NTUA

Athens 29 May 2019

Ship Air Emissions

Main Challenges, Policies and Industry Developments

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RINA Activities

OVER 150 YEARS OF EXPERIENCE

A global firm offering certification, testing, inspection, consulting engineering and compliance services across different sectors

Ship air emissions

Main Greenhouse Gases (GHG)

- CO2: Carbon Dioxide
- CH4: Methane
- N_2O: Nitrous Oxide
- Halons

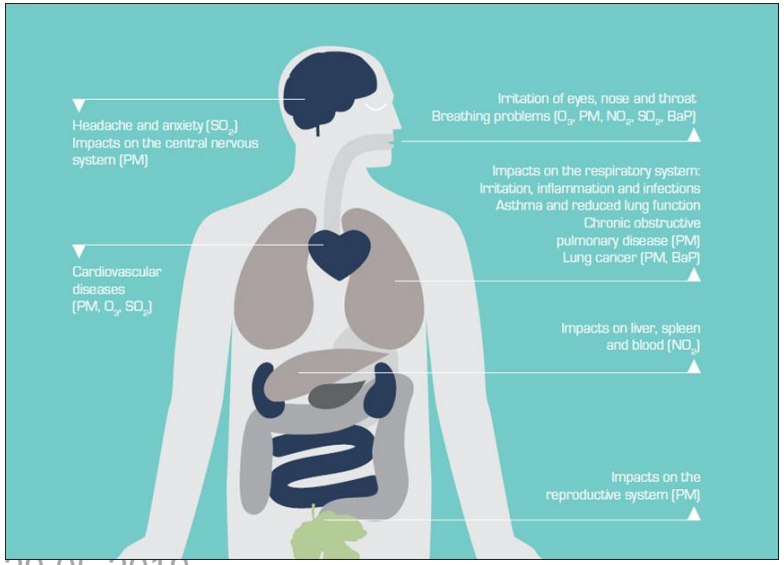
Global Impact

Climate change

Main Air pollutants

- NOx: Nitrogen Oxides
- SOx: Sulfur Oxides
- PM: Particulate Matter
- VOC: Volatile Organic Compounds
- CO: Carbon Monoxide

Local Impact



Human Health
Ecosystems

CO_2 facts of shipping

	Third IMO GHG Study (million tonnes)						ICCT (million tonnes)		
	2007	2008	2009	2010	2011	2012	2013	2014	2015
Global CO_2 Emissions*	31,959	32,133	31,822	33,661	34,726	34,968	35,672	36,084	36,062
International Shipping	881	916	858	773	853	805	801	813	812
Domestic Shipping	133	139	75	83	110	87	73	78	78
Fishing	86	80	44	58	58	51	36	39	42
Total Shipping	1,100	1,135	977	914	1,021	942	910	930	932
% of global	3.5%	3.5%	3.1%	2.7%	2.9%	2.6%	2.5%	2.6%	2.6%

Global CO_2 estimates include CO_2 from fossil fuel use and industrial processes (EDGAR, 2017).

