

PROVEN CARBON CAPTURE SOLUTIONS

CO₂ Capture, Storage & Reuse
Copenhagen

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Agenda

About Pentair

Introduction

Carbon Capture Solutions

- Status of Pentair Carbon Capture Technology
 - Reference projects
- CCS Integration with CHP Plants
- CO₂ Quality for CCUS

Test Results

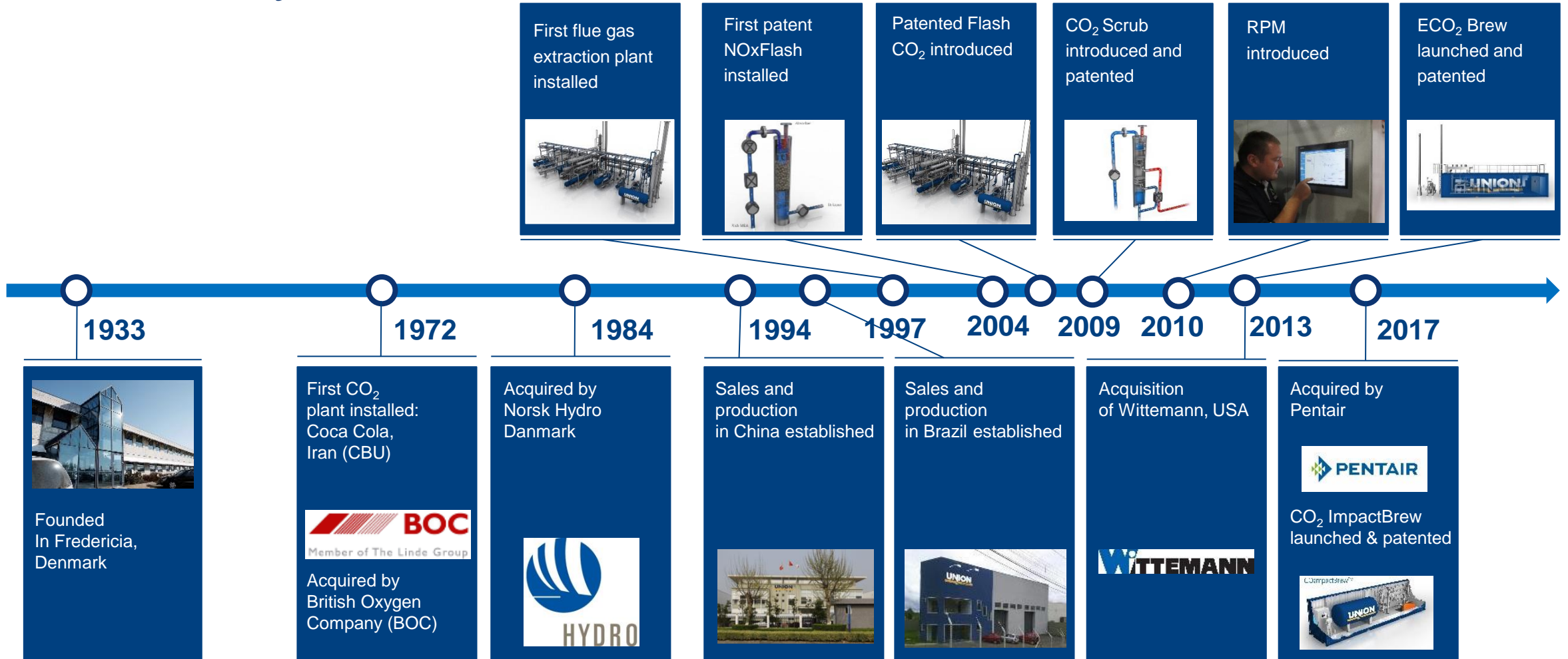




120 locations
In **25** countries
9,500 employees
8 business units
~\$3B in revenue

Mission:
“Deliver Smart,
Sustainable Solutions
that empower customer
to make the most of life’s
essential resources!”

