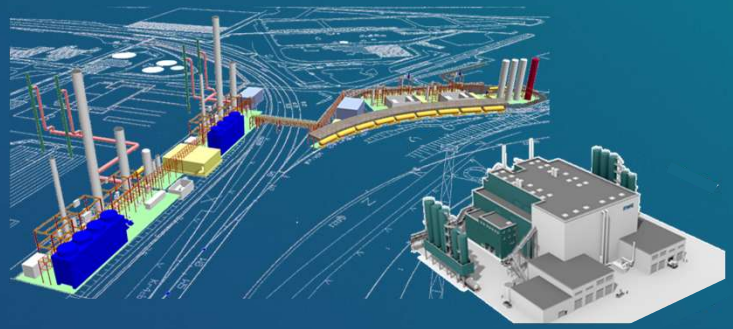
RWE



Advancing CO_2 Capture –

RWE Cutting-Edge Research for Real-World Solutions

ETN CCS Webinar Series

06th February 2025

Dr. Sandra Schmidt
RWE Power AG

CO_2 Capture – Solid knowledge base at RWE

19 years active participation in CO_2 Post-combustion Capture Pilot and Demonstration Projects

CASTOR/
CESAR
Esbjerg,
Denmark

BASF's ***OASE®*** blue
Niederaussem
Germany

24/7 longtime operation under real operating conditions

100,000 operating hours

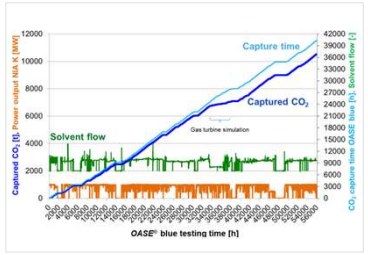
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026

