Challenges to the Deployment of CCS in the Energy Intensive Industries

(Part 2: Cement Industry Sector)

Stanley Santos

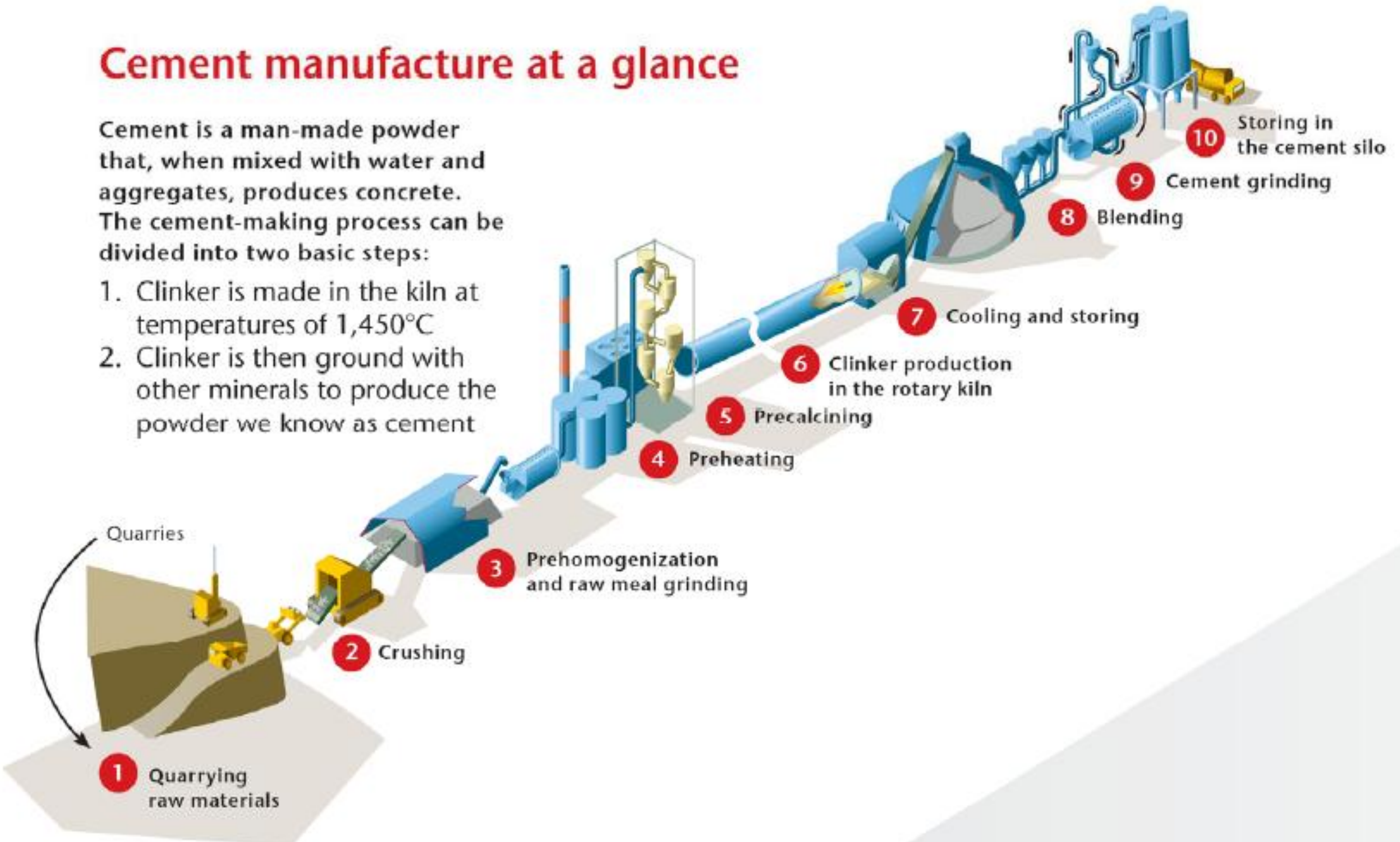
IEA Greenhouse Gas R&D Programme

Cheltenham, UK

Cement manufacture at a glance

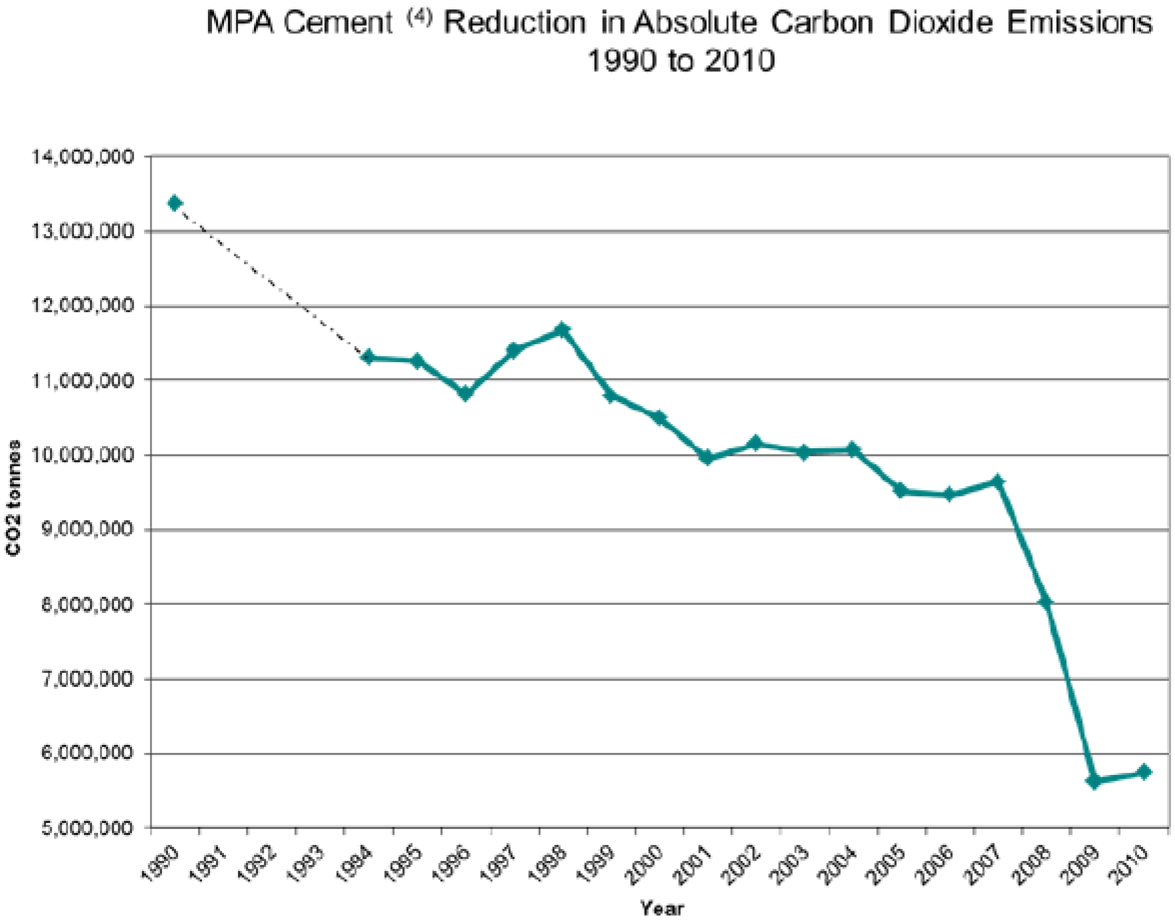
Cement is a man-made powder that, when mixed with water and aggregates, produces concrete. The cement-making process can be divided into two basic steps:

1. Clinker is made in the kiln at temperatures of 1,450°C
2. Clinker is then ground with other minerals to produce the powder we know as cement

