Clean Marine AS

Exhaust Gas Cleaning System

May 2014

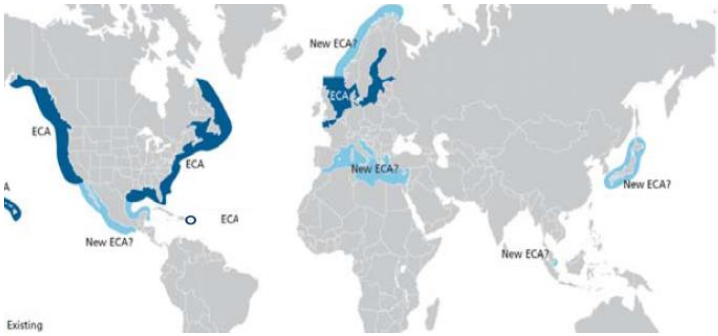
Hong Kong Shipowners Association

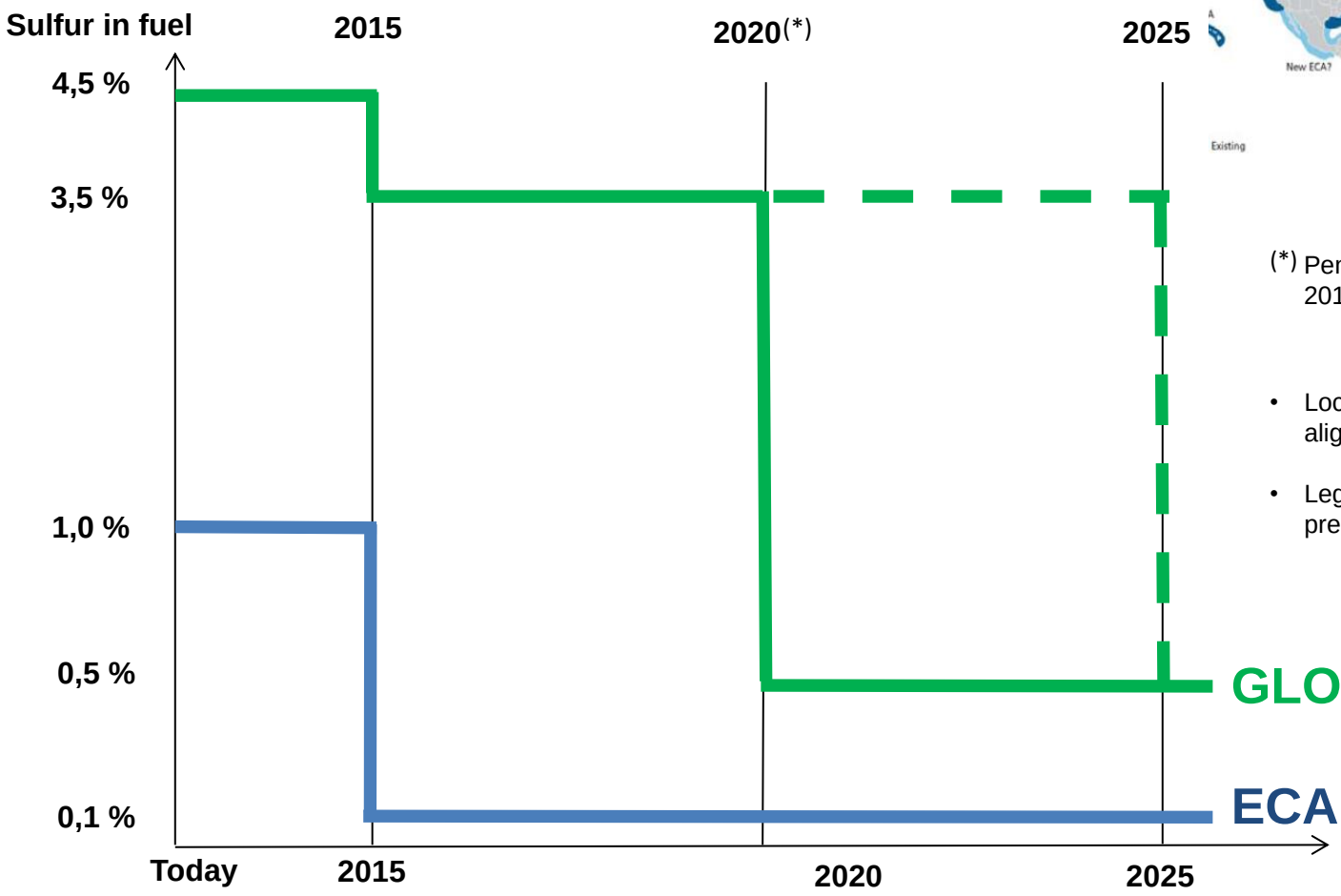
Clean Marine is fully dedicated to emission cleaning

- Company created in 2006
- Invested more than USD 25 mill in EGCS development
- Patented **Hybrid, Allstream** system: connecting all exhaust sources to a single scrubbing unit
- 30 employees with deep maritime and process expertise

- HQ in Oslo, Norway
- The major shareholders are well-reputed maritime investors:
  - Klaveness Invest AS (Klaveness Marine)
  - Nanga Partnership L.P. (advised by Smedvig Capital)
  - AS Atlantis Vest (Rieber)

IMO Annex VI Sulfur requirements





(*) Pending fuel situation in 2018

- Local requirements will probably be aligned with ECA
- Legislation for EU Ports and California presently require 0,1% sulfur content

GLOBAL 60,000 vessels affected?

ECA 8,000 vessels affected?

Only a few months left for ship owners to comply…

CLEAN MARINE

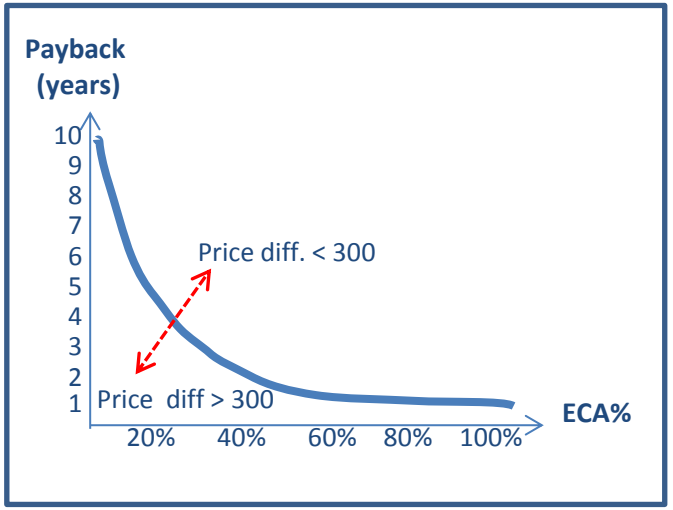
The business case for installing an EGCS

Options for compliance with regulations:

1. Switch to distillate (MGO) – pay the extra fuel bill
2. Install EGCS – continue operation on HFO
3. Switch to other fuel types (LNG or LPG) – limited supply

Optimal choice depend on:

1. How much the vessel will be trading in ECA
2. The power (MW) and fuel consumption of the vessel
3. Assumed price difference between MGO and HFO



Example:
10MW vessel trading in ECA and **USD 300** fuel spread gives fuel cost = **USD 3,4 mill./year**
EGCS price: **USD 2,6 mill +** Installation cost **USD 0,8 mill** = **USD 3,4 mill.**

"The cost savings are so significant that some ship operators may find installing an EGCS a competitive necessity." **The Society of Naval Architects and Marine Engineers**

Conclusions from Fuel Trend study

(Published March'14 by Lloyd's Register & UCL Energy Institute):

- HFO will account for 47%-66% of the fuel mix in 2030
- High share of HFO = High uptake of EGCS
- LNG will reach a maximum 11% share in 2030
- By 2030, HFO combined with abatement technology is considered the most cost-effective option for the majority of the fleet

Operational advantages by having an EGCS installed:

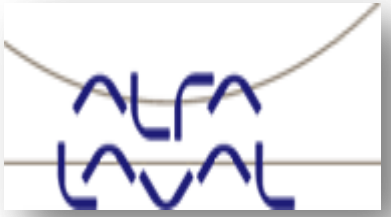
- Unifuel system for vessel using higher sulfur fuels (the vessel running only on HFO which it is designed for)
- Less issues for the crew by fuel planning and switching – will help ship owners attract and retain personnel onboard
- Possible increased availability of fuel in ports vessel services

"A two tier market will develop and the chartering market will very soon have different rate levels for ships with and without scrubber"

Reference: ESN, the Way Forward –project, Nov 2013: http://www.shortsea.info

Suppliers of EGCS

1st



2nd

Akretia GmbH

New?

