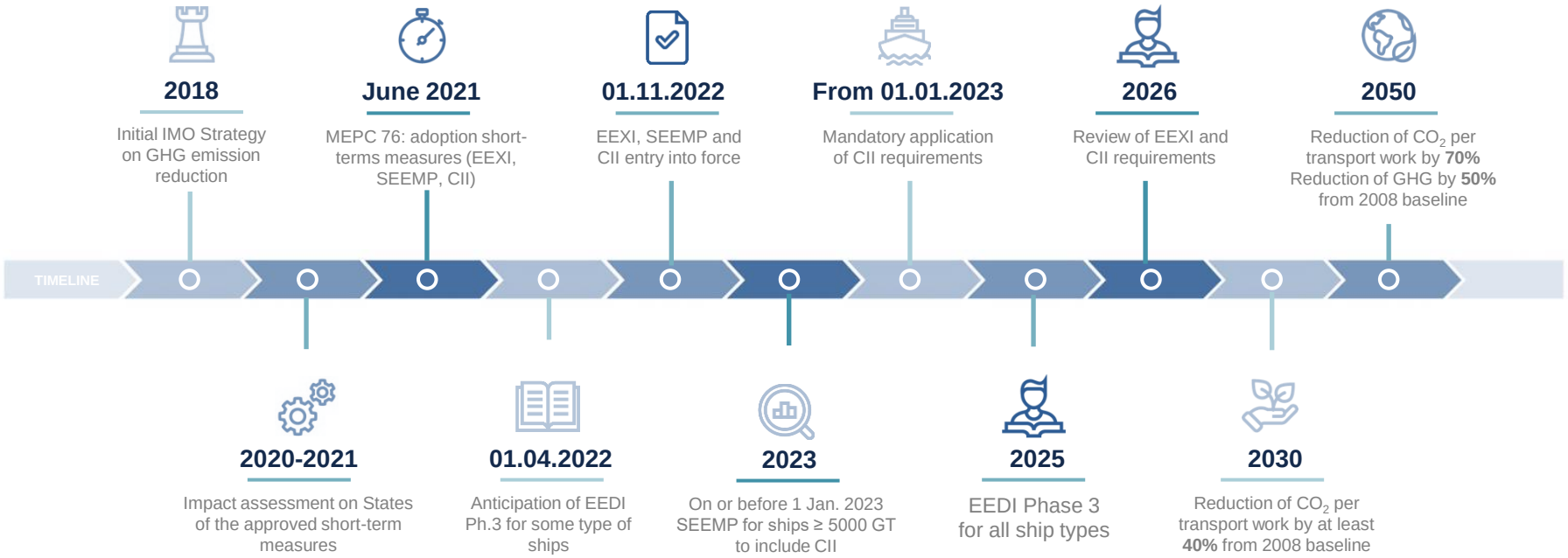
RINA approach

The perfect cocktail: alternative fuels, green tech, digitalization.

The IMO approach



The IMO approach

Nov. 2022 – Jan. 2023

Entry into force of MARPOL Annex VI amendments

Technical Measures

Energy Efficiency Design Index (EEDI)

Energy Efficiency Existing Ship Index (EEXI)

Operational Measures

Carbon Intensity Indicator (CII)

New requirements for Ship Energy Efficiency Management Plan (SEEMP)

2030

40% carbon intensity reduction

- EEDI framework for new ships in place since since 2013.
- EEXI framework for existing ships in 2023.
- CII framework from 2023 onwards.

Technical Measures

EEXI Compliance

$$\text{EEDI \& EEXI} = \frac{\text{Emissions of } CO_2}{\text{Transport Work}} = \frac{\text{Engine Power [kW]} \times CO_2 \text{ conversion factor [-]} \times \text{SFOC [g/kWh]}}{\text{Capacity [t]} \times \text{Reference Speed [kn]}}$$

main engine(s) CO_2 + aux. engine(s) CO_2 + (CO_2 shaft motor − electrical power savings) − propulsion power savings

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

DWT / gt

Reference Speed

- Introduction of an Engine Power Limitation (EPL) or Shaft power limitation (ShaPoLi)
- Introduction of energy efficient consumers
- Reconsideration of Electrical Power Table
- Capacity increasing
- Speed increasing by means of hydrodynamic improving devices
- Innovative energy efficiency technology

Focus on EEXI:
Ro-ro ships

ELECTRIC POWER TABLE

Ship type	Size	Reduction factor	Equivalent EEDI Phase
Ro-ro cargo ship (vehicle carrier)	DWT >= 10,000	15	2
Ro-ro cargo ship	DWT >= 2,000	5	1
	1,000 <= DWT < 2,000	0-5	1
Ro-ro passenger ship	DWT >= 1,000	5	1
	250 <= DWT < 1,000	0-5	1

- EPT
- **Annual average** from onboard monitoring
- **Approximated value** of power of auxiliary engines

Power of auxiliary engines $P_{AE(i)}$

- Correction factor f_j for ro-ro cargo and ro-ro passenger ships (f_{jRoRo}) **fixed Froude number,** F_{n_L}, with ship design speed at 75% of MCR

Power correction factor f_{jRoRo}

- **New capacity correction factor $f_{cVEHICLE}$** for ro-ro cargo (vehicle carrier)

Capacity correction factor $f_{jVEHICLE}$

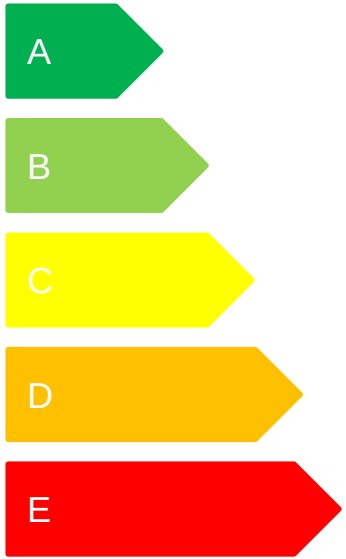
$$P_{AE,app} = 0.866 \times \mathrm{GT}^{0.732} \qquad [\mathrm{kW}]$$