Our history in short



Long history and knowledge of CO₂ technology

Pentair's contribution to decarbonization

CO₂ & METHANE PURIFICATION FROM BIOGAS

3 Stage & 2 Stage with CO₂
No Methane Slip



75+

MEMBRANE
PLANTS

CO₂ CAPTURE FROM INDUSTRIAL PLANTS

500 lb to 15 ton/hr CO₂ Industrial CO₂
Anaerobic Digestion Biogas Upgrading



350+

AMINE PLANTS

CO₂ Plants for
Breweries &
Soft Drinks



2000+

CO₂ PLANTS

20,000+

MEASUREMENT
DEVICES



CO₂/O₂ in Breweries
BioSENSE



CO₂ RECOVERY IN BREWERIES/SOFT DRINKS

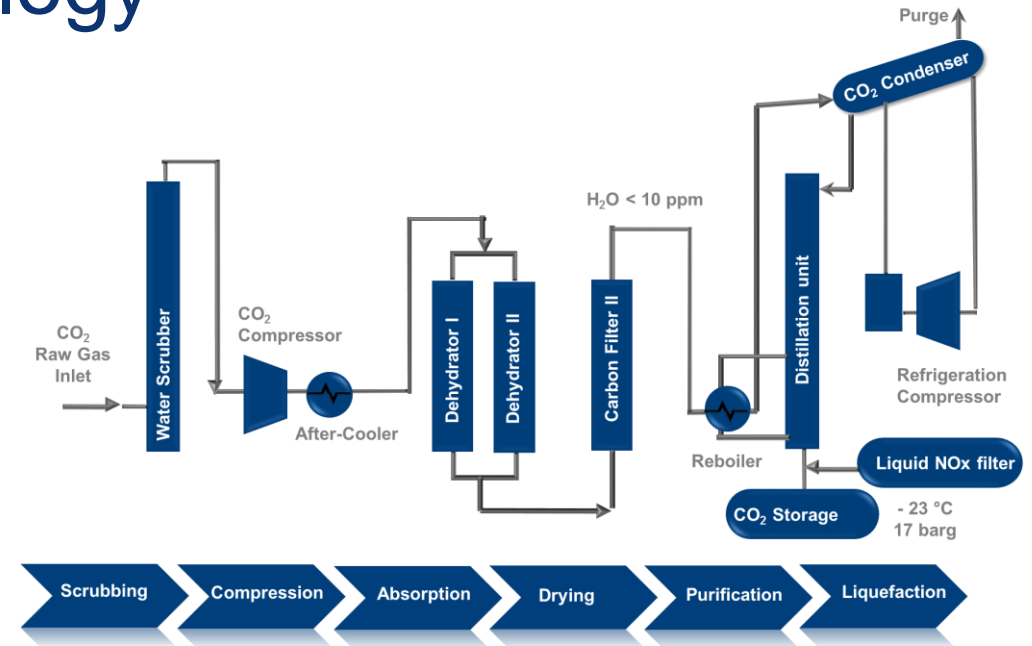
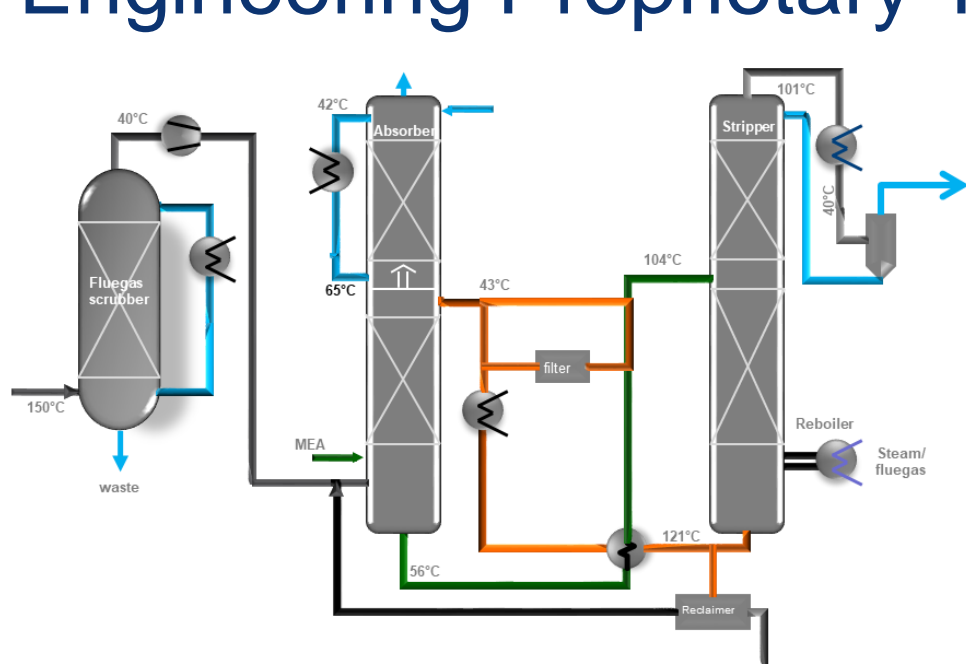
GAS ANALYSIS IN BREWERIES/SD/BIOGAS