Carnival Cruises

Pureteq (DK)?

Product and commercial development

Founded 2006

CLEAN MARINE

2004-2008

Torvald Klaveness

2009-2011

Holeby (DK)

2011-

Marintek (NO)

Torvald Klaveness

2012

DORIAN LPG

Chemical Tanker

VLGC

aet

Shuttle Tanker

2013

2014

Time

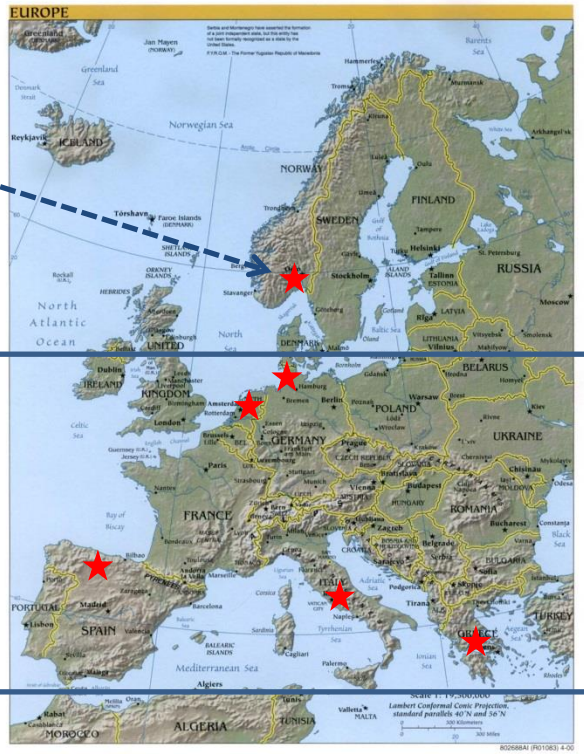
Torvald Klaveness

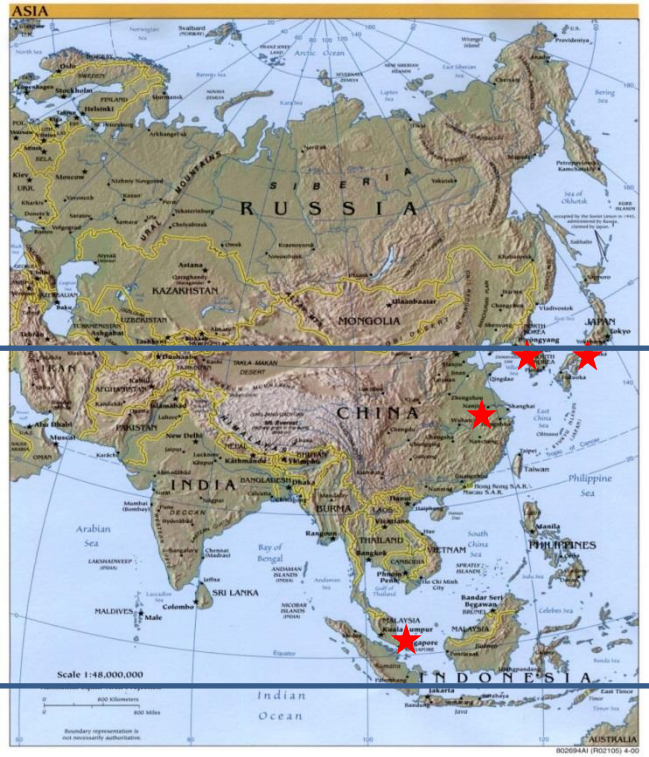
MAN

A growing network of site managers and dedicated agents in Europe/Asia facilitate sales, fabrication & service

Head office

- Sales agents
- Site Managers
- Fabrication
- After Sales

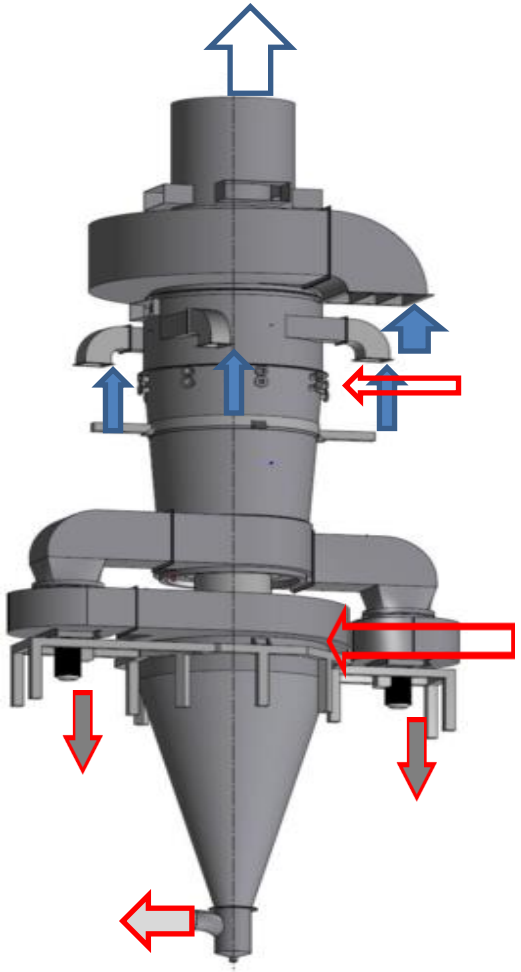




Our EGCS is the only proven “Allstream” system currently on the market

Allstream
- All exhaust sources served by one single scrubbing unit
- Zero back pressure
- No blockage risk

