Reducing Carbon Emissions in Gas Turbines using BASF OASE® Blue Technology

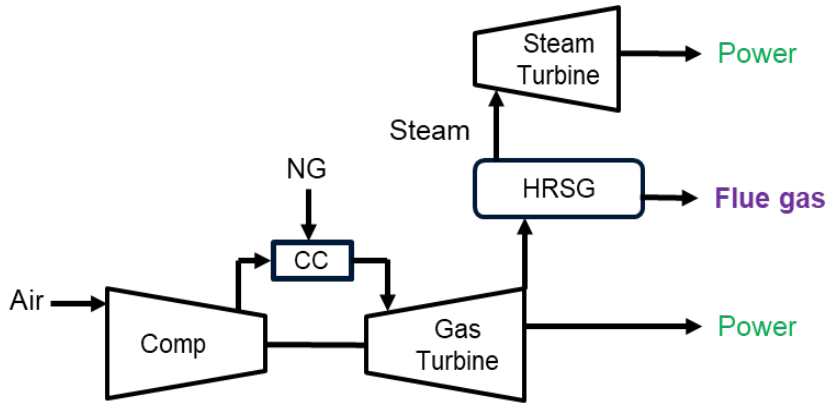
ETN Global - Webinar

June 2024

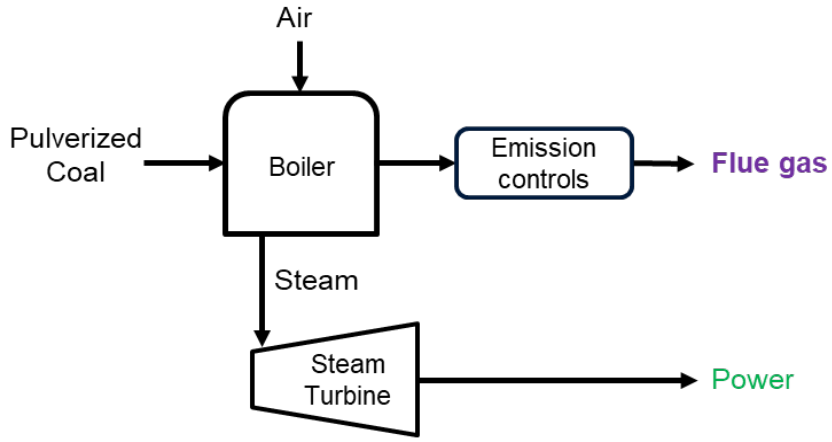
BASF
We create chemistry

Carbon Emission in Gas Turbines

- Power generation → biggest contributor of CO_2
  - Coal and natural gas based
- Increasing investment in LNG projects → drive to produce carbon neutral LNG
- Shift to low carbon power generation → integration of CCS is critical
- Solvent based CO_2 capture is the most proven technology for CCS



Natural Gas Combined Cycle (NGCC) Plant



Coal-based Power Plant

OASE® technologies

have been capturing carbon amongst other things since **1971**

white	Ammonia, Syngas
yellow	Sulfur Selective
sulfexx™	Super Selective
purple	Natural Gas, LNG
blue	Flue Gas
green	Biogas

HiPACT
Joint-development with JGC

FLEXSORB™
Strategic alliance with ExxonMobil

BASF
We create chemistry

OASE blue ® Technology

- Solvent-based CO_2 capture technology
  - package of technology, solvent and services
  - Low regeneration energy & solvent make up

- Knowhow derived from +500 reference plants using OASE® technologies

- CO_2 capture from various flue gas applications:
  - Fossil fuel power generation
  - Cement / steel plant
  - SMR H_2 plant
  - Boilers

Key Needs for Post-combustion CO_2 Capture

Industry needs

- **Proven technology**
- **High capture rates**
- **Low energy & amine consumption**
- **Low environmental impact**
- **Digitalization & operator friendliness**
- **Wide applicability**
- **Scaling & modularization**
- **Secure solvent supply**

BASF OASE® blue technology offering

⇨ Commercial references + over 65,000 hours of testing

⇨ CO_2 Removal Rate (**up to 99%)**

⇨ **2.5 - 3.0 GJ/to$_{CO2}$** / with solvent make up rate of**~0.3 – 0.6 kg$_{amine}$/to$_{CO2}$**

⇨ **OASE® aerozone** (Patented aerosol / emissions reduction zone)

⇨ Proven reclaimer concept

⇨ Nitrosamines management

⇨ **OASE® connect** (Design Software / Operators Training / Analytical DB)

