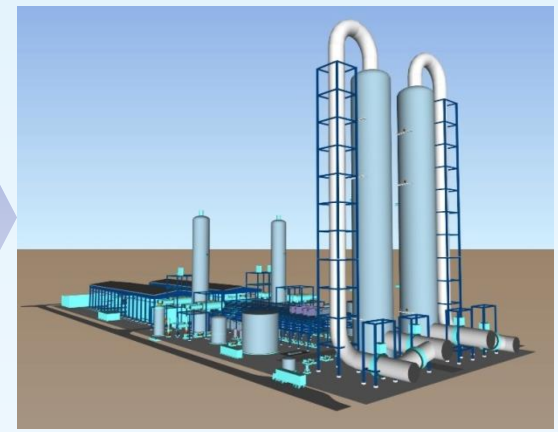
Résumé of the 10-year joint development program of BASF, Linde and RWE Generation at the post-combustion capture pilot plant at Niederaussem –

OASE® blue: 2.5 GJ/t_{CO2}, <300 $g_{solvent}$/t_{CO2}, effective emission control



4^{th} Post Combustion Capture Conference, 7^{th} September 2017, Birmingham, Alabama, USA

The holistic approach of the development program

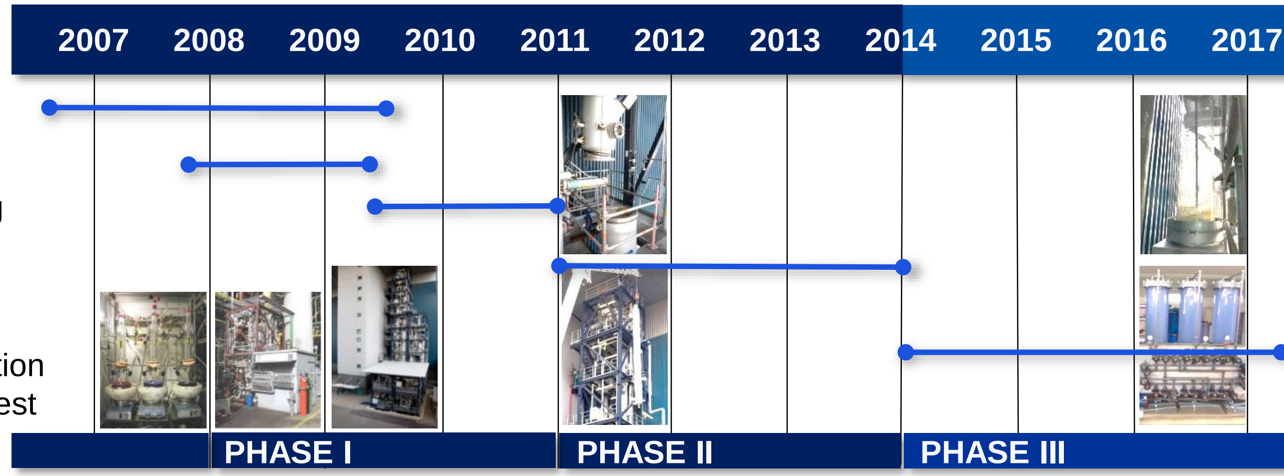
10 years of development

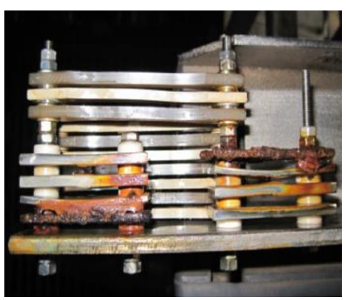
Solvent screening, Mini Plant testing

Construction pilot plant at Niederaussem
MEA benchmark and new solvent testing

OASE® blue long-term testing,
emission reduction

OASE® blue process optimisation, mitigation of aerosol-based emissions, reclaiming test

