Possible ways to decarbonize maritime transport: Broad tracks, narrow paths and potential dead ends

German Weisser

Winterthur Gas & Diesel Ltd.

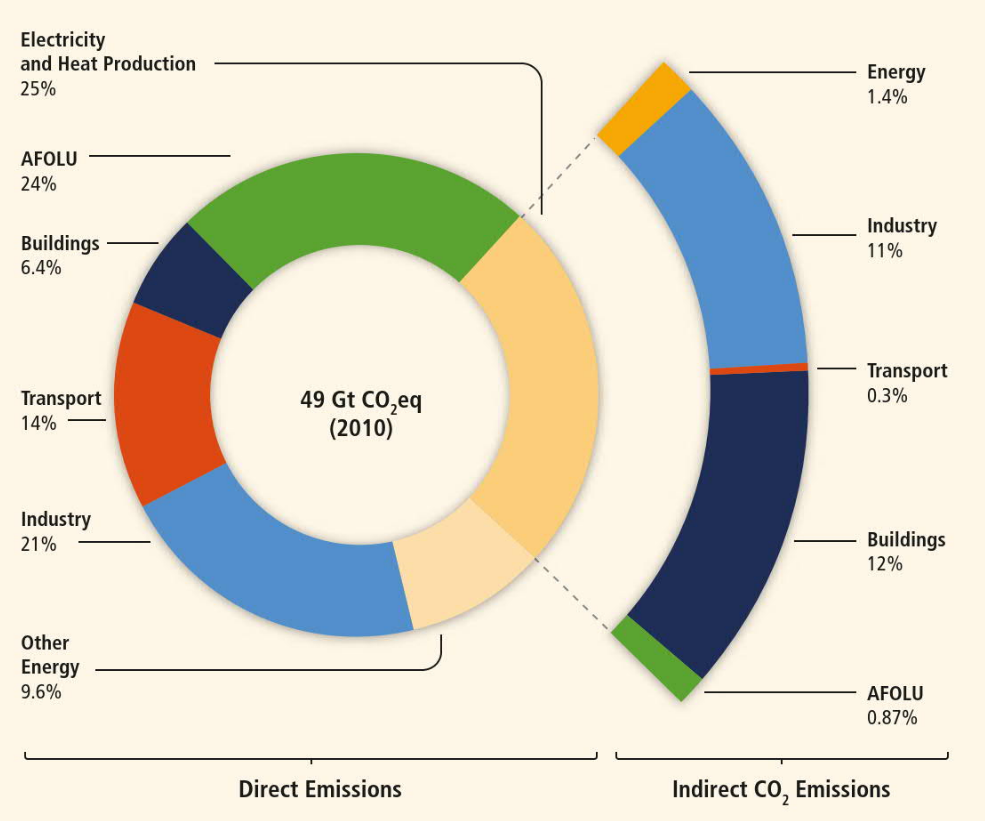
WIN GD

Possible ways to decarbonize maritime transport

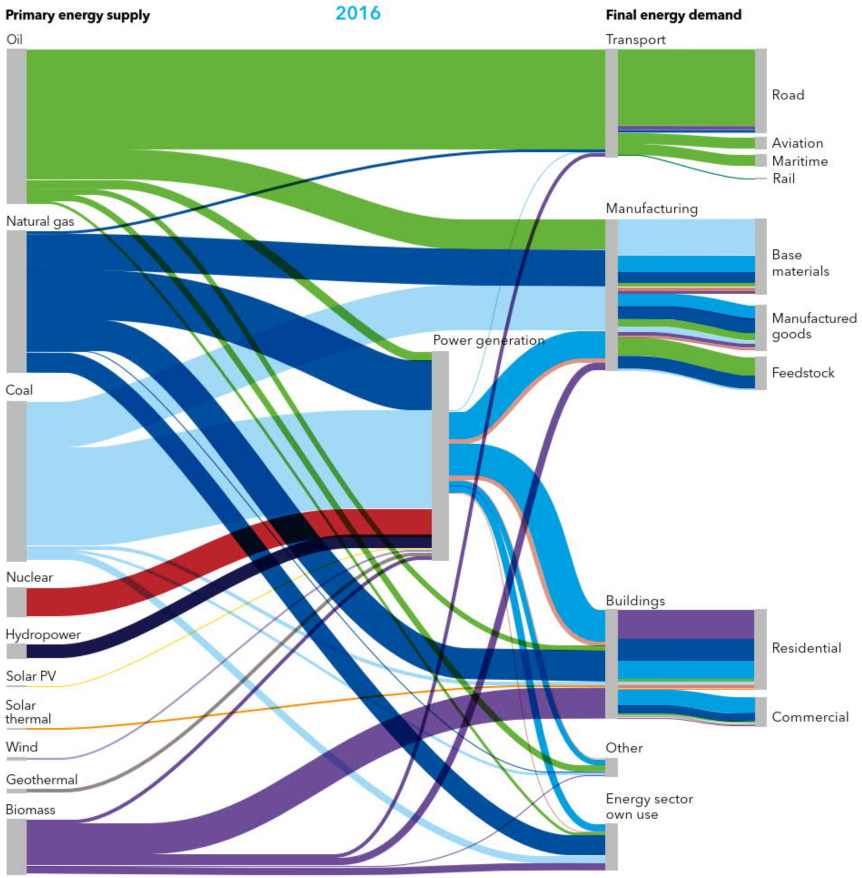
Presentation outline

The challenge

The dimensions of the problem



source: IPCC: Climate Change 2014: Contribution of Working Group III to the Fifth Assessment Report of the IPCC, 2014



source: DNV GL: Energy Transition Outlook 2018

The challenge

The dimensions of the problem, cont.

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

Paris agreement scope:

- Nationally determined contributions to address climate change

Out of scope:

- Contributions from international transport from shipping as well as aviation

Third IMO GHG Study 2014 CO_2

Year	Global CO_2[1]	Total shipping	% of global	International shipping	% of global
2007	31,409	1,100	3.5%	885	2.8%
2008	32,204	1,135	3.5%	921	2.9%
2009	32,047	978	3.1%	855	2.7%
2010	33,612	915	2.7%	771	2.3%
2011	34,723	1,022	2.9%	850	2.4%
2012	35,640	938	2.6%	796	2.2%
Average	33,273	1,015	3.1%	846	2.6%

Third IMO GHG Study 2014 CO_2e

Year	Global CO_2e[2]	Total shipping	% of global	International shipping	% of global
2007	34,881	1,121	3.2%	903	2.6%
2008	35,677	1,157	3.2%	940	2.6%
2009	35,519	998	2.8%	873	2.5%
2010	37,085	935	2.5%	790	2.1%
2011	38,196	1,045	2.7%	871	2.3%
2012	39,113	961	2.5%	816	2.1%
Average	36,745	1,036	2.8%	866	2.4%

source:
IMO: Third IMO Greenhouse Gas Study 2014

The challenge

Initial GHG Emissions Reduction Strategy of the International Maritime Organization (IMO)

