SOLVANG ASA

Emission reduction technologies---advantages and disadvantages
Fleet director Tor Øyvind Ask

A family controlled company – traditional – innovative – a long term shipping partner

7 VLGC (+ 1)

9 LGC

1 MGC

6 (+4) Ethane / Ethylene

- Major ovner -- Steensland Brun family
- A long term industrial shipping partner

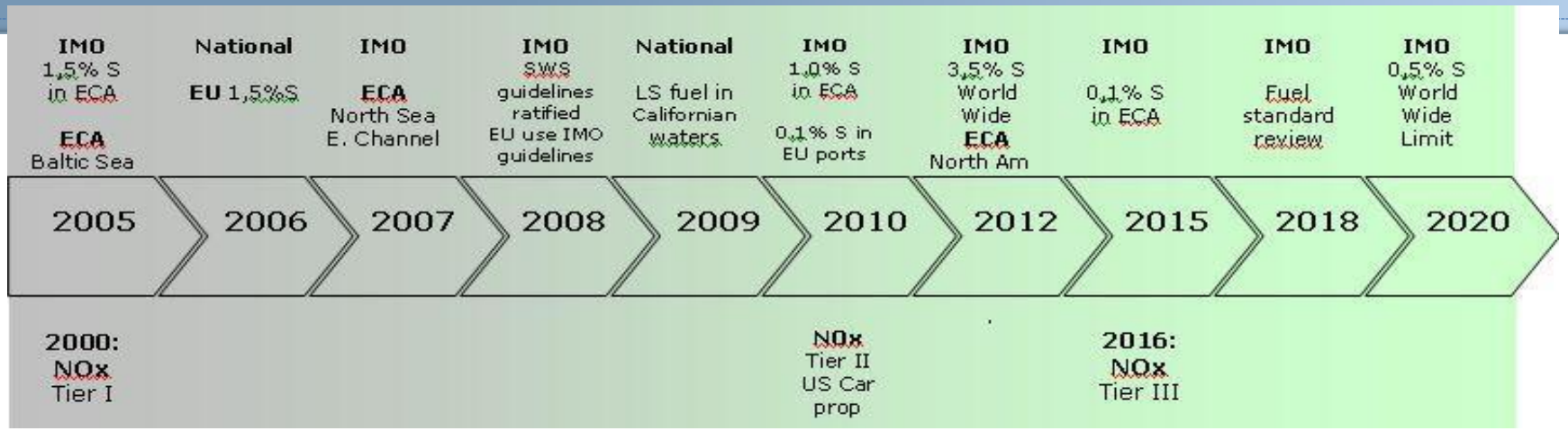
Vessel position (snap shot)

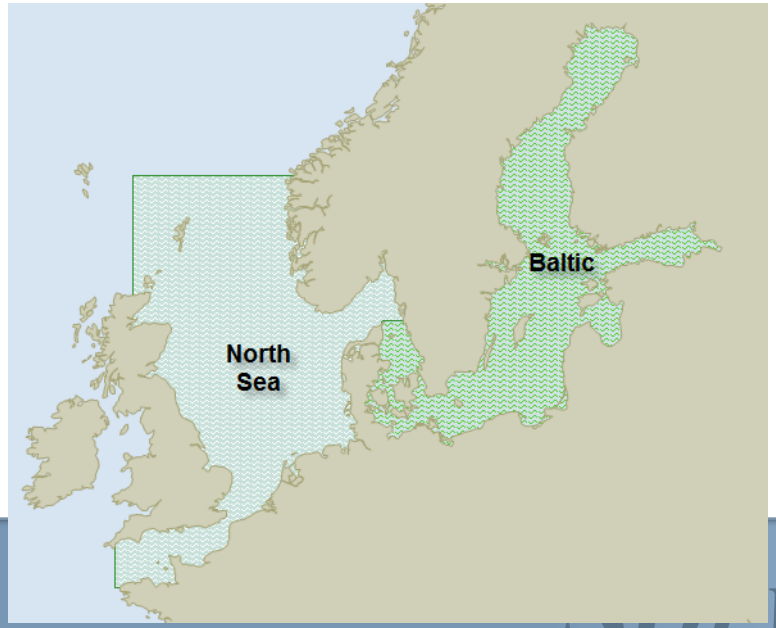
What is green shipping ?

- Off-shore
- Short sea
- Deep Sea

Totally different operation, requirement and solutions.

