EXHAUST GAS CLEANING SYSTEMS

- for the maritime environmental challenges

marine
EXHAUST TECHNOLOGY

CONTENT

- Exhaust gas system
- ECA Areas
- Regulations
- set-up…
- MX-SCR
- MX-SCRUBBER
- Key performance data
- Business cases
- Retrofit installations
- Reference

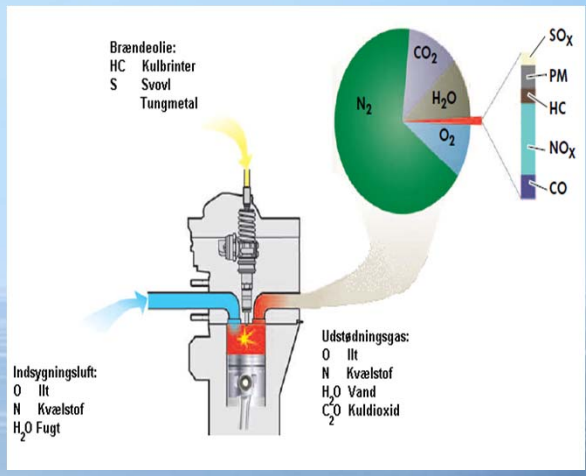
marine
EXHAUST TECHNOLOGY

EXHAUST GAS SYSTEM

The diesel engine combustion process

- In marine diesel engines the combustion transforms the energy of the fuel to a mechanical energy that provides forward propulsion, keeps the generators running and produces the electricity needed on board the vessel.
- The diesel combustion process is noisy and produces relatively high levels of particles as well as oxides of sulphur and oxides of nitrogen called SOx and NOx. The noise, heat, particulate matter, SOx and NOx are emitted through the vessel's exhaust system.

1 MWH ~ 200 kg fuel and 7200 Kg air



marine
EXHAUST TECHNOLOGY

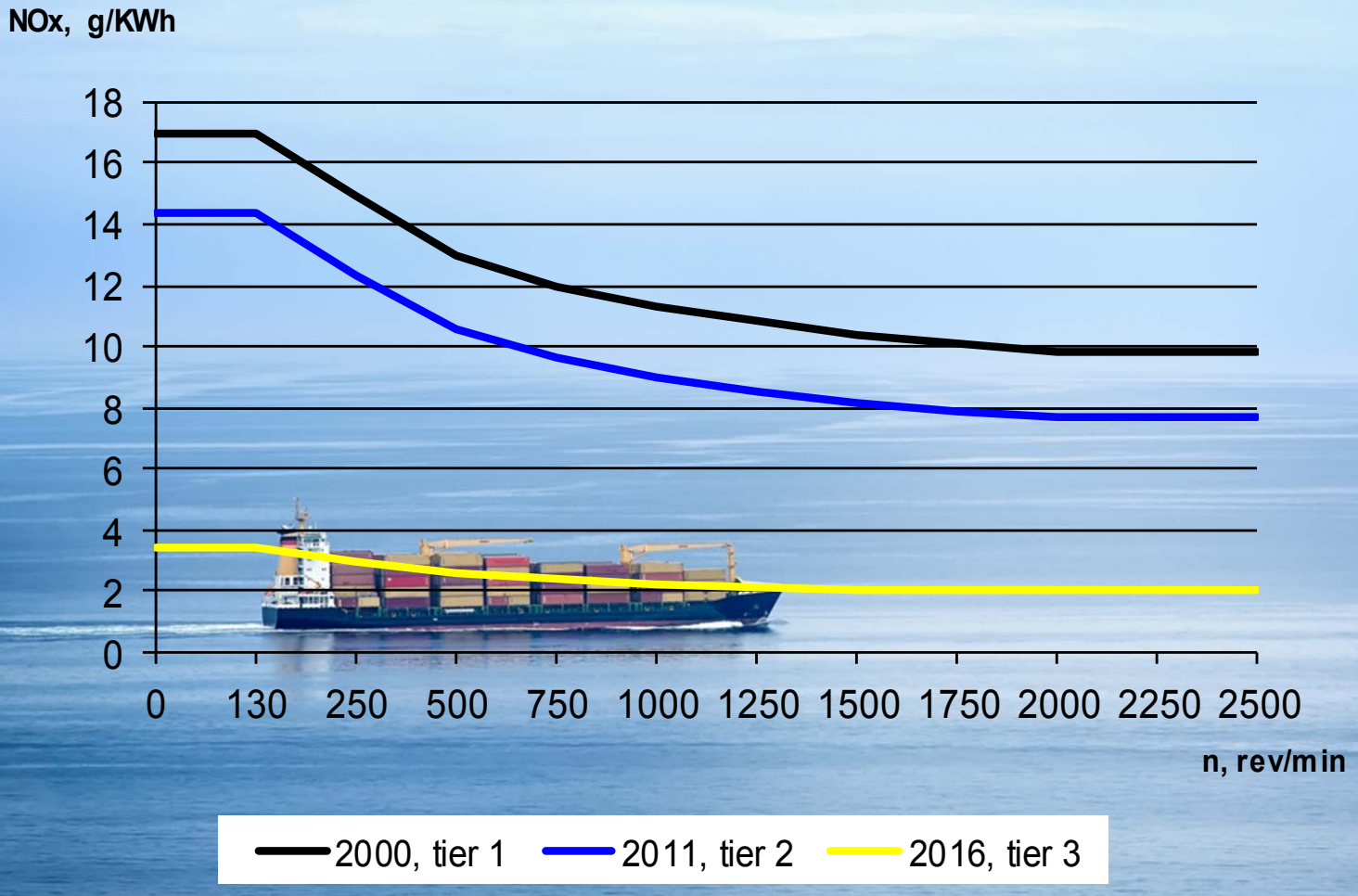
ECA AREAS

Existing fleets	
Requirement	**Compliance option**
2015: SOx < 0,1%	• HFO + scrubber • Distillate fuels • LNG