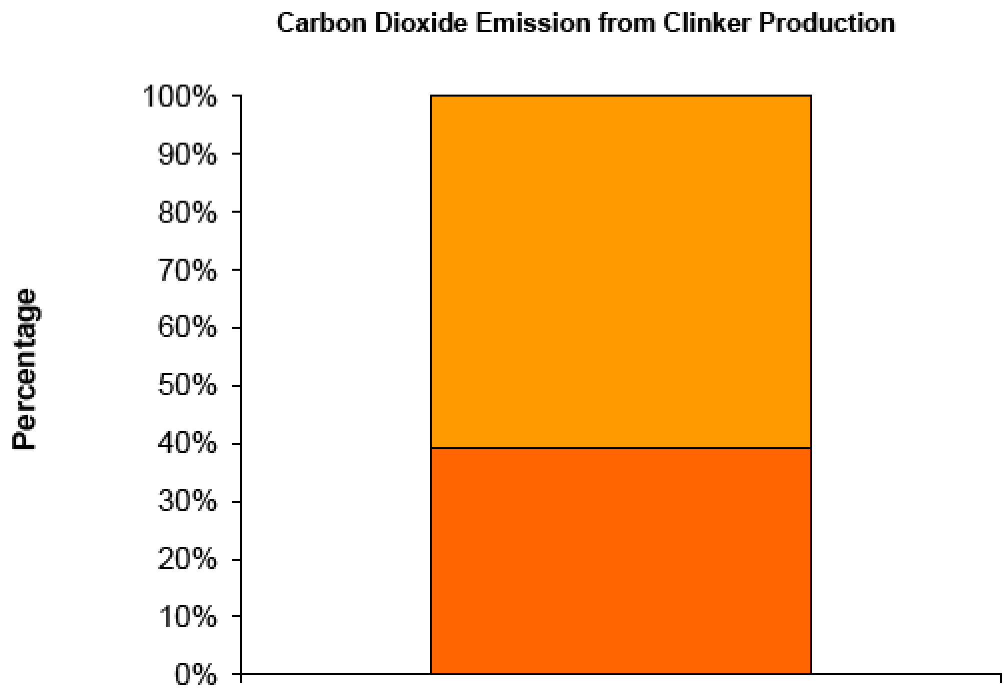


Source: WBCSD Cement Technology Roadmap 2009

Direct CO_2 Emissions Reduction - UK cement



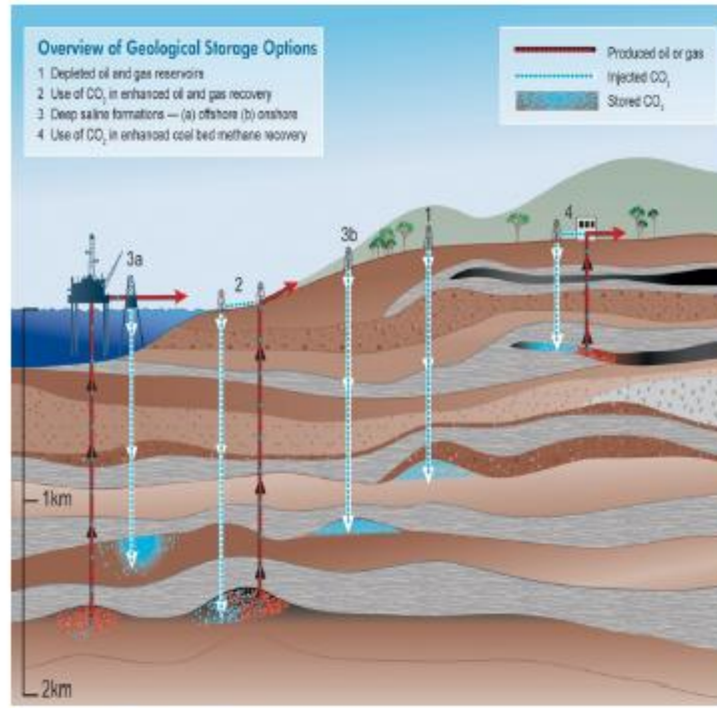
Direct CO_2 emissions - clinker



Calcination (Process) CO2 %	61
Combustion (Fuel) CO2 %	39

Cement industry research

- Cement emission ~25% CO_2
- IEA GHG – UK Cement industry Study
- CCS Cement plant will cost double a non-CCS cement plant
- Operational costs also double
- Need for transport infrastructure
- Technical barriers for Oxyfuel and post combustion
- Need for funding



