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Maritime Seminar

How to proactively respond to the upcoming NOx Legislation

19 April 2012

Chairman: Dan Veen (TNO)

Stichting De Noordzee · KVNR · TNO innovation for life · MARIN · Scheepsbouw Nederland · Port of Rotterdam

Program

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13.30 - 14.00	Registration and Coffee	
14.00 - 14.05	**Opening speech and introduction**	**Dan Veen, TNO**
14.05 - 14.25	Nox emissions, effect on people and Environment	*Marieke Verweij, Pro Sea*
14.25 - 14.45	**The Nox requirments from IMO and EU**	**Dick Brus, Ministry of I&E**
14.45 - 15.05	Solutions for Tier 1 and 2 emission limits	Frank Dames, Wärtsilä
15,05 - 15.25	**Tier 3 solutions**	**Hans van Burk, Soottech**
15.25 - 15.45	Coffee brake	
15.45 - 16.05	**Tier 3 solutions**	**Alwin de Kock, Solfic**
16.05 - 16.25	Out of engine solutions in practice	Piter Oosterhof, Wagenborg Shipping
16.25 - 16.45	**LNG as a solution for limiting Nox emissions**	**Raymond Gense, Pon Power**
16.45 - 17.05	How to fulfil all new emission requirements	Benny Mestemaker
17.05 – 17.45	**Forum discussion**	**Chairman**
17.15	Networking opportunity	

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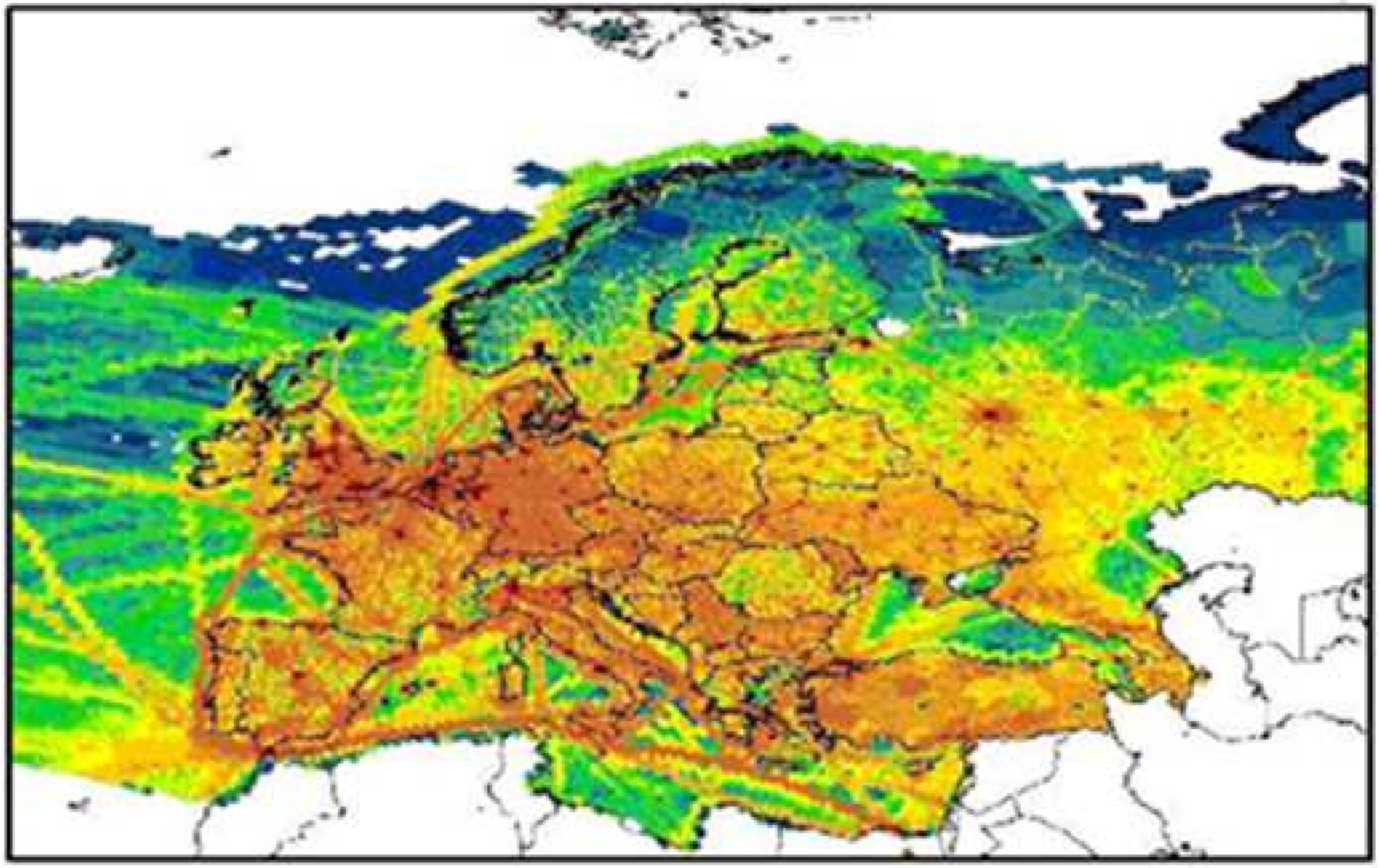

NOx emission intensity ≈ 7x7 km scale (TNO, 2005)

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The presentations can be found on the website by next week

www.scheepsemissies.nl

NOx emissions

Effects on people and environment

19 April 2012 – Platform Scheepsemissies

Marieke Verweij – ProSea Foundation

NOx

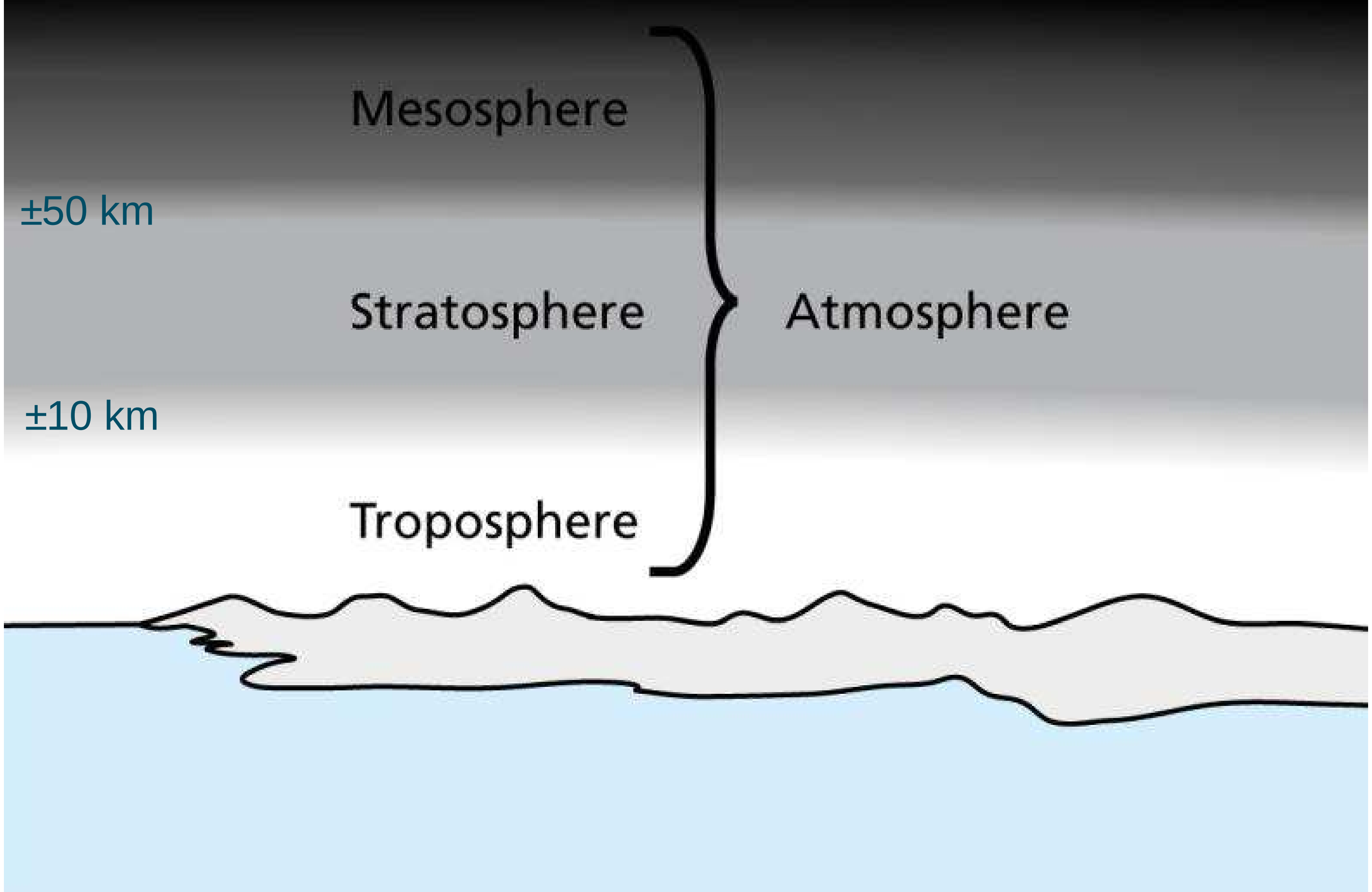
Contents

1. ProSea?
2. Background: sky is the limit
3. Main problem areas NOx
   - Acidification
   - Air quality
4. Role of shipping

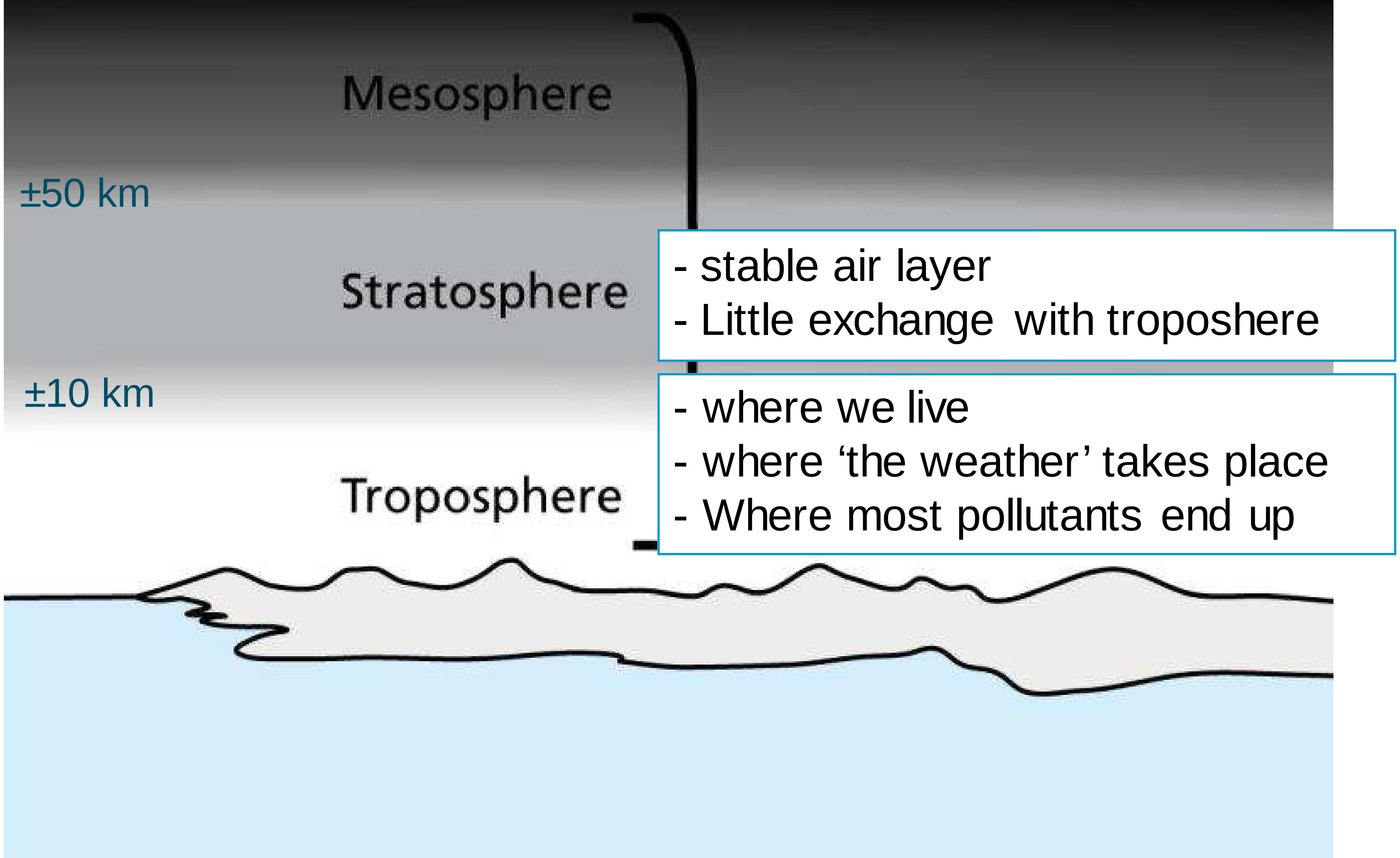
ProSea Foundation

- Non-profit educational organization (founded in 2001)
- Marine Awareness and human element
- Courses
  - for (future) ‘marine professionals’
  - about sustainable shipping / fishing / …
- IMO model course Marine Environmental Awareness

The sky is the limit..?



Most air emissions remain in the troposphere

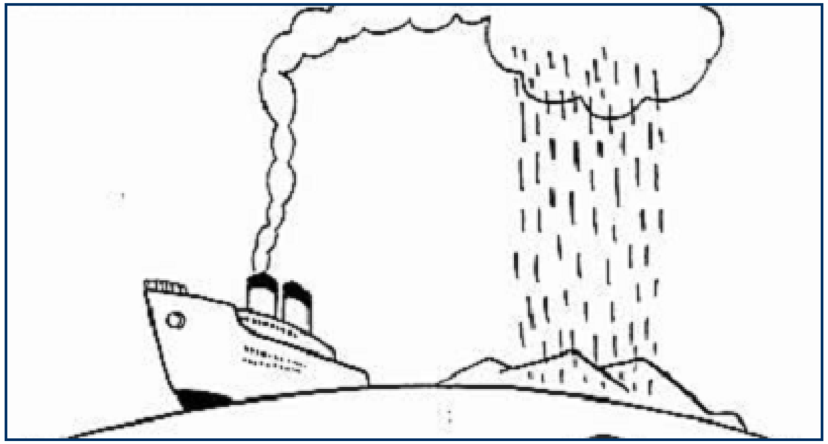


NOx – nitrogen oxides

- examples: NO, NO_2, ...
- Engine emissions: nitrogen (N_2) in air reacts with oxygen (O_2) in air
- level of NOx emissions depend on conditions inside engine (eg temperature, air:fuel ratios)

Main problems areas NOx

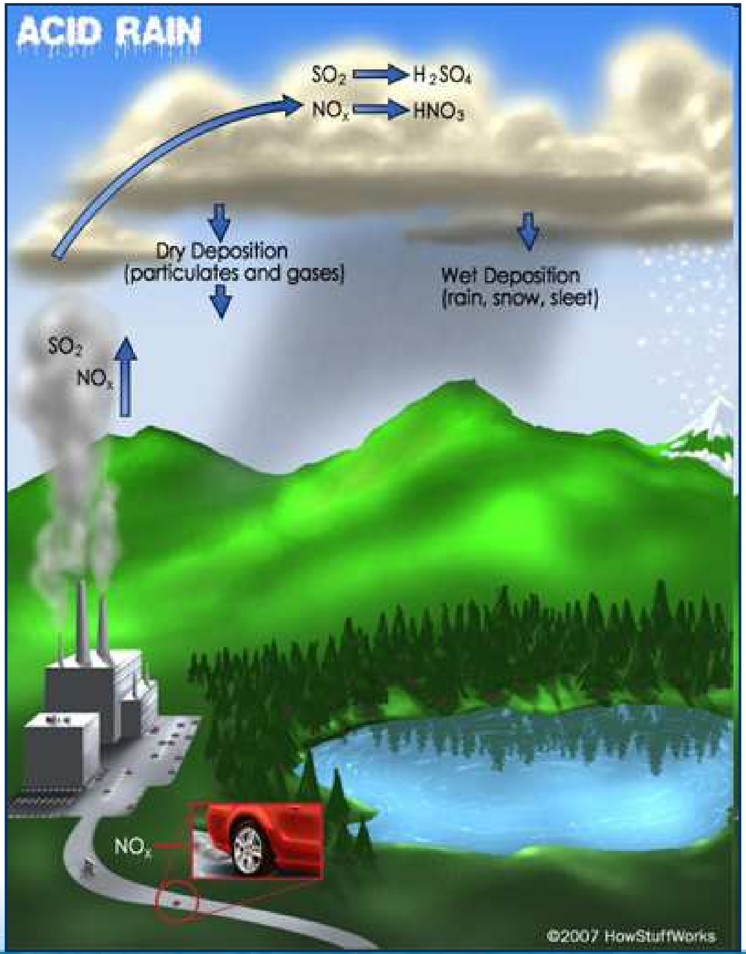
Acidification



Air quality

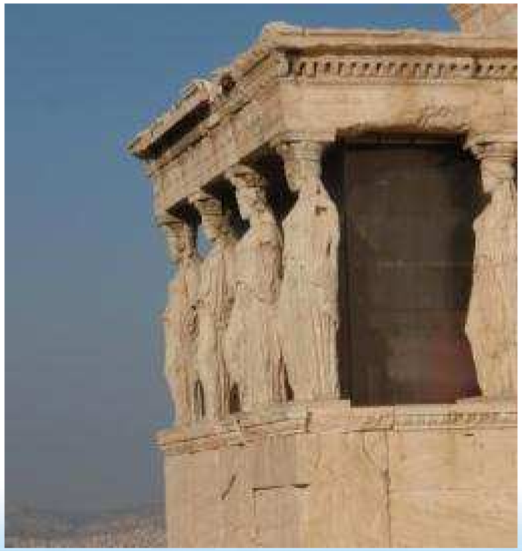
Main impacts: acidification

- NO_x + water (H_2O) in the air = HNO_3 (nitric acid)
- Acids reach the earth (not only with rain)
- decrease the pH of the environment



Consequences of acidification

- soil loses nutrients (e.g. calcium):
  - damage to trees / plants
- soil releases heavy metals:
  - toxic to fish / insects (surface water)
  - toxic to humans (ground water)
- surface waters: over-fertilization
- buildings: damaged by corrosion



Acidification: still a problem?

- Prominent issue in the 70's and 80's
- Now less in the news:
  - Other issues pressing on agenda (eg climate change)
  - we can manage symptoms better
  - Land emissions strongly reduced
- However…

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Sour Showers: Acid Rain Returns--This Time It Is Caused by Nitrogen Emissions

Acid rain is now caused by nitric rather than sulfuric acid--and it comes from more sources than the earlier acidic precipitation did

Main impacts – Air quality – Smog

- NOx + VOC = smog
- main component is ozone (O_3) at ground-level:
  - toxic to humans
  - also a greenhouse gas (climate change)

- Consequences:
  - irritates lungs and eyes
  - chest tightness
  - leaf damage (plants and trees)
  - lower crop yields

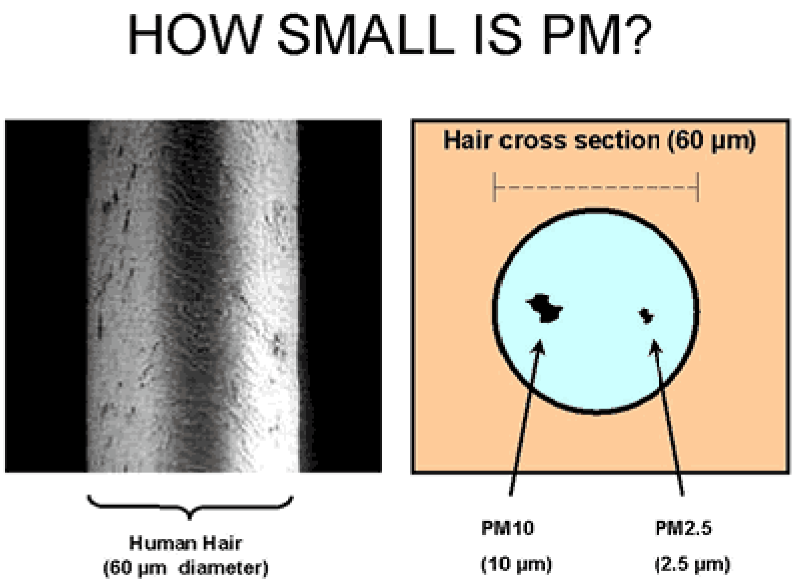
Main impacts – Air quality – PM

Chemical reactions in the air:

part of NOx is formed into small particles – Particulate Matter (PM)

PM10

PM2,5



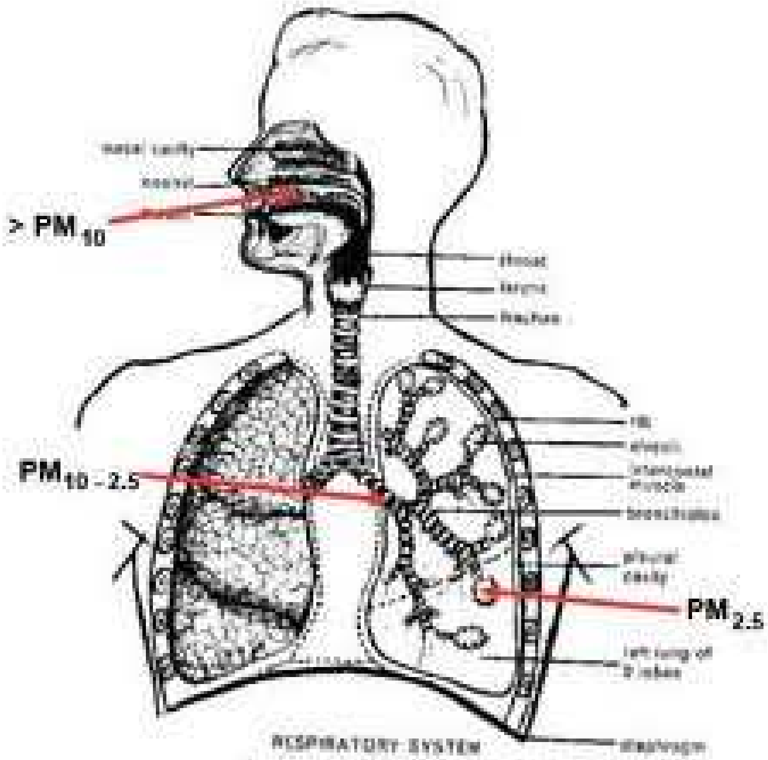
Main impacts – Air quality – PM

PM10 and smaller:

- undetected by our lungs
- remain in respiratory system
- pass into blood stream

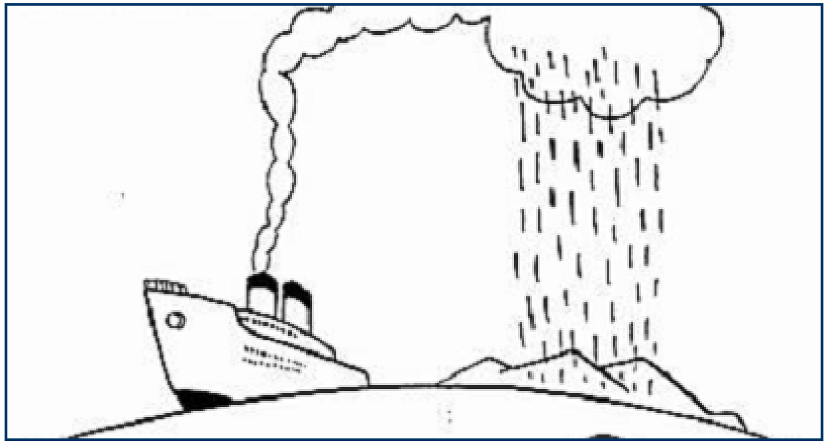
Health effects include:

- premature deaths
- heart and lung failures
- asthma
- (chronic) bronchitis
- cancer (possibly)



Role of shipping

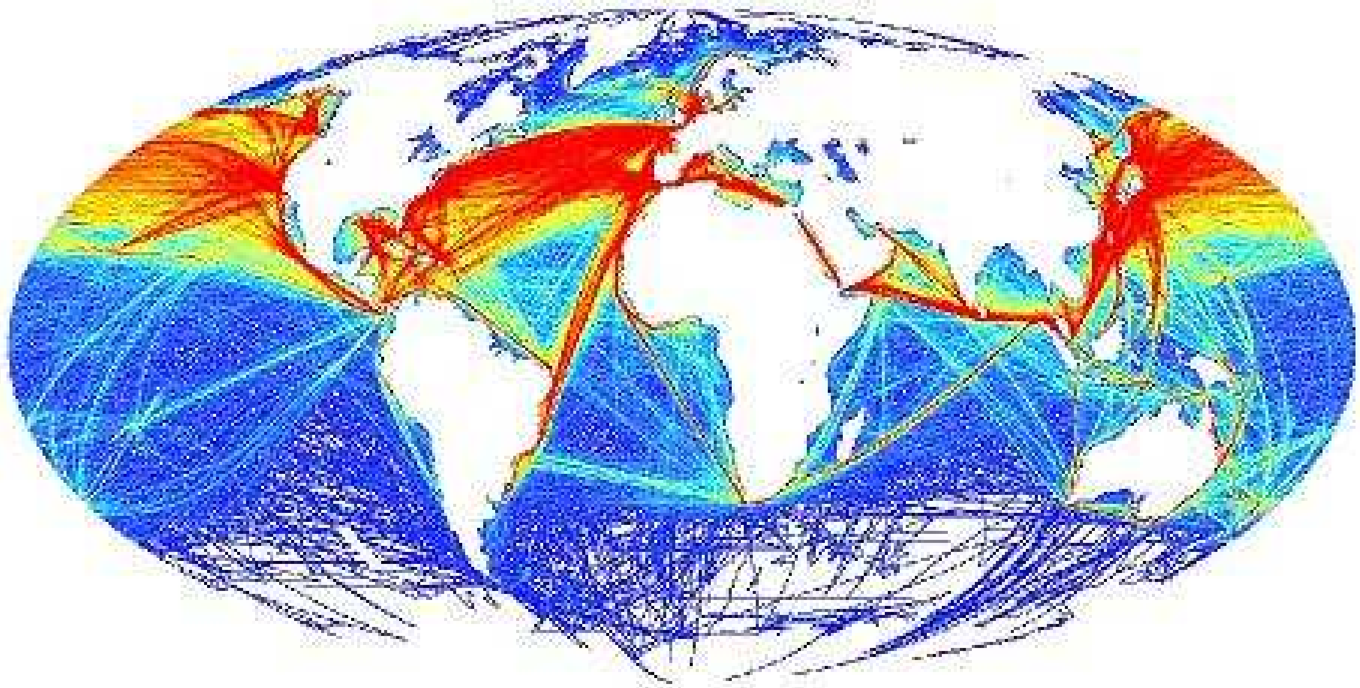
Acidification



Air quality

- regional problems
- air emissions travel hundreds of km

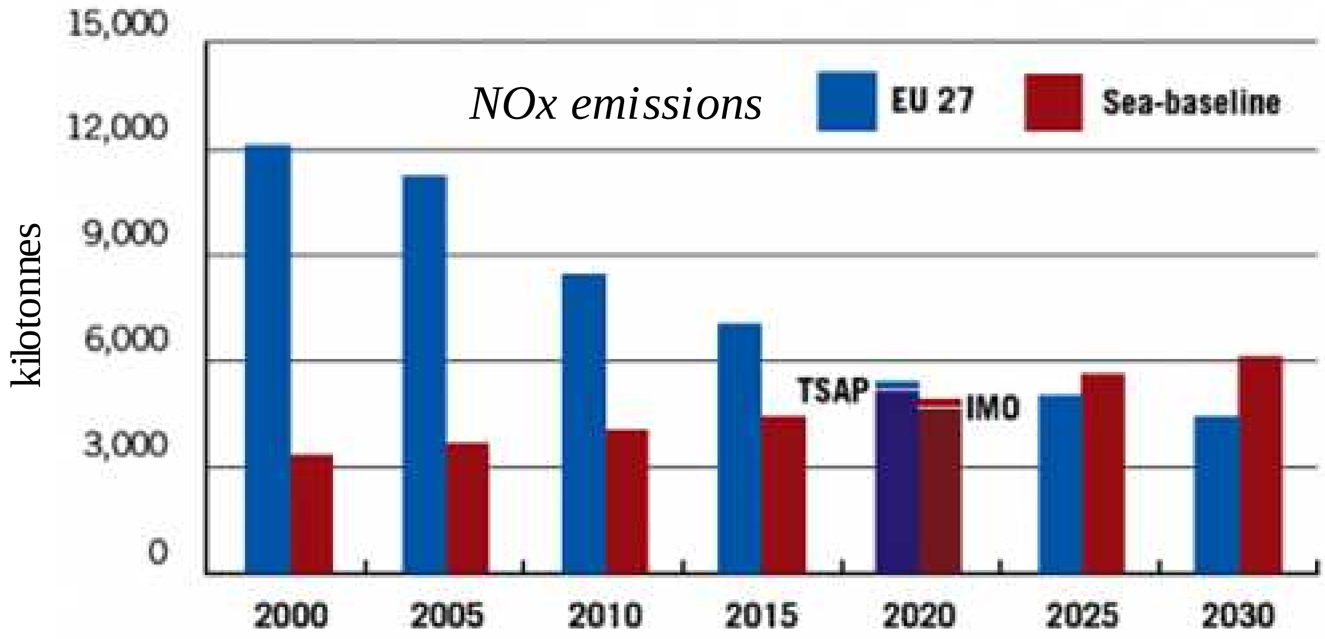
Shipping also contributes to regional air pollution



because 70% of shipping activities are within 400 km distance from coast

Contribution of NOx by shipping

Shipping emissions are expected exceed all EU land emissions by 2025
Business as usual scenario!



EU27 = land-based sources in all EU countries (incl. domestic shipping)

Sea = international shipping in European sea areas

…as land emissions decrease: relative contribution of shipping increases!

Thank you

- Questions?

