Design Simplification – A Feasible Option for IGCC Plants with Carbon Capture?

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Agenda: IGCC Power Plants Concepts with Carbon Capture

- Partnership in IGCC concept development
- IGCC with various carbon capture ratios
- Economical sensitivity analysis
- Effects of concept simplification

Partnership in IGCC Concept Development

E.ON Energie AG

→ Significant share of hard coal fired power plants in E.ON's fleet

→ Commitment for reducing CO_2 footprint by 50 %
(2030 compared to 1990)

Technische Universität Bergakademie Freiberg

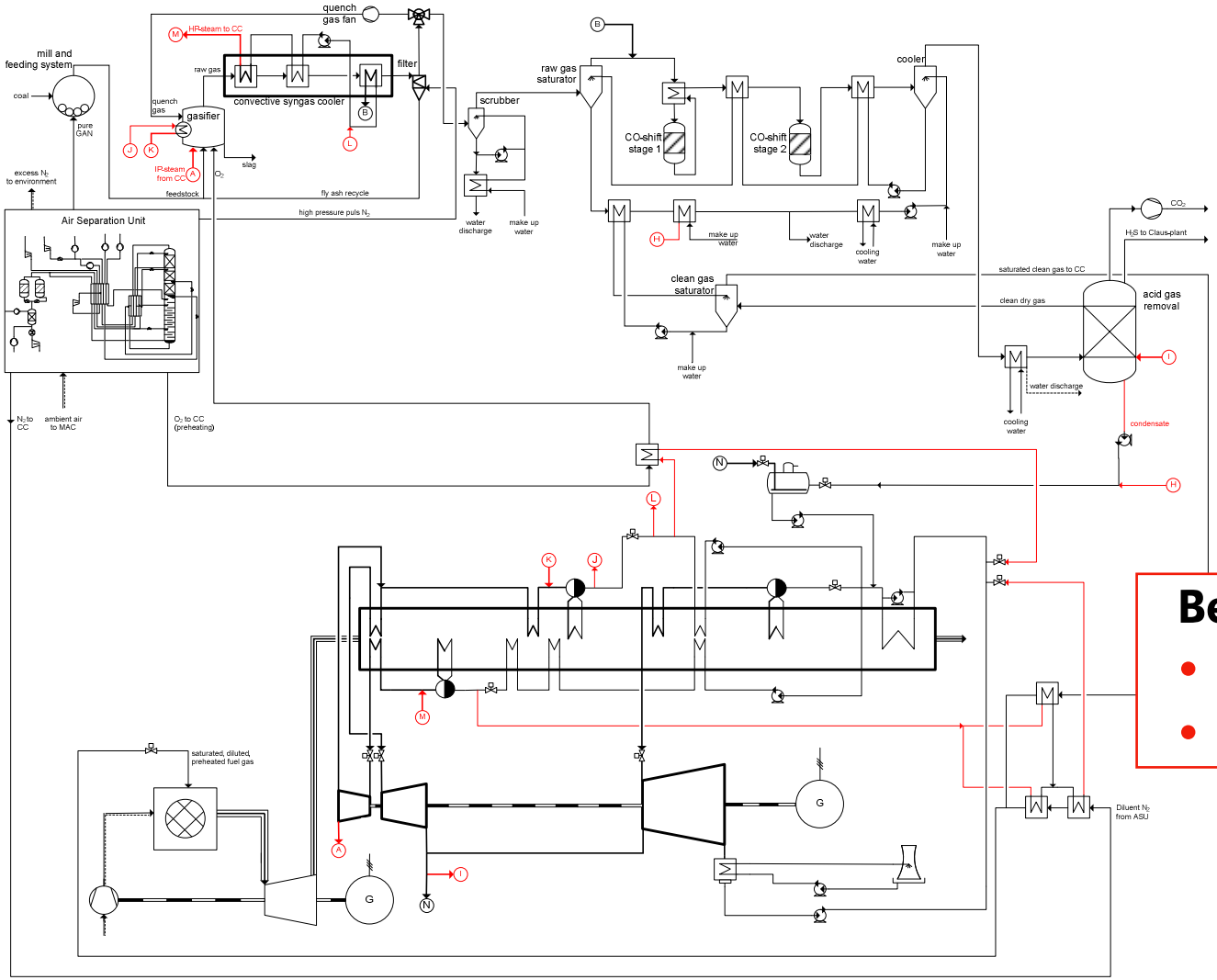
Department for Energy Process Engineering and Chemical Engineering

→ Expertise in the fields of gasifier modelling and IGCC cycle design

Aims:

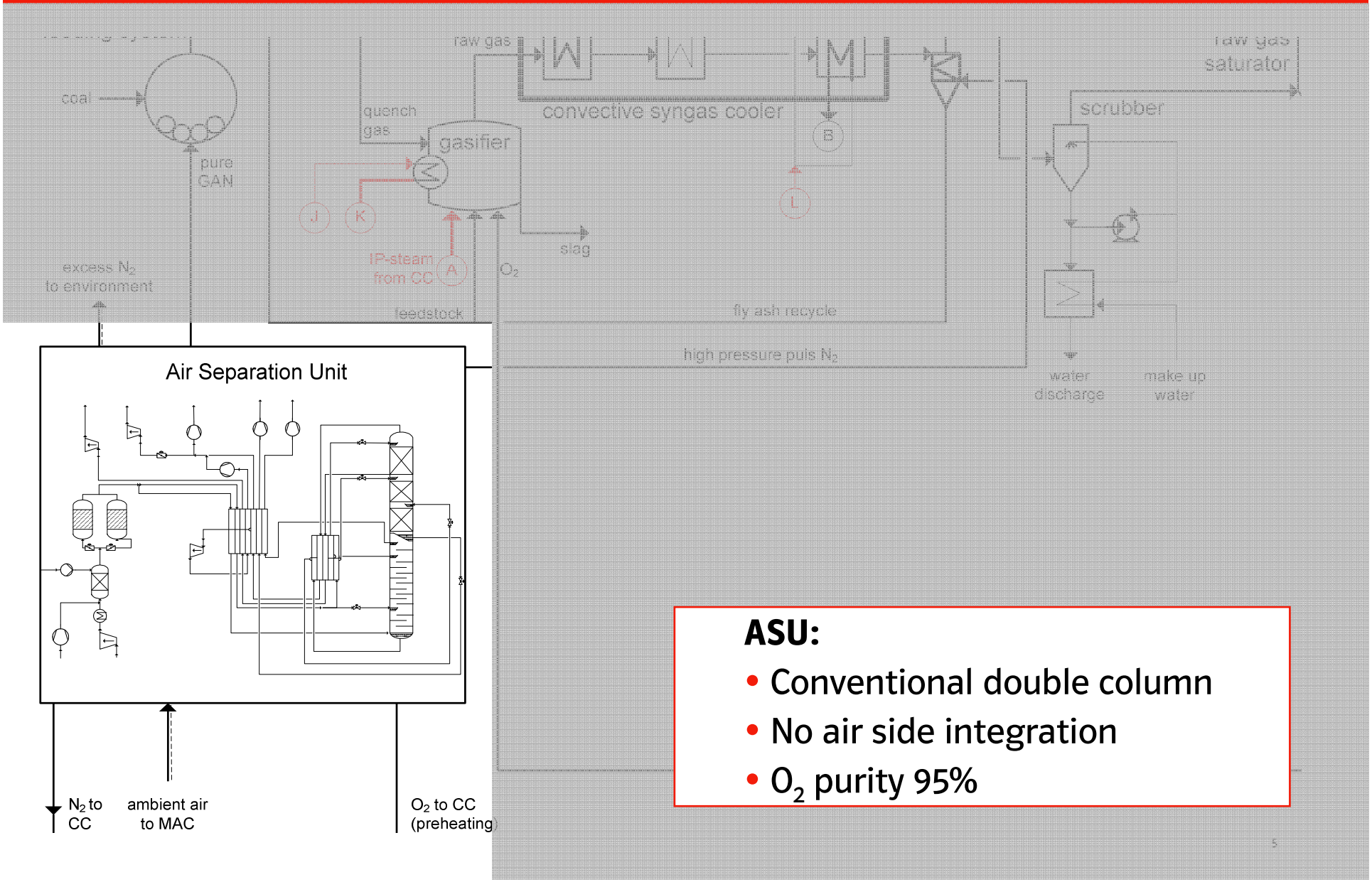
- Performing benchmarking study on adapted IGCC concepts
- Modelling of several Carbon Capture options
- Estimating plant economics
- Developing disintegrated IGCC concepts

IGCC with Carbon Capture: E.ON Base Case Configuration



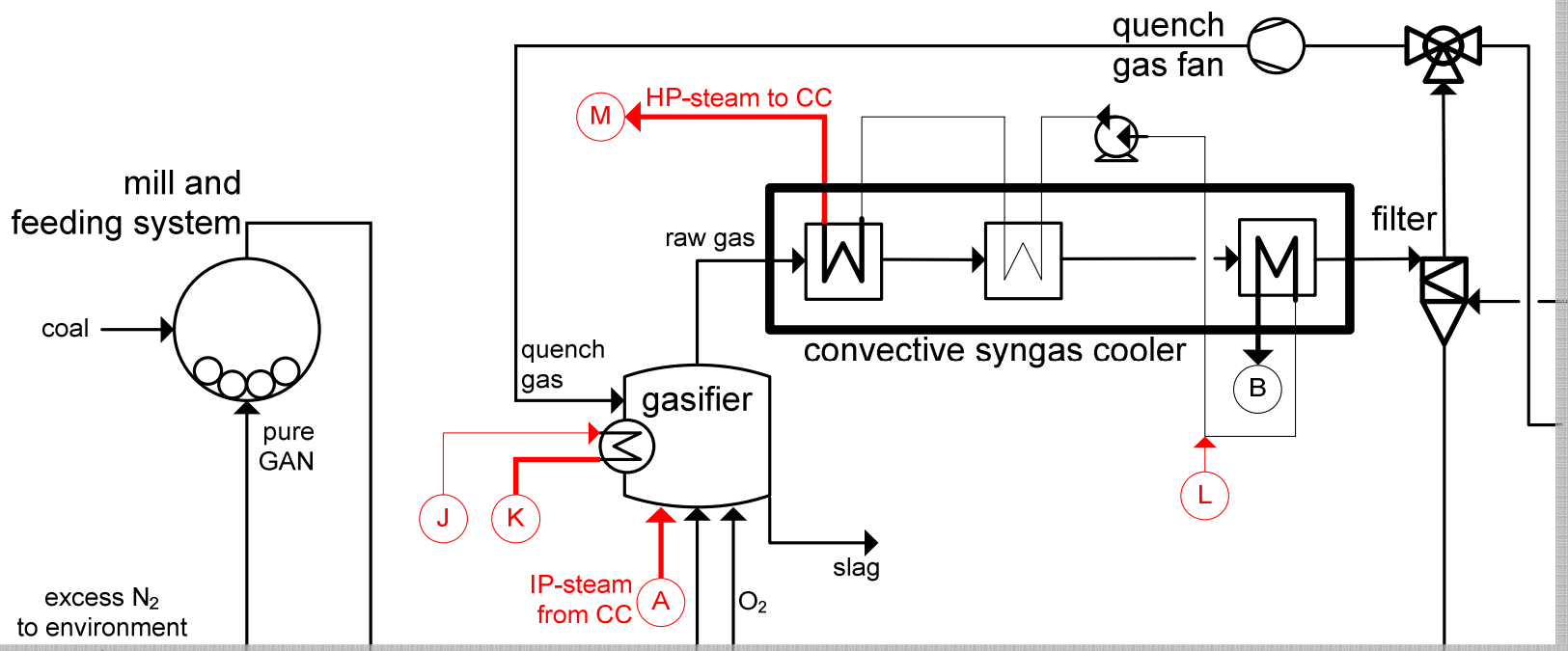
Benchmark: Syngas

- Saturated and diluted
- $H_{u(LHV)}$ = 17 MJ/kg



ASU:

- Conventional double column
- No air side integration
- O_2 purity 95%

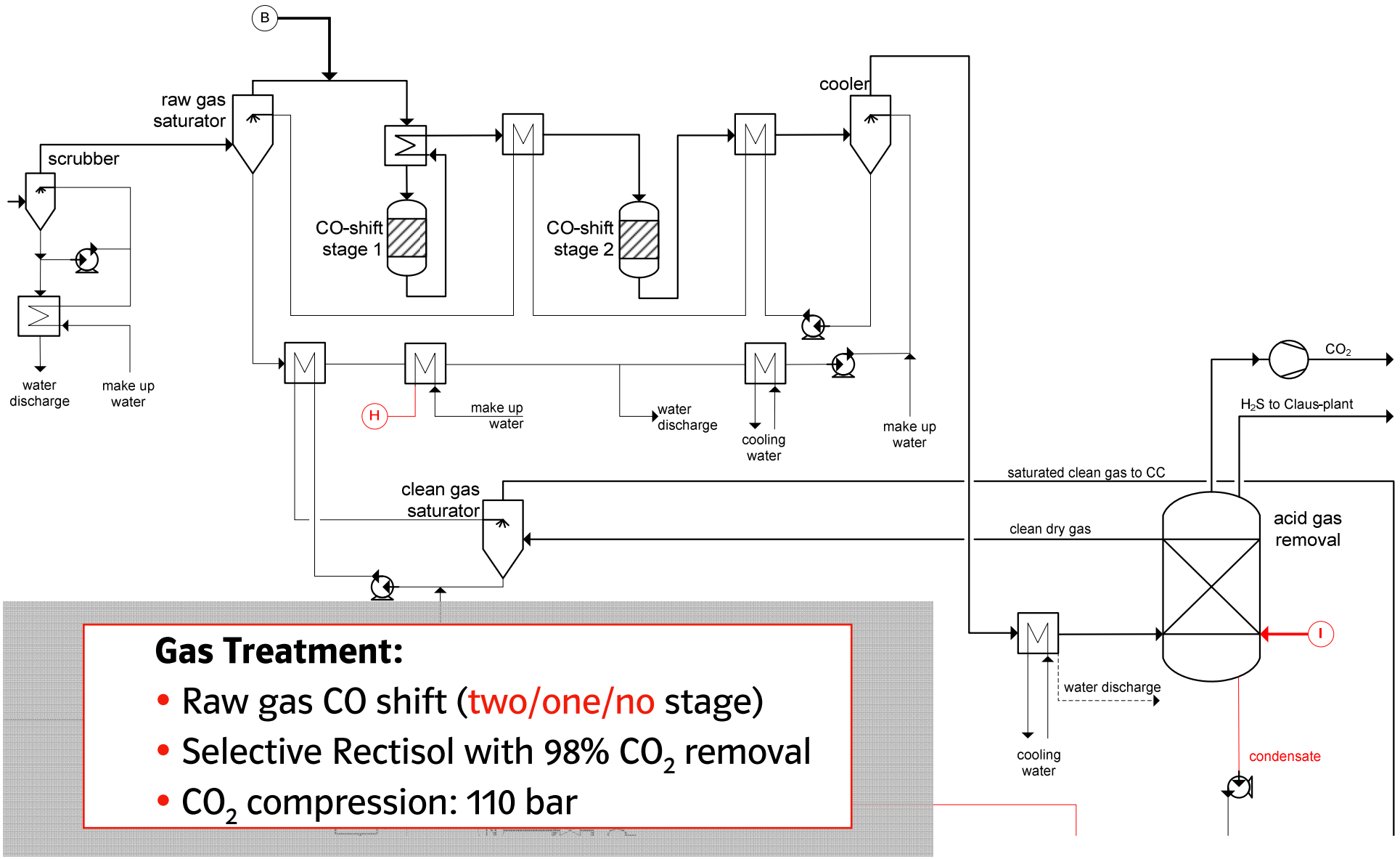


Feed Stock:

Pittsburgh No.8 Bituminous Coal

Gasifier:

- Dry feed system
- Raw gas quench
- 33 bar(a); 1500 °C
- Convective Syngas Cooler



Gas Treatment:

- Raw gas CO shift (two/one/no stage)
- Selective Rectisol with 98% CO_2 removal
- CO_2 compression: 110 bar

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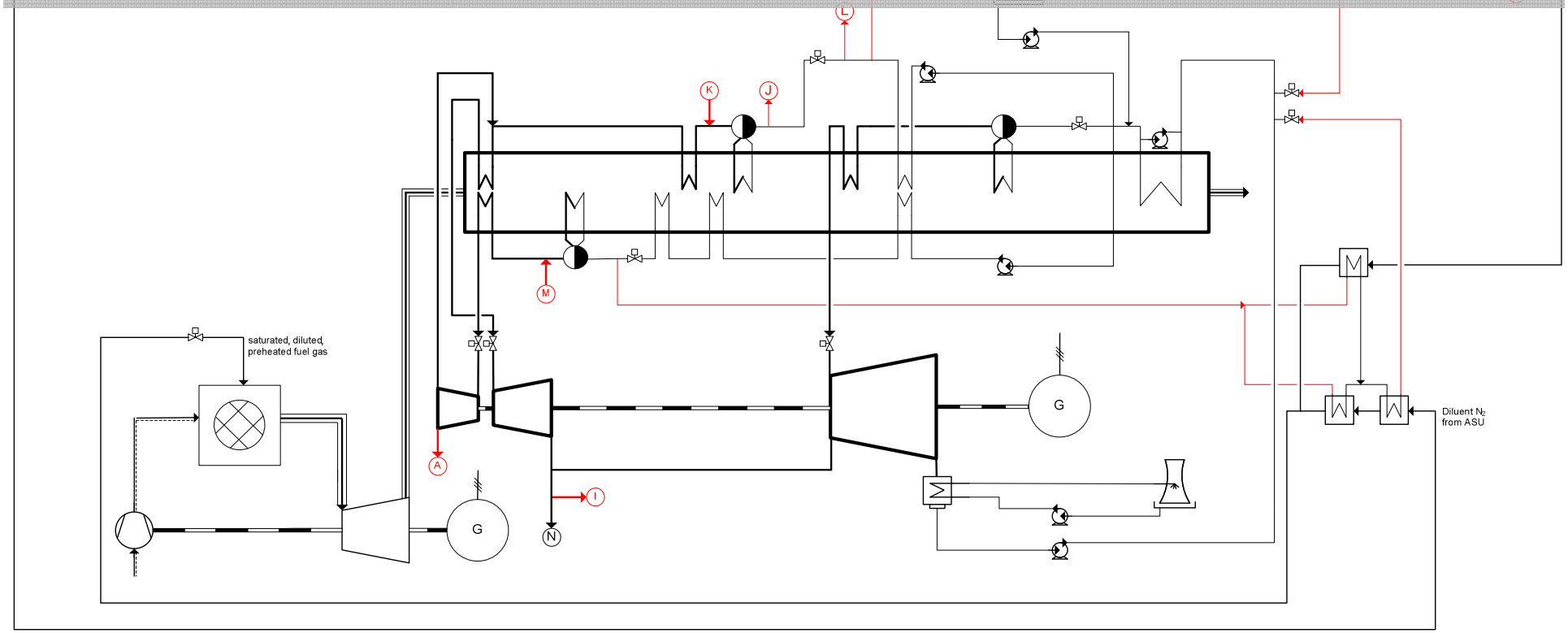
Gas Turbine:

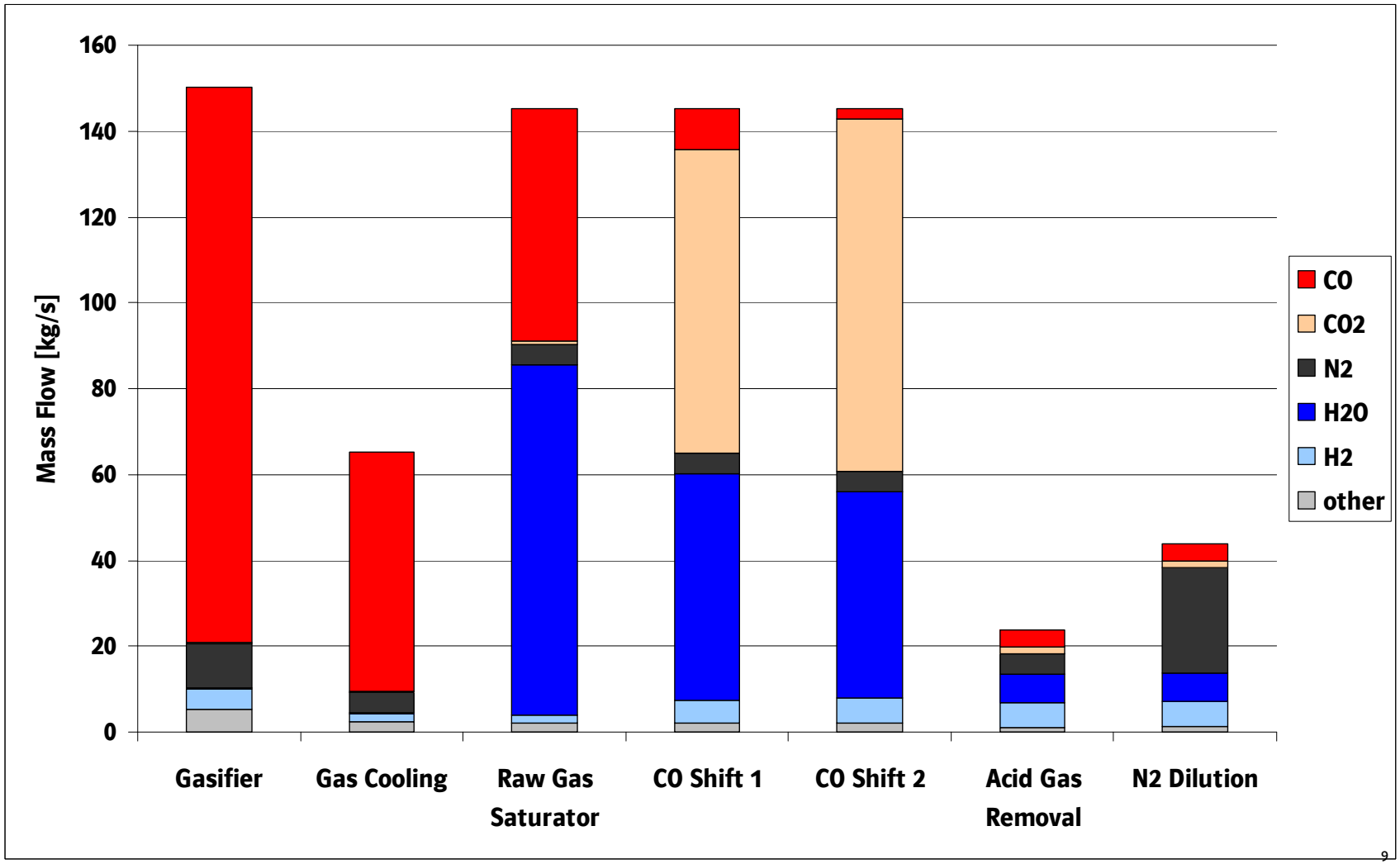
- F class performance
- approx. 320 MW gross

Bottoming Cycle:

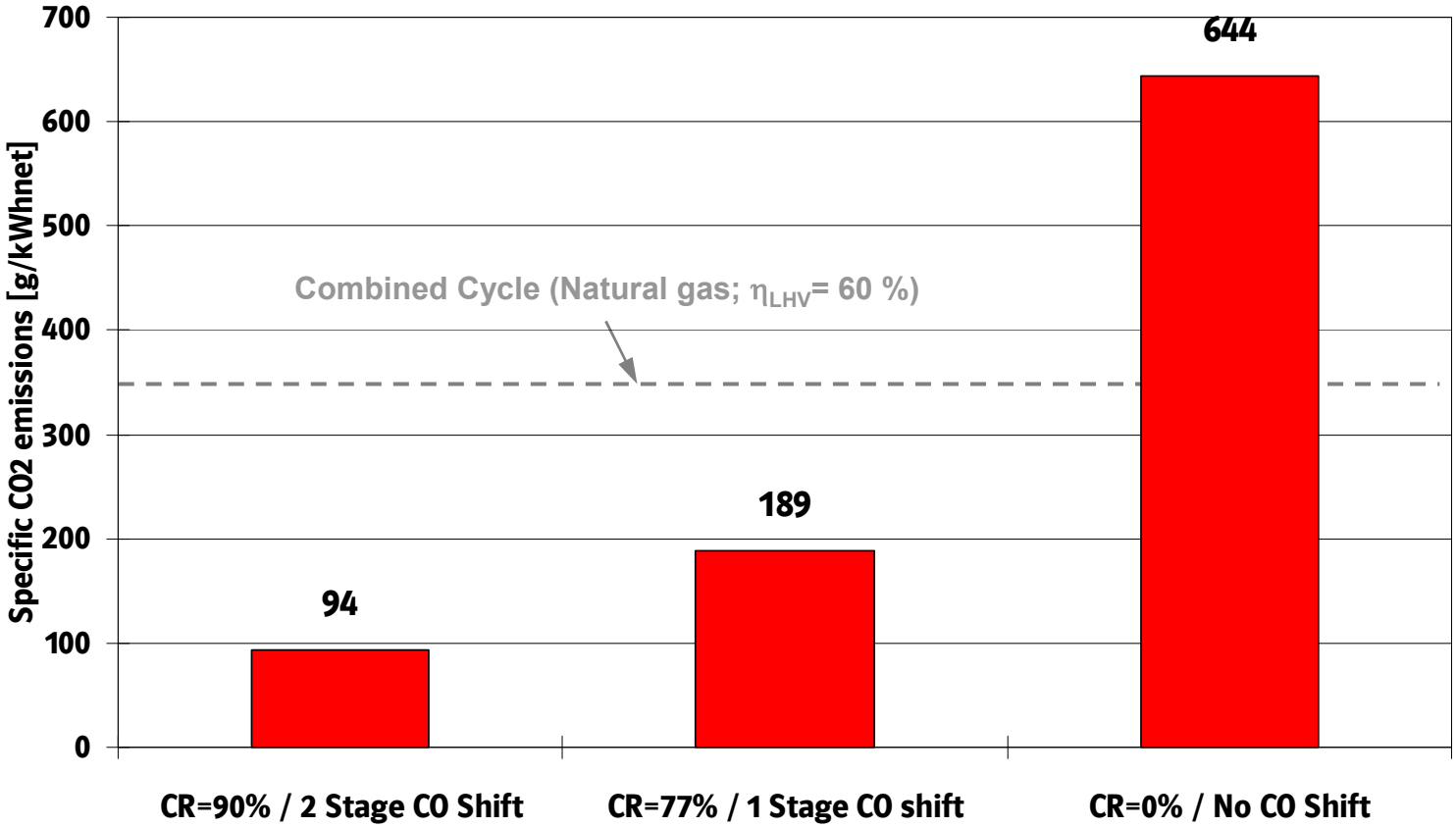
- 3 pressure reheat HRSG
- HP/IP/LP steam turbine



Syngas Mass Flow and Composition



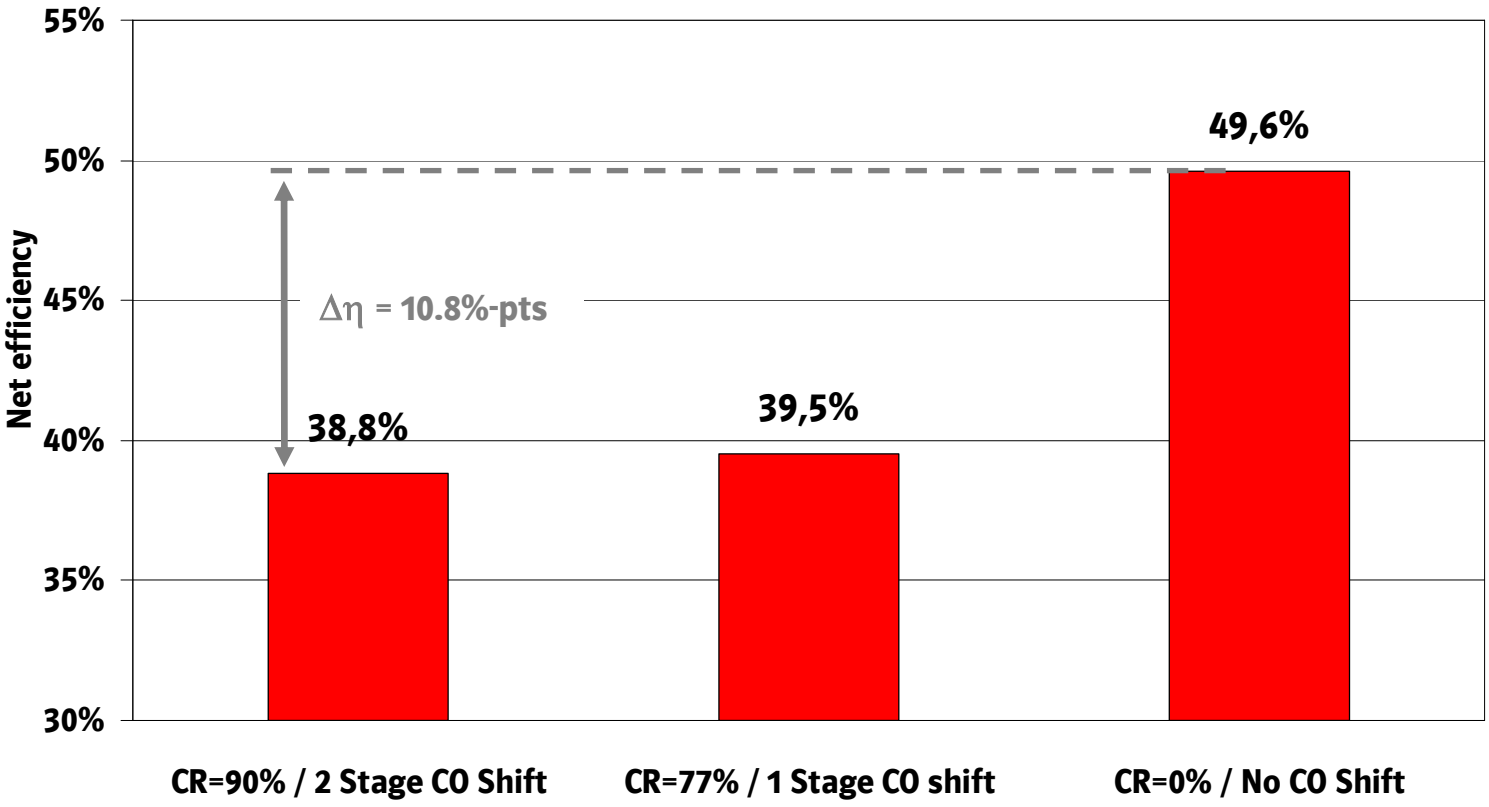
Specific CO_2 Emissions depending on Capture Rate