- **Guidelines of the method of calculation of the attained EEDI for new ships - Res. MEPC.308(73) as amended**
- **Guidelines on the method of calculation of the Attained EEXI - Res. MEPC.333(76)**
- **Guidelines on survey and certification of the EEXI - Res. MEPC.334(76)**
- **Guidelines on the shaft/engine power limitation system to comply with the EEXI requirements and use of a power reserve - Res. MEPC.335(76)**

RINA GUIDE FOR THE EVALUATION OF ENERGY EFFICIENCY EXISTING SHIP INDEX (EEXI)

Operational Measures

CII – Carbon Intensity Indicator



$$Attained\ annual\ CII = f\left(\frac{Mass\ CO_2 emission}{DWT(or\ GT) * sailed\ miles\ NM}\right)$$

$$Required\ annual\ operational\ CII = \left(1 - \frac{Z}{100}\right) x\ CII_{ref}$$

$$CII_{Ref} = a\ Capacity^{-c}$$

Rated D for three years

Rated E in a single year

→ plan of corrective actions in SEEMP → Verification by Administration/RO within 1 month after reporting the Attained annual operational CII

For ship rated D for 3 consecutive years or rated as E, the Statement of Compliance shall not be issued unless the above actions are carried out.

The Significance of CII

- For first time ever, ships are ranked
- Ranking is based not in fuel consumption, but in terms of CO2 emissions

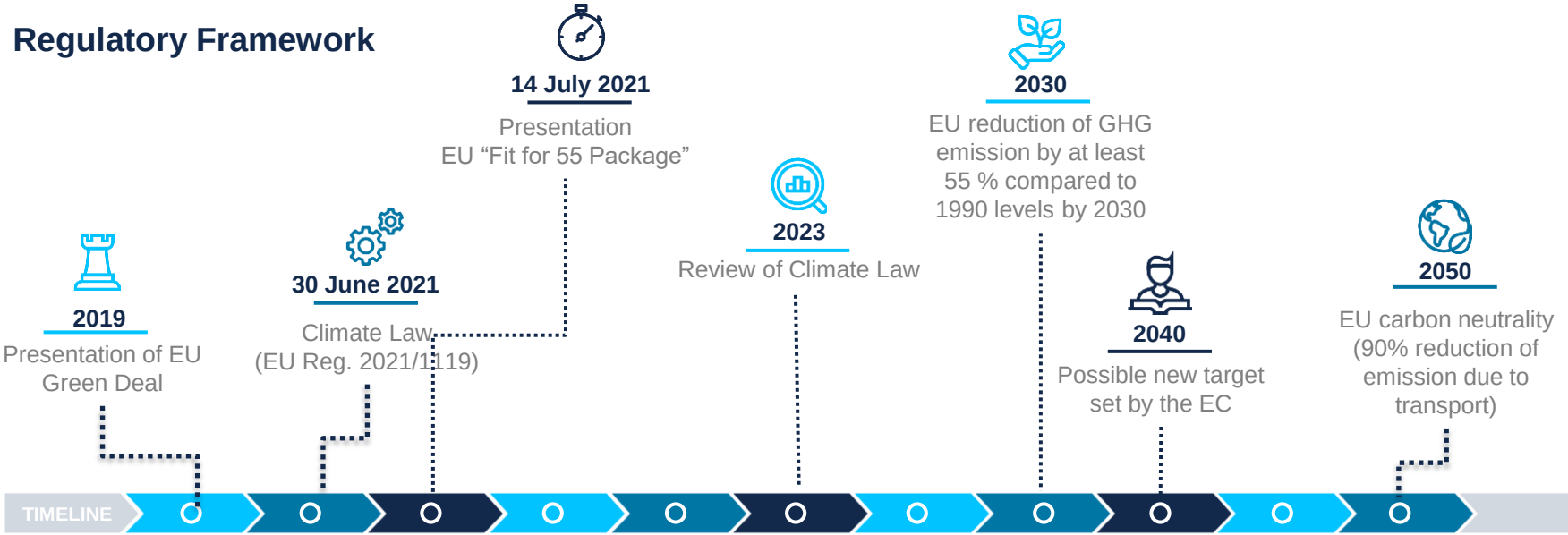
Any solution that aims at decarbonization must fulfill first the requirements of CII

- An Owner may:
  - Either avoid to build new ships: beyond 2030, ships of current technology will be under extreme pressure since it will be practically impossible to maintain high CII rating without a generous discount of speed, which will render them as not competitive any more
  - Order New ships: Having a fuel oil ship, and Waiting for zero carbon fuels, will be equivalent to an existing ship, with same difficulties to remain competitive