Marieke Verweij

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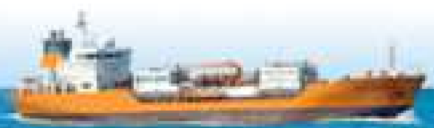


Ministerie van Infrastructuur en Milieu

Nox emission control areas

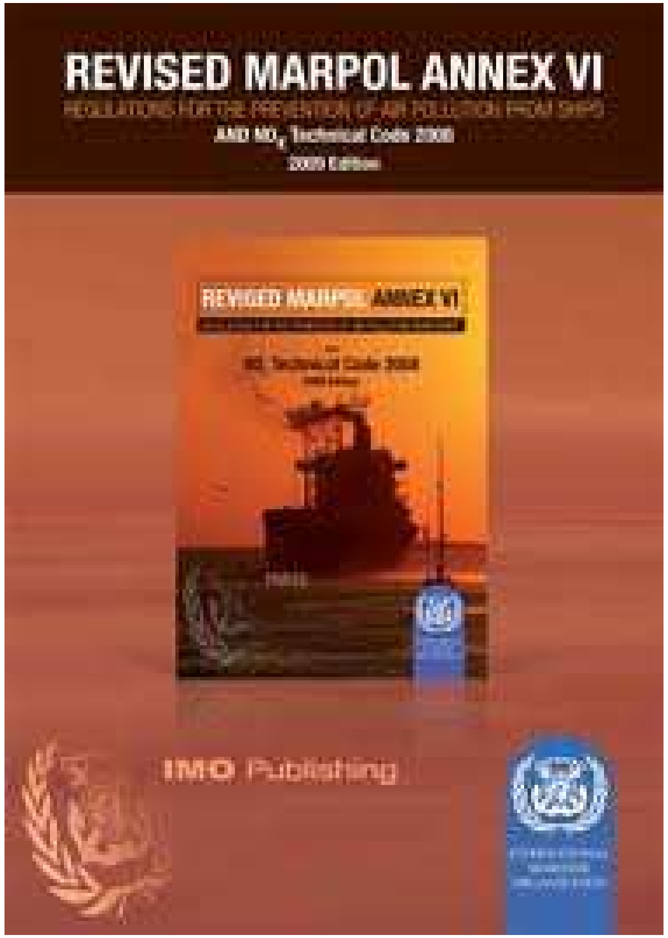
Dick Brus

Ministerie van Infrastructuur en Milieu

Platform Scheepsemissies

3 mei 2012

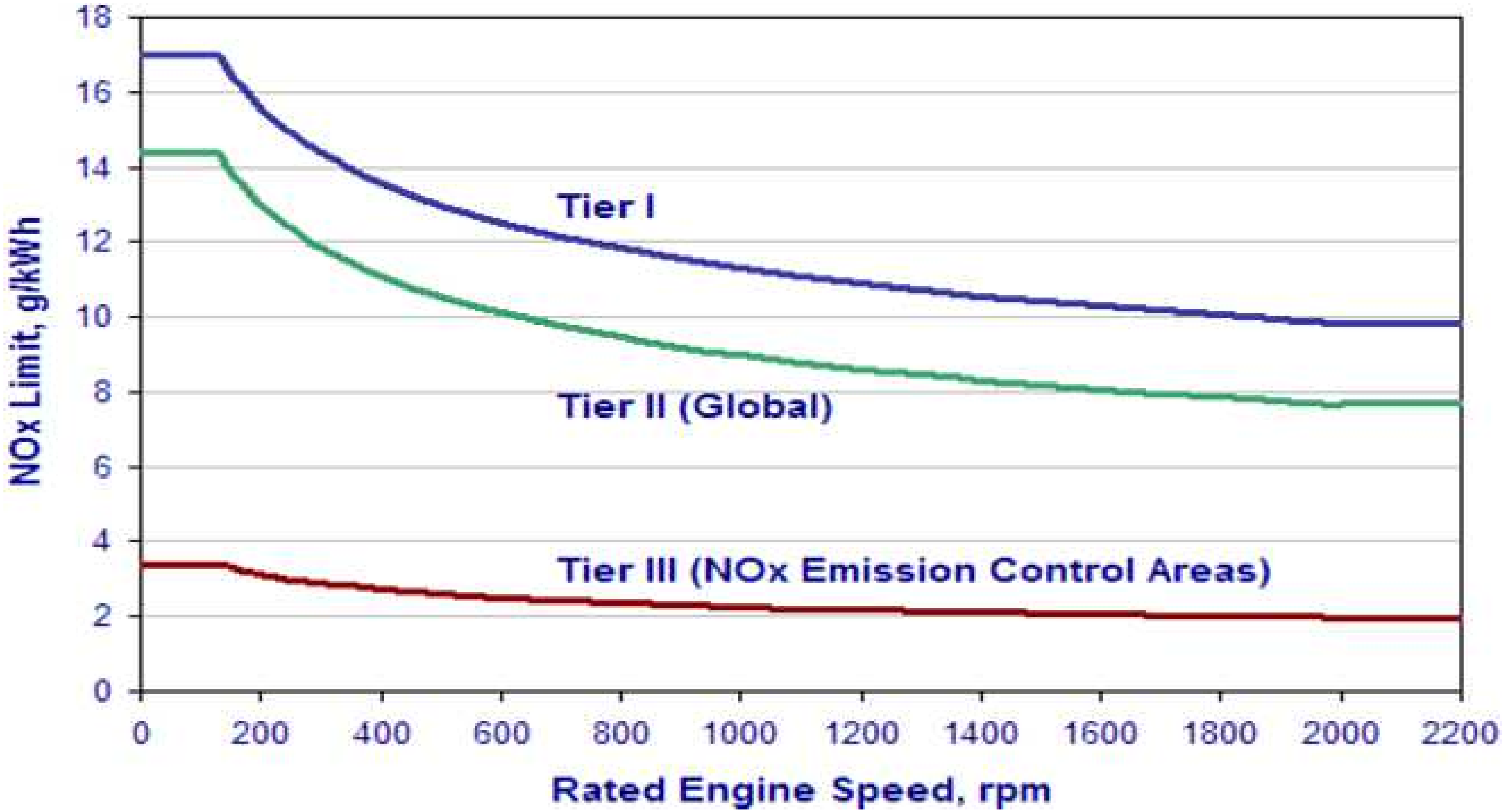
2008, REVISED MARPOL ANNEX VI



For NOx Engines installed on a ship:

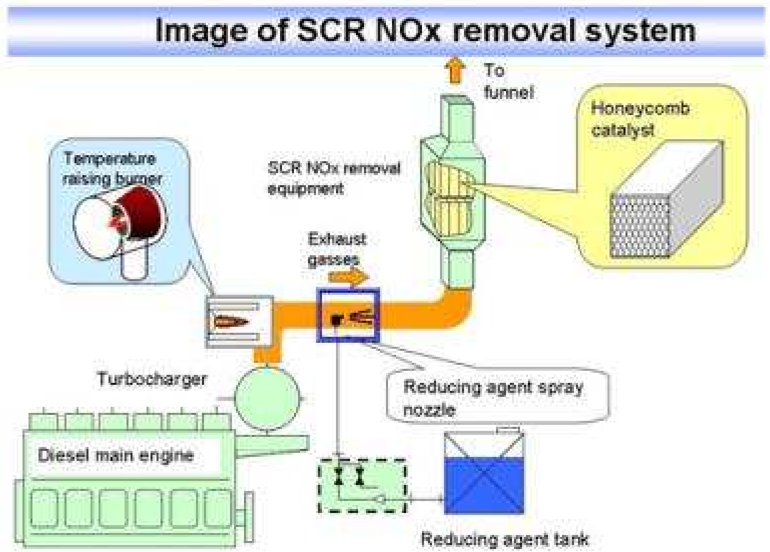
1. 1990-2000, large engines with a power output of more than 5,000kW and cilinder replacement above 90 litres must comply with the existing (after 2000) limits, provided that there is an approved method
2. 2000-2010 exisiting limits (Tier1)
3. 2011- Tier II, on average 20% stricter than tier 1
4. 2016- Tier III, ships in NOx emission Control Areas NECA's, on average 80 % stricter

2008, REVISED MARPOL ANNEX VI



Tier III regulation

- Tier III technology:, retrofitting is not always possible
- So TierIII only mandatory for new engines installed on ships
- Very long term measure: new ships from 2016 on, so only after 2045?: all ships in NECA’s have new Tier III technology



Review available technique

- Beginning in 2012, and completed no later than 2012, the Organization shall review the status of the technological developments to implement the standards set forth in paragraph 5.1.1 of this regulation, and shall, if proven necessary, adjust the time periods (effective date) set forth in that paragraph
- Correspondance group chaired by the United States started work for this review

- **Collated Comments**
-
- ***.1 Range of technologies (engine fitting, material, appliance, apparatus, other procedures, alternative fuels or compliance methods) that may be used to comply with the Tier III NOx standards;.***
- **Q1: What is the practical capability of each of these technologies (*selective catalytic reduction (SCR), operation on alternative fuels such as liquefied natural gas (LNG), and in-cylinder improvements combined with exhaust gas recirculation (EGR) or introduction of water into the combustion process*) for compliance with the Tier III NOx standards?**

Tier III Criteria and procedure for designation of a (N)ECA

- Submitted by two or more parties
- Clear delineation of the proposed area
- Human populations and environmental areas at risk
- Assessment of emissions from ships contributing to air pollution or environmental impacts
- Ship traffic
- Relevant costs reducing emissions from ships compared to land-based controls

The IMO shall consider the proposal taking into account these criteria

The North American ECA

- North America applied for an ECA for Nox and Sox and particulate matter
- In 2010 the IMO adopted the application
- From August 1 2011 the North American coast (200 miles) became an ECA

MARINE ENVIRONMENT PROTECTION COMMITTEE
60th session
Agenda item 5
MEPC 60/5/1
14 September 2009
Original: ENGLISH

CONSIDERATION AND ADOPTION OF AMENDMENTS TO MANDATORY INSTRUMENTS

Amendments to MARPOL Annex VI (North American Emission Control Area)

Note by the Secretariat

A possible BALTIC NECA

- HELCOM is preparing a possible Baltic NECA Application
- No final decision is made at the last Helcom meeting in March 2011
- Studies and a concept application are ready

Attachment 2, Proposal of the Baltic Sea States to designate the Baltic Sea as an Emission Control Area, draft, 7 February 2012

INTERNATIONAL MARITIME ORGANIZATION

IMO

E

MARINE ENVIRONMENT PROTECTION COMMITTEE

6Xth session Agenda item 7

MEPC 6X/7/X xx Month 20YY Original: ENGLISH

INTERPRETATIONS OF, AND AMENDMENTS TO, MARPOL AND RELATED INSTRUMENTS

Proposal to designate the Baltic Sea as an Emission Control Area for Nitrogen Oxides

Submitted by Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, the Russian Federation and Sweden

NECA area's

Approved:

- North America Coast
- US Islands in the Caribbean

Expected:

- Baltic Sea

Mentioned as possible future NECA's:

- North Sea
- Japan
- South East Asia (Singapore with others)
- Australia/New Sealand
- Northern America including Mexico
- Mediterranean

North Sea NECA

Next question: will the North Sea become a NECA?

- 2010 informal meetings IMO representatives from North Sea countries
- 2010 North Sea NECA consultation group: what are the pros and cons of the North Sea becoming a NECA?
- March 2011: meeting in the Hague, with relevant stakeholders

1. The Baltic Sea as a Nox emission control area
2. Helcom Study on economic impacts, lessons for the future North Sea StudyAvailable Nox reduction technologies
3. Available Nox reduction technologies
4. Terms of reference for the evaluation of environmental impacts
5. Terms of reference for the evaluation of economic effects

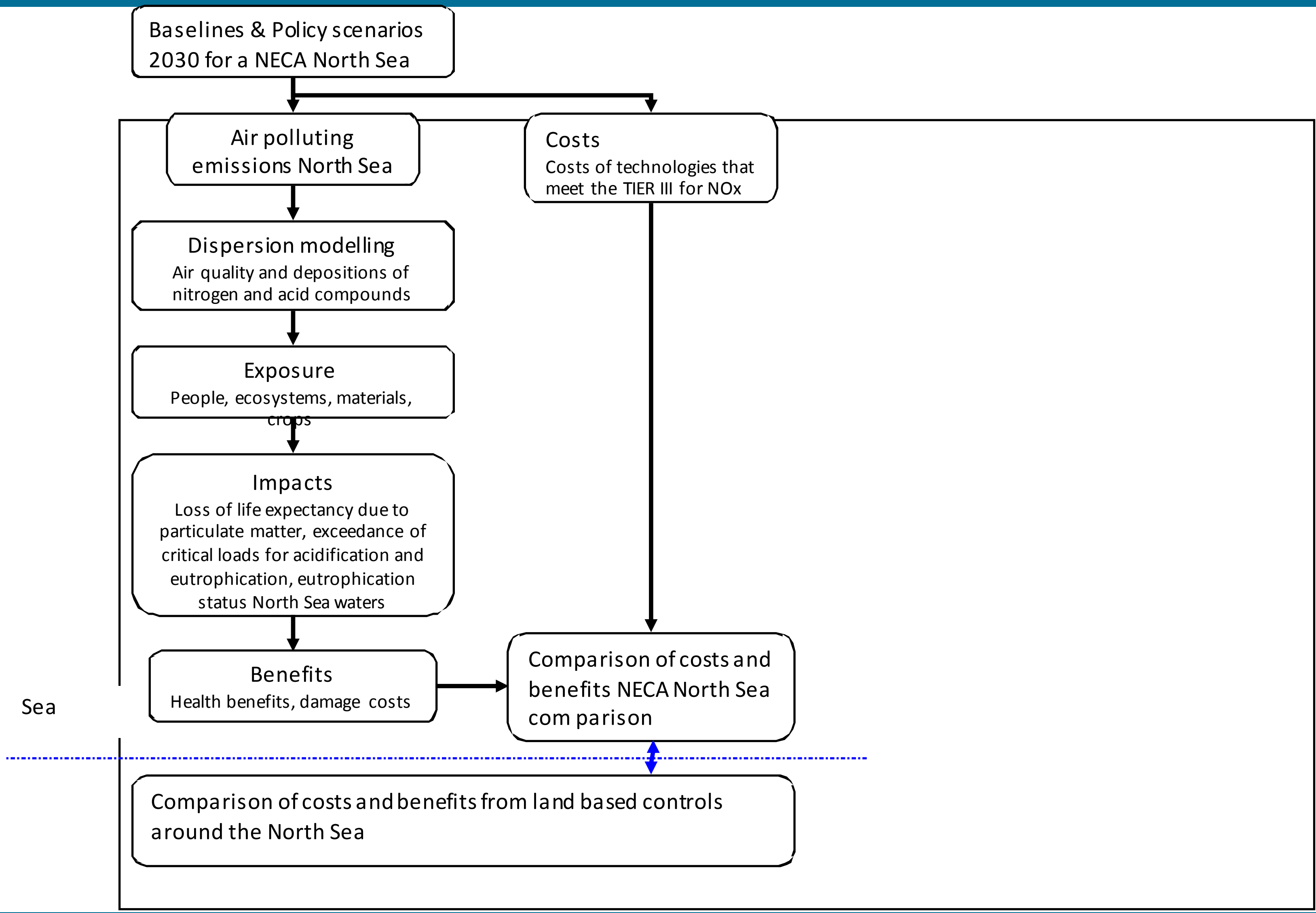
NOx reducing technologies

Wartsila:

- The NOx Tier III measure is far reaching compared to the NOx Tier 1 and Tier 2 measures
- Wärtsilä sees a good future for gas-fueled engines, gas is an attractive alternative to meet the Tier III standards.
- Selective Catalytic Reduction (SCR) can be combined with fuel > 1,0% sulphur.
- SCR is compatible with scrubbers.
- The costs of SCR are 5 -10 % of the fuel costs.
- The experience with SCR in the Baltic is good: 90 % NOx-reduction. Ships with SCR receive reduction on Swedish harbour dues.
- In development: combining technologies
- Wärtsilä will be ready in 2014 to supply engines that comply to Tier III–standards.

Terms of reference Environmental

- Determine the impacts on improving air quality in the North Sea countries by designating the North Sea as a NO_x Emission Control Area (NECA) and relate the cost-effectiveness of a NECA to land-based controls.
- Study commisioned to the Dutch Natiopnal Institute for Public Health and the Environment (RIVM), in cooperation with European Monitoring and Evaluation Programme (EMEP), DEFRA, The DCMR Environmental Protection Agency


Baselines & Policy scenarios 2030 for a NECA North Sea
Air polluting emissions North Sea
Costs
Costs of technologies that meet the TIER III for NOx
Dispersion modelling
Air quality and depositions of nitrogen and acid compounds
Exposure
People, ecosystems, materials, crops
Impacts
Loss of life expectancy due to particulate matter, exceedance of critical loads for acidification and eutrophication, eutrophication status North Sea waters
Benefits
Health benefits, damage costs
Comparison of costs and benefits NECA North Sea com parison
Sea
Comparison of costs and benefits from land based controls around the North Sea

Terms of Reference Economic impact assessment

The aim of the economic impact assessment is:

- To estimate the cost effectiveness of different NOx reducing technologies on sea shipping in order to meet the NECA requirements in the North Sea.
- To estimate the economic impacts of a NECA in the North Sea, including total NOx abatement costs in the period up to 2030 and the economic impacts on the shipping companies (changes in freight rates, changes in turn over),
- To estimate the indirect economic impacts of NECA including potential modal shift and change of ports, the effects on air polluting emissions and their location, and the economic impacts on other sectors.

The Study is coordinated by the Danish Ministry of the Environment, with cooperation from Incentive Partners and Litehauz,

Assumptions

- the environmental study and the economic study are consistent and co-developed
- The same scenario's, assumptions , parameters etc are used
- For all critical assumptions of fleet growth per type ship, efficiency, speed etc IMO assumptions were used.

Further actions

- March 2012, North Sea NECA Consultation Group Meeting in Hamburg
- Discussion of concept studies
- Studies are planned to be finished and published in June 2012
- North Sea countries will come together in Octobre 2012 in London
- The Netherlands starts national consultation with all relevant stakeholders, tentatively scheduled end of June 2012

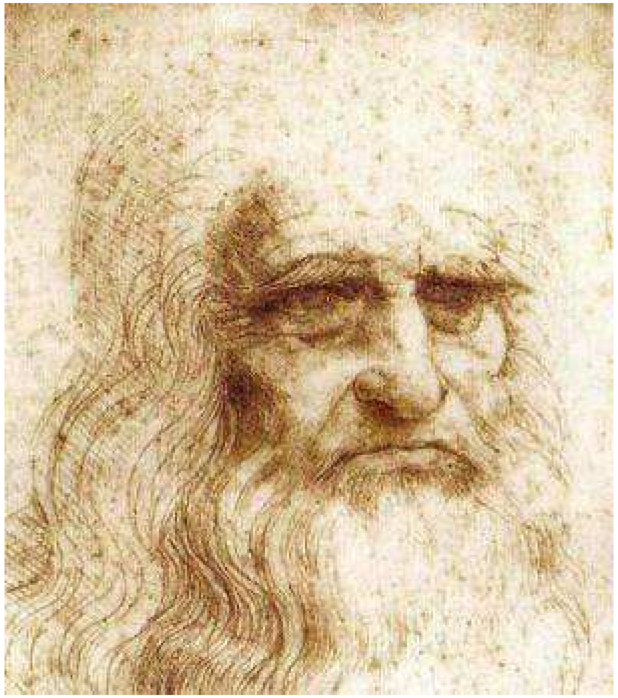
- Dick.Brus@minienm.nl

Solutions for Tier 1 and 2 emission limits

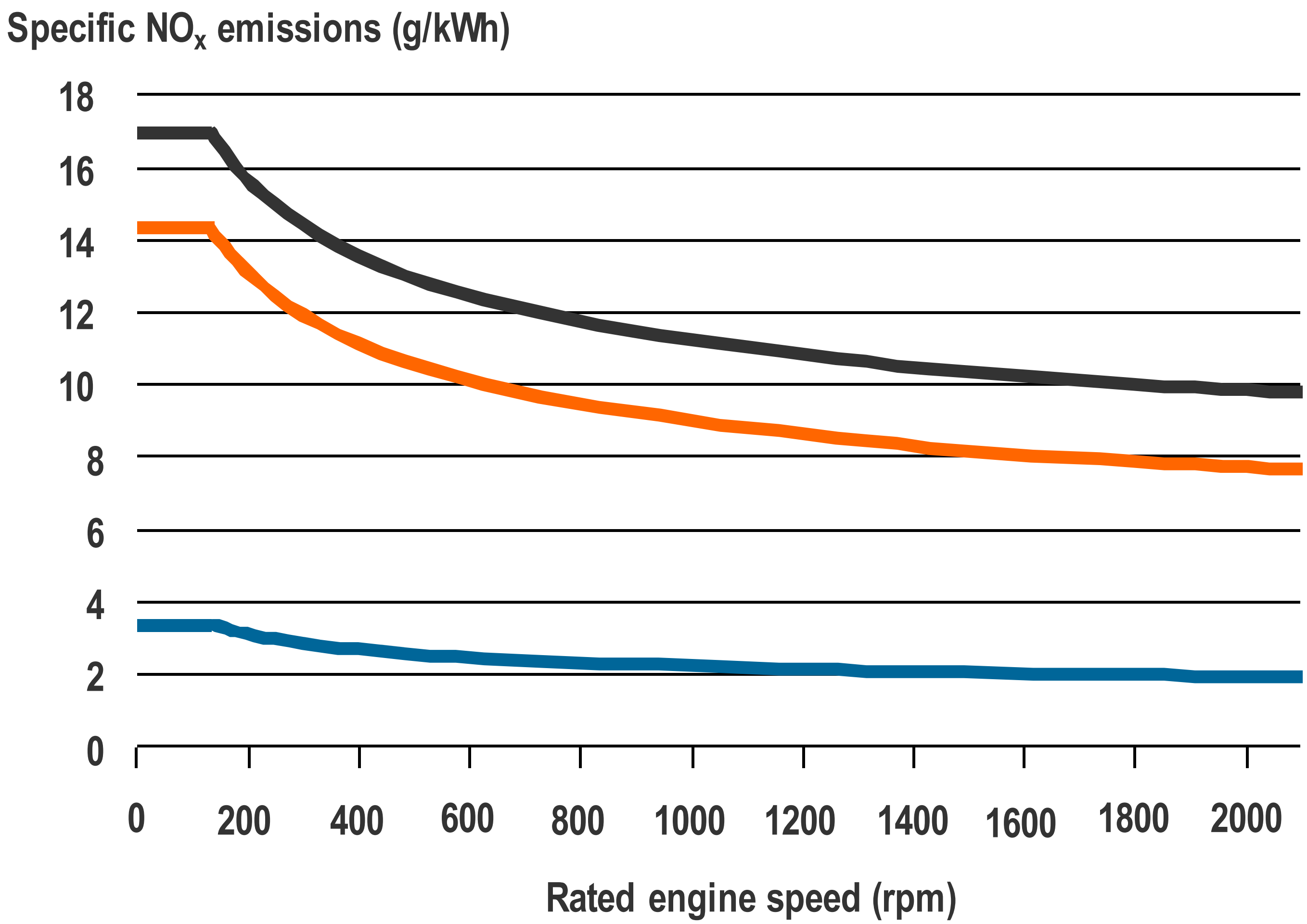
Technological in-engine solutions

Platform Scheepsemissies
Frank Dames
19 April 2012

Where did it start?



NO_x reduction – IMO requirements and methods



Tier I (present)

Ships built 2000 onwards
Engines > 130 kW

Retrofit: Ships built
1990 – 2000
Engines > 90 litres/cylinder
and > 5000 kW

Wärtsilä: RTA, W46, W64

Tier II (global 2011)

Ships built 2011 onwards
Engines > 130 kW

Tier III (ECAs 2016)

Ships in designated
areas, 2016 onwards
Engines > 130 kW

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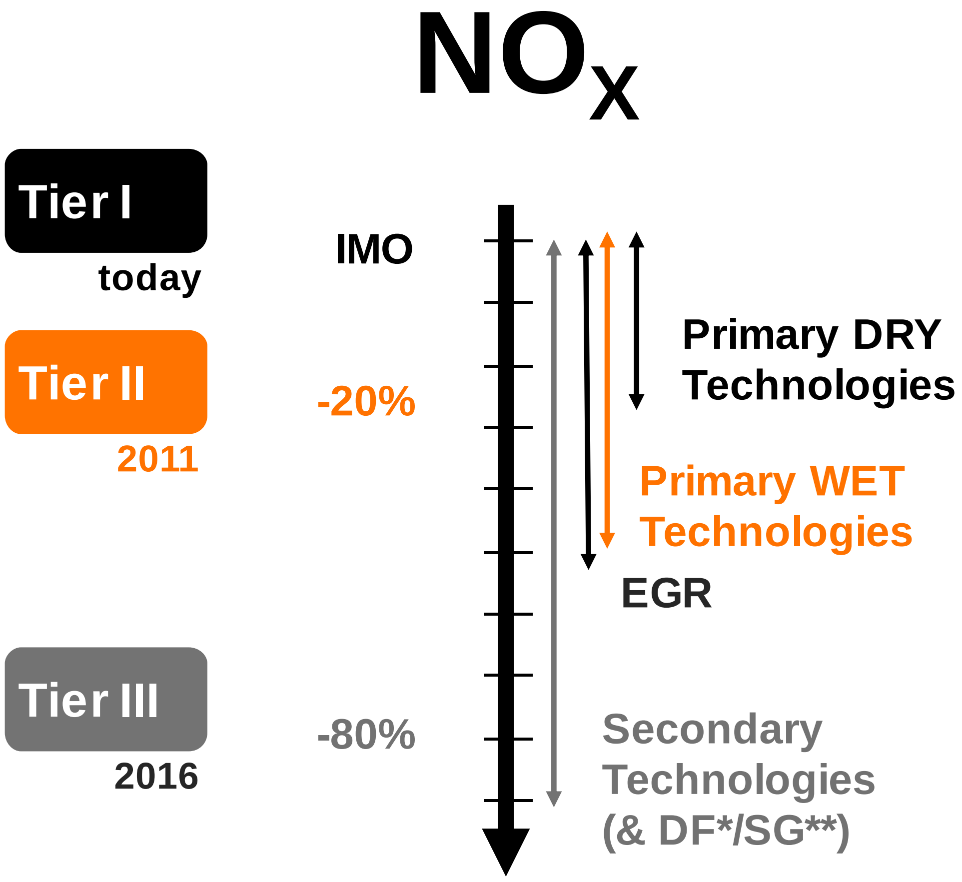
Technologies for NO_X reduction



- Low NOX Tuning
- Miller timing – 1 stage
- Common Rail

- Air intake Humidification
- Direct Water Injection
- Water-Fuel Emulsion

- Exhaust Gas Recirculation

- Specific Catalytic Reduction

DF*= Duel Fuel, ** SG = Spark Ignited
Both alternatives represent Wärtsilä Gas Engine Portfolio

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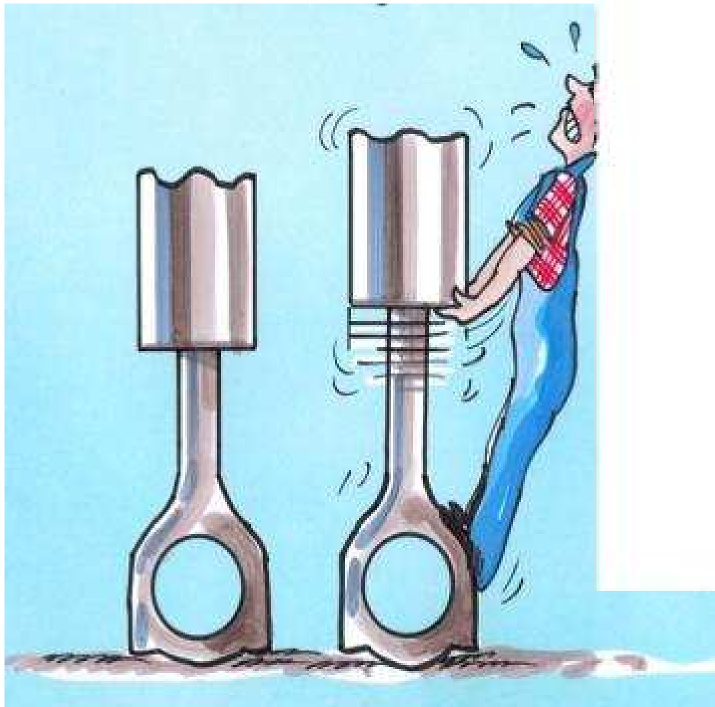
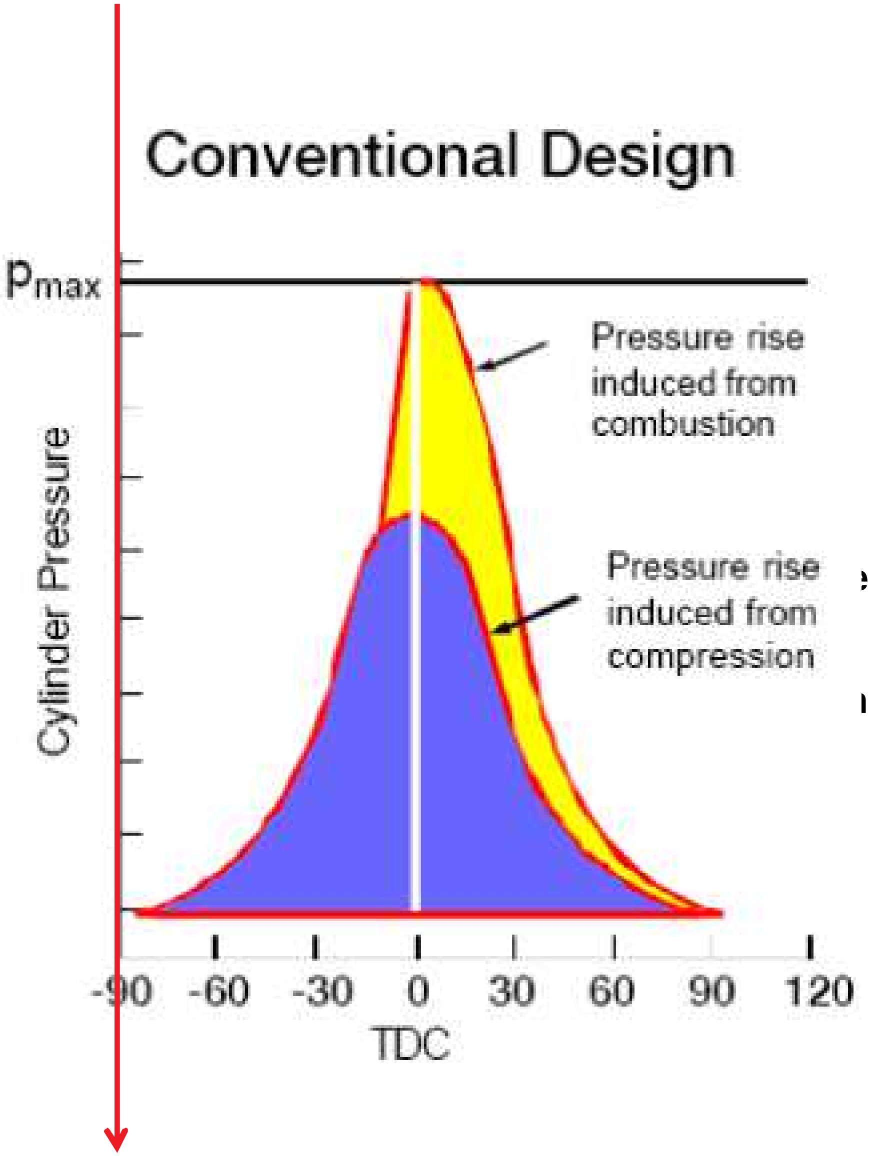
Primary NO_x Reduction Technologies

