LOW-COST CO_2 CAPTURE BY CHEMICAL LOOPING COMBUSTION OF WASTE-DERIVED FUELS

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Demonstration plant concept

LOUISE

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Outline

- Introduction
- Reactor system
- Fluegas cleaning system
- CO_2 processing system
- Plant layout
- Conclusion

Introduction

Target: 10 MW_{th} demonstration plant (TRL 7)

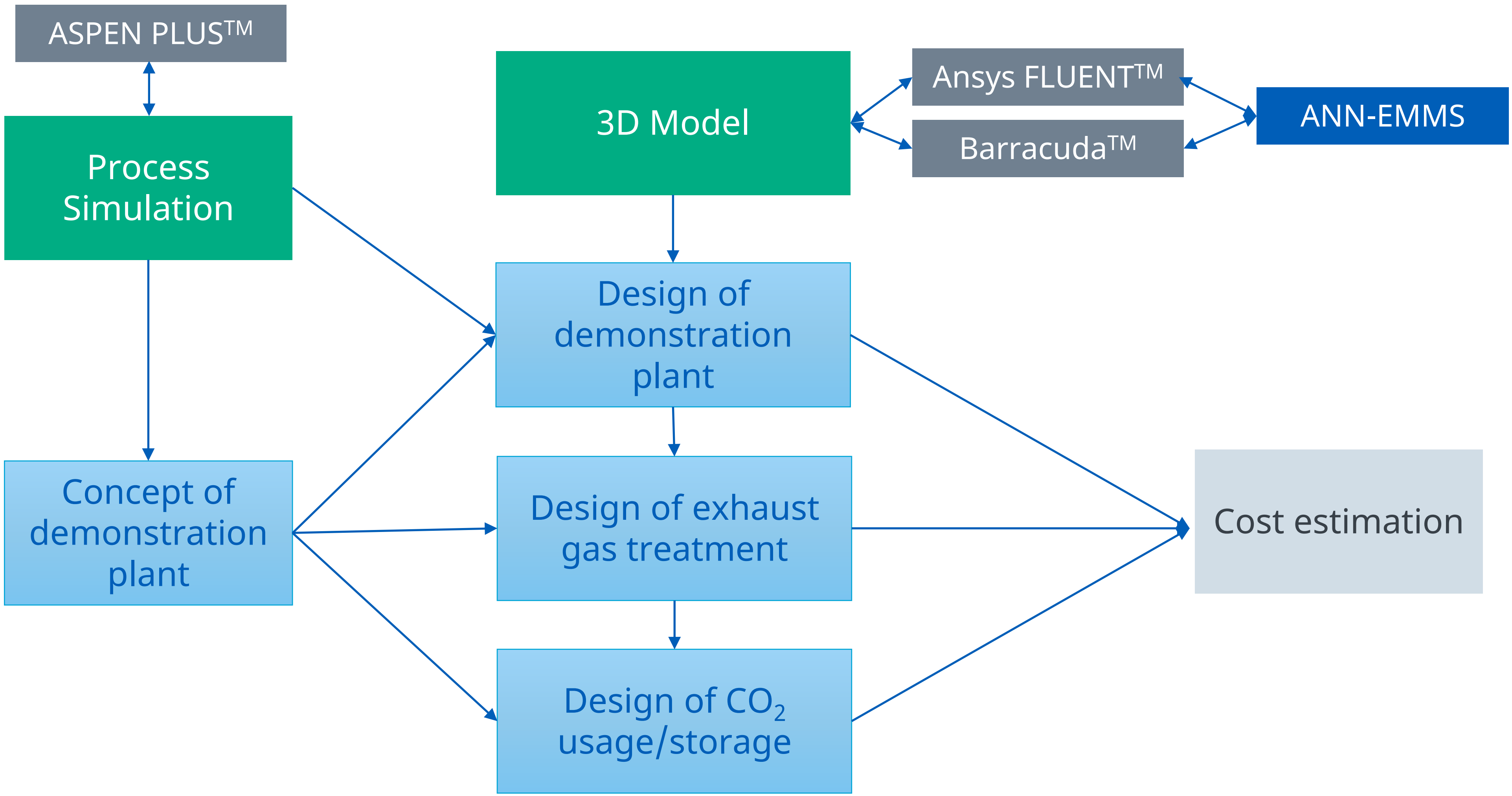
Fuel: Solid recovered fuel (SRF)

