Energy transition in the maritime sector

Global and EU perspective

CE Delft

Committed to the Environment

CE Delft

- Independent research and consultancy since 1978
- Key areas: transport, energy and resources
- Know-how on economics, technologies and policy design
- 80 employees, based in Delft, the Netherlands
- Not-for-profit

Clients

Industries
(Small and medium size enterprises, transport, energy and trade associations)

Governments
(European Commission, European Parliament, regional and local governments)

NGOs

Outline of presentation

1. GHG emissions of maritime shipping
2. CO_2 emissions: determinants and reduction options
3. Post fossil bunker fuels
4. Energy transition
5. Policy measures to stimulate energy transition
6. Conclusions

GHG emissions of maritime shipping

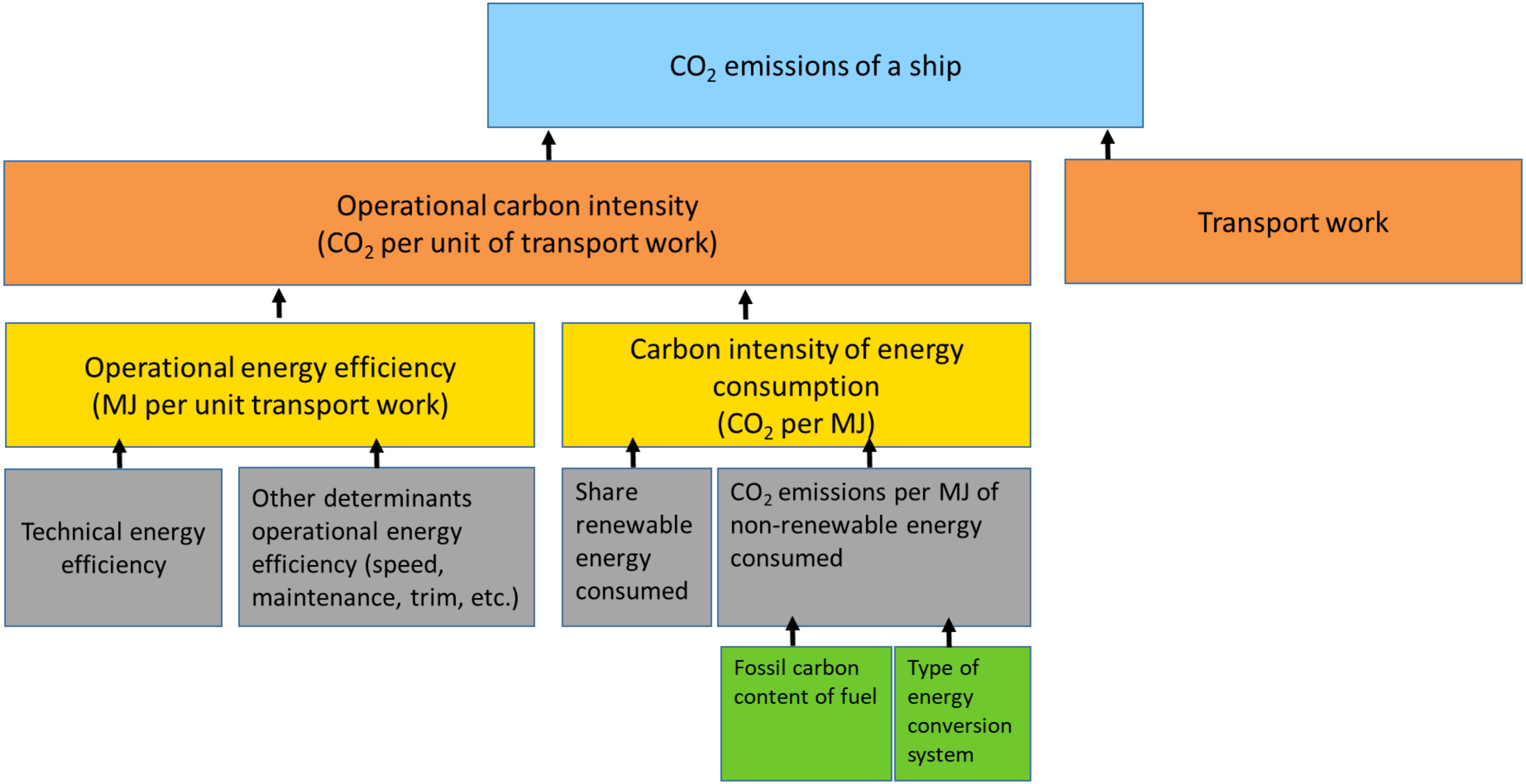
Types of emissions

- From combustion sources: CO_2, CH_4, N_2O, BC
