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C4FF

Developing the Future

Figure 1. The Transport Hierarchy: A Cross-Modal Strategy to Deliver a Sustainable Transport System

https://www.marifuture.org/Publications/Papers/imeche-transport-hierarchy-report.pdf

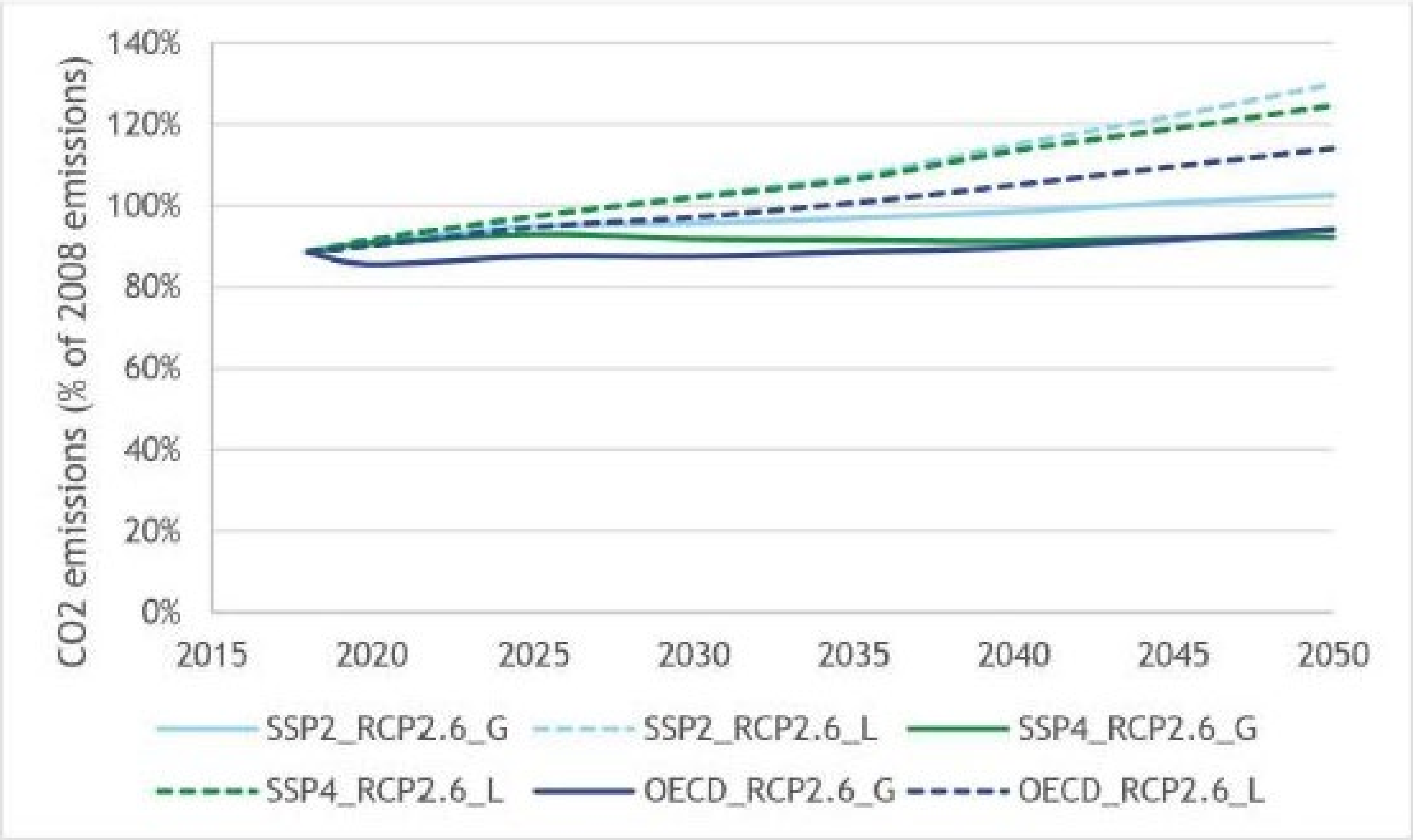


Figure 2. Potential Fuel use and CO_2 reduction from various efficiency approaches for shipping vessels Source: Wang and Lutsey, 2013

