



CCS in the Cement Industry

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IEA Greenhouse Gas R&D Programme (IEAGHG)

CCS in Industry Workshop

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Presentation Overview



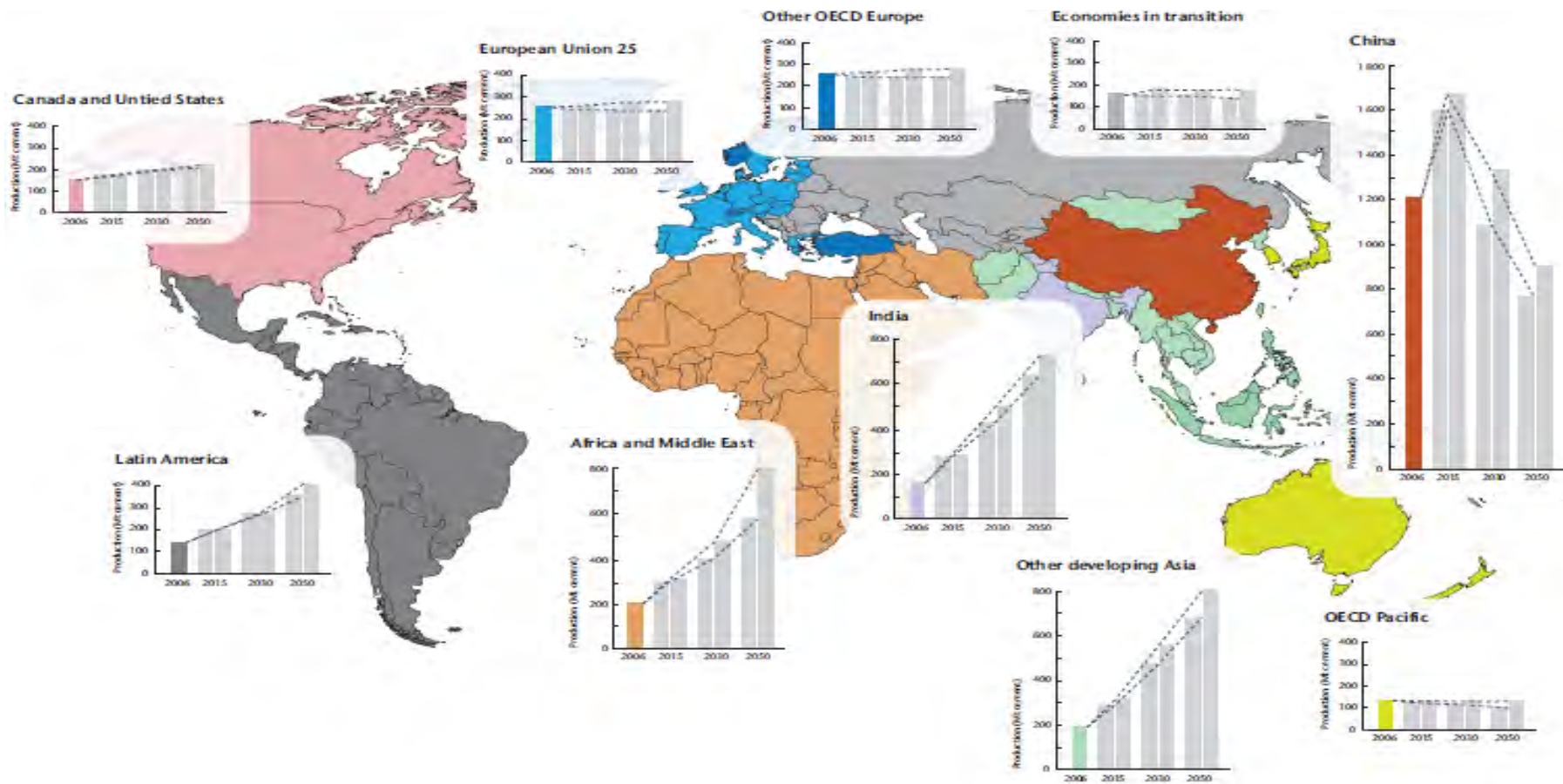
- Overview of cement production
- Techniques to reduce CO₂ emissions
- CCS technologies for cement plants
- Costs of CCS at cement plants
- Barriers to use of CCS in the cement industry