Newbuilds	
Requirement	**Compliance option**
2011: NOx Tier 2 2016: NOx Tier 3	• Scrubber + SCR • LNG, NOx abatement

marine
EXHAUST TECHNOLOGY

NITROGEN OXIDES (NOx) – REGULATION 13



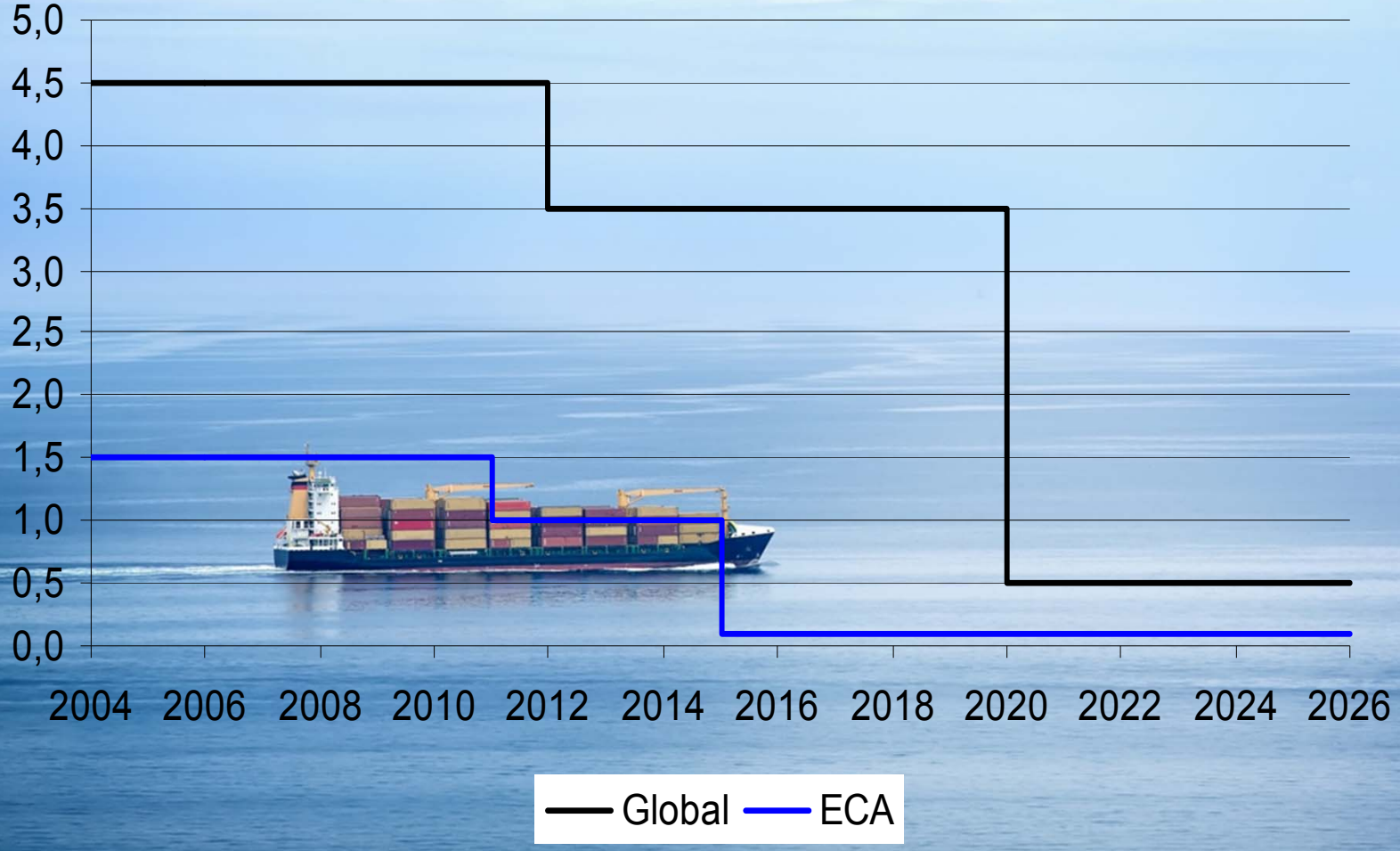
From 2016, new IMO Tier III requirements will require new builds to comply with NOx emission requirements in territorial waters.

At present the only designated NECA is the US/Canada coastline.

The NO_x control requirements of Annex VI apply to installed marine diesel engine of over 130 kW output power

marine EXHAUST TECHNOLOGY

SULPHUR OXIDES (SOx) – REGULATION 14



marine
EXHAUST TECHNOLOGY

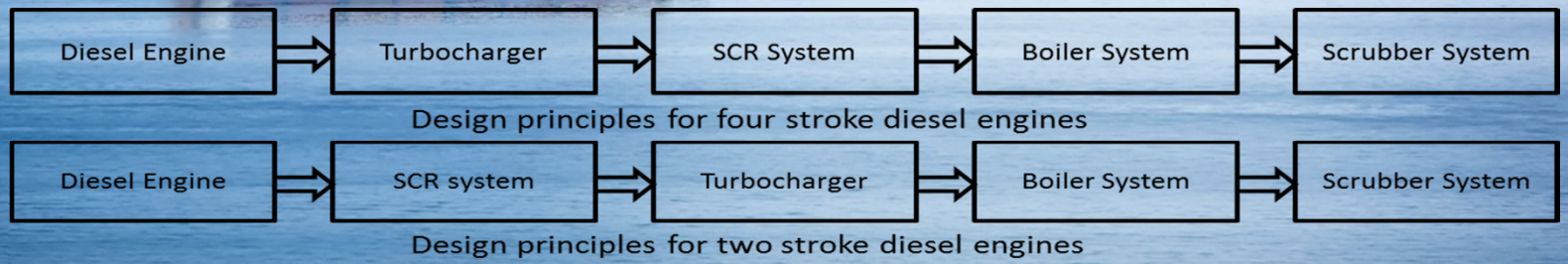
SOx AND NOx REDUCTION

Emissions of SOx and NOx cause severe environmental damage.

Our goal to develop technologies that significantly reduce SOx and NOx emissions from marine diesel engines, protecting the environment and turning the big blue greener.