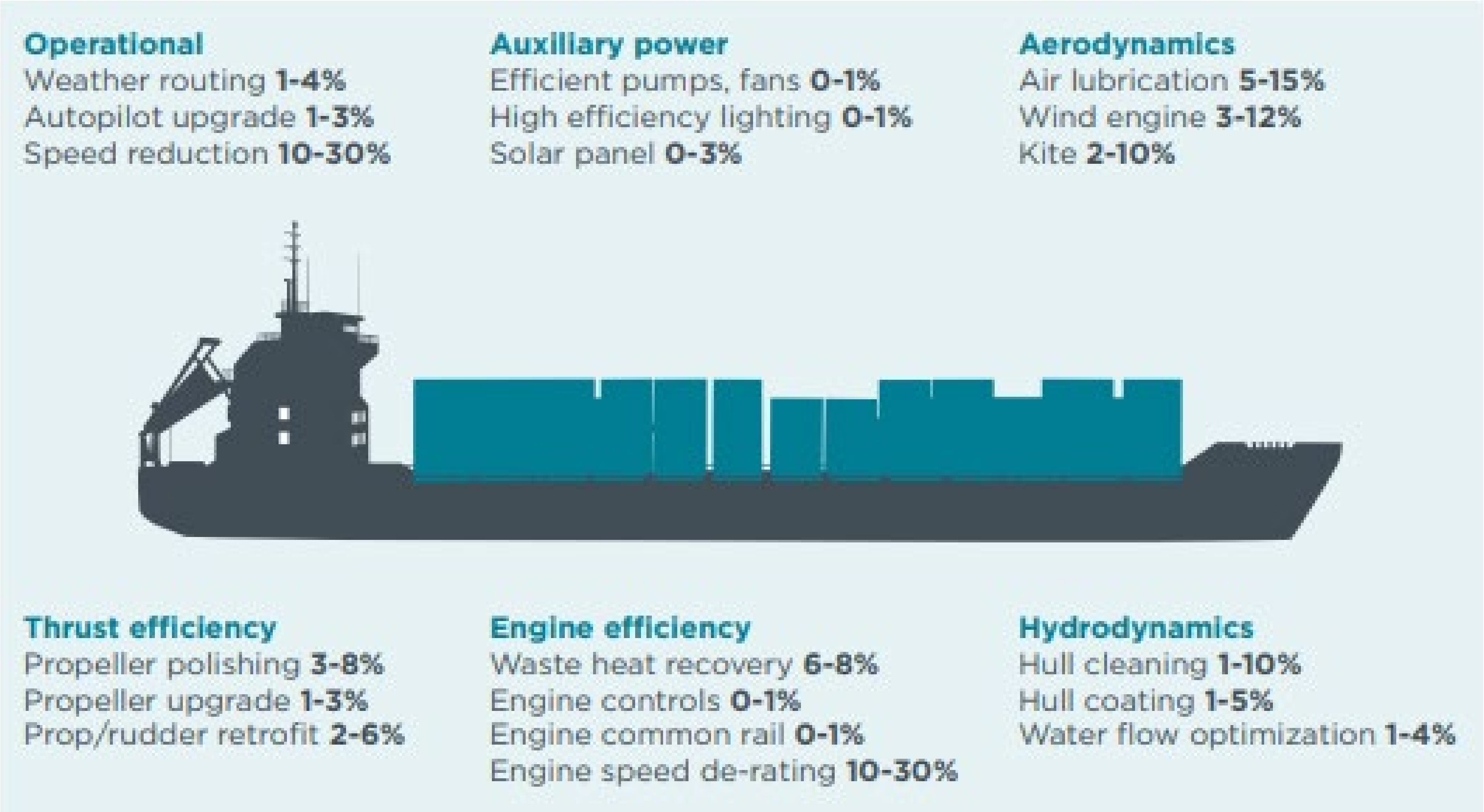
