GreenVoyage 2050

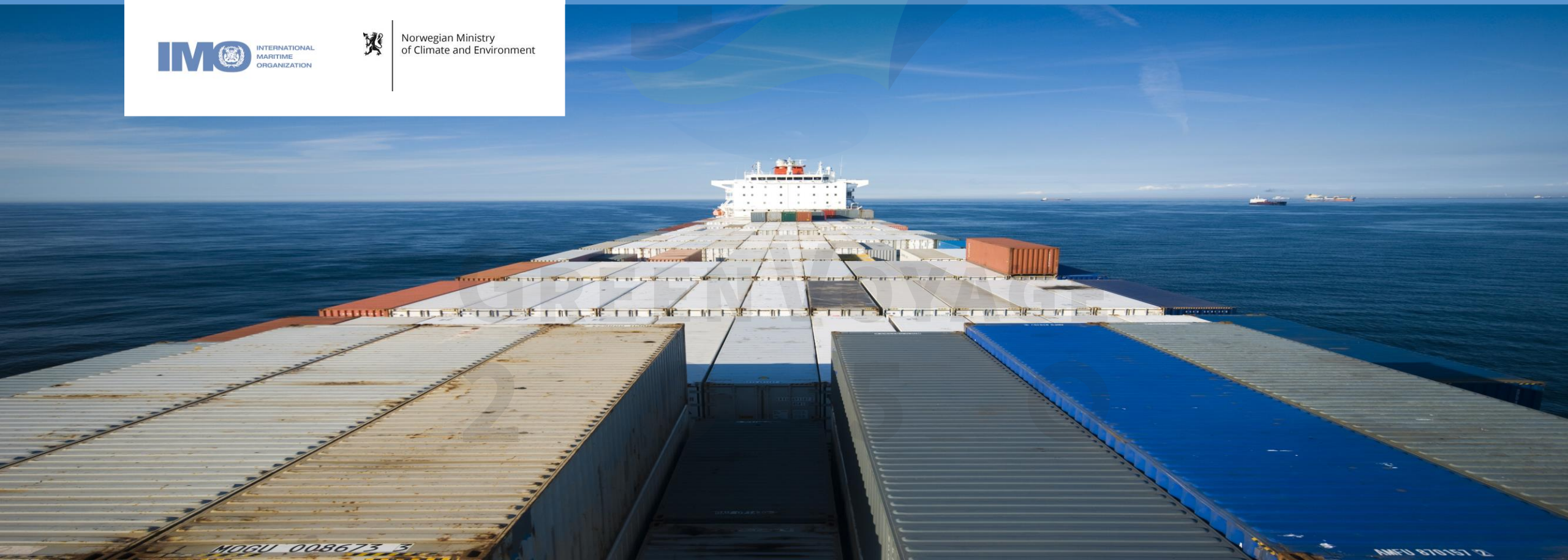
IMO INTERNATIONAL MARITIME ORGANIZATION

Norwegian Ministry of Climate and Environment

Alternative fuels and energy carriers for shipping

Session 1 – Context, background and key concepts

March 2021



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Training course prepared by…

E4tech is an energy and sustainability strategy consultancy. It works internationally with wide range of companies and organisations to maximise opportunities in the clean energy transition. E4tech brings a deep expertise in low-carbon fuels and technologies to the maritime sector, helping governments and companies in the sector understand the options and transition pathways to deep emission reductions.

Houlder is a marine design and engineering consultancy. It has a track record of over 3,000 projects spanning vessel newbuild design, retrofit, and conversions as well as offshore equipment design, installation and mobilisation. Houlder delivers innovative, creative, and often specialised solutions that allow clients to optimise asset efficiency and tackle the challenge of the energy transition.

Please contact:
Chester Lewis – Managing Consultant (Maritime lead), E4tech – chester.lewis@e4tech.com
Chris Bell – Senior Consultant, Houlder – chris.bell@houlderltd.com

Training delivered by…

Astrid Dispert
IMO

Minglee Hoe
IMO

Jamie Jones
IMO

Adam Chase
E4tech

Chester Lewis
E4tech

Chris Sim
E4tech

David Pugh
Houlder

Chris Bell
Houlder

Jonathan Strachan
Houlder

Mike Davis
E4tech

Charlotte Kirk
E4tech

Agenda and objectives

Objectives of this training course

- This training course is about an **important and fundamental transition** in the global maritime sector.
- The aim is to equip participants with the knowledge to help **understand and shape this transition,** by looking at the role of alternative fuels.
- The objective is for all participants to be able answer the following key questions by the end of the course:

Where we are now?

Why do we need to transition to alternative fuels?

What are the key barriers to adoption?

Which options look feasible today?

How do we get there?

How does the maritime sector need to change and adapt to use these fuels?

What are the key opportunities presented by the transition?

Which options look feasible for the medium and long term?

Agenda

1. Introduction to alternative fuels
2. Key concepts related to alternative fuels
3. Summary of day

INTRODUCTION TO ALTERNATIVE FUELS:

CONTEXT AND BACKGROUND

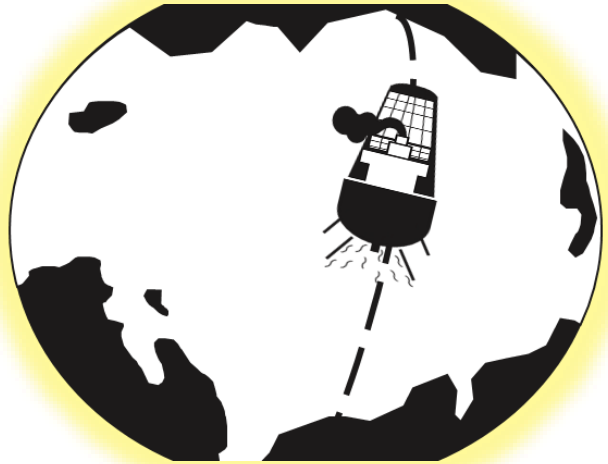
Different types of shipping

There are many different ways to examine shipping:

- Passenger vs. freight
- Type of vessel e.g oil tanker, bulk carrier, container
- Geography and type of operation…