Today >115,000 operating hours

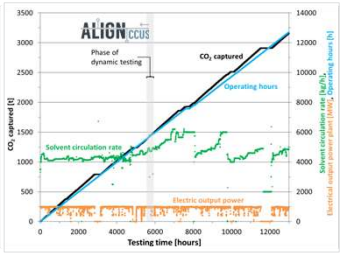
Alstom's
Chilled Ammonia
USA

Alstom's
Chilled Ammonia
Mountaineer
USA

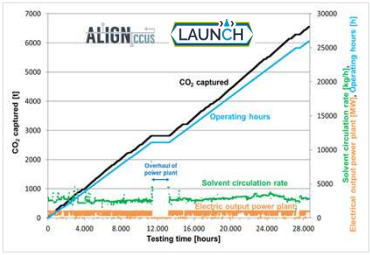
Shell's Cansolv
Aberthaw
UK



OASE® blue
>55,000 h

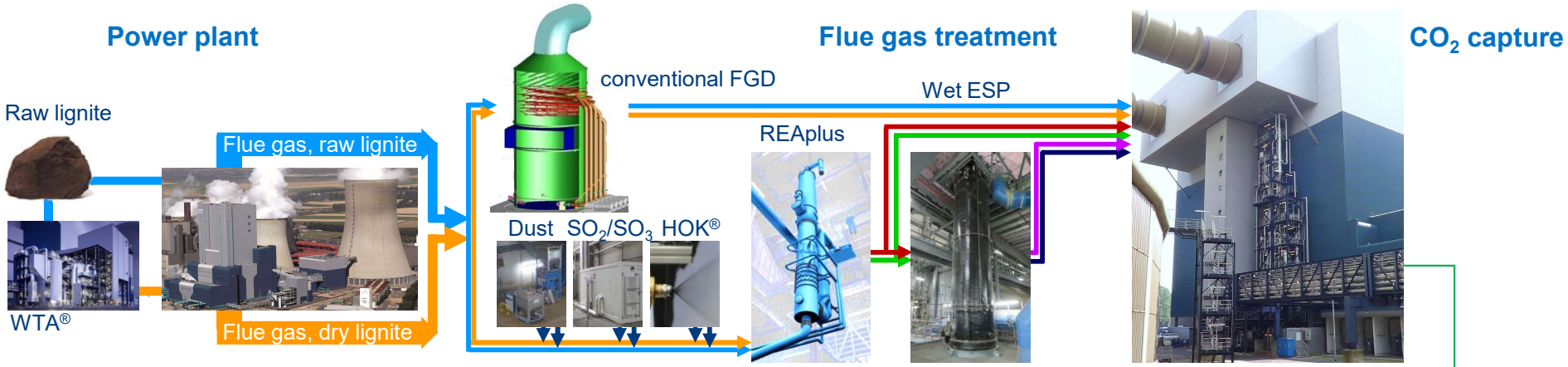


MEA
>18,000 h

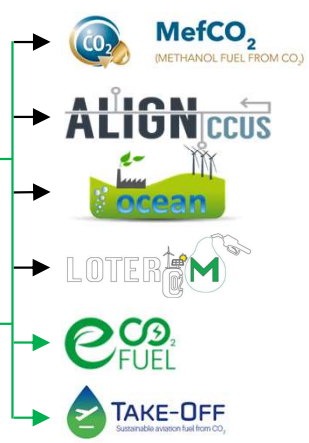


CESAR1
>49,000 h

Post-Combustion Capture at RWE's Innovation Center

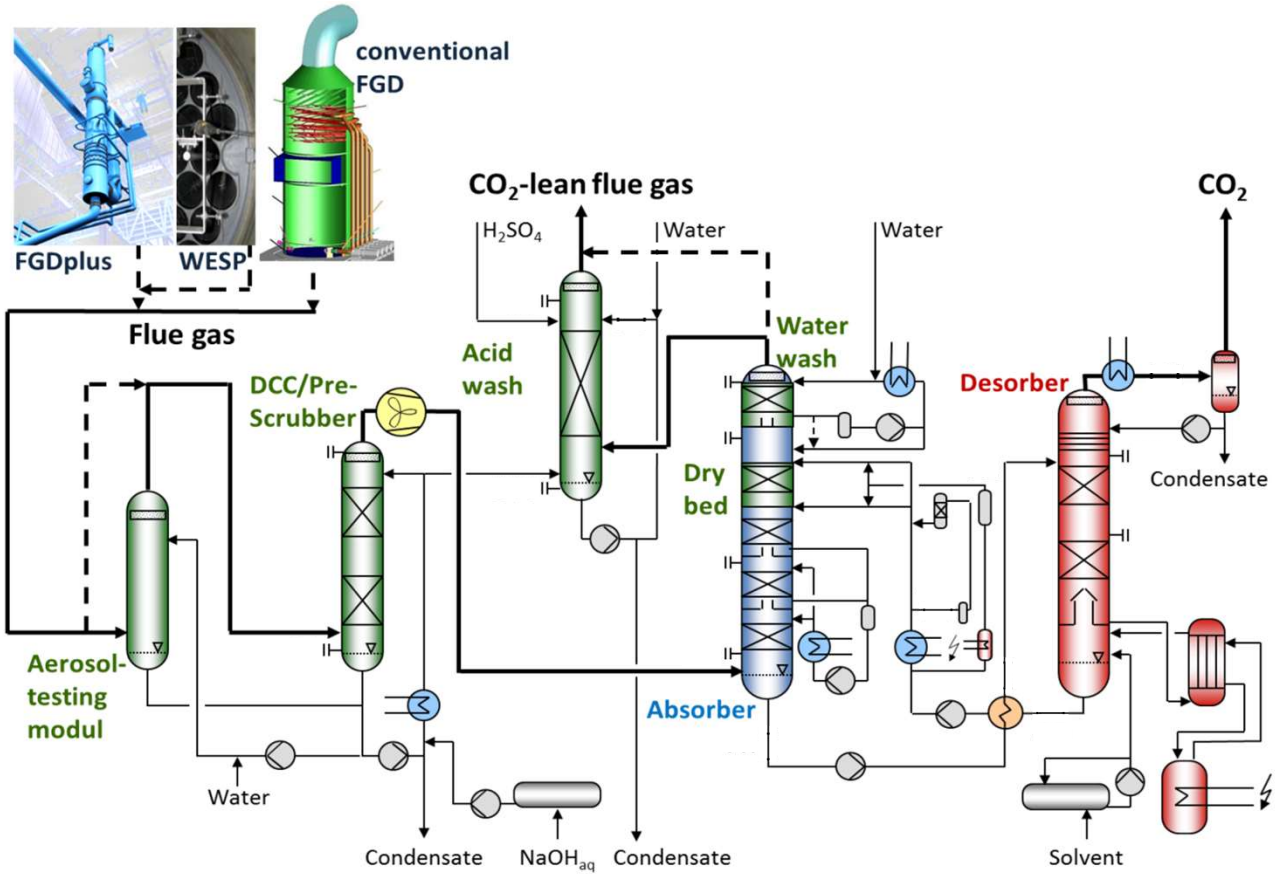


ALIGN CCUS	**All aspects of CCUS**
LAUNCH	**Solvent management**
SCOPE	**Emission mitigation and CO_2 quality**
MeDORA Oxygen Removal System	**Solvent management and CO_2 quality**
D2IVE	**Highest capture rates**



Post-Combustion Capture Pilot Plant at Niederaussem

Evaluation of the process performance needs longtime testing with real flue gas



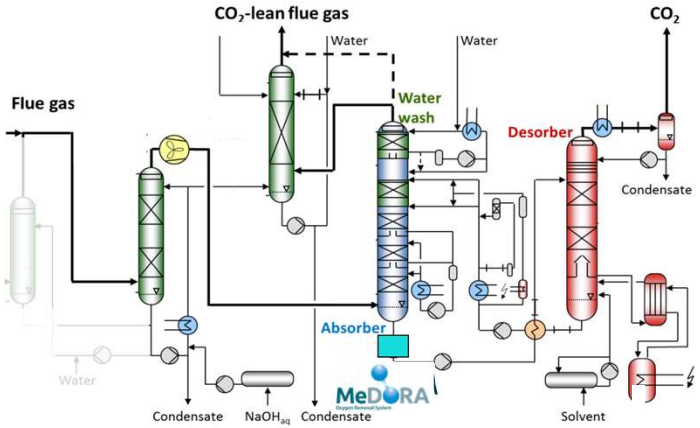
- **1,550 m^3_N/h flue gas flow**
- **7.2 t_{CO2}/day CO_2 product**
- **90% CO_2 capture rate**
- **97% availability**
- **First PCC pilot plant commissioned in Germany**
- **Instrumentation: 285 online measurements**
- **24/7 operation**