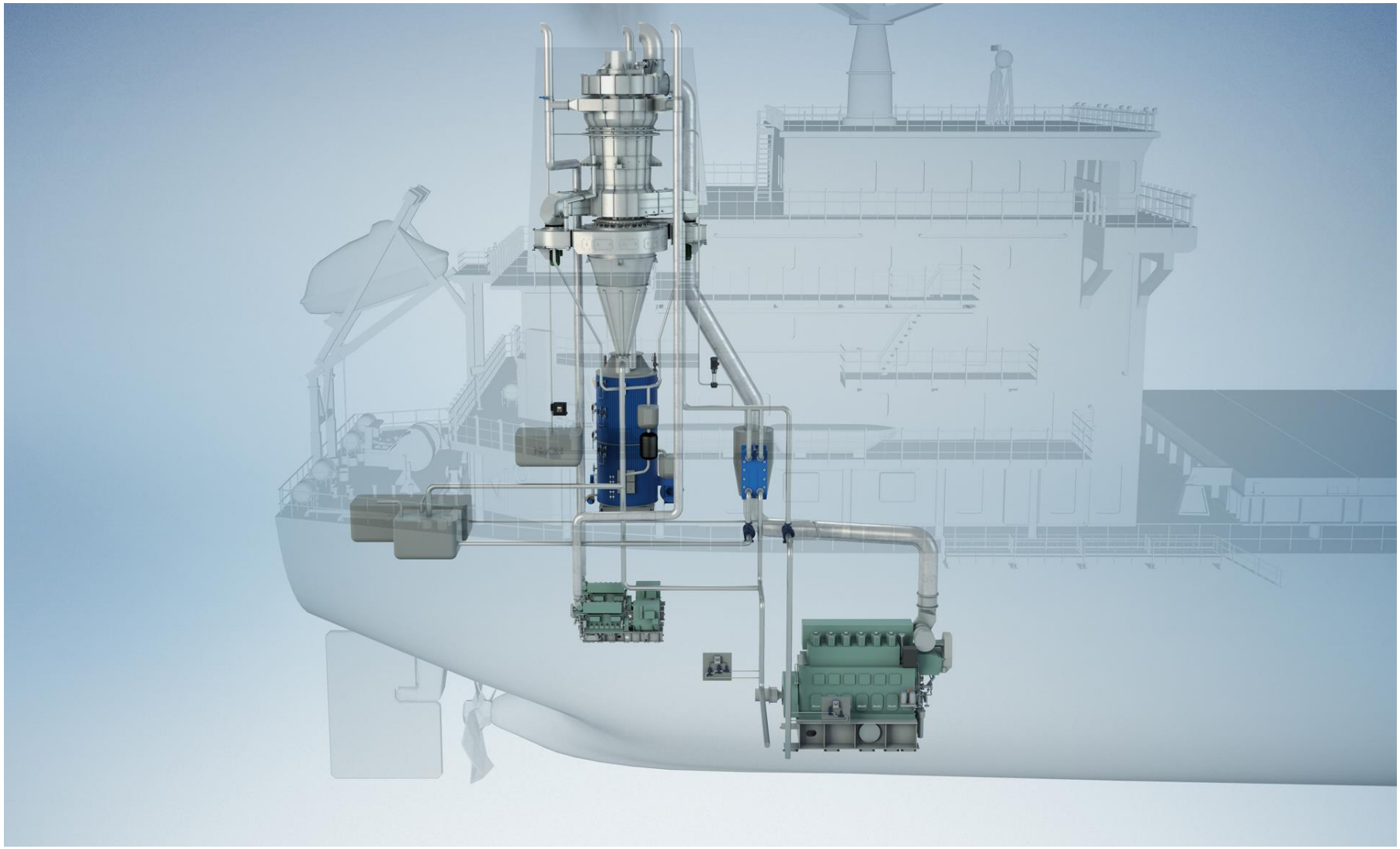
Hybrid – open / closed loop
- Seamless operation
- High pH in washwater, exceeding IMO regulations



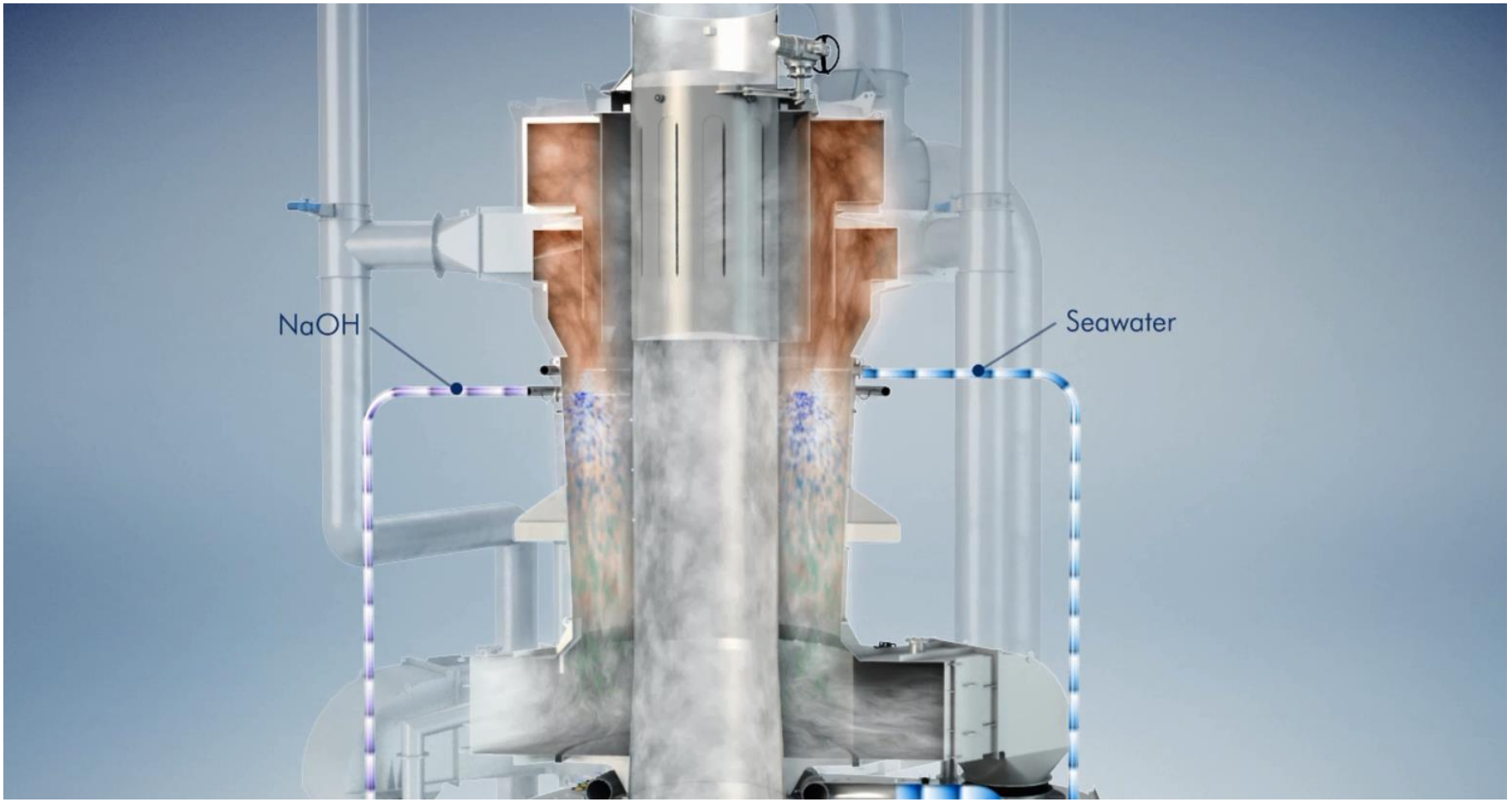
High trapping efficiency
- SOx
- PM

Easy to operate and monitor
- Excellent noise abatement
- Self cleaning
- Installation friendly

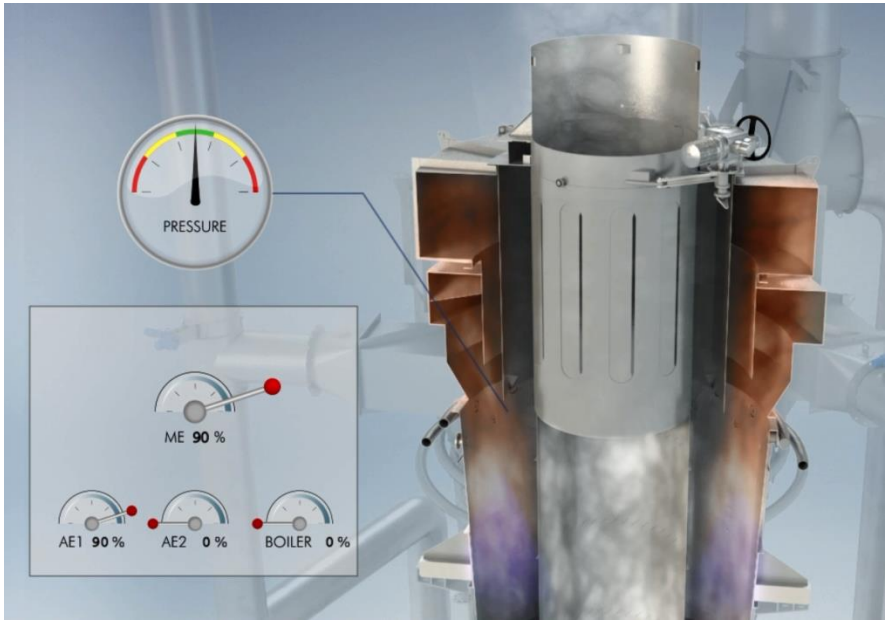
The EGCS is mostly fitted inside the funnel of the vessel

