# Retos en el Retrofit de buques para la utilización de combustibles alternativos.

# Challenges in the retrofit of ships for the use of alternative fuels.

**64º Congreso Internacional de Ingeniería Naval e Industria Marítima**

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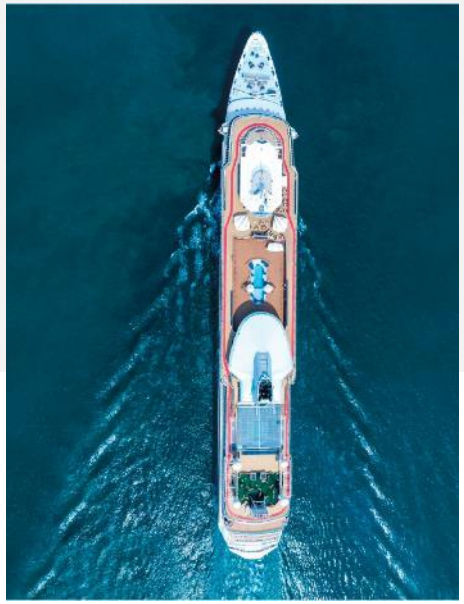
**Montserrat Espín. Bureau Veritas.**

# SUMARY



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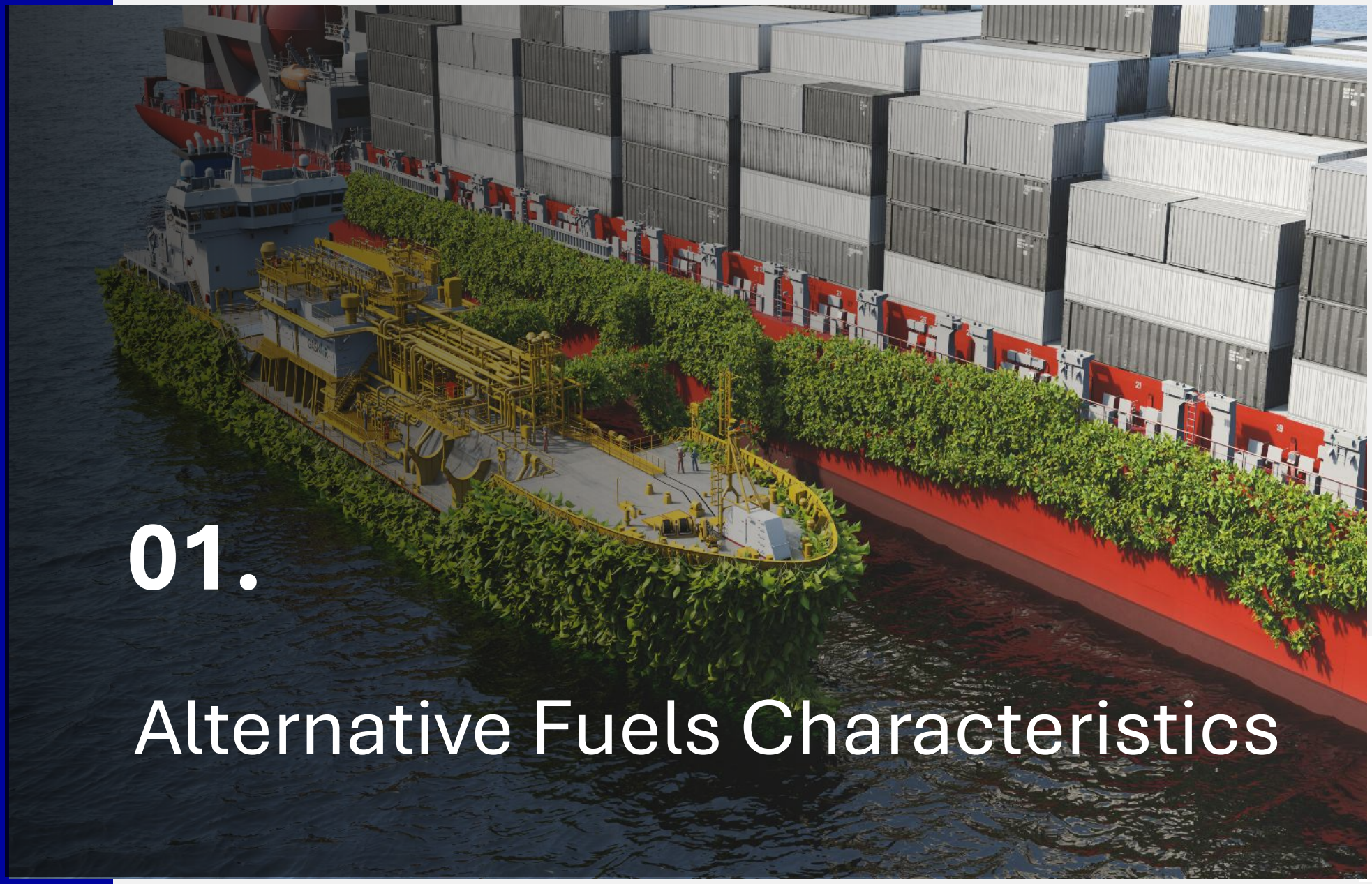