Air-emission controls SOx-NOx





Choice of fuel 2015/2020

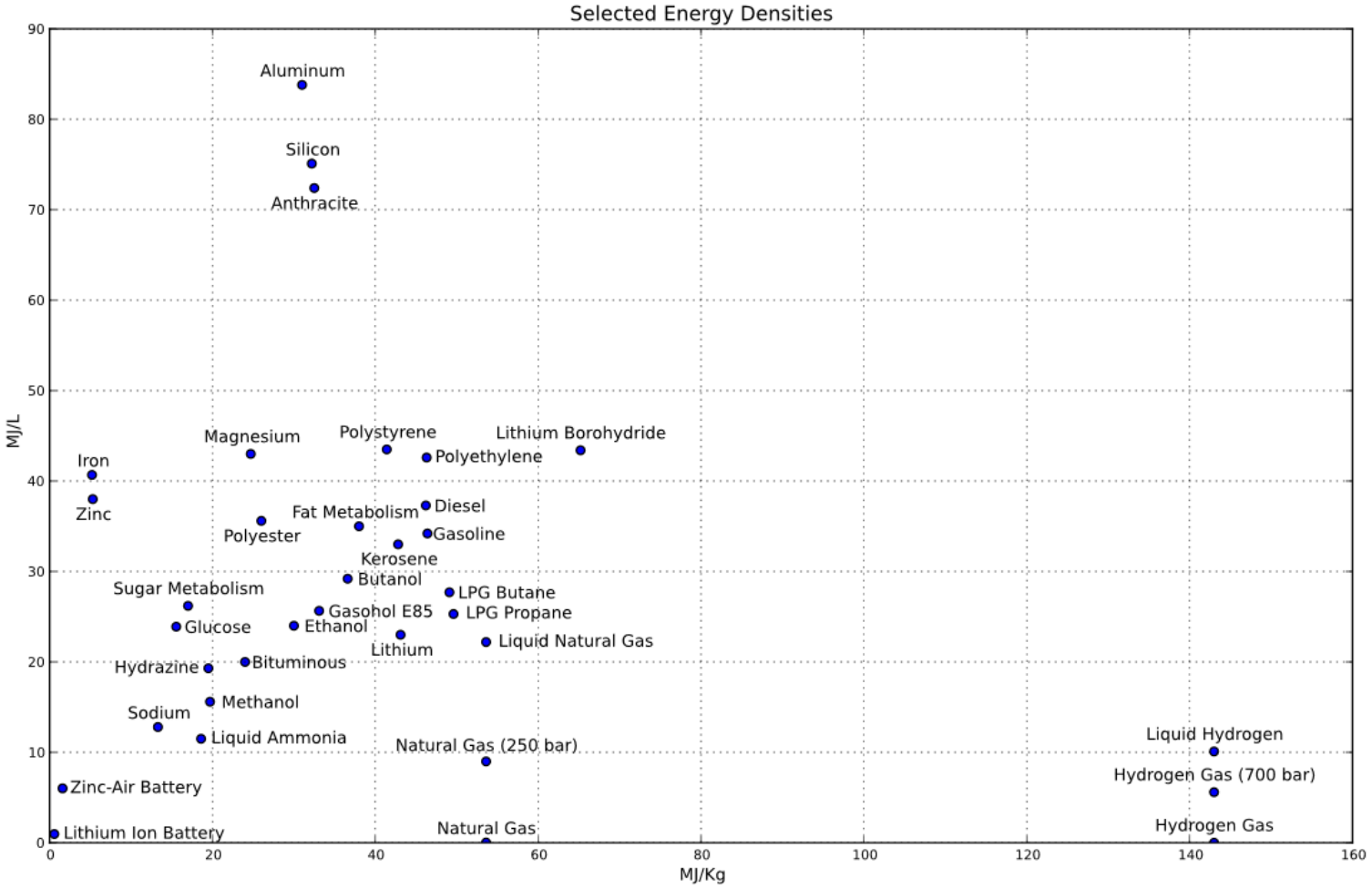
Difficult choices ahead

SOx

