Post-Combustion CO_2 Capture Retrofit

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EIWS, Gliwice, September 24-25, 2009

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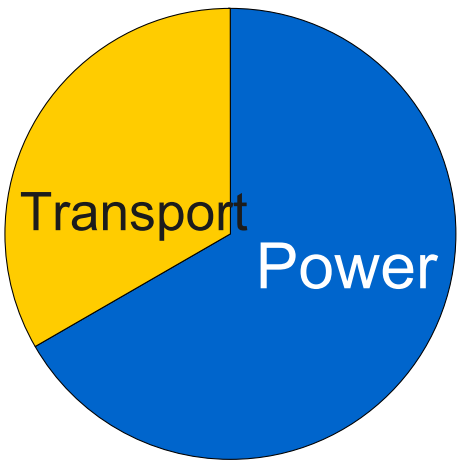
Agenda

- The Alstom Group
- Solutions for CO_2 Capture
- Advanced Amine Process
- Chilled Ammonia Process
- Retrofitting of Coal-fired Power Plants for CO_2 Capture
- Choice of CO_2 Capture Technology
- Layout of a Typical Power Plant with CO_2 Capture, Retrofit
- Main Processes Interfacing to the Power Plant
- Required Heat & Power for the CO_2 Capture
- Power Plant Operation with Integrated CO_2 Capture

The Alstom Group

Total orders 2008/09: € 24.6 bn

N°1 in high speed and very high speed trains



N°1 in Hydro Power

N°1 in Integrated Power Plants

N°1 in conventional nuclear power island

Recent acquisition of wind power

N°1 in air quality control systems

N°1 in services for electric utilities

Solutions for CO_2 Capture

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Power Plant with CO_2 capture

Post-combustion

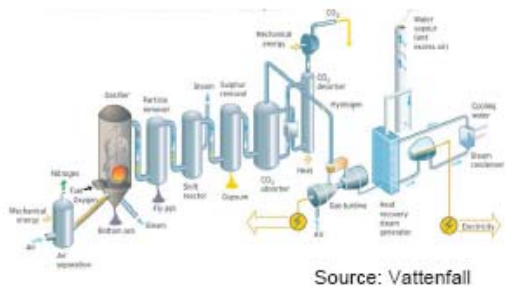
(New + retrofit)

Oxy-combustion

(New + retrofit)

Pre-combustion

(New only)