Established provider in CO₂ Recovery and Biogas Solutions



Status of Pentair Carbon Capture Technology

Advanced Amine Technology (AAT) is a Pentair Union Engineering Proprietary Technology

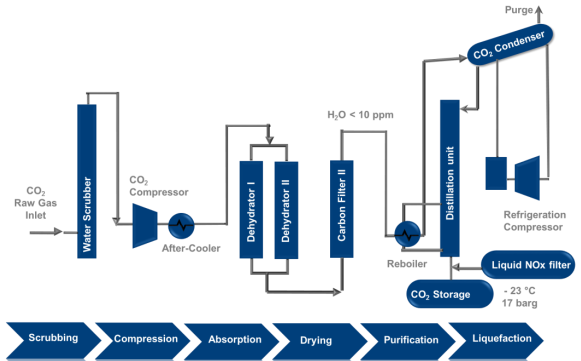
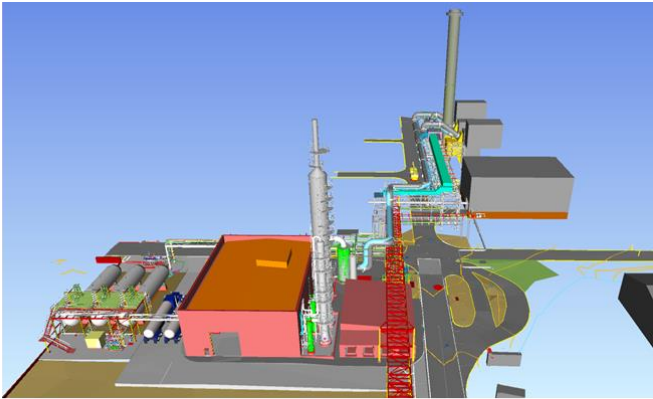
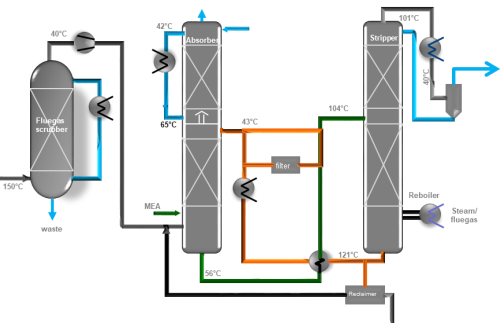


Advanced Amine Technology

- AAT is mainly developed for Flue Gas CO₂ extraction and can be used for biogas upgrading.
- Designed for many different flue gas sources (power plants: fossil fueled, biomass fired, WtE, Cement etc.).
- Permits large scale CO₂ capture from low pressure, high oxygen containing flue gases.
- Based on the current most proven and efficient amine technology available on the market.
- Approved for beverage grade and meets CCU/S final product quality requirements.

Pentair Union Engineering has more than 350 industrial scale amine plants in operation worldwide

Carbon Capture & Utilization Plant, Tata Chemicals, Northwich, UK



115 tpd CO₂ is captured and utilized for on-site sodium bicarbonate production

Carbon Capture & Utilization Plant, Tata Chemicals, Northwich, UK



- 1st industrial scale CCU plant in the UK.
- Capturing 40,000 t of CO₂ from flue gases from on-site gas fired CHP plant, resulting in 11% carbon reduction.
- Captured CO₂ is liquefied, purified to highest standards and used for the manufacturing of high purity sodium bicarbonate.
- 'Capture & Utilization' presents true 'circular economy' opportunity and leads to one of the lowest carbon footprint sodium bicarbonate in the world.
- TCE CCU is mentioned for its valuable contribution towards net zero 2050 in UK government's 10-point plan for the Green Industrial Revolution.

Largest carbon capture utilization plant built in the UK

Australia - Gas Fired Power Plant

- Installed in a very restrictive nature reserve.
- Conservation park at Torrens Island.
- Protected under National Parks and Wildlife Act 1972.
- Supplies beverage grade liquid CO₂ to the Merchant market.



More than 50,000 ton per year of CO₂ is captured and Liquefied

Spain - Biomass Fired Power Plant

- 150 tpd CO₂ capture capacity.
- Supply of both gaseous CO₂ for horticulture and liquid beverage grade CO₂.



