Tests and Results of Vattenfall's Oxyfuel Pilot Plant

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2013-09-11

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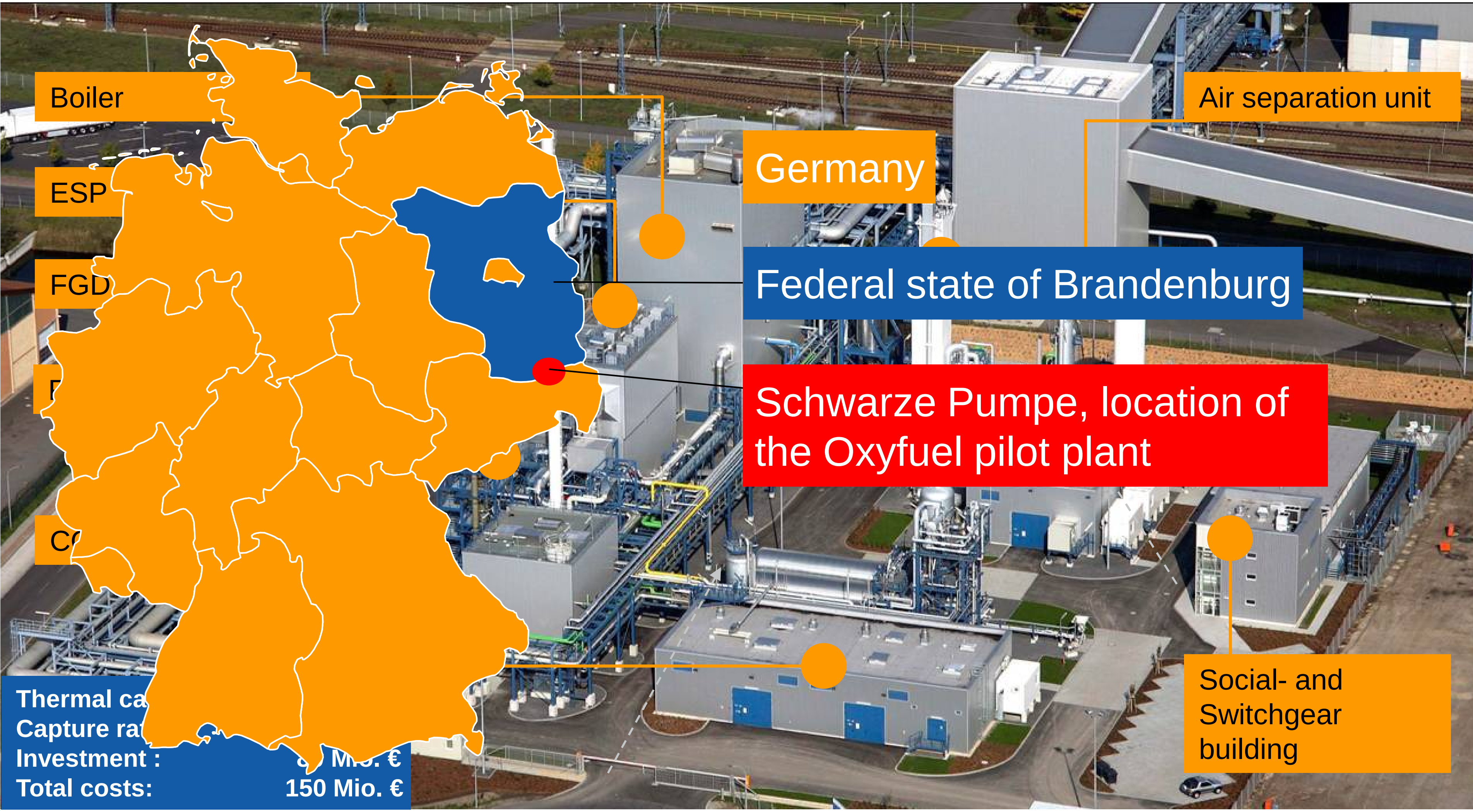
Vattenfall’s Oxyfuel Pilot Plant



Base data and industry partners

Thermal capacity:	30 MW_{th}
Coal demand:	5.2 t/h
Oxygen demand:	10 t/h
CO_2 (liqu.) production:	9 t/h

- Start up test operation Sept. 2008
- Until 17.000 operating hours in total, from it 13.200 in Oxyfuel mode, captured and liquefied CO_2 = 10.660 t
- CO_2 removal rate > 90 %
- High plant availability
- CO_2 quality sufficient for transport, storage and CCU

Industry partner :

ALSTOM
SIEMENS
Linde
Babcock Borsig Steinmüller
HITACHI Inspire the Next
DOOSAN
BABCOCK NOELL
TREMA
GEA
AIR PRODUCTS

