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AIEE ASSOCIAZIONE ITALIANA ECONOMISTI DELL'ENERGIA

4RD AIEE ENERGY SYMPOSIUM
CURRENT AND FUTURE CHALLENGES TO ENERGY SECURITY

FUELS FOR FUTURE MARITIME TRANSPORTATION

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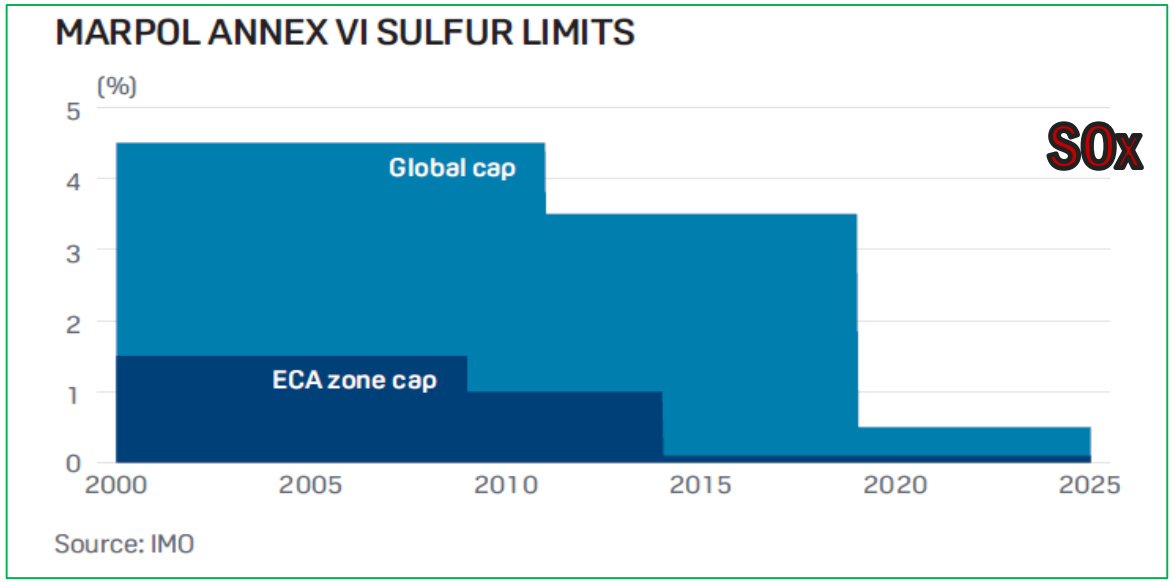
Roma, 12 dicembre 2019

The new IMO regulations for shipping



Outside an ECA established to limit SOx and particulate matter emissions	Inside an ECA established to limit SOx and particulate matter emissions
4.50% m/m prior to 1 January 2012	1.50% m/m prior to 1 July 2010
3.50% m/m on and after 1 January 2012	1.00% m/m on and after 1 July 2010
0.50% m/m on and after 1 January 2020	0.10% m/m on and after 1 January 2015

Tier	Ship construction date on or after	Total weighted cycle emission limit (g/kWh) n = engine's rated speed (rpm)		
		n < 130	n = 130 - 1999	n ≥ 2000
I	1 January 2000	17.0	$45 \cdot n^{(-0.2)}$ e.g., 720 rpm – 12.1	9.8
II	1 January 2011	14.4	$44 \cdot n^{(-0.23)}$ e.g., 720 rpm – 9.7	7.7
III	1 January 2016	3.4	$9 \cdot n^{(-0.2)}$ e.g., 720 rpm – 2.4	2.0

The Tier III controls apply only to the specified ships while operating in Emission Control Areas (ECA) established to limit NOx emissions, outside such areas the Tier II controls apply. In accordance with regulation 13.5.2, certain small ships would not be required to install Tier III engines.

NOx

Initial IMO Strategy on reduction of GHG emissions from ships

- A reduction in total GHG emissions from international shipping which should peak as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008, while, at the same time, pursuing efforts towards phasing them out entirely

CO_2

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The new IMO 2020 sulphur limits

- **Shippers have four main choices:**
  - Use marine gasoil 0,1% Sulphur – available but expensive
  - Buy "new" fuel 0.5% S HFO blends – already available but mandatory from 1st January
  - Install scrubbers to continue to use 3,5% Sulphur bunker – $3-5 million cost per ship – expect fast payback but few shippers choosing this option in time for 2020. Around 3.000 ships are today equipped with scrubbers (mainly container, bulk and tanker ships)
  - Switch to LNG bunkers – only for new vessels; expensive; limited infrastructure