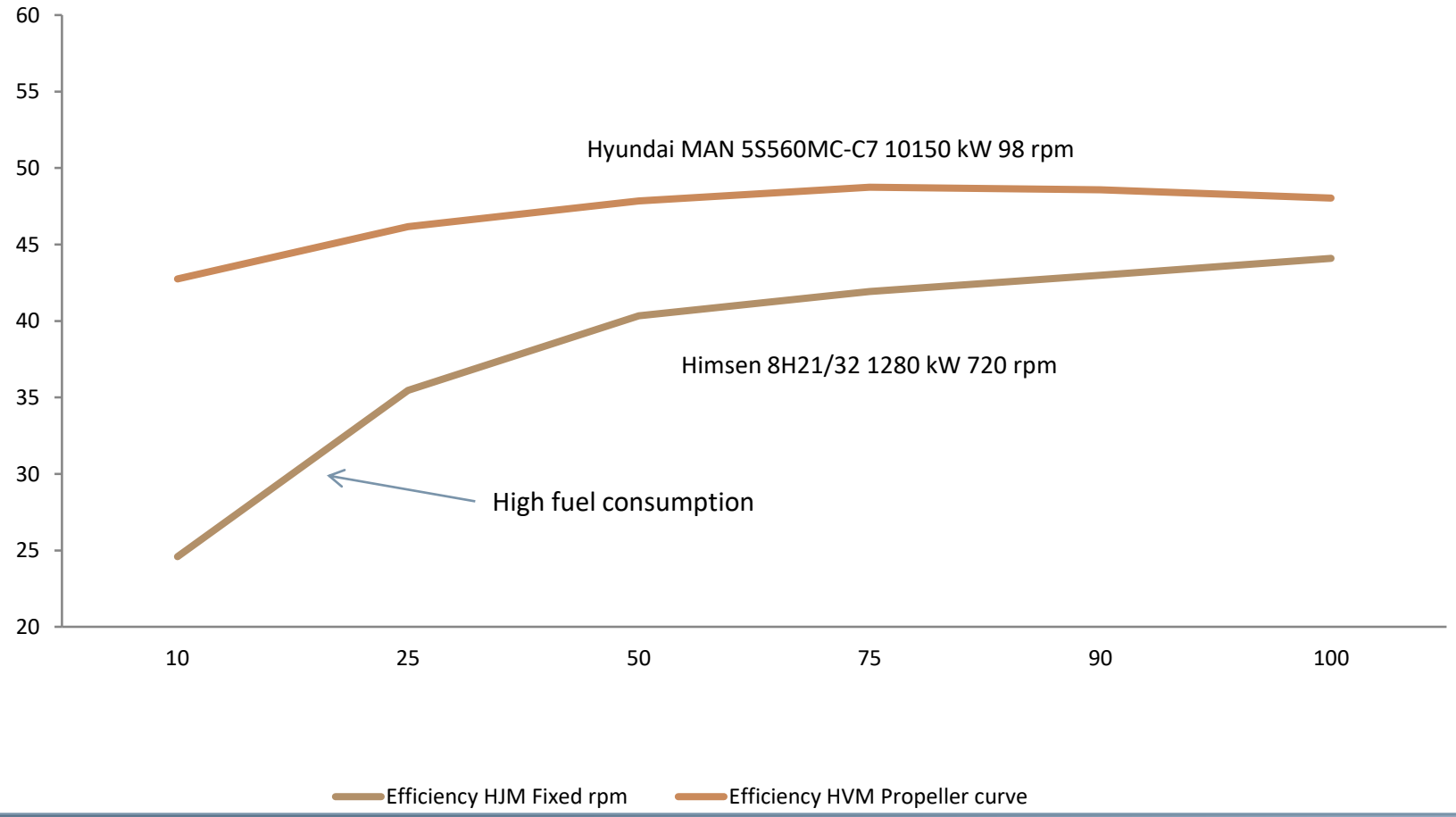
Other alternatives

- Batteries
- Hybrid solutions.
- Methanol/LPG/LNG
- Biofuels

Selected energy densities (Wikipeda)