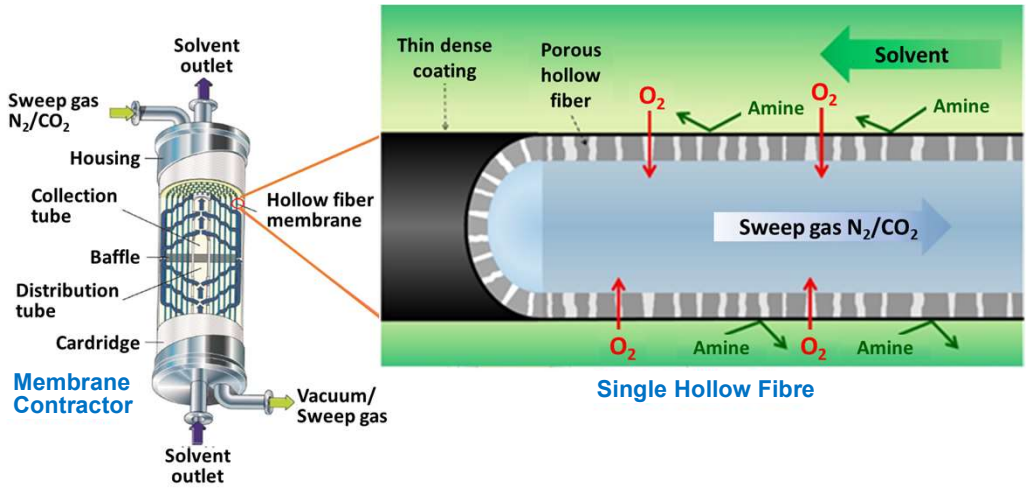
FGD: Flue gas desulphurization
WESP: Wet electrostatic precipitator
DCC: Direct contact cooler

MeDORA – Membrane-assisted Dissolved Oxygen Removal from Amine solution for CO_2 capture

Reduction of the O_2-concentration in the solvent means the reduction of:

- **solvent degradation, make-up demand**
- **solvent flow**
- **corrosion**
- **effort for CO_2 purification**



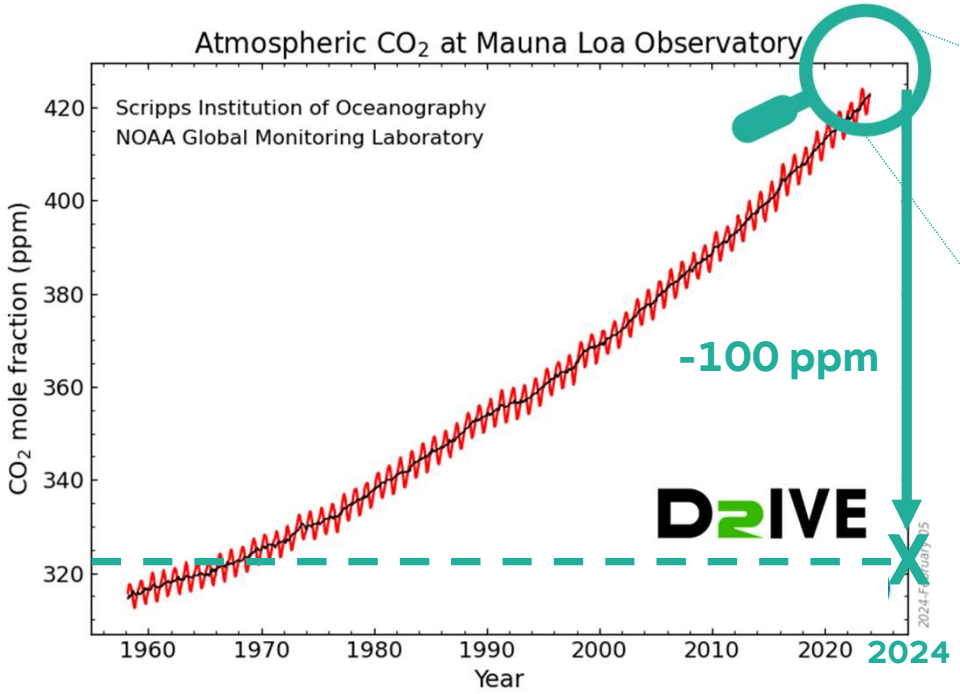


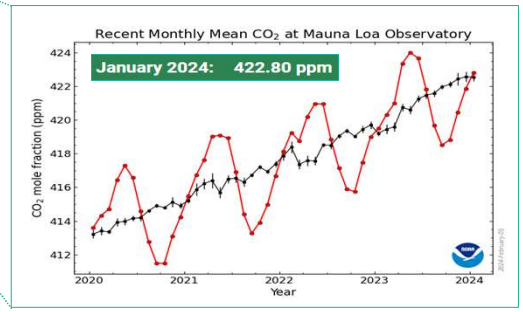
Goals:

- **90% O_2-reduction in the solvent**
- **50% reduction of the degradation rate**
- **Reduction of the O_2-concentration in the CO_2 product to <10 ppm**

DRIVE – Deep Removal of CO_2 and InnoVative Electrification concepts

Negative CO_2 emissions by highest capture rates at amine-based capture plants and by electrochemical technologies (pH swing)



