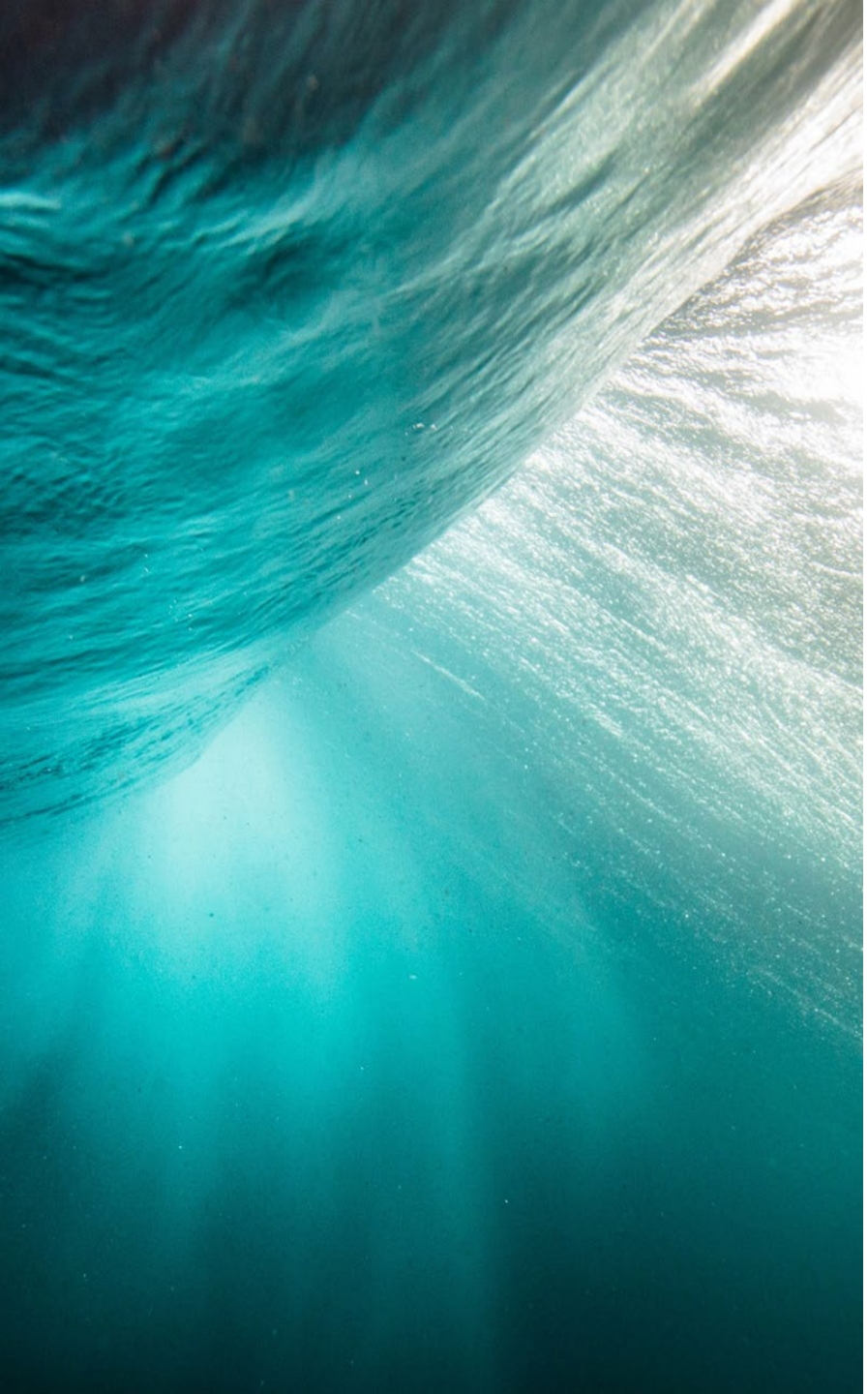


REDUCTION OF GAS EMISSIONS EMITTED BY SHIPS TO COMPLY WITH NEW REGULATIONS.

Redução de emissões de gases emitidos por navios para cumprimento das novas regulamentações

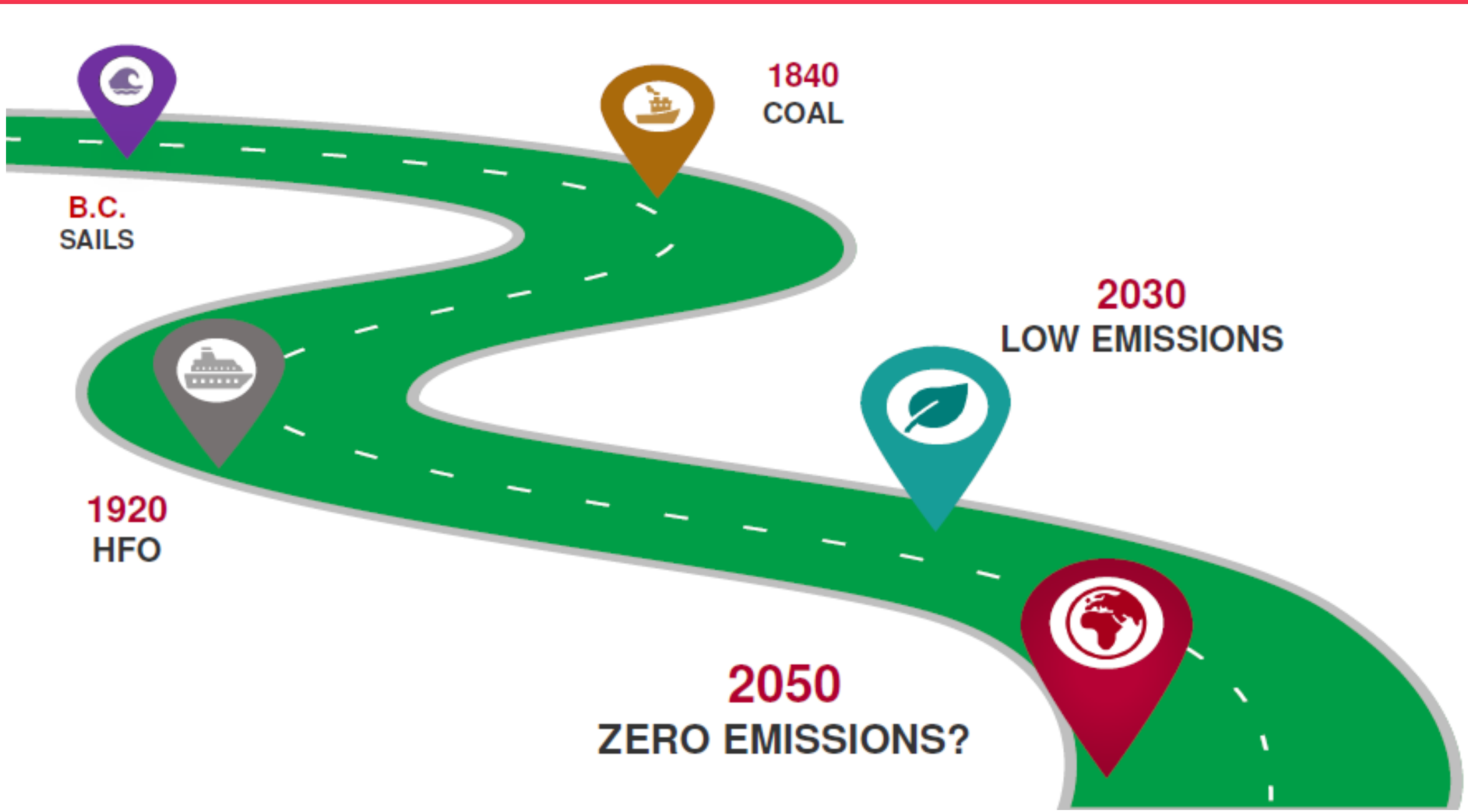
17as JETM 2024.