# 01.

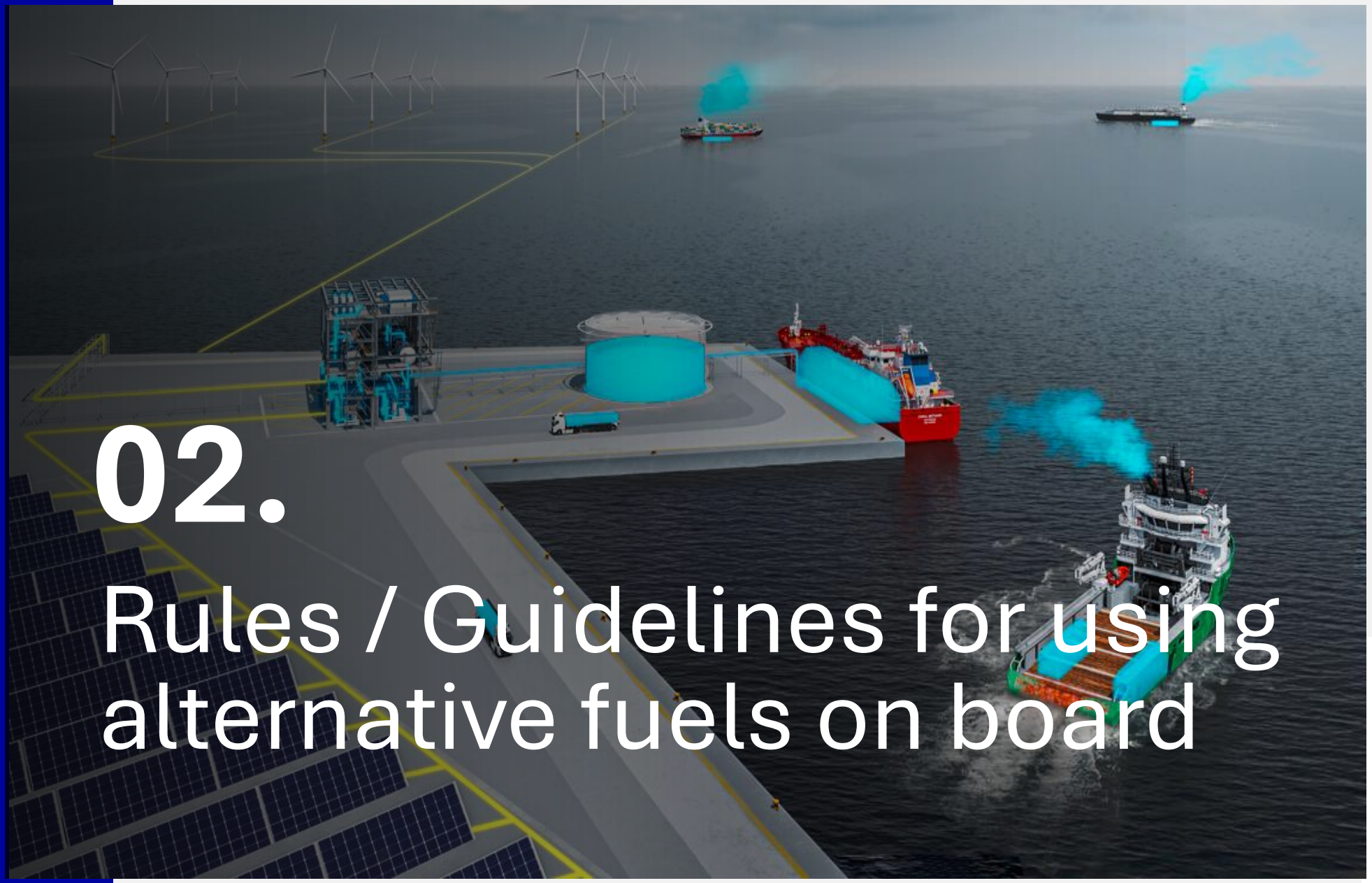
# Alternative Fuels Characteristics

# ALTERNATIVE FUELS CHARACTERISTICS

**TYPICAL PROPERTIES OF MAIN ALTERNATIVE FUELS**

| | LNG | LPG | Methanol | Bio-Diesel | Ammonia | Hydrogen |
|---|---|---|---|---|---|---|
| Physical properties for storage | Liquid at -162°C | Liquid at 18 bar or at -42°C or semi-20°C at 7 bar | Liquid (up to 65°C) | Liquid | Liquid at -33°C | Compressed gas at > 250 bar or liquid at -253°C |
| Fuel tank size for same energy content as MDO | 1.8 times | 1.5 times | 2.5 times | 1 time | 3 times | 5-7 times |
| Fuel Containment System (Cryo/ conventional) | CRYO | COLD | CONV | CONV | COLD | CRYO |
| Flammability limits in air (%V/V) | 5%-15% (Methane) | 1% to 11% | 6%-36.5% | / | 15%-28% | 4-75% |
| Minimum Ignition Energy (mJ) | 0.3 (Methane) | 0.25 | 0.14 | / | 8 to 680 | 0.017 |
| Flashpoint (°C) | -188 | -104 | 12 | >61 | 132 | |
| Density of liquid phase (kg/m$^3$) | 450 | 493 | 790 | 900 | 696 | 71 |
| LCV (MJ/kg) | 50 | 46.4 | 19.9 | 42.7 | 18.6 | 120 |
| Energy density (MJ/L) | 21.2 | 26.5 | 15.7 | 35.7 | 12.7 | 8.5 |