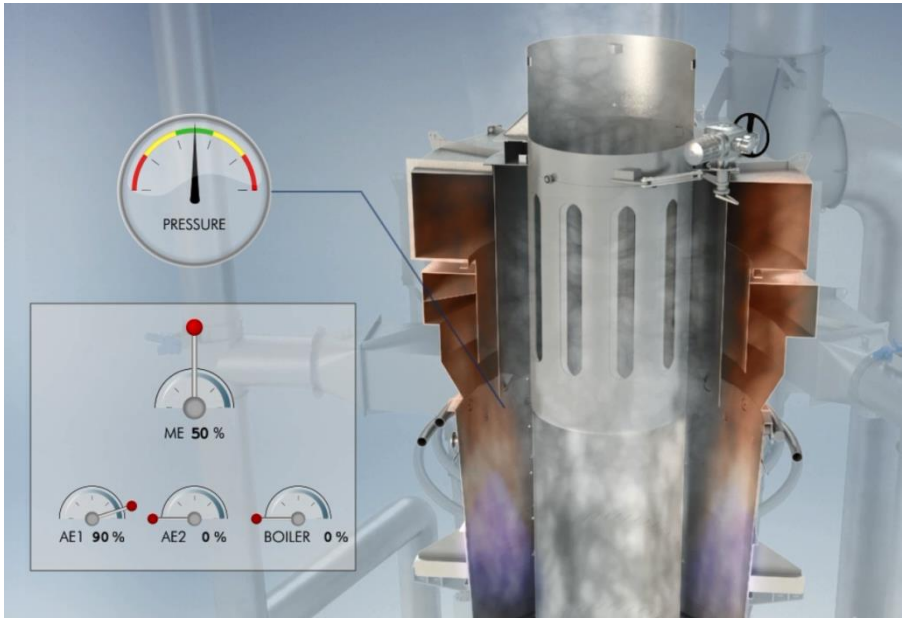


Seawater and NaOH solution is sprayed into the gas steam and the water mix captures the sulfur



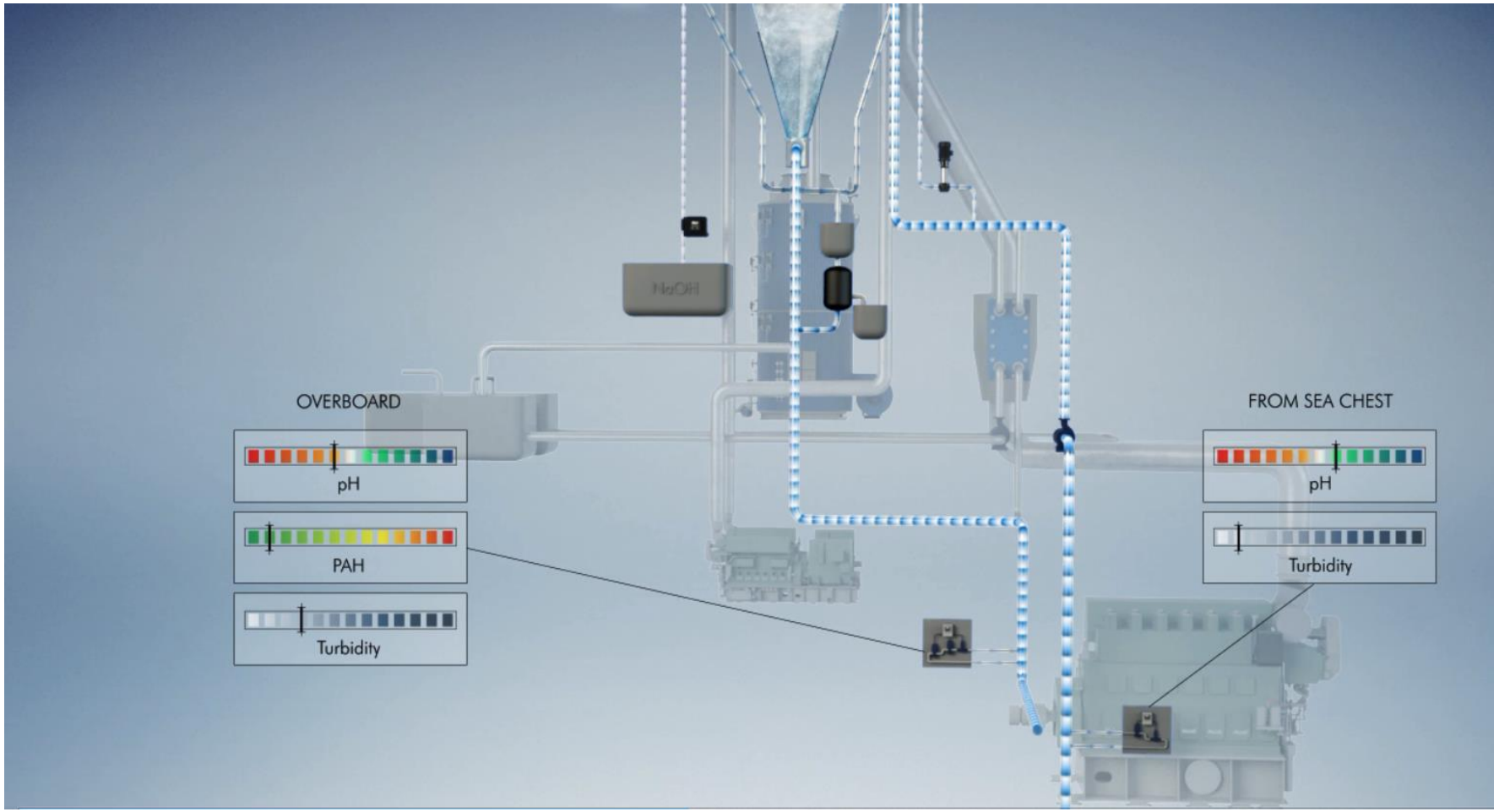
The gas recirculation mechanism ensures there is no backpressure to the engines and boilers