Inland waterways

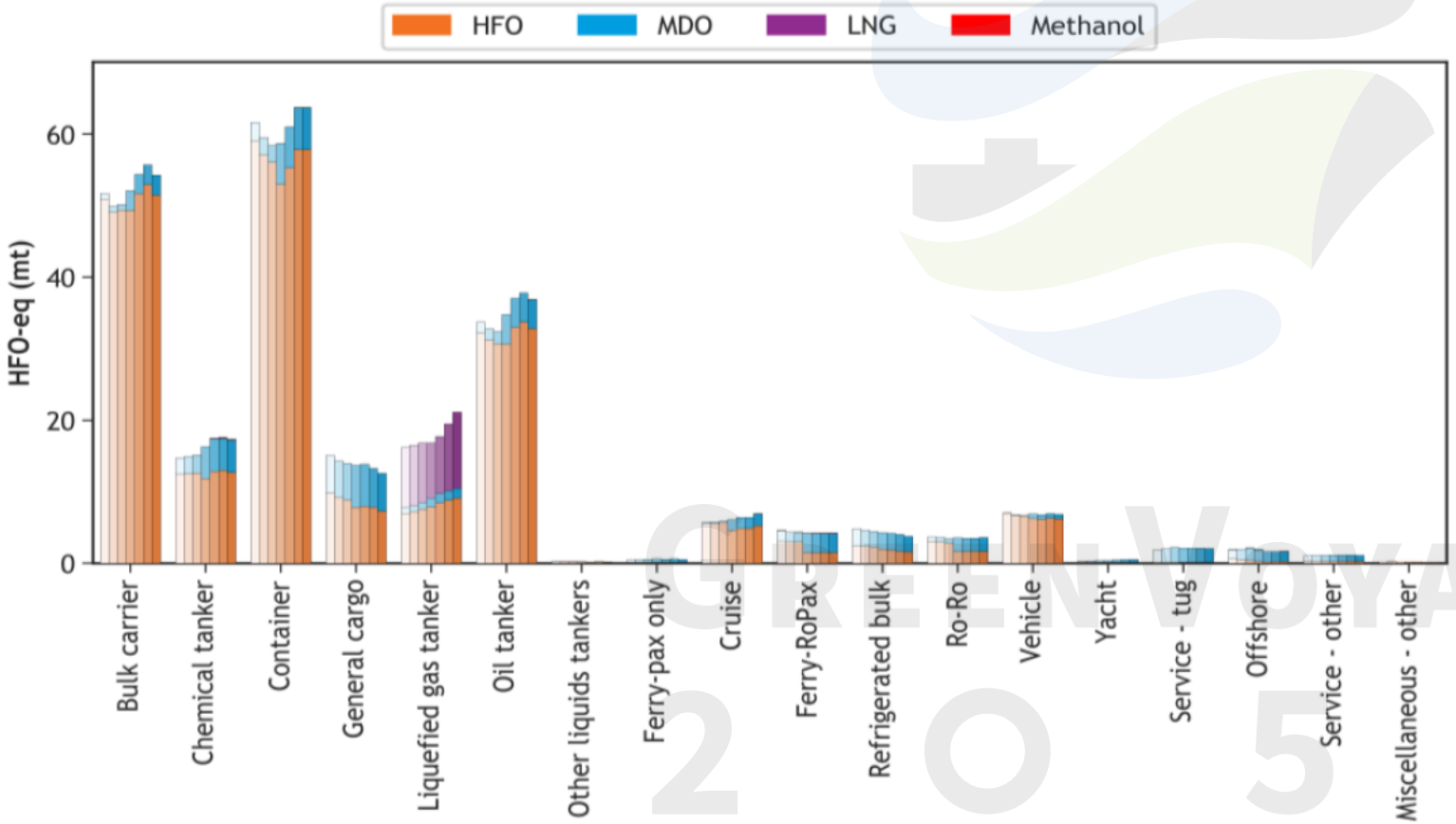
Domestic/coastal shipping



International shipping

International shipping industry is currently dominated by fossil fuels

Estimated global fuel consumption break down across ship types, for each year 2012-2018



Source: UMAS, IMO Fourth GHG study

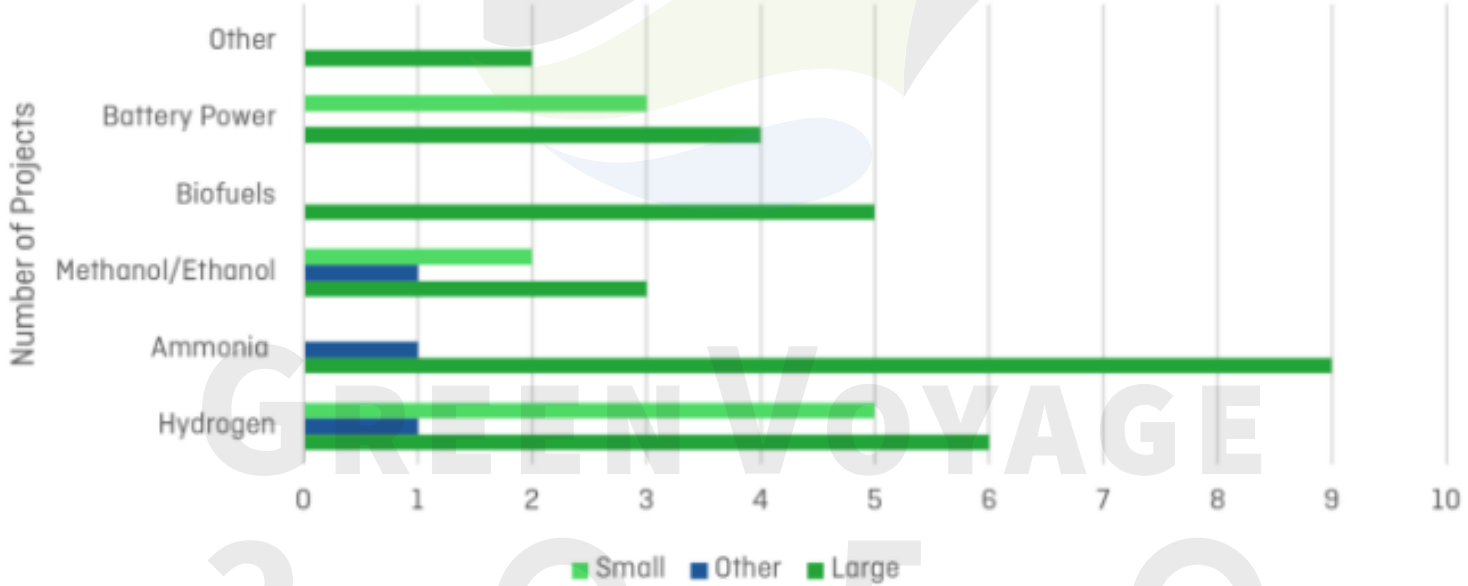
The most used fuels are:

1. Heavy Fuel Oil (HFO)
2. Marine Diesel Oil (MDO)
3. Liquefied Natural Gas (LNG)

International shipping industry is currently dominated by fossil fuels

- Mapping of ongoing zero-emission pilot and demonstration projects has been undertaken by the Getting to Zero Coalition (results shown below for 2020).