More than 50 ton per year CO₂ will be captured soon

CCS INTEGRATION WITH CHP PLANTS

ARC CCS – CO₂ Capture Project



Partnership: EUDP Funding scheme under the Danish Energy Agency

Consortium:

- ARC Waste to Energy plant
- DTU Danish Technical University
- Ramboll Engineering company
- Pentair Technology provider



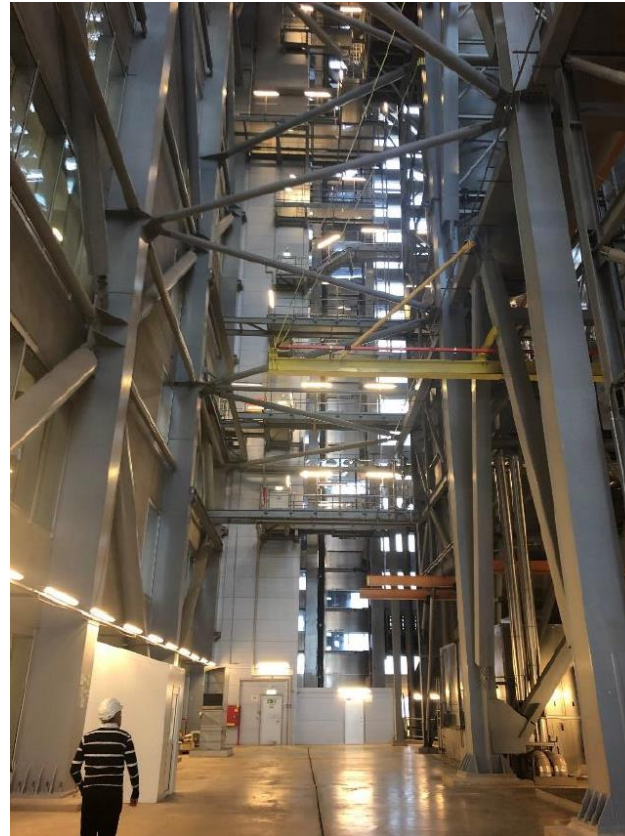
Pentair Union Engineering has supplied more than 350 Industrial Scale carbon capture plants worldwide.

ARC CCS

ARC Copenhagen/Denmark: Net Zero Carbon Capture

Pentair and ARC cooperation, a 3-step process to full scale Carbon Capture

1. Pilot plant completed. Multiple test results have been evaluated and will continue.
2. Demonstration plant of 160 kg/h is under delivery and will be commissioned during 2023.
3. Full scale of 500.000 t/y is planned in 2025.



ARC Copenhagen, Denmark

CO₂-Capture at ARC, WtE Power Plant

- 50 kg/h MEA extraction pilot plant installed.
- Prior to installation at ARC, it was used for testing on biogas.
- Why is Pentair involved:
- Plant is prepared for testing of other solvents.
- Integration of CC plant in Power Plant
- Heat integration in District Heating systems
- Support to DTU



