Sustainability and Decarbonization in Maritime Transport

Background, Applications and Solutions

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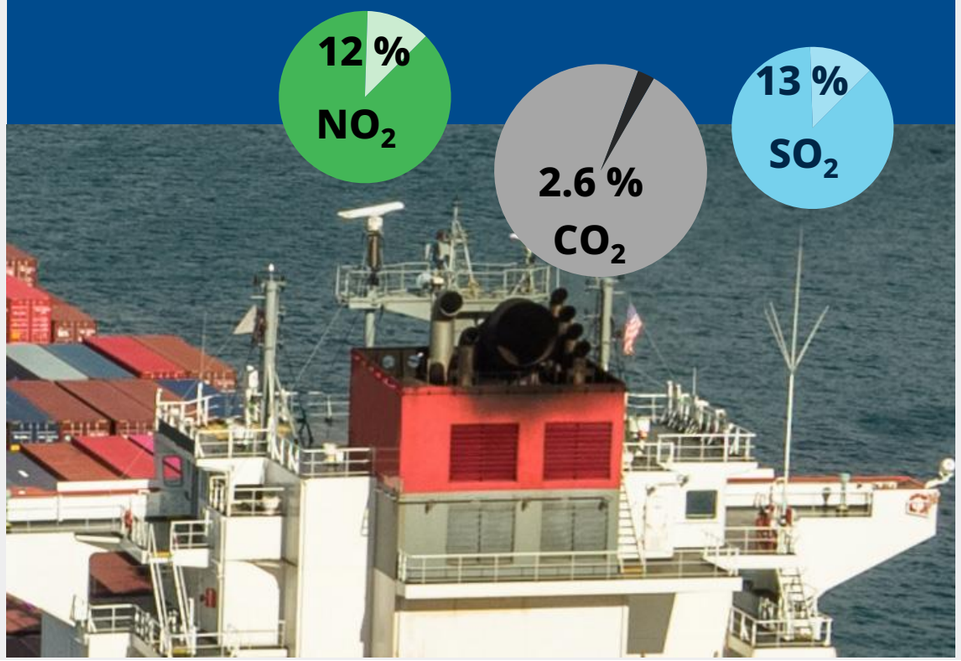
Content

Environmental Impact of Seaborne Trade

Estimated share of maritime shipping in global emissions



Facts:

- 90% of all goods in world trade are transported by sea (IMO).
- Heavy Fuel Oil (HFO) is the dominant fuel type in large transport vessels.
- The combustion of HFO produces emissions that are harmful to climate and environment.

Air Pollutants and Impact

- Oxides of Nitrogen (NOx) – create ozone
- Oxides of Sulphur (SOx) – produce acid rain and enforce greenhouse effect
- Carbon Dioxide (CO2) – ‘greenhouse’ gas
- Carbon Monoxide (CO) – a product of incomplete combustion is converted back to CO2 by oxidation processes in nature
- Hydrocarbons (HC) – gas, soot and other toxic particles, among others, damage respiratory health

Figures acc. To. Meeresatlas 2017, Heinrich-Böll-Stiftung Schleswig Holstein

International Maritime Organization (IMO)

International Maritime Organization

Setting standards for safety, security and environmental performance of maritime shipping

UN organization responsible for the implementation of the UN Sustainable Development Goals (SDGs)

- **adopted** the International Convention for the Prevention of Pollution from Ships, known universally as **MARPOL**
- **Annex VI to MARPOL** addresses air pollution from ship exhaust and prohibits release of ozone depleting substances
- Annex VI includes:
  - Energy Efficiency Design Index **(EEDI):** Indicator which states specific CO_2 emissions of a ship
  - Ship Energy Efficiency Management Plan **(SEEMP):** Framework for energy-efficient ship operation

Picture: www.IMO.org, logo: wikipedia

International Maritime Organization

Setting standards for safety, security and environmental performance of maritime shipping

IMO‘s GreenHouse Gas Strategy (GHGS) aims at reducing the average carbon intensity

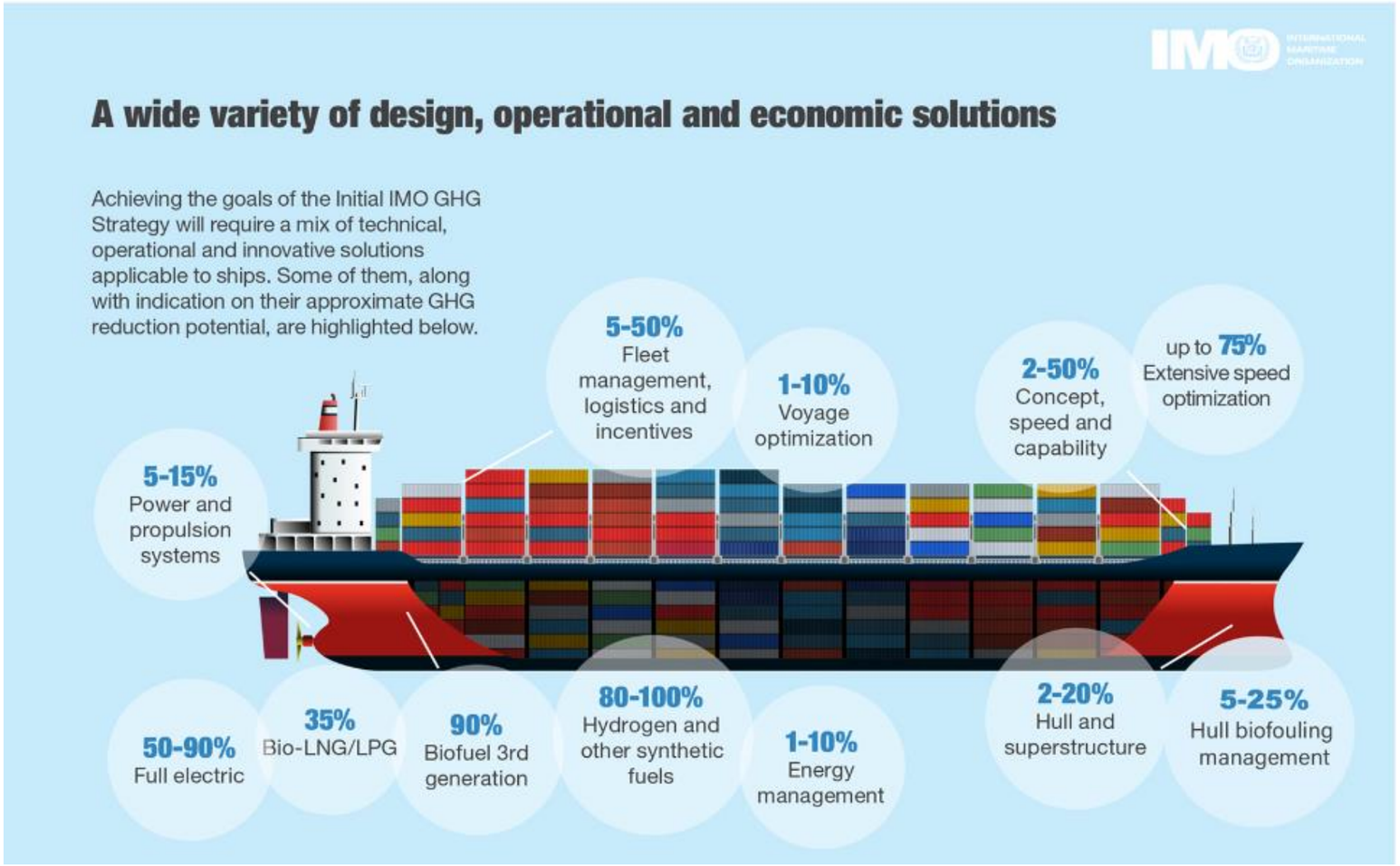
- **40% by 2030**
- **70% by 2050** (both compared to 2008 levels)

