PRIMARINE

Workshop „Alternative Kraftstoffe II“

SCRUBBER | SCR | FUEL ADDITIVES

PRIMARINE

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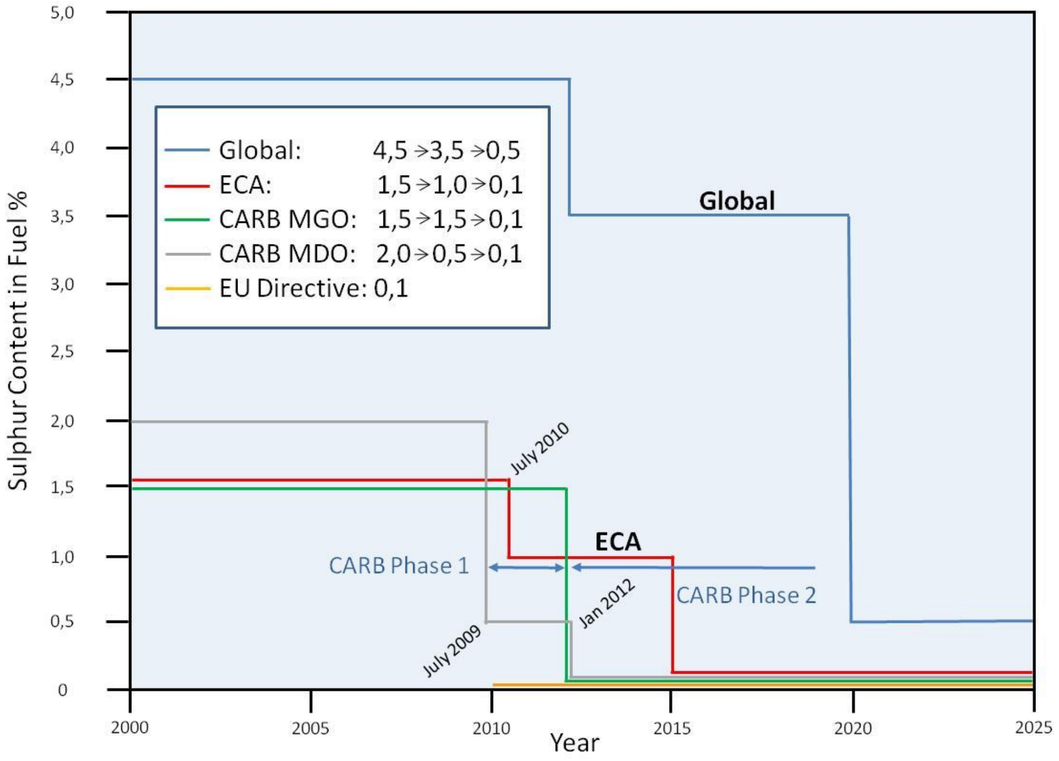
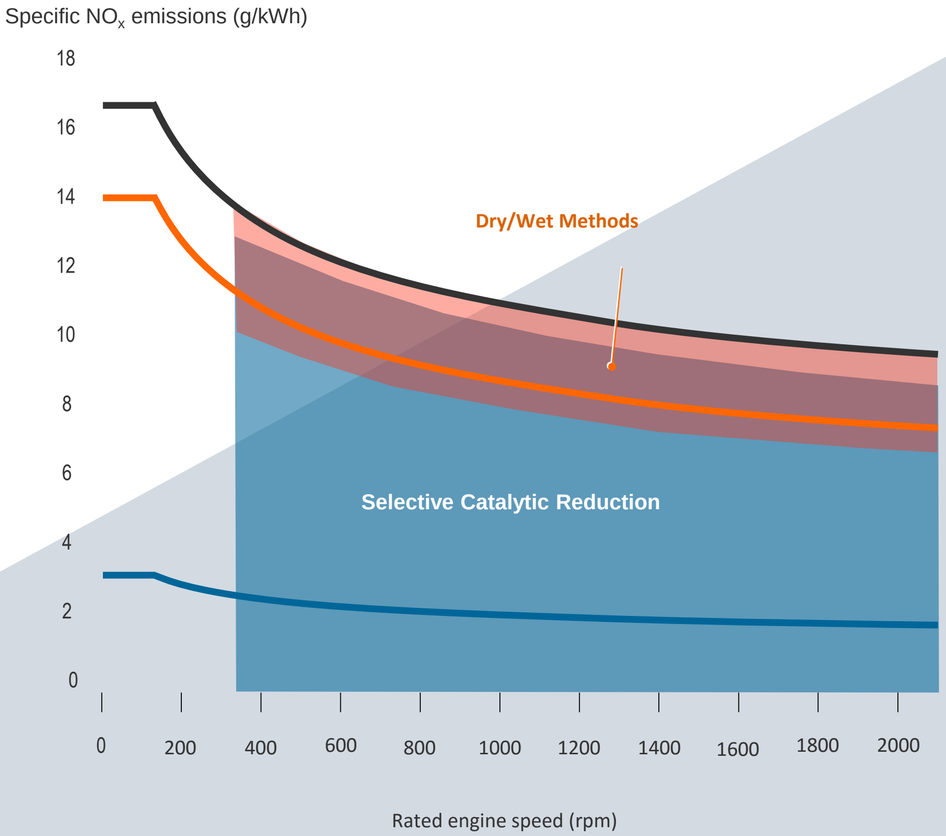
EXHAUST GAS AFTER TREATMENT

LEGISLATION





Tier I (present)
Ships built 2000 onwards
Engines > 130 kW

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

Tier II (global 2011)
Ships built 2011 onwards
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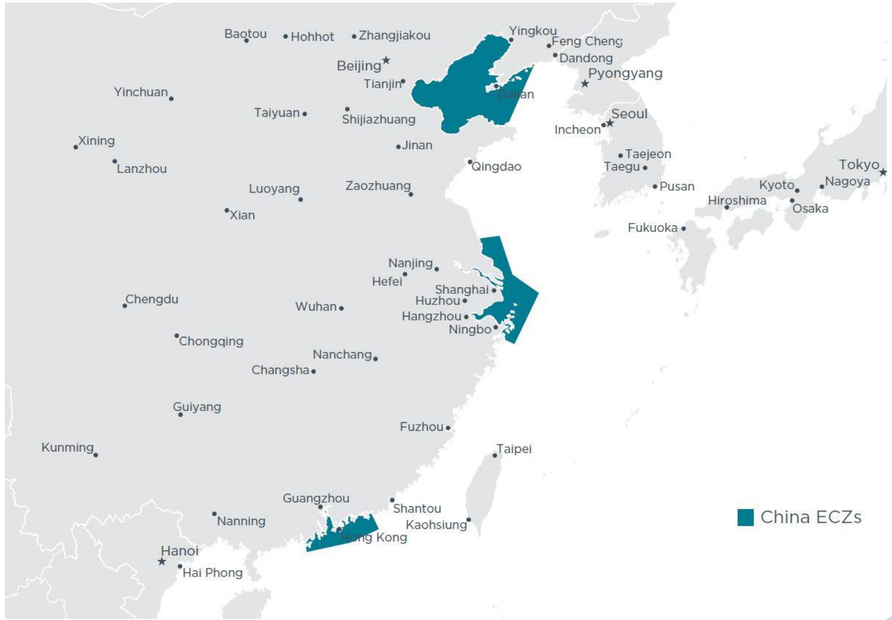
Tier III (ECAs 2016/2021)
Ships in designated
areas, 2016 onwards
Engines > 600 kW