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General aims of Oxyfuel Pilot Plant in Schwarze Pumpe

- Practical proof of Oxyfuel technology in pilot scale (from coal input up to CO_2 output)
- Integration of new components from chemistry (ASU, CO_2)
- Complete approval procedure of a CCS power plant
- Compliance with necessary emission limits in all operating states
- Test of measuring equipment (for Air/Oxyfuel) and different materials
- Inject of “real Oxyfuel CO_2” in a geological CO_2 storage
- Collecting of experiences for operation and maintenance
- Develop of requirements and competitive equipment supply chain for a CCS demo plant

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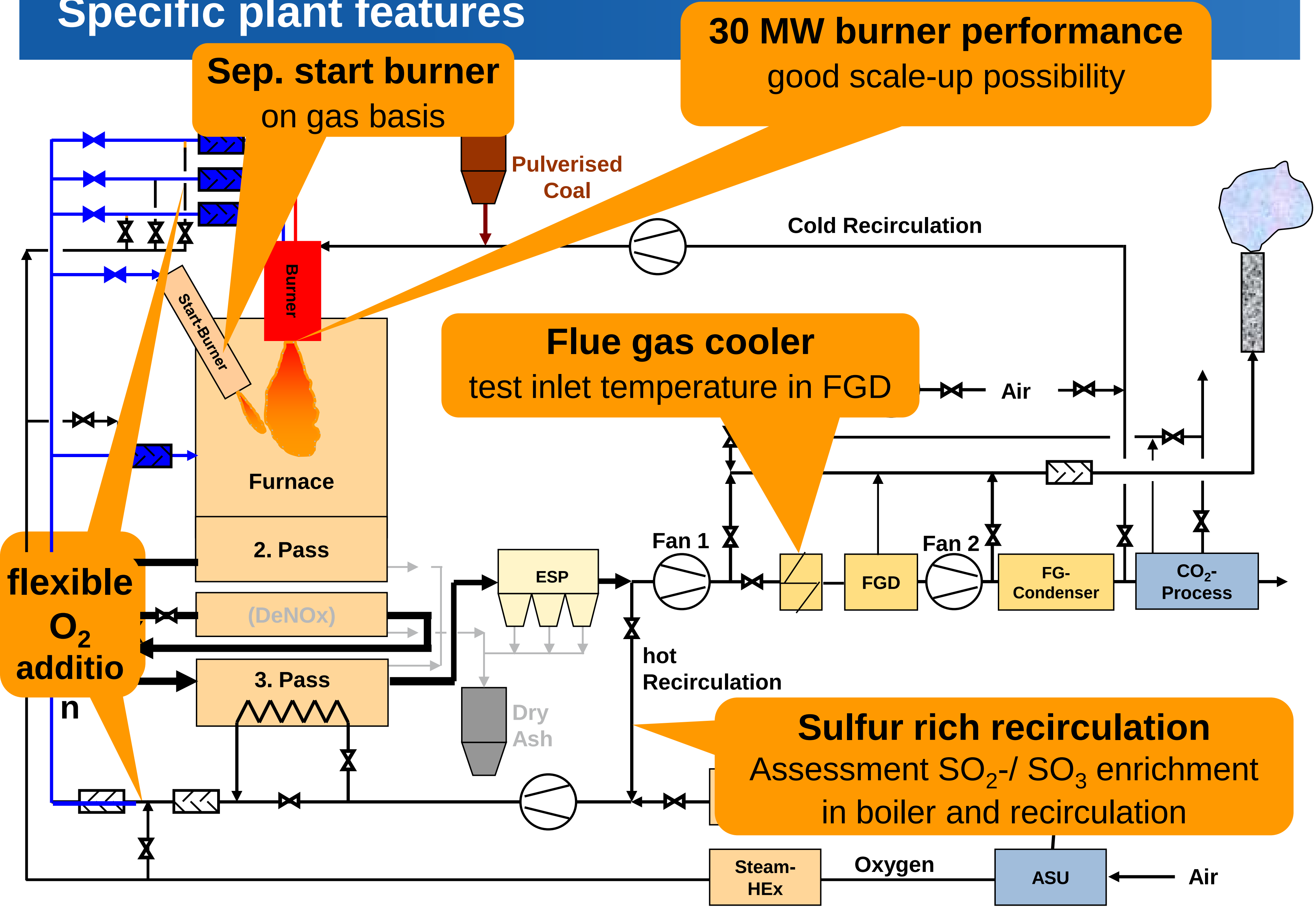
Specific plant features