Lisbon 16 May 2024

Montserrat Espín

montserrat.espin@buerauveritas.com

14-16 MAY 2024


B.C.
SAILS
1840
COAL
1920
HFO
2030
LOW EMISSIONS
2050
ZERO EMISSIONS?

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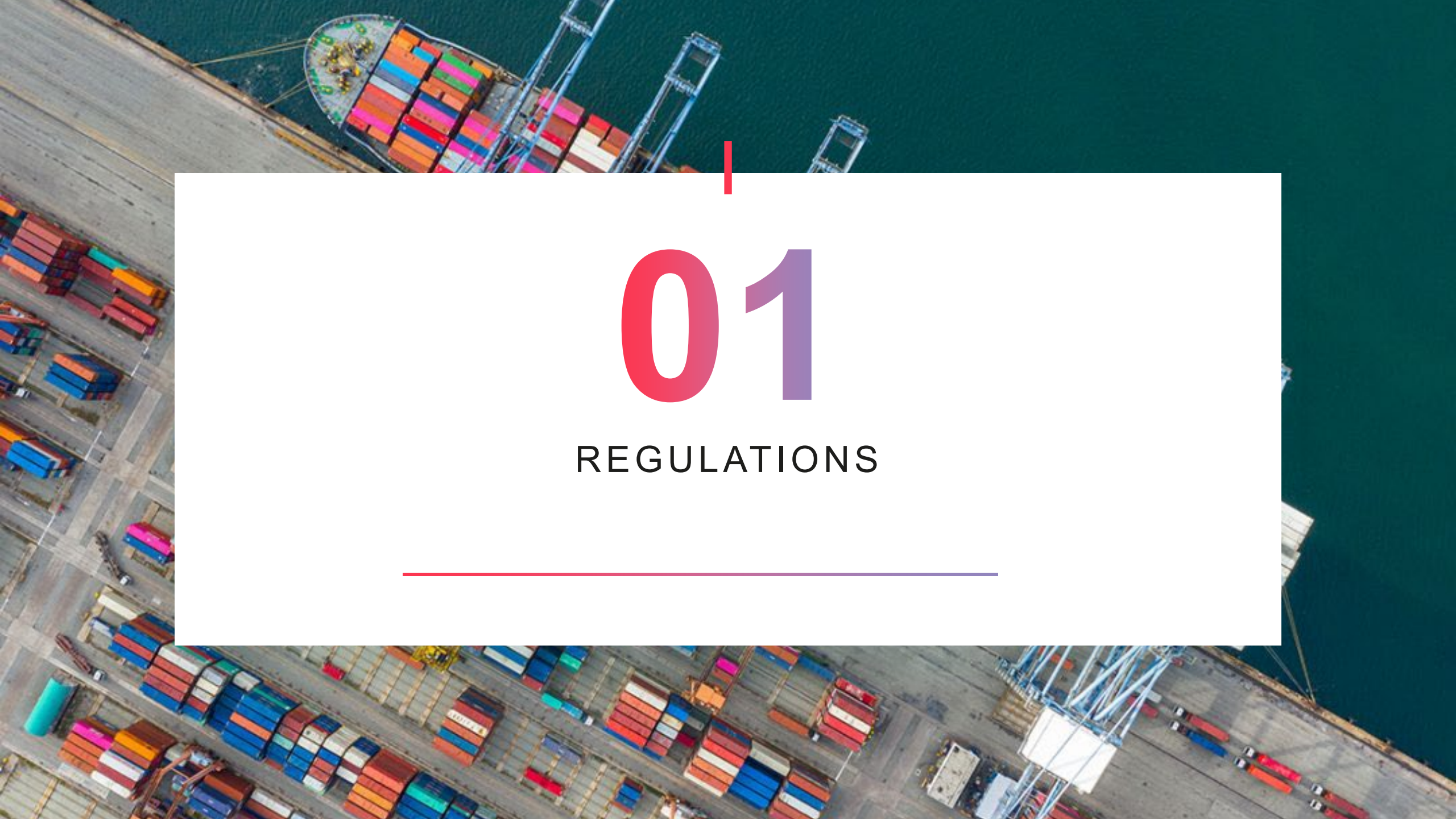


01

REGULATIONS

DECARBONIZATION
SHIPPING CONTEXT

REGULATORY FRAMEWORK

MARPOL. EEDI, EEXI, CII, SEEMP Regulations from 2023 (review from 2026)

Market based measures (MBM) under discussion

2030/50 Strategy under review

- **GHG -50% by 2050 (2008 level)**
- **Intensity GHG**
  - **-40%** by 2030 (2008 level)
  - **-70%** by 2050 (2008 level)

Fuels LCA. Well-to-Wake under discussion

MEPC80 Jun 2023

EU "FIT FOR 55" PACKAGE

- **"FuelEU Maritime" (GHG intensity)**
- **"Emissions Trading Scheme" (ETS) (carbon trade market)**
- **Under vote/discussion**
- **Applicable for ships plying in EU zone**

Absolute reduction (*Fuel EU*) :

- **GHG -55% by 2030 (1990 level)**
- **Intensity GHG up to -75% by 2050 (2020 baseline)**

Well-to-Wake approach

US CLEAN SHIPPING ACT

- **Part of Clean Air Act**
- **Under vote / discussion**
- **Reduction Carbon intensity (vs. 2024) :**
  - -20% by 2027 ; -45% by 2030 ; -80% by 2035 ; -100% by 2040

Well-to-wake approach

All GHG gas (CO_2, CH_4, N_2O, F-)

IMO

Short – term measures:
- Technical: EEDI, EEXI
- Operational: SEEMP

Medium – term measures:
- Economic: basic in the market
- Technical: low carbon fuels

Long – term measures:
- Zero Carbon fuels

UE

	Legislative process (Adoption)	Application
EU Emisstion Trading System (EU ETS)	Finalized	1st Jan 2024
FuelEU Maritime	Finalized	1st Jan 2025
Alternative Fuel Infrastructure Regulation (AFIR)	Finalized	1st Jan 2025
Renewable Energy Directive (RED)	Not Finalized	
Energy Taxation Directive (ETD)	Not Finalized	

EU Green Deal : "FIT FOR 55"

(55% reductions in EU ei 2030 (compared to 1990))

