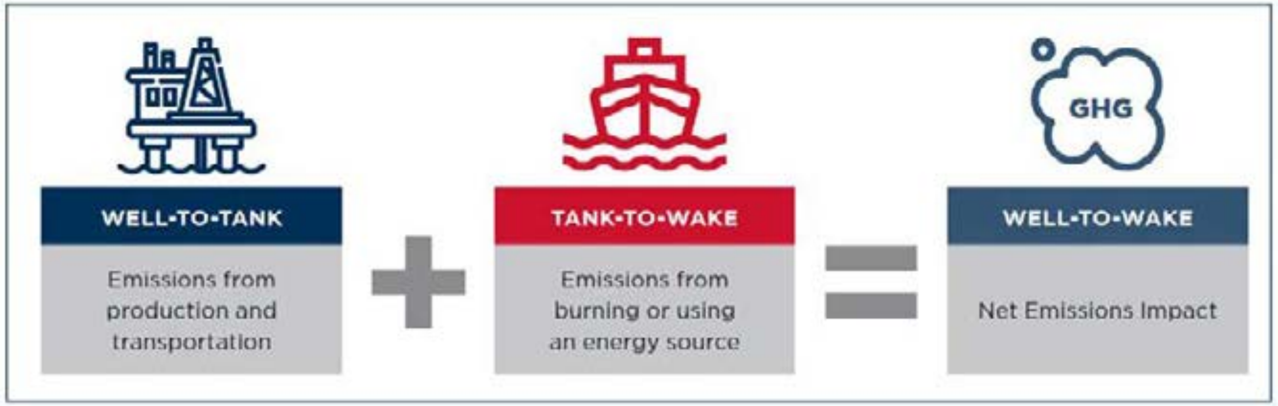
China

Local regulations
[S] < 0.10% m/m
All vessels!

The Green Deal

EU goals:
- 2050 EU-wide climate neutrality
- 2030 target of at least 55% net greenhouse gas emissions reduction

How shipping will be affected?
- European Trading System (EU ETS)
- Fuel EU Maritime Regulation (Fuel EU)
- Renewable Energy Directive (RED II);
- Alternative Fuels Infrastructure Regulation (AFIR);
- Energy Taxation Directive




EMISSIONS
TRADING
CLIMATE CHANGE
STRATEGY

ETS (Tank to Wake)

Emission Allowances

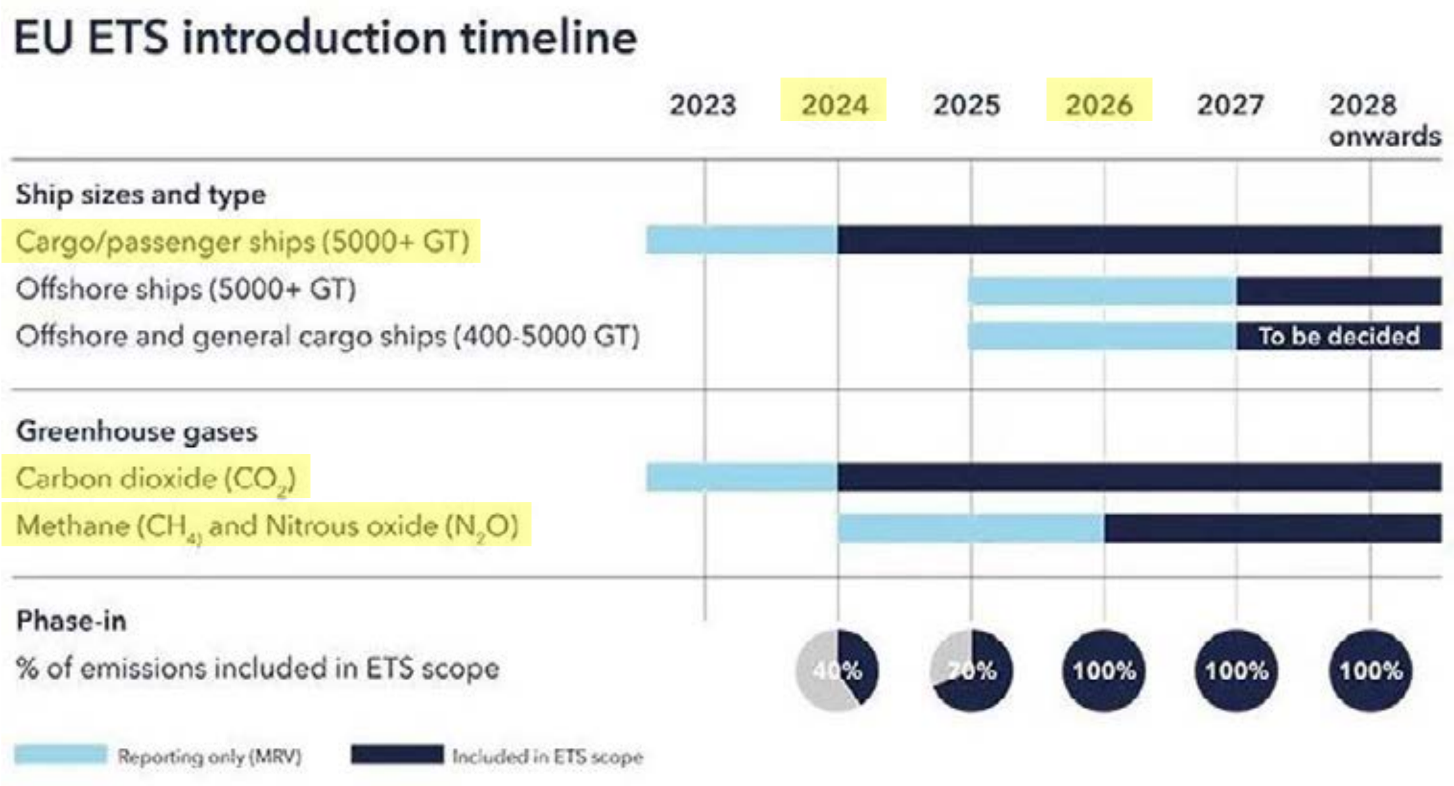
Shipping companies have to purchase and surrender (use) EU ETS emission allowances for each tonne of reported TtW CO2 (or CO2 equivalent) emissions in the scope of the EU ETS system. EUAs can be bought and sold on the market, and the variable market price of EUAs reflects the cost of reducing emissions.

Smooth **transition**, buy allowances for:

2025: for 40% of emissions (reported in 2024)
2026: for 70% of emissions (reported in 2025)
2027 onwards: for 100% of reported emissions

Region

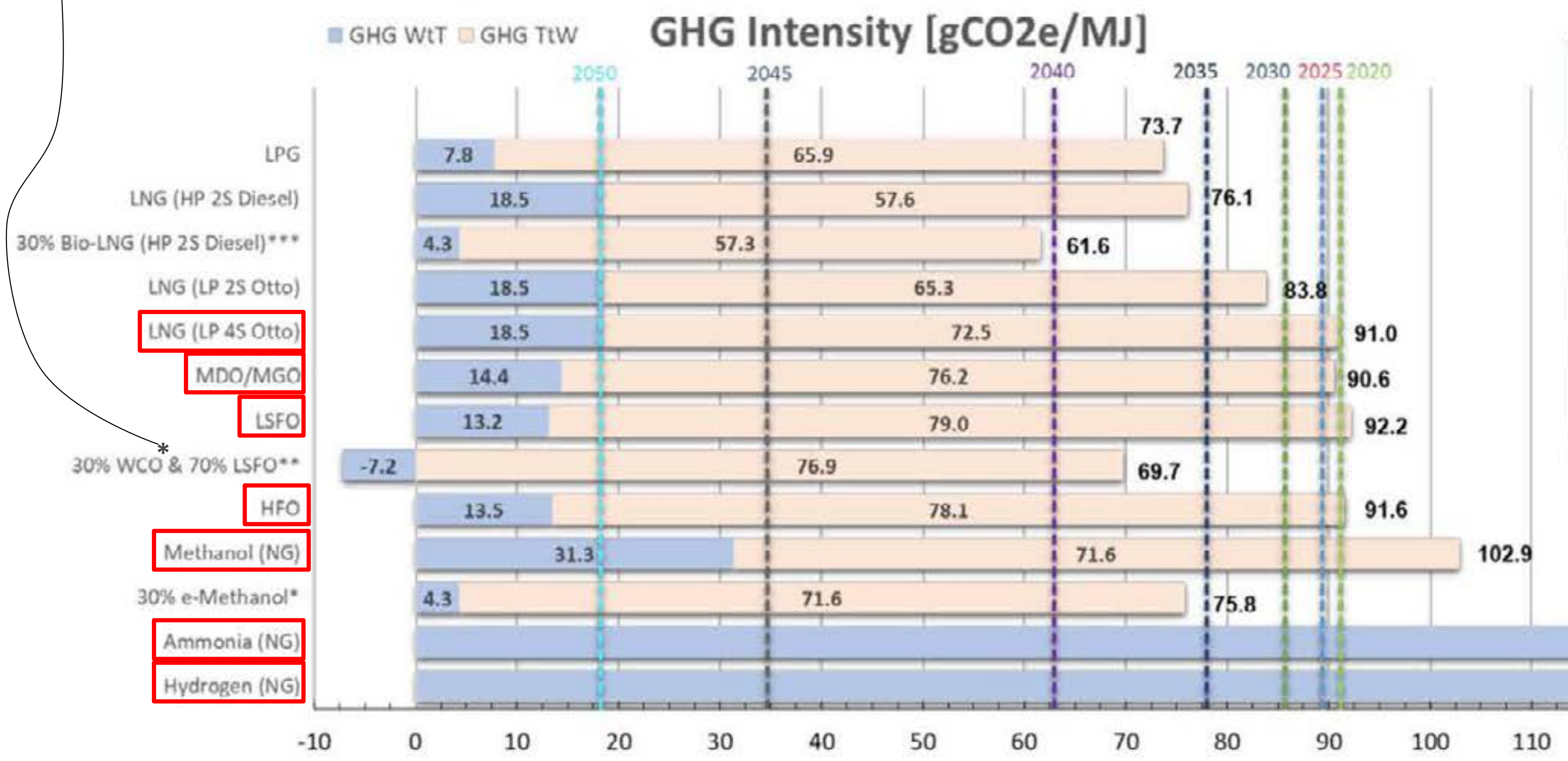
All 100% of emissions on voyages and port calls within the EU/EEA, and 50% of emissions on voyages into or out of the EU/EEA, are subject to the EU ETS.



FuelEU (Well to Wake)

First reduction from 1 January 2025 ! (Methane and nitrous oxides are subsequently converted into CO_2 equivalents)

**WTO = waste cooking oil (WCO)*



Year	Intensity limit ($grCO_{2eq}/MJ$)
2020	Reference
2025	89.34
2030	85.69
2035	77.94
2040	62.90
2045	34.64
2050	18.23

FuelEU Compliance deficit → Penalty

GHG intensity index	WtT	TtW
GHG intensity index $\left[\frac{gCO2eq}{MJ}\right]$ =	$\frac{\sum_i^{n\,fuel} M_i \times CO_{2eq\,WtT,i} \times LCV_i + \sum_k^c E_k \times CO_{2eq\,electricity,k}}{\sum_i^{n\,fuel} M_i \times LCV_i + \sum_k^c E_k}$ +	$\frac{\sum_i^{n\,fuel} \sum_j^{m\,engine} M_{i,j} \times \left[\left(1 - \frac{1}{100} C_{engine\,slip\,j}\right) \times \left(CO_{2eq\,TtW,j}\right) + \left(\frac{1}{100} C_{engine\,slip\,j} \times CO_{2eq\,TtW\,slippage,j}\right)\right]}{\sum_i^{n\,fuel} M_i \times LCV_i + \sum_k^l E_k}$

Compliance balance $[gCO_{2eq}/MJ]$ (MJ crossed out) = $(GHGIE_{target} - GHGIE_{actual}) \times [\sum_i^{n\,fuel} M_i \times LCV_i + \sum_i^l E_i]$

It's the difference between the actual GHG intensity of the ship and the target $[gCO_{2eq}/MJ]$

It's the energy use of the ship [MJ]

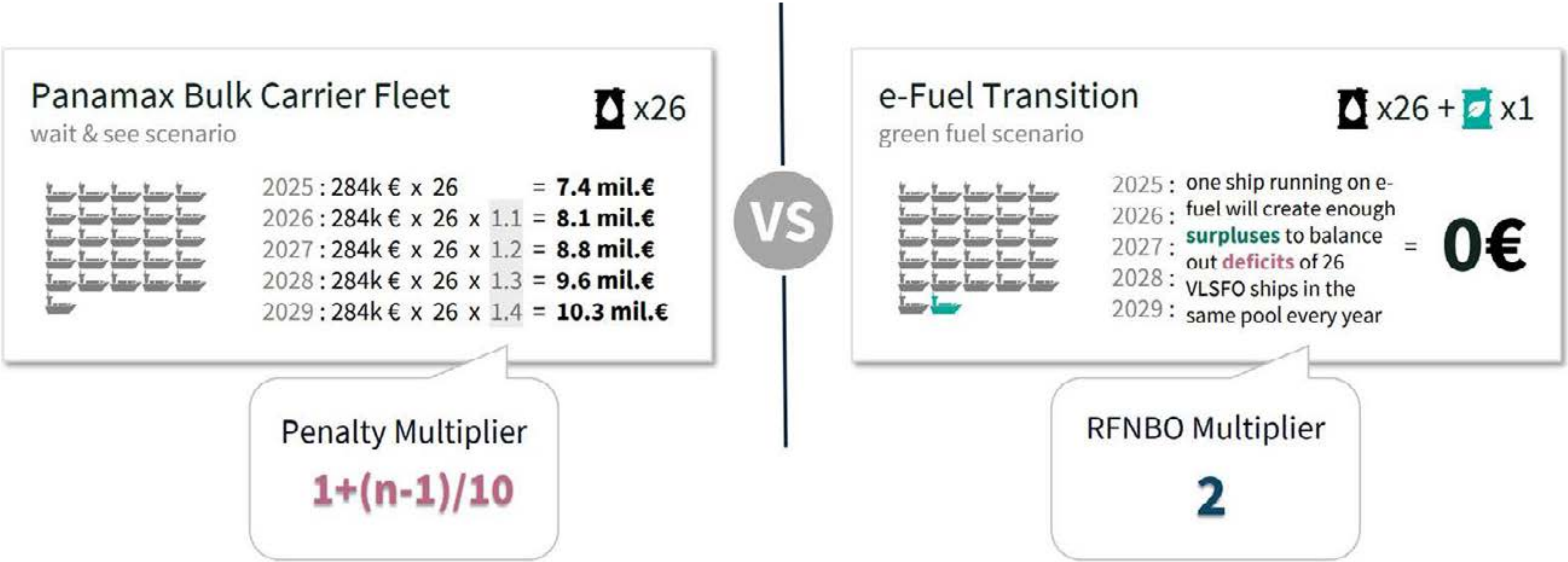
Penalty = $(Compliance\ balance / GHGIE_{actual}) \times$ conversion factor from MJ to tonnes of VLSFO (41.0 MJ / kg) x EUR 2400

It's the amount of MJ of zero-emission energy that the ship should have used to be able to meet the target

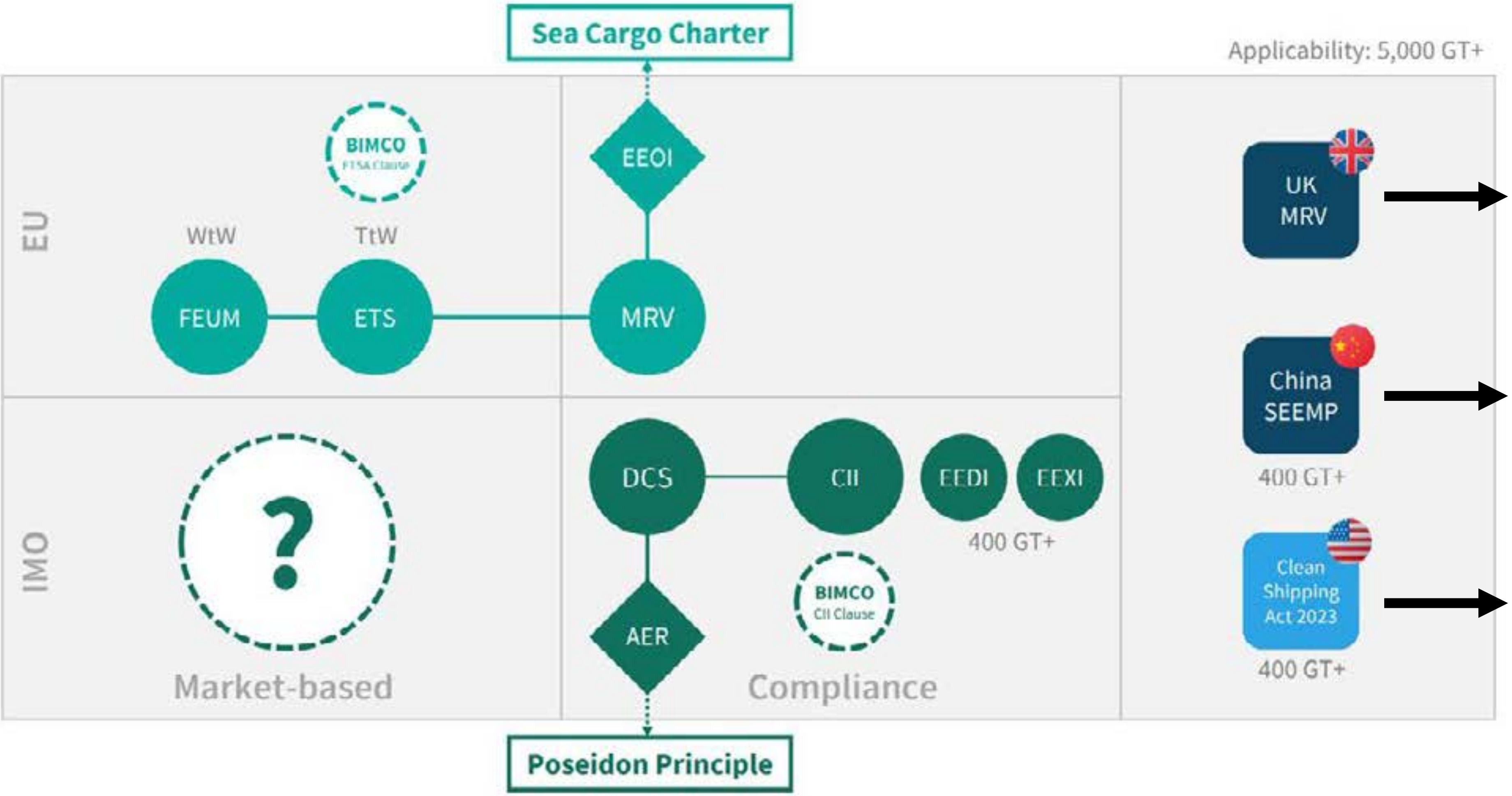
Transforms the MJ in tonnes of VLSFO. Indicates how many tonnes of VLSFO should have been replaced by zero-emission energy

Multiple times the price per tonne of VLSFO !

FuelEU compliance: Fleet Pooling



Emissions Regulations summary



Similar to EU MRV and DCS: A Data Collecting System

- Part I: Ship management plan to improve energy efficiency
- Part II: Ship fuel oil consumption data collection plan
- Part III: Ship operational carbon intensity plan

Mandating all vessels to be zero emission by 2040 and obliging shore power while moored by 2030

Local Regulations on Shore power

California

Initial year	Vessel type
2023	Container, refrigerated cargo and passenger
2025	Roll-on roll-off
2025	Tanker (only LA & Long Beach)
2027	All Tankers

Required to use grid-based power or another CARB-approved emission control technology while at-berth

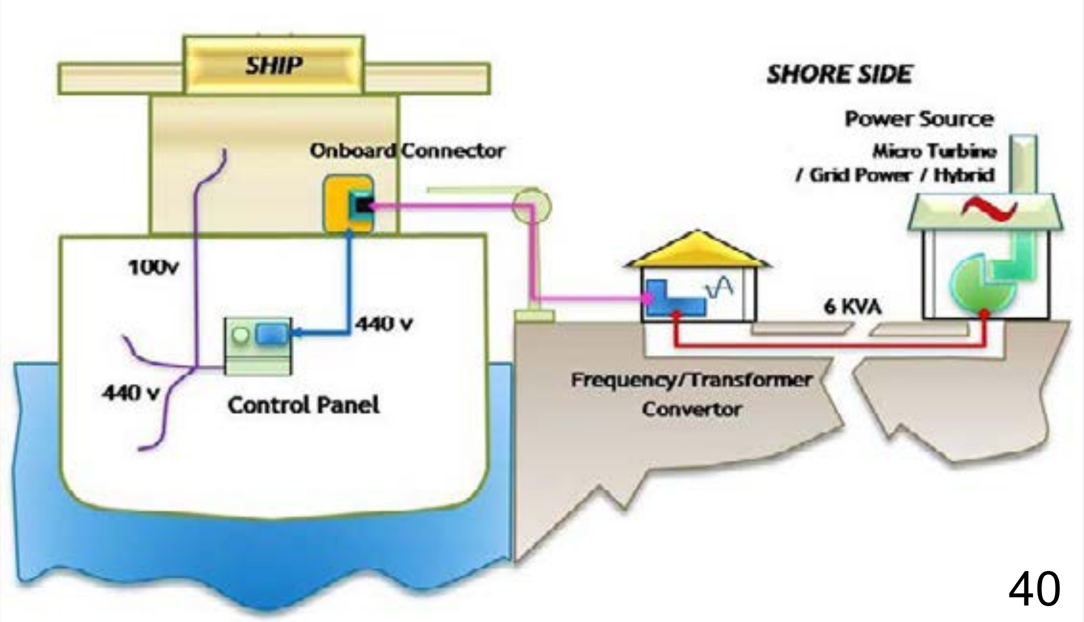
ALTERNATIVE MARITIME POWER

FuelEU

From 2030: containerships required to utilize cold ironing when at berth >2 hours in a TEN-T port.

From 2035: In all AMP supported ports

Most relatively big ports are TEN-T ports: 328 in Europe, from which 25 in Greece



Polar code

EQUIPMENT
WINDOWS ON BRIDGE
Means to clear melted ice, freezing rain, snow, mist, spray and condensation
LIFEBOATS
All lifeboats to be partially or totally enclosed type
CLOTHING I
Adequate thermal protection for all persons on board
CLOTHING II
On passenger ships, an immersion suit or a thermal protective aid for each person on board
ICE REMOVAL
Special equipment for ice removal: such as electrical and pneumatic devices, special tools such as axes or wooden clubs
FIRE SAFETY
Extinguishing equipment operable in cold temperatures; protect from ice; suitable for persons wearing bulky and cumbersome cold weather gear
DESIGN & CONSTRUCTION
SHIP CATEGORIES
Three categories of ship which may operate in Polar Waters, based on:
A) medium first-year ice
B) thin first-year ice
C) open waters/ice conditions less severe than A and B
A
B
C
INTACT STABILITY
Sufficient stability in intact condition when subject to ice accretion and the stability calculations must take into account the icing allowance
MATERIALS
Ships intended to operate in low air temperature must be constructed with materials suitable for operation at the ships polar service temperature
STRUCTURE
In ice strengthened ships, the structure of the ship must be able to resist both global and local structural loads
POLAR Code
IMO
OPERATIONS & MANNING
NAVIGATION
Receive information about ice conditions
CERTIFICATE & MANUAL
Required to have on board a Polar Ship Certificate and the ship's Polar Water Operational Manual
TRAINING
Masters, chief mates and officers in charge of a navigational watch must have completed appropriate basic training (for open-water operations), and advanced training for other waters, including ice
BACKGROUND INFO
THE INTERNATIONAL CODE FOR SHIPS OPERATING IN POLAR WATERS WAS ADOPTED NOVEMBER 2014 BY THE IMO MARITIME SAFETY COMMITTEE
IT APPLIES TO SHIPS OPERATING IN ARCTIC AND ANTARCTIC WATERS
THE AIM IS TO PROVIDE FOR SAFE SHIP OPERATION AND THE PROTECTION OF THE POLAR ENVIRONMENT BY ADDRESSING RISKS PRESENT IN POLAR WATERS AND NOT ADEQUATELY MITIGATED BY OTHER INSTRUMENTS

URN
(Underwater Radiated Noise)

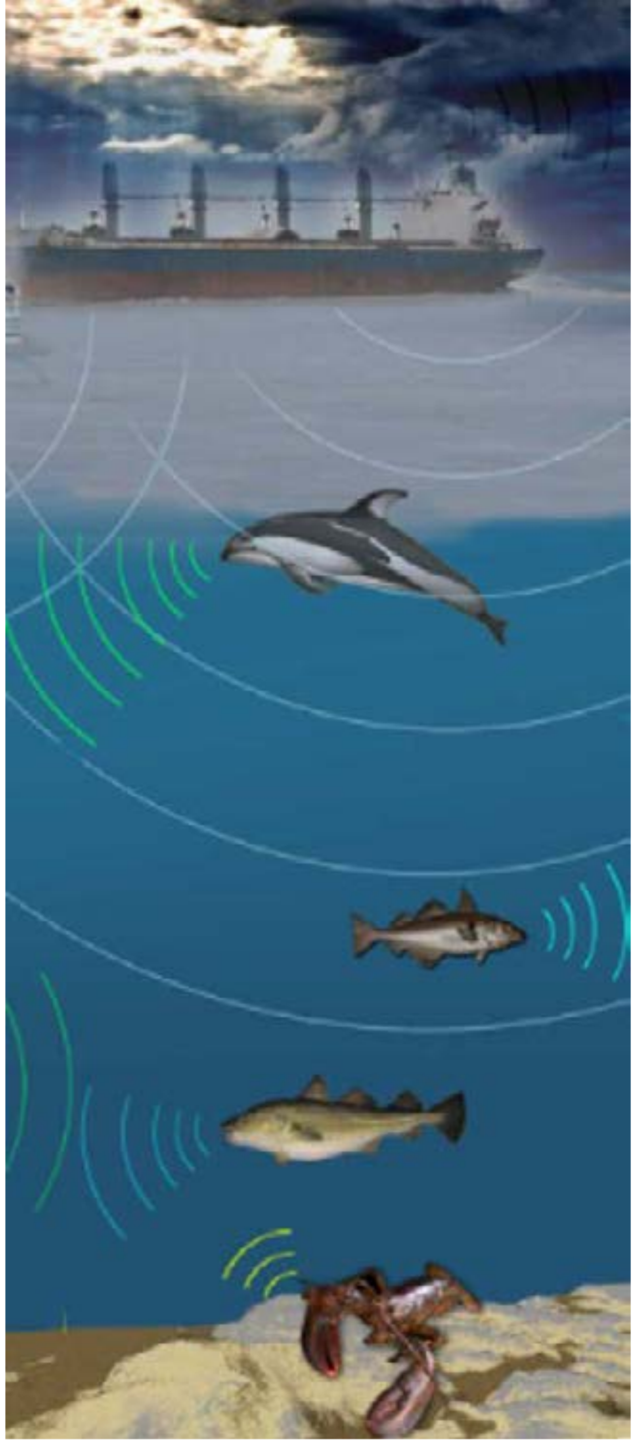
- 2023 IMO Guidelines MEPC.1/Circ.906 (not mandatory)
- Awareness grows especially for protected areas, migratory pathways and ice-covered areas

Causes

When on typical operating speed: mainly propeller cavitation, OB machinery and operational aspects, ALS (Air Lubricating System), ice-breaking.

Solutions

- Design considerations
- Propeller and surface quality (polishing, anti-fouling)
- Maintenance of Machinery
- Trim optimization
- Route planning (avoid protected areas)
- Reduce speed below Cavitation Inspection Speed CIS (ships with fixed propeller). Avoid critical speeds



Canada Shipping Act, 2001

SOR/2010-91:

Pleasure Crafts Small Passenger

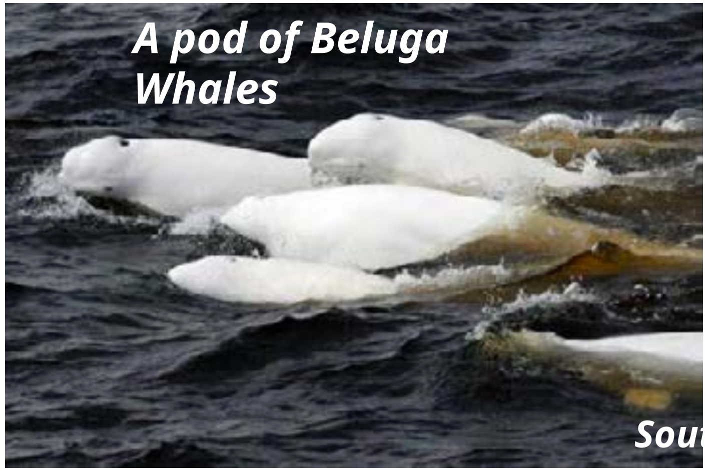
Fines for Muffler condition (means an expansion chamber within the exhaust line specifically designed to reduce engine Noise)

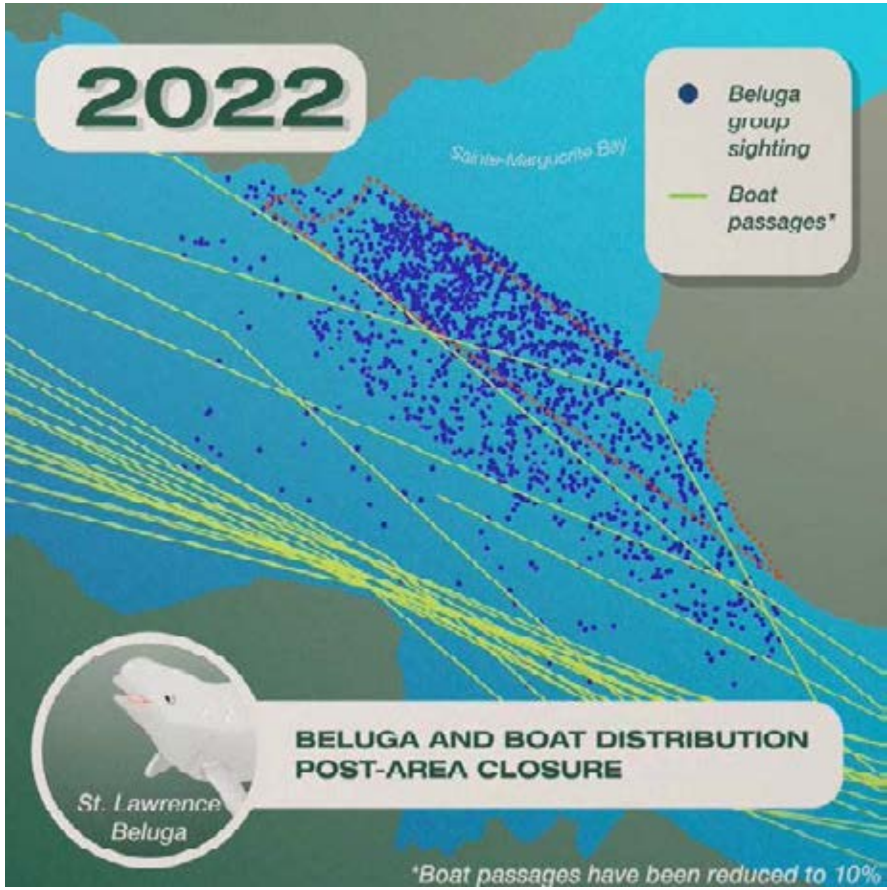
WWF

Pushes administration to take act on ocean going vessels as well

URN (Underwater Radiated Noise)

To protect species at risk, Parks Canada staff have implemented a <u>**peaceful zone**</u> at Saguenay–St. Lawrence Marine Park in Quebec. Area closures reduce disturbance, like noise, for St. Lawrence Belugas. **By protecting habitats from underwater noise, we are helping endangered whales recover.**





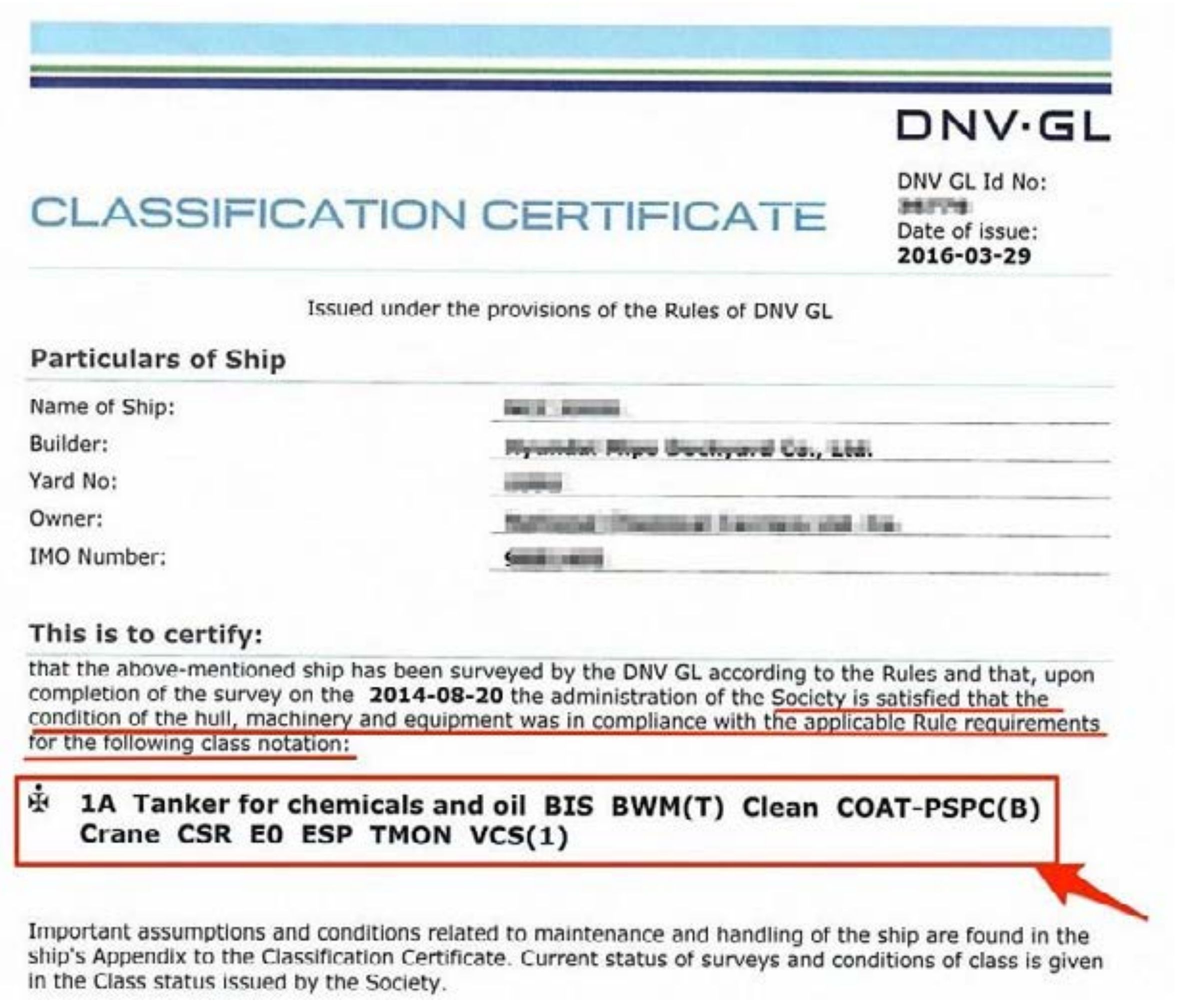
Content

Stavros Hatzigrigoris

25th April 2024, Aikaterini Laskaridis Foundation

Classification Societies

- A **classification certificate** is **required** to **register the ship,** obtain **marine insurance** and maybe allowance to entry into some ports and maybe of interest to charterers and potential buyers. **"In class"**
- Set the **technical standards** for the design, construction and survey of ships. Each CS sets its own, while **IACS** sets minimum standards (ex. CSR).
- Carry out **surveys and inspections** on board ships in order to ensure that ships continue to meet these rules. If it does then the ship is in class.
- **Flag states** can authorize classification societies to act on their behalf to carry out statutory survey and certification work of their ships.