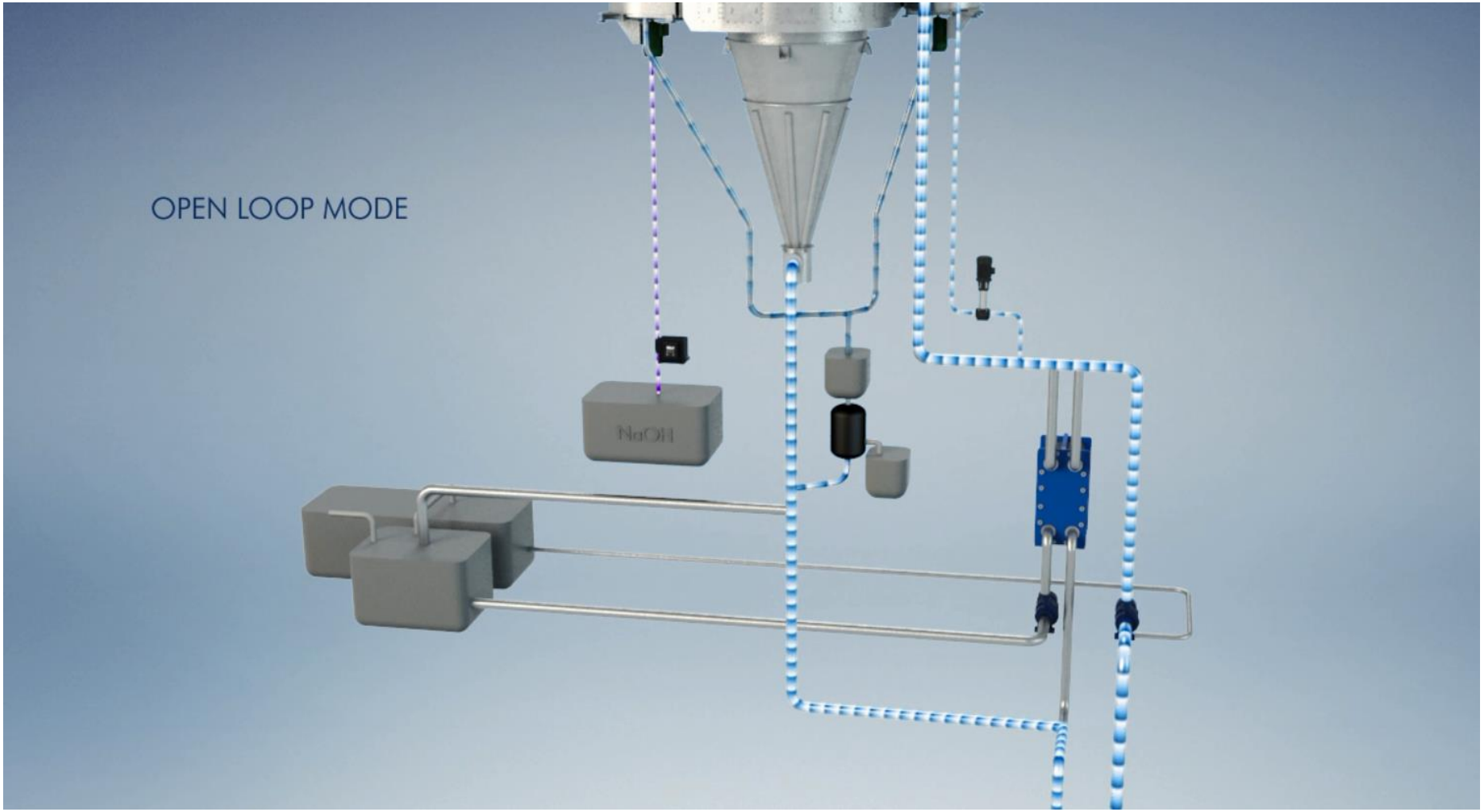


- Two fans with capacity in excess of exhaust production prevents pressure to build up
- An open nozzle ring allows gas to pass between raw gas and clean gas side
- The combined effect of fans and nozzle ring ensure that pressure in manifold is +/- 0
- Pressure detector in manifold activate bypass if exceeding preset values

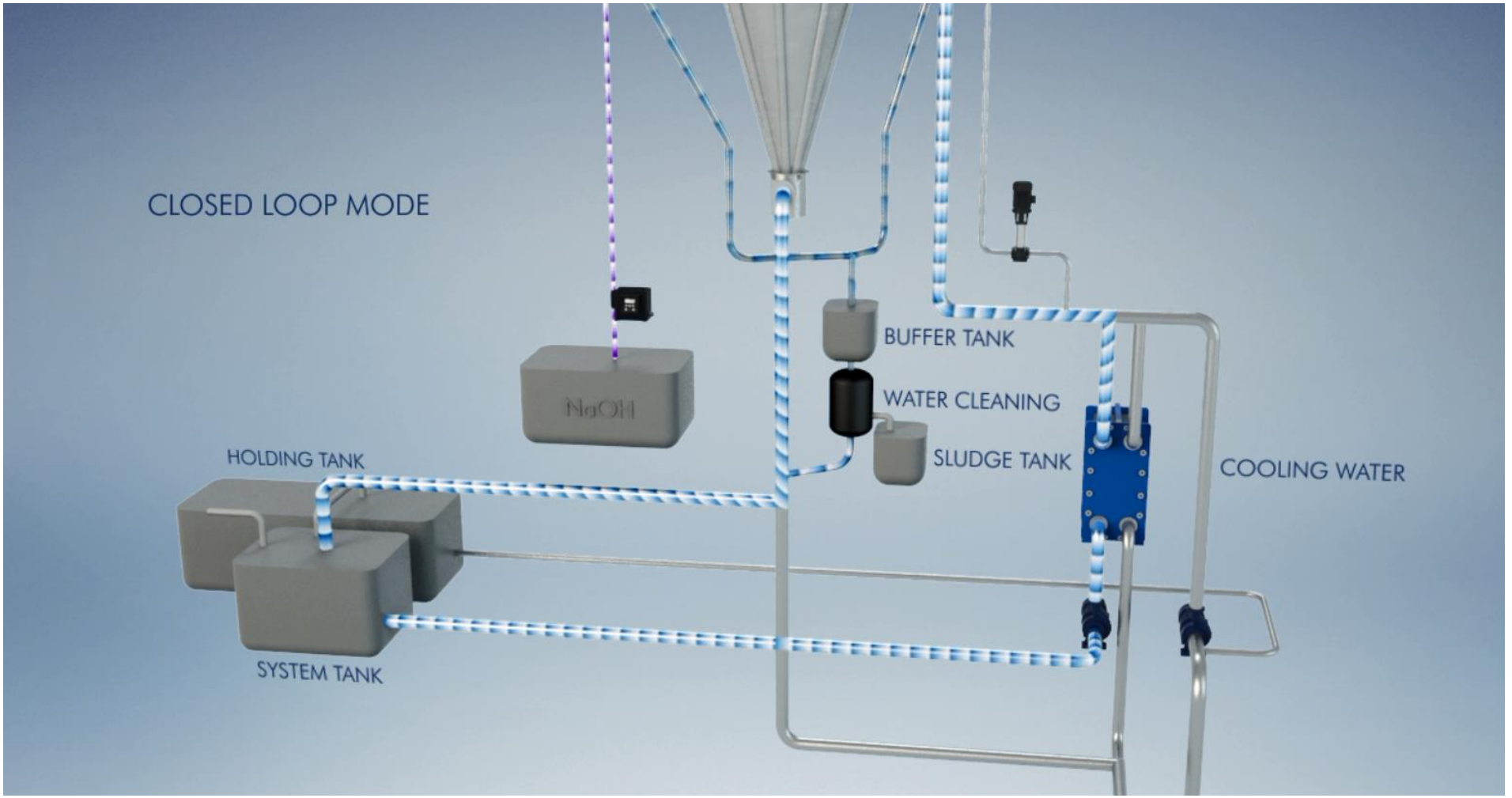
Washwater discharged to sea is well within IMO limits: pH > 5,5 at outlet is harmless for the marine environment



Open Loop = “single cycle process” where the cleaning water is discharged back to sea after the scrubbing process



Closed Loop = cleaning water is recirculated and discharged to a holding tank rather than to the sea

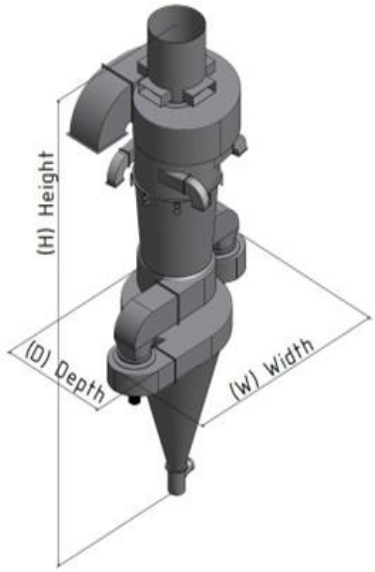


How we decide capacity & layout

Capacity of the EGCS = highest accumulated exhaust flow during operation (not accumulated installed power)