Efficiency main engine & auxiliary engines

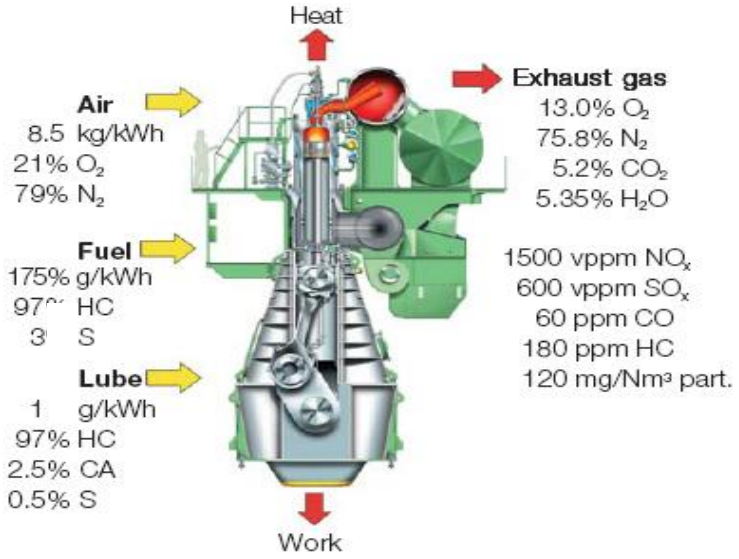


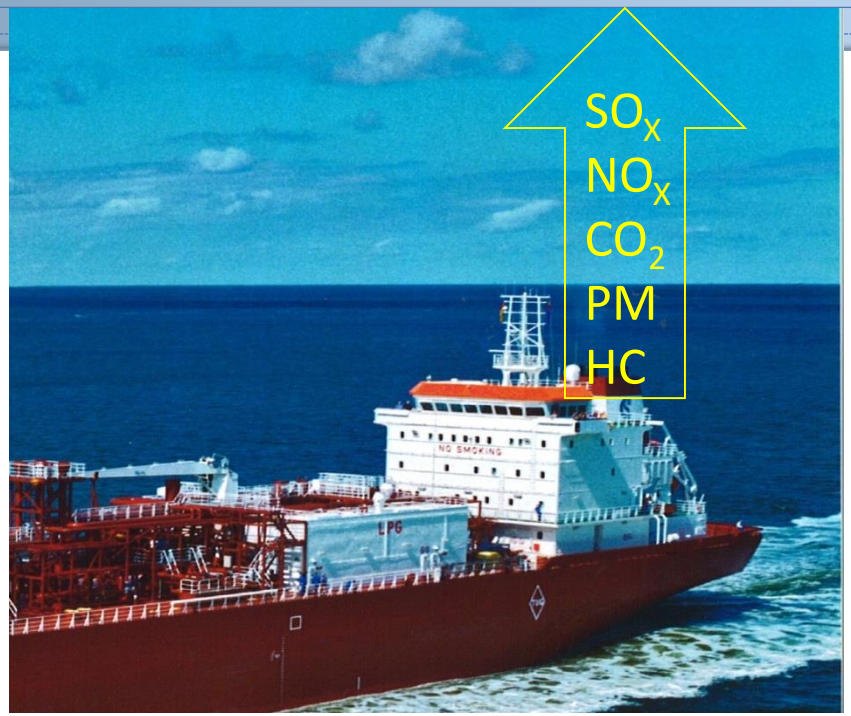
Solvang philosophy

- Design the vessel as fuel efficient and green as possible (Reasonable pay back time on investment)
  - Lower opex and reduced emissions → selling point.
- All technical solution/fuel's need to comply with the emission regulations, meaning that there is only marginally difference in the emissions.
- Finding the most cost effective and smart solutions.
- Energy efficiency from well to propel
- <u>The question is not which fuel you use, but how you use it.</u>

Emissions to AIR HFO/0,1%SMGO

- Power production

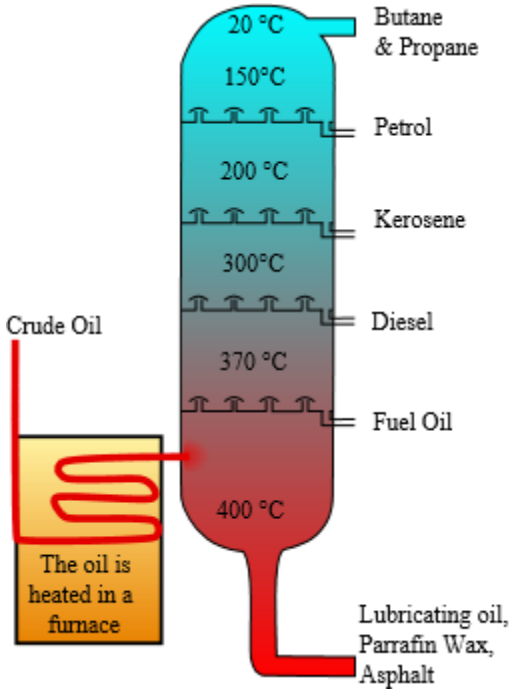




HFO 3%S/0,1 % S MGO gives

- 600/20 ppm Sox
- 120 > xx mg/Nm3

Wat is HFO/MGO



Energy loss through the chain

- Oil
  - Production (1- 5 ? %)
  - Refining Diesel oil (energy loss apr 8 %)
  - Refining Gasoline (energy loss apr 12 %)
  - Transport (energy loss apr 5 %)
  - Rest product HFO (Excellent fuel)
    - If this is going to be upgraded, apr 10-15 % energy loss
- Natural Gas
  - Production (0,1 – 3 %?)
  - LNG production (apr 10 %)
  - Transport (energy loss 5-10 % ?)

HFO as engine fuel

Positive

- Technically an excellent engine fuel
  - Safe and easy to handle
- High energy density
- Available all over the world
- low cost
- Residual fuel with few other alternative users