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

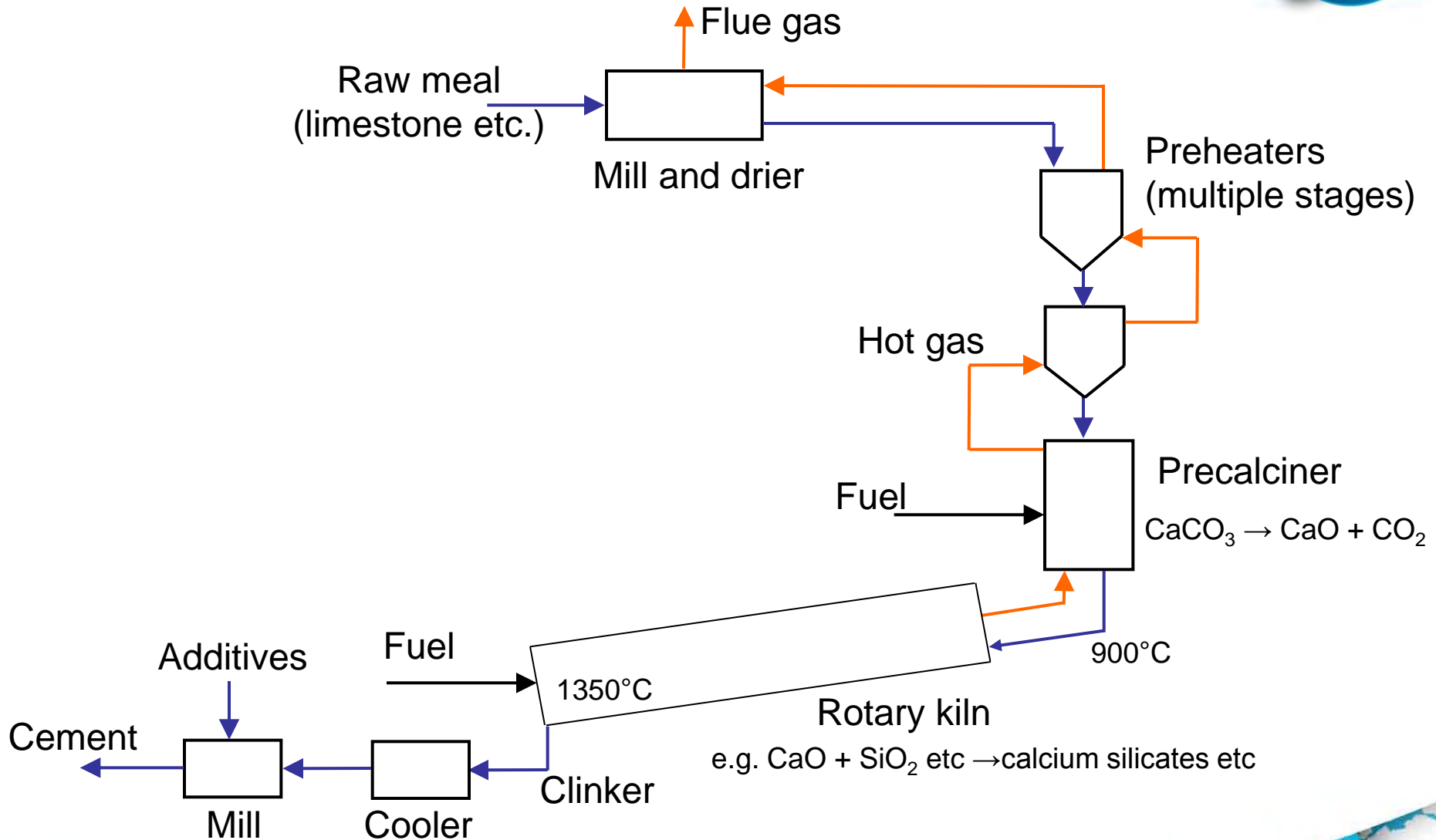
Cement Production



IEA Cement Roadmap



Cement Production



Cement Plant



CO₂ emissions



- Sources of CO₂ 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

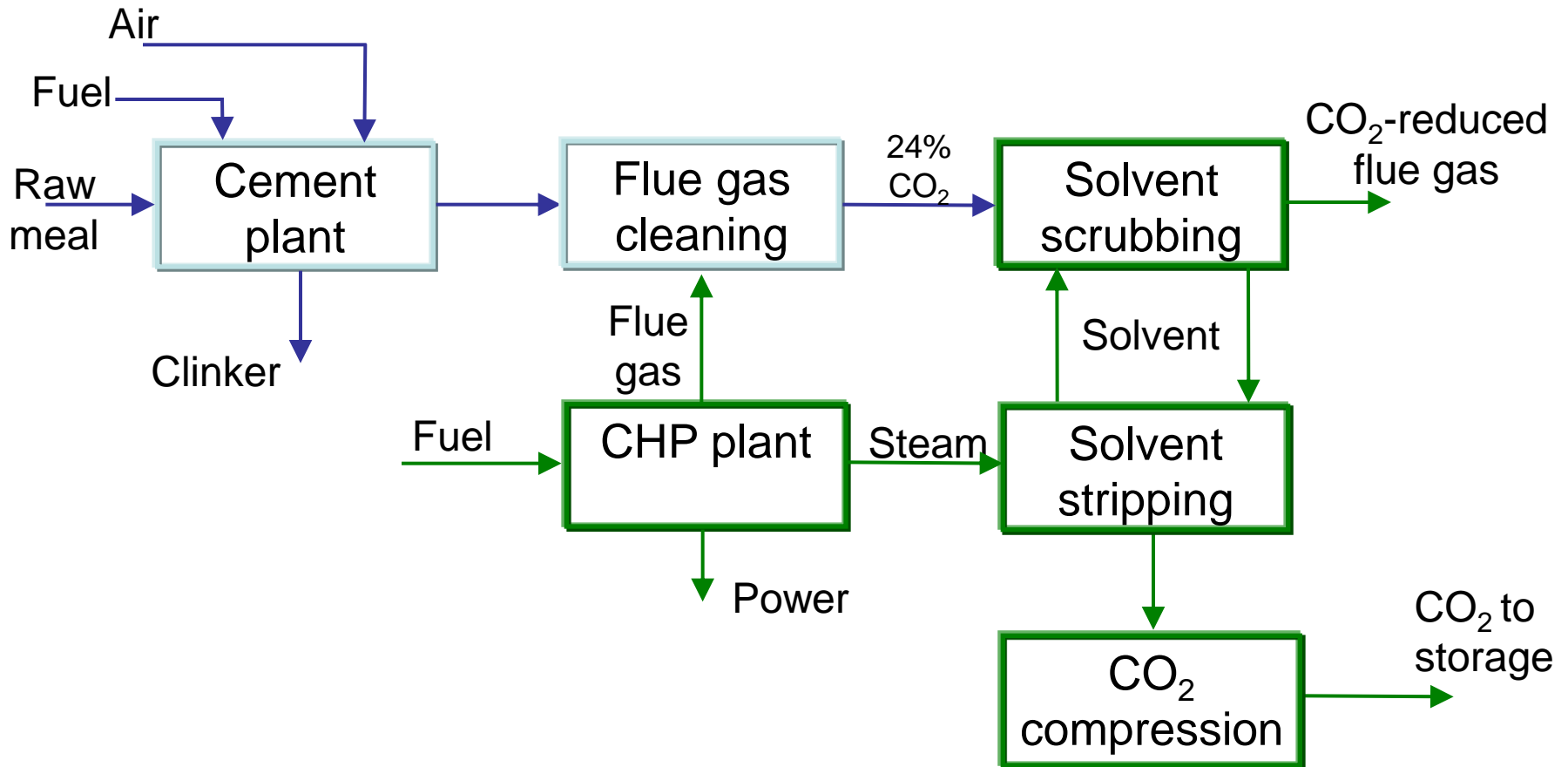


- CCS enables deep reductions in emissions
- CO₂ from limestone decomposition can be avoided
 - Not possible by just using alternative energy sources
- Technologies are broadly similar to those used at power plants
 - Post combustion capture
 - Oxy-combustion
 - Pre-combustion capture
 - Not preferred: would not capture the limestone-derived CO₂

