ALTERNATIVE FUELS AND LNG-FUELLED VESSELS

Maritime LNG training
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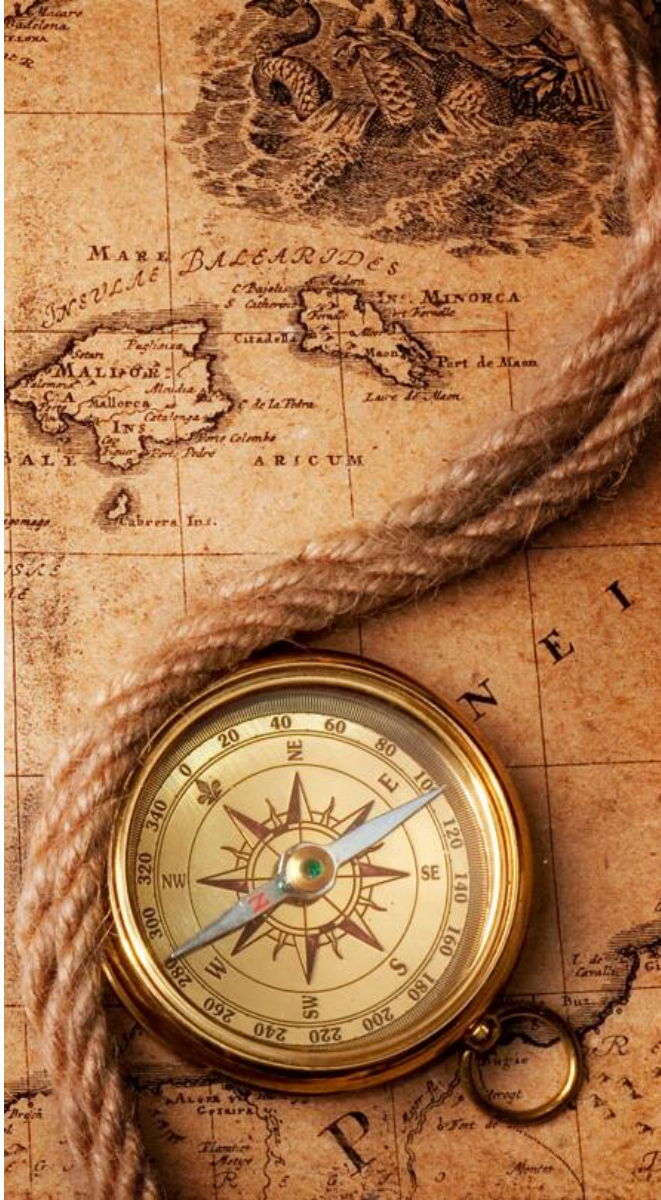
Dr. Elif Bal Besikci
ebb@wmu.se
bale@itu.edu.tr



- Background:
  - PhD, Maritime Transportation Engineering, Istanbul Technical University
  - Oceangoing Chief Officer
- Current Status:
  - Technical Officer OpenRisk Project
  - Assistant Professor Istanbul Technical University
- Research Areas:
  - Maritime safety and transportation
  - Risk, Safety & Reliability Assessments
  - Human factor at sea
  - Maritime energy management and energy efficiency

Background

- CO_2 emissions generated by maritime transport represent a significant part of total global greenhouse gas (GHG) emissions.
- Ships emitted 1046 million tonnes of CO_2 in the year 2007 which make up approximately 3.3% of global emissions.

Background


IF NO ACTION IS TAKEN,
IT IS ASSUMED THAT THE EMISSIONS FROM SHIPPING WILL INCREASE BY 150% –250% UNTIL 2050
EMISSIONS
2007
2050

The International Legal Regimes Governing Ship-Source Exhaust Emissions

The MARPOL Convention

- In 2008 amendments to Annex VI were made, and they became legally effective from 2012.

