The early experience of meeting IMO Tier III NOx requirements: stories of encouragement and challenges yet to be overcome

21 October 2018
London

The role of IACCSEA

IACCSEA - to facilitate the transition to low emission shipping

- The International Association for Catalytic Control of Ship Emissions to Air, IACCSEA, has been formed with a primary focus of demonstrating the technological and economic viability of Selective Catalytic Reduction (SCR) technology capable of reducing NOx emissions from marine engines.
- We use our voice to inform regulators and the shipping community that proposed regulations, such as IMO Tier III, can be met through commercially available catalytic after treatment technology.
- We work closely with other stakeholders in the continued development and implementation of strategies that lead to cleaner shipping.

https://www.iaccsea.com/

Programme

18:30 – Welcome address

18:35 – The role of IACCSEA

18:40 – IMO Tier III compliance

18:55 – Case studies: can retrofit achieve IMO Tier III NOx requirements?

19:10 – Discussion and Q&A

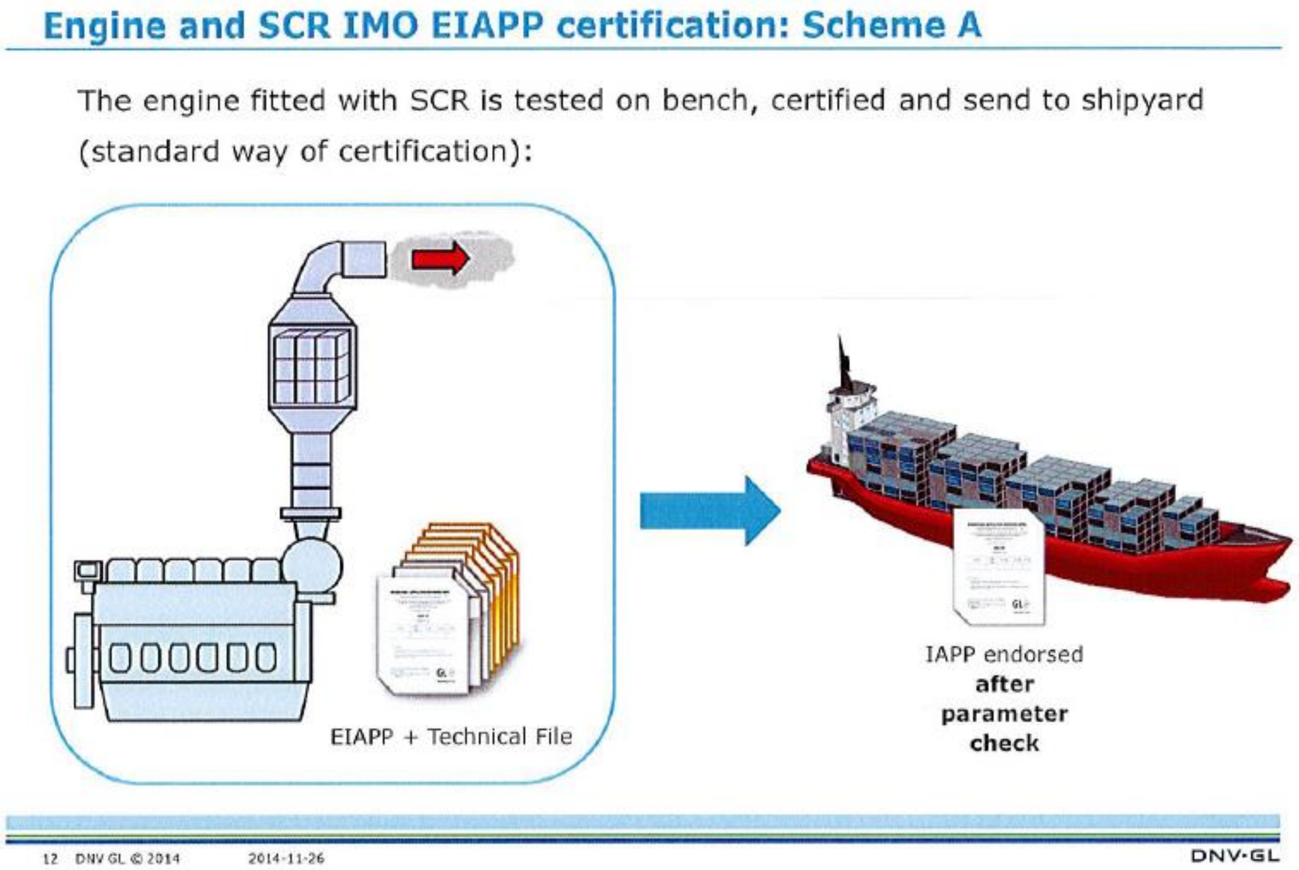
19:25 – Closing remarks by Lord Deben, President of IACCSEA

