GREEN SHIP OF THE FUTURE

Presentation from 9th annual Green Ship Technology Conference, Copenhagen 2012:

VESSEL EMISSION STUDY: COMPARISON OF VARIOUS ABATEMENT TECHNOLOGIES TO MEET EMISSION LEVELS FOR ECA's

Green Ship of the Future

'Green Ship of the Future' is a **Joint Industry Project** for innovation and demonstration of technologies and methods that makes shipping more environmental friendly.

With respect to airborne emission the aim of the project is to provide the necessary technologies and operational means to reduce emissions as follows (2007 level):
- 30 % reduction of CO_2 emissions
- 90 % reduction of NO_x emissions
- 90 % reduction of SO_x emissions

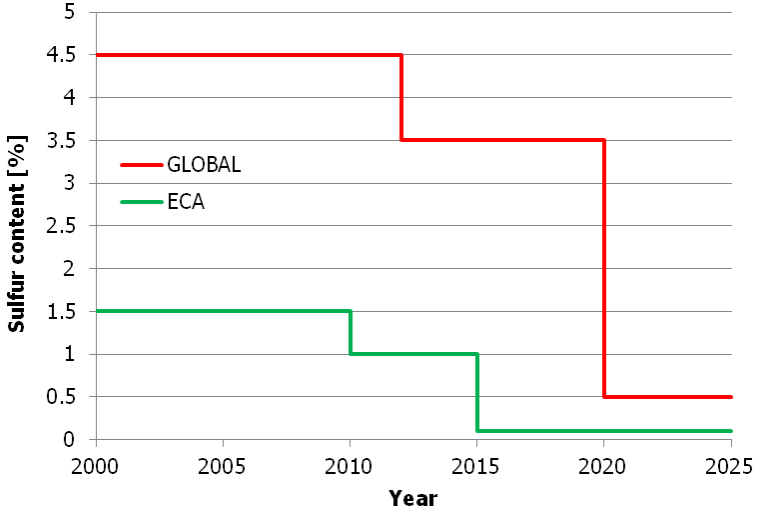
The focus was initially towards new buildings, but the focus has been increased on retrofitting existing ships.

At present 26 projects has been finalised or are still in progress.

The ”ECA RetroFit Technology” project

The purpose of the ”ECA RetroFit Technology” project is to compare different solutions/technologies to reduce SOx emissions in order to comply with the IMO SOx emission limits (<0.1% sulphur) enforced from 2015 in Emission Controlled Areas (ECA).

The global reduction limits of sulphur is included in the current form (<0.5% sulphur after 2020), but a scenario with <0.5% sulphur from 2025 is also included.



The ”ECA RetroFit Technology” project

Three different solutions/technologies are treated:

- Low sulphur fuel (MGO) – reference case
- Scrubber solution
- LNG as fuel

All cases are treated as a retrofit of an existing 38,500dwt tanker.

The project is partly funded by The Danish Maritime Fund

Partners

Partners in the project are:

- Alfa Laval Aalborg – Scrubber solution
- DS NORDEN – Data, drawings and operational issues
- MAN Diesel & Turbo – LNG retrofit of main engine and LNG system
- Lloyds Register – Review of solutions
- Maersk Maritime Technology – Financial evaluation and reporting
- Schmidt Maritime – Technical preparation of designs
- Elland Engineering – Technical preparation of designs
- GSF secretary – Project management, coordination and reporting

NORD BUTTERFLY

Main Particulars

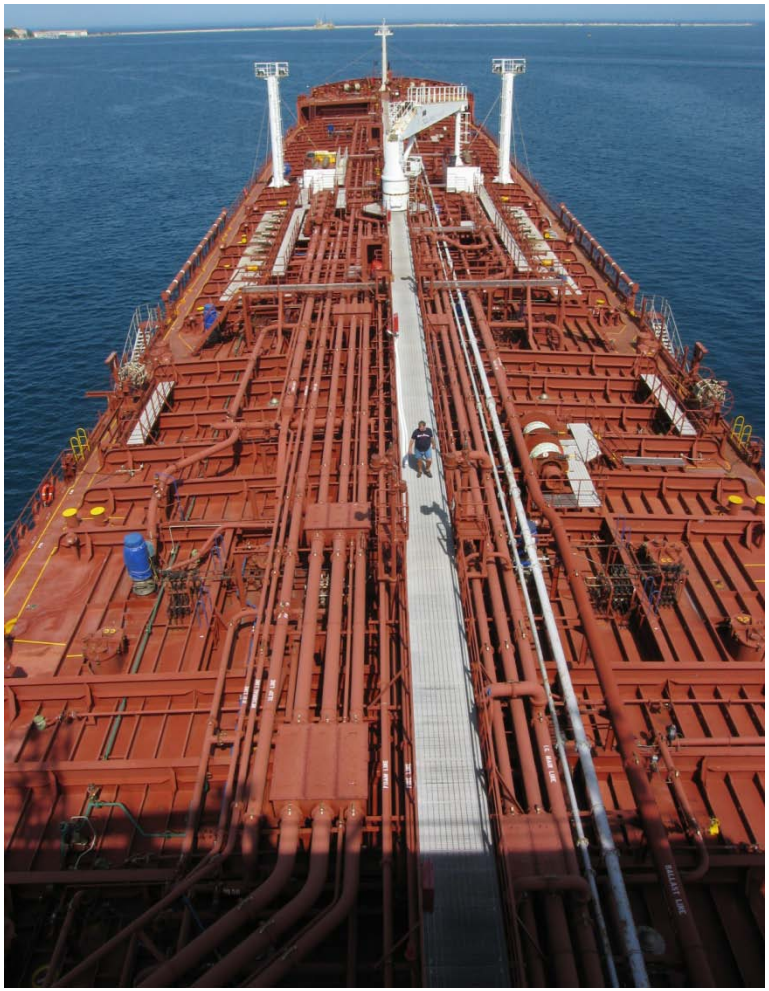
Length over all:	182.86 m
Length PP:	174.50 m
Breadth:	27.40 m
Depth:	16.80 m
Draft:	
Design:	9.55 m
Summer:	11.60 m
Deadweight:	
Design D:	29,000 t
Summer D:	38,500 t

