Екологично и енергийно ефективно корабоплаване в изключителната икономическа зона на България

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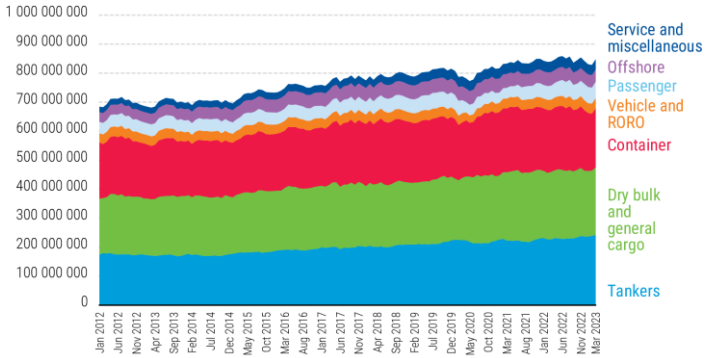
Introduction

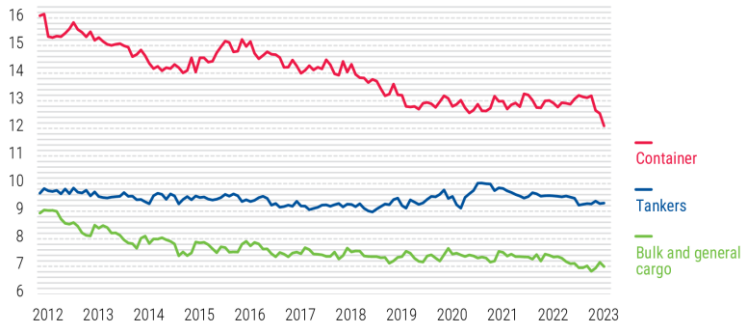
Fourth Greenhouse Gas Study 2020

- The share of shipping in global emissions has increased from **2.76%** in 2012 to **2.89%** in 2018
- CO2 emissions have increased over the period from 848 million tonnes in 2012 to 919 million tonnes in 2018 (**8.4%** increase).
- Emissions are projected to increase from about 90% of 2008 emissions in 2018 to **90-130%** of 2008 emissions by 2050





- In January 2023, global maritime trade was transported on board **105,493** vessels
- More than **80%** of the world merchandise trade by volume is transported by sea.



Total CO_2 emissions have evolved over the last 10 years and continued to grow, even though the emissions per ton-mile have decreased.

https://maritimeindia.org/assessing-the-shipping-emissions/ Source: Review of Maritime Transport 2023: unctad.org/rmt

IMO Activities

2011 Adoption of mandatory energy efficiency regulations for ships under MARPOL Annex VI – Energy Efficiency Design Index (EEDI) for new ships, Ship Energy Efficiency Management Plan (SEEMP) for all ships (15 July 2011) **MEPC.203(62)**

2018 Adoption of the IMO Initial Strategy on reduction of GHG emissions from ships **MEPC.304(72)**

2020 Adoption of short-term measures (EEXI, CII) to reduce carbon intensity of all ships by 40% by 2030, compared to 2008 (**MEPC)75**

2021 **EEXI** survey requirements take effect **MEPC.328(76**) (into force on 1 November 2022)

2023 Carbon intensity measures enter into force on 1 January 2023 **(CII)**

2023 Revision of the IMO Initial GHG Strategy

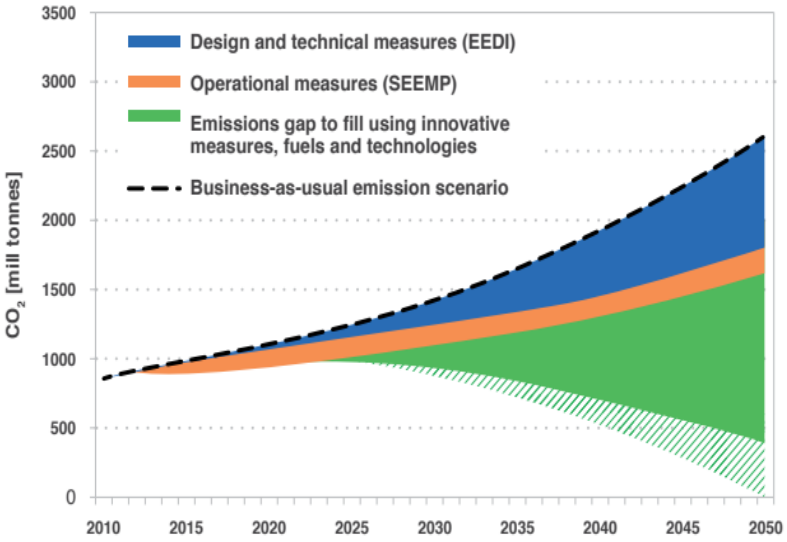
…to reduce the total annual GHG emissions by at least 50% by 2050

…. and to reach **net zero** GHG emissions by or around, i.e., close to 2050.