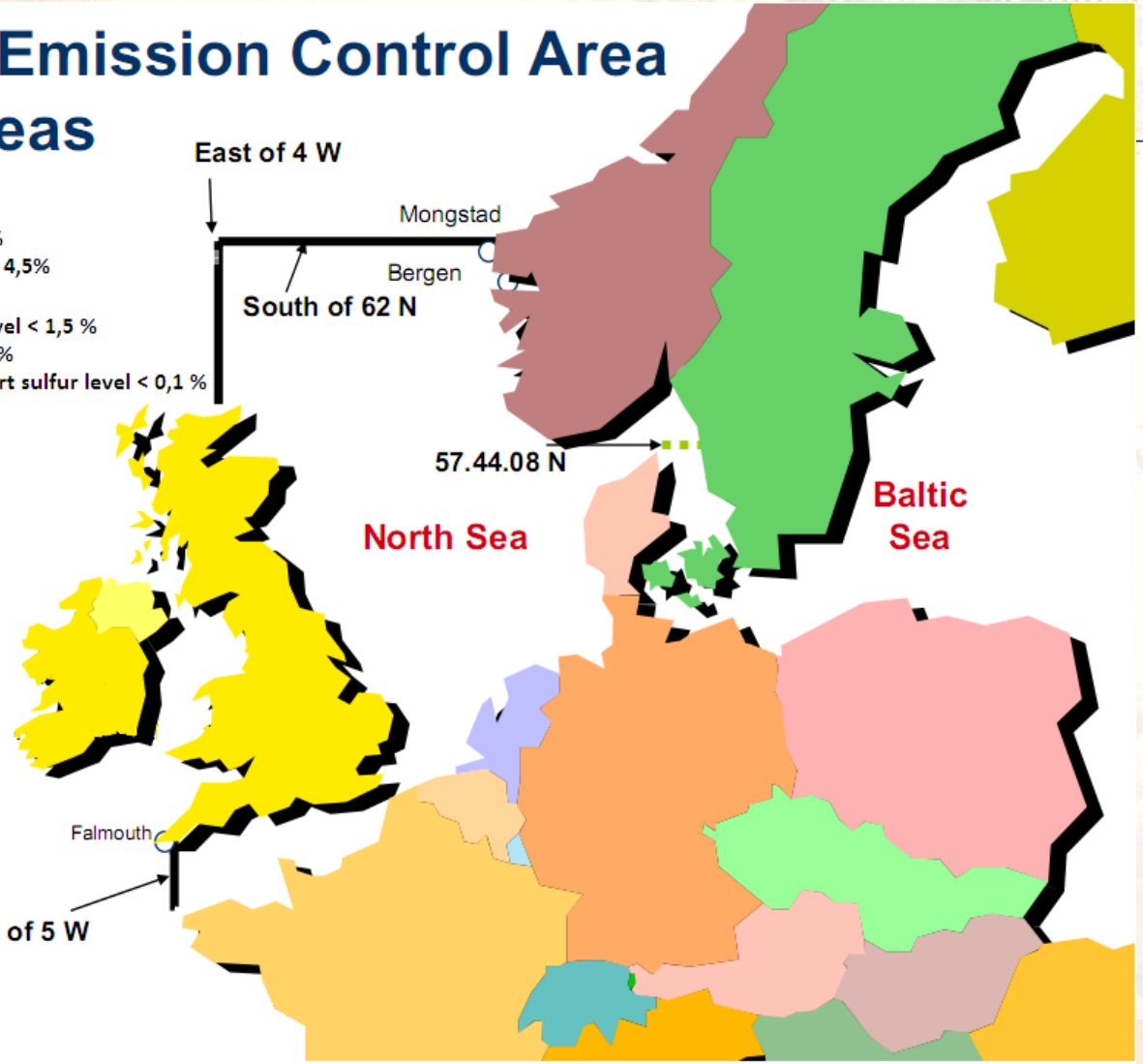
Summary of sulfur content in Regulation 14 to Annex VI

Maximum permissible amount of sulfur content of fuel oil used on board ships in areas outside Emission Control Areas	4.50% m/m prior to 1 January 2012	3.50% m/m on and after 1 January 2012	0.50% m/m on and after 1 January 2020[a]
Maximum permissible amount of sulfur content of fuel oil used on board ships within Emission Control Areas	1.50% m/m prior to 1 July 2010	1.00% m/m on and after 1 July 2010	0.10% m/m on and after 1 January 2015

[a]This reduction is subject to a feasibility review that is to be completed no later than 2018. Depending on fuel supply, the limit of 0.50% may be introduced by the year 2025 at the latest.