Dry Low NOx Technology

- Late fuel injection start
- High compression ratio
- Optimized combustion chamber
- Optimized Fuel Injection



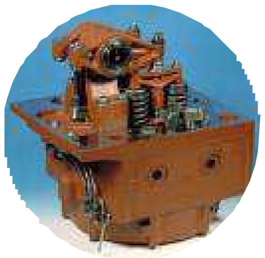


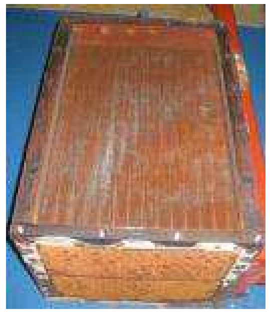
Dry Low NO_x Conversions

Components which may be effected on existing installations:







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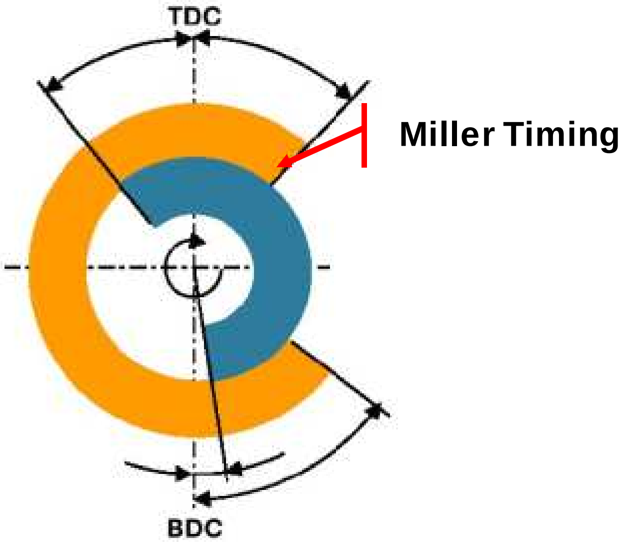
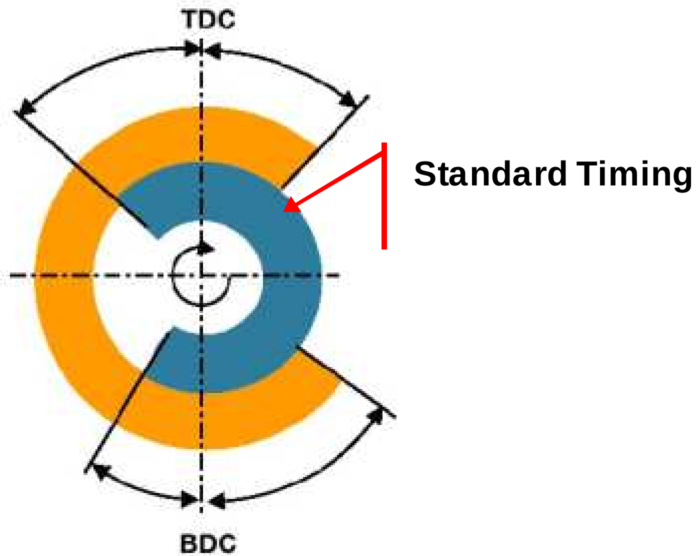
Dry Low NO_x reduction ; Miller timing, a "must"

Principles of Functioning



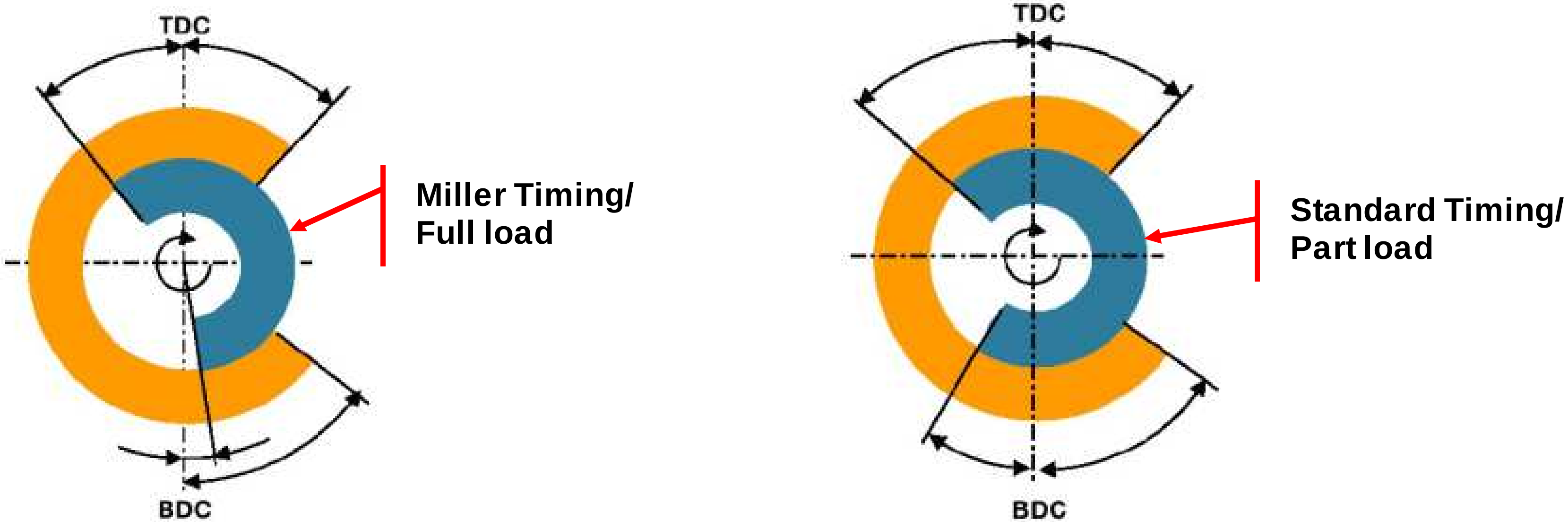


- Miller closes before BDC
  - Expansion aspirated air
    - Lower temperature
      - Lower NO_x level
        - Lower fuel consumption

BUT..

Dry Low NO_x reduction ; Miller timing

- In part load thermal load high
- Smoke.
- Variable Inlet Closing (VIC)



Delay in Inlet Valve Closing → Increase on air quantity and compression pressure → Better combustion process = **LESS SMOKE**

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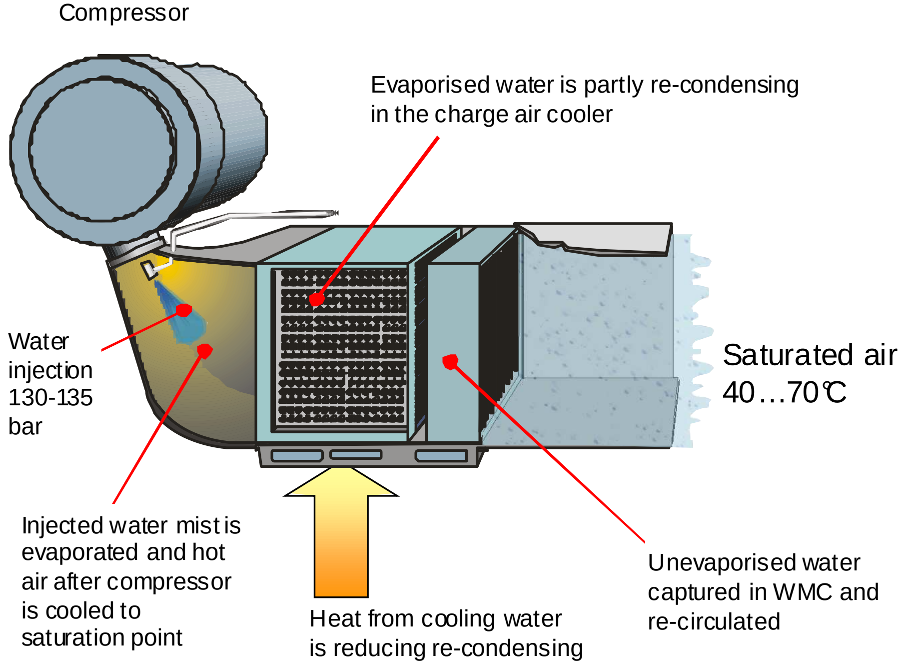
Wet Low NO_x Technologies

NOx reduction due to:

- ***Lower combustion air temperature*** through vaporization of the liquid water prior to and/or during combustion
- ***Increased heat capacity of the cylinder charge***, which reduces the temperature increase during combustion
- ***Dilution of oxygen concentration*** in the cylinder charge

Wetpac H (Humidification)

- Humidification of the combustion air by injecting (and evaporating) water after the turbocharger compressor
- NO_x reduction potential: 40%
- Water-to-Fuel ratio typically: 1.3
- Easy to control



- In general bad experience from the past.
- Mostly problems with corrosion
- 2010 Wetpac H concept updated
- Coating & Stainless parts.
- In operation for > 3000 hrs.
- A working solution!

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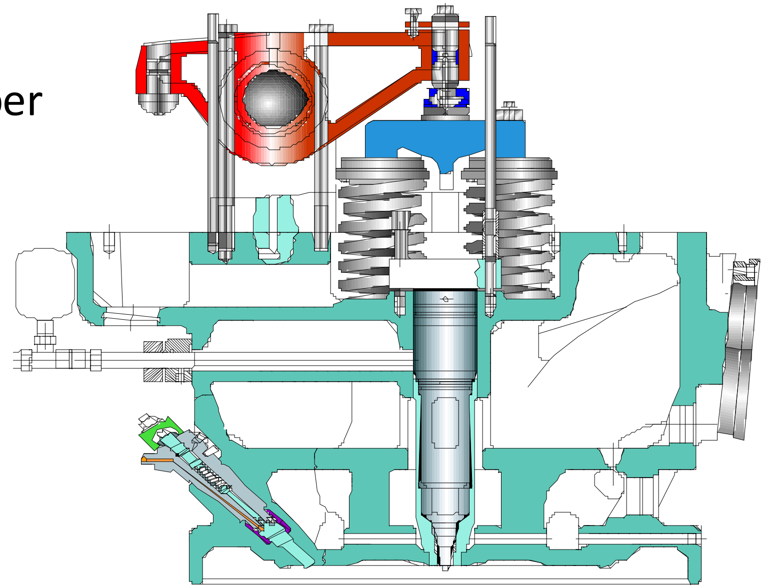
Wetpac DWI (Direct Water Injection)

- Water injection directly into combustion chamber
- NO_x reduction potential: up to 50%
- Water-to-Fuel ratio typically: 0.6



- In general good experience on LS HFO.
- Water quality!
- > 30,000 hrs. on single engine
- Coating piston crown and injectors.

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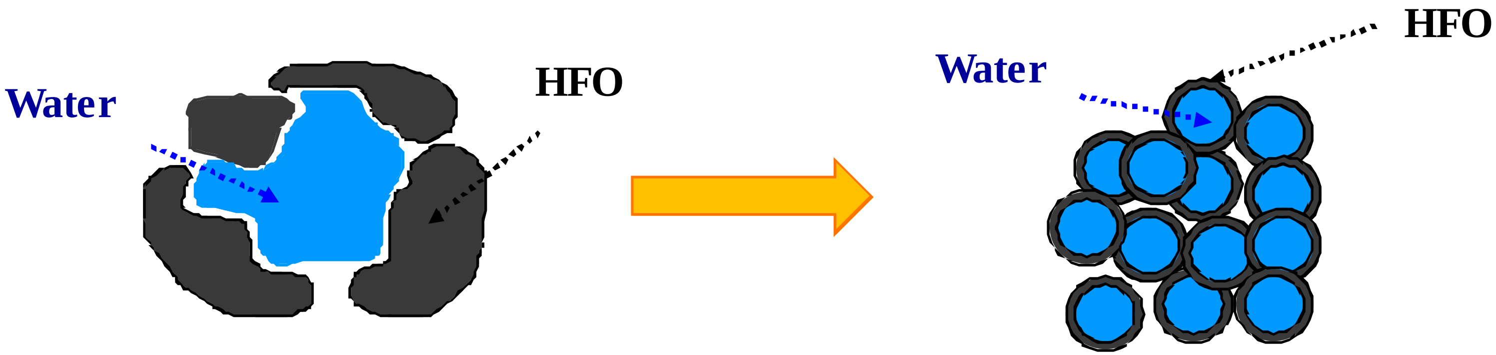
Wetpac E (Emulsion)



- Water-in-Fuel emulsion
- NOx reduction potential typically: up to 20%
- Water-to-Fuel ratio typically: 0.3
- Reduced smoke formation especially at low load
- Easy to adapt in relation to other alternatives

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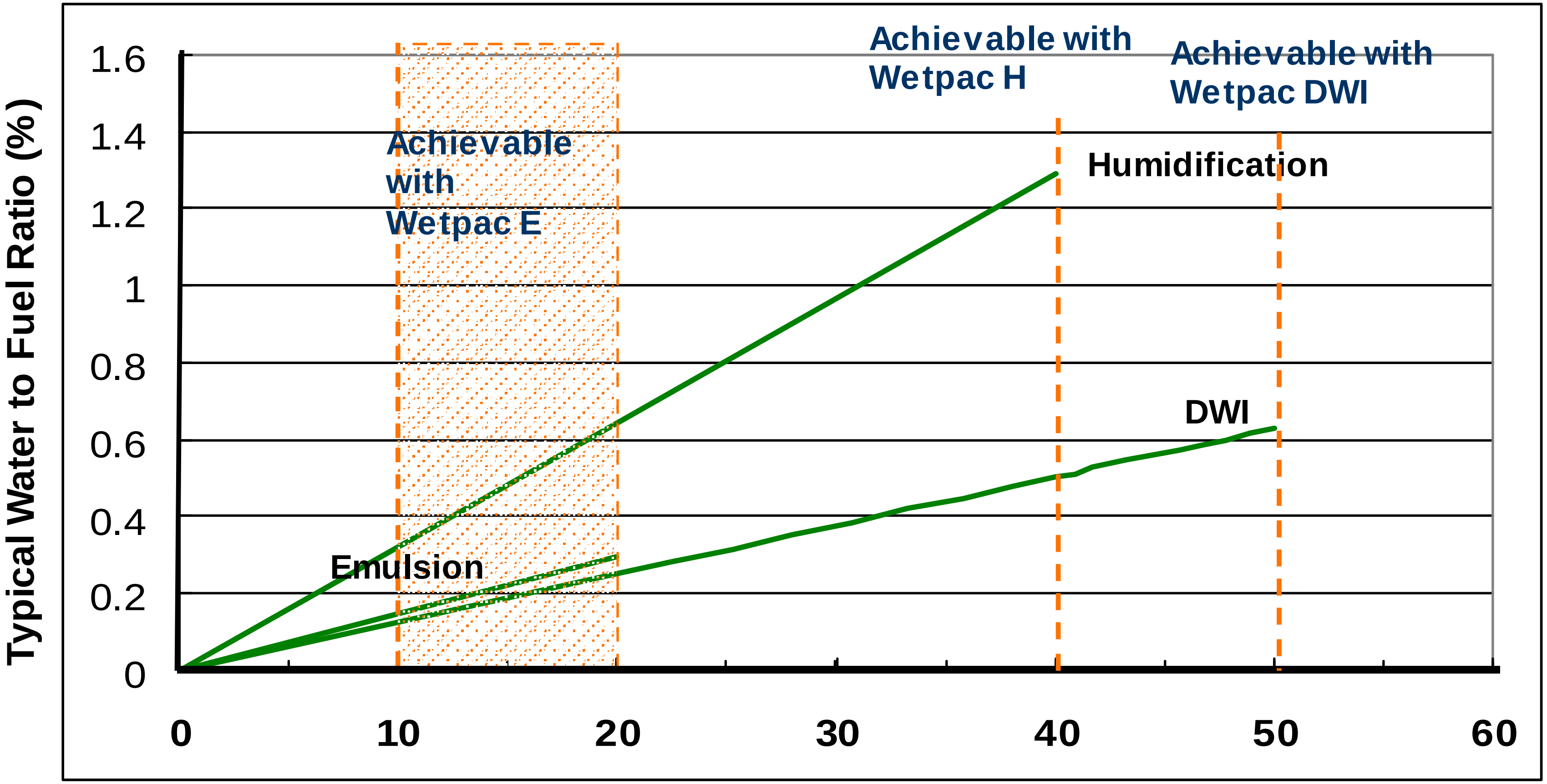
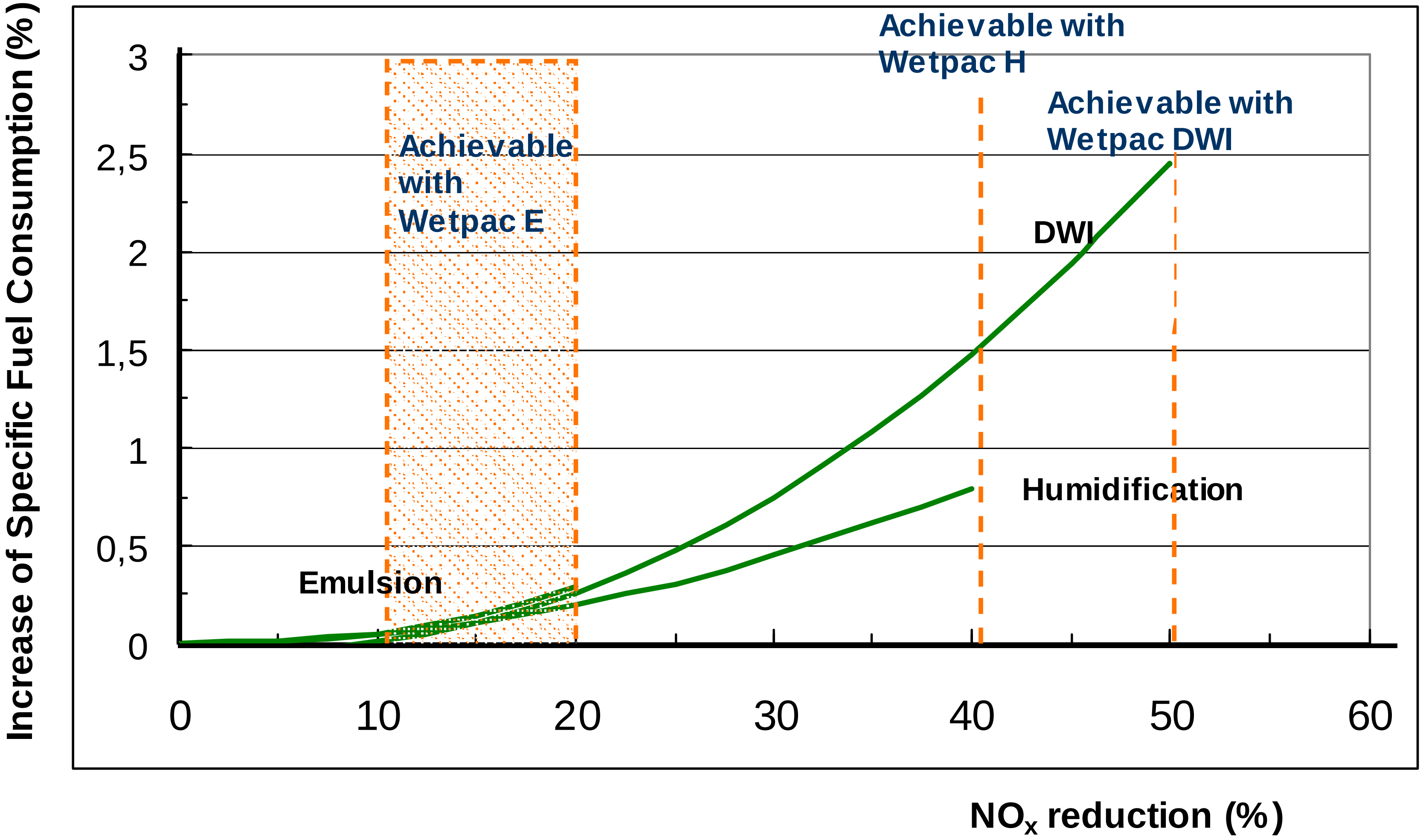
Wetpac – NO_x reduction potentials & typical water to fuel ratios



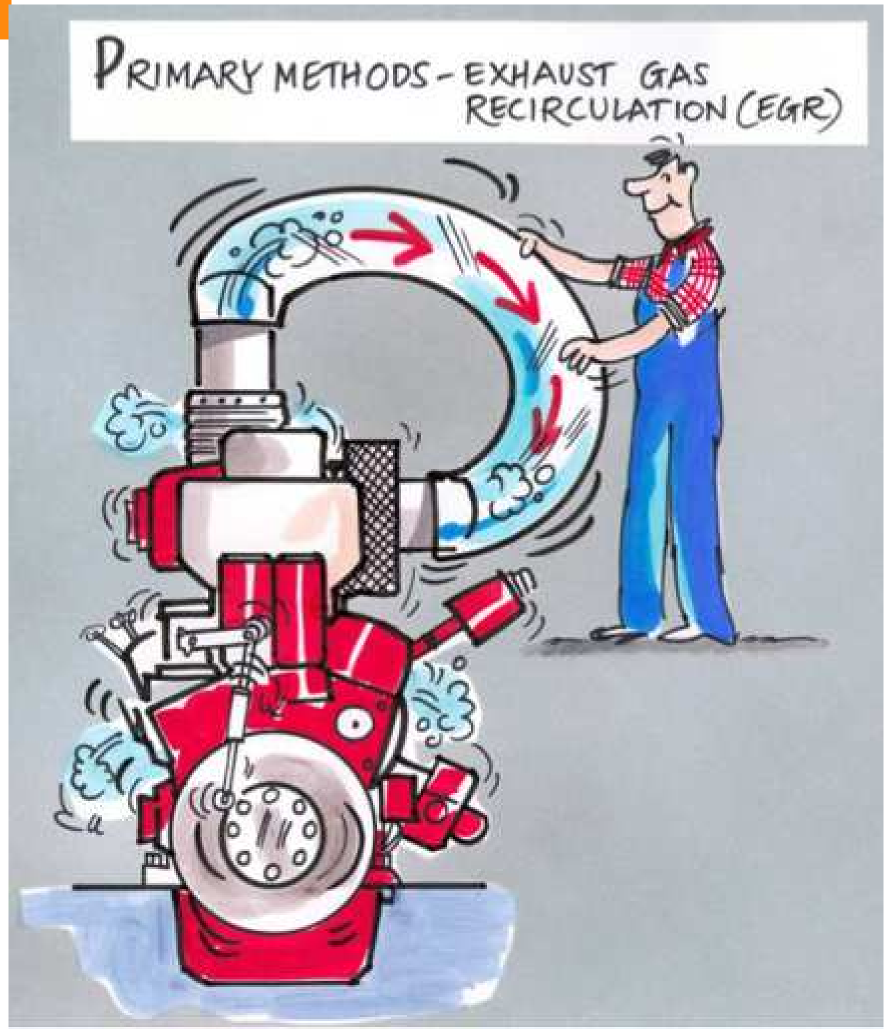
NO_x reduction (%)

Wetpac – NO_x reduction potentials & typical fuel consumption penalties



EGR – Exhaust Gas Recirculation

- A part of the exhaust gases is re-circulated into the combustion air.
- The O_2 concentration is lowered by diluting with exhaust gases.
- The exhaust gases are collected by the EGR pick-up and routed to a particulate filter.
- The wall flow cordierite particulate filter cleans the EGR gases.
- The system re-circulates cleaned and cooled exhaust gas into the turbocharger inlet.
- A potential of 35 – 50% NO_x reduction



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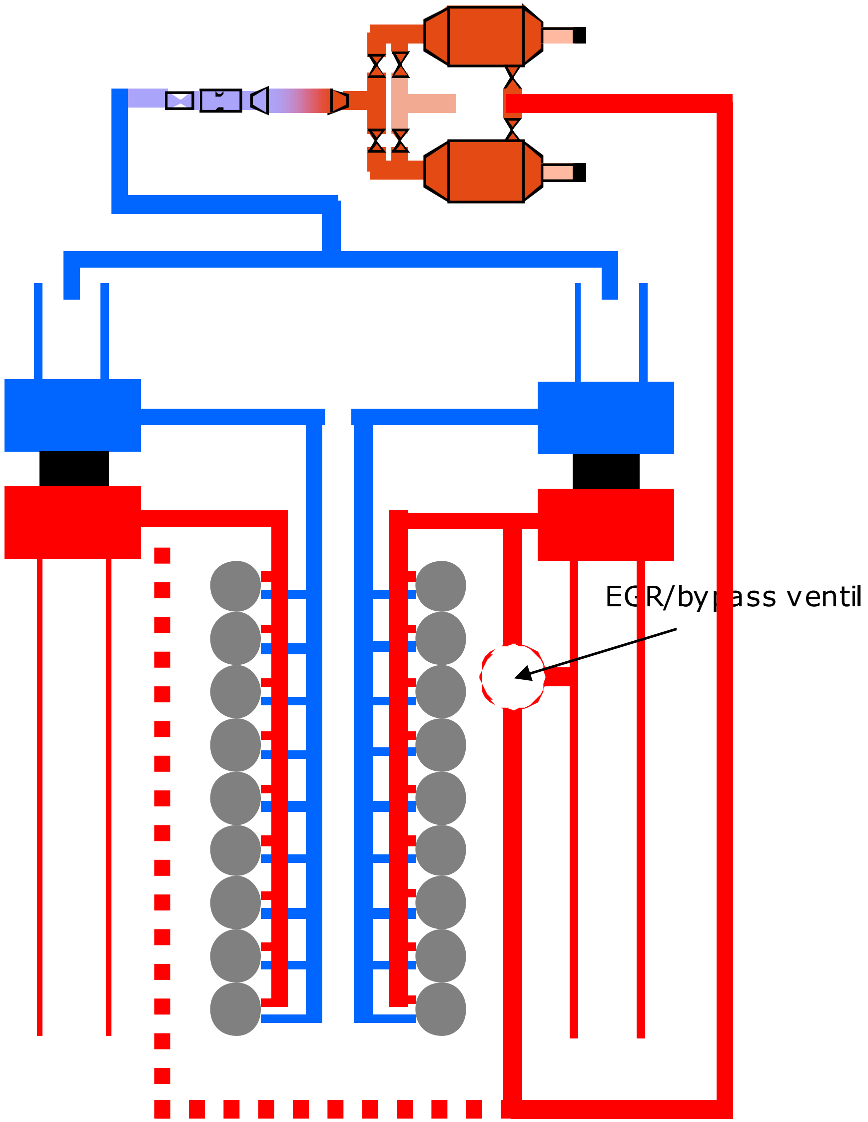
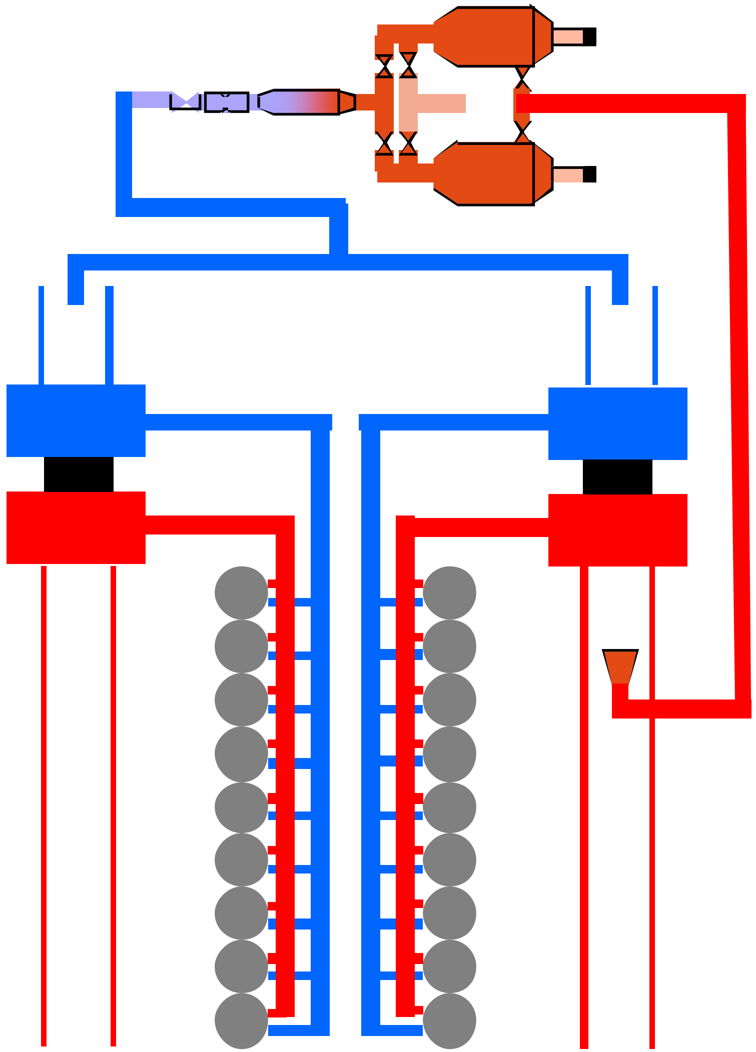
EGR system principle