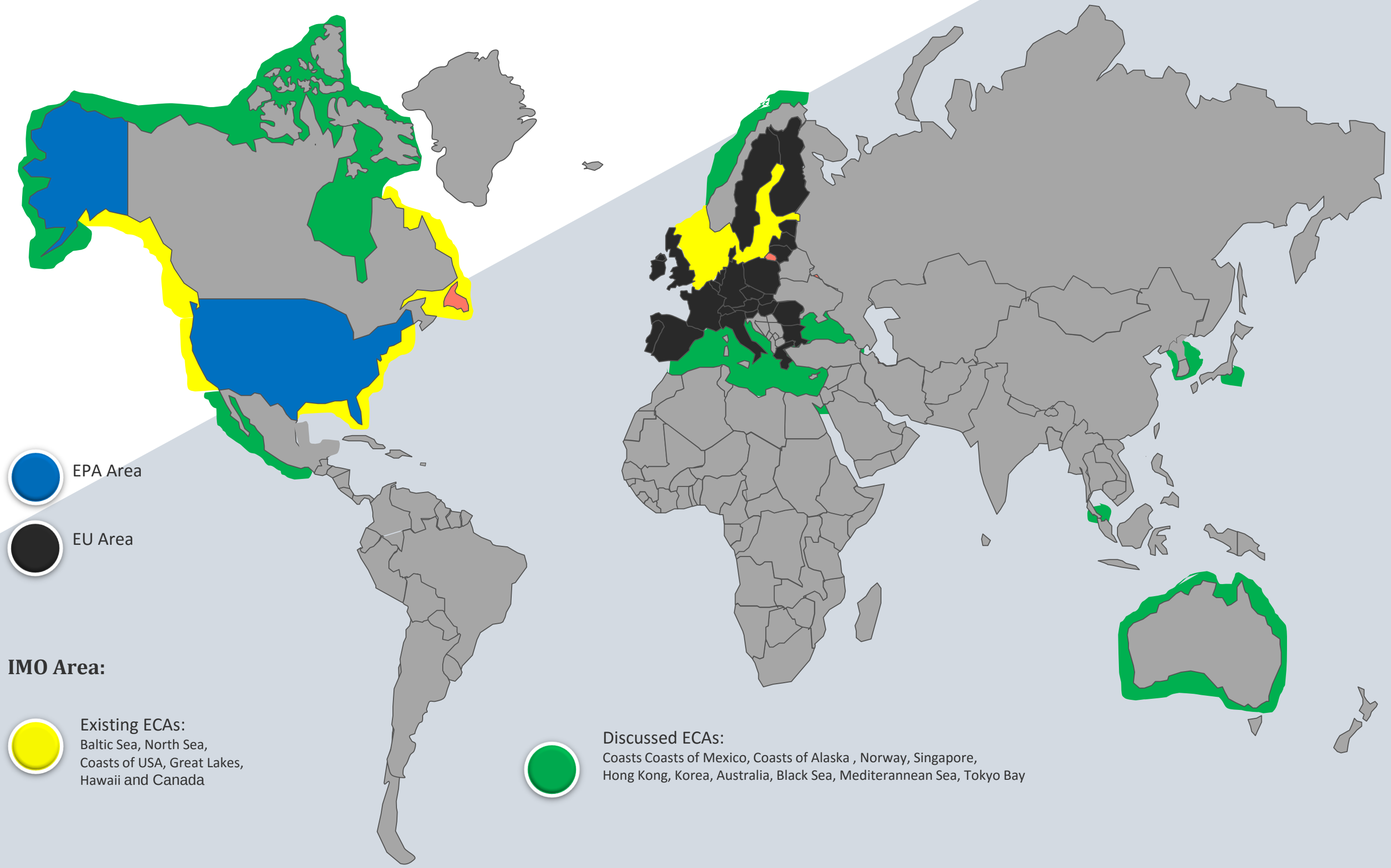
INTERNATIONAL MARITIME ORGANIZATION

LEGISLATION

IMO Marpol Annex VI
2015, 2016, 2020
(MEPC259.68, MEPC198.62)

Regional Regulations
Existing and upcoming ECAs
EU directives
EPA (North America) regulations





LEGISLATION

January 1st 2019	January 1st 2020		
Sulphur 0.5%	Sulphur 0.5%	Sulphur 0.1%	Sulphur 0.1%
Coastal waters	Chinese National 12 nm zone	Chinese National 12 nm zone	Hainan island waters
Berthing & Sailing	Sailing	Berthing	Berthing & Sailing

Applicable for all ships trading in Chinese Coastal Waters.

Except for military vessels, fishing vessels, sport boats, and ships which are used for navigation and berthing.

References: Website of Chines Ministry of Transport

Courtesy: Dr. Fabian Kock, DNVGL

WHAT ARE THE OPTIONS?

January 1st, 2020

3,5 % m/m sulphur | **0,5 % m/m sulphur**

- HFO + Scrubber
- MGO MDO
- Alternative Fuels (LNG, Methanol, etc.)
- New Compliant Fuels?

- Type of vessel
- Sailing route (time in ECA 0,1 %)
- Charter contract
- CAPEX
- OPEX

WHAT ARE THE OPTIONS?

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New compliant fuels

+

- Usable for most engine configurations

-

- Unknown fuel cost
- Not on the market (no track record)
- Uncertain availability
- May create operational issues due to off-spec fuel or incompatibility

LNG as fuel

+

- Had good environmental performance
- Can reach Tier III performance
- Positive impact on EEDI

-

- High investment cost
- Costly to retrofit
- Large variations in LNG price
- Methane slip in exhaust
- Requires space for tank
- Some engine types require additional systems to reach Tier III

HFO with scrubber

+

- Can use HFO
- Possible to retrofit
- Reduce particulate matter as well as SOx

-

- High investment cost
- 3-5% fuel penalty
- Requires space for scrubber tower and aux. systems
- Requires chemical (closed loop)
- Requires process monitoring system

Distillate fuel

+

- Usable for most engine configurations

-

- Higher fuel cost
- May create operational issues due to low viscosity fuel

Courtesy: Dr. Fabian Kock, DNVGL

WHAT ARE THE OPTIONS?

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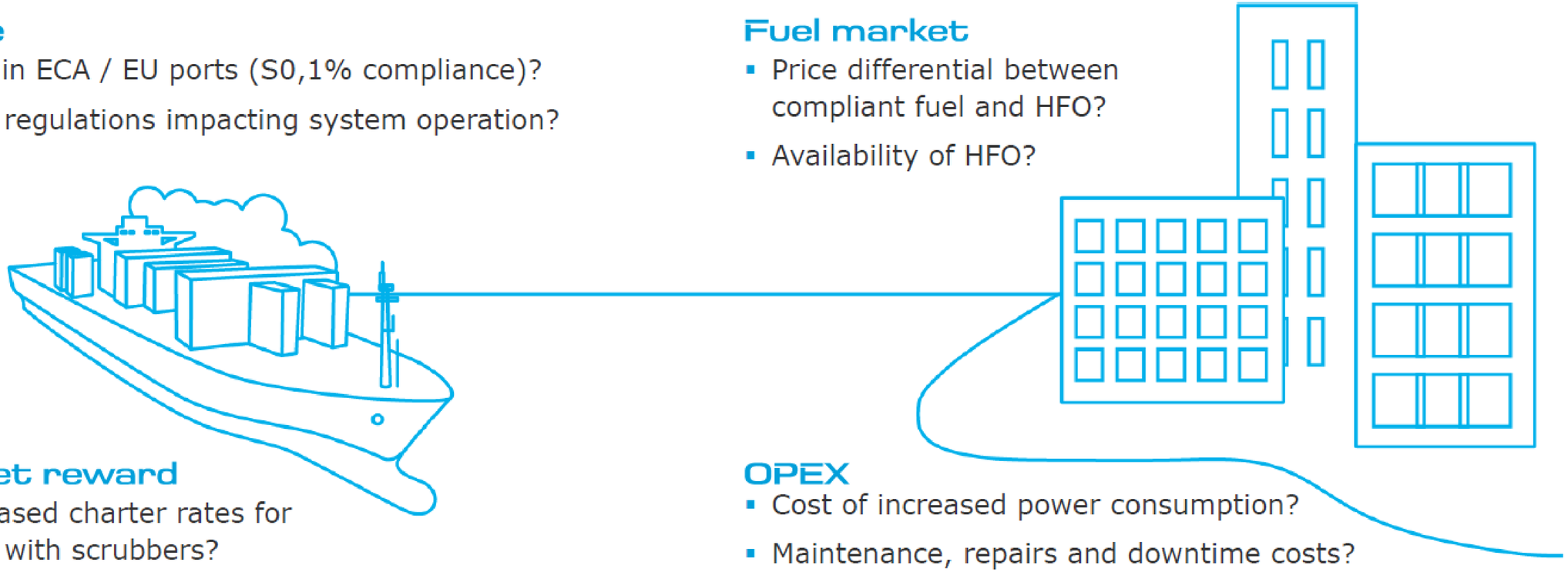
Trade
- Time in ECA / EU ports (S0,1% compliance)?
- Local regulations impacting system operation?

Fuel market
- Price differential between compliant fuel and HFO?
- Availability of HFO?



Market reward
- Increased charter rates for ships with scrubbers?

OPEX
- Cost of increased power consumption?
- Maintenance, repairs and downtime costs?
- Alkali bunkering / sludge landing costs?