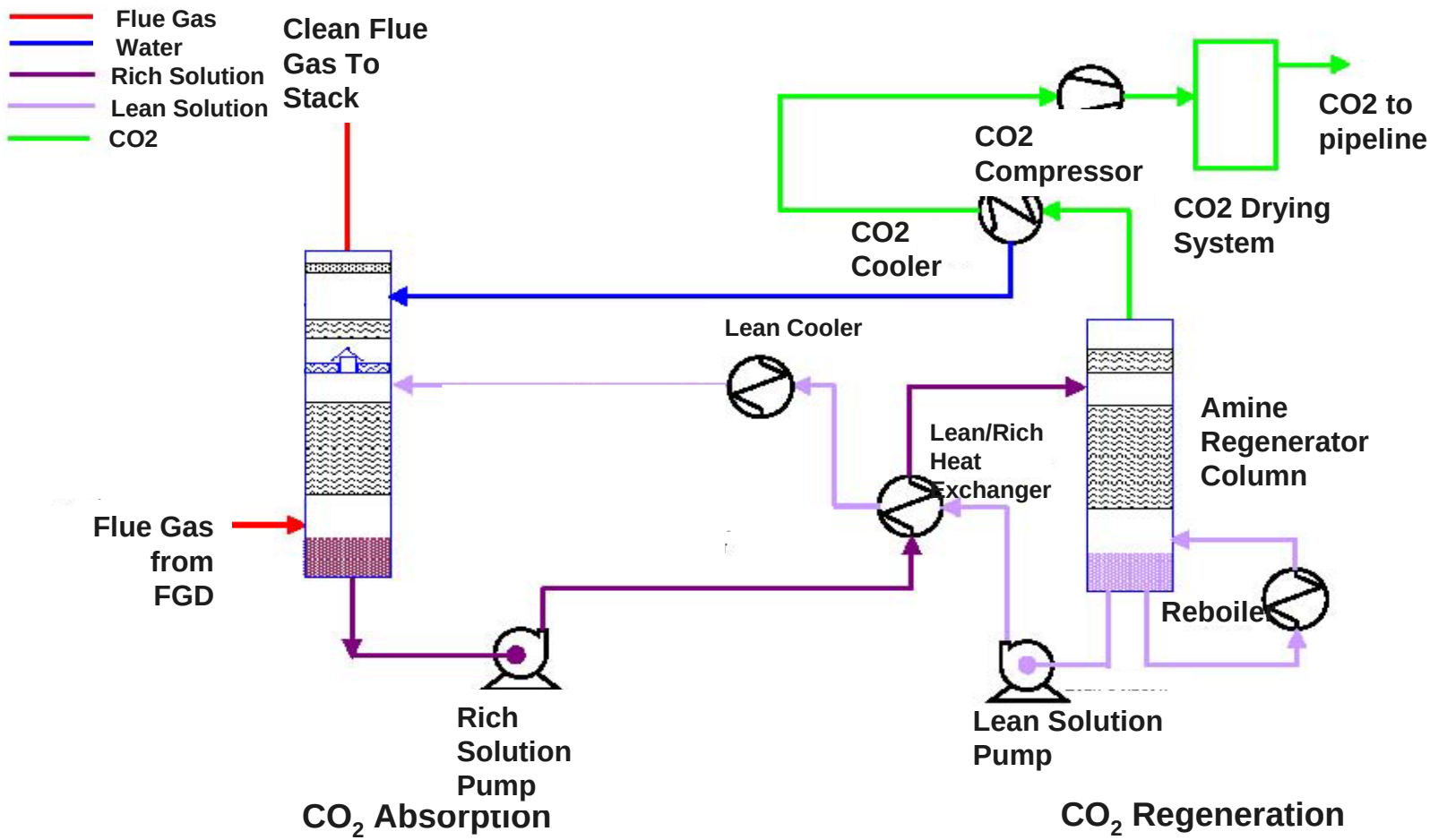


Source: Vattenfall

Solutions developed by Alstom

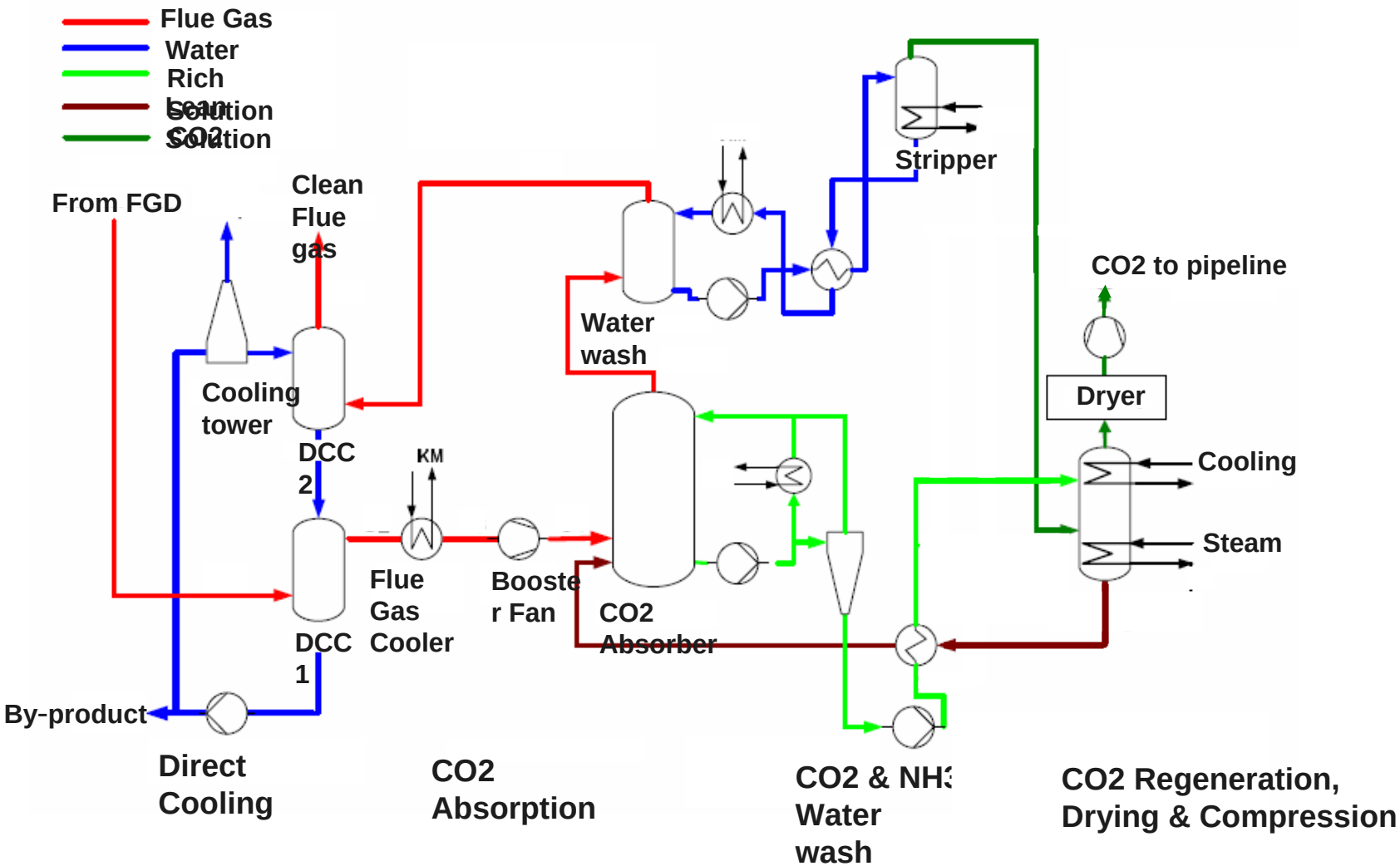
Post-combustion is most suitable for retrofit