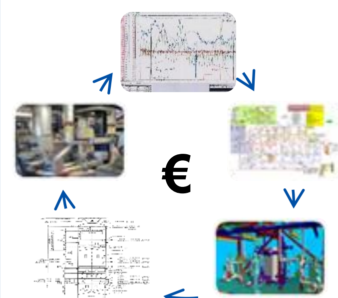




Material testing

Measurement techniques

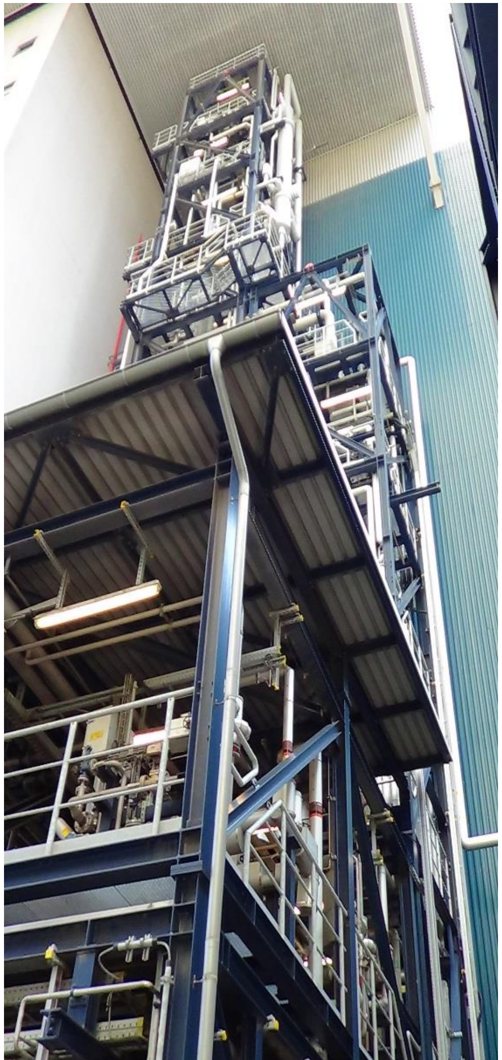
Component testing



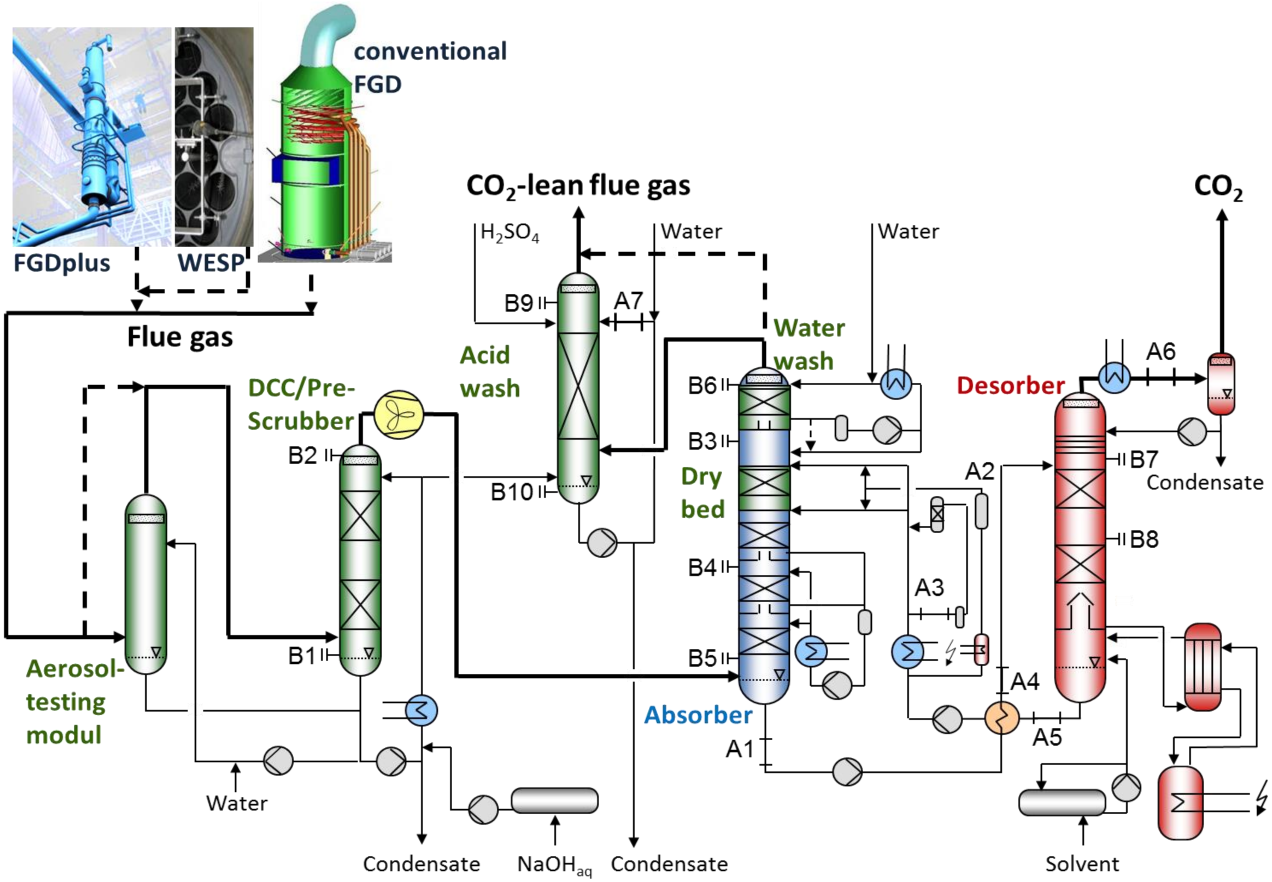
Tech./Econ./Ecol. optimisation

Scale-up

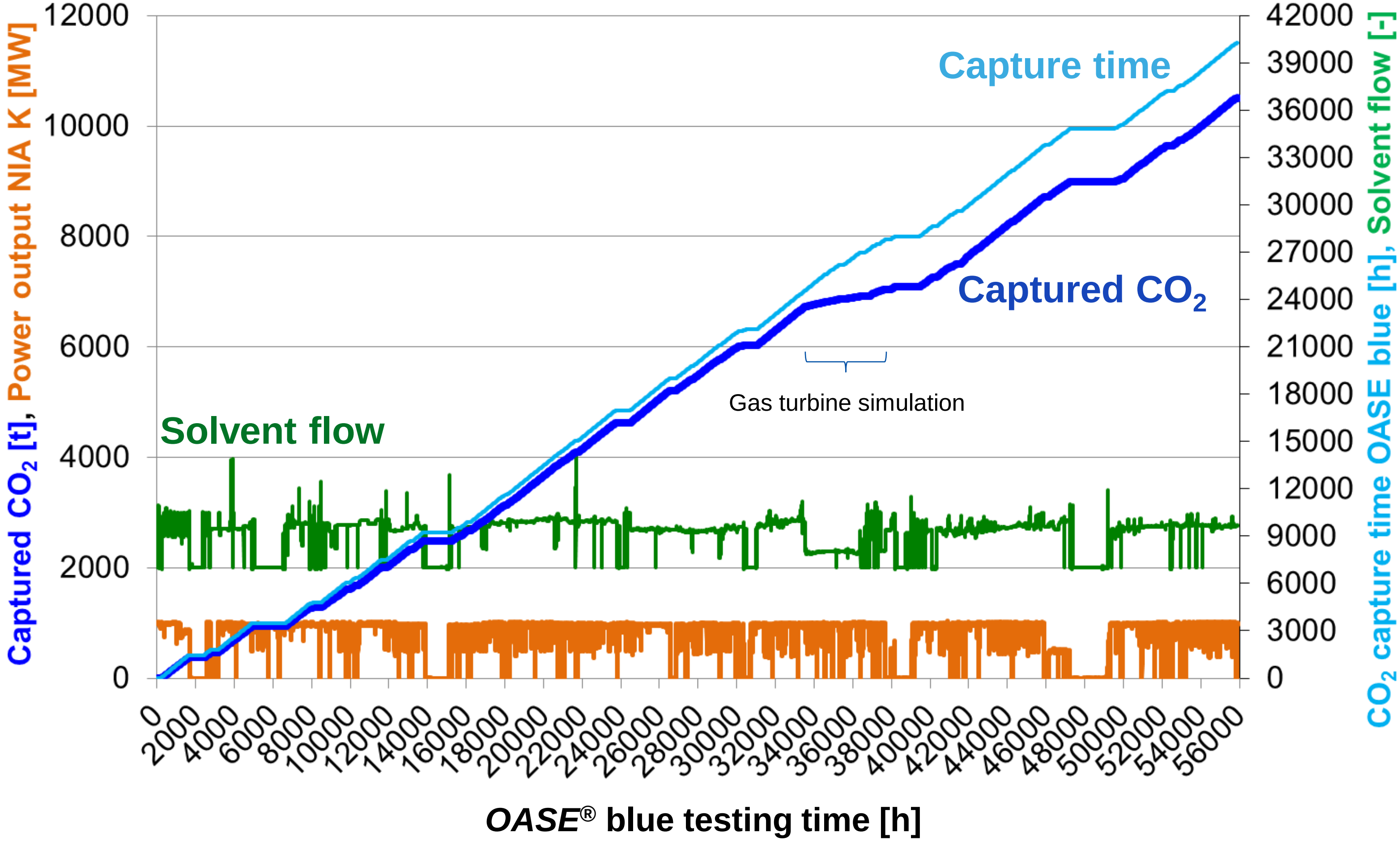
Post-combustion capture pilot plant at Niederaussem