Source: IEA GHG programme

CO_2 CAPTURE IN THE CEMENT INDUSTRY

Technical Study

Report Number: 2008/3

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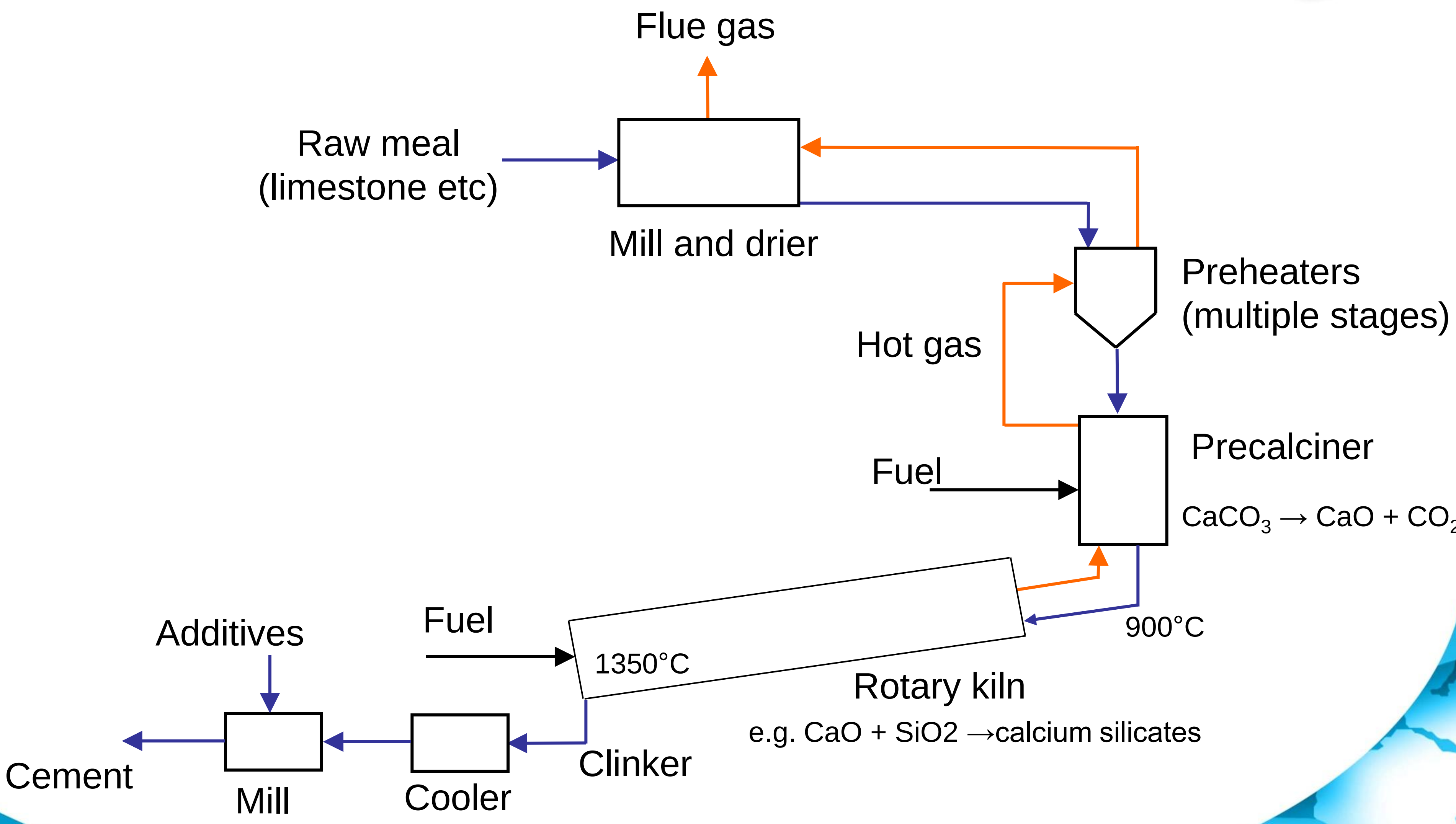
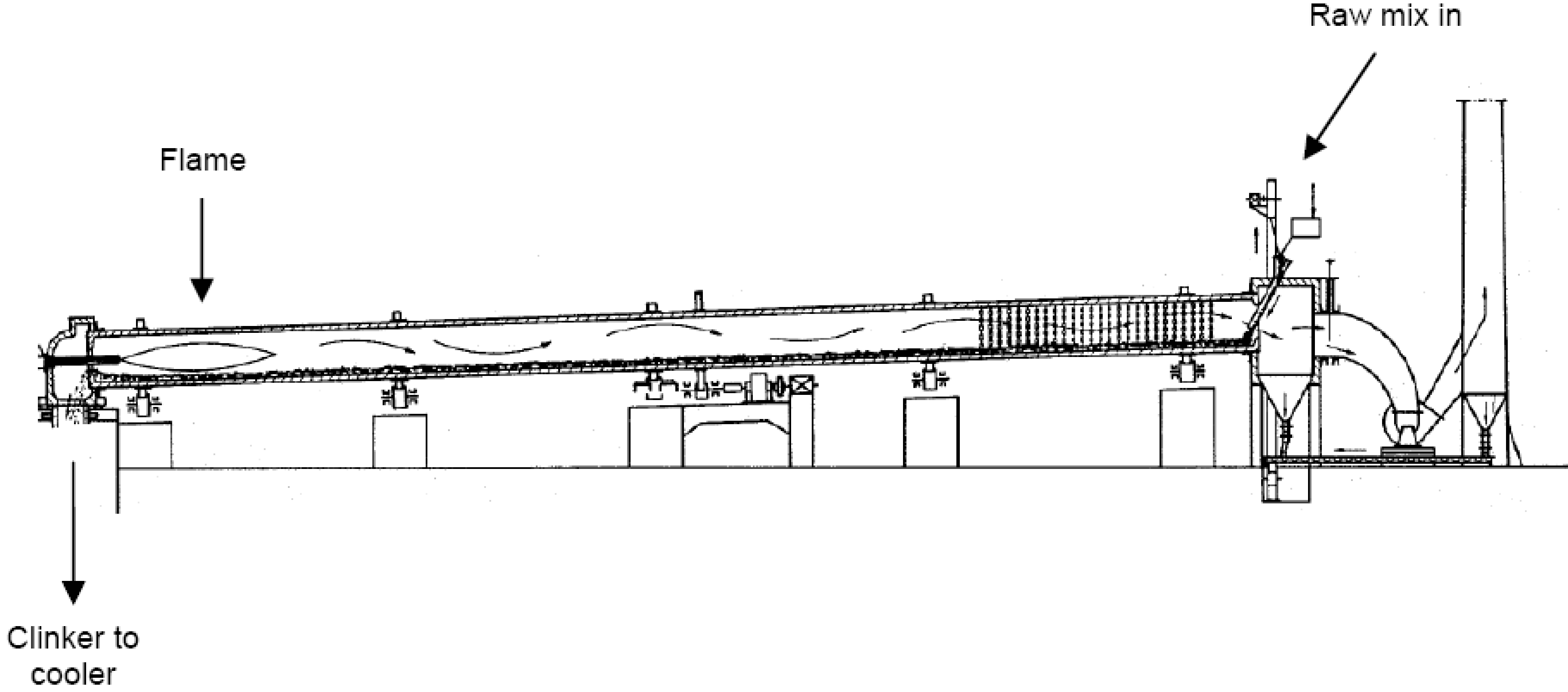
Cement Production