Reducing total GHG emissions by 50% by the year 2050.

Picture: www.IMO.org, logo: wikipedia

Solutions for GHG Reduction

Reaching the targets requires extensive technical and operational changes



- Alternative fuels and electric drives bear high reduction potential, **but implementation takes time**
- **Fleet owners must take steps to improve energy efficiency and transition to cleaner fuels on the existing vessels.**

Source: https://www.imo.org/en

Reducing Emissions on Existing Vessels

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Measures to Reduce Emissions

- **Energy efficiency measures:**
  - Optimized ship design (reduce drag)
  - Advanced propulsion systems (dual-fuel, hybrid, efficient fuel usage)
  - Energy management systems (monitor and control energy usage)
- **Slow steaming:**
  - Operation at slower speed
- **Trim optimization**
  - Maintaining proper trim and ballast to minimize resistance and prevent energy waste
- **Emission monitoring and reporting**
  - Ensure compliance to IMO regulations

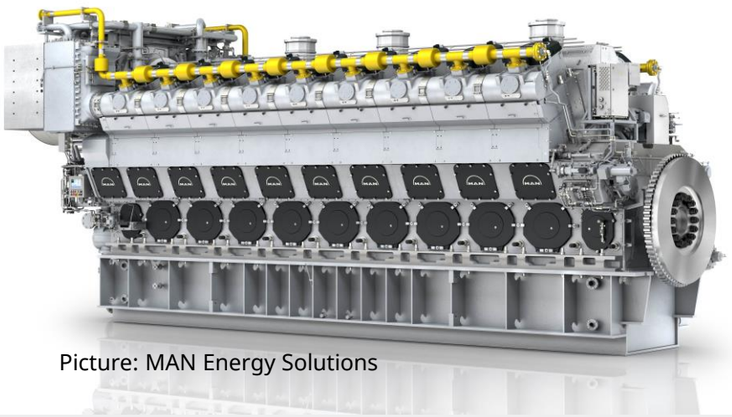
Marex controls

Marex Valve Control and Tank Sounding

Marex SCADA

Marex OS

Control Solutions for
Increased Propulsion Efficiency

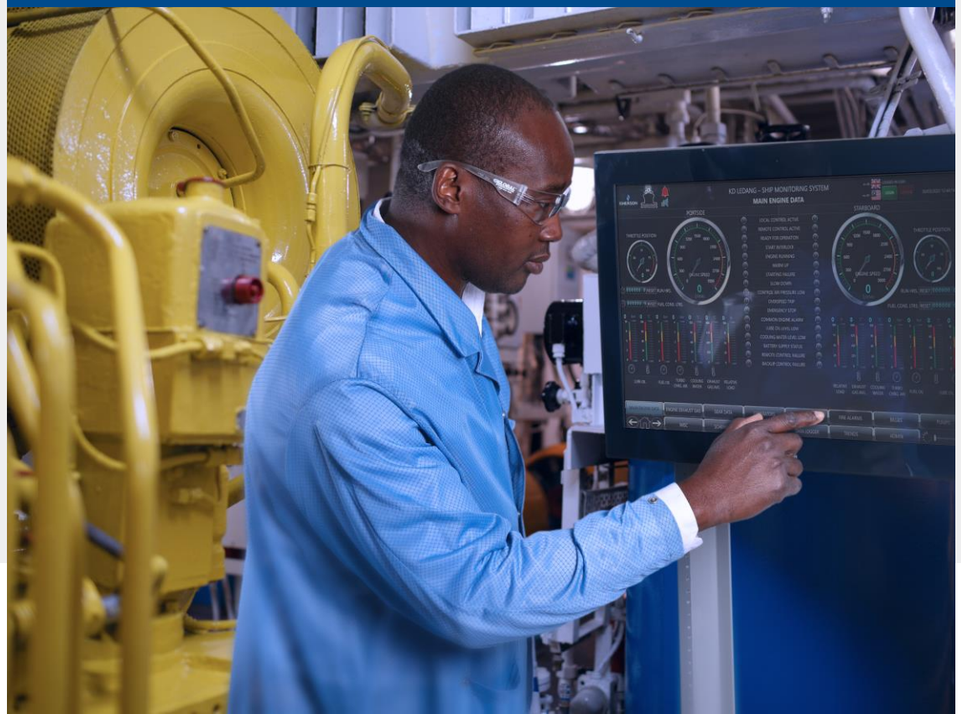


Picture: MAN Energy Solutions

- Efficient control of diesel, LNG, hybrid and dual fuel engines
- Class-approved solutions
- Highly customizable including cabinets, lever options, operating modules and display
- Settings enable fuel-saving and low-wear control
- Selectable maneuvering curves
- Enhanced connectivity via Modbus interfaces
  - Alarm, Monitoring and Control (SCADA)
  - Automated Fuel/CO2 saving
  - VDR
  - DP
- Manufactured at certified production sites