IMO Activities



SOx Emissions Control Area (SECA), 1 May 2025



GHG reduction pathway

GHG – Greenhouse gases

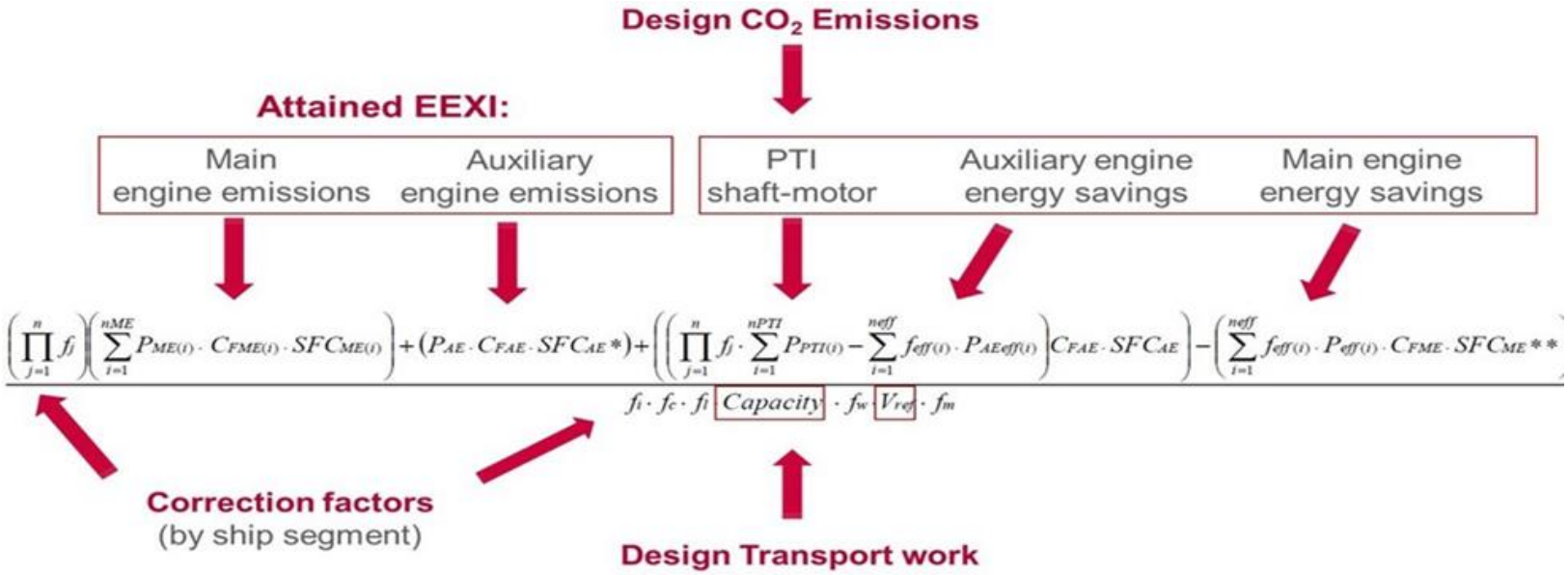
EEDI - Energy Efficiency Design Index

SEMP - Ship Energy Efficiency Management Plan

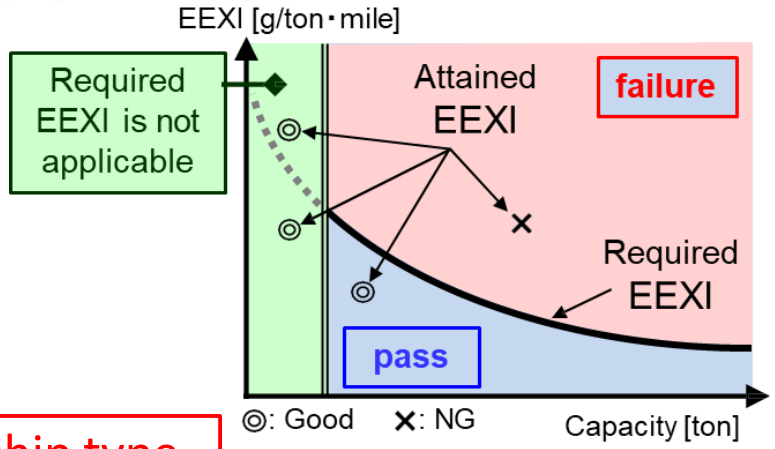
EEXI – Energy Efficiency Existing Ship Index

CII - Carbon Intensity Indicator

Technical approach (EEXI)*



- ✓ Introduce the Energy Efficiency Existing Ship Index (EEXI) as the energy efficiency index for existing ship
- ✓ The required EEXI is almost the same level as required EEDI for new ships as of 2023.



For ships with a certain size of specified ship type,
Attained EEXI ≦ Required EEXI

*ClassNK, Outlines of EEXI regulation, December 2021

Technical approach (EEXI)

Concept formula

$$\text{EEXI [g/ton·mile]} = \frac{CO_2 \text{ Conversion factor} \times \text{SFC [g/kW·h]} \times \text{Engine Power [kW]}}{\text{Capacity [ton]} \times \text{EEXI Speed [knots]}}$$

CO_2 emissions (gram) from a ship when ship sail transport 1 (ton) cargo for 1 (nautical mile)

CO_2 Conversion factor (C_F)	C_F corresponds to the fuel used when determining SFC (HFO grade: 3.114 kg CO_2 /tonne fuel)
SFC	Fuel consumption at 75%MCR (M/E), at 50%MCR (A/E)
Engine Power	75% of the rated installed power (MCR) (In case of EPL*, 83%MCR_{lim})
Capacity	Deadweight (For containerships, 70% of the deadweight)
EEXI Speed (V_{ref})	Ship speed at 75%MCR under the draught condition corresponding to the capacity

