GLOBAL SO_x, NO_x and CO_2 CAPS
CHALLENGES AND TRENDS IN MARITIME ENERGY MANAGEMENT

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Shipping Air Emissions and Its Impacts

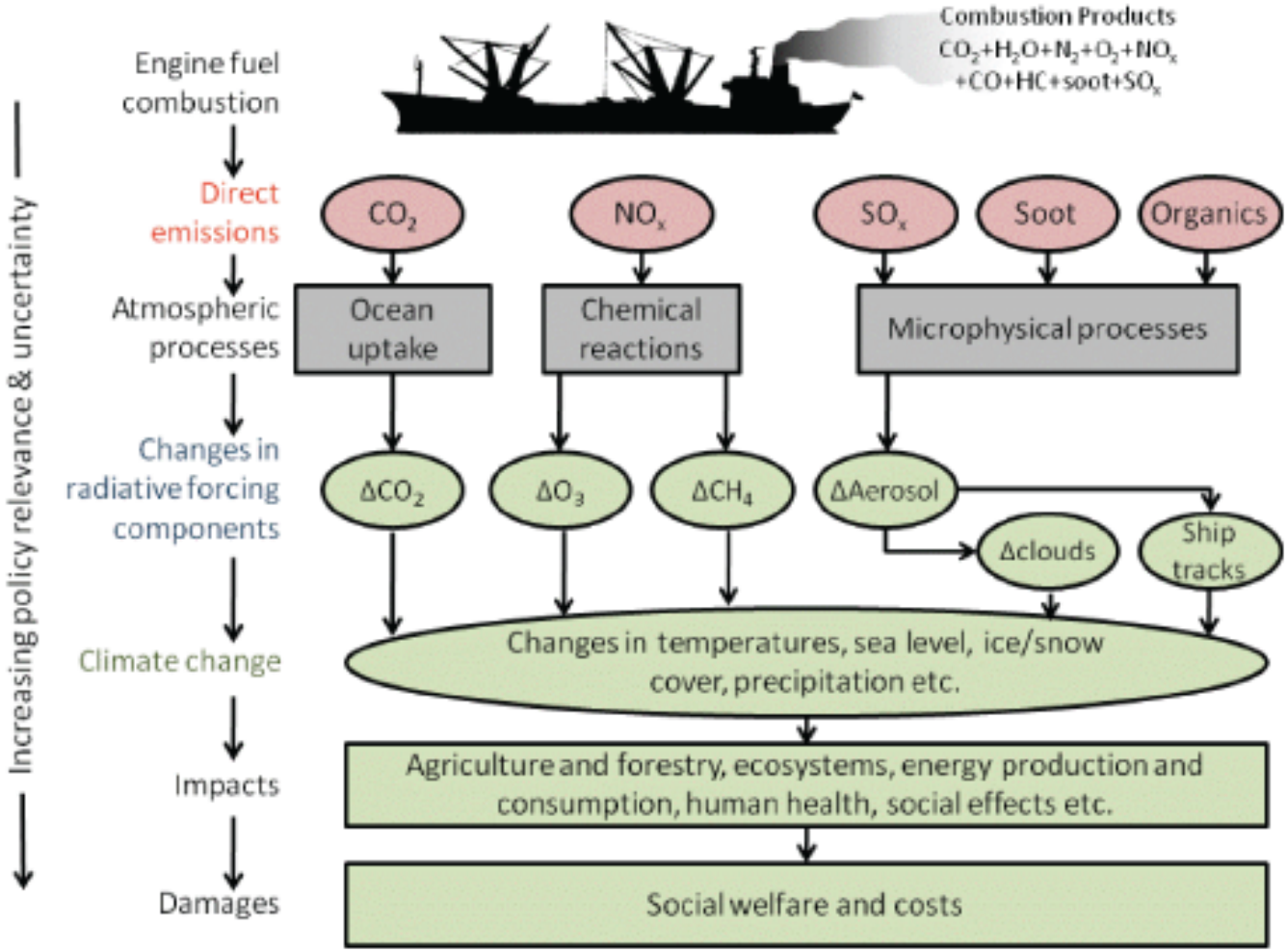


Figure 8.1 *Schematic diagram of the overall impacts of emissions from the shipping sector on climate change (from Lee et al., 2009a)*

(Source: IMO 2nd GHG Study, 2009)

Motivation and Drivers (Why?)