Ongoing pilot or demonstration projects by fuel type and vessel size.



Source: Getting to Zero Coalition, https://www.globalmaritimeforum.org/news/mapping-of-zero-emission-pilots-and-demonstration-projects/

Addressing climate change requires a reduction in the use of fossil fuels

2.02%

Percentage of global CO_2 emissions from international shipping[1]

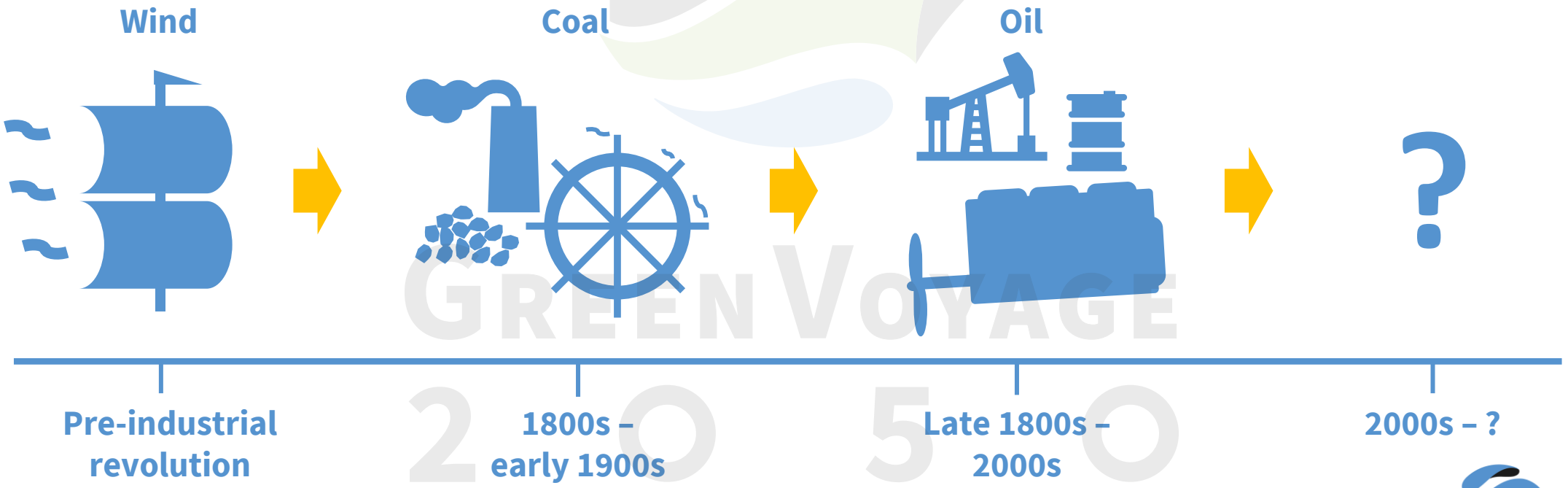
50%

IMO initial GHG strategy target for greenhouse gas emissions reduction by 2050 compared with 2008 levels[2]

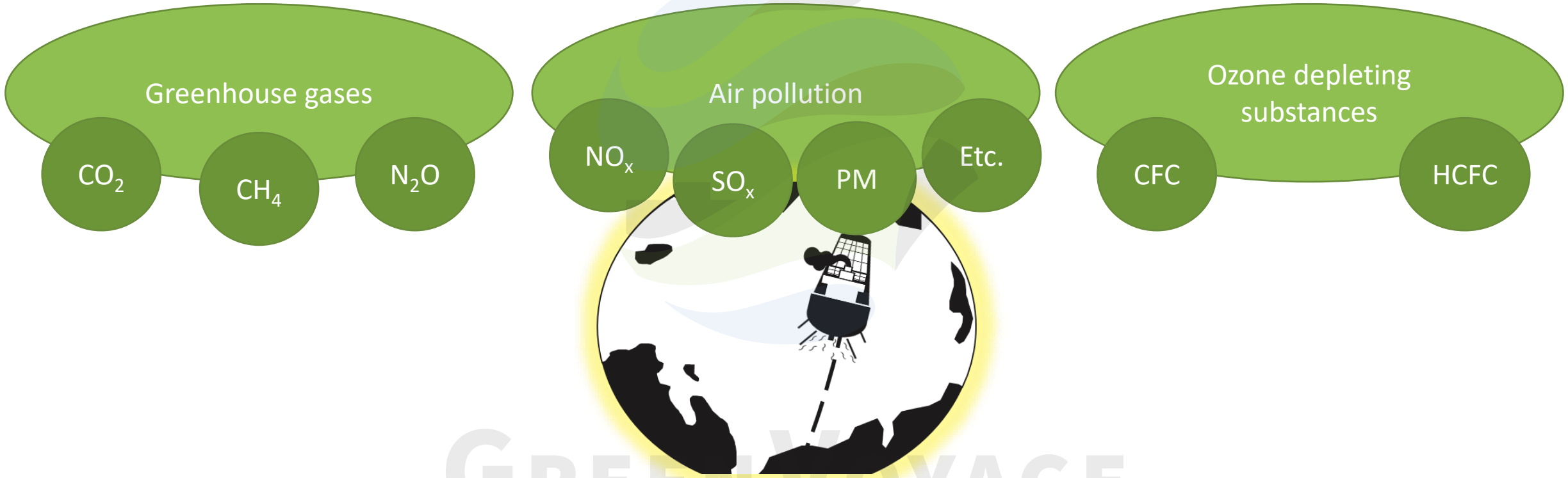
[1] Fourth IMO GHG Study, July 2020. Anthropogenic emissions only. Figure for 2018.
[2] Strategy adopted in 2018 (resolution MEPC.304(72)).