International Shipping

60,000

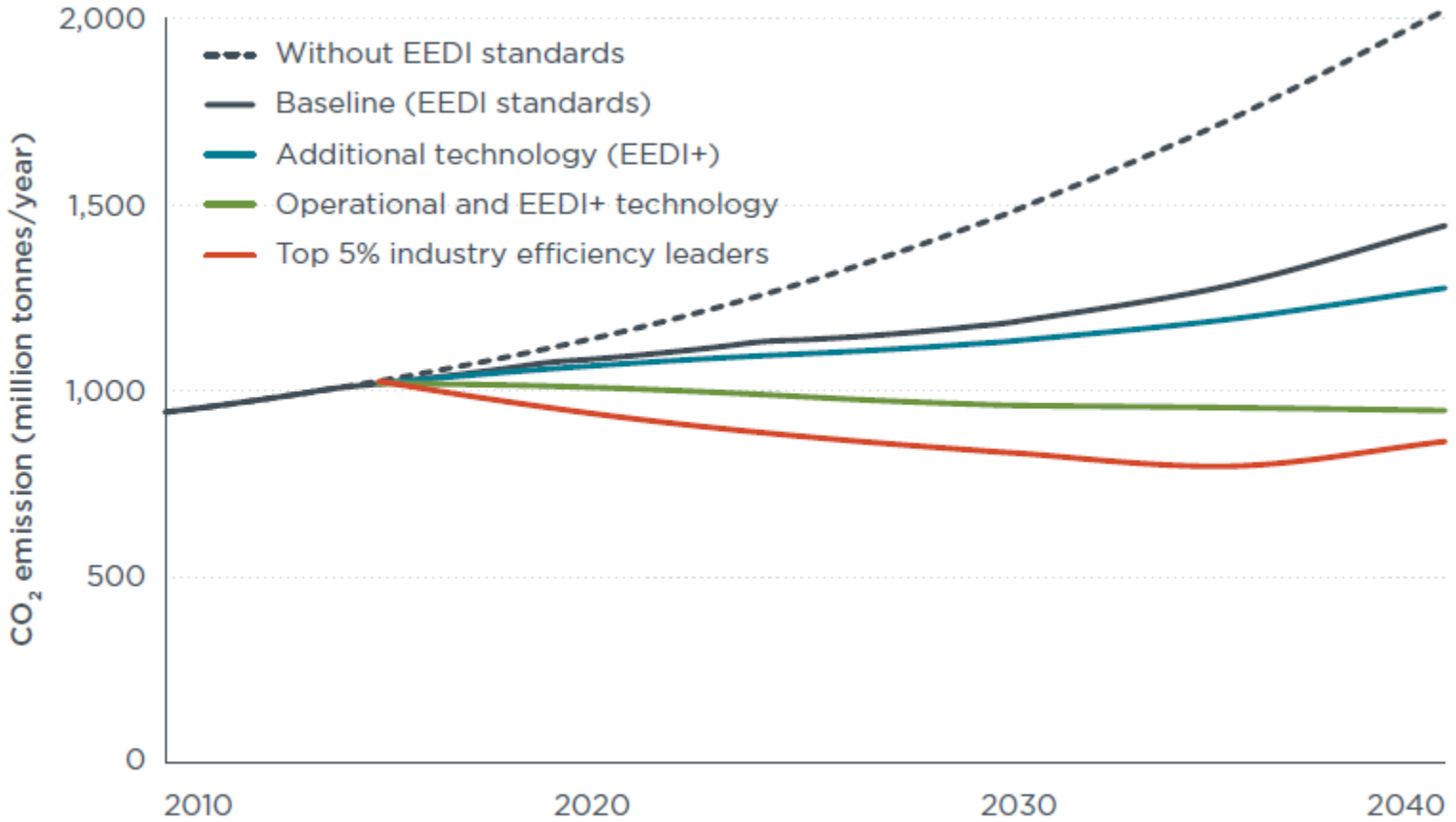
ships

90%

Global transport work

Challenges (1)

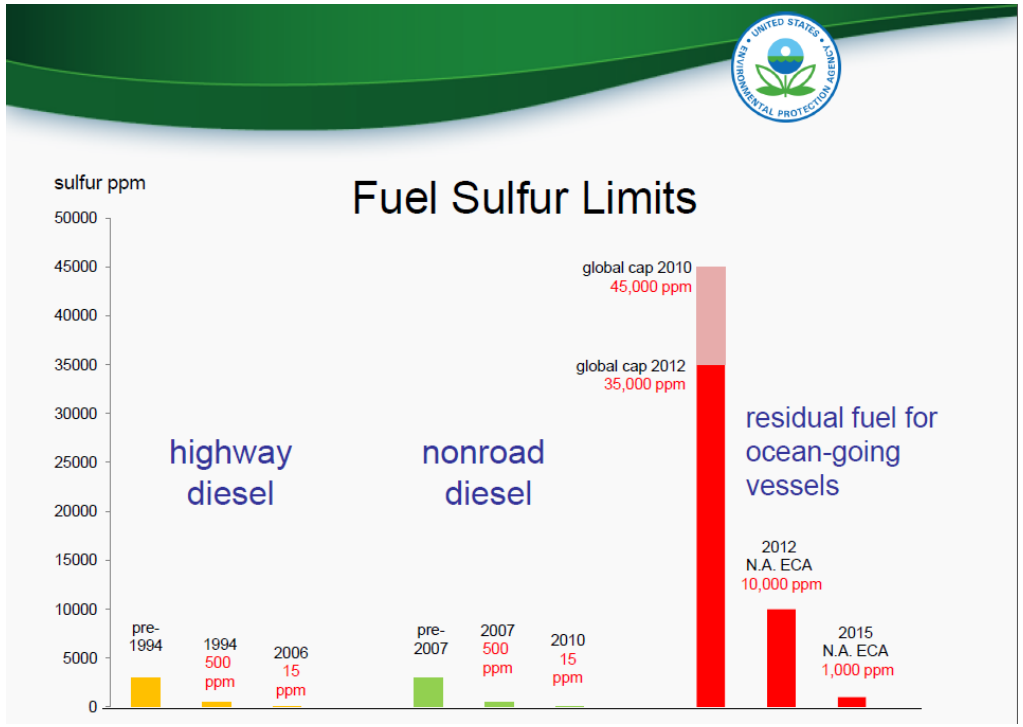
Expected growth of international shipping



Source: International Council on Clean Transportation

Challenges (2)

