Chemical-looping combustion

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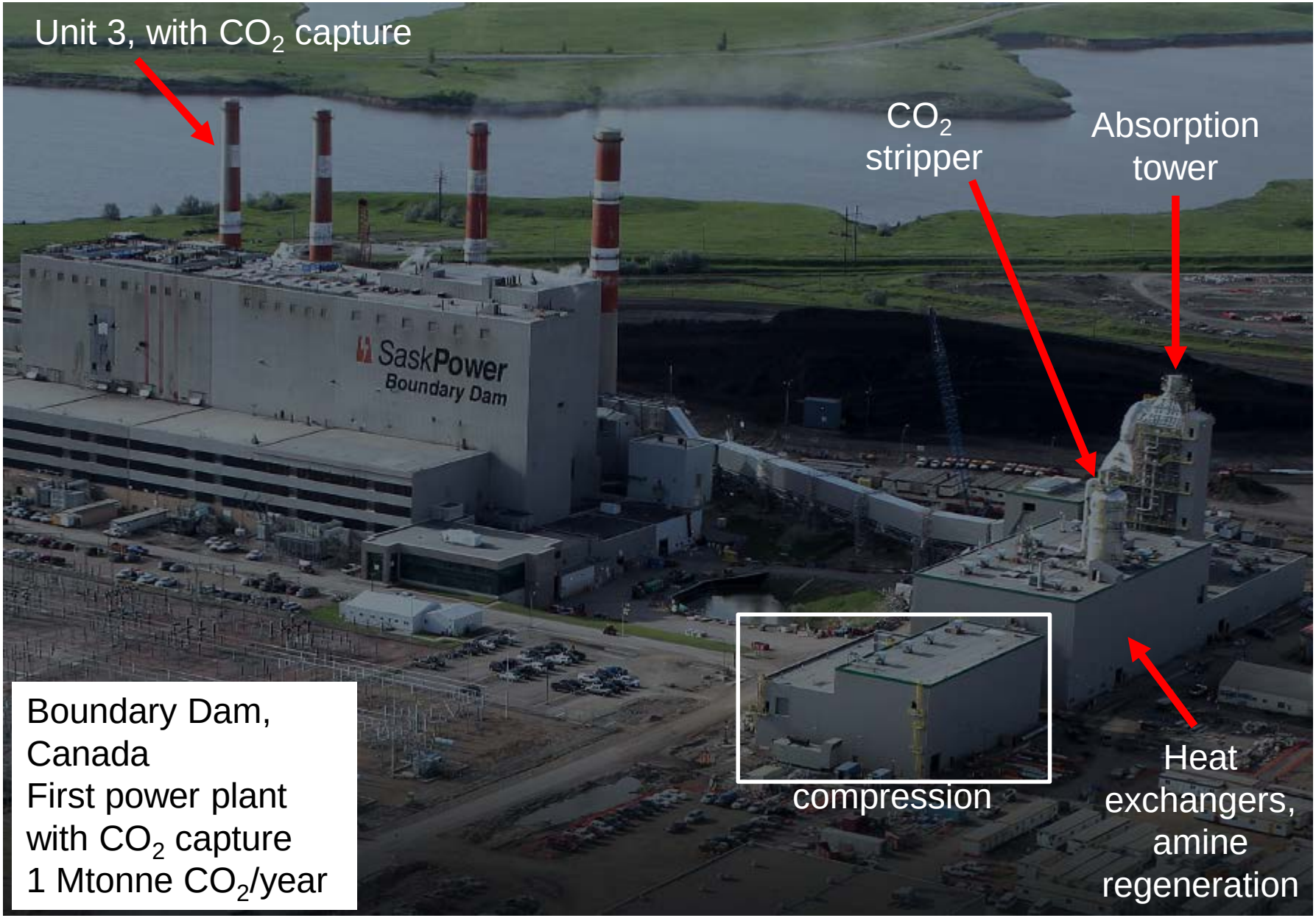
A cost breakthrough technology ?