The story so far…

- While technological development in maritime propulsion has been an ongoing process, it's progress up until now can be defined by three main 'revolutions'.
- We are now entering the **'fourth revolution' of maritime propulsion.**



Greenhouse gas emissions are not the only reason for change



All these gases/substances are currently emitted from shipping

This workshop focuses on greenhouse gases (GHGs) but it is important to consider all of these when thinking about alternative energy/fuel options

HFO has advantages and disadvantages

- Cheap
- Undesirable product of crude oil
- Well understood
- Reliable
- Energy dense

- Greenhouse gas emissions
- Air pollutant emissions
- Viscous
- Hazardous spills

Decarbonization: IMO Strategy on reduction of GHG from ships

Vision

IMO is committed to reducing GHG emissions from international shipping and, as a matter of urgency, aims to phase them out as soon as possible in this century

ANNEX 11

RESOLUTION MEPC.304(72)
(adopted on 13 April 2018)

INITIAL IMO STRATEGY ON REDUCTION OF GHG EMISSIONS FROM SHIPS

THE MARINE ENVIRONMENT PROTECTION COMMITTEE

RECALLING Article 38(e) of the Convention on the International Maritime Organization (the Organization) concerning the functions of the Marine Environment Protection Committee (the Committee) conferred upon it by international conventions for the prevention and control of marine pollution from ships,

ACKNOWLEDGING that work to address greenhouse gas (GHG) emissions from ships has been undertaken by the Organization continuously since 1997, in particular, through adopting global mandatory technical and operational energy efficiency measures for ships under MARPOL Annex VI,

ACKNOWLEDGING ALSO the decision of the thirtieth session of the Assembly in December 2017 that adopted for the Organization a strategic direction entitled "Respond to Climate Change",

RECALLING the United Nations 2030 Agenda for Sustainable Development,

1 ADOPTS the Initial IMO Strategy on reduction of GHG emissions from ships (hereinafter the Initial Strategy) as set out in the annex to the present resolution;

Levels of ambitions set out in the Initial IMO GHG Strategy

.1 carbon intensity of the ship to decline through implementation of further phases of the energy efficiency design index (EEDI) for new ships

to review with the aim to strengthen the energy efficiency design requirements for ships with the percentage improvement for each phase to be determined for each ship type, as appropriate;

.2 carbon intensity of international shipping to decline (for all ships)

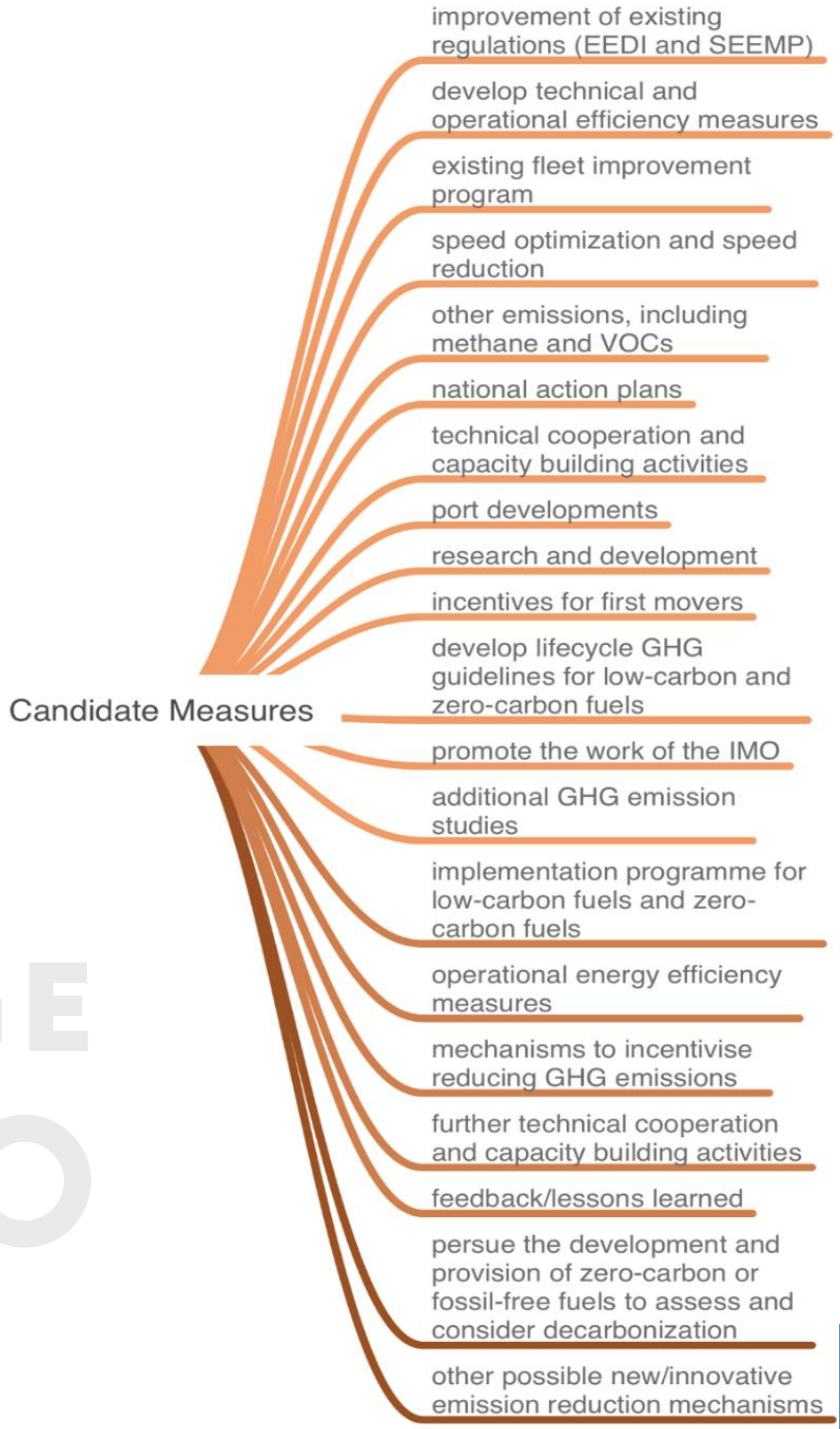
to reduce CO_2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008; and