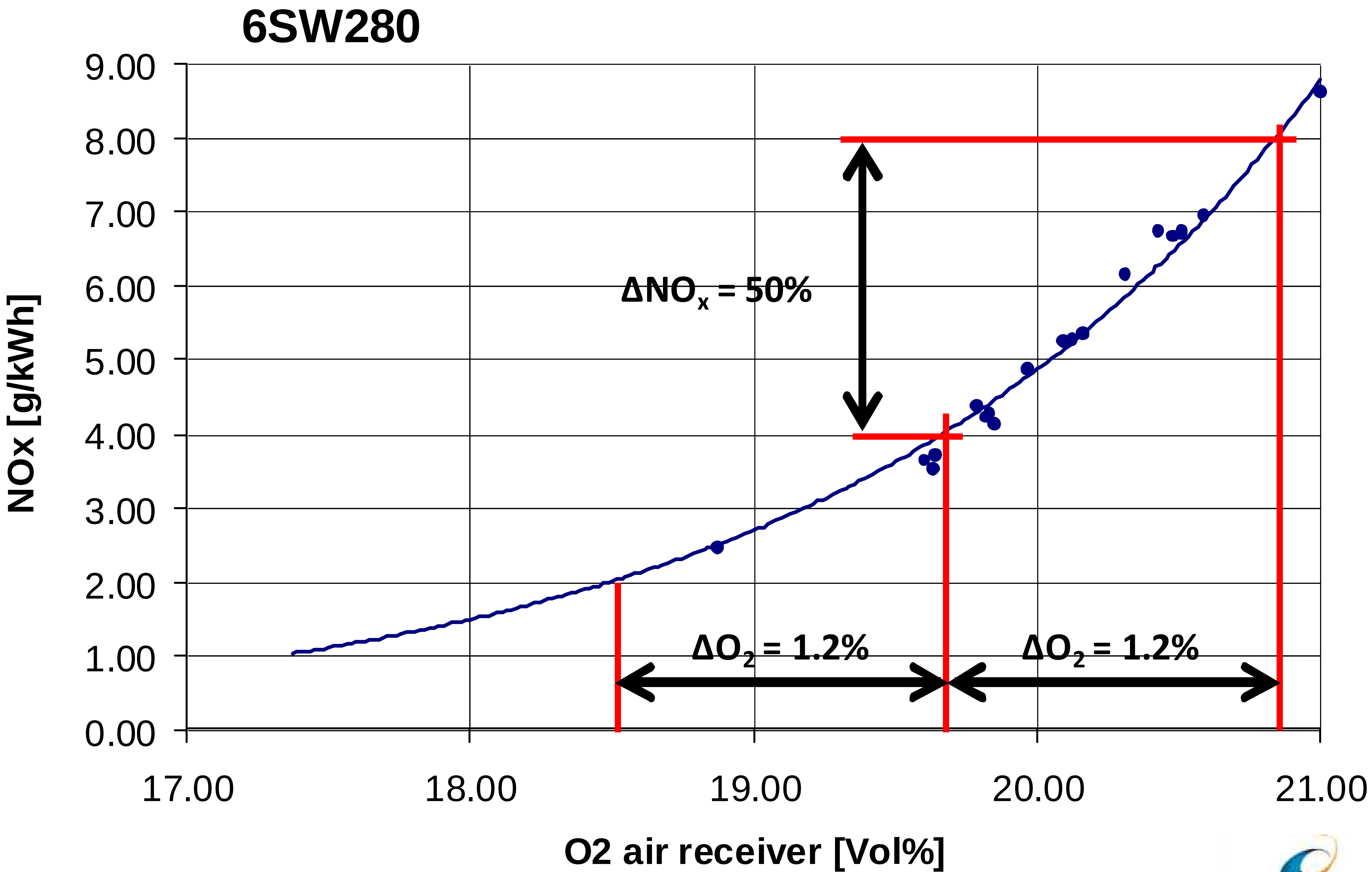
Cross route EGR



Long Route EGR
(Low Pressure EGR)



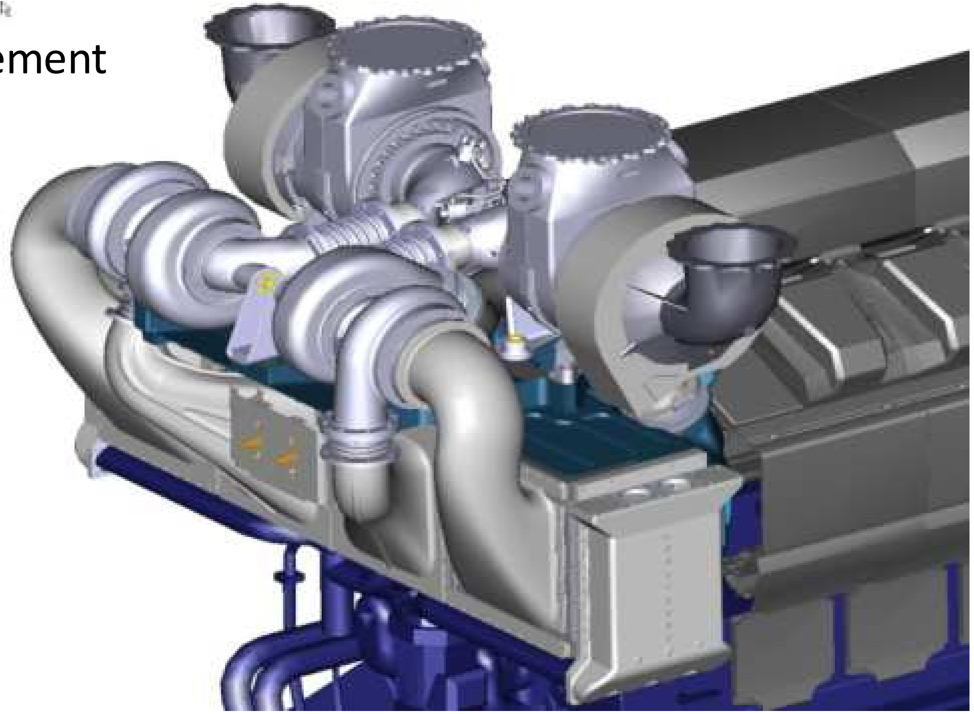
NO_x-Reduction on Intake O_2 Concentration



Development of Low NOx Engines – Future solutions

X-treme Miller timing requires

- High boost pressure & efficiency improvement
  - 2-stage turbo charging



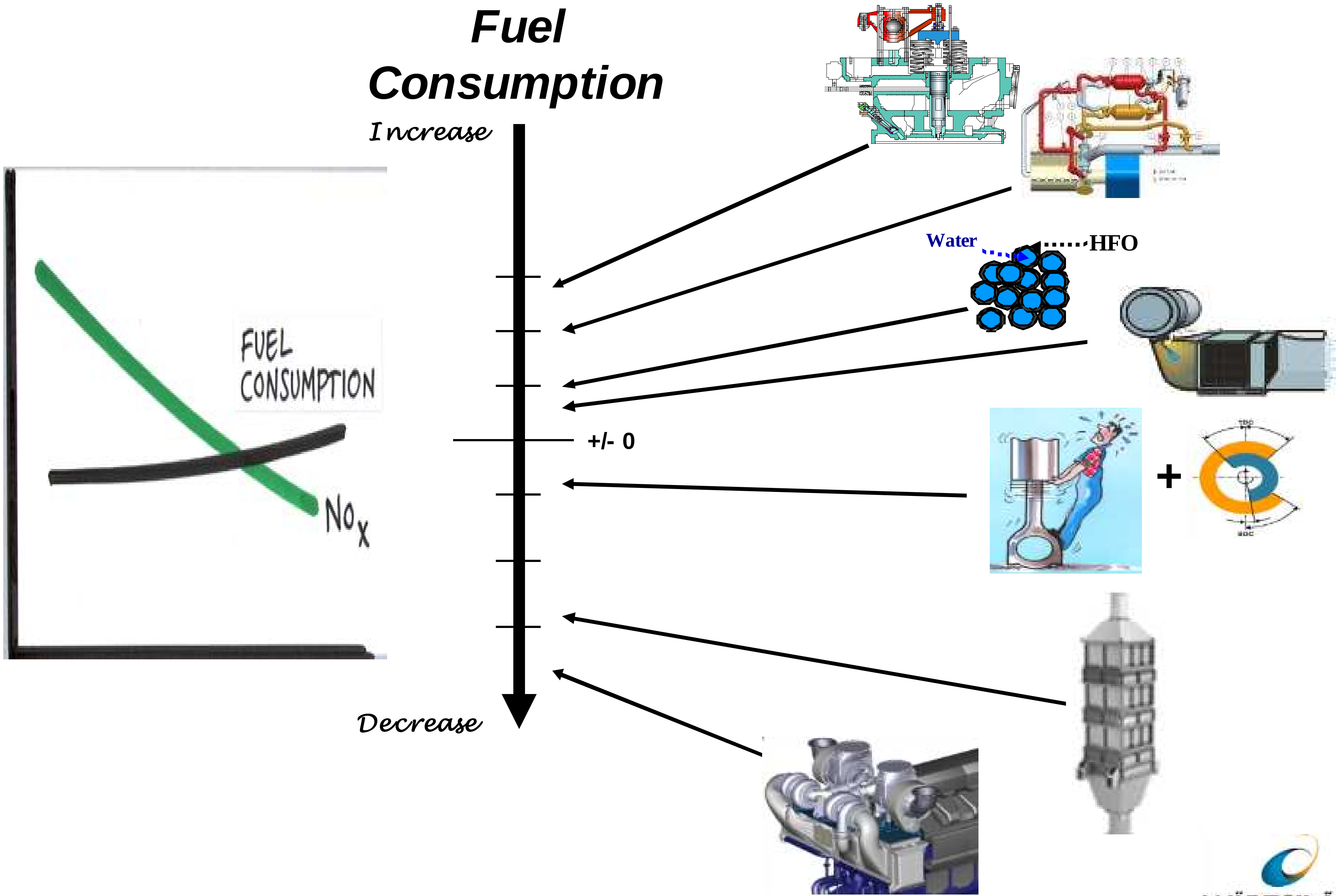
Concequences

- High maximum firing pressure
- Variable inlet valve timing
- Variable injection timing.

Tier 3

can be met with High boost pressure, either in combination with EGR or Wetpac or SCR.

Alterantive NOx Solutions – Fuel Consumption



WÄRTSILÄ


THANK YOU

Emission reduction technology

SootTech

TIER 3 Solutions

hme

SCHEEPSBOUW NEDERLAND

Hans van Burk
Peter Nijkrake

19-4-2012

Content

- Our organisation
- Why emission aftertreatment technology ?
- Reduction possibilities
- Design parameters
- Business case
- Conclusion
- References

Organigram

Hug Engineering AG

Switzerland

HANWEL

Environment & Energy

SootTech

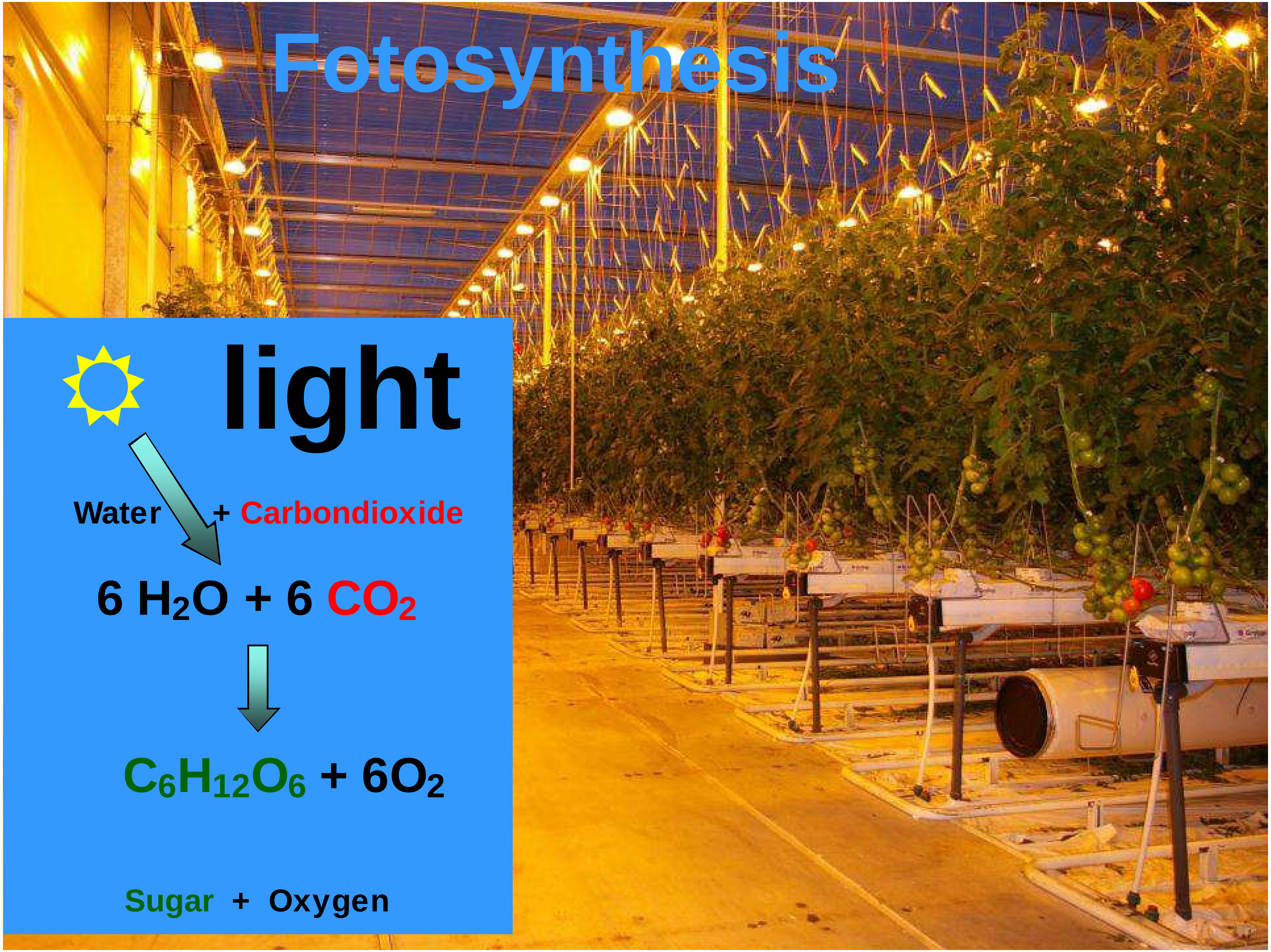
Roetfilter systemen voor dieselmotoren

Hanwel

HANWEL
Environment & Energy

Hanwel started in 1993 with sales and development of exhaust gas cleaning systems for CO_2 fertilization.

Installed base medio 2011 > 2700 MWe! (1500 units)



Fotosynthesis
light
Water + Carbondioxide
$6\ H_2O + 6\ CO_2$
$C_6H_{12}O_6 + 6O_2$
Sugar + Oxygen

Why emission after treatment?

SootTech

- Reduction of NOx,CO and HC-components (CHP in greenhouse industry)
- Port requirements → discount based on NOx reduction
- Green image (example AKZO Nobel, Arcelor Mittal, Bayer)
- Elimination soot production of diesel engines
- Emission requirements: engines **can not** meet the global emission requirements in the future without aftertreatment.

Diesel engine balance

SootTech

1 Kilowatt hour (kWh) mechanical effective energy

requires

200 g Fuel
6,4 kg Air

produces

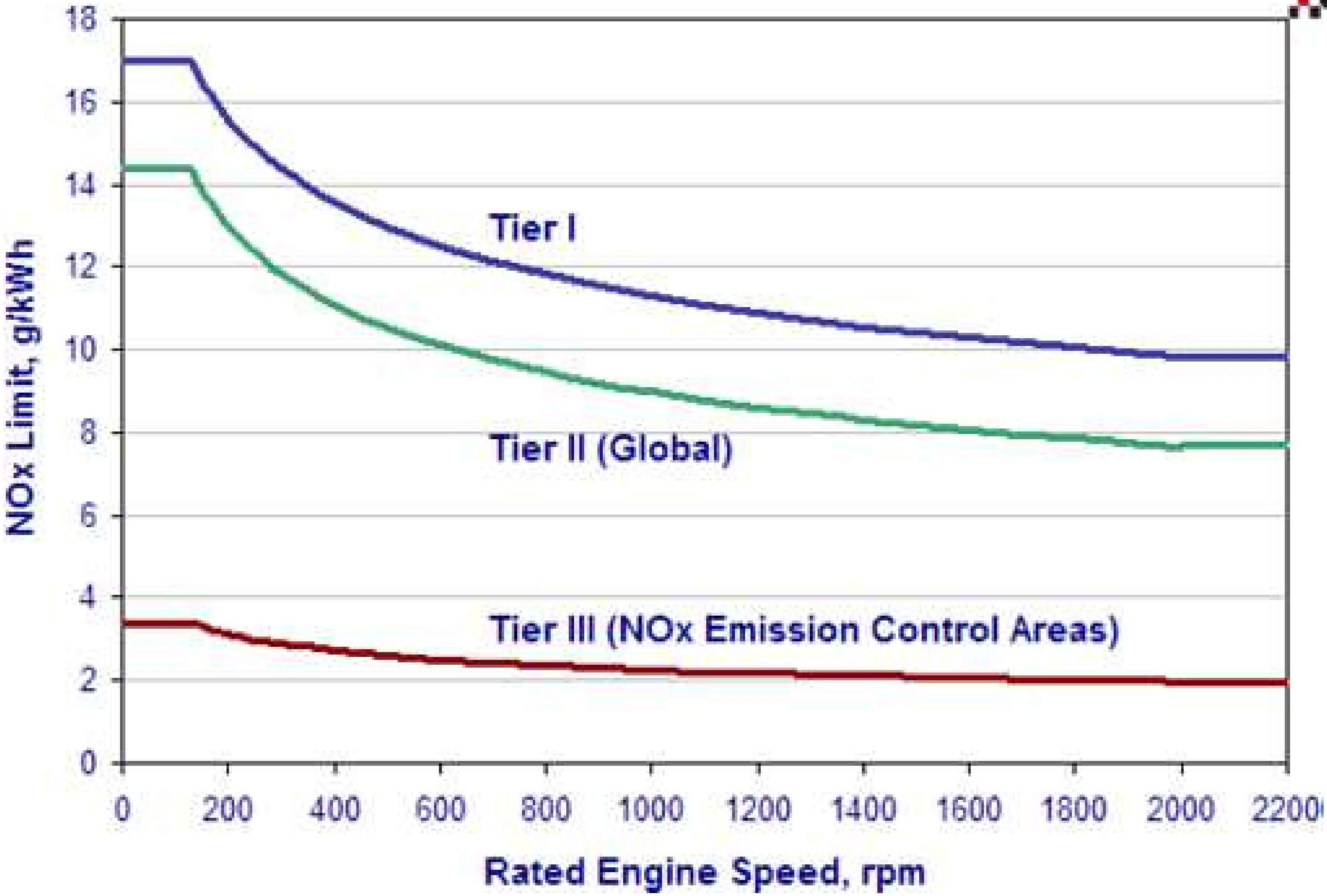
1,3 kWh waste heat
6,6 kg Exhaust gas, thereof:

250 g	Water H_2O
630 g	Carbon dioxides CO_2
7 g	Nitrogen oxides NO_x
1 g	Carbon monoxides CO
0,2 g	Hydro carbons HC
0,15 g	Soot particulates PM
0,03 g	Sulphur oxides SO_x

Harmful exhaust gas components

	Effects on humans	Effects on environment
carbon dioxides CO_2 →	suffocating →	greenhouse effect, acidification
nitrogen oxides NO_x →	neurotoxin →	ozone precursor
carbon monoxides CO →	blood poison →	-
hydro carbons HC →	carcinogenic →	smog precursor
soot particles PM →	carcinogenic →	big greenhouse effect
sulphur oxides SO_x →	acid →	acidification

Why emission after treatment?



NOx Emission standards

MARPOL Annex VI:

TIER	Date	NOx Limit g/kWh		
		n <130	130 ≤ n < 2000	n ≥ 2000
TIER I	2000	17,0	$45 \cdot n^{-0,2}$	9,8
TIER II	2011	14,4	$44 \cdot n^{-0,23}$	7,7
TIER III*	2016	3,4	$9 \cdot n^{-0,2}$	1,96

*) In NOx Emission Control Areas (Tier II standards apply outside ECAs).

Emission Control Areas

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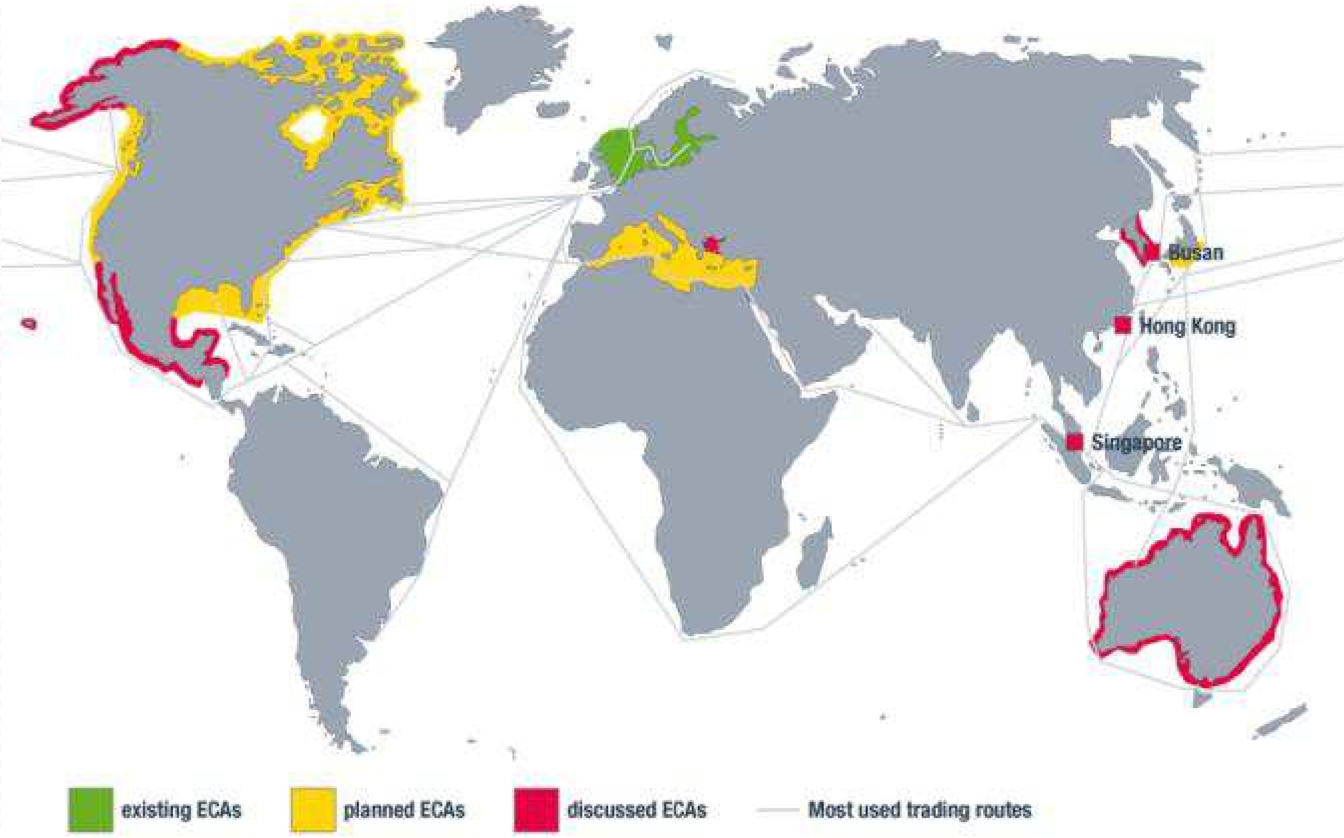
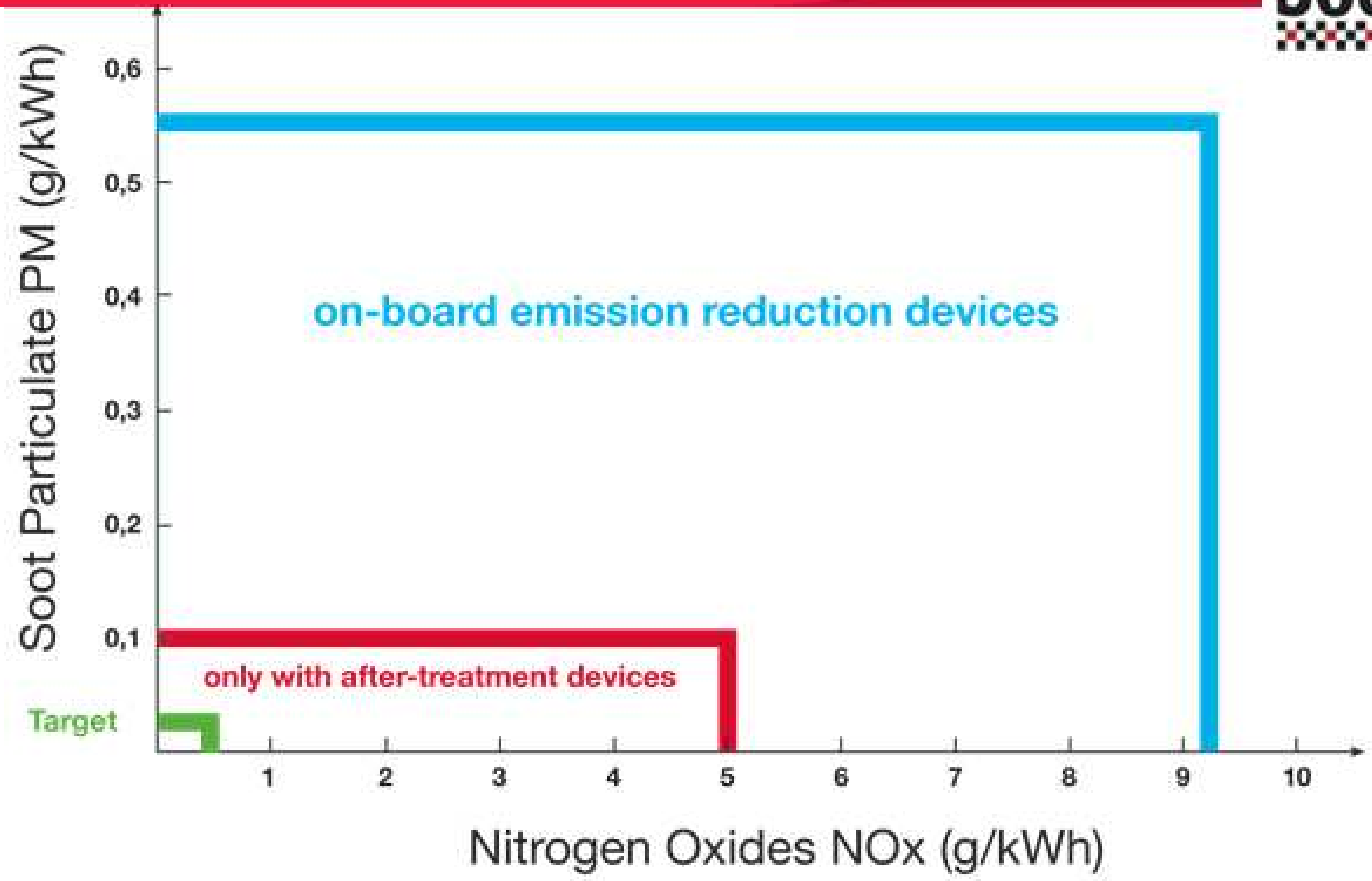


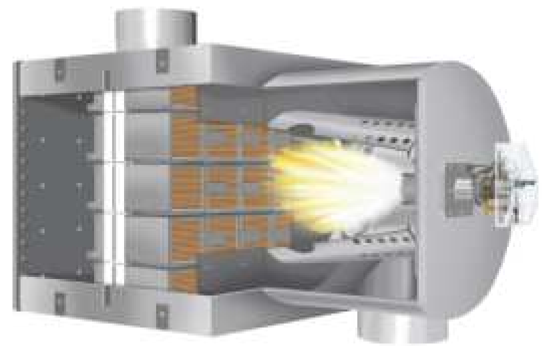
Why emission aftertreatment?



Emission reduction with nauticlean®

Available reduction technics:

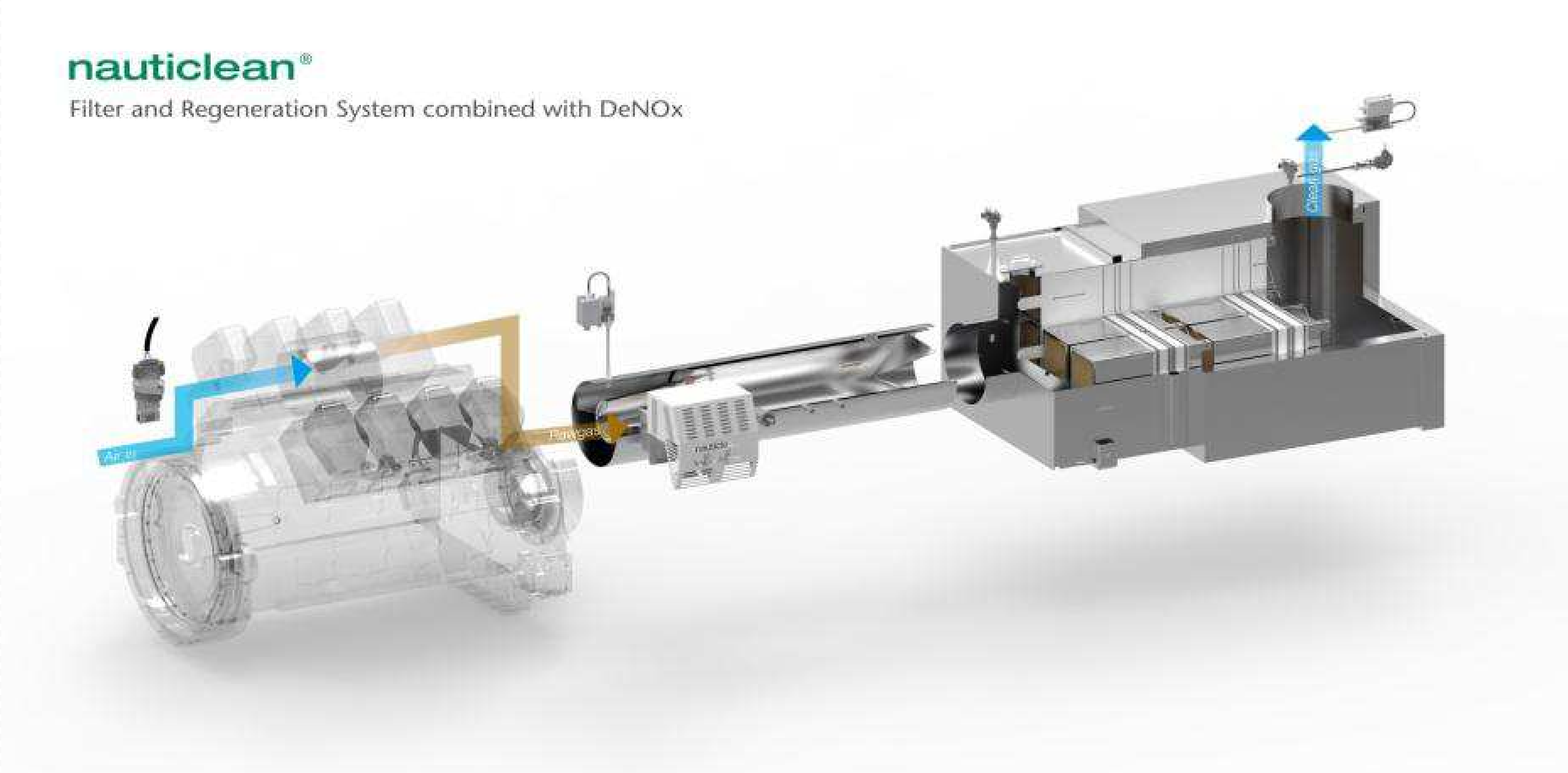
PM	> 97%
NO_X	> 80%
CO	> 70%
HC	> 70%



We are ready for all future requirements!