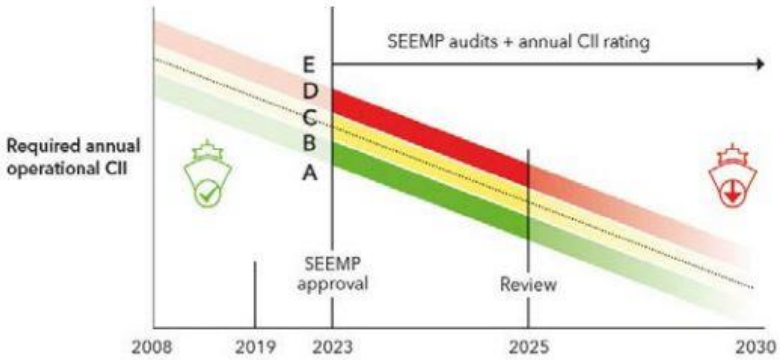
*EPL - Engine Power Limitation

$$\text{Required EEXI} = \left(1 - \frac{X}{100}\right) \times \text{EEDI Reference Line}$$

Operational approach (CII rating)

CII – Carbon Intensity Indicator for ships with GT > 5,000

$$\text{CII} = \frac{\text{Annual fuel consumption} \times \text{CO}_2\text{ factor}}{\text{Annual distance travelled} \times \text{Capacity}} \times \text{Correction factors}$$



Year	Reduction from 2019 ref. (mid-point of C-rating band)
2023	5 %
2024	7 %
2025	9 %
2026	11 %
2027-2030	To be decided

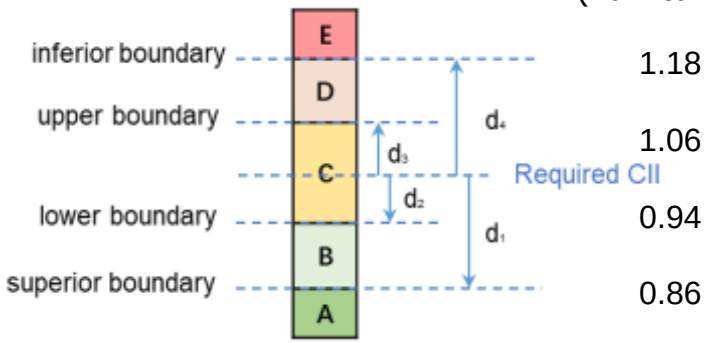
G1- G5:
MEPC.352(78);MEPC.353(78)
MEPC.338(76);MEPC.354(78)
MEPC.355(78)

A - major superior
B - minor superior
C – moderate
D - minor inferior
E - inferior

$$\text{Required CII} = \left(1 - \frac{Z}{100}\right) \cdot \text{CII}_{\text{Ref}}$$

$$\text{CII}_{\text{ref}} = a \times \text{Capacity}^{-c}$$

Attained CII / Required CII
(Bulk carriers)