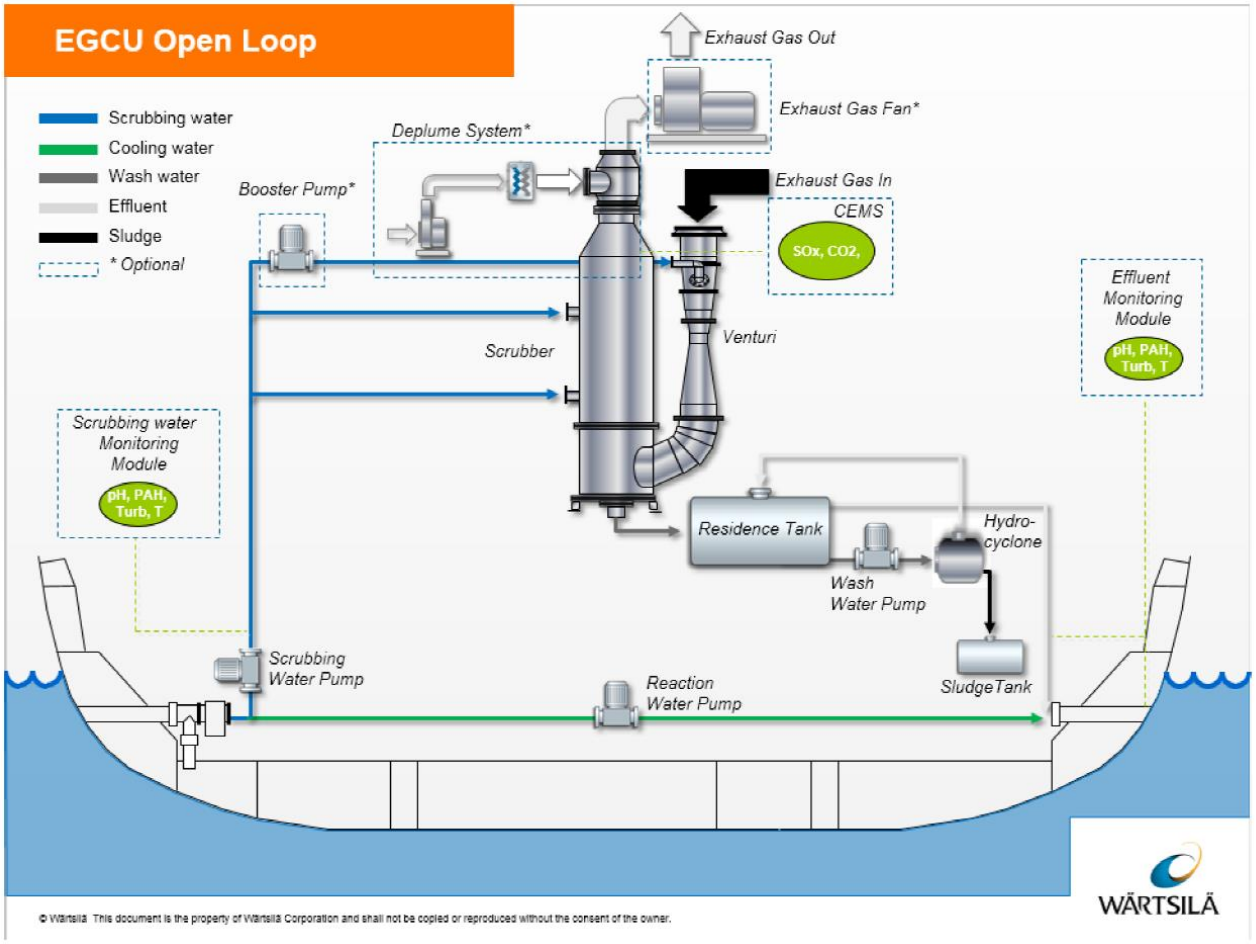
HFO as engine fuel (cont)

- Negative
  - Negative reputation (dirty fuel-not true anymore)
  - Imo Annex VI, Regulation 18
  - Contain high levels of sulphur
  - Contains traces of metals