- From non-combustion sources/fugitive emissions from
  - refrigeration systems (e.g. HFCs)
  - transporting oil/gas (e.g. NMVOCs)
- Combustion CO_2 emissions currently dominant GHG

Level of CO_2 emissions in 2018

- Global total (intern.+ domestic + fishing): ~1,055 Mt; ~2.9% of global anthropogenic CO_2 emissions
- EEA (EU MRV scope): ~ 145 Mt,
- Reported to UNFCCC by EU (intern.+ domestic; KP scope): ~ 162 Mt; ~4% of total EU CO_2 emissions.

CO_2 emissions: determinants



CO_2 emissions: reduction options

Technical and operational energy efficiency improvement options, e.g. waste heat recovery or speed reduction

Use of **renewable energy**, e.g. wind assisted propulsion or renewable zero/low carbon fuels

Use of **fossil low carbon fuels**

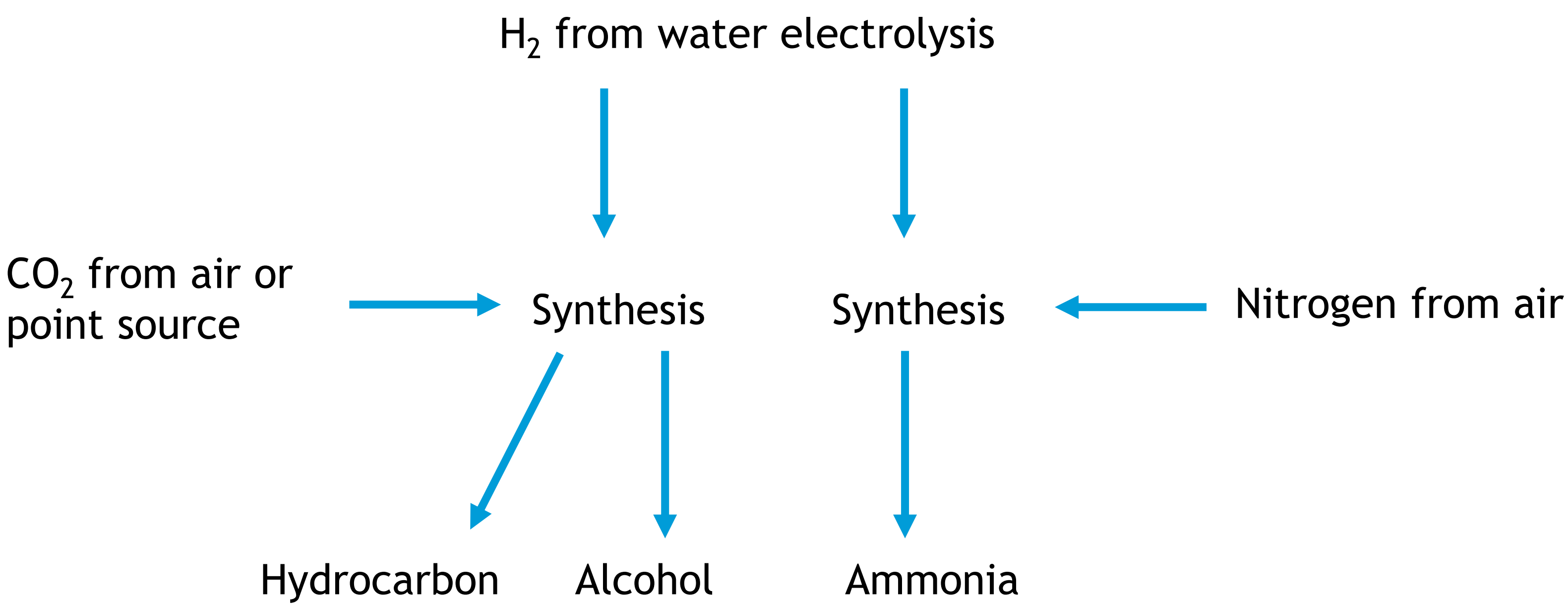
Decarbonisation of sector requires **energy transition**, i.e. use of **post fossil fuels**:

- renewable, zero carbon fuels or
- renewable fuels based on recycled carbon

(Fossil) low carbon fuels are options for **transition path.**

Post fossil bunker fuels

Main principle of (synthetic) e-fuel production



To qualify as renewable fuel,

- renewable electricity has to be used throughout entire process
- if a CO_2 point source is used, biogenic source is preferable.

Upscaling requires, for all e-fuels, upscaling of renewable electricity production and of water electrolysis.

Post fossil bunker fuels

Main principle of biofuel production

CO_2 is taken up by plants, plants are converted into fuels, which are burned, releasing CO_2 into the atmosphere where it becomes available again for plants

Biomass can be converted to energy through various processes, including:

- Direct combustion (burning) to produce heat
- Thermochemical conversion to produce solid, gaseous, and liquid fuels
- Chemical conversion to produce liquid fuels
- Biological conversion to produce liquid and gaseous fuels

(eia, 2021)

The same stream of biomass can be used to produce different types of biofuels.

Upscaling of advanced biofuel production requires more intensive use of e.g., waste streams or algae to avoid land use change and competition with food crops.

Post fossil fuels

Bunker fuel options under discussion

	Examples	Production options		Currently used as fossil fuel in sector
		(Synthetic) e-fuel	Biofuel	
Hydrocarbons	Diesel	x	x	x
	Methane	x	x	x (LNG; small but growing extent)
	Ethane	x	x	x (very small extent)
	Propane	x	x	x (very small extent)
Alcohols	Methanol	x	x	x (small extent)
	Ethanol	x	x	-
Other	Hydrogen	x		x (very small extent)
	Ammonia	x		-

(Synthetic) e-fuels are not available for shipping yet.

Some biofuels are available and used by sector, but to a very limited extend.

Post fossil bunker fuels

Deployment options

Internal combustion engines (ICE)

- For each type of ICE (2-stroke slow speed etc.) there is a post fossil fuel option that could be applied, but not each fuel option can be used in all engine types.
- ICEs for ammonia and hydrogen least developed

Fuel cell + electric engine

- Option for hydrogen and H_2-rich hydrogen carriers
- Different fuel cells require different pre-processing steps, depending on hydrogen carrier
- Rather an option for smaller ships than for ocean-going ships
- Attractive due to relative high efficiency, but still relative expensive and lifetime still limited.

Post fossil bunker fuels

Barriers to the use of post fossil fuels in shipping

- **Technological** barriers, like
  - technological readiness of internal combustion engines, of ships to transport fuels, of port infrastructure etc.
- (Scale of) **availability** of fuels
- **Economic** barriers, like
  - system and fuel costs, safety related costs, costs related to lower volumetric energy density of fuels
- **Institutional & legal** barriers, like
  - gaps in class rules, IMO codes, guidelines, ISO standards

