Stabilization of hazardous waste by using CO_2-rich flue gas – Carbon Capture and Storage

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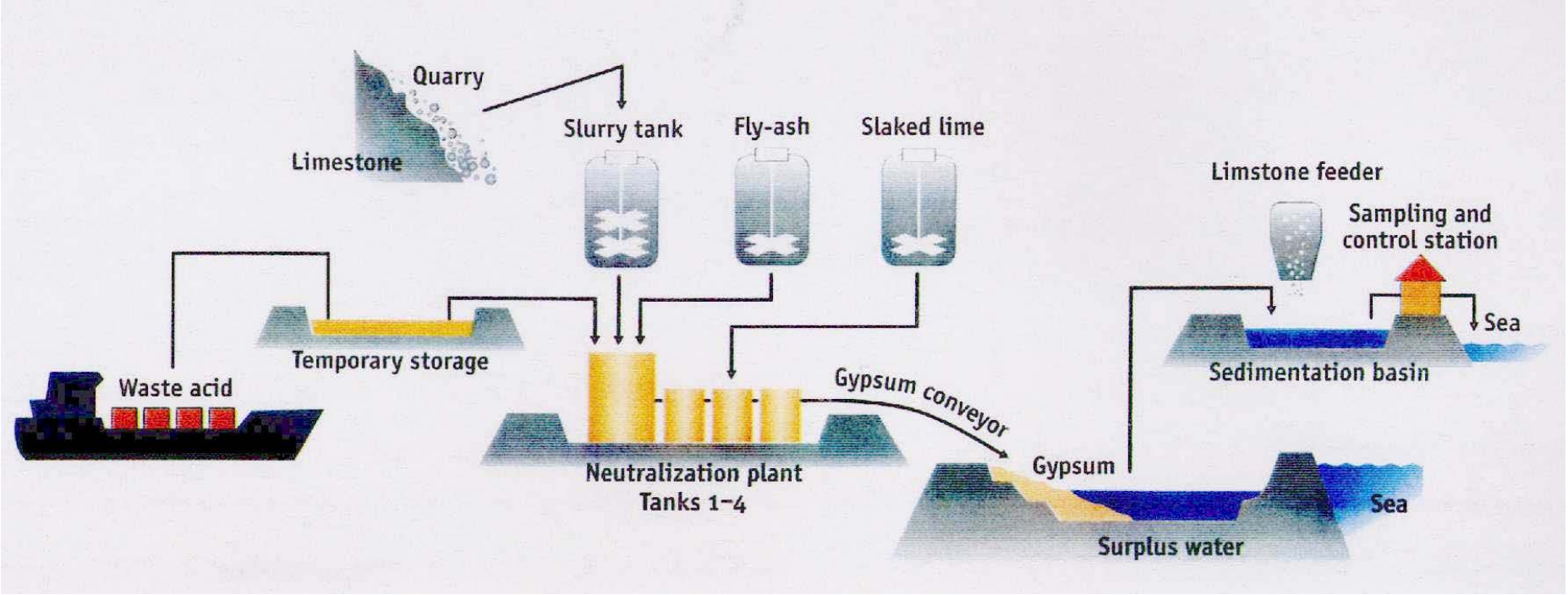
Langøya Island

Neutralisation process

Sulphuric acid is neutralised by using alkaline fly ash from incinerators of solid municipal waste