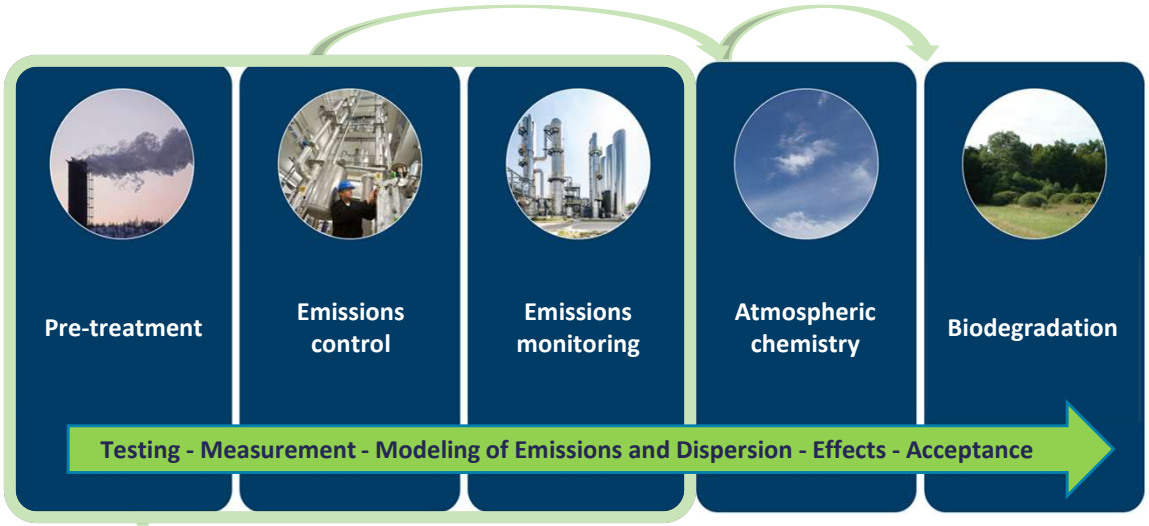


First results:

- **CO_2 content in the CO_2-lean flue gas less than ambient air achieved**
- **321 ppmv @ only 30% higher energy demand**
- **99.8% capture rate**

SCOPE – Sustainable OPEration of post-combustion Capture plants

Providing facts to the discussion on BAT from 24/7 longtime testing



- **Testing of emission mitigation technologies**
- **Effects of solvent aging at capture rates of 90-98%**
- **tests on dynamic and start/stop behaviour**
- **Validation of simulation tools (ASPEN, ProTreat, ML)**
- **Mimicked off-gas of natural gas fired plants (CO_2 4%, O_2 15%)**

Demonstration and holistic analysis of emission management technologies at Niederaussem

Niederaußem
Lignite
300 kg CO_2/h

Hengelo
Waste-to Engergy
500 kg CO_2/h

Tiller CO_2 Lab
Biomass, propane
30-40 kg CO_2/h

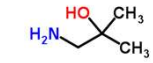
Alkmaar
Waste-to Energy
540 kg CO_2/h

Vindyachal
Hard coal
830 kg CO_2/h

Tuticorin
Chemicals
7.500 kg CO_2/h

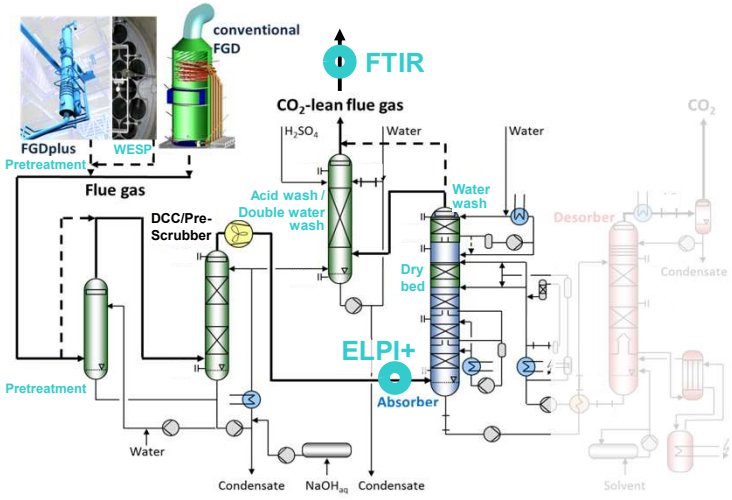
Test of emission mitigation technologies for CESAR1 at Niederaussem

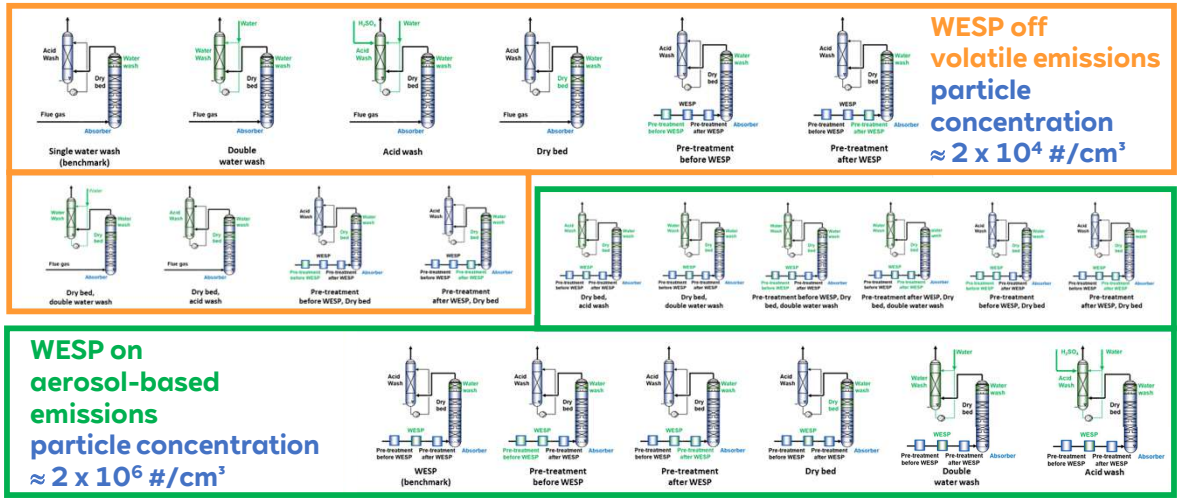
- **Flue gas source: 1,000 MW lignite-fired power plant**
- **Operation mode: 24/7, 300 kg_{CO2}/h@90% capture rate,**
- **Solvent: CESAR1**
- **Test campaigns with more than 20 configurations of emission mitigation technologies: water wash, double water wash, acid wash, dry bed (OASE aerozone®), pretreatment.**



