CCS in the Cement Industry

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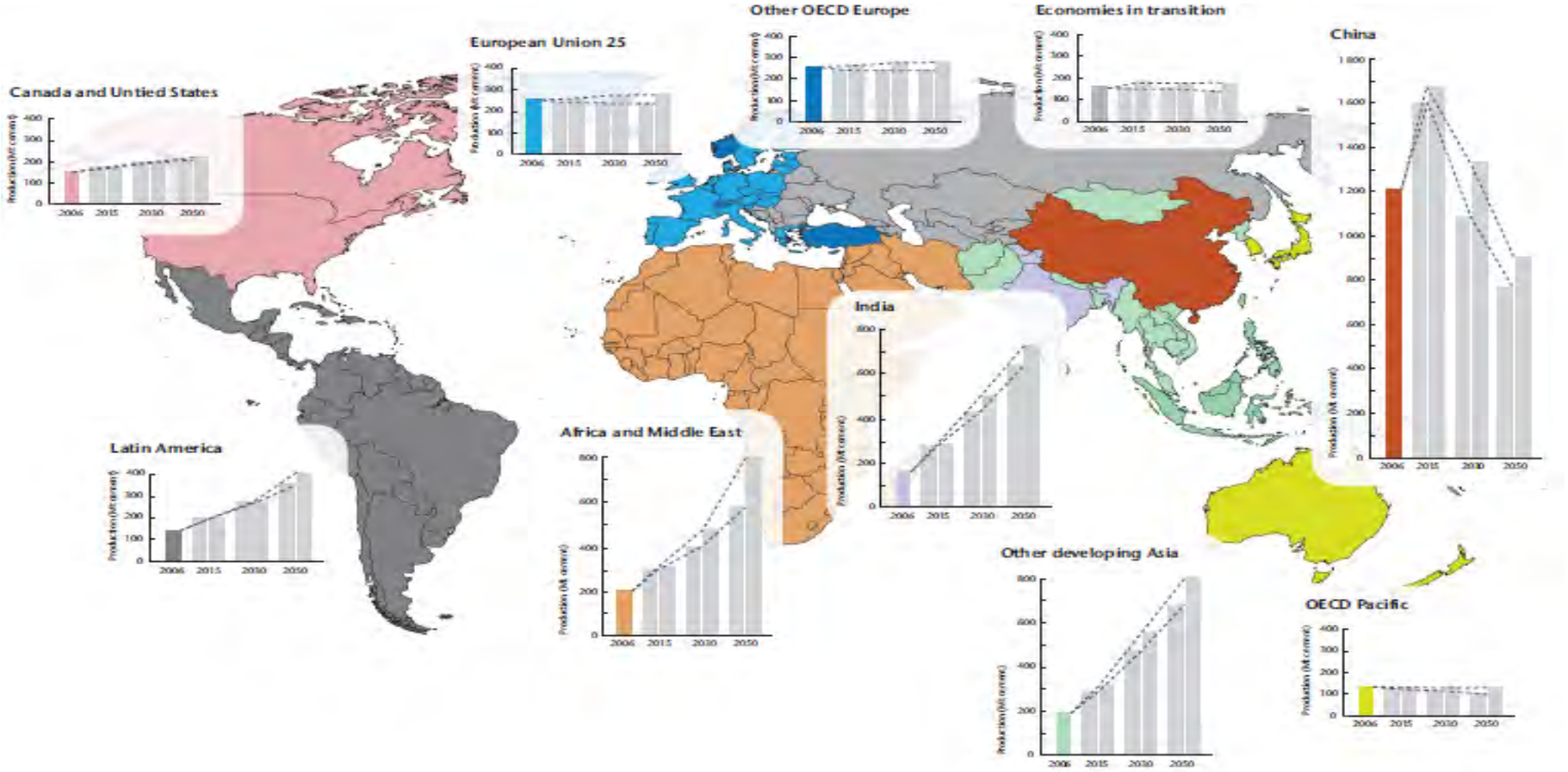
Presentation Overview