.3 GHG emissions from international shipping to peak and decline

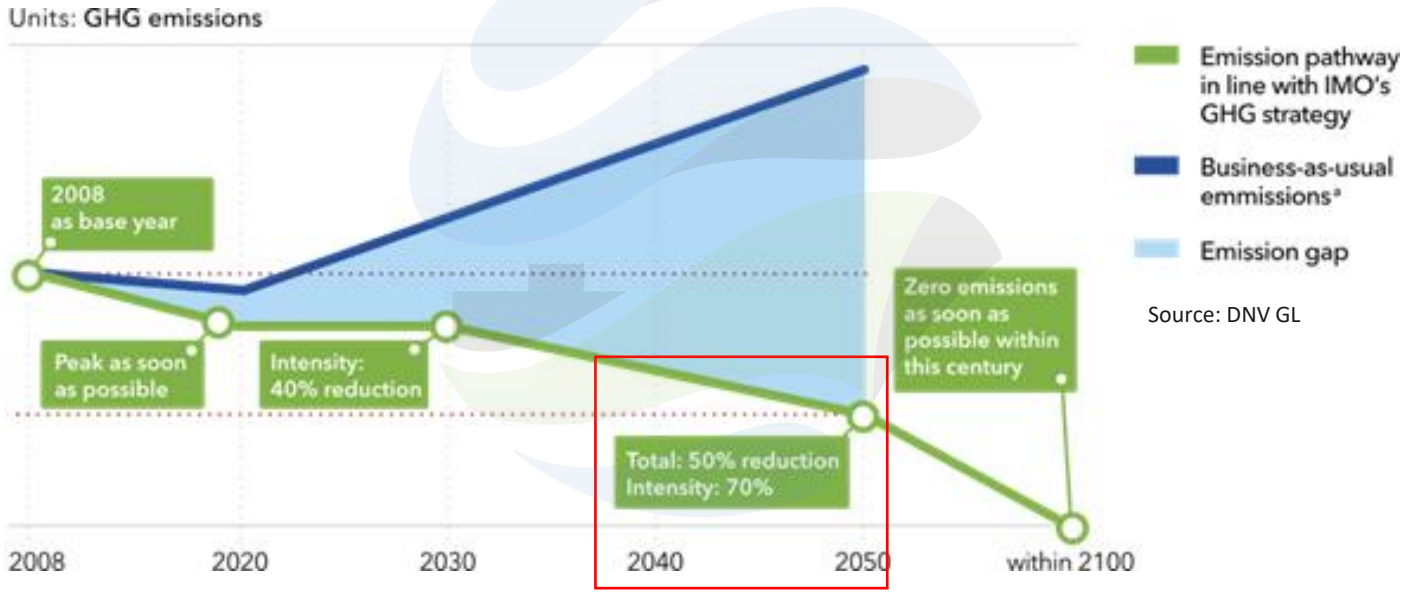
to peak GHG emissions from international shipping as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 whilst pursuing efforts towards phasing them out as called for in the Vision as a point on a pathway of CO_2 emissions reduction consistent with the Paris Agreement temperature goals.

Candidate measures

- Initial GHG Strategy contains a list of "**candidate GHG measures**" with the following timelines for finalization and agreement:
  - Short-term measures - between 2018 and 2023
  - Mid-term measures - between 2023 and 2030
  - Long-term measures - beyond 2030
- Proposals for candidate measures need to be accompanied by an **assessment of impacts on States**
- Current negotiations focus on a mandatory goal-based short-term GHG reduction measure for existing ships aimed at achieving **40% carbon intensity reduction by 2030**



In practice, 50% means deep decarbonisation per vessel



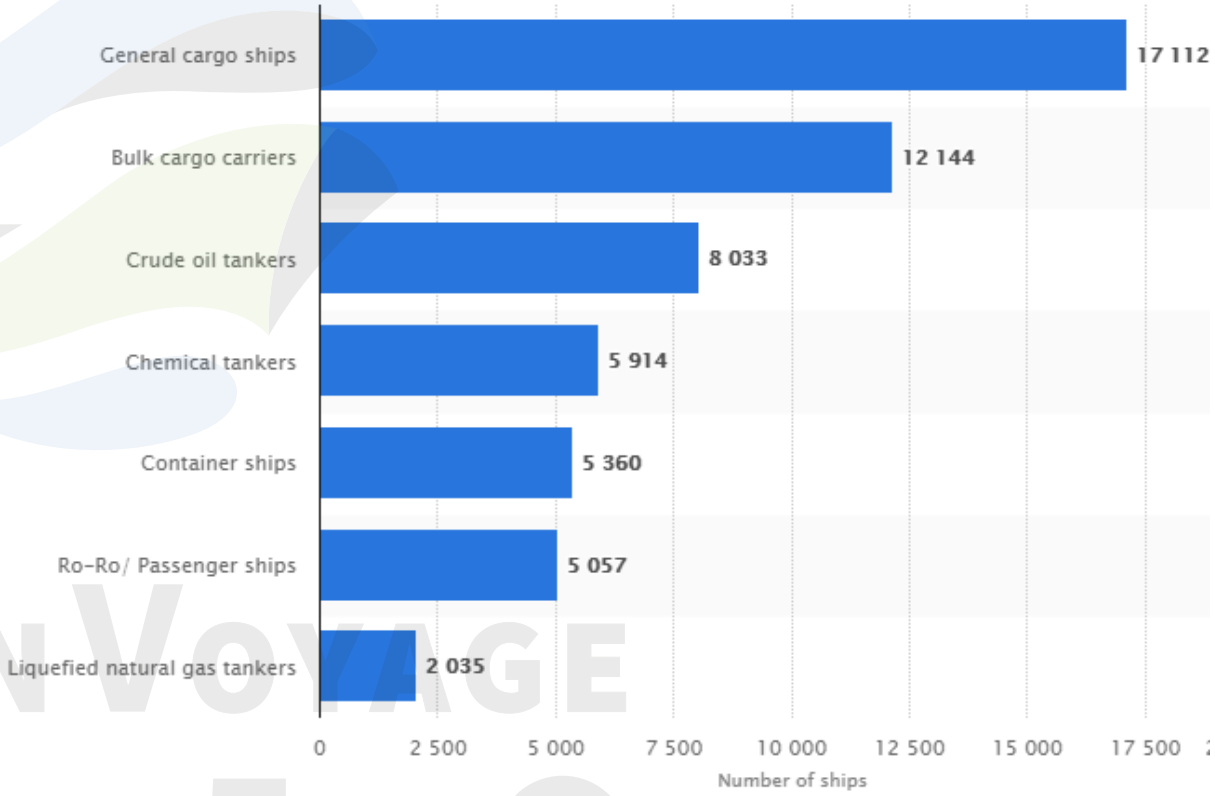
Source: DNV GL

- 50% reduction is the target for the international shipping sector
- The demand for shipping is expected to continue to grow as our economies grow
- How much the demand for shipping will grow is heavily debated…
- … however scenarios suggest 70%+ reduction per vessel will be needed by 2050 to reach this target

>70% reduction per vessel needs to average across the fleet

- Merchant fleet currently comprises of approximately 50,000-60,000 vessels.
- Most vessels have a lifetime of approximately 30 years.
- This means the vessels ordered and built today will be operating in 2030.
- And the supply of alternative fuels and/or technologies and their associated infrastructure needs to be built
- A massive challenge for the sector, but definitely not impossible

Today's global fleet composition (merchant ships)



Source: Statista https://www.statista.com/statistics/264024/number-of-merchant-ships-worldwide-by-type/

Why do we need alternative fuels and energy carriers?