AMP:
2-amino-2-methylpropan-1-ol

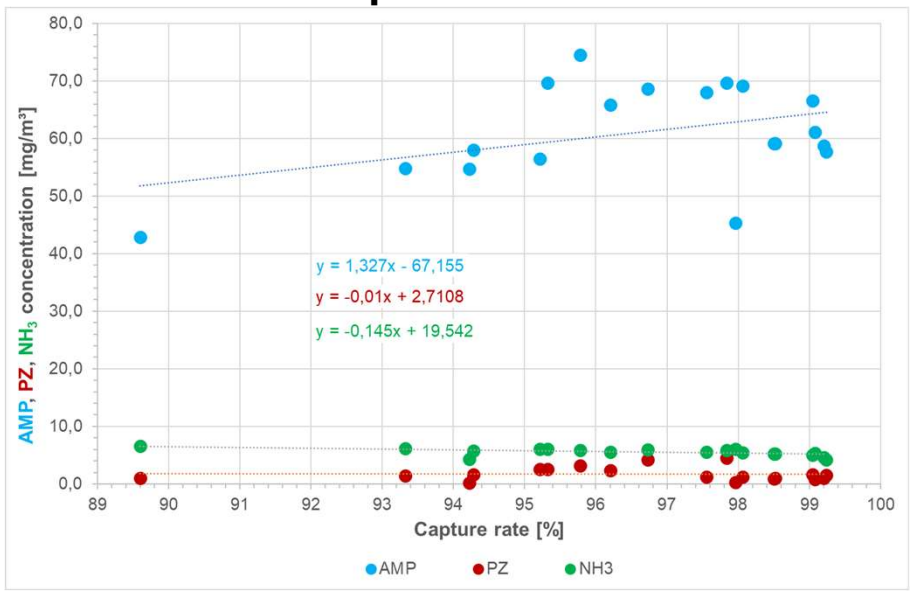
PZ:
piperazine

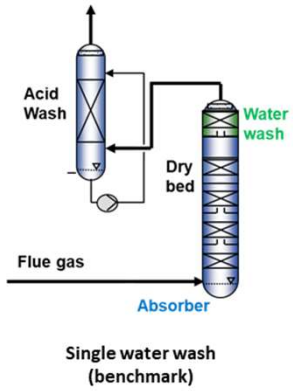


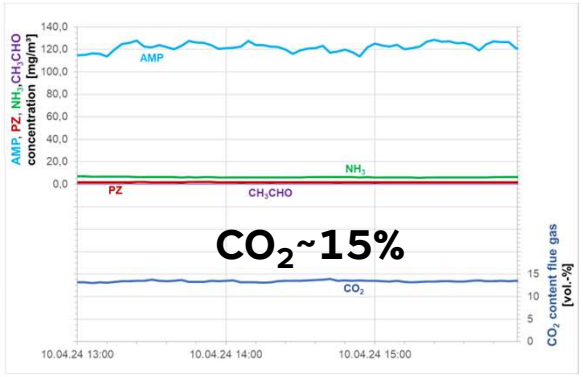


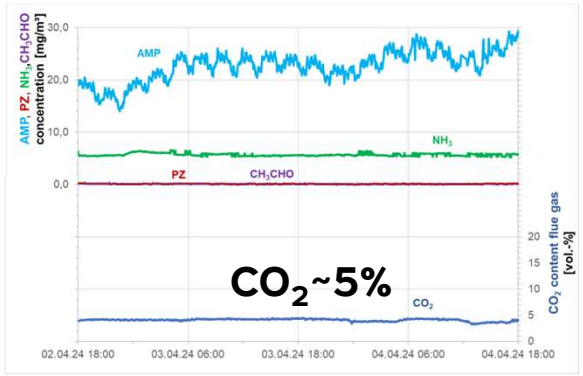
Effects of high capture rates and of CO_2/O_2 content in the flue gas

For CESAR1 only small effects of the capture rate on emissions; changes of the CO_2/O_2 concentration affect the temperature profile in the absorber and emissions