- **Refining industry approach:**
  - The refining industry will supply the IMO bunker with a number of alternatives - Marine diesel, heavy distillates, residual fuel oil
  - Each refinery will make available the fuel on the basis of its present configuration
  - No new plants are planned by 2020, specifically designed for these fuels

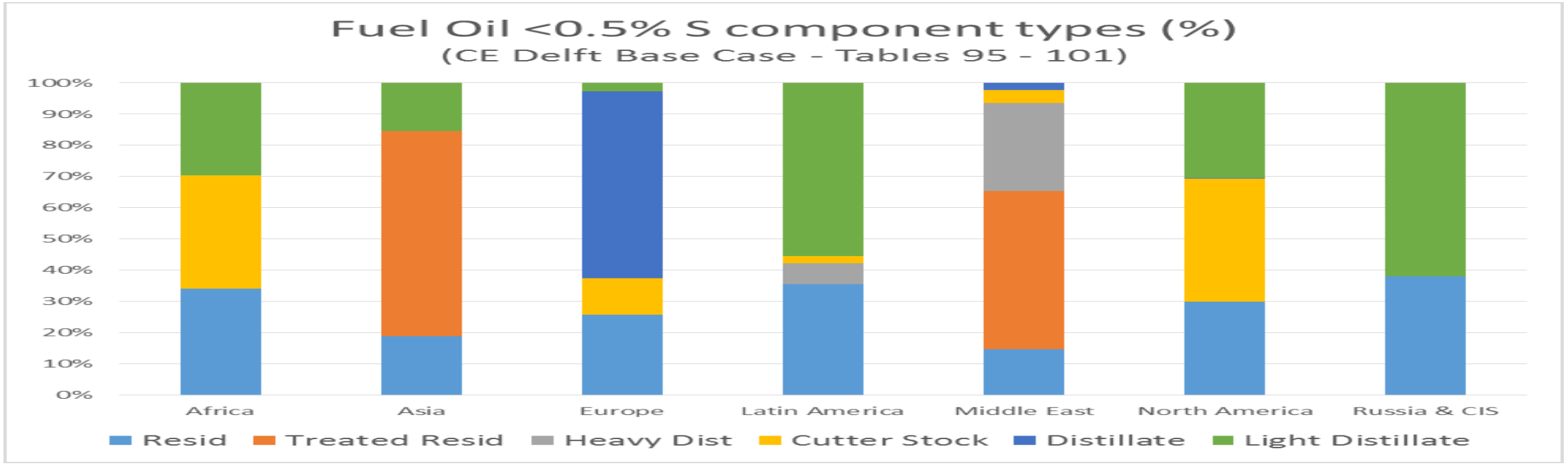
Evolution of bunker fuels demand

- Based on the latest news on scrubber installations and LNG development, the 2020 world bunker fuels market can be estimated as follow:

Marine bunker fuels	2017	2020
Marine diesel MGO 0,1 % sulphur	40 – 50 Mton	40 - 50 Mton
Marine diesel MGO > 0,1 % sulphur	30 – 40 Mton	-
LNG	6 – 8 Mton	8 - 10 Mton
Bunker IFO 380/IFO 180 3,5% sulphur	150 - 160 Mton	60 - 80 Mton (partially scrubbed)
Bunker IMO 0,5% sulphur	-	150 - 200 Mton

Quality problems to address on new IMO bunker fuels

- The fuel formulations vary widely across World Regions
- This could lead to the following issues:
  - Wide variation in fuel pre-heat temperature prior to injection when using fuel deliveries with varying viscosities
  - Risk of incompatibility - In many cases it would not be advisable for ships to commingle fuels from different regions



Quality problems to address on new IMO bunker fuels

- Concerns have been raised about these fuels which may differ in their composition from supplier to supplier and port to port. This could potentially lead to compatibility and mechanical problems.