Post-combustion CO_2 Capture
Advanced Amine Process



$$2R\text{-}NH_2 + CO_2(g) \rightarrow R\text{-}NH_3^+ + R\text{-}NH\text{-}COO^-$$

Post-combustion CO_2 Capture
Chilled Ammonia



$$2(NH4)^{+} + CO_3^{2-} + CO_2\,(g) + H_2O \rightarrow 2(NH_4)^{+} + 2HCO_3^{-}$$

Retrofitting Coal-fired Power Plants for CO_2 Capture (cont'd)

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Selection of Capture Technology

- Determining parameters:
  - Site condition
  - Free space
  - Flue gas condition
  - Steam & cooling water availability

Parameter	Advanced Amine	Chilled Ammonia
Space requirement	Low	High
Flue gas temperature	Rel. High (40-50 °C)	Rel. Low (10-20 °C)
Cooling demand	Low	High
Steam requirement	High	Low

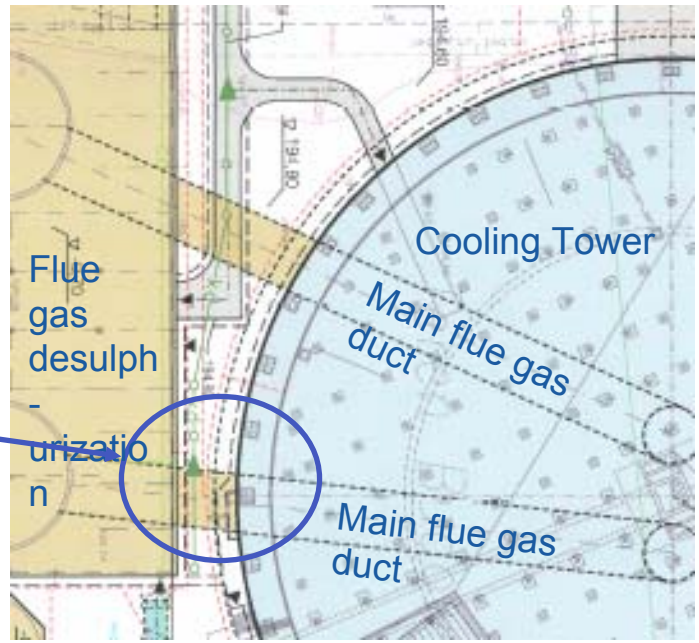
Retrofitting Coal-fired Power Plants for CO_2 Capture

Installation of CO_2 capture at existing & power plants under construction e.g Belchatow

Capture size is limited due to:

- Space constraint
- Access to the main flue gas ducts

Narrow distance, flue gas extraction requires re-arrangement



- Steam & cooling water availability

Layout of a Typical Coal-fired Power Plant with CO_2 Capture, Retrofit

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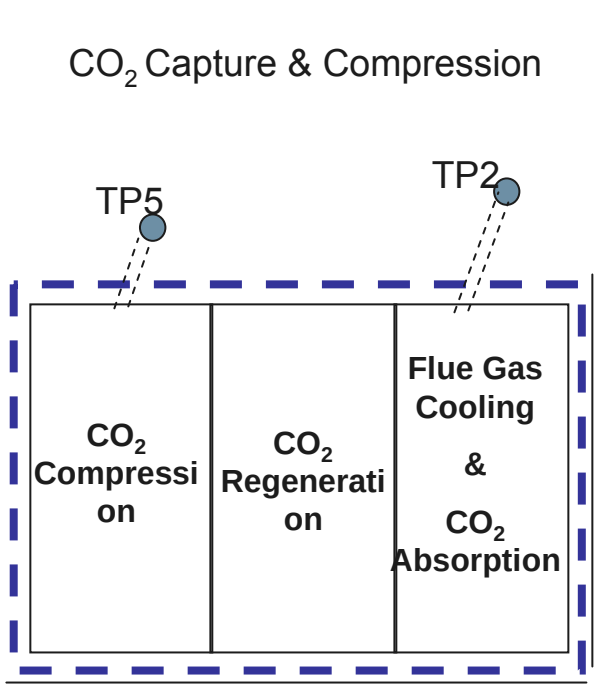

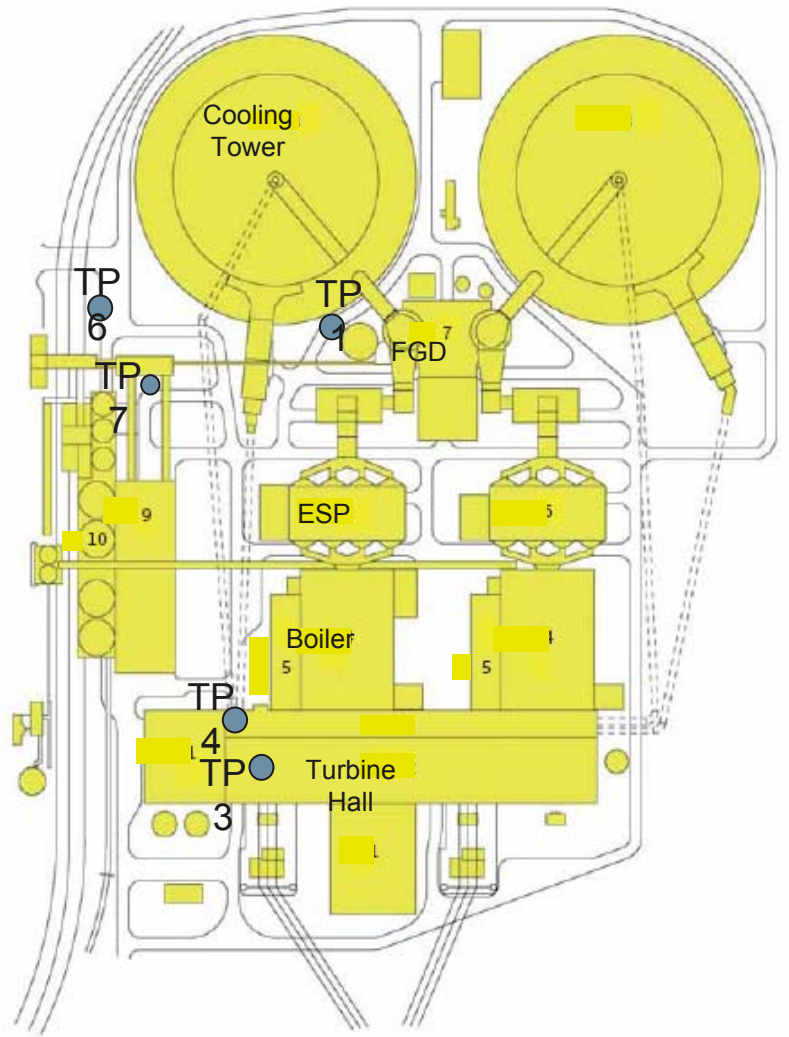

Terminal Points:

TP1 Flue gas extraction

TP2 Flue gas outlet

TP3 Steam extraction

TP4 Condensate return

TP5 Compressed CO_2

TP6 Cooling water to CO_2 plant

TP7 Cooling water return to cooling tower

Layout of a Typical Coal-fired Power Plant with CO_2 Capture, Retrofit

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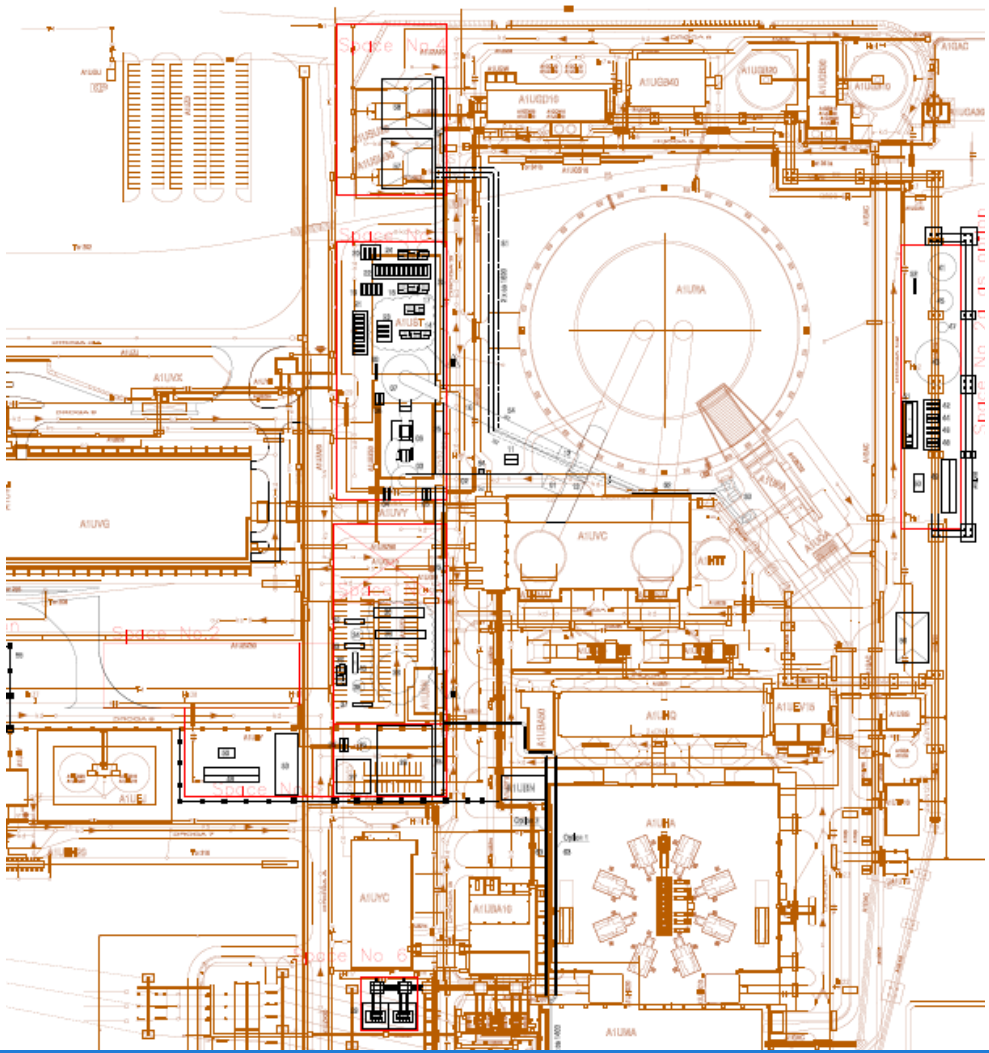
Some arrangement challenges for retrofit plants:

- Steam piping routing
- Flue gas duct routing
- CEMS (Continuous Emission Monitoring System)