Emission reduction with nauticlean®

SootTech



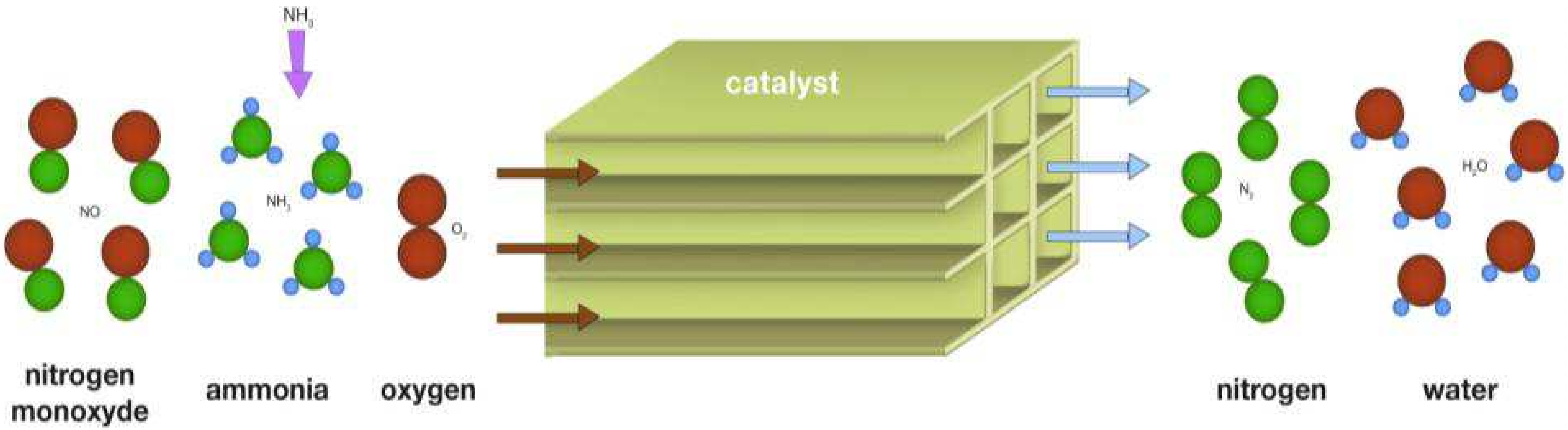
Urea – NH_3 conversion

SootTech

Urea Hydrolization

$$NH_2\,CO\,NH_2 + H_2O \xrightarrow{\text{hydrolization}} 2NH_3 + CO_2$$

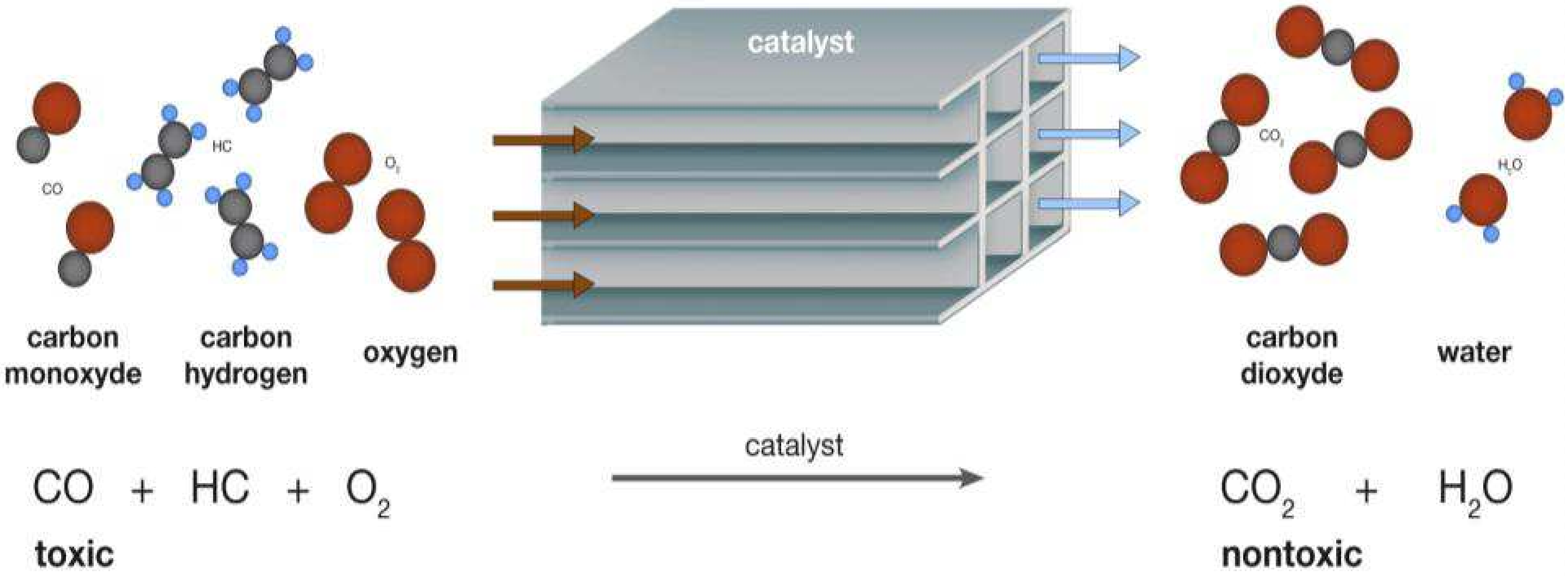
SCR – Selective Catalytic Reduction



$$4\,NO + 4\,NH_3 + 0_2 \xrightarrow{\text{catalyst}} 4\,N_2 + 6\,H_2\,0$$

toxic **nontoxic**

Catalytic oxidation of HC, CO and NH_3



Design parameters SCR technology

- Maximum allowable backpressure engine
- Fuel type (MDO, HFO, S content)
- Lubrication oil type and consumption
- Available space
- NOx-reduction requirements
- Exhaust gas temperatures (load factor)

Critical parameters SCR technology

- Available space, tank for urea is needed!
  - Urea consumption is 5-7% of fuel consumption @ 32,5% urea-water solution (AdBlue)
- When oxidation catalyst is installed: The max. S content in the fuel is 50 ppm
- Global availability of urea

Global availability of urea 2012

Source: yara

Business case

SootTech

input example:

- MTU 16V4000M93L (3440 kW)
- n = 2100 1/min
- Reduction IMO TIER II → IMO TIER III
  - Reduction NOx: 7,7 g/kWh → 1,98 g/kWh (approx. 75%)

Cummins pon CAT mtu WÄRTSILÄ

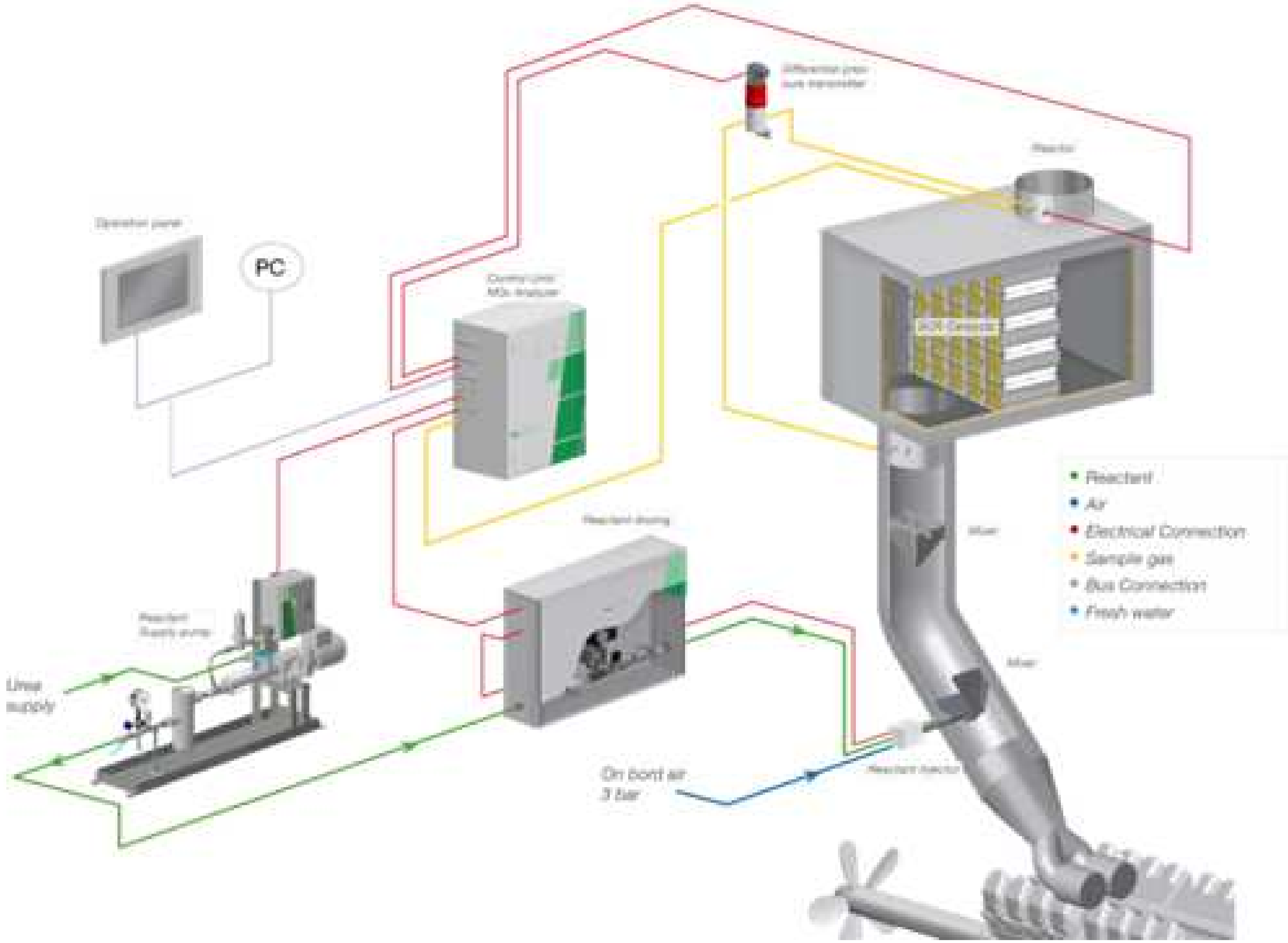
Business case NOx reduction

SootTech

Proposal:

• Type of converter	: FEN42.520
• NOx “clean”	: 1,8 gr/kWh
• Pressure drop	: 25 mbar (full load)
• Dimensions reactor (LxWxH)	: 1450 x 1560 x 1360 mm
• Weight	: 1800 kg
• Length of mixing pipe	: 2300 mm
• Urea consumption (32.5%)	: approx. 65 l/h

Business case NOx reduction



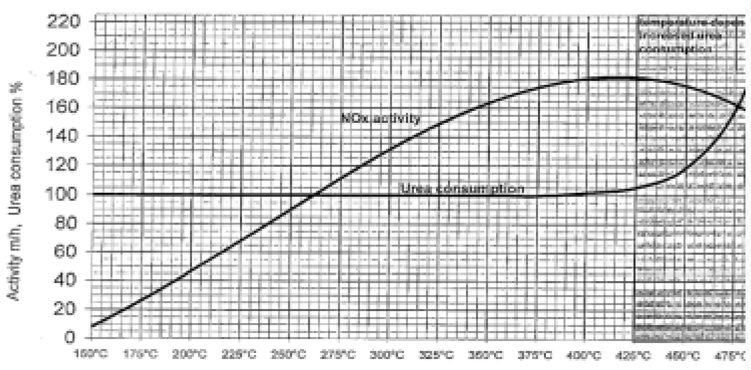
Conclusion

- Size of reactor is depending on:

  - Allowable backpressure engine
  - Pitch of SCR material and activity*
  - Reduction requirement

} Equilibrium

- Depending on exhaust gas temperatures



Conclusion

- To comply with IMO TIER III has a serious impact on ships:
  - Size and weight equipment
  - Urea storage /consumption

- Global availability of urea is not clear yet

Some references inland vessels

SootTech


Reductions:

PM > 97%
NOx > 85%
CO > 70%
HC > 70%


MS Victoria	MS Jacob Hessel
MS Wending	MS Anna
MS Syracusa	MS Ortygia
MS Linda	MS Onderneming
MS Shalimar	MS Oural
MS Cofelica	MS Onderneming IV
MS Antonie	MS Tanja Deymann
MS Corrado	MS Marina

Some references public authorities

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Reductions:

PM > 97%
NOx > 85%
CO > 70%
HC > 70%

References on yachts

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Reduction:

PM > 97%

Soot reduction on gensets

Thank you for your attention

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Fax 0031-53- 4882121
verkoop@soottech.nl
www.soottech.nl

Royal Wagenborg

SCR Experience – Platform Scheepsemissies

Content

- Introduction Royal Wagenborg
- Upcoming regulations
- SCR Installation onboard
- Process, measurement, rebate
- Operations and costs

Royal Wagenborg

Our company...

- serves clients since 1898
- is 100% privately owned
- provides integrated logistic solutions
- works with state of the art equipment
- employs 3000 people

Our people…

- focus on solutions
- are dedicated and experienced
- have passion for the job
- don’t know the word impossible

Wagenborg Nedlift

- Crane rental (Benelux and Germany)
- Heavy transport and logistic management
- Turnkey heavy transport and lifting projects
- Factory-to-foundation projects with 100% Wagenborg resources
- Engineering and project management





Wagenborg Passenger Services

- Almost 10,000 departures a year
- 1.8 million passengers a year
- 5 ferries sailing to the Dutch isles, Ameland & Schiermonnikoog
- 3 High speed Water taxis operating in the Dutch Northern Coastal waters

Reining

- Integrated solutions: transport, warehousing and distribution
- 320 vehicles
- Warehousing 100,000 m^2
- 4 European branche offices in the Netherlands and in Hungary
- Intermodal solutions
- Real-time information throughout supply chain

Wagenborg Offshore

Area of operations

- Worldwide
- Focus on activities in former CIS and Caspian Sea

Activities in the Oil- & Gas industry

- Operator and owner of vessels, rigging- and hydraulic piling equipment
- Rig move-, Inspection-, Management- and Consultant activities
- Commissioning of offshore structures and assembly of new drilling rigs

Wagenborg Shipping

Area of operations

- Worldwide
- Focus on activities in Europe, Middle East and Americas

Activities in the Multi Purpose Shipping Segment

- Operator and owner of vessels
- Commercial and technical operations
- Crewing
- Sale & purchase
- Insurance
- Projects and Newbuilding

Wagenborg Shipping

- 180 modern multi-purpose vessels ranging from 2.000 to 22.000 tons, mostly fully ice-classed, geared and gearless
- One of the largest ship owners in Europe by number of vessels
- Youngest fleet in Europe with an average age of 6.2 years due to continuous new building program
- Seamless access to the entire logistic chain through close cooperation with other Wagenborg companies
- More than 150,000 m2 of high quality storage facilities

Wagenborg Shipping

•Spaarne-/ Schie-/ Slingeborg

1. SCR on two stroke main diesel engine
2. Zero Dumping
3. Closed water lubricated propeller shaft
4. Low solvent paint system
5. 6 kV Shore connection
6. Waste management system

•In operation since 1999.

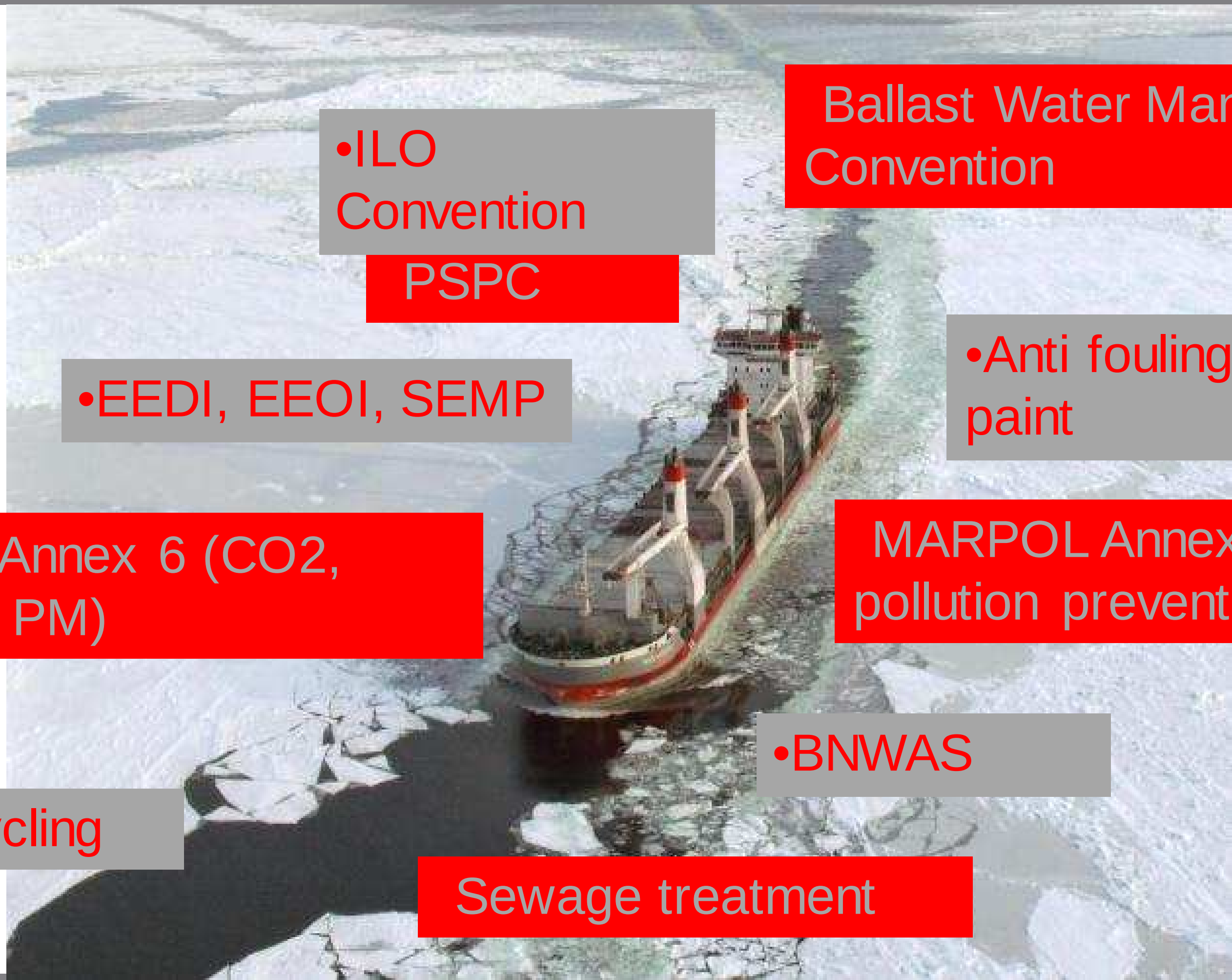
Wagenborg Shipping

•Baltic-/ Bothniaborg

1. 6 kV Shore connection
2. SCR
3. Environmental friendly propeller shaft seals
4. Zero Dumping
5. Ballast Water Treatment
6. Environmental Design Review

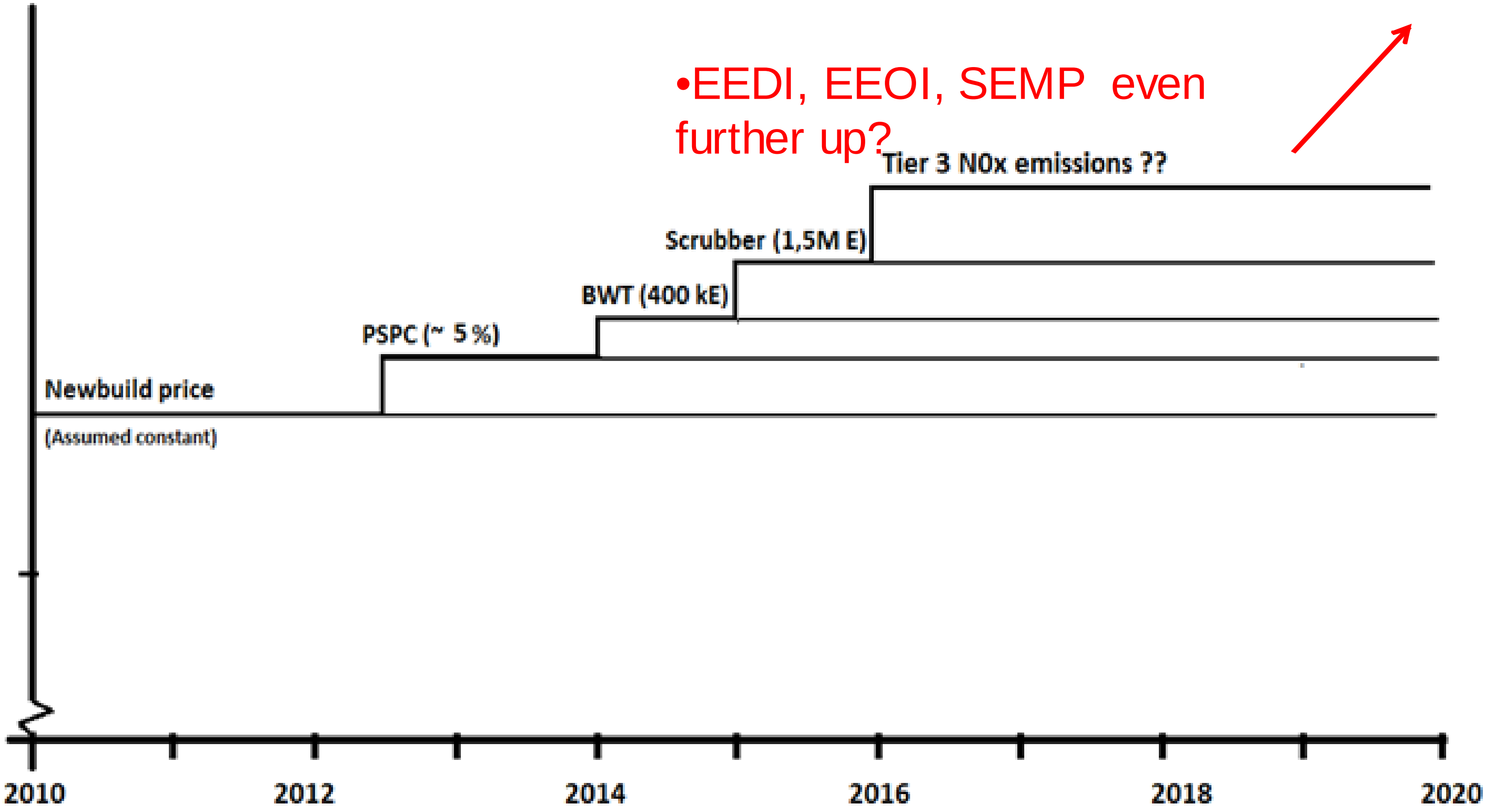
•In operation since 2004.

Upcoming Regulations



- Ballast Water Management Convention
- •ILO Convention
- PSPC
- •Anti fouling paint
- •EEDI, EEOI, SEMP
- MARPOL Annex 6 (CO_2, NO_x, SO_x, PM)
- MARPOL Annex 1 (oil-pollution prevention)
- •BNWAS
- •Ship recycling
- Sewage treatment

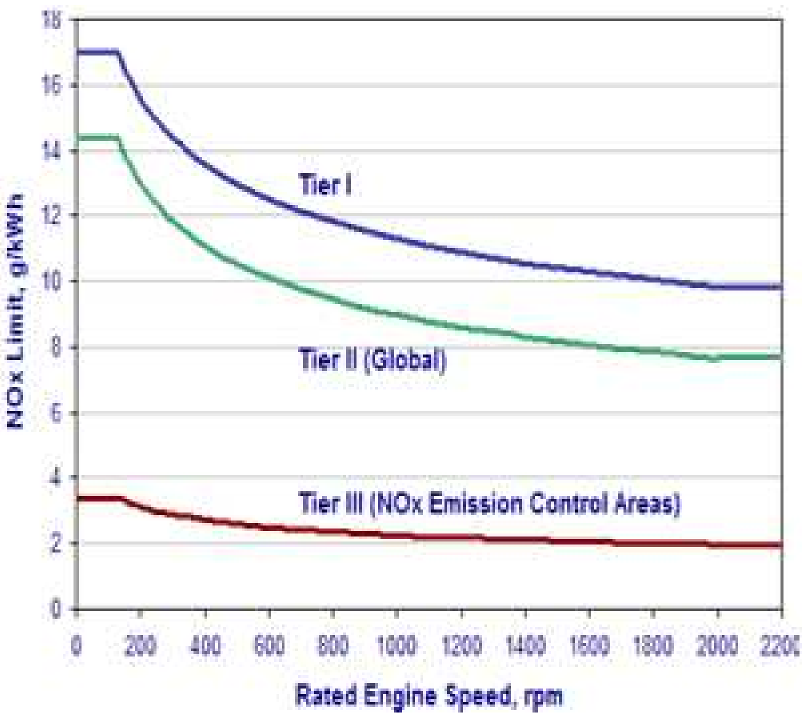
Effect of Upcoming Regulations



Marpol Annex VI NOX Emission limits

Table 1. MARPOL Annex VI NOx Emission Limits				
Tier	Date	NOx Limit, g/kWh		
		n < 130	130 ≤ n < 2000	n ≥ 2000
Tier I	2000	17.0	$45 \cdot n^{-0.2}$	9.8
Tier II	2011	14.4	$44 \cdot n^{-0.23}$	7.7
Tier III	2016†	3.4	$9 \cdot n^{-0.2}$	1.96
† In NOx Emission Control Areas (Tier II standards apply				

•**Table 1.** MARPOL Annex VI NOx Emission Limits

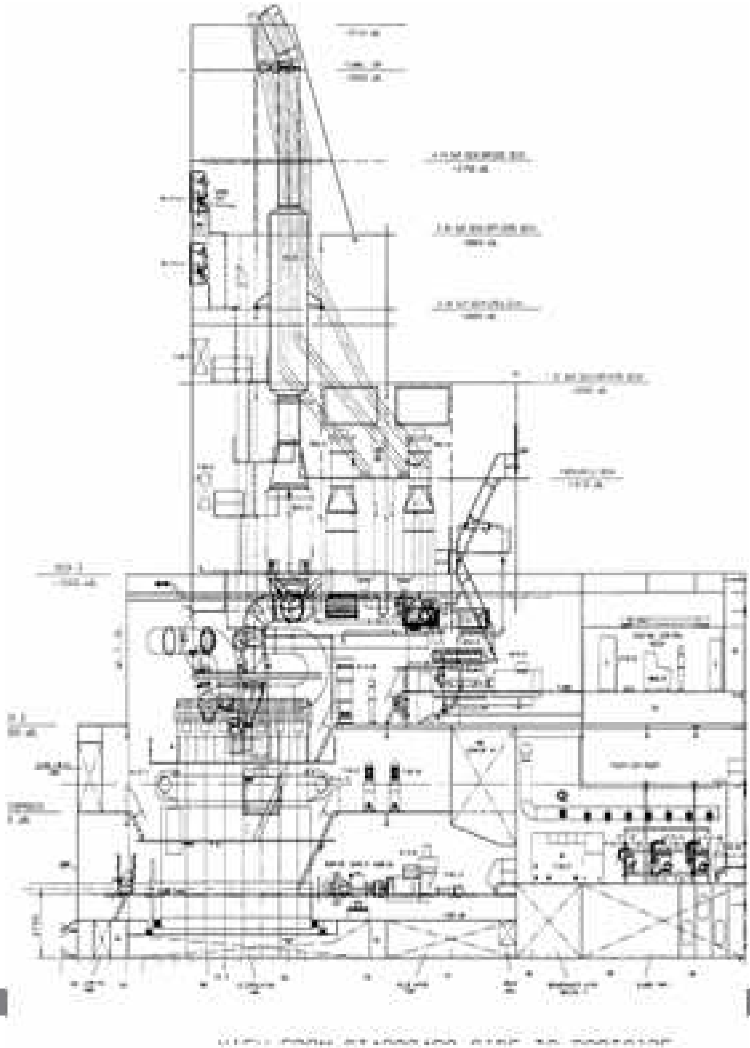


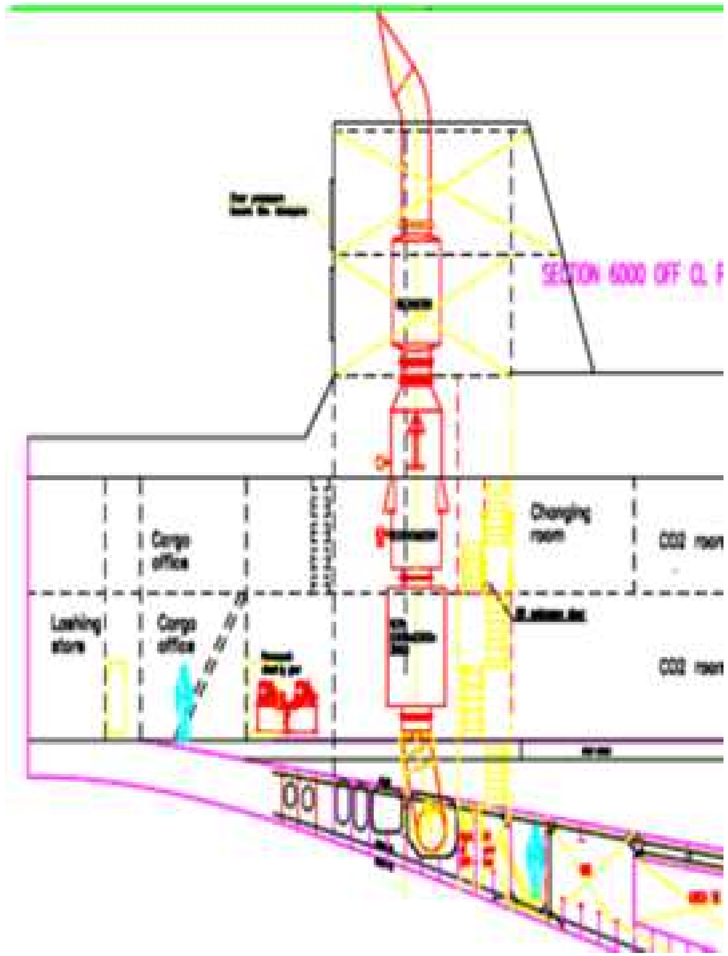
•**Figure 1**. MARPOL Annex VI NOx Emission Limits