⇨ **OASE® digilab** (Analyzer combined with OASE® connect)

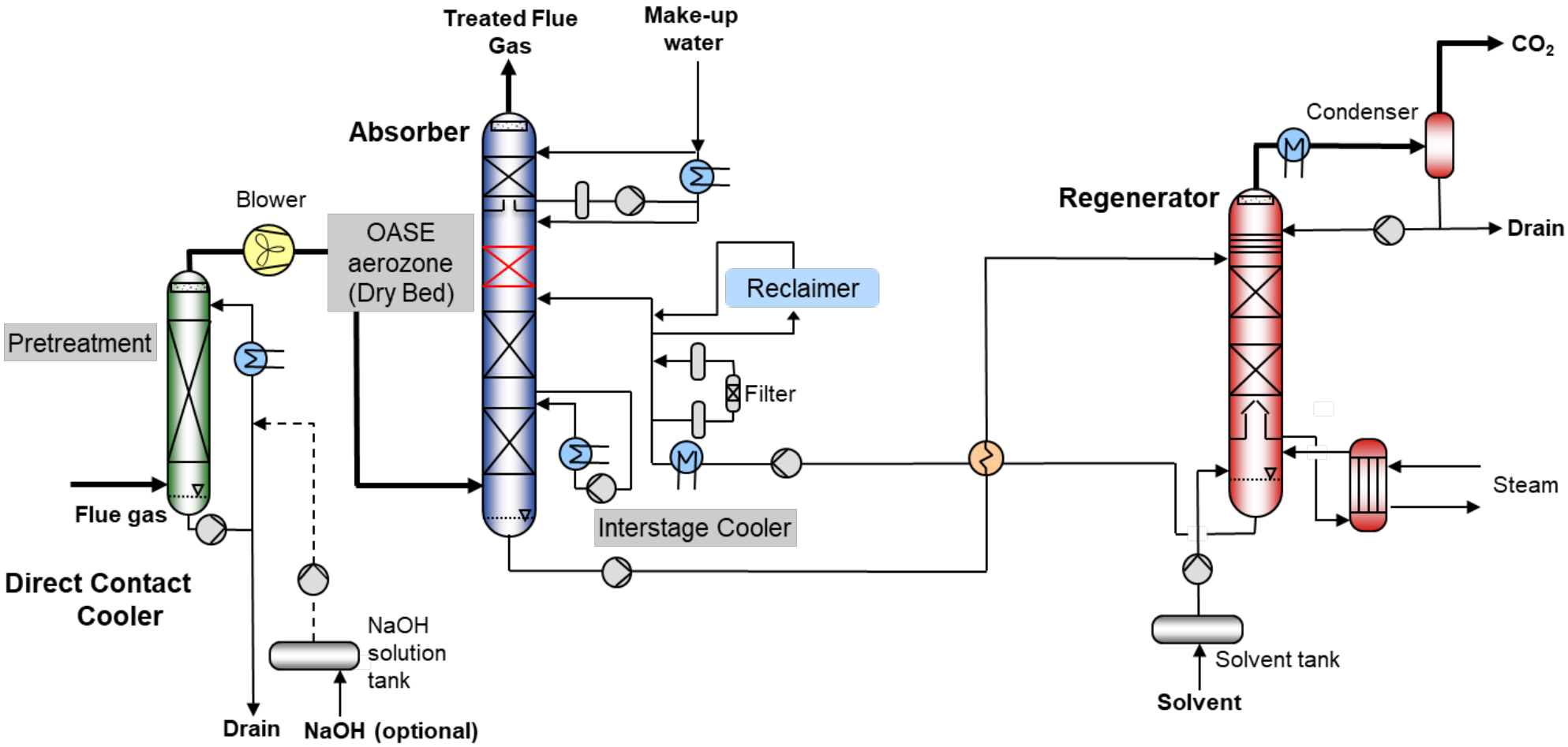
⇨ Tested range O_2 (4 – 16 v%) / CO_2 (4 – 25 v%) / CO_2