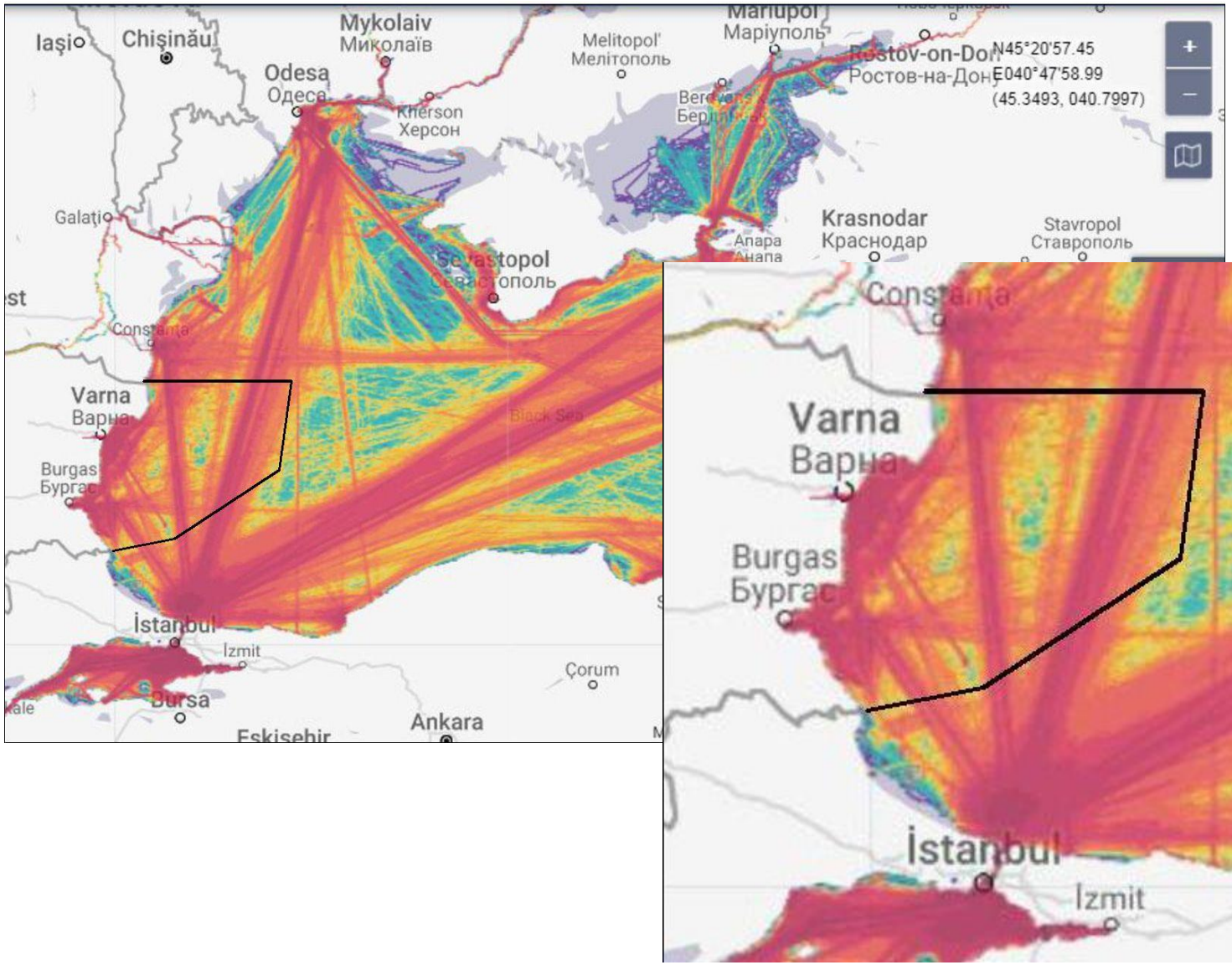


To submit a SEEMP Corrective Actions Plan

- D-Rating 3 years in a row
- E-Rating for the previous reporting year

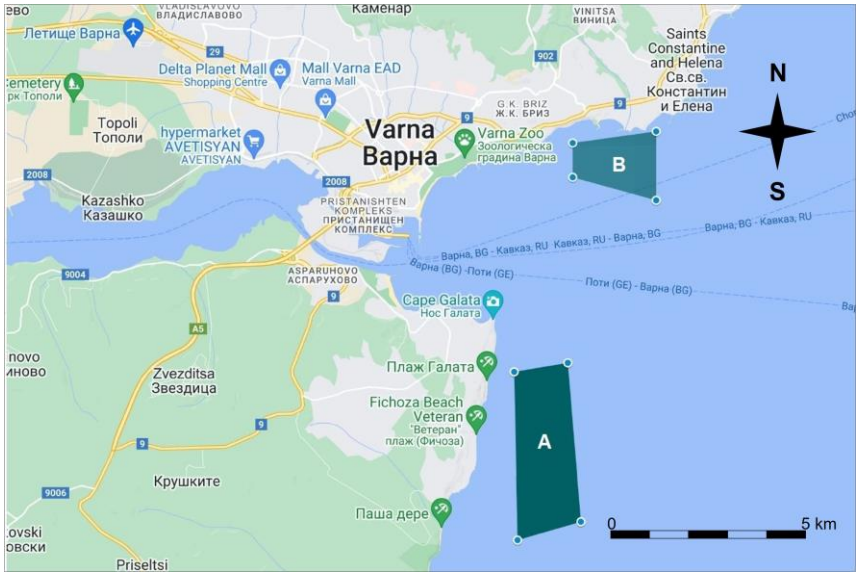
https://www.dnv.com/news/seemp-part-iii-and-the-upcoming-seemp-generator-from-dnv-221055