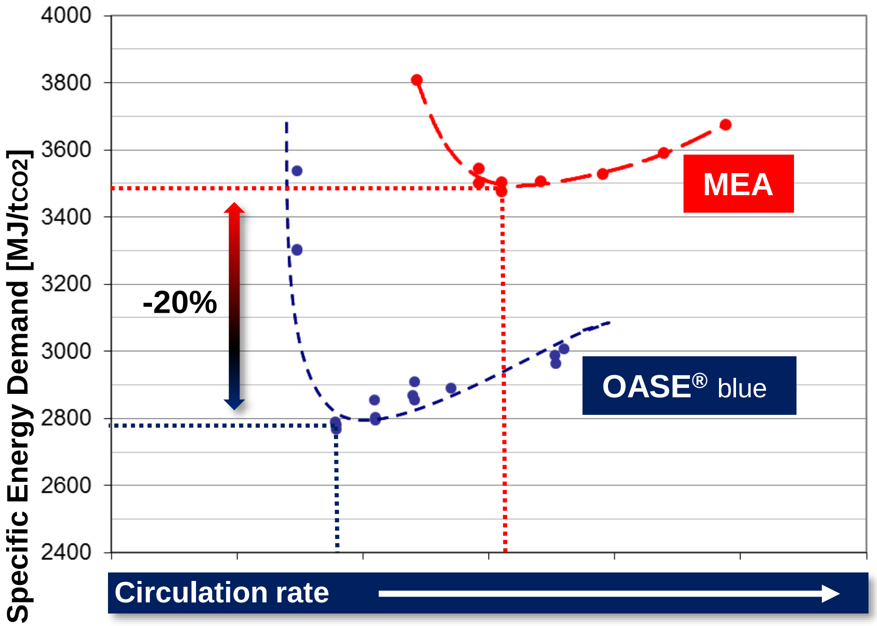
- Flue gas: 1,550 Nm^3/h; CO_2 product: 7.2 t CO_2/day; capture rate 90%
- Commissioning and start-up 2009, availability ~97%
- 285 online measuring points and 18 material testing points



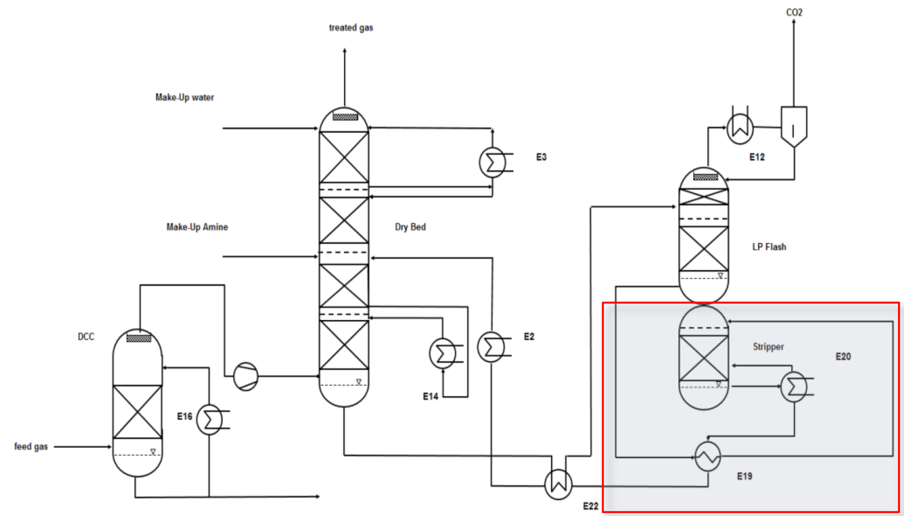
OASE® blue - testing for >55,000 hours under real power plant conditions