Main Engine: MAN B&W 6S50MC-C

Power: MCR 9480kW @ 127 rpm

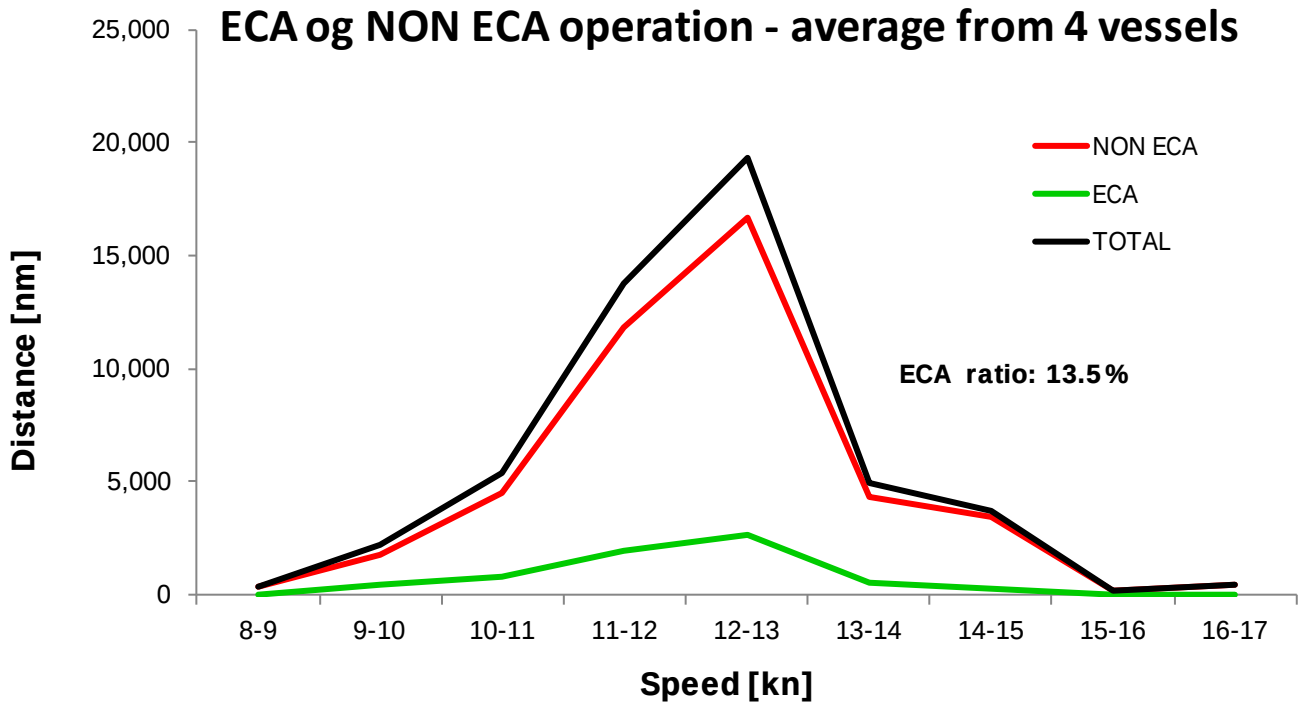
CSR 8058kW @ 120 rpm

Service speed at CSR: 15.2 knots



Operation Profile

Average ECA operation: 13.5%
Maximum 17% ECA operation for one vessel.



Switch to low sulphur fuel (MGO)

The reference case for the study is a fuel switch to MGO.