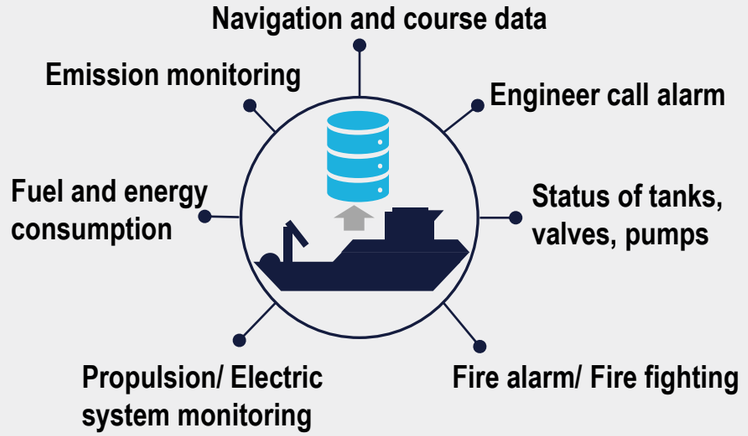
Marex SCADA Controls and Software

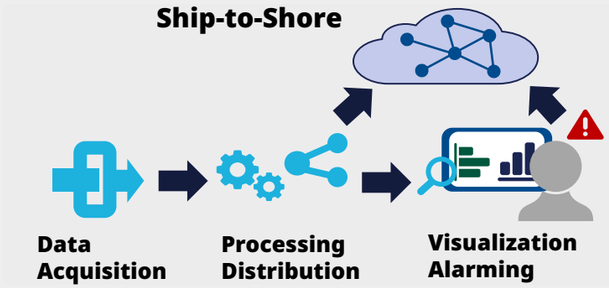
Digitization and visualization of data from ship to shore



Enabling safe and energy-efficient vessel operation:

- Detect critical conditions
- Enable fast crew response
- Monitor and report emissions
- Ensure compliance with environmental rules
- Provide data e.g. for predictive maintenance
- Enable remote monitoring



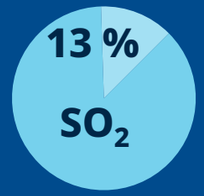


Exhaust Gas Cleaning

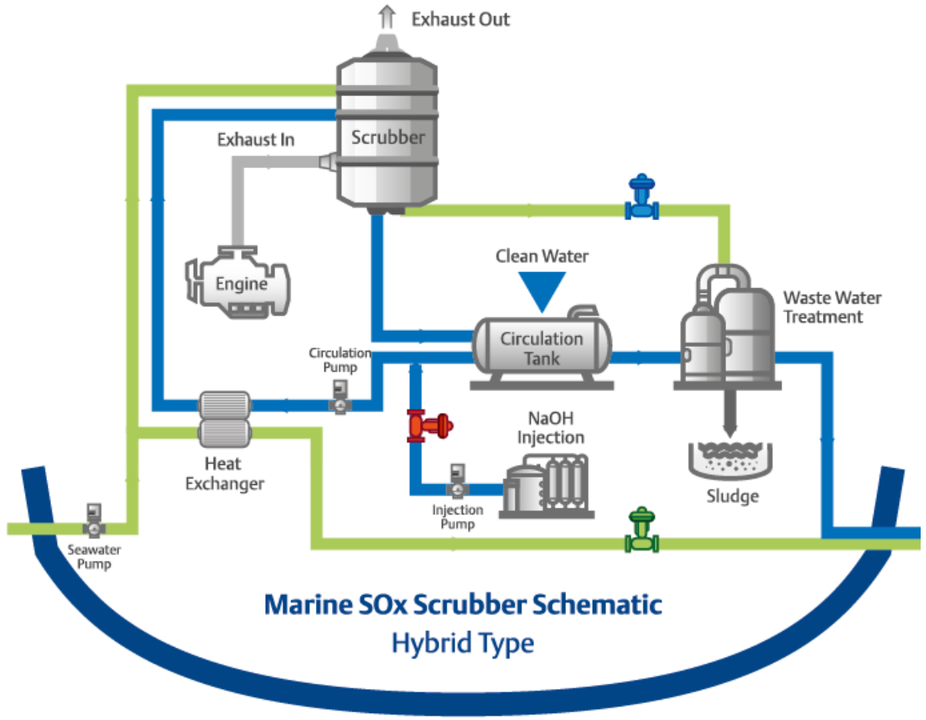
Exhaust Gas Cleaning Systems (EGCS)

1. Elimination of **Sulfur Oxides (SO_2)**

Scrubber Systems



- Ship operators must either change from Heavy Fuel Oil (HFO) to Very Low Sulfur Fuel Oil (VLSFO) or retrofit engines with **Scrubber Systems** which neutralize the sulfur oxides.
- The decision to install a scrubber system depends in large part on the price spread between Heavy Fuel Oil and VLSFO.



Scrubbers contribute to GHG reduction indirectly:

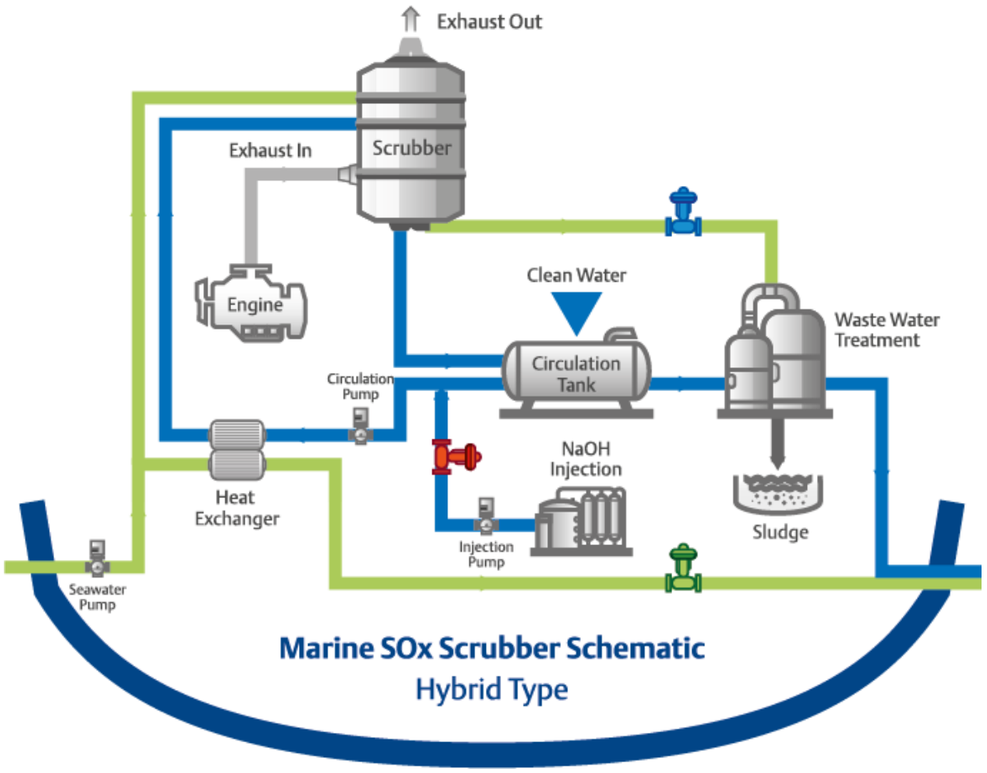
- Enable vessels to continue using higher sulfur fuels while still meeting the emission standards
- Prevent ships from switching to low-sulphur fuels which have a higher carbon footprint due the fuel production process.