Traffic in the Black Sea

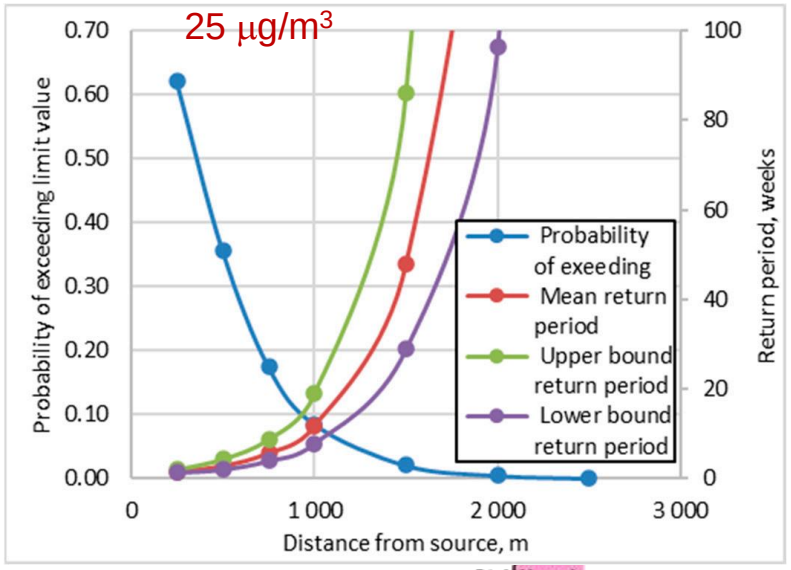


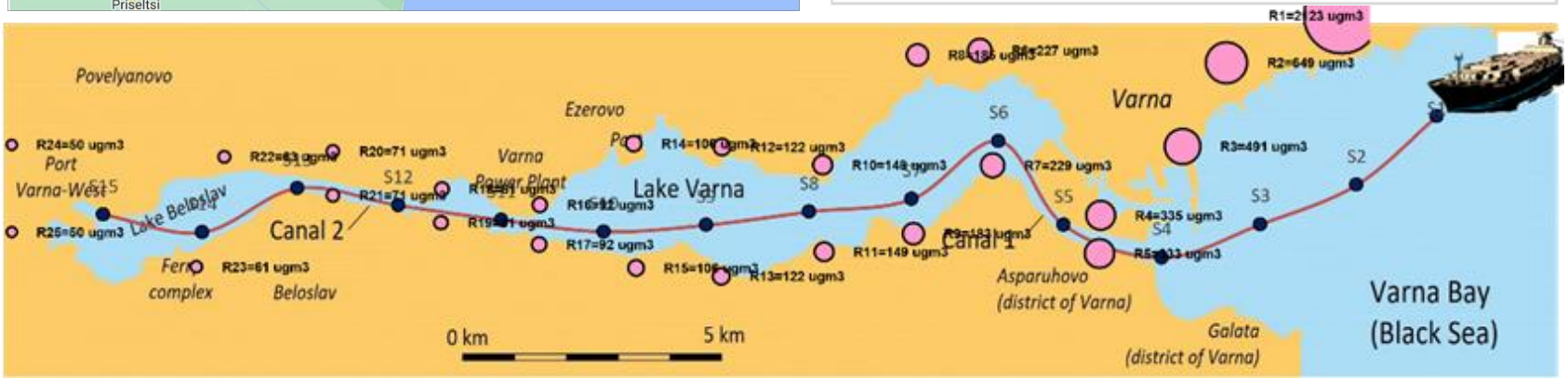
Some results from own research

Emissions from ship at anchor



Concentration of NOx

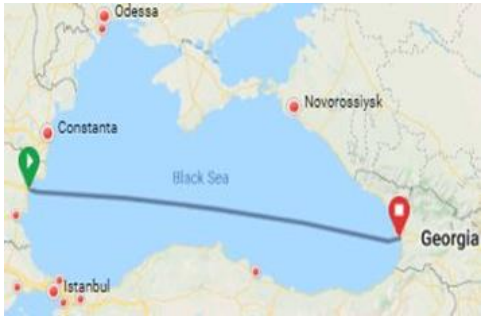




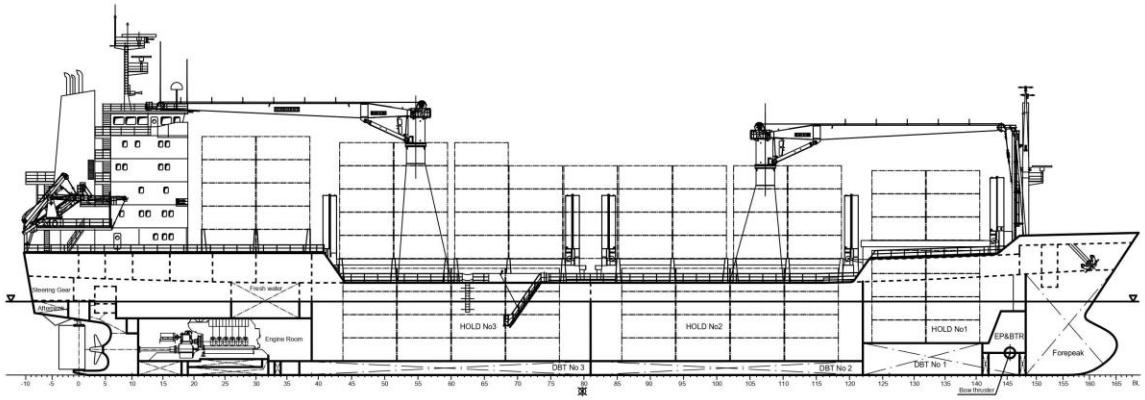
Garbatov, Y.; Georgiev, P. Air Pollution and Economic Impact from Ships Operating in the Port of Varna. Atmosphere 2022, 13, 1526
Garbatov Y, Georgiev P, Fuchedzhieva I. Extreme Value Analysis of NOx Air Pollution in the Winter Seaport of Varna. Atmosphere. 2022; 13(11):1921. .