Sulphur Emission Control Area
SECA areas

IMO:
SECA - sulfur level < 1,5 %
Otherwise - sulfur level < 4,5%
EU:
Passengerships -sulfur level < 1,5 %
Gasoil - sulfur level < 0,1 %
Inland waterway & at port sulfur level < 0,1 %

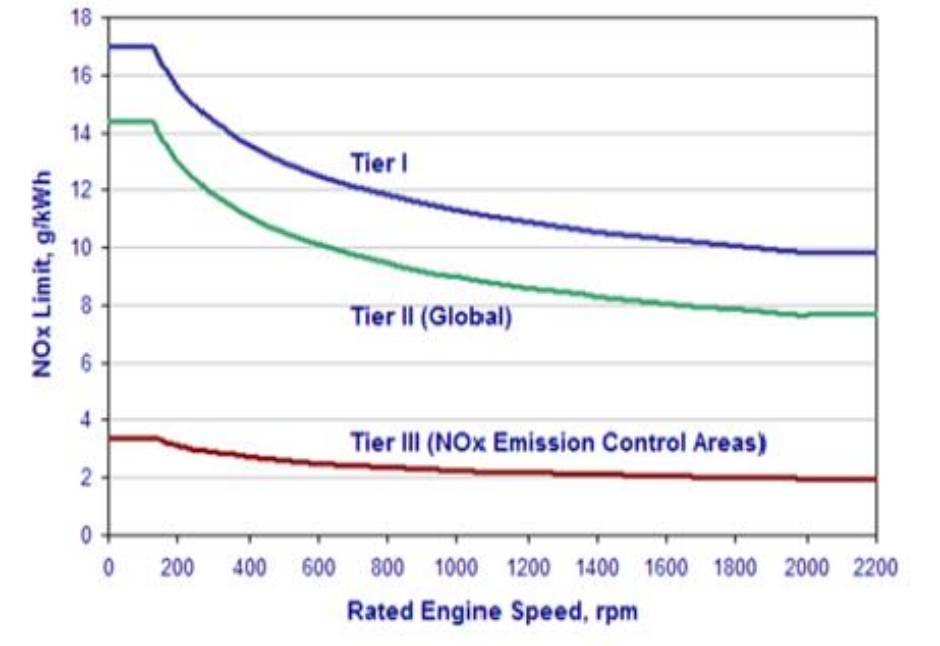


MARPOL 73/78 Annex VI

Tier	Date	Nox Limit, g/kWh		
		n < 130	$130 \leq n < n^{-0,2}$	$n \geq 2000$
Tier I	2000	17	$45 \cdot n^{-0,2}$	9,8
Tier II	2011	14,4	$44 \cdot n^{-0,23}$	7,7
Tier III	2016ǂ	3,4	$9 \cdot n^{-0,2}$	1,96

ǂ In NO_x Emission Control Areas (Tier II standards apply outside ECAs).