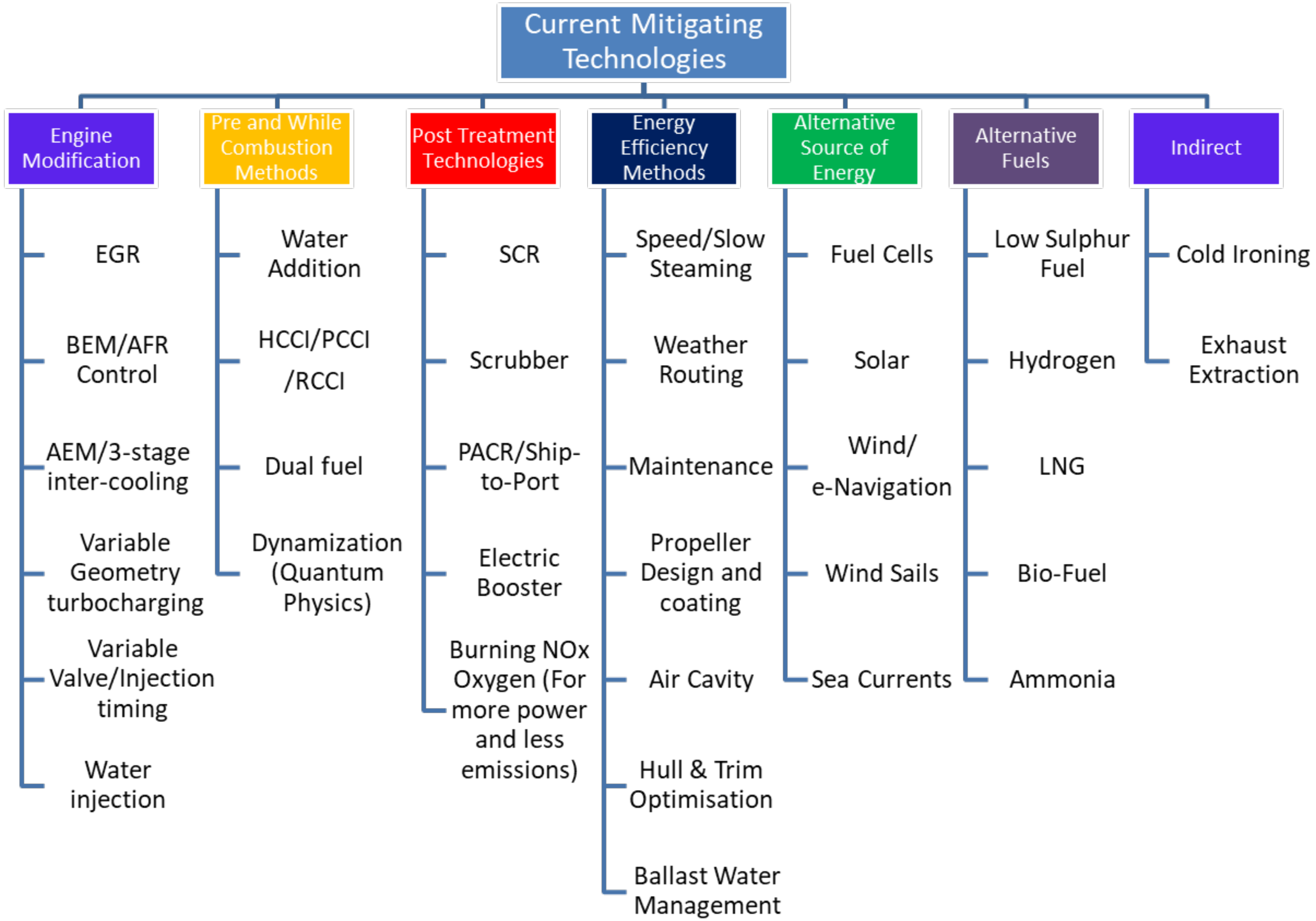