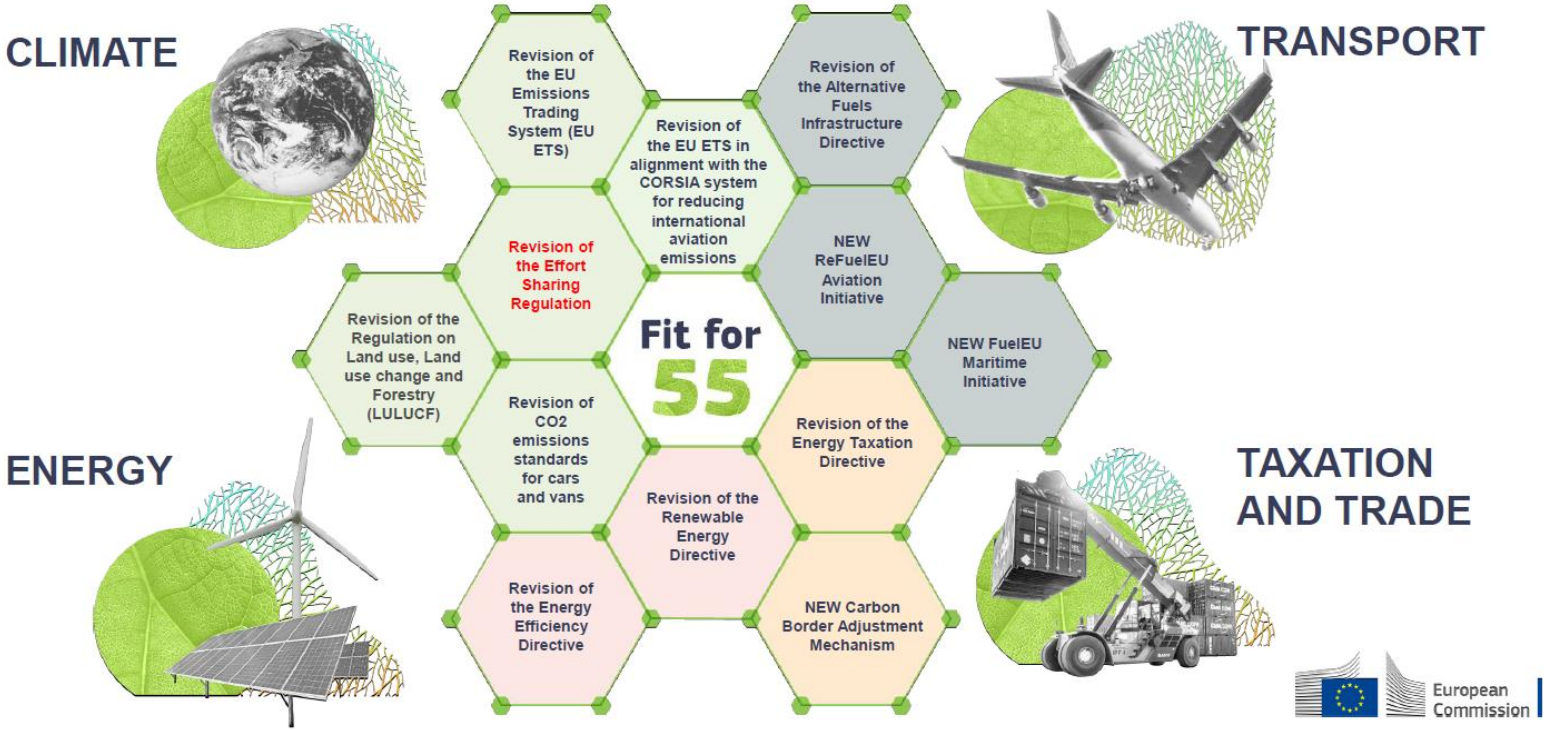
It seems the most challenging decision for an Owner, is depending the age of his fleet, when to replace it with new ships and of which technology

The EU approach

Regulatory Framework

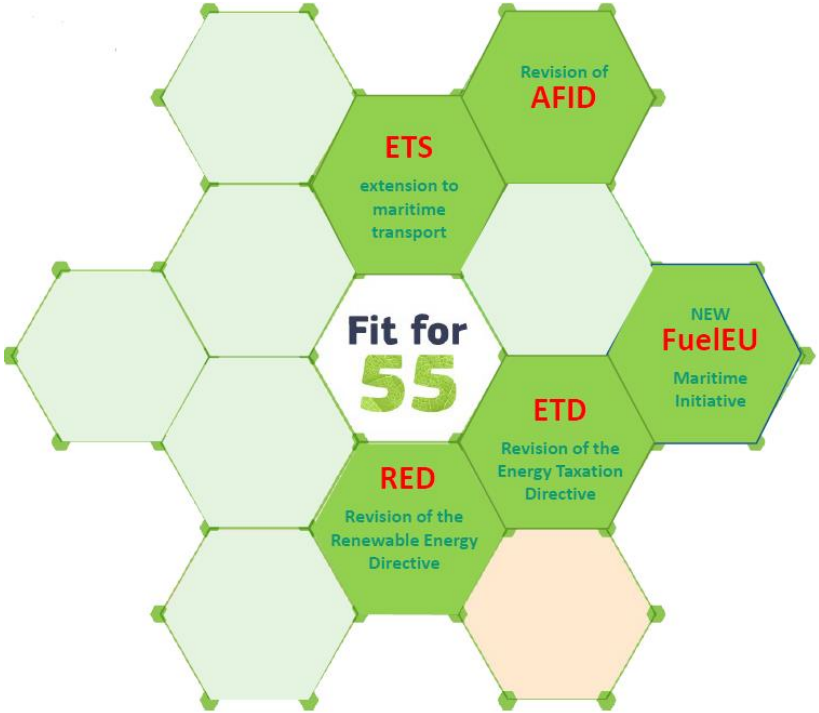


EU Fit for 55 Package



EU Fit for 55 Package

Maritime-related proposals



MARITIME

European Commission | Mobility and Transport

EU Fit for 55 Package

DRAFT ETS Directive

The main changes to the ETS Directive, compared to the text proposed by the Commission, are the following:

1) from 1 January 2024 the allowances to be surrendered are equal to 100% of the emissions (without phase-in period);
2) 2) from 1 January 2027, ETS also applies to ships between 400GT and 5000GT (and MRV is modified accordingly);
3) obligation to have a contractual clause in the event that the ship is not operated by the shipowner;
4) 4) the establishment of the Ocean Fund - a fund for investments in the maritime sector, which includes 75% of the proceeds from the emission quotas returned by the dedicated maritime sector;
5) 5) clause to revise the Directive in the event that the IMO adopts international measures.