- Some regions are expected to provide a 0.50% m/m solution based primarily on fuel oil, whilst others are expected to provide distillate-based solutions

- The relevant specification in force for all bunker fuel (residual and distillate) is the ISO 8217. Waiting a new standard to include the new IMO bunker ISO adopted a Publicly Available Specification (PAS 2363) to provide with a quality reference by 2020

- ISO PAS 23263 provide with general considerations and recommendations on stability, compatibility, flash point, kinematic viscosity, cold flow properties, ignition characteristics

Joint industry initiative on guidance document and training materials

- In order to manage the transition from the high sulfur bunker to the IMO low Sulphur bunker, the industrial sectors have also prepared a series of Guidelines. The most relevant are the following:
  - Joint Industry Guidance - The supply and use of 0.5% sulfur marine fuel; links
  - International Chamber of Shipping - Compliance with 2020 "Global Sulfur Cap" Link
  - CIMAC Guideline - Marine fuel handling in connection to stability and compatibility
- The Guidelines have been developed by representatives from the shipping industry, the refining industry, bunker suppliers, standards organizations and other parties
- These documents are primarily addressed to the ship operators but will also provide information for fuel suppliers and will address the potential safety and operational issues related to the supply and use of new fuel blends or fuel types

Alternative fuels - LNG

- Liquid natural gas (LNG) can be used in reciprocating engine propulsion systems and is a known technology with several years of operational experiences
- Around 400 LNG ships in the market (80% dual fuel, 20% pure gas)
- The actual number and size of bunkering facilities is limited but rapidly increasing
- LNG has concrete benefits in terms CO2, NOX, SOX and PM emissions

Emissions g/g fuel	HFO 0,5%S	MDO 0,1%S	LNG
SOx	0.007	0.002	trace
CO2	3.114	3.206	2.750 (near zero with Bio LNG)
CH4	trace	trace	0.051
NOx	0.093	0.087	0.008
PM	0.007	0.001	trace

Source IMO 2014

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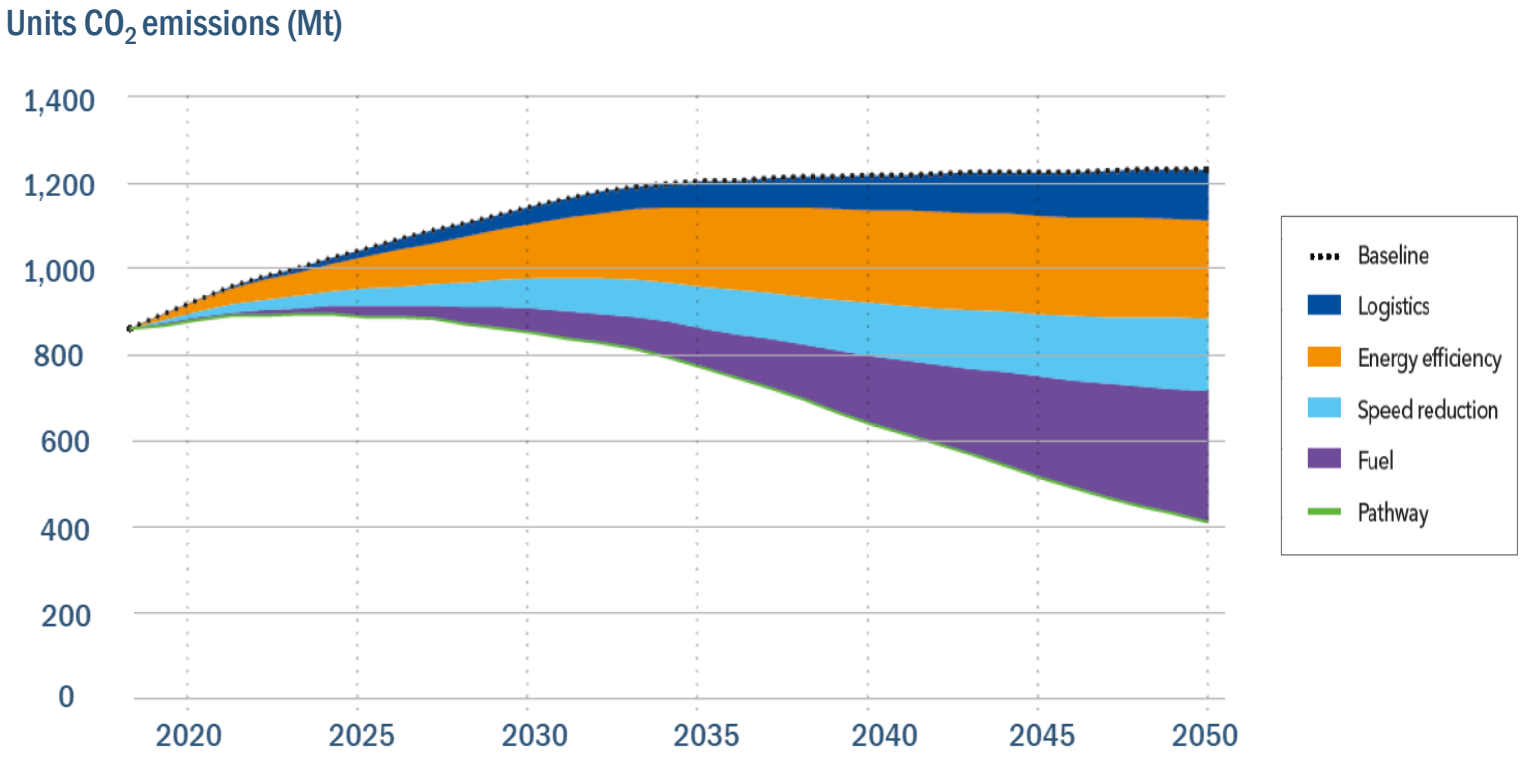
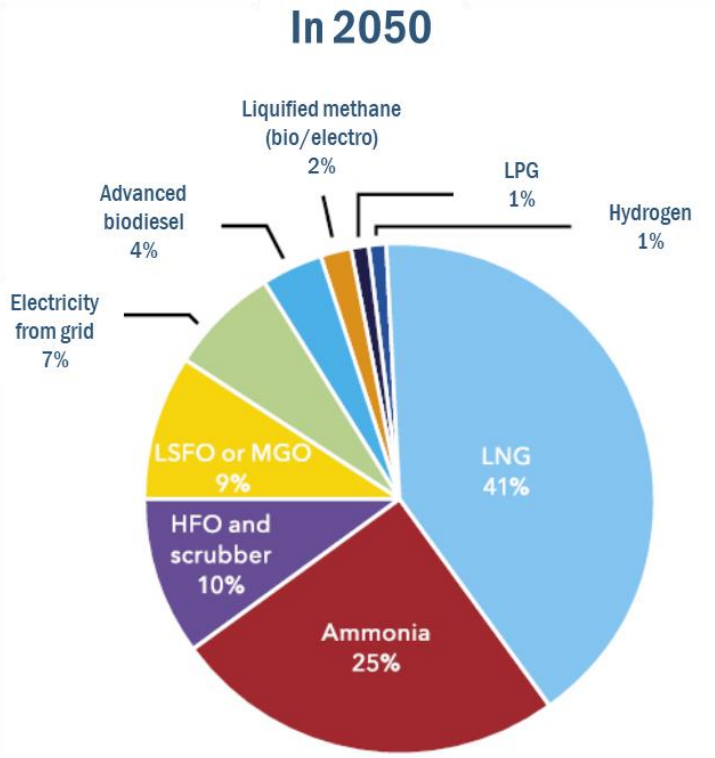
All other alternative fuels