Post fossil bunker fuels

There is no silver bullet

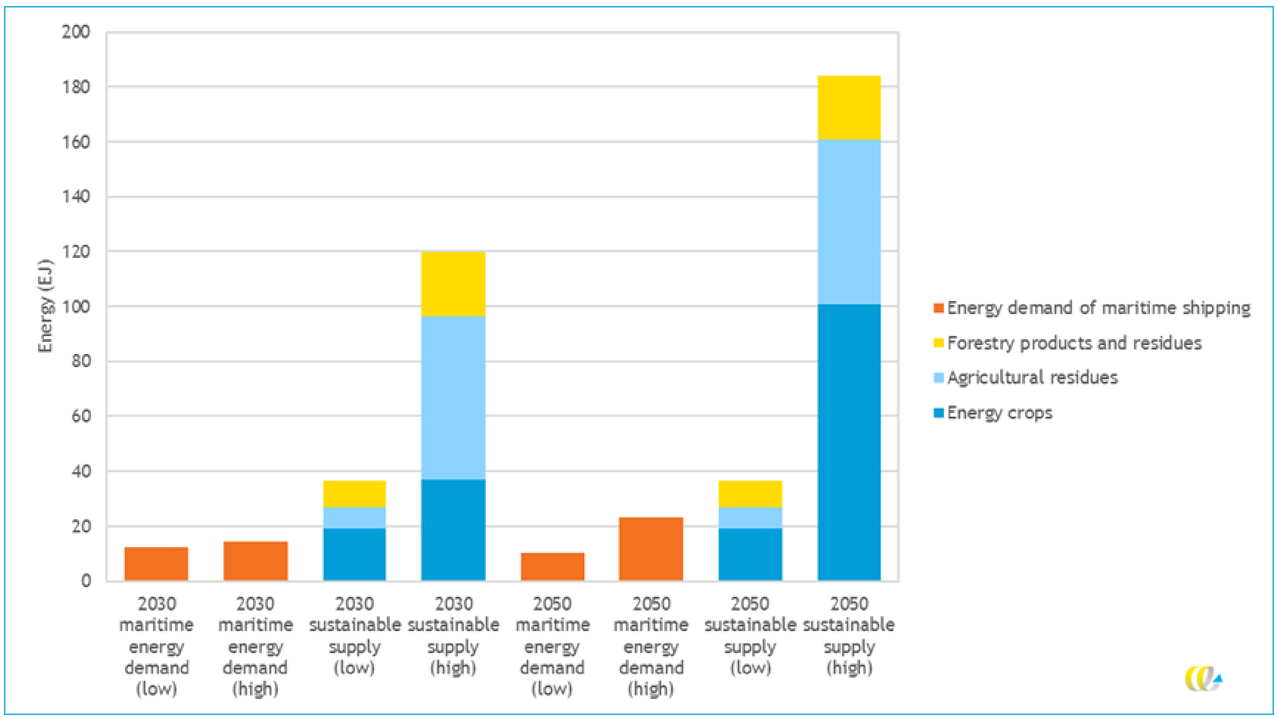
Disadvantages and advantages per fuel type (not comprehensive):

	Disadvantages	Advantages
All post fossil fuel types (except diesel-like fuels)	Lower volumetric energy density than conventional fuel	
	Higher costs	
Methane	Cryogenic storage required	Can build on infrastructure and logistics for LNG
	Methane slip from Otto-cycle engines	
Hydrogen	Very low volumetric energy density	Relatively low production costs compared to other e-fuels
	Cryogenic storage required	
	High safety requirements	
	TRL of ICE and of ships to transport hydrogen	
Ammonia	Very toxic to aquatic life	Can build on infrastructure and logistics for fossil ammonia
	ICE not developed yet	
	Low flammability	
Methanol	Poor lubrication, low cetane number	Liquid at ambient temperature
		Can build on infrastructure and logistics for fossil methanol