Overview

- Ships above 5000 GT, intra-EU voayages, 50% extra-EU voyages, EU ports
- Definitions of Shipping Company and Administering authority
- Company shall submit to the responsible administering authority **the verified aggregated emissions data** (based on MRV Regulation) at Company level that covers the emissions in the reporting period
- By 30 April of each year, Company shall **surrender a number of allowances** equal to its total emissions
- **Phase-in period** of allowance surrendering
  - 20 % of verified emissions reported for 2023
  - 45 % of verified emissions reported for 2024
  - 70 % of verified emissions reported for 2025
  - 100 % of verified emissions reported for 2026 and after
- **Penalties** in case of non-compliance

EU Fit for 55 Package

DRAFT FuelEU Maritime Regulation

Overview

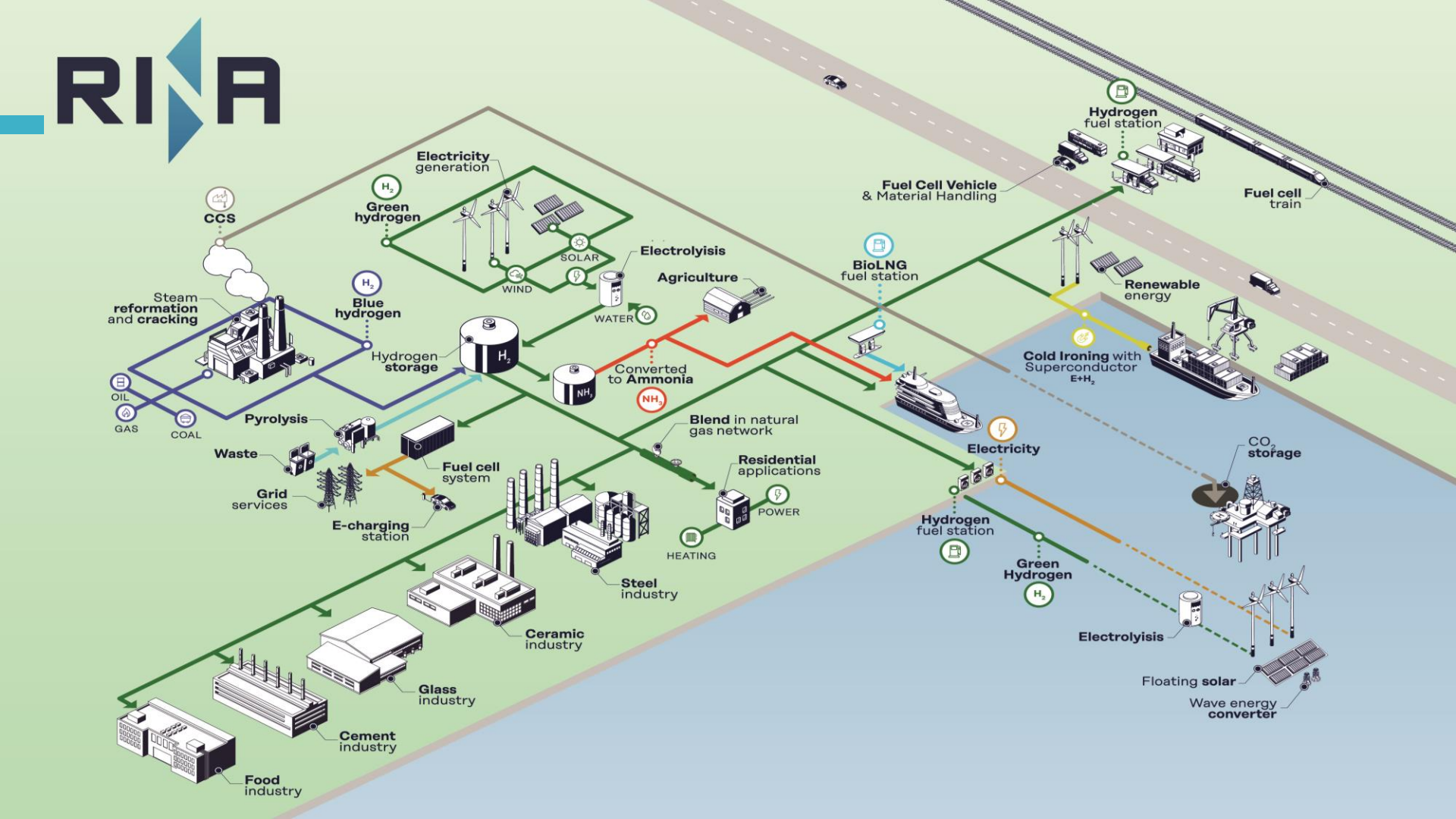
- Same scope as in ETS (ships above 5000 GT, intra-EU voayages, 50% extra-EU voyages, EU ports)
- **GHG intensity of the energy used on-board** – introduction of limits on the yearly average GHG intensity of energy used on-board (CO2eq/MJ)

- OPS or zero-emission technology compulsory as of 2030 for containerships and passenger ships
- Possibility of **banking and borrowing** of compliance surplus between reporting periods
- Possibility of **pooling** of compliance between two or more ships, even of different Companies but with the same verifier
- **Penalties** in case of non-compliance
- **EU Fuel Certificate of Compliance** to be kept on board