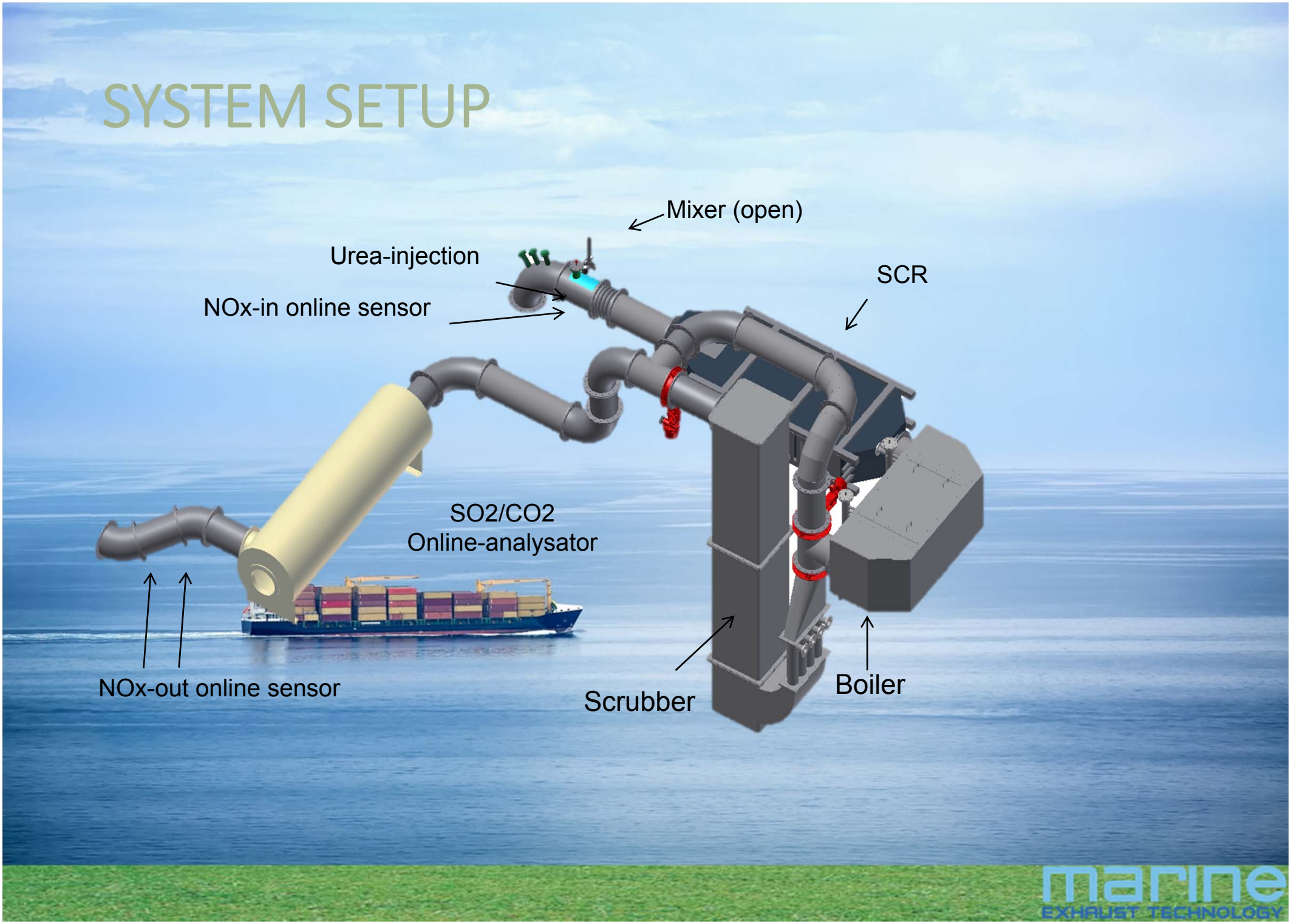
The technologies that can be integrated into the exhaust gas system and reduce noise, heat, NOx or SOx emissions. Each of these technologies has proven to be very efficient on their own, but they can also be set to work together.

We work with all the different technologies perceiving the exhaust gas system as a whole.



marine
EXHAUST TECHNOLOGY

SYSTEM SETUP



marine
EXHAUST TECHNOLOGY

THE SCR PROCESS

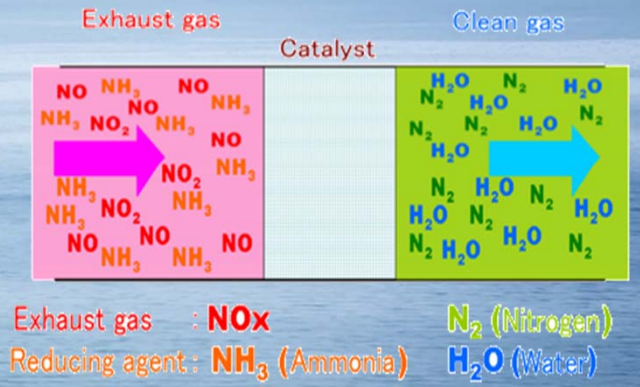
The most recognized and viable method for reducing NOx emissions is the SCR process - the selective catalytic reduction process.

SCR reduces NOx emissions by injecting an urea-water solution into the exhaust stream when the exhaust gas has reached the right temperature. This sets off a chemical reaction in the catalyst that converts the nitrogen oxides – NOx – present in the diesel engine's exhaust gas into nitrogen and water.

NOx is composed mainly of NO and a lower content of NO2. Their reaction patterns are as outlined below:

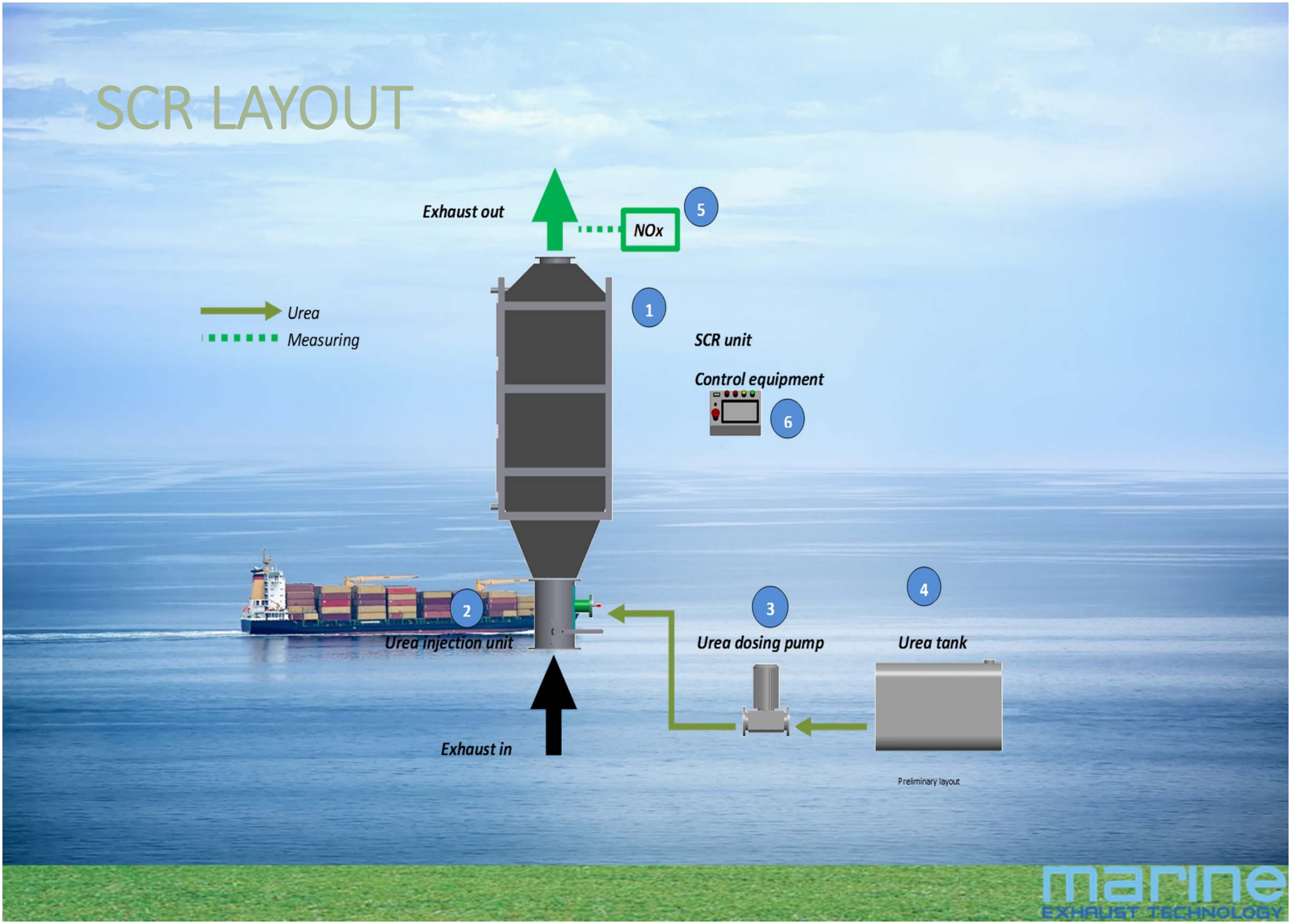
$$4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$$