- Overview of cement production
- Techniques to reduce CO_2 emissions
- CCS technologies for cement plants
- Costs of CCS at cement plants
- Barriers to use of CCS in the cement industry

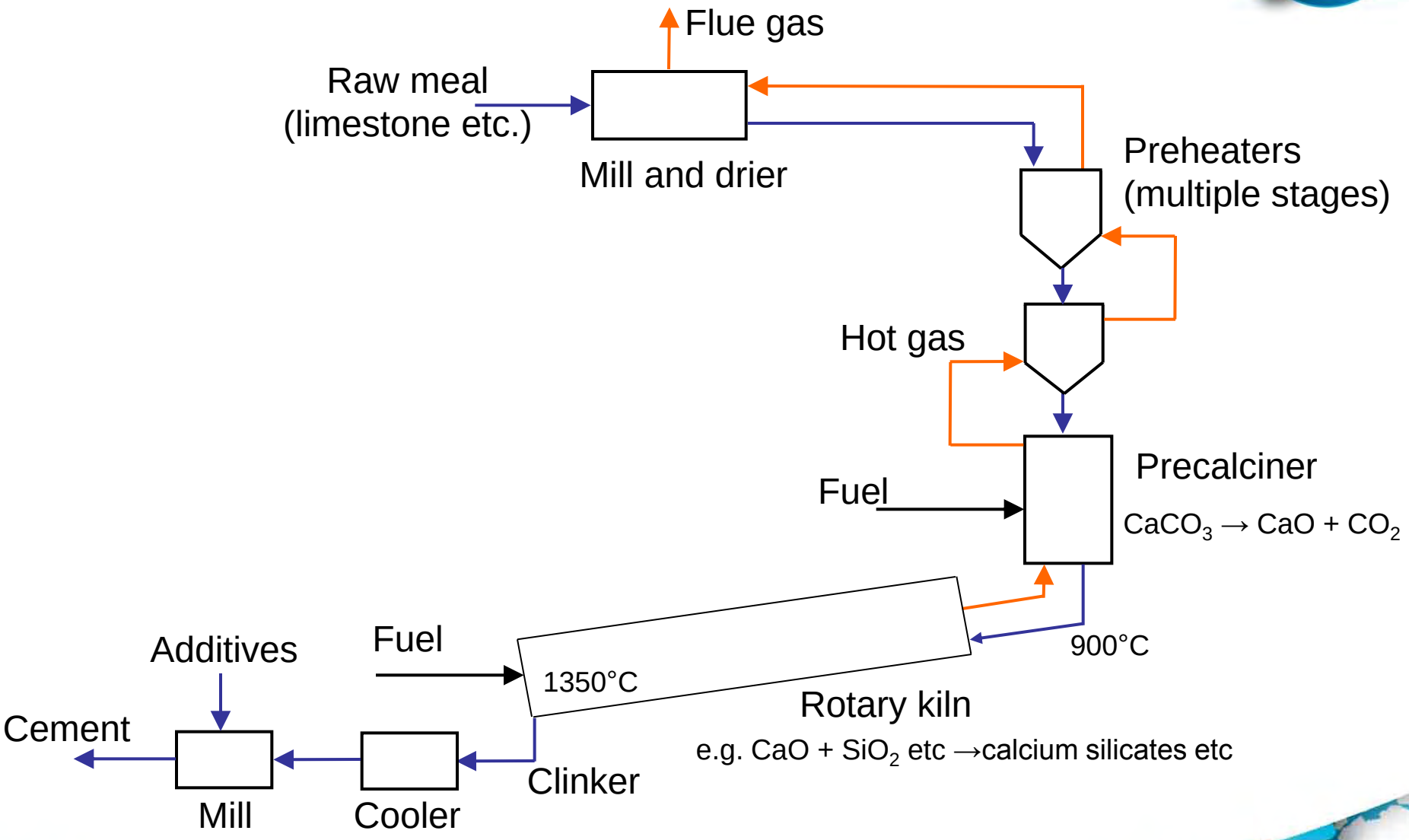
- Based on a recent study
  - Commissioned by Global CCS Institute
  - Managed by IEAGHG
  - Undertaken by European Cement Research Academy (ECRA), Germany