The fuel switch to MGO only require small modifications:

- Installation of fuel cooling system to increase the viscosity of the MGO
- Extra attention should be paid to the lubrication of the engine

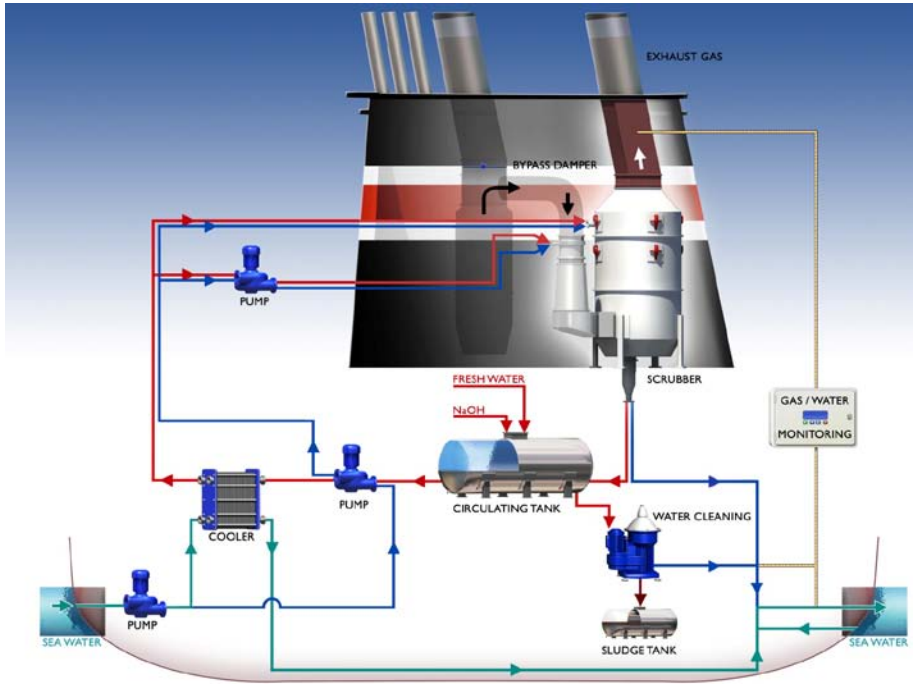
Scrubber solution

Alfa Laval Aalborg has designed a scrubber solution like the one used on Ficaria Seaways.

The scrubber is a hybrid scrubber and works both in open and closed loop and uses water (seawater or freshwater) to wash out the sulphur from the exhaust. Heavy fuel oil can then still be used in ECA's after 2015 since the scrubber reduces the SOx emission to less than 0.1%.

The scrubber works both on the main engine and auxiliary engine.

Scrubber solution



- Scrubber designed for an alkalinity of 1300 microMol/L, => NORD BUTTERFLY can operate as high as Rauma in the Baltic
- This gives a 10-25% increase of scrubber size and means that there is a potential cost saving if the vessel does not operate in low alkalinity areas
- The amount of sludge from the scrubber water cleaning system will amount to 2.5 liters/MWh engine output ~ 370 liters/day

  (20% solid and 80% water).

Scrubber Solution Conversion

The conversion to the scrubber solution require some larger changes most importantly:

- New funnel layout
- Scrubber
- Installation of Scrubber Auxiliary Machinery and Pipe Connections
- Installation of new tanks
- Steel Work

Scrubber Solution
CAPEX

3 shipyards (1 Danish, 1 German and 1 Chinese) have been ask to submit a tender for the rebuilt and the prices were remarkable identical.

Scrubber machinery and equipment	2,600,000 USD
Steel (150t) / pipe / electrical installation and modification	2,400,000 USD
Design and classification cost	500,000 USD
Off-Hire (20 days @ rate 17.000 USD/day)	340,000 USD
TOTAL	5,840,000 USD

Scrubber – Review Conclusion

- **MARPOL requirements**: Resolution MEPC.184(59)
  Scheme A & B, Washwater

- **Class requirements**: Safety & installation on board

- **Observations**:
  Redundancy, Chemicals, Multiengine inlet scrubber

- **Scrubber is one possible solution**

LNG technology and solution

Operating a ship on LNG is no new technology. Today especially LNG tankers use the boil-off from the LNG tanks as fuel.

The technology exist, but to get an existing ship to use LNG as fuel require a retrofit of the main engine and the fuel system should be present onboard.

MAN Diesel & Turbo have in the project worked on retrofitting the main engine – MAN B&W 6S50MC-C (9,480kW).

The main engine should be:

- converted to a ME-type engine (electronic fuel injection)
- converted to ME-GI dual fuel engine.

The auxiliary engines will still run on HFO/MGO depended on operation area.