OASE® blue - 2.5 GJ/t_{CO2} solvent performance and advanced process concept



Advanced process concept



Basic process design

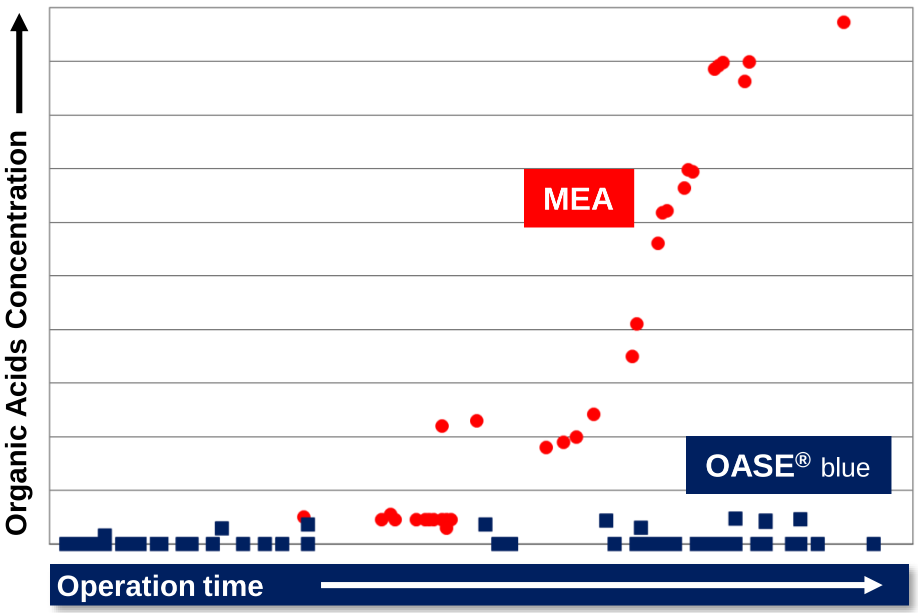
⇨ Reduction in circulation rate and energy (by 20%) (simple configuration): 2.8 GJ/t_{CO2}

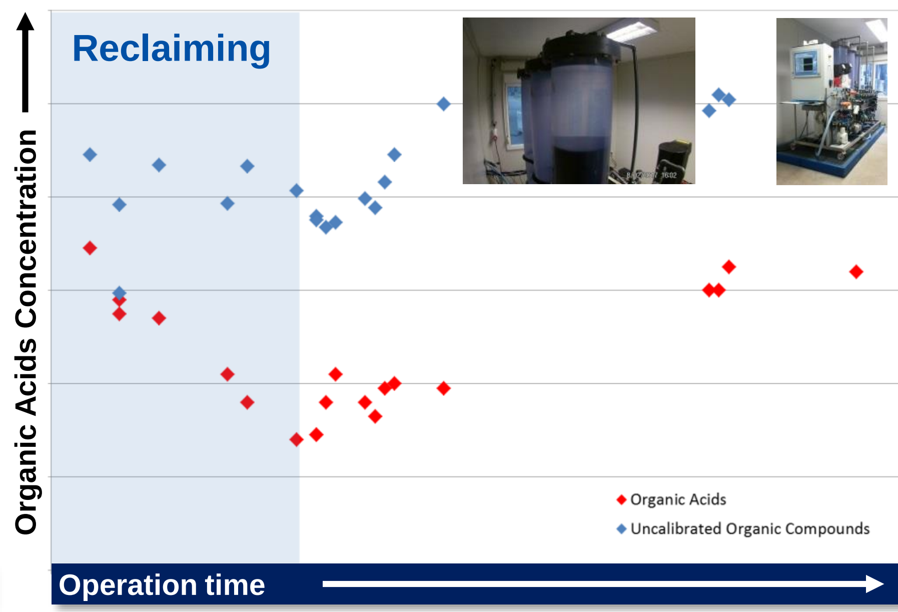
Advanced process concept

⇨ Reduction of specific energy demand by around 0.3 GJ/t_{CO2}: 2.5 GJ/t_{CO2}

⇨ Low additional CAPEX

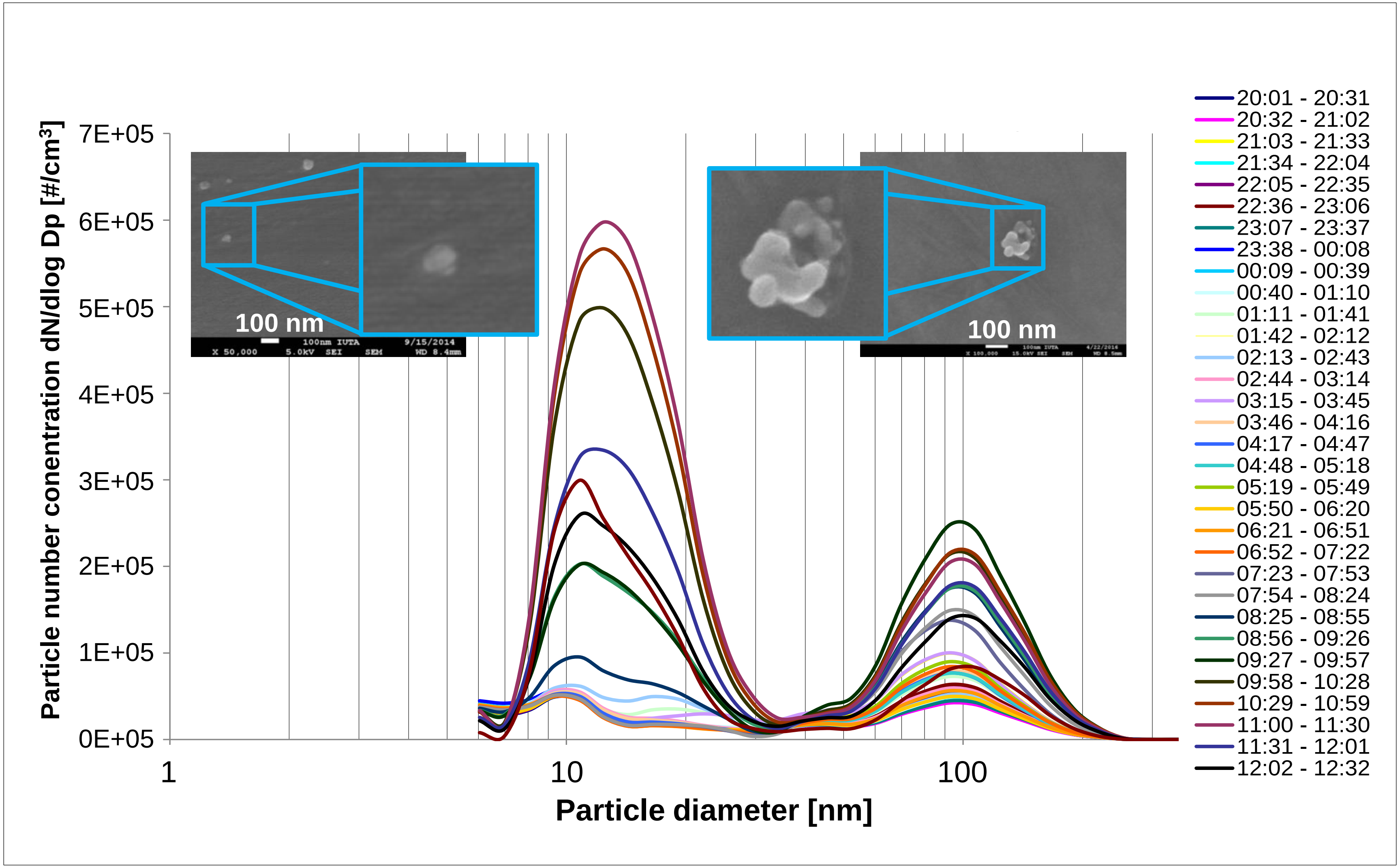
OASE® blue - < 300 g/t_{CO2} solvent consumption and high degradation stability