Cement Production

IEA Cement Roadmap



Cement Production



Cement Plant

CO_2 emissions

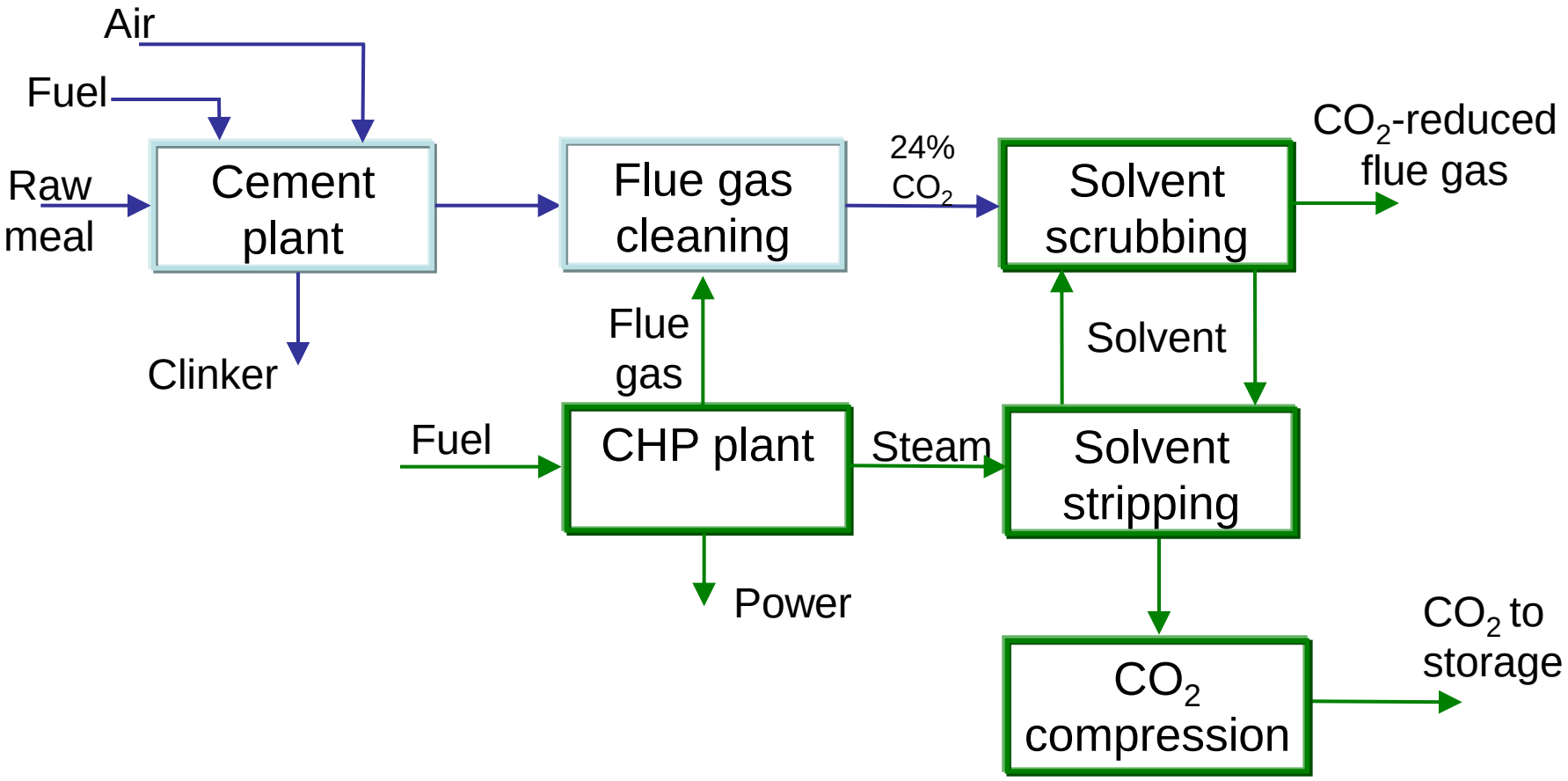
- Sources of CO_2 emissions
  - Limestone decomposition (>60%)
  - Fuel combustion
  - Imported electricity (indirect emission)
- Techniques to reduce emissions
  - Increased energy efficiency
    - Limited scope for improvements, e.g 10% by 2050
  - Alternative fuels
    - Tyres, waste oil, bio-wastes etc: ‘zero carbon’ biogenic material
  - Alternative raw materials and lower cement:clinker ratio
    - Limited by material availability and product quality
  - CCS