- Environmental impact of Air Pollutants and GHGs (climate change, externalities, ….)
- More stringent environmental regulations (Paris Agreement ?, MARPOL Annex VI Chapter 3 (SOx, NOx, ..) & Chapter 4 (GHG))
- Volatile fuel oil price
- World population, energy demand and prices
- Energy resources scarcity and Energy security
- UN2030 Agenda (SDGs 7, 12 & 13 in particular)

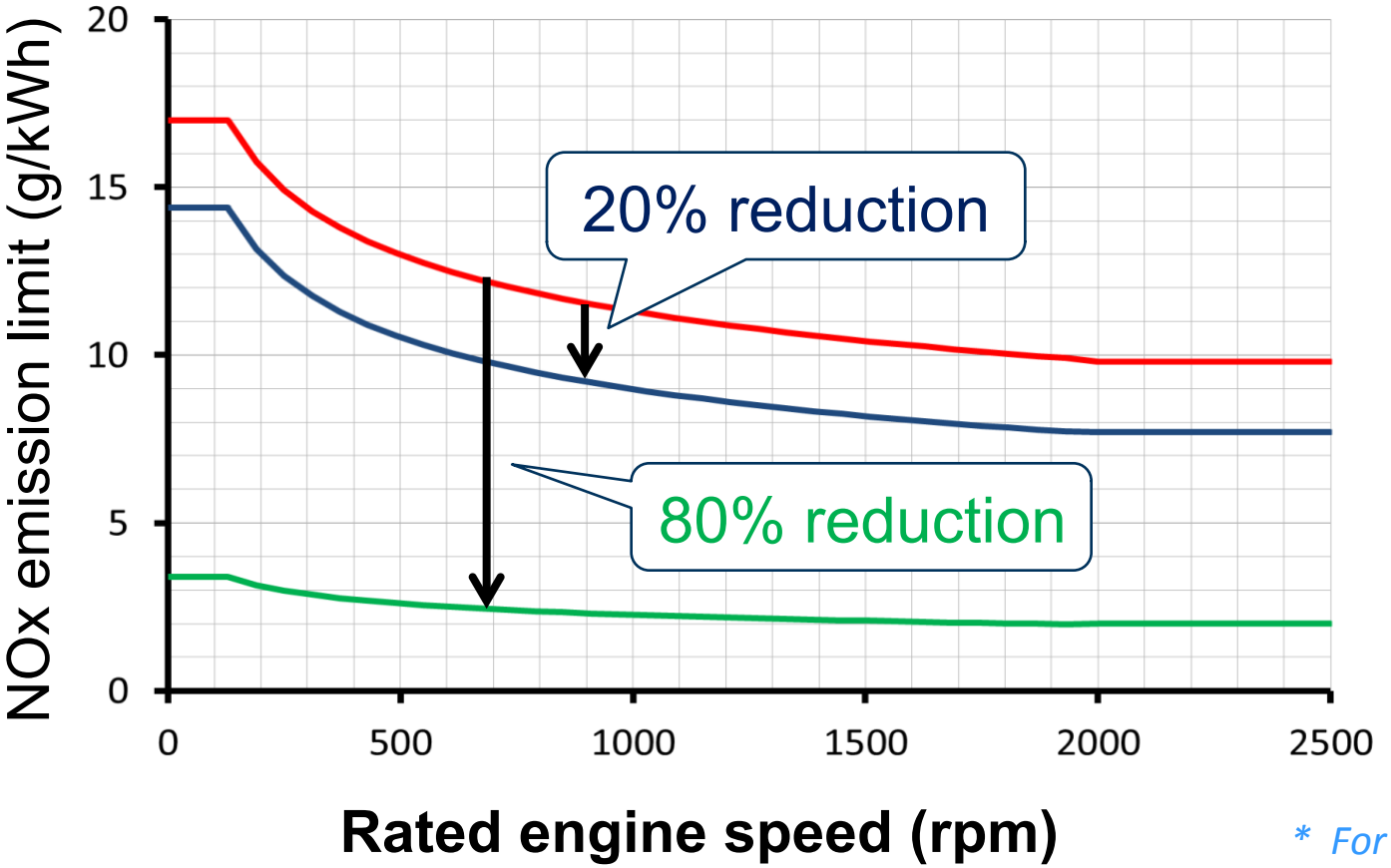
Source: Introduction Chapter, Trends and Challenges in Maritime Energy Management, Ölçer, A.I., Kitada, M., Dalaklis, D., Ballini, F. (Eds.), ISBN 978-3-319-74576-3, Springer