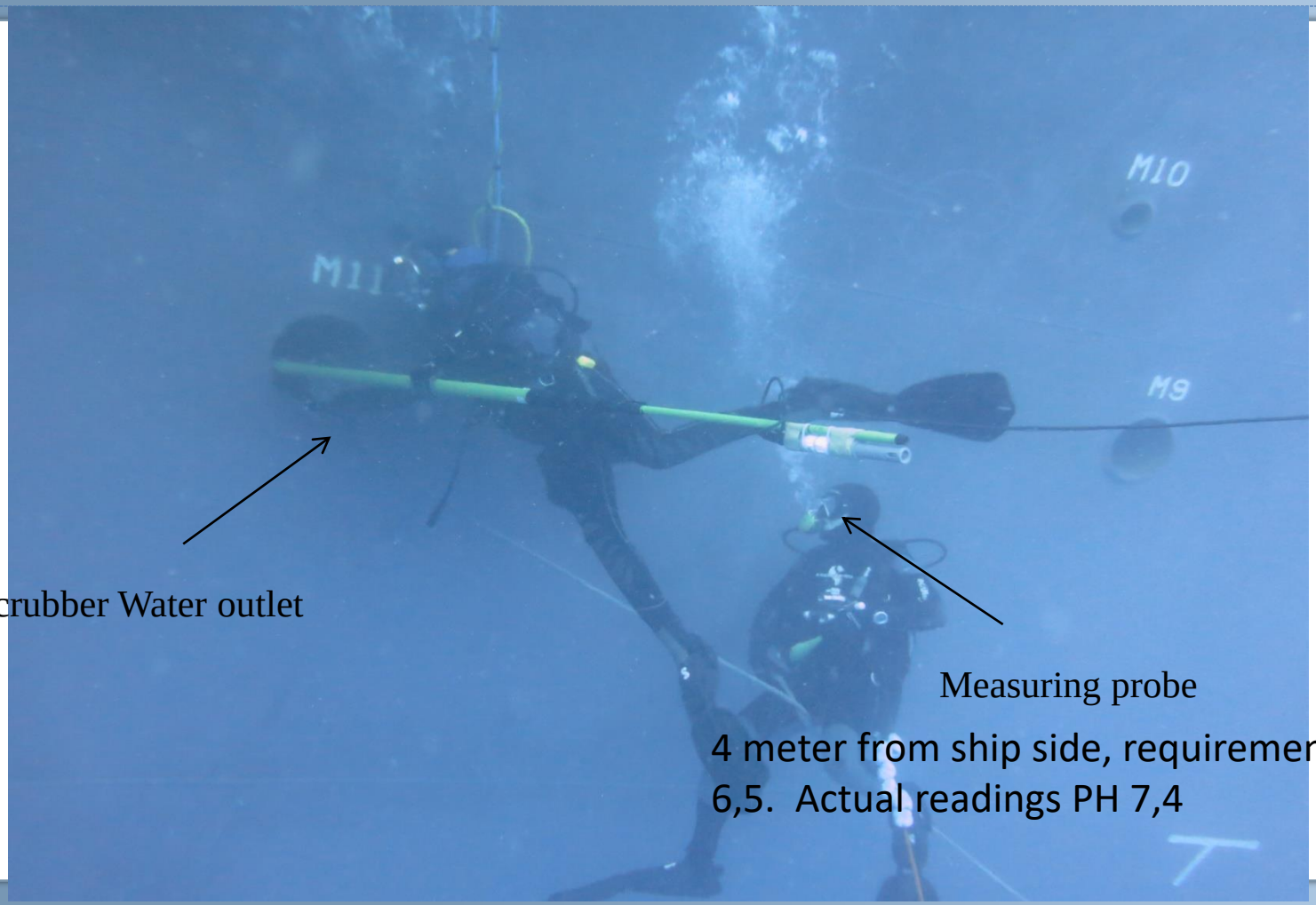
Exhaust gas cleaning an important tool to make shipping greener

- Open loop
- Open loop with water cleaning
- Hybrid
- Closed loop

Exhaust gas cleaning-Scrubber



Commissioning of Exhaust gas scrubber first vessel
Measurement of PH 4 meter from ship side.



Scrubber Water outlet

Measuring probe

4 meter from ship side, requirement PH > 6,5. Actual readings PH 7,4

NOx control

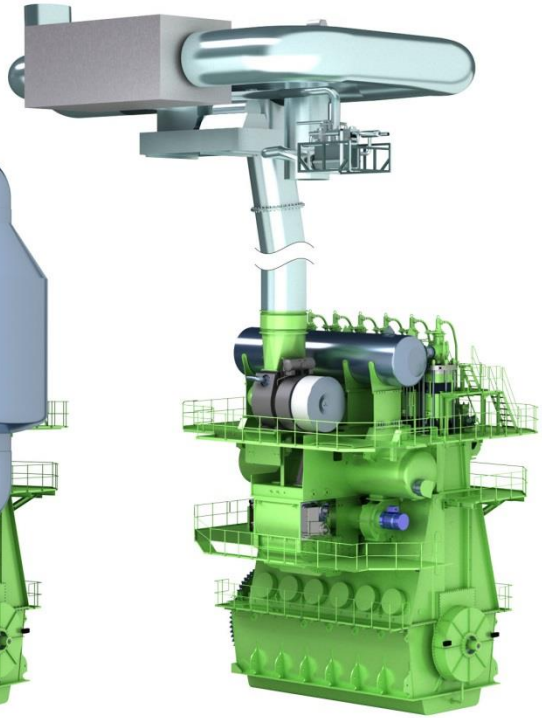
- Two main techniques
  - EGR
  - SCR

Tier III NO_x Control Technologies

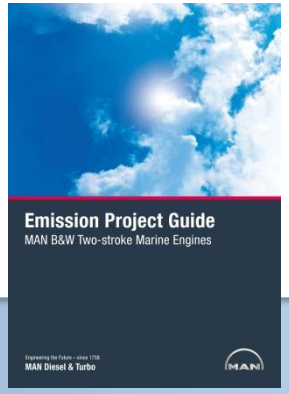
Tier III compliance for MAN B&W two-stroke engines

EGR
On-Engine

SCR
High-Pressure



SCR
Low-Pressure



Use of low-sulphur fuels is standard for all three technologies.
Optional version for HFO use for EGR and HP SCR.