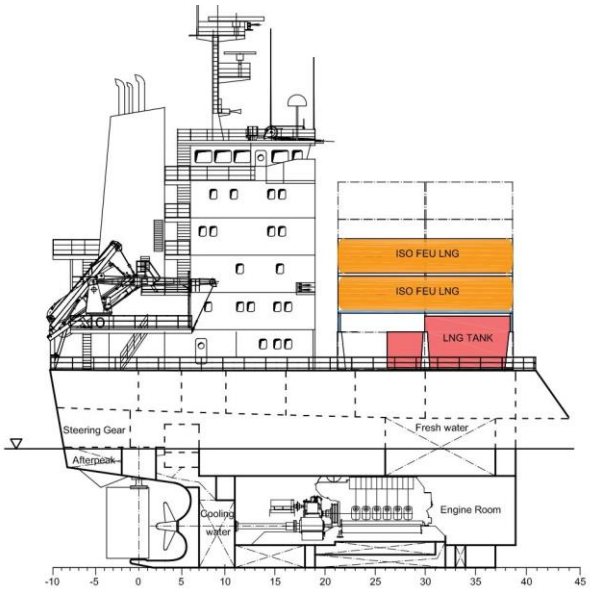
Some results from own research

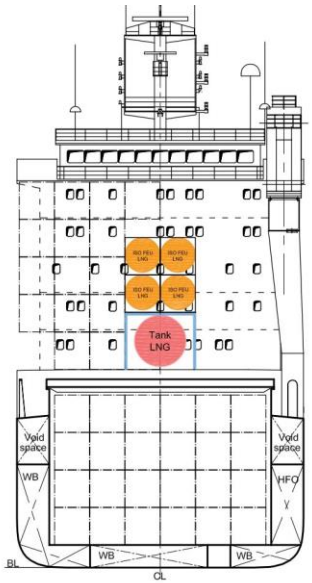
Retrofitting to eco-friendly ship







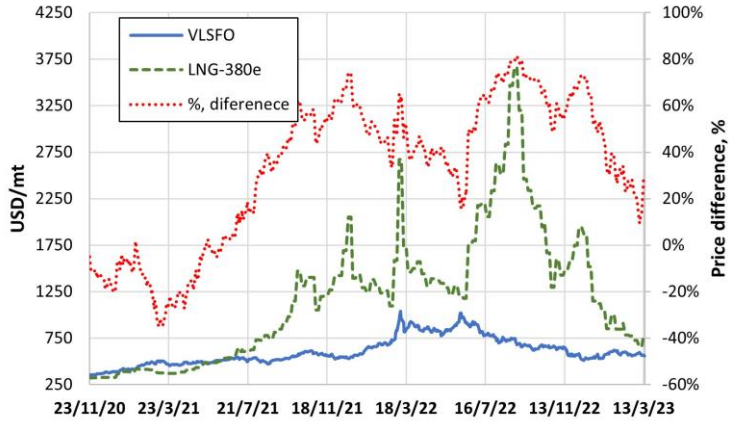


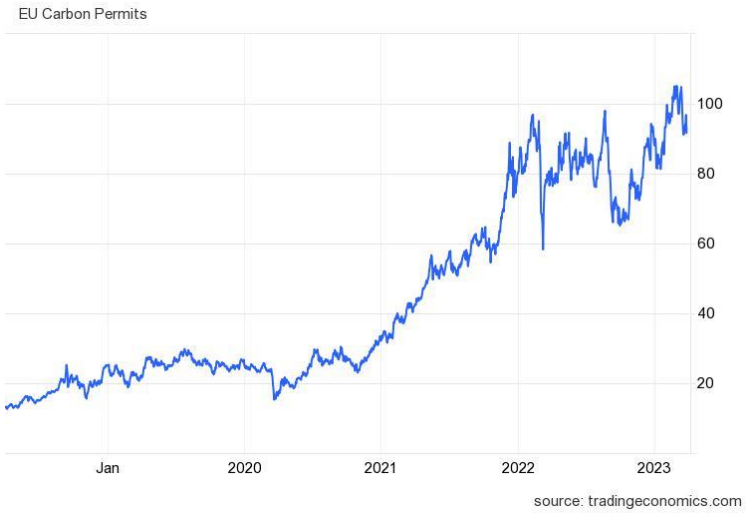


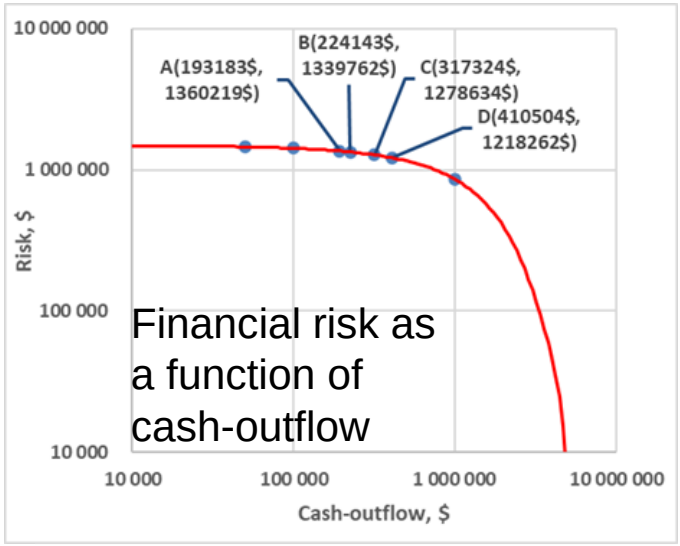
Yalamov, D., Georgiev, P., Garbatov, Y. Liquefied natural gas, an alternative for retrofitting ageing ships. 2022. Proc. of Sixteenth International Conference on Marine Sciences and Technologies, Black Sea 2022, Varna, 20 October 2022, pp 87-98
Yalamov D, Georgiev P, Garbatov Y. Economic Feasibility of Retrofitting an Ageing Ship to Improve the Environmental Footprint. Applied Sciences. 2023; 13(2):1199
Yalamov, D., Georgiev, P., & Garbatov, Y. (2023, June 30). Retrofitting measure of an ageing multi-purpose ship exposed to short-sea LNG operation. ANNUAL JOURNAL OF TECHNICAL UNIVERSITY OF VARNA, BULGARIA, 7(1), 68-87.