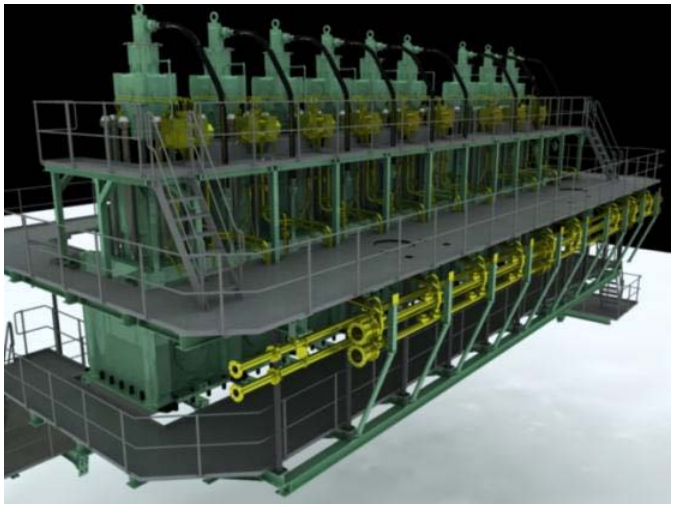
LNG Solution - Conversion

The conversion to LNG as fuel require some larger changes most importantly:

- Main Engine Conversion of MC-C to ME-GI
- LNG / Inert Gas System
- Auxiliary Systems

- LNG Storage Tanks (2 x 350m3)
- Fuel Supply Systems

- Removal of Existing Piping and Equipment
- Tank Foundations
- Deck Houses and Foundations



LNG Solution
CAPEX

LNG machinery, tanks and equipment, main engine conversion	4,380,000 USD
Steel (300t)	2,000,000 USD
Design and classification cost	500,000 USD
Off-Hire (40 days @ rate 17.000 USD/day)	680,000 USD
TOTAL	7,560,000 USD

The MC to ME conversion has increased CAPEX by 800,000 USD.

The price difference between the scrubber and LNG solution is 1,720,000 USD.

LNG as Fuel – Review Conclusion

- **Conclusion of the ”Conceptual Design Review”**
  - More detailed design and documentation work to be carried out
  - Risk assessment to be conducted
  - The project is feasible from a regulative point of view
  - **No show stoppers!**

Financial evaluation

The Scrubber and LNG alternatives are evaluated on the basis of investment costs (CAPEX) and operational costs (OPEX).

NPV and payback period are calculated for a 10-year period (2015-2024) assuming an interest rate of 9%.

Results are presented as a function of spread in fuel cost and percentage of operation inside ECA's. The financial results are based on the cost differences between the Scrubber (with HFO) and LNG alternatives and the 'do nothing' scenario of simply shifting to MGO.

Fuel scenarios for the alternatives

If the global sulfur cap is applicable as of 2020, then the operational fuel scenarios are as shown below:

Base scenario: MGO	2015 - 2019		2020 - 2024	
	Non ECA	ECA	Non ECA	ECA
Consumption at sea (ME)	HFO	MGO	MGO	MGO
Consumption at sea (AE)	HFO	MGO	MGO	MGO
Consumption at port, idling (AE's)	HFO	MGO	MGO	MGO
Consumption at port, unloading (AE's)	HFO	MGO	MGO	MGO

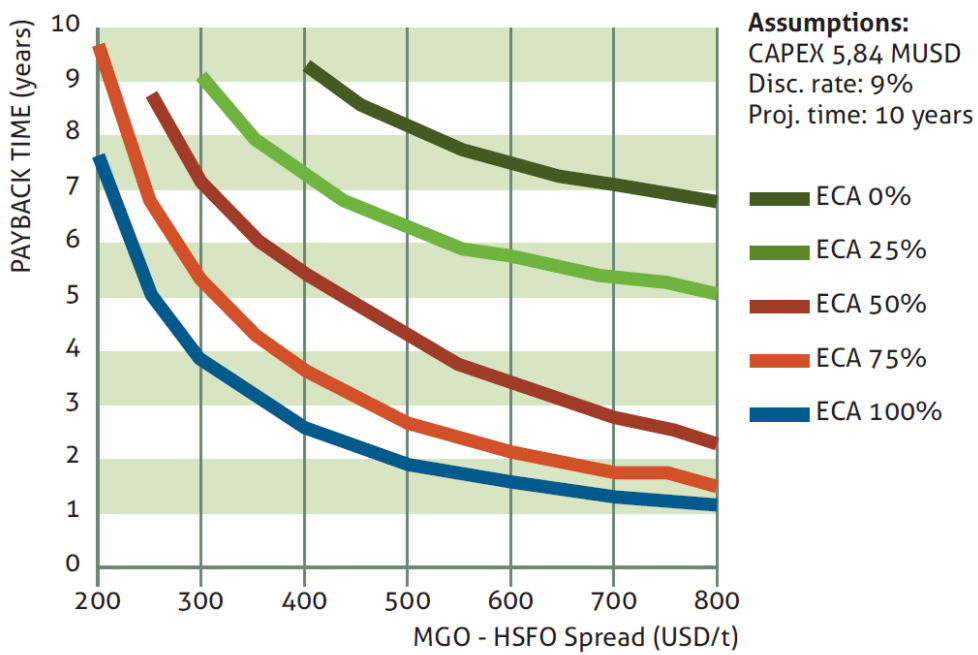
Alternative 1: Scrubber operation	2015 - 2019		2020 - 2024	
	Non ECA	ECA	Non ECA	ECA
Consumption at sea (ME)	HFO	HFO	HFO	HFO
Consumption at sea (AE)	HFO	HFO	HFO	HFO
Consumption at port, idling (AE's)	HFO	HFO	HFO	HFO
Consumption at port, unloading (AE's)	HFO	HFO	HFO	HFO

