CICCS
CENTRE FOR INNOVATION IN CARBON CAPTURE AND STORAGE

HERIOT WATT UNIVERSITY

Making Carbon Capture Feasible:

Development of a Circulating Fluidised Bed with Microwave Regeneration

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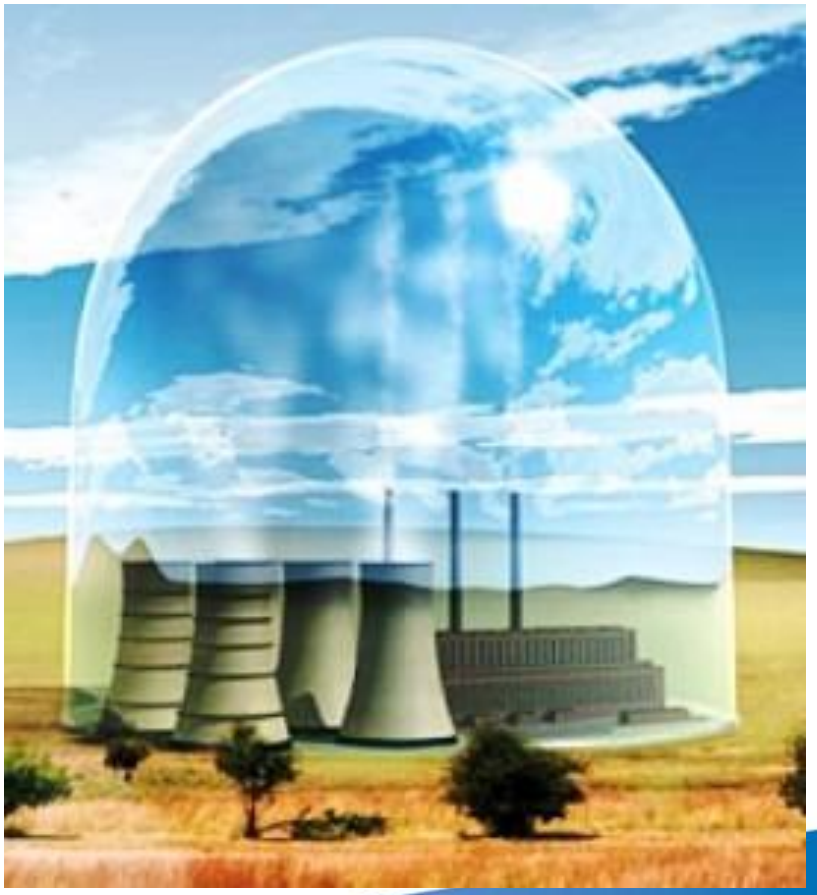
PIN Meeting – Newcastle 2013

Overview

- Introduction
  - Is CCS competitive?
  - Costs & Energy penalties in IGCC
  - Areas for improvement
- Project description
  - IGCC power plant
  - Process Intensification Hypothesis
  - Project model
  - Previous evidence
  - Current work