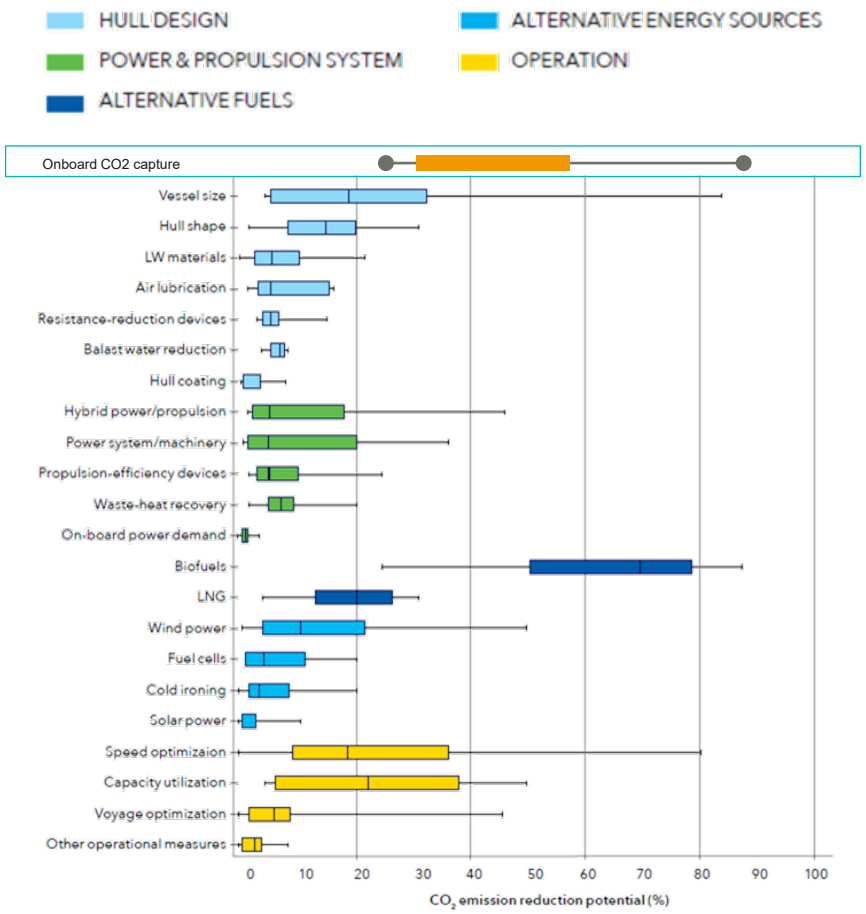
EU ETS : taxes emissions, promotes energy savings
Fuel EU : addresses fuel technology, ship fuel demand

AFIR : Fuel distribution (infrastructure)
RED : Fuel supply
ETD : Taxation level

02

HOW THE RULES CAN HELP US

DECARBONIZATION MEASURES



Energy Efficiency

- Hull shapes
- Propulsion Efficiency devices
- Advanced in machinery
- Batteries
- Air Lubrication
- WHR

…

~ 10-20%

Logistic & Speed

- Speed reduction/slow navigation.
- Capacity
- Trip optimization.
- Alternative routes

…

Alternative fuels

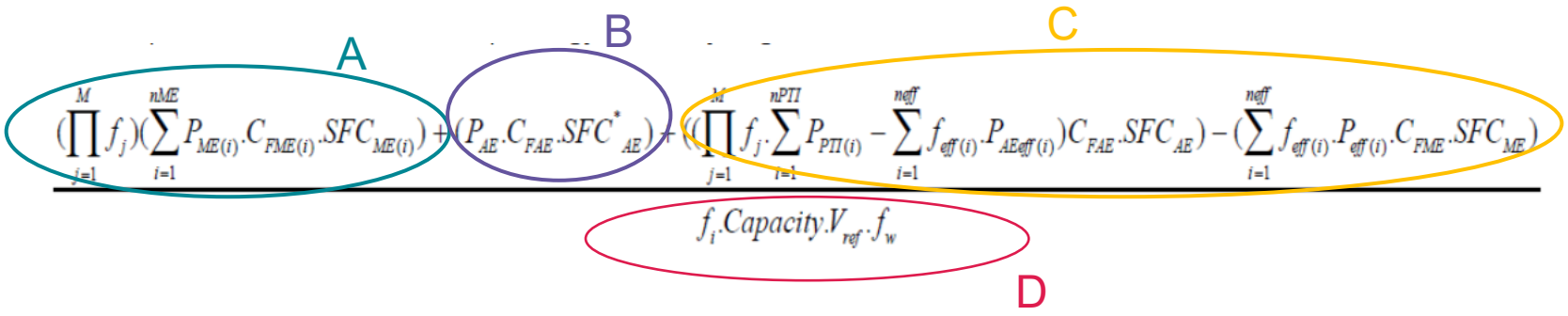
- HFO with scrubbers
- LNG
- Bio fuels (gas or liquid)
- Electricity
- Ammonia
- H2
- CO_2 Capture.
- Nuclear?

…

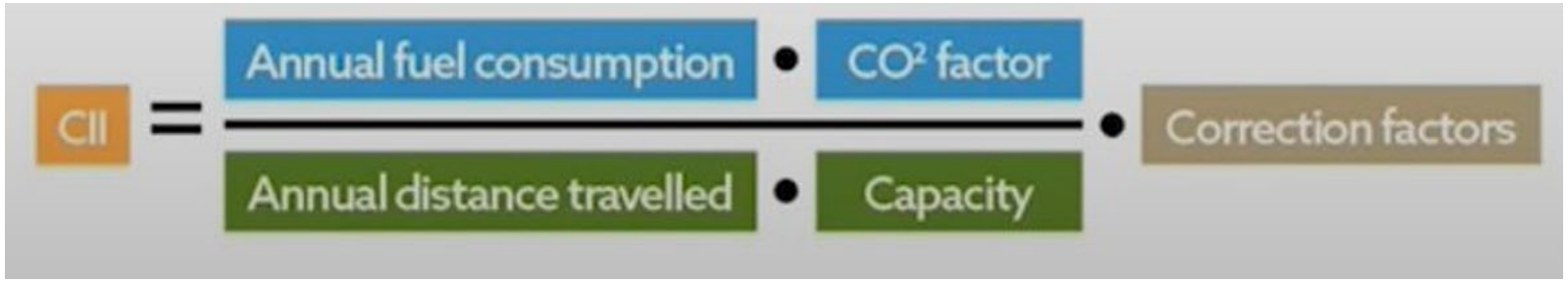
~ up to 80%

REGULATIONS - MEASURES

- **Short – term measures**: Basic on improving energy efficiency
  - EEXI/EEDI:



  - CII:



REGULATIONS - MEASURES

- **To reduce emissions, we can:**

Main Propulsion engine emissions:
· Power
· Fuel
· Energy saving devices

Auxiliary engine emissions:
· Power
· fuels.
· Batteries

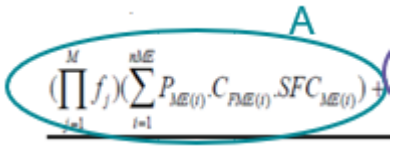
A B C

$$\frac{(\prod_{j=1}^{M} f_j)(\sum_{i=1}^{nME} P_{ME(i)}.C_{FME(i)}.SFC_{ME(i)}) + (P_{AE}.C_{FAE}.SFC^{*}_{AE}) + ((\prod_{j=1}^{M} f_j.\sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)}.P_{AEeff(i)})C_{FAE}.SFC_{AE}) - (\sum_{i=1}^{neff} f_{eff(i)}.P_{eff(i)}.C_{FME}.SFC_{ME})}{f_i.Capacity.V_{ref}.f_w}$$