Test objectives for Air and Oxyfuel operation

- Optimization combustion behaviour (burner, O_2 mix, OFA, emissions) and heat transfer behaviour
- Test of different burners for Air- and Oxyfuel- operation
- Test of sulphur rich (hot) flue gas recirculation
- Optimized interaction in combination of all components
- CO_2 removal rate > 90 % reached
- Reduction of air ingress, maximization CO_2 concentration
- CO_2 purity > 99 % (Request for geological storage in project Ketzin)

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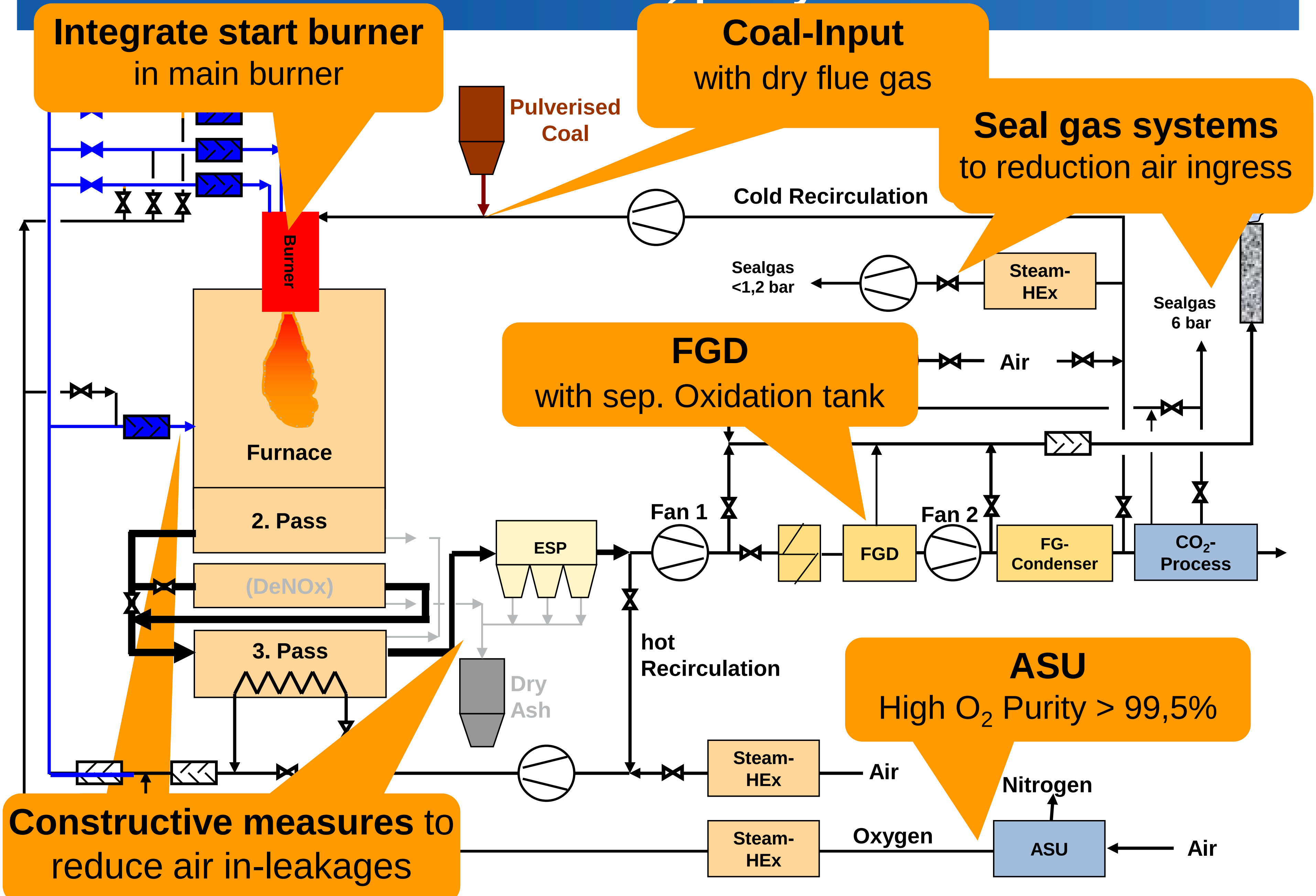
Effort for maximization of CO_2 purity



Is effort worthwhile for maximization of CO_2 purity?