Alternative 2: LNG operation	2015 - 2019		2020 - 2024	
	Non ECA	ECA	Non ECA	ECA
Consumption at sea (ME)	HFO*	LNG	LNG	LNG
Consumption at sea (AE)	HFO	MGO	MGO	MGO
Consumption at harbour, idling (AE)	HFO	MGO	MGO	MGO
Consumption at harbour, unloading (AE)	HFO	MGO	MGO	MGO

Scrubber

Global sulphur cap in 2020

Payback time - Scrubber vs MGO Scenario



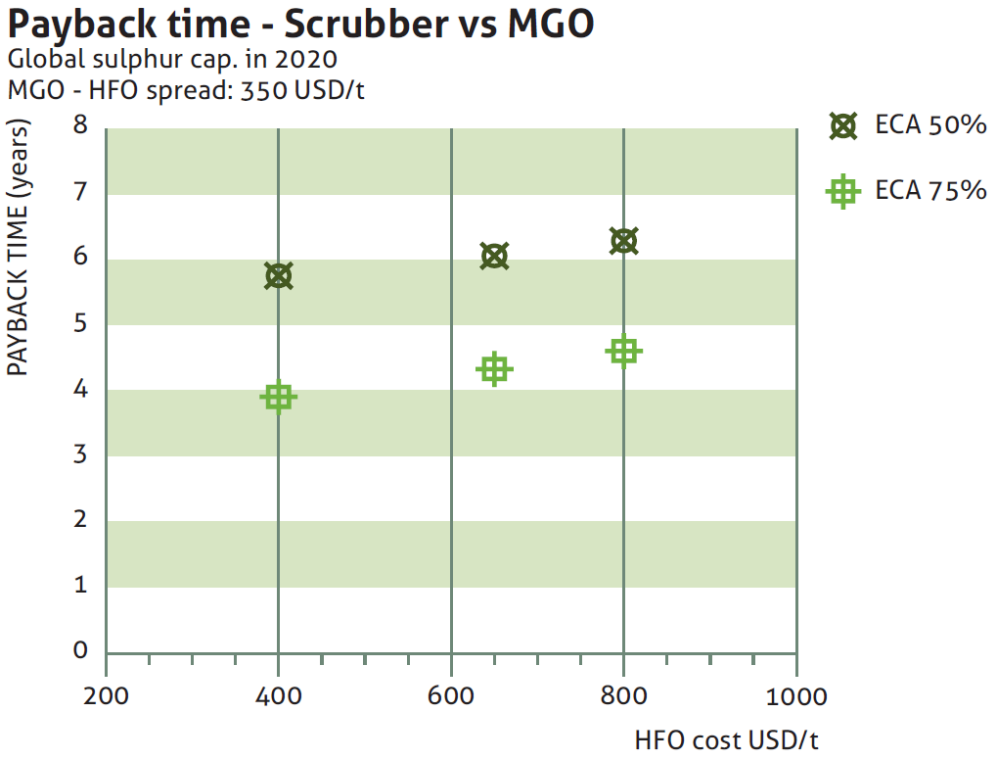
Assumption: HFO cost is 650 USD/t

Assuming a spread of 350 USD/t between MGO and HFO the PBP is around 3 years at 100% ECA operation.

At 50% ECA operation: PBP is approx 6 years. If a 3 year PBP is desired, then the MGO-HFO spread would have to be 650 USD/t.

For NORD BUTTERFLY with 13% ECA operation the PBP is approx. 9 years with a spread of 350 USD/t between MGO and HFO.

Scrubber – Payback time as a function of HFO cost



The payback period is not very sensitive to absolute level of HFO cost

- PBP increase with approx 0.5 years if HFO cost increases with 250 USD/t

With a global sulphur cap applicable as of 2025 the PBP tends to increase compared with the 2020 case

- For 50% ECA operation the PBP will increase by 1.5 years and the sensitivity to HFO cost becomes more pronounced.