Picture: Scrubber system example, source: YouTube

Exhaust Gas Cleaning Systems (EGCS)

1. Elimination of **Sulfur Oxides (SO_2)**

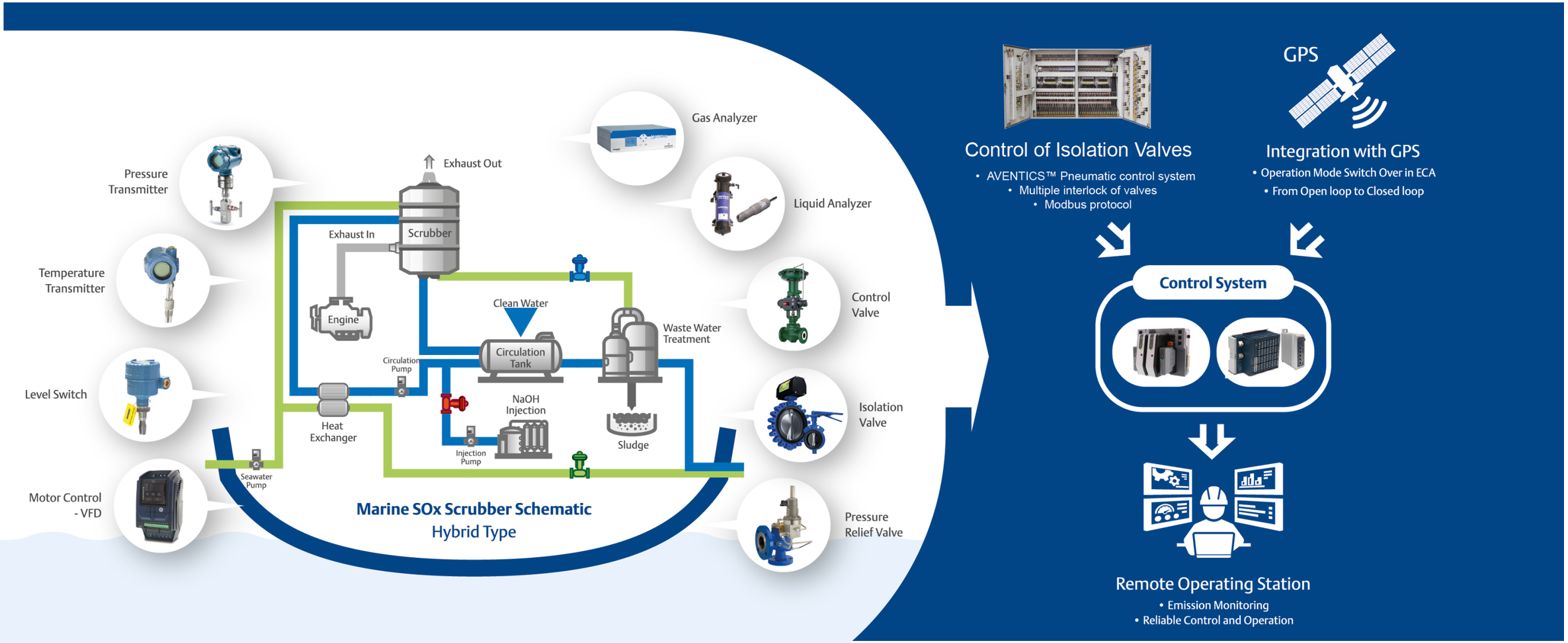
Scrubber Systems



Working Principle of Scrubbers

1. Exhaust gasses enter via the bottom side of the scrubber tower
2. Seawater is inserted at the top of the scrubber through spraying nozzles
3. This results in an equally divided spray pattern throughout the scrubber
4. Sulphur particles in the exhaust gas attach to the water droplets under the right temperature and process conditions
5. Cleaned exhaust gas leaves via the top of the scrubber tower
6. The seawater leaves via the bottom and is discharged overboard ***(open loop)***
6. **OR** process water is led to the circulation tank ***(closed loop)***
7. Sodium Hydroxide (NaOH=base) is added to the process water to neutralize acidity
8. Cleaned process water is pumped upwards again to the top
9. Polluted water is drained and led through a separator
10. Solids and oil are removed from the polluted water forming sludge
11. Sludge is pumped to the sludge storage tank on the ship and disposed of in the port.

Emerson‘s offering for Scrubber Systems

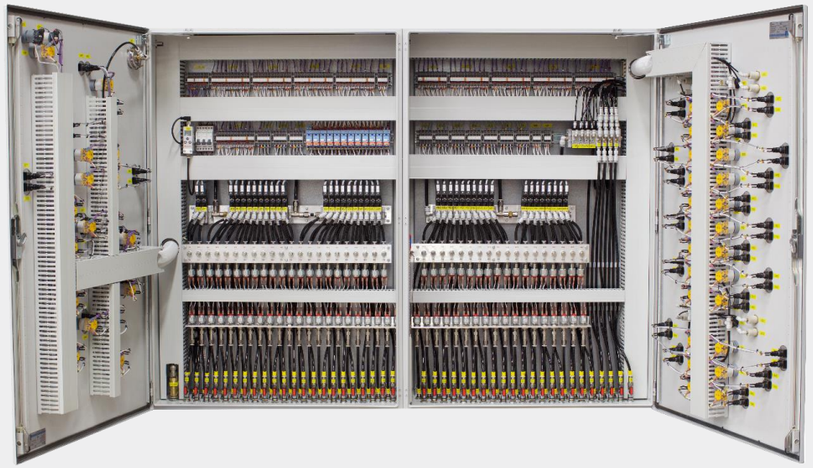


Exhaust Gas Cleaning Systems (EGCS)

1. Elimination of **Sulfur Oxides (SO_2)**

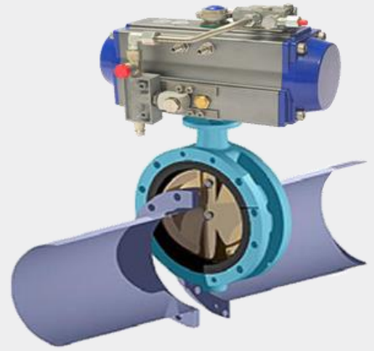
Scrubber System

Control Solution for Isolating Valves



The pneumatic **AVENTICS Valve Control System Marex VCS** controls the flow of seawater as it passes the different stages in the scrubber system by providing remote operation of the butterfly (isolating) valves installed in the pipes.

Marex VCS is part of specialist scrubber solutions that are tailor-made for specific customer requirements.