Figure 3 Current mitigation technologies in marine industry



Nomenclature:

EGR - Engine Gas Recirculation

BEM - Before Exhaust Method

AFR - Air Flow Ratio

AEM - After Exhaust Method

HCCI/PCCI/RCCI - Homogeneous Charge Compression Ignition/Pre-mixed Controlled Compression Ignition/Reactivity Controlled Compression Ignition

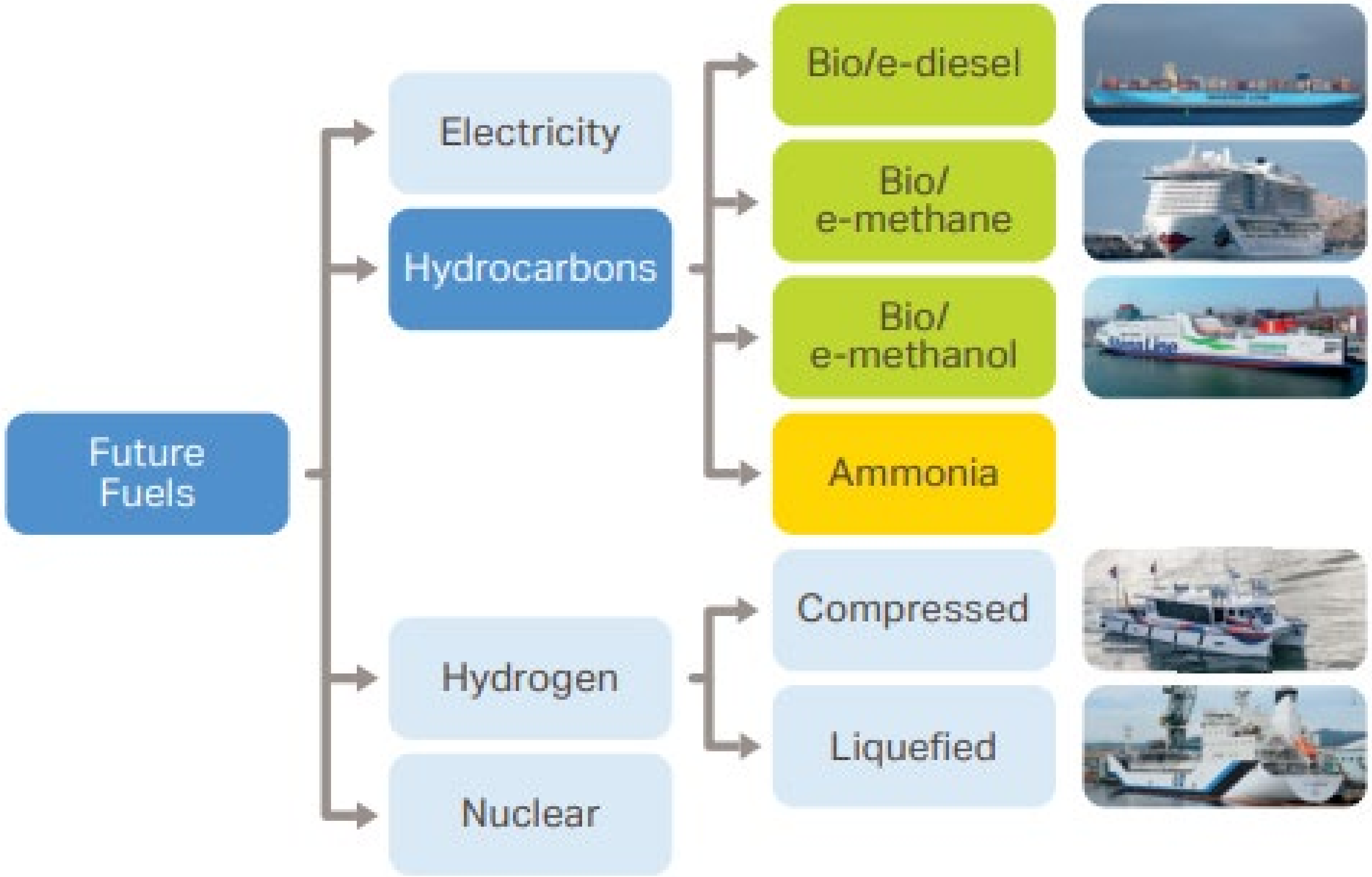
SCR - Selective Catalytic Reduction

PACR - Plasma Assisted Catalytic Reduction

Air Cavity - A thin sheet of air is maintained over the flat portions of a ship's bottom with the aid of pumps and hull appendages

Cold Ironing - the process of providing shoreside electrical power to a ship at berth while its main and auxiliary engines are turned off

Figure 4. Alternative future fuel options for marine industry



On the Sea – Ammonia-Powered Ships

- Although poisonous, Ammonia (NH_3) is a practical way of storing large volumes of hydrogen. Ammonia is liquid below -33 Degree Celsius or at room temperature at a pressure of 10 bars. Volumetric energy density of liquid ammonia is a third that of diesel and can be burnt directly in diesel engines with a suitable catalyst that provides long term pathway to fuel cells, (Zero Emission HGV Infrastructure Requirements, 2020).