Anders Lyngfelt

Prepared for GHGT-13 Panel Discussion:
Will advanced technologies significantly reduce the cost of Capture
November 16, 2016, Lausanne

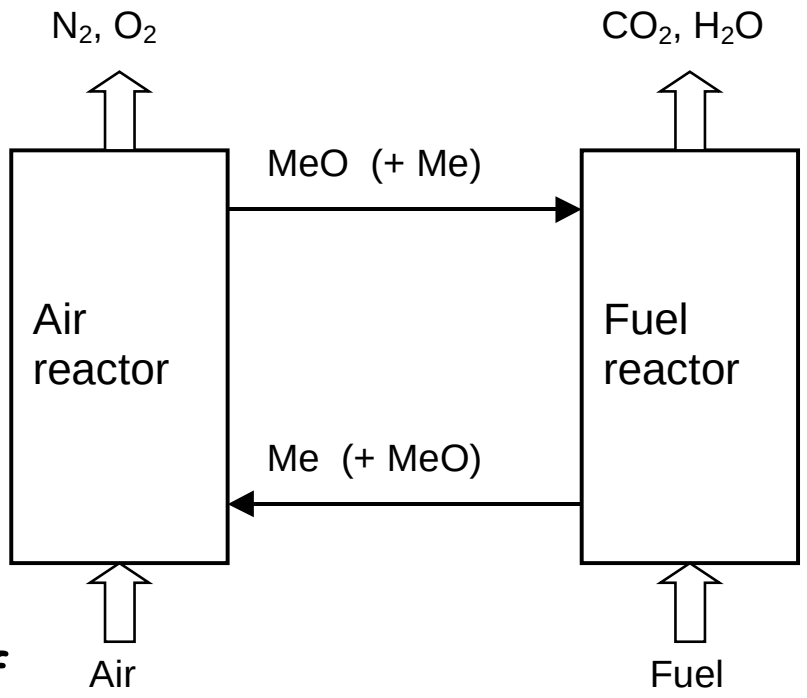

Unit 3, with CO_2 capture
CO_2 stripper
Absorption tower
SaskPower
Boundary Dam
compression
Heat exchangers, amine regeneration
Boundary Dam, Canada
First power plant with CO_2 capture
1 Mtonne CO_2/year

Why chemical-looping combustion (CLC) ?

Oxygen is transferred from air to fuel by metal oxide particles

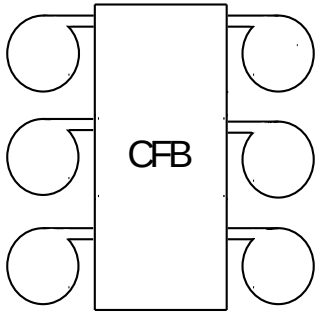
Inherent CO_2 capture:

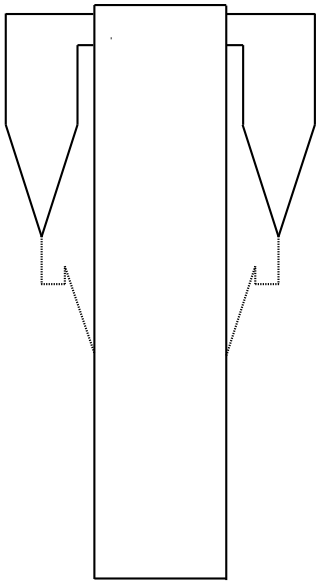
- fuel and combustion air *never mixed*
- *no active gas separation needed*
- large costs/energy penalties of gas separation avoided