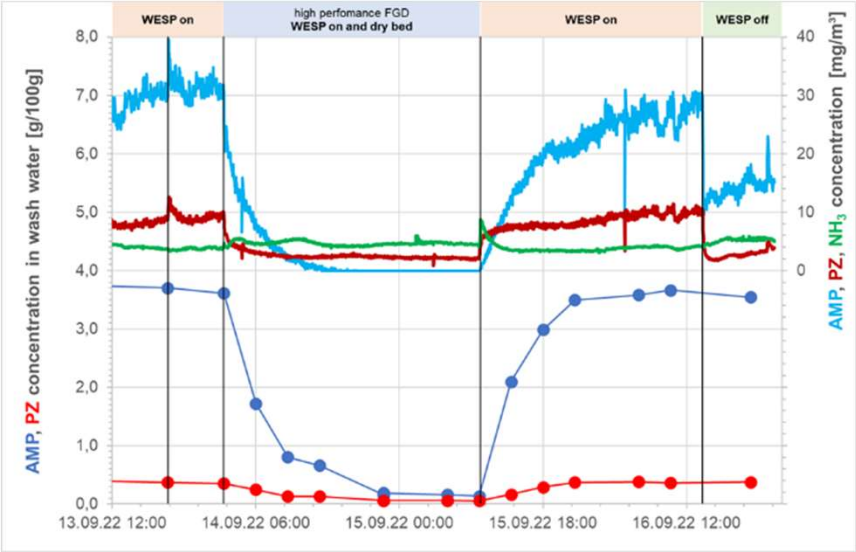


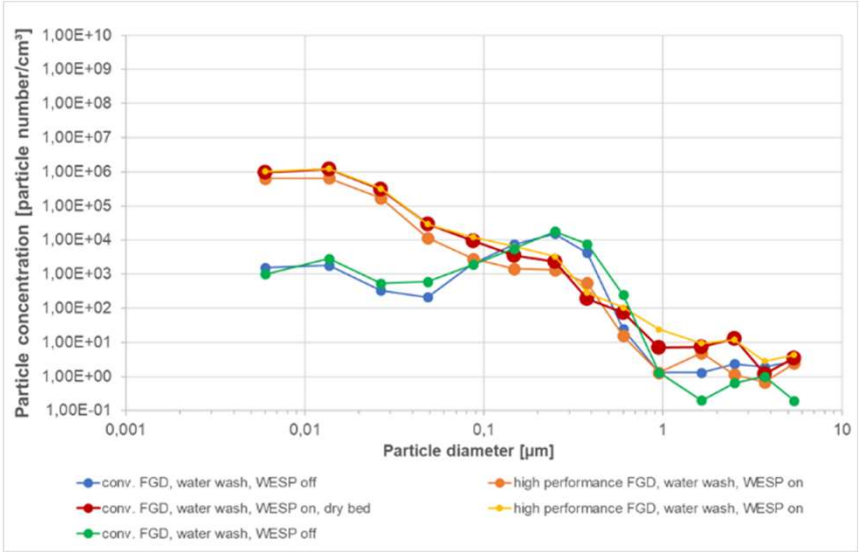


(Proprietary) emission mitigation technologies are available to control emissions regardless of the capture rate and the O_2 content in the flue gas

Emission management

Aerosol and vapor-based emissions – solvent CESAR1



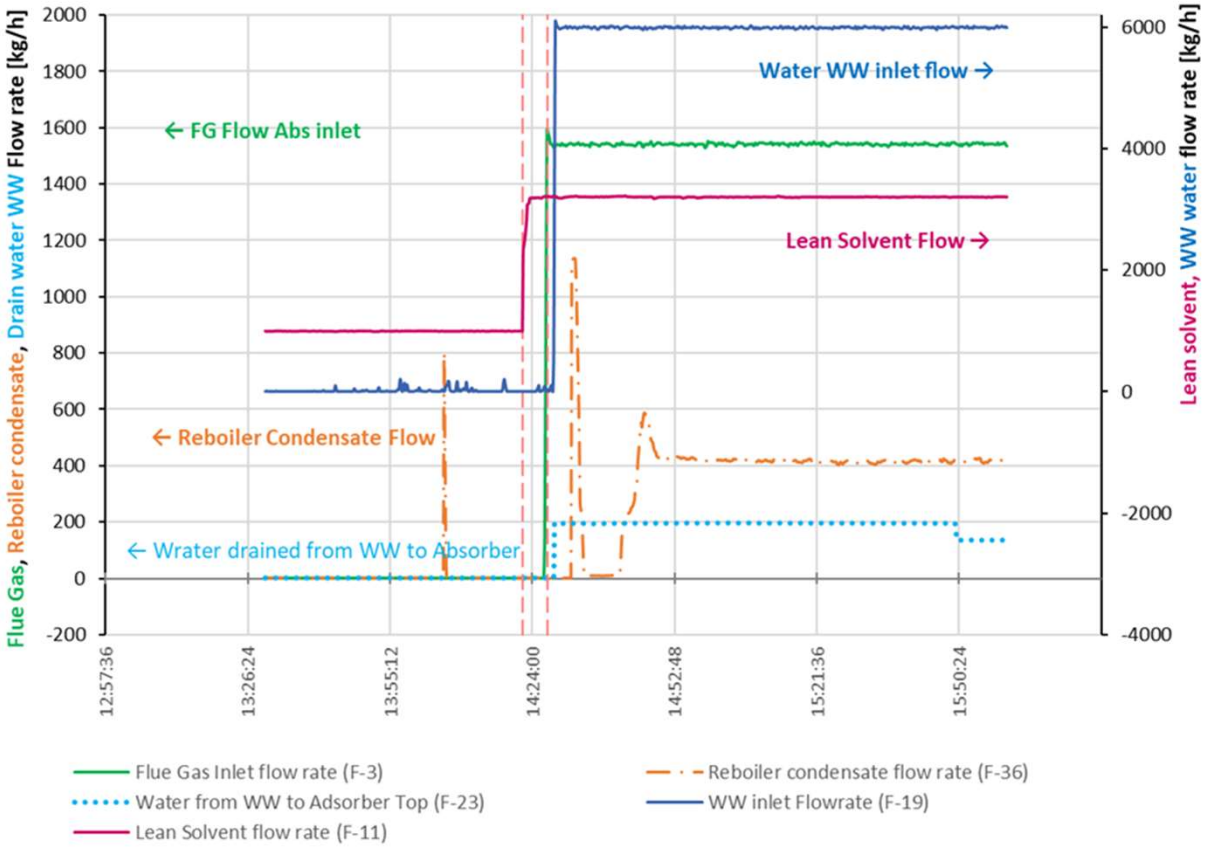


Solid particles in the flue gas with diameter <100 nm can cause aerosol formation