- IMO has set a new decarbonisation milestone and new ammonia-powered vessels planned. The IMO's new regulation is intended to drive the decarbonisation of global shipping. A scheduled is now enforced (commenced 2023) and known as Regulation 28, it mandates: "a linear reduction in the in-service carbon intensity of ships between 2023 and 2030", such that the global fleet achieves an average reduction of at least 40% by 2030 when compared with 2008. The initial trials with internal combustion engines and gas turbines have been successful but one application which is considered promising is with fuel cells.

- Zero Emission HGV Infrastructure Requirements. Ricardo Energy & Environment reference (2020).

- https://www.ammoniaenergy.org/organisation/international-maritime-organisation-imo/

- https://www.ammoniaenergy.org/articles/safe-and-effective-new-study-evaluates-ammonia-as-a-marine-fuel/

Ammonia

- C4FF in interactions with several universities in the UK (Cardiff, Nottingham, Birmingham and Southampton) has shown ammonia to be a possible marine fuel in the near future. As there is considerable industry experience and some safety procedures for handling ammonia are already available, stemming mainly from transporting it as cargo in gas carriers.

- C4FF, considering recent studies of the required storage and distribution, onboard storage, and conversion to energy – in either an internal combustion engine or in a fuel cell – is of the view that there is no insurmountable barriers to the use of ammonia as a marine fuel. Ammonia is toxic and crew training remains a challenge. C4FF believes the ammonia should be considered as part of the fuel mix.

Biofuels

- Use of Biofuels in diesel engines is now well-known. In a study by C4FF, a range of biofuels for marine use in terms of sustainability, availability, technological readiness for production, suitability and cost were identified. Some of these biofuels can be directly used in existing engine systems with no modification or very minor. C4FF is of the view that bio-methanol and bio-methane can be considered as a direct replacement of their respective fossil fuel equivalents. What is significant is that biofuels such as biomethane are known to result in a 20-30% NOx emission reduction compared to using distillate fuels, however, for this to be achieved, recalibration of engines for low NOx modes is required.
- C4FF’s ICE Digital Twin can support use of a range of alternative fuels.

Hydrogen

- Hydrogen has already been used as part of marine fuel mix using diesel fuel and ammonia. The key weakness of hydrogen is its very low energy density, which requires it to be significantly compressed and cooled; similar problem to the compression of methane to produce LNG.

- Its implementation and use on ships have important challenges. Hydrogen is extremely flammable with a large ignition rate and has a high-speed flame and invisible combustion.

- Depending on the method used in its production, hydrogen can have a carbon footprint ranging from one similar to that of natural gas (grey hydrogen), to just over half that footprint if produced together with a carbon capture technology (blue hydrogen) and to close-to-zero (green hydrogen) if produced, for instance, through electrolysis using electricity from renewable energy. This makes it an almost carbon-free production process.

- Blue- and green- hydrogen are potentially offering shipping a very promising solution for a significant reduction in its GHG emissions. It is known that liquid hydrogen in fuel cells on ships has been tested already in a few real case scenarios for smaller ships, and is being subject to research for deep-sea shipping.

DNV Report

In a DNV report (2022) entitled Insights into Seafarer Training and Skills Needed to Support a Decarbonized Shipping Industry, there were five key findings as outlined in the following paragraphs:

- Key finding 1: All three potential decarbonisation scenarios point towards an immediate need to train seafarers. However, the timing and type of training provided will depend on the ambition of decarbonisation trajectories and the future fuel mix.
- Key finding 1a: In the 'IMO 2018 scenario' modelled by DNV, the number of seafarers working on ships with alternative fuels and technologies would peak at 310,000 in 2050.
- Key finding 1b: In the 'Decarbonisation by 2050 scenario' modelled by DNV, 750,000 seafarers would require additional training to handle alternative fuels and technologies by 2050.
- Key finding 1c: In the 'Zero Carbon by 2050 scenario', modelled by Lloyds Register and University Maritime Advisory Services (UMAS), 450,000 seafarers would require some additional training by 2030, while 800,000 seafarers would require some additional training by the mid-2030s. This scenario assumes a sharp ramp-up of alternative fuels in the 2020s.

DNV Report

- Key Finding 2: In the ‘IMO 2018 scenario’ and the ‘Decarbonisation by 2050 scenario’, modelled by DNV, there is expected to be a significant rise in the number of seafarers needing training on alternative fuel technologies in the 2040s, between 310,000 and 750,000. In the ‘Zero Carbon by 2050 scenario’, the number of seafarers requiring some kind of additional training rises steeply from the 2020s until 2050.