DNV·GL

CLASSIFICATION CERTIFICATE

DNV GL Id No: [redacted]

Date of issue: **2016-03-29**

Issued under the provisions of the Rules of DNV GL

Particulars of Ship

Name of Ship:	[redacted]
Builder:	[redacted]
Yard No:	[redacted]
Owner:	[redacted]
IMO Number:	[redacted]

This is to certify:

that the above-mentioned ship has been surveyed by the DNV GL according to the Rules and that, upon completion of the survey on the **2014-08-20** the administration of the Society is satisfied that the condition of the hull, machinery and equipment was in compliance with the applicable Rule requirements for the following class notation:

✠ **1A Tanker for chemicals and oil BIS BWM(T) Clean COAT-PSPC(B) Crane CSR E0 ESP TMON VCS(1)**

Important assumptions and conditions related to maintenance and handling of the ship are found in the ship's Appendix to the Classification Certificate. Current status of surveys and conditions of class is given in the Class status issued by the Society.

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CLASS SURVEYS

Initial Survey of the Ship

Periodical Survey

Renewal/Special Survey *(5 year, DD)*

Intermediate Survey *(2.5 year)*

Annual Survey *(1 year)*

Additional Survey *(after repair)*

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"Condition of class“

In case a defect is found, one would expect the class to evokes the "Certificate of class“. But that would prohibit the vessel from sailing.

Instead a CC is issued that means that **in order to retain class the said defect need to be renewed before the specified period**. This way the "certificate of class" remains valid but with a condition.

Content

0. Intro

1. Regulatory Recap
    - IMO (SOLAS, MARPOL, Polar, Noise)
    - Local Regulations
    - Classification Societies
    - Port State Control
    - Associations & Networks

2. Solutions, Goals & Priorities
    - Logistics & Digitalization
    - Hydrodynamics & Aerodynamics
    - Machinery
    - Fuels
    - Carbon Capture

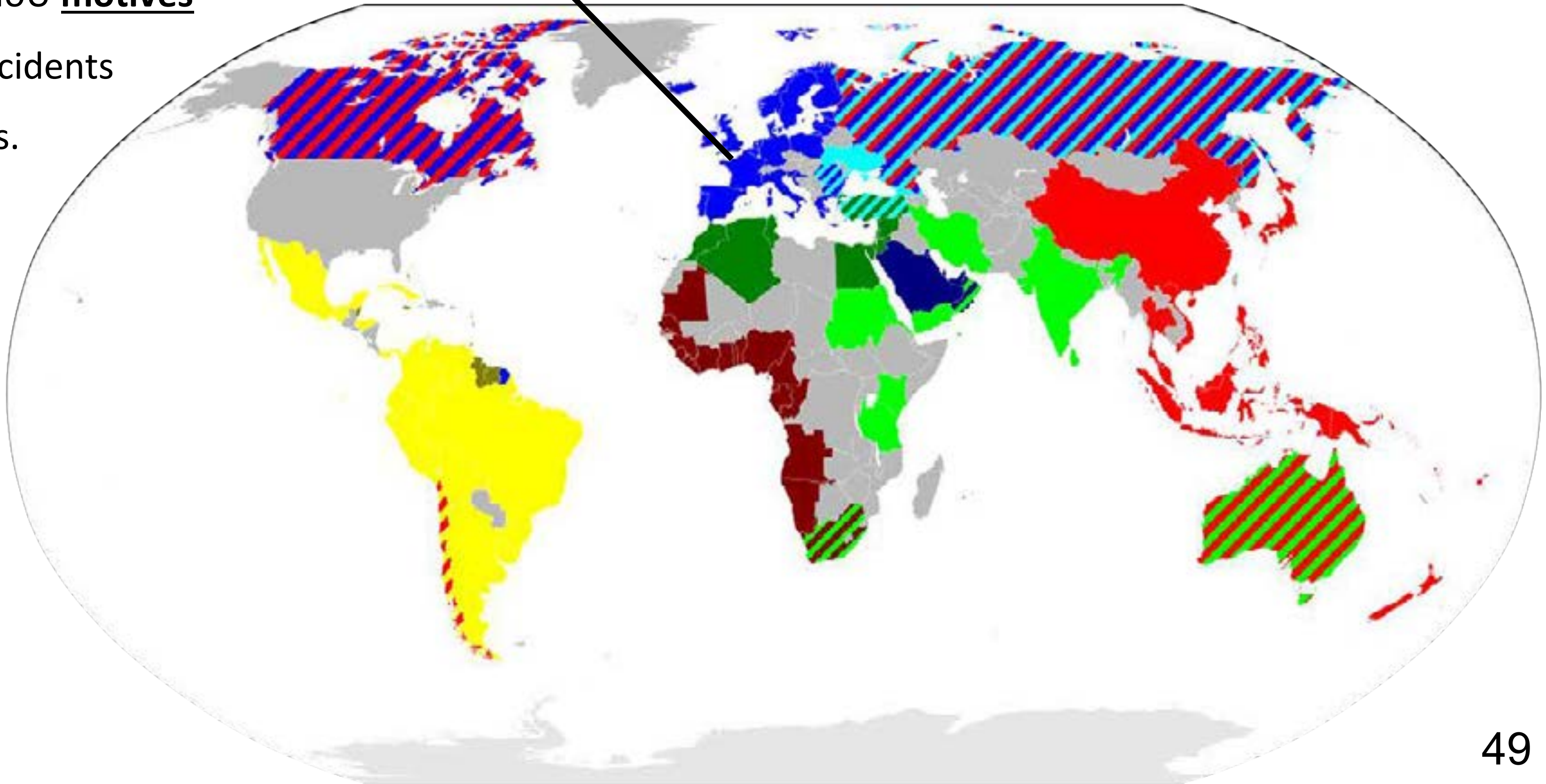
Stavros Hatzigrigoris

25th April 2024, Aikaterini Laskaridis Foundation

PSC

Port State Control (PSC) is the inspection of foreign ships in national ports to verify that the condition of the ship and its equipment comply with the requirements of international regulations and that the ship is manned and operated in compliance with these rules. MoU **motives** are to protect their coasts from possible accidents caused by ships, by detaining high-risk ships.

The sinking ***Amoco Cadiz*** (Liberian flag) grounding 1978 on Portsall Rocks, 2 km from the coast of Brittany, France. Ultimately she split in three and sank. Largest oil spill of its kind in history to that date. Was the motive for creating the **Paris MoU**.



Key points:

- Deficiencies
- Detentions
- Campaigns

(ex. Baltimore accident)

PSC

Some common ship deficiencies found by PSC inspections are listed below. Most of these are related to LSA (Life Saving Appliances) and FFAs (Fire Fighting Appliances):

- deck fire line: holed
- fire pump: not working: unable to build pressure
- oily water separator: not working
- sounding pipes: broken, wasted
- lifeboats: keel plate wasted; engine not operational; rudder frozen; launching arrangement seized; hull holed; seats rotten; brackets wasted; winch break defect
- fire extinguishers: not charged
- EPIRB 406 MHz: defect
- GMDSS MF/HF radio: defect; officers cannot use the equipment
- ship maintenance: does not conform to Safety Management System (SMS)
- accommodation: watertight doors inoperative; side scuttles deadlight not tight
- water ballast tank vents: non-return floats not working; vent piping corroded
- fuel oil tank quick closing valves: defective
- ventilators: steering gear ventilator sized open; engine room fire dampers corroded
- emergency generator: not working

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Associations & Networks

There are a number of international associations and environmental networks which participate actively in the rulemaking process at international, regional and national levels. Including:

- **INTERTANKO** (International Association of Independent Tanker Owners)
- **INTERCARGO** (International Association of Dry Cargo Shipowners)
- **BIMCO** (Baltic and International Marine Council)
- **OCIMF** (Oil Companies International Marine Forum)
- **ICS** (International Chamber of Shipping)
- **SIGTTO** (Society of International Gas Tanker and Terminal Operators)
- **WWF** (World Wide Fund for Nature)
- **GreenPeace**

OCIMF

Torrey Canyon incident (1967)

↓

Oil companies founded OCIMF

Vetting

Oil companies and charterers conduct tanker inspections as part of their vetting programs to identify poorly maintained vessels, prompting shipowners to take immediate corrective actions.

↓ No common standards for vetting inspection!

So in 1993 OCIMF launched the Ship Inspection & Reporting (**SIRE**)

VIQ7 (2019 edition) → **SIRE 2.0** (active since Jan 2024)

- Include **human factor** (ex. Where the crew familiar with us of machinery and procedures? Is the underlying task performed in an appropriate manner?). Crew evaluation.
- Vessel Inspection Questionnaire (CVIQ): An algorithm generates custom-tailored questions for each inspection in real-time using a **tablet device**.
- Take **photos**, verify the ones provided by vessel's operator
- Approximately 8 hours OB

RightShip

“Ships of Shame”

- **Bulk carrier** accidents
- 1988-1991
- Nearly 100 seafarers lost
- Western Australia coast

ex. MV "Derwent Hunter“, MV "Jervis Bay"

↓

Class, Flag & PSC proved insufficient

↓

A group of Charterers founded RightShip

- RightShip Safety Score

Ship’s 5 year history of

Incidents & accidents
PSC deficiencies & detentions
Ship Managers (DOC) performance
Vessel’s flag and class

Algorithm →

5 4 3	Considered Safe, proposes vet
2 1	Charterers will avoid

RightShip platform

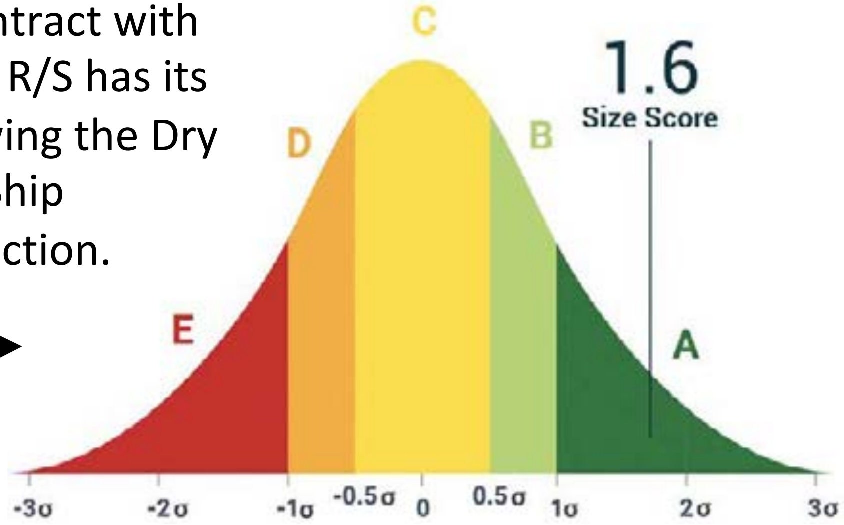
The platform collects all this information which presents to charterers for each vessel and company

- Vetting for dry bulk carriers

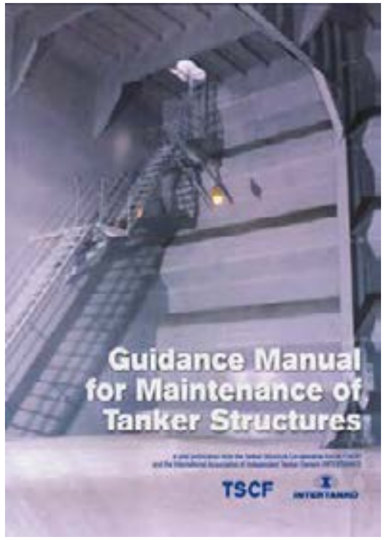
Request of customers who have a Vetting service contract with RightShip (including BHP, Vale, Cargill and Rio Tinto). R/S has its own trained inspectors or uses subcontractors following the Dry Bulk Standard Vetting Criteria. RightShip Inspection Ship Questionnaire (RISQ 3.0) is tool for planning an inspection.

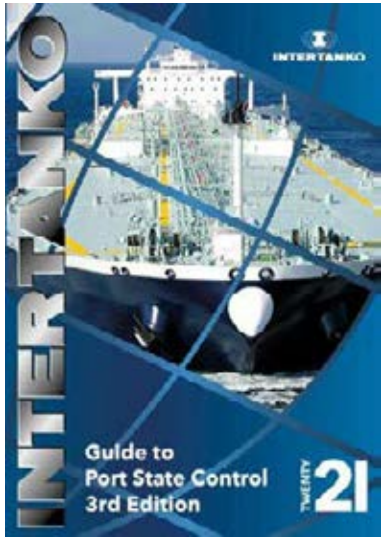
- GHG Rating 2.0 (A-E Ratings) →

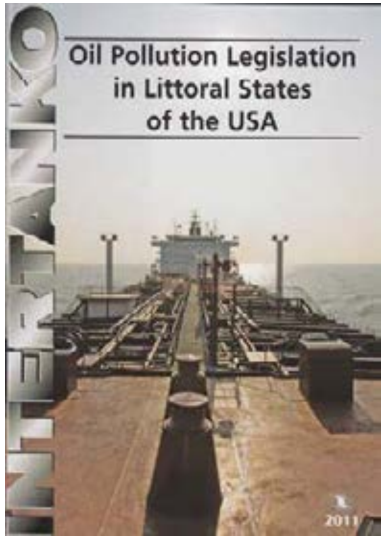
Based on design + operation (EEDI/EEXI + CII).
Dynamic, compares vessel to rest of the fleet.

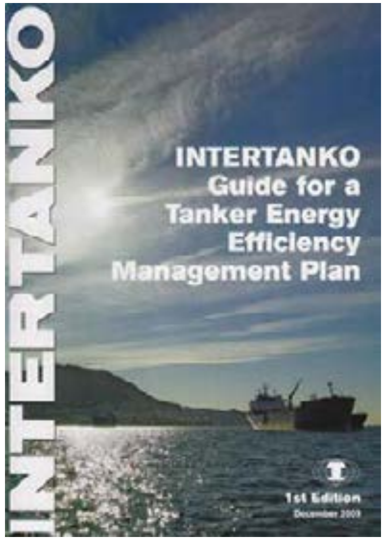


INTERTANKO









The role of INTERTANKO

INTERTANKO has been the voice of independent tanker owners since 1970, ensuring that the oil, products and chemicals that keep the world economy turning is shipped safely, responsibly and competitively.

Membership is open to independent tanker owners and operators of oil and chemical tankers, i.e. non-oil companies and non-state controlled tanker owners, who fulfil the Association's membership criteria. Independent owners operate some 80% of the world's tanker fleet and the vast majority are INTERTANKO members. As of June 2003, the organisation has 242 members, whose combined fleet comprises more than 2,160 tankers totalling 160 million dwt, which is 70% of the world's independent tanker fleet above 10,000 dwt. INTERTANKO's associate membership stands at 273 companies with an interest in the shipping of oil and chemicals.

INTERTANKO is a forum where the industry meets, policies are discussed and statements are created. It is a valuable source of first-hand information, opinions and guidance. INTERTANKO has a vision of a professional, efficient and respected industry that is dedicated to achieving safe transport, cleaner seas and free competition.

Complexity

There are examples reported of some tanker being inspected as 35 times a year! An average tanker portfolio of inspections each year contains (may be outdated):

(a) Chemical Distribution Institute (CDI): 1-2;
(b) SIRE: 2-7;
(c) independent charterer vetting inspections: 2-3;
(d) terminal vetting inspections: 3-4;
(e) P&I Club inspections: 1;
(f) ISM audits: 1, either internal or external;
(g) PSC: 3-4;
(h) flag state: 1;
(i) Class: upwards of 8 concurrent annual/intermediate surveys, e.g. IOPP, Certificate of Fitness, Load Line, Safety Equipment, Safety Construction, Class and Safety Radio: and
(j) USCG: 1 (Depending on how often will call US ports)

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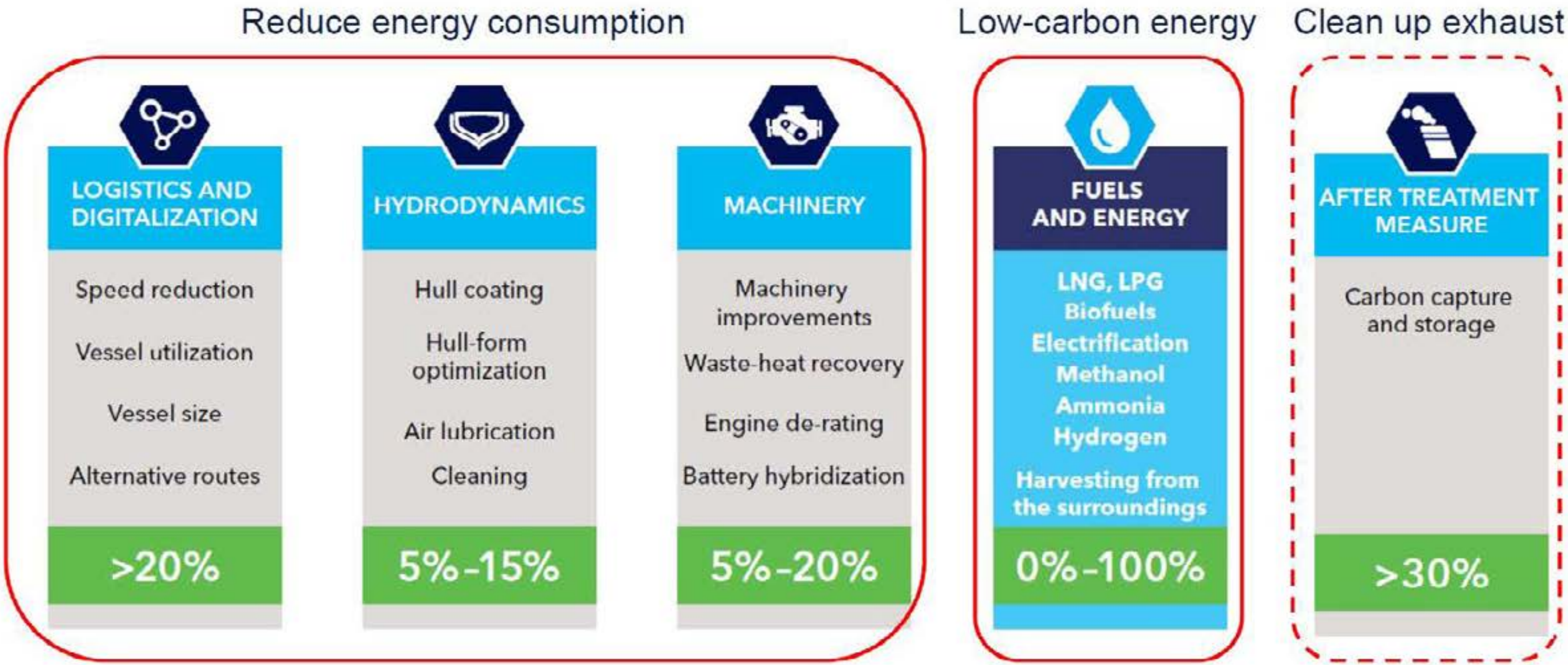
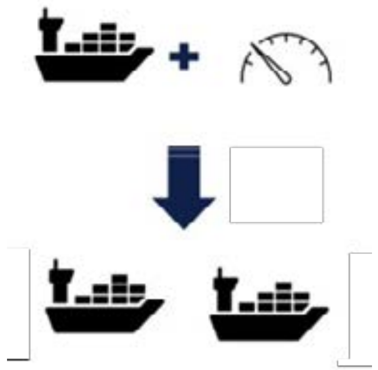
25th April 2024, Aikaterini Laskaridis Foundation

What can be done to reduce emissions?

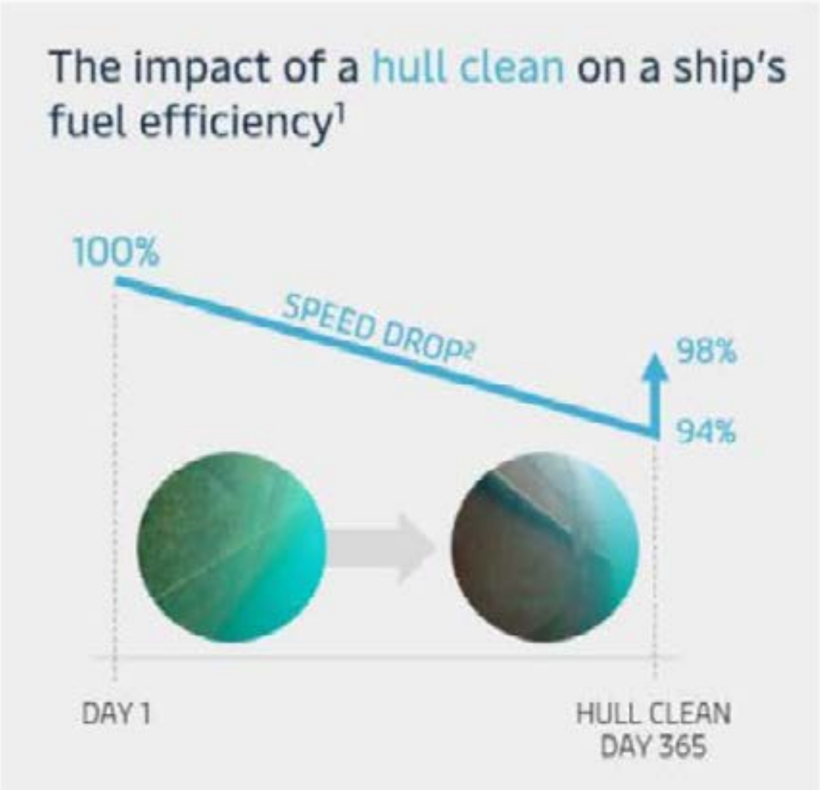


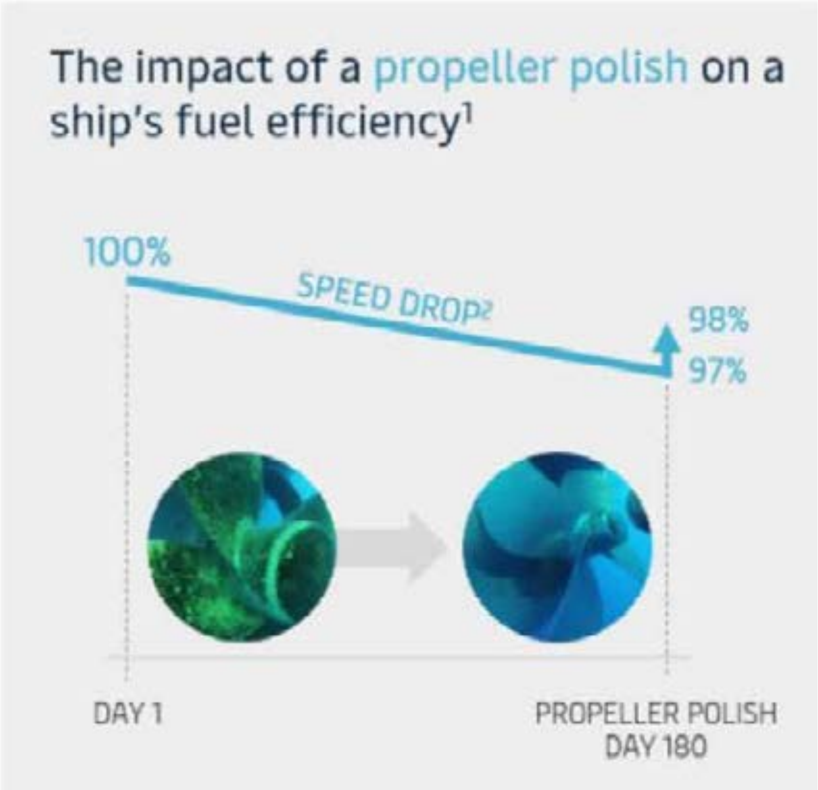
Logistics

- Slow steaming (5-15% speed reduction or more!)
- Port call optimization (ships and ports can coordinate on-time arrivals)
- Hull Cleaning



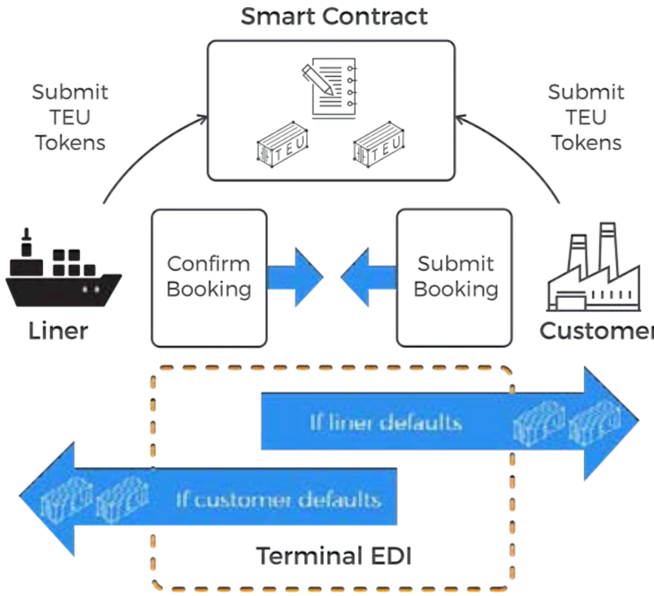
Side effect: Slow Steaming increases demand for maritime transport





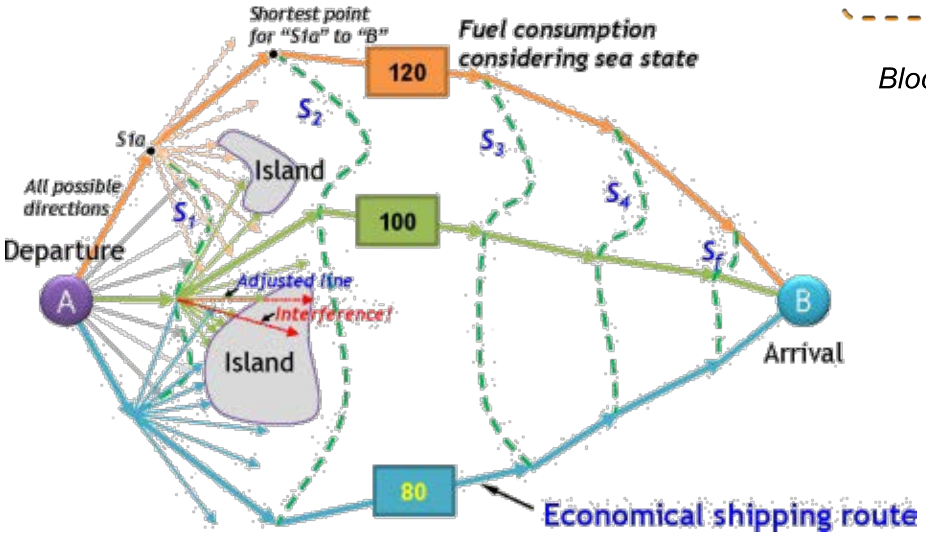
Digitalization

- Artificial intelligence (AI)
- Machine Learning (ML)
- Internet of Things (IoT)
- Blockchain
- Digital Twins
- Weather Routing



Blockchain in shipping

Digital Twins



Weather Routing

Emission and CII Monitoring

Content

0. Intro

1. Regulatory Recap
   - IMO (SOLAS, MARPOL, Polar, Noise)
   - Local Regulations
   - Classification Societies
   - Port State Control
   - Associations & Networks

2. Solutions, Goals & Priorities
   - Logistics & Digitalization
   - Hydrodynamics & Aerodynamics
   - Machinery
   - Fuels
   - Carbon Capture

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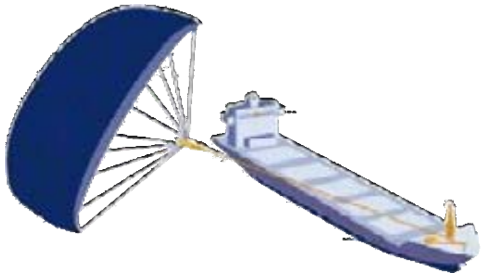
a go maritime initiative

Stavros Hatzigrigoris

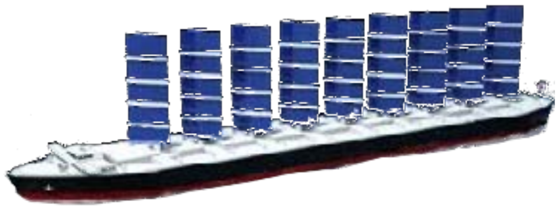
25th April 2024, Aikaterini Laskaridis Foundation

Wind Assisted Propulsion (WAP) Technologies

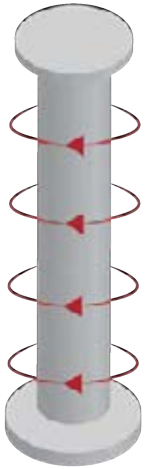


Towing Kite

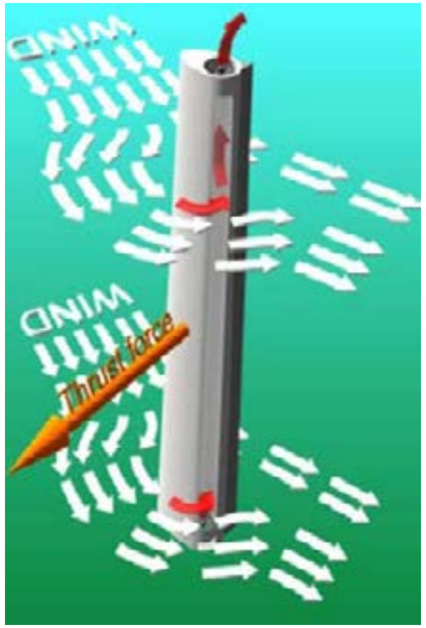
Rigid Wing Sails



- ***Flettner Rotors*** *(Magnus effect)*: tall, cylindrical rotors mounted vertically on a ship's deck. It is the most common application with CAPEX = 3M$ - 6M$
- ***Suction Wing Sails*** *(thrust mainly from Airfoil's lift force):* vertical non-rotating wings shaped as adjustable airfoils. Internal vents and fans suck air from the low pressure side increasing ΔP and thrust.
- ***Towing Kite*** *(thrust mainly from drag force):* large kite-like device deployed from bow.
- ***Rigid Wing Sails*** *(Variable-camber, both drag & lift);* are comprised of a fixed, rigid structure to maintain a consistent aerodynamic shape.
- ***Soft Wing Sails*** *(Variable-camber, both drag & lift):* combine the benefits of soft sails and rigid wing sails.
- ***Soft Sails*** *(both drag & lift):* derived from the traditional yacht sails and they are typically consist of multiple freestanding, rotating masts, each carrying series of individual sails.