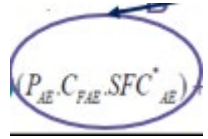
D

Transported work:
· Speed → power/fuel
· Capacity

Shaft generators



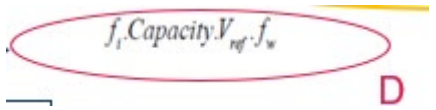
REGULATIONS - MEASURES



Reduce emissions from engines (propulsion and auxiliaries), measures:

- Optimization of Hull shapes → decreasing hull resistance (5-17% / 2%-8%). Applicable to ships in service?
- Power limitation → fuel consumption . Be careful with the reduction of speed – specific consumption and the reserve power. The most important measure to apply in existing vessels (5%-15% saving).
- Energy saving devices - hull and propulsion - → easy retrofit. Higher performance propellers, nozzles, hull appendages, air lubrication, paints, heat recovery systems… (saving: 2-20%).
- Hybridization → batteries. Permanent engine operation. Interesting as a retrofit and new construction (saving between 50 to 90%). Important keys: battery weight, location on board, safety matters (fire risk, gas emissions, …)
- Wind propulsion.
- New fuels.
- CO2 Capture? / Nuclear?

REGULATIONS - MEASURES



<u>Reduce emissions by modifying transport work, mainly logistical measures:</u>

- Focus in exising ships.
- Maintenaince of hull → paints, scheduled cleaning, … (5-25%).
- Trim optimization → power.
- Routes optimization, weather conditions, …

03

NEW FUELS REGULATIONS.

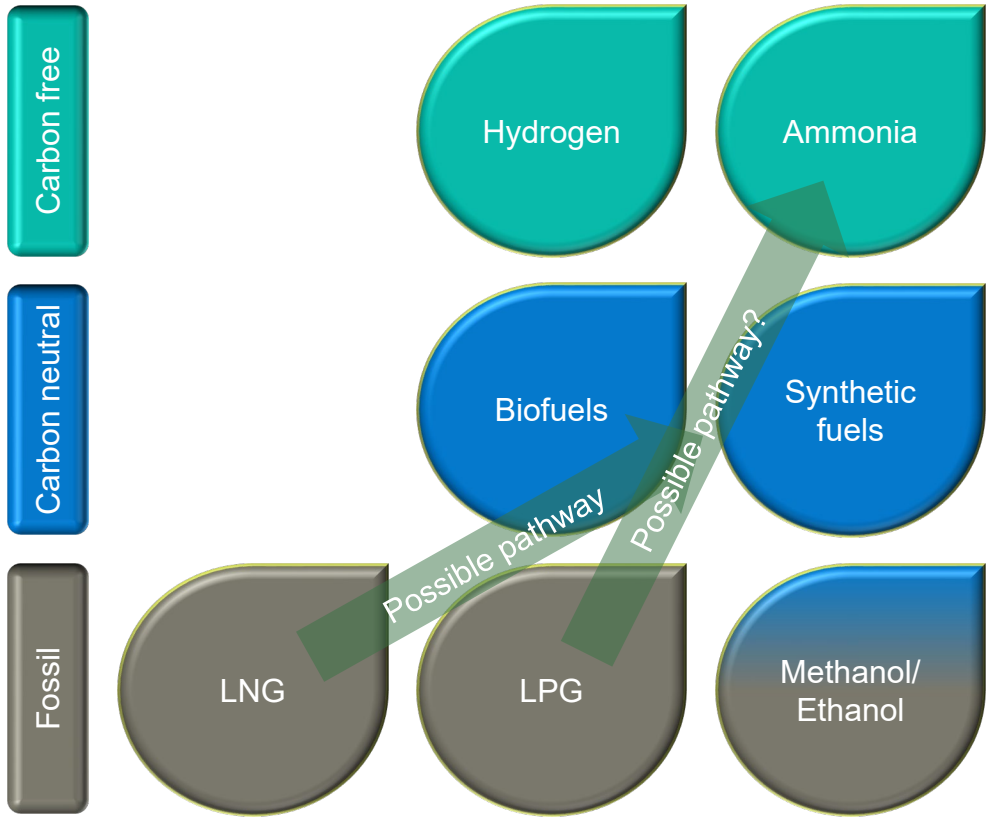
HOW TO REDUCE EMISSIONS ON BOARD?

Alternative fuels, Available?

- The new fuels which the maritime transport is focusing:
  - Bio fuels: to replace the fossil fuels (MDO, MGO, HFO).
  - LNG
  - Methanol.
  - Ammonia
  - Hydrogen

NEW FUELS?

Alternative fuels



Key considerations
Maturity & availability of technology
Specific energy (weight) & density (volume)
Safety considerations (flammability, toxicity)
Regulatory framework
Global availability of fuel (terminal network)
Availability of bunkering facilities
Sustainability (Environmental, Social and Governance/Corporate Social Responsibility aspects)
Economics: CAPEX
Economics: OPEX
Flexibility for future adaptation