Relevant text from IMO Resolution MEPC.304(72): Levels of ambition

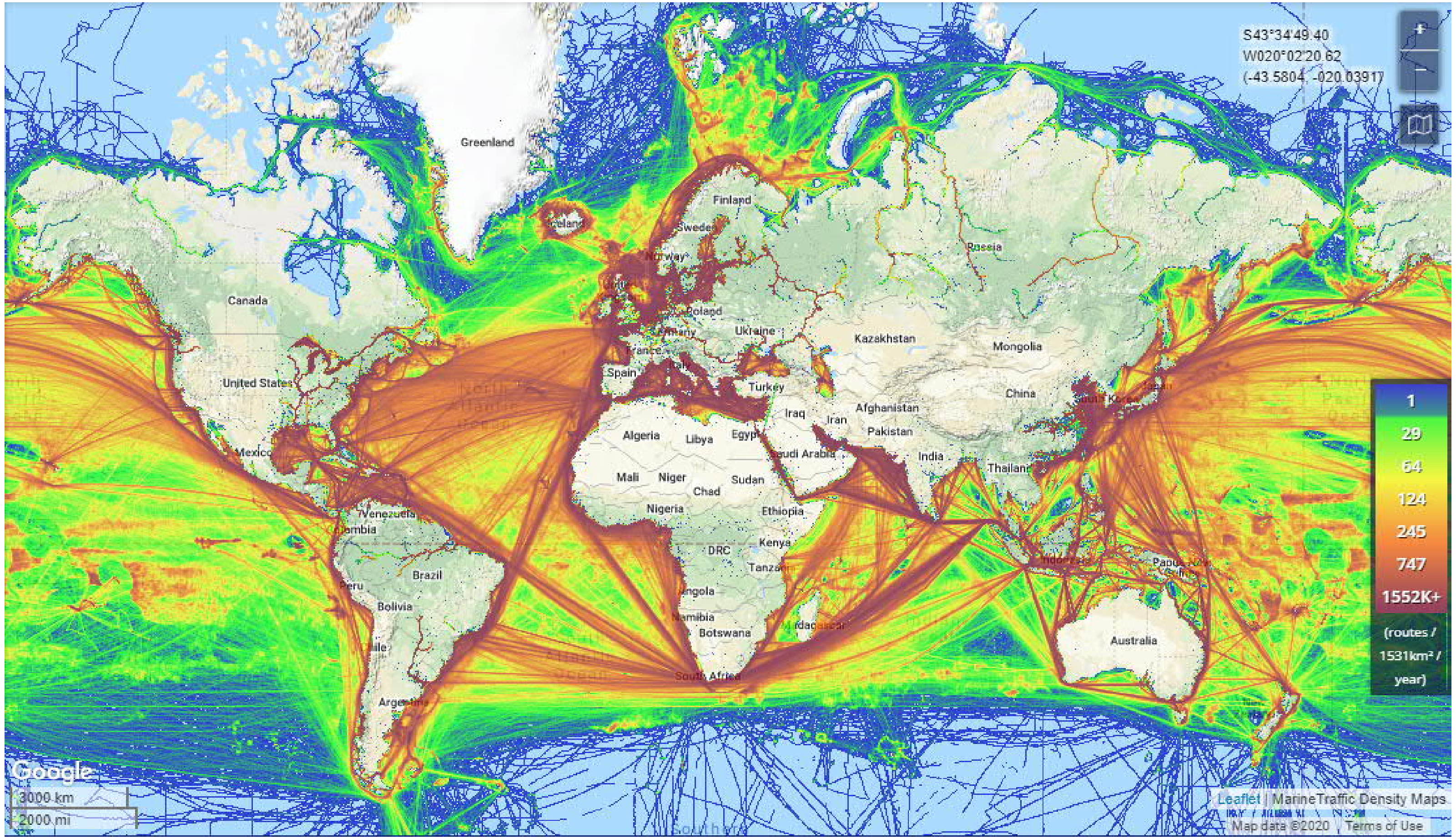
1 **carbon intensity** of the ship to decline through implementation of further phases of the energy efficiency design index (EEDI) **for new ships**
to review with the aim to strengthen the energy efficiency design requirements for ships with the percentage improvement for each phase to be determined for each ship type, as appropriate;

2 **carbon intensity of international shipping** to decline
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.

The challenge

Global shipping traffic density



Data for the full year 2017,

- All marine traffic
- Tracking of vessel positions by satellite based on automatic identification system (AIS) signals