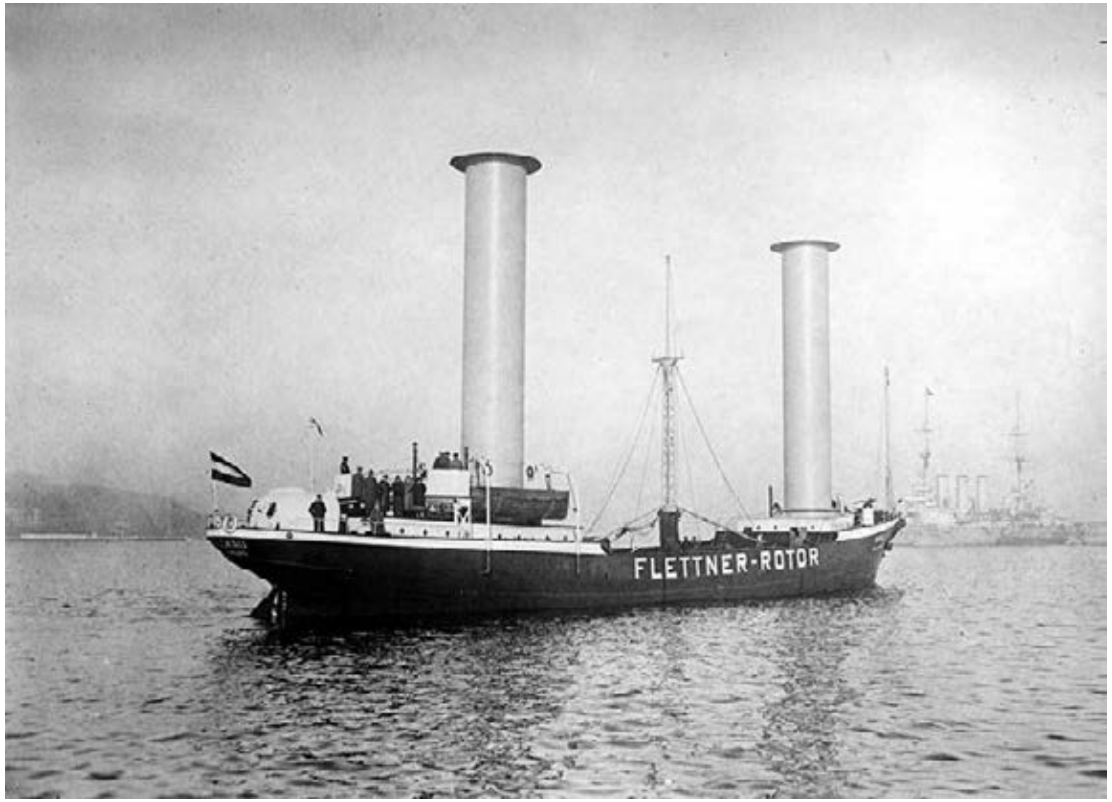
Flettner Rotor



Suction Wing Sail

Flettner Rotor ships since 1924

The rotor ship *Buckau (1924)*
experimental rotor vessel

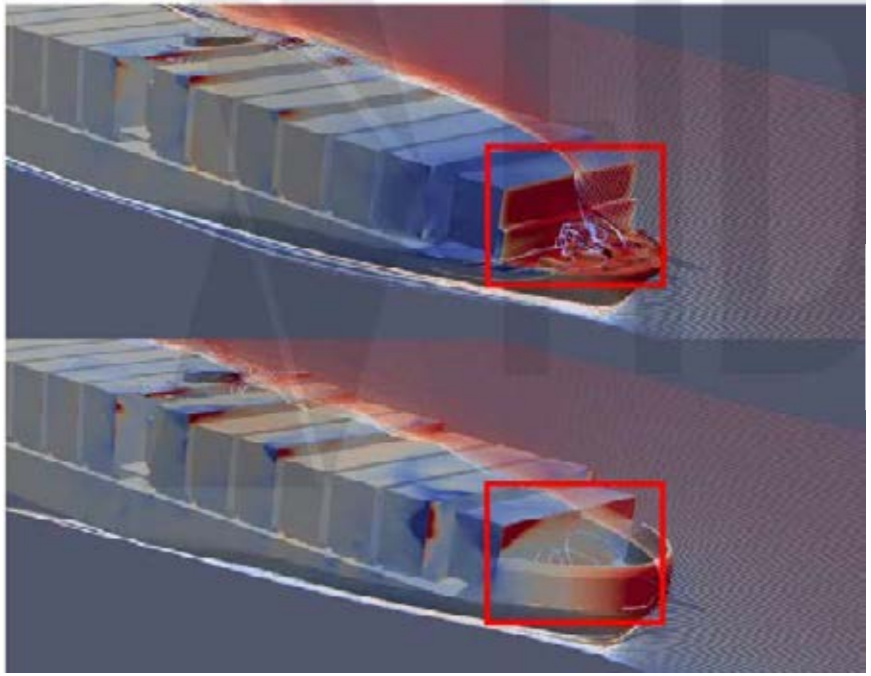


The rotor ship *Barbara* (1926)
normal freighter ship

Wind cover (containerships)

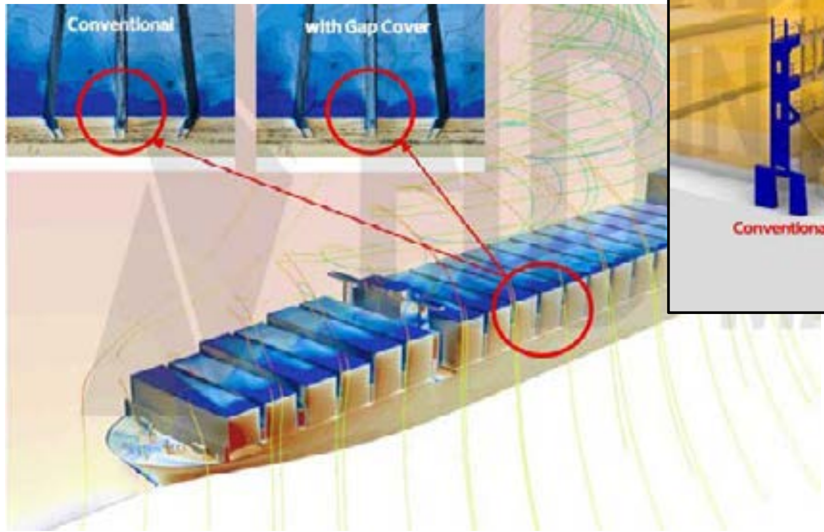
- Wind Cover **(up to 1% net savings for containerships)**

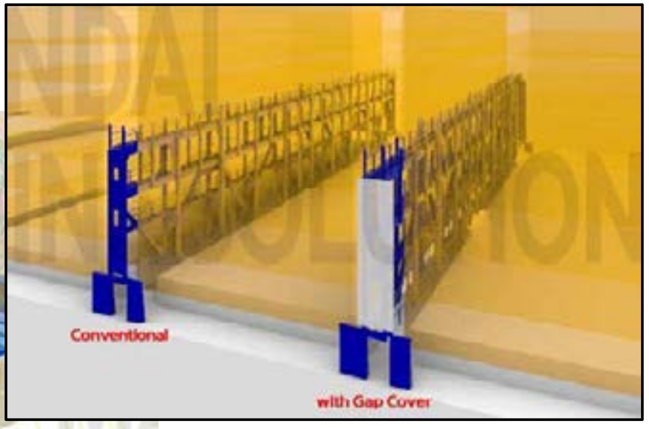
Air resistance normally represents about 2% of the total resistance, however, for loaded container ships in head wind, the air resistance can be as much as 10%.



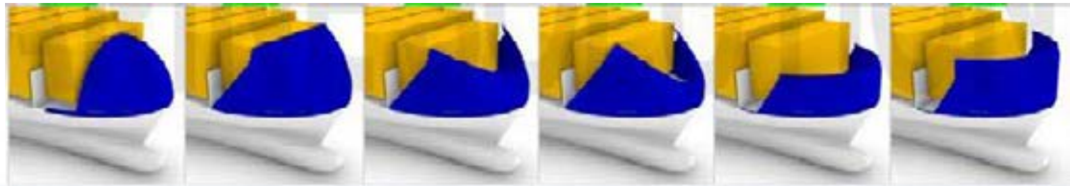
- SGC (Side Gap Cover) in containerships

(~0.5% net savings)



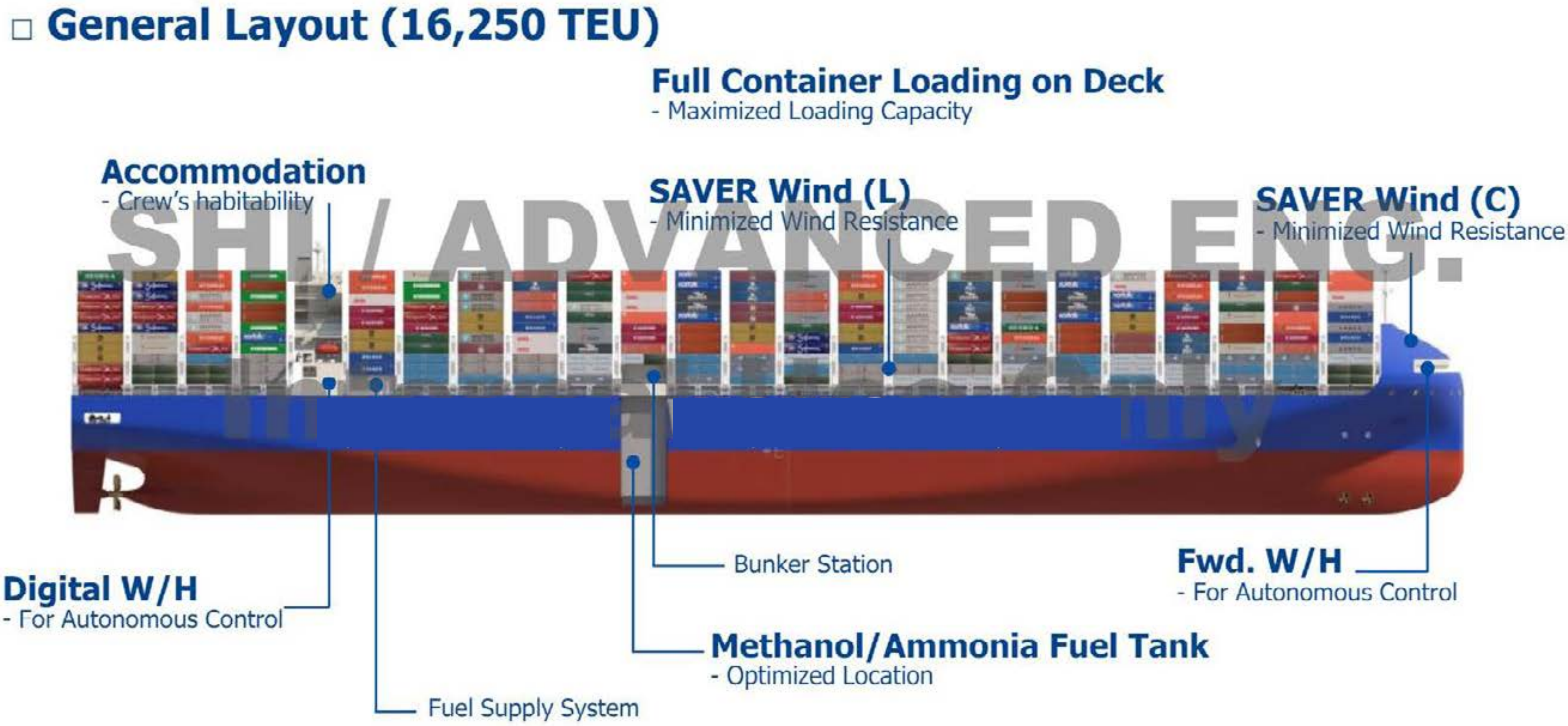


Typical Lashing bridge configuration

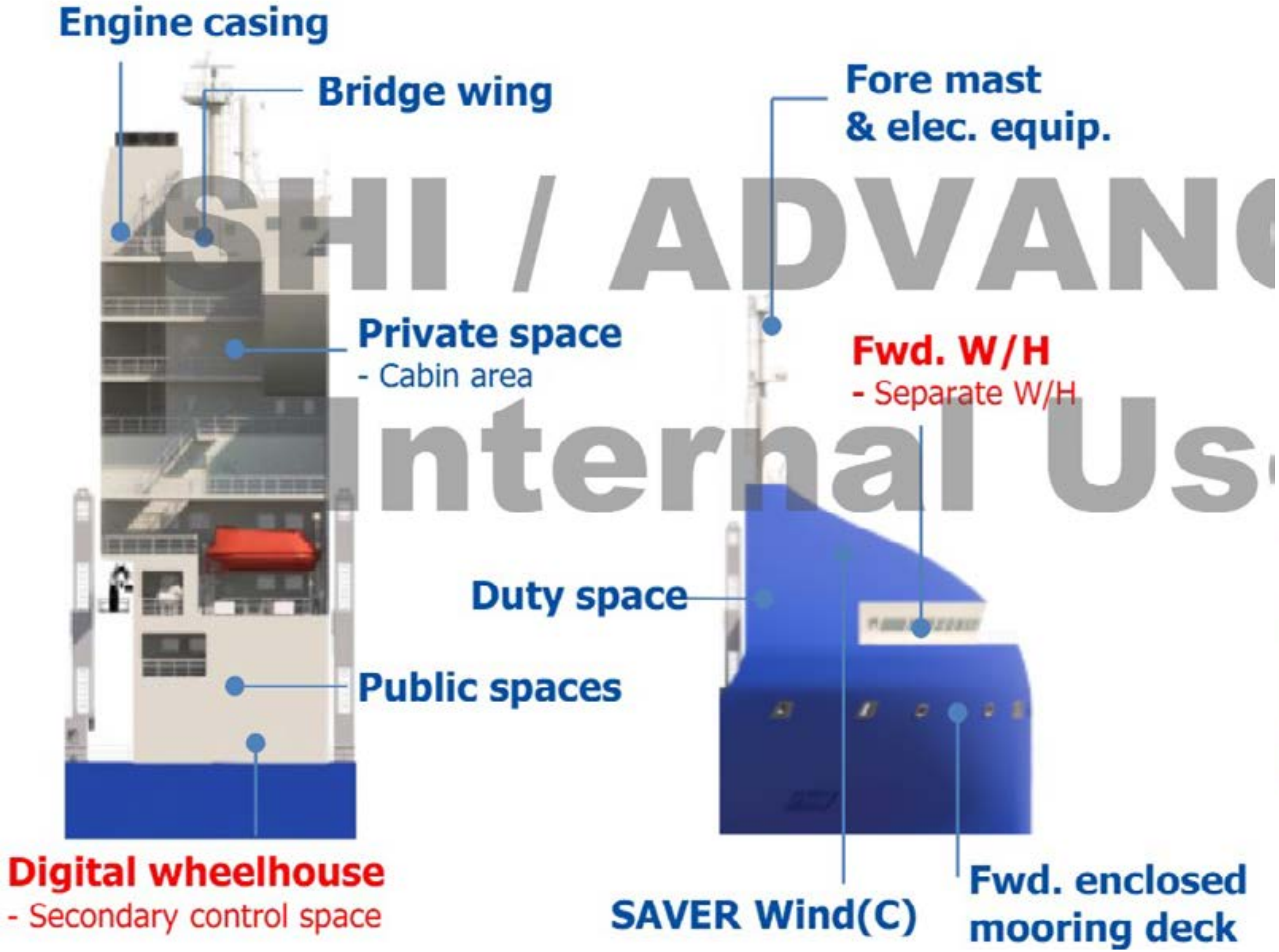


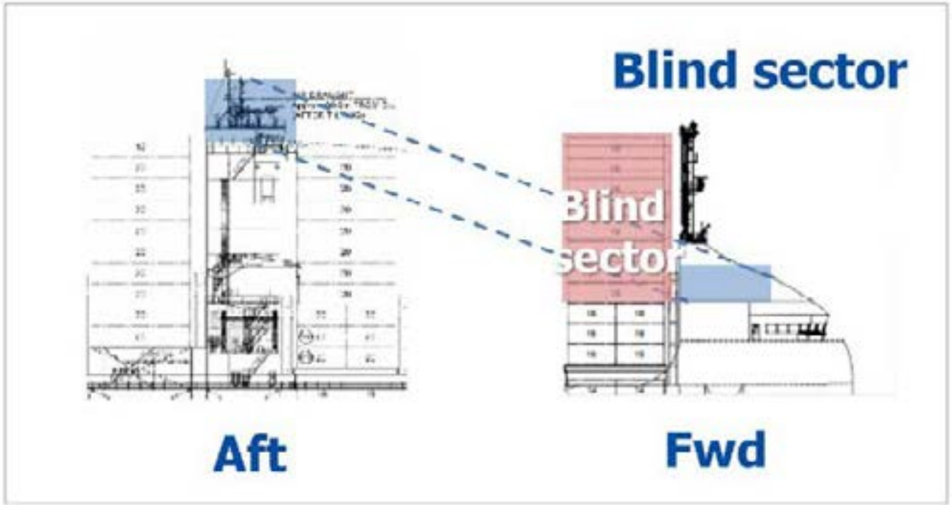
Case	1	2	3	4	5	6
Wind resistance reduction rate	Abt. 10%	Abt. 13%	Abt. 11%	Abt. 12%	Abt. 11%	Abt. 12%

A state of the art Design



A state of the art Design

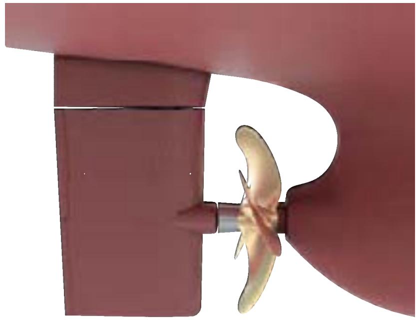




Sports Center

Cinema

Rudder Design



Rudder bulb / Costa bulb

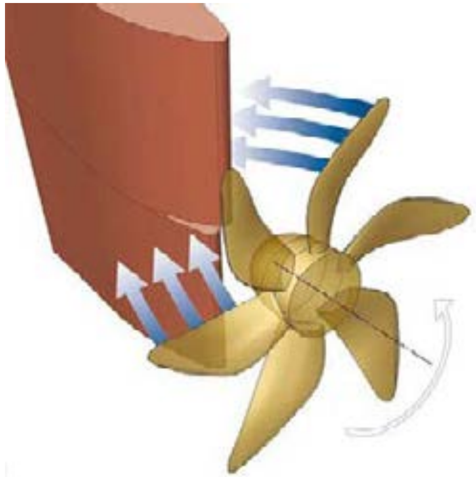
Integrated propeller and rudder

Becker Rudder

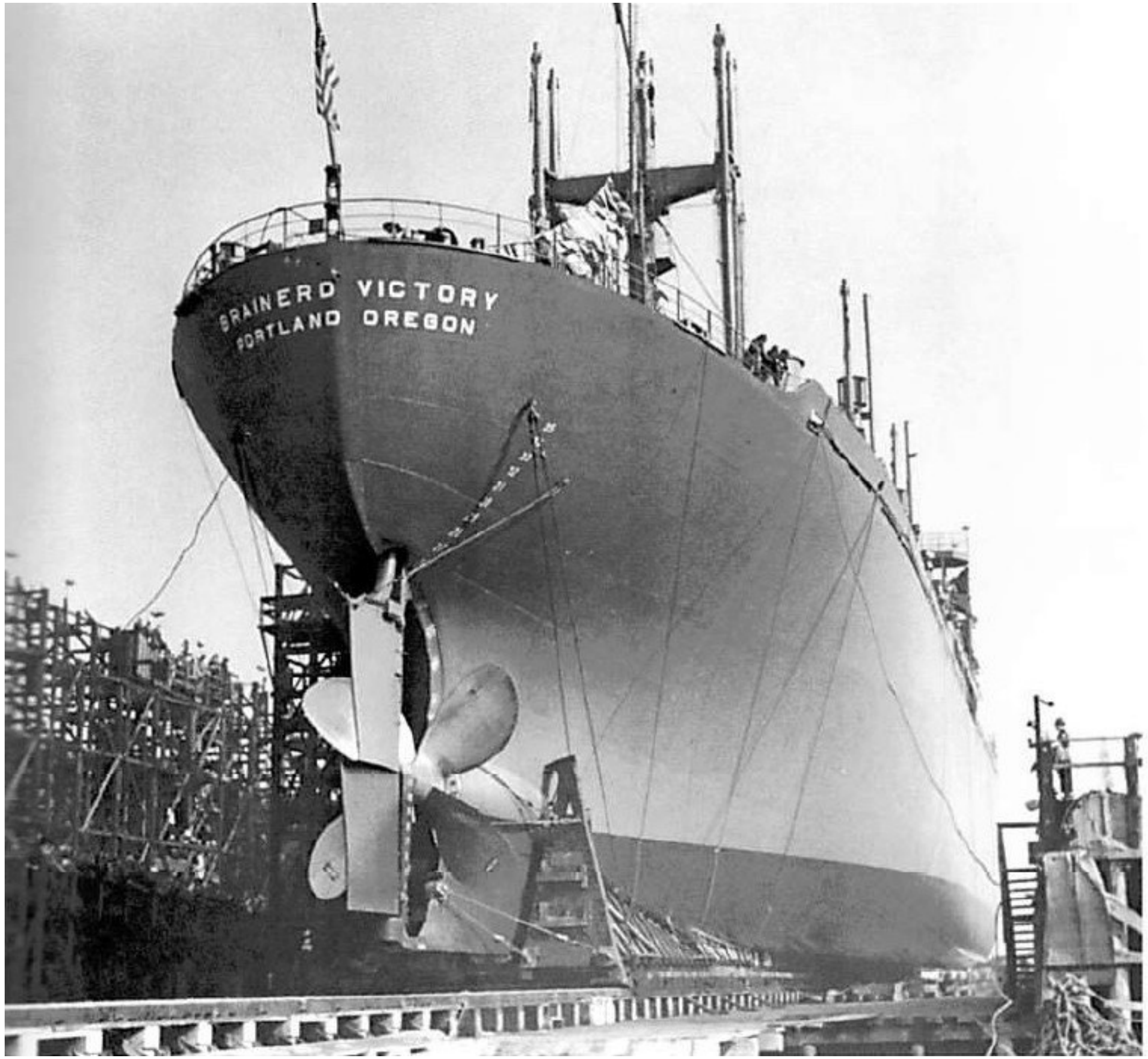
- **Gate Rudder** consists of two asymmetrical rudders placed in parallel either side of the propeller instead of placing behind the propeller
- **Twisted Rudder** is a type of full-spade rudder with upper and lower sides that are designed asymmetrically to consider the wake inlet angle of the propellers.
- **Becker Rudder** is a multi-section rudder; the hinged aft section gives the rudder an extra control surface, enhancing maneuverability with small effect on efficiency.
- **Rudder bulb / Costa bulb** consists of a bulb attached on the rudder in line with the propeller resulting to smoother inflow to the rudder.
- **Integrated propeller and rudder**, where the propeller is directly mounted to the rudder.

Gate Rudder

Twisted Rudder



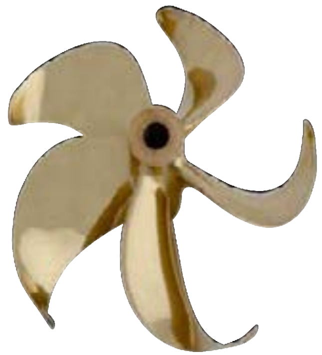
Twisted rudder (1940s Victory ships)



Left: Final preparations before the launch of the *Brainerd Victory*. Note 19ft diameter propeller and rudder with twisted trailing edge to improve steering.

Propeller Design

- **Kappel propeller** has blades curved towards the suction side in especially towards the blade tip.
- **Contracted Loaded Tip (CLT) propeller**, has end plates at the blade tips.
- **New Profile Technology (NPT) propeller,** designed with special blade sections
- **High skew propeller**, with skew angle more than 25 degrees.
- **Controllable-Pitch (CPP) Propeller,** blades that can rotate relative to the hub.
- **Sharrow Propeller**, consisting of a loop blade design.
- **ABB Dynafin™** composed of rotating vertical blades, mimicking a whale tale motion.

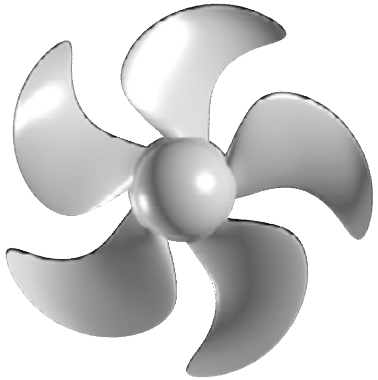


Kappel propeller

CLT propeller

NPT propeller

Sharrow Propeller

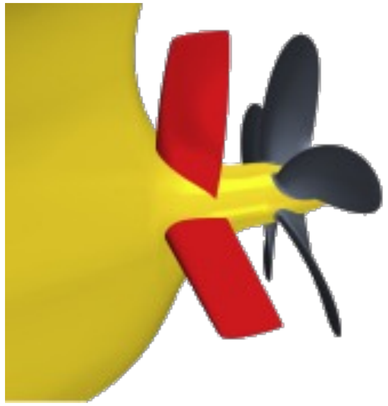


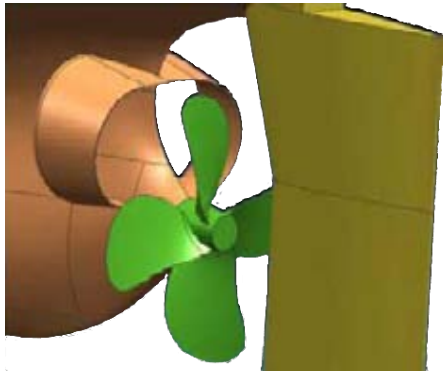
High skew propeller

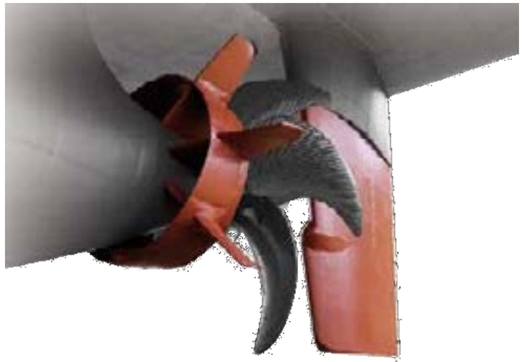
CPP propeller

ABB Dynafin™

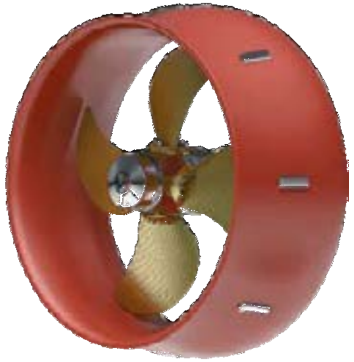
Devices for propeller efficiency

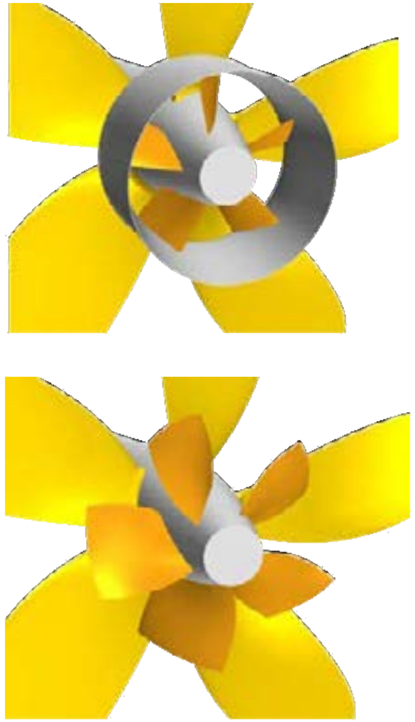

Pre-swirl stator


Schneekluth
Wake Equalizing Duct


Becker / Mewis duct

- **Propeller boss cap fins (PBCF)** consists of a propeller boss fitted with short blades inclined to convert hub vortex energy into additional torque and thrust.
- **Becker / Mewis duct** consists of a wake equalizing duct combined with an integrated pre-swirl fin system positioned ahead of the propeller.
- **Schneekluth Wake Equalizing Duct** consists of two nozzle-shaped halfring ducts installed on both sides of the stern ahead of the propeller.
- **Pre-swirl stator** consists of multiple curved fins and a ring attached to the ship's hull, ahead of the propeller.
- **Propeller nozzle** is a circular casing enclosing the propeller which increases the thrust at low speeds.


Propeller nozzle


Propeller boss cap fins (PBCF)

Bow design

- No bulbous bow: Designers may even choose not to include a bulbous bow if the intended operating speed of the ship is such that the benefits gained from reduced wave-induced resistance are outweighed by the increase in frictional resistance.

1975 VLCC
(No bulbous bow)

2000 VLCC
(Full bulbous bow)

Bow design

CAPEX

100k$ - 300k$

- **Bulbous bow retrofit**

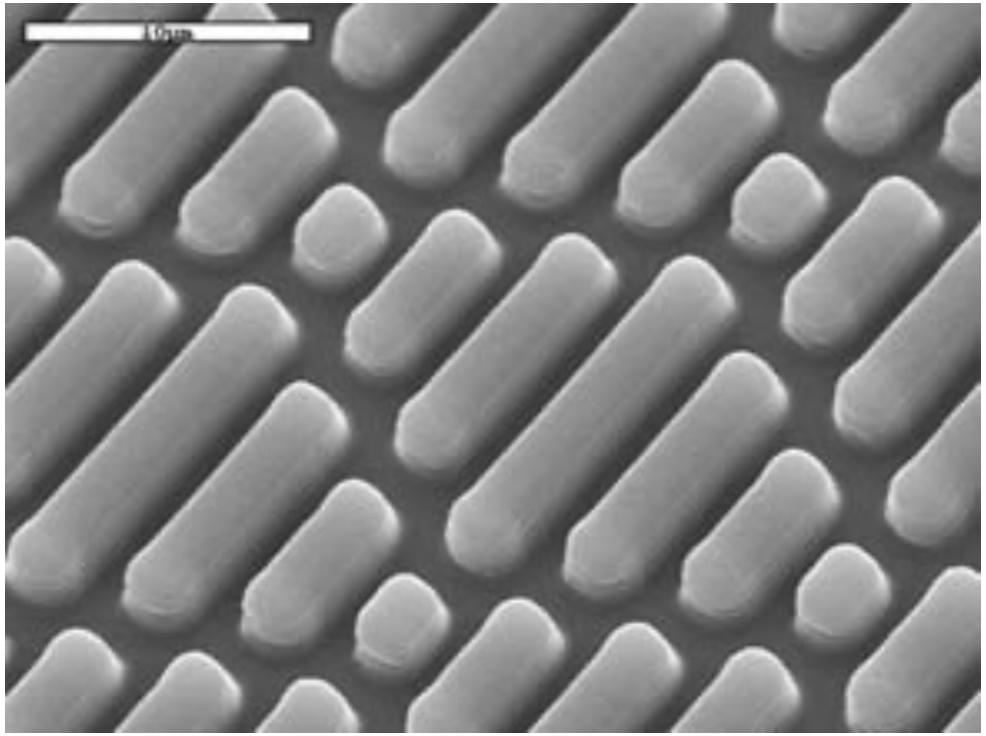
Bulbous bow is optimized for the new operating profile provided by the ship owner. Use optimization tools and CFD programs to search for different shapes of bulbous bows and use optimization algorithms to generate the optimal shape.