CCS

- CCS enables deep reductions in emissions
- CO_2 from limestone decomposition can be avoided
  - Not possible by just using alternative energy sources
- Technologies are broadly similar to those used at power plants
  - Post combustion capture
  - Oxy-combustion
  - Pre-combustion capture
    - Not preferred: would not capture the limestone-derived CO_2

Post Combustion Capture

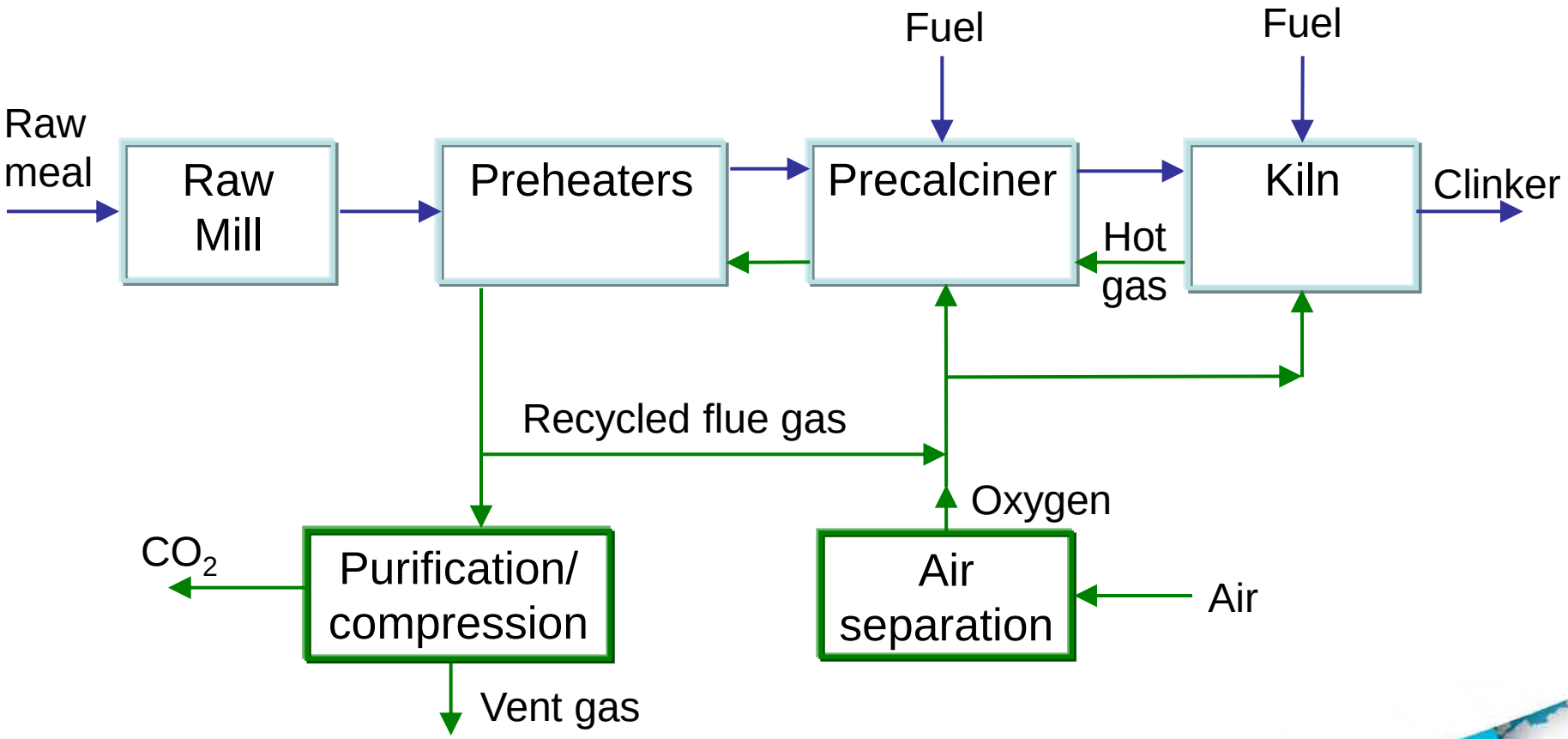
Core cement plant is unaffected



Full Oxy-Fuel

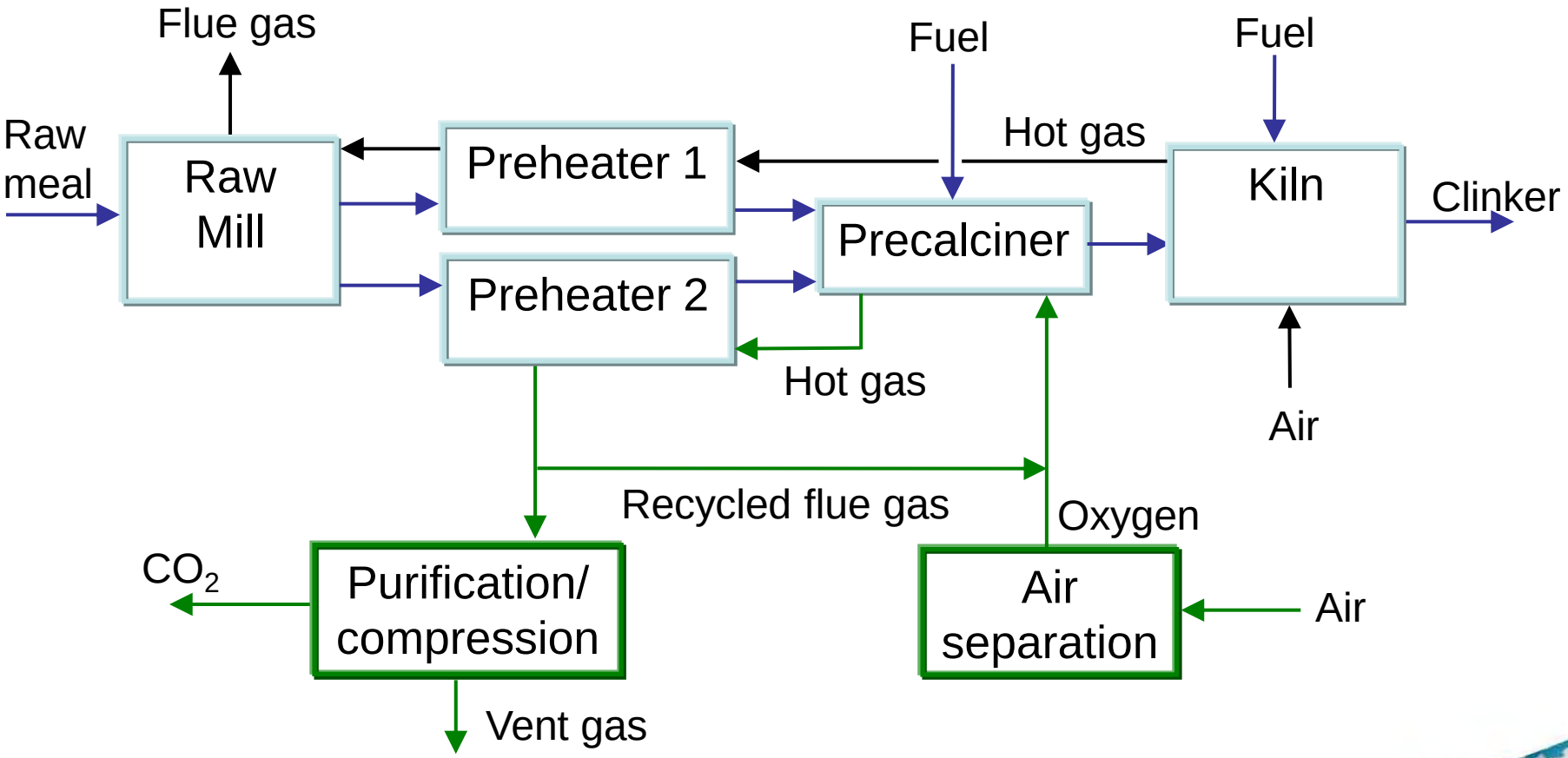
Oxygen to calciner and kiln, ~90% capture