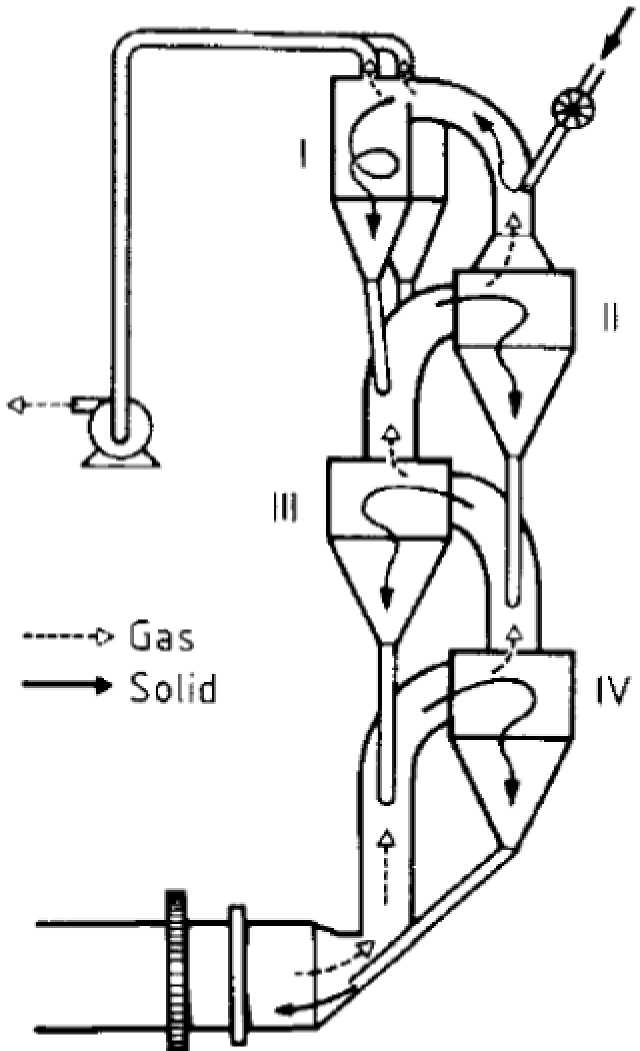


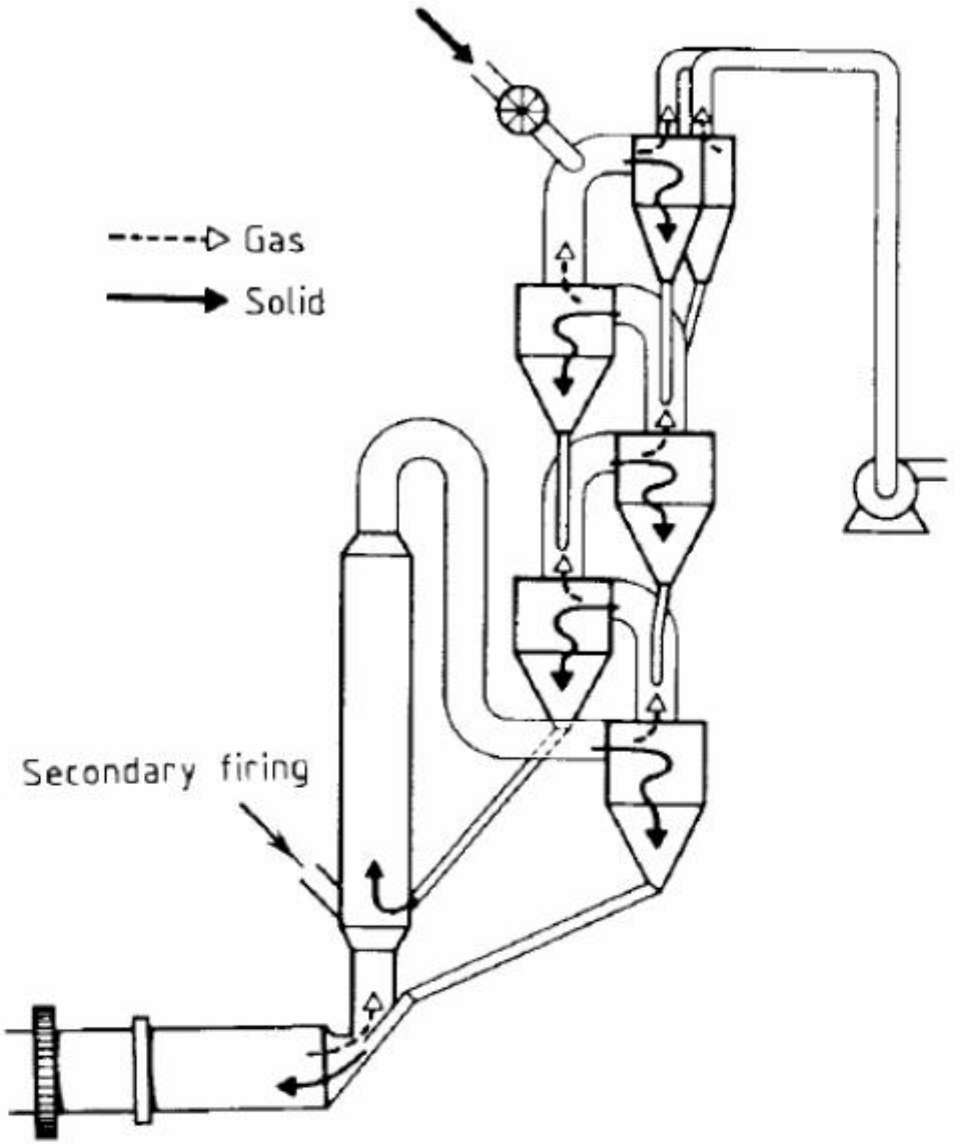
Rotary Kilns

Figure 2-7: Long Wet Rotary Kiln (Adapted from CEMBUREAU,1999)