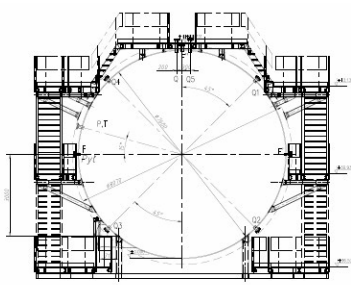


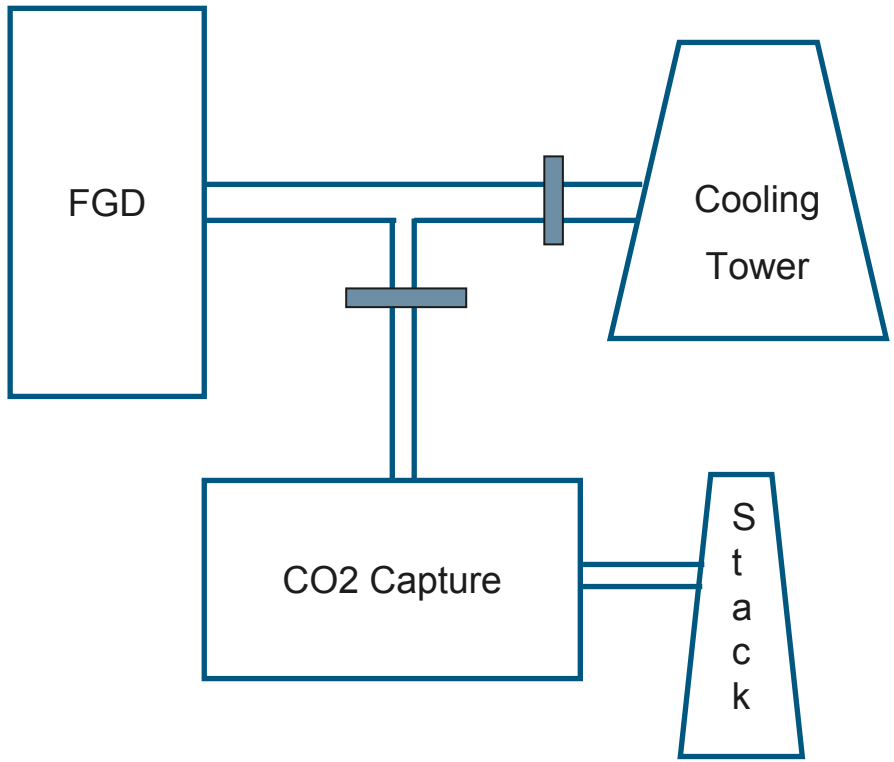
Modification and adaption of the power plant processes interfacing to the CO_2 capture plant is necessary

Main Processes Interfacing to the Power Plant (cont'd)

Flue Gas Extraction

- Flue gas extraction downstream the FGD
- Diameter ≈ 5-8 m: Shortest possible distance to the CO_2 absorber
- Installation of isolation valves to avoid backflow
- Outlet flue gas from the CO_2 capture plant returned to the existing cooling tower or to be released to a new separate stack