Work contents:

- Design of
    - Fluidized bed reactors
    - Exhaust gas treatment
    - Heat recovery
    - Usage or storage of CO_2

Introduction

Basic design of a demonstration plant

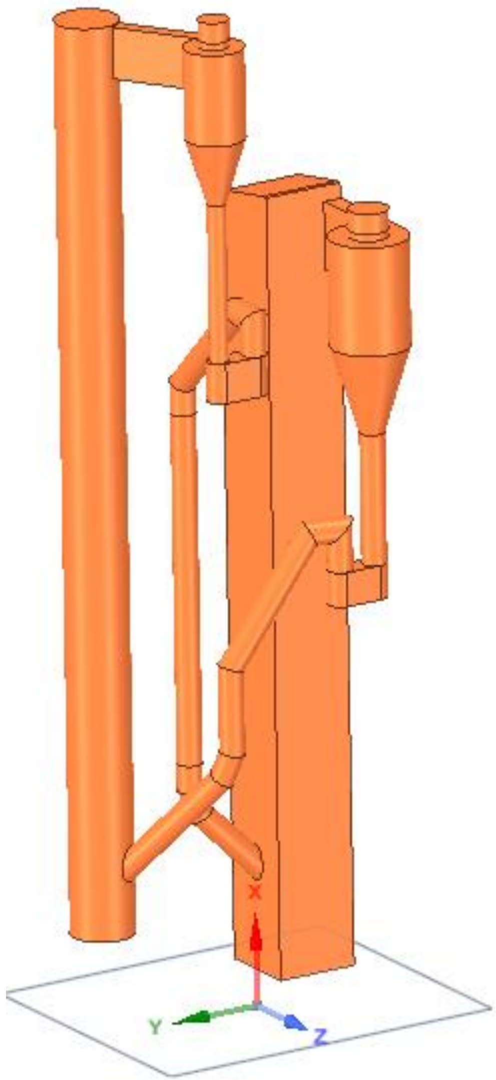


Status of concept

Status of concept

Reactor system:

- Two interconnected Circulating Fluidized Bed Reactors
- Air reactor is cooled (by means of evaporator membrane walls) and rectangular in design
- Fuel reactor is round and adiabatic design
- Two cyclones separate the solids from the exhaust gas flow and transports the particles to the other reactor
- A loop seal is fitted under both cyclones to pass the particles on without nitrogen entering the fuel reactor and without CO_2 or pyrolysis gases entering the air reactor.



Heat recovery system

- Water-Steam system: 60 bar, 430 ° C (corresponding to waste-to-energy plants)
- Natural circulation boiler
- Boiler efficiency 99.7%
- Electric efficiency 30.3%
- Air reactor:
    - External economizer 1
    - Superheater 1.3, 2
    - Evaporator:
        - Air reactor membrane walls
        - 1th pass membrane walls
        - 2nd pass membrane walls
- Fuel reactor:
    - External economizer 2, 3, 4
    - Superheater 1.1, 1.2
    - Evaporator:
        - 1st pass membrane walls with middle wall
        - 2nd pass membrane walls

Post oxidation chamber

- Unconverted pyrolysis gases (H_2, CO, CH_4 and other hydrocarbons) are oxidised in a combustion chamber using pure oxygen to H_2O and CO_2.
- The post oxidation chamber (POC) leads to a complete fuel conversion and increases the energy conversion
- Exhaust gas is recirculated to control the combustion temperatures. The design of the POC is based on a gas combustion chamber

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Status of flue gas cleaning system

Flue gas cleaning system

- Cleaning of FR flue gas (after Post oxidation chamber)
  - Removal of:
    - NO_x
    - SO_x
    - HCl, HF
    - Hg and PCDD/PCDF
    - Dust