Most demanding operational mode for AET Shutte Tanker: "Sea going with tank heating":

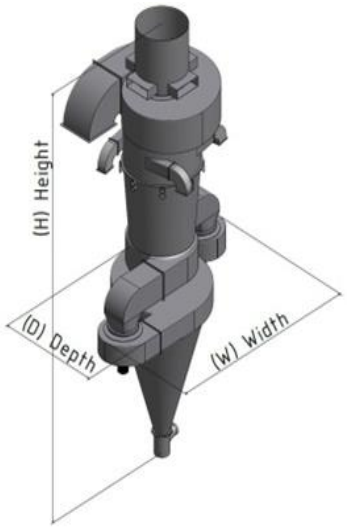
Machinery in operation	kW at 100% MCR	Load %	Load kW	Exhaust production kg/h
2 x ME (6G50ME-B9.3)	2 X 7 250	2 X 90%	13 500	128 250
3 x AE (6H32/40)	3 x 3 000	0%	0	0
2 x AE (8H32/40)	2 x 4 000	1 x 85%	3 400	25 500
2 x Oil-fired boiler	2 x 25 ton /h	2 X 80%		49 920
1 x Donkey boiler	1 x 4 ton/h	0%		0
Total exhaust that may be produced simultaneously				**203 670**
EGCS model = nearest size in product range				**220 000**



DIMENSIONS OF THE EGC UNIT

Height (H):	19 m
Width (W):	9,8 m
Depth (D):	5,6 m
Weight:	35 mt
Water flow:	900 m3/h
NaOH flow:	280 l/h Max
El power requirement.:	400 kW (*1,5-2% of load*)

The EGCS is sized according to the highest practical load



Machinery in operation	Load %	Load kW	Exhaust production kg/h
1xME MAN	100	5640	47750
2x AE Himsen	75	2 x 750	11836
2xThermal heater	100	2 x 2000	7000
Sum			66586

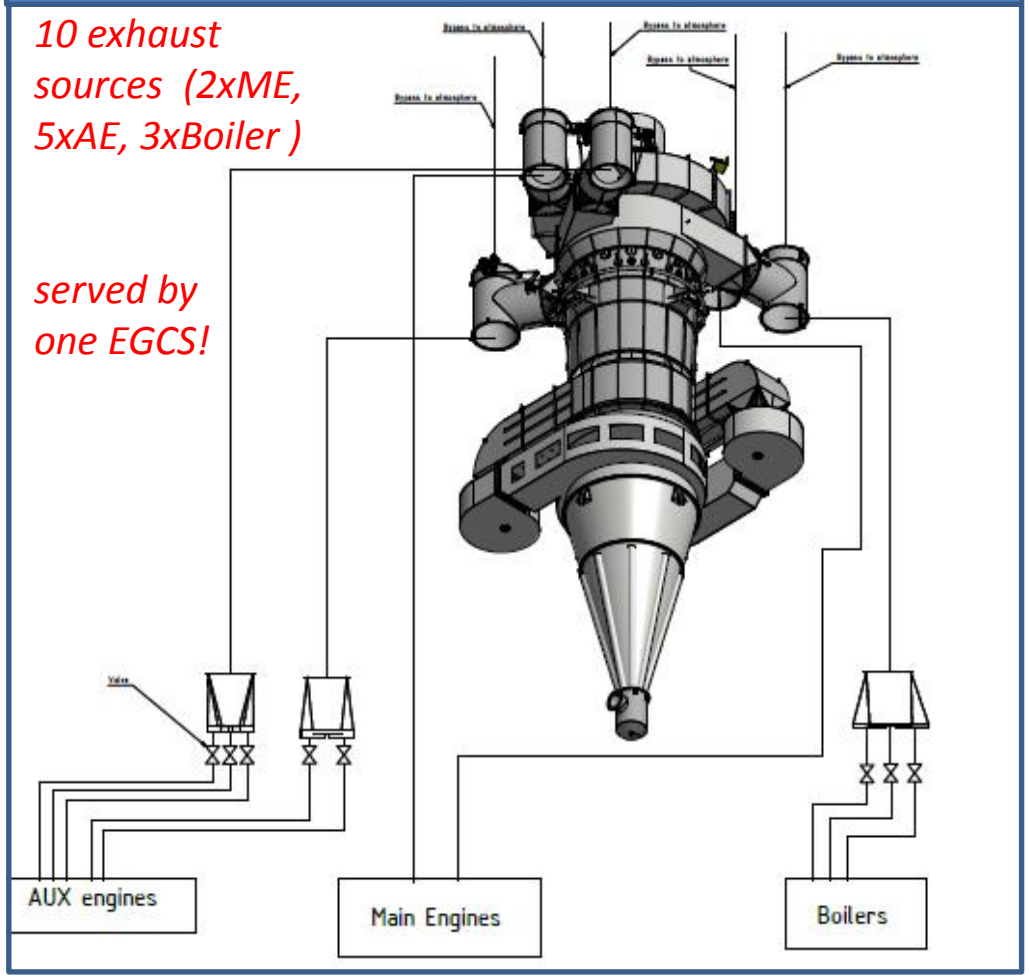
Amount Exhaust 1000kg	300	260	240	220	200	180	160	140	120	100	90	80	70	60	50	40	30	20
Ø Inner tube	2,3	2,1	2,0	1,9	1,8	1,7	1,6	1,5	1,4	1,3	1,2	1,2	1,1	1,1	1,0	1,0	0,9	0,9
Ø Outer tube	3,8	3,5	3,4	3,3	3,1	3,0	2,9	2,7	2,6	2,5	2,4	2,3	2,3	2,2	2,1	2,1	2,0	1,9
H1 (Double pipe)	4,1	3,9	3,7	3,6	3,5	3,3	3,2	3,0	2,9	2,8	2,7	2,6	2,6	2,5	2,4	2,3	2,3	2,2
H2 (Inlet section)	4,1	3,9	3,7	3,6	3,5	3,3	3,2	3,0	2,9	2,8	2,7	2,6	2,6	2,5	2,4	2,3	2,3	2,2
H3 (Branch pipe section)	2,2	2,0	2,0	1,9	1,8	1,7	1,6	1,6	1,5	1,4	1,4	1,3	1,3	1,2	1,2	1,2	1,1	1,1
H4 (AVC)	11,4	10,2	9,6	9,0	8,4	7,8	7,2	6,6	6,0	5,4	5,1	4,8	4,5	4,2	3,9	3,6	3,3	3,0
H5 (Water trap)	1,8	1,6	1,5	1,4	1,3	1,2	1,1	1,0	0,9	0,7	0,7	0,6	0,6	0,5	0,5	0,4	0,4	0,3
H6 (Exhaust outlet pipe)	1,2	1,0	1,0	0,9	0,9	0,8	0,8	0,7	0,7	0,6	0,6	0,6	0,6	0,5	0,5	0,5	0,5	0,4
Total height H	24,9	22,6	21,5	20,4	19,3	18,2	17,1	15,9	14,8	13,7	13,1	12,6	12,0	11,5	10,9	10,4	9,8	9,2
Width W	12,3	11,2	10,7	10,1	9,6	9,0	8,5	8,0	7,4	6,9	6,6	6,3	6,1	5,8	5,5	5,3	5,0	4,7
Depth D	7,3	6,6	6,2	5,9	5,5	5,1	4,8	4,4	4,1	3,7	3,5	3,3	3,2	3,0	2,8	2,6	2,4	2,3
Mass mt	33,2	30,0	28,4	26,8	25,2	23,6	22,0	20,4	18,8	17,2	16,4	15,6	14,8	14,0	13,2	12,4	11,6	10,8
Main water pump	1200	1040	960	880	800	720	640	560	480	400	360	320	280	240	200	160	120	80
Preinjection pump	60	52	48	44	40	36	32	28	24	20	18	16	14	12	10	8	6	4