Note: n is an engine specific parameter



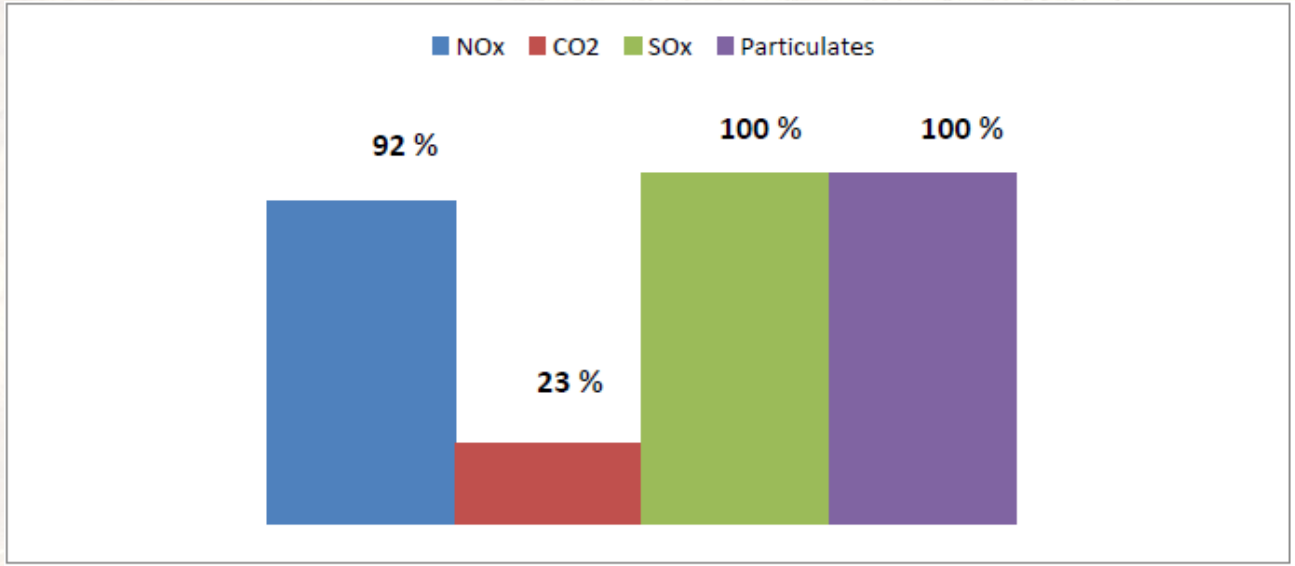
MARPOL 73/78 Annex VI

- In addition, IMO's Marine Environment Protection Committee (MEPC) adopted the addition of new regulations related energy efficiency of ships to MARPOL (International Convention for the Prevention of Pollution from Ships) Annex VI, as a new chapter (Chapter 4). Through this, since 1st of January 2013;

  - ❑EEDI (all new ships)
  - ❑SEEMP (all ships)

LNG Fuelled Vessel

- The use of LNG allows for a significant reduction of NOx, SOx, and also CO2. In particular, the use of LNG compared to the use of HFO, leads to the following emission advantages (Smith, 2010).
  - ❑NOx emissions are reduced by approximately 80-85% thanks to the lean burn combustion process implemented in dual fuel internal combustion engines;
  - ❑SOx emissions are almost completely eliminated as LNG does not contain sulphur;
  - ❑particle matter production is very low;
  - ❑CO2 emissions are reduced by 20-30% due to higher hydrogen content in molecules in comparison with HFO/MDO.



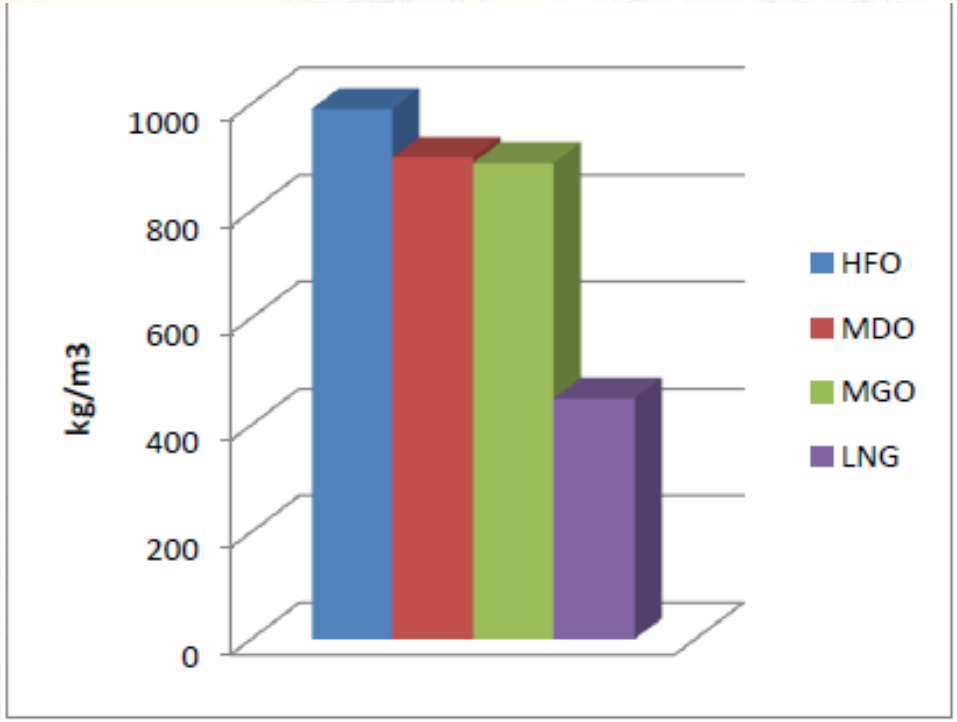
Emission reduction of medium ships with gas engine (Nogva 2008)