source:
https://www.marinetraffic.com/

The challenge

Vessel types and their contributions

Passenger and recreational vessels


Cruise vessels


Car ferries


Pass. ferries


Superyachts

Fishing vessels


Large


Medium-size


Small

Cargo vessels and their contribution along the value chain

raw materials, energy carriers → finished, consumer goods


Oil tankers


LNG carriers

Bulk carriers


General cargo vessels


Chemical / product tankers

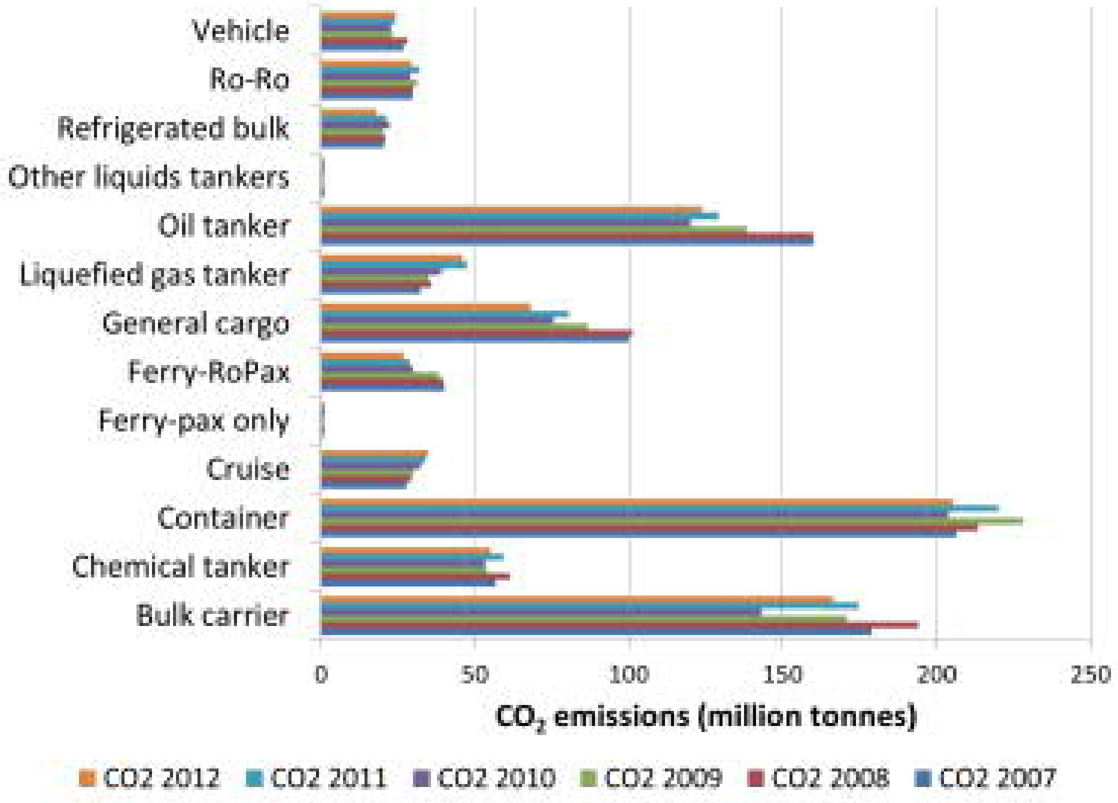

Container vessels

Reefers


Car carriers


The challenge

Vessel types and their contributions – cont.

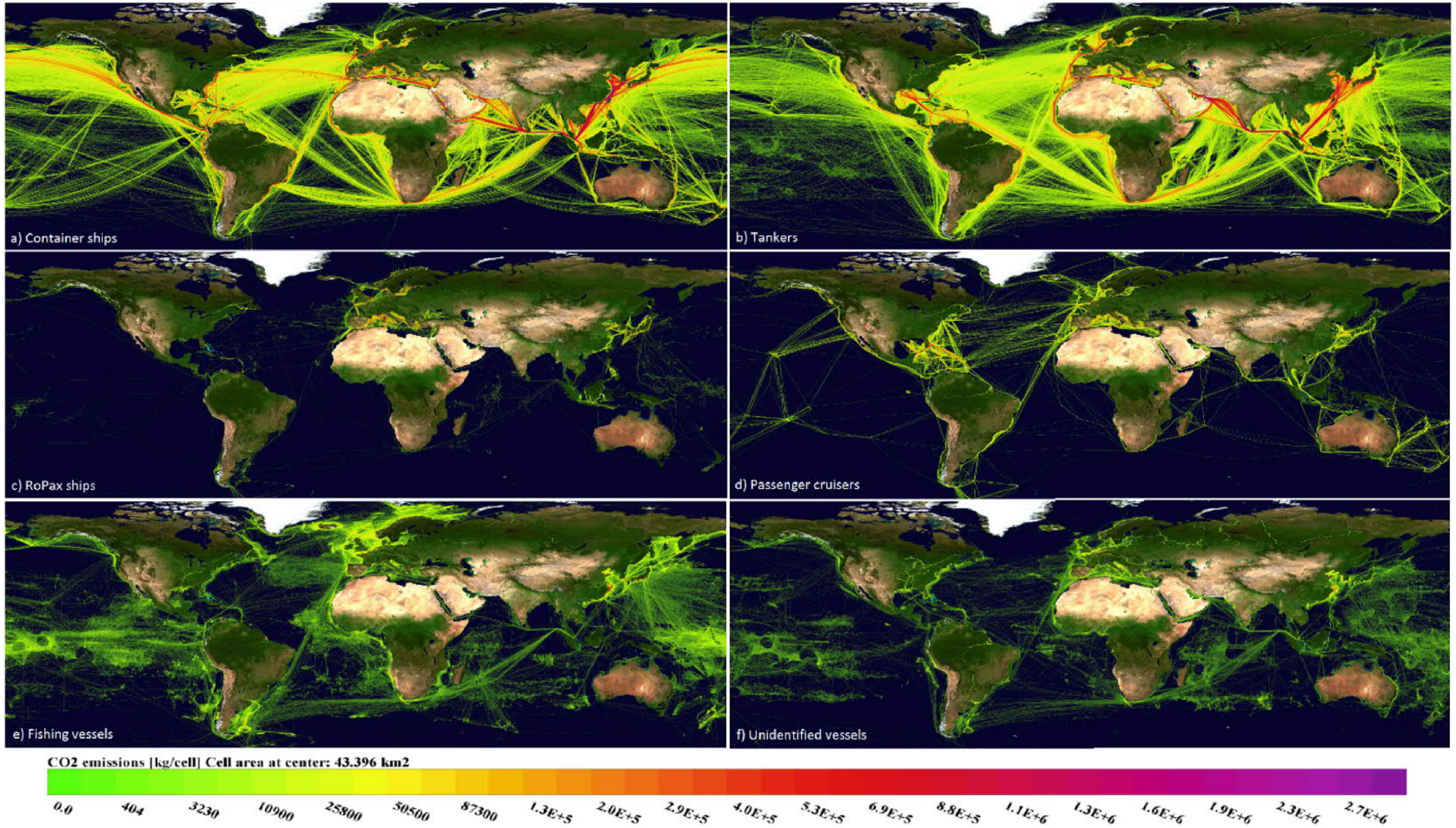


Marine sector	Fuel type	2007	2008	2009	2010	2011
International shipping	HFO	542.1	551.2	516.6	557.1	554.0
	MDO	83.4	72.8	79.8	90.4	94.9
	LNG	0.0	0.0	0.0	0.0	0.0
Top-down international total	**All**	**625.5**	**624.0**	**596.4**	**647.5**	**648.9**
Domestic navigation	HFO	62.0	44.2	47.6	44.5	39.5
	MDO	72.8	76.6	75.7	82.4	87.8
	LNG	0.1	0.1	0.1	0.1	0.2
Top-down domestic total	**All**	**134.9**	**121.0**	**123.4**	**127.1**	**127.6**
Fishing	HFO	3.4	3.4	3.1	2.5	2.5
	MDO	17.3	15.7	16.0	16.7	16.4
	LNG	0.1	0.1	0.1	0.1	0.1
Top-down fishing total	**All**	**20.8**	**19.2**	**19.3**	**19.2**	**19.0**
Total CO_2 emissions		**781.2**	**764.1**	**739.1**	**793.8**	**795.4**

source: IMO: Third IMO Greenhouse Gas Study 2014

The challenge

Vessel types and their contributions – cont. 2



source:
Johansson et al., Atmospheric Environment 167 (2017)