(Proprietary) emission mitigation technologies are available to control emissions regardless of the particle number concentration and size distribution

Dynamic operation of CO_2 capture plants

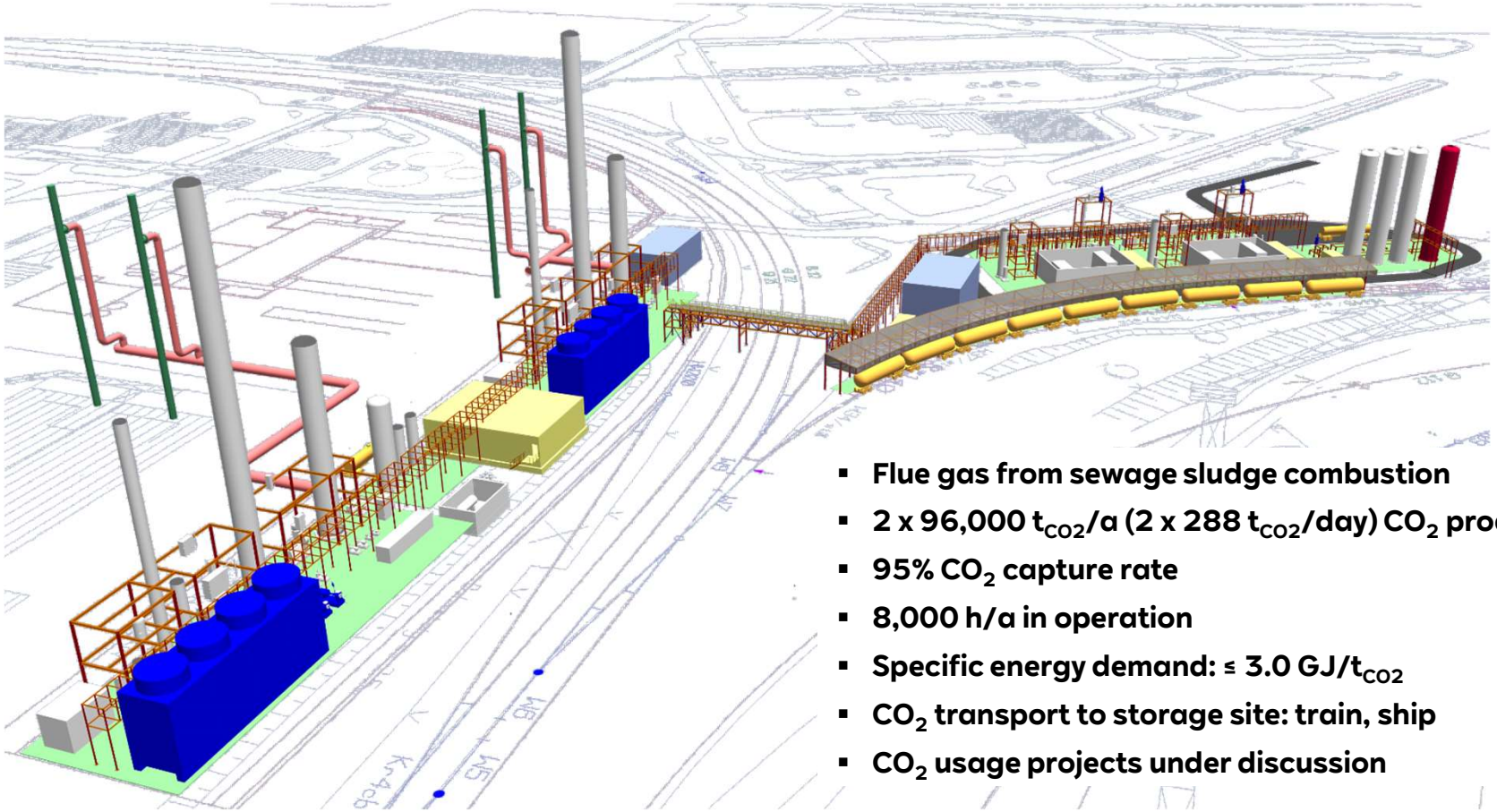
Load changes, Start/Stop behaviour – not only important for capture rate and thermodynamics, but also regarding emissions



Until now, the dynamic behaviour of capture plants cannot be simulated.
But real-world data are available for model validation and for the prognosis of trends.