- Cleaning of air reactor
  - Removal of:
    - Dust

Equipment & Process

- Low dust **S**elective **C**atalytic **R**eduction (SCR)

- Main components:
    - Ammonia Injection
    - Static Mixer
    - Reactor Housing
    - 1 Catalyst Layer

Chemical Reactions

Oxygen necessary!

$$4NO + 4NH_3 + O_2 \xrightarrow{\text{Catalyst}} 4N_2 + 6H_2O$$

$$6NO_2 + 8NH_3 \xrightarrow{\text{Catalyst}} 7N_2 + 12H_2O$$

Catalyst Operation Temperature

- Flue gas temperature range
- > 265° C to avoid ammonium bisulfate formation
- < 440 ° C to avoid catalyst material fusion

Parallel Reactions

$$NH_3 + SO_3 + H_2O \xrightarrow{\text{Catalyst}} NH_4HSO_4$$

Ammonium Bisulfate

$$2NH_3 + SO_3 + H_2O \xrightarrow{\text{Catalyst}} (NH_4)_2SO_4$$

Ammonium Sulfate

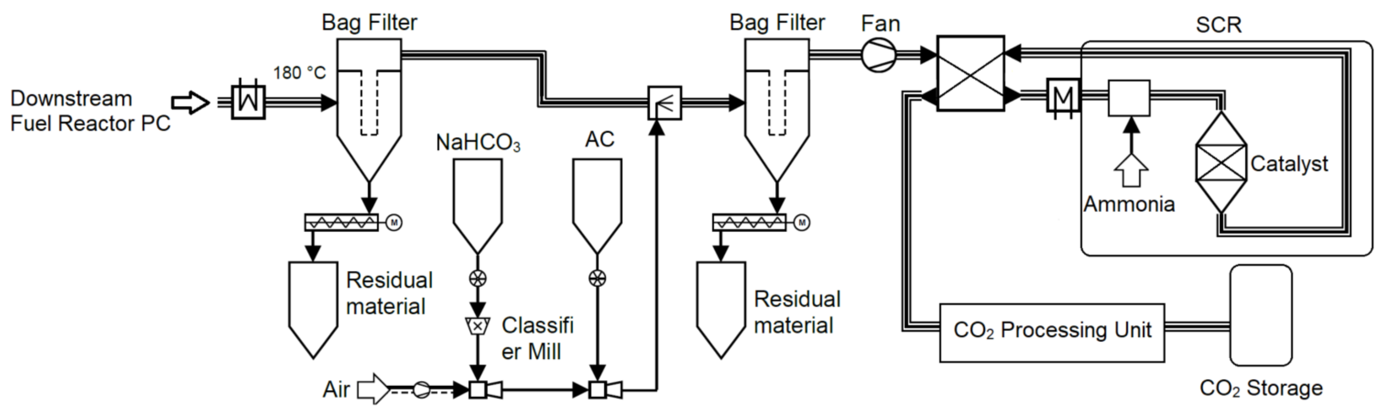
Both salts form at flue gas temperatures below 320°C