Component	Measure	Remarks
ASU	O_2 purity > 99,5%	Standard ASU, higher operating costs
Boiler and ESP	Constructive measures for sealing	Proportional impact of air ingress in requirement openings is lower in big boilers
Two flue gas fans	Reduction of under pressure	2nd. flue gas fan used as a „wet fan“, better optimization of both fans
Wet FGD	Separate oxidation tank	measure is effective, but more equipment/I&C, reduce oxy-air (-12% inert gas) ➔ -1,5% FG
Separate seal gas systems	Recirculation of cold flue gases for sealing and cooling equipment	To avoidance of 3% air-cooling streams: technical operational problems (humidity, corrosion) and higher maintenance effort

➔ Partly measures influence operating behavior disproportionately

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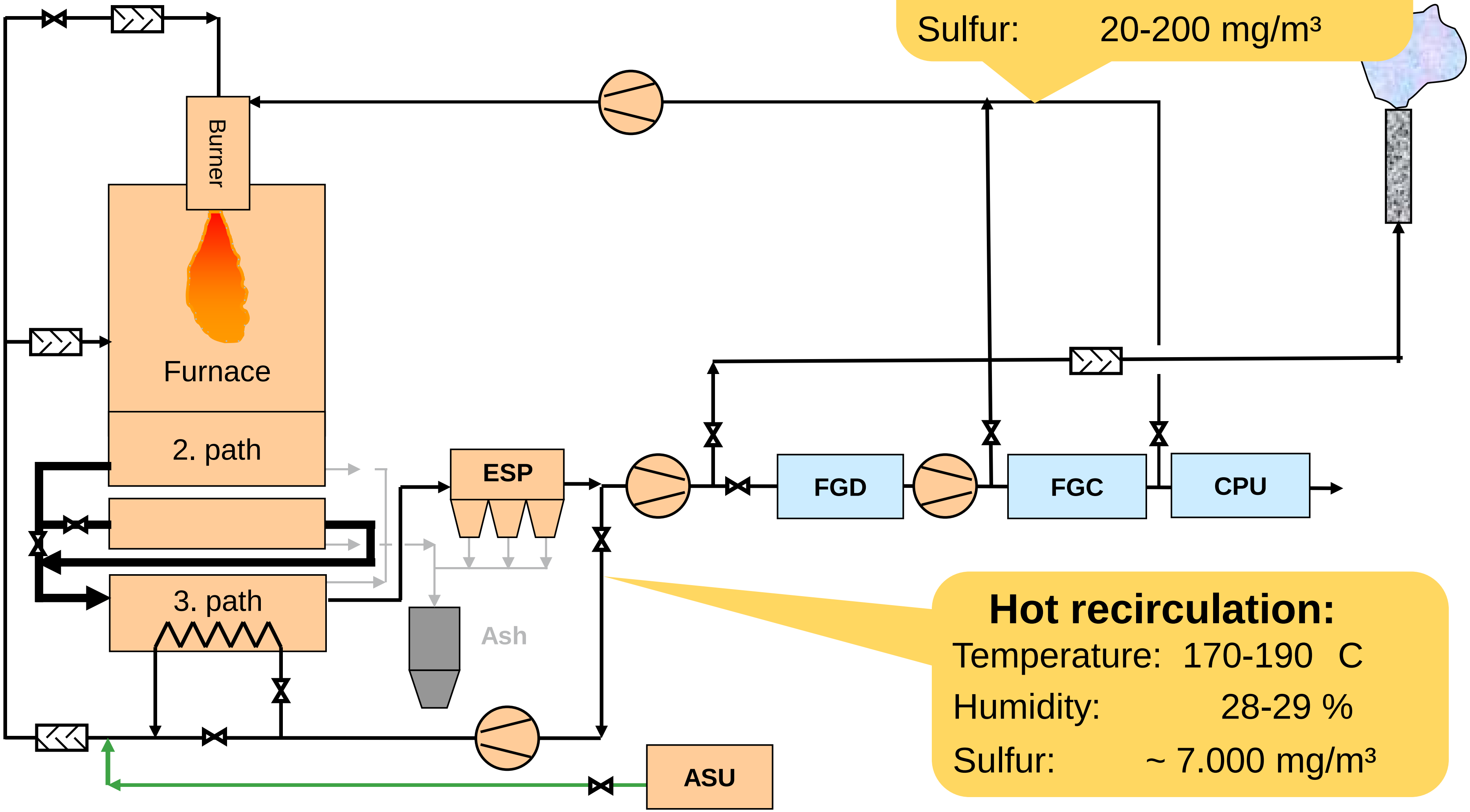
Hot vs. cold recirculation

Cold recirculation:
Temperature: 40-70 C
Humidity: 4-31 %
Sulfur: 20-200 mg/m³



Hot recirculation:
Temperature: 170-190 C
Humidity: 28-29 %
Sulfur: ~ 7.000 mg/m³

But: Difference of efficiency approx. 1% !!