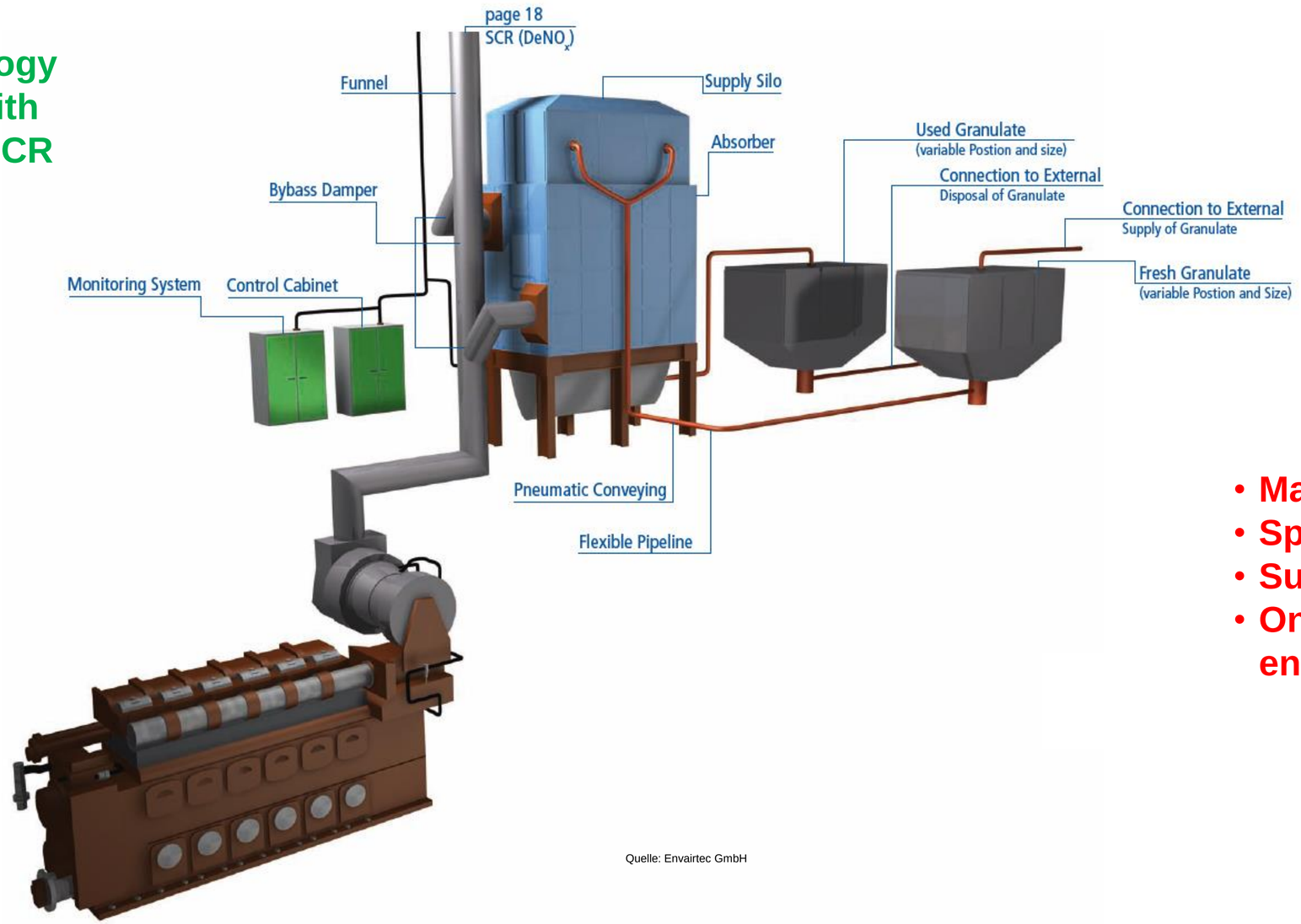
Courtesy: Dr. Fabian Kock, DNVGL

Scrubber Technologies

- **Open Loop**
- **Closed Loop**
- **Triloop©**
- **Dry Scrubber**
- **Membrane Scrubber**

Scrubber Technologies

- **Simple technology**
- **Combination with WHRS and/or SCR**

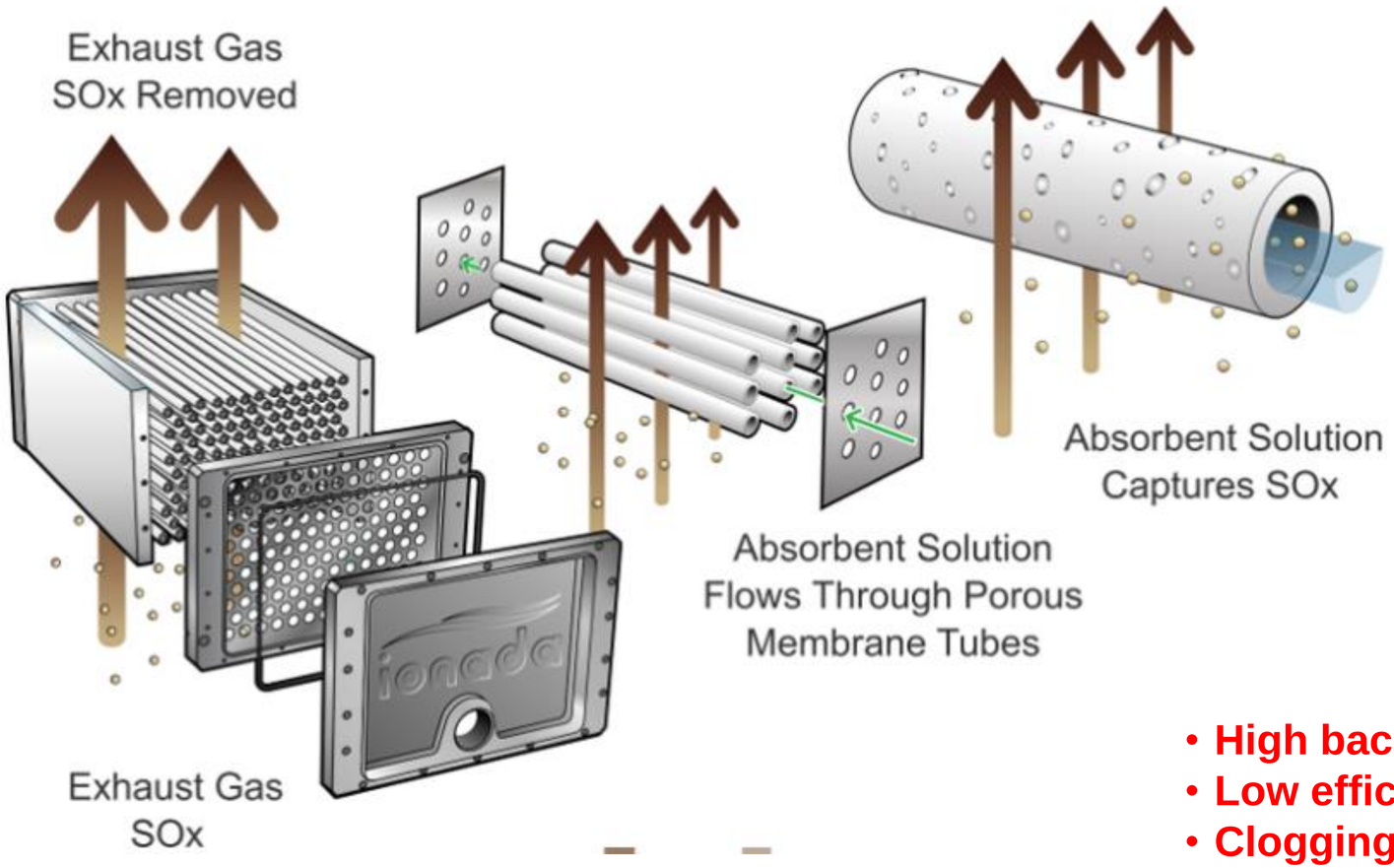


Quelle: Envairtec GmbH

- **Massive weight**
- **Space requirements**
- **Supply of granulate**
- **Only for 4-stroke engines**