The Post-Combustion Capture Project at Knapsacker Hügel I

From R&D to use



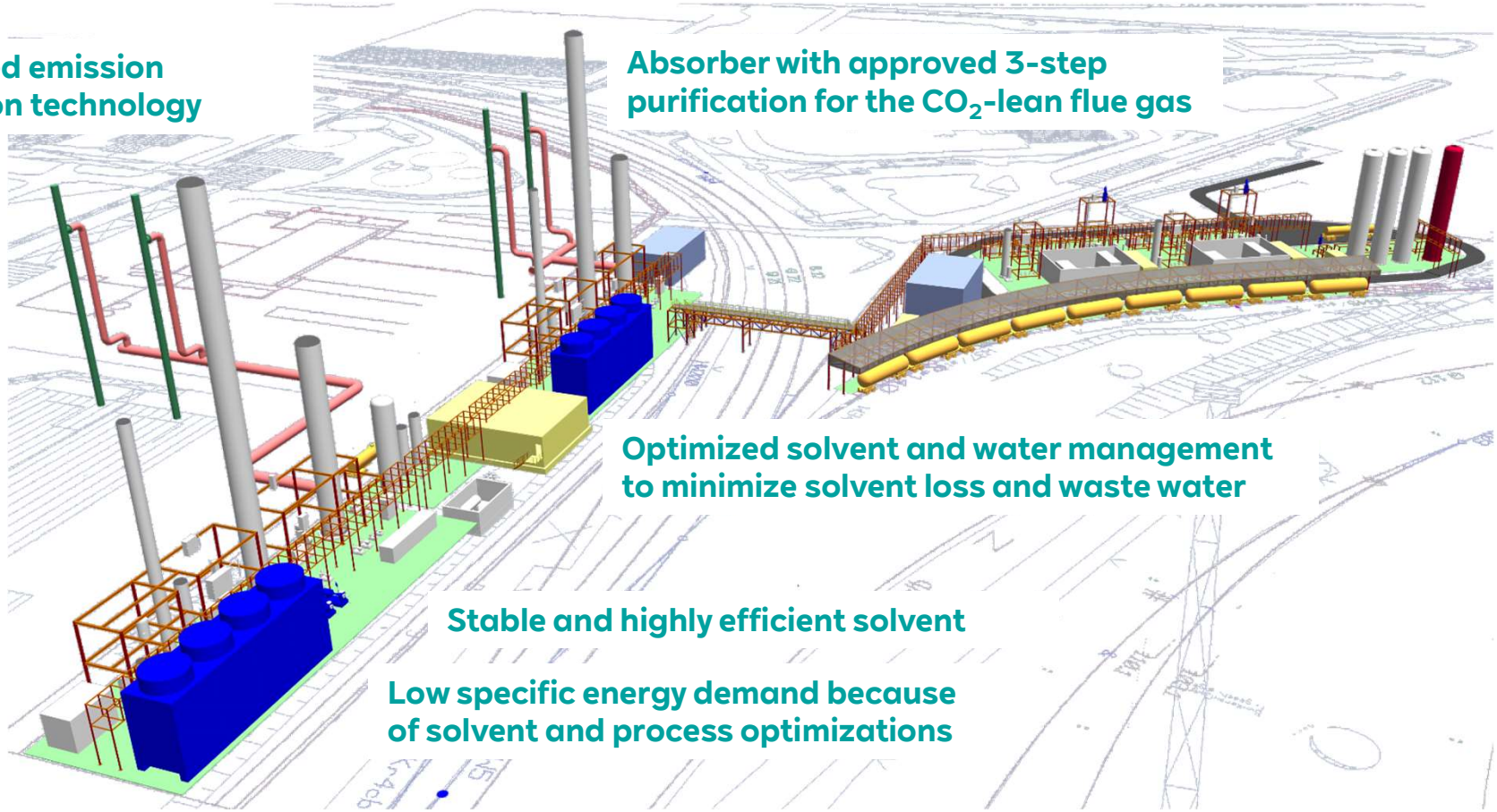
- **Flue gas from sewage sludge combustion**
- **2 x 96,000 t_{CO2}/a (2 x 288 t_{CO2}/day) CO_2 product**
- **95% CO_2 capture rate**
- **8,000 h/a in operation**
- **Specific energy demand: ≤ 3.0 GJ/t_{CO2}**
- **CO_2 transport to storage site: train, ship**
- **CO_2 usage projects under discussion**

The Post-Combustion Capture Project at Knapsacker Hügel II

From R&D to use

Optimized emission mitigation technology

Absorber with approved 3-step purification for the CO_2-lean flue gas



Optimized solvent and water management to minimize solvent loss and waste water

Stable and highly efficient solvent

Low specific energy demand because of solvent and process optimizations

Conclusion

Experience of more than 115,000 operating hours of the CO_2 capture pilot plant at Niederaussem and 20 years of CCUS projects

Project development, Design, Funding, Permitting, Construction, Commissioning

Solvent Management

Process chain, Plant configuration, Integration, Operation, Measurement technologies

Mitigation of Wastes and Emissions, Health & Safety & Environment

De-Risking and Minimisation of CAPEX and OPEX, Use of Synergies

Consultancy and Supporting Work for RWE's BECCUS projects (Technology Provider, Authorities, Networks)

Acknowledgements

ACT SCOPE Project No 327341
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ACT MeDORA
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www.sintef.no/en/projects/2023/medora-membrane-assisted-dissolved-oxygenremoval-from-amine-solution-for-co2-capture/

DRIVE
This Project has been funded by partners of the CETpartnership (https://cetpartnership.eu) and FZJ/PTJ-MWIKE (no EFO-0216), https://DRIVE-co2.eu/

Co-funded by the European Union

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101006799. www.takeoff-project.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No www. eco2fuel-project.eu