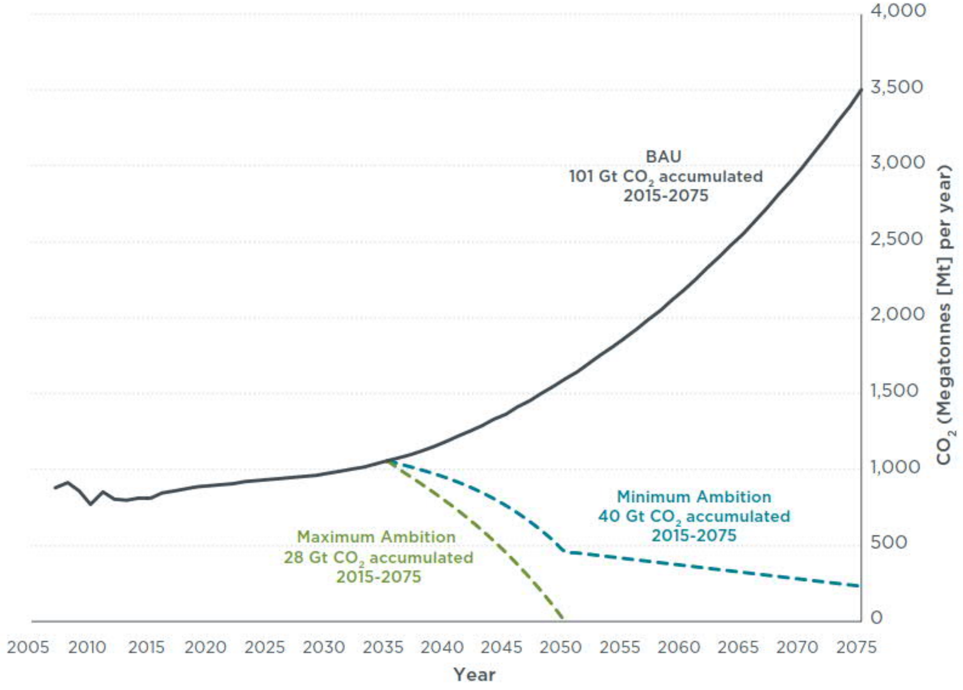
Global assessment of shipping emissions 2015,

- Tracking of vessel positions by satellite based on automatic identification system (AIS) signals
- Route reconstruction modelling approach
- Evaluation based on Ship Traffic Emission Assessment Model (STEAM3)

The challenge

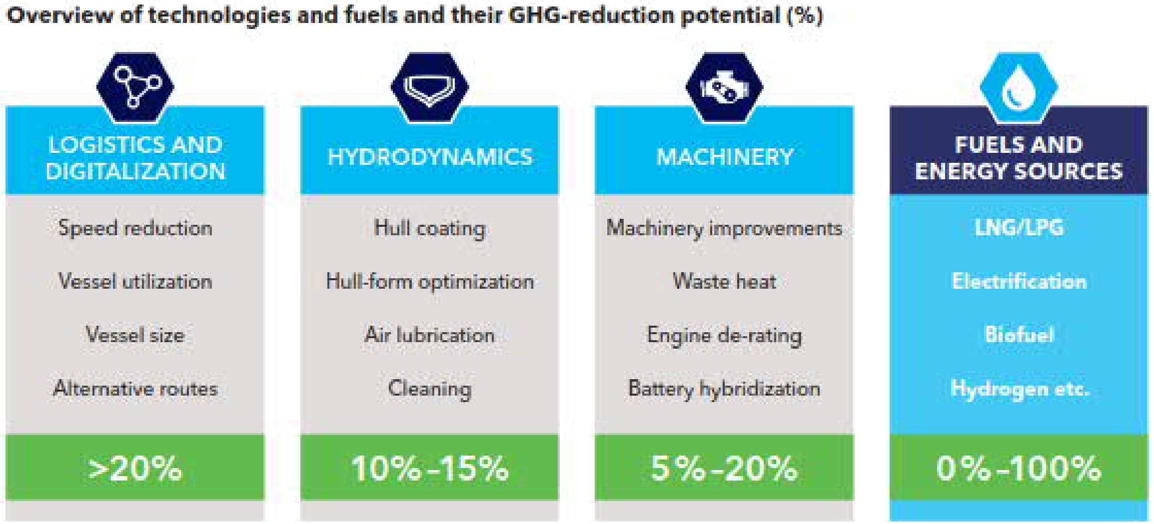
Requirements towards fleet development and possible steps

Projections of CO2 emissions from shipping:



source: ICCT: Policy Update – The International Maritime Organizations Initial Greenhouse Gas Strategy, 2018

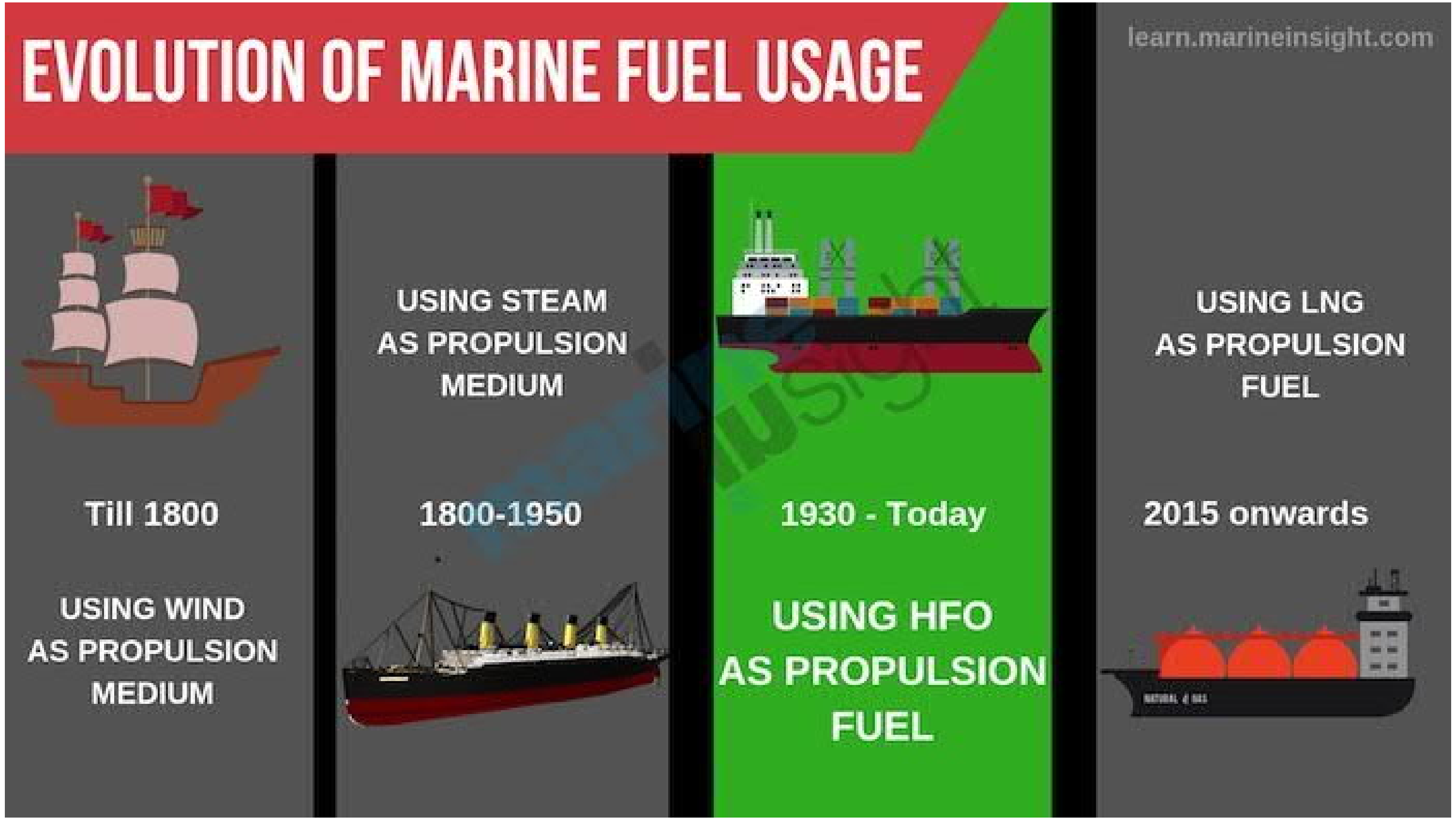
Potential contributions:



source: DNV GL: Energy Transition Outlook 2019, Maritime – Forecast to 2050

History of fuels used in maritime transport

The long-term perspective

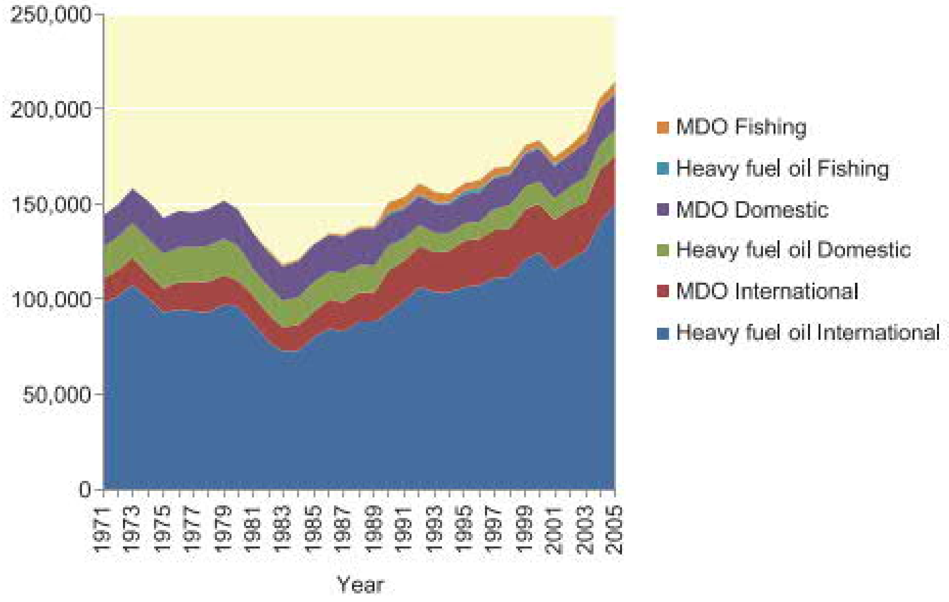


source: https://www.marineinsight.com/tech/

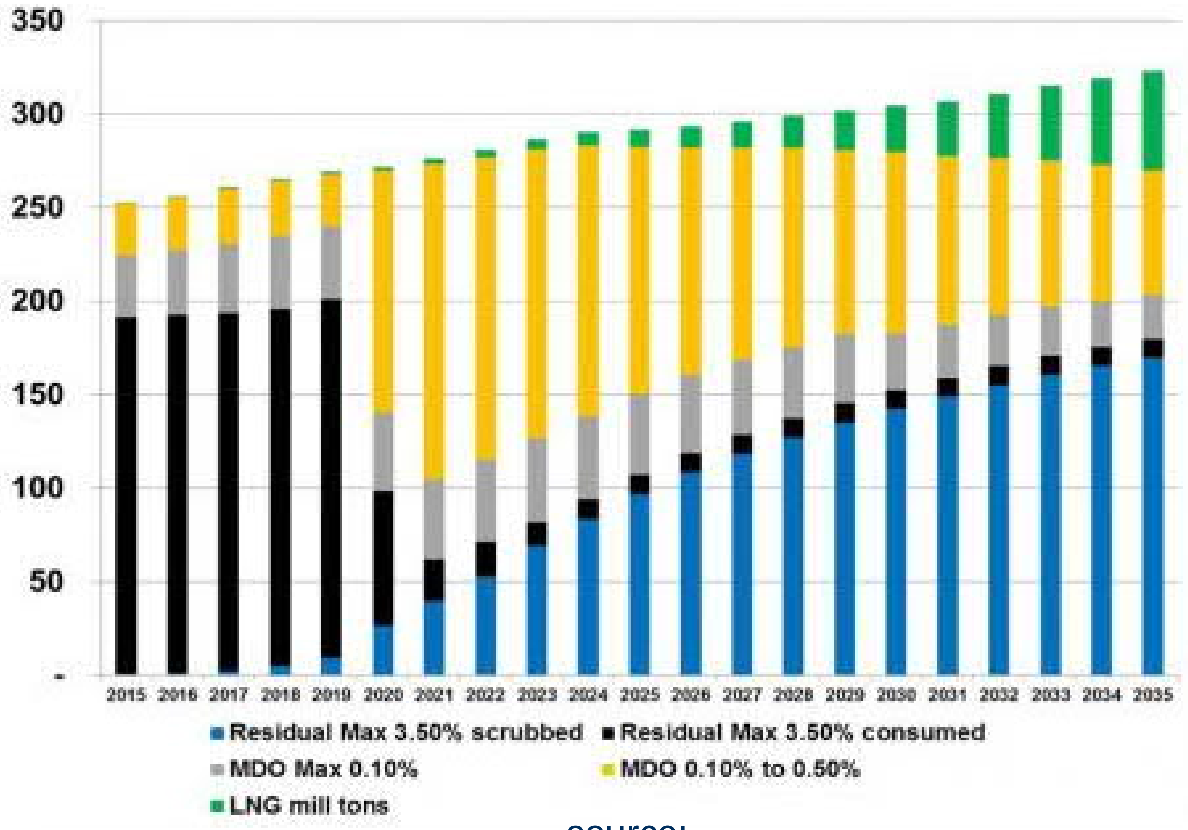
History of fuels used in maritime transport