$$NO + NO_2 + 2\ NH_3 \rightarrow 2\ N_2 + 3\ H_2O$$



marine
EXHAUST TECHNOLOGY

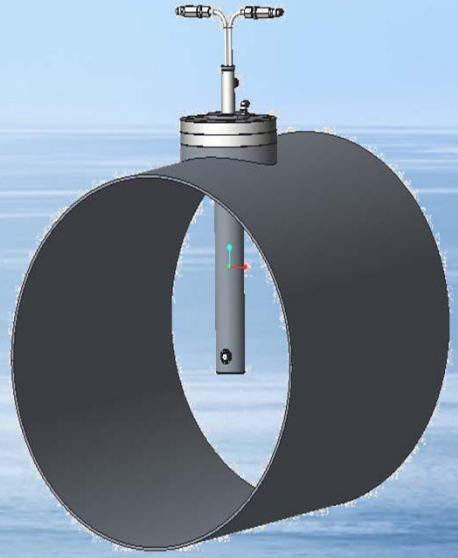
SCR LAYOUT


Exhaust out
NOx
5
Urea
Measuring
1
SCR unit
Control equipment
6
2
Urea injection unit
3
Urea dosing pump
4
Urea tank
Exhaust in
Preliminary layout

ANALYSING/UREA INJECTION

ANALYSER

- Continuously monitored and logged directly after the SCR unit.
- NOx/O2 analysing system
- In-situ and direct monitoring
- 2x4…20mA output signal selectable range
- Need continuous air supply 5 l/min

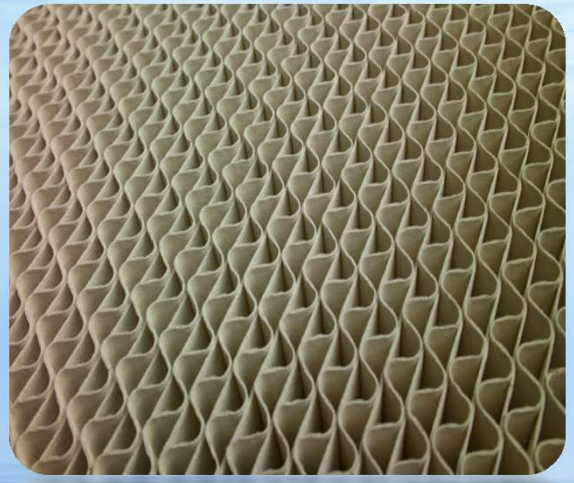


UREA INJECTOR

- Only regularly air/water for cleaning of urea nozzle
- Urea injection is adjusted by NOx level/engine load
- Urea consumption app.: 10,5 l/MW
- 5xDN between reactor/injection
- Stainless Steel