- ⇨ Low solvent losses and degradation
- ⇨ Reclaiming: The ion exchanger is effectively removing heat stable salts

Aerosol formation – bimodal particle size distribution of solid aerosol nuclei

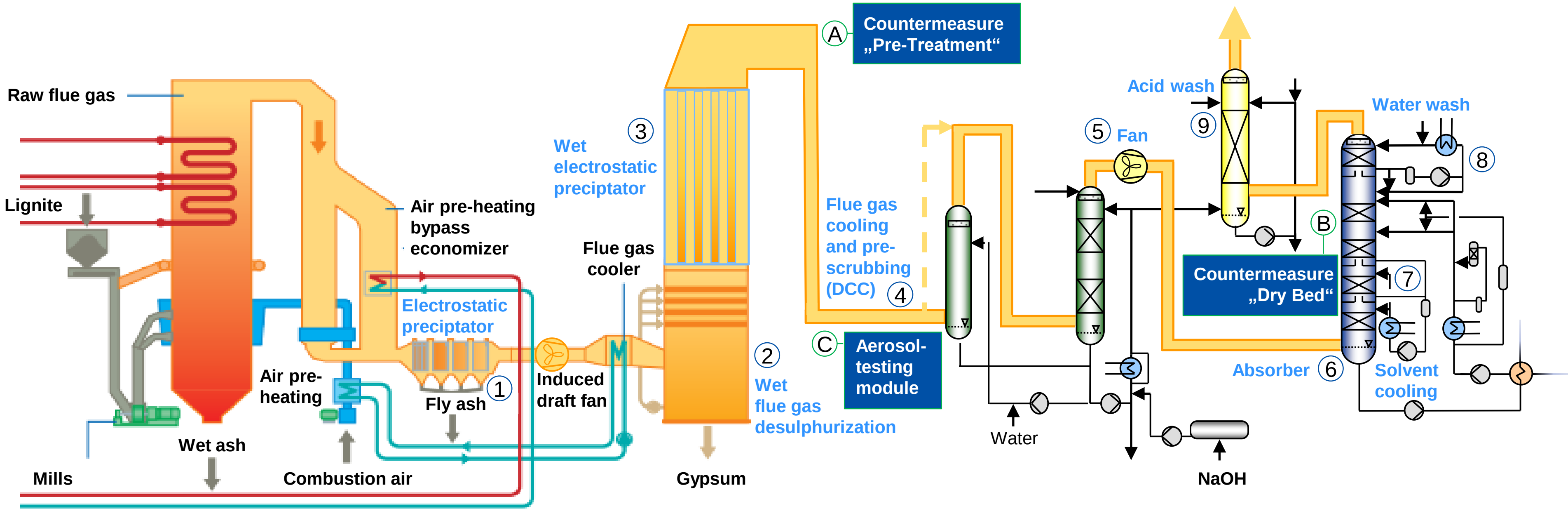


Investigation of aerosol formation and development of effective countermeasures

RWE

BASF We create chemistry

THE LINDE GROUP Linde



1 - particulate removal
-SO_3 formation
ESP

3 - particulate removal
- aerosol formation
- SO_3 formation
WESP

5 - heating
- H_2O undersaturation
Fan

7 - cooling
Interstage cooler and solvent feed-in