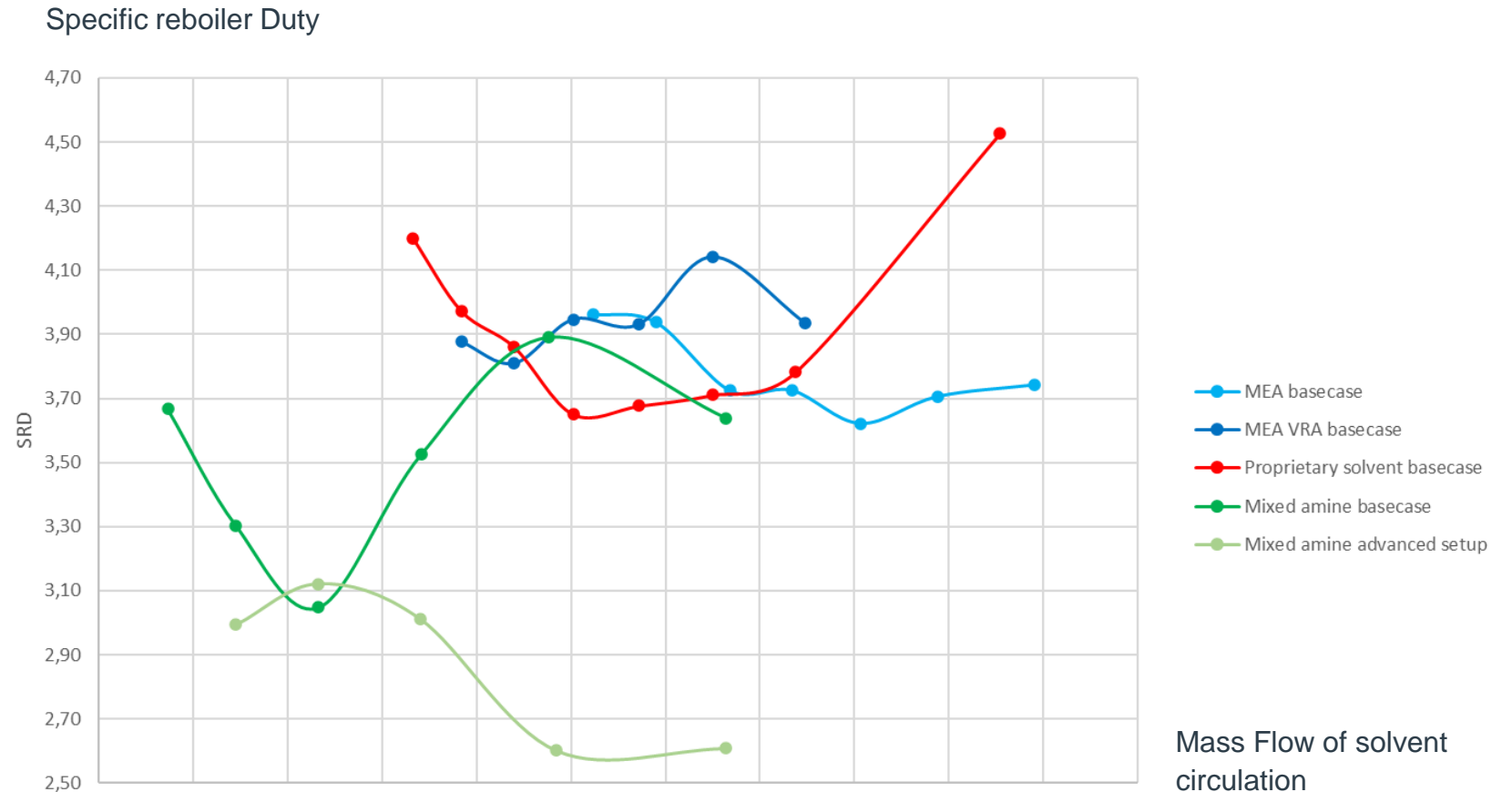
CO₂ Pilot Plant Installation

Pilot unit campaigns

- Extensive test for MEA
 - **Process setup and conditions varied**
- Test of additive for better performance
- **Test of 2nd generation solvent open proprietary solvent**

Ongoing testing

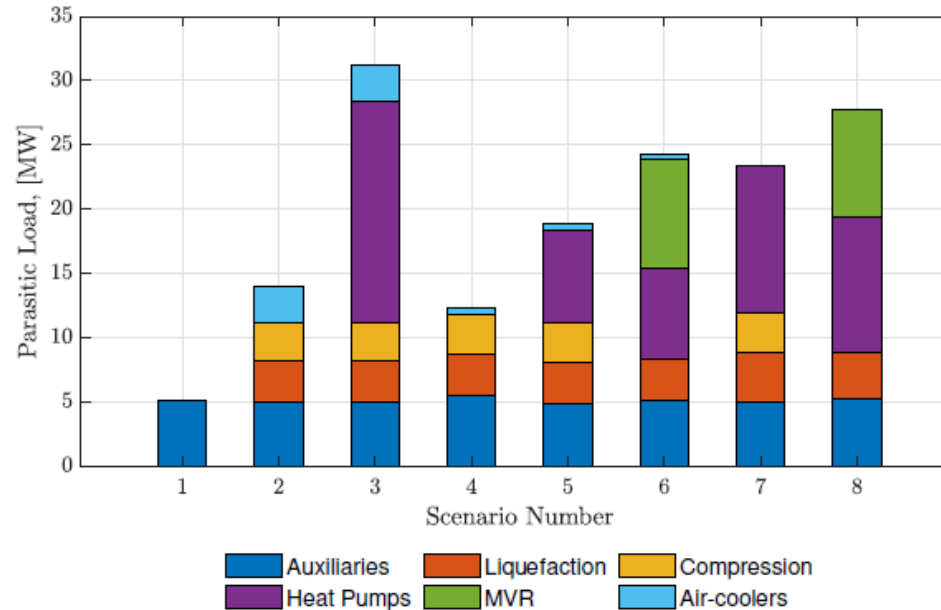
- Test of 2nd generation solvent open-source solvent