Dry sorption using sodium bicarbonate

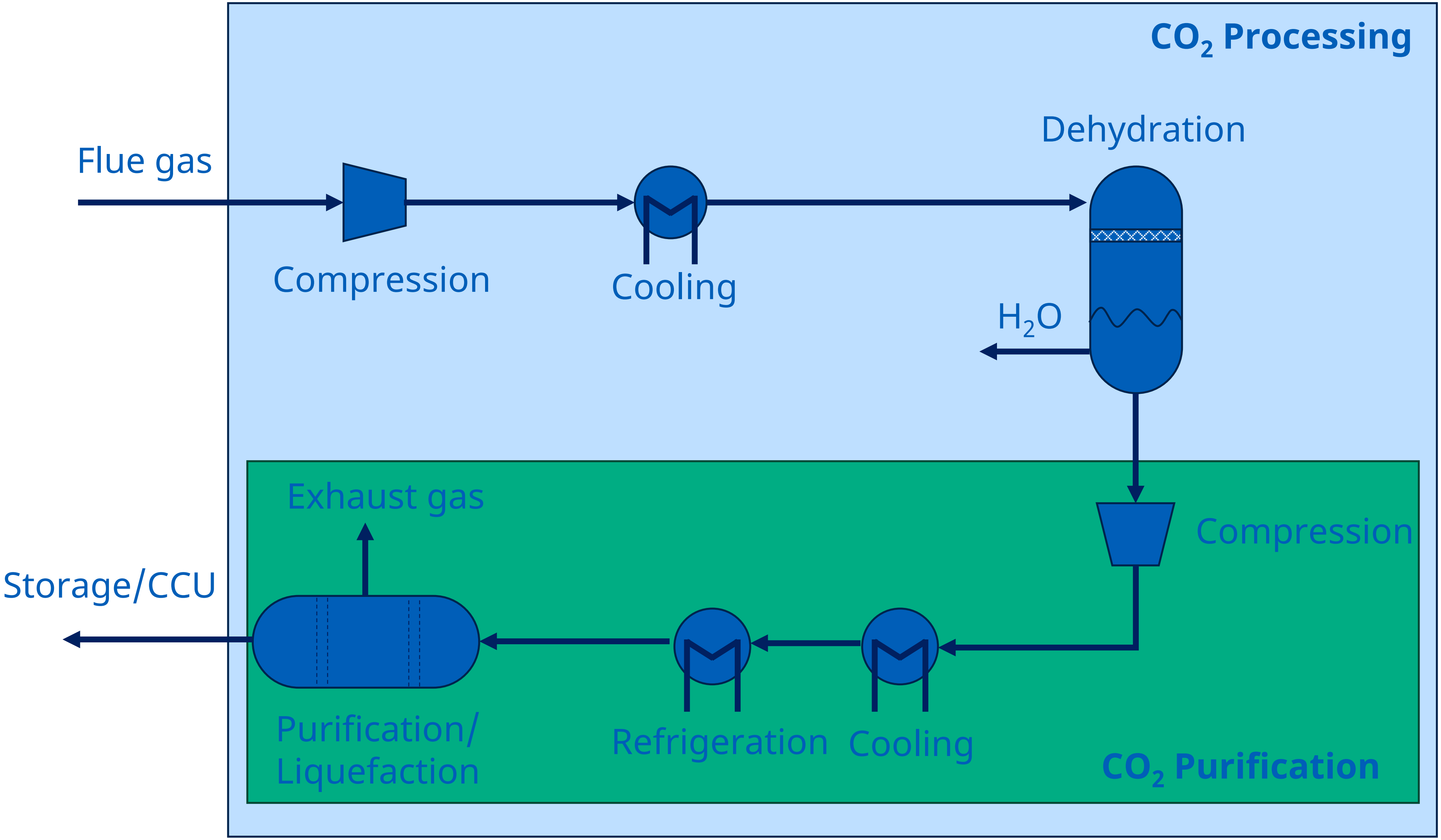
- **Dry sorption:**
- Dosing of sodium bicarbonate: separation of HCl, HF and SO_X
- Dosing of activated carbon: separation of Hg and PCDD/PCDF

Fabric filter:

- Separation of fly ash, dust and reaction products
- Outward transfer of residues into the residues silo
- Recirculation of residues into the circulating fluidized bed reactor