With proven technology and the recent contracts with major Asian yards we are well positioned for sales growth

Samsung / AET project:

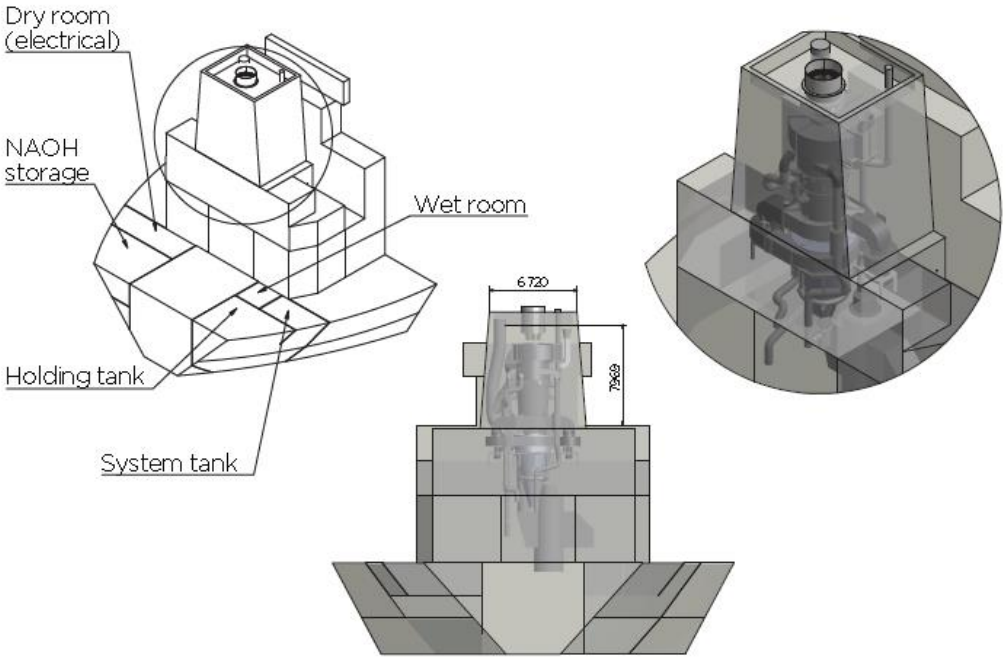
10 exhaust sources (2xME, 5xAE, 3xBoiler)

served by one EGCS!



- Contracts for EGCS installations:
  - MV Balder: EGCS retrofitted in 2012/2013 and is now **fully certified**
  - Samsung / AET – 2 Shuttle Tankers (delivery Q4 2014 + Q1 2015)
  - Hyundai / Dorian– 1 VLGC (delivery Dec. 2014)
  - Hudong / Stolt Tankers – 2 Chemical Tankers (delivery 2016 & 2017)
- Main focus: tankers, bulk, Ro-Ro, containers

MV BALDER
HANDYMAX BULKER



VESSEL DESCRIPTION:

Name: Balder
Type: Handymax bulk carrier
Owner: Torvald Klaveness
Class: DNV
Yard: Oshima Shipbuilding
Year built: 2002
Imo. No.: 9233416
Flag: Marshall Island
Deadweight: 48.148 dwt
Length overall: 189.99 metres
Breadth Moulded: 32,26 metres
Depth Moulded: 16,67 metres

SCRUBBER DETAILS:

ALLSTREAM HYBRID - MK III 110 (OPEN AND CLOSED LOOP)
SERVING THE FOLLOWING EXHAUST PRODUCING MACHINERIES:
Main Engine: 1 x Kawaskai MAN B&W 6S50MC-C, 2 stroke
Aux. Engines: 3 x Daihatsu Diesel 8 DK-20
Boiler: 1 x Alborg Industries GCS - 22ST

DIMENSIONS & WEIGHT OF THE EGC UNIT HANDLING 110.000 KG EXHAUST/HOUR:

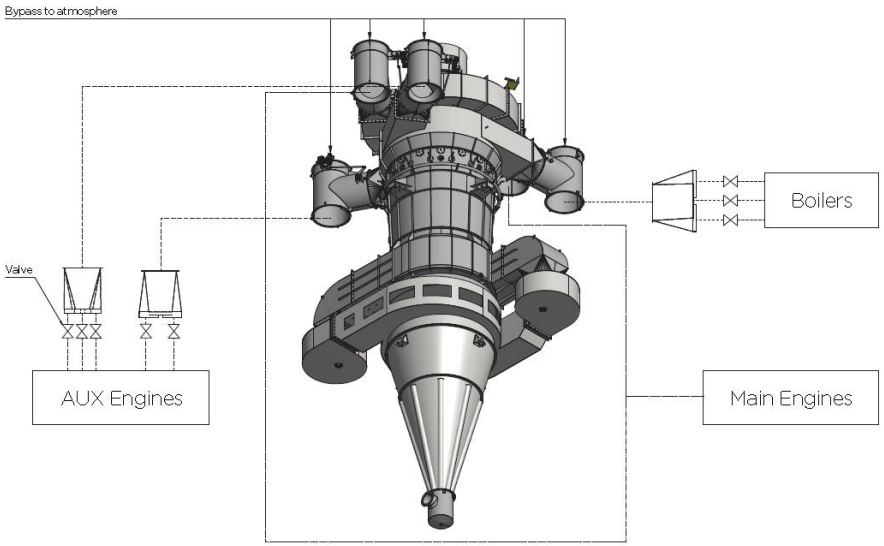
Height (H): 13,7 m
Width (W): 6,9 m
Depth (D): 3,7 m
Weight: 27,2 mt
Water flow: 400 m3/h
El power rqmt.: 240 kW

MAJOR SCOPE:

2 x Sea water pumps
2 x High pressure pumps
1 x NaOH dosage system
1 x Water Treatment Unit (filter)
1 x PLC, switch board and frequency drives for pumps and fans
1 x Gas (SO2/CO2) -, PAH -, Turbidity, pH, flow, temp and pressure monitoring, Internal valves, water inlet filter, flow meters, exhaust dampers (by-pass).

CLEAN MARINE

SAMSUNG HEAVY INDUSTRIES
HULL NO. 2065/66
DP SHUTTLE TANKER



GENERAL DESCRIPTION:

Name: H2065 and H2066
Type: DP Shuttle tanker
Owner: AET SEA Shuttle AS
Management: OSM Ship Management
Charterer: Statoil
Class: DNV
Yard: Samsung Heavy Industries
Delivery date: 30th November 2014 and 31st March 2015
Imo. No.: 9676125 and 9676137
Flag: Bahamas
Deadweight: 120.000 dwt

SCRUBBER DETAILS:

ALLSTREAM HYBRID (OPEN AND CLOSED LOOP)

SERVING THE FOLLOWING EXHAUST PRODUCING MACHINERIES:

- 2 x ME, MAN 6G50ME-B9.3, 7250 kW at 85 rpm at 100% MCR
- 3 x AE, 6H32/40, 3000 kW each at 720 rpm 100% MCR
- 2 x AE, 8H32/40, 4000 kW each at 720 rpm at 100% MCR.
- 2 x Oil-fired boilers, 25 ton/h each at 100% MCR.
- 1 x Donkey boiler, 4 ton/h at 100% MCR.