19:30 – Refreshments

IMO Tier III Compliance

Yara Environmental Technologies GmbH
Michael Rutkowski – Head of Technology Sales

Scheme A Procedure Overview



Engine International Air Pollution Prevention Certificate (EIAPP Certificate)

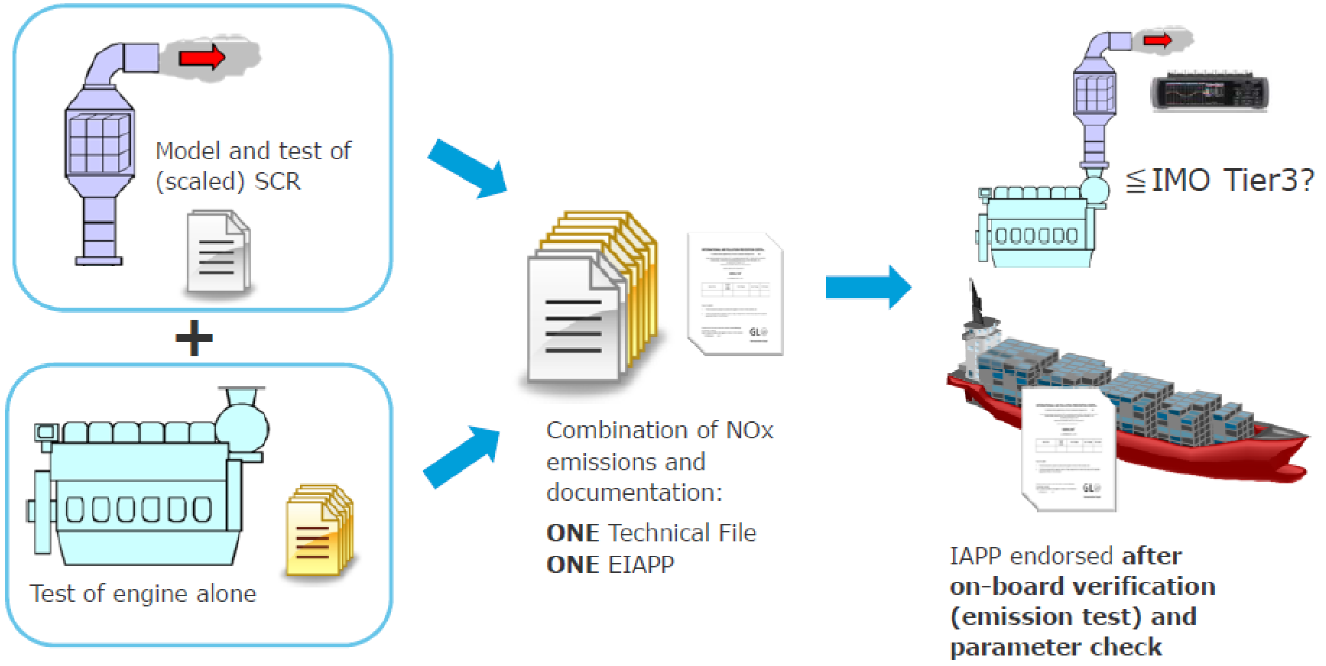
International Air Pollution Prevention certificate (IAPP Certificate)