AL SAFAT
الصفاة

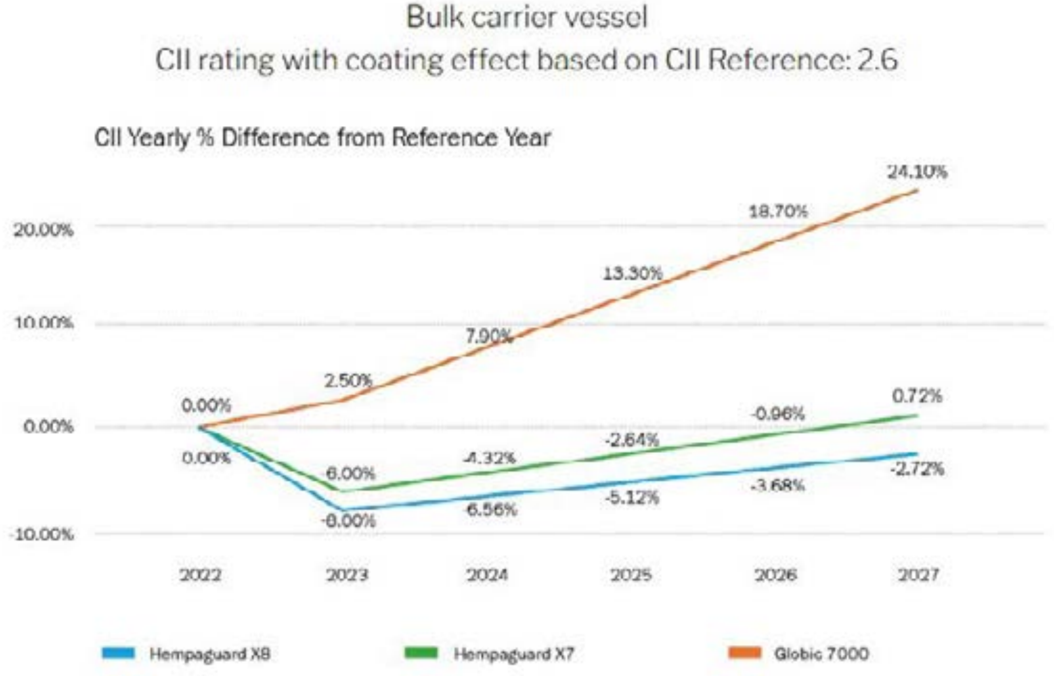
Coatings

- Shark Skin Coating

Composed of tiny scale-like elements that can actually flex in and out to impede growth. In the future it could replace conventional antifouling coatings



- Silicon coatings > biocidal copper coatings
- Full blast > Spot blast



BootTop, Vertical Bottom & Flat Bottom	2022	2023	2024	2025	2026	2027
Full blast • Hempaguard X8	2.55 (C)	2.35 (C)	2.39 (C)	2.42 (C)	2.46 (D)	2.5 (D)
Full blast • Hempaguard X7	2.55 (C)	2.4 (C)	2.44 (C)	2.49 (D)	2.53 (D)	2.57 (D)
Spot blast • Globic 7000	2.55 (C)	2.62 (D)	2.76 (D)	2.89 (E)	3.03 (E)	3.17 (E)

Assumptions: Same trade every year. 3:1 Power to Speed Relationship

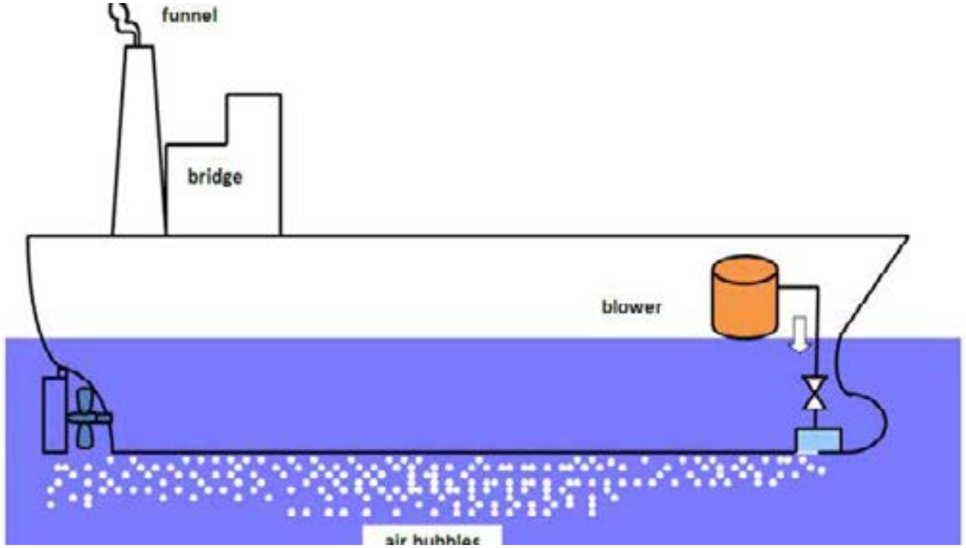
by HEMPEL

Air lubrication System (ALS)

CAPEX 3.5M$ - 4M$

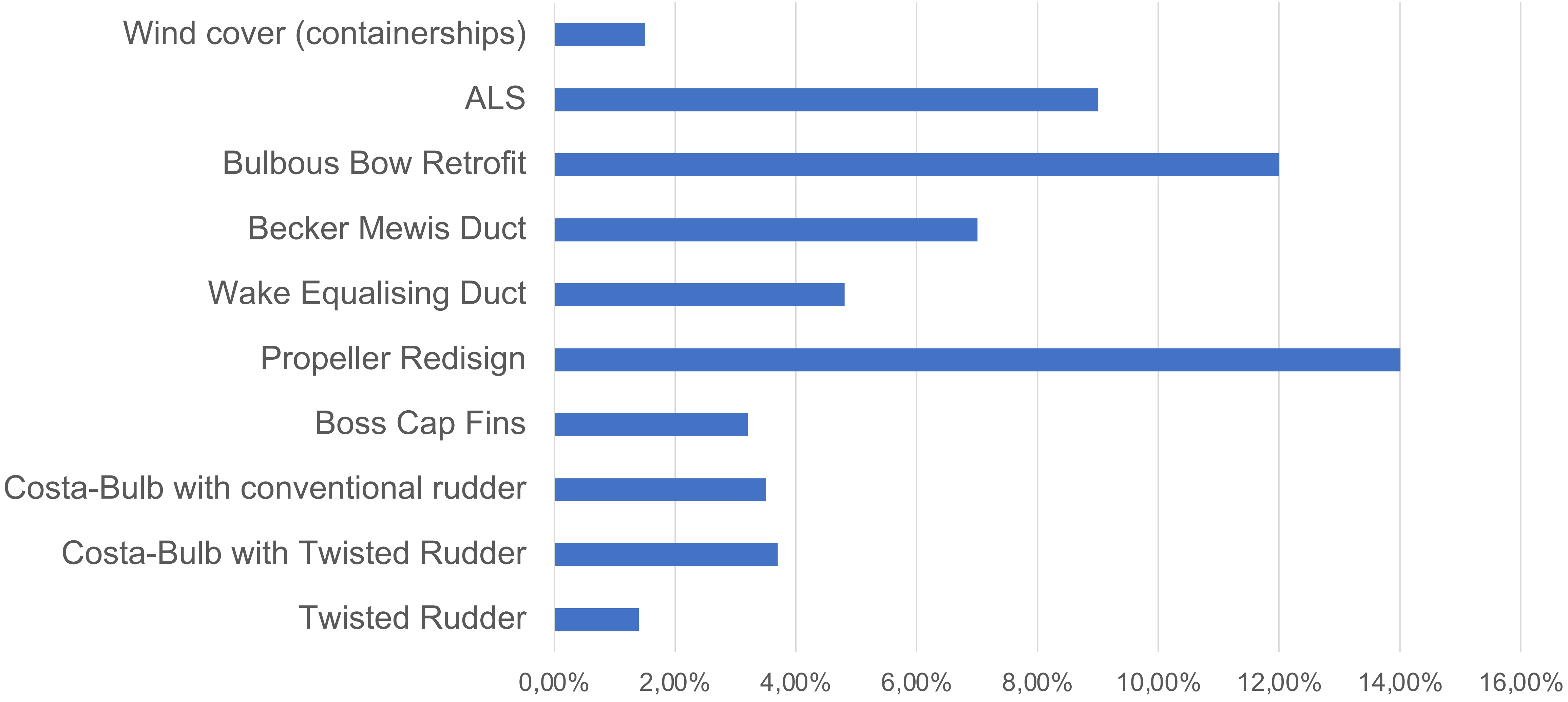
Up to **9%** net savings

Air lubrication reduces the drag force on the wetted surfaces of the hull due to the lower viscosity of air compared to water (it reduces the friction resistance of the FOB).



Ship Type	Typical Operational Speed [kts]	Typical Operational Draught [m]	Flat of Bottom as a % of total WSA	Expected Net Silverstream© System Performance
Tanker & Bulk Carrier	13 – 15	13 - 20	35% - 50%	4% - 6 %
Containership >9000 TEU	20 - 23	14 - 16	25% - 30%	4% - 6.5%
LNG Carrier	16 - 18	9 - 12	35% - 42%	6% - 9%
Cruise Vessel	18 - 20	8 - 9	20% - 30%	4% - 7%
Large RoRo	18 - 22	7 - 8	26% - 32%	5% - 7%

Hydrodynamics & Aerodynamics
Maximum power savings



Content

NO SMOKING
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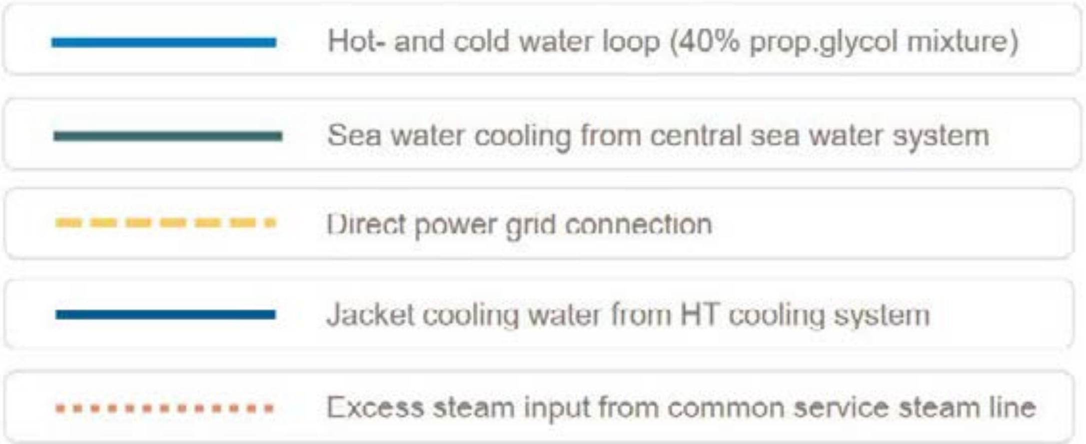
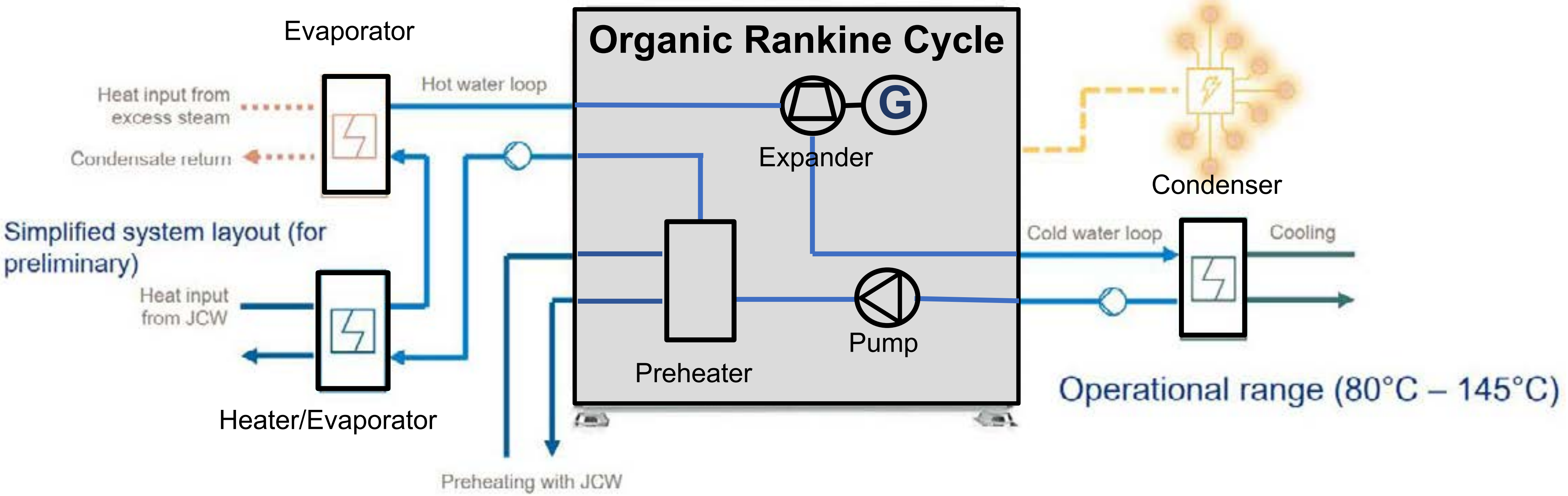
25th April 2024, Aikaterini Laskaridis Foundation

Waste Heat Recovery (WHR)

Up to 500 KW electrical power with no CO2 generation

Converting an engine's excess thermal energy into electrical power. This can be achieved by an Organic Rankine Cycle (with working fluid ex. 40% prop. Glycol mixture). The electricity is automatically fed into the ship's grid, reducing demand on the auxiliary engines, so CO2 ⬇.





Engine Part Load Optimization (De-rating)

From **2%** to **10%** CO2 reduction

From design, the vessel engine and propeller are both designed and optimized for a given operational and maximum speed. If the vessel true speed is generally lower than originally optimized for, derating of the main engine and propeller may be considered. ...not favored by engine makers

ROI = 2-3 years
6-7 mo project
<1 mo DD

Part- and low load	**T/C Cut-Out**	Fuel savings up to 6 g/kWh
	ECT	Fuel savings up to 3 g/kWh
	VTA (or VGT)	Fuel savings up to 5 g/kWh
	EGB	Fuel savings up to 5 g/kWh
	HPT	Fuel savings up to 5 g/kWh
High load	**TCS-PTG**	Fuel savings up to 7 g/kWh

T/C Cut-out

Electric Turbo Compounding

Variable Turbine Angle

Exhaust Gas Bypass

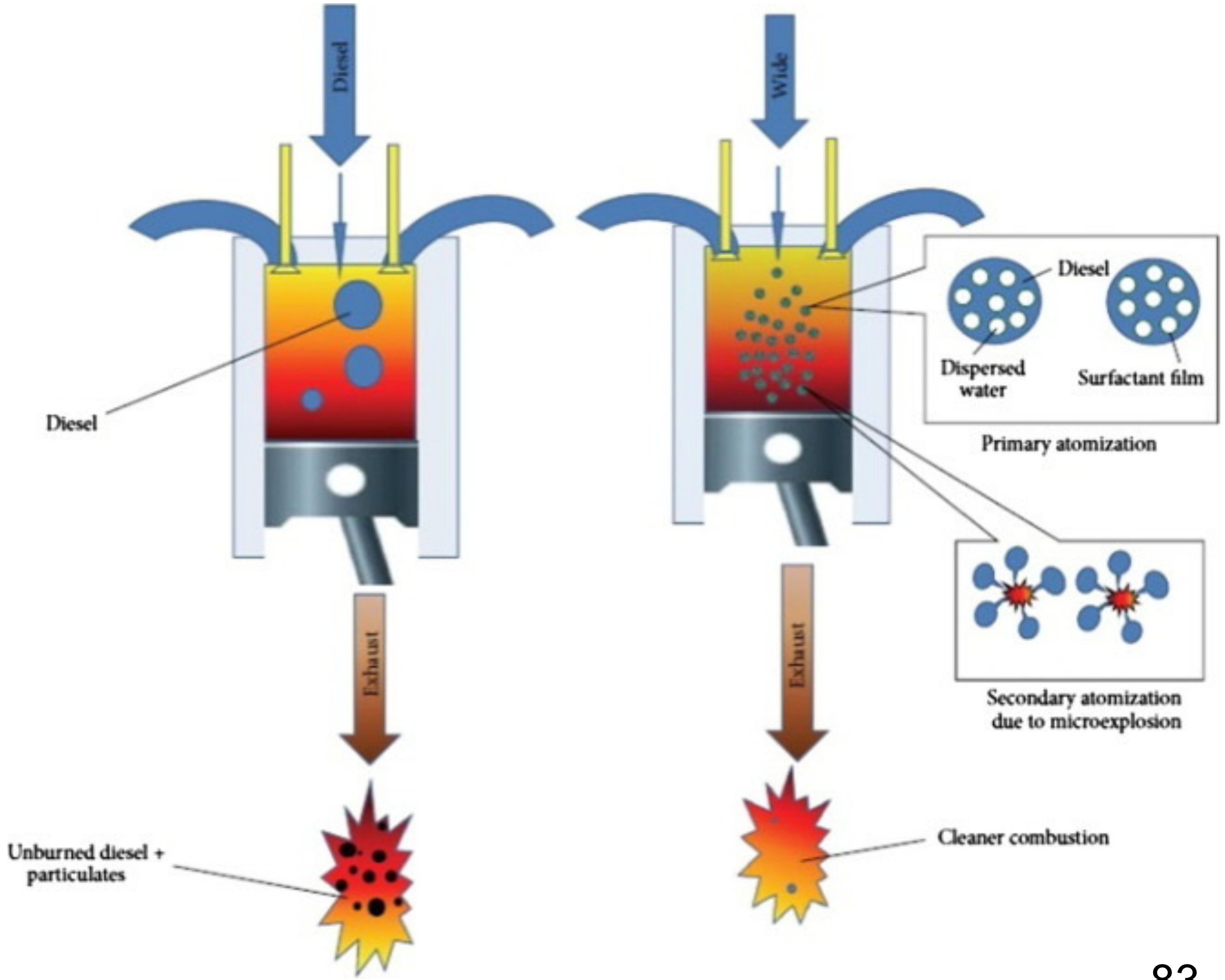
High-pressure tuning

Turbo Compound Systems with Power Turbine and Generator

Emulsion

ME efficiency increase up to **5%**

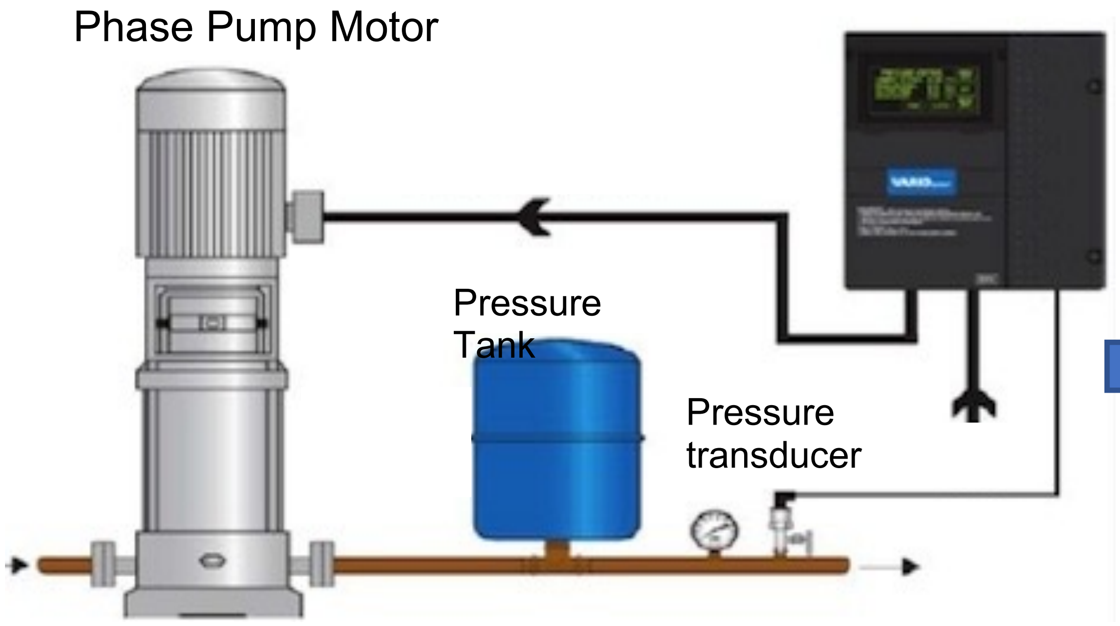
Mixing water and fuel to an emulsion will lead to an altered combustion characteristic and an optimized fuel system (atomizers). NOx reduction. Possible reduction in fuel consumption by utilizing the evaporation energy from the water in the power stroke of the engine.

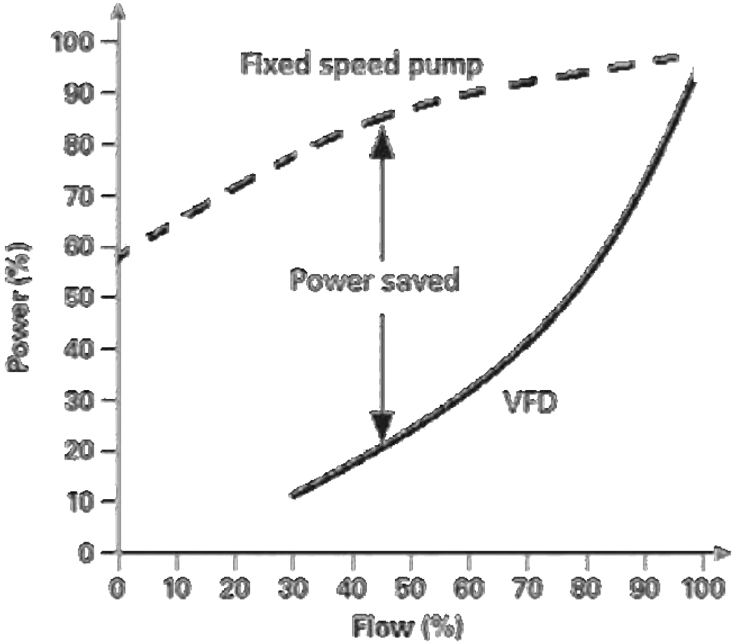


Variable Frequency Drives (VFDs)

Up to **1%** CO_2 reduction

Fans and pumps often operate binarily, (either off or operating at full capacity). Instead these can be dynamically operated depending on the real requirements. *Applications e.x. cranes, winches, bow thrusters, ventilation, pumps, compressors, OW separators, S/G*



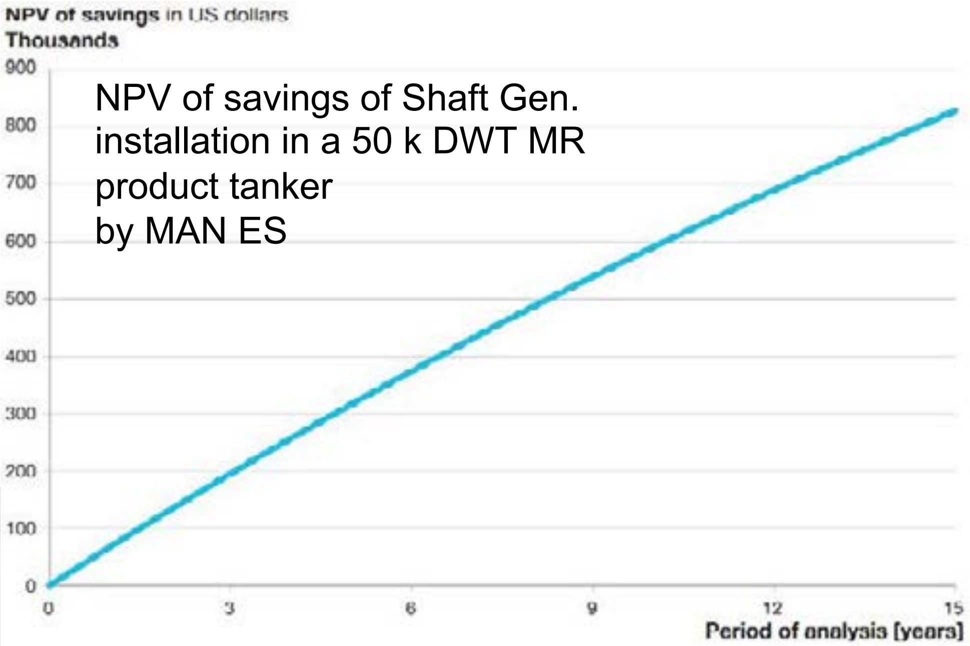


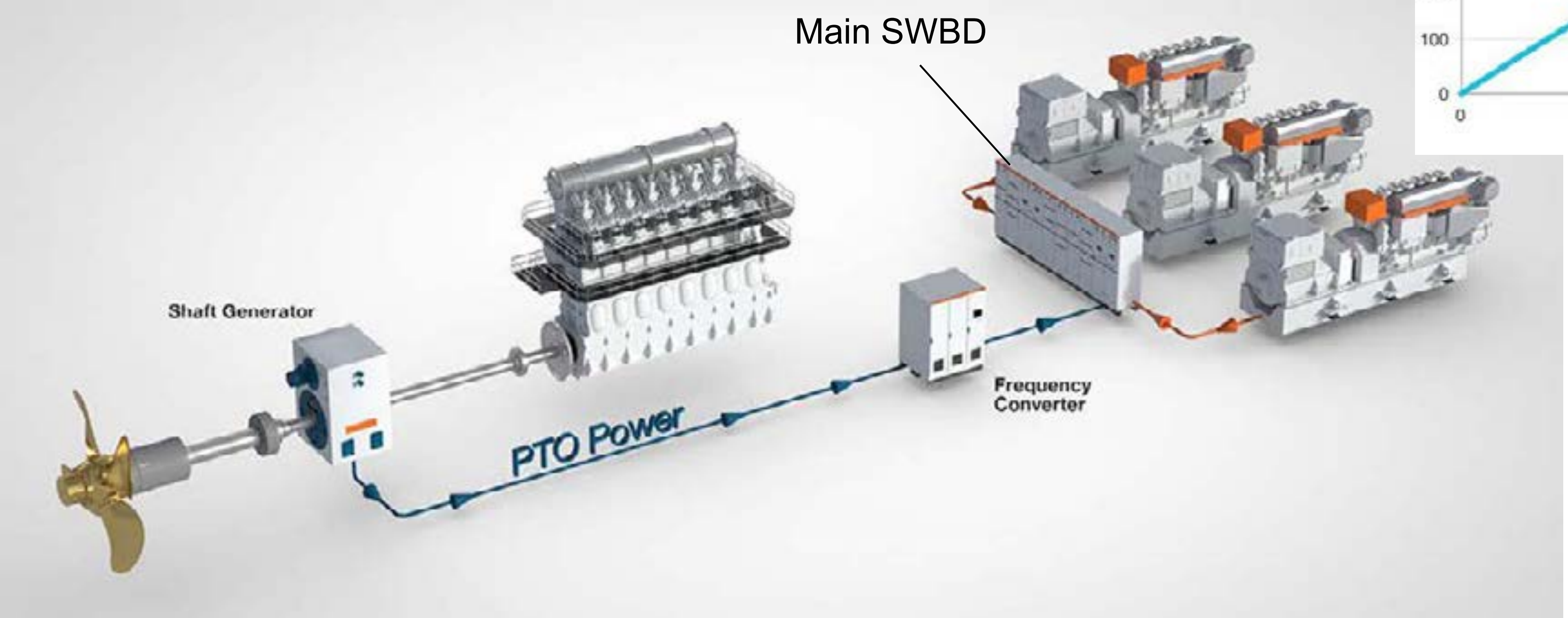
by Journal of Marine Engineering & Technology

Shaft Generators (S/G)

Saves up to **20%** of original GE consumption

Improved efficiency for electricity generation (due to the higher efficiency of main engine compared to auxiliary ones). Decreased fuel, lubrication and maintenance costs





2 MONTHS RETROFIT

CAPEX = 3.5M$ - 4M$

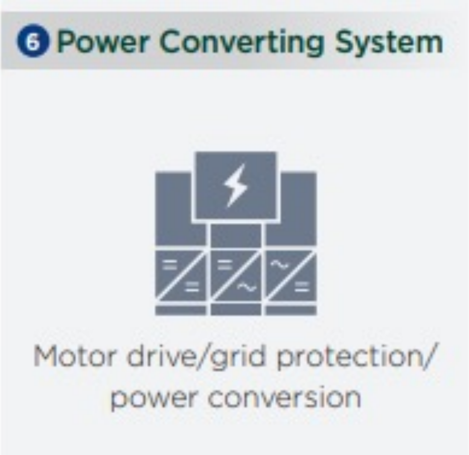
Shaft Generators (S/G): Types

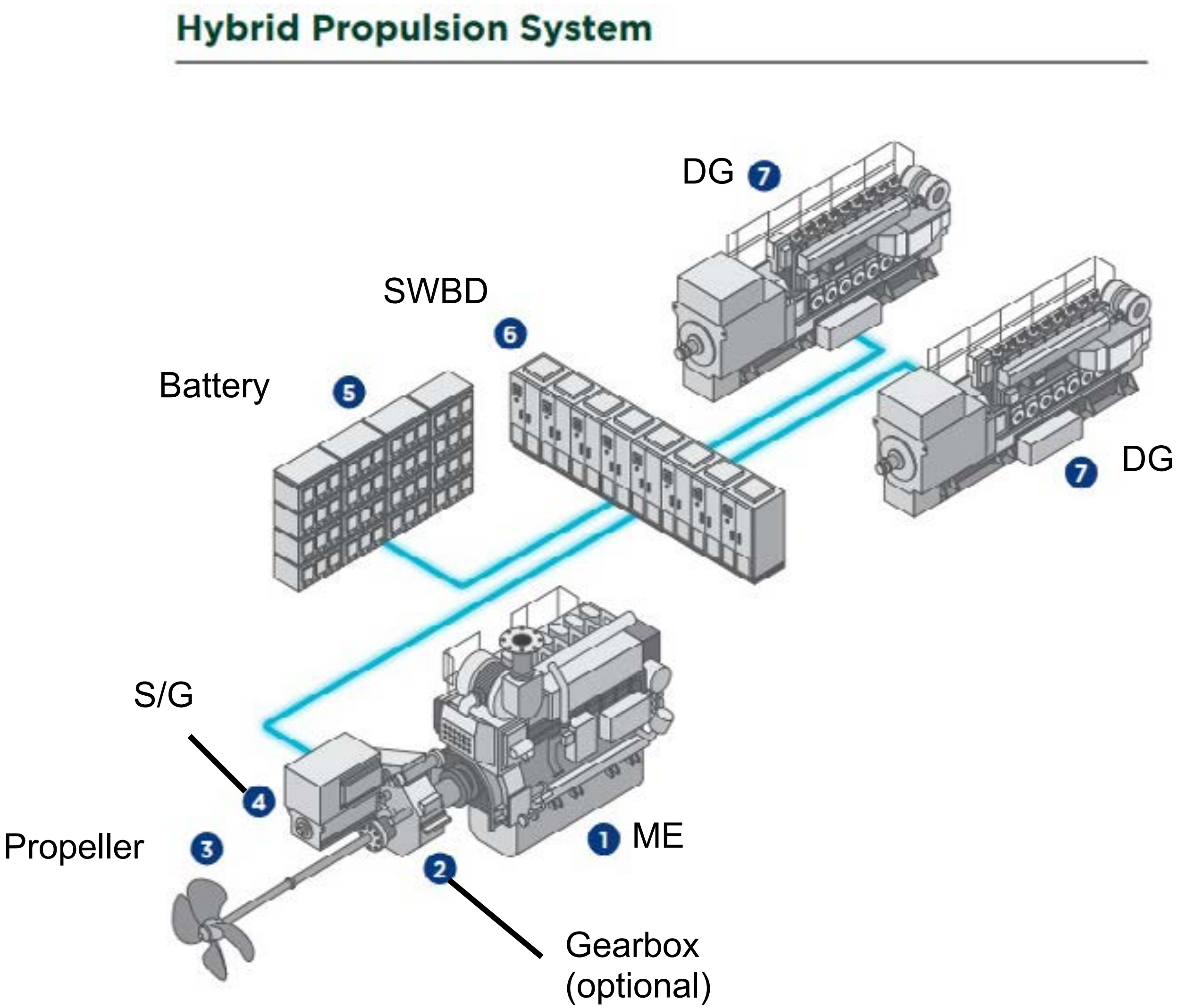
TYPE	Salient Pole (Synchronous)	Permanent Magnet (Synchronous)	Squirrel Cage (Induction)
EMG (Engine Mounted)	 Up to 2MW	Not Applicable	 Up to 2MW
In-line (with Shaft)	No Photo But Capable to produce Up to 5.5MW	 Up to 5.5MW	 Up to 5.5MW
Gear Box	Conventional type		

Batteries

Up to **1%** net savings

Redundancy is crucial on ships, prompting the use of multiple auxiliary generators. Incorporating a battery as a "spinning reserve" ensures continuous operation with a single engine, maintaining redundancy in case of issues and improving power generation efficiency during peak loads.