Feasibility of LNG as a transport fuel

- In addition to environmental regulations driving this technology, aspects of LNG as a transport fuel in the maritime sector can be split into three:

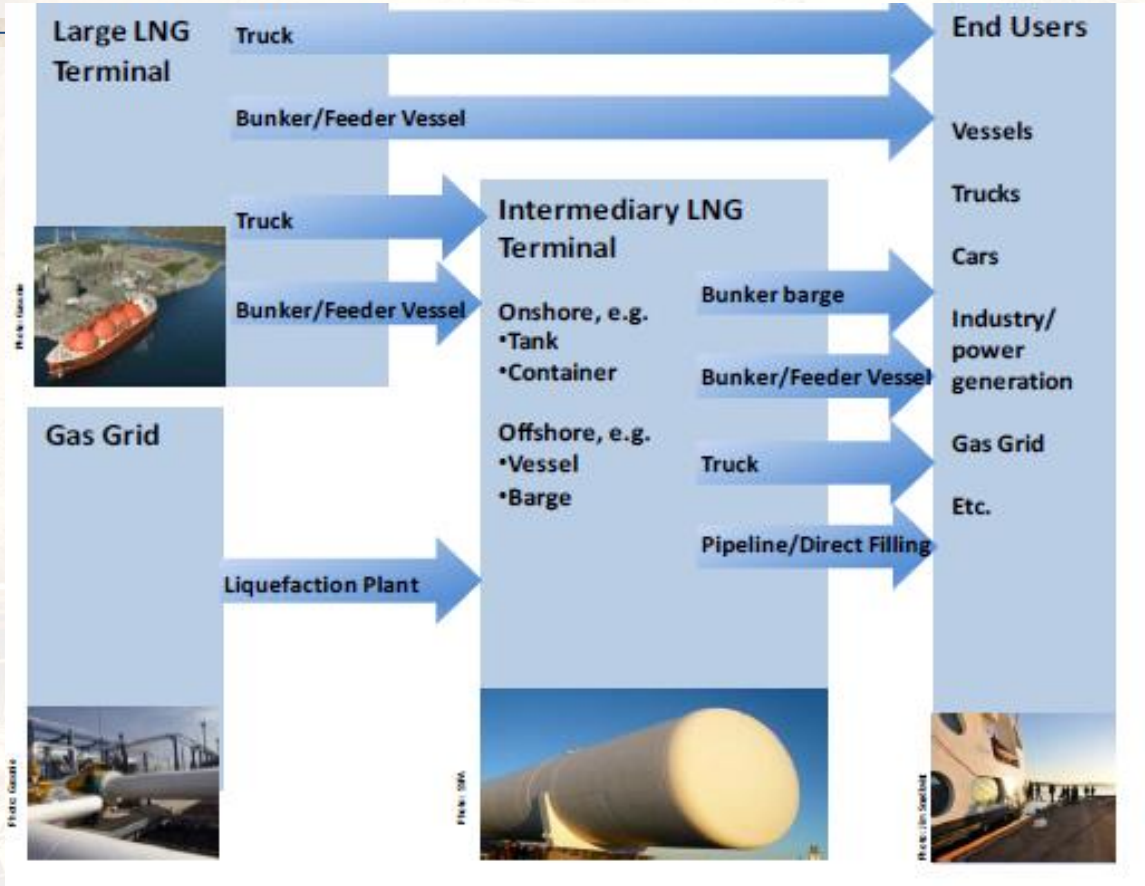
  - ❑Technological feasibility
  - ❑Commercial viability
  - ❑Economic feasibility