Source: DNV-GL

Scheme B Procedure Overview

Engine and SCR IMO EIAPP certification: Scheme B

The engine and SCR are tested separately due to restrictions in size (not the standard way of certification):



Engine International Air Pollution Prevention Certificate (EIAPP Certificate)

International Air Pollution Prevention certificate (IAPP Certificate)

Source: DNV-GL

Advantages / Disadvantages of Methods

Scheme A (Testbench)		Scheme B (Scaled Test + Onboard)	
+	-	+	-
No need of testing on board Engine family can be certified	Long Time frame for documentation longer High Costs of Testbench (mounting/dismounting engine) SCR measured with pre-settled parameter, no real conditions No possibility to change the parameters on board and during running in the ECA zone.	Shorter timeframe (1 day in laboratory, 1 week calculation model, few days on board for verification and finalisation of the documents) Lower CAPEX (labtest and class inspector only) Exact measurement of engine delivered, real operation emissions Identical engines: later only onboard verification test Optimization of urea injection -> Lower OPEX	Engine documentation must be delivered to the applicant (customer has to order it accordingly)

Alternative Scheme “C”

- Scheme „C“
  In particular cases a different method of certification can be implemented under some circumstances.
- Engine measurements according to cycle and load conditions are executed directly on board.

Scheme „C“	
+	**-**
Exact measurement of engine delivered, real operation emissions	Each engine needs to be measured onboard
Documentation for engine+SCR prepared simultaneously	Cost Impact
	Case by Case Certification

Experiences - Case Studies Scheme A

- Yara Assistance at Engine Test Bench -

STATUS

- **1 x Vessel / Korea**
  Engine 16V32/40 8000 kW – 720 rpm, → **ABS** — ✓ Completed
- **1 x Vessel / Korea**
  Engine 9L21/31 1980 kW – 900 rpm, → **Korean Register** — ✓ Completed
- **2 x Vessels / China - each**
  B33:45L6 3600kW 750 rpm
  C25:33L6 1920 kW 1000rpm → **CCS** — ✓ Completed
- **3 x Tanker: Korea - each**
  6S50ME-B8.2 7620kW - 115,4 rpm
  6H21/32 1320 kW – 900 rpm → **DNV-GL** — ✓ Completed
- **2 x DWT Tanker, Korea**
  WinGD 6X72 - 15 080kW - 74,7 rpm → **ABS** — ✓ Completed