- Key finding 3: The number of seafarers expected to work on ships fuelled by LNG/LPG would increase by approximately 100,000 new seafarers every second year until 2038, in both the DNV modelled ‘IMO 2018 scenario’ and the ‘Decarbonisation by 2050 scenario’.

DNV Report continues

- Key Finding 4: There are a number of safety challenges related to alternative fuels in shipping. These include pressurized storage, low flashpoint and toxicity. Hydrogen, for example, is substantially more flammable than diesel. Ammonia, a method of chemically storing hydrogen for propulsion, is toxic to humans and the marine environment. With the exception of hydrogen, which was until recently only transported in packaged form, most of the alternative fuels are currently carried as bulk marine cargo. The shipping industry is therefore both knowledgeable and experienced with regard to their handling. However, seafarers will need additional training concerning the particular risks associated with using these fuels for propulsion in order to ensure not only their safety, but the safety of the environment and local communities.

- Key Finding 5: Training seafarers to support shipping's decarbonisation is already subject to several constraints.

STCW Convention chapters

- Chapter I: General provisions
- Chapter II: Master and deck department
- Chapter III: Engine department
- Chapter IV: Radiocommunication and radio operators
- Chapter V: Special training requirements for personnel on certain types of ships
- Chapter VI: Emergency, occupational safety, security, medical care and survival functions
- Chapter VII: Alternative certification
- Chapter VIII: Watchkeeping
- The details of STCW introduction and subsequent changes are given in the IMO's International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978.
- https://www.imo.org/en/OurWork/HumanElement/Pages/STCW-Convention.aspx.

Changes to STCW

- Although this presentation is primarily in support Chapter III of the STCW, it is also prepared in support of Chapters II, V and VII. C4FF and partners are of the view that tables A-V/3-1 and A-V/3-2 of the STCW Code for basic and advanced training for seafarers on ships, subject to the IGF* Code, should include other alternative fuels as outlined in this presentation. Furthermore, the respective IMO Model Courses 7.13 and 7.14 need revision in light of the emergence of alternative fuels.

* International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels (IGF Code)