Post fossil bunker fuels

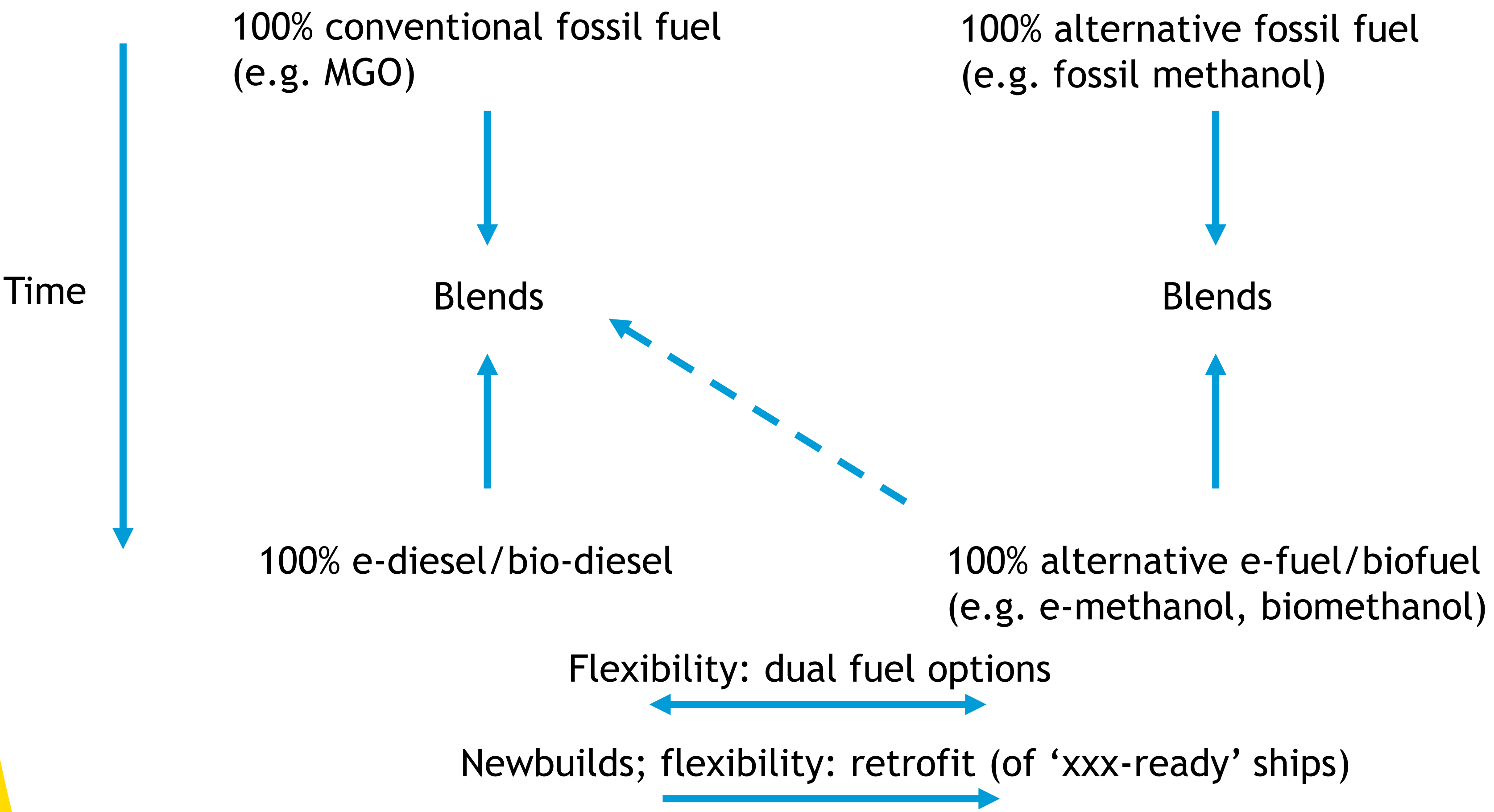
Scale of availability: example liquefied biomethane

- More than sufficient supply if global max. conceivable supply of biomass is converted into biomethane, and if all biomethane became available for shipping, but this of course very optimistic assumptions
- Sustainable supply in 2050 potentially much higher than in 2030, however no consensus on this in literature



Energy transition

Transition pathways



Energy transition

- Use of post fossil fuels more expensive than use of conventional fossil bunker fuels
- Chicken and egg problem wrt demand and supply of post fossil fuels
- Policy maker
  - Can stimulate/obligate use of post fossil fuels
  - Important considerations:
    - Fuel specific vs fuel unspecific policy approach =

      Quicker transition + scale effects + reduction of uncertainty vs potentially betting on wrong/suboptimal horse leading to obsolete investments/higher costs
      - Optimal fuel solution may vary between ship types/sizes
      - Optimal supply solution may vary locally