Technical specifications

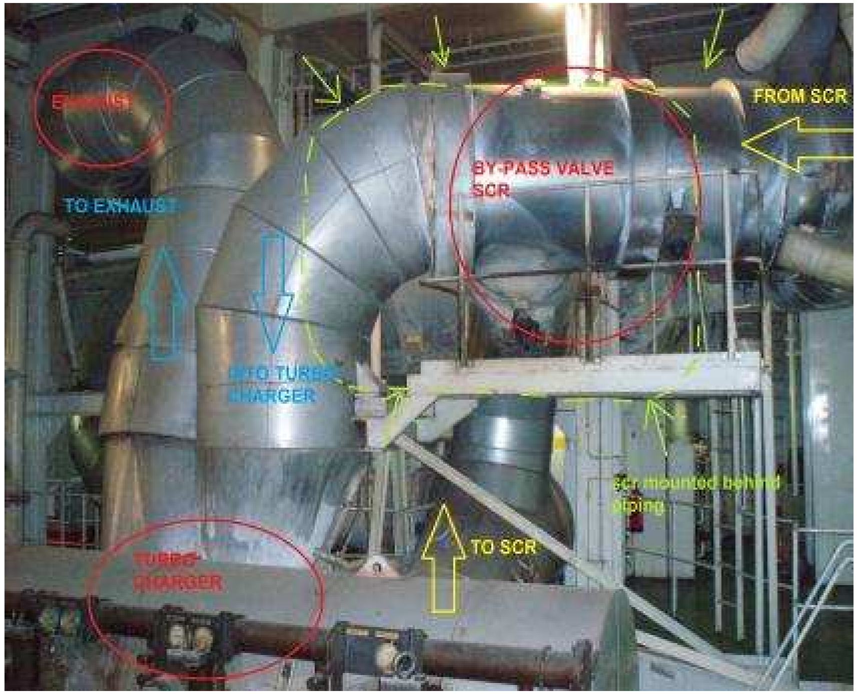
Engine / SCR data	B-Series	S-Series
Engine Make/type	Wartsila 7RTA52U	Wartsila 9L46C
Power at MCR	10.920kW	9.450kW
Exhaust gas flow	89.544kg/h	59.400kg/h
Exhaust gas press.	3,2bar	1,0bar
Exhaust gas temp.	430°C (385°C at 75%MCR)	365°C (330°C at 75%MCR)
SCR Make/type	ABB 147H/PT	Munters 196V
Size (lxwd)/weight		4.000x2.400x2.400mm. (9.500kg)
NOx baseline at 75%MCR	17,0g/kWh	13,0g/kWh
NOx performance at 75%MCR	2,0g/kWh	2,0g/kWh
Urea consumption	191 l/h	120 l/h

Schematic installation onboard





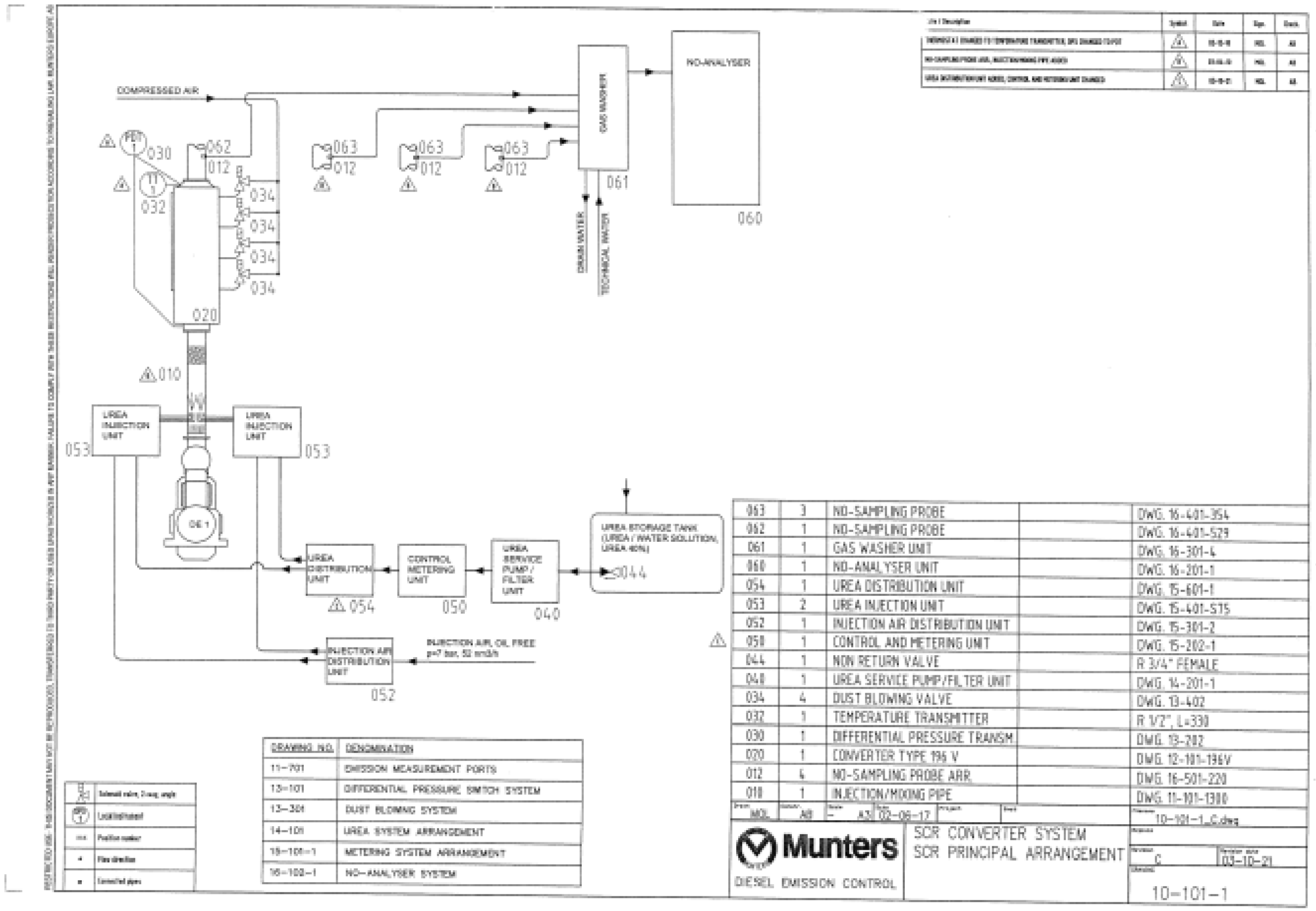
SCR



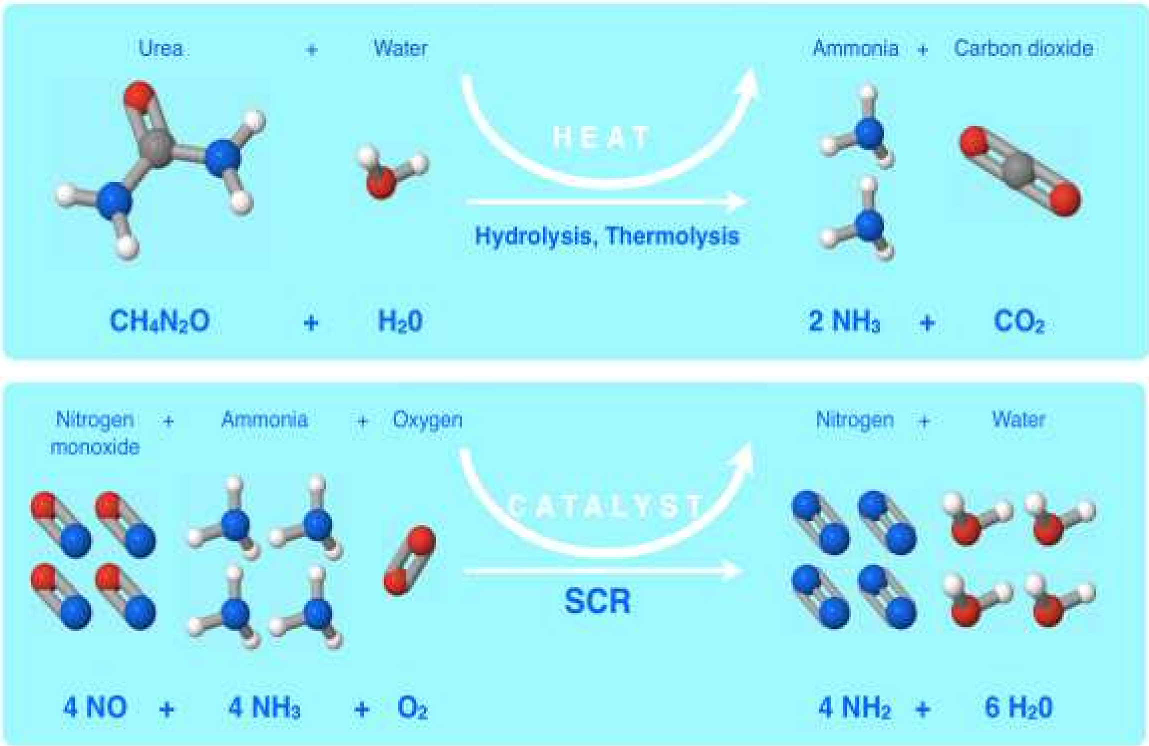
Exhaust gas system S-series

Internals SCR B-series

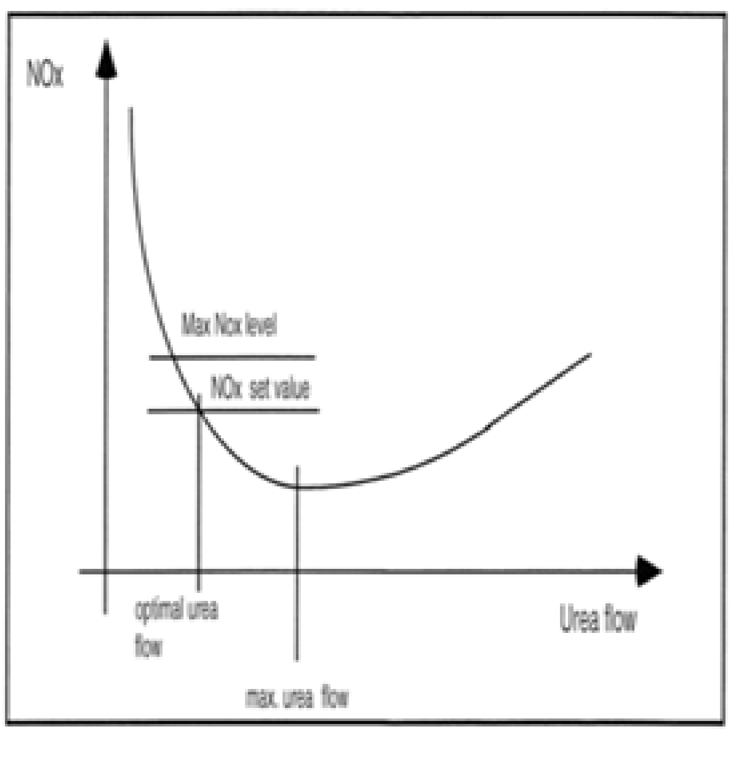
SCR Schematic



SCR Process



Urea + Water
HEAT
Hydrolysis, Thermolysis
Ammonia + Carbon dioxide
CH_4N_2O + H_20
$2 NH_3$ + CO_2
Nitrogen monoxide + Ammonia + Oxygen
CATALYST
SCR
Nitrogen + Water
$4 NO$ + $4 NH_3$ + O_2
$4 NH_2$ + $6 H_20$



NOx
Max Nox level
NOx set value
optimal urea flow
max. urea flow
Urea flow

Urea product specification

DEC Marine	**SPECIFICATION SHEET** For 40% Urea Solution	Doc.No: DEC 920 Date: 2007-10-09 Sheet no: 1 (1)

Chemical name: Urea Solution

Molecular Formula: $(H_2N)_2CO + H_2O$

Physical Properties: Absolutely Clear (Visual Inspection)
Odourless

Analytic Specification:			
Urea Concentration		Percent by Weight	40 ± 1
Biuret		Percent by Weight	< 0.3
Aldehyde		mg / kg	< 5
Insoluble		mg / kg	< 20
Phosphate	PO_4	mg / kg	< 0.5
Calcium	Ca	mg / kg	< 0.5
Iron	Fe	mg / kg	< 0.5
Copper	Cu	mg / kg	< 0.2
Zinc	Zn	mg / kg	< 0.2
Chromium	Cr	mg / kg	< 0.2
Nickel	Ni	mg / kg	< 0.2
Aluminium	Al	mg / kg	< 0.5
Magnesium	Mg	mg / kg	< 0.5
Sodium	Na	mg / kg	< 0.5
Potassium	K	mg / kg	< 0.5

UREA for use in DEC's SCR Converter System must follow the above specifications. The Urea tank approval according to requirements specified in doc DEC921 shall also be fulfilled before filling of the tank

Accreditated measurements

EMK

The REPORT is done by an accredited laboratory No 1879

REPORT
Edition 1
11/12/2009/EF/HSn

Engine		Main engine	Auxiliary engine 1	Auxiliary engine 2	Auxiliary engine 3
Day of test	date	16/10/09	15/10/09	15/10/09	15/10/09
Power	%	78 %	48%	50%	52 %
Test started	time	11:26	17:06	15:54	14:42
Effective test duration	h	0.50	0:40	0:43	0,41
Air temperature outside	°C	5	7	7	7
Air temperature on board	°C	22,8	25,2	22,2	20,8
Atmosphere pressure	kPa	103,0	102,2	102,2	102,3
Air humidity on board	%	33,5	28,6	29,6	31,8
O_2- content	vol % dg	12,4	13,4	13,3	13,3
CO_2- content	vol % dg	6,58	5,71	5,81	5,77
CO- content	vol ppm dg	87,0	54,3	47,2	48,0
Equivalent CO- content	g/kWh	0,49	0,41	0,33	0,33
NO_x-content	vol ppm dg	82,9	606	671	641
Equivalent NO_x -content	g/kWh	0,70	7,23	7,42	6,72
TOC content as metan	vol ppm wg	0,03	0,08	0,04	0,03
Equivalent TOC content	g/kWh	0,0001	0,001	0,0002	0,0001
Ammonium-nitrogen at 15 % O2	ppm	4,0	-	-	-
Gas temperature	°C	374	229	243	241
Exhaust flow	m^3wg/h	71339	3184	3127	3141
Exhaust flow	m^3(n)wg/h	34796	1553	1525	1532

NO_x-emission		
Weighted average value	g/kWh	--------------------1,32------------------------
Expanded uncertainty*	g/kWh	----------------1,16 - 1,48--------------------

Remarks: m^3(n) = gas volume at 1 bar (abs) and 0°C
dg = dry gas
wg = wet gas
* = Expanded uncertainty at 95 % confidence level with a coverage factor of 2.

Swedish Fairway dues

SWEDISH MARITIME ADMINISTRATION

Nox Rebate on GT based portion of the fairway dues:

Emission level, Nox g/kWH	Passenger vessels. SEK	Cruising vessels, SEK	Other vessels, SEK
0 – 0,50	0	0	0
0,51 – 1,00	0,15	0,03	0,25
1,01 -2,00	0,40	0,08	0,61
2,01 – 3,00	0,63	0,16	0,77
3,01 – 4,00	0,77	0,24	0,93
Etc.			
10,01 -	1,80	0,80	2,05

Operational issues

- Increase of delta P (alarm setting 3kPa);
  - Clogging of stones; Calcium from luboil (TBN), impurities from HFO and Urea.
- Reduction of reactivity; increase of ammonium slip.
- Failing of stones
- Operational above 300℃ exhaust gas temp
- Bunkering of Urea and availability

Problems with catalyst stones

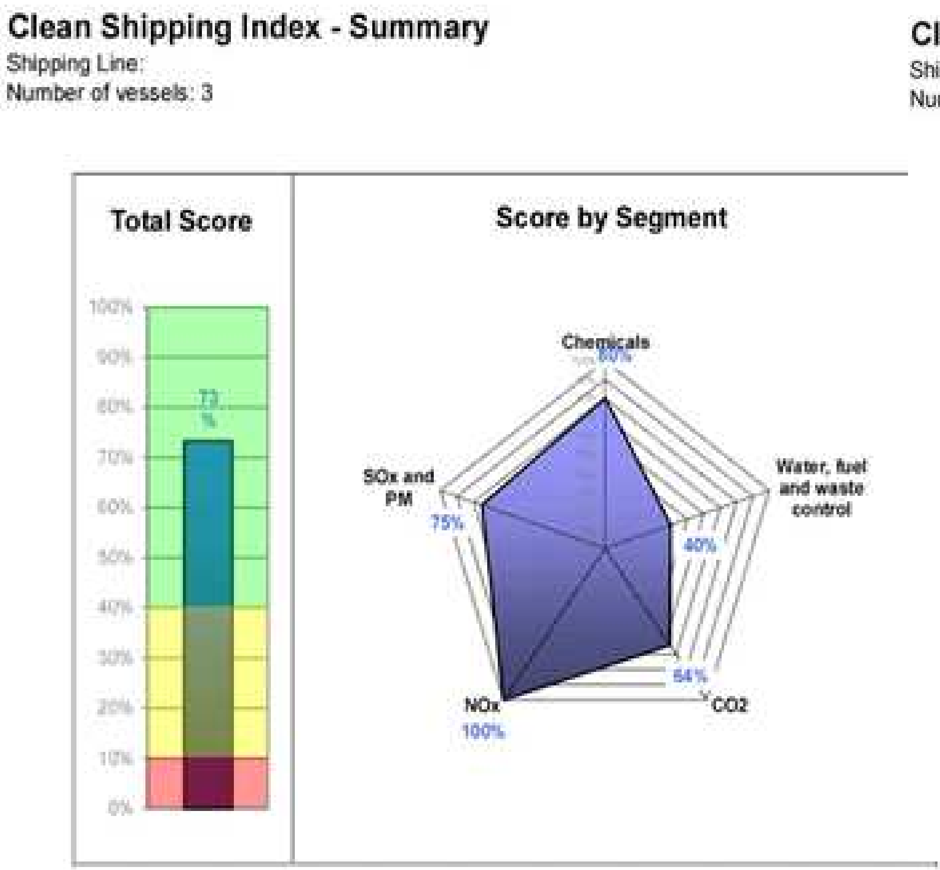
Broken stones
B- series: 50% of
total 576

Clogged
stones

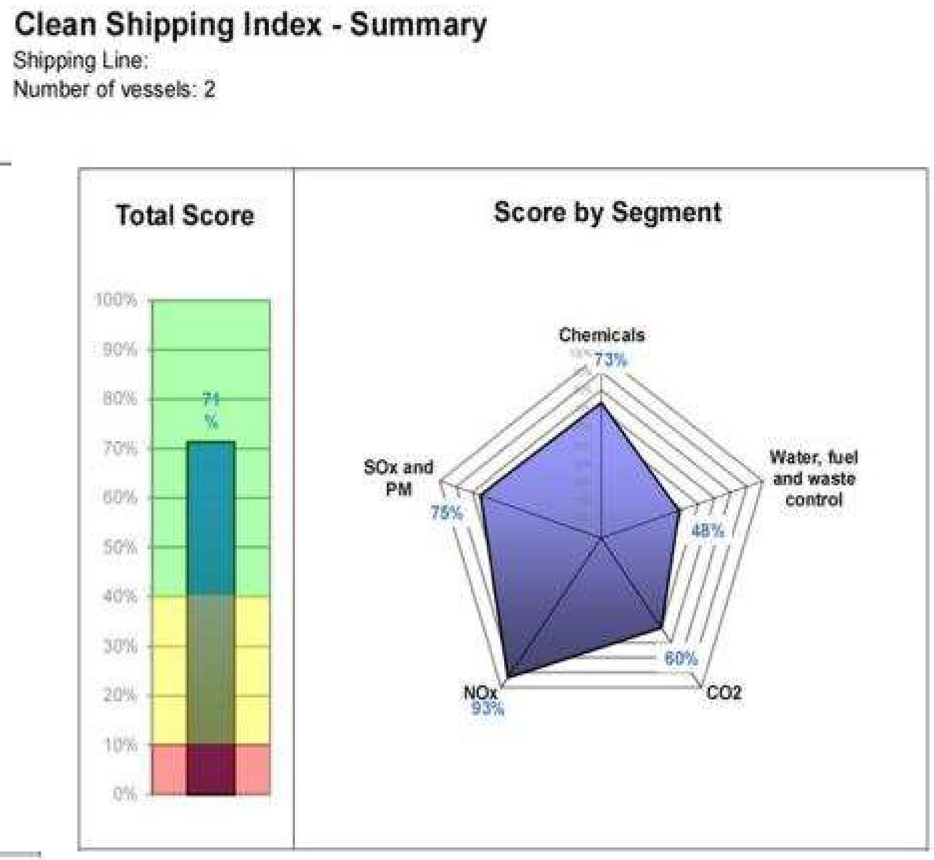
Operating costs

- Costs of Urea; +/- €160-200/ton
- Consumption of Urea; approx. 10% of HFO consumption
- Costs of measurements for Swedish Fairway reduction;
  +/- €10.000 every 3 years
- Calibration, check up costs
- Urea analyzing costs
- General maintenance costs; i.e. dust blowers, injectors etc.
- Exchange of catalyst stones, when needed; €60.000 -
€100.000.

Clean Shipping Index



S-Series



B-Series

ROYAL WAGENBORG

Royal Wagenborg

Duurzame binnenvaart

LNG als oplossing voor lage NOx emissies in de binnenvaart

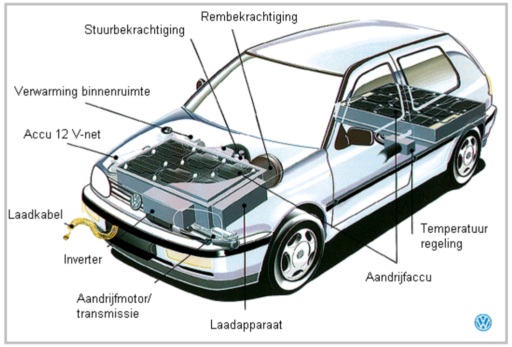
Raymond Gense

mei 2012

Ontwikkelingen tot 2030

Verbranding fossiel → **Elektrisch/ Non fossiel**

- Benzine
- Diesel
- Gas



- Batterij
- Waterstof
- Groengas/Biodiesel

Drijvende krachten

Lokale luchtkwaliteit

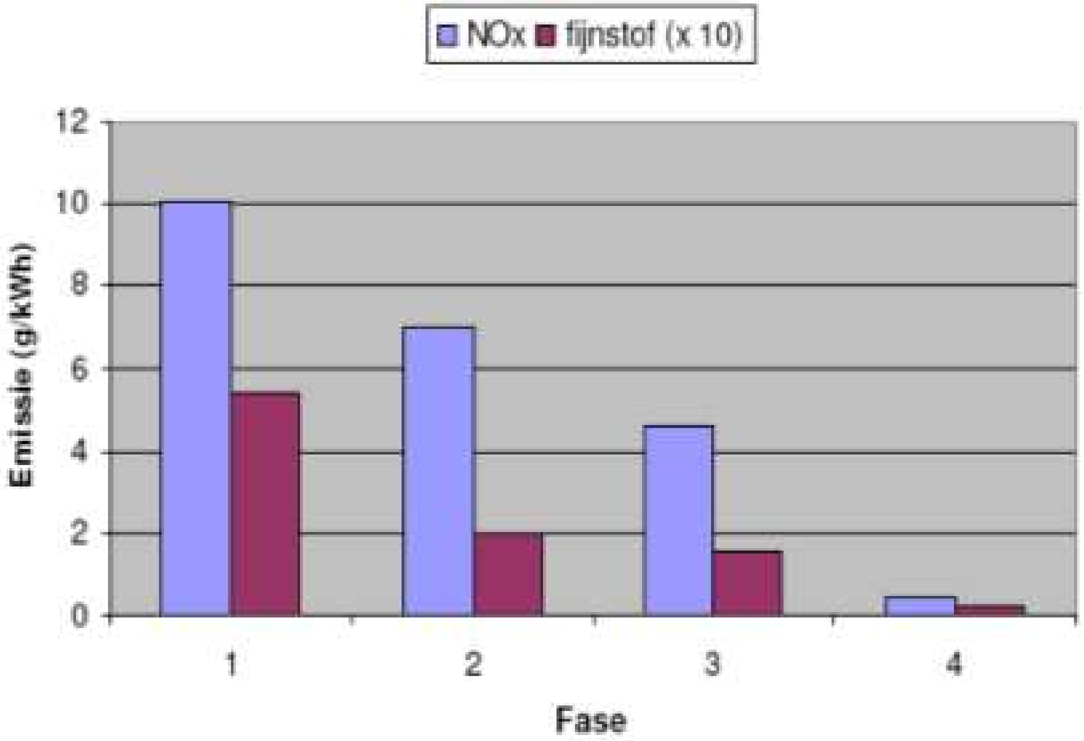
Brandstofschaarste

Klimaatverandering

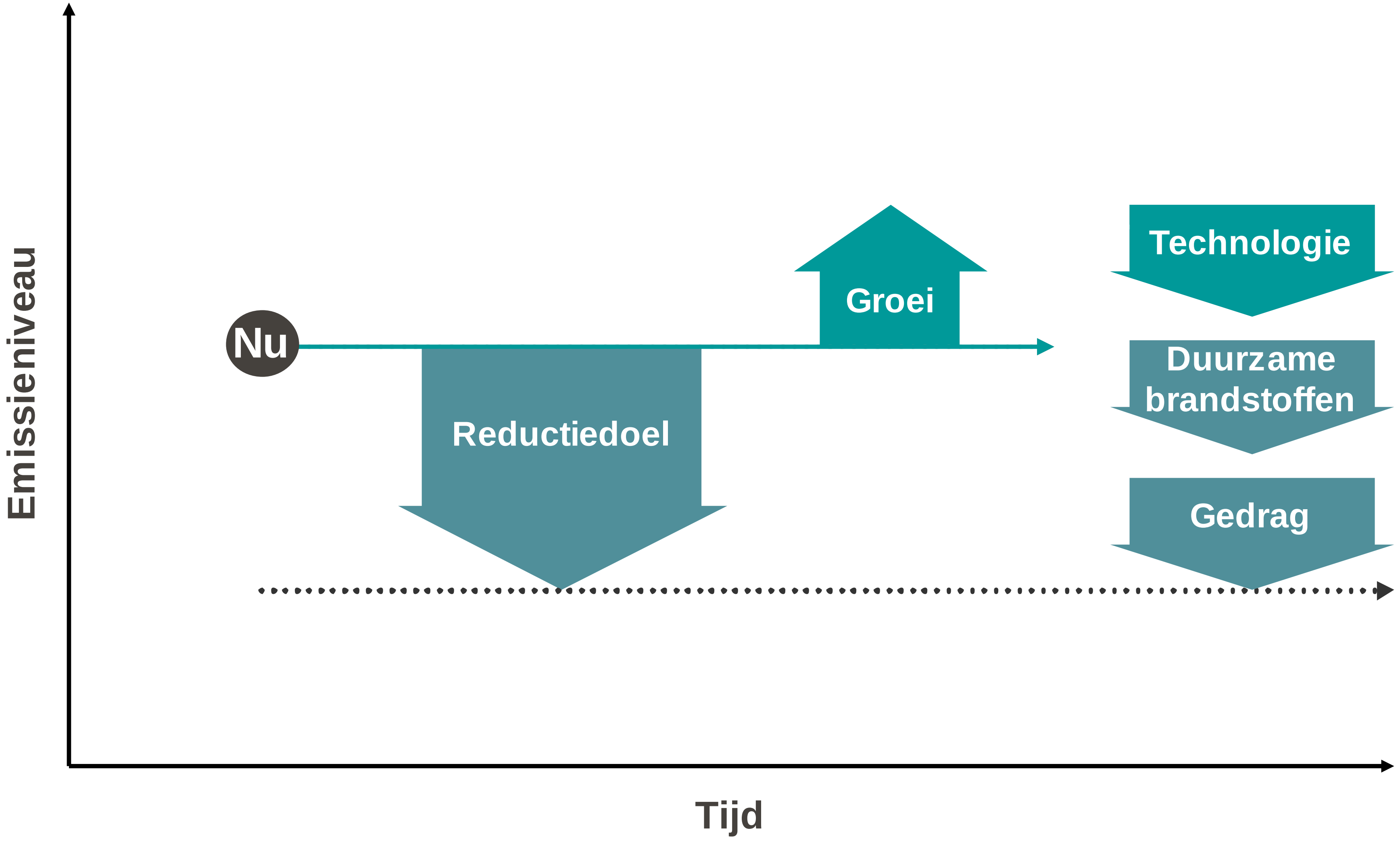
Wetgeving ter stimulering voor duurzaam varen

CCR (Centrale Commissie Rijnvaart):