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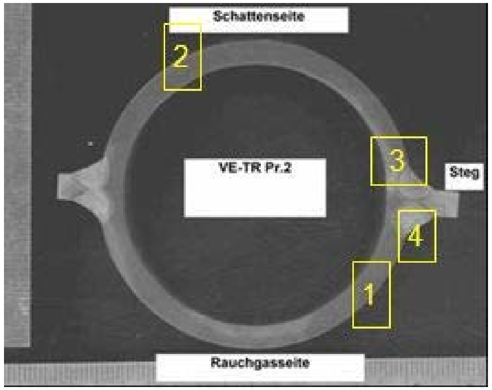
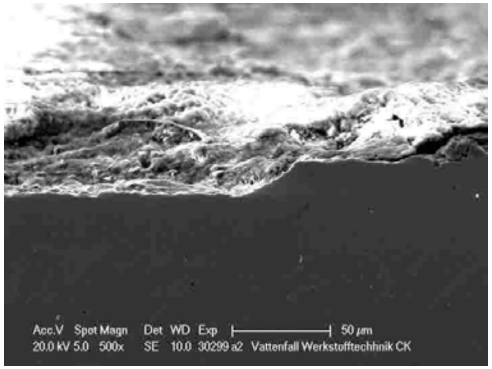
Analysis of test heating surfaces after 10.000 operating hours

Result to material examinations



- Long-term material examinations due to changing operation parameters and more start ups and shut downs difficult (Pilot Plant).
- Results indicated by overlapping of all sorts of operating states (Air/Oxyfuel, coal quality, boiler cleaning)
- Assessment of the results for this reason very complex
- Indicators like abrasion (material loss) as well as local and areal corrosion of examined boiler pipes and material samples trends to result in:



Selected materials can be used in conventional power plants and also in Oxyfuel plants

➔ Influence of "sulphur richer flue gases" does not have any effects on additional material uses apparently

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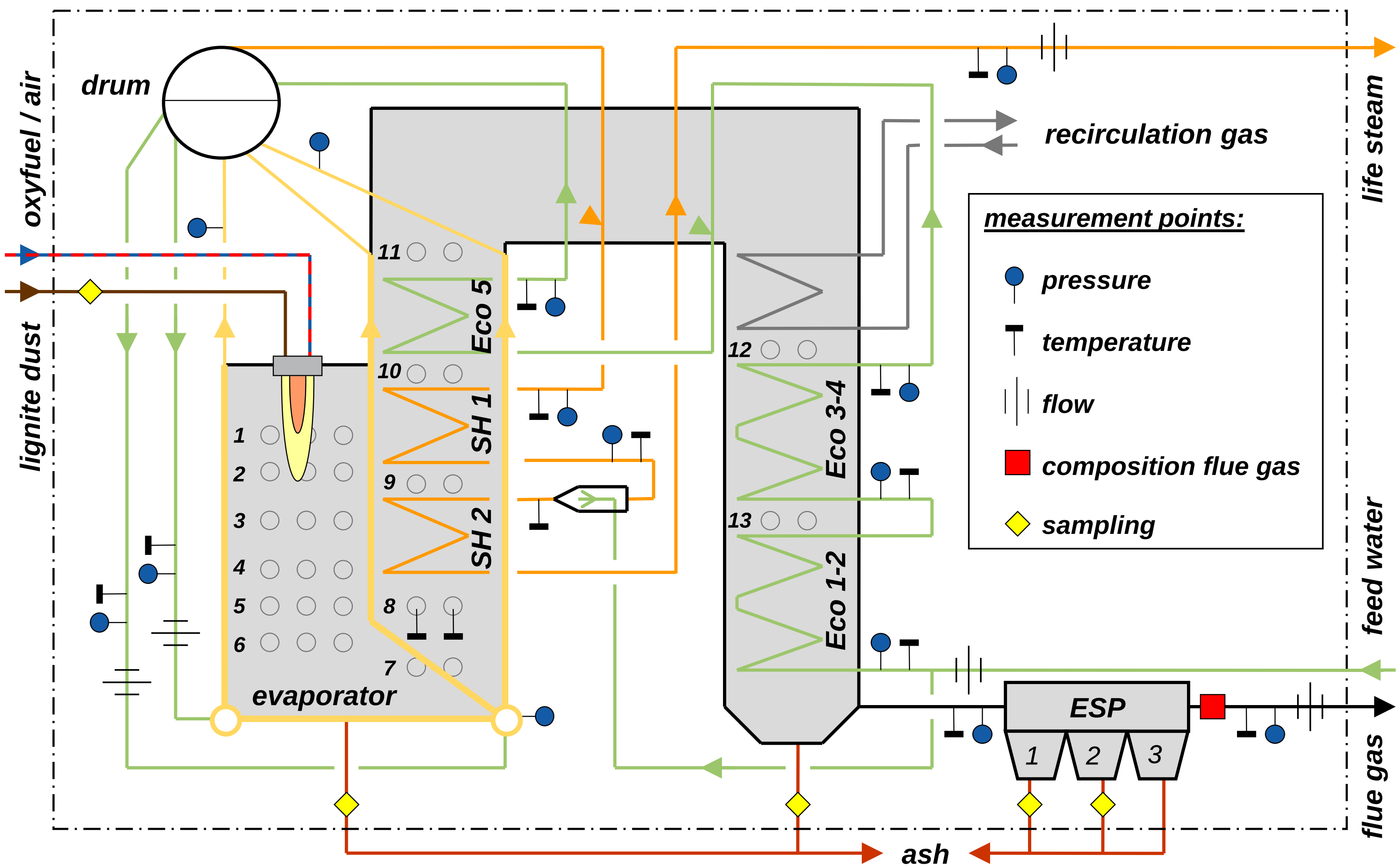
Measurement concept