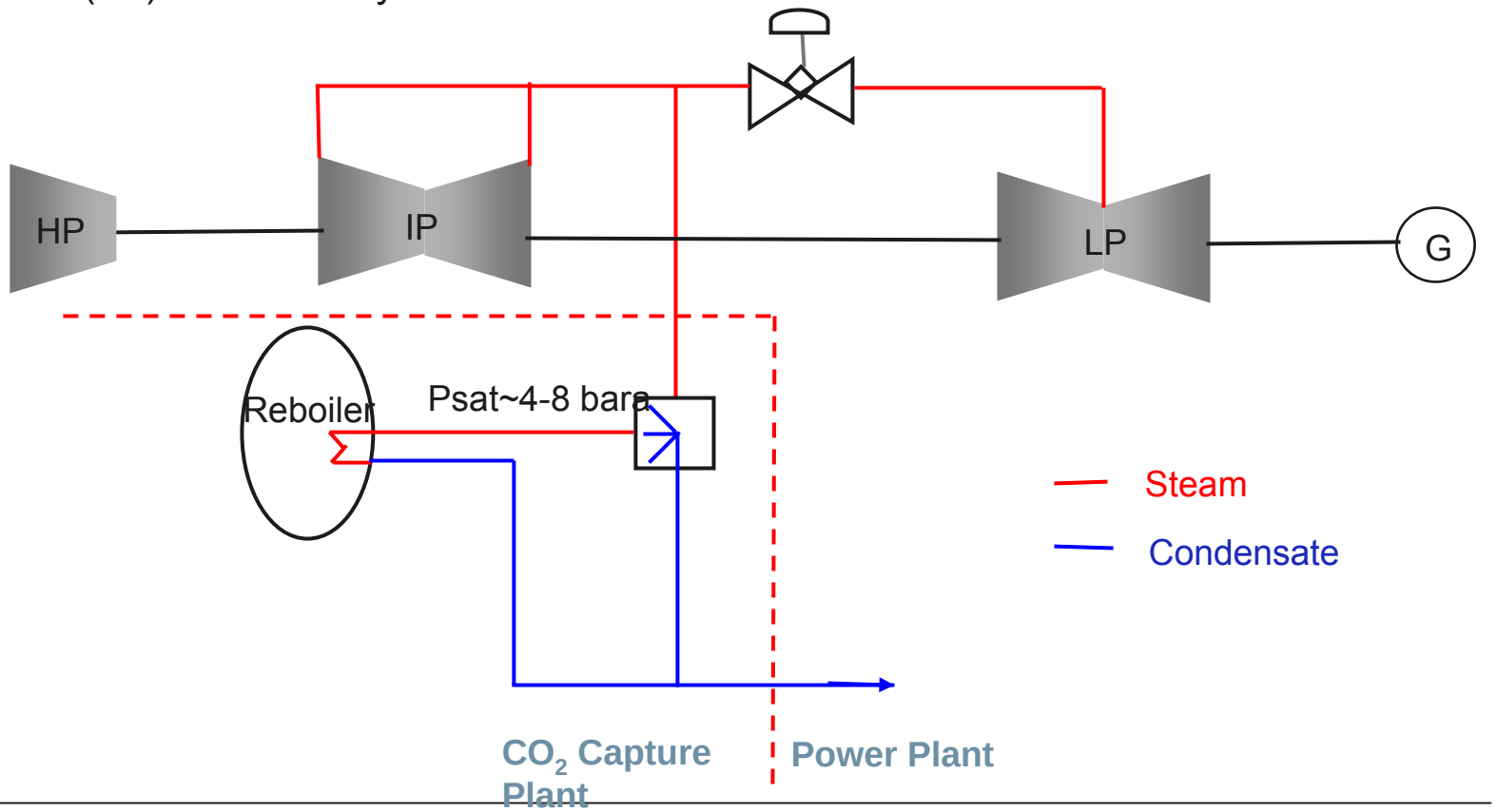




Main Processes Interfacing to the Power Plant (cont'd)

Steam Extraction

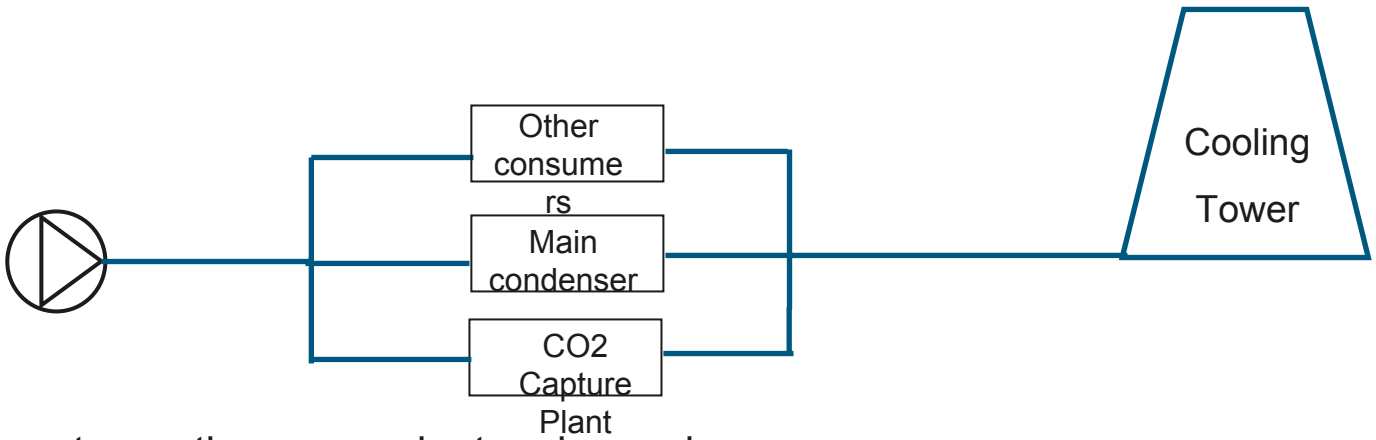
- Steam source: Superheated low pressure steam from the power plant water & steam cycle
- Modification of the steam pipe between the Intermediate Pressure (IP) & Low Pressure (LP) is necessary