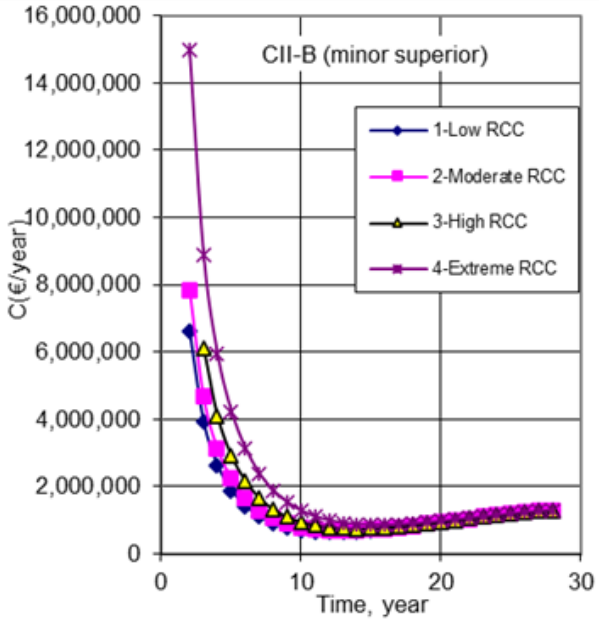
Some results from own research

Retrofitting to eco-friendly ship

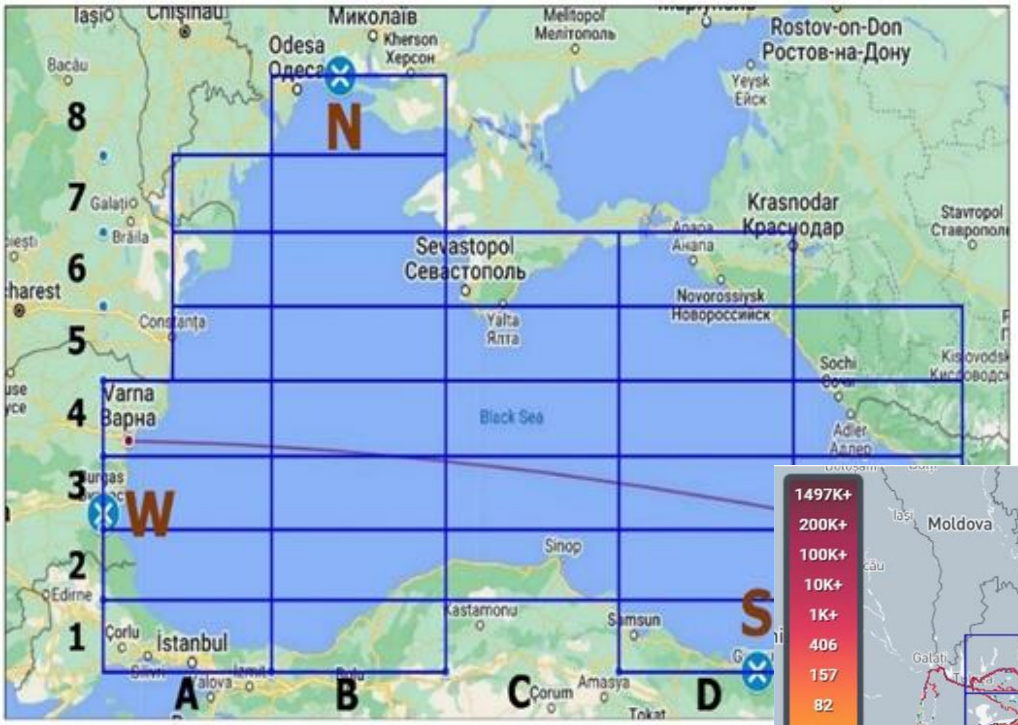


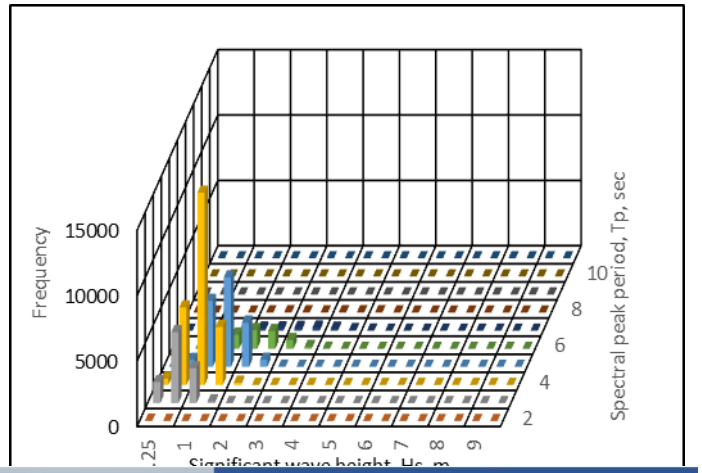


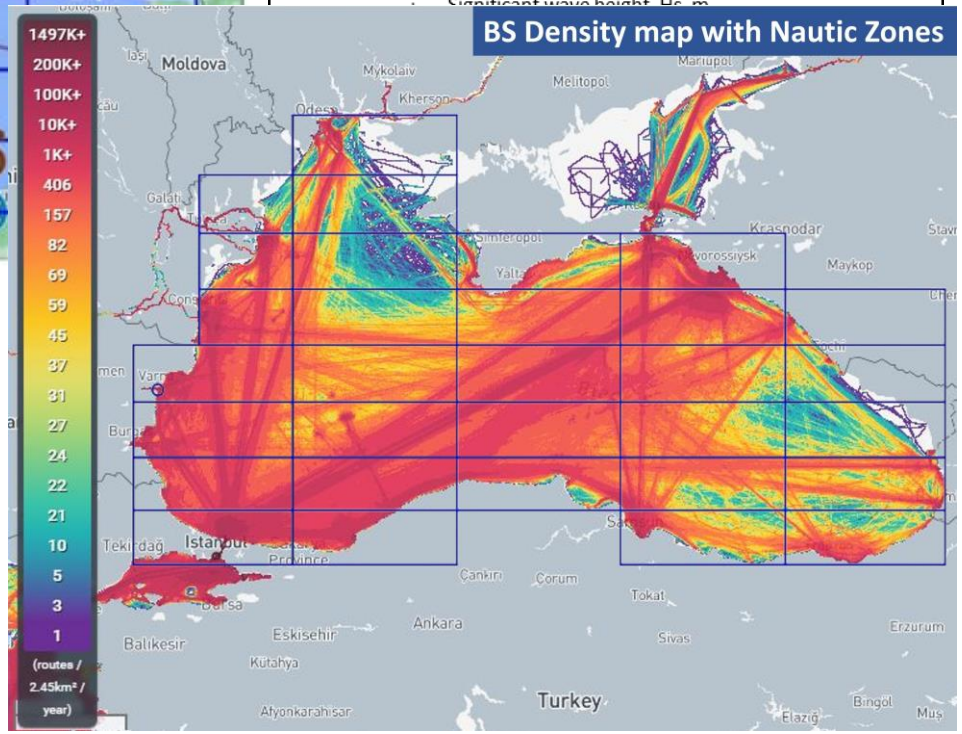




Nautic zones in the Black Sea







Проектна идея, включена в ПИРО- Варна 2021-2027

Мониторинг, анализ на риска и мерки свързани с намаляване на ефекта от газовите емисии генерирани от корабоплаването и кораборемонта в крайбрежната зона и пристанище Варна- Запад.

Д1: Изграждане на система за мониторинг и екологичен контрол и оценка на риска за качеството на въздуха с цел изолиране и минимизиране на ефекта от концентрацията на CO_2, SO_x, NO_x, PM_{10}, $PM_{2.5}$ от корабния трафик в частта от ИИЗ край Варна, стоящите край брега на котва кораби, плаването през канала до Пристанище Варна-Запад и кораборемонтната и корабостроителна дейност в индустриалната зона на града. Това включва изграждането на автоматизирана мрежа от сензори на невралгични места с акумулиране на данни и последваща обработка;