marine
EXHAUST TECHNOLOGY

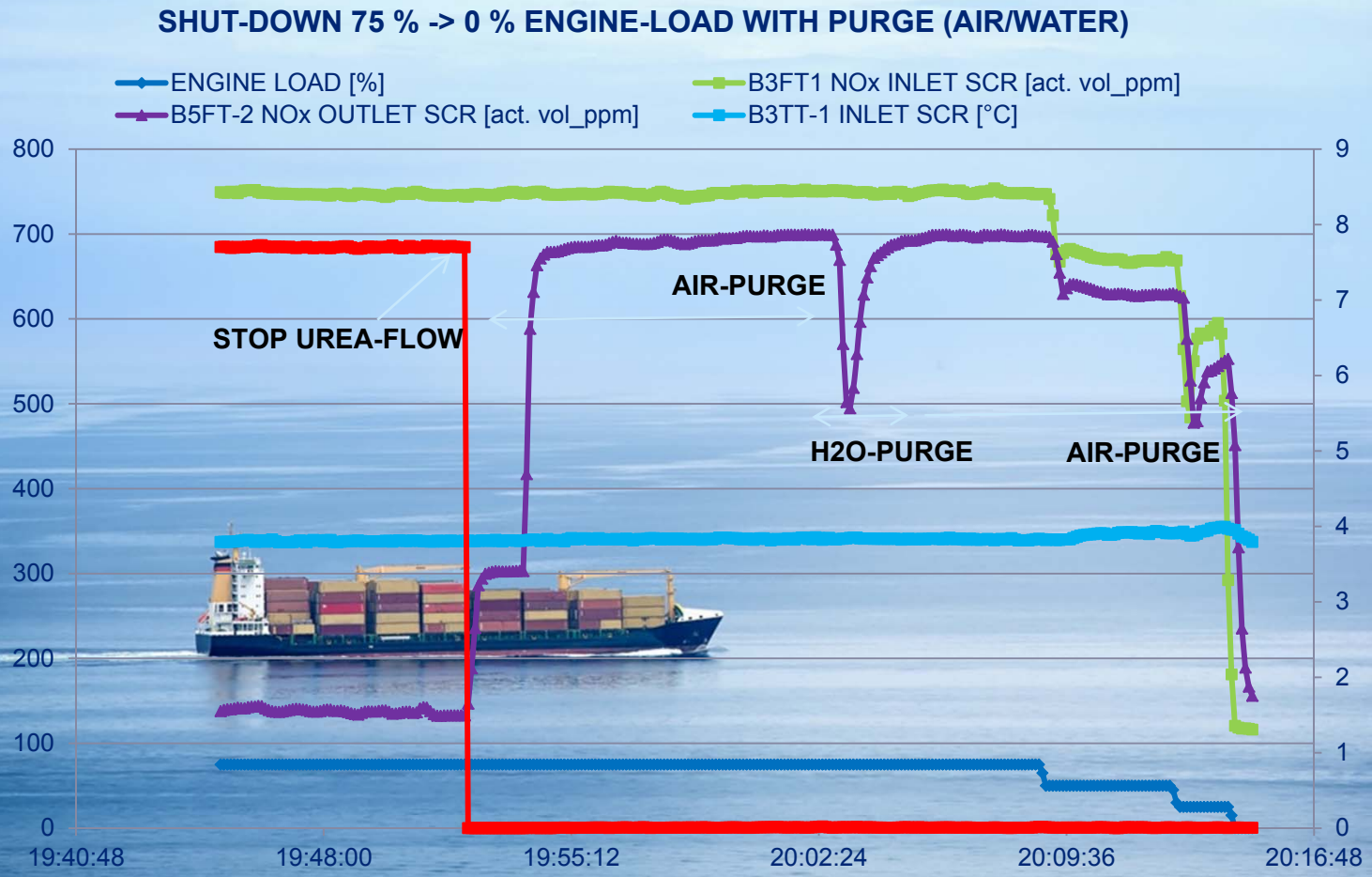
CATALYSTS



- Topsøe is one of the world's largest manufacturers of SCR DeNOx catalysts.
- The SCR reference list consists of more than 1000 catalyst installations
- Topsøe offers the most compact and cost-effective DeNOx solutions for any engine type.
- Vanadium-Tungsten-Titania catalyst.
- Most efficient Temperature 360 – 440 degrees

marine
EXHAUST TECHNOLOGY

CLEANING CYCLE



marine
EXHAUST TECHNOLOGY

KEY PERFORMANCE DATA

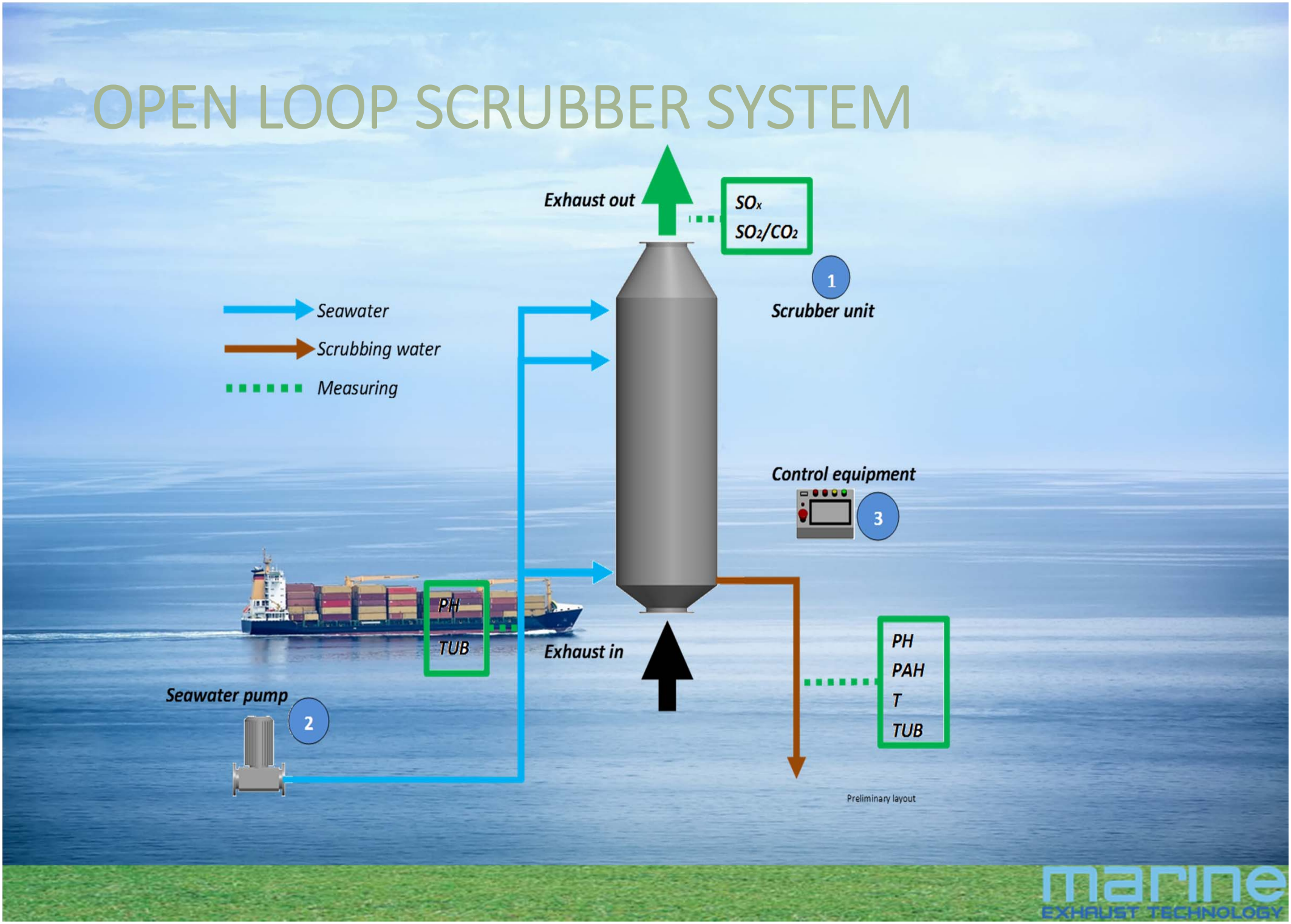
- NOx reduction max 97%
- Operational temperature in 300 – 540 °C
- Back pressure 800 Pa
- Urea consumption per MWh 10,5 l
- Pumping power requirement per MW 0,5 kW
- App. 0,75 m3 per MW