Quality of Marine fuels

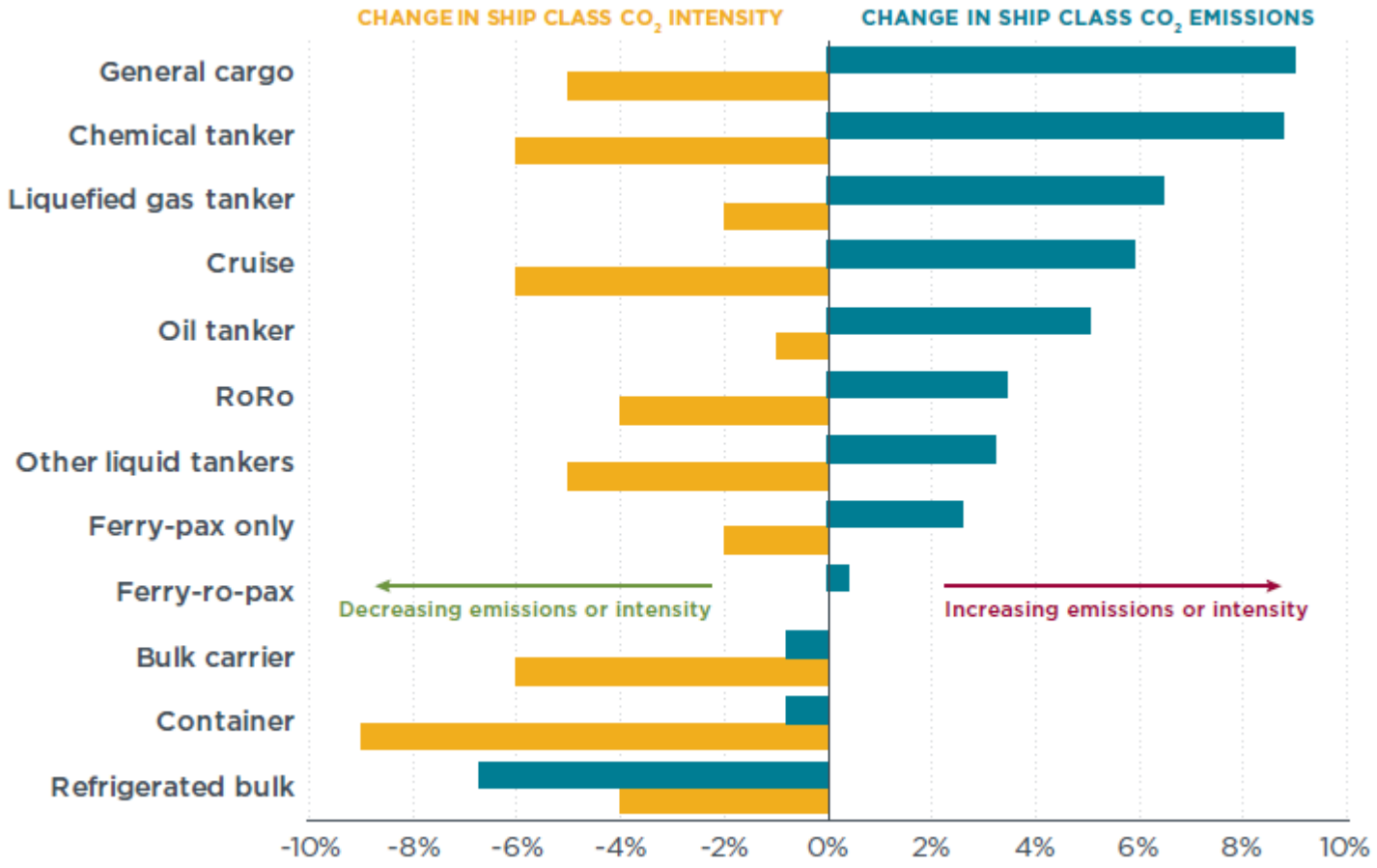


Challenges (3)

Green house gas reduction potential

DESIGN (New ships)	Saving of CO_2/tonne-mile	Combined	Combined
Concept, speed & capability	2% to 50%	10% to 50%	25% to 75%
Hull and superstructure	2% to 20%		
Power and propulsion systems	5% to 15%		
Low-carbon fuels	5% to 15%		
Renewable energy	1% to 10%		
Exhaust gas CO_2 reduction	0%		
OPERATION (All ships)			
Fleet management, logistics & incentives	5% to 50%	10% to 50%	
Voyage optimization	1% to 10%		
Energy management	1% to 10%		

Challenges (4): Is energy efficiency effective?



Although ships became more efficient from 2013 to 2015, total CO2 emissions from ships increased.

Overall CO2 intensity of cargo carrying ships decreased (improved) by 3.5% from 2013 to 2015, compared a 7% increase in transport supply (dwt-nm).

Change in CO2 emissions and CO2 intensity for key ship types (International Council on Clean Transportation, 2017)

Environmental Challenges

- Shipping GHG emissions represent less than **3%** of the global anthropogenic GHG emissions
- International shipping is expected to grow its volume in the future (its emissions in a BAU scenario to double or triple until 2050)
- Shipping's non GHG emissions are important contributors to air pollution effects (NOx, SOx, $PM_{2.5}$ VOC)
- Shipping uses lower quality fuels compared to other modes of transport
- Shipping has great emissions reduction potential (from design, operation, market mechanisms, solutions)
- Current energy efficiency measures are simply not enough!