Energy transition

- (Further) important considerations:
  - Timing of stringency: high initial requirements favour solutions that are currently best options, but might not be best long-term options, potentially leading to lock-in/higher costs.
  - Overall environmental effects (Are fuels sustainably produced? Do Well-to-Tank-emissions increase? Do non-CO_2 emissions go up?)
  - Challenge: certification/verification of fuel production is crucial for environmental effect and level playing field
  - Regional vs global measure = timing of transition vs potential uneven level playing field

Policy measures to stimulate energy transition

Policy measures proposed at **EU level**

1. European Emissions Trading Scheme (EU ETS)
2. FuelEU Maritime Regulation
3. Alternative Fuels Infrastructure Regulation (AFIR)
4. Energy Taxation Directive

EU ETS Directive

- Phased-in inclusion of sector between 2023 and 2026
- Scope
  - Tank-to-propeller-CO_2 emissions
  - Ships and activity of ships just as under EU MRV Regulation, except geographical scope (only 50% of extra-EEA voyage emissions)
- Carbon price not expected to incentivize uptake of post fossil fuels; therefore also FuelEU Maritime Initiative

Policy measures to stimulate energy transition

FuelEU Maritime Regulation

- **Measure 1**: GHG intensity target for the energy used on bord ships
  - Target increases gradually: -2% in 2025 to -75% in 2050 compared to average 2020 fleet intensity
  - No specific fuels stimulated
  - Pooled compliance possible under same classification society
  - Scope
    - WtW-emissions
    - CO_2, CH_4, N_20
    - Ships and activity of ships just as under EU MRV Regulation, except geographical scope (only 50% of extra-EEA voyage emissions)

- **Measure 2**: Obligation to use onshore power or zero-emission technology at berth
  - Holds for container and passenger ships from 2030 on

Policy measures to stimulate energy transition

Alternative Fuels Infrastructure Regulation

- Fuel/technology specific approach
- Additional binding requirements for **onshore power supply** in certain EEA ports:
  - Requirements for seagoing container and passenger ships > 5,000 GT
  - Applies to TEN-T core/comprehensive maritime ports if number of port calls of these ships above certain threshold
  - From 2030: OPS must be provided to cover 90% of energy demand of these ships at berth

Policy measures to stimulate energy transition

Energy Taxation Directive

- Minimum tax levels for energy supplied for purposes of intra-EU waterborne regular service navigation, fishing and freight transport proposed.
- Motor fuels and electricity used for dredging operations in navigable waterways and in ports are included
- Minimum tax rates differentiated between different fuel type categories
- Zero minimum rate for electricity, advanced biofuels, bioliquids, biogases and hydrogen of renewable origin for 10 years.
- Minimum tax rates for sector lower than for general motor fuel use
- Member States may exempt or apply same levels of taxation to extra-EU waterborne navigation
- Measure requires unanimity to be adopted

Policy measures to stimulate energy transition

- Initial **IMO** Strategy on Reduction of GHG Emissions from Ships aims at
  - phasing-out GHG emissions from intern. shipping as soon as possible in this century;
  - improving carbon intensity of shipping by at least 40 % in 2030, rel. to 2008 and pursuing efforts to improve it by 70 % by 2050; and
  - reducing GHG emissions of shipping by at least 50 % in 2050, rel. to 2008.
- Energy efficiency design index for new ships in place.
- Additional short-, medium- and long-term policy measures shall implement the strategy.
- Short term measures recently adopted: ship label based on carbon intensity indicator + energy efficiency index for existing ships.
- Medium-term measures to specifically stimulate uptake of post fossil fuels under discussion (see e.g., EU submission)

Conclusions

- Decarbonisation of maritime shipping requires the use of post fossil fuels
- A variety of options are conceivable, many of them still to be developed and upscaled
- There is no silver bullet
- Due to the higher costs, only frontrunners will use post fossil fuels without regulation
- Regulation to stimulate uptake of post fossil fuels has been proposed by EU Commission and discussion on such a measure will start at IMO level
- Timing of stringency of measures and approach (fuel specific/non-specific) will have a major impact on energy transition
- Certification of fuels is an issue to be solved
- Dredgers
  - EU measures: directly only affected by energy taxation, if at all
  - Might be able to profit from solutions developed for other fleet segments, just as entire sector might profit from demand and logistics for fuels by other sectors