Benefits

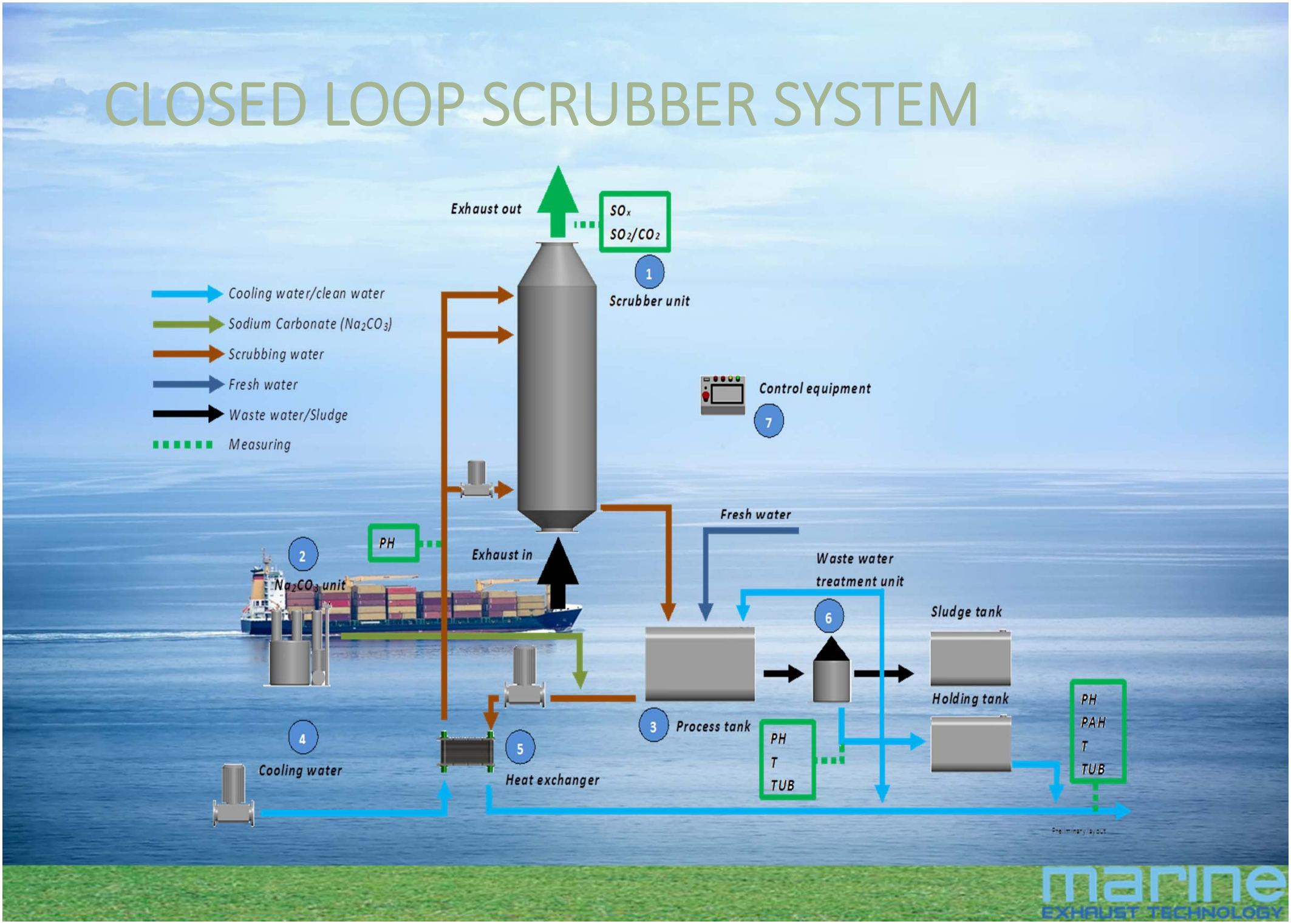
Cost-effective solution to emissions regulations
We offer turn key solutions
We provide customised designs for retrofit installations
Solution includes complete control and monitoring system
Low weight and space-saving compact modular design
Easy installation