Key Pillars of Maritime Energy Management

- Regulatory framework
- Energy efficiency
- Renewable/cleaner energy
- Technology and innovation
- Human factors
- Economics of energy management

Source: Appendix I: Maritime Energy Management Research Strategy, Trends and Challenges in Maritime Energy Management, Ölçer, A.I., Kitada, M., Dalaklis, D., Ballini, F. (Eds.), ISBN 978-3-319-74576-3, Springer

Regulation 13 – NO_x Emission Limits



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*

(Source: WMU Maritime Energy Management Specialization EGY102 Lecture Notes)

NO_x Regulations

- Tier I emission limits apply to all marine diesel engines with a power output of more than 130 kW installed on ships constructed on or after 1 January 2000 and prior to 1 January 2011.

- Emission limits equivalent to Tier I may apply to marine diesel engines with a power output of more than 5,000 kW and a per cylinder displacement at or above 90 litres installed on a ship constructed on or after 1 January 1990 but prior to 1 January 2000 according to regulation VI/13.7.

- Tier II emission limits apply to all marine diesel engines with a power output of more than 130 kW installed on ships constructed on or after 1 January 2011.

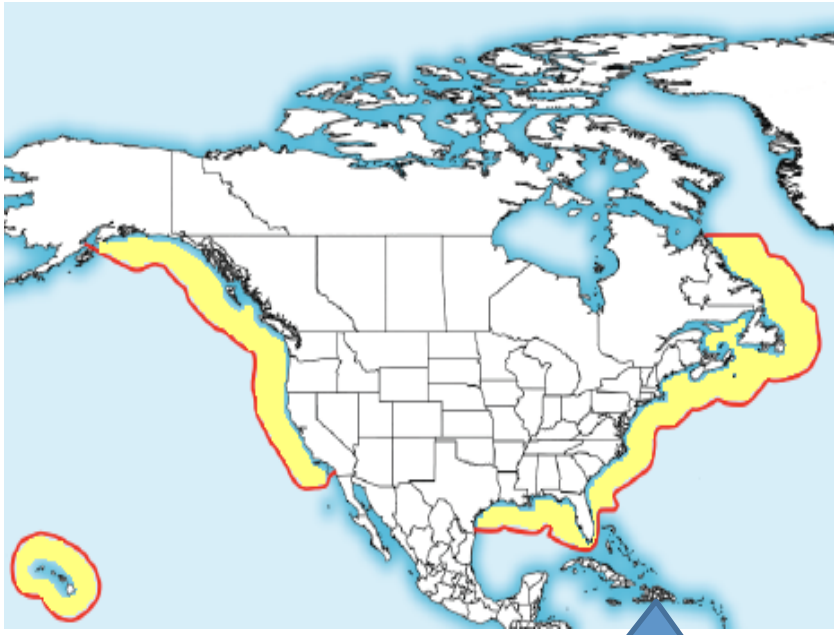
- Tier III emission limits apply to all marine diesel engines with a power output of more than 130 kW installed on ships, operating in a NO_x emission control area, constructed on or after the date of adoption of the NECA (or a later date as may be specified in the amendment to the Convention designating the NECA, whichever is later).

(Source: WMU Maritime Energy Management Specialization EGY102 Lecture Notes)

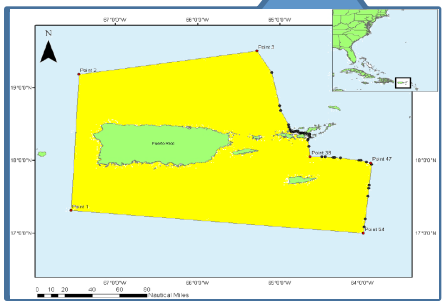
Tier III

Emission Control Areas (ECAs) for NO_X Emission Control

North American ECA



U.S. Caribbean ECA



Reg. 13.5.1:

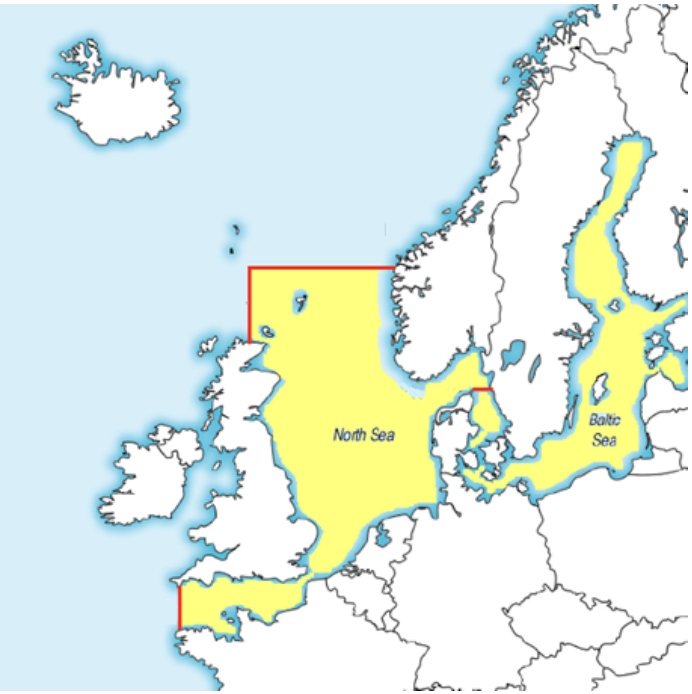
Tier III controls apply only to the specified ships while operating in ECAs established to limit NO_x emissions, outside such areas the Tier II controls apply.

- North America ECA + US Caribbean ECA for ships constructed on or after 1 January 2016
- Baltic Sea and North Sea ECAs for ships constructed on or after 1 January 2021.

(Source: WMU Maritime Energy Management Specialization EGY102 Lecture Notes)

North Sea and Baltic Sea NECAs

- MEPC 70 approved North Sea and Baltic Sea as an ECA-NOx
- This will require marine diesel engines to comply with Tier III NOx emission limit when installed on ships constructed on or after 1 January 2021 and operating in North Sea and Baltic Sea
- MEPC 70 agreed to the need for exemption provisions to allow ships fitted with dual fuel engines or with only Tier II engines to be built, converted, repaired and/or maintained at shipyards located in NO_x Tier III ECAs



(Source: WMU Maritime Energy Management Specialization EGY102 Lecture Notes)

Regulation 14 - Sulphur Oxides (SOx) and Particulate Matter

From 19 May'05, Sulphur Oxide (SOx) emission from ships is controlled by setting a limit of 4.5% on sulphur content of Marine Fuels.

From 1 January 2012, the global sulphur limit of marine fuels reduced to 3.5%.