Source: www.ecohustler.co.uk

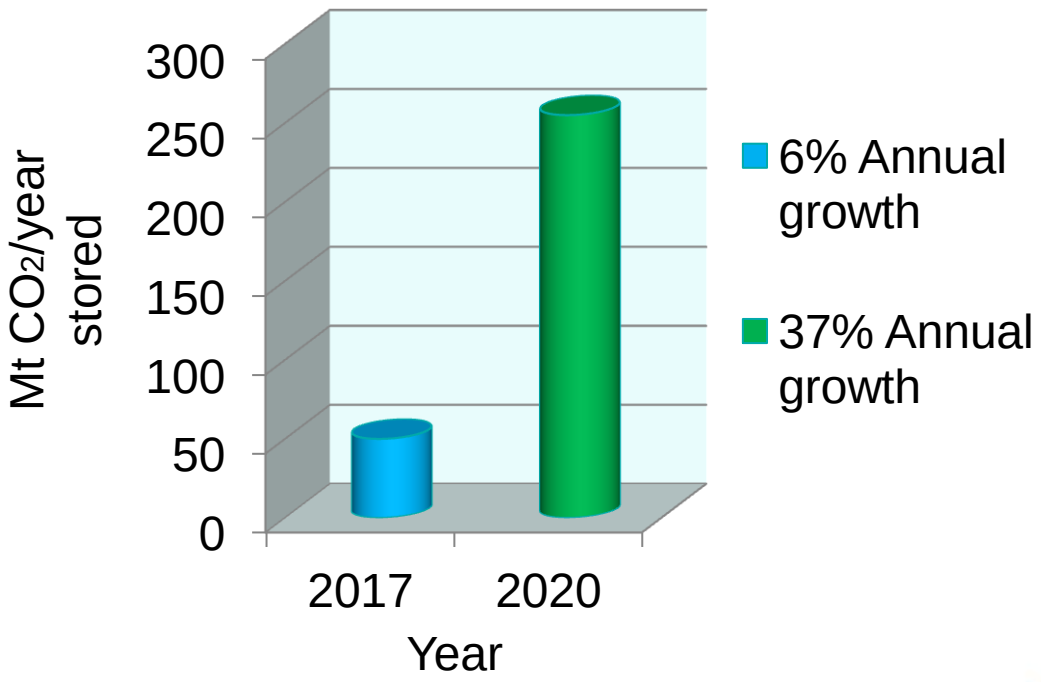
Is CCS Competitive?

Abatement costs

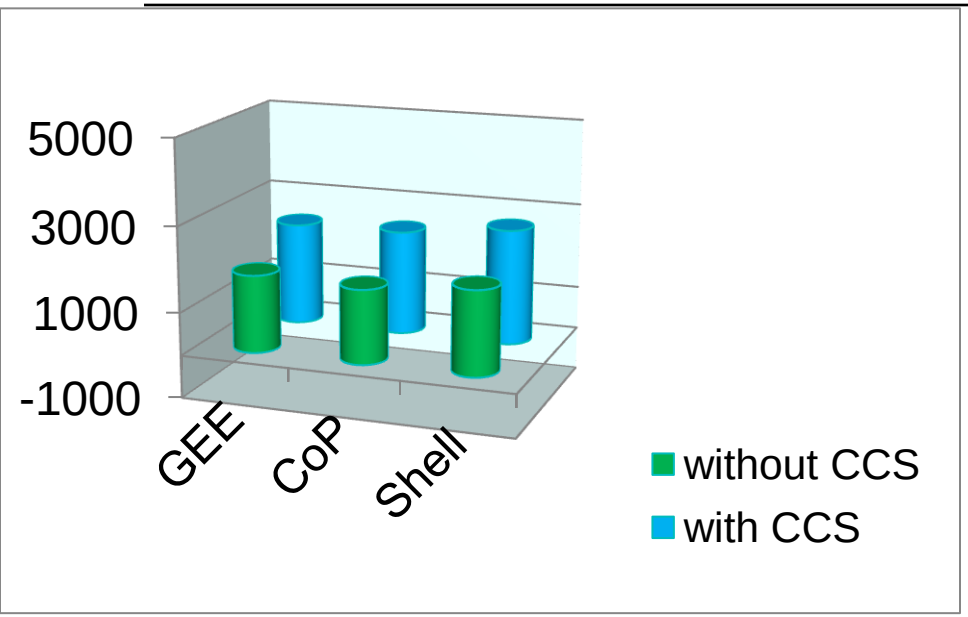
- Coal fired electricity with CCS:
  - $54 - $92/t CO_2
- Replace coal with:
  - solar plants: $105 - $239/t CO_2;
  - Wind farms: $90 - $176/t CO_2