marine
EXHAUST TECHNOLOGY

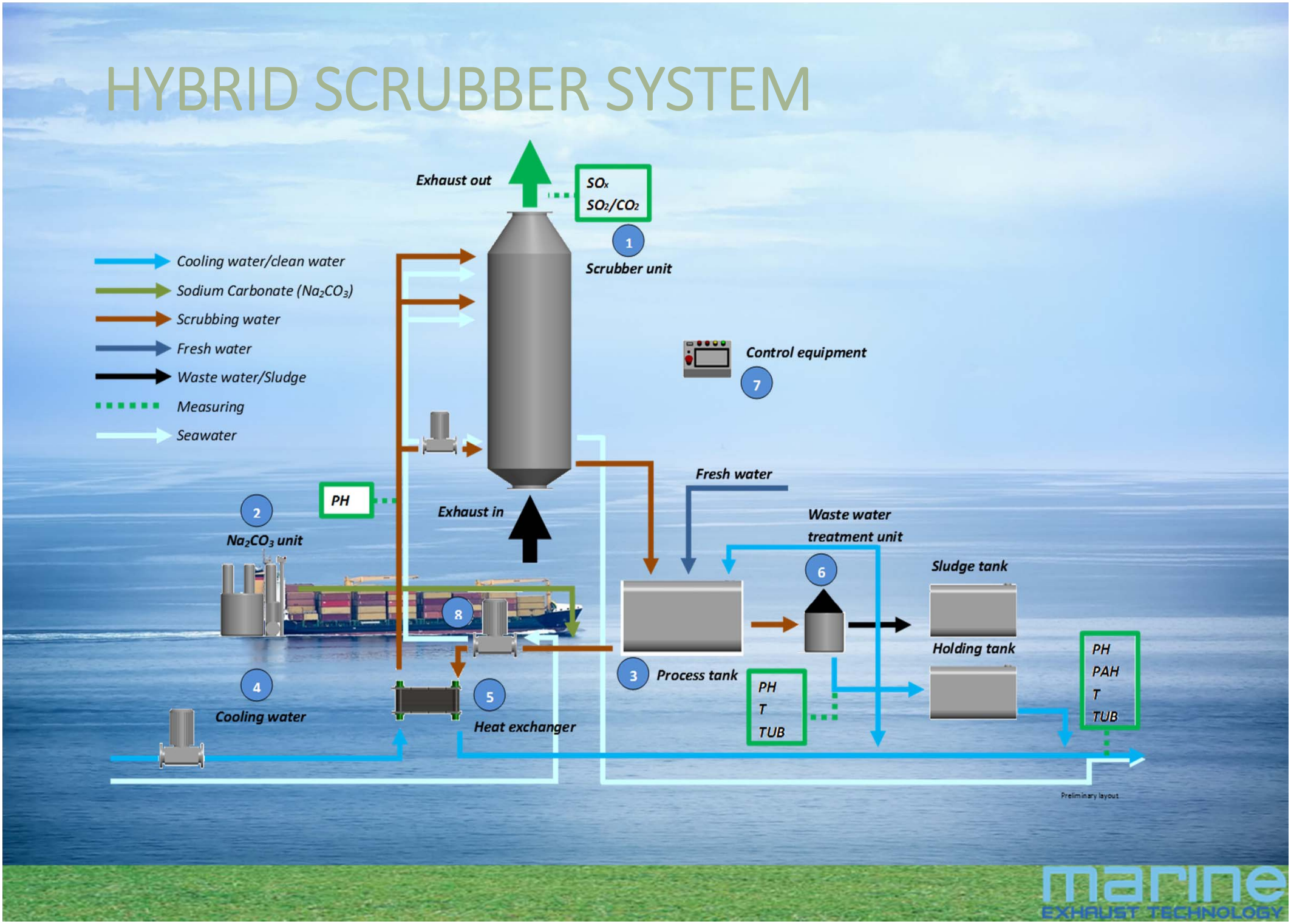
OPEN LOOP SCRUBBER SYSTEM



CLOSED LOOP SCRUBBER SYSTEM



HYBRID SCRUBBER SYSTEM



DISCHARGE WATER QUALITY

International Maritime Organization (IMO) requires following

- Complying with regulations acc. MEPC.259(68).
- Calculation based methodology
- Wash water parameters are continuously monitored and the results securely logged against time and ship's position:
- – pH (minimum pH 6.5 at 4 m from the overboard discharge point)
- – PAH *(Polycyclic Aromatic Hydrocarbons)* concentration in the washwater should not be greater than 50 µg/L PAHphe)
- – Turbidity (Maximum continuous turbidity in washwater should not be greater than 25 NTU)
- Each parameter has a limit that the discharge water must fulfill
- U.S. EPA has the same approach with some small differences in the pH limit measurement

marine
EXHAUST TECHNOLOGY

ALKALINITY LEVEL

PORTS Alkalinity Location	Min	Maks	PORTS Alkalinity Location	Min	Maks	Estuary
Arabian Sea	2300		Ansterdan	2200		
Baltic Sea	500	2000	Antwerpen	2200	4500	Scheldt
Bay of Bengal	2300		Bilbao	2200		
Black Sea	2500		Bordeaux	2300	2400	Gironde
Caribbian Sea	2250		Calais	2800	3100	
Coral Sea	2150		Dover	1100	1300	
Gulf of Alaska	2000		El Ferrol	2280		
Gulf of California	2150		Hamburg	2050	2400	Elbe
Gulf of Mexico	2250		Hanko	1600		
Gulf of Thailand	2000		Helsinki	1250	1500	
Indian Ocean	2200		Hull	1350		Humber
Mediterranean Sea	2400		Krota	900	1000	Kymijoki
North Atlantic Ocean	2300		Miami	2300		
North Pacific Ocean	2100		Moss	850	2000	
North Sea	2200		New Orleans	2400	3000	Mississippi
Norwegian Sea	2300		Oslo	1350		
Panama	1800		Rotterdam	2200	2700	Rhine
Panama Canal	1000		St. Petersburg	490		Neva
Persian Gulf	2500		Travemünd	1800		
Philippine Sea	2100					
Red Sea	2400					
South Atlantic Ocean	2300					umol/l

KEY PERFORMANCE DATA

"The main benefits of the closed-loop system are of course the ability to operate in a zero-discharge mode, and that it works independently of the alkalinity in the seawater."

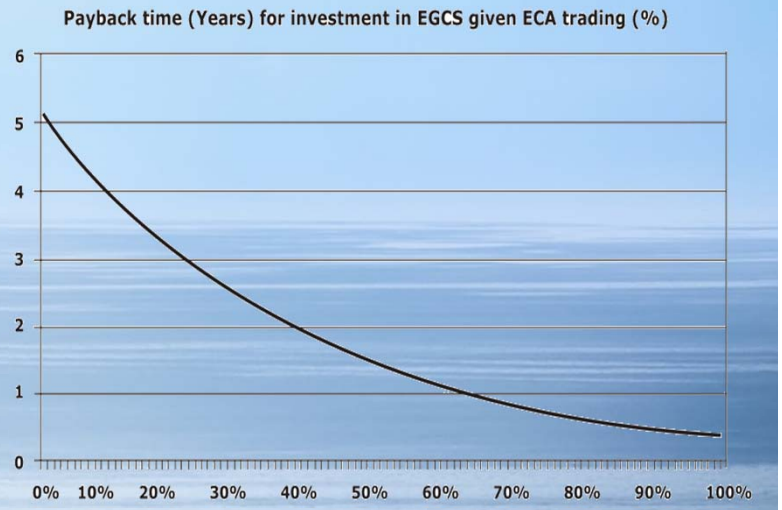
- SOx reduction 97-99%
- Particulate matter removal 80%
- Alcaline reactant Na2CO3 or Sodium Carbonate
- Waterflow scrubbing per MWh 25 m3
- Freshwater consumption 150-200 l/MWh
- NaOH consumption app. 15 liter/MWh
- Exhaust gas temp., max in 380°C
- Exhaust gas temp., out 45°C
- Back pressure, max 800 Pa
- Pumping power requirement per MW 6,5 kW
- Sludge produced per tonne fuel burned 0,4 kg
- Compliant with RESOLUTION MEPC.259(68) – 2015 GUIDELINES FOR EXHAUST GAS CLEANING SYSTEMS
- Scheme B (continuous emission monitoring with parameter checks).

marine
EXHAUST TECHNOLOGY

SCRUBBER BUSINESS CASE

If a vessel sails roughly 50% of its time in SECA areas, investment in an exhaust gas cleaning system is a solid business-case.

In the case of a vessel with large installed power, there is a positive business-case even if the vessel sails less than half of its time in a SECA area.



- **Save up to 50% on your fuel cost**
- **Payback time down to 2 years (100% SECA areas)**