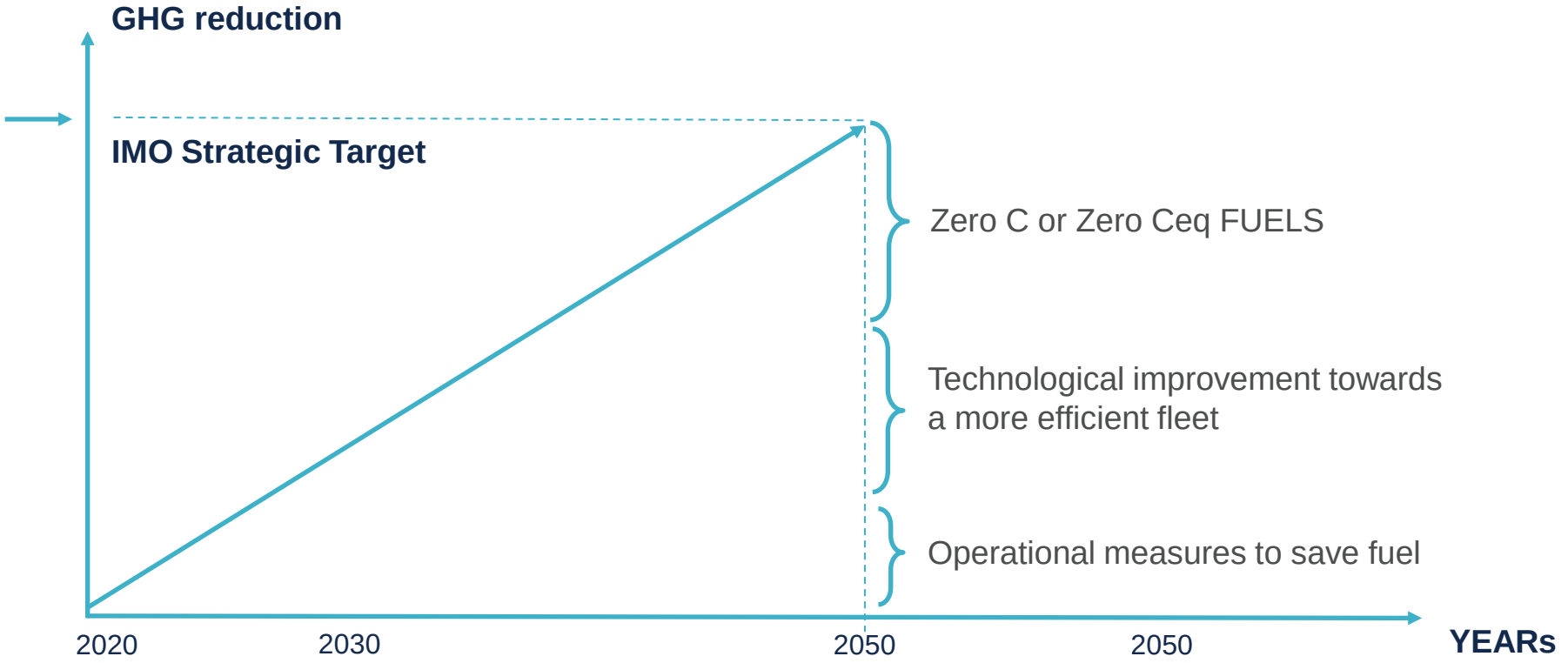
Marine Decarbonization Strategy
Alternative fuels… and?

- Many solutions are presently investigated
- One solution will not ‘fit for all’
- The shipping industry will not be the main player to take the decision on the fuel(s) that will decarbonize the sector

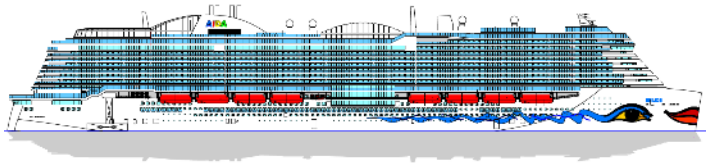
RINA strongly believe that “**to be prepared**” is key factor in this transition


Electricity generation
Green hydrogen
CCS
SOLAR
WIND
Electrolysis
Agriculture
WATER
Steam reformation and cracking
Blue hydrogen
Hydrogen storage
Converted to Ammonia
OIL
GAS
COAL
Pyrolysis
Waste
Grid services
Fuel cell system
E-charging station
Blend in natural gas network
Residential applications
POWER
HEATING
Steel industry
Ceramic industry
Glass industry
Cement industry
Food industry
Hydrogen fuel station
Fuel Cell Vehicle & Material Handling
Fuel cell train
BioLNG fuel station
Renewable energy
Cold Ironing with Superconductor E+H2
Electricity
CO2 storage
Hydrogen fuel station
Green Hydrogen
Electrolysis
Floating solar
Wave energy converter

Marine Decarbonization Strategy
Alternative fuels, Fuel Saving Solutions, Operation



Where we are with alternative fuels?

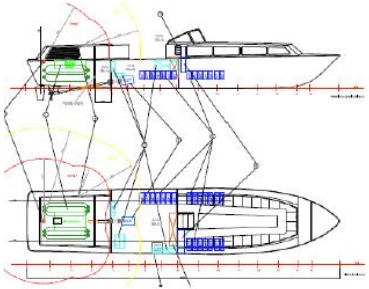


GREEN TECHNOLOGIES

H2 Fuel cell Projects

First hydrogen boat in Venice

Venice saw its first hydrogen boat circling its canals on **April 6, 2009**. Developed by Venezia Tecnologia, a Venice based company, in cooperation with ENI and co-financed by the Italian Ministry of Environment and the Veneto Region, the 7 m boat features two 5 kW PEM fuel cells.



HEPIC Project - Alilaguna& C.N. Vizianello

Small passenger ship intended for Laguna Venice Service -**2016**.
The design based on **compressed Hydrogen Fuel Cells** is completed. The use of Hydrogen on the ship is on hold waiting for the approval of the Flag Administration.

TecBIAProject - FINCANTIERI

Experimental ship intended for Fuel Cells testing.
Based on Hydrogen stored in tanks. **Fuel Cell will develop up to 120kW**, Lithium Batteries up to130kW, stored Hydrogen up to50kg.
Now under construction in Fincantieri Castellamare, delivery expected **first quarter 2022**

Future Fuels – RINA Rules & IMO updates

RINA RULES	Ammonia	LPG	LNG	Hydrogen	Methanol	Nuclear
Fuelled ready	Completed	Completed	Completed	Completed	Completed	2022
Fuelled	Completed	Completed	Completed	Completed	Completed	2022

IMO work done

- MSC.1/Circ.1621 - Guidelines for the Safety of Ships using Methyl/Ethyl Alcohol as Fuel
- MSC.1/Circ.1647 - Interim guidelines for the safety of ships using fuel cell power installations

IMO Work in progress

MSC 105 (April 2022) agreed to:

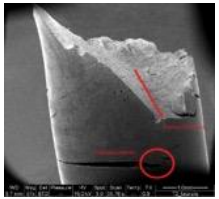
- develop guidelines for the safety of ships using ammonia as fuel (by 2023);
- review of the interim recommendations for carriage of liquefied hydrogen in bulk; and
- consider the impact on safety from the use of potential GHG reduction solutions such as ammonia, hydrogen, biofuels, dimethyl ether, nuclear power, and carbon capture and storage systems.

Alternative Fuels

Hydrogen ΔH Laboratory

Materials development and qualification for high pressure gaseous H2 transportation and storage equipment.