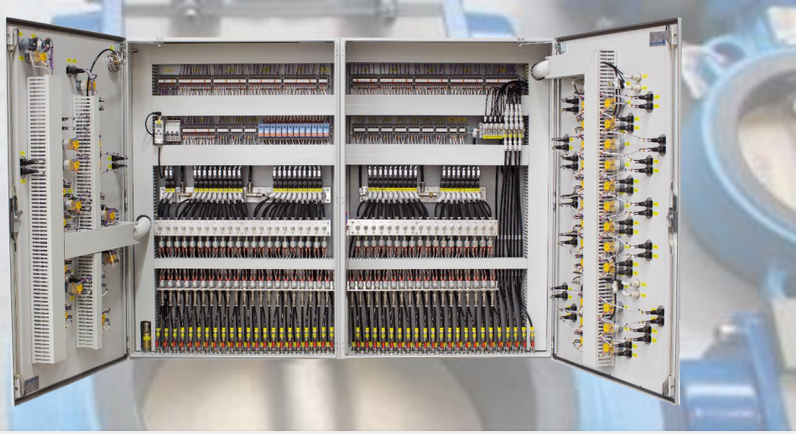
Pneumatic actuator and isolating valve

Exhaust Gas Cleaning Systems (EGCS)

1. Elimination of **Sulfur Oxides (SO_2)**

Scrubber System

Control Solution for Isolating Valves



Features

- One control cabinet for pneumatic control of 15 single acting fail-to-safe butterfly valves, in accordance with customer’s specification.
- **Full pneumatic control of the butterfly valves**
- **Full pneumatic position feedback** – active open and active closed
- No electrical wiring outside the cabinet
- The complete valve system can be commissioned from one location even without remote operating system.
- **Active multiple interlock** of valve movement: Dedicated valves can not close or move unless other valves are fully opened.
- Remote control by **MODbus** over TCP/IP
- Free assignment of outputs and valves without the need of software

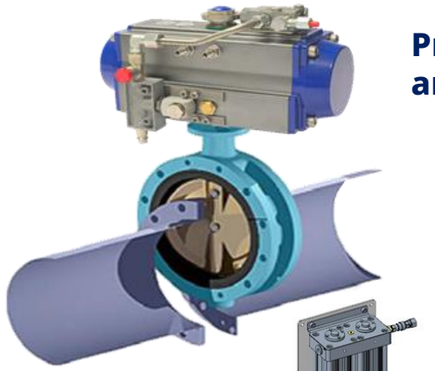
Exhaust Gas Cleaning Systems (EGCS)

1. Elimination of **Sulfur Oxides (SO_2)**

Scrubber System

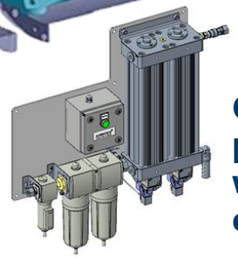
Control Solution for Isolating Valves

- Auxiliary Parts -

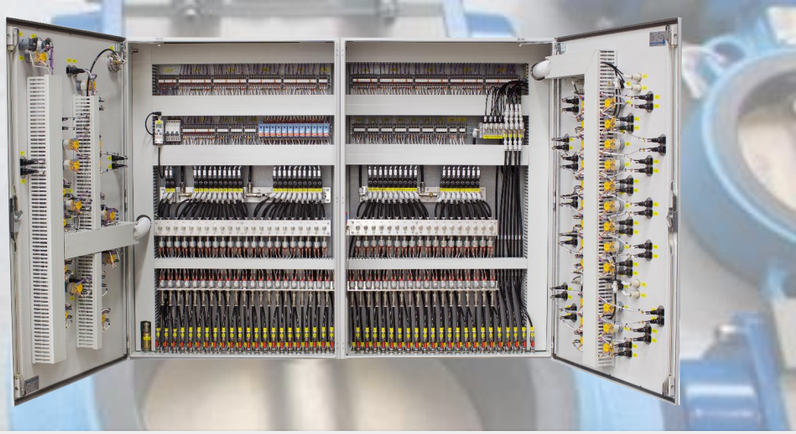


Pneumatic actuators and butterfly valves

Polyamide tubing



Customizable air preparation units with redundancy option



Scope of Supply

- Control cabinets
- Modbus interface
- Air preparation
- Tubing
- Actuators and butterfly valves

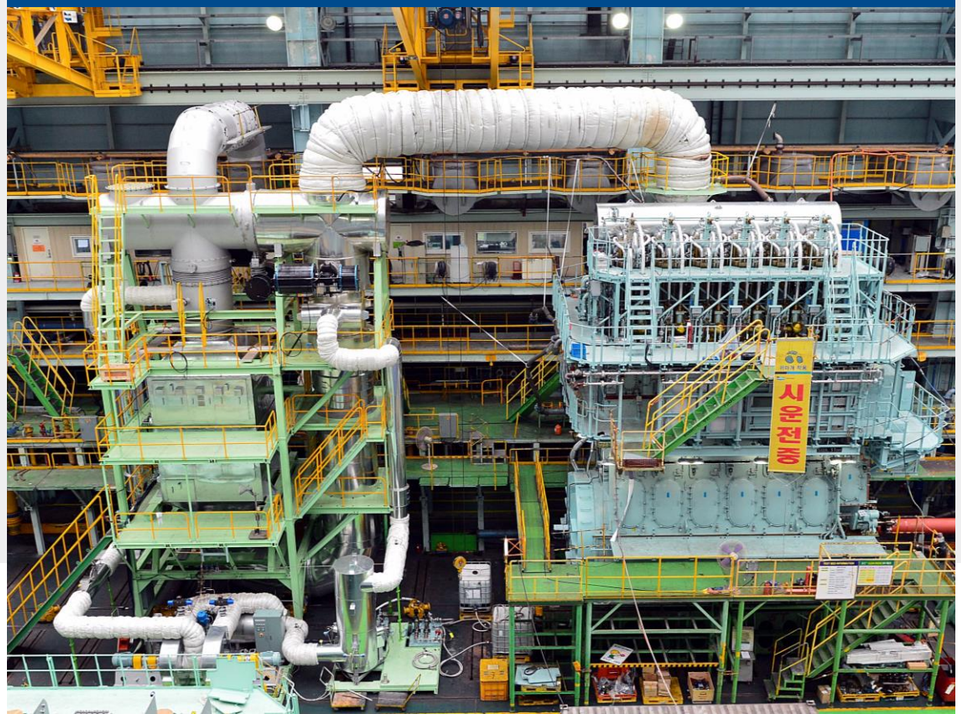
Benefits

- Cost-effective purchase, installation and service
- Fully pneumatic, highly reliable actuator control and feedback
- Single, double acting and proportional control
- Clear local control and position indication

Exhaust Gas Cleaning Systems (EGCS)

2. Conversion of **Nitrogen (NO_x)**

Selective Catalytic Reduction (SCR)



- Selective Catalytic Reduction Systems reduce the level of nitrogen oxides in the exhaust gas by means of catalyst elements and a reducing agent.
- These nitrogen oxides consist mainly of two molecules, nitric oxide (NO) and nitrogen dioxide (NO_2)

- Nitrogen oxides are a significant greenhouse gas that plays an important role in Global Climate Change
- NOx pollution can lead to respiratory and heart diseases.
- Global limits are defined in IMO standards Tier I and II, Tier III standard applies to Emission Control Areas (ECA).