*Source: Bureau Veritas*



# 02.

# Rules / Guidelines for using alternative fuels on board

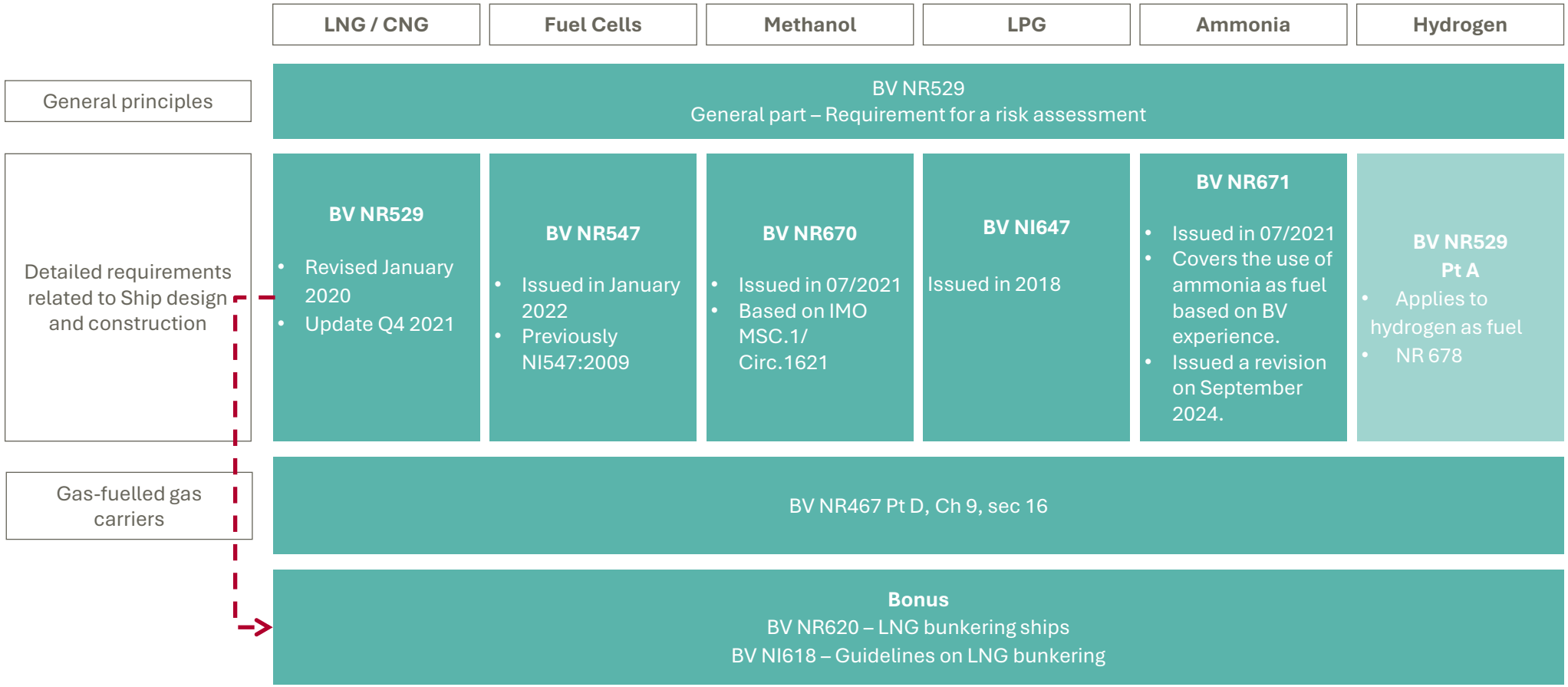
# ALTERNATIVE FUELS

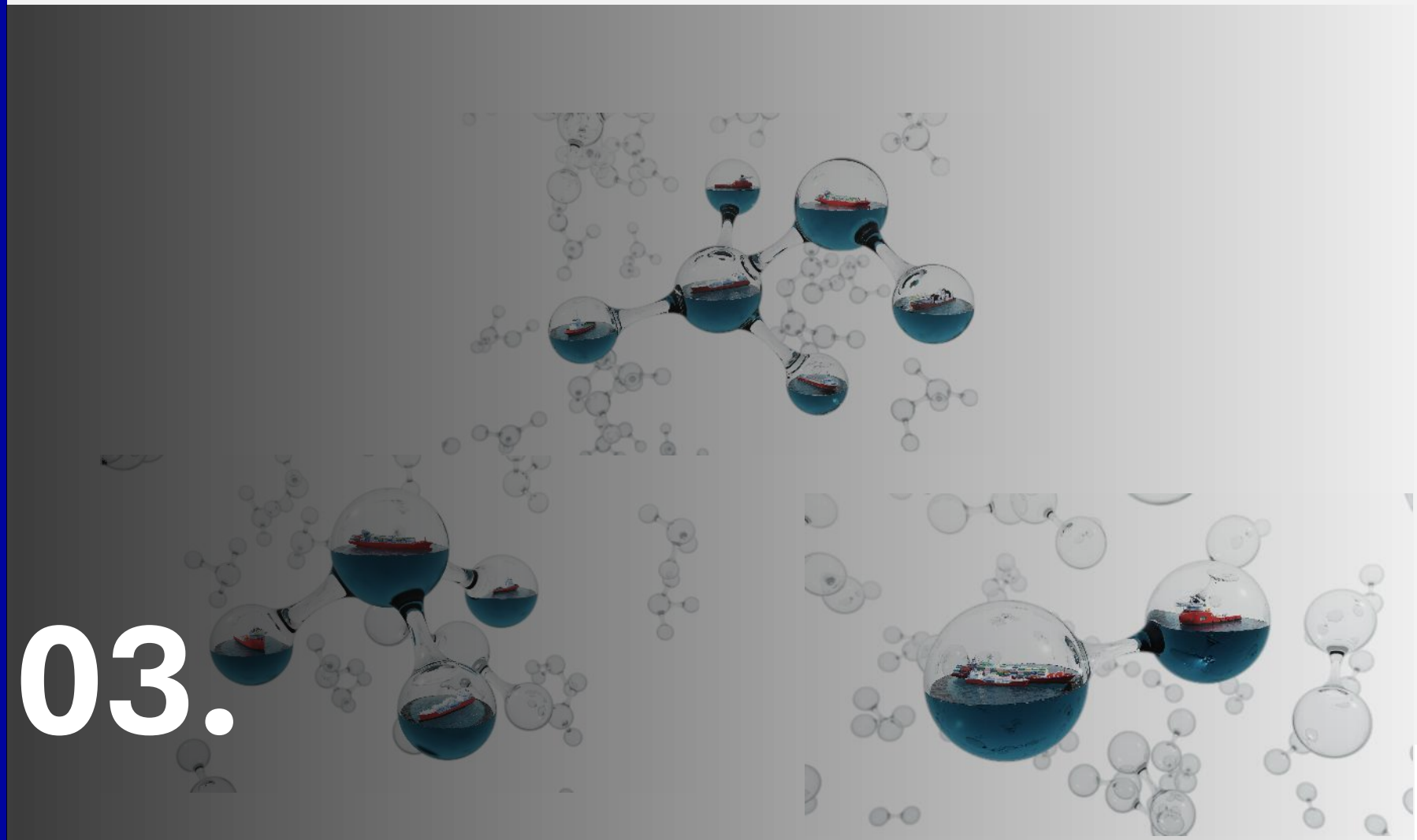
## Alternative Fuels Rules Framework: IMO

| | LNG / CNG | Fuel Cells | Methanol | LPG | Ammonia | Hydrogen |
|---|---|---|---|---|---|---|
| Functional requirements, goals and principles (Ship design, construction and operation) | IGF Code Part A<br>- Detailed risk analysis<br>- 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**<br>• Draft finalized by CCC7 (09/2021)<br>• Approved by MSC105 (04/2022) | **MSC.1/Circ.1621**<br>• Interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel<br>• Approved by MSC102 in November 2020 | **Guideline under development**<br>• Work started at CCC6 (2019)<br>• Draft to be finalized at CCC9 (2022)<br>• To be approved by MSC107 (2023) ? | **MSC.1/Circ.1687**<br>Interim guidelines for safety of ships using ammonia as fuel.<br>(February 2025) | **Guideline to be initiated**<br>Development initiated by the CCC correspondance group dedicated to IGF Code-related matters |
| Functional requirements and goals related to training | IGF Code Part D | | | | | |

# ALTERNATIVE FUELS

## Alternative Fuels Rules Framework: BV





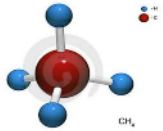
# 03.

# Challenges in the retrofit

# MAIN CHALLENGES

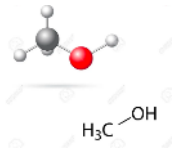
| Main Challenges |
| --- |
| 1. Fuel storage and handling → space, toxicity, flammability |
| 2. Engine modifications → dual fuel engines, adapting existing engines, new equipement |
| 3. Infrastructure & bunkering |
| 4. Operation → energy density, combustion characteristics, flammability, …. |
| 5. Crew training and operational procedures. |
| 6. Life cost and payback period |
| 7. Safety and Regulatory compliance |