Scrubber Technologies

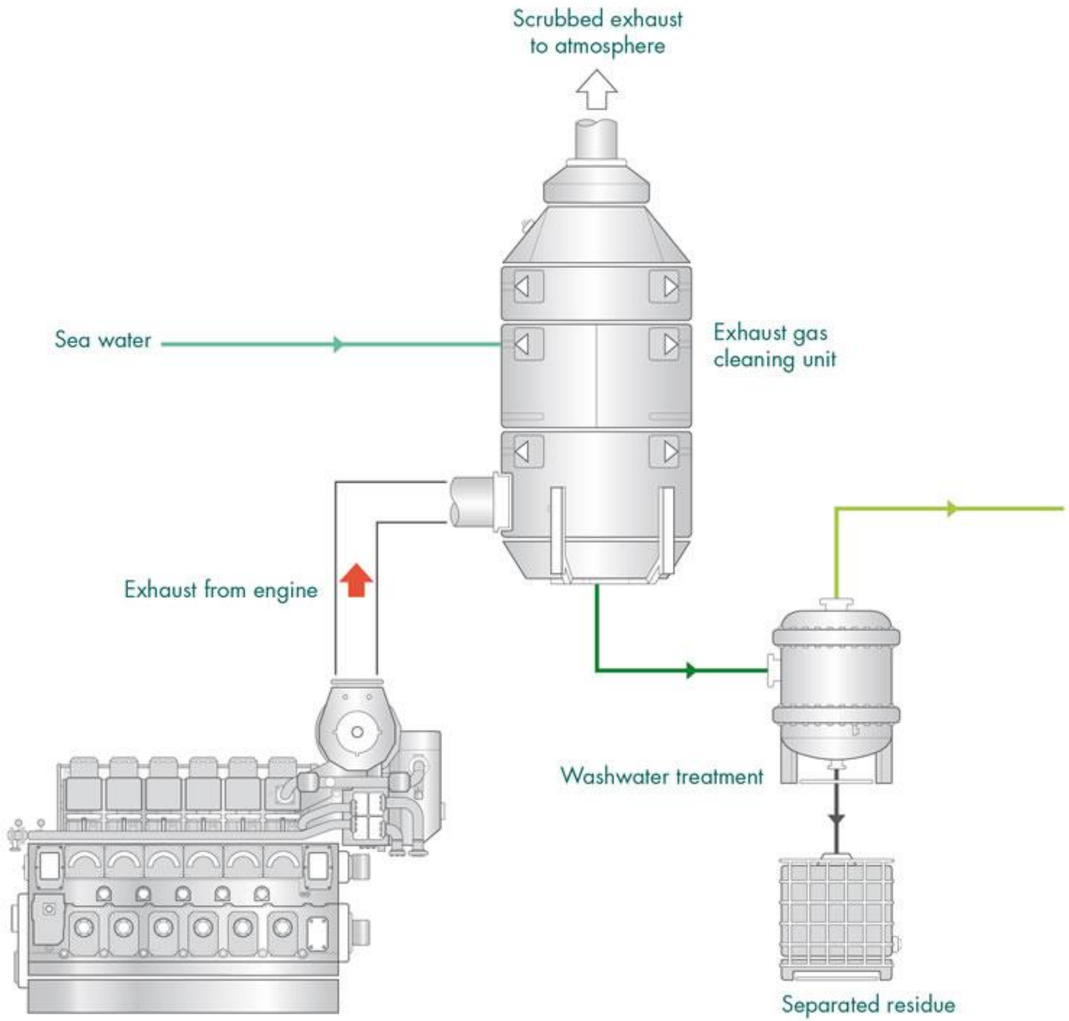
- Small footprint
- Low energy consumption
- No moving parts



- High backpressure
- Low efficiency
- Clogging of membrane structure

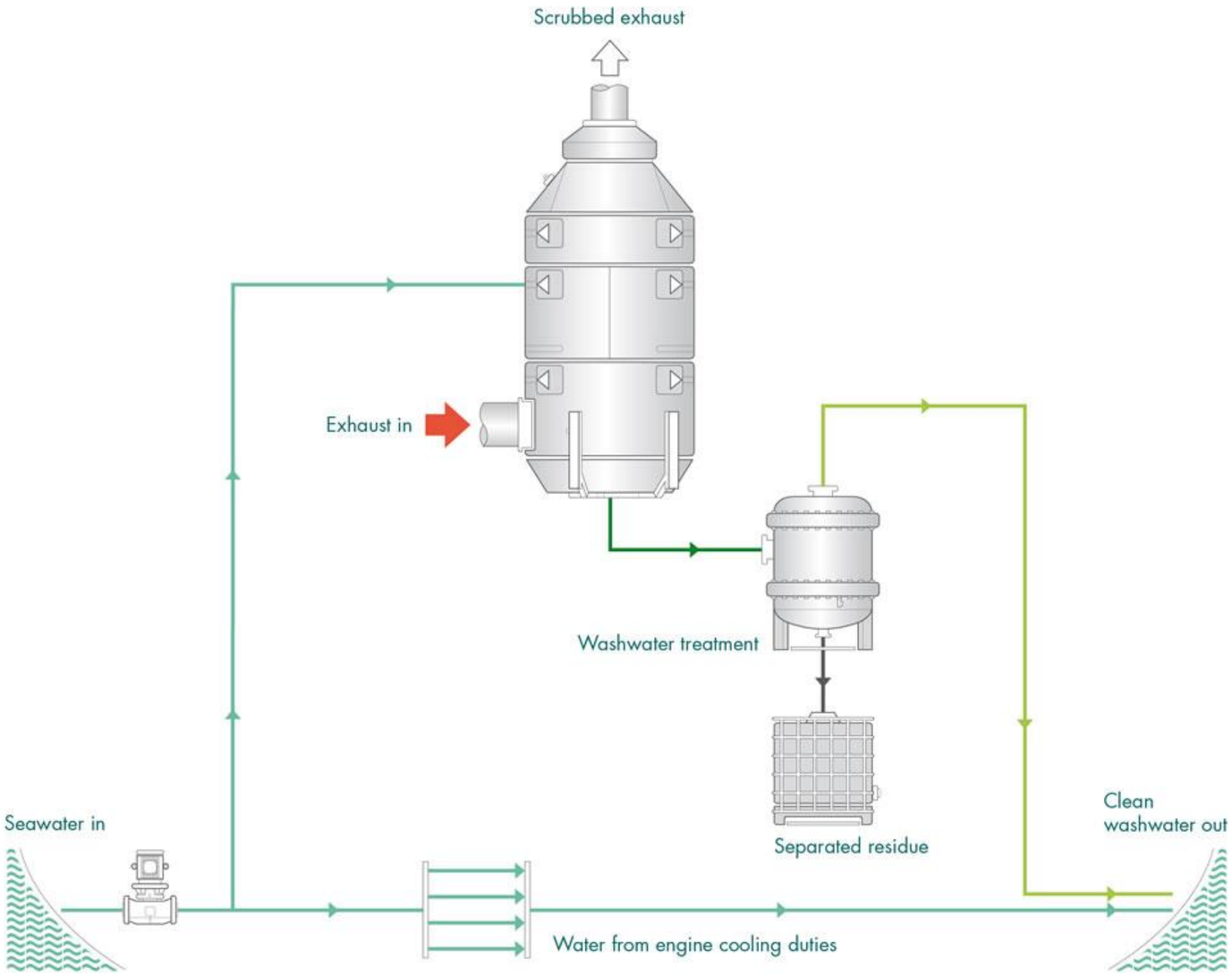
Quelle: Ionada Inc.

WET Scrubber, basic components



Source: EGCSA

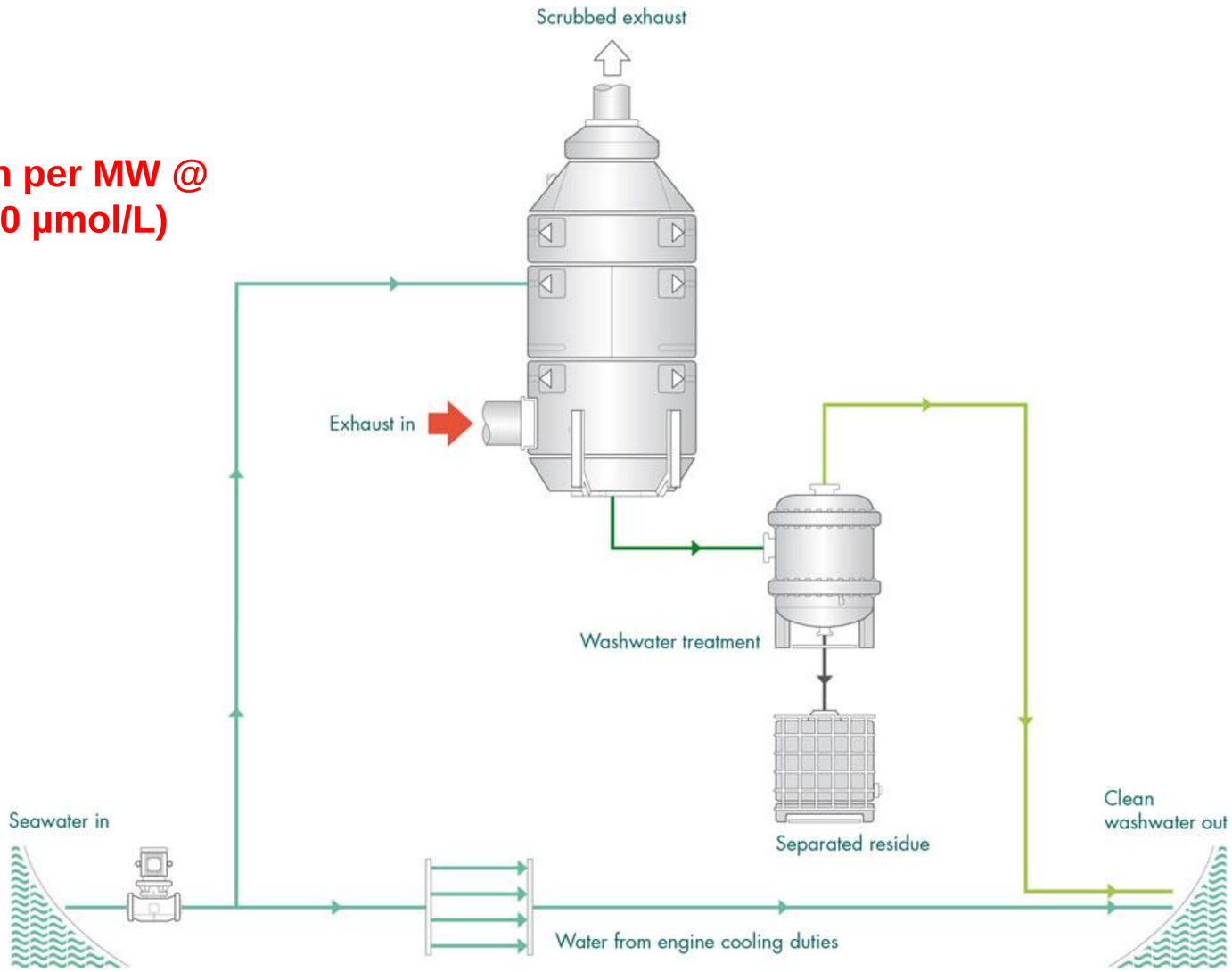
WET Scrubber Open Loop



Source: EGCSA

WET Scrubber Open Loop

app. 45 m³/h per MW @ 2,7% S (2100 µmol/L)