Slow revolving 2-stroke engine with SCR system under construction
(picture Hyundai Heavy Industries)

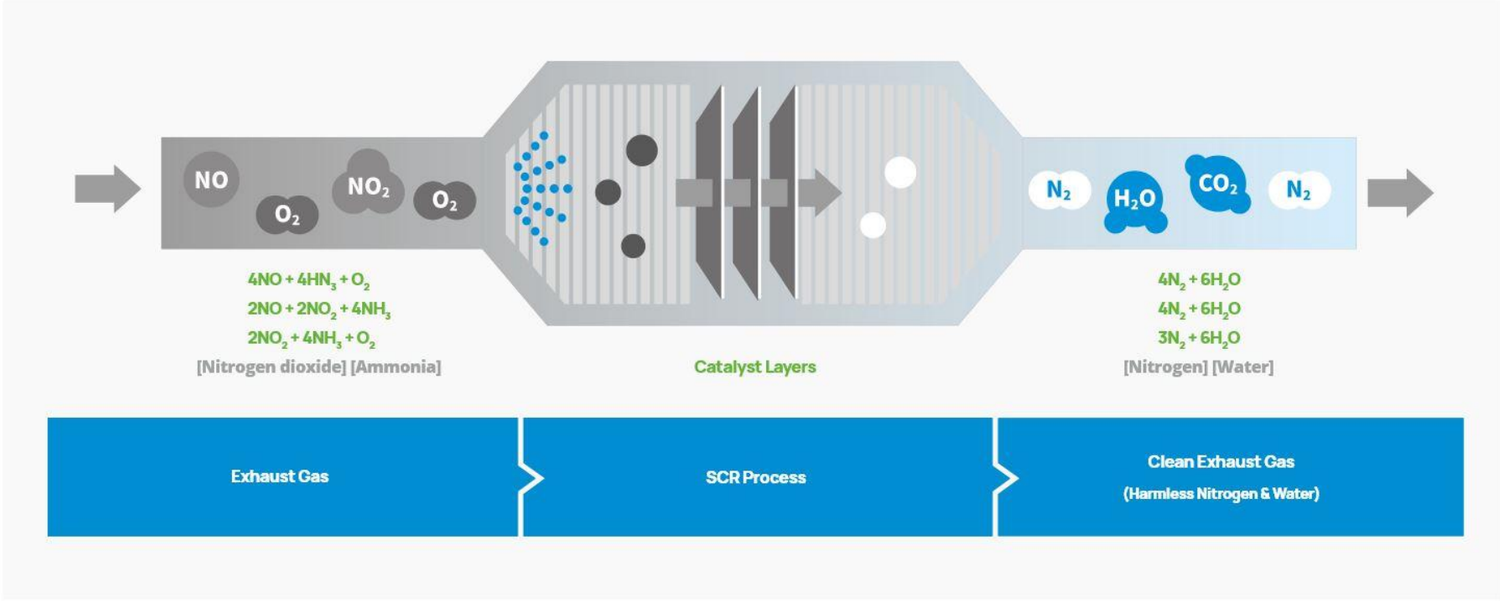
Exhaust Gas Cleaning Systems (EGCS)

2. Convertion of **Nitrogen (NO_x)**

Selective Catalytic Reduction (SCR) Systems

Working Principle of SCR-Systems

1. Urea water solution is added to the exhaust gas stream.
2. The water in the urea solution evaporates as the solution is injected into the hot exhaust gas.
3. The high temperature causes the decomposition of urea ($(NH_2)_2CO$) into ammonia (NH_3) and carbon dioxide (CO_2).
4. Exhaust gas NO_x emissions are thereafter transformed into molecular nitrogen (N_2) and water (H_2O), as they react with the ammonia at a catalytic surface.



Sources: www.Wärtsilä.com; www.Hyundai-engine.com

Exhaust Gas Cleaning Systems (EGCS)

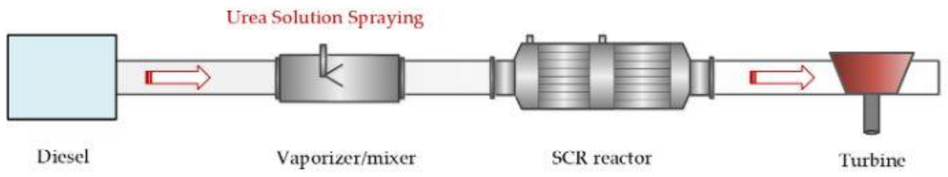
2. Convertion of **Nitrogen (NO_x)**

Selective Catalytic Reduction (SCR) Systems

<u>High pressure (HP) SCR System (1)</u>

- The catalyst/reactor is placed before the turbocharger/turbine
- Mainly used in 2-stroke-engines burning High Sulphur Heavy Fuel Oil
- Makes full use of high exhaust gas temperature
- High impact on engines and turbo chargers (wear, fuel consumption)
- Engine modification required
- Must be installed in engine room