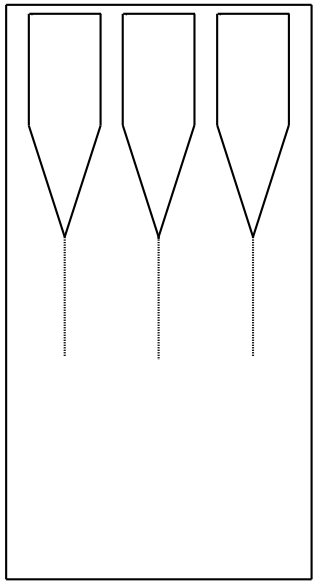


- **Potential for real breakthrough in costs of CO_2 capture**

1000 MW_{th}
CFB boiler
dimensions
11x25.5x48







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CLC boiler
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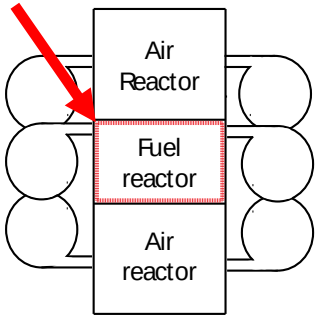
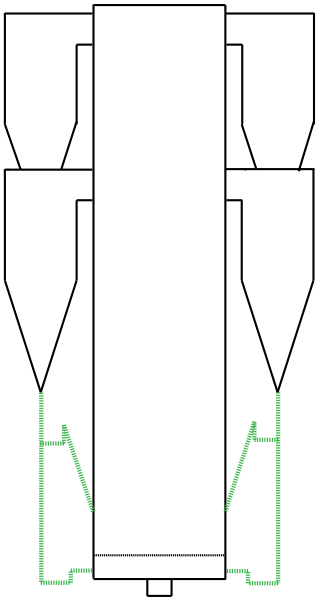
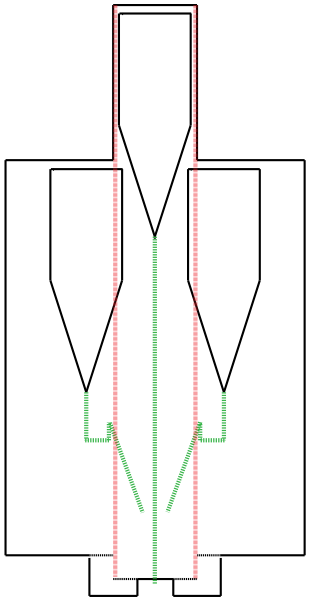
Added cost: insulation of fuel reactor







Fuel reactor, cyclones, ducts and post-oxidation chamber: 2500 m^2

Cost: 1500 €/m^2

Added cost of fuel reactor:

4 M€

⇒ 0.4 M€/year

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2 Mton CO_2/year

= 0.2 €/ton CO_2

From: Lyngfelt, A., and Leckner, B., A 1000 MWth Boiler for Chemical-Looping Combustion of Solid Fuels - Discussion of Design and Costs, *Applied Energy* in press *(available on-line)*

Other costs

- **CO_2 compression**
  - Similar to other capture technologies

- **Oxygen production (incomplete conversion)**
  - 5-10 times less oxygen needed compared to oxyfuel

- **CO_2 purification**
  - As in oxyfuel, option for SO_2/NO_x capture

- **Oxygen carrier**
  - With low cost ores, estimated to 1-4 €/tonne CO_2

- **Total costs, estimated to 16-26 €/tonne CO_2**

But does it work ?

- **CLC operation worldwide**
  - 34 pilots : 0.3 kW – 3 MW
  - >9000 h operation: of which solid fuels >3000 h

- **CLC with *solid* fuels**
  - Low cost oxygen carriers can be used
  - Incomplete conversion/capture
    - Some oxy-polishing needed, estimate: 10-20%
    - Up to 98% CO_2 capture attained

Conclusions

- **Low additional cost relative to CFB**
- **Major costs downstream**
  - CO2 compression
  - Oxygen production
  - CO_2 purification
- **Pilot operation shows process works**

THANK YOU !

QUESTIONS ?