⇨ Easily scaled & modularized

⇨ Large scale solvent production

BASF
We create chemistry

OASE® blue Flow Scheme



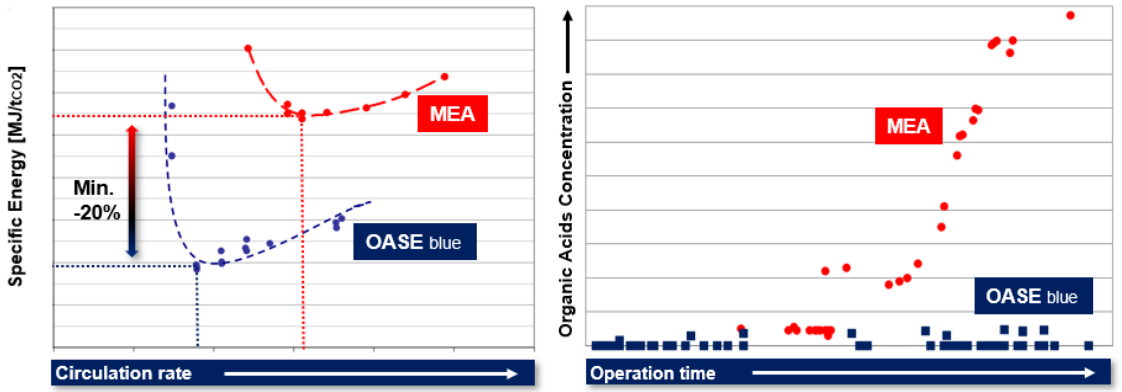
BASF
We create chemistry

Challenges : Flue Gas Composition

- Low CO_2 / O_2 ratio
  - Lower CO_2 kinetics
  - Higher degradation rate
    - Oxidative versus thermal degradation
    - OPEX consideration

- OASE blue versus MEA
  - Minimum 20% saving in regeneration energy
  - > 70% make up rate saving

Flue Gas	NGCC	Coal based power
Source	Natural gas	Pulverised coal
CO_2 (mol%)	3 - 6	12 - 15
O_2 (mol%)	10 – 16	3 - 8
Major impurities	NO_x	NO_x / Sulfur / Acidic Components / Metals
Dust /Aerosols	No / moderate	Yes

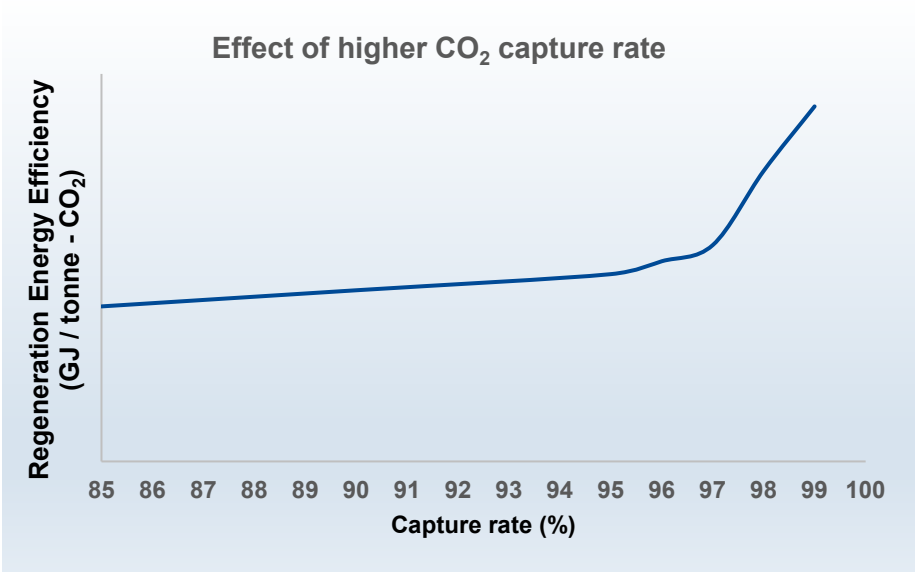


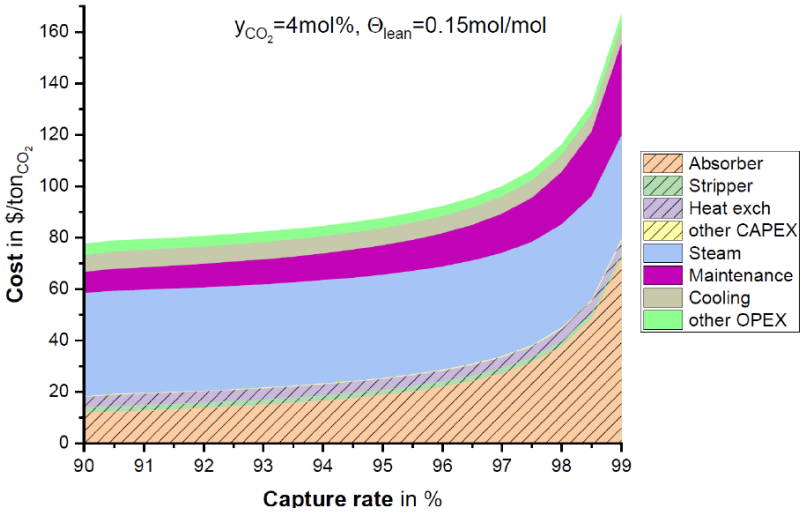
Regeneration energy & make up rate comparison