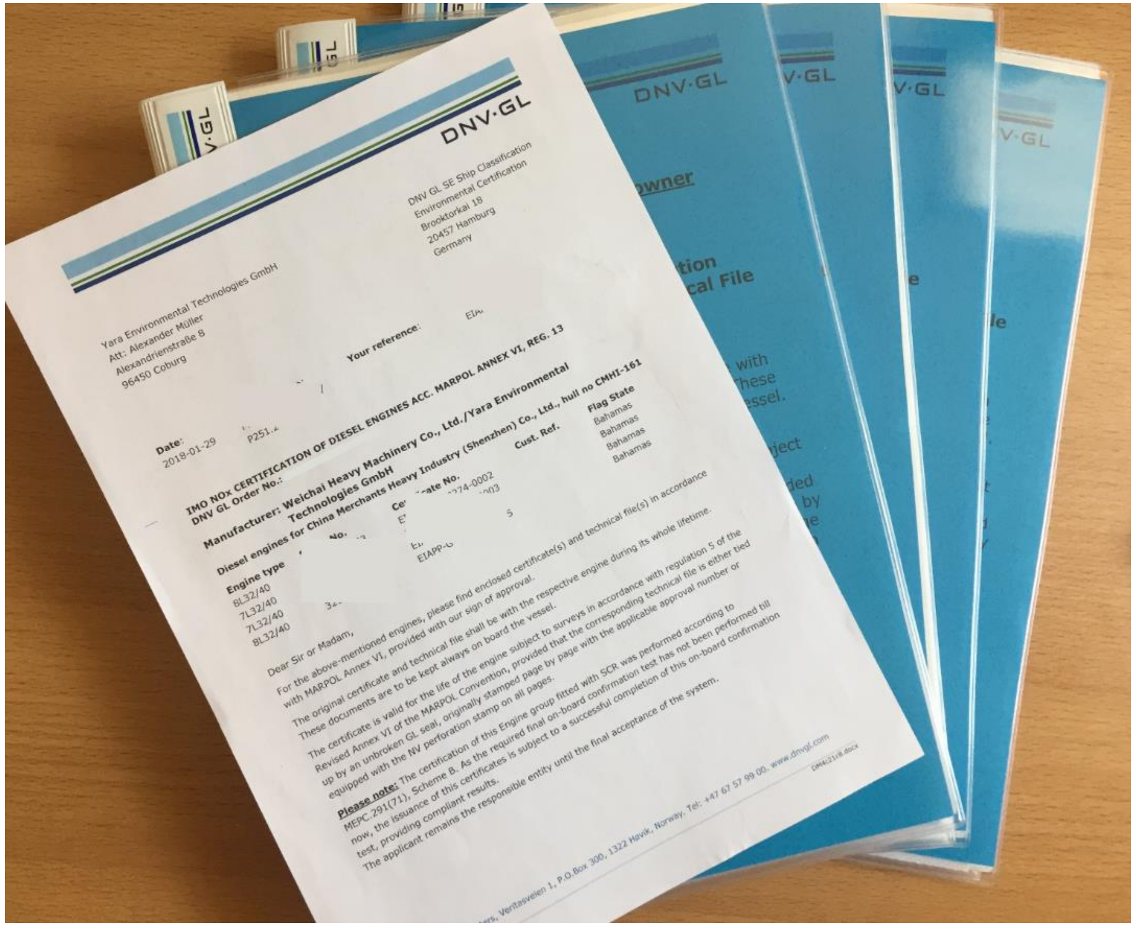
Experiences - Case Studies Scheme B

- Yara as Applicant for EIAPP -

		STATUS
1 x Vessel / China 2 x MAN 7L32/40 4000kW 3 x MAN 8L32/40 3000kW	→ DNV-GL	✓ Completed
1 x Vessel / US 1 x BERGEN B33:45L8, 4800kW, 750 rpm (Scaled Test Only)	→ ABS	✓ Completed
2 x Vessel / China - each 2 x YANMAR 6YE22ALW Engines,1180 kW 1 x YANMAR 6EY18ALW, 550 kW	→ DNV-GL	✓ Completed
2 x Cruise Vessel – Europe - each 2 x Wärtsilä 12V46F, 14 400 kW each 2 x Wärtsilä 16V46F, 19 200 kW each	→ BV	→ In progress

Conclusion

- Certification can be achieved with different methods
- Processes, impact in terms of time and costs can be optimized
- Good cooperation with all Class Societies is needed



DeNOx, Maritime history

Case studies: can retrofit achieve IMO Tier III NOx requirements?

Umicore, Henrik Trolle – Business Development Manager Catalysts
H+H Engineering, Jürgen Müller – General Manager Germany

DeNOx, Maritime history

DeNOx, Maritime history

- 1. SCR installed in 1988
- 4 Ships total
- MAN 6S50MC, 8MW
- NOx in: 22.3 g/kWh
- NOx out: 1.8 g/kWh
- 3 vessels still in operation (2013)
- With original catalyst

The Point: SCR retrofitting is an old and well-proven technology

DeNOx Retrofit Impact Example

- NOx in: 22 g/kWh = 22 kg/MW/h
- 8 MW, old vessel @ 25% load = 44 kg/h!