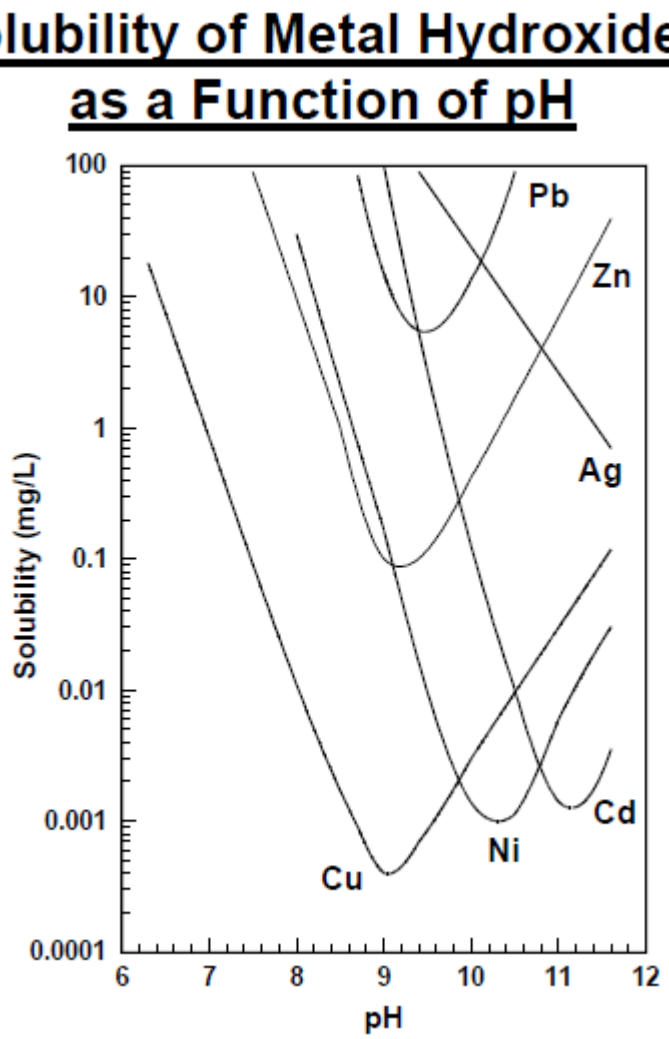
- 200 000 m^3/year 25 % H_2SO_4
- 300 000 tonnes/year fly ash

$$H_2SO_4 + CaO/\text{fly ash} \rightarrow CaSO_4 + \text{stabilised fly ash}$$



Properties of fly ash

- Fly ash contains:
  - 5-20 % CaO (pH 12.2-12.4)
  - 1-3 % heavy metals
- Leaching of heavy metals is high in alkaline environment
- pH needs to be lowered to about 10 to reduce leaching of heavy metals
- CO_2 is an excellent acid to neutralise fly ash
  - $CO_2 + CaO \rightarrow CaCO_3$
- $CaCO_3$ ensures an «infinite» pH buffer effect