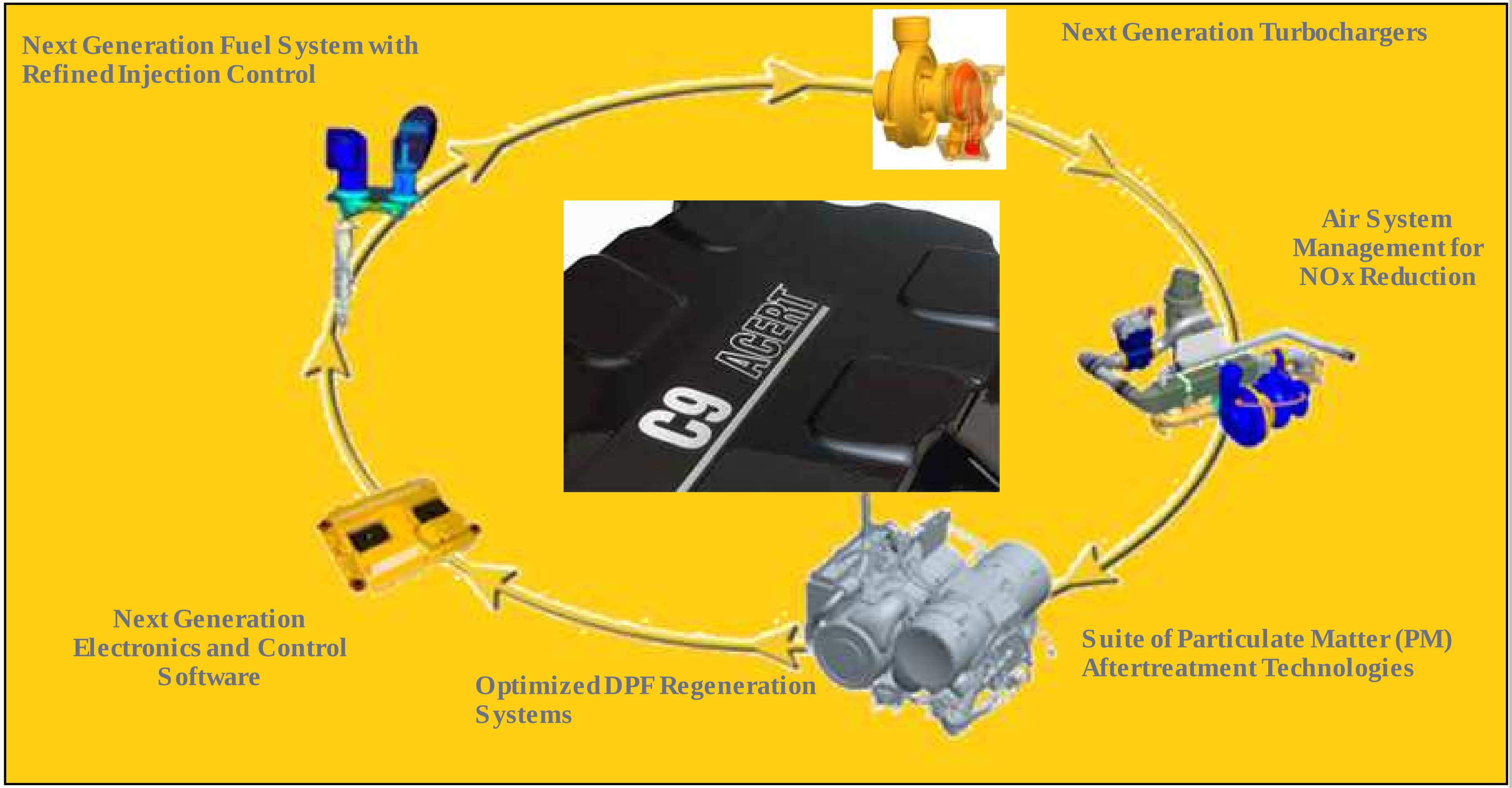
- **Eisen aan zwavelgehalte brandstof**
- **Eisen aan uitstoot NOx en Fijnstof uitstoot**



Oplossingen

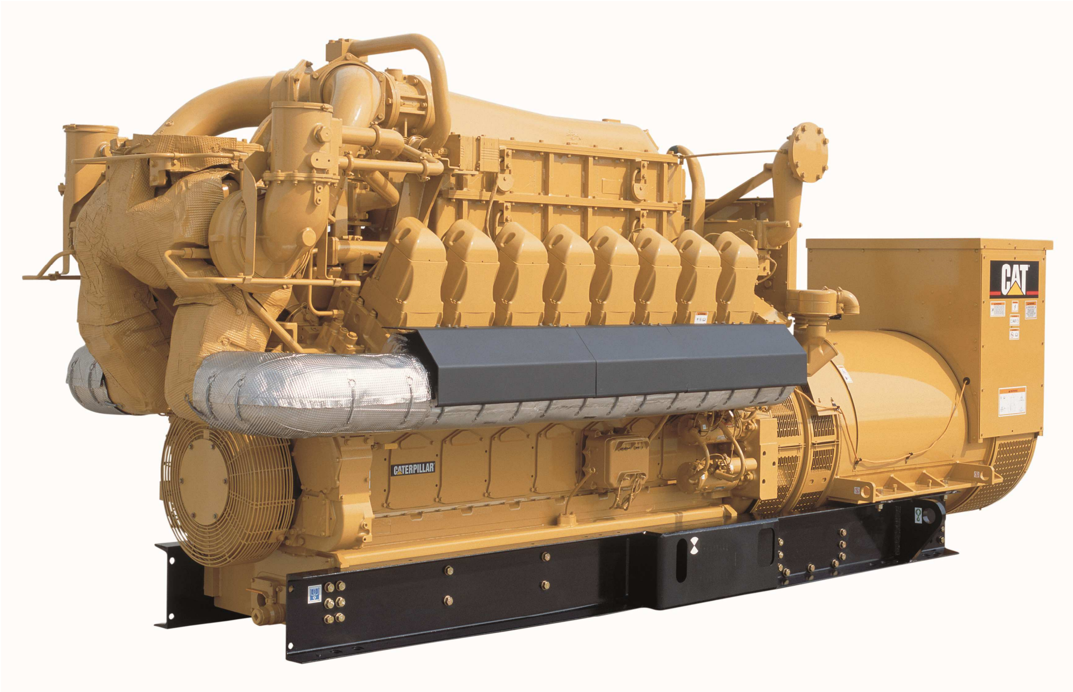


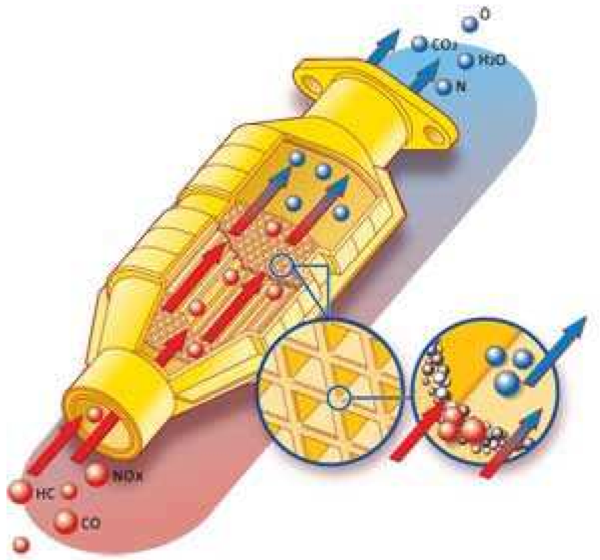
Geoptimaliseerde diesel motor + uitlaatgasnabehandeling



Schoon, maar tegen extra kosten en nauwelijks CO_2 reductie potentie

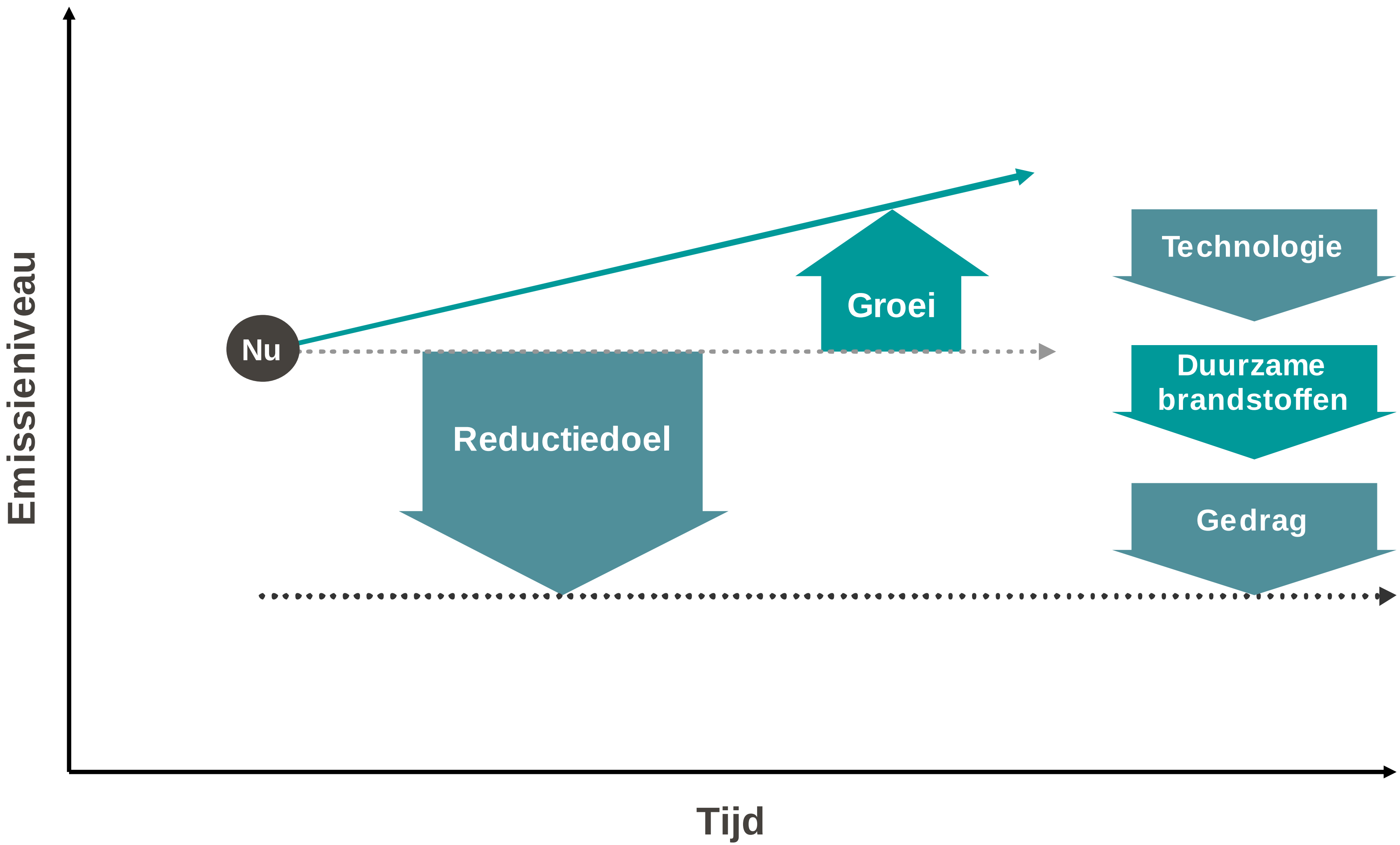
Gasmotor + uitlaatgasnabehandeling (3-weg katalysator)



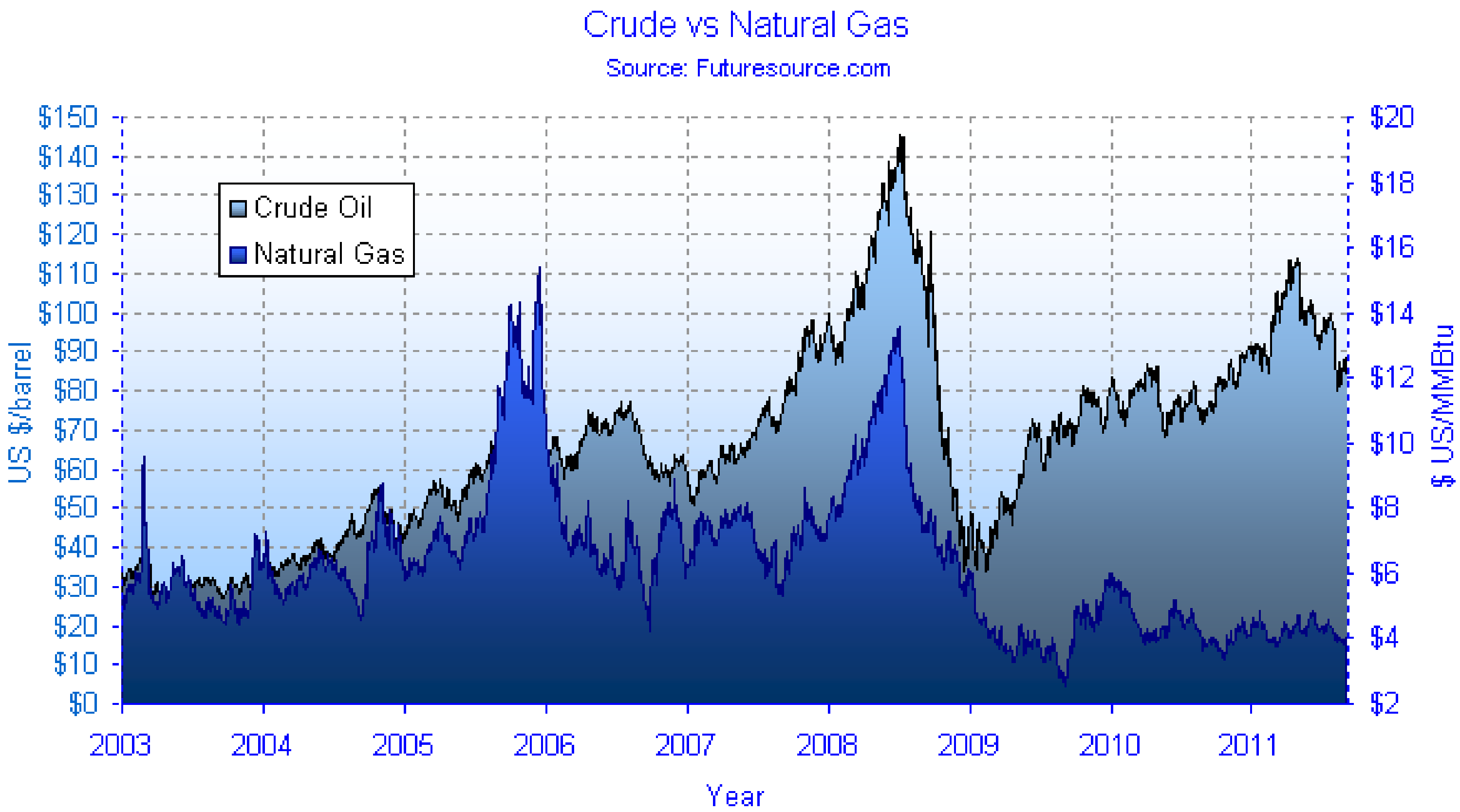


Zeer schoon, matig dynamisch gedrag en hoge CO_2 reductie potentie

Oplossingen



De stap naar Liquid Bio Methane (LBM)



En lage brandstofkosten door grote gasvoorraden wereldwijd

Voor en nadelen van varen op diesel en methaan

- **Diesel SCR/PM filter**
  - Voordelen:
    - Bewezen betrouwbare diesel technologie
    - Bewezen Fijnstof en NOX filter technologie (automotive, power plants)
  - Nadelen:
    - Dure technologie zonder terugverdientijd
    - Grote installatie omvang
    - CO2 reductie enkel als 2e generatie biodiesel betaalbaar beschikbaar (>2020)

- **Methaan (CNG/LNG)**
  - Voordelen
    - Bewezen schone technologie (gensets en automotive)
    - Hoog CO2 reductie potentieel: 20% op aardgas, >80 % op biogas
    - Hoog terugverdienpotentieel via goedkope stabiele brandstofprijs
  - Nadelen
    - Geen binnenvaart scheepmotoren beschikbaar (wel zeevaart)
    - Nog geen tankinfrastuctuur beschikbaar (moeilijke overgangsfase)
    - Klasse goedkeuring noodzakelijk via nieuw protocol

Dual Fuel

Dual Fuel LNG : Het beste van 2 werelden

- Betrouwbare dieseltechniek als basis
- Eenvoudige bewezen gastechnologie als toevoeging
- Toepassing van brandstof met stabiele lage prijs (LNG)
- Upgrade naar CO_2 arme biobrandstof mogelijk (LBM)
- Varen op 100% diesel nog steeds mogelijk
- Retrofit van bestaande machinekamers eenvoudig mogelijk

Maar, bij initieel idee (2009):

- Varen op 2 brandstoffen niet voorzien in Europese wetgeving
- Klasse moest nog worden opgelijnd
- Brandstofbunkering nog niet geregeld
- Transient gedrag en maximale bijmenging niet bewezen

EFRO subsidieproject “Argonon”

Dual Fuel :

Hoog efficient Dieselproces met (bio)methaan als hoofdbrandstof

Introduction
Dual-Fuel Explanation
System Operation
Maintenance
Possible Applications

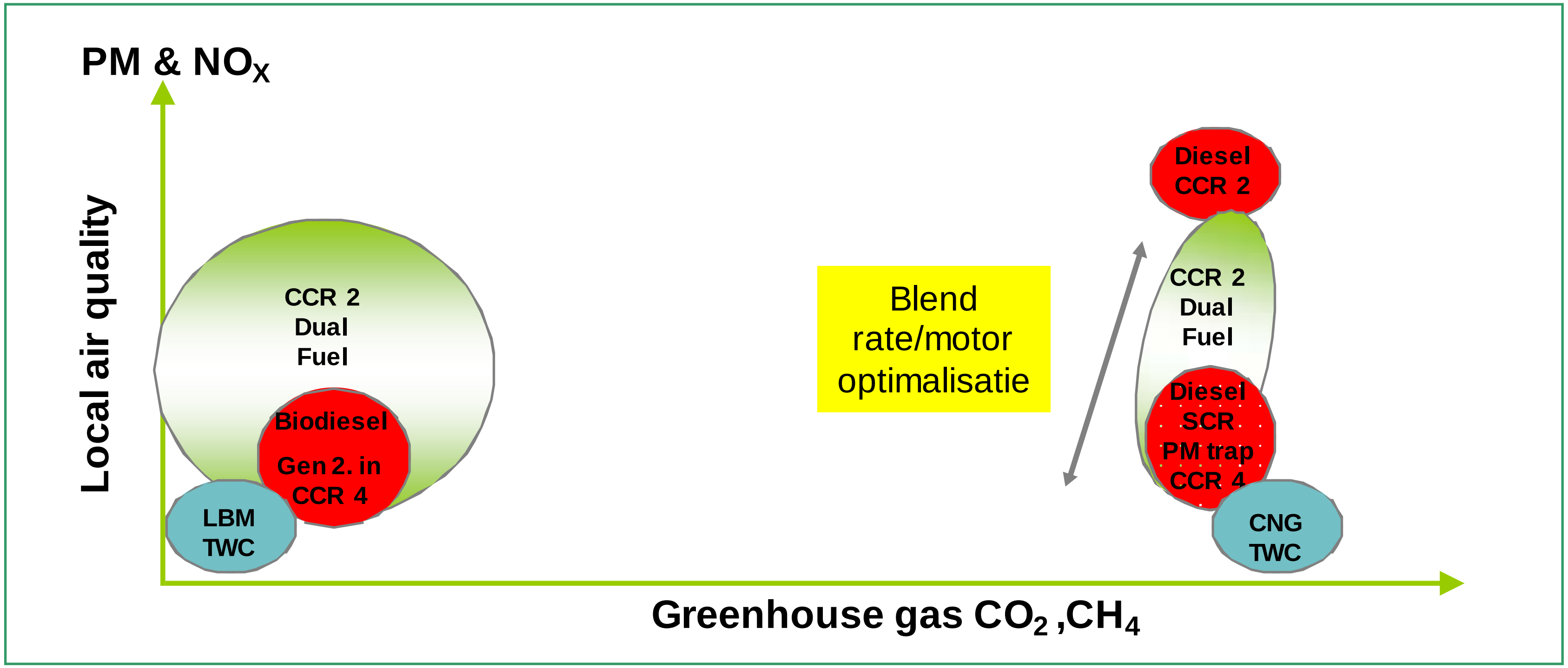
Resultaten Argonon project

- Argonon sinds januari 2012 in de vaart
- Klasse, CCR en ADR goedkeuring verkregen voor geheel Europa
- Bijmenging is constant tijdens alle vaaromstandigheden
- Schip vaart geheel stabiel bij 80% gasbijmenging,
- Geen verschil met Dieselaandrijving in vermogen en responstijd
- Geen methaanslip door toepassing van katalysator
- Bunkering via vrachtwagens geregeld
- Motorrendement op dieselniveau (CO2 reductie op fossiel LNG 25%!)
- CO2 reductie Argonon op LNG : 300 ton/jaar (= uitstoot 350 vrachtwagens)
- CO2 reductie Argonon op LBM: 1190 ton/jaar
- Brandstofkosten besparing: 30% = € 110.000/j

Volgende stappen:

- **NOx reductie optimalisatie**
- **Retrofit Dual Fuel op bestaande schepen**

NOx reductie optimalisatie



Retrofit Dual Fuel op bestaande schepen

Waarom?

- Directe kostenbesparing
- Directe CO_2 uitstoot reductie (25% op LNG)
- Direct beperkte NOx-en fijnstof uitstoot reductie
- Stimuleren opstart “varen op LNG/LBM” (bunkeren/LBM productie)

Hoe?

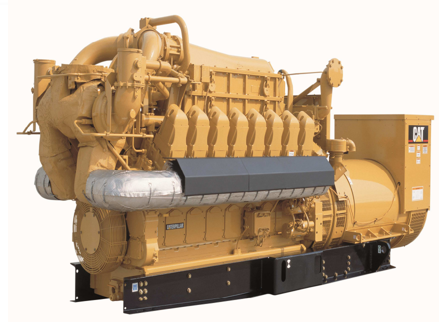
- Pon Power verzorgd gehele retrofit
  - Technische installatie inclusief cryogene LNG tank
  - Ombouw + oplevering
  - Begeleiding bij Klasse (veiligheidsstudie)

- Resultaat:
  - Emissies beter dan CCR 2 motor
  - Terugverdientijd bij 350 ton gasolie verbruik per jaar : 5 jaar

Conclusie

- Het varen op LNG/LBM biedt grote kansen voor de binnenvaart
- De eerste stappen in de richting van schone, CO_2 neutrale en betaalbare binnenvaart zijn nu gezet met de Argonon
- Nu moet de “keten” snel op gang komen
- Pon zet de eerste stap met het aanbieden van Dual Fuel Retrofit

Dank voor uw aandacht!



SEAT | ŠKODA | Bedrijfswagens | Audi | Gazelle

SAF | Linde | MAN | Continental | MaK | CAT | Kalkhoff

IHC MERWEDE

Operating in Emission Control Areas

After treatment and Natural Gas powered ships

Platform Scheepsemissies NOx seminar

April 19th 2012, Benny Mestemaker

The technology innovator.

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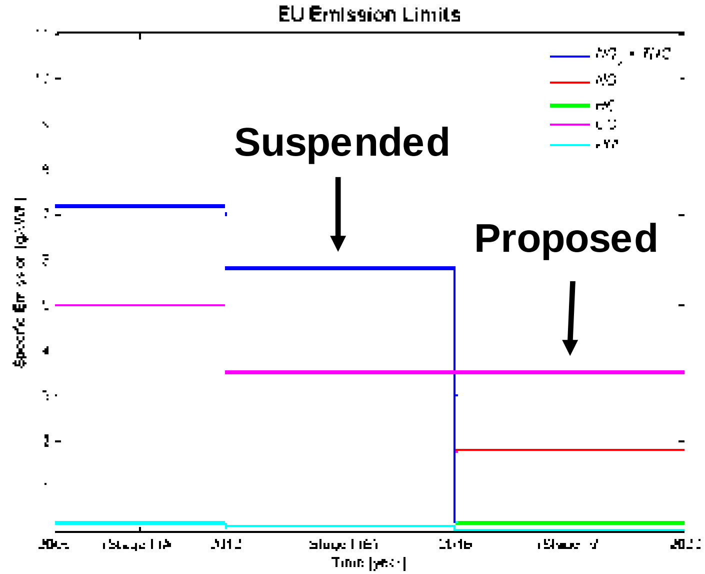
Content

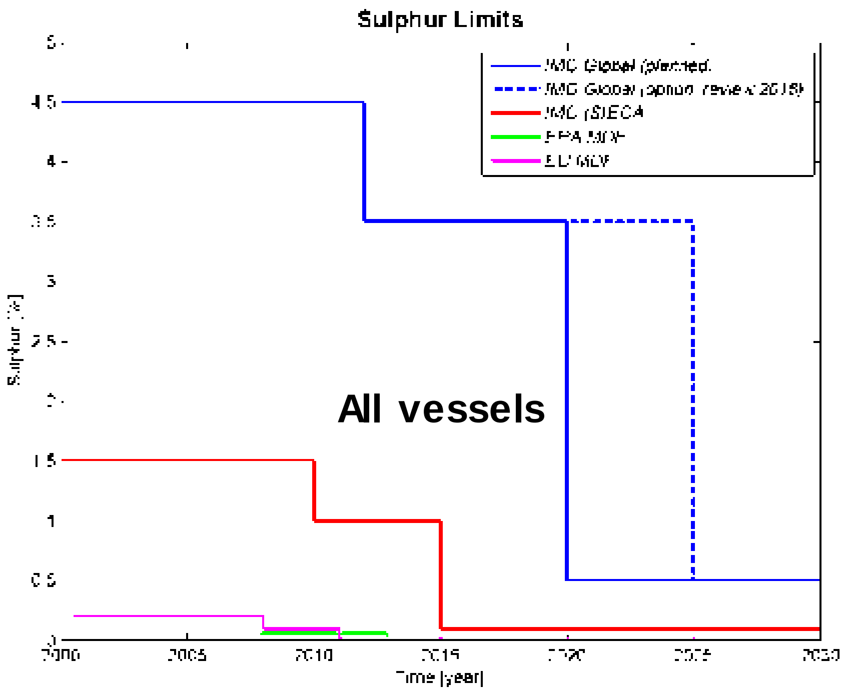
- Emission regulations
- Fuel price developments
- Offshore & dredging activities
- Possible solutions
    - After treatment
    - Natural Gas
- The road ahead
- Conclusions

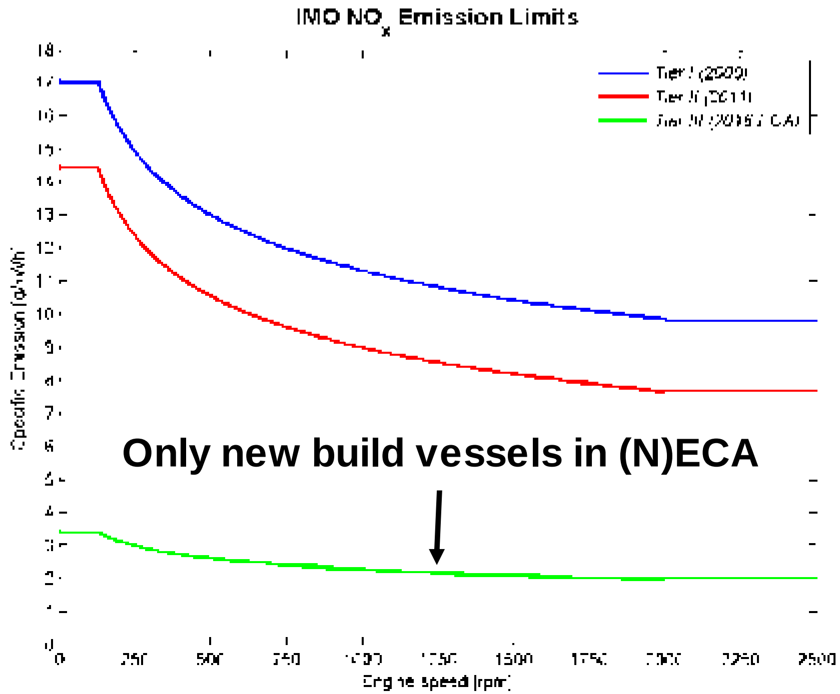
Emission regulations

Legislation

- Emission legislation IMO/EPA/EU/CCNR
- Legislation Trend:
  - Shipping follows road transport/ inland power generation
  - Decrease emission limits







Emission regulations

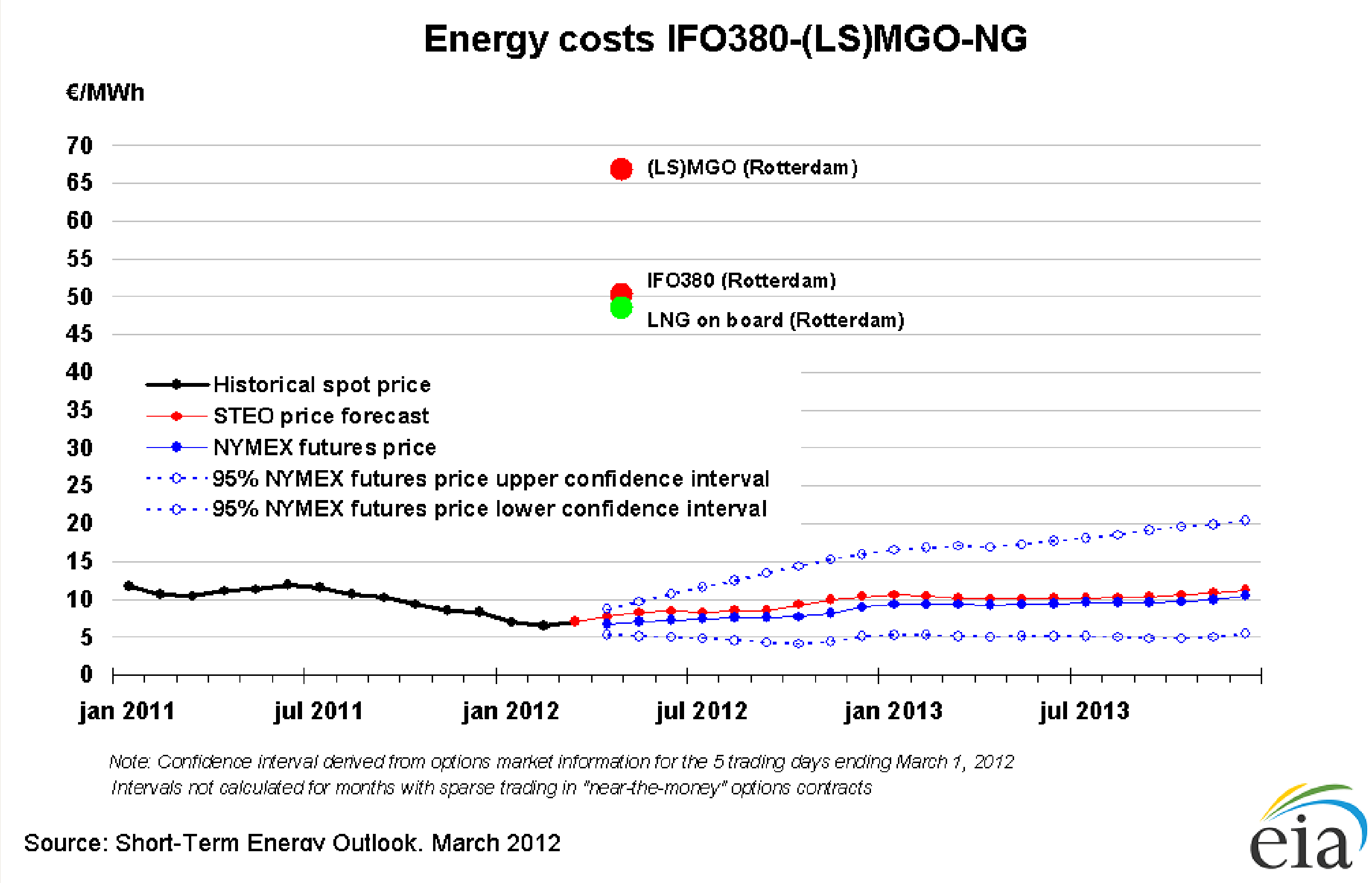
ECA's (Emission Control Areas)

- ECA: NOx + SOx (USA (incl. Hawaii) & Canada)
- SECA: SOx (North sea & Baltic Sea)

Fuel price developments

Natural Gas versus fuel oil

- LNG on board same price as HFO
- Large availability NG: (±200yrs)



Payback time?