(Before SCR that is)

- 5000 h/y => emitting 220 t. of NOx per year
- Social cost, 5 €/kg[*1]
- 220 t. per year => € 1.1 mill per year
- SCR can easily reduce these figure 80%
- at an investment of less than 500.000 €[*2]

The Point: SCR retrofitting is <u>very good business</u> for our society

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A CATALYST FOR CLEAN SHIPPING

*1

- The Clean Air for Europe (CAFE) Programme developed monetized damage costs per tonne of pollutant for each European Union country (excluding Cyprus) and for surrounding seas. The analysis provides a range of estimates based on various input values. The table below summarizes overall average values. Emissions occurring at sea impose 50-80% of the damage of the same emissions occurring on land.

Table 5.10.4-6 **Average Damages Per Tonne of Emissions** (2005)[50]

Assumptions				
PM mortality	VOLY median	VSL median	VOLY mean	VSL mean
O3 Mortality	Mortality	VOLY median	VOLY mean	VOLY mean
Health Care?	Included	Included	Included	Included
Health sensitivity?	Not included	Not included	Included	Included
Crops	Included	Included	Included	Included
O3/health Metric	SOMO 35	SOMO 35	SOMO 0	SOMO 0
European Land Areas				
NH_3	€11,000	€16,000	€21,000	€31,000
NOx	€4,400	€6,600	€8,200	€12,000
$PM_{2.5}$	€26,000	€40,000	€51,000	€75,000
SO_2	€5,600	€8,700	€11,000	€16,000
VOCs	€950	€1,400	€2,100	€2,800
European Area Seas				
NOx	€2,500	€3,800	€4,700	€6,900
$PM_{2.5}$	€13,000	€19,000	€25,000	€36,000
SO_2	€3,700	€5,700	€7,300	€11,000
VOCs	€780	€1,100	€1,730	€2,300

This table summarizes air pollution unit cost values from a major study sponsored by the European Union. The full report provides a variety of cost values reflecting various assumptions, with individual values for each country reflecting their specific geographic situation. (VOLY = "Value Of a Life Year"; VSL = "Value of a Statistical Life"; SOMO = "Sum of Means Over 35 ppbV")