Technological feasibility



Density of fuels (DNV 2010)

Commercial viability



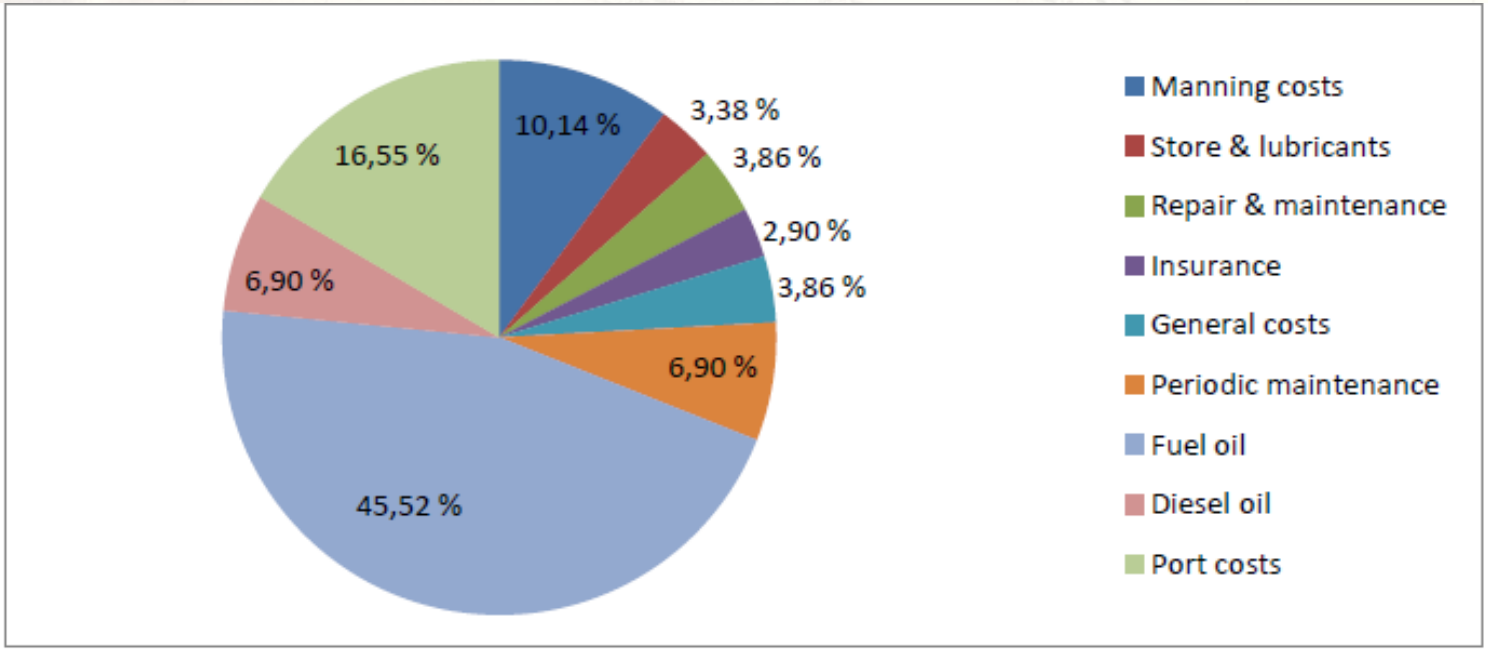
Infrastructure arrangements for supplying different end-users with LNG fuel through large, medium and small terminal/ storage facilities (DMA, 2012)