Pre-Calciners

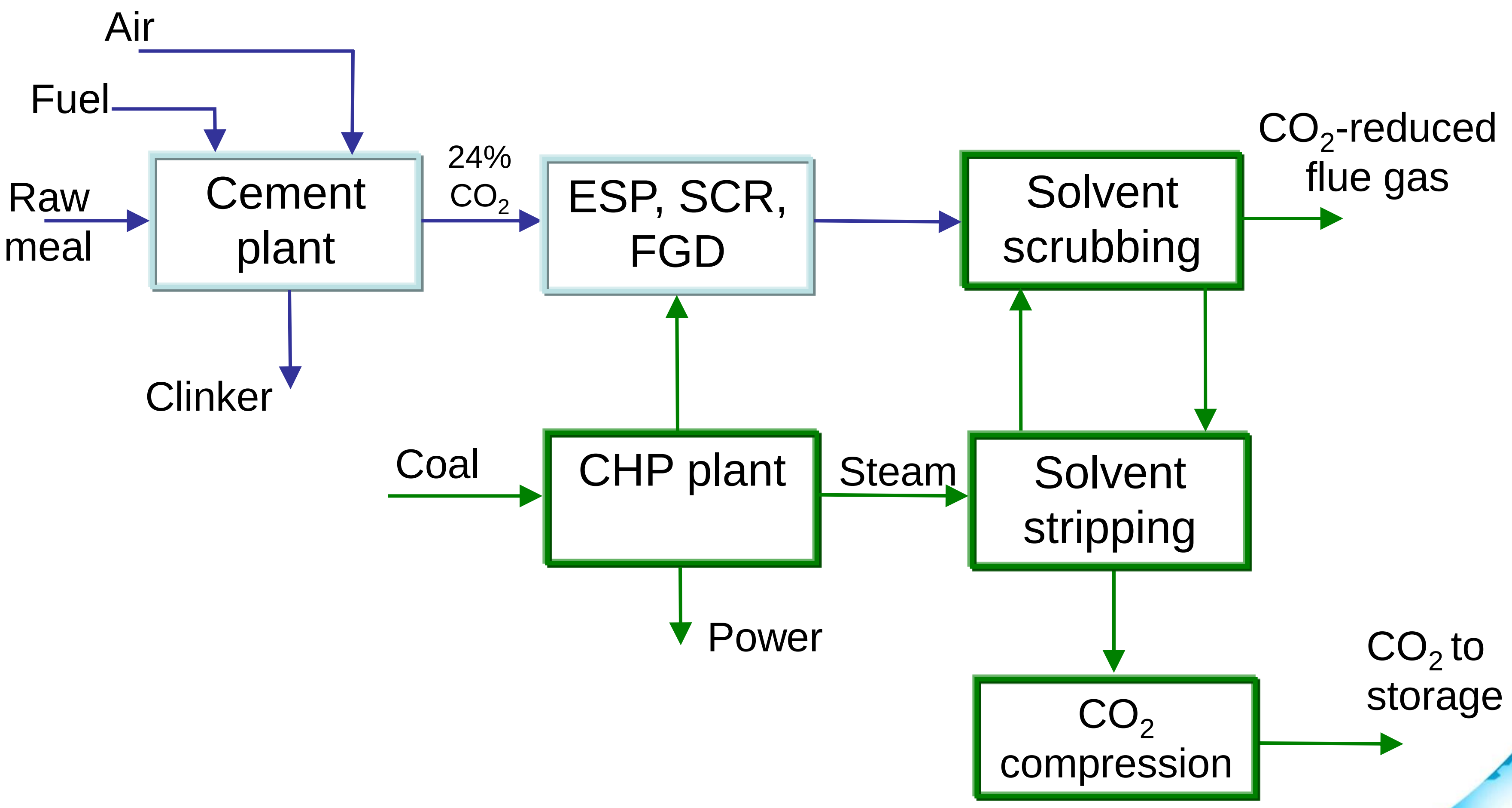




Pre-combustion Capture

- ***Not a good option for cement plants***
- ***Almost two thirds of the CO_2 emissions are from limestone calcination***
- ***Pre-combustion capture would only capture the fuel-derived CO_2***
- ***Not evaluated in IEA GHG's study***

Post-Combustion Capture at a Cement Plant



Post Combustion Capture in Cement Kiln
(Picture Courtesy of ECRA)