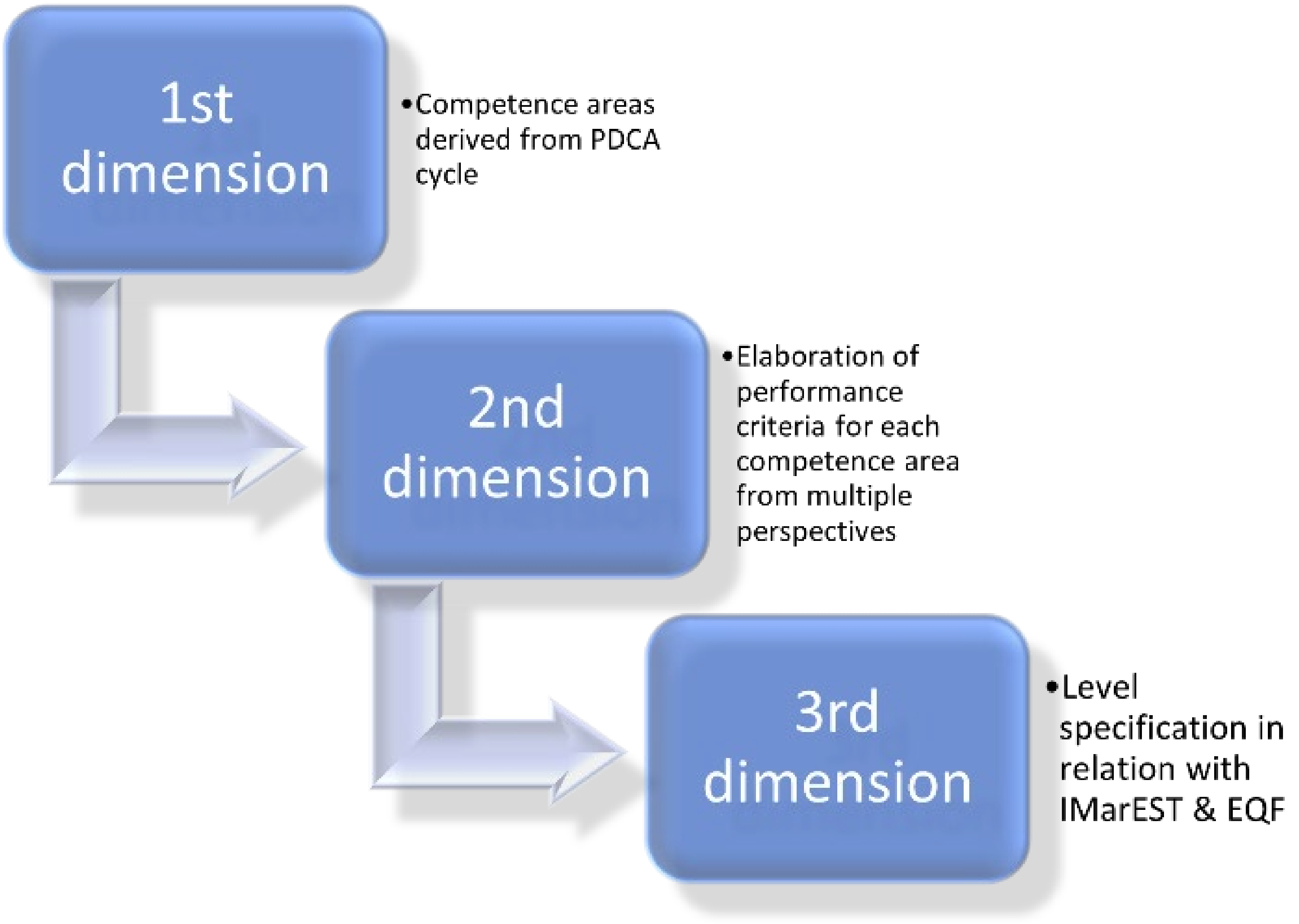
Proposed Training Programme

- The proposal also identifies the knowledge, skills and competences in a long course (60Hours) needed both for senior ship, junior/cadet officers and also ratings. Further, this will be broken down to two sections; a course for ship engineering officers and a course for deck officers at three levels, senior and junior/cadet officers and ratings. The courses are designed for competences needed to handle and burn new and alternative fuels and use of systems and processes in this connection. A continuous professional development (CPD) short course (3-days with an optional assignment) will also be prepared for all types of ship crews and shipping company personnel making references to IMO and EU latest requirements and the trends in fuels and associated systems being developed as possible ship bunkers.

- The CPD course will be an e-learning short course, similar to C4FF's EU awarded 'Best in Europe' and will form a supporting material for the long course. It will have a self-assessment section with the option of carrying out an assignment if an IMarEST CPD Certificate is required.

- See projects EGMDSS, SailAhead, ACTs, ACTS Plus, IMPACT - https://www.marifuture.org/Projects/Projects.aspx

The Competence Matrix Development Process



Concluding Remark

- C4FF cannot but agree with the recent EMSA study's* conclusions and is fully in line with the findings of DVN and Ricardo reports on alternative fuels. It is clear that the use of certain fuel cell technologies in shipping have been already demonstrated as one of the power technologies that can start to reduce the GHG in shipping and help in its decarbonisation process. This is mainly due to their relatively advanced technical maturity and, specifically, those that use LNG, ethyl-methyl alcohols, hydrogen, low flashpoint diesel and bio diesel as fuels. As concluded from the EMSA's Study, three specific fuel cell technologies are the most promising for marine use: **Solid Oxide Fuel Cell** (SOCF), the **Proton Exchange Membrane Fuel Cell** (PEMFC) and the **High Temperature Proton Exchange Membrane Fuel Cell** (HT-PEMFC). Several Classification Societies have already issued 'rule notes' applicable to fuel cell installation in ships, while the IMO MSC issued already in 2022, its MSC.1/Circ.1647, interim guidelines for the safety of ships using fuel cell power installations. Yet relevant minimum competence standards and training requirements are not yet specified.

* Study on the Use of Fuel Cells in Shipping" commissioned by EMSA back in 2017.

Conclusions

- 1: A lack of clarity surrounding the viability and uptake of alternative fuel technologies and decarbonisation trajectories, coupled with uncertainty surrounding regulatory developments and financing, are making it difficult to plan for the further training of the maritime workforce and attract investment in skills programmes compatible with the industry's future needs.

Conclusions

- 2: Guidelines for alternative fuel technologies are already under development by the International Maritime Organisation (IMO). Once developed, the model for IGF Code compliance, consisting of basic and advanced model courses at an approved training facility, plus minimum seagoing experience (including familiarisation), could be adapted by the IMO for training on alternative fuel technologies. This would serve as a minimum training framework. Training requirements for seafarers with regard to LNG/LPG have already been set out in the STCW International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code).