IMO roadmap

October 2016 (MEPC 70)	Adoption of Data Collection System (DCS) Approval of Roadmap
Week before MEPC 71	Intersessional meeting to start discussions on a comprehensive IMO strategy
July 2017 (MEPC 71)	Discussion continues
October 2017	Intersessional meeting
Week before MEPC 72	Intersessional meeting
Spring 2018 (MEPC 72)	**Adoption of initial IMO Strategy (including short-, mid- and long term measures)**
January 2019	Start of Phase 1: Data collection (Ships to collect data)
Spring 2019 (MEPC 74)	Discussion continues Initiation of Fourth IMO GHG Study using data from 2012-2018
Summer 2020	Data for 2019 to be reported to IMO

MEPC 72 Outcome

Targets set for shipping's GHG

Level1

Carbon Intensity of the ship

- Carbon intensity at the ship level to decline
- implementation of further phases of the EEDI for new ships
- to review and strengthen the EEDI limits for ships (improvement for each phase to be determined for each ship type, as appropriate

Level 2

Carbon Intensity of international shipping

- Carbon intensity of international shipping to decline
- 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

Level 3

GHG from international shipping

- to peak GHG emissions from international shipping as soon as possible
- to reduce the **total annual GHG emissions by at least 50% by 2050** compared to 2008
- whilst pursuing efforts towards **phasing them out** consistent with the Paris Agreement temperature goals

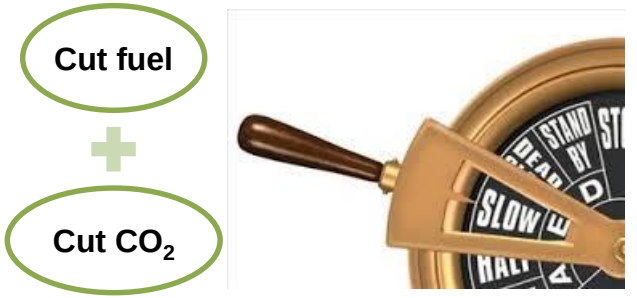
What is next?

IMO GHG Strategy, Short term measures (2018 – 2023)

1. Energy efficiency with focus on EEDI and SEEMP

$$\text{EEDI} = \frac{Power \times SFC \times Cf}{Cargo\ Capacity \times speed} \quad \left[\frac{g\ (CO2)}{Tons \times Miles}\right]$$

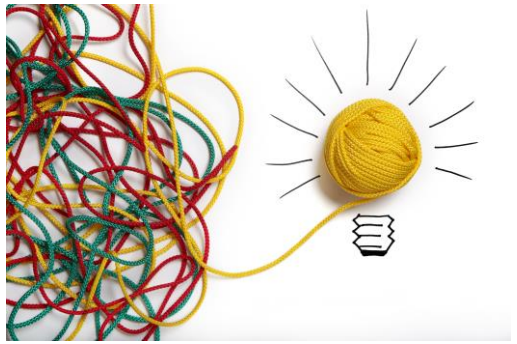
2. Consider and analyse speed optimization and *speed reduction* as a measure



What is next?

IMO GHG Strategy, Short term measures (2018 – 2023)

3 Initiate R&D. Establish an International Maritime Research Board to coordinate research



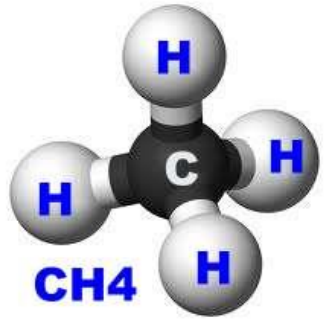
4 Consideration of other indicators that can be utilized to indicate and enhance the energy efficiency

- Annual Efficiency Ratio (AER),
- Energy Efficiency per Service Hour (EESH),
- Individual Ship Performance Indicator (ISPI)
- Fuel Oil Reduction Strategy (FORS);

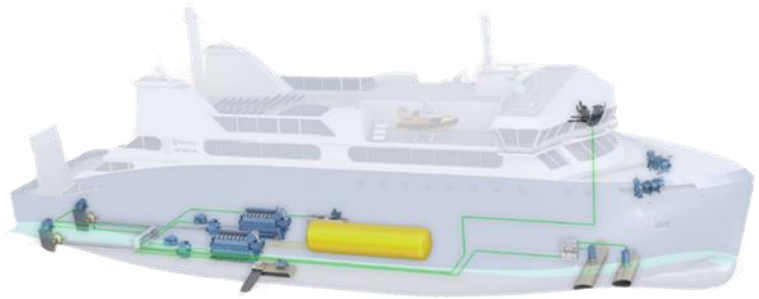
What is next?

IMO GHG Strategy, Short term measures (2018 – 2023)

5 Address emissions of methane and Volatile Organic Compounds



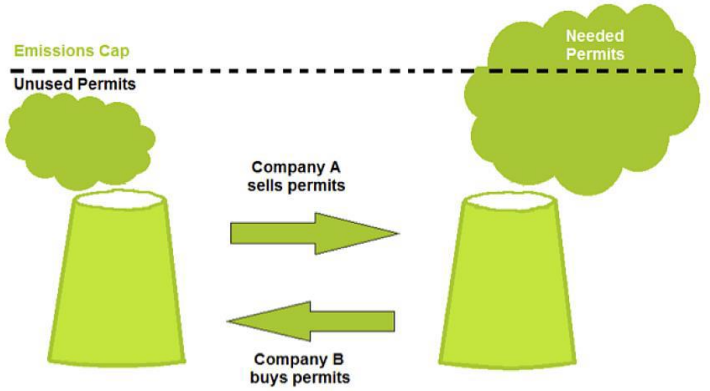
6 Incentives for first movers to develop and take up new technologies



What is next?