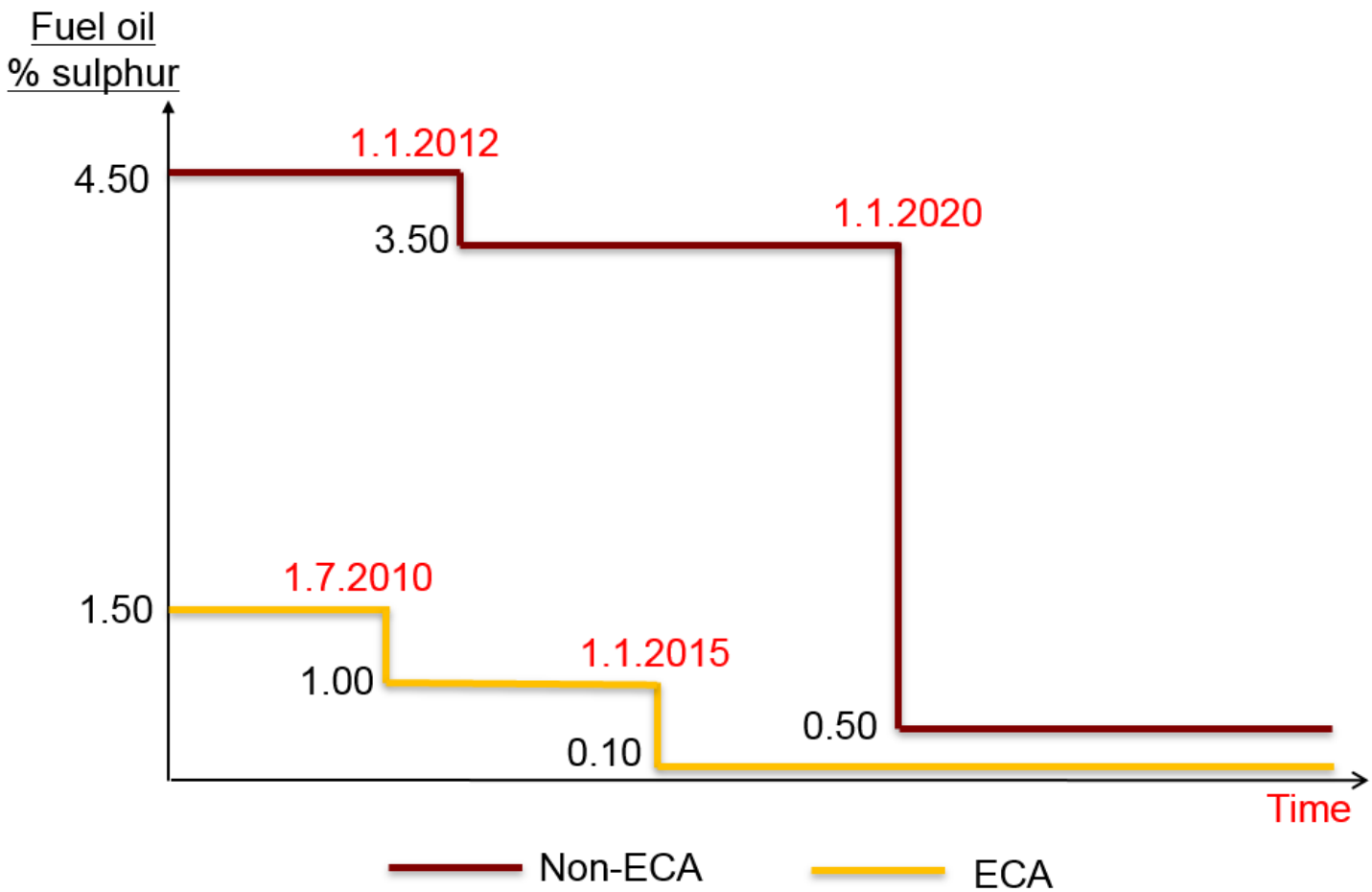
From 1 January 2020, the global sulphur limit of marine fuels reduced to 0.5%.

A number of agreed ECA-SOx has been set up.

The sulphur limits in ECA-SOx are more stringent and currently at 0.1% sulphur.

(Source: WMU Maritime Energy Management Specialization EGY102 Lecture Notes)

Regulation 14 - Fuel Sulphur Limits



(Source: WMU Maritime Energy Management Specialization EGY102 Lecture Notes)

IMO Response and Enhancing EE (Reducing CO_2)

- Technical Measures

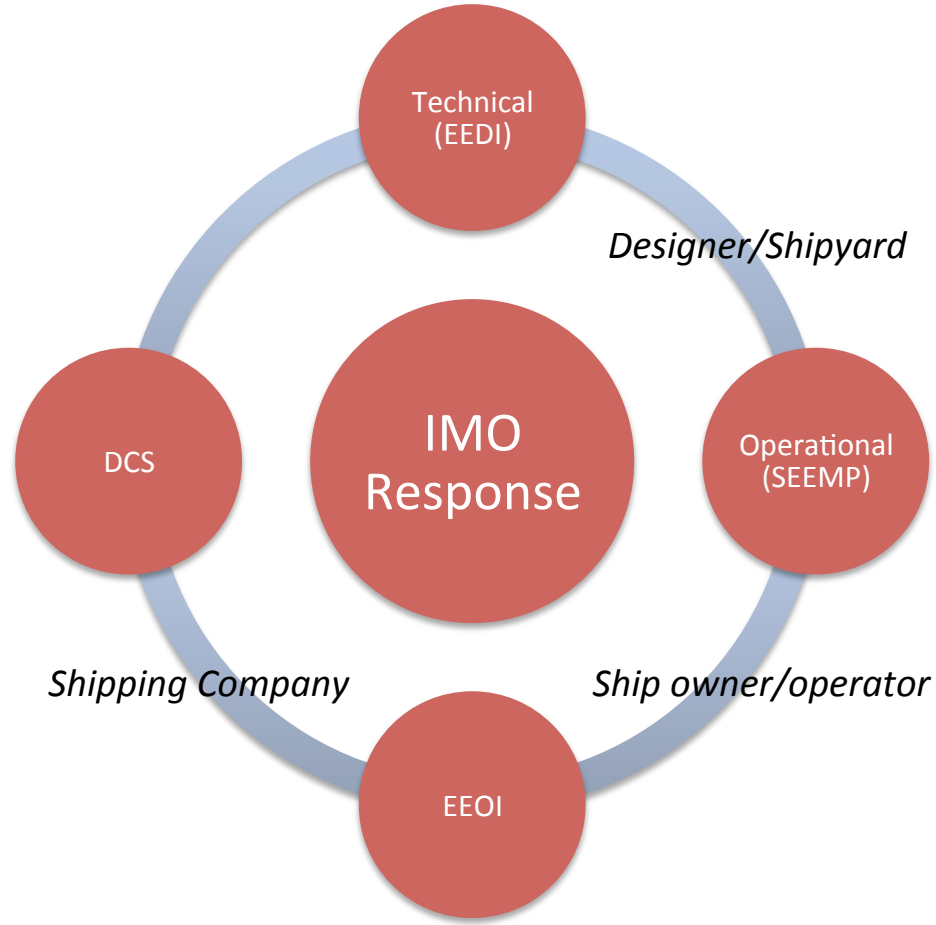
(Better design of ships and equipment)