9 - caustic compounds removal
Acid wash

2 - cooling/H_2O saturation
- SO_2/SO_3 removal
- particulate removal
FGD

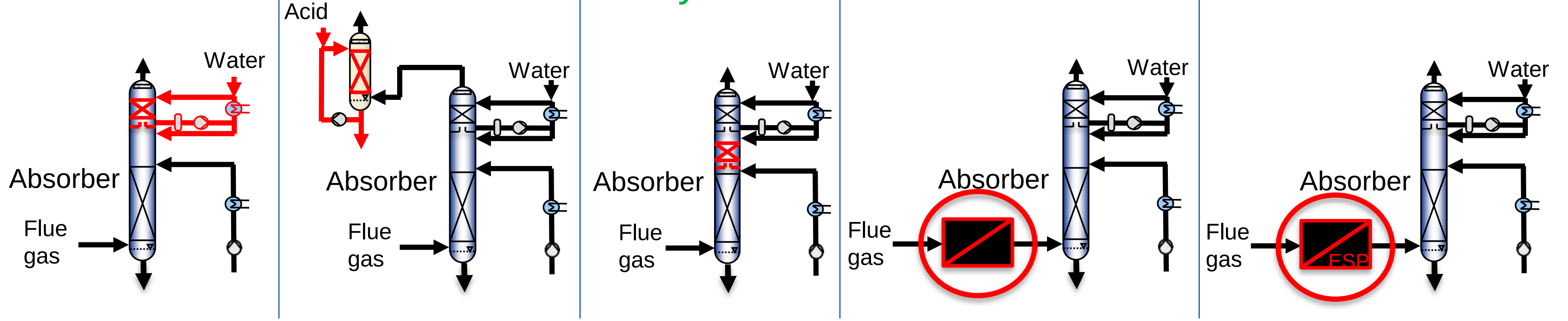
4 - cooling
- SO_2/SO_3 removal
DCC

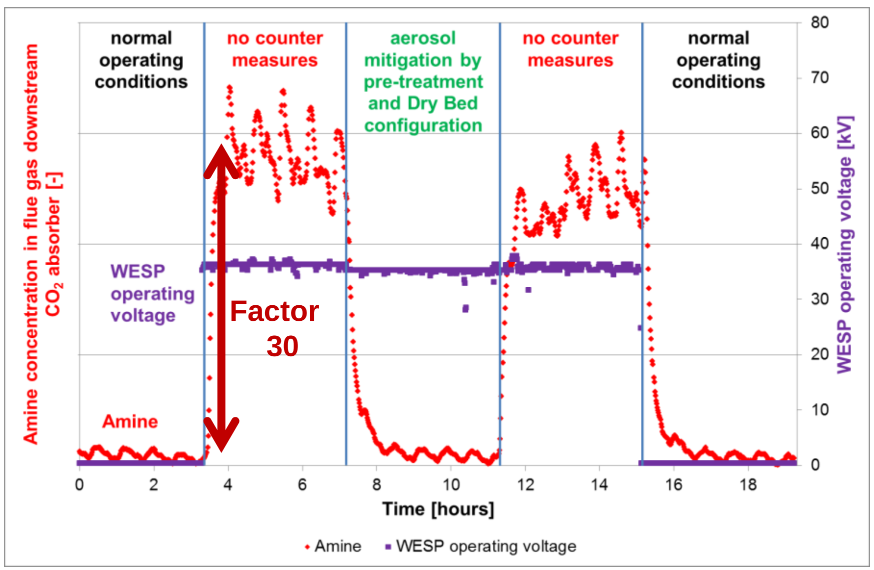
6 - heating/cooling
- organic compounds
Absorber

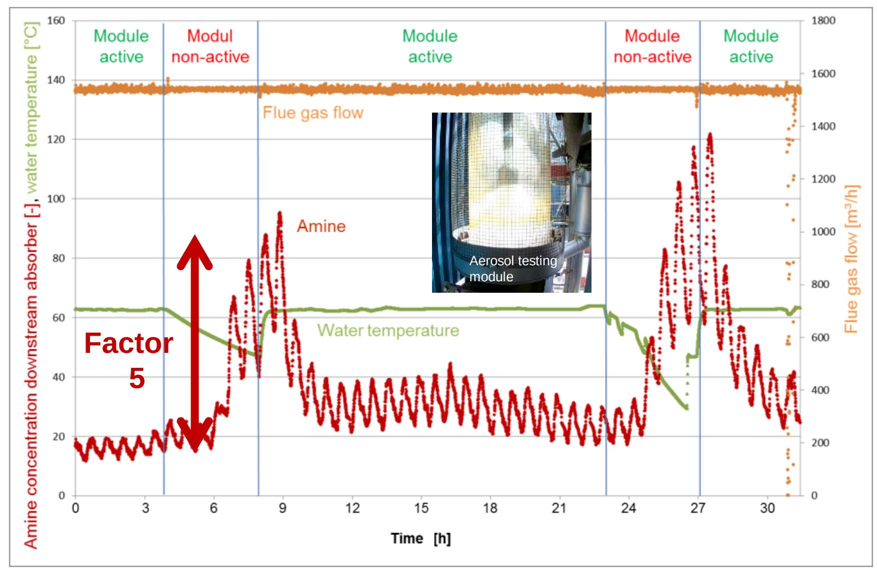
8 - cooling and organic compounds removal
Water wash

Optimal emission reduction measures: "Pre-treatment" and "Dry Bed"

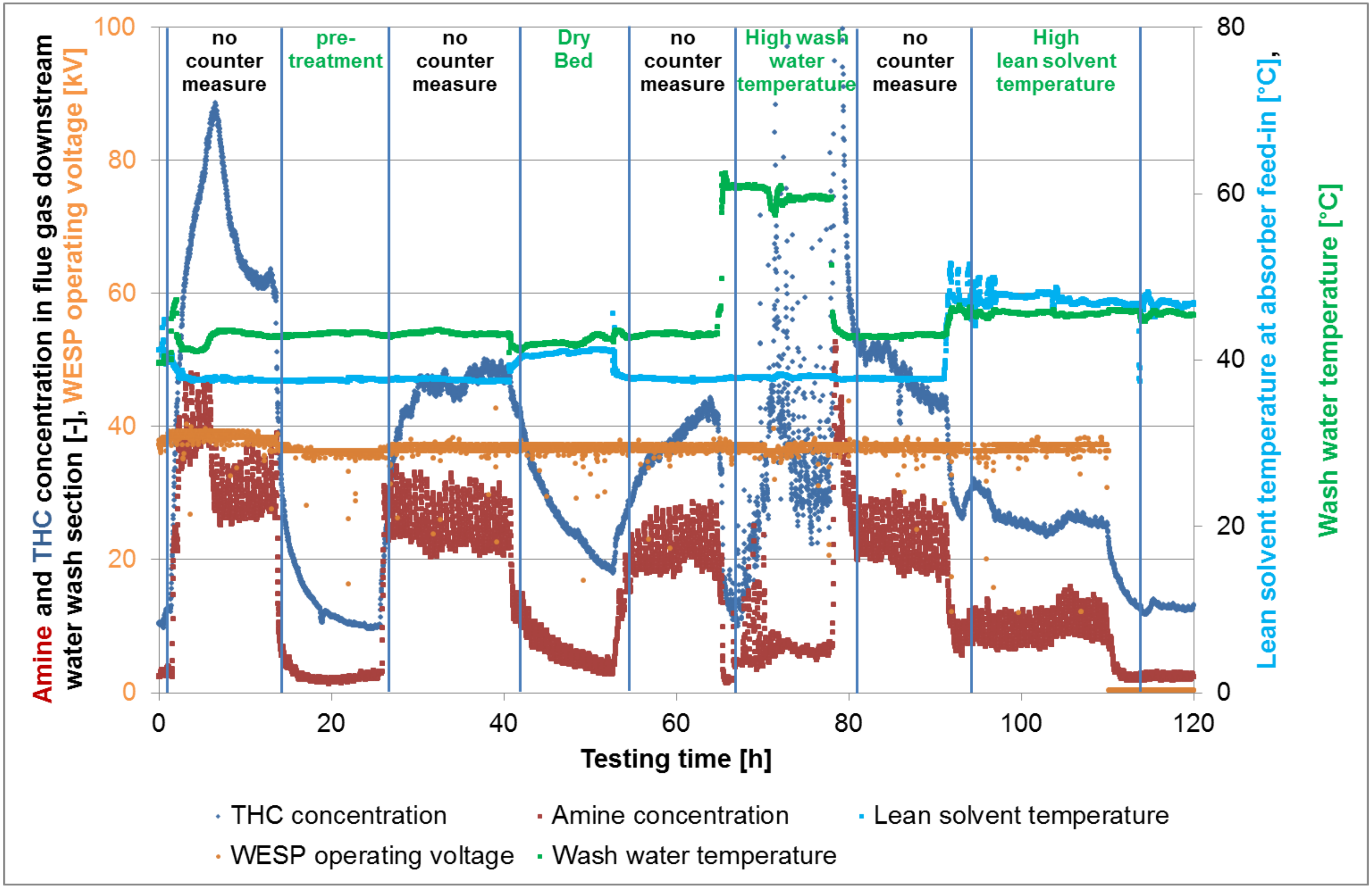
Water wash | Acid wash | Dry bed | Pre-treatment | WESP