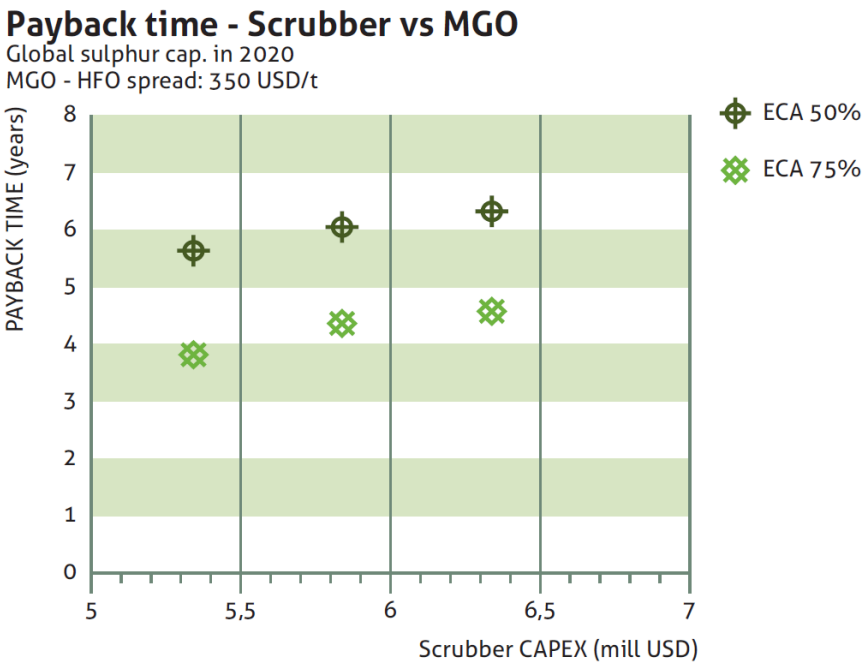
Scrubber – Influence of CAPEX

Sensitivity of PBP to variation in CAPEX by ±500,000 USD assuming MGO-HFO spread of 350 USD/t.

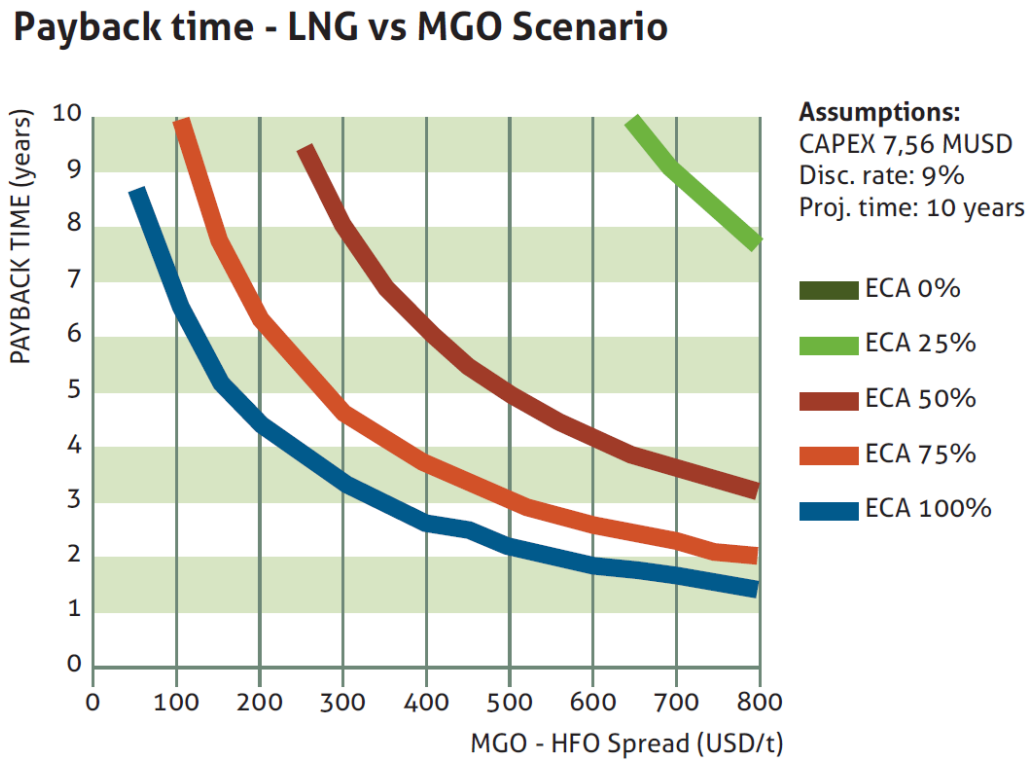
An increase of 500,000 USD results in increase of PBP by around 0.5 years.

For comparison a change of 100 USD/t in MGO-HFO spread (300 USD/t->400 USD/t) would cause a decrease of 1.5 years in PBP for 50% and 75% ECA operation.

Hence the cost difference MGO-HFO has the most dominant influence on payback period.