Are there other ways we can reduce GHG emissions? What can each contribute?

Message: IMO GHG target cannot be met without alternative fuels and energy sources that offer deep GHG emission savings compared to current fossil fuels

Why does change need to happen now?

Proving technology and equipment

Developing regulation and policy

Preparing supply chain (production, distribution and refuelling)

Ships are capital-intensive assets, with lifetimes of 20 – 30 years

Which alternative fuels and energy sources are we considering?

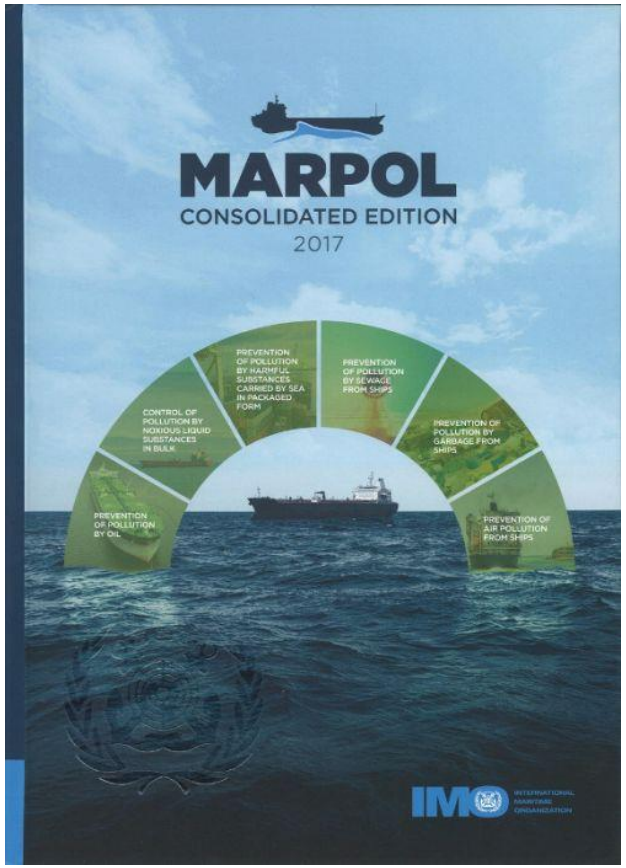
- In these sessions we will cover:
  - LNG
  - LPG
  - Methanol
  - Biofuels
  - Batteries
  - Hydrogen
  - Ammonia

- Other fuels or energy options that could have been considered:
  - Ethanol -> Feedstock currently more highly valued for road transport, and restrictions due to fuel properties (covered later)
  - E-diesel -> High cost
  - Nuclear -> Concerns over safety, cost and political challenges limit applicability

- All these fuels or energy sources have a case for being an alternative option for shipping
- More detail will be given on these fuels in following sessions

Safety and environmental regulation

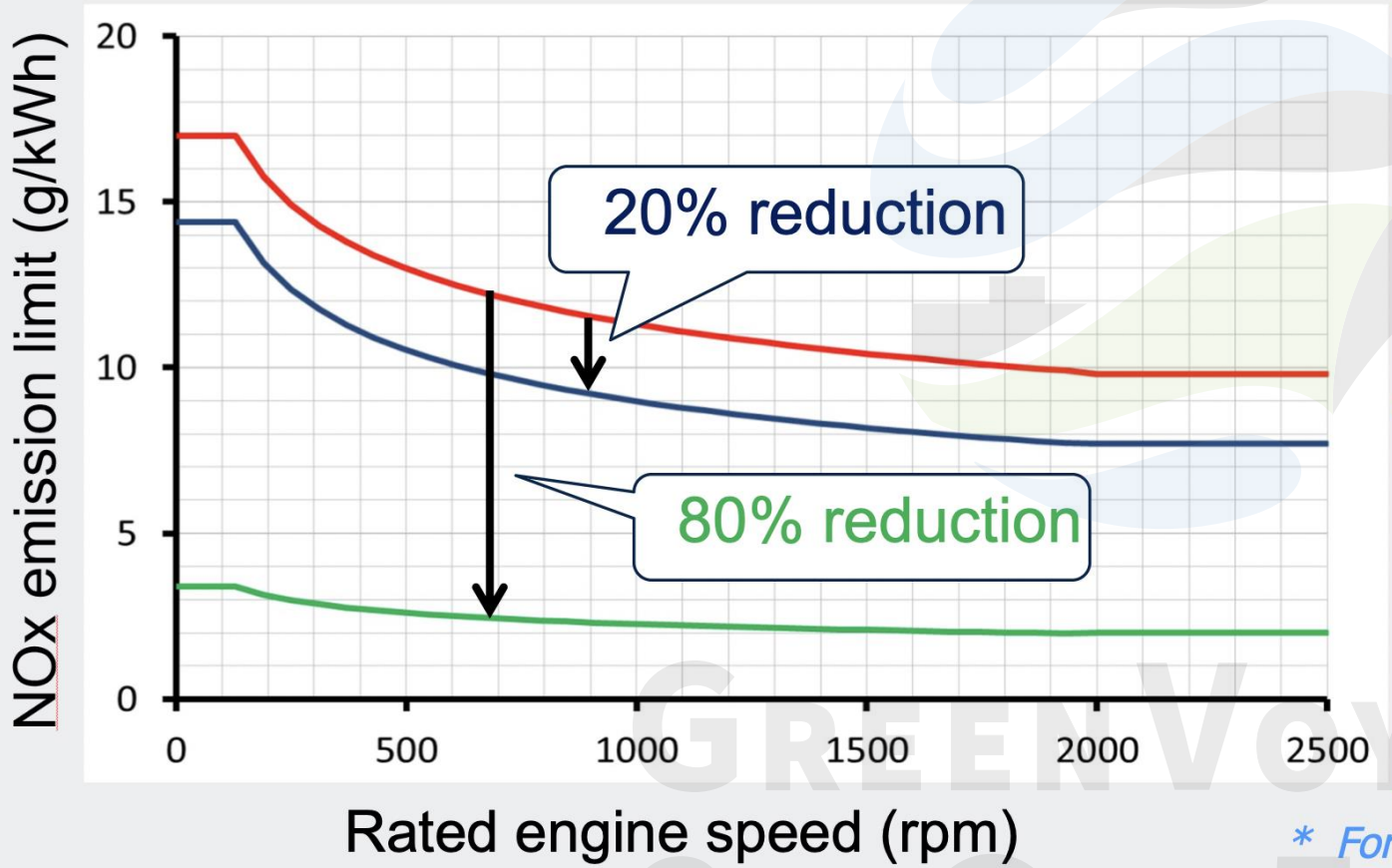
- Environmental regulation is primarily provided by the International Convention for the Prevention of Pollution from Ships (**MARPOL**).
- Adopted on 2 November 1973 at IMO and updated over the years since then.
- Includes regulations to prevent and minimise pollution from ships via six annexes. Of particular interest for this course is **Annex VI - Prevention of Air Pollution from Ships**, which includes the following key chapters:
  - **Chapter 3: Requirements for control of emissions**
    - Includes regulations covering NOx, SOx and particulate matter;
    - Also regulates fuel oil availability and quality.
  - **Chapter 4: Energy efficiency regulations**
    - Includes measures to reduce GHG emissions through energy efficiency improvements;
    - Key aspect is the Energy Efficiency Design Index (EEDI), which sets minimum energy efficiency levels per capacity mile.