Solvang Project LPG-EGR NOx Cleaning

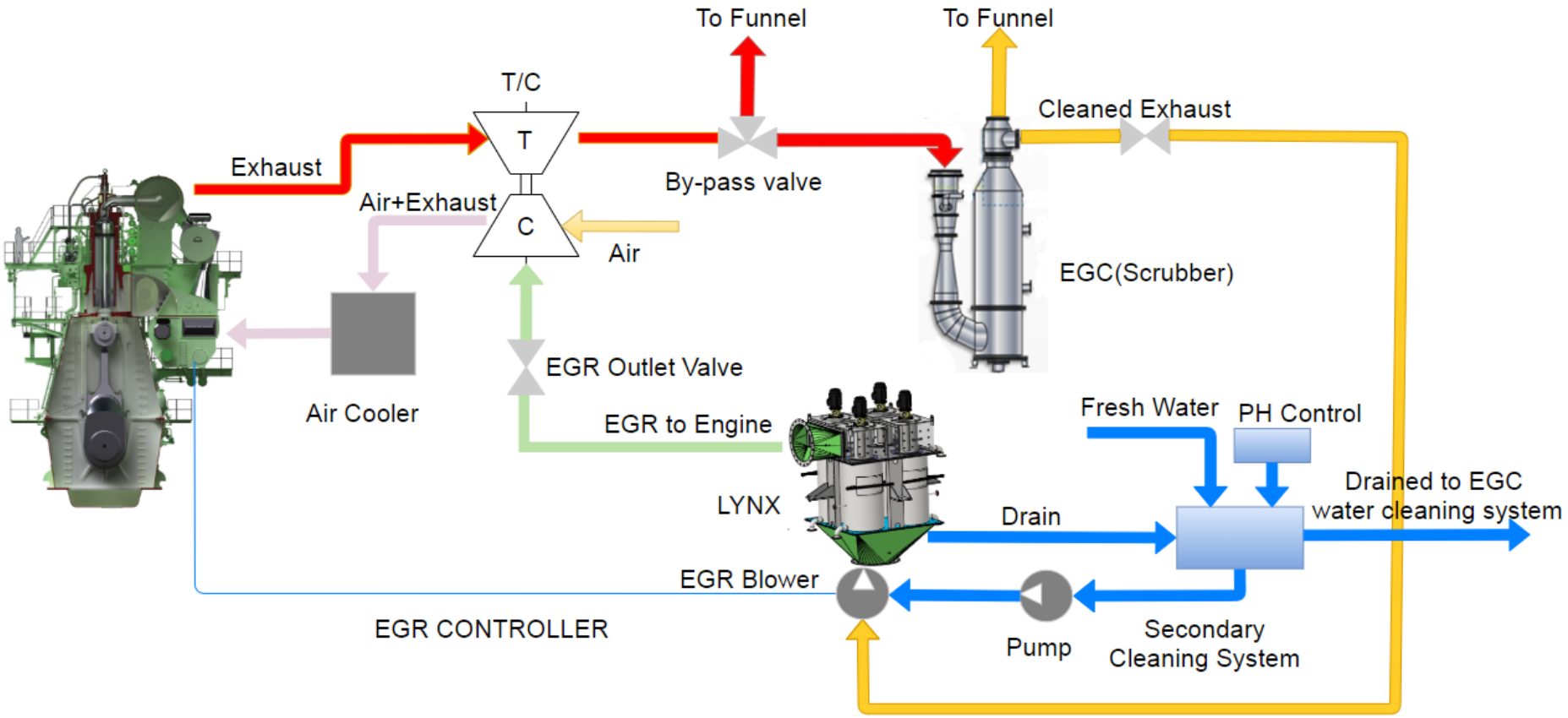
- To combine Exhaust gas cleaning system with Exhaust Gas Recirculation one would have a very simple and low cost NOx control system.