Data: SBC Energy Institute, 2013, published in CCJ Jan – Feb 2013

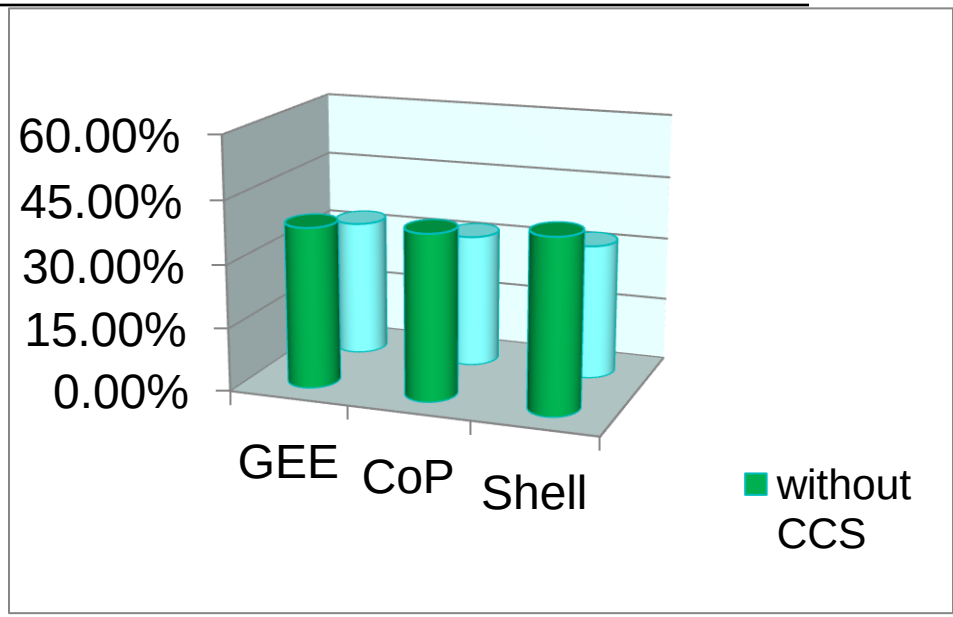
Projected and hypothetical CO_2 stored



Costs & Energy penalties in IGCC Power Plants



Total Plant cost



Net plant efficiency

IGCC without CCS: $78/MWh (at 80% capacity factor)
IGCC with CCS : $106/MWh

Source: Wimer et. al, 2007 IGCC Plants With and Without Carbon Capture and Sequestration