Changes to the core cement production process



Partial Oxy-Fuel

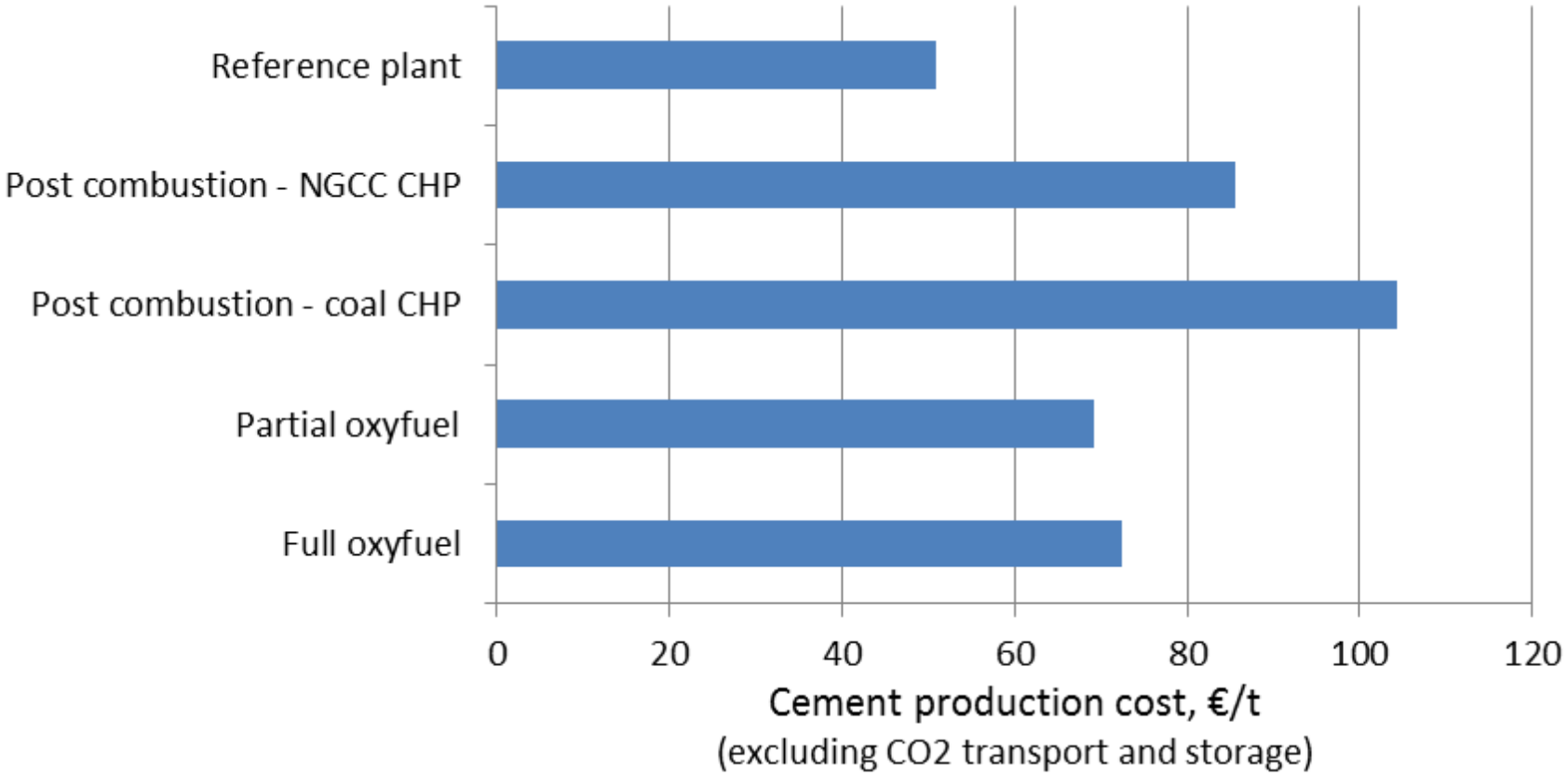
Oxygen to calciner only, ~60% capture



Calcium Looping

- Post combustion capture: $CO_2 + CaO \rightarrow CaCO_3$
- Oxy-combustion regeneration: $CaCO_3 \rightarrow CaO + CO_2$
- High temperature process
- Various integration options
- Degraded sorbent can be used in the cement process
  - Degraded sorbent from power plant capture units can be used in cement plants