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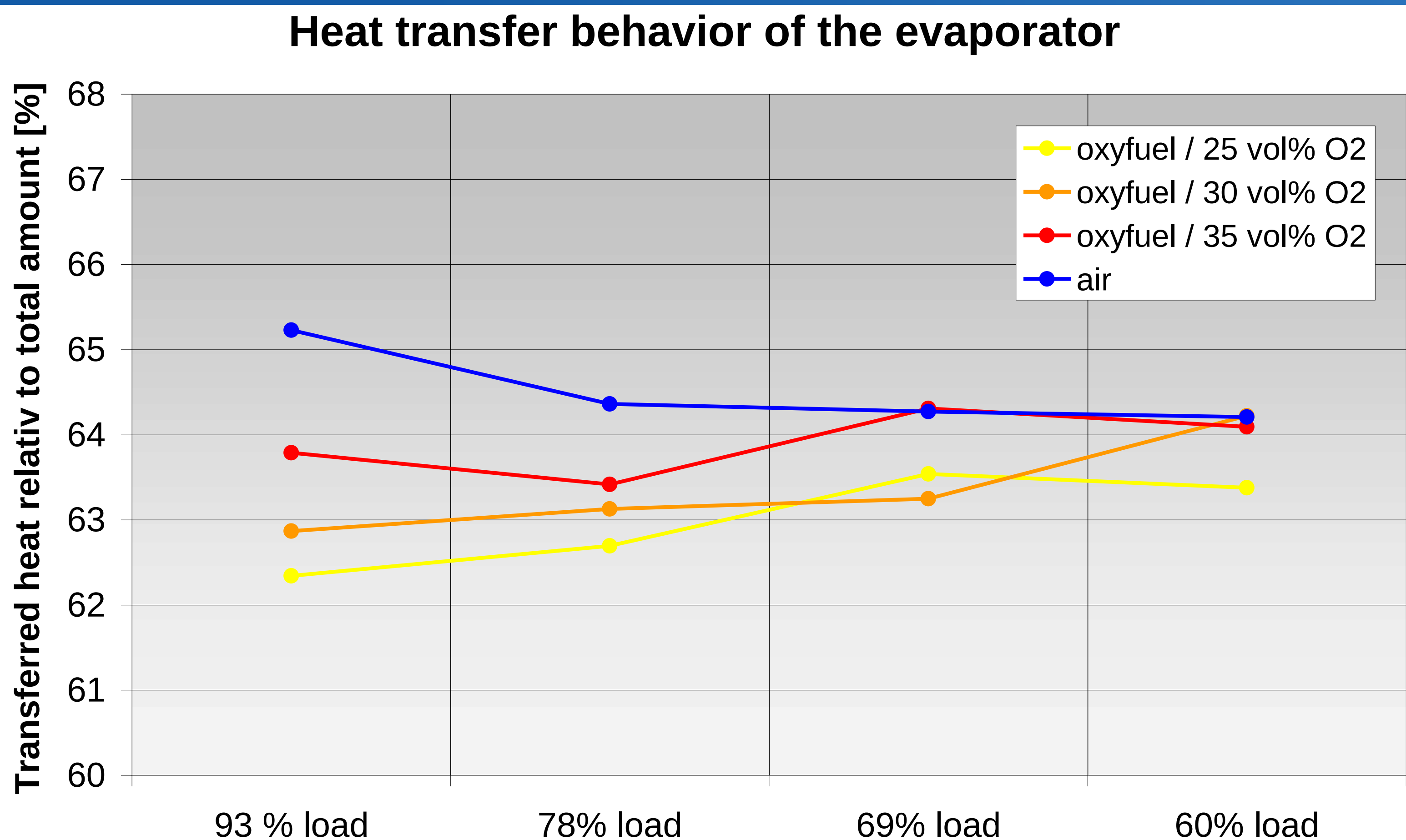
Results for different loads in furnace