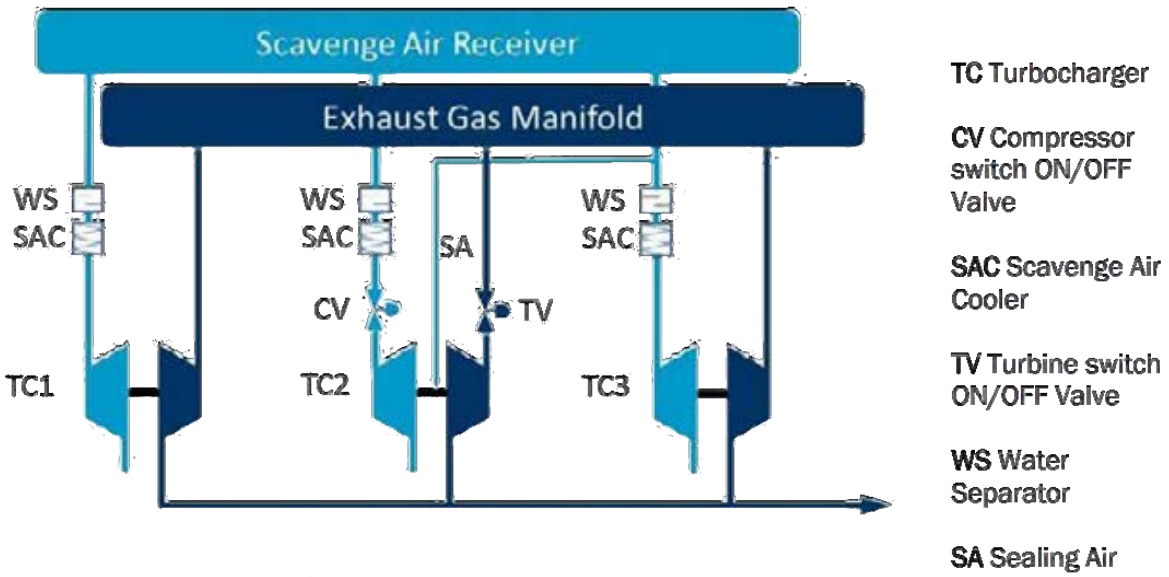
Main Engine Upgrades

MAN Energy Solutions

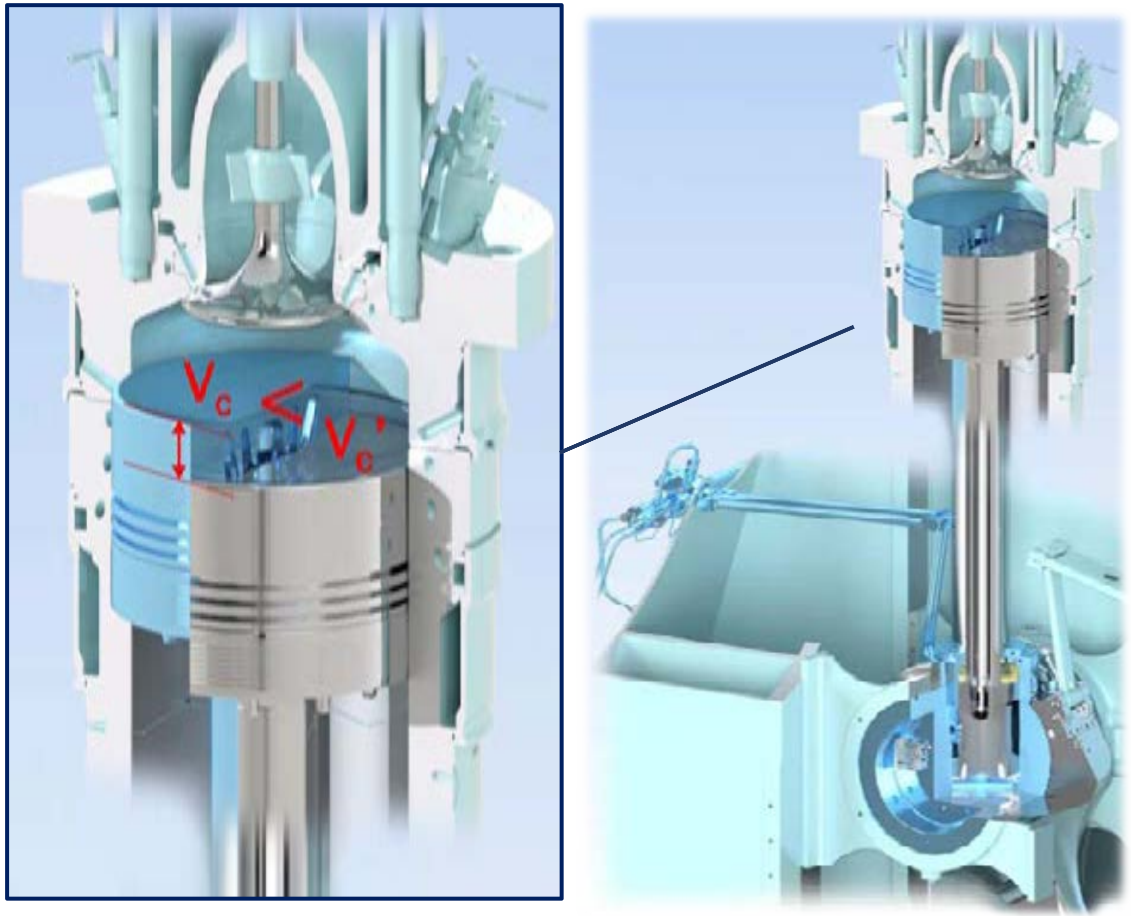
- **PMI VIT** (Performance Measuring Indicator Variable Injection Timing), with 9% fuel savings.
- **PMI ACCo** (Performance Measuring Indicator Adaptive Cylinder Control) with fuel savings of 1 to 3.5 g/kWH
- **EcoCam** enables efficient slow steaming with operational flexibility for mechanical engines, with fuel savings of 2-6 g/kWh.
- **EcoNozzle** with fuel savings of 2 to 7 g/kWh.

Main Engine Upgrades

- **aSTC** (automated Sequential Turbocharging) with fuel savings of up to 5 g/kWh at low engine load.
- Improved combustion efficiency by increasing the cylinder pressure, increasing compression ratio and optimized fuel injection an exhaust valve closing timing



- **VCR** (Variable Compression Ratio) with fuel savings up to 6 g/kWH (for Gas Mode) and 8-12 g/kWh (for Diesel Mode).



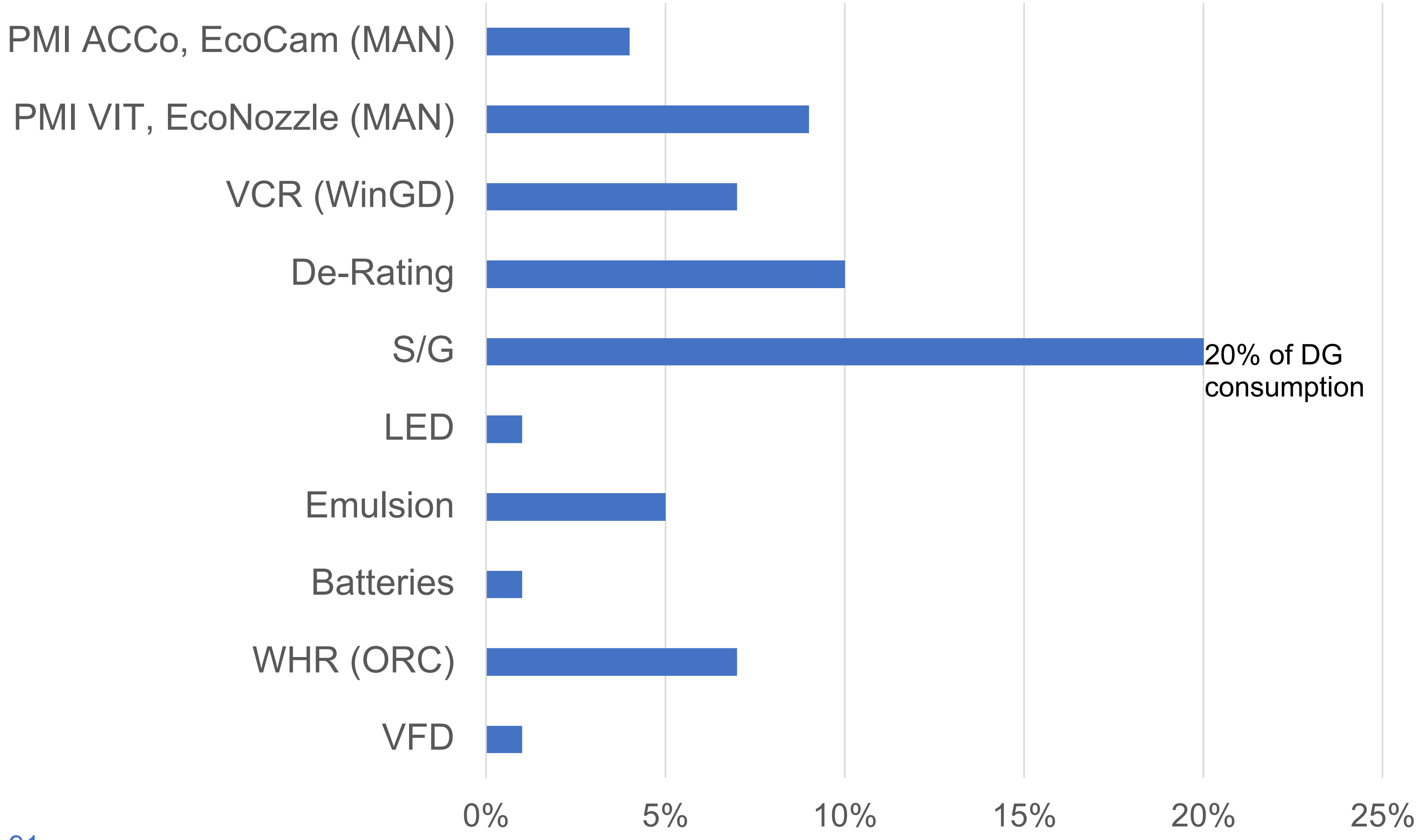
Electrical/Electronic Upgrades

- LED lighting (~**1%**)

Comparison of the energy consumption, economic, and environmental factors of the lighting systems

Lighting systems	Lamp type	System power [kW]	Electrical energy consumption [kWh/year]	Fuel consumption [ton/year]	Lighting cost [USD/year]	Exhaust emissions from lighting [ton/year]			
						CO_2	NO_x	SO_2	PM
Existing lighting	FL	16.6	119 674	27.8	9 193	75.04	1.90	1.27	0.19
	IL	6.1	5 160	1.2	396	3.24	0.08	0.05	0.01
	MFL	21.3	90 034	20.9	6 916	56.45	1.43	0.95	0.14
	Total	44.1	214 868	49.8	16 505	134.72	3.42	2.28	0.35
LED lighting	LED	17.9	100 810	23.4	7 744	63.21	1.60	1.07	0.16

Machinery Upgrades: Maximum power savings



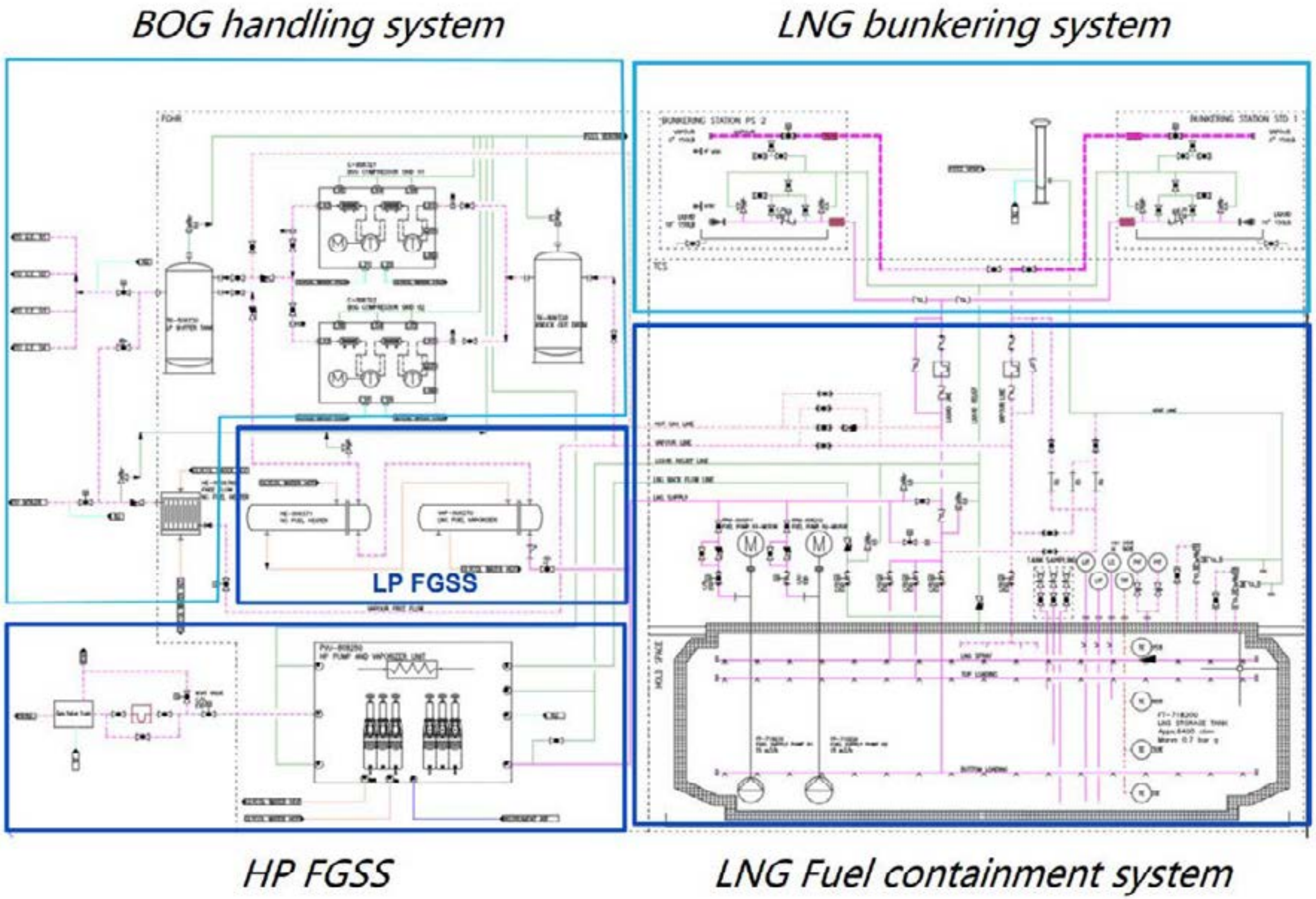
LNG Carriers : RE-Liquefaction

- Payback of abt. 4 years
- <2 mo DD & gas trials

CAPEX
11M$ - 13M$

Trend → Re-liquefaction & ALS retrofit
- All the natural BOG generated from cargo tanks is used as fuel due to low propulsion efficiency.
- The need for re-liquefaction and surplus gas management is low.

LNG Carriers : RE-Liquefaction



Content

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a go maritime initiative

Stavros Hatzigrigoris

25th April 2024, Aikaterini Laskaridis Foundation

Alternative fuels

As seen in Part 1, regulations are getting stricter with time. Older ships will not live to experience the final regulations. So, for them it is more profitable to stick to the ESD technologies (discussed so far), achieving 3% – 15% GHG reductions. In contrast newbuildings and younger ships will experience the final stage of the regulations, so for them the alternative fuels and Carbon Capture are also considered.

Best compliance investments depending on ship's age:

VESSEL AGE	GREEN SOLUTIONS	CII IMPROVEMENT	CAPEX
Under 5 Year	DF Conversion / OCCS	HIGH	HIGH
Under 10 Year	Re-liquefaction/ ALS / Rotor Sail / Shaft Generator	MEDIUM	MEDIUM
No Limit	PBCF / Pre Swirl Duct / Bulbous Bow / Propeller Retrofit / Wind Cover / VFD / LED / WHRS / MSS / Coatings	LOW - MEDIUM	LOW

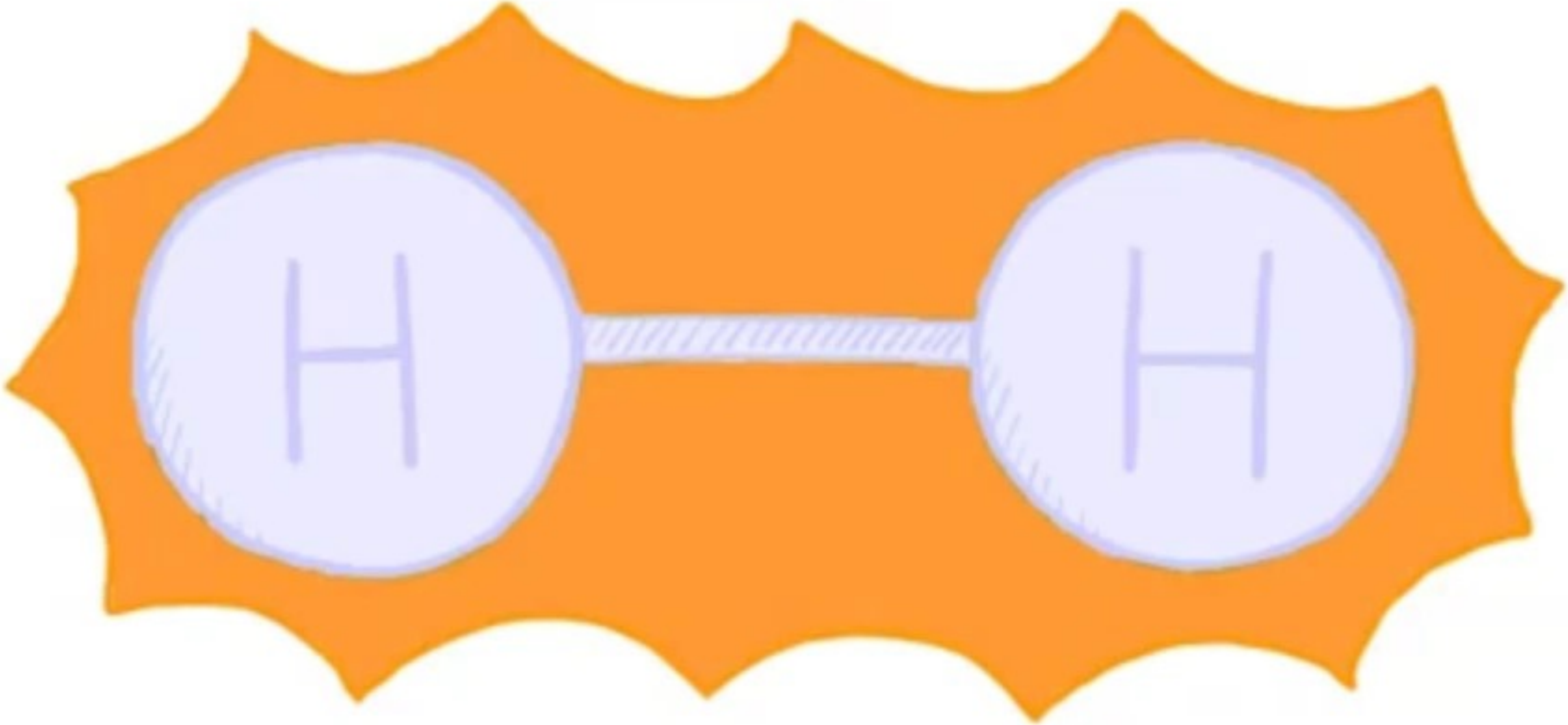
Next slides → (Under 5 Year)

Later on → (Under 10 Year, No Limit)

[HMI Green Solution]

HYDROGEN GAS = ENERGY CARRIER

used to store and move energy



FULL of POTENTIAL!

Alternative fuels: Definitions

Grey/Black/Brown fuels

Grey/Black and Brown fuels are generated from traditional fossil fuels sources with the shades normally referring to the fossil fuel feedstock which is used in the process (eg brown/black for coal and grey for natural gas). The carbon dioxide (CO_2) and any carbon monoxide (CO) generated during the process of fuel production are not recaptured.

Green fuels

Green fuels are those where the production employs electrolysis—the separation of hydrogen and oxygen molecules by applying electrical energy to water. To be a green fuel, renewable sources such as wind and solar power are used to generate the electricity for the separation process. When applied to fuels such as methanol, it normally means that the hydrogen is produced in this way and the carbon dioxide (CO_2) used has been captured from the air. For ammonia, it means the hydrogen has been produced in this way and the nitrogen used has been separated from air using renewable energy.

Yellow fuels

Yellow fuels are those where the hydrogen used is generated through electrolysis using solar power.

Alternative fuels: Definitions

- **Blue fuels**
  Blue fuels are those which use hydrogen produced from traditional fossil fuels but where the carbon dioxide (CO2) from steam reforming is captured and stored- using carbon capture and storage (CCS). Blue ammonia therefore means that the carbon generated in the production of hydrogen has been captured and stored using industrial CCS. The term blue is also used when the gases used to generate the fuel have been recycled or are reused from another industrial purpose eg blue methanol.
- **Turquoise fuels**
  Turquoise fuels are those which use hydrogen that is generated from the decomposition of methane by pyrolysis (which creates hydrogen and solid carbon) and where the electricity used in the pyrolysis is generated by renewable energy sources.
- **Pink/red/purple fuels**
  Pink fuels are those where the hydrogen used is generated through electrolysis powered by nuclear energy. Nuclear-produced hydrogen can also be referred to as purple hydrogen or red hydrogen.

White fuels

White fuels are those where hydrogen, which is naturally occurring and geological found in underground deposits, is created through fracking. There are no strategies to exploit this hydrogen at present.

Alternative fuels: Definitions

s Synthetic fuels

Synthetic fuel is a generic term applied to any manufactured fuel with the approximate composition and comparable specific energy of a natural fuel. It is primarily used to refer to carbon-based liquid or gaseous fuels manufactured, via chemical conversion processes, from a carbon source such as coal, carbon dioxide (CO2), natural gas, biogas, or biomass. This includes using established conventional fossil-based processes.

e Electrofuels (eFuels)

Electrofuels are advanced gaseous and liquid fuels normally produced from hydrogen and often captured carbon dioxide (CO2) and which use sustainable electricity as the principal power source for the generation of the fuel. The “e” refers to the method of production of the fuel.

Alternative fuels: Definitions

b **Biofuels**

Biofuels are liquid fuels produced from biomass. Biomass means the biodegradable fraction of products, waste, and residues from biological origin from agriculture, including plants, vegetables, and animal substances, from forestry and related industries, including fisheries and aquaculture, as well as the biodegradable fraction of waste, including industrial and municipal waste of biological origin. (European Parliament & Council of the European Union, 2018; Jeswani et al., 2020)

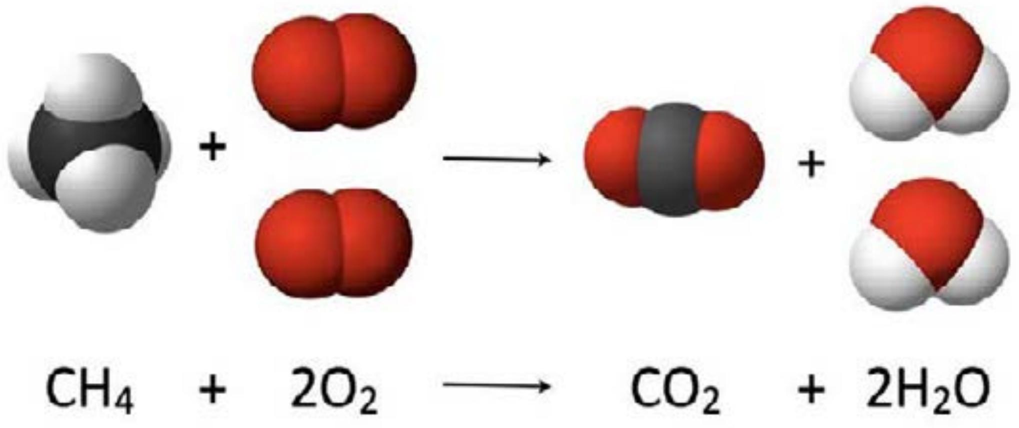
W **WCO Biofuel**

Waste cooking oil (WCO) is a food waste generated domestically and industrially as a result of cooking and frying food using edible vegetable oil. WCOs primarily consist of triglycerides, monoglycerides, diglycerides, and free fatty acids, with varying amounts typically ranging from 5 to 20% by w/w. Can serves as feedstock in the synthesis of biodiesel & biolubricant.

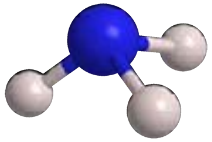
GLOSSARY OF CLIMATE CHANGE DEFINITIONS IN RELATION TO SHIPPING

Alternative fuels: Definitions

LNG: Liquefied natural gas (LNG) is a relatively mature low-carbon fuel, (predominantly methane, CH_4, with some mixture of ethane, C_2H_6). The gas extracted from underground hydrocarbon deposits contains a varying mix of hydrocarbon components, which usually includes mostly methane (CH_4), along with ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}). Because of its **carbon to hydrogen (C/H) ratio** offers a reduction in CO2 emissions of up to 20 percent compared to baseline heavy fuel oil (HFO). Reduces NOx emissions by up to 80% and almost eliminates SOx.

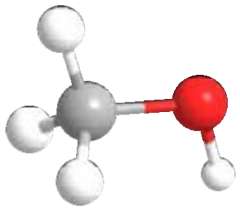


Alternative fuels: Definitions



Ammonia: Ammonia is an inorganic chemical compound of nitrogen and hydrogen with the formula NH_3. The process of making ammonia is currently not a “green” process. It is most commonly made from methane, water and air, using steam methane reforming (SMR) (to produce the hydrogen) and the Haber process. Approximately 90% of the carbon dioxide produced is from the SMR process. This process consumes a lot of energy and produces around 1.8% of global carbon dioxide emissions. Although, TtW emissions are zero:

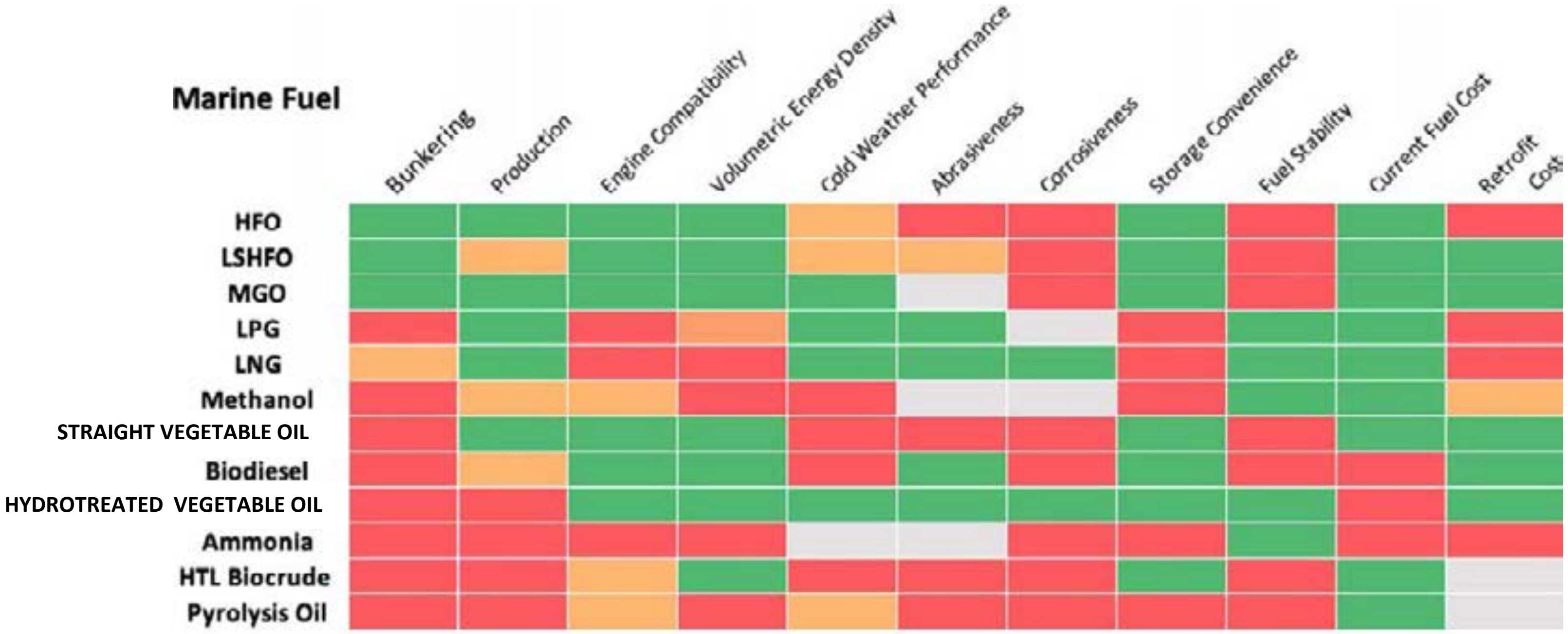
$$4\ NH_3 + 3\ O_2 \rightarrow 2\ N_2 + 6\ H_2O$$

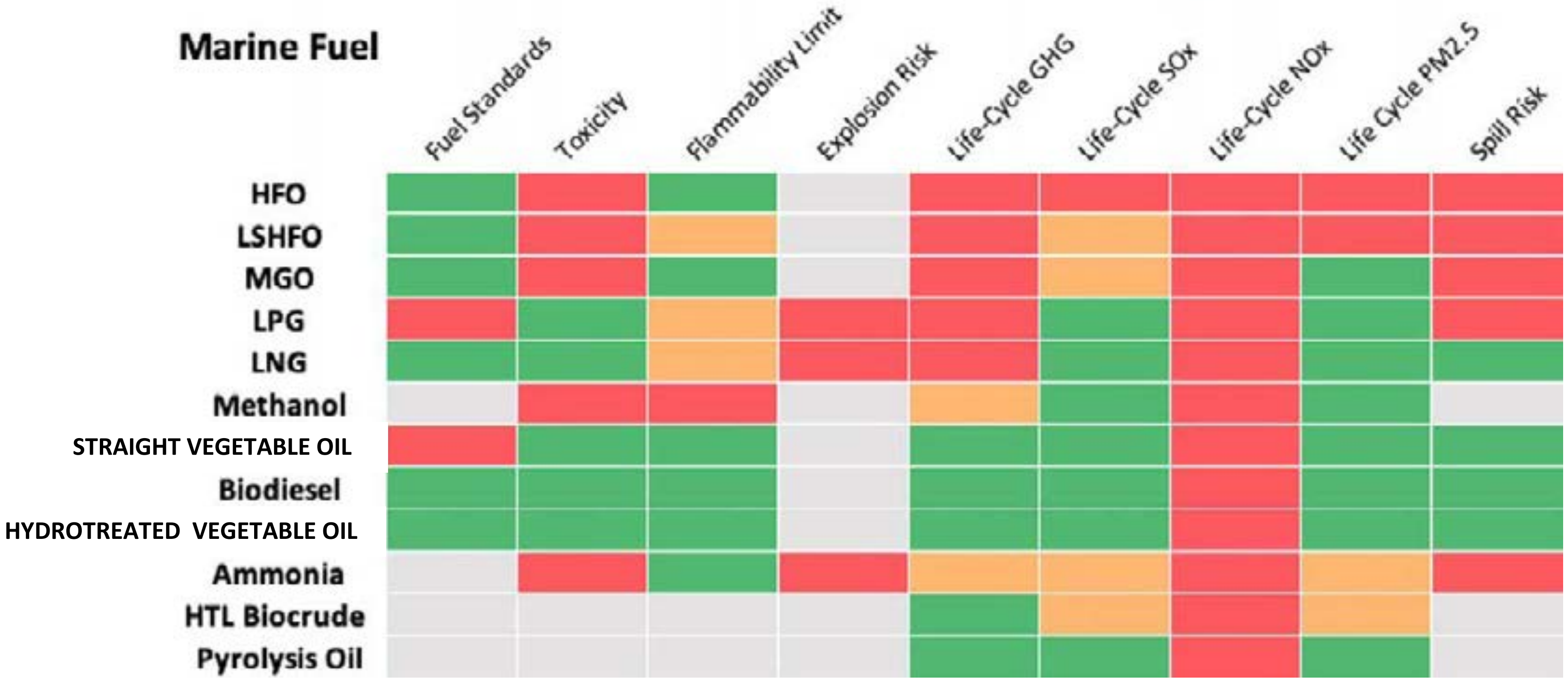


Methanol: Is the simplest aliphatic alcohol, with the chemical formula CH_3OH (abbreviated as MeOH). Methanol may be made from fossil fuels or renewable resources, in particular natural gas and coal, or biomass respectively. In the case of the latter, it can be synthesized from CO2 (carbon dioxide) and hydrogen. The vast majority of methanol produced globally is currently made with gas and coal.

Hydrogen: In 2022 less than 1% of hydrogen production was low-carbon.[1] Fossil fuels are the dominant source of hydrogen, for example by steam reforming of natural gas.[2] Other methods of hydrogen production include biomass gasification and methane pyrolysis. Methane pyrolysis and water electrolysis can use any source of electricity including renewable energy. Underground hydrogen is extracted. Although, TtW emissions are zero:

$$2\ H_2 + O_2 \rightarrow 2\ H_2O$$





Alternative fuels

- **p** **Pyrolysis oil**, (**bio-crude**) is a synthetic fuel. It is obtained by heating dried biomass without oxygen in a reactor at a temperature of about 500 °C with subsequent cooling, separation from the aqueous phase and other processes. High oxygen content, non-volatility, corrosiveness, partial miscibility with fossil fuels, thermal instability, tendency to polymerize when exposed to air.