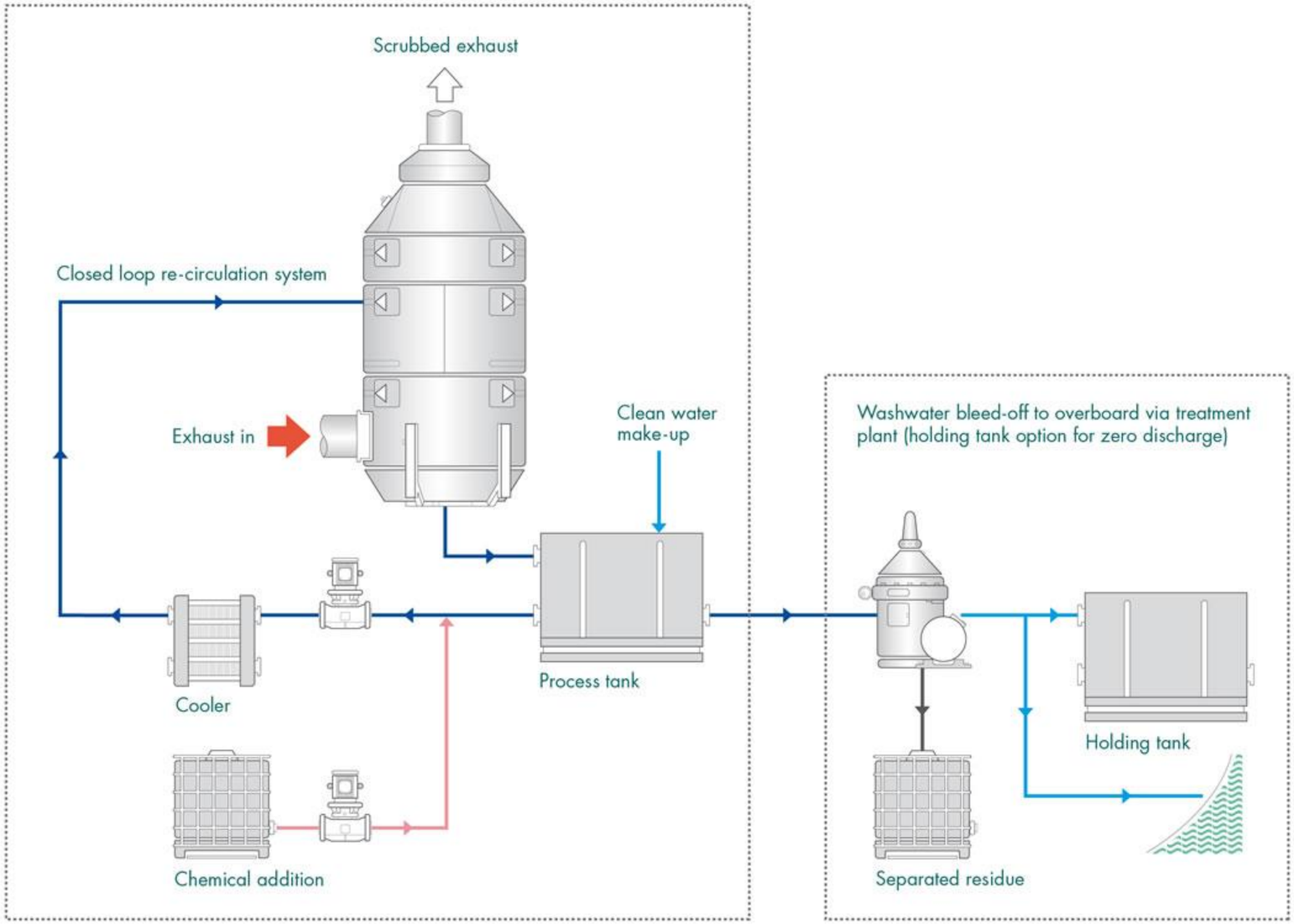


app. 100 to 130 m³/h per MW dilution water (US Coast)

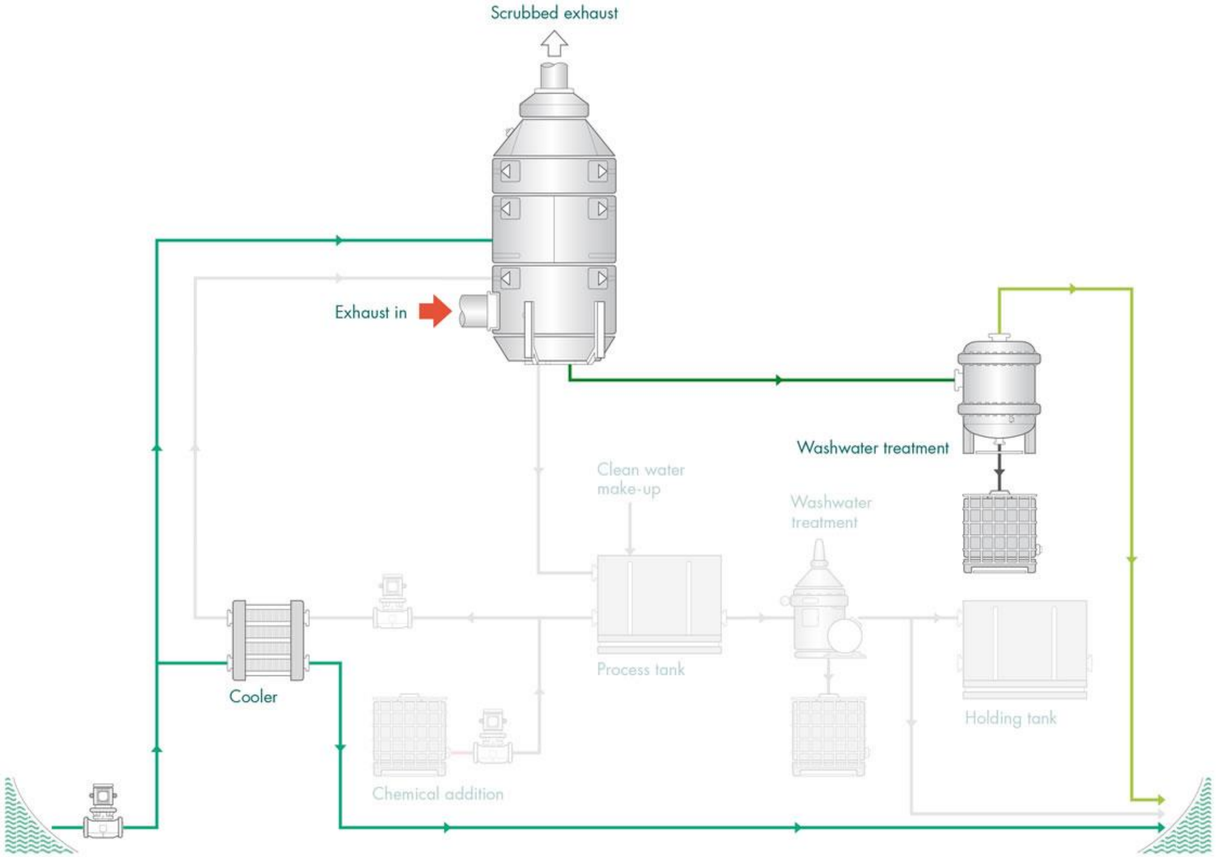
Wash Water Treatment: PAH and Particulate Matter