*2 https://www.iaccsea.com/scr-cost-model/

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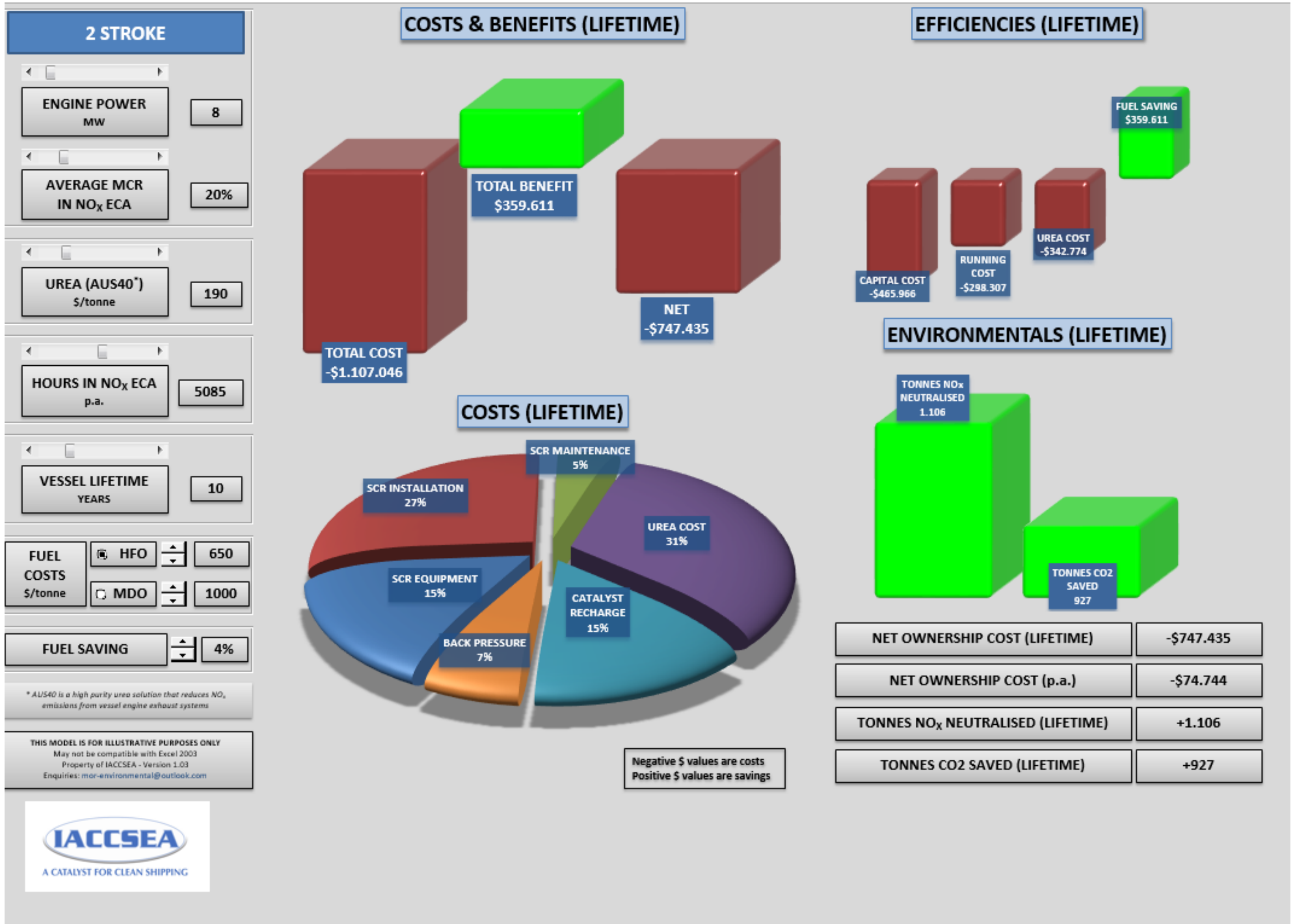
A CATALYST FOR CLEAN SHIPPING



The 1988 vessels had slightly higher NOx g/kWh than used in IACCSEA model

Marine NOx Regulation, Taxes and Incentive Schemes

Sweden: Differentiated Port and Fairway Dues

http://www.sjofartsverket.se/en/About-us/Finances/Fairway-Dues/

Norway: NOx Tax and NOx Fund

https://www.nho.no/samarbeid/nox-fondet/the-nox-fund/articles/about-the-nox-fund/

The Environmental Ship Index

http://www.environmentalshipindex.org/Public/Home

Global IMO Tier III NOx Regulations

http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Nitrogen-oxides-(NOx)-%E2%80%93-Regulation-13.aspx

Case Study Retrofit - North Sea Giant

Engine Producer: GE
Type: 16V250
Power: 3500 kW
No. of engines: 6

NOx without SCR: ~ 10 g/kWh

NOx emitted from Jan 2018: 47,000 kg = 235,000 € social costs

Case Study Retrofit - North Sea Giant

Engine Producer:	GE
Type:	16V250
Power:	3500 kW
No. of engines:	6

NOx with SCR: ~ 1 g/kWh

NOx emitted from Jan 2018: 4,000 kg = 20,000 € social costs

How many ships have been equipped with SCR by retrofit?

Ships with SCR supported by the NOx-fond	222
New builds	171
Retrofit ships	51
NOx reduced	**14,091 ton**
Total estimated investment cost	861,191,520 NOK (~95,687,946 €)

How many ships have been equipped with SCR by retrofit?

NOx reduced	**14,091 ton**
Total estimated investment cost	861,191,520 NOK (~95,687,946 €)
Savings in social cost:	**70,455,000 €**

Summary

Retrofiting of ships with SCR units is proven technology since 1988

Retrofit technology is available for all type of vessels

- Cruise
- Offshore
- Fishing
- Cargo

Closing remarks

Lord Deben – President of IACCSEA

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https://www.iaccsea.com/