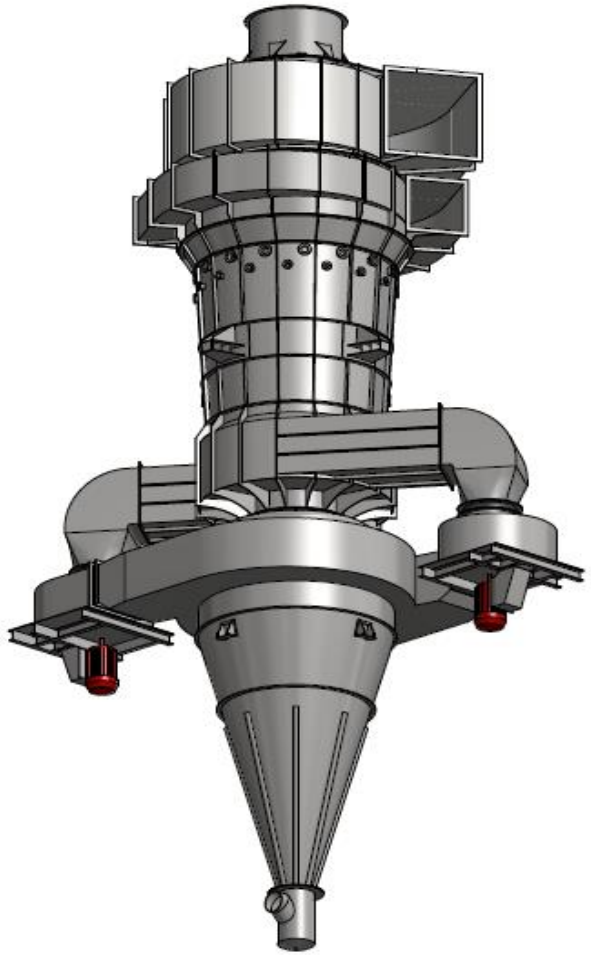
DIMENSIONS & WEIGHT OF THE EGC UNIT
HANDLING 220.000 KG EXHAUST/HOUR:

Height (H): 19 m
Width (W): 9,8 m
Depth (D): 5,6 m
Weight: 35 mt
Water flow: 900 m3/h
NaOH flow: 280 l/hMax
El power rqmt.: 400 kW (max 1,5-2% of load)

MAJOR SCOPE:
pumps with variable frequency drive, filters, cooler, gas (Nox, PM, CO2 and SO2) and water quality (pH, PAH, Turbidity) monitoring, valves, flow meters, sensors (pressure, temp, level),switchboard, PLC

CLEAN MARINE

HYUNDAI HEAVY INDUSTRIES
HULL NO. 2658 (Dorian Corvette)
VERY LARGE GAS CARRIER



CLEAN MARINE

GENERAL DESCRIPTION:

Name:	Dorian Corvette
Type:	ECO VLGC
Owner:	Dorian LPG Ltd.
Operator:	Dorian Hellas
Class:	ABS
Yard:	Hyundai Heavy Industries Co. Ltd.
Delivery :	December 2014
Imo. No.:	9703837
Flag:	Marshall Island
Deadweight:	51 620 dwt
Gas capacity:	84 000 m3

SCRUBBER DETAILS:

ALLSTREAM HYBRID (OPEN AND CLOSED LOOP)

SERVING FOLLOWING EXHAUST PRODUCING MACHINERY:
- 1 × ME, MAN-B&W 6G60ME-C9.2, 12400 kW at 100% MCR
- 3 × AE, HYUNDAI-HIMSEN 8H21/32, 1600 kW each at 100% MCR
- 1 × Oil-fired boiler

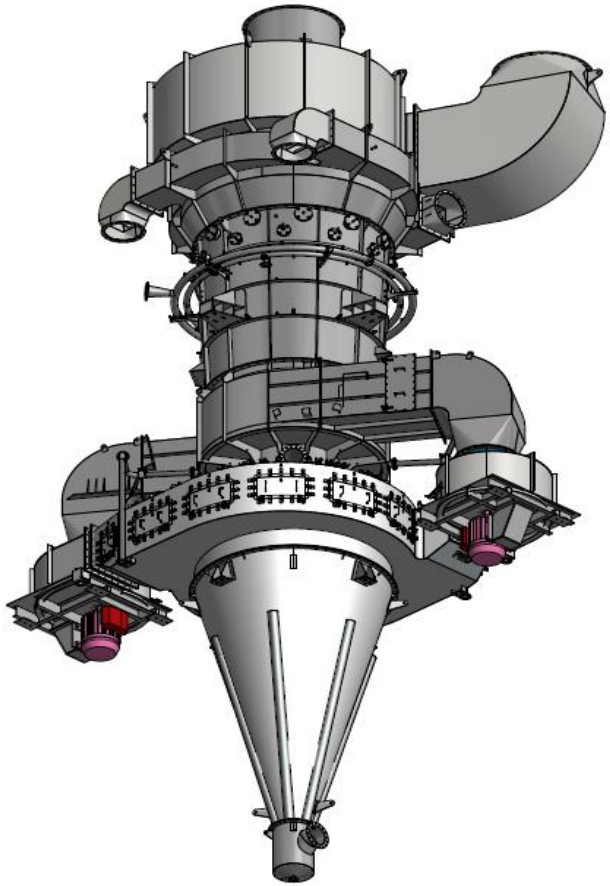
DIMENSIONS & WEIGHT OF THE EGC UNIT
HANDLING 140.000 KG EXHAUST/HOUR:

Height (H):	17 m
Width (W):	8,9 m
Depth (D):	5 m
Weight:	33,2 mt
Water flow::	560 m3/h
El. power req.:	Max. 280 Kw (1,5-2% of load)

MAJOR SCOPE:
EGC unit complete with 2 fans and 5 exhaust gas connections, pumps with variable frequency drive, filters, cooler, NaOH dosage system, gas (SO2/CO2) and water (PAH , turbidity, pH, flow) analyzers, temperature and pressure monitoring, valves, flow meters, exhaust dampers (bypass), switchboard, PLC, Documentation and Certification, Services during planning, installation and commissioning.

HUDONG ZHONGHUA SHIPBUILDING GROUP

HULL NO. 1711 A and 1712A CHEMICAL TANKER



GENERAL DESCRIPTION:

Name: H1711A and H1712A
Type: Chemical Tanker
Owner: Stolt Tankers
Class: DNV
Yard: Hudong Zhonghua Shipbuilding Group Co., Ltd.
Delivery: Dec 2016 and Feb 2017
Imo. No.: 9680114 and 9720081
Flag: Cayman Islands
Dwt: 38.000 dwt

SCRUBBER DETAILS:

- HYBRID (OPEN & CLOSED LOOP)
- ONE SINGLE MULTI STREAM EGC UNIT

SERVING FOLLOWING EXHAUST PRODUCING MACHINERY:

- 1 x ME, 7900 kW at 100% MCR
- 3 x AE, 1100 kW each at 100% MCR
- 2 x Boiler, 13000 kW each at 100% MCR
- 1 x Composite Boiler

DIMENSIONS & WEIGHT OF THE EGC UNIT
HANDLING 140.000 KG EXHAUST/HOUR:

Height (H): 16,8 m
Width (W): 8,9 m
Depth (D): 4,7 m
Weight: 30,5 mt
Water flow:: 560 m3/h
El. power req.: Max. 280 Kw (1,5-2% of load)

MAJOR SCOPE:
EGC unit complete with 2 fans and 5 exhaust gas connections, pumps with variable frequency drive, filters, cooler, NaOH dosage system, gas (SO2/CO2) and water (PAH , turbidity, pH, flow) analyzers, temperature and pressure monitoring, valves, flow meters, exhaust dampers (bypass), switchboard, PLC, Documentation and Certification, Services during planning, installation and commissioning.

CLEAN MARINE

Thank you!