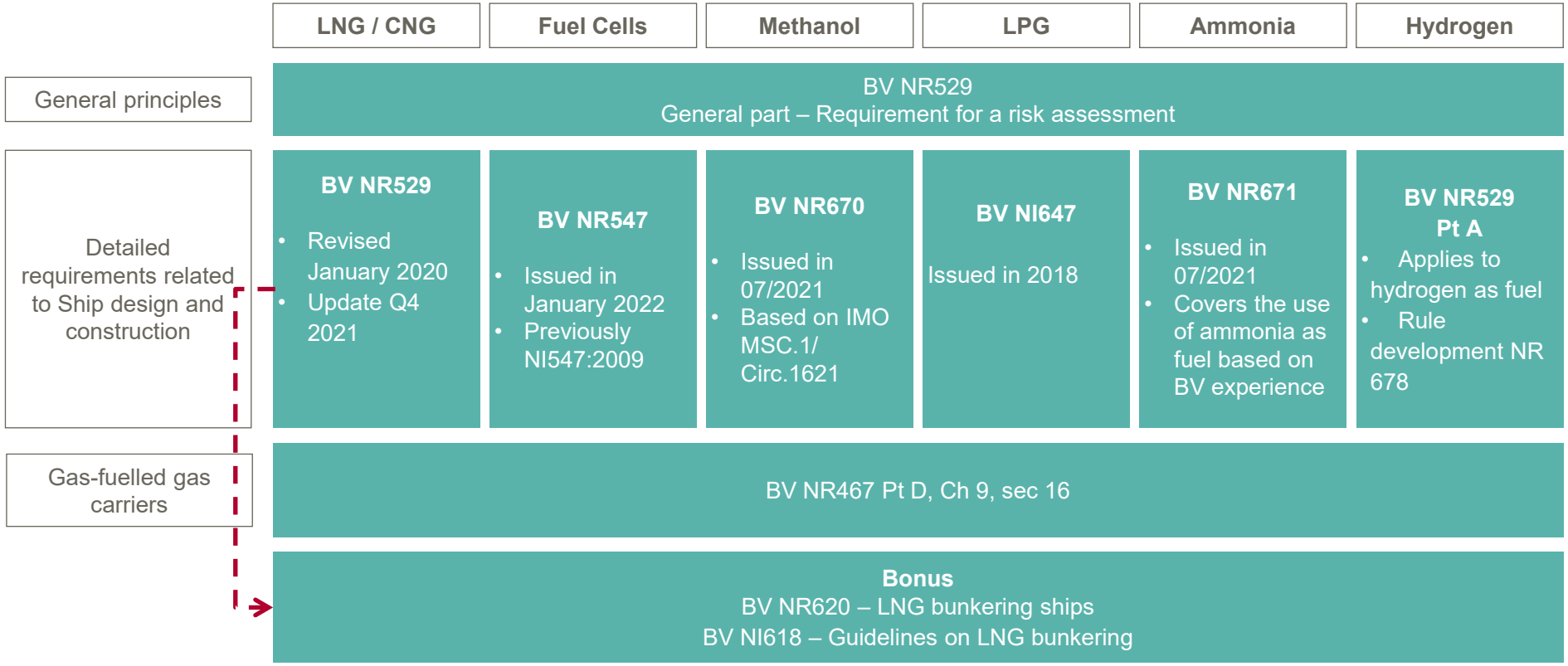
NEW FUELS – DESING RULES

Alternative Fuels: IMO Regulatory Framework

	LNG / CNG	Fuel Cells	Methanol	LPG	Ammonia	Hydrogen
Functional requirements, goals and principles (Ship design, construction and operation)	IGF Code Part A - Detailed risk analysis - Alternative design approach if no detailed requirements available in IGF Code					
Detailed requirements related to Ship design, construction and operation	IGF Code Parts A-1, B-1, C-1	**MSC.1/Circ.1647** • Draft finalized by CCC7 (09/2021) • Approved by MSC105 (04/2022)	**MSC.1/Circ.1621** • Interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel • Approved by MSC102 in November 2020	**Guideline under development** • Work started at CCC6 (2019) • Draft to be finalized at CCC9 (2022) • To be approved by MSC107 (2023) ?	**IMO work item under discussion** • CCC CG is gathering safety information • Decision by MSC105 (04/2022) to develop guidelines	**Guideline to be initiated** Development initiated by the CCC correspondance group dedicated to IGF Code-related matters
Functional requirements and goals related to training	IGF Code Part D					