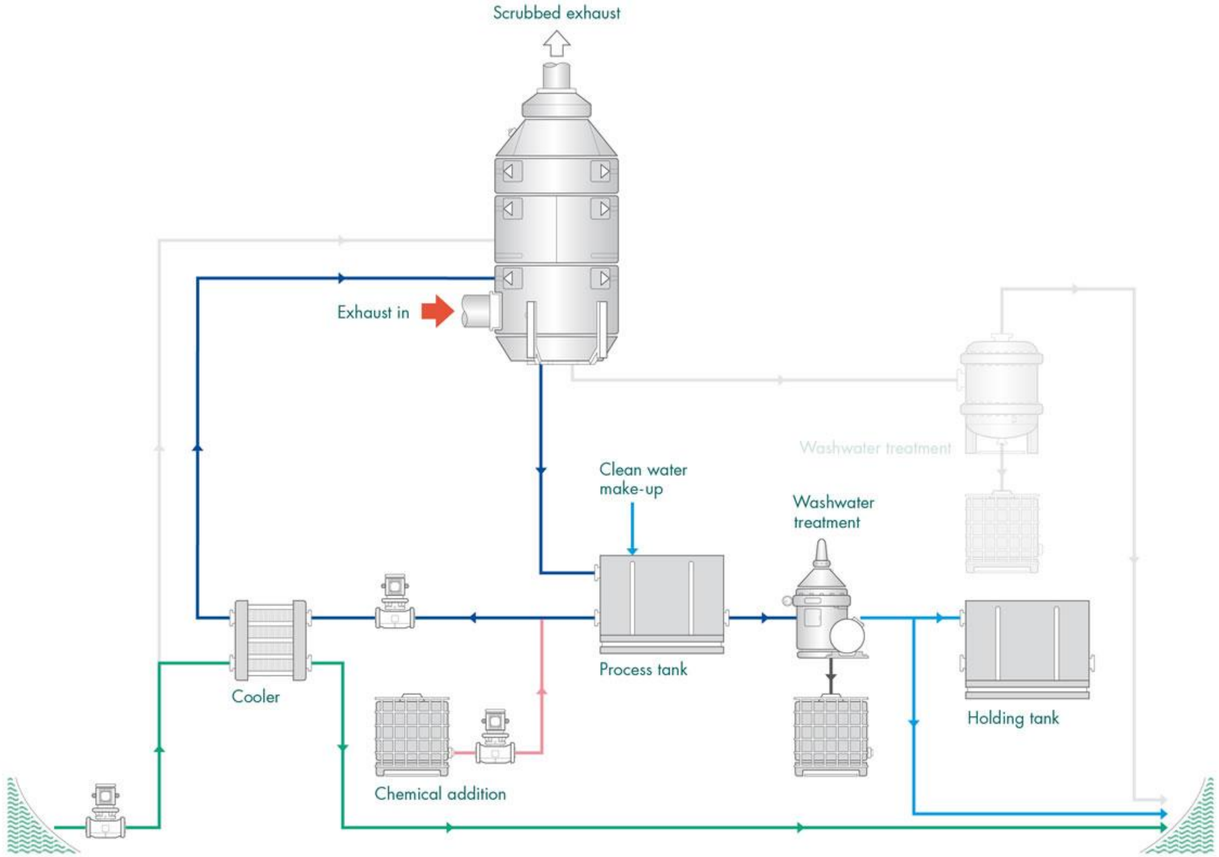
Source: EGCSA

WET Scrubber Closed Loop



Hybrid Scrubber





Source: EGCSA

Open Loop Operation

Closed Loop Operation

Hybrid Scrubber

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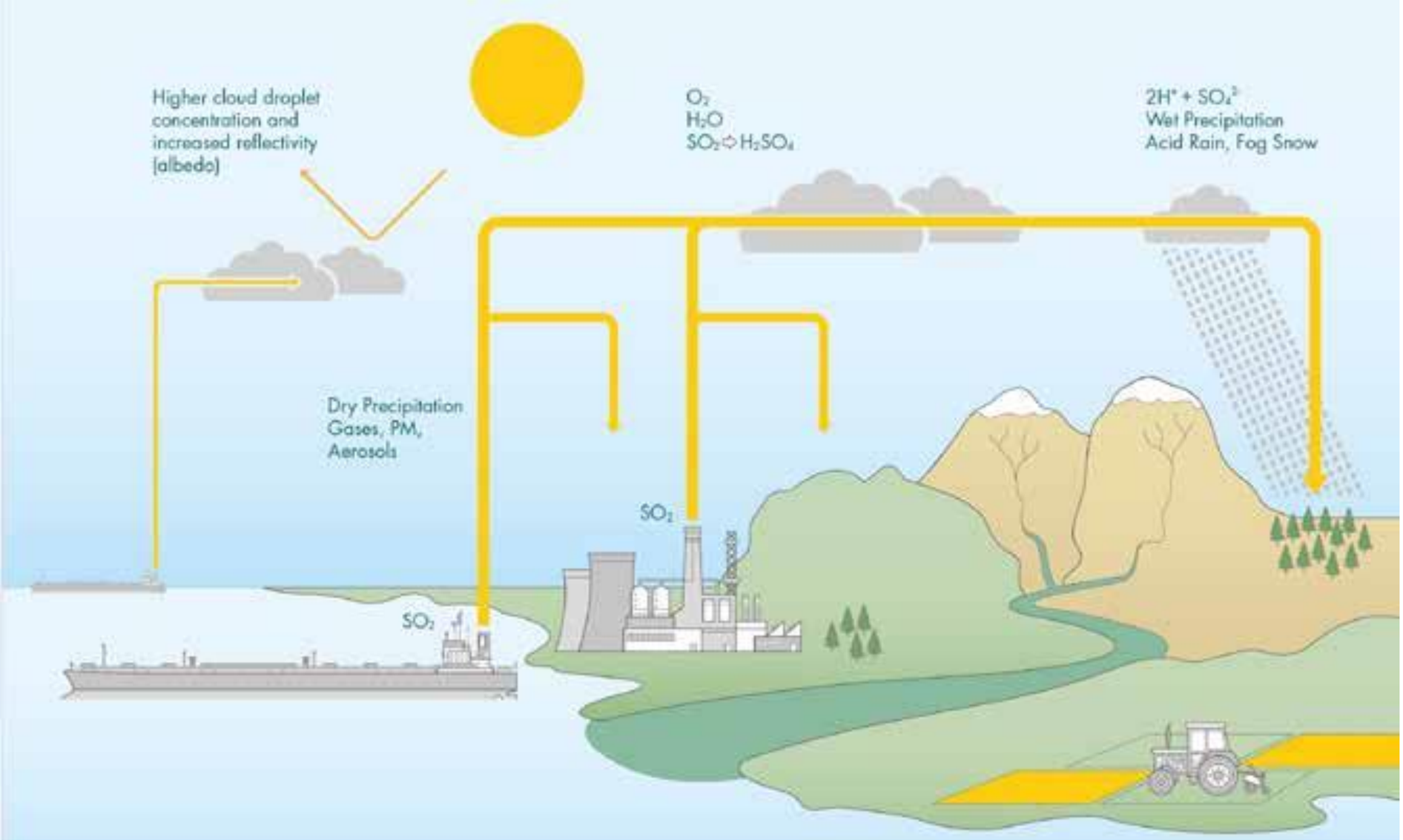
Advantages	Open Loop Operation	Disadvantages
• Simple Process • No chemical agents needed (if alkalinity is sufficient) • Suitable for large engines • Equivalent value of 0,5% S easy to meet		• Slight cleaning of wash water • Energy consumption of diltution pumps (if used) • Wash water mass flow determined by alkalinity of seawater • Low acceptance (baltic sea, harbours, estuaries) • Only PAH and solid particles precipitated