IMO GHG Strategy, Mid-term measures (2023 – 2030)

7 Market based measurers, (e.g. emissions trading)



8 Implementation programme for the effective uptake of alternative low-carbon and zero-carbon fuels,

What is next?

IMO GHG Strategy, Long- term measures (2030 -)

9 De – carbonization (fossil free, or zero carbon fuels)

Global Sulphur Limit

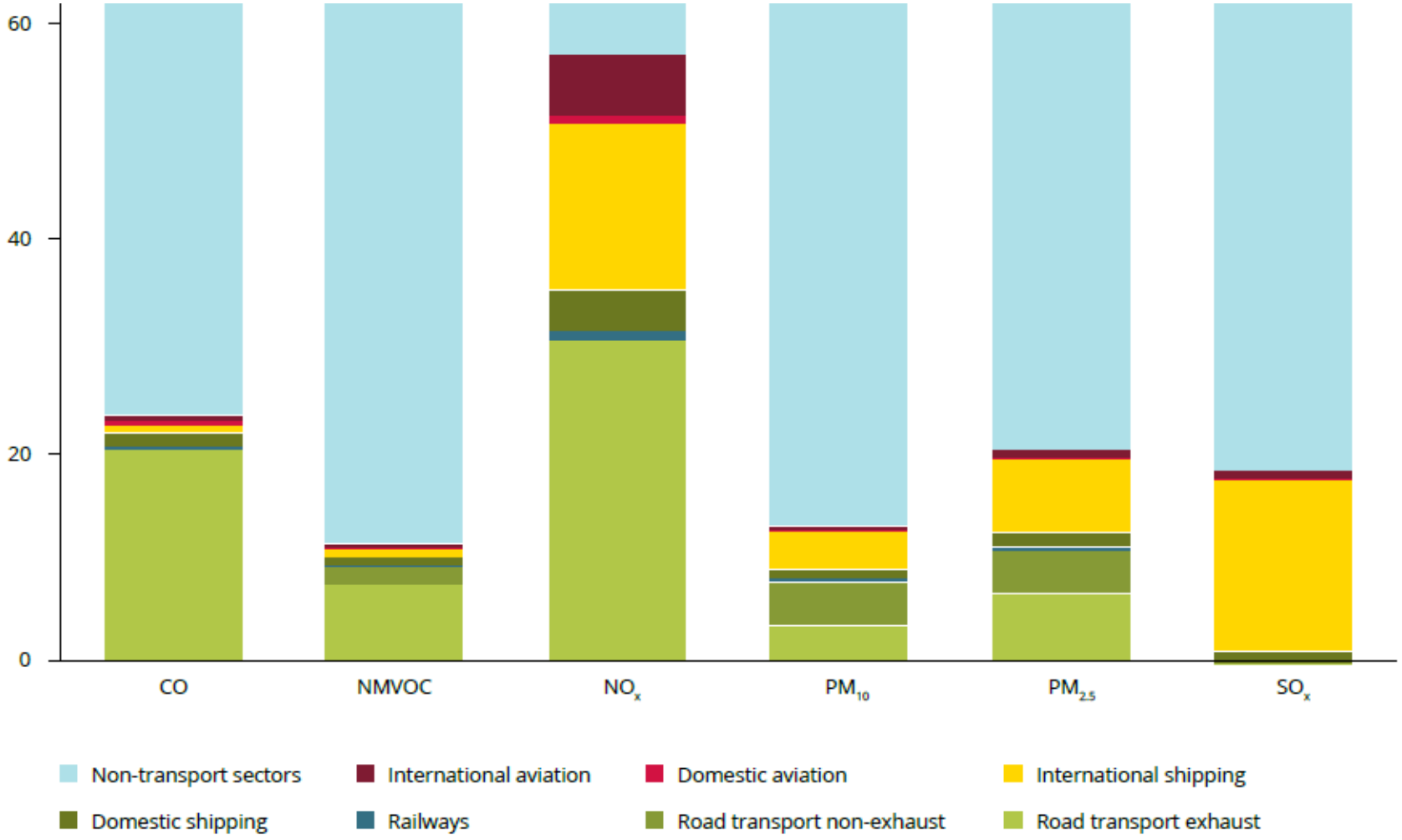
Facts – Air Pollution

Contribution of the transport sector to total emissions of the main air pollutants (%)

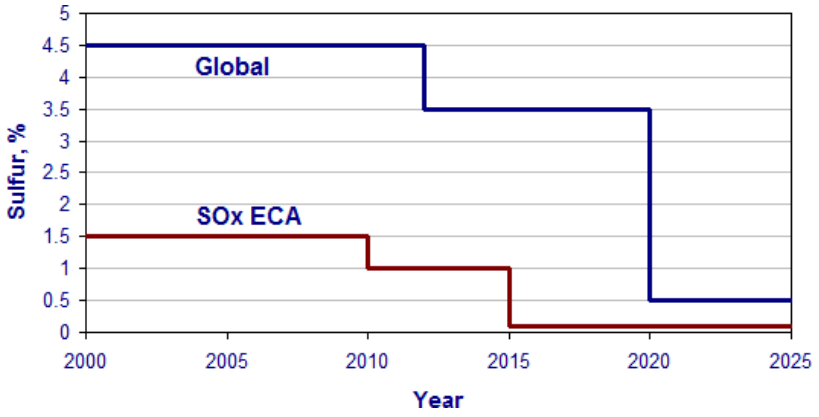
international shipping in EU

- **16 % of NO_x,**
- 4 % of PM_{10},
- 7 % of $PM_{2.5}$
- **16 % of SO_x**

(European Environmental Agency, 2017).