- Operational Measures

(Better operation of ships)

- MBM

(Discussions suspended)



Decision Making and Trade-Off

- Cost/Benefit
- Cost (for whom?) (CAPEX, OPEX, Externality?)
- Benefit (for whom?)
- Perspective and decision maker
- Individual solutions and right combination?

No.	ESP	Cost	Savings
1	Slow steaming	negligible/indirect	High
2	Virtual port arrival	Zero	High
3	Propulsion efficiency monitoring	High	High
4	Weather routing software	High	High
5	Port turn-around time	Zero	High
6	Ballast & trim optimization	Low / Medium	High
7	Speed optimization	Negligible	High
8	Autopilot upgrade/ adjustment	Low	Low
9	Optimized voyage planning	Negligible	High
10	Optimization of use of fans and pumps	Zero	Medium
11	Optimization of use of bow-thrusters	Zero	Medium
12	Efficiency control of HVAC system	Zero	High
13	Speed/ Power control units for electrical equipment	Low	Medium
14	Cargo heating and temp. control optimization	Zero	High
15	Optimum lighting operation management	Zero	Low
16	Usage of Fuel Oil additives	Low	High
17	Ballast water exchange optimization/minimization	Zero	Medium
18	Even main engine / e-load operation	Zero	Medium
19	Elimination of voltage unbalance in motors	Low	Low
20	On-shore power supply (Cold Ironing)	High	High
21	Proper use of FO purifiers	Zero	Medium
22	Improved Machinery Maintenance[1]	High	High
23	Energy Management	High	Medium

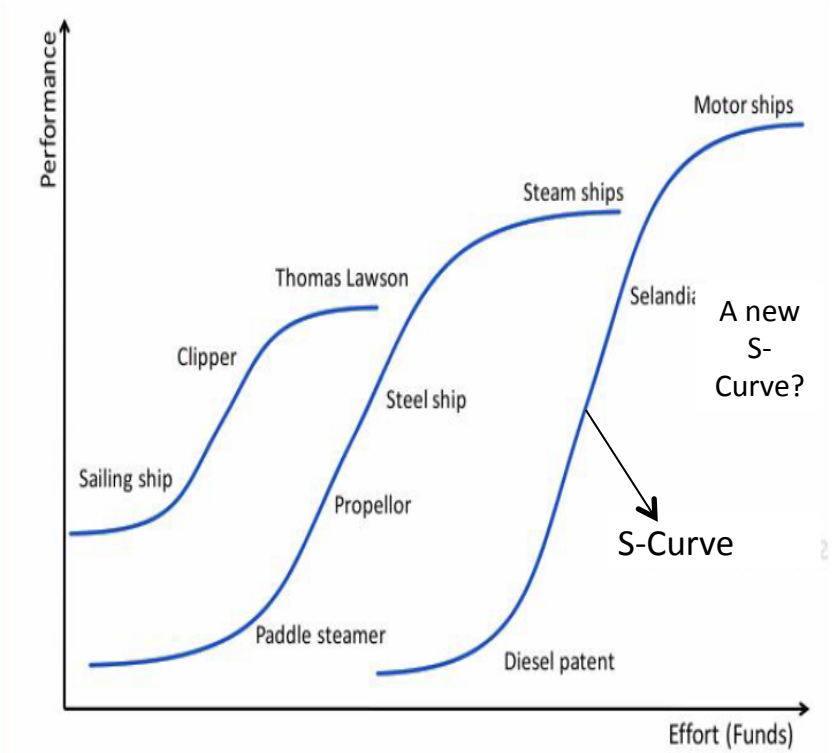
(Source: IMO/MEPC-67-INF-9-TARGETS)