LNG solution –
LNG used only inside ECA



Assumption: HFO cost is 650 USD/t, LNG cost is 550 USD/t

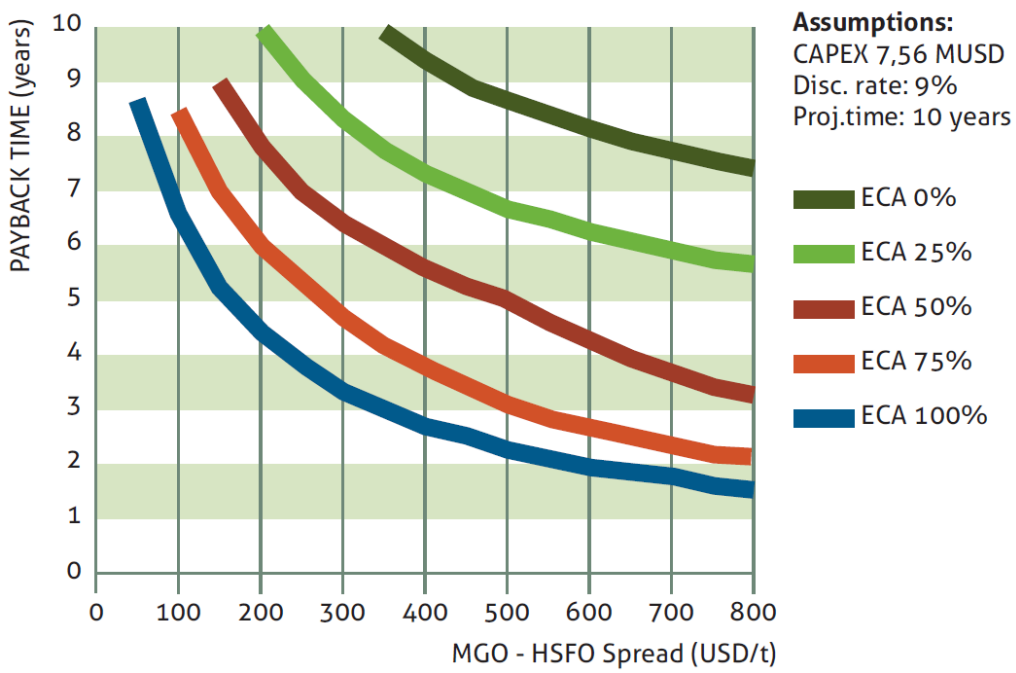
For a spread of 350 USD/t between MGO and HFO the PBP is around 3 years for 100% ECA operation.

At 50% ECA operation: PBP is approx. 7 years. If a 5 year PBP is desired, then the MGO-HFO spread would have to be 500 USD/t.

For NORD BUTTERFLY with 13% ECA operation the PBP would exceed 10 years.

LNG solution –
LNG used inside and outside ECA

Payback time - LNG vs MGO Scenario



Assumption: **LNG used inside and outside ECA after 2020**
HFO cost is 650 USD/t, LNG cost is 550 USD/t

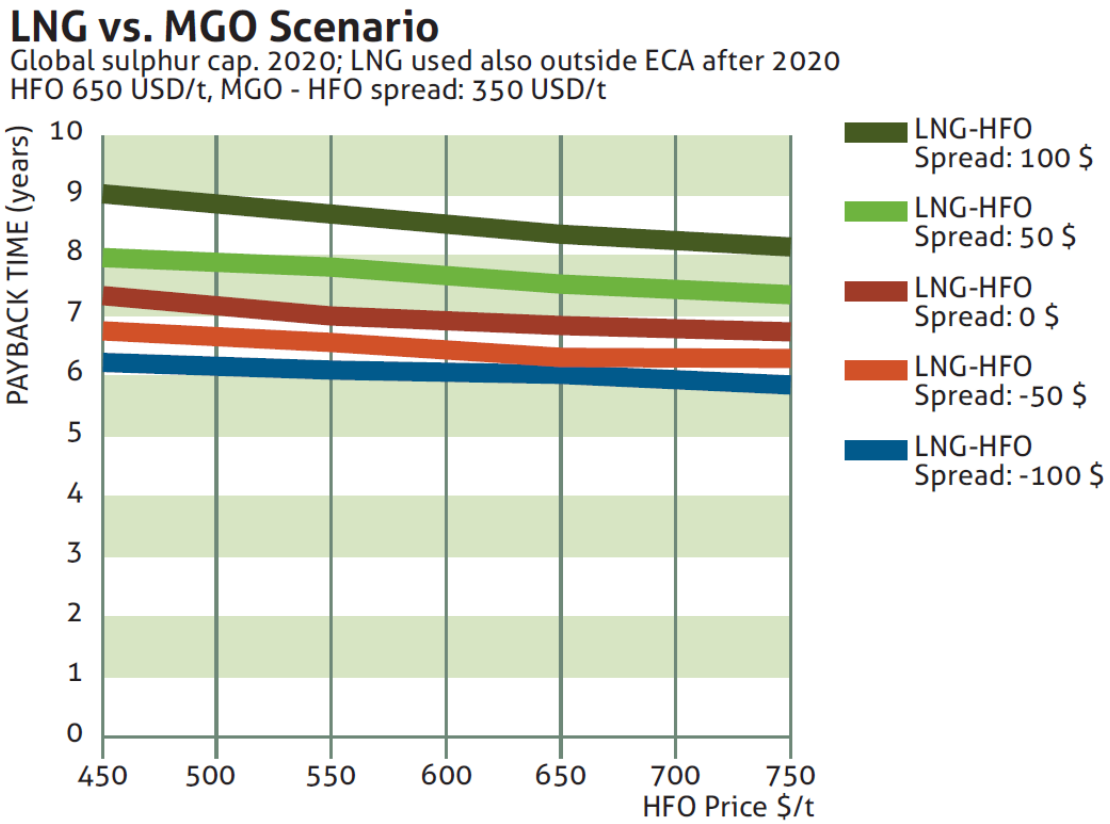
For a spread of 350 USD/t between MGO and HFO the PBP is around 3 years for 100% ECA operation.