Global Sulphur Limit



AREA	Sulphur Limit	Scrubbers
Global	0.5 %	Accepted
ECA	0.1 %	Accepted
Europe	0.1% in ports	Open loop not accepted in specific ports
China	0.5% in selected areas	Accepted
California	0.1% within 24nm	Submit research results to be accepted

Global Sulphur Limit

Options

Low Sulphur fuels	• MDO, • MGO • Low Sulphur HFO
Alternative fuels	• Bio fuels • Methanol • LNG
Scrubbers	• Wet type - open loop • Wet type - closed loop • Wet type - Hybrid • Dry type

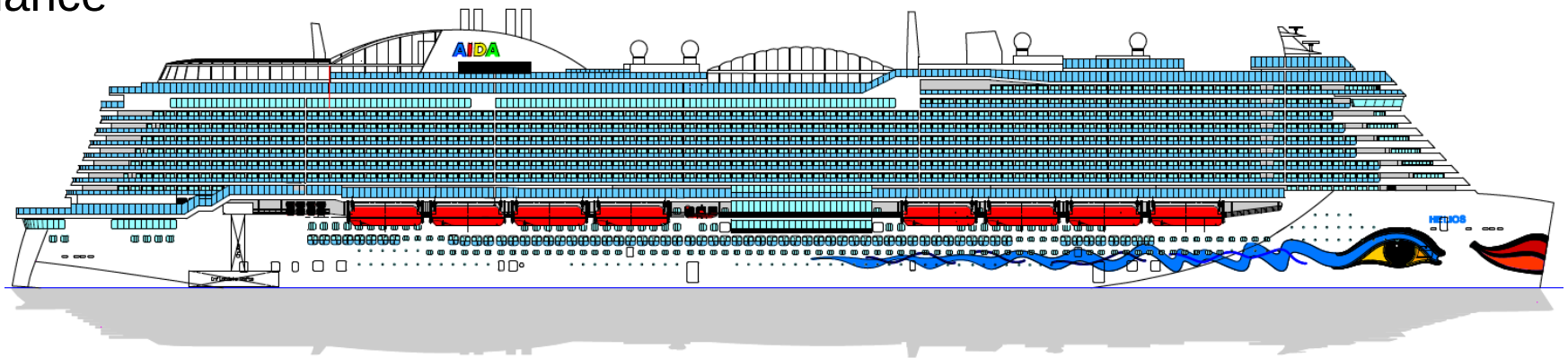
Global Sulphur Limit

Option 2 – Alternative fuels

LNG is leading the market of alternative fuels

- **Main Tech & Operational Challenges**
- Bunkering
- Storage
- Distribution
- Use
- Maintenance

LNG as fuel ≠ **Oil as a fuel**



RINA activities

Newbuilding: Carnival XL Project

Shipowner: AIDA - P&O

Size: 5 × cruise ships (183,200 gt)

Shipowner: Costa Crociere - Carnival Cruise Line

Size: 4 × cruise ships (183,200 gt)

Revolutionary “green design”

The first ships in the cruise industry to be powered at sea by LNG

RINA activities

Newbuilding: LNG ferries

- **Shipyard:** Sefine Shipyard
- **Shipowner:** Caronte & Tourist
- **Size:** 1+1 × Ro-Ro passenger ferry (290 cars; 1,000 pax)

- Designed to provide a 20-25% efficiency saving
- The first ferries to be powered at sea by LNG in the Mediterranean

LNG as fuel

Remarks

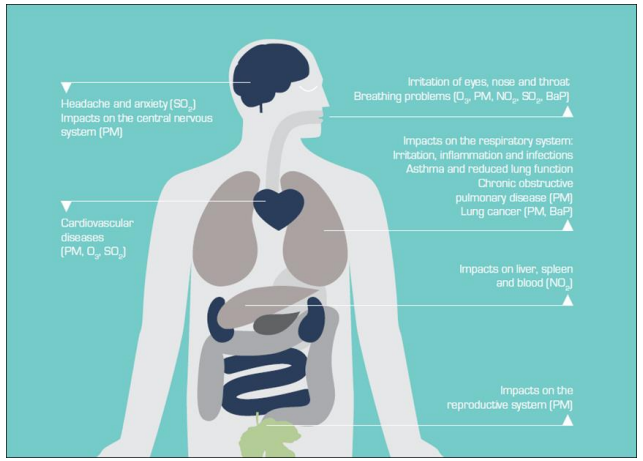
A. Transition fuel: LNG is going to be a transition fuel for maritime transport,