Hybrid Scrubber

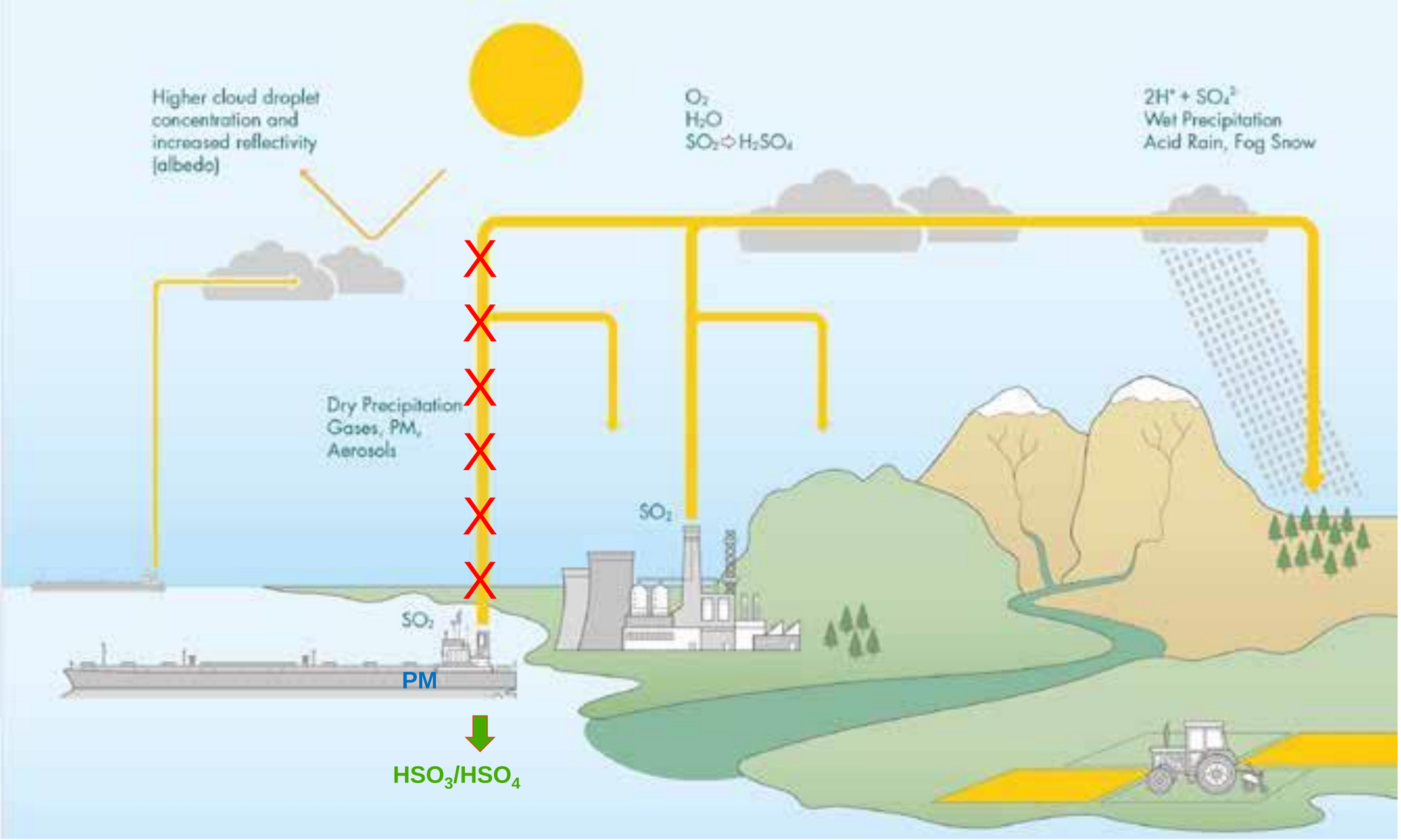
Advantages	Closed Loop Operation	Disadvantages
•High flexibility •Lower pump capacity •High SO_2 reduction through usage of alkalies •Equivalent value of 0,1% S easy to meet •Minor emission to environment (sea and air)		•Larger complexity •Potable water to be produced onboard (Some scrubbers can use seawater as well) •Autonomy of vessel determined by size of sludge and holding tank •Costs for chemicals •(NaOH, MgO or $NaHCO_3$) •Only PAH and solid particles precipitated

SCRUBBER



EGCSA, A practical guide to exhaust gas cleaning systems for the maritime industry

SCRUBBER



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Ship	Power (kW)	Speed (kn)	HFO 24h	CO_2 24h	NOx 24h	SOx 24h	Particulates
VC8500TEU	62.000	26.5	283t	878t	26t	17t	3t
Bulker 35.000dwt	6.300	14	26t	85,4	2,7t	1,7t	0,3

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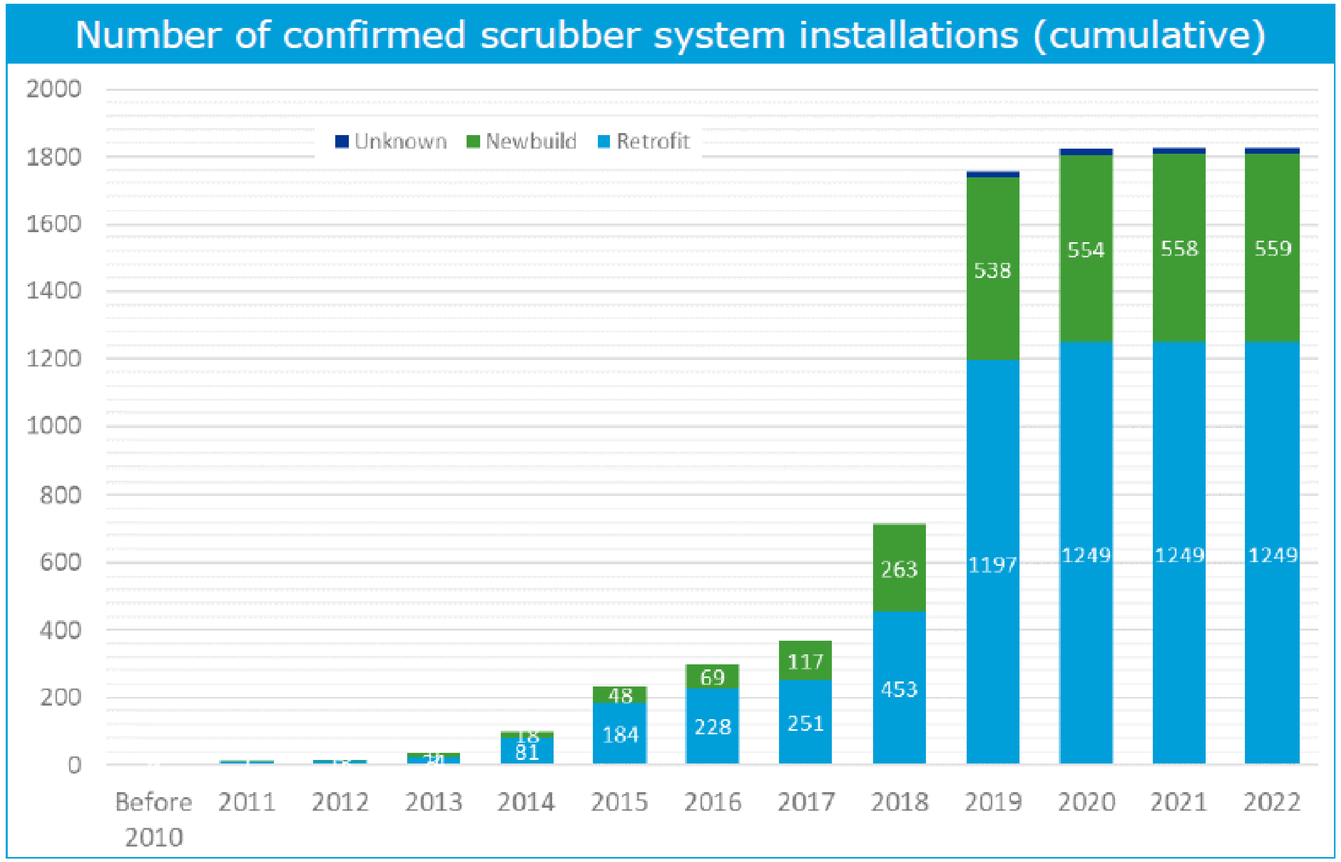
> 90% removed by scrubbing