Future Ship Propulsion

- From Human to Diesel Engines
- Fuel cells, batteries
- Nuclear (Thorium?)
- Alternative fuels and Renewable

(Solar, Wind, LNG, biofuel, Methanol, ..)

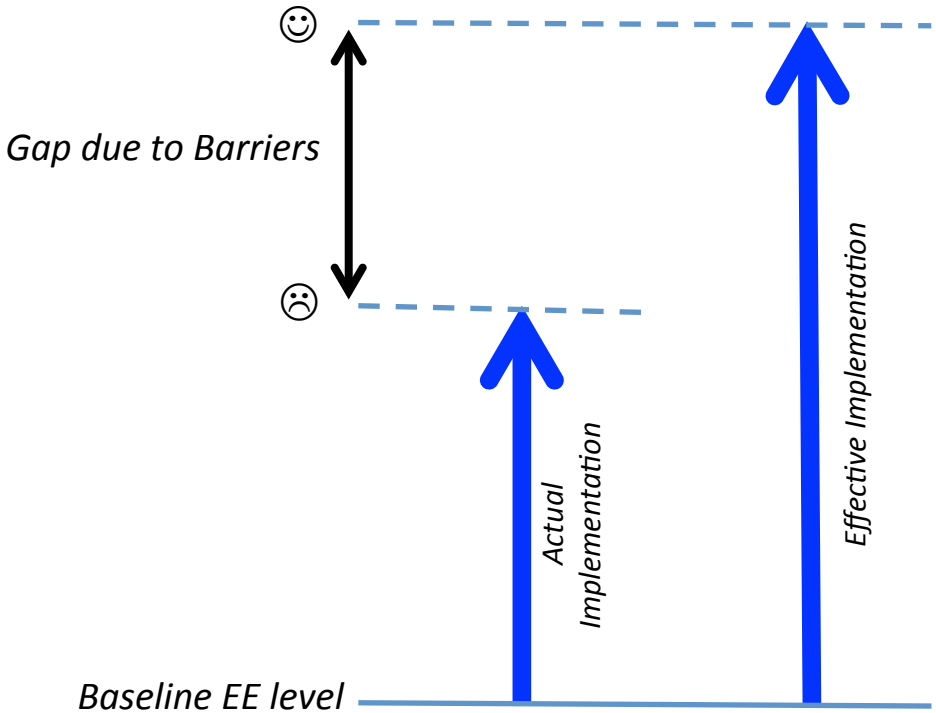
- Hybrid (right mix?)



(Ref: Shipping innovation by Niko Wijnolst, Tor Wergeland, Figure 407, page 378)

Barriers

- Individual
- Organisational
- Technological
- Economical
- ……..



(Source: WMU Maritime Energy Management Specialization EGY102 Lecture Notes)

Other Challenges

- Maritime Digitalisation (big data)
- Autonomous vs. Zero Emission Shipping
- System blindness
- ..

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Thank You

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Trends and Challenges in Maritime Energy Management

Editors: **Ölçer**, A.I., **Kitada**, M., **Dalaklis**, D., **Ballini**, F. (Eds.)

Provides an overview of contemporary trends and challenges in maritime energy management (MEM) Covers broader industry perspectives, as well as academia, and regulatory bodies

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About this book

This book provides an overview of contemporary trends and challenges in maritime energy management (MEM). Coordinated action is necessary to achieve a low carbon and energy-efficient maritime future, and MEM is the prevailing framework aimed at reducing greenhouse gas emissions resulting from maritime industry activities. The book familiarizes readers with the status quo in the field, and paves the way for finding solutions to perceived challenges. The 34 contributions cover

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