# LNG

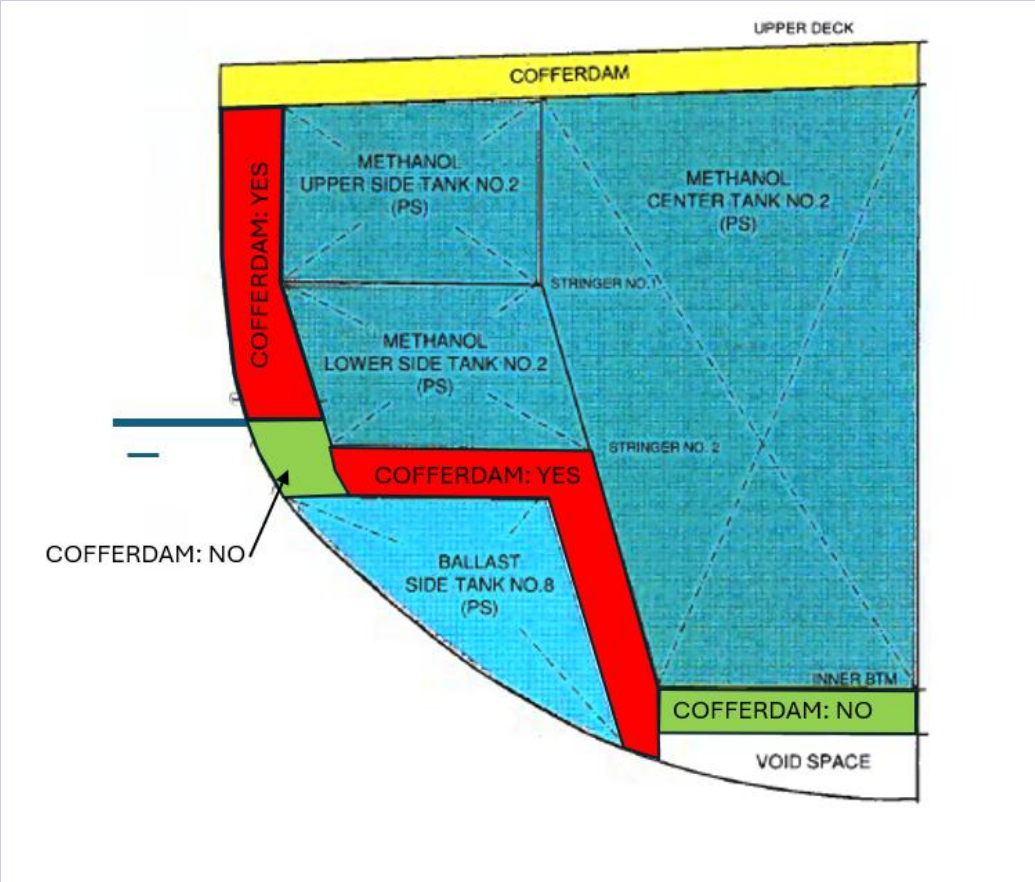


| LNG | | |
|---|---|---|
| | Fuel storage and handling | 1,8 times; liquid (-163 C). In retrofit, usually, tanks type C in the open deck. In containers, cargo space used for installing the tanks.<br>Location according to IGF (NR529)<br>Segregation → ventilation mast<br>Use of double wall piping.<br>Hazardous areas → small vessels. |
| | Engine modifications | Several dual fuels available in the market.<br>Space → preparation room, …<br>Safe machinery space / ESD.<br>Ventilation, detection, several machinery spaces, …. |
| | Infrastructure & bunkering | Available in Europe, America, …. |
| | Operation | Lower autonomy (new routes, ports, …). Hazardous areas. … |
| | Crew training and operational procedures | |
| | Safety and Regulatory compliance | IMO rules: IGF<br>BV NR529 |

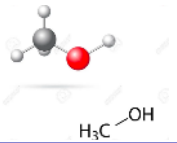
# METHANOL




| METHANOL | | |
|---|---|---|
|  | Fuel storage and handling | 2,5 times; liquid. Requirements for tanks → Cofferdams |

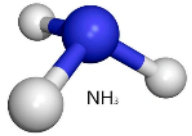


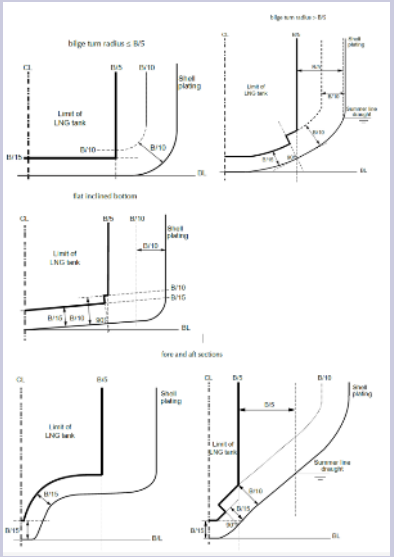
# METHANOL



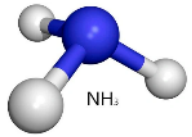

| METHANOL | | |
|---|---|---|
| | Fuel storage and handling | Segregation: if structural failure, methanol not spread in other spaces → cofferdams (between fuel tanks and machinery spaces).<br>Ventilation mast → extended hazardous areas (Gas dispersion analysis).<br>Double wall piping.<br>Hazardous areas(FP 11ºC)<br>Invisible flames → detection.<br>Tank inerting.<br>Access: air locks, direct access to fuel tanks and cofferdams. |
| | Engine modifications | Several dual fuels available in the market. |
| | Infrastructure & bunkering | Green methanol??. No special requirements. Liquid. |
| | Operation | Lower autonomy 2,5 times (new routes, ports, …). Hazardous areas. |
| | Crew training and operational procedures | |
| | Safety and Regulatory compliance | IMO rules: IGF / BV NR529<br>IMO MSC.1/Circ.1621 (Interim Guidelines) / NR670 |