Conclusions

- 3: Maritime schools and training centres would be able to use the IMO model courses once developed, forming part of the education for all seafarers. Specific training and familiarisation onboard are seen as an important part of future training models to ensure seafarers are competent to make use of new technology and ensure a safe transition to alternative fuels and technologies. Such specific training for certain ships, fuels and technologies can be provided by the industry closer to the implementation of the new technology.

Conclusions

- 4: The skills required for safe operation of ships using alternative fuel technologies are known in parts of the maritime industry. However, meeting decarbonisation goals, coupled with fast-moving technological developments, including increased automation, requires careful monitoring and reflects a general trend towards a ‘higher-skilled’ seafarer. Increased IT, digital, technical and organisational competence will be needed in future to meet the demands associated with decarbonisation. Special attention should be paid to systems which can equip all relevant seafarers with new skills and help them transfer to new types of jobs created by new technologies. Bridge and engine officers may face higher skill requirements than ratings.

Conclusions

- 5:A holistic view, taking into consideration human, organisational and technical challenges, when adopting alternative fuels and technologies is important, alongside a strong safety culture and the provision of familiarisation periods during the implementation of alternative fuels aboard ship.
- 6: Attracting and retaining seafarers is a problem in the maritime industry and poses a significant challenge to ensuring that there are sufficient competent seafarers to support shipping's green transition.

Recommendations

- Having reviewed the discussions at IMO, C4FF and partners are of the view that tables A-V/3-1 and A-V/3-2 of the STCW Code for basic and advanced training for seafarers on ships, subject to the IGF Code, should include other alternative fuels as outlined in this proposal. Furthermore, the intention so far is also to revise the respective IMO Model Courses 7.13 and 7.14 as part of the response to this Tender.

- C4FF and partners will follow the developments at IMO and are taking any decision at HTW 10/6/7 into consideration. This includes the training requirements and qualifications for seafarers on battery-powered ships that is expected to be considered by IMO STCW part B.

Final Remark

- The proposed course will also explore the role of shore power in decarbonizing maritime transportation in the European Union (EU) based on two recently adopted regulations: the FuelEU Maritime regulation and the Alternative Fuels Infrastructure Regulation (AFIR).

- The FuelEU Maritime regulation requires that from January 1, 2030, container and passenger ships (including cruise ships) greater than or equal to 5,000 GT must connect to shore power in main EU ports listed in the trans-European transport network (TEN-T). Ships using alternative zero-emission technologies are exempted from this requirement. The AFIR aims to regulate shore power supply and incentivize infrastructure development in TEN-T ports.

- It is reported that there are currently, 51 ports in 15 EU coastal Member States have shore power infrastructure, supplying 309 MW of power, 283 MW of which are intended for container, passenger, and cruise ships. It is estimated* that the EU needs to triple or quadruple its installed shore power by 2030 to meet the current ambitions of average or maximum demand of container, passenger, and cruise ships.

* Osipova, L. and Carraro, C. (2023), Shore power needs and CO2 emissions reductions of ships in European Union ports: Meeting the ambitions of the FuelEU Maritime and AFIR, International Council of Clean Transportation, October 2023.

Final Remark

- Considering that there are 489 EU ports as of 2019 and that only 51 ports provide shore power, the requirement necessary to meet regulatory targets is substantial. It would not meet these for some time. It is for this reason that encouragement should be provided for ship to use alternative fuels using zero-emission technologies and to seek exemption.

- The current level of ambitions of the FuelEU Maritime regulation and AFIR* will only lead to a 24% reduction in the EU's estimated annual 4.37 Mt at-berth CO2 emissions. This clearly indicates the need to for ships to be equipped with facilities which allow them to use alternative fuels to fossil ones. The clear message will need to be included in the course content so as to ensure ship boilers should be also retrofitted, electrified, or connected to shore power facilities. This measure should include the auxiliary engines, since they are reported* to be responsible for 44% of all at-berth CO2 emissions.

* Osipova, L. and Carraro, C. (2023), Shore power needs and CO2 emissions reductions of ships in European Union ports: Meeting the ambitions of the FuelEU Maritime and AFIR, International Council of Clean Transportation, October 2023.

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Thank you for your attention