The mid- to short-term perspective

Bunker demand evolution, in million tons



source:
IMO: Second IMO Greenhouse Gas Study 2009

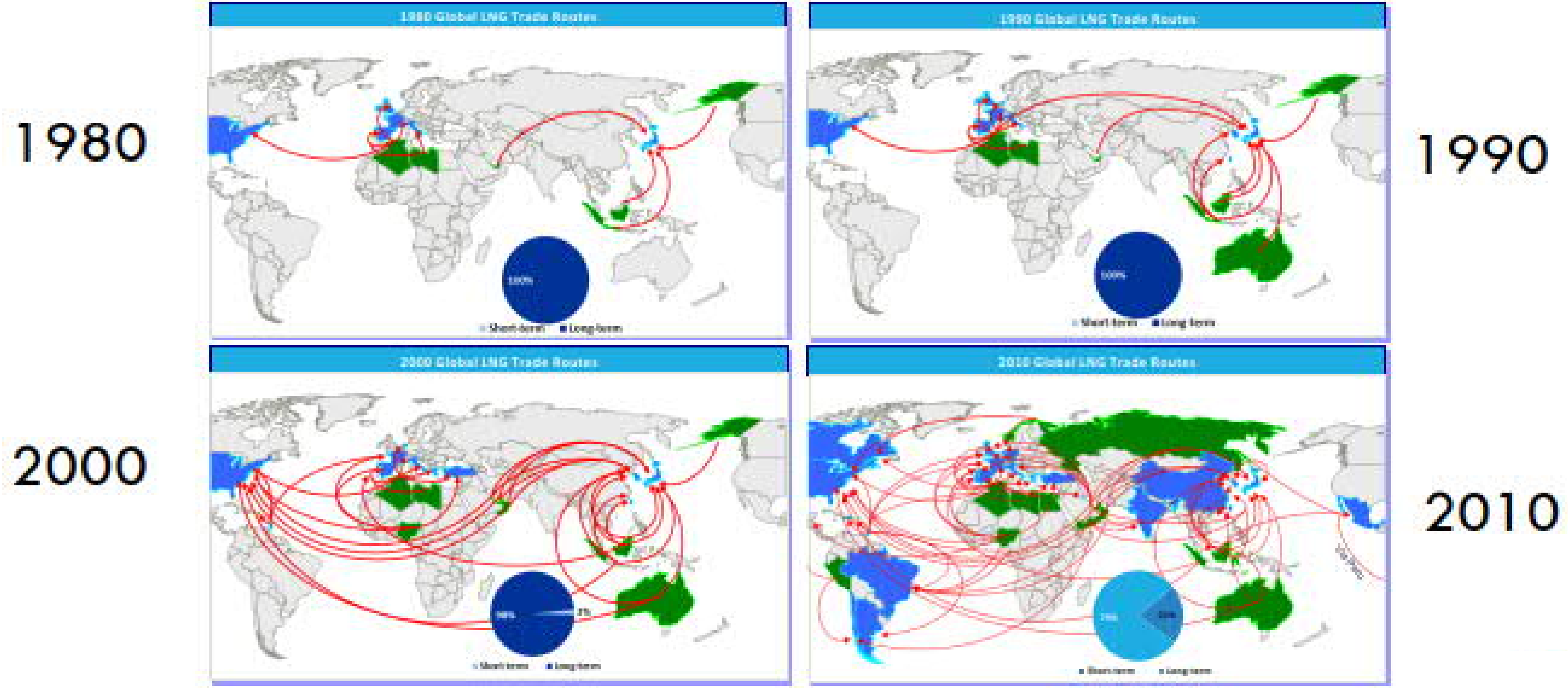


source:
Meech et al., IBIA, 2014

History of fuels used in maritime transport

The history of the LNG business

Projects were initially developed on a conservative and rigid point-to-point basis to mitigate risks due to the high infrastructure costs and address financing constraints. By 2010 the industry had grown with new supply availability, liquid markets and speculative shipbuilding