# AMMONIA




| AMMONIA | | |
|---|---|---|
| | Fuel storage and handling | Tanks: Type A (refrigerated) or Type C (pressure or/and refrigerated).<br>   <br>Location → in accordance with NR529 or ICG.<br>  |

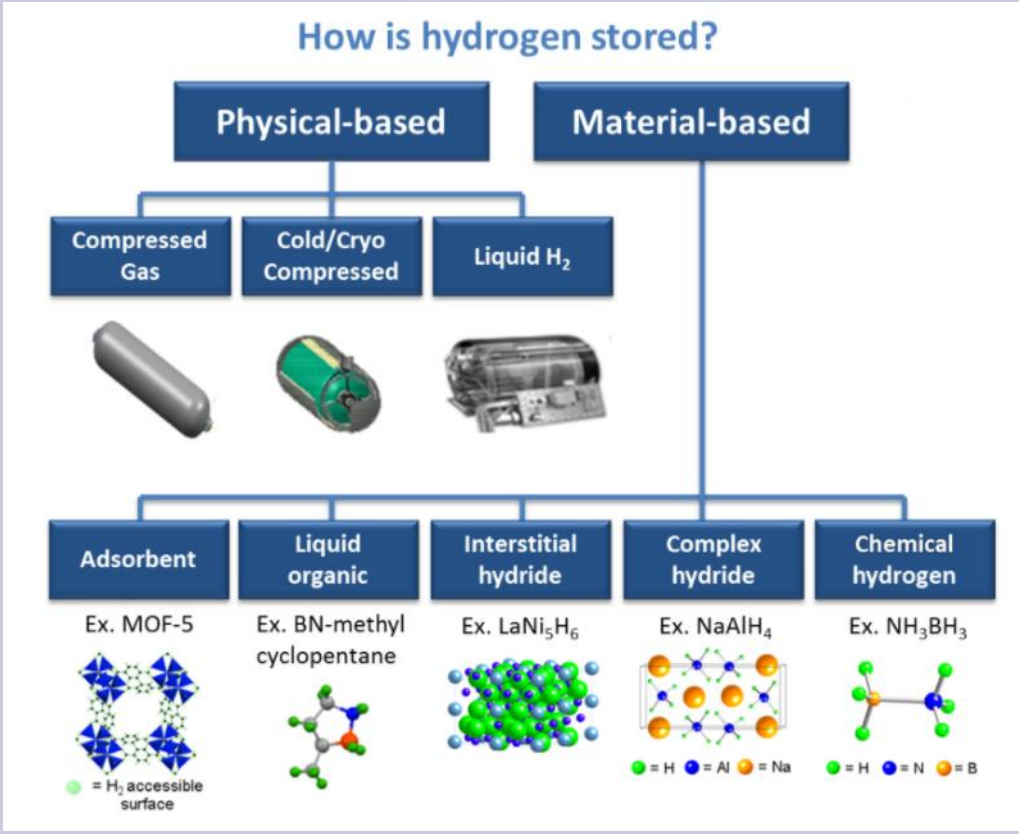
# AMMONIA




| AMMONIA | | |
|---|---|---|
| | Fuel storage and handling | Tanks: Type A (refrigerated) or Type C (pressure or/and refrigerated).<br>Ventilation mast → extended hazardous areas (Gas dispersion analysis).<br>Double wall piping → inside and outside –> Zero leak philosophy<br>Material compatibility: cooper & cooper alloys. Steel Ni>5%.<br>Unattended machinery spaces → inertizing. Maintain? Repair?<br>Non water – based fire extinguishing systems.<br>Access: air locks, direct access to fuel tanks and cofferdams. |
| | Engine modifications | Limited dual fuels available in the market. |
| | Infrastructure & bunkering | Green ammonia??. No available |
| | Operation | Lower autonomy 3 times (new routes, ports, …). Hazardous areas. |
| | Crew training and operational procedures | No developed. Experience in the Maritime sector, transporting ammonia. |
| | Safety and Regulatory compliance | IMO rules: IGF / BV NR529<br>IMO MSC.1/Circ.1687 (Interim Guidelines) / NR671 |

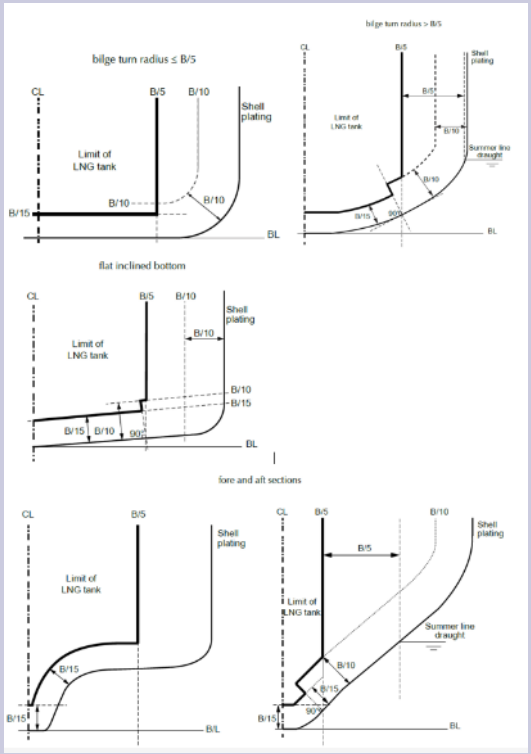
# HYDROGEN

| HYDROGEN | | |
|---|---|---|
| 😐 | Fuel storage and handling | Liquid / Gas / Volume / Space? |