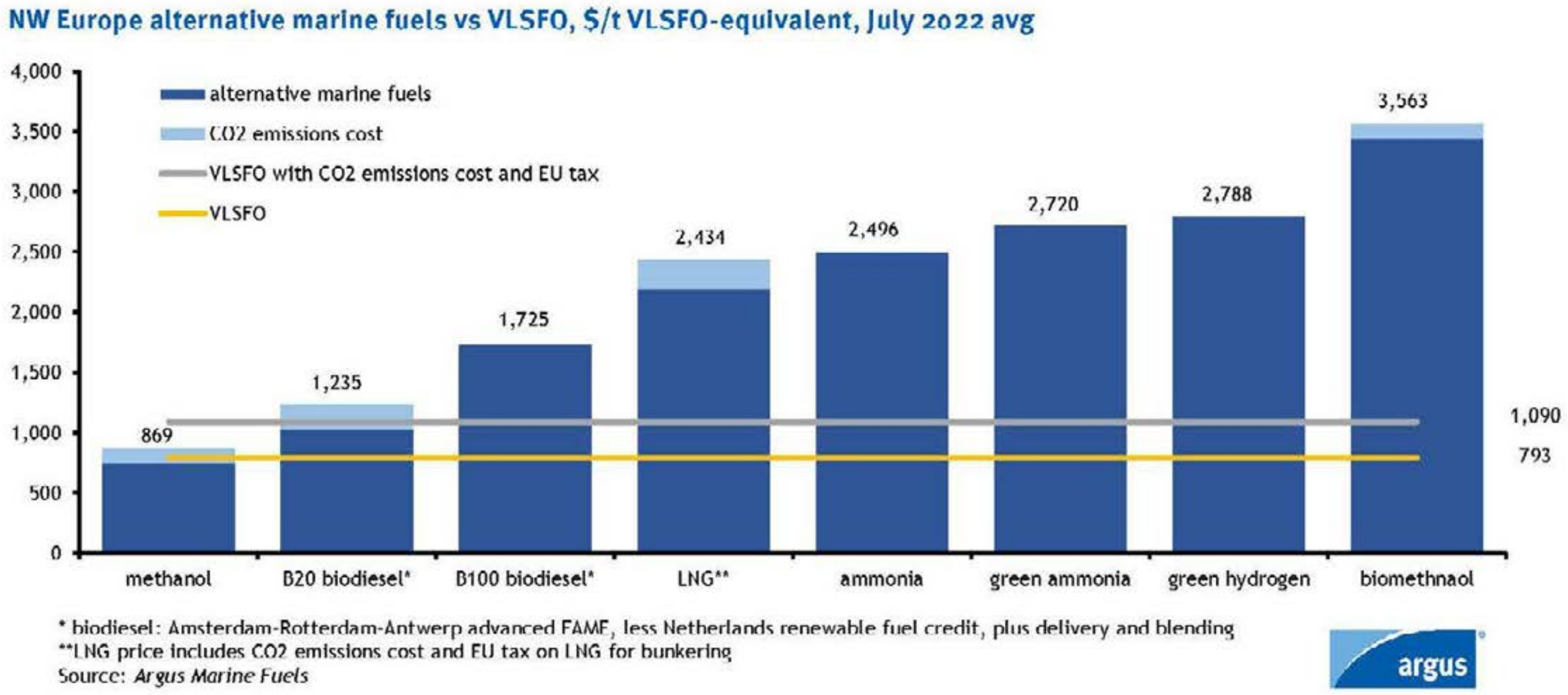
- **HV** **Hydrotreated vegetable oil** (**HVO**) is a biofuel made by the hydrocracking or hydrogenation of vegetable oil.

- **v** Vegetable oil can be used as an alternative fuel in diesel engines and in heating oil burners. When vegetable oil is used directly as a fuel, in either modified or unmodified equipment, it is referred to as **straight vegetable oil** (**SVO**) or **pure plant oil** (**PPO**).

Challenges and opportunities for alternative fuels in the maritime sector

Alternative fuels: Price

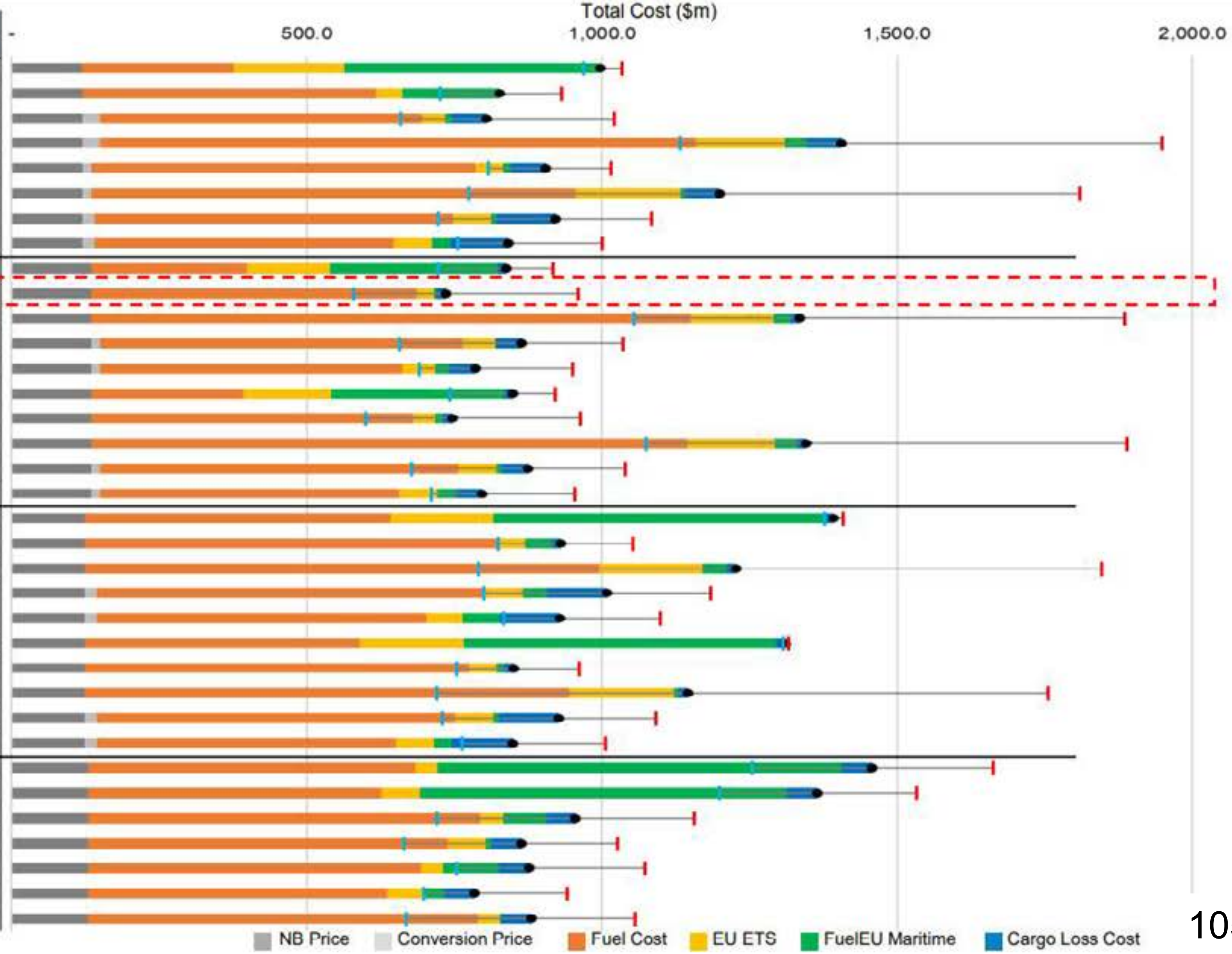
$ / ton. of VLSFO equivalent



Total cost = Price + Penalties

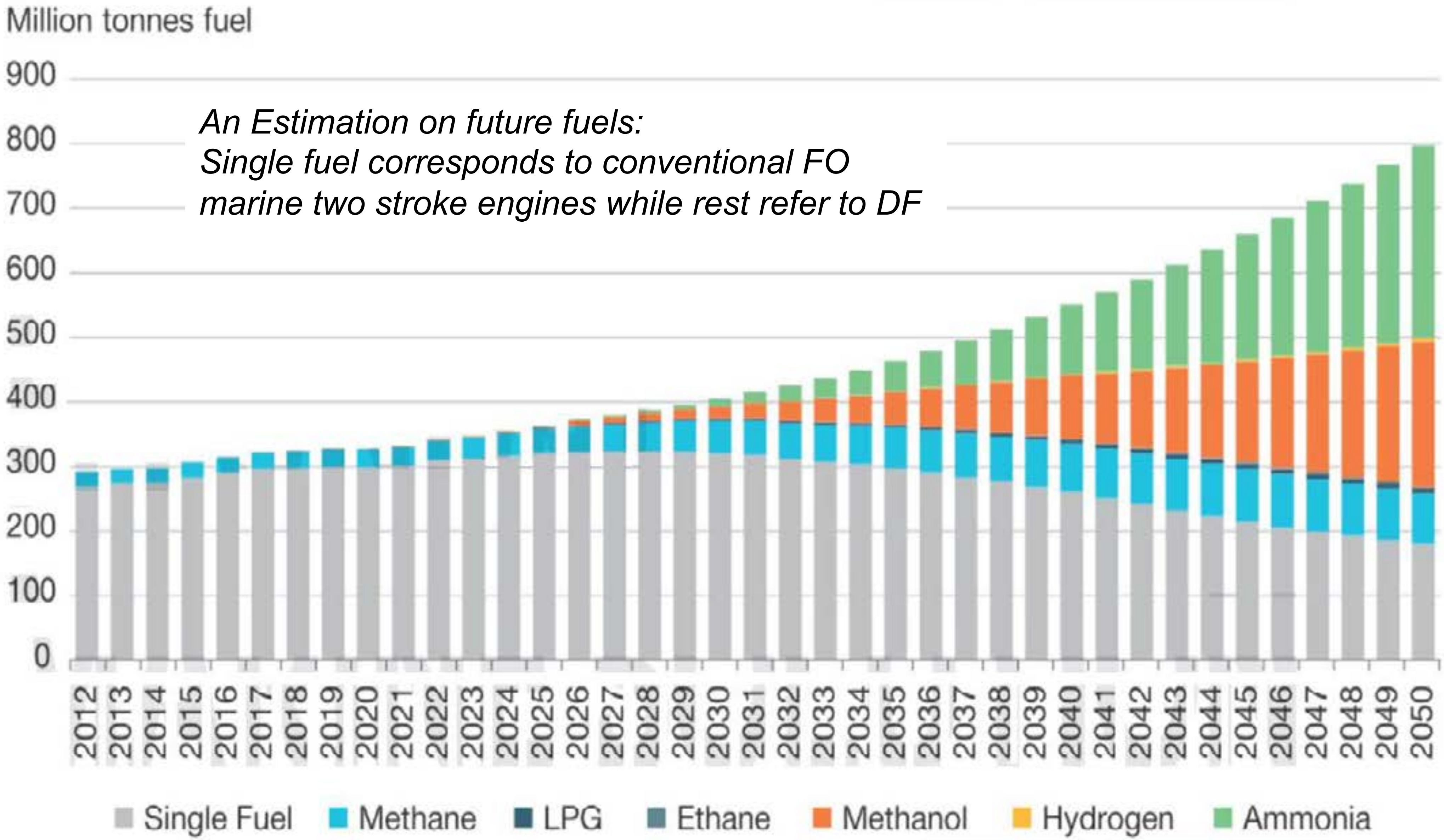
Source: ABS (Jan 2024)

Case No.	Engine Type	Fuel 2025~2029	Fuel 2030~2050	Total Cost ($m)	Rank
1	Conventional	HFO	HFO	997	24
2	Conventional	HFO	Bio-diesel	827	7
3	Conventional	HFO	Bio-LNG	805	6
4	Conventional	HFO	e-LNG	1405	34
5	Conventional	HFO	Bio-Methanol	905	18
6	Conventional	HFO	e-Methanol	1200	27
7	Conventional	HFO	e-Ammonia	921	19
8	Conventional	HFO	Blue-Ammonia	842	9
9	LNG DF	LNG	LNG	838	8
10	LNG DF	LNG	Bio-LNG	735	1
11	LNG DF	LNG	e-LNG	1335	30
12	LNG DF	LNG	e-Ammonia	865	14
13	LNG DF	LNG	Blue-Ammonia	785	4
14	LNG DF	HFO	LNG	849	11
15	LNG DF	HFO	Bio-LNG	746	2
16	LNG DF	HFO	e-LNG	1346	31
17	LNG DF	HFO	e-Ammonia	876	15
18	LNG DF	HFO	Blue-Ammonia	796	5
19	Methanol DF	Methanol	Methanol	1392	33
20	Methanol DF	Methanol	Bio-Methanol	932	22
21	Methanol DF	Methanol	e-Methanol	1227	28
22	Methanol DF	Methanol	e-Ammonia	1009	25
23	Methanol DF	Methanol	Blue-Ammonia	930	21
24	Methanol DF	HFO	Methanol	1310	29
25	Methanol DF	HFO	Bio-Methanol	850	12
26	Methanol DF	HFO	e-Methanol	1145	26
27	Methanol DF	HFO	e-Ammonia	928	20
28	Methanol DF	HFO	Blue-Ammonia	848	10
29	Ammonia DF	Ammonia	Ammonia	1457	35
30	Ammonia DF	HFO	Ammonia	1365	32
31	Ammonia DF	Ammonia	e-Ammonia	956	23
32	Ammonia DF	HFO	e-Ammonia	863	13
33	Ammonia DF	Ammonia	Blue-Ammonia	876	16
34	Ammonia DF	HFO	Blue-Ammonia	784	3
35	Ammonia DF	Blue-Ammonia	e-Ammonia	880	17



Conversion in 2030

Alternative fuels: A guess



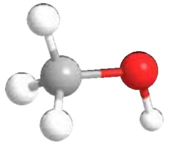
Engine Technology readiness

Alternative fuel / DF Combustion Engines

Key issues to be solved:

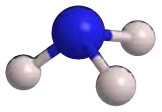
LNG: in service

- Methane slip



Methanol: in service since 2016

- No substantial WtW reduction if it is grey methanol



Ammonia: still in research level.

Expected NB engines ~ 2025
Expected retrofits ~ 2026-27

- **Banned from certain Ports!**
- Safety aspects
- Regulatory gaps
- No IMO requirements (only class)
- N20 emissions (Ammonia slip)
- Crew training & maintenance

Hydrogen: still in research level

7 Mar 2024: World-First Hydrogen Test! on a marine two-stroke engine

- Safety aspects
- Regulatory gaps
- No IMO requirements (class recently)
- Unburn H2 → GHG (Hydrogen slip)
- Crew training & maintenance

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2022-01-01T19:00:00Z
ne emissions [kg/cell]
With around 90% of world trade being transported by sea,
1.1
5.1
11
21
34
51
70
93
120
149
183
219

LNG: Methane slip

Engine load ↓
MS rate ↑

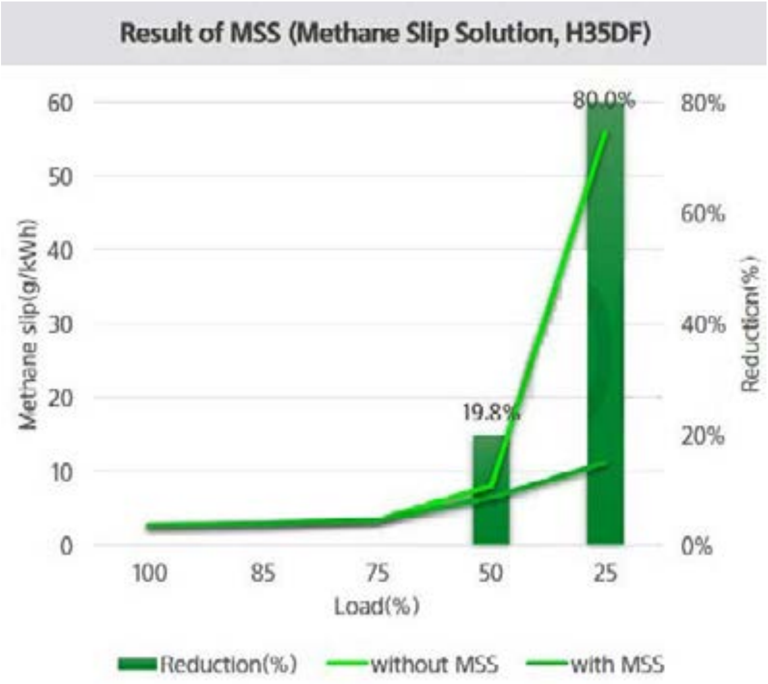
EU ETS included by 2026

Methane is an extremely powerful GHG.

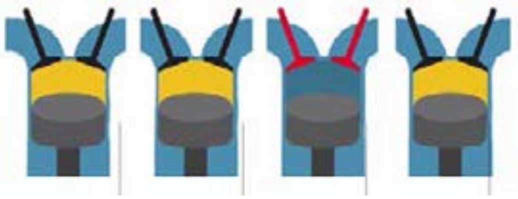
Methane slip (MS) can potentially offset the climate benefits of LNG if not addressed.

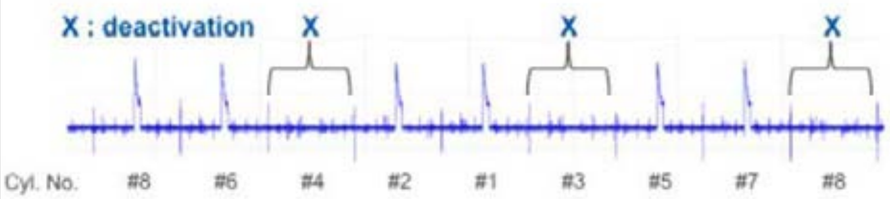
LNG contains 90% methane

Some of the methane remains unburned and escapes into the atmosphere because of flame quenching and scavenging losses



Cylinder Cut-Off (CCO)



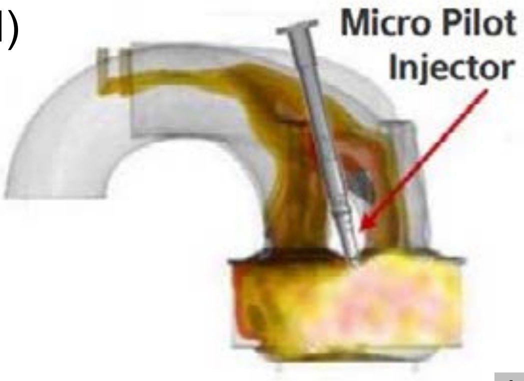


Possible solutions (CCO need no physical installations) :

Engine Gas Recirculation (EGR)

Reduction methane slip by ~ 45 %

Multi Pilot Injection (MPI)

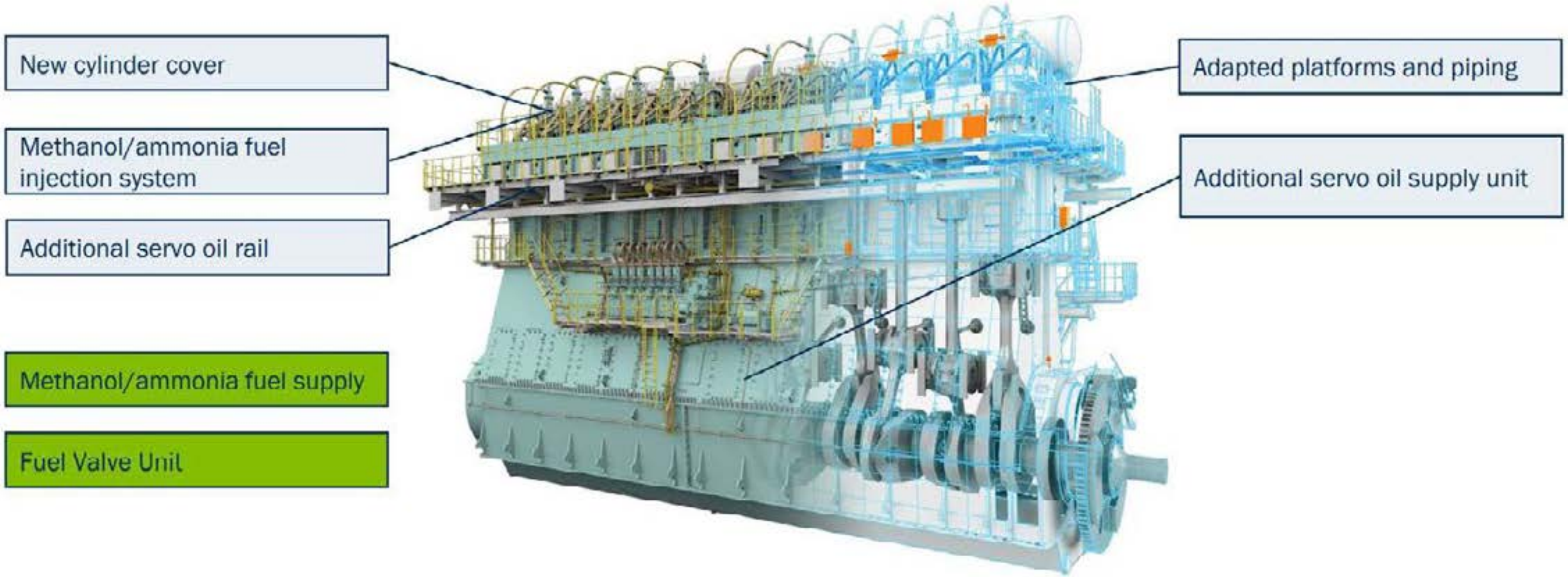


Dual Fuel (DF) Engines vs Conventional

<u>Concept</u>: conventional diesel engine basis with additional methanol/ ammonia injection system

Ex. below WinGD DF engine differences from conventional:

What changes when burning alternative fuels?
In order to burn alternative fuels (LNG, LPG, MeOH, Ammonia) for marine propulsion, a conventional diesel engine can be used with modifications in the **fuel injection and supply system.**

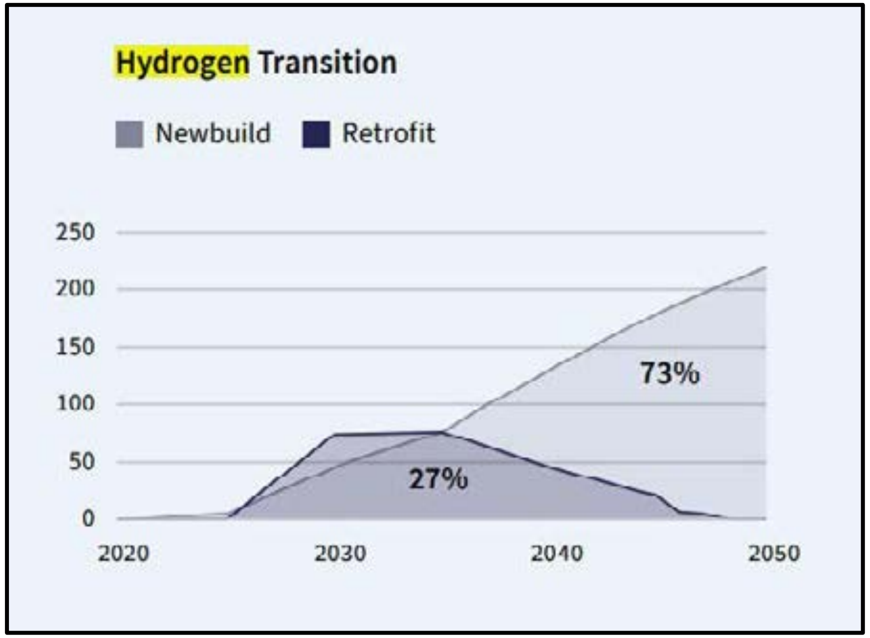


Hydrogen Engines

7 Mar 2024:
World-First Hydrogen Test!
on a marine two-stroke engine

ISSUES TO OVERCOME…

- Safety aspects
- Regulatory gaps
- No IMO requirements (class recently)
- Unburn H2 → GHG (Hydrogen slip)
- Crew training & maintenance



Fuel Cells

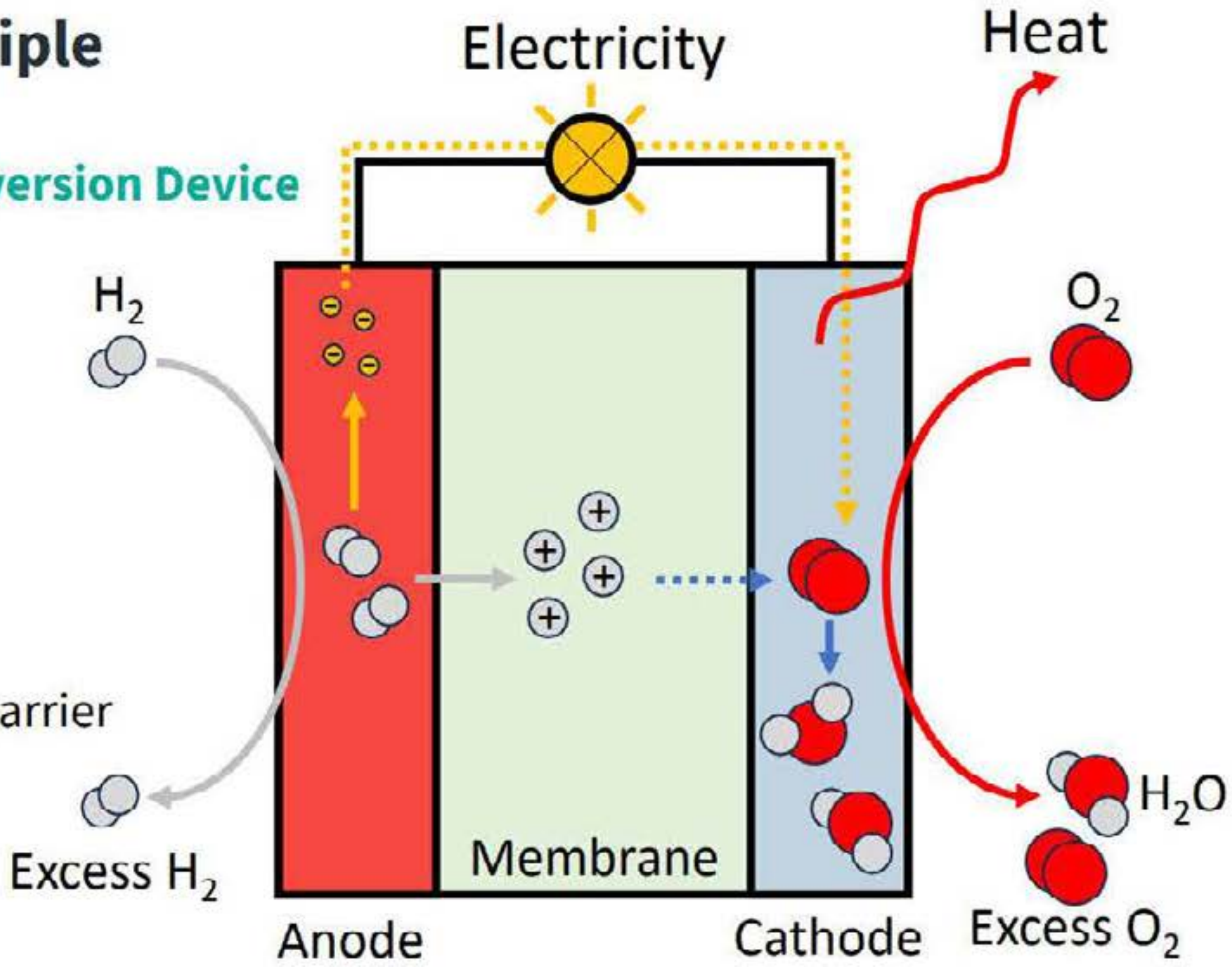
Fuel Cell Basics: Working Principle

Fuel Cell = Electrochemical Energy Conversion Device

- Input: Fuel and oxidant
- Output: Electricity, water & heat

Membrane Electrode Assembly (MEA)

- Anode → Hydrogen oxidation
- Cathode → Oxygen reduction
- Membrane → Proton transport & gas barrier



Fuel Cells

Fuel Cell Type	Common Electrolyte	Operating Temperature	Typical Stack Size	Electrical Efficiency (LHV)	Applications	Advantages	Challenges
Polymer Electrolyte Membrane (PEM)	Perfluorosulfonic acid	<120°C	<1 kW - 100 kW	60% direct H_2;[i] 40% reformed fuel[ii]	• Backup power • Portable power • Distributed generation • Transportation • Specialty vehicles	• Solid electrolyte reduces corrosion & electrolyte management problems • Low temperature • Quick start-up and load following	• Expensive catalysts • Sensitive to fuel impurities
Alkaline (AFC)	Aqueous potassium hydroxide soaked in a porous matrix, or alkaline polymer membrane	<100°C	1 - 100 kW	60%[iii]	• Military • Space • Backup power • Transportation	• Wider range of stable materials allows lower cost components • Low temperature • Quick start-up	• Sensitive to CO_2 in fuel and air • Electrolyte management (aqueous) • Electrolyte conductivity (polymer)
Phosphoric Acid (PAFC)	Phosphoric acid soaked in a porous matrix or imbibed in a polymer membrane	150 - 200°C	5 - 400 kW, 100 kW module (liquid PAFC); <10 kW (polymer membrane)	40%[iv]	• Distributed generation	• Suitable for CHP • Increased tolerance to fuel impurities	• Expensive catalysts • Long start-up time • Sulfur sensitivity
Molten Carbonate (MCFC)	Molten lithium, sodium, and/or potassium carbonates, soaked in a porous matrix	600 - 700°C	300 kW - 3 MW, 300 kW module	50%[v]	• Electric utility • Distributed generation	• High efficiency • Fuel flexibility • Suitable for CHP • Hybrid/gas turbine cycle	• High temperature corrosion and breakdown of cell components • Long start-up time • Low power density
Solid Oxide (SOFC)	Yttria stabilized zirconia	500 - 1000°C	1 kW - 2 MW	60%[vi]	• Auxiliary power • Electric utility • Distributed generation	• High efficiency • Fuel flexibility • Solid electrolyte • Suitable for CHP • Hybrid/gas turbine cycle	• High temperature corrosion and breakdown of cell components • Long start-up time • Limited number of shutdowns

Commercially successful fuel cell technologies

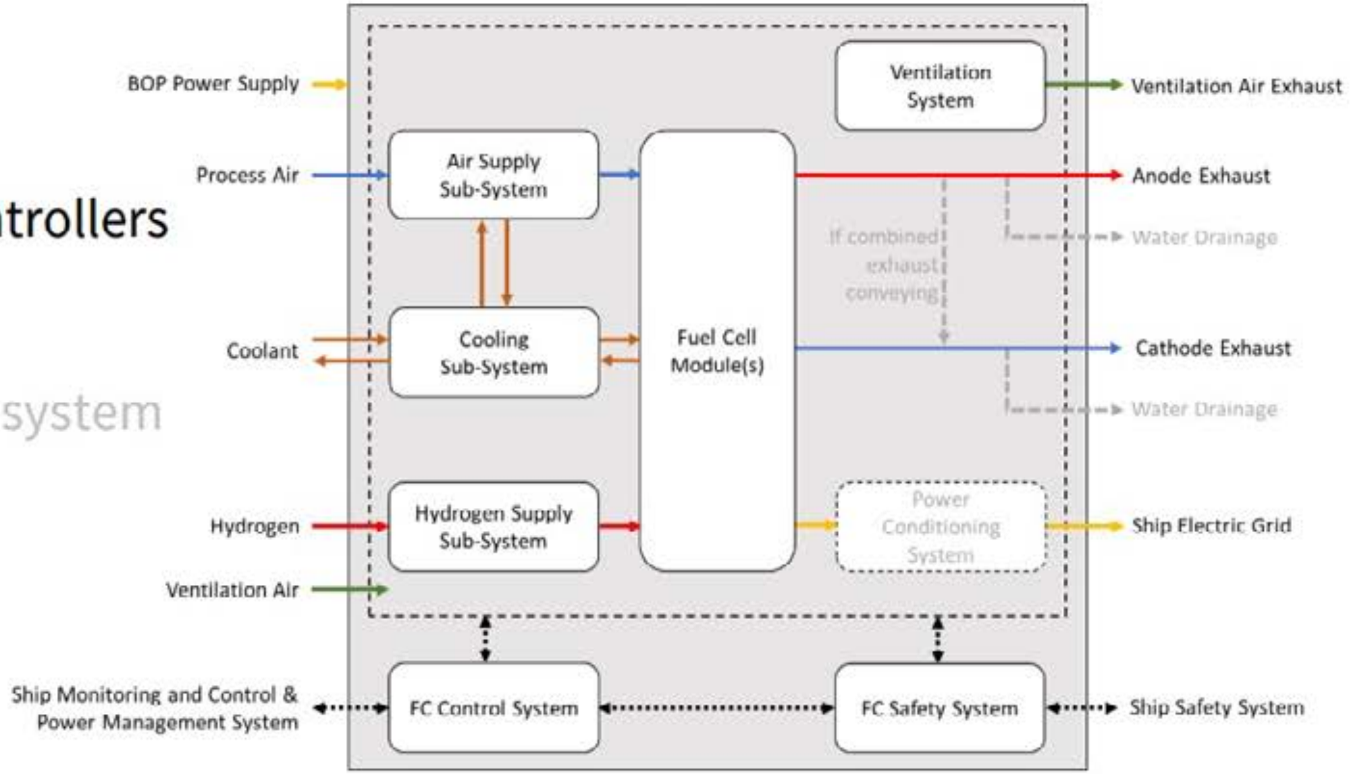
Fuel Cells

Marine Fuel Cell Systems

Official term in the rules: Fuel Cell Power System

- Self-controlled unit, containing
  - FC module(s)
  - BOP sub-systems
  - System & Safety controllers
  - Ventilation system
  - Power conditioning system
- Power Range
  - 100 – 500 kW