NOx - what is the impact and how is it produced?

- Refers to oxides of nitrogen including NO2 and NO.
- NOx is a reactive gas, in the presence of sunlight:
  - Causes health problem; in particular on respiratory system.
  - NOx together with Volatile Organic Compounds and other reactive gases in the atmosphere can lead to smog.
  - Additionally, NOx contributes to global warming and acid rain.
- NOx: Formed in the process of fuel combustion where O_2 and N_2 meet at high temperature.
- The higher the temperature (and longer the exposure time at high temp.), the more NOx is formed.
- In engines, the higher the temperature, the more efficient the engine is; thus more NOx produced.

Chapter 3: IMO regulation on NOx



Tier I
- Constructed on or after 1 Jan. 2000

Tier II
- Constructed on or after 1 Jan. 2011

Tier III*
- Constructed on or after 1 Jan. 2016
- Applied in ECAs
- Tier II applied outside of ECAs

** For a ship operating within North American ECA and US Caribbean Sea Area ECA*

NOx emission limits of MARPOL Annex VI apply to each marine diesel engine with a power output of more than 130 kW installed on a ship.

Source: *DNV GL* (2019)

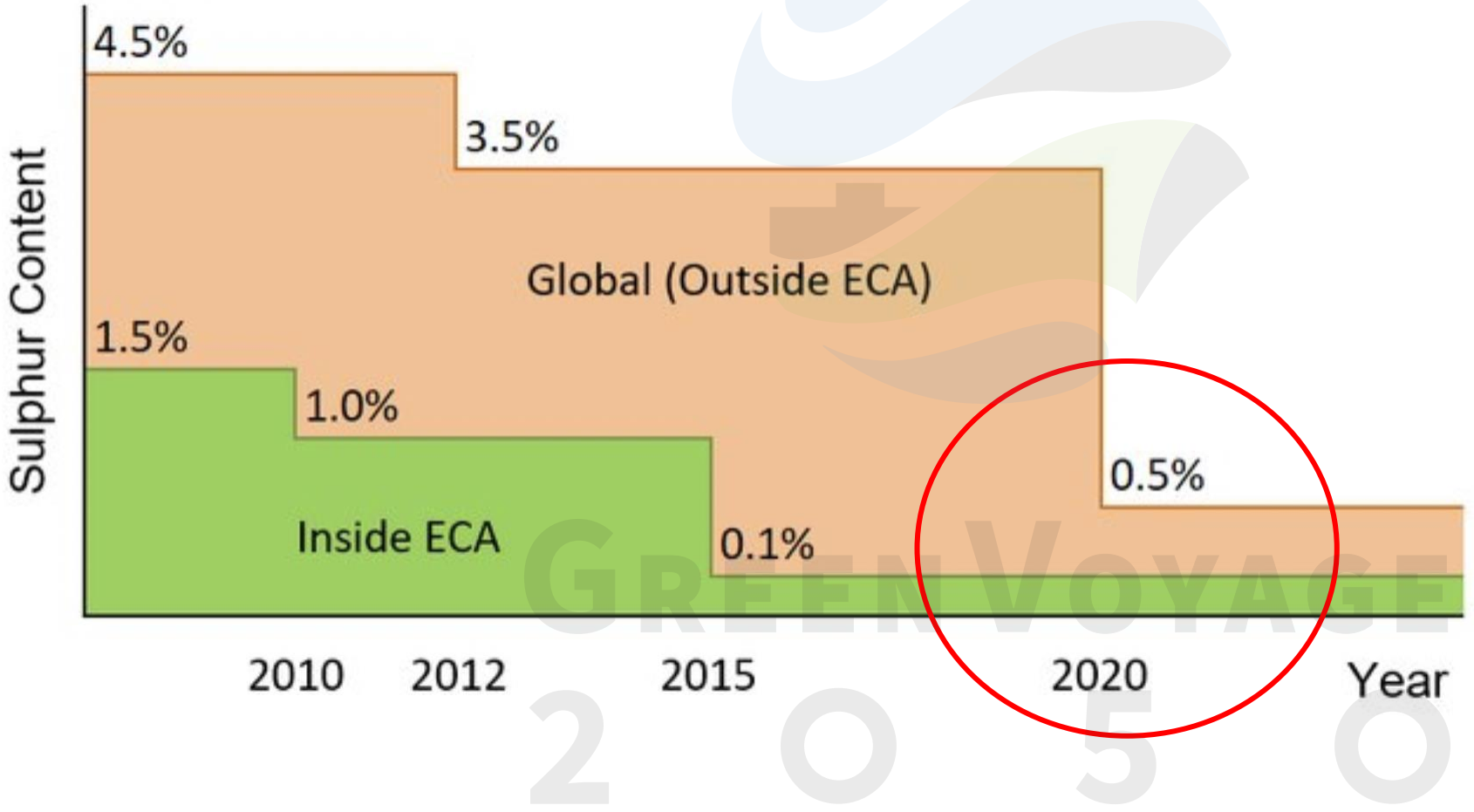
How is SOx and PM produced and what is the impact?