# HYDROGEN

| HYDROGEN | | |
|---|---|---|
| | Fuel storage and handling | Location → in accordance with NR529 or ICG. |



# HYDROGEN

| AMMONIA | | |
|---|---|---|
| ☺ | Fuel storage and handling | Machinery Space: safe machinery concept.<br>Ventilation of spaces: prevent accumulation of H2. Inclined<br>Air pipes / ventilation ducts: small curvature radio.<br>Inerting systems to be provided. Monitoring leakages.<br>No contact between inert gas and H2 to cryogenic temperatures.<br>Fire detection → No flame.<br>Water spray system for cooling and fire prevention if H2 storage tanks on open deck.<br>Double wall piping → separated from side and bottom. Ventilated or inerted<br>Material compatibility: embrittlement.<br>Unattended machinery spaces → inertizing. Maintain? Repair?<br>Non water – based fire extinguishing systems.<br>Access: air locks, direct access to fuel tanks and cofferdams. |
| ☹ | Engine modifications | Limited dual fuels available in the market. Fuel cells Power limited |
| ☹ | Infrastructure & bunkering | Green Hydrogen??. No available for fuel purpouse |

# HYDROGEN

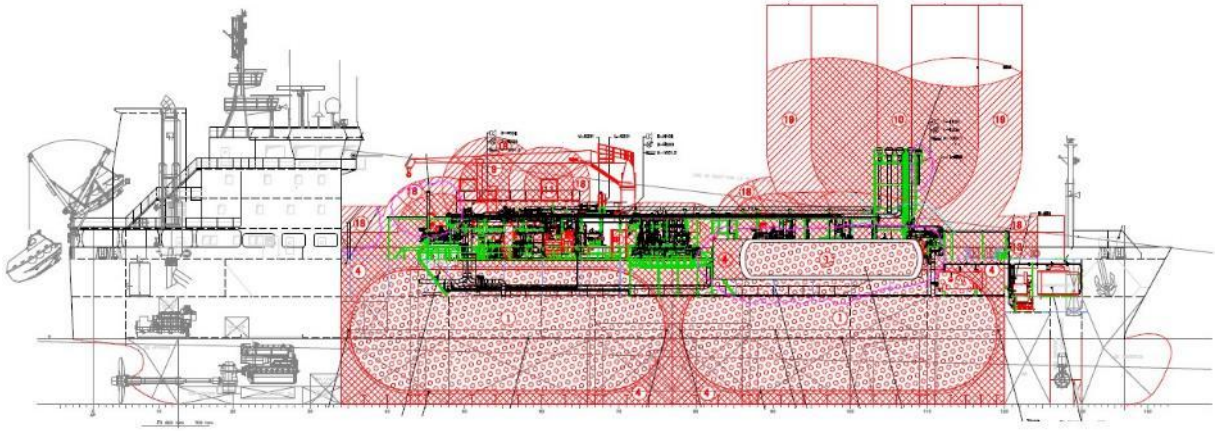
| HYDROGEN | | |
|---|---|---|
| 😐 | Operation | Lower autonomy 5/7 times (small vessels, short routes, ….<br>Hazardous areas. |
| ☹ | Crew training and operational procedures | No developed. No experience in maritime transport. |
| 😐 | Safety and Regulatory compliance | IMO rules: IGF / BV NR529<br>IMO under development/ NR678 and NR547 |

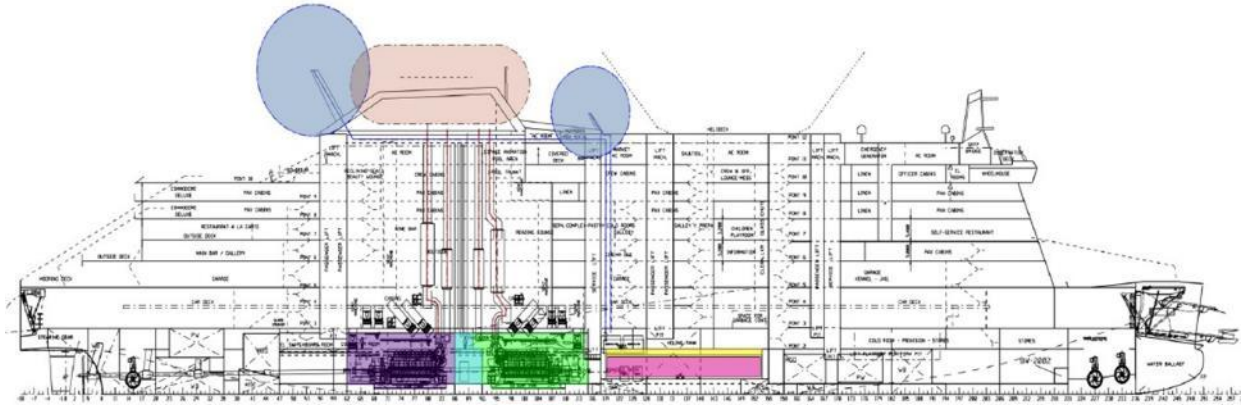
# 04.