Post Combustion Capture



Core cement plant is unaffected

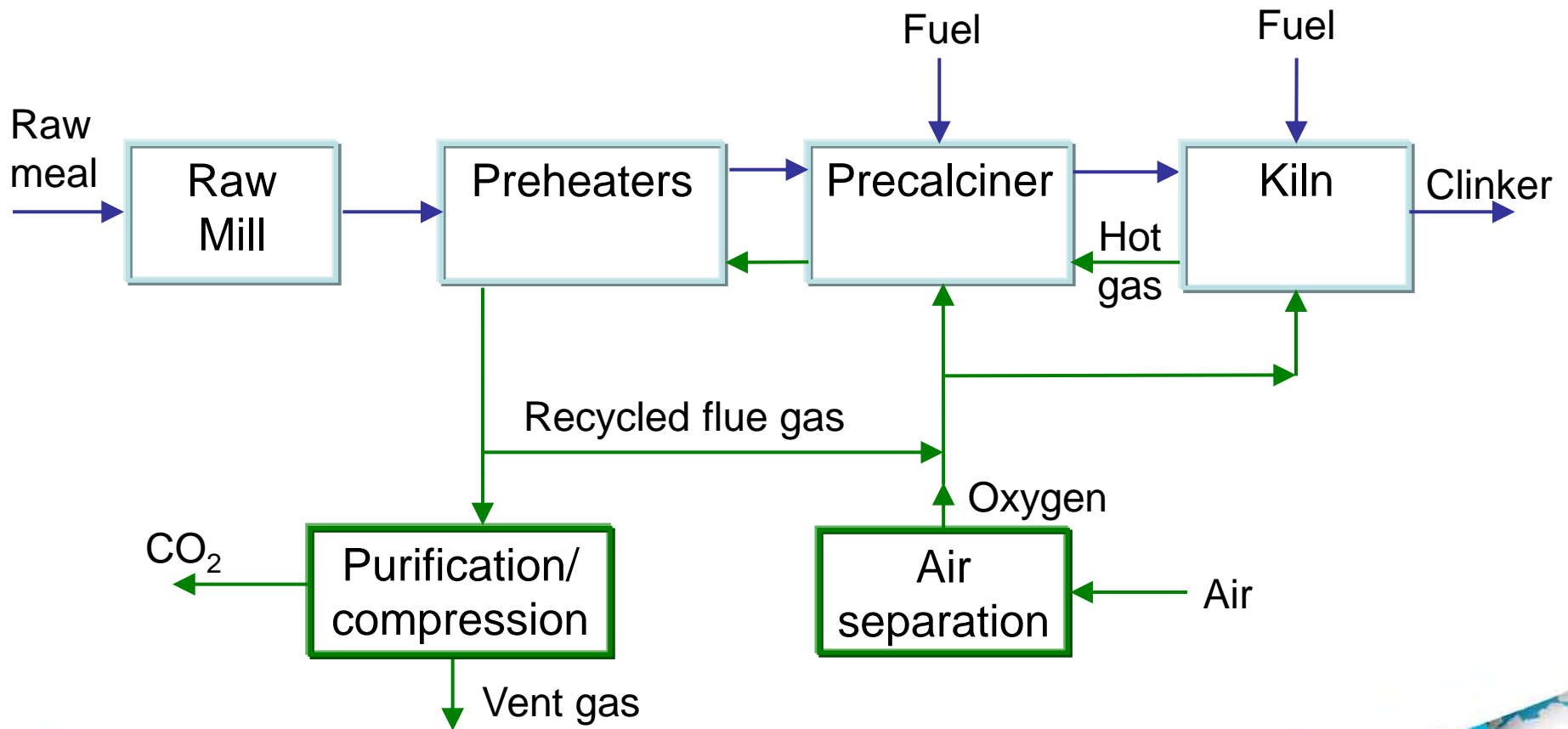


Full Oxy-Fuel

Oxygen to calciner and kiln, ~90% capture

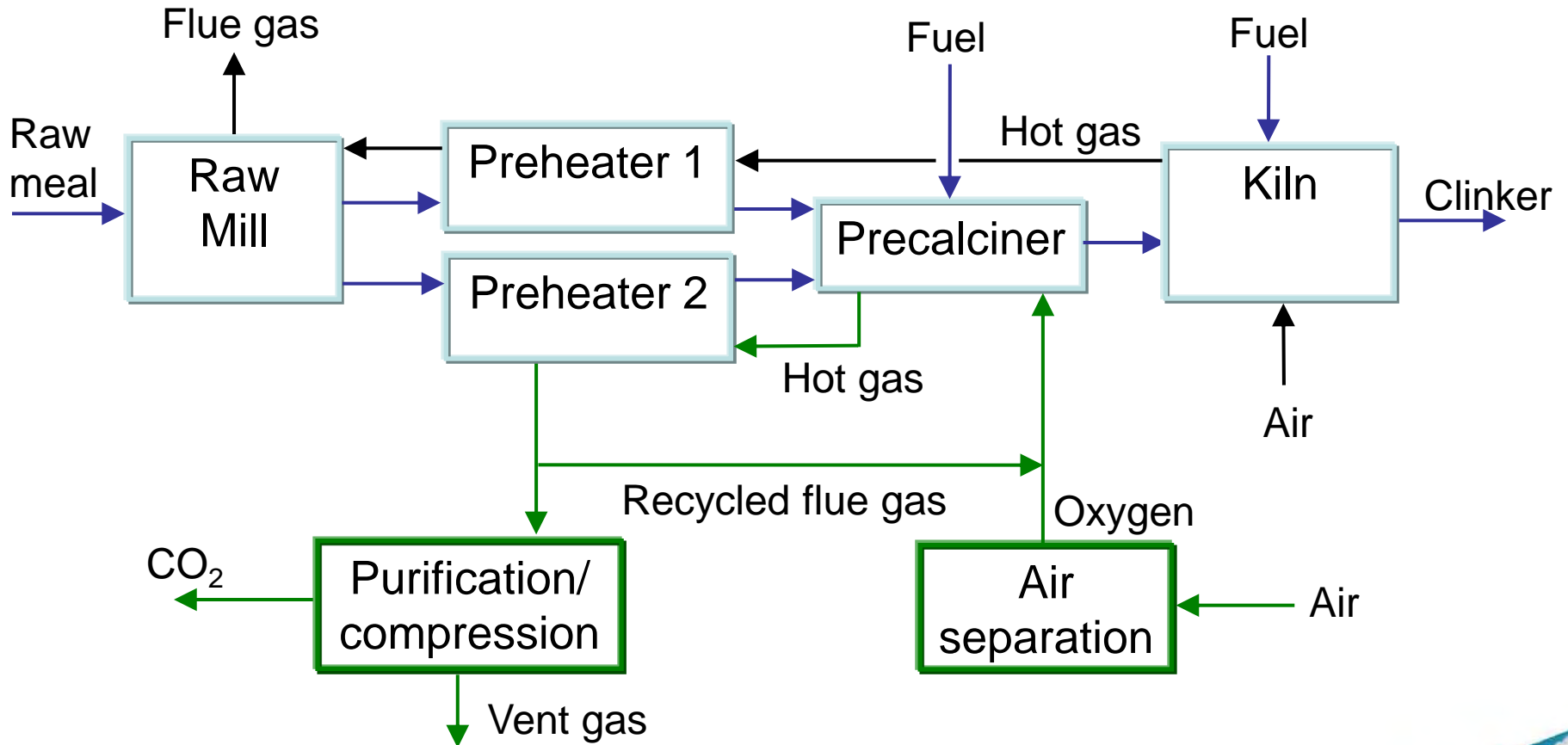