marine
EXHAUST TECHNOLOGY

AKALINE ADDITIVE

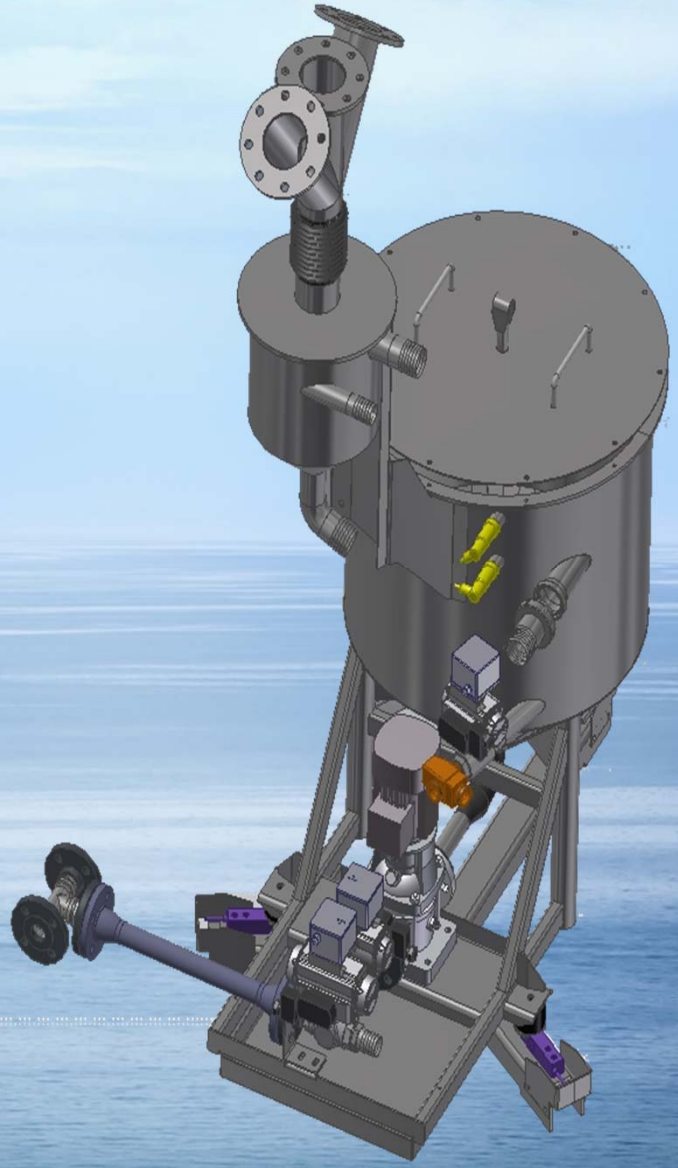
Closed-loop and hybrid configurations; when running in closed-loop mode, alkaline additive need to be injected in the process water as the reacting agent to remove SOx in the exhaust gas.

Until now this has always been the liquid additive Sodium Hydroxide(caustic soda), but in this unit sodium carbonate can be used instead.

This cuts operating costs, and reduces the potential onboard hazard.

Mixing Unit including;

- Dosing pump
- Circulation system
- Loading cells
- Control valves
- Control touch panel
- Stainless steel



marine
EXHAUST TECHNOLOGY

SAFETY – A TOP PRIORITY

We enforce high demands for safety and every Marine Exhaust Technology solution conforms to all applicable regulatory requirements. In addition, our exhaust gas cleaning solutions feature a variety of alarm settings that alert the user in case of operational problems.

The system conforms to classification society requirements, environmental requirements and customer demands.

BUREAU VERITAS 1828 BUREAU VERITAS

GL GL Group

Lloyd's Register

ABS

DNV

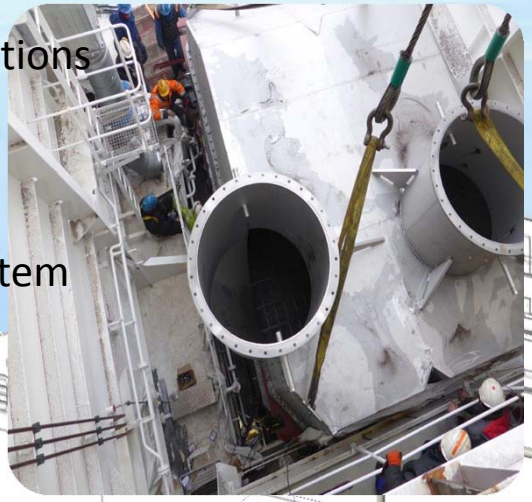
RINA 1861

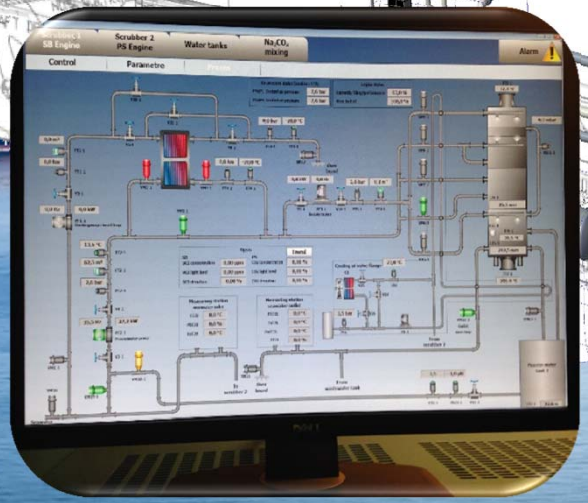
CCS CHINA CLASSIFICATION SOCIETY 中国船级社

marine EXHAUST TECHNOLOGY

RETROFIT INSTALLATION

- Turn key solutions
- Customize designs for retrofit installations
- Low weight
- Easy installation
- Cost efficient
- Complete control and monitoring system





marine
EXHAUST TECHNOLOGY

DESIGN POSSIBILITIES

- Minimizing downtime
- Fewer equipment means lower cost
- Lower installation cost
- Operational flexibility
- Designed to save space
- All SOx emission regulations are m

MX Inline Scrubber

marine
EXHAUST TECHNOLOGY

REFERENCE

MX Inline Hybrid Scrubber – ARK DANIA

Scrubber information	
Closed Scrubber for main engine	2 X 9080 KW
Scrubber dimensions	HxW: 6000 x 800 mm
Dry weight	1.500/2.500kg
Flow	14.000kg
Power	85.000
Materiel	Duplex EN.EN1.4462 Super Duplex 1.4410
Engine information	
Engine make	Man Diesel
Engine type	8S40ME-B9
Engine rated power	9,08 MW
Fuel type	HFO
Fuel Sulphur content	3,5%

MX Inline Hybrid Scrubber – ARK GERMANIA

Scrubber information	
Closed Scrubber for main engine	2 X 9080 KW
Scrubber dimensions	HxLxW: 15.000 mm x 3100 mm x 3100 mm
Dry weight	14.000kg
Flow	85.000
Power	9,08 MW
Engine Information	
Engine make	Man Diesel
Engine type	8S40ME-B9
Engine rated power	9,08 MW
Fuel type	HFO
Fuel Sulphur content	3,5 %

MX Inline Open Loop Scrubber - Finlandia

Scrubber information	
Open Scrubber for main engine	1 x ME 12,6 MW
Height	7,4m
Width	3,6m
Depth	3,1m
Dry weight	11.800kg
Flow	88.000kg/h
Power	12,6MW
Materiel	Duplex EN.EN1.4462 Super Duplex
Engine Information	
Engine make	Man Diesel
Engine type	12V48/60
Engine rated power	12,6 MW
Fuel type	HFO
Fuel Sulphur content	3,0 %

MX Inline Hybrid Scrubber

Scrubber information	
Open Scrubber for main engine	1 x 2.660 KW
Scrubber dimensions	DxH: 1600 mm x 7000
Dry weight	4.000kg
Flow	19.575kh/hr
Power	2660@750 RPM
Materiel	SMO 254
Engine information	
Engine make	MAK
Engine type	8M25C
Engine rated power	2660@750RPM
Fuel type	HFO
Fuel Sulphur content	3,5%