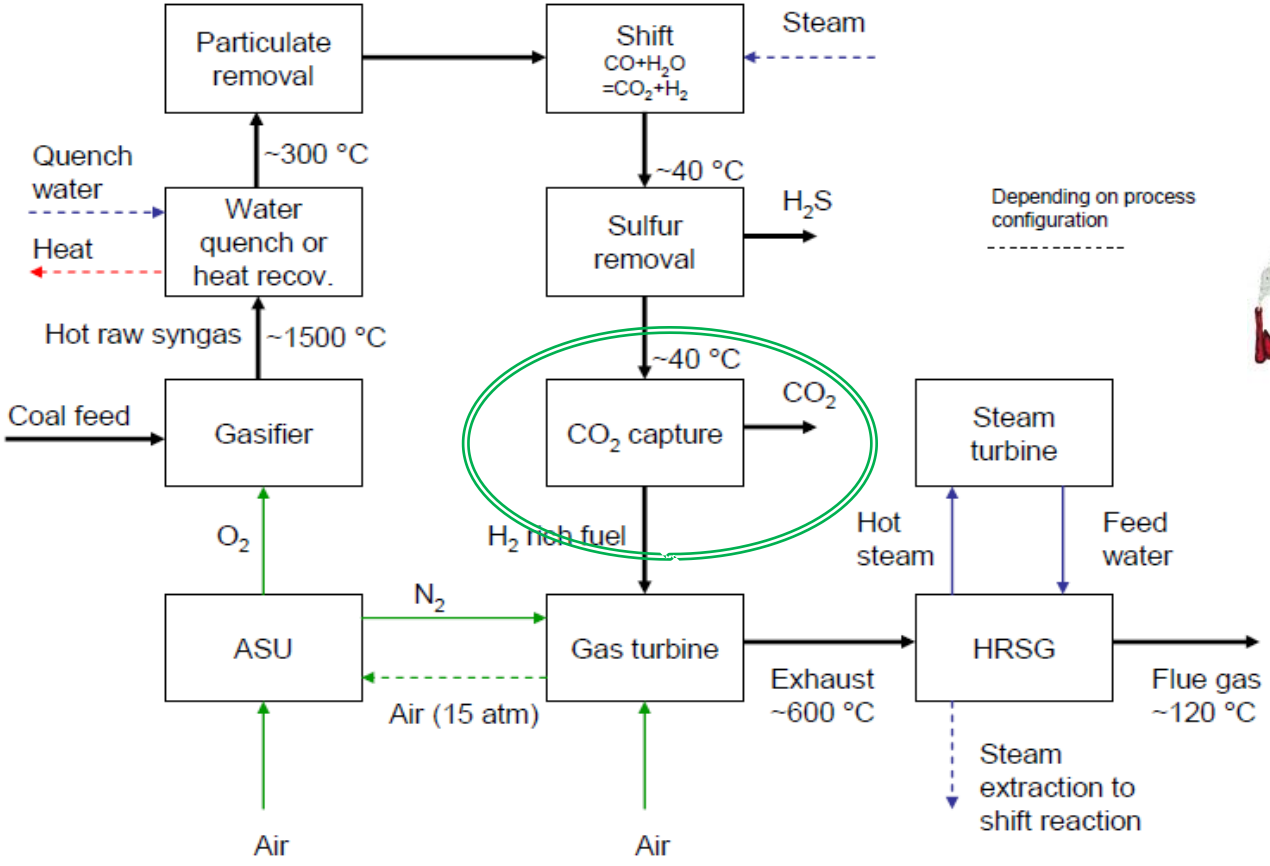
Areas for Improvement

- ❑ Innovative process concepts discovery;
- ❑ Design, synthesis and assembly of novel low-cost material architectures;

✓Outcome:

- Higher mass transfer rates;
- Improve overall kinetics;
- Lower costs;
- Improve CO_2 adsorption capacity;
- Lower energy penalty