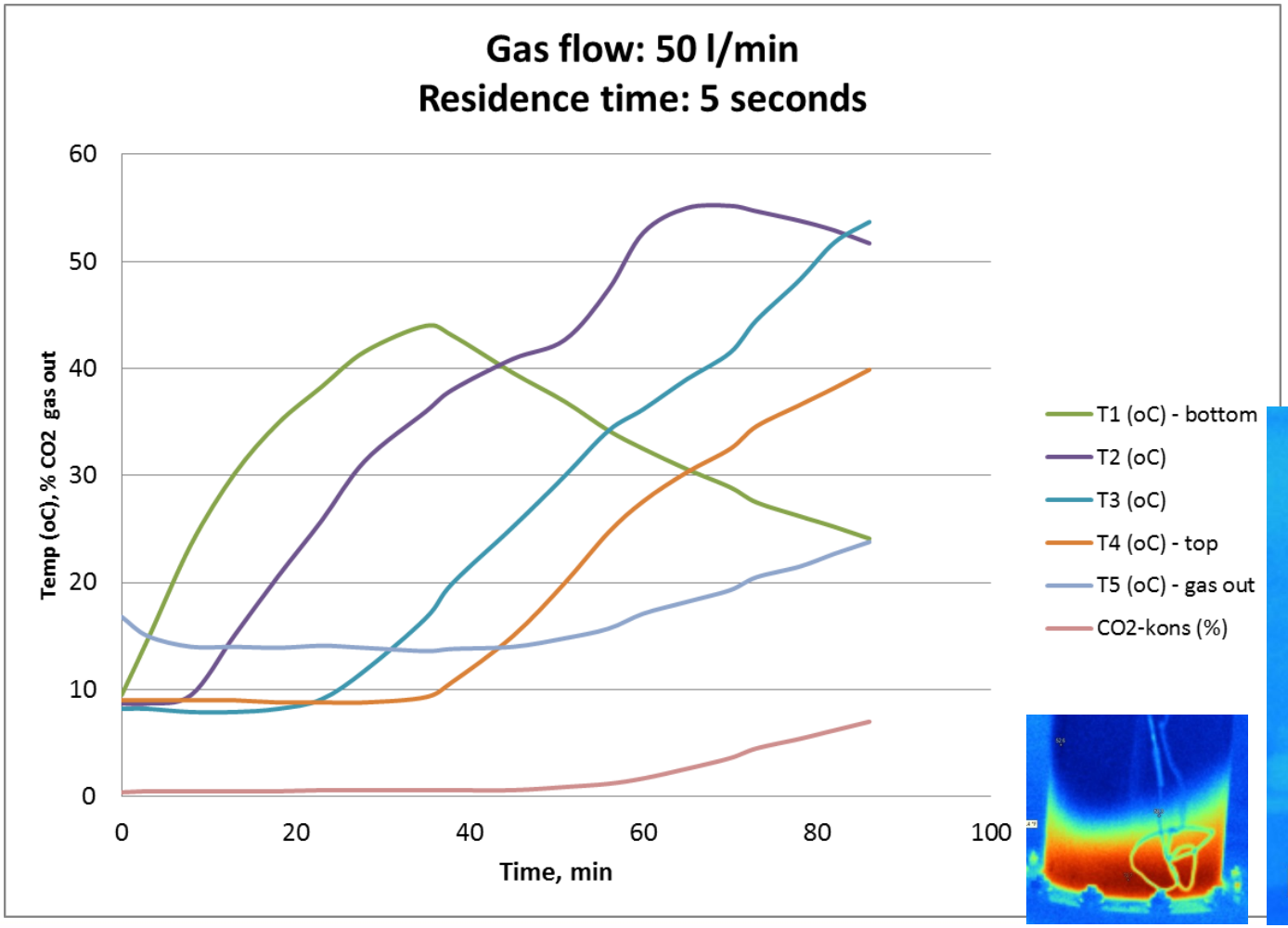
Possible reaction routes

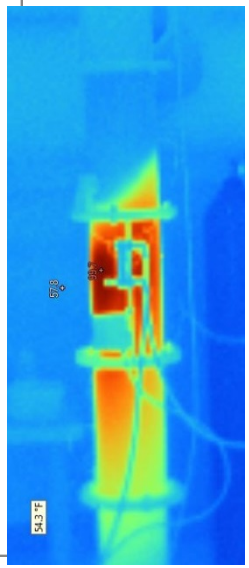
- Dry fly ash – requires high temperatures (>400 ^{o}C)
  - $CO_{2(g)} + CaO_{(s)} \rightarrow CaCO_{3(s)}$
- Slurry – diffusion limited, slow reaction
- Moist fly ash – fast reaction and works and ambient temperature and pressure. Water phase reaction:
  - $CO_{2(aq)} + Ca(OH)_{2(aq)} \rightarrow CaCO_{3(s)} + H_2O_{(l)}$

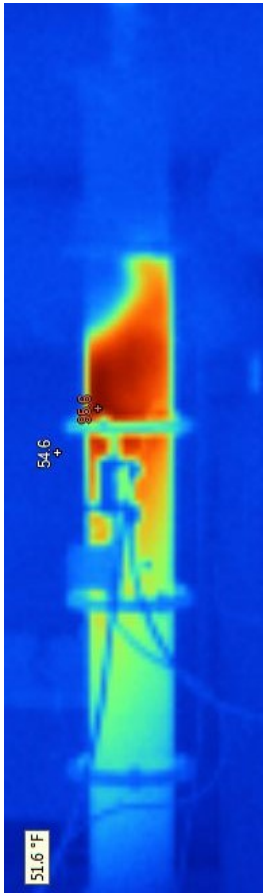
Reaction kinetic experiments

- **Fly ash mixed with water**
  - 40-60 kg
- **Gas**
  - 18 % CO_2 and 82 % Argon
  - Heated to 0-20 ^oC prior to reaction
- **Fixed bed reactor**
  - D_{inner} = 188 mm, H =1600 mm bed
- **Flow**
  - 50 l/min
  - Assuming 90 % packing → 27 cm/s
    (residence time: 5 seconds)

Results


Gas flow: 50 l/min
Residence time: 5 seconds
Temp (oC), % CO2 gas out
60
50
40
30
20
10
0
0
20
40
60
80
100
Time, min
T1 (oC) - bottom
T2 (oC)
T3 (oC)
T4 (oC) - top
T5 (oC) - gas out
CO2-kons (%)




54.6
51.6 °F

Conclusions

- Extremely rapid reaction → commercially interesting
- Leaching of heavy metals after carbonation is very low – similar to our established process on Langøya (H_2SO_4)
- CO_2 uptake of 50-100 grams/kg fly ash
- Fixed bed reactors have some major flaws:
  - Channelling of gas
  - Difficult to charge and discharge
- After two years of research and testing of different reactor concepts, we have opted for a paddle mixer reactor
  - Ensures homogenous reaction between CO_2 and fly ash