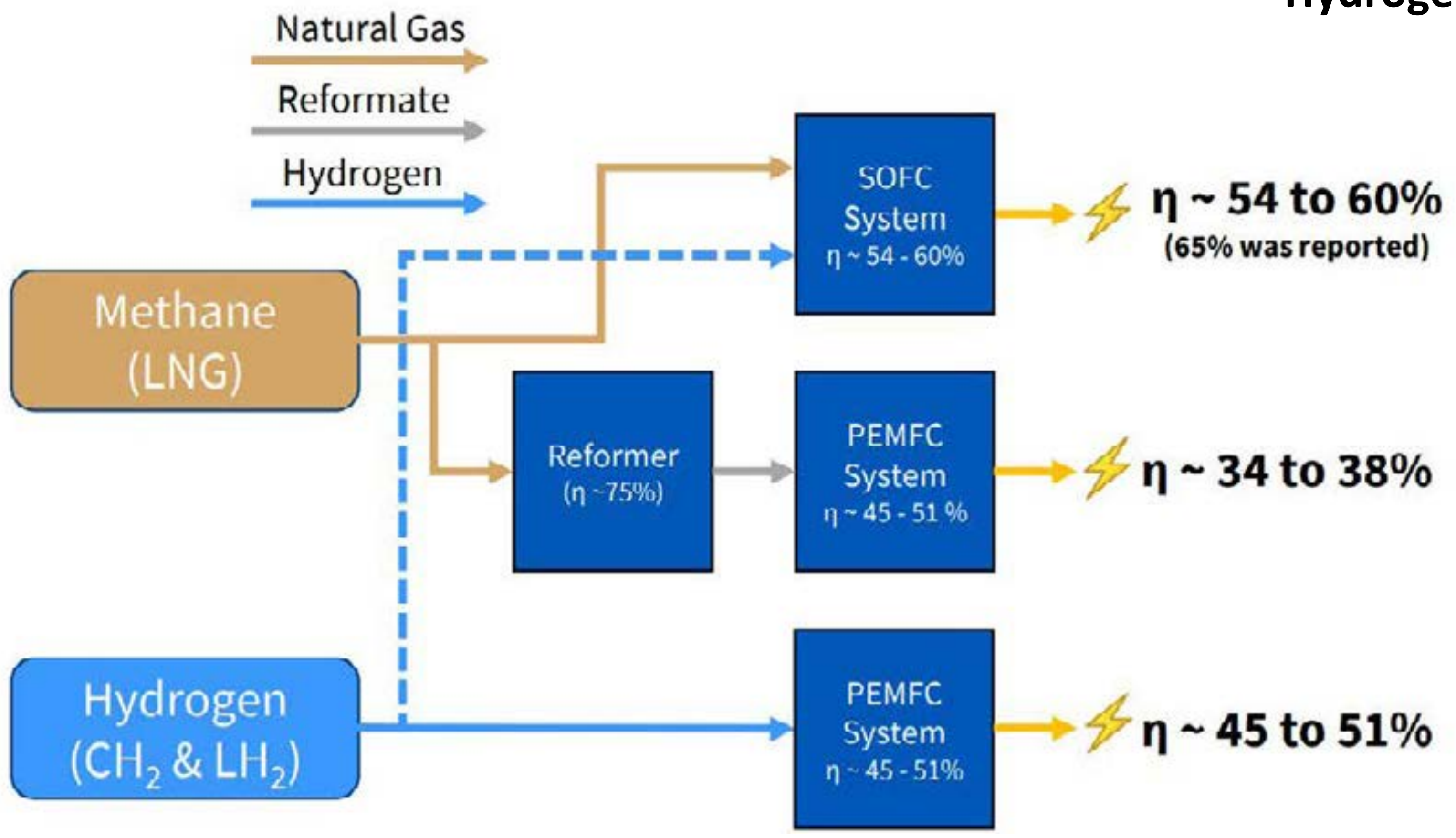
Example: Power Cell's 200kW Marine System[1]



Fuel cell power system schematic including sub-systems

Fuel Cells

Fueling Options



Main Hazard:

Hydrogen leakage → high risk for crew and ship

Major fuel options for fuel cells:

- Hydrogen
- Methane
- Methanol
- Ammonia

High efficiencies:

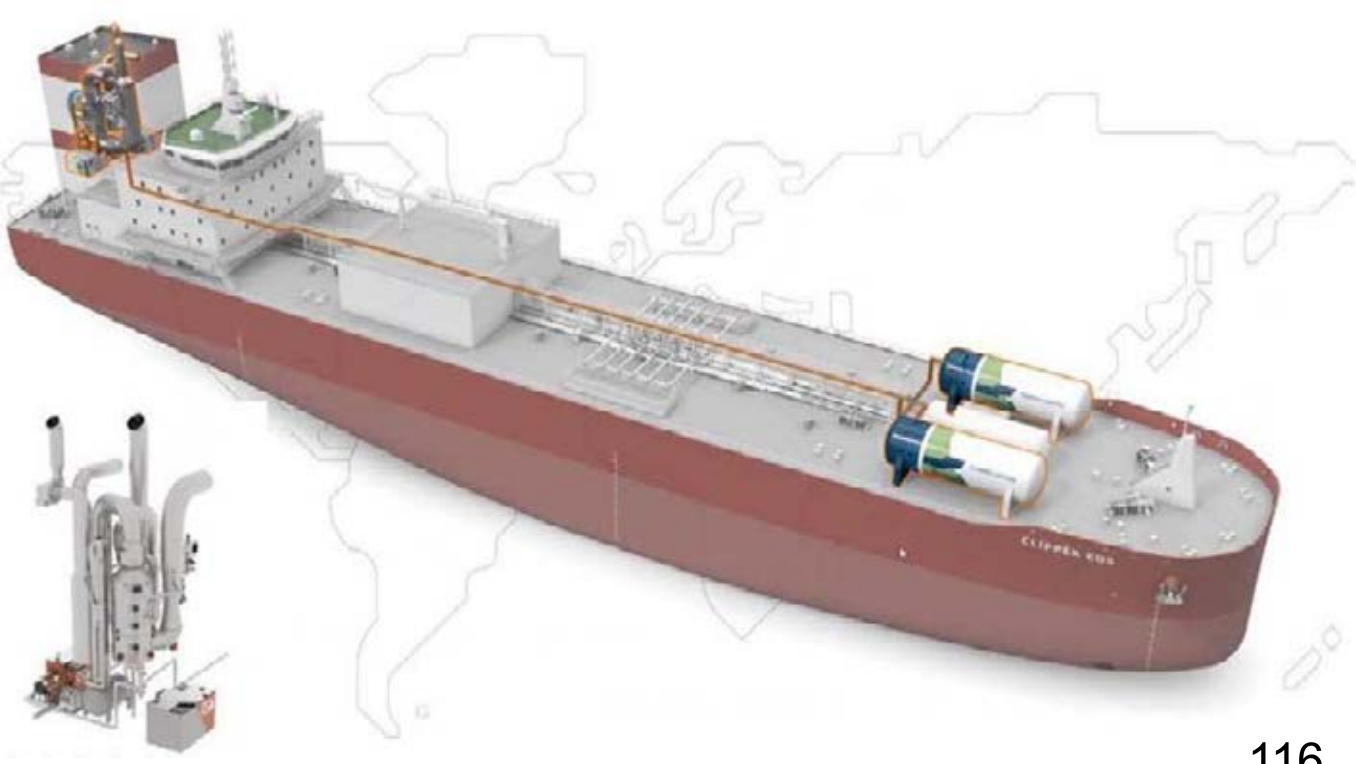
- PEMFC: 34-51%
- SOFC: 54-60%

Onboard Carbon Capture Sys (OCCS)

The **key challenge** for CCS onboard lies with Storage and onward Management of CO_2. Other challenges are

- Energy demand
- Solvent or other process means availability, storage management
- Purity of exhaust gas treated – Sensitivity to some impurities may be very challenging e.g., Minimal concentration of SOx (even ULSFO) maybe a barrier.
- Purity of CO_2 produced – CO_2 global value chain may have strict standards on CO_2 quality, greater purity requirement may apply

Still in research level…
High potential: Research prototypes up to 70-85% capture rates



Onboard Carbon Capture Sys (OCCS)

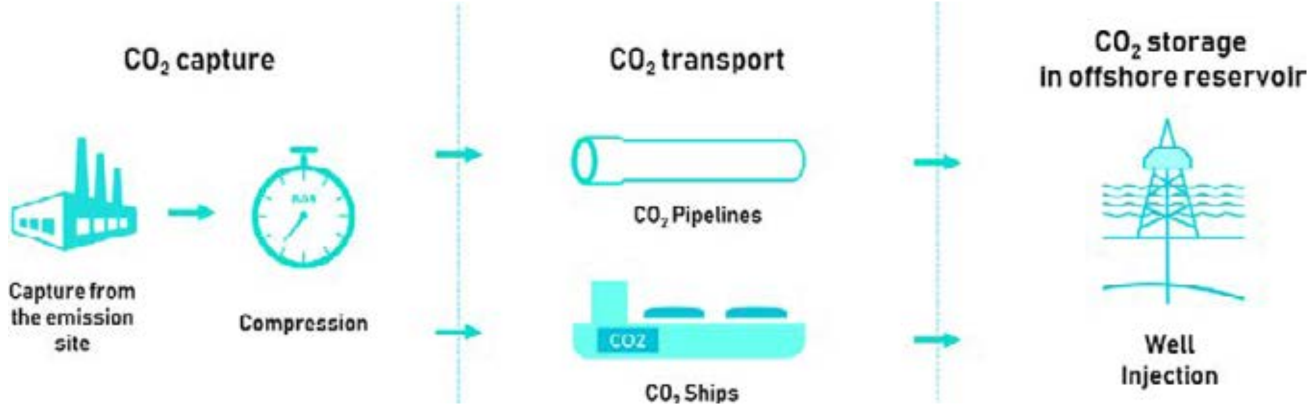
KEY POINTS

➢ Based on the volume/mass of CO2 produced onboard but also cost and energy demand, partial capture seems more feasible (starting from a 25% rate of absorption)

➢ Other storage options include transformation of CO2 to a solid by-product or even disposal at sea (3rd option seems quite remote and immature)

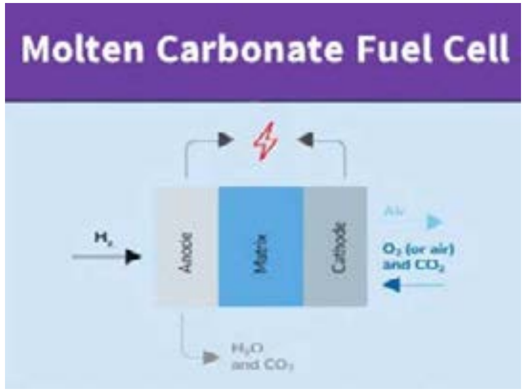
➢ LNG as fuel presents > 30% efficiency in terms of volume/mass of CO2 produced

➢ Based on volumes of CO2, a **global value chain of CO2** with many collection points is a key prerequisite



CO2 to become a traded commodity

Onboard Carbon Capture Sys (OCCS)



Chemical Adsorption: CO2 in Exhaust absorbed by chemical solvent

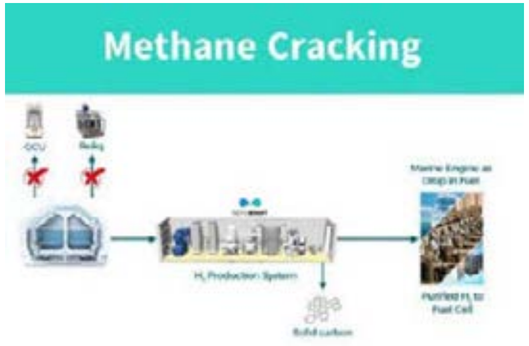
Calcium Looping: The process consists of two main cycles: an air contractor (CO2 capture cycle) and a sorbent regeneration cycle

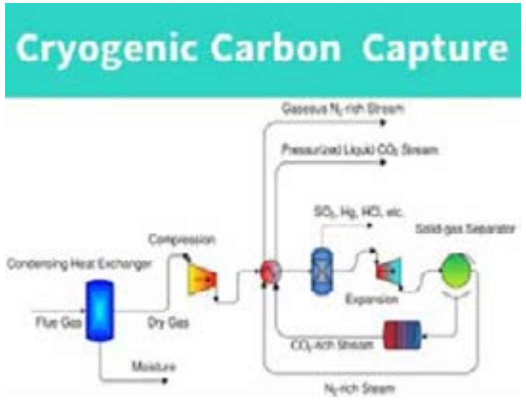
Membrane Technology: Selective permeation of gases in exhaust through membrane

Cryogenic Carbon Capture: CO2 in exhaust cryogenically cooled with other components separated

Molten Carbonate Fuel Cells: MCFC can operate as a CO2 separator and concentrator while generating power

Pre–Combustion Carbon Capture: The process primarily focuses on methane cracking , capture of carbon in solid form and use of the deriving hydrogen in combustion blending or fuel cells





Onboard Carbon Capture Sys (OCCS)

World's First Full-Scale OCCS Retrofit → Feb 2024

Seatrium will install a seven-megawatt capacity carbon capture system from Wärtsilä aboard the ethylene carrier *Clipper Eris*, owned by gas carrier and petchem specialist Solvang ASA.

The capture system will use amine scrubber technology to pull about 70% of the CO_2 out of the exhaust gas from the main engine. This CO_2 stream will be chilled, liquefied and stored on board the vessel for later offloading.

Nuclear propulsion: NS *Savannah*

Hurdles to be overcome:

- IMO resolution to allow nuclear ships to trade in port
- Proof of concept (technical and safety issues)
- Commercial employment of the ships
- Leasing of the reactor
- Lifetime supply of nuclear fuel
- Exchange of the reactor enrichment of the fuel when depleted
- Provision of nuclear reactor operators by the reactor manufacturers
- Back to steam for the engineers of the ships
- Control of operating costs

Small Modular Reactors (SMR)

Copenhagen Atomic developed from 4 to 78 persons in 8 year.

Thorium based Molten salt reactor expected test start during 2025

1

TO WATCH

Green propulsion technology and digitalization (one following the other) will lead to more expensive and complicated ships, making shipping, an already high-risk business, even more complex. As a result:

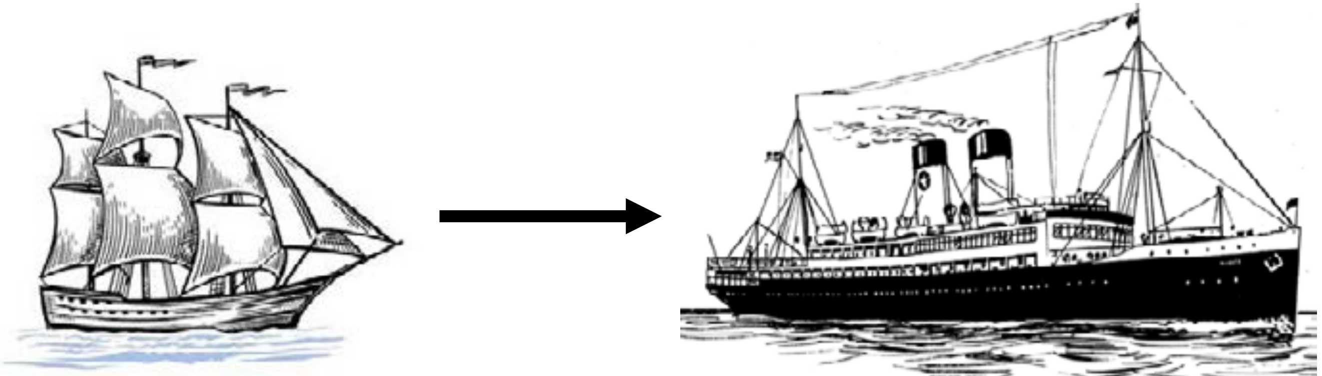
1) Ships will become more expensive to purchase and operate. This might affect traditional ship investing and ship owning as we know it to date. We might see new-type owners, alternative ship financing and management schemes.

2) Crew and shore personnel competency will be a challenge. The next generation of officers, naval architects, marine engineers and the management staff will have to deal with a completely different landscape compared to the past generations. Universities and marine academies will probably need to update their curriculums.

TO WATCH

During the transition period from sails to steam, Victor Hugo in his "Toilers of the Sea" (1866) wrote:

> *"Οι σοφοί απέρριψαν τα ατμοπλοία ως αδύνατα. Οι ιερείς τα καταδίκασαν ως ασεβή. Η επιστήμη τα καταδίκασε και η θρησκεία τα εγκατέλειψε στην απαξίωση. Ο Φούλτον θεωρήθηκε νέα μορφή του Λούσιφερ. Οι απλοί άνθρωποι στις ακτές και στα χωριά επιβεβαίωσαν τις προκαταλήψεις τους ανησυχώντας για το παράξενο αυτό θέαμα."*



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Thank you, questions?

Stavros Hatzigrigoris

25th April 2024, Aikaterini Laskaridis Foundation

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APPENDIX

Stavros Hatzigrigoris

25th April 2024, Aikaterini Laskaridis Foundation

Appendix 1: *Generic Rules and Regulations*

Rules and Regulations

The Vessel shall be registered in a Port of Greece and shall comply with the following Rules and Regulations:

(a) Maritime Rules and Regulations of the country of registry
(b) Maritime Rules and Regulations of the loading and discharging ports
(c) International Convention on Load Lines, 1966 with the Protocol of 1988 up to Amendment 2021
(d) International Convention for the Safety of Life at Sea, 1974 with the Protocol of 1978/1988 and Amendments up to 2020 including International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC-code), International Code for the Security of Ships and Port Facilities (ISPS Code) and International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code)
(e) International Life-Saving Appliance (LSA) Code, 2017
(f) International Code for Fire Safety Systems, 2015
(g) International Code on Intact Stability, 2008 with the Amendments up to 2020
(h) International Convention for the Prevention of Pollution from Ships, 1973 (Annex I, IV, V & VI), as modified by the Protocol 1978/1997 and Amendments up to 2020 (herein called "MARPOL 73/78")
(i) Convention on the International Regulations for Preventing Collisions at Sea, 1972 with the Amendments up to 2013
(j) International Convention on Tonnage Measurement of Ships, 1969
(k) International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001
(l) International Telecommunication Union (ITU) Radio Regulation, 2020
(m) Rules of Navigation of the Suez Canal Authority, including Regulations for the Measurement of Tonnage
(n) Rules and Regulations of USCG for Foreign Vessels Operating in the Navigable Waters of the United States (CFR title 33 - Navigation and Navigable Waters, Part 155, 157, 159 and 164, CFR title 46 – Shipping, Part 154 (except Alaska) without Certificate nor Inspection), with the Amendments up to 2022 (Subpart:32.53, 34.05, 35.01-1,35.30, 35.35 and Part 39 without Certificate nor Inspection)
(o) Regulation of Canadian Department of Transport for Foreign Flag vessels
(p) Regulations for protection against accidents of workers employed in loading and unloading of ships in Canada
(q) Maritime Labour Convention 2006, (MLC 2006) with Amendments up to 2016, Title 3, Regulation Standard A 3.1
(r) ILO Convention 133: concerning crew accommodation on board ship 1970, as revised in 2000
(s) IACS Unified Requirements for New building which has been formal published and in force at the date of signing contract
(t) ILO Codes of Practice, Safety and Health in Dockwork, 1976 as amended in 1979.
(u) International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009
(v) Regulation (EU) No 1257/2013 of the European Parliament and of the Council of 20 November 2013 on ship recycling and amending Regulation (EC) No 1013/2006 and Directive 2009/16/EC (Text with EEA relevance)
(w) Rules and Regulations Governing Navigation of the Panama Canal and Adjacent Waters and Rules for the Measurement (Panama Canal Universal Measurement System) of Vessels (OP NOTICE TO SHIPPING NO N-1-2021)
(x) International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004
(y) Australian and New Zealand Rules for Seagoing Vessels Part 32, No. 12 of 1986 and Guidelines of waterside Worker's Federation of Australia
(z) ILO Convention 92: Accommodation of Crews Convention, 1949
(aa) In compliance with Rules and Regulations which are in force at the date of signing the contract and as ratified and coming into force before delivery as per "Future IMO legislation" issued by LR dated December 2021

Various Regulations and Standards

(a) Radiocommunications and Navigational Equipment (2020 Edition)
(b) SIGTTO/OCIMF Recommendations for Liquefied Gas Carrier Manifolds 2018
(c) SIGTTO Guidelines for the Alleviation of Excessive Surge Pressures on ESD, 2018
(d) SIGTTO Emergency Shutdown Arrangements & Linked Ship/Shore Systems for Liquefied Gas Carrier, 2009
(e) SIGTTO Recommendations for the Installation of Cargo Strainers, 1992
(f) SIGTTO Recommendations for Relief Valves on Gas Carriers, 2020
(g) SIGTTO Liquefied Gas Handling Principles on Ships and in Terminals, 2016
(h) SIGTTO Guide for Purchasing High Modulus Synthetic Fibre Mooring Lines, 2014
(i) SIGTTO LNG Marine Loading Arms and Manifold Draining, Purging and Disconnection Procedures 2017
(j) SIGTTO Thermowells in LNG Carrier Liquid Lines, 2011
(k) SIGTTO The selection and Testing of Valves for LNG applications, 2008
(l) SIGTTO Guidelines for Automatic Cargo Tank Overfill Protection Aboard Gas Carriers, 1993
(m) SIGTTO, Report of a Working Group on Liquefied Gas Sampling Procedures, 1988 (Recommendations 1, Standard for sampling connection fittings only)
(n) OCIMF Guidelines and Recommendations for the Safe Mooring of Large Ships at Piers and Sea Islands, 1994 (except special conditions of the intended terminals)
(o) OCIMF Recommendations for ship's fittings for use with tugs, 2002
(p) OCIMF Health Safety and Environment at New-Building and Repair Shipyards and During Factory Acceptance Testing, 2003
(q) OCIMF Anchoring Systems and Procedures, 2010
(r) OCIMF Prevention of Oil Spillages through Pumproom Sea Valves, 1991
(s) OCIMF An Information Paper on Pumproom Safety, 1995
- Capacity & outreach
- Crane shall have local control only without ship side control
- Basket & safety device for personnel lifting shall be of Buyer's supply

(t) OCIMF Information paper on Pump room Safety, 1995 (Reprinted) (Ch.3 Recommendations for Equipment Fittings – New Ships)

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(u) OCIMF, Ship's Inspection Report Program (SIRE), 7th Edition 2019
(v) OCIMF Effective mooring 2019
(w) OCIMF Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases, 2013 (Fixed fittings only for STBL)
(x) OCIMF - Recommendations for Oil and Chemical Tanker Manifolds and Associated Equipment, 1st Edition, 2017 (except ESD)
(y) OCIMF - Recommendations for Equipment Employed in the Bow Mooring of Conventional Tankers at Single Point Moorings, 4th Edition, 2007
(z) OCIMF - Guidelines for Offshore Tanker Operations, 1st Edition 2018 (for Single Point Moorings only)
(aa) OCIMF - Mooring Equipment Guidelines, 4th Edition, 2018 (Compliance with the Guidelines shall be as specified in Group 4 of the Specifications)
(bb) OCIMF, Recommendations for the Tagging/Labelling, Testing and Maintenance, Documentation/Certification for Ship's lifting Equipment, May 2005, for Ch. 4 Tagging and Labelling and Ch. 6 Certification only (For testing and certification)
(cc) ICS Guide to Helicopter/Ship Operations, Fifth Edition, 2021 (Winching Area for Day Operation only)
(dd) IMPA Guidance for Naval Architects and Shipyards on the Provision of Pilot Boarding Arrangements, 2012 (for pilot ladder)
(ee) Council Directive 96/98/EC on Marine Equipment as amended by Commission Directive 2009/26/EC for MED Certification
(ff) Council Directive 2005/33/EC as regards the sulphur content of Marine Fuels (implemented with Legislative Decree No. 205, 2007)
(gg) Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC
(hh) ILO R141 - Crew Accommodation (Noise Control) Recommendation, 1970 (No.141)
(ii) IACS UR A2 Shipboard fittings and supporting hull structures associated with towing and mooring on conventional ships - Rev.5 Sep 2020
(jj) IACS UR Z23 Hull Survey for New Construction, Rev.7 Oct 2020
(kk) IACS UR S10 Rudders, Sole Pieces and Rudder Horns - Rev.6 Sep 2019
(ll) IACS UR S26 Strength and Securing of Small Hatches on the Exposed Fore Deck, 2010
(mm) IACS UR S27 Strength Requirements for Deck Fittings and Equipment, 2013
(nn) IACS UR L5 Onboard computers for stability calculations - Rev.4 June 2020
(oo) IACS Unified Requirements for New building which has been formal published and in force at the date of signing contract
(pp) IACS UI SC93 Enclosure of stern tubes on cargo ships (Chapter II-1, Regulation 12.11) - Rev.2 Feb 2021
(qq) IACS Rec 10 Chain Anchoring, Mooring and Towing Equipment - Rev.4 Sep 2020
(rr) IACS Rec No. 47 Shipbuilding & Repair Quality Standards, 2010
(ss) IACS Rec 68 Guidelines for non-destructive testing of hull and machinery steel forgings - Rev.1 Apr 2021
(tt) IACS Rec 69 Guidelines for non-destructive testing of marine steel castings – Rev.2 Oct 2020
(uu) DNV Additional Fire Protection Requirement F-AMC, 2006 (without Certificate nor Inspection)
(vv) ExxonMobil Marine Environmental, Safety and Quality Assurance Criteria 2017 (for Industry Vessels in Affiliate Service)
- The items marked with "MUST" and "Strongly Preferred" shall be applied
- Ship operating policy/procedure including maintenance procedure and rule publication, SEEMP and planned maintenance system, and drug and alcohol policy shall be prepared / provided by the Owner
- Risk assessment for safety and security management at a piracy-infested area shall be prepared / provided by the Owner
- Pollution control equipment i.e., sorbents, protective cloth, portable pumps, etc. shall be provided by the Owner
- OCIMF, Ship to Ship Transfer Guide (Liquefied Gas) required by the said criteria shall be applied based on the provision of fixed fittings only for STBL as described in the Specifications
- Necessary documentation which are required on board such as procedures, manuals, plans, certificates, data sheets, records, emergency response plans, etc.shall be provided by the Owner
- Lightering service in specific location (i.e., Gulf of Mexico, etc.) shall not be considered
- The item of S.2 not to be applied
- The item of F.6, F20, K.8, K.16, and P.3 shall be discussed further with the Owner

(ww) The Montreal Protocol on Substances that Deplete the Ozone Layer
(xx) EU Directive 2005/33/EC and 2012/33/EU with regards to Operation within European Territory
(yy) UK Health and Safety Commission Document EH40/2005 Workplace Exposure Limits, Table 1 'List of approved workplace exposure limits' (Exposures to be demonstrated during wind tunnel tests)
(zz) USCG Generic Protocol for the Verification of Ballast Water Treatment Technology (EPA/600/R-10/146), 2010
(aaa) USCG 40 CFR Part 3 – Control of Tec, Sox and PM Emissions from marine Engines and Vessels subject to Marpol Protocol, 2010
(bbb) California Air Resource Board (CARB) with regards to Sulphur content of marine fuels, 2009
(ccc) ILO R140 - Crew Accommodation (Air Conditioning) Recommendation, 1970 (No. 140)
(ddd) ILO Convention 152 for Lifting Appliances, 1985
(eee) Saudi Aramco Terminals (Ras Tanura and Juaymah) Recommendation regarding Mooring Arrangement/Fittings
(fff) SGMF FP07-01 Safety Guidelines – Bunkering, Version 2.0 – Chapter 5 (as attached "#4_ SGMF FP07-01 Safety Guidelines – Bunkering, Version 2.0"), March 2017
(ggg) SGMF-TGN06-04 Manifold arrangement for gas fueled vessels, ver.1, May 2019
(hhh) SGMF TGN06-05 (Ver. 1.0) - Recommendations for linked emergency shutdown (ESD) arrangement for LNG bunkering
(iii) Swedish Standard SS 780726 Shipbuilding - Engine room ventilation in turbineships - Conditions and basis of calculations, 1979
(jjj) SNAME Technical & Research Bulletins 3-47 - Guide for Sea Trials, 2015
(kkk) SNAME Technical & Research bulletin 3-39 - Guide for Shop and Installation Tests, 2018
(lll) SNAME Technical & Research Bulletins 5-2 - Gas Trials Guide for LNG Vessels, 1977
(mmm) Maritime Traffic Safety Law of Japan
(nnn) Guidance Implementing the International Convention on the Control of Harmful

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Anti-Fouling Systems Law of Japan

(ooo) US EPA Vessel General Permit for Discharges incidental to the Normal Operation of Vessels (VGP) 2013 (2.2.9 excluding Controllable Pitch Propeller, Paddle Wheel Propulsion, Stabilizers, Azimuth Thrusters and Propulsion Pod Lubrication)

(ppp) ITTC – Recommended Procedures and Guidelines – Full Scale Manoeuvring Trials, 2017

(qqq) Directive (EU) 2016/802 of the European Parliament and of the Council relating to a reduction in the sulphur content of certain liquid fuel (Initial arrangement only as specified in the Specifications), May 2016

(rrr) Chevron Requirement for Chartered Vessels (Voyage Charter and Third party Vessel Operating Requirements) shall be applied as follows:

-The items marked with "Requirements" and "Strong Preferences" shall be applied

-Accommodations arrangement and facilities proposed by the Builder without additional cabin(s) or facilities shall be applied

(sss) Shell Bunker Interface Documents

(ttt) AMSA Marine Order 32 (MO32) – Cargo handling equipment, October 2017

(uuu) AMSA Marine Order 57 - Helicopter Operations, November 2019

(vvv) AMSA Marine order 97—Marine pollution prevention—air pollution

(www) Requirement of Australian Maritime safety Authority (AMSA) for hold ladders. (without certificate but letter of approval from recognized authority or authorized agency should be submitted and drawings to be endorsed by authorized agents.)

(xxx) LRS Guidance Notes for Gas Combustion Units (Thermal Oxidizers), Rev.3, 2004

(yyy) Code of Safe Working Practice for Merchant Seamen

(zzz) El Segundo Terminal recommendations in California

(aaaa) CFR 29/part 1918 - Safety and Health Regulations for Long Shoring, 1997 without Certificate nor Inspection for foreign

(bbbb)

(cccc) flag vessel (Permanent fitting only).