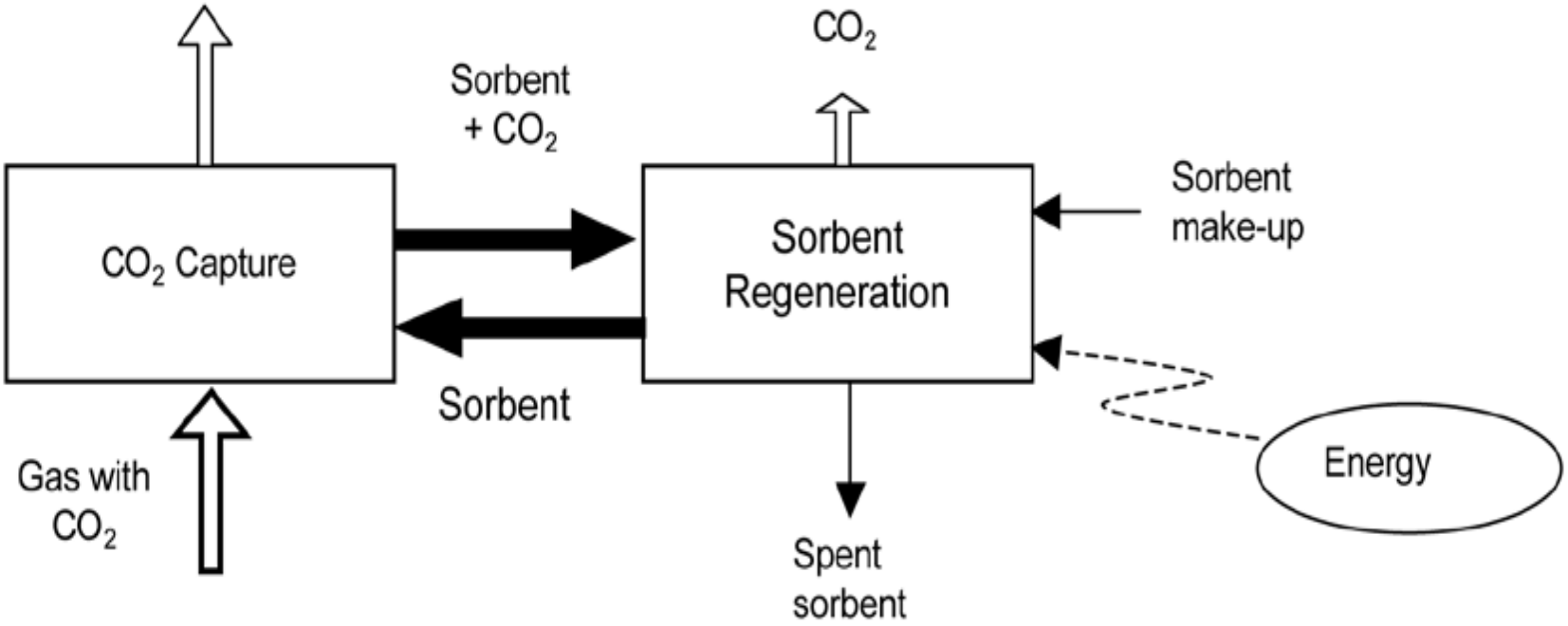
IGCC Power plant



Source: www.ecohustler.co.uk

Source: Maurstad, O., 2005, An Overview of Coal based Integrated Gasification Combined Cycle (IGCC) Technology