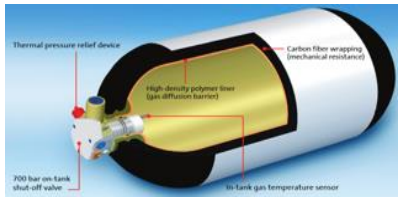
Test on materials
SMALL SCALE unit
Fatigue, Fracture Mechanics, SSR



H_2 test pressure up to 1000 bar
Hydrogen Piping & Pipelines

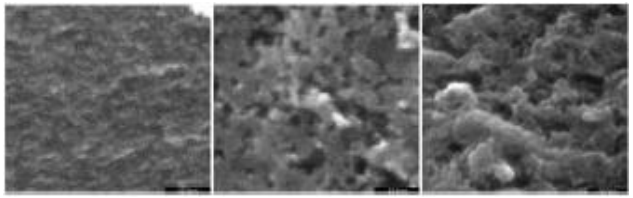
US standards (ASME B31.12, ASME BPVC, ASTM E1681) and the European guideline (EIGA, IGC Doc 121/14)

Test on components
Full Scale



H_2 test pressure
100÷1000 bar
Test on component and storage equipment

Test on nano-materials
HPCT unit



H_2 test pressure
0÷300 bar
Test on adsorption

Alternative Fuels full scale test H2 and CH4

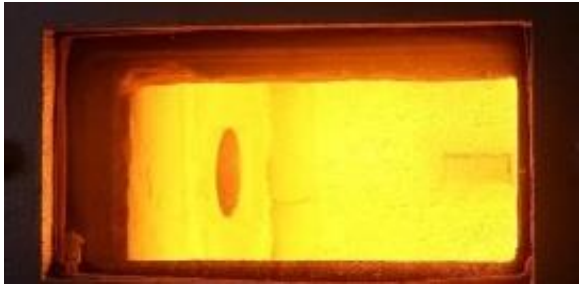
Alternative Fuels
Hydrogen Combustion Laboratory

Hydrogen Combustion Laboratory (Dalmine)
Material for Storage and Transportation - Industrial burner assessment & qualification

- Development / validation of existing / new industrial burners for H_2 / N_2 - NG mixtures

Hydrogen Burner performances assessment (Steel Making, Glass, Cement, EII)

- **Assess the feasibility to use** both existing and on purpose developed burners and associated piping and fittings, with **different H2 - NG mixtures** from both technical and regulatory perspectives
- **Potential Costs savings** associated with CO_2 quote reduction
- **Impact on HSE** (ATEX) and on characteristics of the **thermally treated steel material**



GREEN TECHNOLOGIES

Our Experience

Vessel Ankie

- General Cargo
- DWT: 3,600 t
- Retrofit year: 2020

Retrofitted with two vent foils (wings) from Econowind

RINA carried out:

- the design approval
- survey of vent foil production and installation
- supervision of the commissioning

https://www.rina.org/en/media/news/2020/02/24/key-wind-propulsion-installation

GREEN TECHNOLOGIES

Our Experience

Vessel Tharsis

- General cargo
- DWT 2300 t
- Retrofit year: 2021

Retrofitted with Wind Assisted Propulsion System Twinfoils by Econowind

RINA carried out:

- the project design approval
- Construction supervision

https://www.rina.org/en/media/news/2021/12/09/wind-assisted-vessel

GREEN TECHNOLOGIES

Our Experience

Vessel Tharsis

- General cargo
- DWT 2300 t
- Retrofit year: 2020

Retrofitted with fluidic air lubrication system by Marine Performance System

RINA carried out:

- the project design approval
- Construction supervision

www.marineperformancesystems.com

GREEN TECHNOLOGIES

Our Experience

Vessel Eco Valencia & Grimaldi Group Ro-Ro Carriers

- 12x RO-RO cargo vessels
- DWT 24000 t
- Year: 2020
- New Buildings with air lubrication system by Silverstream

RINA carried out:

- the design approval
- survey of production and installation
- supervision of the commissioning

GREEN TECHNOLOGIES – OSV Battery Retrofit

Supply vessel with DP2 and power supply from ion-lithium battery system.

Shipyard: Havyard Ship Technology
Shipowner: Skansi Offshore
Type: Offshore Support Vessel
Size: 4000 GT
Special Feature: Battery Powered Ship 565kW/h
Notations: ICE class, DYNAPOS DP2,Green Plus

“LNG ready” Cruise Ferry for MOBY

Shipyard: Guangzhou Shipyard International (CSSC)
Shipowner: MOBY
Size: : 2+2 × Ro-Ro passenger ferry (3,765 lm; 2,500 pax)

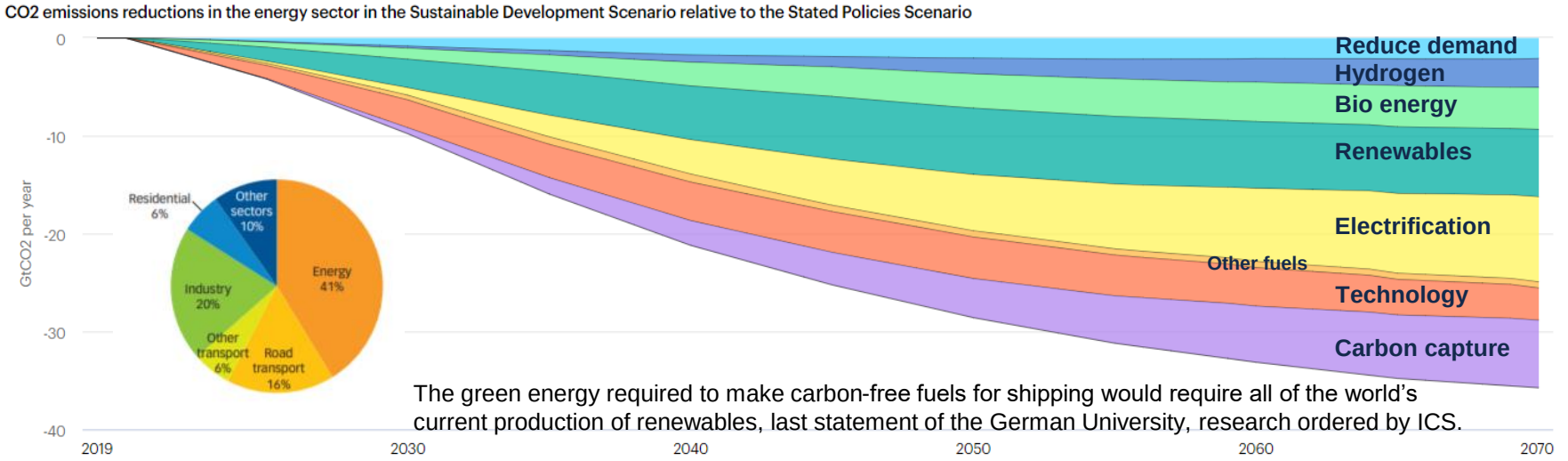
The ships, LNG ready, will be able to reach 25 knots speed with highest comfort standard