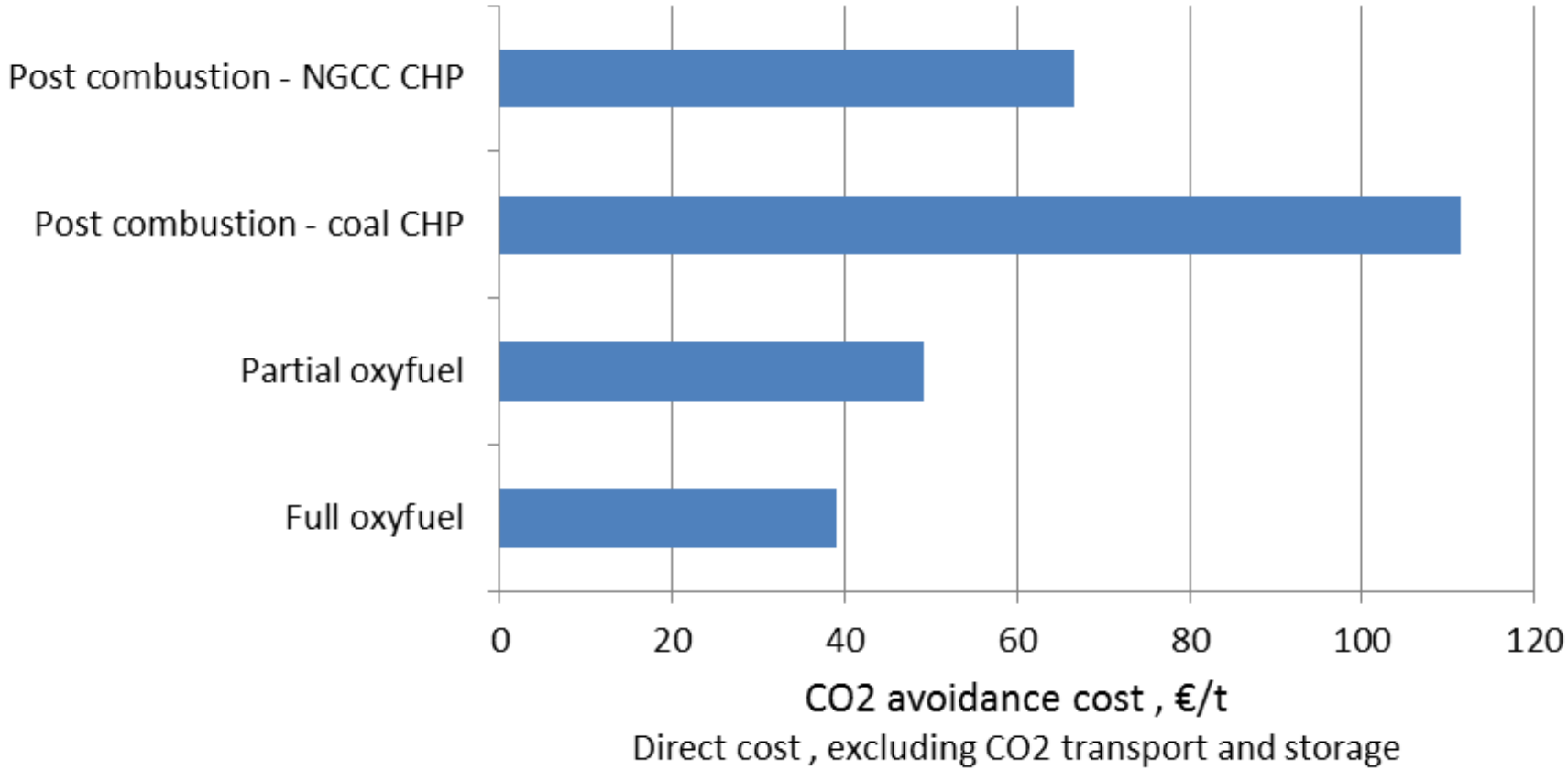
Cement Production Cost



(€20/t CO_2 stored increases cement cost by about €10/t for full oxyfuel case)

1Mt/y clinker (1.36Mt/y cement) plant, Europe
8% discount rate, 25 year plant life, 80% capacity factor,
Coal €3/GJ, Gas €6/GJ, electricity €80/MWh

CO_2 Avoidance Cost



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Coal €3/GJ, Gas €6/GJ, electricity €80/MWh

Avoidance costs 50% lower in China and Middle East

Cement Plant Capture R&D

- Norcem, Brevik, Norway
  - Test centre for small scale and pilot trials at a cement plant (2013-17)
    - Aker Solutions: amine scrubbing, mobile test unit
    - RTI: Dry adsorption, small scale trial
    - KEMA, Yodfat, NTNU: Membranes, small scale trial
    - Alstom: Calcium looping de-risking study
- ITRI/Taiwan Cement Corp.
  - 1t/h CO_2 calcium looping unit, commissioned 2013
- Skyonic Corp, Texas
  - 83 kt/y CO_2 plant at a cement plant, under construction
  - “Sky Mine” post combustion process
  - NaOH + flue gas CO_2 → sodium bicarbonate

Cement Plant Capture R&D

- Oxyfuel
  - Still at the basic research and laboratory testing stage
  - No pilot plants initiated or planned
  - ECRA is preparing a concept study for an oxyfuel pilot cement kiln

Stakeholder Survey

- Survey of the cement industry
  - Mainly cement producers, also plant manufacturers, researchers etc
  - Mainly international businesses
  - Mainly European, also N. America, Asia, Middle East
- Most respondents think CCS is relevant to them and are aware of research projects
- More than half would be willing to contribute to CCS research
- Only a third willing to contribute to pilot and demonstration projects due to high cost

Barriers to CCS

- Lack of specific funding for CCS research and demonstration in the cement industry
- Currently CCS would impair the competitiveness of cement plants
- High risk of import of cement from countries with lower abatement costs: carbon leakage
- Lack of adequate legal framework for CO_2 storage in some countries

Conclusions

- Established techniques can reduce cement plant emissions but scope for further reductions is limited
- CCS for the cement industry is at an early state of development
- Post combustion solvent scrubbing has potential for shorter timescale applications
- Oxy-fuel has potentially lower cost in the longer term
- Cement industry thinks CCS is relevant, they are aware of R&D but there is low willingness to contribute to pilot/demonstration plants
- Most cement production is in developing countries
- Impact on competitiveness and under-developed legal frameworks are barriers to use of CCS

Thank you, any Questions?