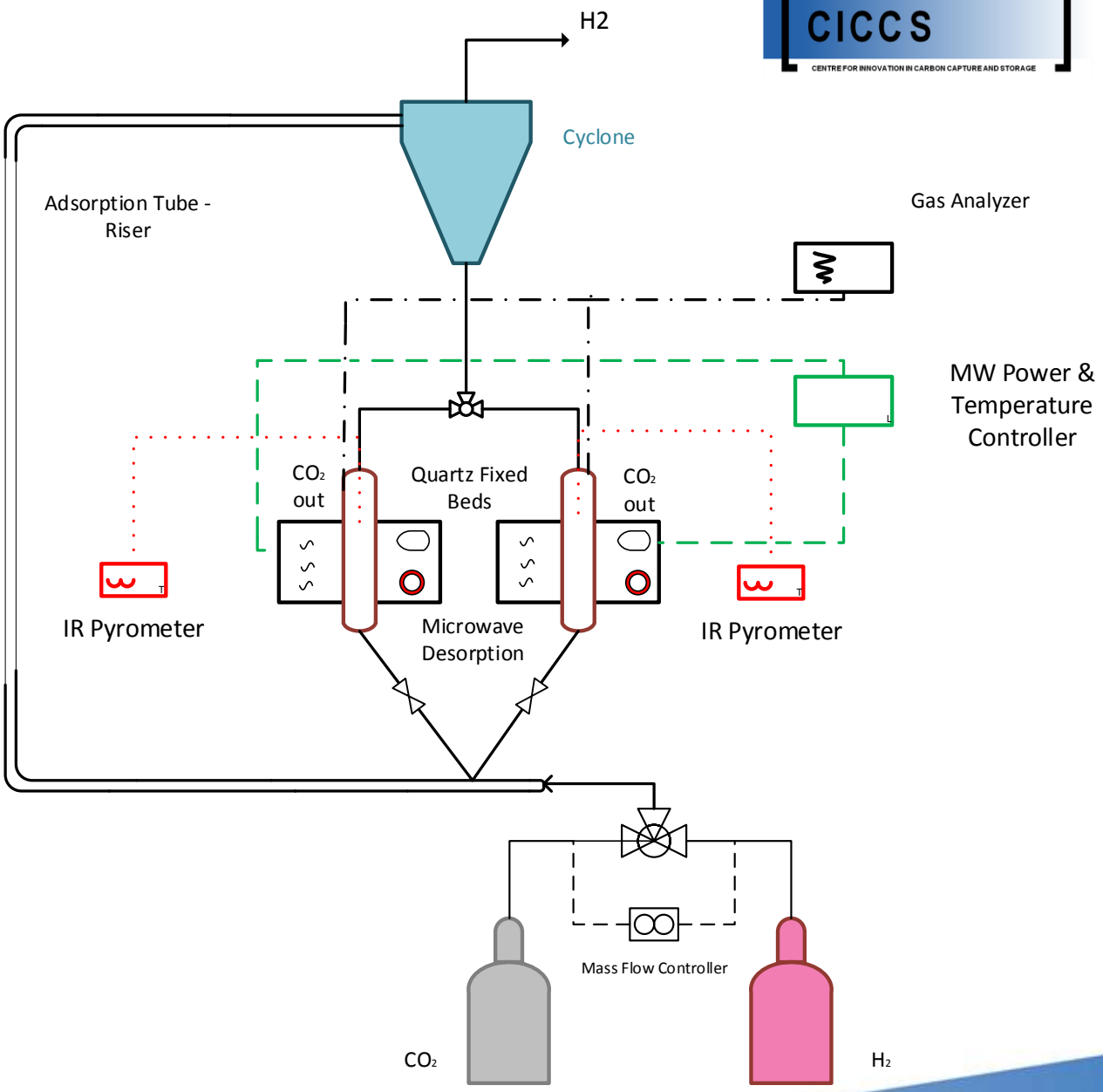
Adsorption/Desorption cycles



Source: *2005, Carbon Dioxide Capture and Storage*

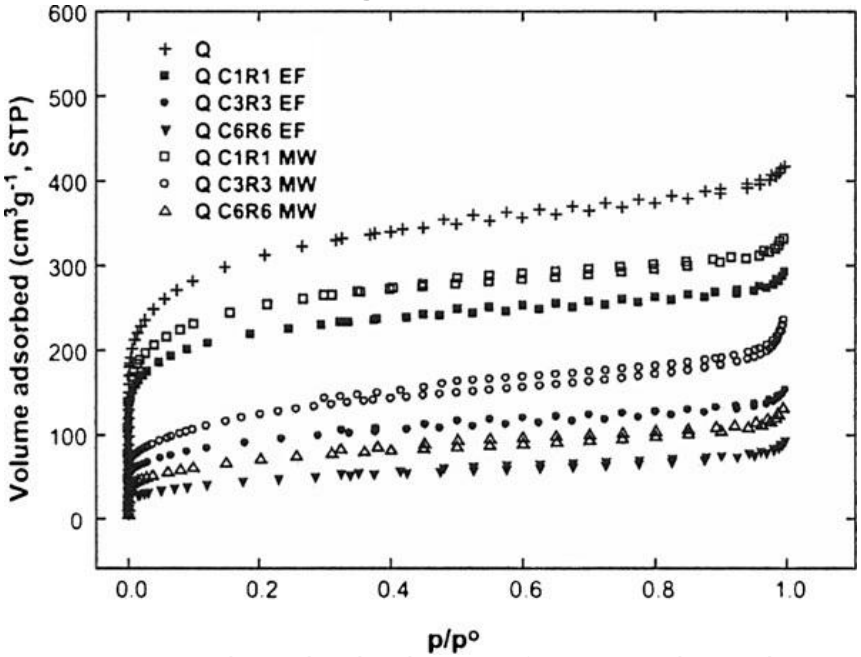
Process Intensification Hypothesis

- Replace fixed bed with a Circulating Fluidized Bed (CFB):
  - faster adsorption kinetics;
  - Increase the mass transfer rate;
  - Increase the surface area exposed to the gases for separation;
  - High gas-flow rates with a low pressure drop are possible;
- Use microwaves for regeneration:
  - Faster desorption ratio;
  - Lower energy consumption;
  - Sorbent preservation ⟶ More regeneration cycles


H2
Cyclone
Adsorption Tube - Riser
Gas Analyzer
MW Power & Temperature Controller
CO2 out
Quartz Fixed Beds
CO2 out
IR Pyrometer
Microwave Desorption
IR Pyrometer
Mass Flow Controller
CO2
H2

Previous Evidence for Microwave Regeneration

- Adsorption capacity after regeneration:



AC N_2 adsorption isotherms after 1,3 and 6 cycles. Comparison between Electric furnace and MW

- Time parameter:
  - Experimental temperature (850° C):
    - 5-6 min with MW;
    - 13 min with EF;
  - Regeneration:
    - 4-5 min with MW;
    - 37 with EF

Source: *Ania et.al, 2005, 'Effect of microwave and conventional regeneration on the microporous and mesoporous network and on the adsorptive capacity f activated carbons'*

Current Work

- Development of low-cost CO_2 sorbents from waste materials:
  - Microporous AC with 50-500μm particle size;
  - Impregnation with amines;
  - Sorbent characterisation;
- Design of the CFB reactor;
- Design of the MW desorption system;

Acknowledgements

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  - Prof. Raffaella Ocone
  - Prof. David Reay
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  - Dr. Yolanda Fernandez Diez

Source: www.ecohustler.co.uk

Thank you!!

Any Questions??

Source: www.ecohustler.co.uk