- Results were calculated by process model (Ebsilon software) and measurement results from testing
- No significantly higher radiant heat transfer at evaporator in oxyfuel operation. Not general, because specific for burners and boilers

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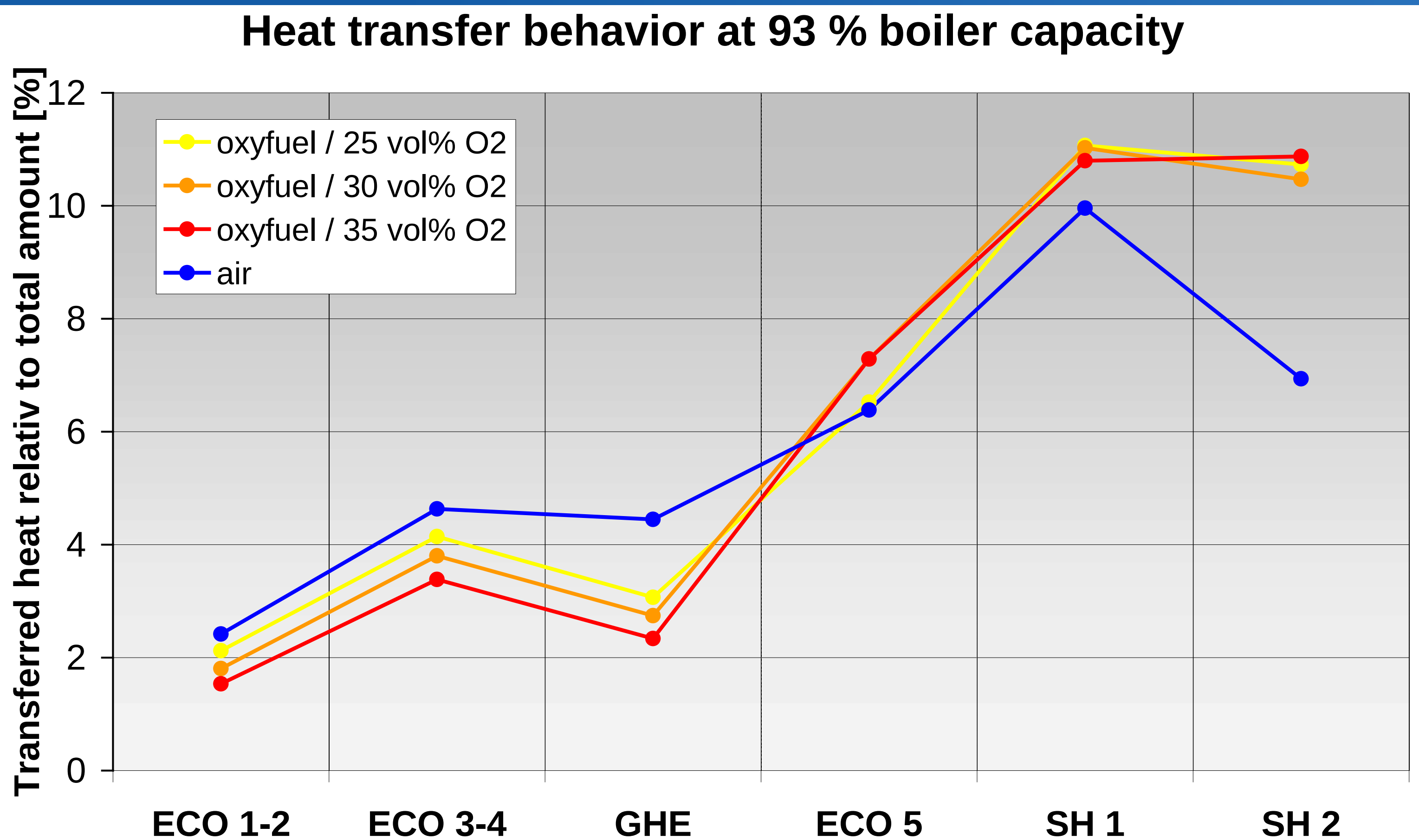
Results for different heat exchanger



- Changed flue gas composition does not have significantly influence on heat transfer in the convective pass (boiler specific result) but for superheater
- Significantly higher participation of gas heat exchanger in air operation because of a higher combustion air demand for preheating