Economic feasibility

General Cost Classification		Cost Items	
Operating costs	14 %	Manning costs	42 %
		Store & lubricants	14 %
		Repair & maintenance	16 %
		Insurance	12 %
		General costs	16 %
Periodic maintenance	4 %		n.a.
Voyage costs	40 %	Fuel oil	66 %
		Diesel oil	10 %
		Port costs	24 %
		Canal dues	n.a.
		Emission costs	?
Cargo-handeling costs	n.a.		
Capital costs	42 %	Interest/dividend	?
		Debt repayment	?
SUM	100 %		
Note: This analysis is for a 10-year-old Capesize bulk carrier under the Liberian flag at 2005 prices. Relative costs depend on many factors that change over time, so this is just a rough guide.			

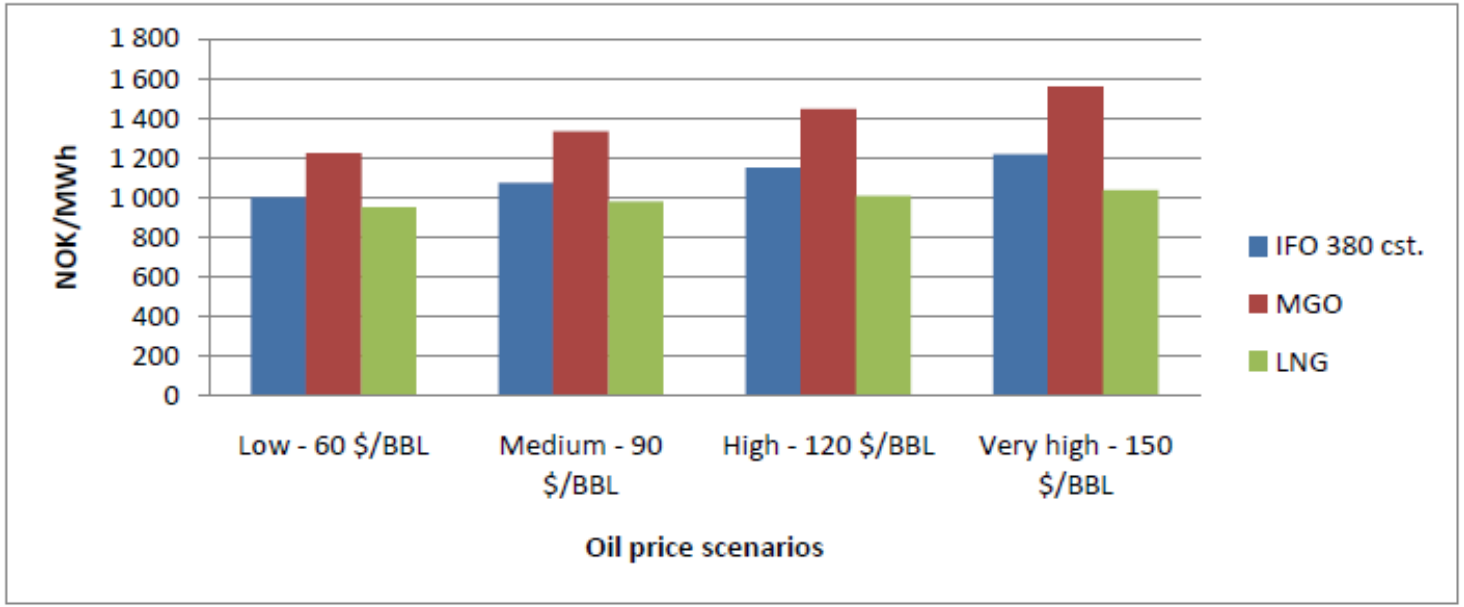
Cost structure for bulk carrier (Stopford 2009)