Demotest - Norcem

- NOAH received nearly MNOK 4 funding from Gassnova to verify whether CO_2 rich flue gas from Norcem can be used to stabilise fly ash
- Aker Solutions is also testing their amine technology in Brevik, and NOAH gets conditioned gas from Aker's direct contact cooler
- Installed a paddle mixer batch reactor
  - 1000-1500 kg of fly ash
  - Continuous feeding of gas (200-500 Nm^3/h)
- Started up testing in May 2015 and will be testing until September 2015

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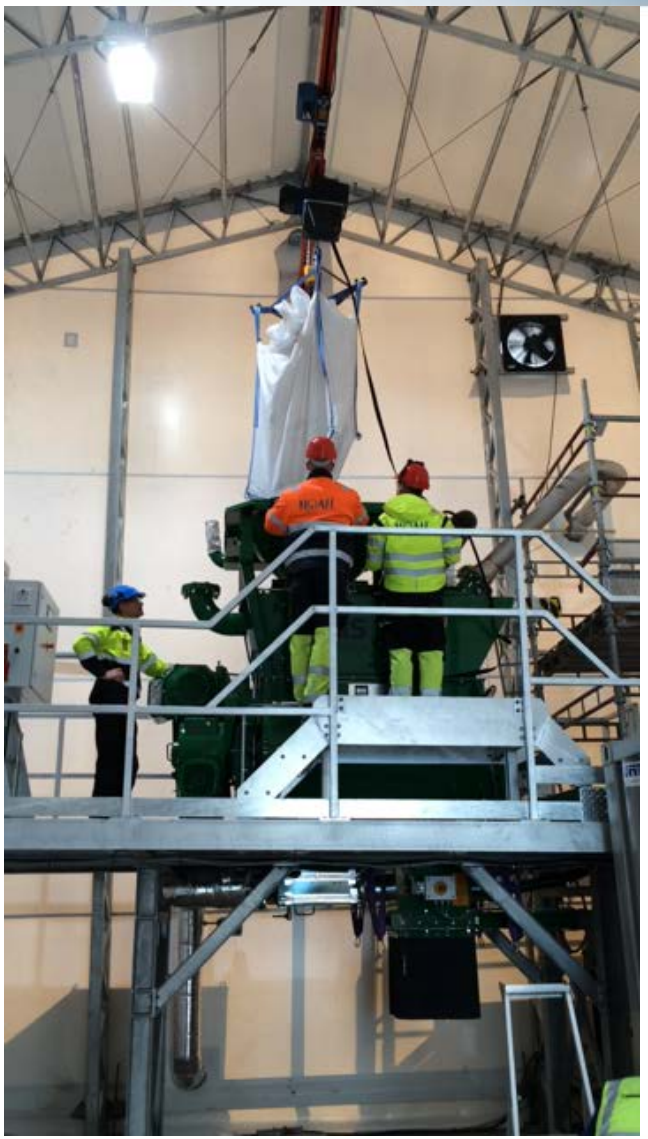
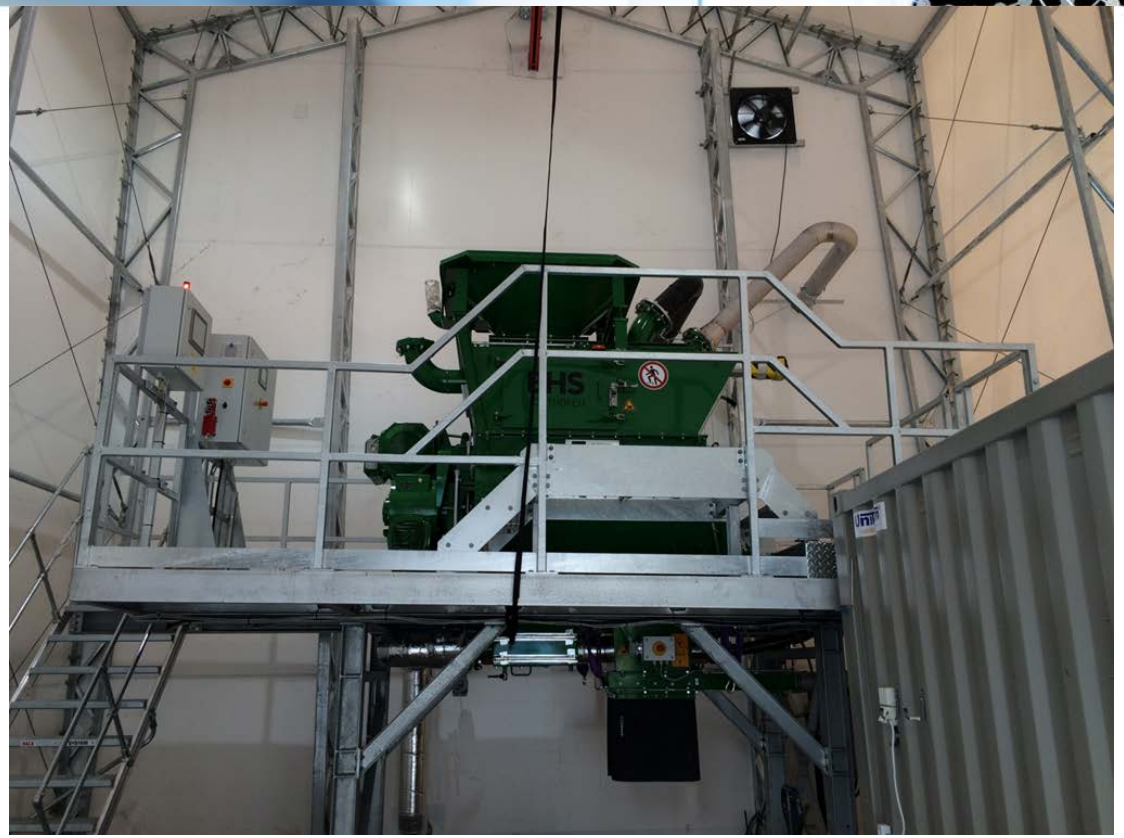
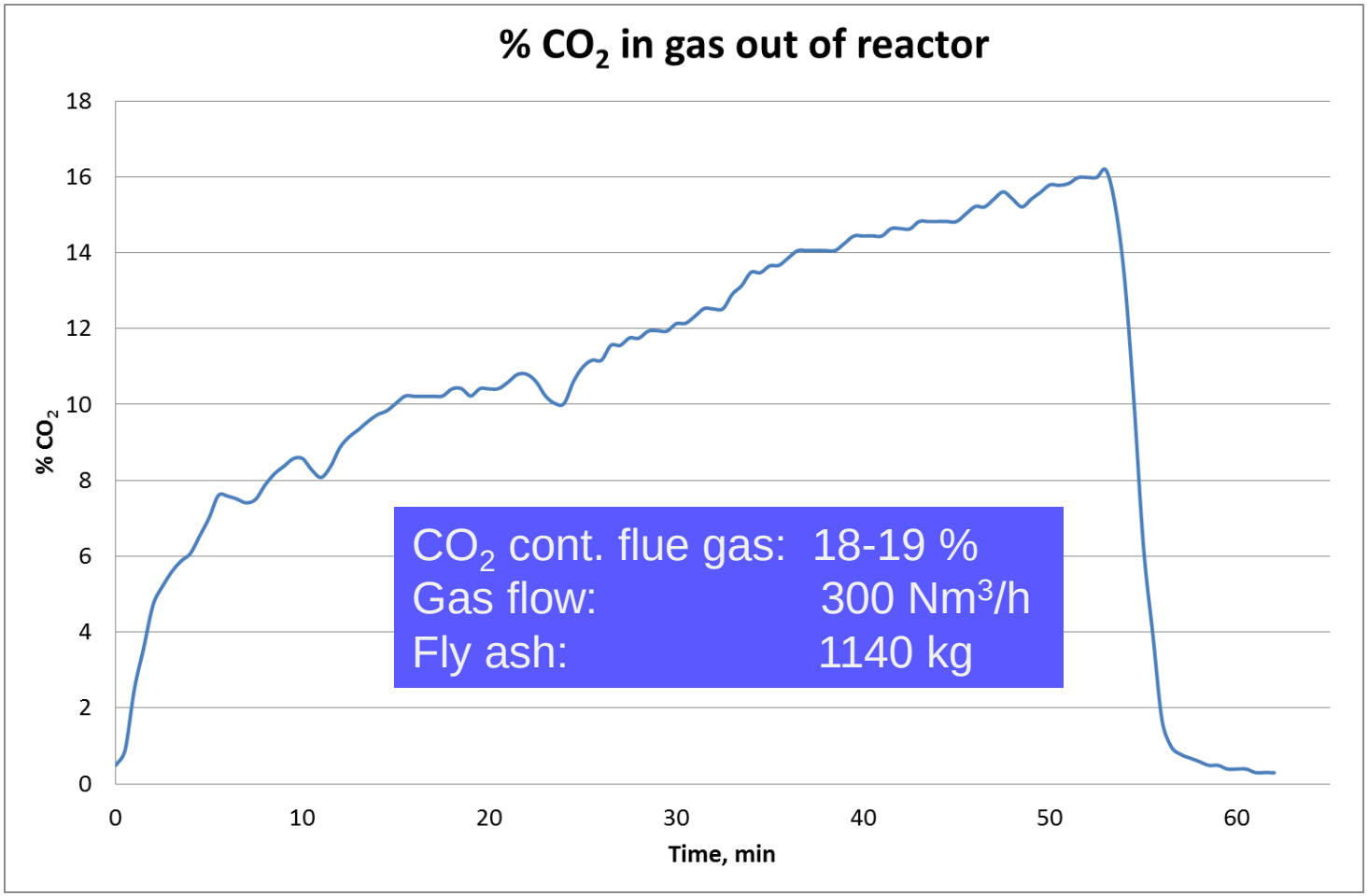
CLIMIT