For 50% ECA operation and 350 USD/t spread between MGO and HFO: PBP is approx. 6 years.

For NORD BUTTERFLY with 13% ECA operation PBP would be approx. 9 years with 350 USD/t spread between MGO and HFO.

LNG solution – Payback period as a function of LNG-HFO spread

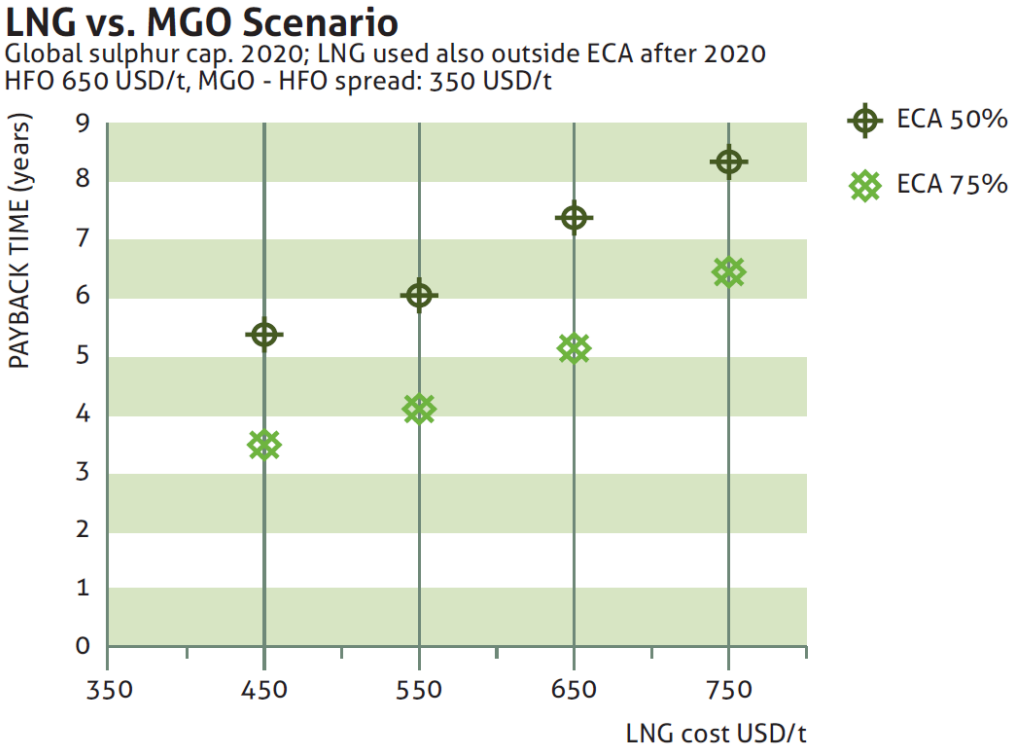
High sensitivity to the LNG-HFO price spread increasing the payback period by 0.5-1 years by changing the LNG-HFO spread by 50 USD/t.



LNG solution – Sensitivity to fuel cost

LNG cost has been varied assuming a fixed HFO cost and spread with MGO:

- If LNG cost is half of MGO (i.e. 500 USD/t) PBP is around 4 years at 75% ECA operation
- If LNG cost would be same as MGO (1,000 USD/t) the payback period will be around 10 year at 75% ECA operation.



Conclusion

- It is possible to reduce or remove SOx emissions by converting an existing tanker.
- For the existing vessel with an average ECA operation of 13% it will be most favourable to make a fuel switch to MGO when entering an ECA.
- Scrubber solution
  - It works on both main and auxiliary engine.
  - For ECA operation above 50% doubling the MGO-HFO spread halve the Payback Period (PBP).
  - The PBP is primarily sensitive to the spread between MGO-HFO. CAPEX and absolute fuel price has less influence.
  - With a cost spread of 350USD/t between MGO-HFO a PBP of 3 years is obtained for 100% ECA operation. At 50% ECA operation PBP is 6 years.
  - A lower PBP could be obtained for ships with large engines as the cost for the scrubber installation is relatively lower.
  - If the global sulphur cap is first applied from 2025, the PBP will increase about 1.5 years

Conclusion

- LNG solution
  - Is more expensive than the scrubber solution (1,720,000USD).
  - If LNG is only used in ECA long PBP are obtained (except for 100% ECA).
  - If LNG is also used outside ECA a PBP of about 6 years is obtained for 50% ECA operation and a MGO-HFO spread of 350 USD/t. For 100% ECA operation PBP is about 3 years.
  - PBP is primarily sensitive to the spread between MGO and HFO, but the absolute LNG price and LNG-HFO spread are also important.
  - Can be more attractive if the tanker originally was fitted with a ME-engine (CAPEX reduced by 800,000USD) and even more interesting if it is include at a new building.

- Future work
  - Investigation of an DME alternative solution in cooperation with Haldor Topsoe

Thanks for your attention.

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