→ Maximum carbon capture rate about 90%

→ IGCC-CCS below carbon emissions of natural gas fired Combined Cycles

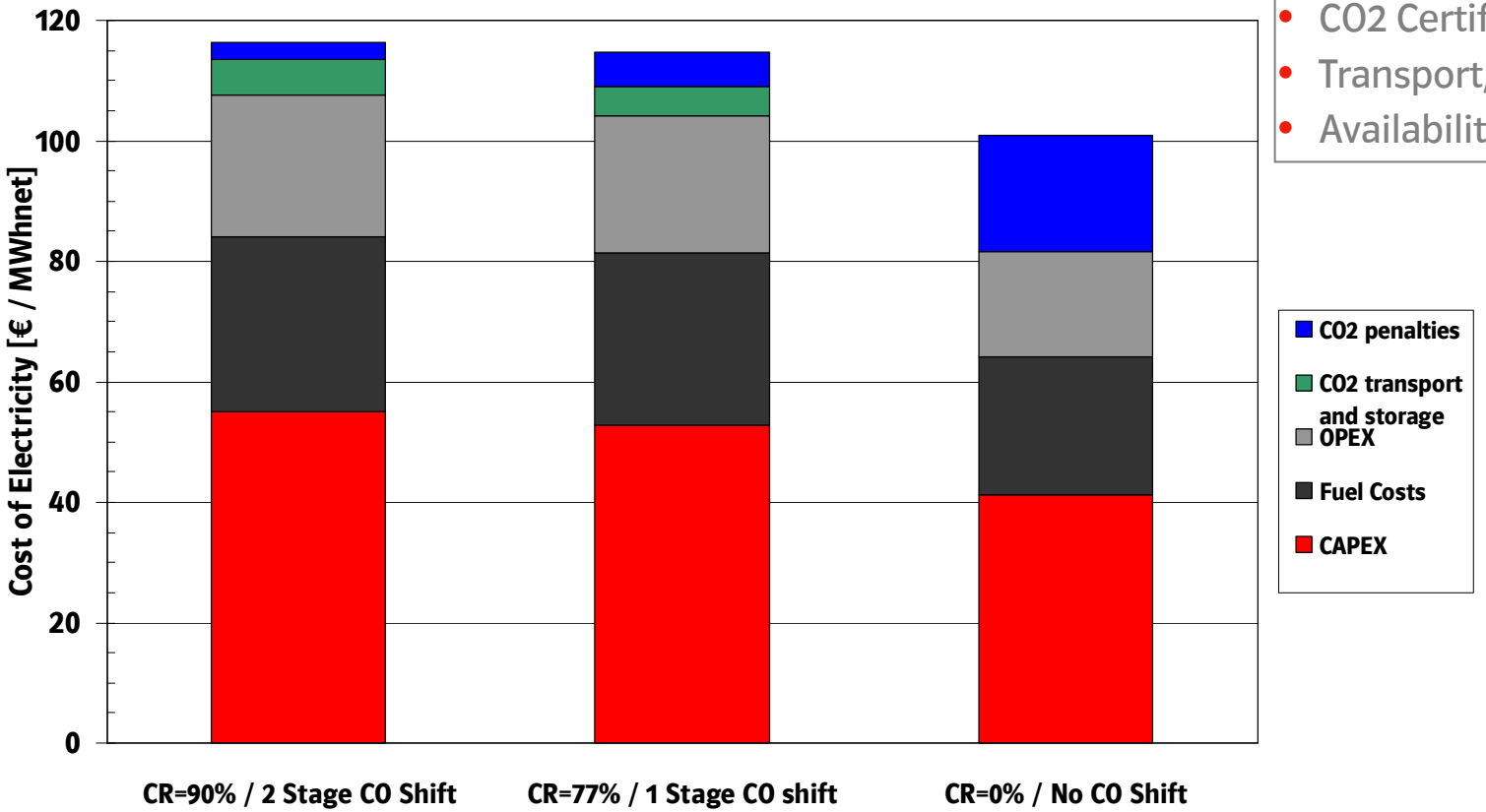
IGCC Net Efficiency depending on Capture Rate



→ Significant drop in efficiency for IGCC with carbon capture

→ Increase of auxiliary load (mainly for CO_2 compression and AGR)