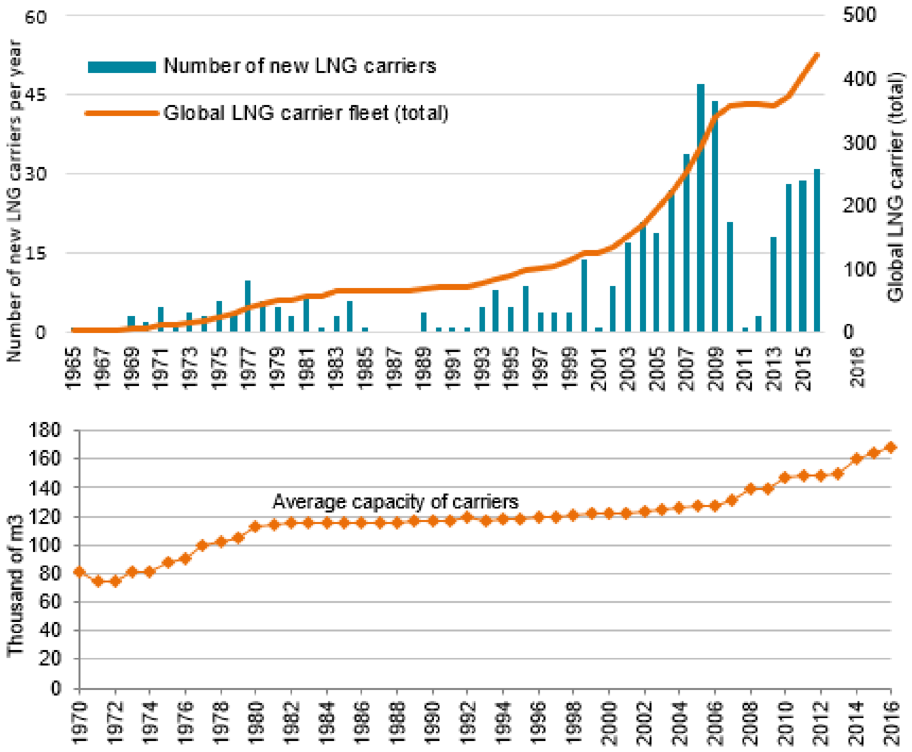


source: Poten & partners

History of fuels used in maritime transport

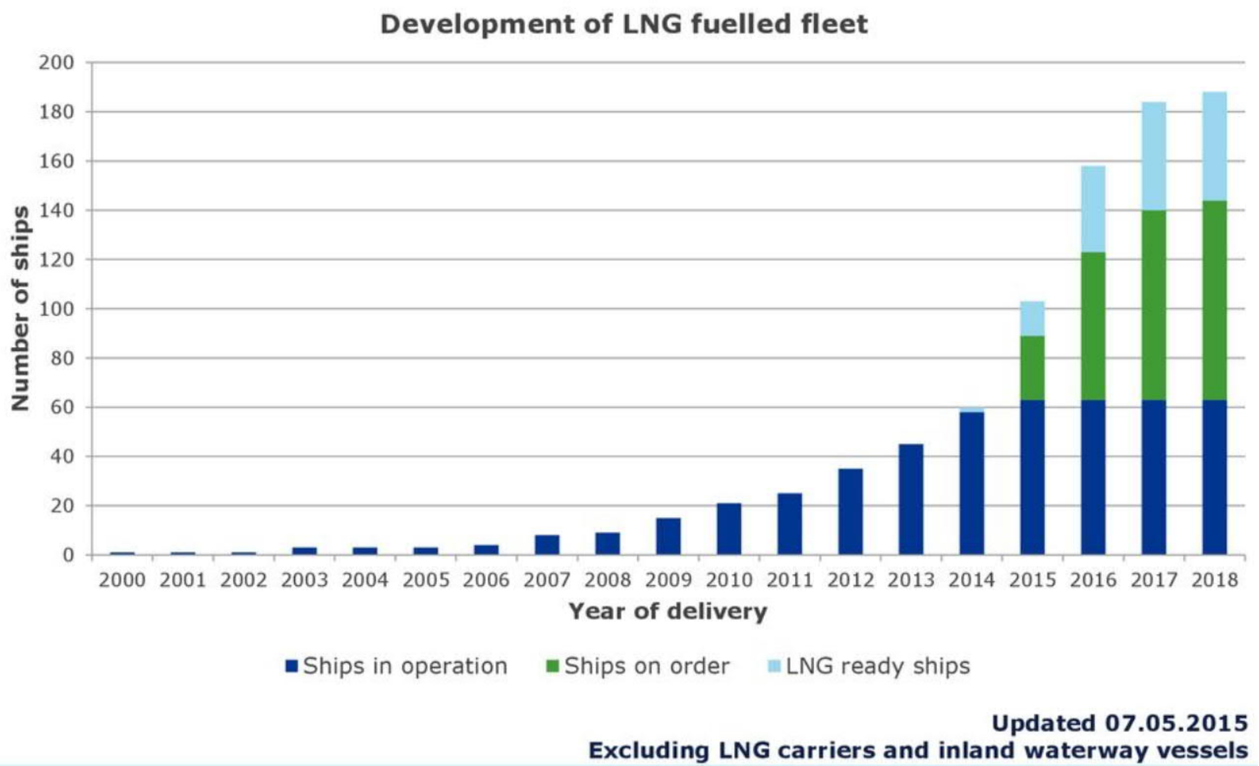
The history of the LNG business – impact on LNG-fuelled fleet

LNG carriers



source: IGU: World LNG Report, 2017

Other LNG-fuelled vessels



source: Tellkamp, DNV GL, 2015

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History of fuels used in maritime transport

LNG bunkering infrastructure – 2017 status

source: https://www.dnvgl.com/lngi

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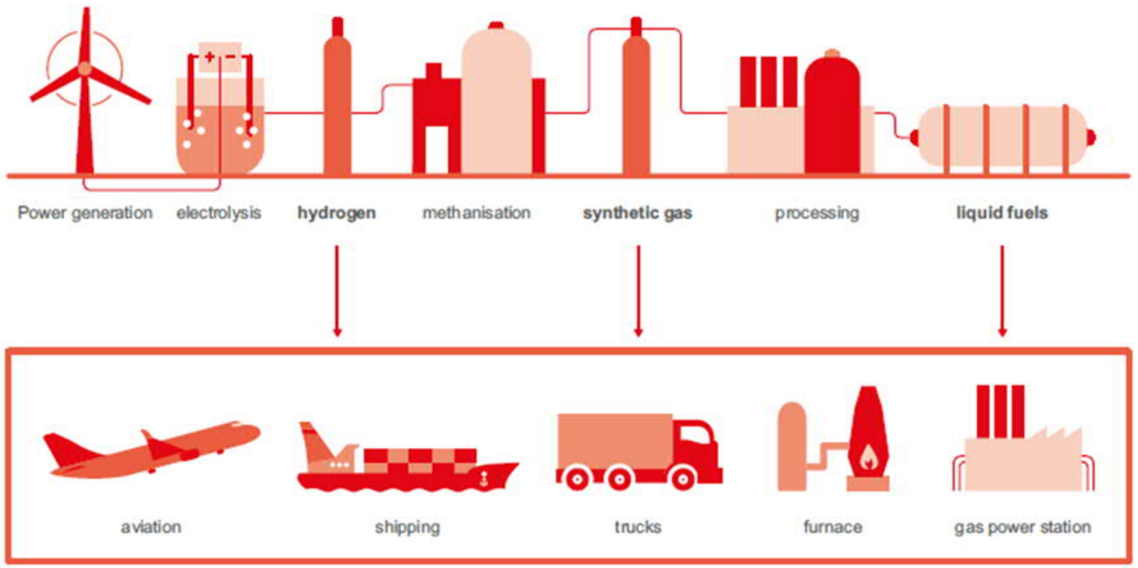
Future marine fuel candidates

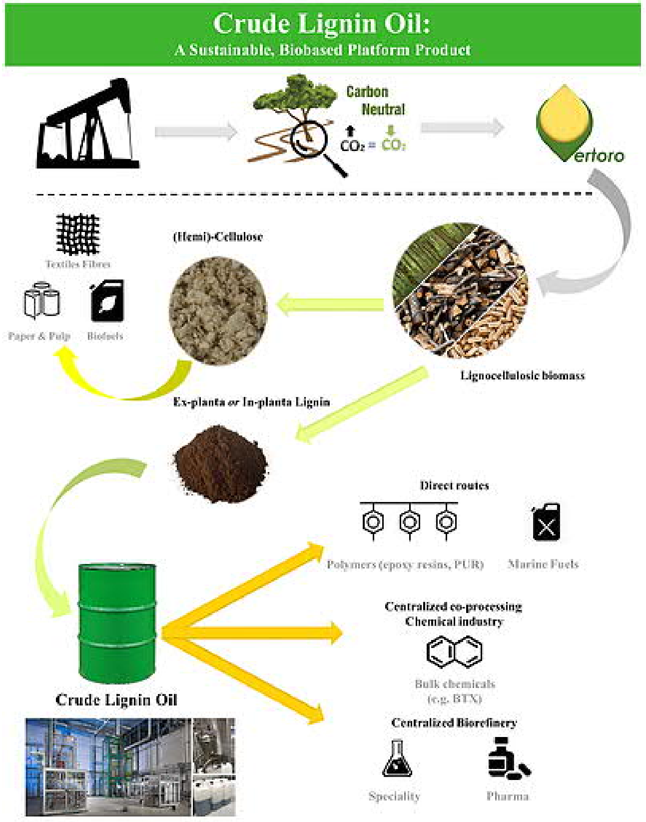
Aspects related with fuel production

Production from different sources / feedstock:

- From (solid) biomass (right)
- Using excess electrical power (PtX, below)



source: p2x4a.vdma.org



source: www.vertoro.com

Future marine fuel candidates

Grouping on basis of production pathway

Biomass-based:

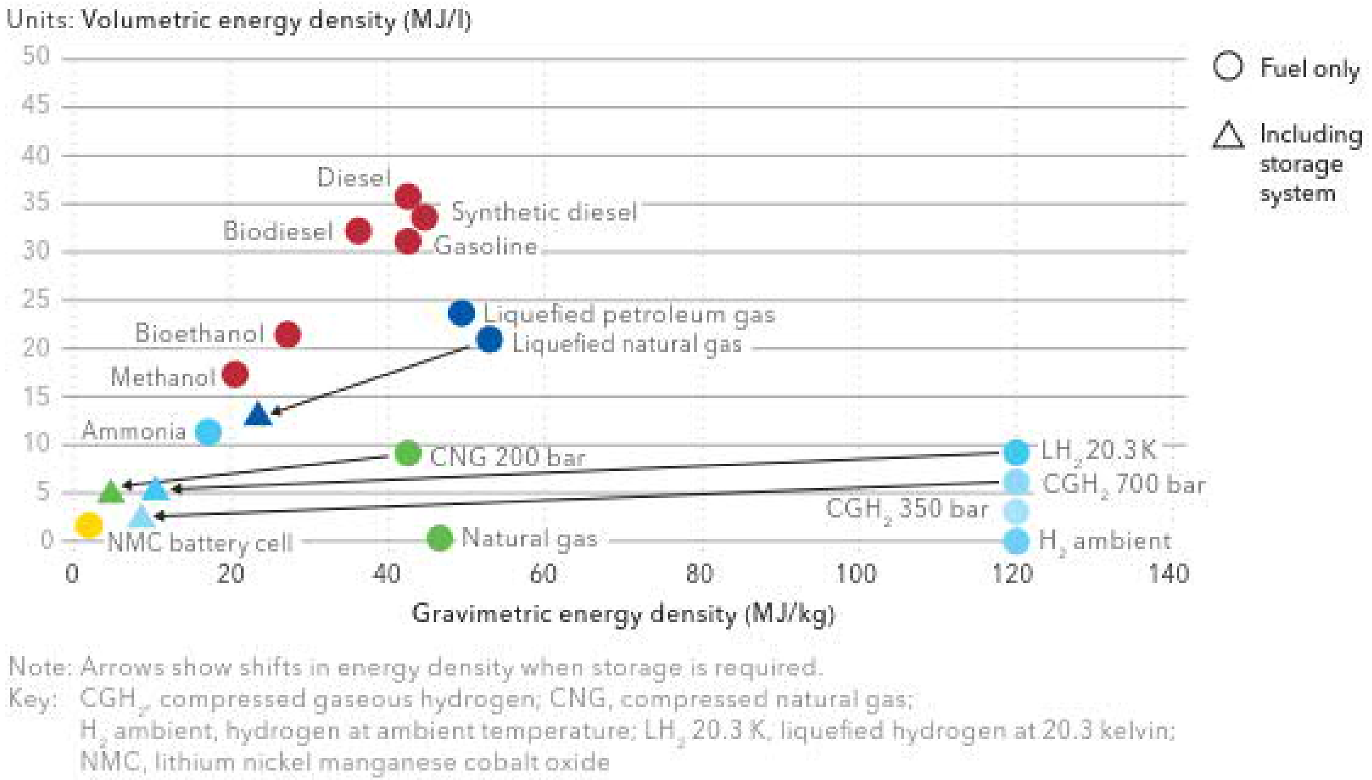
- Residual fuels from refinery of «bio-crude»
- Bio-diesel
- Bio-ethanol
- Biogas

PtX-based:

- Hydrogen
- Synthetic methane
- Ammonia
- Synthetic methanol
- Synthetic higher molecular hydrocarbons
- DME, OME, synthetic diesel, ...

Future marine fuel candidates

The energy density challenge of replacing conventional fuel



source: DNV GL: Energy Transition Outlook 2019,
Maritime – Forecast to 2050

Using LNG instead of HFO:

- Tank volume 1.6 times higher + insulation on top

From LNG to Hydrogen (cryogenic):

- Tank volume >2 times higher + additional insulation on top

Ammonia and Methanol:

- Challenge on tank volume increase
- Challenge in weight increase
- ...and both are toxic!

Batteries compared to HFO:

- Storage volume min 8 times higher
- Weight more than 20 times higher

Key criteria and preliminary assessment

With focus on maritime market specific aspects

Drop-in capability:

- As a surrogate
- For blending into present fuels

Storage and handling on board:

- Cargo capacity impact
- Health and operational safety implications

Business maturity and perspectives:

- Market existing
- Proximity of production capacities and major shipping routes
- International trade existing
- Intersectoral competition

Key criteria and preliminary assessment

With focus on maritime market specific aspects

	as surro-gate	for blending	capacity impact	safety impli-cations	intnl. market existing	proxi-mity	sector compe-tition
Residual fuels from refinery of «bio-crude»	teal	teal	teal	teal	teal	?	teal
Bio-diesel	teal	teal	teal	teal	teal	?	yellow
Bio-ethanol	yellow	teal	teal	teal	teal	?	yellow
Biogas	teal	teal	teal	teal	teal	?	teal
Hydrogen	red	yellow	red	yellow	yellow	?	teal
Synthetic methane	teal	teal	teal	teal	teal	?	teal
Ammonia	yellow	yellow	yellow	red	teal	?	teal
Synthetic methanol	yellow	teal	yellow	yellow	teal	?	yellow
Synthetic higher molecular hydrocarbons	yellow	teal	teal	teal	teal	?	red
DME, OME, synthetic diesel, ...	teal	teal	teal	teal	teal	?	red

Discussion

Key hypotheses

- Decarbonization of maritime transport will only be possible if low net carbon fuels are either made economically attractive or the phase-out of traditional fuels is enforced
- Drop-in capable fuels are the fastest way to decarbonize maritime transport
- New fuels need to be made available worldwide
  - Production, transport, storage and bunkering infrastructure has to be put in place, in a first stage for serving the main sectors (container vessels, bulk carriers) along their shipping routes
  - A global market for any candidate fuel is a key enabler for its adoption in the maritime sector
  - Dedicated vessels for shipping such fuels are a prerequisite for establishing such global market, at the same time, they facilitate the introduction of propulsion / ship energy systems using these fuels
- The regulatory framework needs to be updated before any new fuels associated with health or operational safety implications can be introduced
- High-quality, high energy-density fuels will not be a viable solution for marine applications as other sectors will be more prepared to pay the price premium associated