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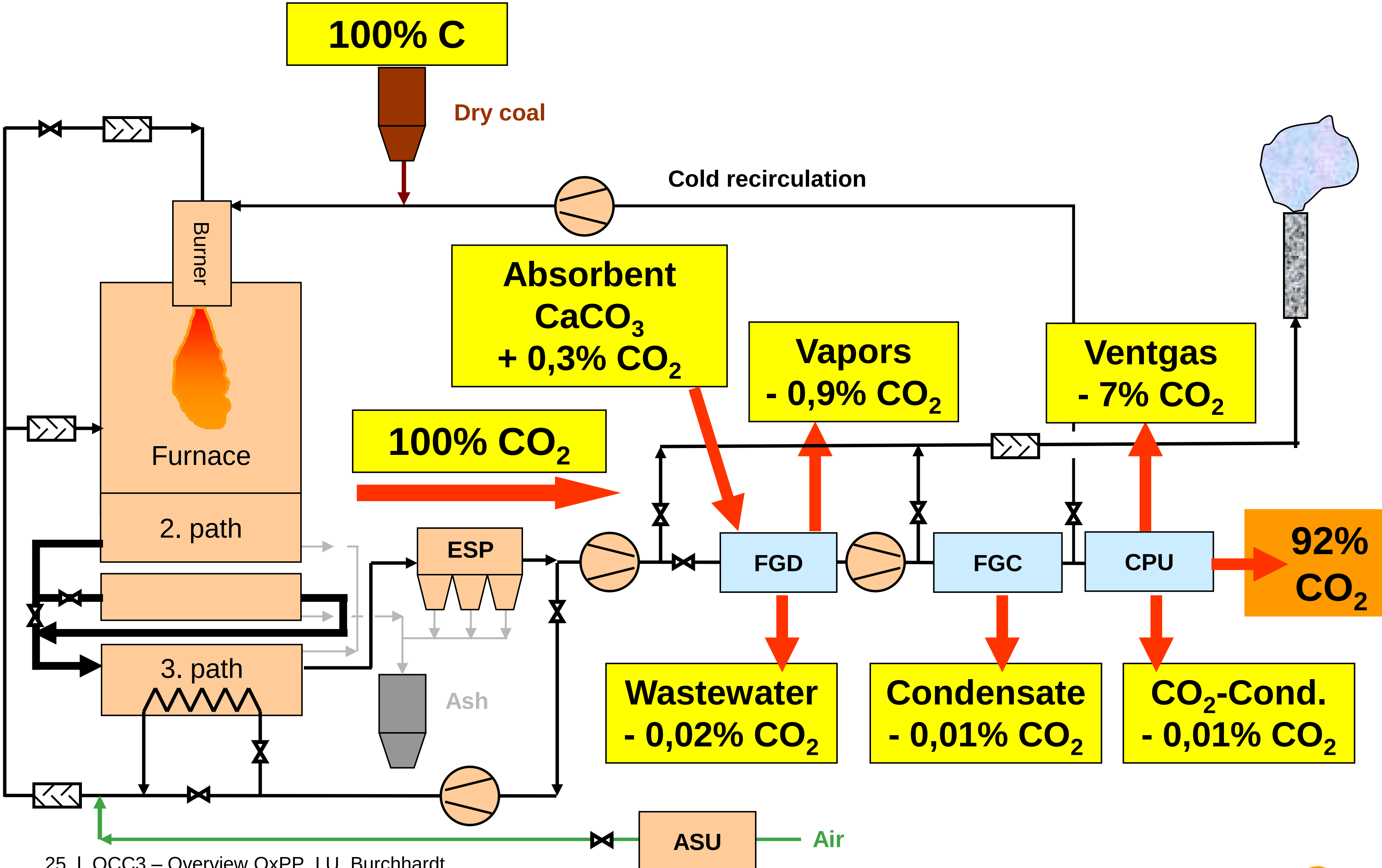
CO_2 balance in Oxyfuel operation



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Summary and outlook

- Goals of Oxyfuel Pilot Plant were accomplished completely, Oxyfuel works in pilot scale, all emissions are compliance to.
- CO_2 removal rates > 90 % were proved
- A sulphur rich recirculation is practicable after material examinations
- For Oxyfuel was proved, that a CO_2 purity > 99 % is possible. However, it depends on geological storage and economy, which CO_2 purity is necessary
- CCS chain was closed:
  Oxyfuel-CO_2 successfully stored in storage project CO2MAN (Ketzin)
- Further potentials for Oxyfuel technology are available

→ Ready to scale up to a demo plan

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Thank you for your attention!