SCRUBBER MARKET OVERVIEW

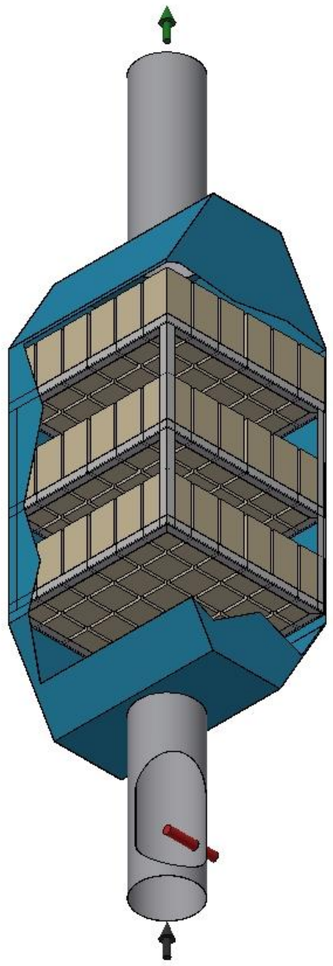


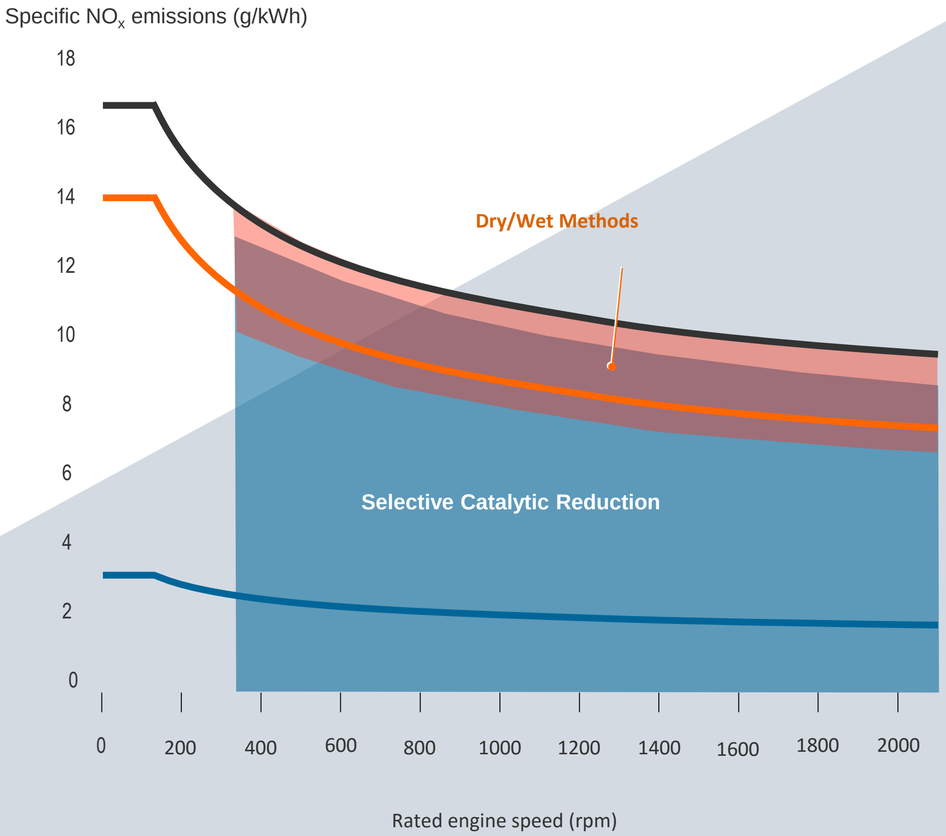
- There are about 1850 ships with installed or confirmed scrubber systems installations
- The "first scrubber wave" started in 2014 in preparation of SECA in North America
- The "second scrubber wave" is now on its way with over 1000 confirmed projects it the past 6 months
- A majority of the orders are for retrofits

Early predication by the IMO indicated that 4000 ships would be fitted with scrubber systems by 2020

Courtesy: Dr. Fabian Kock, DNVGL

SCR





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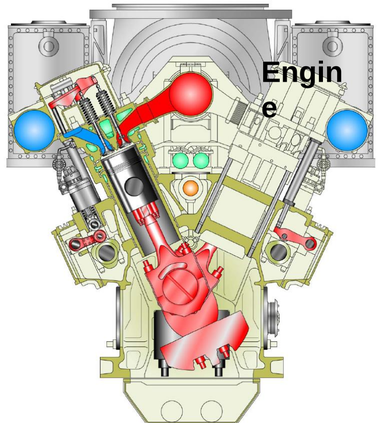
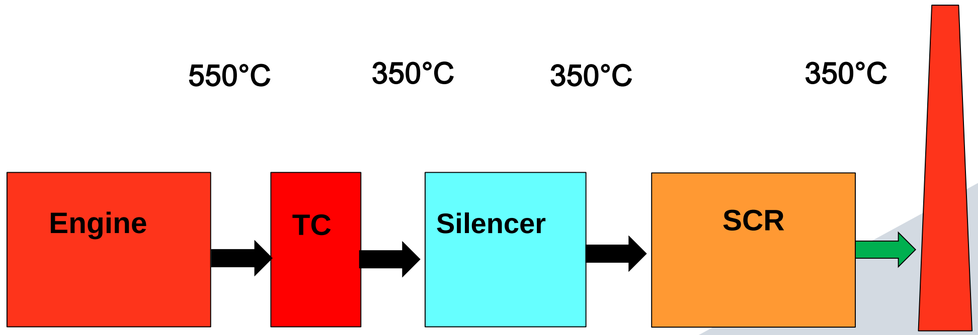
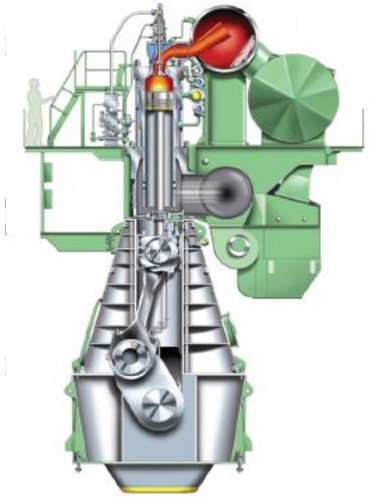
SCR



Quelle: MAN Diesel & Turbo





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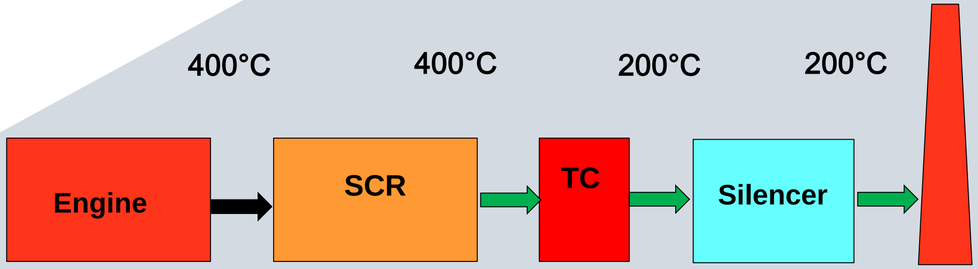


FUEL ADDITIVES

Combustion improvement

Mechanism

- Metal based combustion catalysts; mixture of metal soaps

Customer benefit

- Norm fulfillment (emission reduction)
- Soot / opacity reduction
- Ash reduction
- Efficiency gain
- Maintenance benefit

Performance justification

- Fuel related tests on a pilot boiler / engine
- Bacharach; VDI 2066; Opacity measurements

FUEL ADDITIVES

Fuel stabilisation / compatibility improvement / sludge removing

Mechanism

Combination of high polar detergents and asphaltene stabilization

Customer benefit

No sludge buildup in storage tanks
Higher compatibility with other feed stocks
No/less blockings in filters/feeding lines
Clean nozzles and pistons
Higher performance in engines and boiler

Performance justification

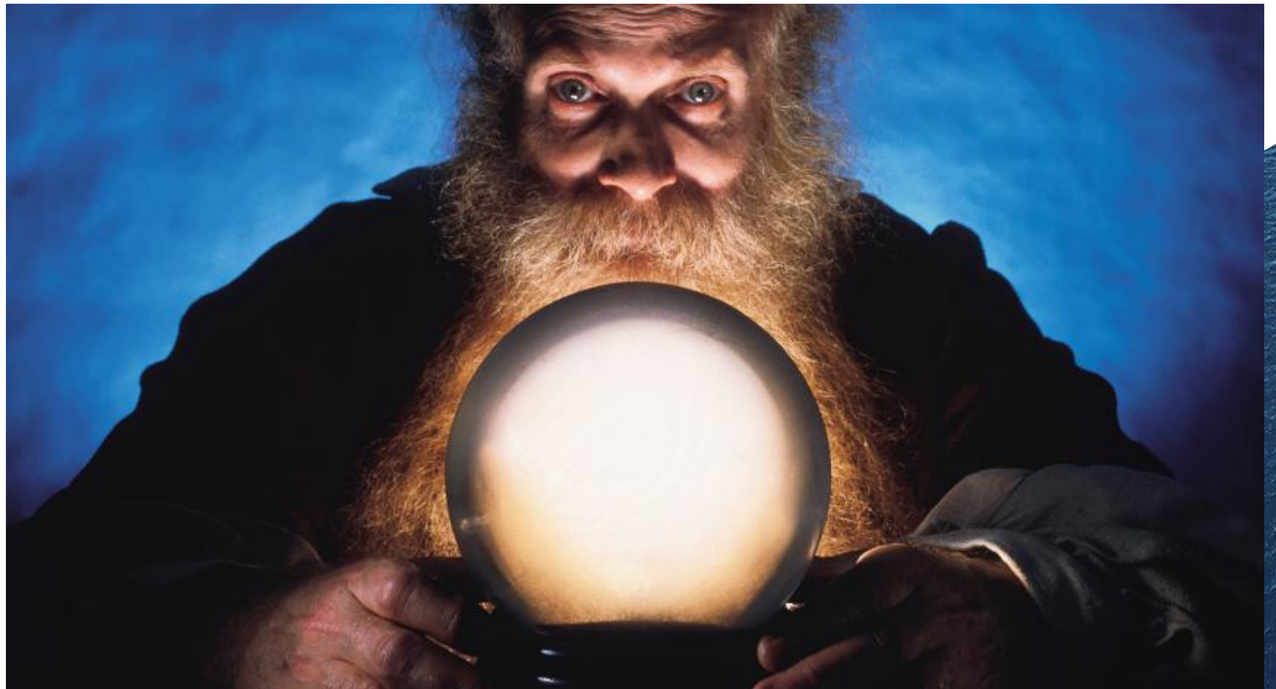
Lab scale tests possible (optimization)
On site tests as demonstration tools

Source: Shell Global Solution Studie with ERC Additives
engine cleanliness (piston crown area)

SUMMARY

Many challenges, but also many options
(all driven more or less by cost efficiency)

Environment will be the winner
The future will be very complex but hard to predict



THANK YOU!

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