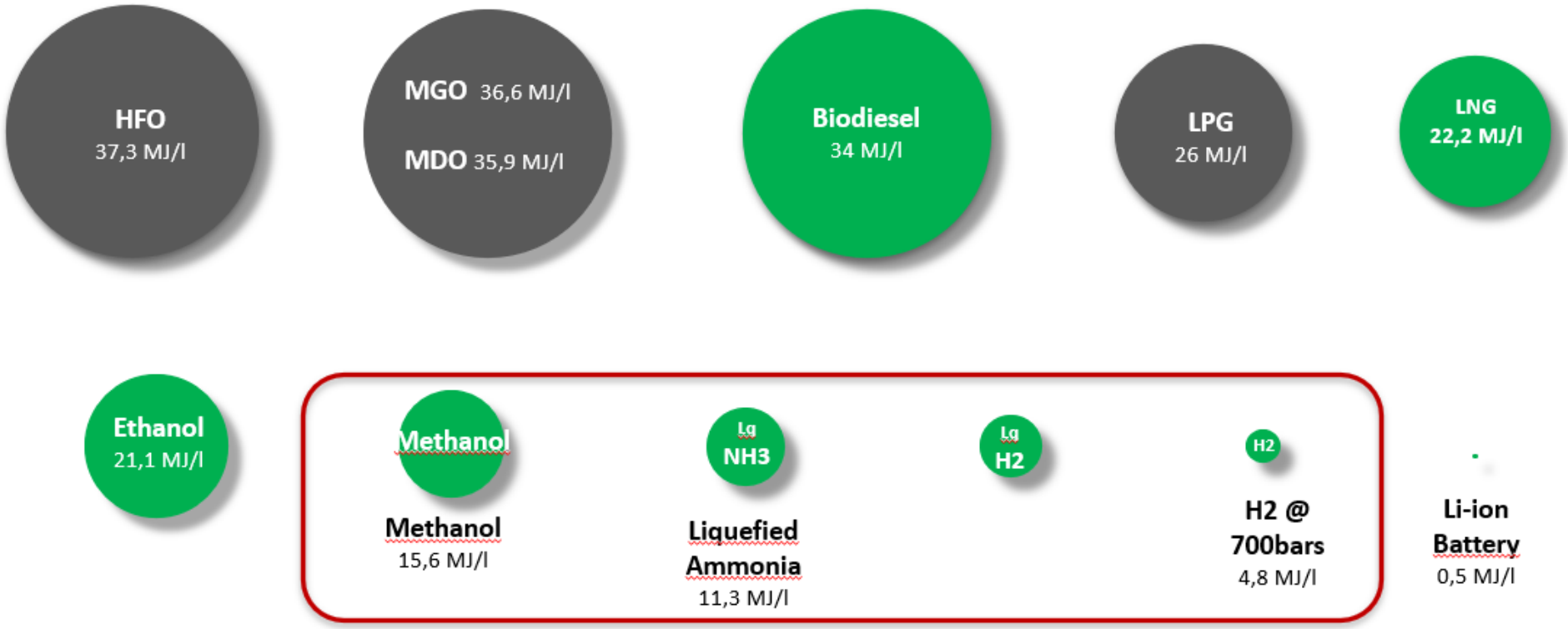
NEW FUELS – DESING RULES

Alternative Fuels: Bureau Veritas Rules



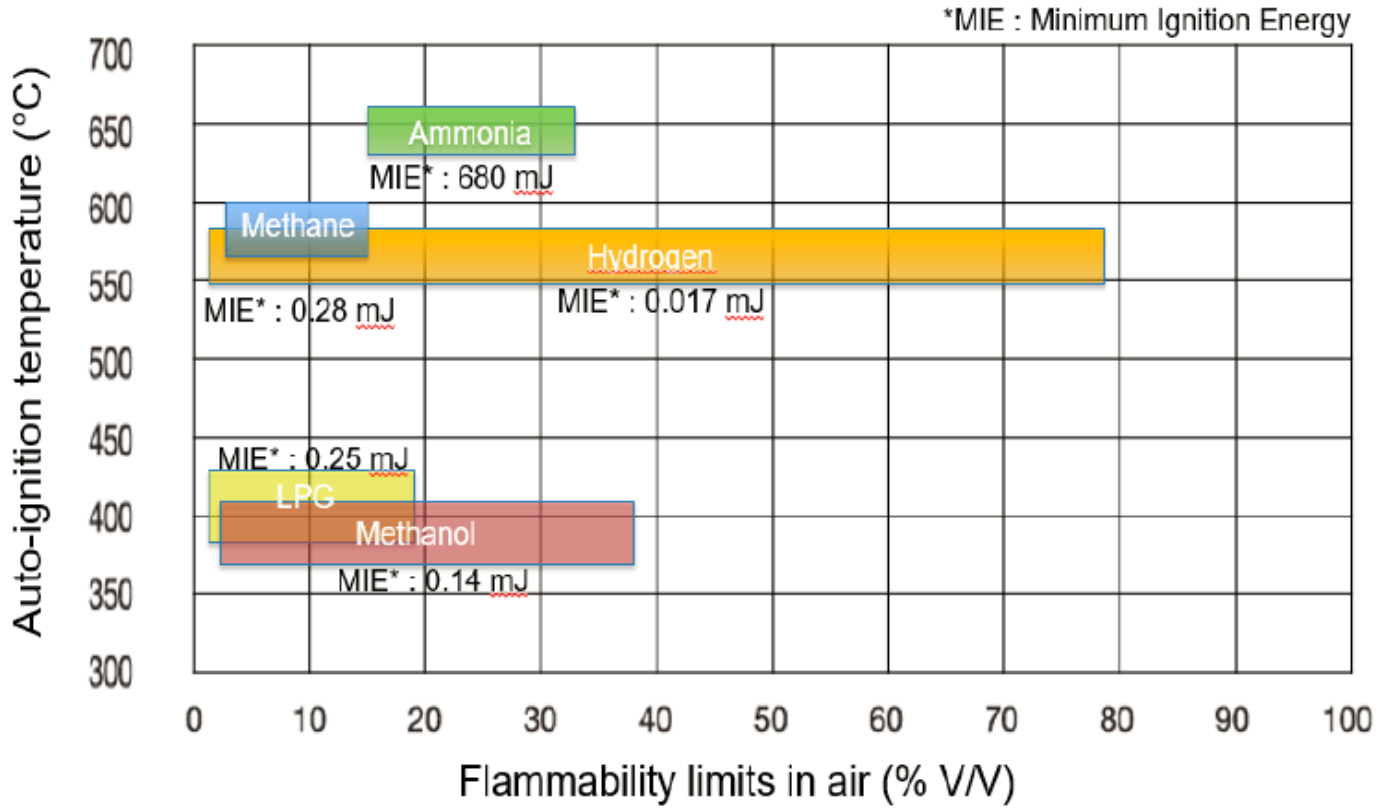
NEW FUELS - CHARACTERISTICS

Alternative Fuels: Volume - energy



NEW FUELS - CHARACTERISTICS

Alternative fuels: Flammability limits/ Ignition



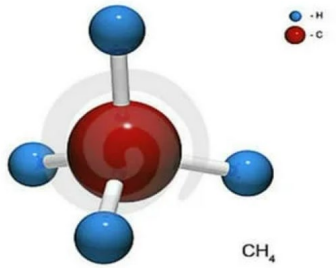
NEW FUELS

Biofuels

- Biofuels:
  - Versatility:
    - *Apply to all vessels!!, (new and existing).*
    - *Liquid: bunkering.*
    - *Full controlled risks*
    - *Same volume*
  - No so much modifications → Current rules applicable without modifications.

NEW FUELS

LNG

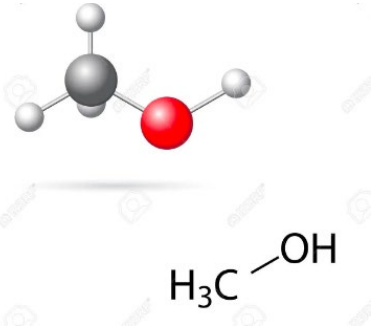


- Considered transition fuel.
  - Developed regulations → there are reliable design guides/rules.
  - Extensive experience in LNG use and transportation. No major accidents recorded.
  - Challenges: “methane slip” reduction:
    - Engine manufacturers very involved and actively working.
    - Standards are being proposed for the actual measurement of methane slip in engines_
      - Improve the CO_2 emissions (equivalent CO_2).
      - The use of this fuel in the world fleet is expanding.
- It will be possible to use biomethane and E – methane (green hydrogen + CO2) → reduction of the emisión in the life cycle.
  - No NOx emissions!!! .

NEW FUELS

Methanol

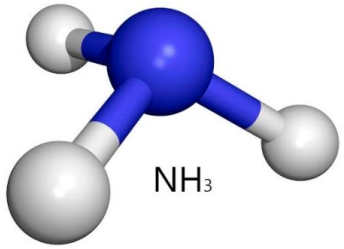
- Methanol will reduce the emissions if it is produced from renewables energies.
  - Design rules developed. They are in use → they are applicable to vessels
  - Advantages:
    - liquid
    - Chemical product widely used in industry process. Known marine transport
    - Infrastructures: the current infrastructures can be adapted with minor modifications.
    - Biodegradable.
    - Available in the marked 2T / 4T engines and retrofitting kits
  - Disadvantage:
    - Volume: 2,5 higher.
    - Almost invisible flame → detection.
    - Toxicity.



NEW FUELS

Ammonia

- Ammonia will reduce the emissions if produced from renewable energies.
  - Rules under development. First ship designs.
  - Advantages:
    - Zero carbon, no SOx, but there are NOx emissions.
    - Chemical product widely used in industry process and refrigeration. Known handling and transport on board of vessel and use as refrigerant in ammonia refrigerating plants → fishing vessels.
  - Disadvantages:
    - Volume: three times.
    - Fire extinguishing systems.
    - High toxicity → Passenger vessels?.
    - There are not engines in the marked. The fuel cells using ammonia are not a mature technology.
    - Low flammability → very careful control of the explosion point in the engines..