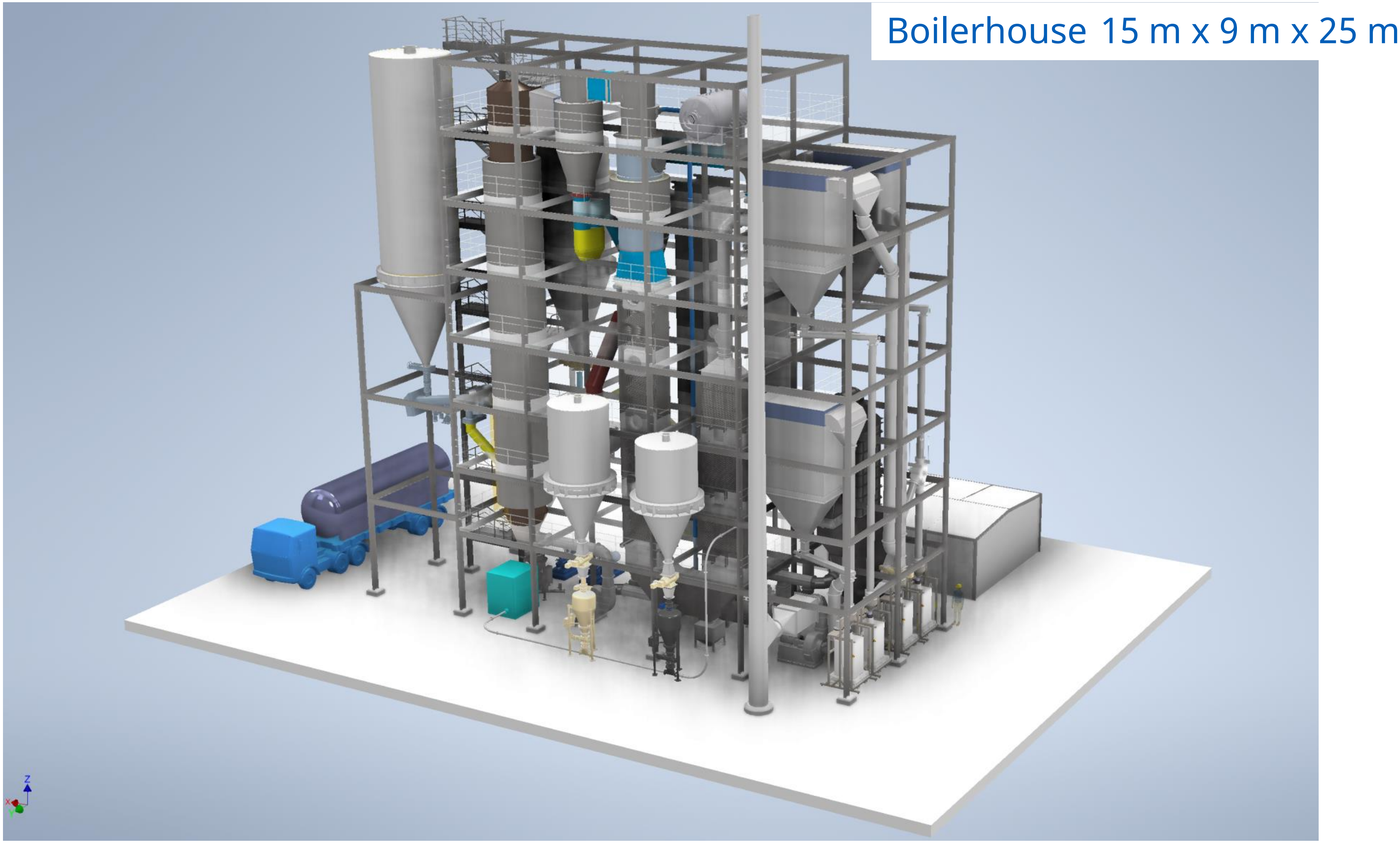


CO_2 processing



Toftegaard, M. B., Brix, J., Jensen, P. A., Glarborg, P., & Jensen, A. D. (2010). Oxy-fuel combustion of solid fuels. *Progress in Energy and Combustion Science*, *36*(5), 581-622. https://doi.org/10.1016/j.pecs.2010.02.001

Layout reactorsystem



Conclusion

- Two interconnected CFBs
- Water-Steam system corresponding to waste-to-energy plants to prevent corrosion
- Post oxidation chamber oxidise not converted pyrolysis gas
- SCR system to remove NOx
- Sodium bicarbonate & activated carbon in two-pass reactor to remove SO_x, HCl, HF, Hg and PCDD/PCDF
- Fabric filters to remove particles

Thank you for your attention!
Do you have any questions?

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