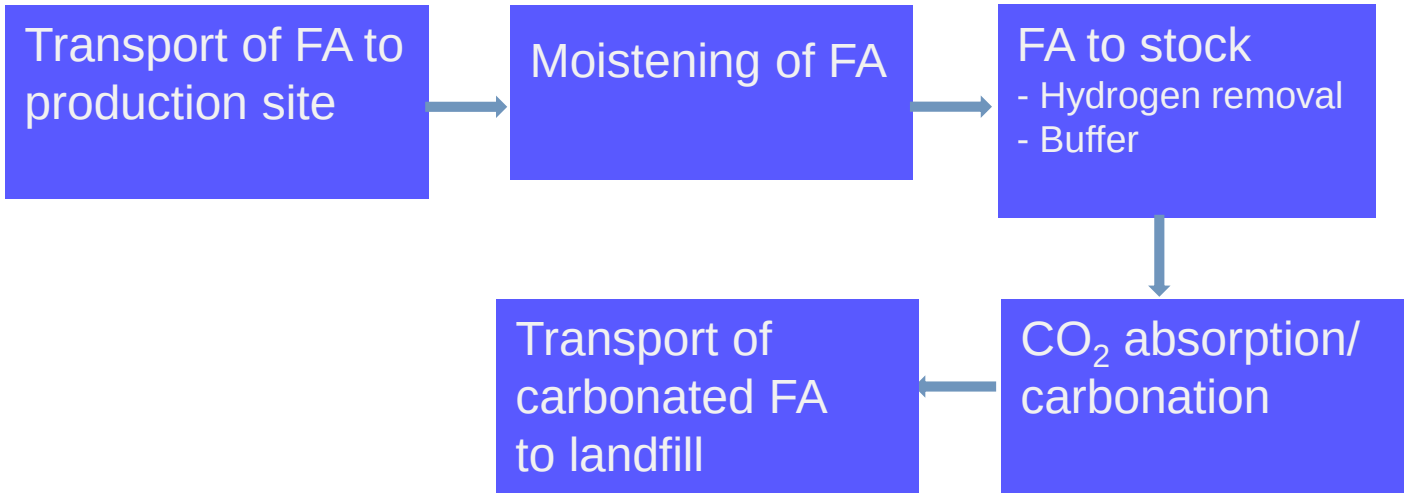



% CO2 in gas out of reactor
18
16
14
12
10
8
6
4
2
0
% CO2
0
10
20
30
40
50
60
Time, min
CO2 cont. flue gas: 18-19 %
Gas flow: 300 Nm3/h
Fly ash: 1140 kg

Preliminary results

- Robust system
- Easy to charge and discharge the reactor
- Distribution of gas to reactor works very well
- Paddle mixer reactor ensures that all fly ash gets in contact with the flue gas
- pH of the ash after carbonation is about 10
  - Low leaching of heavy metals
- One hour residence time

Process flow – full scale carbonation process of fly ash (FA)



- Future plans to treat and stabilise 500 000 tonnes of fly ash pr year
- Capture and permanent storage of 25 000 – 50 000 tonnes CO_2 pr year

Thank you for your attention!