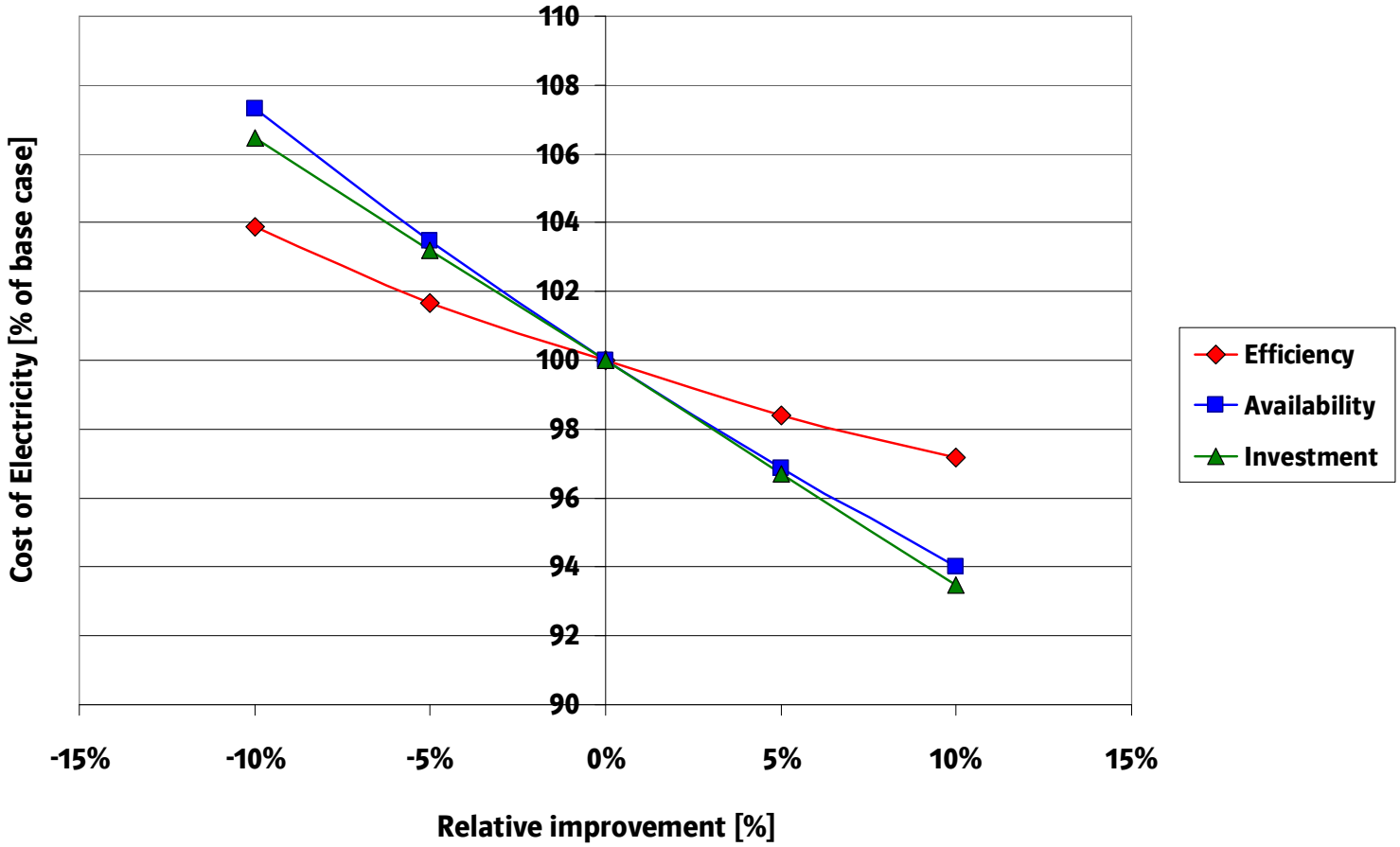
Cost of Electricity depending on Capture Rate



Boundary Conditions

- Invest: 4000 €/kWnet
- Fuel: 3.15 €/GJ
- Other Opex: 5 % of Invest
- CO2 Certificate: 30 €/tCO2
- Transport/Storage: 8€/tCO2
- Availability = 85%

Cost of Electricity: Sensitivity Analysis



→ CoE more sensitive to investment costs and availability than to efficiency

Intermediate Summary

- Significant impact of carbon capture rate on IGCC efficiency
- Comparatively high Cost of Electricity
- **Conclusion:**

  Capital cost reduction and **availability enhancements** are the key for competitive Cost of Electricity of IGCC with Carbon Capture