Two types of SCR Systems



(1) HP-SCR

(2) LP-SCR

<u>Low pressure (LP) SCR System (2)</u>

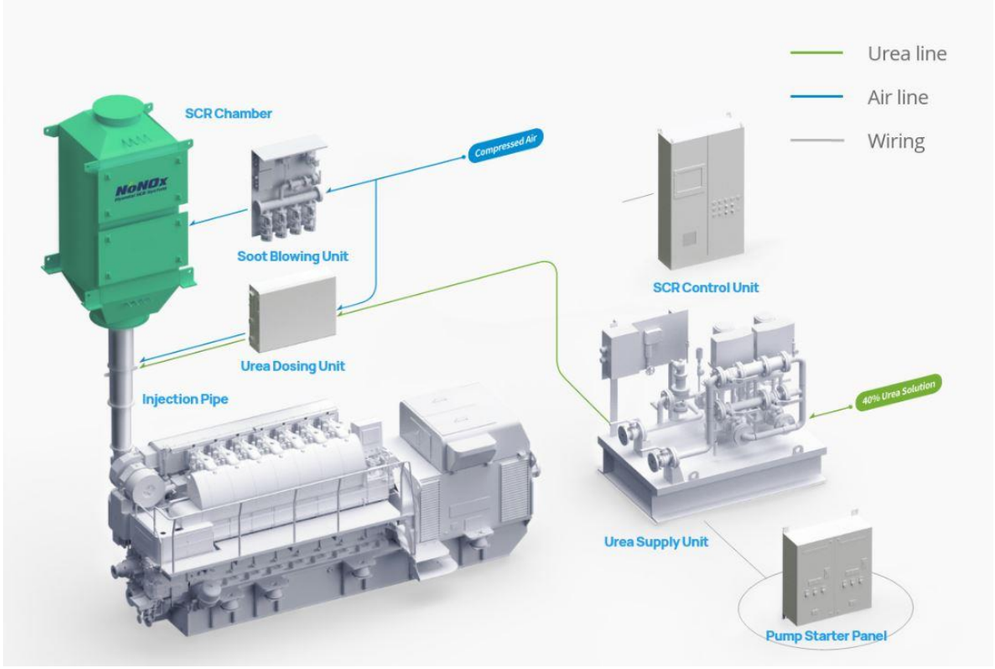
- The catalyst/reactor is placed after the turbocharger/turbine
- Makes use of low exhaust gas temperature
- Frequent with medium and high-speed engines
- Exhaust heating device required with 2-stroke-engines (due to limited nitrogen reduction capacity)
- Engine modification not required
- System can be installed in the chimney/stack

Sources: https://encyclopedia.pub/

Exhaust Gas Cleaning Systems (EGCS)

2. Convertion of **Nitrogen (NO_x)**

Selective Catalytic Reduction (SCR) Systems



LP SCR System designed by Hyundai Heavy Industries

Pneumatic components in SCR Systems:

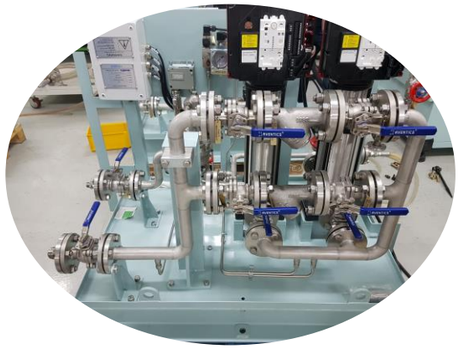
- Compressed air preparation
- Urea supply unit
- Urea dosing unit
- Urea regulating unit
- Venting and sealing unit
- Soot blowing system
- Pump starter panel
- SCR valves

Picture: Hyundai Heavy Industries

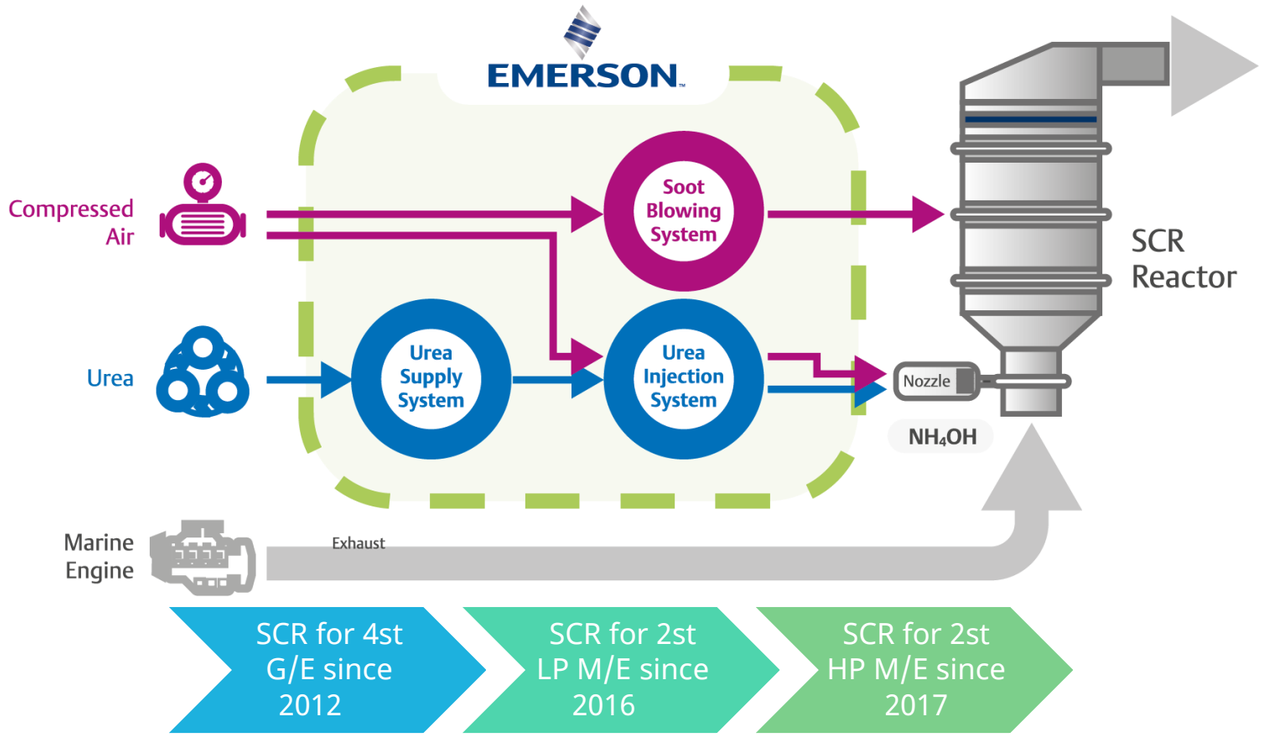
AVENTICS Customized Solutions for SCR Systems

Soot Blowing Unit

Urea Supply Unit



Urea Supply Unit



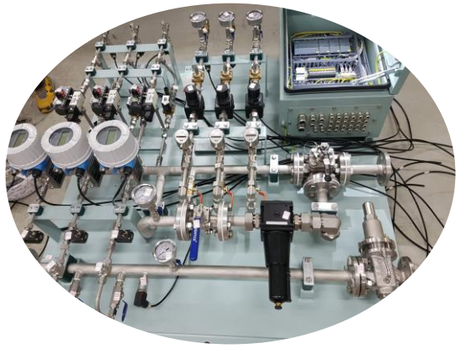
Air Preparation Unit R417003733

- For filtering and drying compressed air
- Delivers air quality to ISO Standard 2:2:2
- Includes innovative AVENTICS Roll-up Dessiccant Dryer