LNG Passenger Ferry for Balearia

Shipyard: Cantiere Navale Visentini
Shipowner: Balearia
Size: 2 × Ro-Ro passenger ferry (25,000 GT; 810 pax)

The ships will be able to reach 24 knots speed with a total power of 20,600 KW CO_2 and NOx emissions reduced by more than 40%

GREEN TECHNOLOGIES The role of CCUS



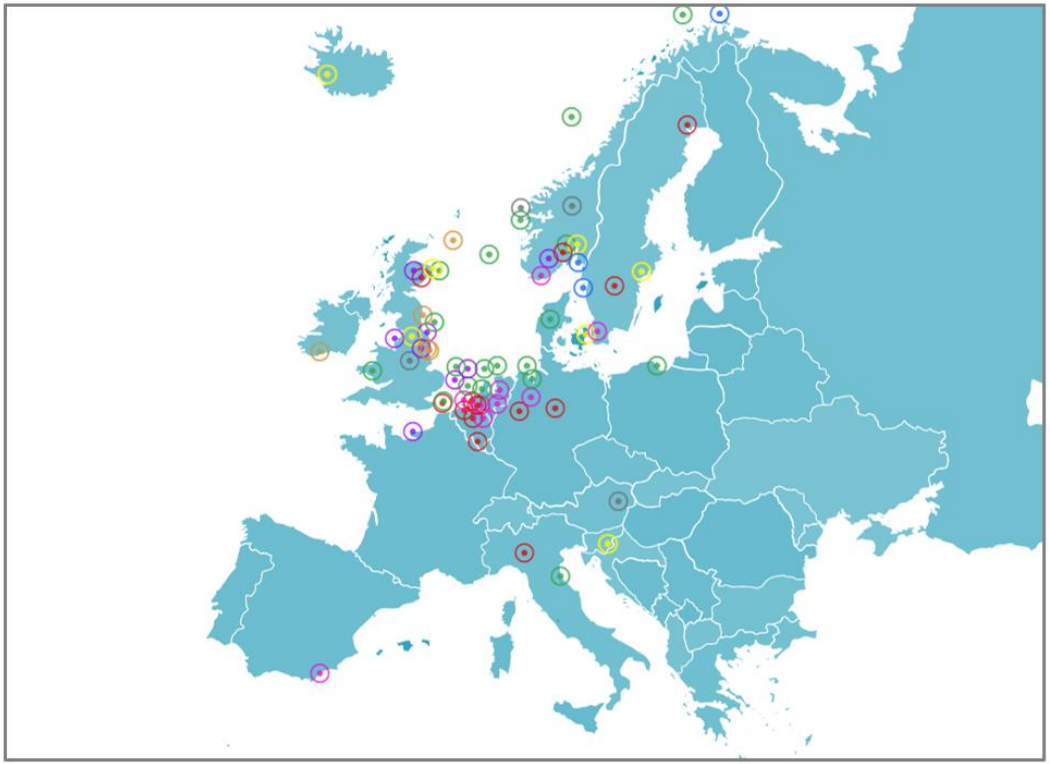
The green energy required to make carbon-free fuels for shipping would require all of the world's current production of renewables, last statement of the German University, research ordered by ICS.

Source: https://www.iea.org/reports/ccus-in-clean-energy-transitions/ccus-in-the-transition-to-net-zero-emissions