(dddd) MIL-A-18001K (W/ Amendment 3) (Notice 1), Military Specification: Anodes, Sacrificial Zinc Alloy (28 Aug 2008)

(eeee) International Safety Guidelines for Oil Tankers & Terminals (ISGOTT) 6th Edition, 2020

(ffff) International Maritime Solid Bulk Cargoes (IMSBC Code) (for coal only)

(gggg) USA Public law 95-474 - OCT. 17, 1978 - Port and Tanker Safety Act of 1978

(hhhh) USCG Final Rule of Double Hull Standards for Vessels Carrying Oil in Bulk, 2001

(iiii) Revised MARPOL VI/12 Use of CFCs MEPC.176(58) - Installations (except permanently sealed equipment where there are no refrigerant charging connections or potentially removable components containing ozone depleting substances) which contain hydrochlorofluorocarbons are prohibited - Compliance date: 1/1/2020 for new and existing vessels

(jjjj) EN 469 Protective clothing for firefighters - Performance requirements for protective clothing for firefighting activities

(kkkk) Bioko, Braefoot Bay, and BASF LPG terminals latest requirements

(llll) Dow Chemical, "Fully Refrigerated LPG Tanker Safety Rules and Regulation 94" (Chapter 3 tanks and Cargo handling Equipment only) (except for cargo heater)

(mmmm) Equipment Specification for LPG Carriers Mooring in Tandem at ESCRAVOS FSO. (total 7 sheets)

(nnnn) Minimum Requirements for LPG (P)/(B) Gas Tankers Discharging at Berths 759 (Q801), 763 (805) and 767B (810)

IMO Resolutions and Circulars

(a) IMO Resolution A.330(IX) - Safe Access to and Working in Large Ballast Space – (17 December 1975)

(b) IMO Resolution A.343(IX) - Recommendation on Methods of Measuring Noise Levels at Listening Posts - (Adopted on 12 November 1975)

(c) IMO Resolution A.601(15) – Provision and Display of Manoeuvring Information on Board Ships – (Adopted on 19 November 1987)

(d) IMO Resolution A.653(16) – Recommendation on Improved Fire Test Procedures for Surface Flammability of Bulkhead, Ceiling and Deck Finish Materials – (Adopted on 19 October 1989)

(e) IMO Resolution A.708(17) – Navigation Bridge Visibility and Functions – (Adopted on 6 November 1991)

(f) IMO Resolution A.798(19) – Guidelines for the Selection, Application and Maintenance of Corrosion Prevention Systems of Dedicated Seawater Ballast Tanks – (Adopted on 23 November 1995)

(g) IMO Resolution A.824(19) – Performance Standards for Devices to Indicate Speed and Distance – (Adopted on 23 November 1995)

(h) IMO Resolution A.868(20) – Guidelines for the Control and Management of Ships Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens – (Adopted on 27 November 1997)

(i) IMO Resolution A.889(21) – Pilot Transfer Arrangements – (Adopted on 25 November 1999)

(j) IMO Resolution A.1021(26) – Code on Alerts and Indicators, 2009 – (Adopted on 2 December 2009)

(k) IMO Resolution A.1045(27) – Pilot Transfer Arrangements – (Adopted on 30 November 2011)

(l) IMO Resolution A.1116(30) – Escape Route Signs and Equipment Location Markings – (Adopted on 5 December 2017)

(m) IMO Resolution MEPC.107(49) - Revised Guidelines and Specifications for Pollution Prevention Equipment for Machinery Space Bilges of Ships - (adopted on 18 July 2003)

(n) IMO Resolution MEPC.122(52) - Explanatory Notes on Matters Related to the Accidental Oil Outflow Performance under Regulation 23 of the Revised MARPOL

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Annex I - (Adopted on 15 October 2004)Amended by Resolution MEPC.146(54)

(o) IMO Resolution MEPC.127(53) - Guidelines for Ballast Water Management and Development of Ballast Water Management Plans (G4) - (Adopted on 22 July 2005)

(p) IMO Resolution MEPC.177(58) – Amendments to the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines – (NOx Technical Code 2008) – (Adopted on 10 October 2008)

(q) IMO Resolution MEPC.208(62) – 2011 Guidelines for Inspection of Anti-Fouling Systems on Ships – (Adopted on 15 July 2011)

(r) IMO Resolution MEPC.213(63) – 2012 Guidelines for the Development of a Ship Energy Efficiency Management Plan (SEEMP) – (Adopted on 2 March 2012)

(s) IMO Resolution MEPC.214(63) – 2012 Guidelines on Survey and Certification of the Energy Efficiency Design Index (EEDI) – (Adopted on 2 March 2012) Amended by Resolution MEPC.234(65)

(t) IMO Resolution MEPC.227(64) – 2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants – (Adopted on 5 October 2012)

(u) IMO Resolution MEPC.231(65) – 2013 Guidelines for Calculation of Reference Lines for Use with the Energy Efficiency Design Index (EEDI)

(v) IMO Resolution MEPC.234(65) – Amendments to the 2012 Guidelines on Survey and Certification of the Energy Efficiency Design Index (EEDI) (Resolution MEPC.214(63)), as Amended – (Adopted 17 May 2013)

(w) IMO Resolution MEPC.254(67) – 2014 Guidelines on Survey and Certification of The Energy Efficiency Design Index (EEDI) – (Adopted on 17 October 2014)

(x) IMO Res. MEPC.269(68) - Guidelines for the Development of the Inventory of Hazardous Materials, 2015

(y) IMO Resolution MEPC.282(70) – 2016 Guidelines for the Development of a Ship Energy Efficiency Management Plan (SEEMP) – (Adopted on 28 October 2016)

(z) IMO Resolution MEPC.306(73) - Amendments to the Guidelines for Ballast Water Management and Development of Ballast Water Management Plans (G4) (Resolution MEPC.127(53)) - (Adopted on 26 October 2018)

(aa) IMO Resolution MEPC.308(73) - 2018 Guidelines on the Method of Calculation of the Attained Energy Efficiency Design Index (EEDI) for New Ships - (adopted on 26 October 2018)

(bb) IMO Resolution MSC.35(63) - Adoption of Guidelines for Emergency Towing Arrangements on Tankers - (adopted on 20 May 1994) Amended by Resolution MSC.132(75)

(cc) IMO Resolution MSC.62(67)/Rev.1 - Revised Guidelines for Safe Access to Tanker Bows - (adopted on 9 November 2020)

(dd) IMO Resolution MSC.74(69) - Adoption of New and Amended Performance Standards - (Adopted on 12 May 1998)

(ee) IMO Resolution MSC.81(70) - Revised Recommendation on Testing of Life-Saving Appliances - (adopted on 11 December 1998)

(ff) IMO Resolution MSC.96(72) – Adoption of Amendments to Performance Standards for Devices to Measure and Indicate Speed and Distance (Resolution A.824(19)) – (Adopted on 22 May 2000)

(gg) IMO Resolution MSC.137(76) - Standards for Ship Manoeuvrability - (adopted on 4 December 2002)

(hh) IMO Resolution MSC.148(77) - Adoption of the Revised Performance Standards for Narrow-Band Direct-Printing Telegraph Equipment for the Reception of Navigational and Meteorological Warnings and Urgent Information to Ships (NAVTEX) - (adopted on 3 June 2003)

(ii) IMO Resolution MSC.158(78) - Adoption of Amendments to the Technical Provisions for Means of Access for Inspections - (adopted on 20 May 2004)

(jj) IMO Resolution MSC.192(79) - Adoption of the Revised Performance Standards for Radar Equipment - (Adopted on 6 December 2004)

(kk) IMO Resolution MSC.215(82) - Performance Standard for Protective Coatings for Dedicated Seawater Ballast Tanks in all Types of Ships and Double-Side Skin Spaces of Bulk Carriers - (Adopted on 8 December 2006)

(ll) IMO Resolution MSC.244(83) - Adoption of Performance Standard for Protective Coatings for Void Spaces on Bulk Carriers and Oil Tankers - (Adopted on 5 October 2007)

(mm) IMO Resolution MSC.247(83) - Adoption of Amendments to Performance Standards for Survival Craft Radar Transponders for Use in Search and Rescue Operations (Resolution A.802(19)) - (Adopted on 8 October 2007)

(nn) IMO Resolution MSC.252(83) - Adoption of the Revised Performance Standards for Integrated Navigation Systems (INS) - (Adopted on 8 October 2007)

(oo) IMO Resolution MSC.256(84) – Adoption of Amendments to the International Convention for the Safety of Life at Sea, 1974, as Amended – (Adopted on 16 May 2008)

(pp) IMO Resolution MSC.269(85) – Adoption of Amendments to the International Convention for the Safety of Life at Sea, 1974, as Amended - (Adopted on 4 December 2008)

(qq) IMO Resolution MSC.288(87) – Performance Standard for Protective Coatings for Cargo Oil Tanks of Crude Oil Tankers – (Adopted on 14 May 2010)

(rr) IMO Resolution MSC.306(87) – Revised Performance Standards for Enhanced Group Call (EGC) Equipment – (Adopted on 17 May 2010)

(ss) IMO Resolution MSC.323(89) – Adoption of Amendments to the Revised Recommendation on Testing of Life-Saving Appliances (Resolution MSC.81(70)) – (Adopted on 20 May 2011) This Annex of this document has been consolidated into Resolution MSC.81(70)

(tt) IMO Resolution MSC.337(91) – Adoption of the Code on Noise Levels on Board Ships – (Adopted on 30 November 2012) The Annex below is consolidated into Resolution MSC.337(91)

(uu) IMO Resolution MSC.363(92) – Performance Standards for Electronic Inclinometers – (Adopted on 14 June 2013)

(vv) IMO Resolution MSC.365(93) – Amendments to the International Convention For the Safety of Life at Sea, 1974, as amended – (Adopted on 22 May 2014)

(ww) IMO Resolution MSC.430(98) - Amendments to the Revised Performance Standards for Narrow-Band Direct-Printing Telegraph Equipment for the Reception of Navigational and Meteorological Warnings and Urgent Information to Ships (NAVTEX) (Resolution MSC.148(77)) - (Adopted on 16 June 2017)

(xx) IMO Resolution MSC.431(98) - Amendments to the Revised Performance Standards for Enhanced Group Call (EGC) Equipment (Resolution MSC.306(87)) - (Adopted on 16 June 2017)

(yy) IMO MEPC.1/Circular.641 – Supplementary Guidelines for Approval of Bilge and Sludge Handling Systems – (11 November 2008)

(zz) IMO MEPC.1/Circular.642 – 2008 Revised Guidelines for Systems for Handling Oily Wastes in Machinery Spaces of Ships Incorporating Guidance Notes for an Integrated Bilge Water Treatment System (IBTS) – (12 November 2008) Amended by MEPC.1/Circular.676Amended by MEPC.1/Circ.760

(aaa) IMO MEPC.1/Circular.676 – Amendment to the 2008 Revised Guidelines for Systems for Handling Oily Wastes in Machinery Spaces of Ships Incorporating

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Guidance Notes for an Integrated Bilge Water Treatment System (IBTS) – (31 July 2009)

(bbb) IMO MEPC.1/Circular.683 – Guidance for the Development of a Ship Energy Efficiency Management Plan (SEEMP) – (17 August 2009)

(ccc) IMO MEPC.1/Circular.760 – Amendments to the 2008 Revised Guidelines for Systems for Handling Oily Wastes in Machinery Spaces of Ships Incorporating Guidance Notes for an IBTS (MEPC.1/Circ.642, as Amended by MEPC.1/Circ.676) – (25 August 2011)

(ddd) IMO MEPC.1/Circular.850/Rev.2 - 2013 Interim Guidelines for Determining Minimum Propulsion Power to Maintain the Manoeuvrability of Ships in Adverse Conditions, as Amended (Resolution MEPC.232(65), as Amended by Resolutions MEPC.255(67) and MEPC.262(68)) – (30 August 2017)

(eee) IMO MEPC.1/Circular.854 - Guidance on the Application of Regulation 13 of MARPOL Annex VI Tier III Requirements to Dual Fuel and Gas-Fuelled Engines – (1 July 2015)

(fff) IMO MSC/Circular.601 – Fire Protection in Machinery Spaces – (Adopted on 29 January 1993)

(ggg) IMO MSC/Circular.834 – Guidelines for Engine-Room Layout, Design and Arrangement – (Adopted on 9 January 1998)

(hhh) IMO MSC/Circular.982 – Guidelines on Ergonomic Criteria for Bridge Equipment and Layout – (Adopted on 20 December 2000)

(iii)IMO MSC/Circular.1091 – Issues to be Considered when Introducing New Technology on board Ship – (Adopted on 6 June 2003)

(jjj)IMO MSC/Circular.1053 – Explanatory Notes to the Standards for Ship Manoeuvrability – (Adopted on 16 December 2002)

(kkk) IMO MSC/Circular.1097 – Guidance Relating to the Implementation of SOLAS chapter XI-2 and the ISPS Code – (Adopted on 6 June 2003)

(lll)IMO MSC/Circular.1151 – Revised List of Certificates and Documents Required to be Carried on Board Ships – (17 December 2004)

(mmm) IMO MSC/Circular.1175 – Guidance on Shipboard Towing and Mooring Equipment – (24 May 2005)

(nnn) IMO MSC.1/Circular.1205/Rev.1 - Revised Guidelines for Developing Operation and Maintenance Manuals for Lifeboat Systems - (26 June 2019)

(ooo) IMO MSC.1/Circular.1245 – Guidelines for Damage Control Plans and Information to the Master – (29 October 2007)

(ppp) IMO MSC.1/Circular.1321 – Guidelines for Measures to Prevent Fires in Engine Rooms and Cargo Pump-Rooms – (11 June 2009)

(qqq) IMO MSC MSC.1/Circular.1331 – Guidelines for Construction, Installation, Maintenance and Inspection/Survey of Means of Embarkation and Disembarkation – (11 June 2009)

(rrr) IMO MSC.1/Circular.1352/Rev.1 – Amendments to the Code of Safe Practice for Cargo Stowage and Securing (CSS Code) – (15 December 2014)The Annex of this document has been consolidated into CSS Code

(sss) IMO MSC.1/Circular.1353/Rev.2 – Revised Guidelines for the Preparation of the Cargo Securing Manual – (7 December 2020)

(ttt)IMO MSC.1/Circular.1370 – Guidelines for the Design, Construction and Testing of Fixed Hydrocarbon Gas Detection Systems – (22 June 2010)

(uuu) IMO MSC.1/Circular.1392 – Guidelines for Evaluation and Replacement of Lifeboat Release and Retrieval Systems – (27 May 2011)

(vvv) IMO MSC.1/Circular.1505 - Unified Interpretation of SOLAS Regulation II-2/13.6 – (5 June 2015)

(www) The IMDG Code. 2020 Edition (inc. Amendment 40-20)

(xxx) IMO Publication No.978 Performance Standards for Shipborne Radiocommunications and Navigational Equipment

<u>ISO Standards</u>

To be applied as a minimum if no more severe standards are included in International Regulations, Guidelines, Classification Rules etc.

(a) ISO 484-1:2015 Ship Screw Propellers – Manufacturing Tolerances – Part 1 Propellers of diameter greater than 2.5m

(b) ISO 799-1:2019 Shipbuilding – Pilot Ladders — Part 1: Design and specification

(c) ISO 2923:1996 Acoustic Measurement of Noise on Board Vessels

(d) ISO 3046-1:2002 Reciprocating internal combustion engines — Performance — Part 1: Declarations of power, fuel and lubricating oil consumptions, and test methods — Additional requirements for engines for general use

(e) ISO 3730:2012 Shipbuilding – Mooring Winches

(f) ISO 4406:2021 Hydraulic Fluid Power

(g) ISO 5488:2015 Ships and Marine Technology – Accommodation Ladders

(h) ISO 7061:2015 Ship and Marine Technology – Aluminium Shore Gangways for Seagoing Vessels

(i) ISO 7547:2002 Ships and Marine Technology - Air-conditioning and Ventilation of Accommodation Spaces - Design Conditions and Basis of Calculations

(j) ISO 7825:2017 Shipbuilding – Deck Machinery – General Requirements.

(k) ISO 8309-1991 Refrigerated light hydrocarbon fluid - Measurement of liquid levels in tanks containing liquefied gases

(l) ISO 8310:2012 Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels — General requirements for automatic tank thermometers on board marine carriers and floating storage

(m)ISO 8468:2007 Ships and Marine Technology – Ship's Bridge Layout and Associated Equipment – Requirements and Guidelines

(n) ISO 8501-1:2007 Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings

(o) ISO 8503:2012 Preparation of Steel Substrates before Application of Paints and related Products – Surface Roughness of Blast Cleaned Substrate.

- Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces.

Appendix 1: *Generic Rules and Regulations*

- Part 2: Method for grading of surface profile of abrasive blast-cleaned steel – Comparator procedure

(p) ISO 8528 Reciprocating Internal Combustion Engine Driven Alternating Current Generating Sets

- Part 1: Application, Ratings and Performance.
- Part 2: Engines.
- Part 3: Alternating Current Generators for Generating Sets.
- Part 4: Control gear and Switchgear.
- Part 5: Generating Sets.
- Part 6: Test Methods.
- Part 7: Technical Declarations for Specification and Design.
- Part 8: Requirements and Tests for Low-Power Generating Sets.
- Part 9: Measurement and Evaluation of Mechanical Vibrations.

(q) ISO 8573-1: 2001 Compressed air — Part 1: Contaminants and purity classes

(r) ISO 8861: 1998(E) – Shipbuilding – Engine room ventilation in diesel engine ships – Design requirements and basis of calculation

(s) ISO 8862:1987 Air-conditioning and ventilation of machinery control-rooms on board ships – Design conditions and basis of calculations

(t) ISO 8863:1987 Ship's wheelhouse windows — Heating by hot air of glass panes

(u) ISO 8864:1987 Air-conditioning and ventilation of wheelhouse on board ships – Design conditions and basis of calculations

(v) ISO 9203:1989 Shipbuilding — Topology of ship hull structure elements

(w) ISO 9943:2009 Shipbuilding – Ventilation and air-treatment of galleys and pantries with cooking appliances

(x) ISO 9099:1987 Air-conditioning and ventilation of dry provision rooms on board ships -- Design conditions and basis of calculations

(y) ISO 10816 – Mechanical vibration – Evaluation of Machine Vibration by Measurements on Rotating Parts

- Part 1: General Guidelines
- Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15,000 r/min when measured in situ
- Part 6: Reciprocating machines with power rating above 100 kW
- Part 7: Rotodynamic pumps for industrial applications, including measurements on rotating shafts

(z) ISO 10976:2012 Refrigerated light hydrocarbon fluids - Measurement of cargoes on board LNG carriers

(aa) ISO 11064-4:2013 Ergonomic design of control centres — Part 4: Layout and dimensions of workstations

(bb) ISO/IEC 11801-1:2017 Information technology — Generic cabling for customer premises

(cc) ISO 13776:2020 Ships and marine technology — Ship's mooring and towing fittings — Pedestal fairleads

(dd) ISO 13795:2020 Ships and marine technology — Ship's mooring and towing fittings — Welded steel bollards for sea-going vessels

(ee) ISO 13797:2020 Ships and marine technology — Ship's mooring and towing fittings — Cruciform bollards

(ff) ISO 14122:2016 - Safety of machinery, Permanent means of access to machinery.

- Part 1: Choice of fixed means and general requirements of access
- Part 2: Working platforms and walkways
- Part 3: Stairs, stepladders and guard-rails
- Part 4: Fixed ladders

(gg) ISO 14726:2008 – Ships and Marine technology – Identification colours for the content of piping systems

- Part 1: Main colours and media.
- Part 2: Additional colours for different media and/or functions.

(hh) ISO 14692:2017 Petroleum and natural gas industries – Glass-reinforced plastics (GRP) piping

- Part 1: Vocabulary, symbols, applications and materials
- Part 2: Qualification and manufacture
- Part 3: System design
- Part 4: Fabrication, installation and operation

(ii) ISO 15016:2015 "Guidelines for the assessment of speed and power performance by analysis of speed trial data"

(jj) ISO 15550:2016 Internal combustion engines — Determination and method for the measurement of engine power — General requirements

(kk) ISO 15748:2002 Ships and marine technology — Potable water supply on ships and marine structures

- Part 1: Planning and design
- Part 2: Method of calculation

(ll) ISO 17894:2005 Ships and marine technology -- Computer applications - General principles for the development and use of programmable electronic systems in marine applications

(mm) ISO 18132-1:2011 Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels — General requirements for automatic tank gauges — Part 1: Automatic tank gauges for liquefied natural gas on board marine carriers and floating storage

(a) ISO 18611:2014 Ships and marine technology-Marine NO_x reduction agent AUS 40

- Part 1: Quality requirements
- Part 2: Test methods
- Part 3: Handling transportation and storage

(nn) ISO 19019:2005 – Sea-going vessels and marine technology – Instructions for planning, carrying out and reporting sea trials

(oo) ISO 19970:2017: Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels - metering of gas as fuel on LNG carriers during cargo transfer operations

(pp) ISO 20283-2:2008 Mechanical vibration — Measurement of vibration on ships — Part 2: Measurement of structural vibration

(qq) ISO 20283-5: 2016 Mechanical vibration -- Measurement of vibration on ships - Part 5: Guidelines for measurement, evaluation and reporting of vibration with regard to habitability on passenger and merchant ships

(rr) ISO 21940-11:2016 Mechanical vibration — Rotor balancing — Part 11: Procedures and tolerances for rotors with rigid behaviour

(ss) ISO 21984:2018 Ships and marine technology — Guidelines for measurement, evaluation and reporting of vibration with regard to habitability on specific ships

IEC Standards

To be applied as a minimum if no more severe standards are included in International Regulations, Guidelines, Classification Rules etc.

(a) IEC 60034 – Rotating Electrical Machines

(b) IEC 60072-1:1991 Dimensions and output series for rotating electrical machines - Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080

(c) IEC 60092:2022 SER Series Electrical installations in ships - ALL PARTS

(d) IEC 60331-1:2018 Tests for electric cables under fire conditions - Circuit integrity - Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm

Appendix 1: *Generic Rules and Regulations*

(e) IEC 60332:2022 SER Series Tests on electric and optical fibre cables under fire conditions - ALL PARTS
(f) IEC 60445:2021 Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors
(g) IEC 60533:2015 Electrical and electronic installations in ships - Electromagnetic compatibility (EMC) - Ships with a metallic hull
(h) IEC 60754-1:2011 Test on gases evolved during combustion of materials from cables - Part 1: Determination of the halogen acid gas content
(i) IEC 60945:2002 Maritime navigation and radiocommunication equipment and systems - General requirements – Methods of testing and required test results
(j) IEC 61034-1:2005/AMD2:2019 Amendment 2 - Measurement of smoke density of cables burning under defined conditions
(k) IEC 61111:2009 Live working - Electrical insulating matting
(l) IEC TR 61641:2014 Enclosed low-voltage switchgear and controlgear assemblies - Guide for testing under conditions of arcing due to internal fault
(m) IEC 62271:2022 SER Series High-voltage switchgear and controlgear – ALL PARTS

VDI Standards

To be applied as a minimum if no more severe standards are included in International Regulations, Guidelines, Classification Rules etc.

(a) VDI 2056 (1964) Standards of evaluation for mechanical vibrations of machines
(b) VDI 2063 (1985) Measurement and Evaluation of Mechanical Vibration of Reciprocating Piston engines and Compressors
(c) VDI 3838 (2004) Measurement and evaluation of mechanical vibration of reciprocating piston engines and piston compressors with power ratings above 100 kW - Addition to DIN ISO 10816-6

BS Standards

To be applied as a minimum if no more severe standards included in International Regulations, Guidelines, Classification Rules etc.

(a) BS 336:1989 Specification for Fire Hose Couplings and Ancillary Equipment
(b) BS 1807-1981 Surface finish requirements for reduction gears

NEK Standards

To be applied as a minimum if no more severe standards are applied by International Regulations, Guidelines, Classification Rules etc.

(a) NEK TS 606:2016 Cables for offshore installations – Halogen-free low smoke and flame-retardant / fire resistant (HFFR-LS)

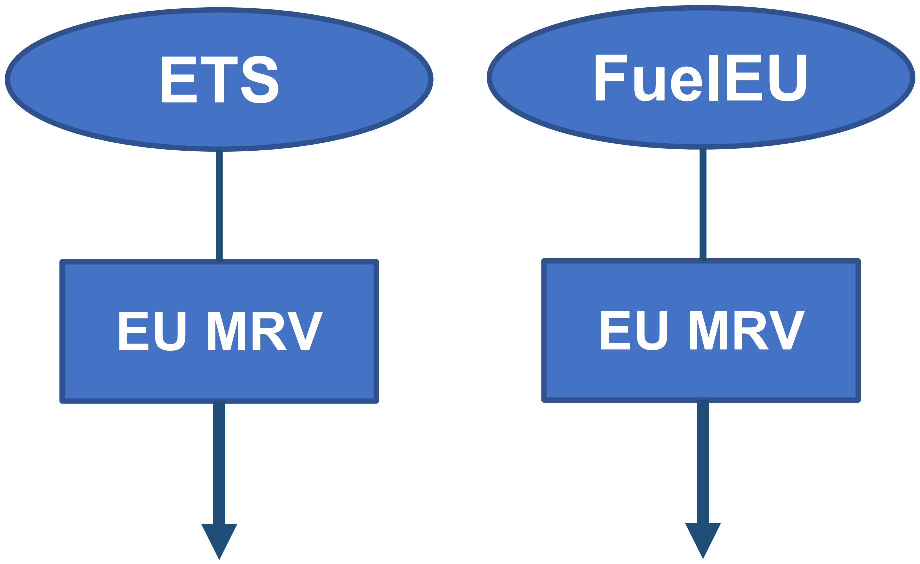
MRV

The overall purpose of EU MRV emissions collection and reporting is to assess the environmental impact of maritime transport and to serve as the basis for carbon tax determination through the EU ETS and Fuel EU Maritime regulations.

Description of the method chosen to **monitor** and report emissions

The **Emissions Report** contains information about the amount of consumed fuel and the distance travelled, as well as the cargo carried on voyages to, between and from EU ports.

The verified Emissions Report for a year must be submitted by the shipping company to the European Commission



Overall view of the maritime industry
How much to tax?

DIY: How to get a RightShip score below 3

Rule	Safety Score	Rule	Resolution options
SS1-1	1	Open Abandonment of Seafarers case at the vessel level	Vessel needs to be removed from ILO list of abandoned seafarers, once removed RightShip to review
SS1-3	1	Vessel on the Paris MOU banned list	Vessel needs to be removed from Paris MOU banned list, once removed RightShip to review
SS1-4	1	Vessel on the AMSA banned list	Vessel needs to be removed from AMSA banned list, once removed RightShip to review
SS1-5	1	Vessel on the USCG banned list	Vessel needs to be removed from USCG banned list, once removed RightShip to review
SS1-6	1	Vessel on the RightShip Vessel Restriction list	Vessel is removed from RightShip's proprietary vessel restriction list
SS1-7	1	Company on the RightShip Company Restriction list	Change of Company association or the company is removed from RightShip proprietary Company Restriction list
SS1-8	1	Any vessel with 3 PSC detentions in the last 24 months	Send RightShip information to review severity of detention and RightShip may suggest a RightShip Inspection. Owner may appeal to the MOU with backing of Flag or Class. Vessel needs to display good performance over 24 months such that the rule will automatically resolve.
SS1-9	1	Vessel with CAT-A incident in 12 months	The vessel will require a RightShip Inspection & close out of incidents before rule release. Vessel needs to display good performance over 24 months such that the rule will automatically resolve.
SS1-10	1	Any vessel with an unacceptable last RightShip inspection	The vessel will require a RightShip Inspection.
SS1-11	1	Any vessel flagged with a Paris MOU scored flag which is Medium to High or High Risk	The vessel needs to change it's Flag to one which is not a Medium or High / High Risk with Paris MOU
SS1-12	1	Any vessel flagged with a Paris MOU scored flag which is on their Blacklist, and combined with Low or Very Low performing Class Society	Change of Flag which is not on the Paris MOU Blacklist or flag to change status with Paris MOU .
SS1-13	1	Vessel with 2 incidents (CAT-A or CAT-B) in 36 months	The vessel will require a RightShip Inspection and provide close out of both incidents. Vessel needs to display good performance over 36 months such that the rule will automatically resolve.
SS1-14	1	Vessel with 3 incidents (CAT-A or CAT-B or CAT-C) in 60 months	The vessel will require a RightShip Inspection and provide close out of all three incidents. Vessel needs to display good performance over 60 months such that the rule will automatically resolve.

Rule	Safety Score	Rule	Resolution options
SS2-1	2	Any vessel with 2 PSC detentions in the last 24 months	Send RightShip information to review severity of detention and possible a RightShip Inspection. Vessel needs to display good performance over 24 months such that the rule will automatically resolve. Owner may appeal to the MOU with backing of Flag or Class.
SS2-2	2	Any vessel with excessively high numbers (50) of PSC deficiencies over 24 months	RightShip to review the PSC records and potentially ask for an Inspection if required.
SS2-4	2	Vessel with CAT-A incident in last 12 months, which already has an acceptable RightShip Inspection, and incident close out	Vessel needs to display good performance over 12 months such that the rule will automatically resolve. Part resolution for rule SS1-9.
SS2-5	2	Vessel over 14 years and over 8000 DWT without a satisfactory RightShip inspection in last 12 months(excl tankers)	RightShip Inspection must be completed
SS2-6	2	Vessel over 25 years and less than 8000 DWT without a satisfactory right inspection in the last 12 months	RightShip Inspection must be completed
SS2-7	2	Any vessel with an open detention over the past 2 years and is still with same DOC or current DOC unknown	Owner to provide RightShip with an acceptable close out to the open detention.
SS2-8	2	Any vessel with an open incident over the past 2 years and is still with same DOC or current DOC unknown	Owner to provide RightShip with an acceptable close out to the open detention.
SS2-9	2	Any vessel whose classes is not an IASC Member	Change Class
SS2-11	2	Any vessel with an unknown class for more than 3 months	Provide Class information
SS2-12	2	Any vessel with an unknown flag for more than 3 months	Provide Flag information
SS2-13	2	Any vessel with an unknown DOC for more than 3 months	Provide DOC information
SS2-14	2	Vessel with 2 incidents in last 36 (CAT-A or CAT-B) months, which already has an acceptable RightShip Inspection and incident close Out	Vessel needs to display good performance over 36 months such that the rule will automatically resolve. Part resolution for rule SS1-13.
SS2-15	2	Vessel with 3 incidents in last 60 months (CAT-A or CAT-B or CAT-C), which already has an acceptable RightShip Inspection, and incident close Out	Vessel needs to display good performance over 60 months such that the rule will automatically resolve. Part resolution for rule SS1-14.

Alternative fuels

	MDO	LNG	Methanol	Biofuel	Ammonia	Hydrogen	Battery
SOx, NOx, PM emissions	✗ (orange)	✓ (light green)	✓ (light green)	✗ (orange)	✓ (yellow)	✓ (green)	✓ (green)
Carbon (CO_2) emissions	✗ (red)	✗ (orange)	✓ (light green)	✓ (light green)	✓ (green)	✓ (green)	✓ (green)
Flammability	✓ (green)	✓ (green)	✓ (yellow)	✓ (green)	✓ (light green)	✗ (red)	-
Toxicity	✓ (green)	✓ (green)	✓ (yellow)	✓ (green)	✗ (red)	✓ (green)	-
Technological maturity	✓ (green)	✓ (green)	✓ (yellow)	✓ (light green)	✗ (orange)	✗ (orange)	✓ (light green)
Energy cost	✓ (light green)	✓ (green)	✓ (yellow)	✗ (orange)	✗ (red)	✗ (red)	✗ (red)
Bunkering availability	✓ (green)	✓ (yellow)	✗ (orange)	✗ (orange)	✗ (orange)	✗ (orange)	✓ (yellow)

Readings - Sources

5.2 Port state control (PSC) and vetting inspections

Oil companies and other charterers maintain a regular programme of tanker inspections as part of their ship vetting programmes. Such inspections often reveal ships that are poorly maintained and to a standard much lower than what is deemed to be desirable for safe tanker operations. When shipowners find that their tanker is not acceptable to potential charterers, they will normally take corrective action very quickly.

Although ship vetting is an essential activity and provides another important way of identifying substandard ships, it is also true to say that vetting inspectors have not always been coordinated to a common standard or correct in their assessments of tankers. Ship vetting, already the most common discussion topic at INTERTANKO meetings with its members, came even more sharply into focus as a result of the Erika sinking in December 1999. In the many safety-related meetings prompted by the loss of this ship, INTERTANKO has stressed the importance of a rationalised ship inspection regime.

The Ship Inspection & Reporting (SIRE) system for oil tankers, administered by the Oil Companies International Marine Forum (OCIMF), and the Chemical Distribution Institute (CDI) scheme for chemical and chemical gas carriers, provide important vehicles for minimising the proliferation of ship inspections now prevailing. Both have been developed as industry-wide systems in which specially trained, independent inspectors carry out ship inspections, and compile detailed inspection reports which are filed in a central database, on behalf of all potential charterers. In this respect, it is good to note the ongoing improvements to the two systems and efforts to harmonise the two approaches in areas where it makes sense to do so. INTERTANKO has welcomed the creation by SIRE of a system for the examination, accreditation and ongoing assessment of SIRE inspectors and the ongoing work to finalise a common CDI/SIRE Vessel Particulars Questionnaire (VPQ).

Years ago it was normal practice to throw ship's garbage over the side. In recent years the disposal of ships' garbage is becoming increasingly regulated, primarily through MARPOL Annex V. Some types of garbage can still be dumped overboard, provided it is beyond a specified distance from shore. Other types of garbage, like PVC and other plastic materials, have to be landed and disposed of ashore. Most ships are now provided with garbage containers onboard to comply with the international regulations and specific port requirements.

It has long been common practice to incinerate garbage onboard ship and onboard incineration of waste is an approved garbage treatment process. Incinerator equipment has developed over the years and has now to comply with various emission regulations. As gaseous emissions from incinerators are also of environmental concern, some shipowners are looking at the role of compactors and shredders and the role they can play in reducing the volume of garbage for disposal ashore. A range of garbage compression units are available on the market.

Ship garbage-handling facilities and associated equipment should be of adequate size and properly laid out. These are matters which are often neglected by the shipyard. It is advisable to get input from those who deal with garbage disposal on a daily basis, i.e. the seafarers themselves, whether it be master, chief officer or cook.

As pointed out in Section 4.2, not all ports have the necessary reception facilities, including for garbage. This is a critical factor, as the availability of such facilities would do much to reduce the potential of pollution from this source.

Classification Societies

3.2.1 Special surveys, technical specifications and life-cycle costs

A tanker is, broadly speaking, designed and built for a commercial life expectancy of 20 years and, following delivery, is operated with five-year intervals between special surveys in accordance with the class society rules and statutory regulations. Each tanker will have to drydock during its economic life at prescribed intervals in compliance with mandatory regulations.

The most important and extensive surveys are the so-called special surveys (SSs) which are carried out at 5, 10, 15, 20, 25 years of age, and so on at five-year intervals. The principal intention of the SS is to overhaul, repair and raise the ship's technical standard to the necessary level in order to ensure another safe five-year trading interval until the next SS. There are also requirements for various annual and periodical surveys for the period between the special surveys that must be complied with during either a

drydocking or an in-water survey. In fact, the "in-between" surveys are now equivalent to the previous special survey for tankers over 15 years of age.

It is the classification society's responsibility to ensure that a new tanker is built to a minimum technical standard in compliance with the applicable rules and regulations and, thereafter, that this minimum standard and compliance with regulations is fulfilled throughout the tanker's commercial lifespan by means of regular scheduled surveys and drydockings.

3.2.2 Tanker repairs and Condition of Class

Historically, the tanker market has followed a cyclical pattern. There will be periods during the tanker's working life when the market return is poor. At such times, after financial and crew costs have been taken into account, there will be less cash available, if any, for maintenance and repairs determined to be necessary following compulsory surveys related to certificate renewals. In such circumstances the extent of repairs may be solely dependent on the opinion and decisions of the attending class surveyor.

If necessary in such a situation, the class surveyor is able to issue a Condition of Class (CC) that will specify a date by which time the CC must be addressed and corrected. If the reason for the CC is not dealt with within the stated time, the ship risks losing class and its ability to trade. Until recently, it was possible for a ship in such a situation to get away without carrying out the necessary repairs, but continue to trade by "jumping class", i.e. switching the ship to a more tolerant, less strict class society. Often, such class jumping, or hopping, was accompanied by a switch to another, less discerning ship register. However, a number of notable maritime accidents have resulted in the maritime safety regime being tightened. In addition to the revision of a number of international regulations, IACS has upgraded its procedures, making it difficult for owners to move their ships from one member society to another without strict adherence to a set of specific procedures.

As mentioned earlier, a tanker built to the minimum specification will reach a point relatively early in its life where major repairs and maintenance will be required to keep it up to the necessary standard. Thus, it may be that the class society begins issuing Conditions of Class to a ship within 8-10 years of its delivery from the shipbuilder. The tanker owner will either have to start a rigorous maintenance programme or leave the identification and discovery of further deficiencies to the class surveyor as the tanker gets older. Even if the class surveyor does not discover these deficiencies, and they will officially pass undetected, there will inevitably be someone associated with the ship that knows or should have known its actual condition.