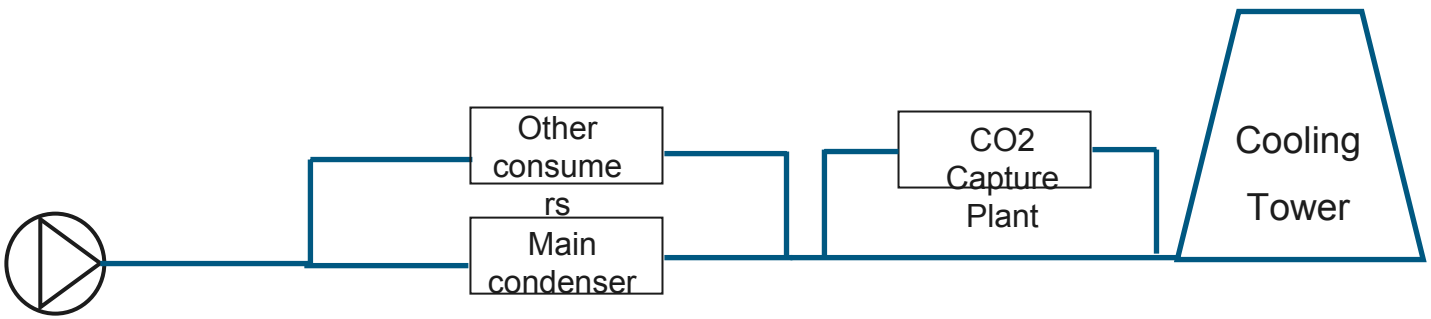
Cooling Water to CO_2 Capture Plant

Option 1: From spare cooling water capacity of the power plant

1) Parallel to the power plant main condenser



2) Downstream the power plant main condenser



Main Processes Interfacing to the Power Plant (cont'd)

Cooling Water to CO_2 Capture Plant

Option 2: Using a combination of option 1 & alternative cooling system e.g. air cooler

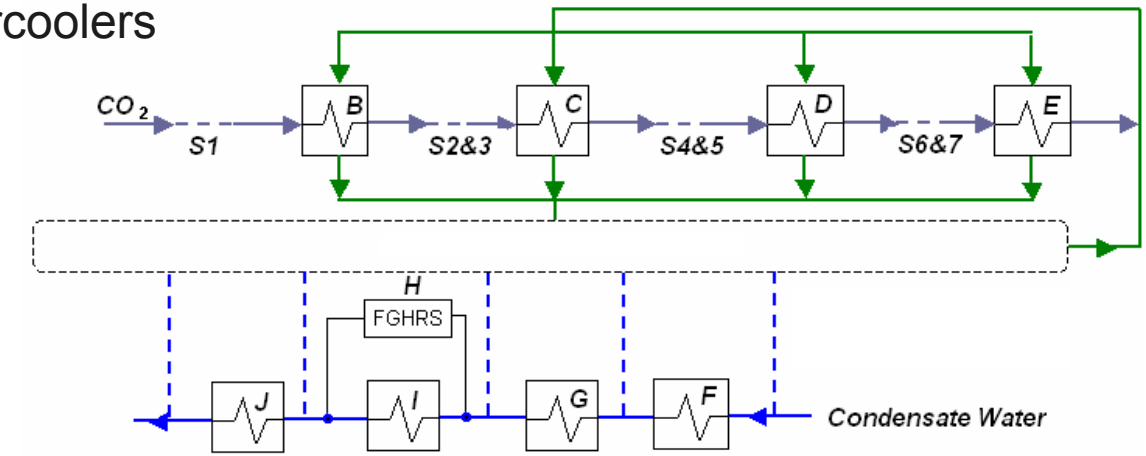
Option 3: To install a separate cooling tower for the CO_2 capture plant

Option 1 requires lowest investment cost

Main Processes Interfacing to the Power Plant (cont'd)

Heat Integration

- Heat from the CO_2 compressor intercoolers



- Heat from condensate return from CO_2 regenerator reboilers

Overall Performance of the Integrated Power Plant with CO_2 Capture has to be assessed

Required Heat & Power for the CO2 Capture Processes

Heat:

- Steam: Power output reduction = f(steam mass flow & pressure)

Power:

- CO_2 compressor: Power demand = f(CO_2 mass flow, CO_2 inlet & discharge pressure, impurities, distance to storage)
- Auxiliaries (pumps, fan, ...): Power demand = f(process parameters)

Power Plant Operation with Integrated CO_2 Capture

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Plant Reliability

- Annual operation time: ~8000 hours
- Plant life time: ~40 years
- The CO2 capture to be designed for the power plant transient operation, shut-down and start-up

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