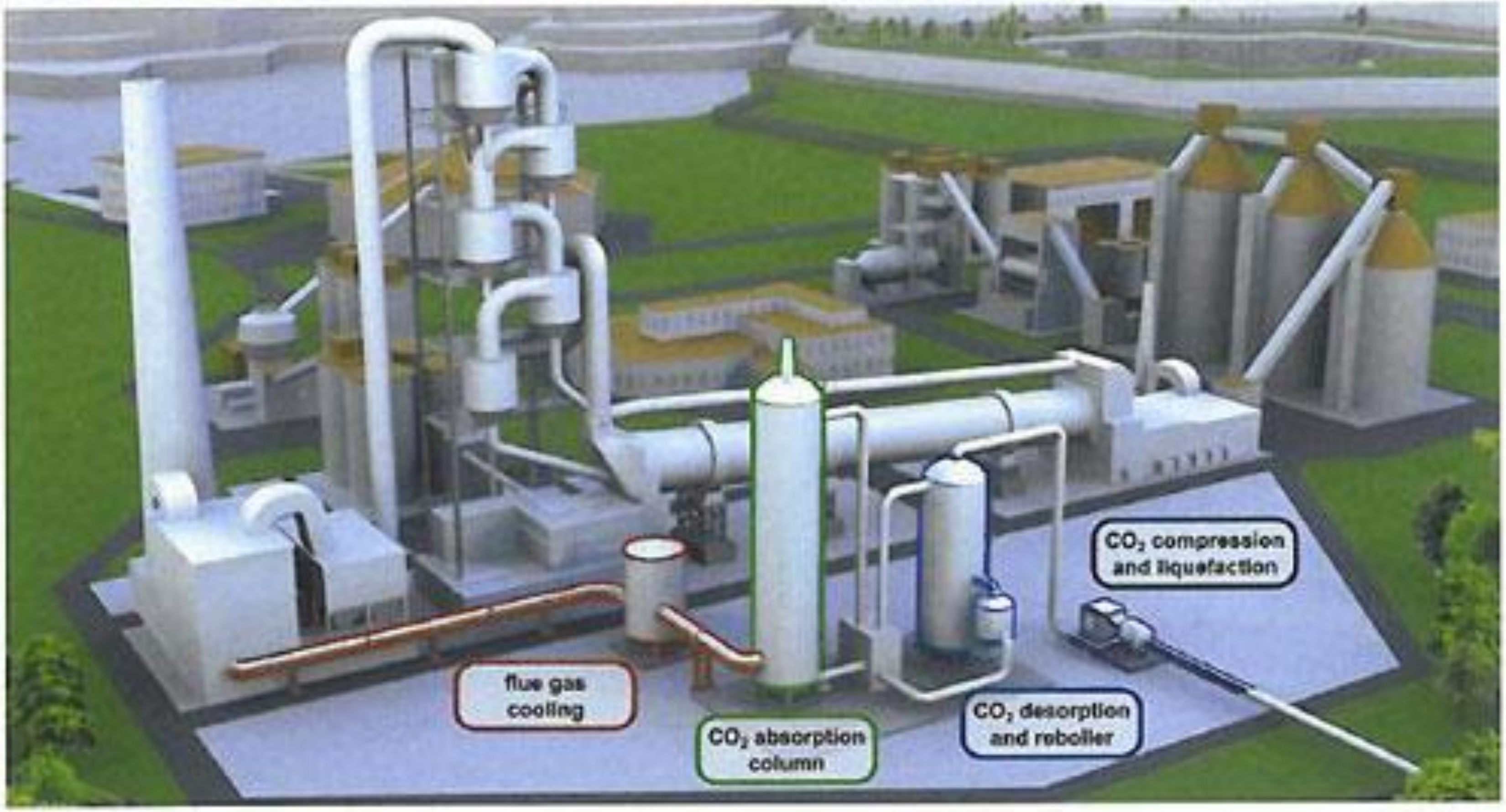
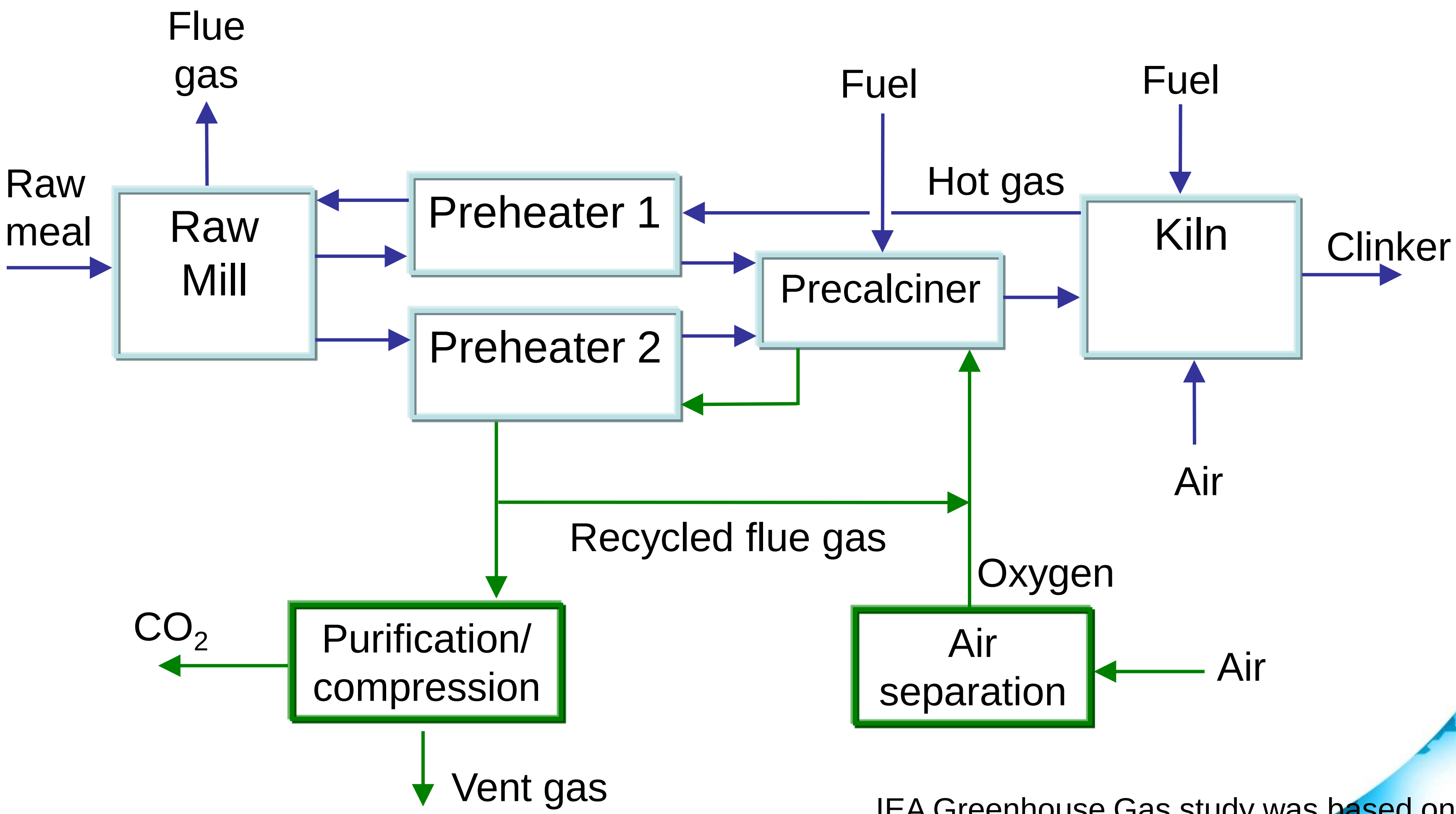