CCUS will have a special role in reducing global GHG emissions

GREEN TECHNOLOGIES

The role of CCUS

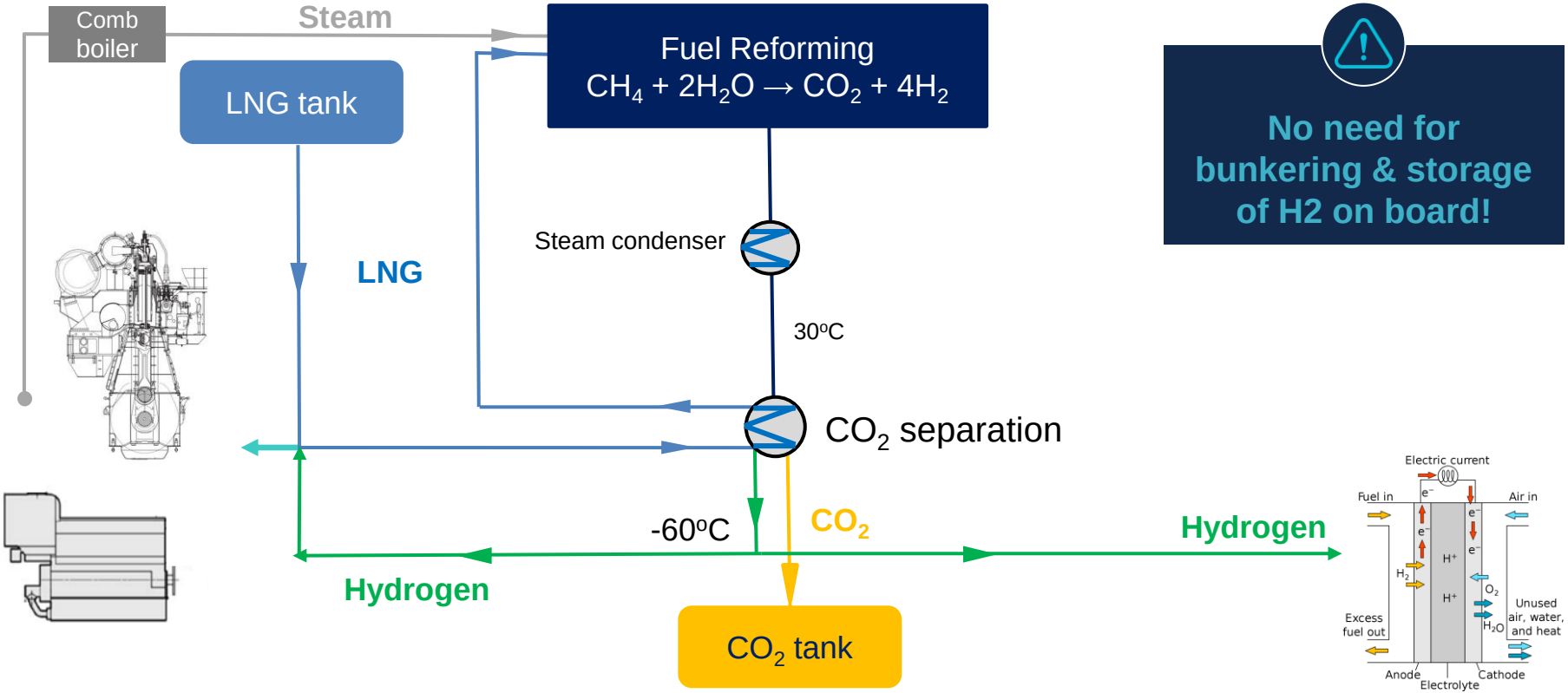


(Source: **https://zeroemissionsplatform.eu/about-ccs-ccu/css-ccu-projects/**)

Nowadays, there are at least 182 ongoing carbon tech projects in at least 14 different countries, including the U.S., Canada, Germany, China, and India.

In Europe, there are projects on track to become operational before 2030, and the map presents the market-ready projects, provided that **supportive policy and financial frameworks are in place.**

GREEN TECHNOLOGIES Steam Methane Reforming



No need for bunkering & storage of H2 on board!

DEGI-CARBONIZATION
The RINA Digital Offer at a Glance

TECH. MANAGEMENT & OPTIMIZATION

COMPLIANCE

INSPECTIONS

SERTICA

Fleet Management System

Optimum

Fleet performance management suite, creating value from big data

Voyage Optimization

Spped optimization and weather routing module

Forms MRV - DCS

Making crew reporting easier and allow compliance with EU & IMO regulations

ELB

Electronic Logbooks for simplified and verified reporting onboard

IHM Maintenance

Stand-alone application or bundle with HazMat Expert support service

Inspection Master

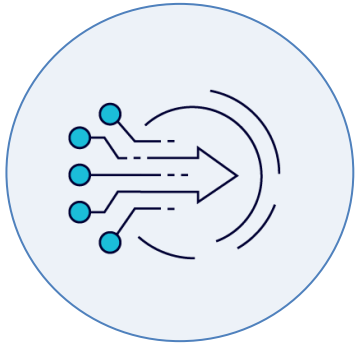
Record PSC Inspections and manage company checklists inspections/ audits

KIBER Helmets & Apps

Technology for remote and smart inspections

OPTIMUM

DATA COLLECTOR

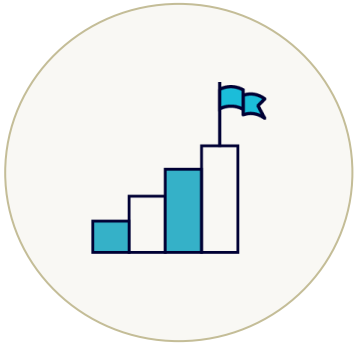


- Navigation, Automation
- Manual Input
- External Data

EFFICIENCY KPIs

- Realtime Monitoring
- Traditional Methods
- Machine Learning

ANALYTICS



- Drydock Planning
- Intervention Analysis
- EEOI/CII status

Comply with new regulations

ANALYZE

- Analyze data to understand the efficiency of the vessels

OPTIMIZE

- Operate the vessels in the best possible way

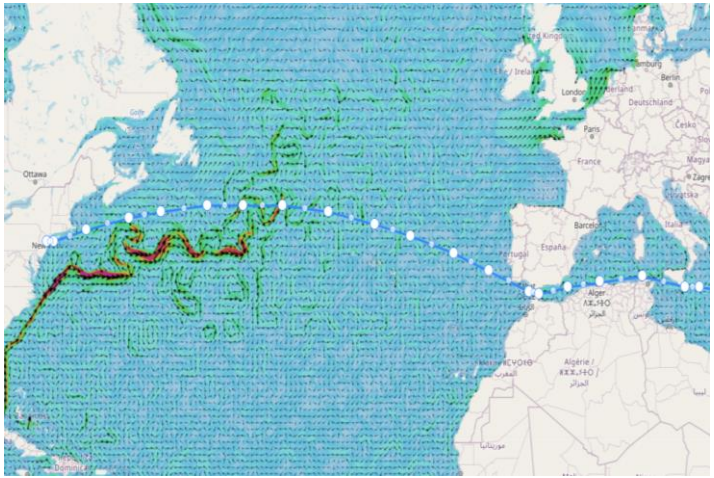
MONITOR

- Monitor over time vessel efficiency to ensure compliance

Optimize Voyage

OPTIMIZE

Enter simulation mode and understand how to improve efficiency and meet the targets with the actual fleet.



Model

- Ship models based on AI

Plan

- Plan a voyage with a specific ship, departure date/time, arrival date/time

Optimize

- Shall the ship reduce speed or be more loaded?
- Shall I deploy a different ship on this trade?

RINA

Make it sure, make it simple.