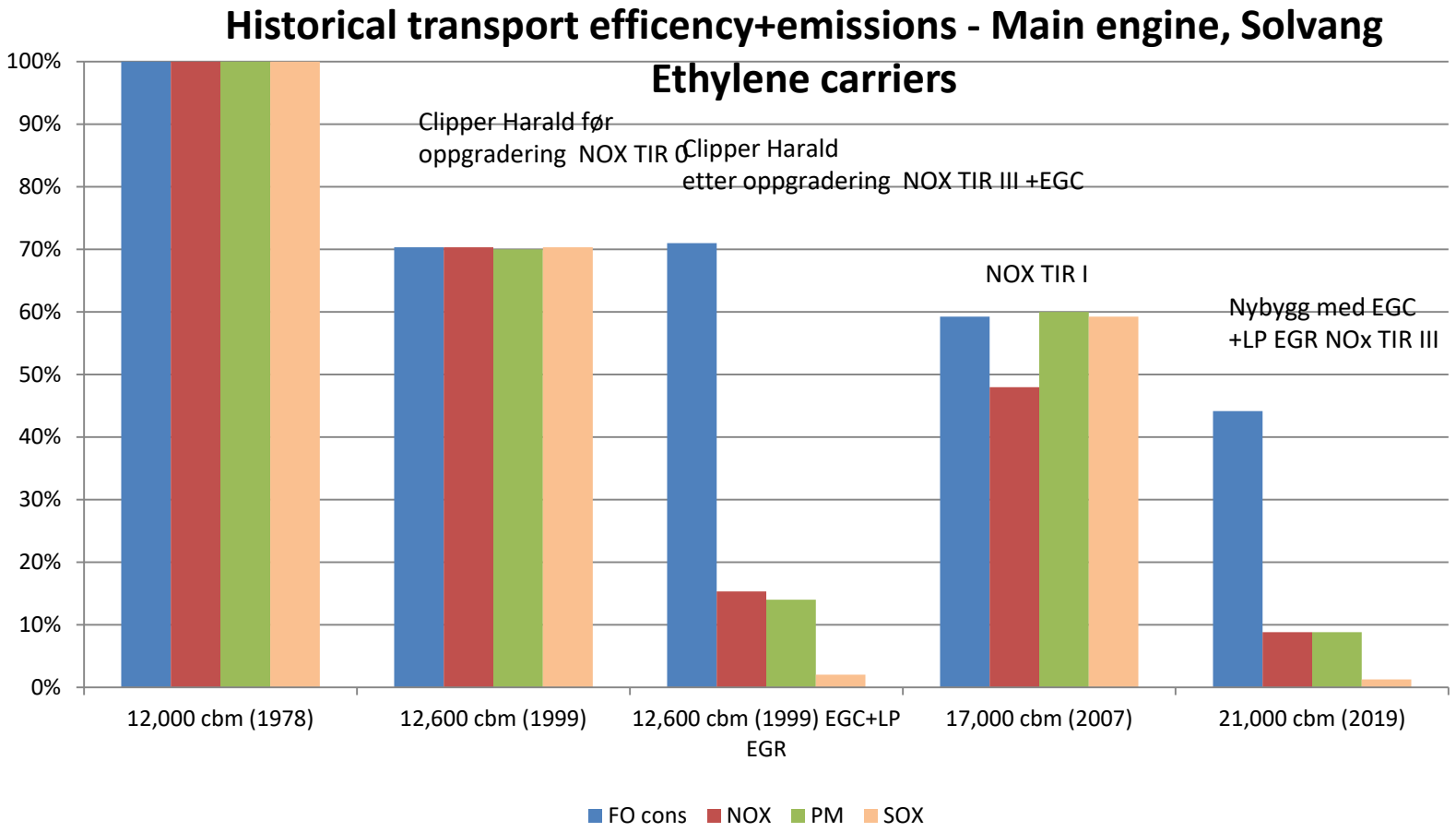
- Discussion with MAN and Wartsila 2011/2012
  - MAN has High Pressuren EGR and not resources for developing Low Pressure EGR.
  - But could act as a consult to Solvang

Clipper Harald EGC+EGR project

- Contract with retrofit of EGC on Clipper Harald end of 2013
- Clipper Harald (IAPP 12-12-2014)
  - Installation of EGR system Q2 2015 +
  - Modification Q4 2017

Solvang LP-EGR: Clipper Harald




Historical transport efficency+emissions - Main engine, Solvang
Ethylene carriers
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Clipper Harald før oppgradering NOX TIR C
Clipper Harald etter oppgradering NOX TIR III +EGC
NOX TIR I
Nybygg med EGC +LP EGR NOx TIR III
12,000 cbm (1978)
12,600 cbm (1999)
12,600 cbm (1999) EGC+LP EGR
17,000 cbm (2007)
21,000 cbm (2019)
FO cons
NOX
PM
SOX

Conclusion

- Advantages
  - Low opex cost for Nox and Sox reduction
  - The price difference of the fuel pay for the NOx and SOx cleaning,
  - No chemical needed and no Urea slip.
  - SOx cleaning >> 0,1%S fuel
- Disadvantages
  - Capex (but relatively short pay back time)
  - More equipment to maintain and operate
    - But not a big issue (5 year experience).
  - Apr 2 % increase in fuel consumption (removing the sulphure in oil refinery 10-15 %)

New possibilities

- Working with MAN to test TIR II operation with LP-EGR (Special interesting after 2020)
  - TIR II with LP – EGR has a potential to 3-4 % fuel savings compared to standard TIR II mode, meaning that a vessel equipped with EGC+LP-EGR will consume less fuel than a vessel running on MGO.
  - Solvang will in the end of 2019 have 6 vessel with EGC+LP-EGR

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Thank you for listening