Alternative fuel	Source	Storage	Use
Biofuels	Non edible crops, waste, residue, algae	Liquid or gas form in tank	Internal combustion engine
Methanol	Mainly natural gas and coal. However also from renewable sources or synthesised from waste CO2 and renewable electricity	Liquid form in tank	Internal combustion engine
Ammonia	Mainly from energy derived from fossil fuel. However also from Air and Water using renewable electricity	Liquid form in tank at low pressure	Internal combustion engine and as Hydrogen carrier in fuel cell/electric motor
Hydrogen	Mainly from natural gas and energy derived from fossil fuel. However also from biomethane or water using renewable electricity	High pressure gas in tank or in liquid form at very low temperature	Internal combustion engine and fuel cell/electric motor
Electricity	From fossil fuel, nuclear and renewable sources	Batteries	Electric motor and Hybrid system with ICE
E-fuels	From waste CO2 and hydrogen produced using renewable electricity	Liquid form in tank	Internal combustion engine

Alternative fuels – 2050 fuel mix to be in compliance with CO2 IMO Strategy

Carbon-neutral fuels need to supply 30%-40% of total energy in 2050





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Conclusions

- In the near term diesel engine will continue to be dominant mainly fueled by petroleum products (0,1%S; 0,5%S; 3,5%S with scrubbers) but also by LNG (0,2% of the bunker market)
- The main drivers for future fuels, in the medium and long term, are the decarbonization targets adopted by IMO
- In the medium term LNG is expected to reach 8 – 10 % of the bunker demand and also Advanced Biofuels and HVO will increase their shares
- Hybrid powertrains will also appear on the market
- In the long term E-fuel and Ammonia produced by renewable electricity are the most promising fuels for transoceanic routes, due to their high energy density
- Hydrogen for fuel cell and batteries will be introduced in small specific shipping segments only

THANK YOU FOR YOUR ATTENTION

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