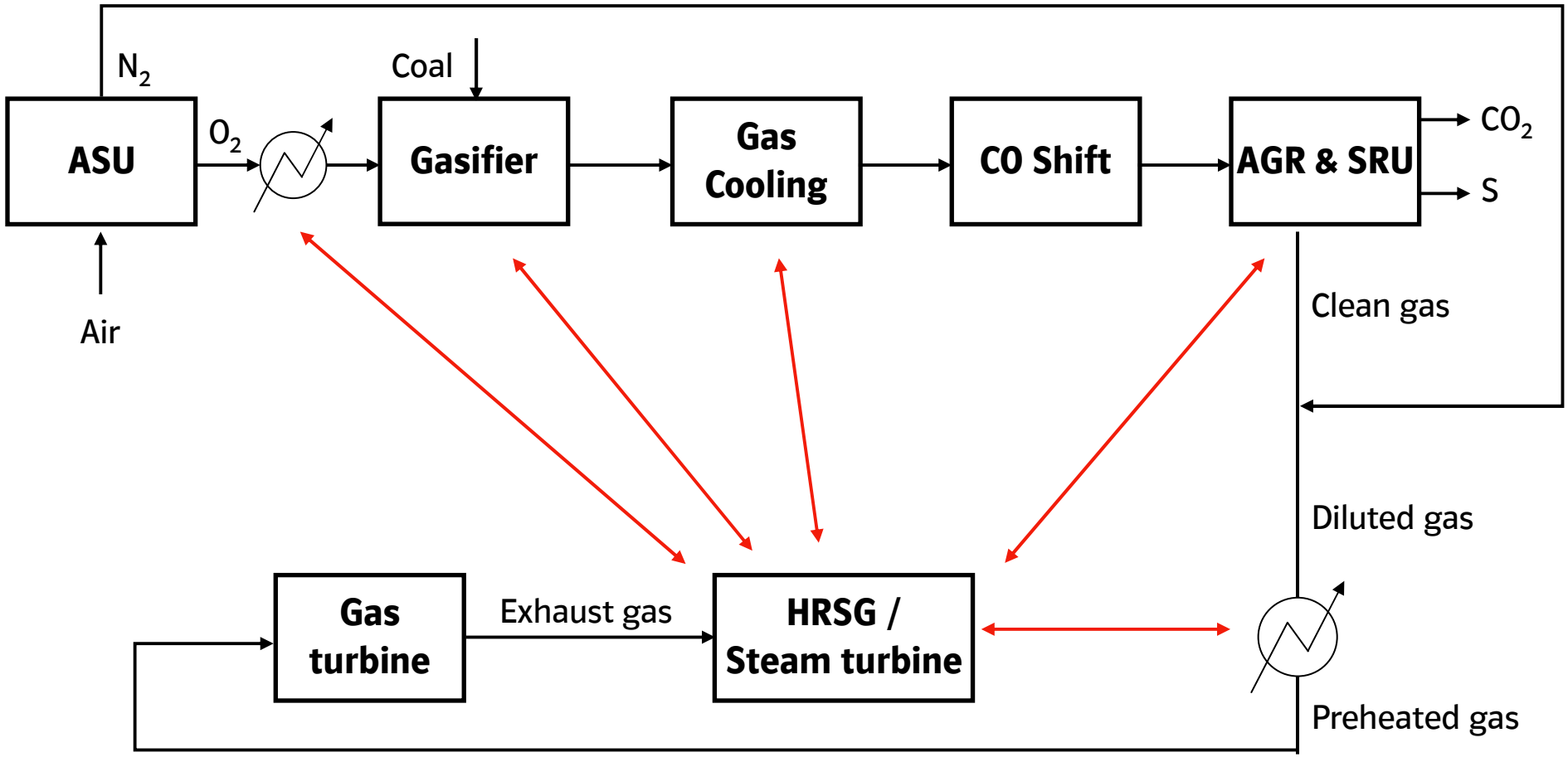
- **Options:**

  → Standardisation

  → Separating Combined Cycle from Gas Island

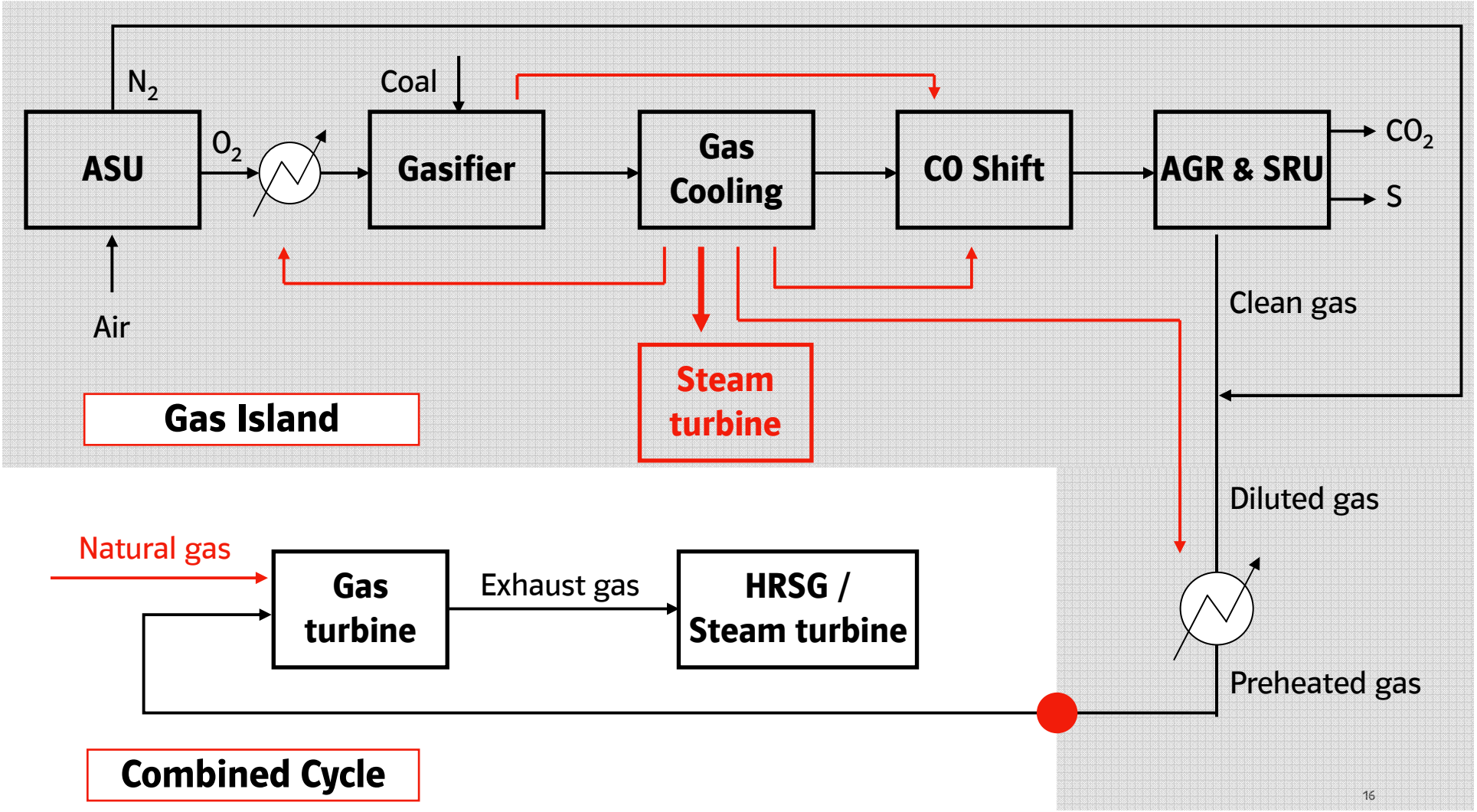
→ **Benchmarking study on simplified IGCC concept**

IGCC Configuration with Carbon Capture



→ Highly integrated system (especially the water steam cycle)

Disintegrated IGCC Configuration with Carbon Capture



Results for Disintegrated IGCC with Carbon Capture

- Δ Efficiency ≈ - 0.35 %-pts.
- Δ Investment ≈ slightly higher
- Δ Availability ≈ + 11 %-pts.

Δ Cost of Electricity ≈ - 10 %

→ Key component: Dual fuel gas turbine

Conclusions:

- Maximum efficiency is not necessarily the key target for IGCC plant design.
- Disintegration offers higher availability and more operational flexibility.
- Disintegrated IGCC could be an ″add-on option″ for an existing Combined Cycle plant.
- Further research on disintegrated IGCC concepts with Carbon Capture are on E.ON's agenda.

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Thank you for your attention.