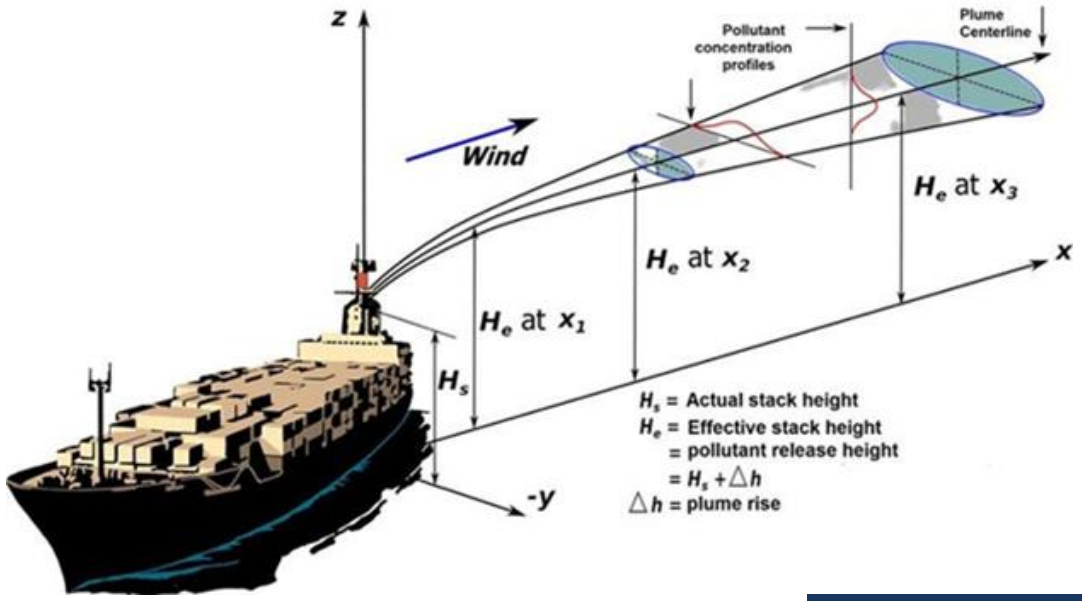
Д2:Осъществяване на мерки за повишаване на енергийната ефективност на работата в пристанище Варна и предоставяне на енергия от ВЕИ на корабите на кея;

Проектна идея, включена в ПИРО- Варна 2021-2027

Д3: Икономически и технически анализ за въвеждане в експлоатация на хибридни фериботи за пътнически морски транспорт между пристанище Варна и кв. Аспарухово, както и до други по-малки места по периферията на Варненското езеро;

Д4: Изграждане на концепция, транспортни системи и пътища за реализирането им за изграждането на Варна като мултимодален център за морски транспорт на къси разстояния през Черно море, включваш магистралите А2- „Хемус“ и А5 - „Черно море“, железопътния коридор свързващ пристанище Солун, Александруполис, Бургас, Варна и Русе.

Благодаря за вниманието!



Gaussian dispersion model