BASF
We create chemistry

Challenges : Capture Rate Efficiency

- Shifting capture rate benchmark to > 90%
- Major impacts to solvent-based CO_2 capture unit
  - Higher reboiler duty & cooling load
  - Higher solvent circulation flowrate
  - Bigger absorber diameter





- Theoretical study based on 30 wt% MEA
  - 90 – 98% capture → utility cost (OPEX)
  - Above 98% capture → absorber diameter (CAPEX)

Brandl, P., Bui, M., Hallett, J. P. & Mac Dowell, N. (2021). Beyond 90% capture: Possible, but at what cost? International Journal of Greenhouse Gas Control,105,103239.

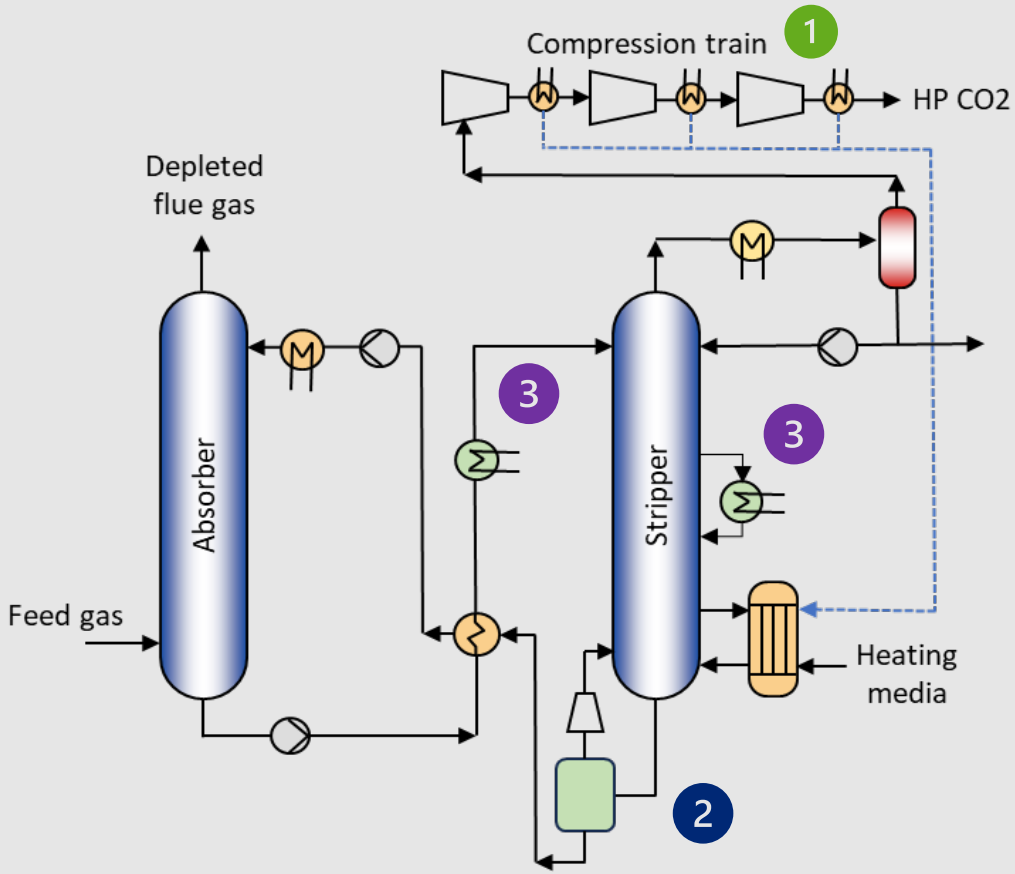
BASF
We create chemistry

Energy Reduction Potential

1 Compression train heat recovery

2 Lean vapor compression

3 Waste heat integration

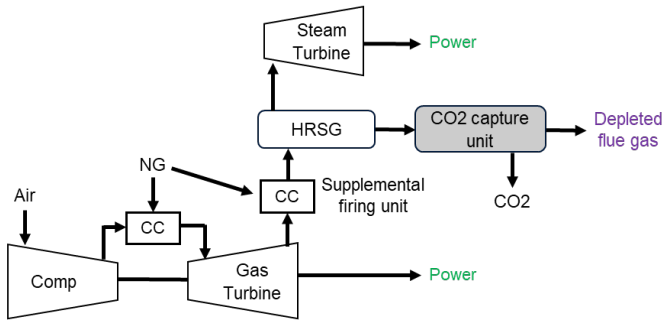


- Regeneration efficiency saving between 0.2 – 0.5 GJ / tonne - CO_2
- Saving of 0.1 GJ / tonne of CO_2 in 1100 MWel plant
  - ~ 37 tonnes of LP steam / hour
  - ~ 0.5 % of electrical power plant output