Optimal emission reduction measures: “Pre-treatment” and “Dry Bed”



Improved packing for scale-up

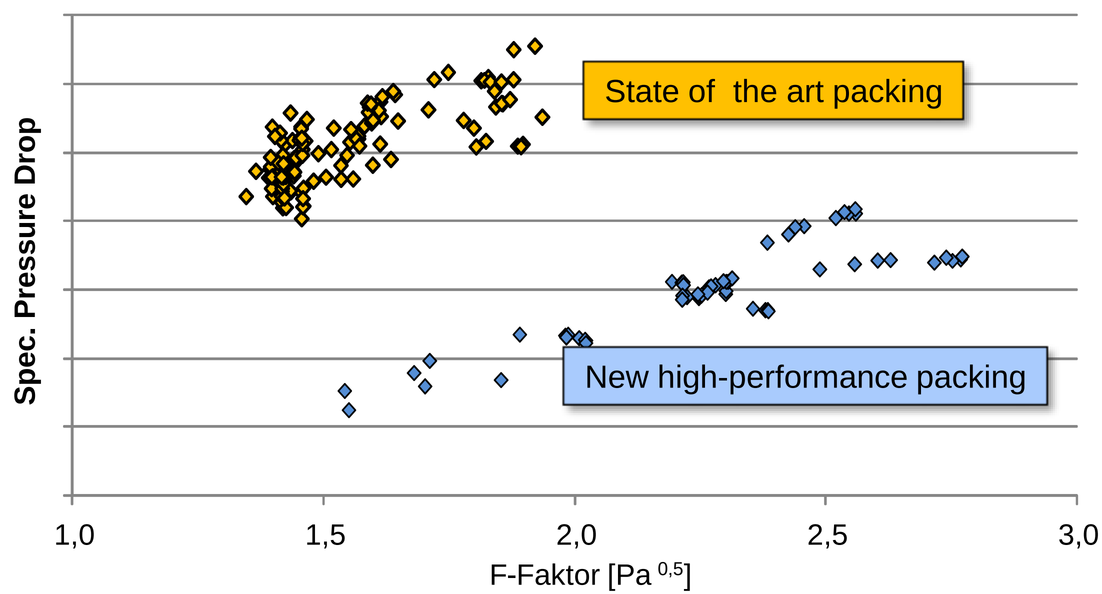
Implementation of new high performance packing

Reduction in:

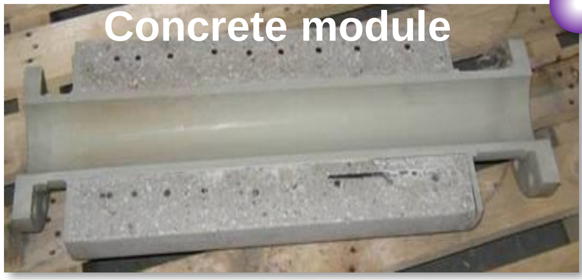
- ➔ Pressure drop by up to 50%
- ➔ Absorber diameter up to 14%

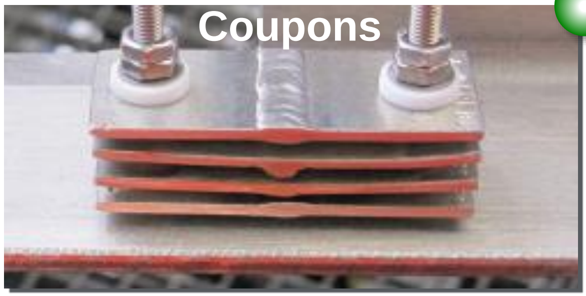
1,100 MW_{el} Plant:

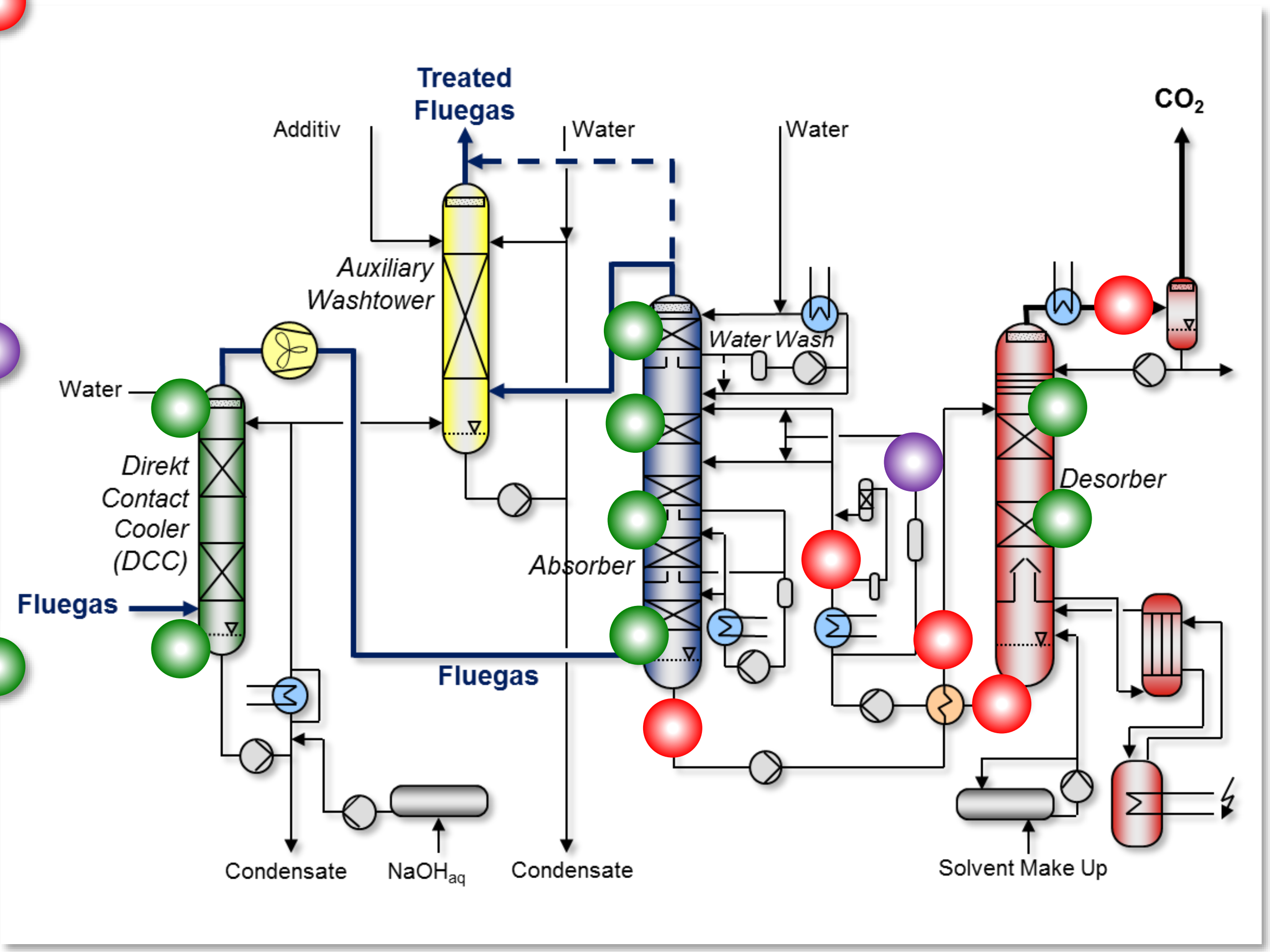
Up to 2 m reduction in diameter



Equipment specific material selection







Scale-up risks handled

Solvent specific's tested

- performance (specific energy consumption, recovery rate, loading, circulation rate) √
- impact from real flue gas (foaming, impurities) √
- degradation, O_2 stability, emissions → solvent losses √
- long term behavior/stability √

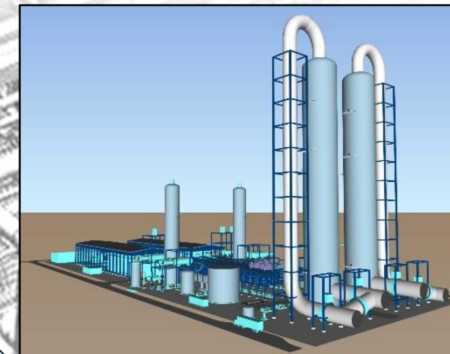
Equipment specific's tested

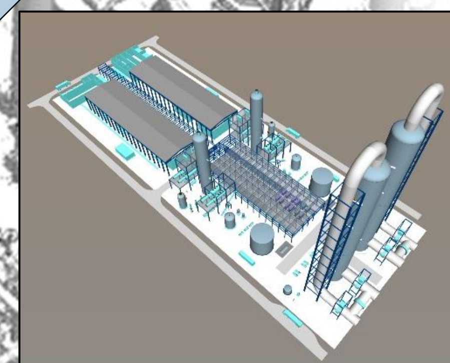
- packings (height, pressure drop) √
- emission control system (design, performance optimization) √
- heat exchanger type and performance √
- materials of construction (equipment, piping, seals, gaskets) √

Design verification finalized

- verification of process simulation tools √
- consideration of design ranges based on test results √
- Design tools for scale-up developed √

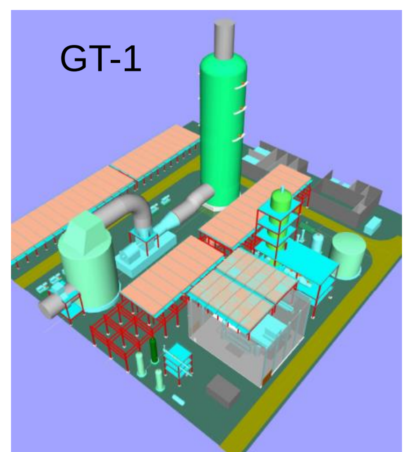
Low scale-up risk





Commercial designs are developed

- Customized designs for different applications are developed
  - Feed gas sources from coal and gas fired power plants and from steam reformer
  - Absorber design depending on flue gas flow (2 parallel trains if required)
  - Material concept depending on flue gas source
  - Designs available for water cooling or air cooling application



Summary and conclusions

- BASF, RWE and Linde have jointly developed an energy efficient process for PCC from coal fired power plants.
- An outstanding test period of >55.000 hours was reached for OASE® blue solvent.
- Process and solvent are applicable for a wide range of different flue gas sources.
- Emission control for environment protection and low amine losses.
- New approaches for installations with substantial Capex reduction tested.

→ PCC process is commercial available

- for delivery of large amounts of CO_2 for EOR and storage (> 1000 MTD)
- as CO_2 source for chemical use in small and midsize scale (200 – 2000 MTD)
- as CO_2 source for CO_2 food grade in smaller scale (< 500 MTD)

Acknowledgements

Authors

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BASF: Gerald Vorberg and Gustavo Lozano

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