Economic feasibility



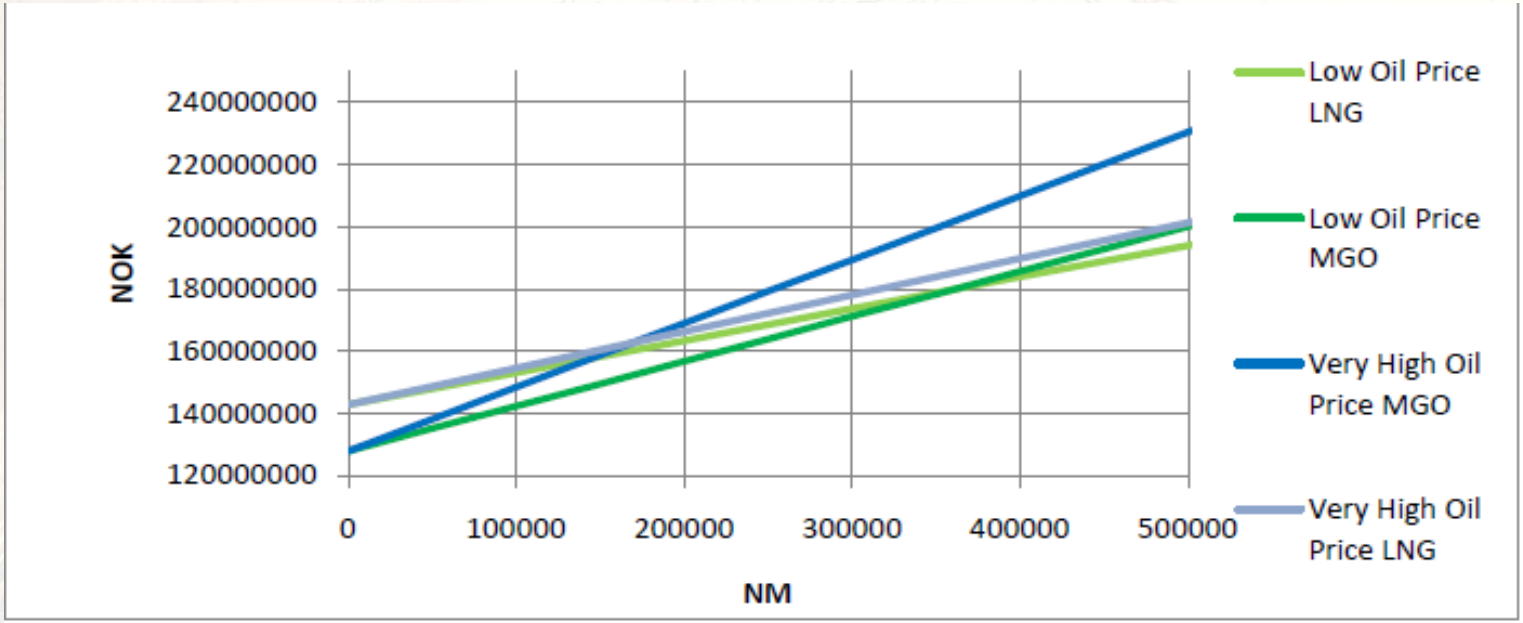
Operating costs (Stopford 2009)

Economic feasibility



Costs for a bulk carrier (Baumgart and Olsen, 2010)

Economic feasibility



Intersection of costs (NOK) per nautical mile (NM) driven for a bulk carrier (Baumgart and Olsen, 2010)

Economic feasibility

No environmental regulation					Environmental regulation			
Oil price	Low 60 $/bbl	Medium 90 $/bbl	High 120 $/bbl	Very high 150 $/bbl	Low 60 $/bbl	Medium 90 $/bbl	High 120 $/bbl	Very high 150 $/bbl
Fuel Type:								
IFO 380 cst. (NOK/MWh)	994,94	1067,37	1139,81	1212,24	994,94	1067,37	1139,81	1212,24
MGO (NOK/MWh)	1155,16	1267,85	1380,55	1493,24	1214,71	1327,40	1440,09	1552,79
LNG (NOK/MWh)	943,57	972,13	1000,69	1029,25	944,32	972,88	1001,44	1030,00

Economic impact of environmental regulations for a bulk carrier (Baumgart and Olsen, 2010)

References

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- Baumgart, M. and Olsen, J.H.B., 2010, *LNG Fueled Vessels in the Norwegian Short-Sea Market*, MSc, Energy, Natural Resources and the Environment, Norway.
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