NEW FUELS

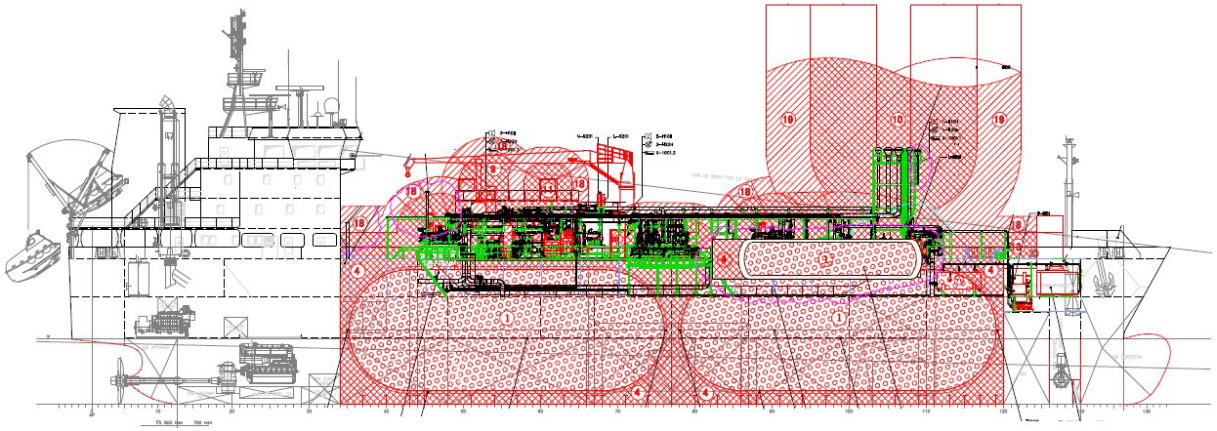
Hydrogen

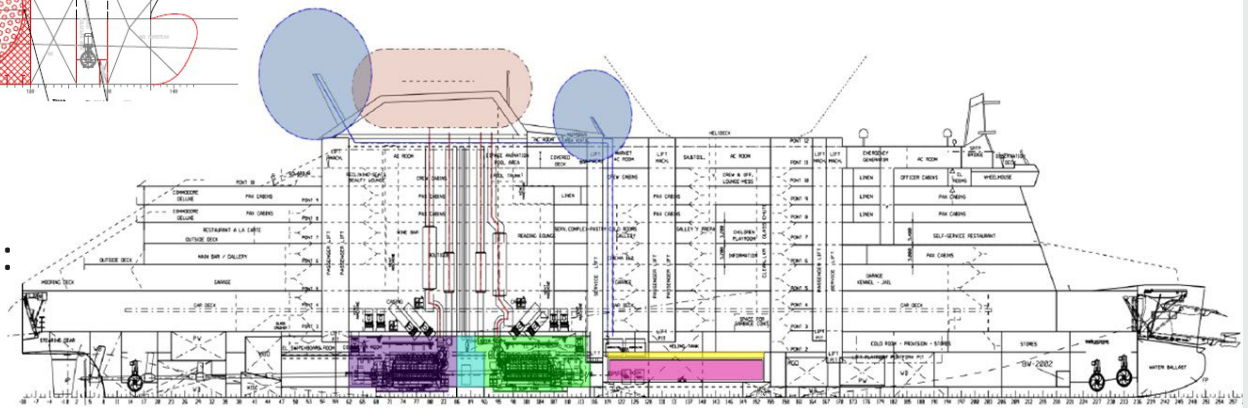
- Hydrogen will reduce the emissions if produced from renewable energies.
  - Rules and design guidelines under development. First ship designs (I+D). No experience.
  - Advantages:
    - Zero carbon, no SOx emissions, no NOx.
    - It could be a solution for inland and cabotage navigation (volume)
  - Disadvantages:
    - Tanks 5-7 higher volume.
    - High flammability → a lot of challenge in safety matters.
    - Invisible flame.
    - The technologies are developing. Fuel cells for marine used limited by power (200 kW?) Manufacturer working in it..
    - Bunkering.
    - Transport.

NEW FUEL GUIDELINES

New Fuels FP<60ºC

- Design guidelines based in the following principles:
  - Tank arrangement: segregation principle.





  - Minimum distance to bottom and sides:

avoid risk when collision or grounding

NEW FUEL GUIDELINES

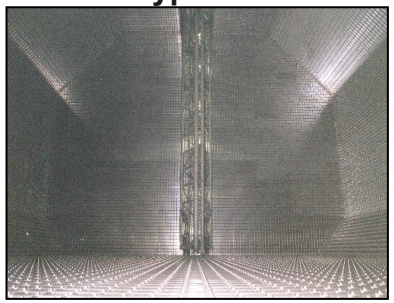
New Fuels FP<60ºC

- Compatibility of materials principle. Tanks:
  - Tanks types: based on the fuel. Compatibility of materials.

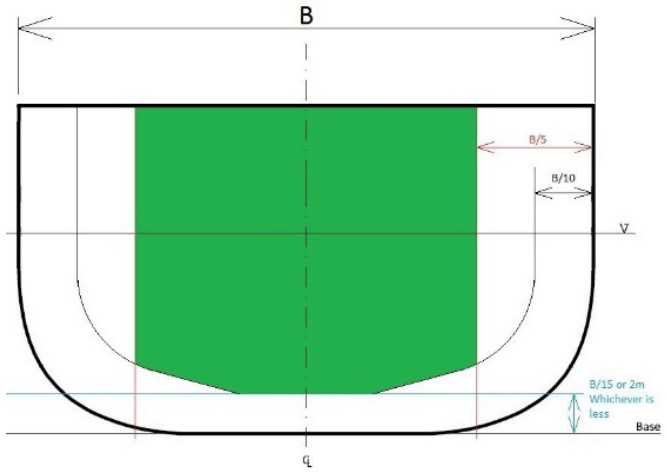
Type C

Typeo B

Type A



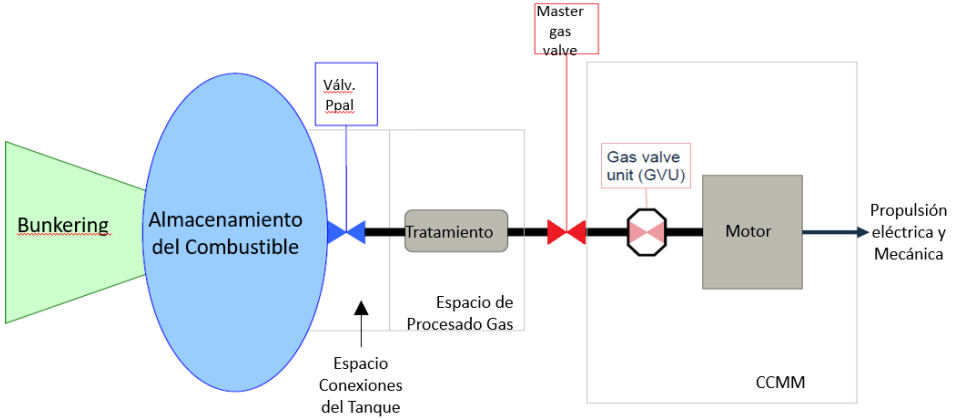
Membrane

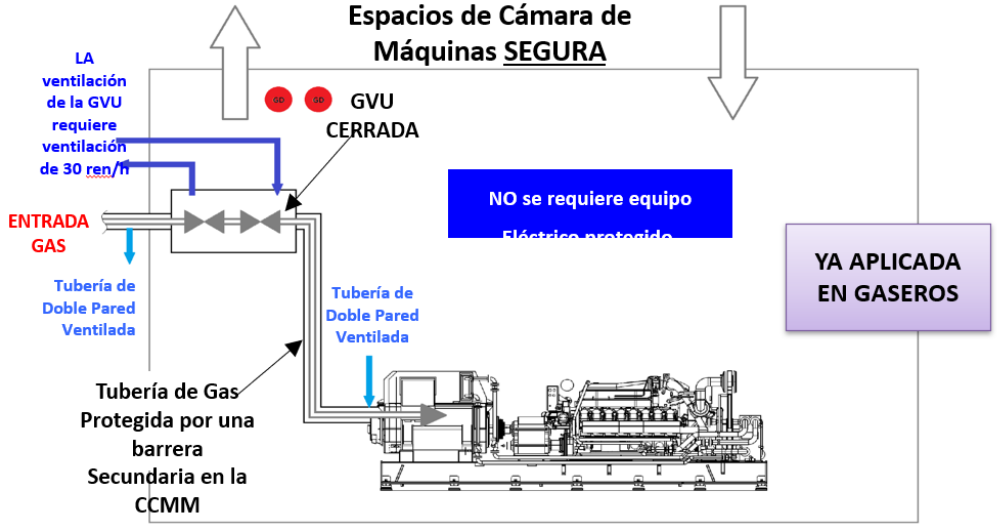


NEW FUEL GUIDELINES

New Fuels FP<60ºC

- Safety principle:
  - Piping design (double wall), safety machinery spaces …:





NEW FUEL GUIDELINES

New Fuels FP<60ºC

- Safety principle:

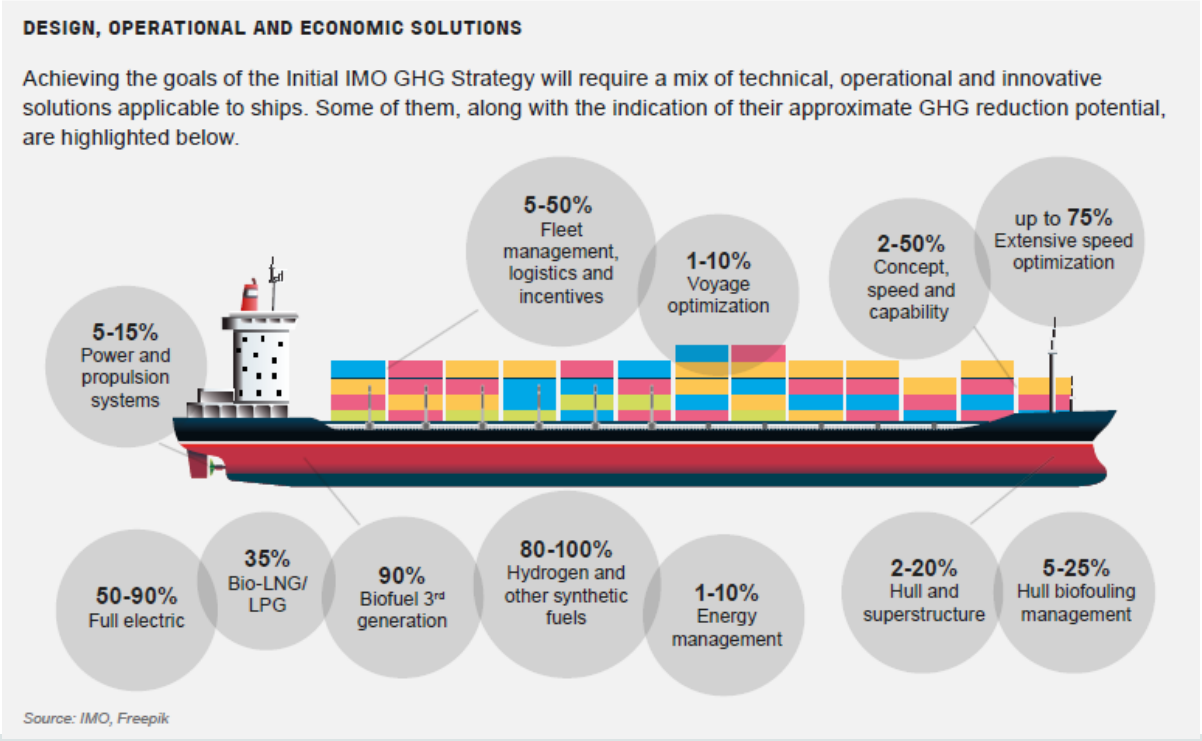
  - Risk analysis. In new design mandatory.
  - Hazardous areas definition → depending on the fuel.
  - Ventilation system design, Ventilation mast → extended hazardous areas, location, limitations…
  - Ex Electrical equipment → de energization. Disconnection of electrical equipment if gas detection.
  - Toxicity → Zero leakage philosophy.
  - Material compatibility.
  - ….
  -

04

CONCLUSIONS / SUMMARY

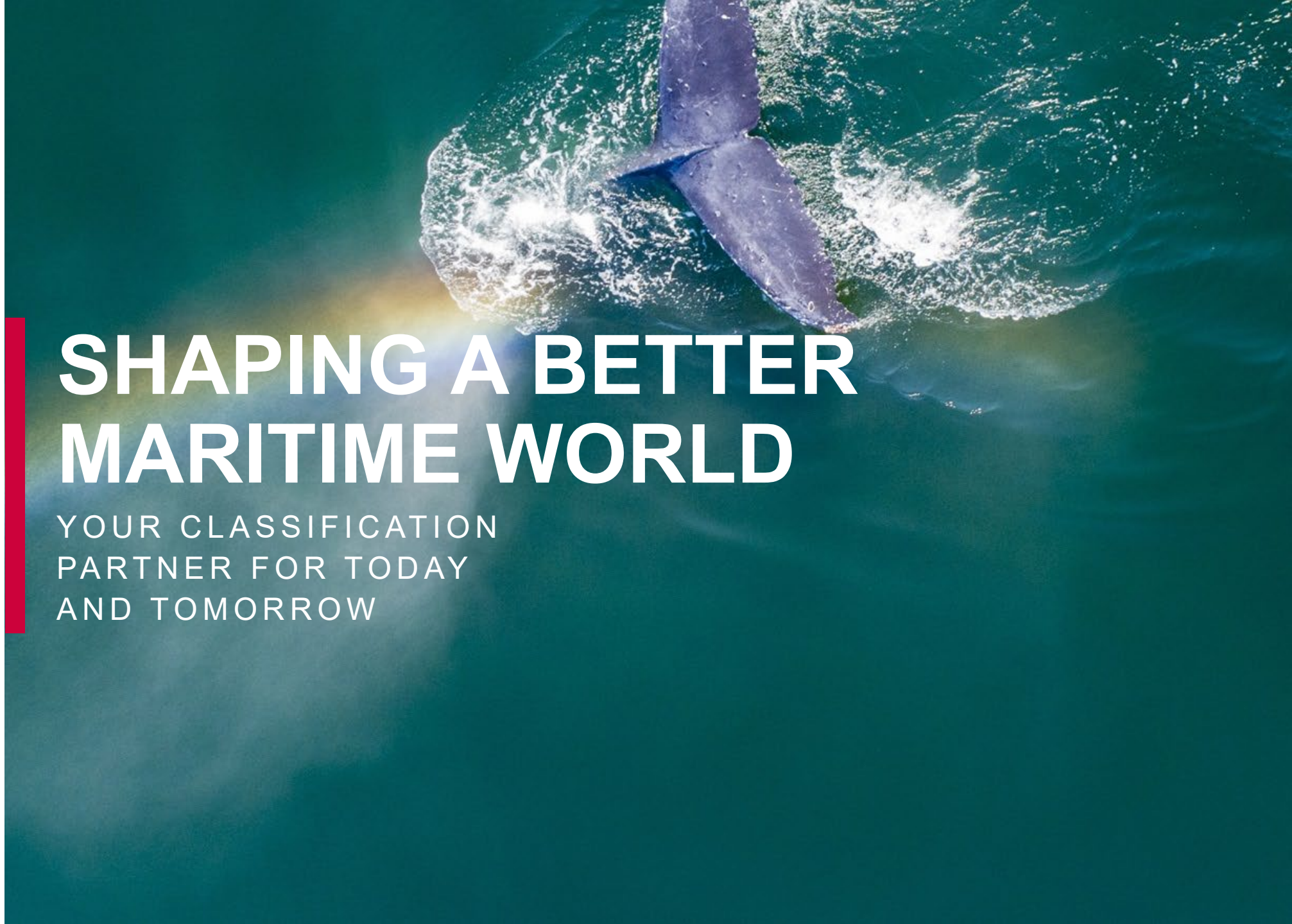
CONCLUSIONS

- To achieve the goals proposed by IMO / EU: will be needed using several decarbonization measures **mixed several Solutions: technical and operacionals and inovation.**



CONCLUSIONES / SUMMARY

- **There are technologies to be able to comply with regulations in the coming years → mainly ships in service.**
- **Interesting to study or valuate several measurements: CAPEX and OPEX studies should be present in the new projects and modification of the existing vessels.**
- **Final solution: new fuels.**
- **New fuels mainly characteristics to be considered in the designs:**
  - The volume use for storing is higher than fossil fuels.
  - New design Philosophy: focused on the flammability and toxicity.
  - What will the final new fuel be to use? → complicate decision.
  - Challenge in the design, transport and bunkering.



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