B. Air pollution: Clear benefits in the elimination of air pollution, expensive option

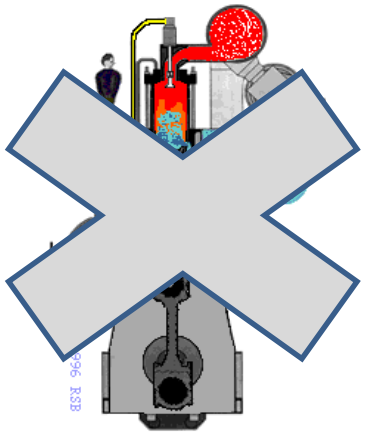
C. Climate change: LNG **is not** the solution for combating climate change

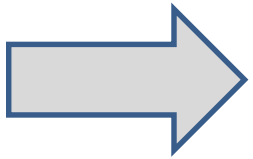
Climate change

Human Health & Ecosystems




TIME
FOR
CHANGE

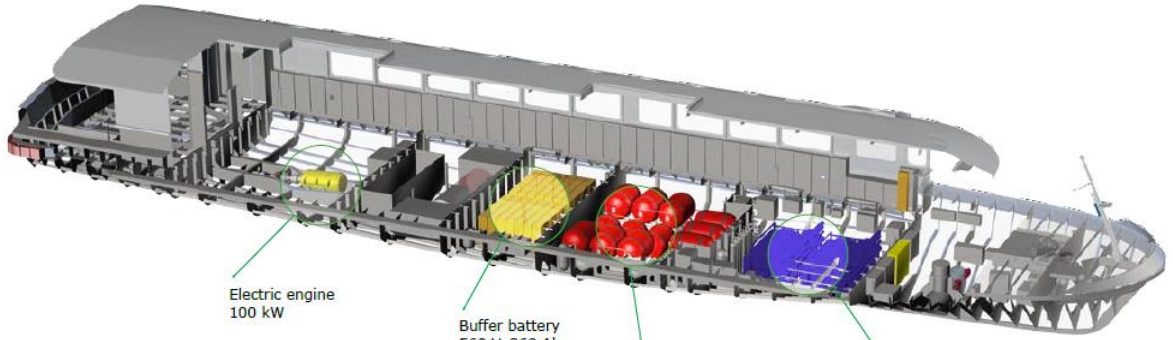





+
BATTERY

Real projects…

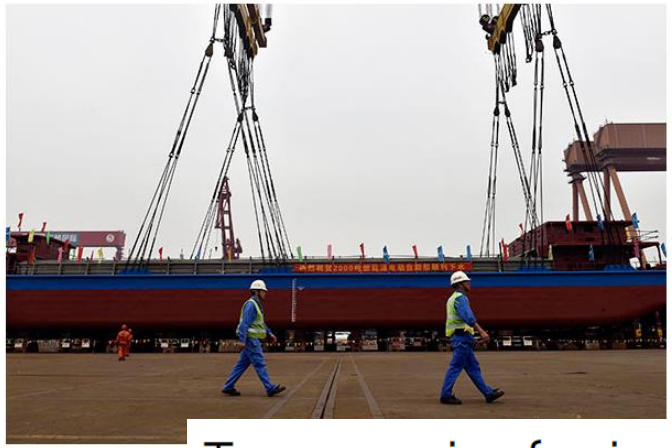
Electric Ships



The propulsion system (Source: Schiffstechnik Buchloh)

Fully electric cargo ship launched in Guangzhou

By Qiu Quanlin in Guangzhou | China Daily | Updated: 2017-11-14 09:28



A new all-electric and autonomous cargo ship is planned for operation in 2018

Fred Lambert - May. 11th 2017 10:14 am ET @FredericLambert

Two massive ferries are about to become the biggest all-electric ships in the world

Fred Lambert - Aug. 24th 2017 8:37 am ET @FredericLambert

World's First Hydrogen-Powered Cruise Ship Scheduled

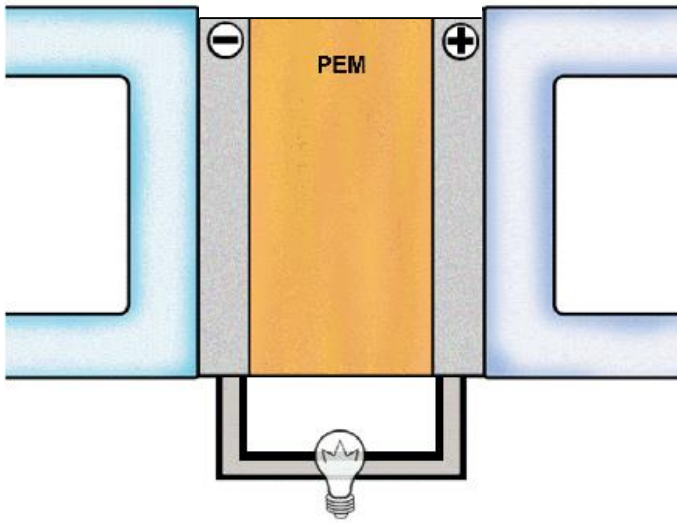
Christening of Viking Sea

By **MarEx** 2017-10-02 18:17:55

FEATURE 5.2019

Future trends…

Fuel cells, Hydrogen



- Half Reactions on the electrodes

Anode: $H_2 \longrightarrow 2H^+ + 2e^-$

Cathode: $1/2\ O_2 + 2H^+ + 2e^- \longrightarrow H_2O$

- Total Reaction

$H_2 + 1/2\ O_2 \longrightarrow H_2O$

RINA activities

Newbuilding: Hybrid Ro-Ro Cargo ships

Shipowner: Grimaldi

Size: : 12 × Ro-Ro cargo (500 trucks - ICE Class)