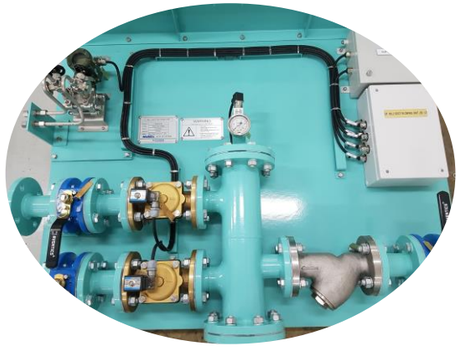
Differential Pressure Valve R417002825

- Used in SCR-bypass control of MAN 2-stroke engines

Pump Starter Panel



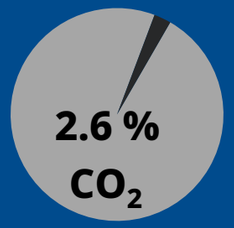
Urea injection unit



Soot Blowing Unit

Decarbonization

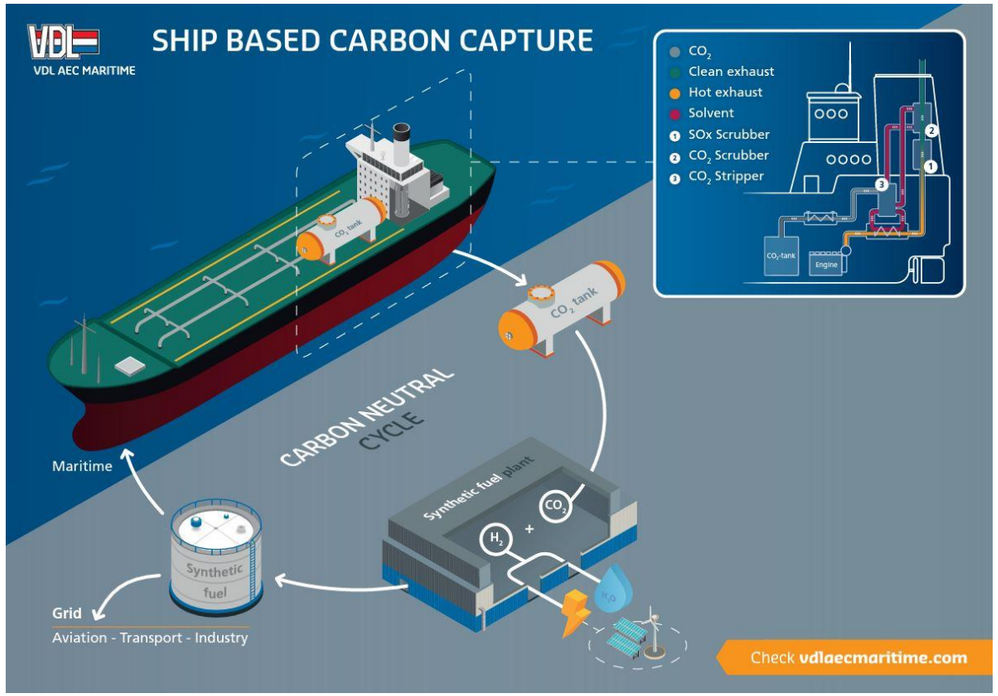
Carbon Capture (CO_2)



Why ship-based carbon capture?

1. It is expected that the existing CO_2 reduction efforts, e. g.
   - Use of less carbon-intensive fuels
   - Reducing fuel consumption

   will not be enough to meet the IMO targets.
2. Renewable energy sources will not be sufficiently available to produce the required amount of e-fuels necessary in the medium to long term.



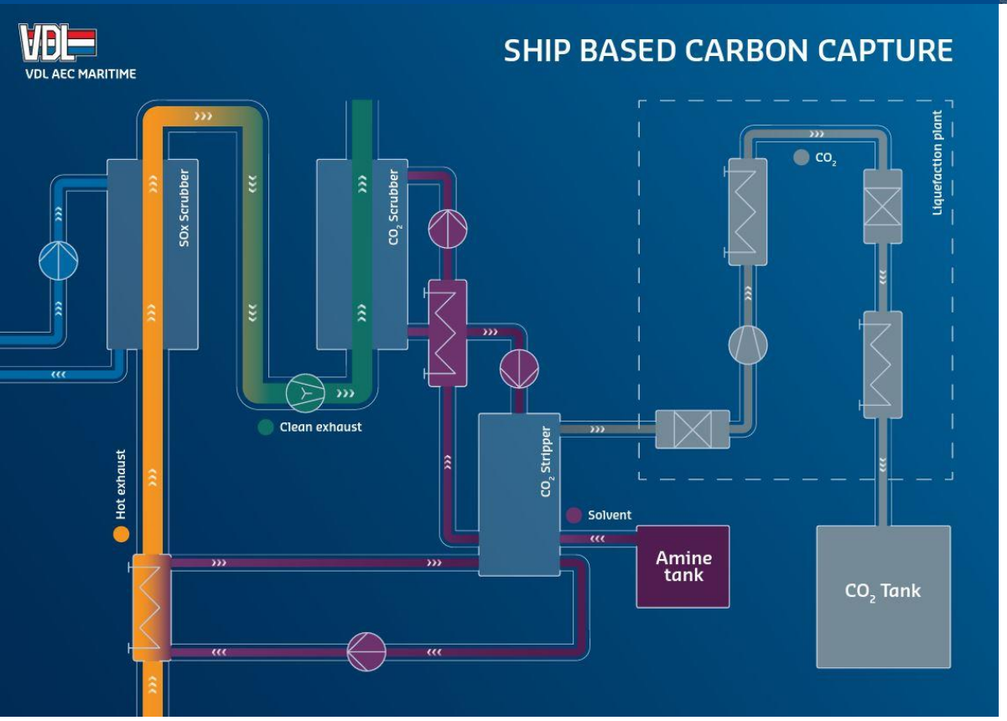
Carbon Capture

- CO_2 captured from the exhaust gas can be used to make Methanol based on green energy.
- This methanol has a low carbon intensity and can be used again on board as ships fuel.
- This creates a carbon neutral cycle and contributes to a more gradual transition to synthetic fuels.

Source: https://www.vdlaecmaritime.com/

Decarbonization

Carbon Capture (CO_2)



Function

1. Exhaust gas is cooled and cleaned inside, reducing particulate matter and temperature (optional: SOx).
2. CO_2 Scrubber: Exhaust gas is brought into contact with a solvent, dissolving up to 90% CO_2 from the exhaust gas which leaves via the top of the funnel.
3. CO_2 Stripper: The solvent is heated, releasing the CO_2, after which the solvent is re-used in a closed loop system.
4. CO_2 Tank: The CO_2 is liquefied and stored in a tank. To do this, the CO_2 is pressurized and cooled, using compressors and cooling units.

Source: https://www.vdlaecmaritime.com/