BASF
We create chemistry

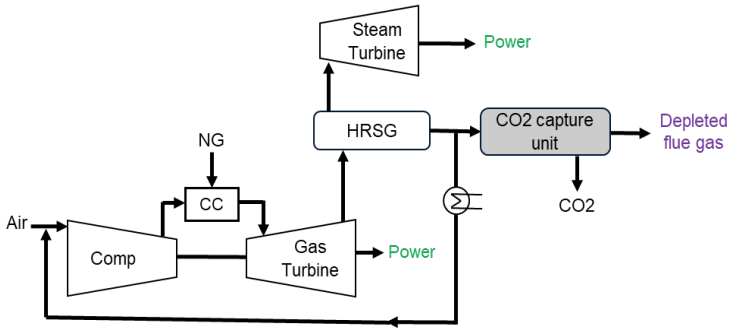
How to Increase CO_2 in Flue Gas?

Supplemental firing



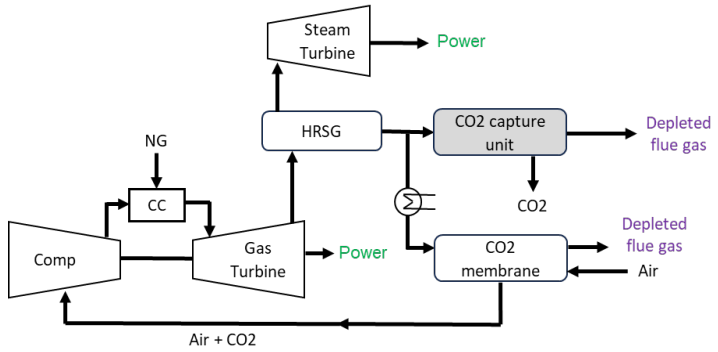
- Combustion of additional fuel at outlet of GT
- Reduces O_2 and increases CO_2 to 10 mol%
- **Challenge**: Higher T at inlet of HRSG affects material selection

Exhaust gas recirculation (EGR)



- Recycle portion of flue gas to compressor inlet
- Reduces O_2 and increases CO_2 to 6.5 mol%, limited by 40% EGR ratio
- **Challenge**: flame stability in combustor

Selective EGR with CO2 membrane



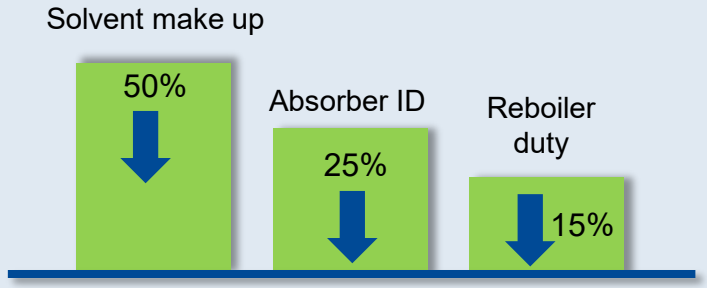
- Install CO_2 membrane to further concentrate CO_2. Combustion air not diluted with N_2
- Increases CO_2 to 14-18 mol% & maintain 16 mol% O2 at inlet combustor
- **Challenge**: increasing operational complexity, reducing flexibility

1500 TPD CO_2 capture plant

OASE blue technology

Increases CO_2 from **4 to 8 mol%**

Decreases O_2 from **13 to 7 mol%**



BASF
We create chemistry

Key Takeways

Challenges

- Low CO_2/O_2 ratio in CCGT
- Higher solvent degradation rate → OPEX
- Higher CO_2 capture rate requirement

OASE® GAS TREATING EXCELLENCE

High Performance

- Significant energy saving over MEA solvent
- CO_2 capture rate up to 99% with CO_2 product purity exceeds 99%

Optimization

- Various energy reduction options within CCS flowsheet
- Allows significant savings on CAPEX and OPEX to enable CCS implementation

BASF
We create chemistry

We create chemistry

BASF
We create chemistry