Offshore and dredging activities

State of technology for offshore

Areas

- Activity in ECA's is high (Norway)

Technical

- Low engine loads
- Large part of fleet diesel-electric
- High redundancy

Current status

- First gas fuelled ships already in service

Offshore and dredging activities

State of technology for dredging

Areas

- Worldwide applications; small part of fleet, temporary in ECA

Technical

- Highly transient behaviour of engine loads
- Almost always diesel-direct propulsion
- Sometimes diesel-electric pump drive

Current status

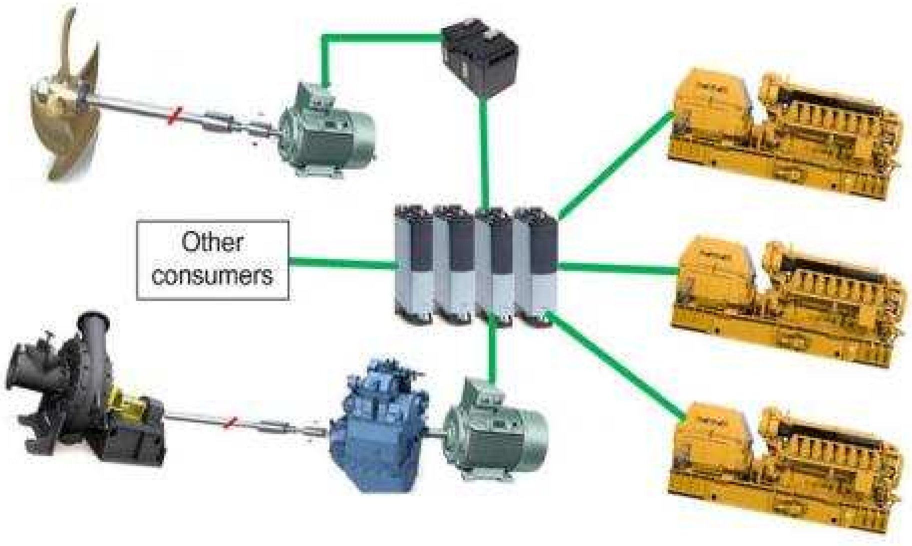
- Principal class approval by IHC Merwede

Offshore and dredging activities

IHC Merwede knowledge development on:

- Energy management
- Drive system design and integration
- After treatment system design and specification
- Natural gas powered dredger design and specification
- (Emission) field measurements (validation)

Total drive system solutions



Offshore and dredging activities

IHC Merwede knowledge development for:

- Innovative product development for offshore and dredging activities

- Optimal drive system design for ships (new build & retrofit)

  Advising client for most optimal solution/system

  Enabling system trade-offs (from risk, cost, etc. perspective)

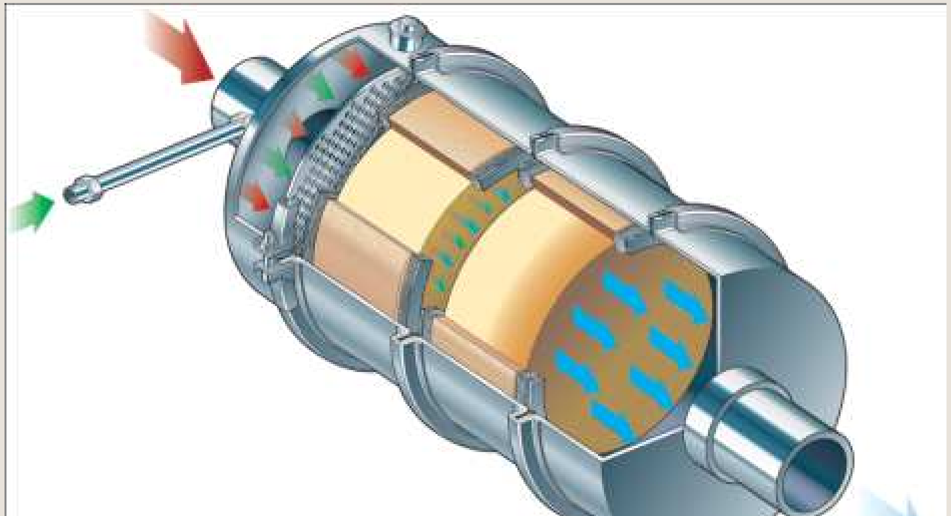
- Development of simulators for new concepts

  For integration of all drive system components

Possible solutions

Options to comply to the emission regulations of SO_x & NO_x

- New diesel engine developments
- Gas turbines & fuel cells
- **After treatment exhaust gasses (SCR & scrubber)**
- **Natural gas engines**
  - Dual fuel
  - Lean burn



SCR (Johnson Matthey)

Possible solutions

Options to comply to the emission regulations of SO_x & NO_x

- New diesel engine developments
- Gas turbines & fuel cells
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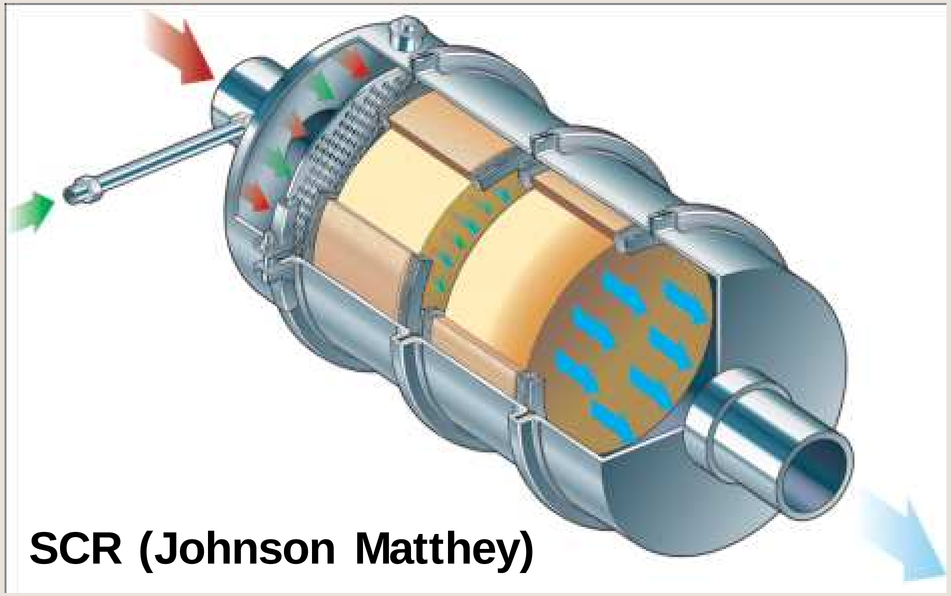


SCR (Johnson Matthey)

Possible solutions

After treatment: SO_x reduction

- Location:
  - (S)ECA: → 0.1% Sulphur (2015)
  - World: → 0.5% Sulphur (2020/2025)

- Possible systems:
  - **Wet scrubber**
  - Dry scrubber
  - CSNOx (Ecospec)
  - *Clean fuel (low sulphur <0.1%S)*
    - *(LS)MGO*
    - *Natural Gas*

Scrubber (Alfa Laval Aalborg)

Possible solutions

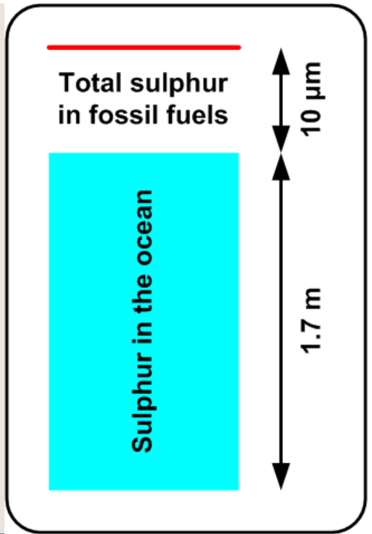
After treatment: Wet scrubber

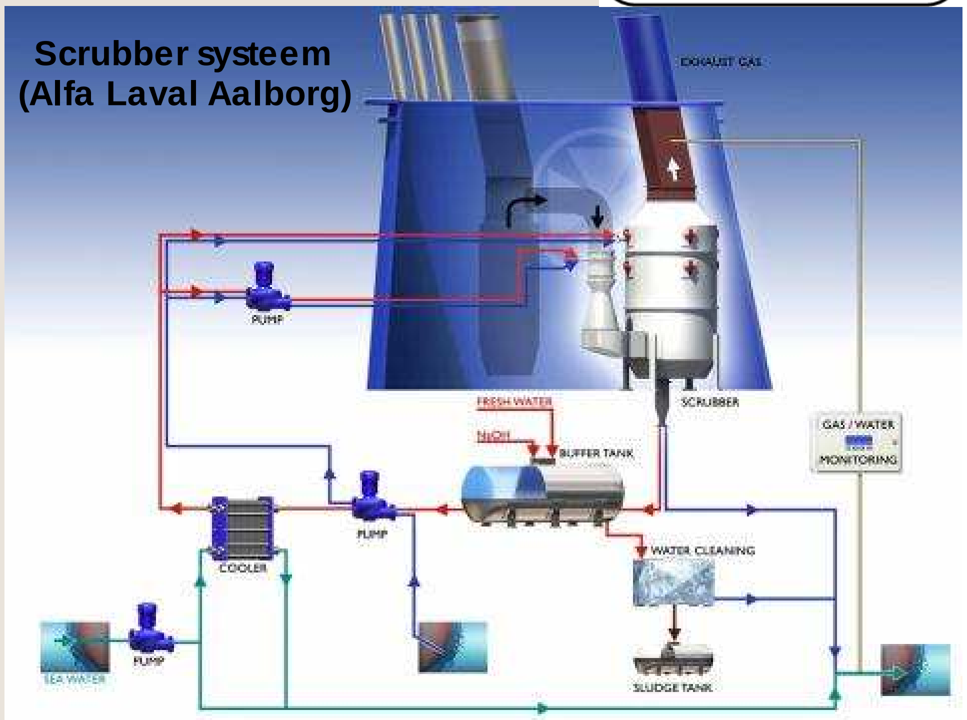
- Emission reduction
  - SO_x: 97-99% (continuous monitoring required)
  - PM: 70-80% (coarse particulates)
  - NO_x: 5-10% (only NO_2)

- 3 wash water systems:
  - Seawater (1300 umol/L)
  - Fresh water (caustic soda)
  - Hybrid system

- Installation end pipe

- *Response to dynamics*

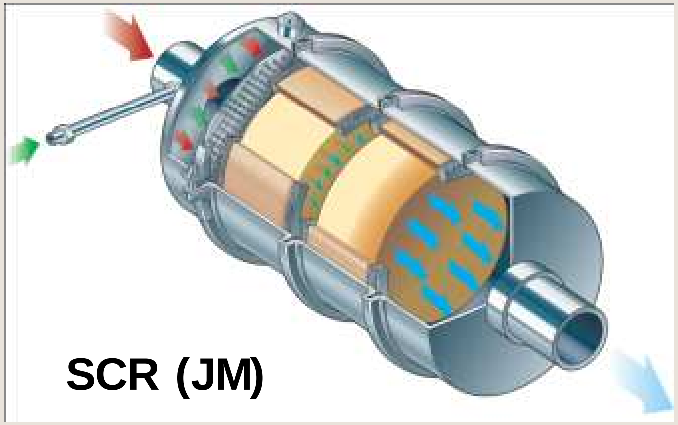




Possible solutions

After treatment: NO_x reduction

- Area's:
  - ECA: New builds (2016), all vessels
  - IWW: New builds (2016), ocean going exempted
- Possible systems
  - **Selective Catalyst Reduction (SCR)**
  - Selective Non Catalyst Reduction (SNCR)
  - NO_x absorber
  - CSNOx (Ecospec)
  - *Natural Gas*

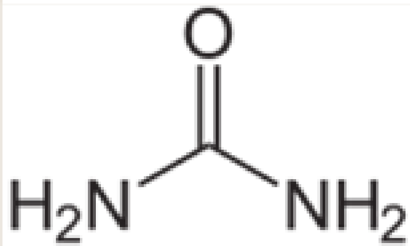


Possible solutions

After treatment: Selective Catalyst Reduction (SCR)

- Low sulphur fuels:
  - Urea consumption: 5-10% (fuel)
  - Ammonia slip catalyst (AMOX)
  - Temperature requirement in range diesel engine

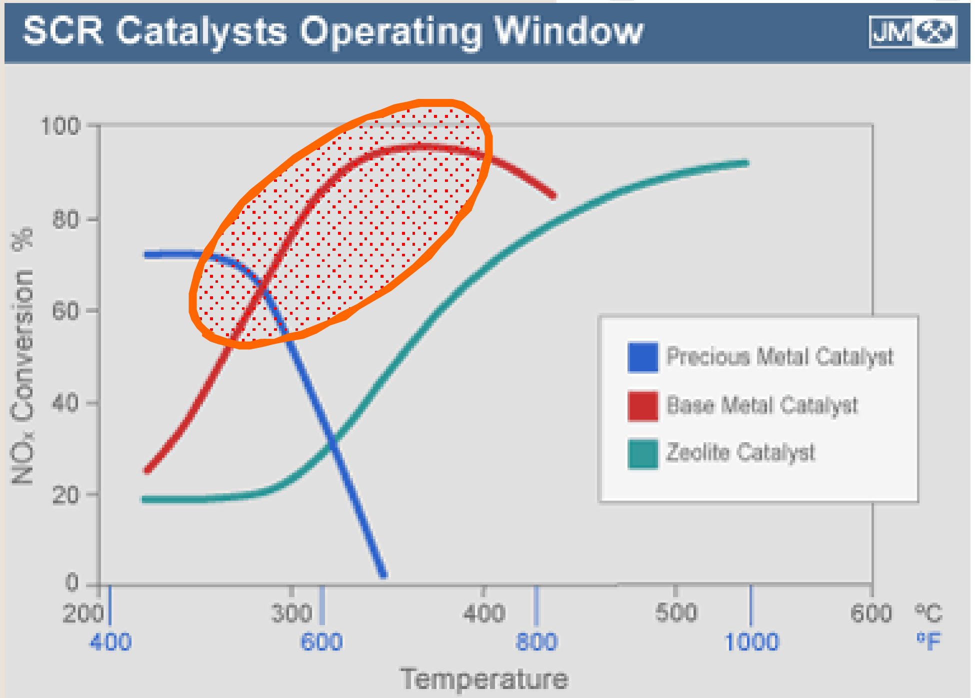
Urea



- Emission reduction:
  - NOx: 80-90%
  - CO: 98% (AMOX)
  - HC: 95% (AMOX)
  - PM: 30% (AMOX)

- Installation directly behind engine

- *Response to dynamics*

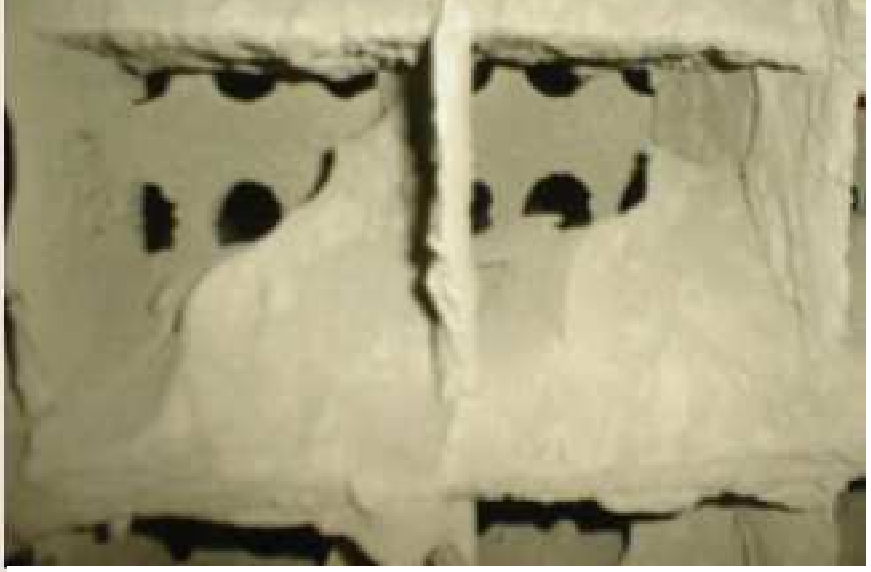


Possible solutions

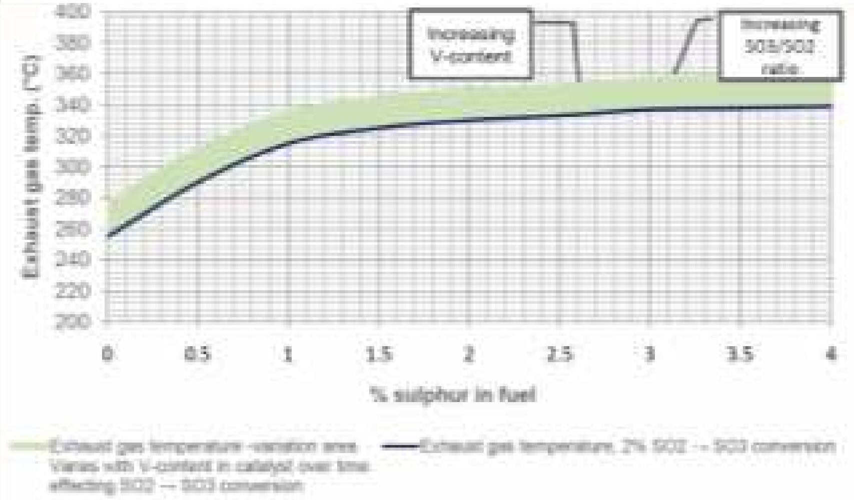
After treatment: SCR HFO

- High sulphur also possible
    - Bigger SCR (more catalyst)
    - Temperature requirement
    - Increased urea consumption
- NOx reduction: 70-80%
- Installation directly behind engine
- *Response to dynamics: ammonia slip*
- *Ammonium (bi) sulphate formation at low temperatures*
- *Catalyst poisoning heavy metals HFO*

Ammonium bisulphate (Lehigh)



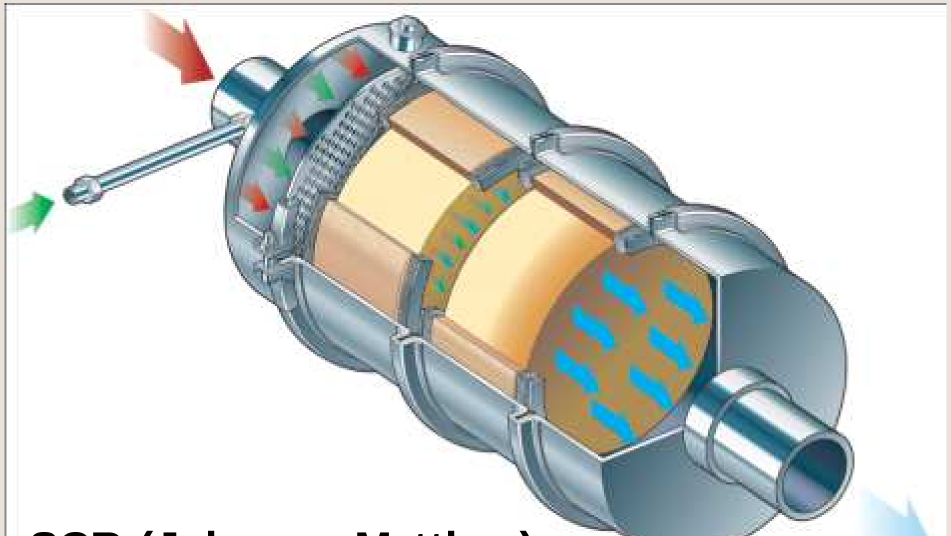
Minimum temperature SCR (Yarwil)



Possible solutions

Options to comply to the emission regulations of SO_x & NO_x

- New diesel engine developments
- Gas turbines & fuel cells
- **After treatment exhaust gasses (SCR & scrubber)**
- **Natural gas engines**
  - Dual fuel
  - Lean burn


SCR (Johnson Matthey)

Possible solutions

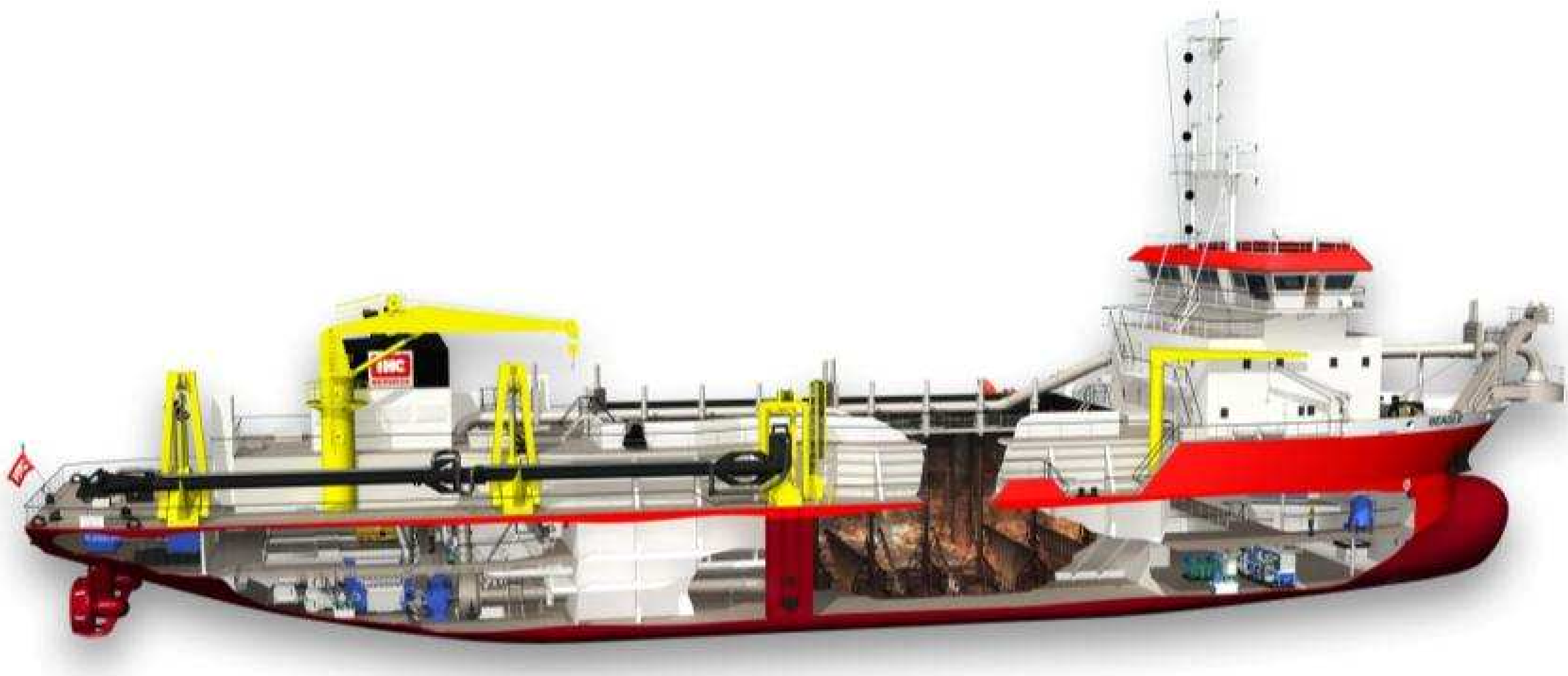
Natural Gas powered ships

Pros/profits

- Low emissions
- Fuel price
- Future availability

Challenges

- Transient behaviour
- Energy storage density
- Methane slip



Possible solutions

Natural Gas powered ships: Prime mover transient capability

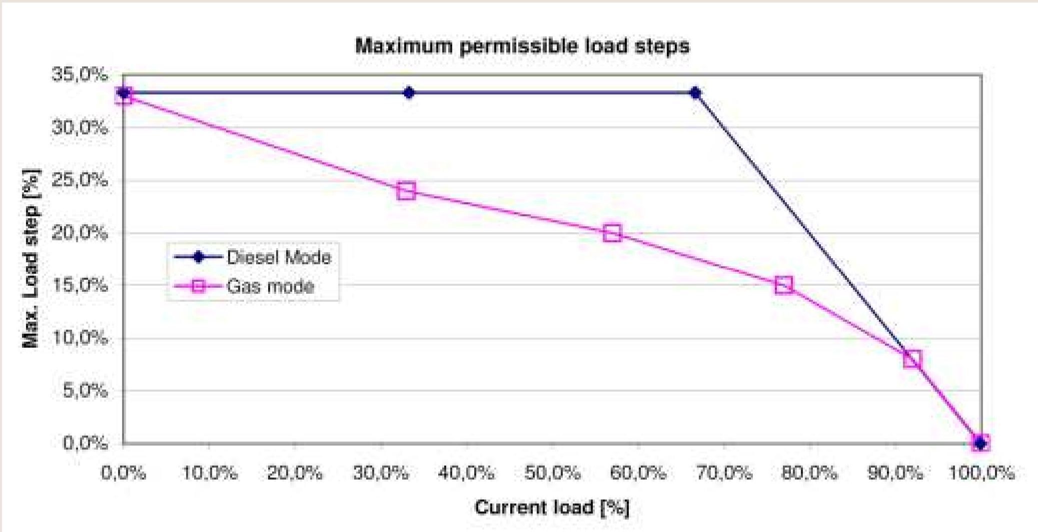
- Dual fuel engine: preliminary data MAK M46DF
- Gas mode: half of diesel mode

  (at 60-100% load)
- Recovery time from step:

  5-10s (warmed up)
- Above gas mode limit switch to diesel mode

  (instant NG → Diesel)

  (gradual Diesel → NG)



The road ahead

Required after treatment system: overview

	2015 SECA (Sulphur → 0.1%)	**2016 ECA** (NOx + Sulphur)	**2020/2025 Global** (Sulphur → 0.5%)
HFO (3.5% S)	Scrubber (now also required)	Scrubber + SCR	Scrubber
LSHFO (<1% S)	Scrubber (now not required)	Scrubber + SCR	Scrubber
MDO/MGO (<0.1% S)	*NA*	SCR	*NA*
LNG (dual fuel)	*NA*	SCR (diesel mode)	*NA*
LNG (single fuel)	*NA*	*NA*	*NA*

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The road ahead

Technological risk

Required after treatment system: risks

	2015 SECA (Sulphur → 0.1%)	2016 ECA (NOx + Sulphur)	2020/2025 Global (Sulphur → 0.5%)
HFO (3.5% S)	Scrubber (now also required)	Scrubber + SCR	Scrubber
LSHFO (<1% S)	Scrubber (now not required)	Scrubber + SCR	Scrubber
MDO/MGO (<0.1% S)	*NA*	SCR	*NA*
LNG (dual fuel)	*NA*	SCR (diesel mode)	*NA*
LNG (single fuel)	*NA*	*NA*	*NA*

Legislation risk

Bunkering/fuel risk

The road ahead

Investment & operational costs: overview

	2015 SECA (Sulphur → 0.1%)	2016 ECA (NOx + Sulphur)	2020/2025 Global (Sulphur → 0.5%)
HFO (3.5% S)	CAPEX: +- OPEX: ++	CAPEX: -- OPEX: +	CAPEX: +- OPEX: ++
LSHFO (<1% S)	CAPEX: +- OPEX: +-	CAPEX: -- OPEX: -	CAPEX: +- OPEX: +-
MDO/MGO (<0.1% S)	CAPEX: ++ OPEX: -	CAPEX: + OPEX: --	CAPEX: ++ OPEX: -
LNG (dual fuel)	CAPEX: --? OPEX: ++?	CAPEX: --? OPEX: +?	CAPEX: --? OPEX: ++?
LNG (single fuel)	CAPEX: -? OPEX: +++?	CAPEX: -? OPEX: +++?	CAPEX: -? OPEX: +++?

The road ahead

Investment & operational costs: remarks

	2015 SECA (Sulphur → 0.1%)	2016 ECA (NOx + Sulphur)	2020/2025 Global (Sulphur → 0.5%)
HFO (3.5% S)	CAPEX: +- OPEX: ++	CAPEX: -- OPEX: +	CAPEX: +- OPEX: ++
LSHFO (<1% S)	CAPEX: +- OPEX: +-	CAPEX: -- OPEX: -	CAPEX: +- OPEX: +-
MDO/MGO (<0.1% S)	CAPEX: ++ OPEX: -	CAPEX: + OPEX: --	CAPEX: ++ OPEX: -
LNG (dual fuel)	CAPEX: --? OPEX: ++?	CAPEX: --? OPEX: +?	CAPEX: --? OPEX: ++?
LNG (single fuel)	CAPEX: -? OPEX: +++?	CAPEX: -? OPEX: +++?	CAPEX: -? OPEX: +++?

LSHFO: Practically unavailable

LNG (dual fuel): Temporary solution

LNG (single fuel): Worldwide bunker network

Conclusions

- IHC Merwede recognizes that compliance to future legislation can come from different **technologies and fuels**.
- Our R&D focuses on **knowledge development** on the application of the new technologies in all the ships drive systems in order to create customer value
- In doing so IHC Merwede enables her customers to make **trade-offs** in the different ways to comply to the future legislation

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Platform Scheepsemissies NOx seminar

April 19th 2012, Benny Mestemaker

The technology innovator.

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Discussion

1

We will have ships which will not be allowed into ECA's, the so called "no ECA ships".

2

The requirements for new ships will have a negative effect on newbuilding orders.

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3

The Nox techniques are not widely available and the investments are too high.

- "Availability of Technology" - clause Marpol Annex 6 should be used-

4

New and more strict requirements are positive because it will boost innovations in the maritime world.

5

The phased in approach in Marpol Annex 6, regulation 13 (NOx) should be an example for all environmental legislation.

6

The maritime sector is not ready to combine all measures to fulfill all ECA requirements.

7

Engine manufactures will not be able to supply enough spare parts.

8

Maintenance costs will rise.

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9

In a few years IMO should increase the requirements on NOx (and PM and Black Carbon).

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The presentations can be found on the website by next week

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