Figure 1. General arrangement of post-combustion CO_2 capture in a cement plant. The full animation can be seen at www.ecra-online.org.

Post-combustion Capture

- Kilns are sited on/near quarries normally with around 50-60 years of limestone reserves
- ***Advantages for cement plants***
  - The cement plant itself is unaffected
    - But more stringent flue gas cleaning may be needed
  - Retrofit to existing plants is possible
    - Provided space is available and CO2 can be transported away from the site for storage
- ***Disadvantages***
  - A large quantity of low pressure steam is needed for solvent stripping, requiring an on-site CHP plant

Oxy-Combustion at a Cement Plant



IEA Greenhouse Gas study was based on oxy-combustion in just the pre-calciner

Oxyfuel Combustion Capture in Cement Kiln
(Picture Courtesy of ECRA)

Figure 2. The general arrangement of oxyfuel technology on a rotary cement kiln.

Oxy-combustion Capture

- ***Advantages for cement plants***
  - Low oxygen consumption
    - Compared to a coal fired boiler, 1/3 of the amount of O_2 is needed per tonne of CO_2 captured
  - Costs are expected to be relatively low
- ***Disadvantages***
  - Retrofit would be difficult
  - Oxy-firing the pre-calciner captures only about 60% of the CO_2
  - For full oxy-firing, air in-leakage in mills and the kiln would have to be greatly reduced
  - Impacts of full oxy-firing on kiln chemistry etc need investigating
  - More R&D is needed

Costs of CO2 Capture

- ***Costs estimated for a 1Mt/y cement plant in N-W Europe***
- ***Post combustion capture***
  - €107/t of CO2 emissions avoided
  - Could be reduced to €55/t by locating a cement plant next to a power plant and using a low sulphur raw meal
  - Alternative CO2 capture solvents could significantly reduce costs
- ***Oxy-combustion***
  - €40/t CO2 emissions avoided
- ***Cement plants would need to be close to other CO2 sources to minimise CO_2 transport costs***
  - CO2 captured is 0.5-1.0 Mt/y
  - Equivalent to about 100-200 MWe coal fired power plant

Costs – Developing Countries

- ***Most cement production is in developing countries***
  - Almost 50% in China alone
- ***New cement plants are often larger in developing countries and construction costs are lower***
- ***Sensitivity case: 3Mt/y cement plant in Asia***
  - Costs of CO_2 abatement would be lower
  - e.g. €23/t for oxy-combustion

Conclusions

- ***CO_2 could be captured at cement plants***
- ***Post-combustion capture is the lowest risk option and is well suited to retrofit but costs are relatively high***
- ***Oxy-combustion would have similar costs to CO_2 capture at large power plants***
- ***Most cement production is in developing countries***
- ***Abatement costs would be lower in developing countries***
- ***Imports of cement from countries without CO_2 abatement requirements is a concern***

Cement industry research - ECRA

- Initiated in 2007
- Work package A - Oxyfuel
- Work Package B - Post Combustion

Oxyfuel

- Integrated concept
- Burning process is affected
- Oxygen enrichment has been applied to cement kilns
- CO_2 from the combustion process is concentrated
- Kiln plant needs redesign, retrofitting would be difficult
- High energy consumption for oxygen production

Post-combustion

- End-of-the pipe technology
- Commercially available in other industry sectors
- Minimal impact on existing clinker process
- Pure CO_2 stream for compression
- Retrofitting is possible, no kiln redesign required
- Very high energy consumption for solvent regeneration