New hybrid (battery powered) ro-ro cargo ships

Lithium batteries (5 Mega Watt), 600 m^2 of solar panels

Low emissions due to a revolutionary hull design

RINA activities

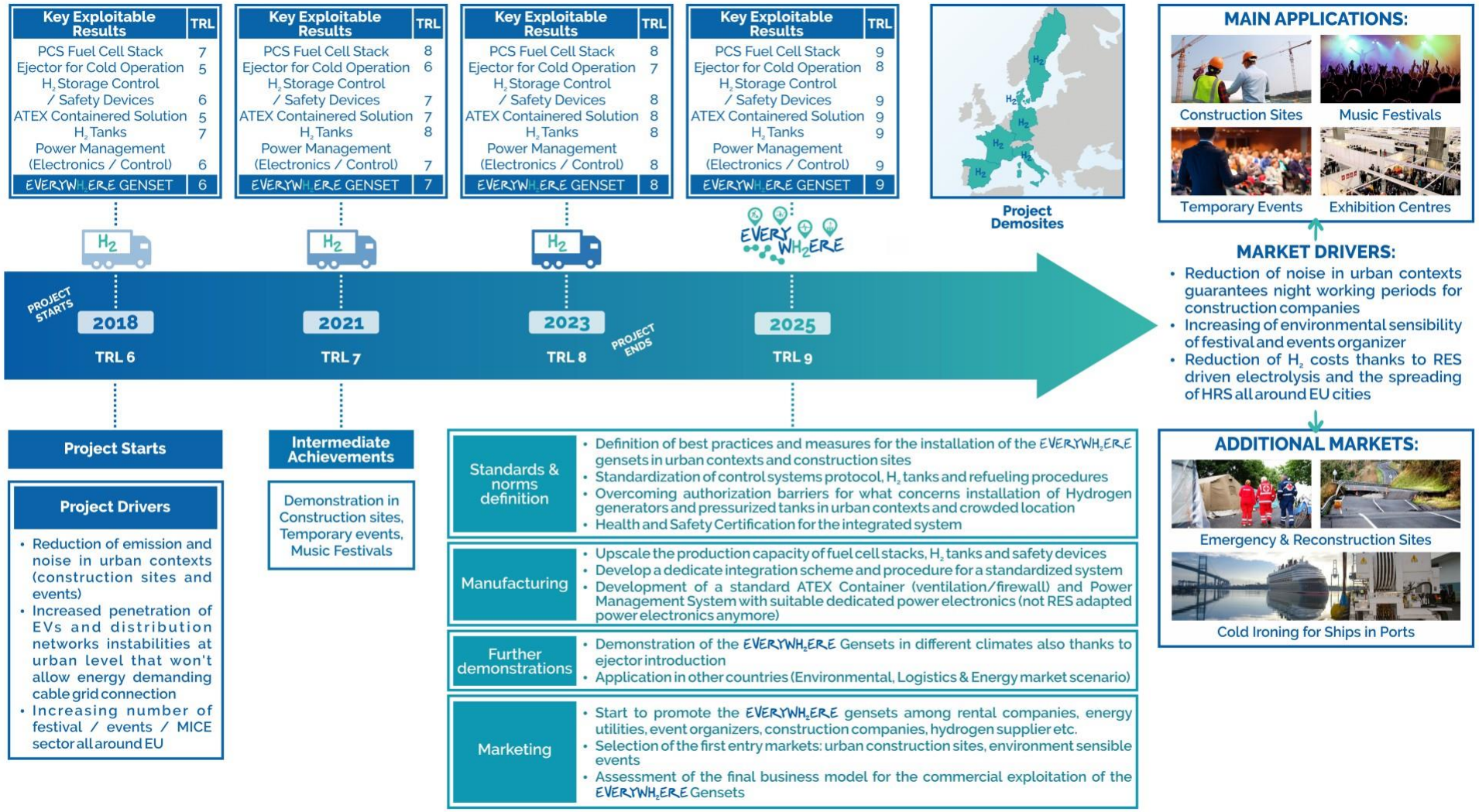
Research & Innovation projects

EVERYWH2ERE

Upscaling hydrogen technology in EU cities

8 FC containered “plug and play”gensets (4×25 kW + 4×100 kW) will be tested

FCH | FUEL CELLS AND HYDROGEN JOINT UNDERTAKING



Remarks

Shipping is now in the era of alternative fuels (mainly LNG)

Decarbonisation is the decisions makers policy for the future of shipping

Maturity and upscaling are needed for the use of batteries and fuel cells onboard

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