# Conclusions

# CONCLUSIONS

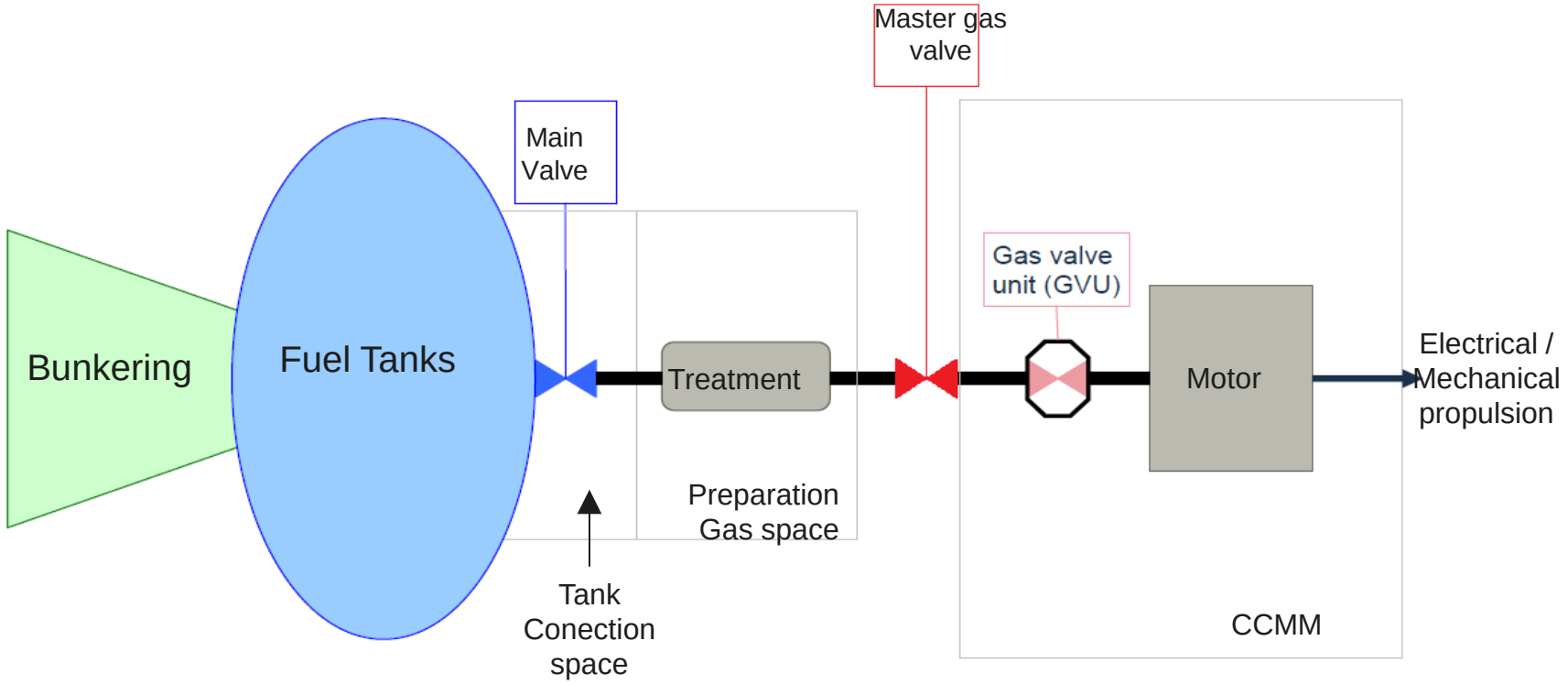
- General provisions used in retrofit of LNG vessels can be used:
  - Segregation Principle: avoid leakage of fuel to spaces where it is not present





# CONCLUSIONS

- General provisions used in retrofit of LNG vessels can be used:
  - Propulsion System:



# CONCLUSIONS

- Main challenges are not only technical also:
  - production of green alternative fuels.
  - Availability in the port facilities.
  - Prices
- Challenges:
  - Space → limited space in retrofit.
  - Hazardous areas → segregation is not easy.
  - Additional machinery → preparation rooms, …Space?
  - The fuel tanks are only re used in methanol → cofferdams!!!
  - Leakage → control to avoid explosions or toxicity.
- No all technologies have engines in the market (hydrogen, ammonia (limited)). Internal diesel engines / fuel cells to develop

- The experience handling these combustibles is limited → used experience handling LNG!!!
- Retrofitting? → experience with LNG.

- **We are starting the journey …**

Shaping a World of Trust

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