Specific Reboiler Duty (SRD) Findings

Amine unit and WtE plant integration

- Analysis done by Ramboll, in cooperation with Pentair.
- Study of most efficient integration configuration [site specific to ARC].
- **Qualifying ideas and process solutions for the amine unit in relation to WtE power plant in general.**
- **Considerations:**
 - The optimum solution for a capture system is specific to the single site.
 - Integration of CC excess heat in the District Heating network possible?
 - Reliability (uptime) of the CC technology
 - OPEC/CAPEX, Propriety technologies



- Contributors to the Levelized Cost due to power consumed at CC plant and Heat Pumps (Steam consumption not included)
- 1: Power Plant as built
 - 2: CO₂ Capture w/o heat recovery
 - 3: Same as 2, but with external Air Source Heat Pumps (ASHP) for District Heating
 - 4: Same as 2 & 3, utilizing waste heat from CC facility in Absorption Heat (AHP)Pumps
 - 5: Same as 4, using VCHP
 - 6: A Mechanical Vapor Re-compression (MVR) is implemented to recycle heat energy in the CC process. (Generating steam to the reboiler)
 - 7: No MVR, All heat sources from the CC system are utilized as useful heating.
 - 8: Integration of VCHP and MVR. Compression, Liquefaction and Condensing heat is utilized for DH.

Amine unit and WtE plant integration

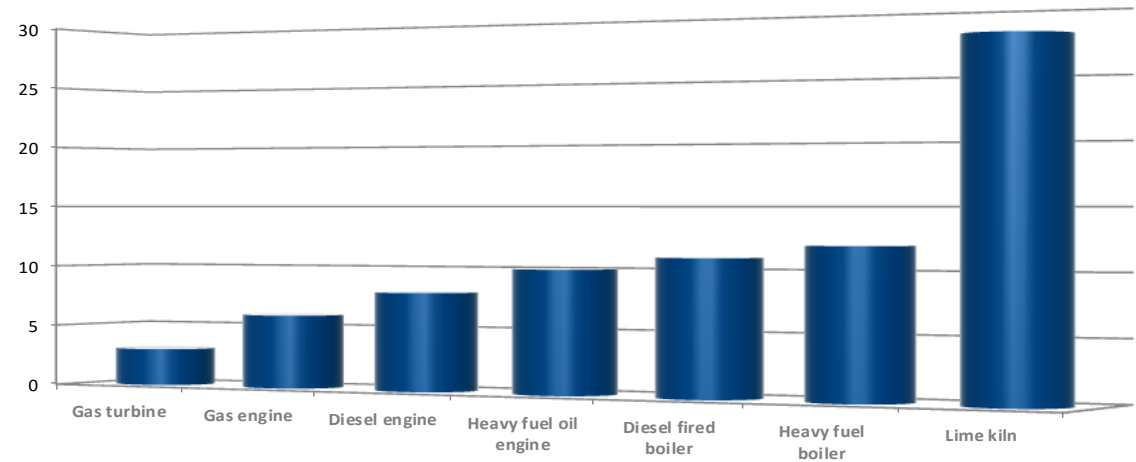
CO₂ Quality for CCUS

CO₂ quality for CCUS

COMPONENT	CONCENTRATION, PPM (MOL)
Water, H ₂ O	≤ 30
Oxygen, O ₂	≤ 10
Sulphur oxides, SO _x	≤ 10
Nitric oxide, Nitrogen dioxide, NO _x	≤ 10
Hydrogen sulfide, H ₂ S	≤ 9
Carbon monoxide, CO	≤ 100
Amine	≤ 10
Ammonia, NH ₃	≤ 10
Hydrogen, H ₂	≤ 50
Formaldehyde	≤ 20
Acetaldehyde	≤ 20
Mercury, Hg	≤ 0.03
Cadmium, Cd	≤ 0.03
Thallium, Tl	(sum)

- Northern Light – specs
- Horticulture
- Beverage Grade
 - Exceed the ISBT standards
- Electronic grade
- Extensive references from all sources such as...

CO₂%



CO₂ quality



THANK YOU FOR YOUR
KIND ATTENTION