- SO_x : normally Sulphur dioxide (SO_2) and to some extent Sulphur trioxide (SO_3).
- SO_x is produced from combustion (oxidation) of sulphur contained in most fuel-oil.
- SO_x causes:
  - acid rain
  - sea and soil acidification
  - human health issues

- PM (Particulate Matter) is produced due to incomplete combustion of fuel.
- Level of PM is dependent on fuel sulphur level.

=> Reduction of fuel sulphur **will reduce both: SO_x and PM.**

Chapter 3: IMO regulation on SOx



“IMO 2020”

Limits the sulphur in the fuel oil used on board ships operating outside designated emission control areas to 0.5% by mass

Source: *DNV GL* (2019)

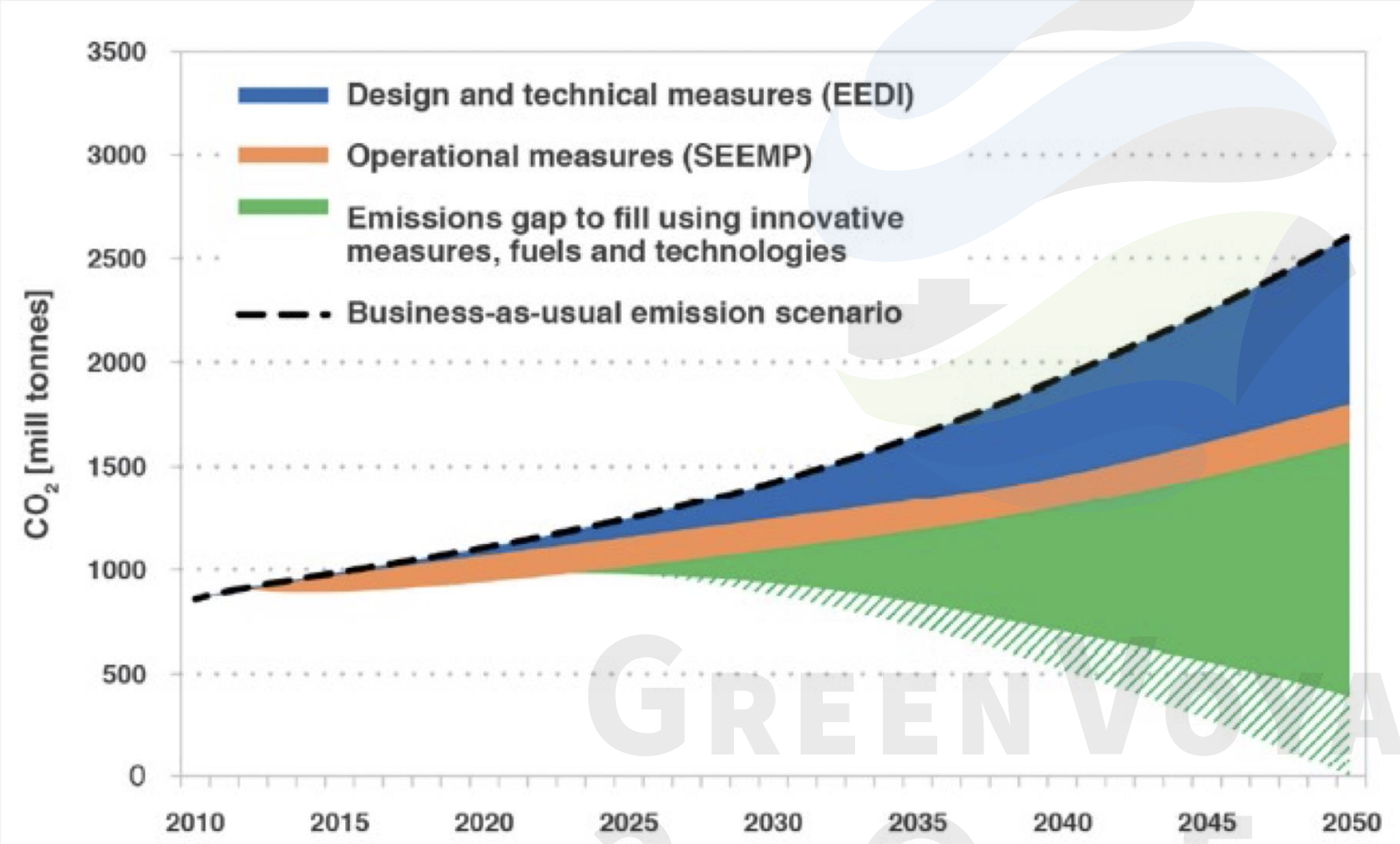
IMO 2020: global 0.50% sulphur limit in marine fuels

- On 1 January 2020, the 0.50% global sulphur cap - “IMO2020” took effect.
- Reduction of max. 3.50% to 0.50% sulphur content in bunker fuels resulted in a 77% drop of overall SOx emissions from international shipping.
- March 2020: IMO’s ‘**Carriage Ban**’ (global prohibition to carry non-compliant fuel for propulsion) entered into force, further reinforcing IMO2020.

Chapter 4: Energy efficiency regulations for ships

SHIP DESIGN	SHIP OPERATION
Energy Efficiency Design Index (EEDI) For new ships	**Ship Energy Efficiency Management Plan (SEEMP)** For all ships
• Requires new ships to be built to a minimum level of energy efficiency. • Ship designers/builders free to choose technologies to satisfy EEDI requirements. • EEDI level is tightened over time. Shipbuilders deliver on this: More technologically advanced/ complex ships. • Promotes innovation at design stage of ships.	• On-board management tool. • Framework, against which, a shipowner can develop best practice and energy efficient operations. • Aims to catalyze uptake of operational Energy Efficiency Measures.

Chapter 4: Energy efficiency regulations for ships



Reduction % are indicative estimate.
This is illustration purpose only and not approved by MEPC.

- Energy efficiency improvements through the current framework (EEDI and SEEMP) are important, but will not be enough to reach the 2050 ambition.
- MEPC 75 (Nov 2020) approved amendments to MARPOL Annex VI introducing new regulations to reduce GHG emissions from existing ships (pending final adoption).

Safety and environmental regulation

- Regulation of maritime safety is primarily provided by the International Convention for the Safety of Life at Sea (**SOLAS**).
- The version in force today was adopted in 1974, with multiple updates and amendments made since then.
- It includes important codes such as:
  - IGF Code – referring to safety of using gases or other low-flashpoint fuels
  - Codes referring to the safe transport of dangerous goods e.g IBC code and IGC code