Changes to the core cement production process



Partial Oxy-Fuel

Oxygen to calciner only, ~60% capture

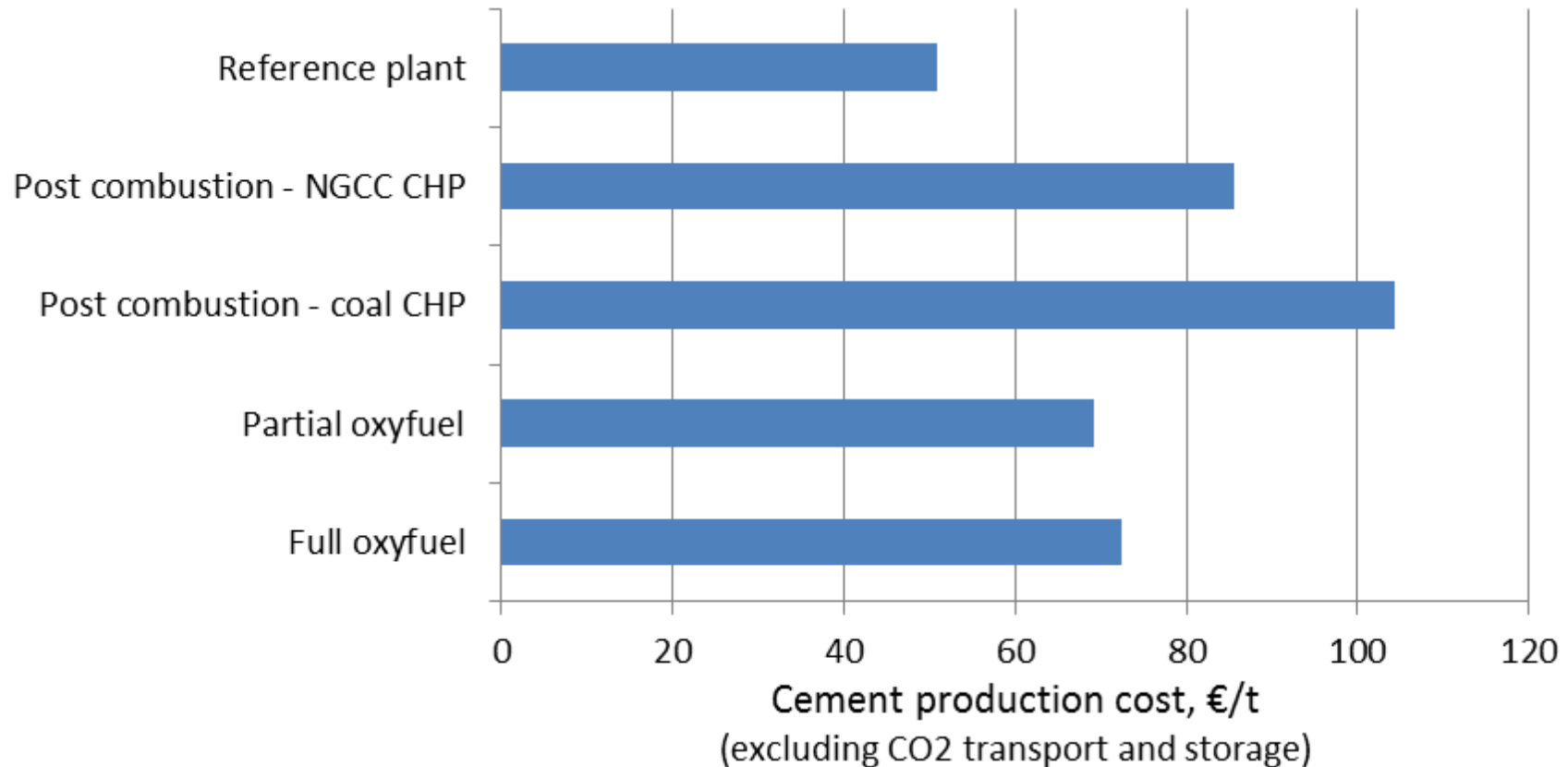


Calcium Looping



- Post combustion capture: $\text{CO}_2 + \text{CaO} \rightarrow \text{CaCO}_3$
- Oxy-combustion regeneration: $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$
- 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



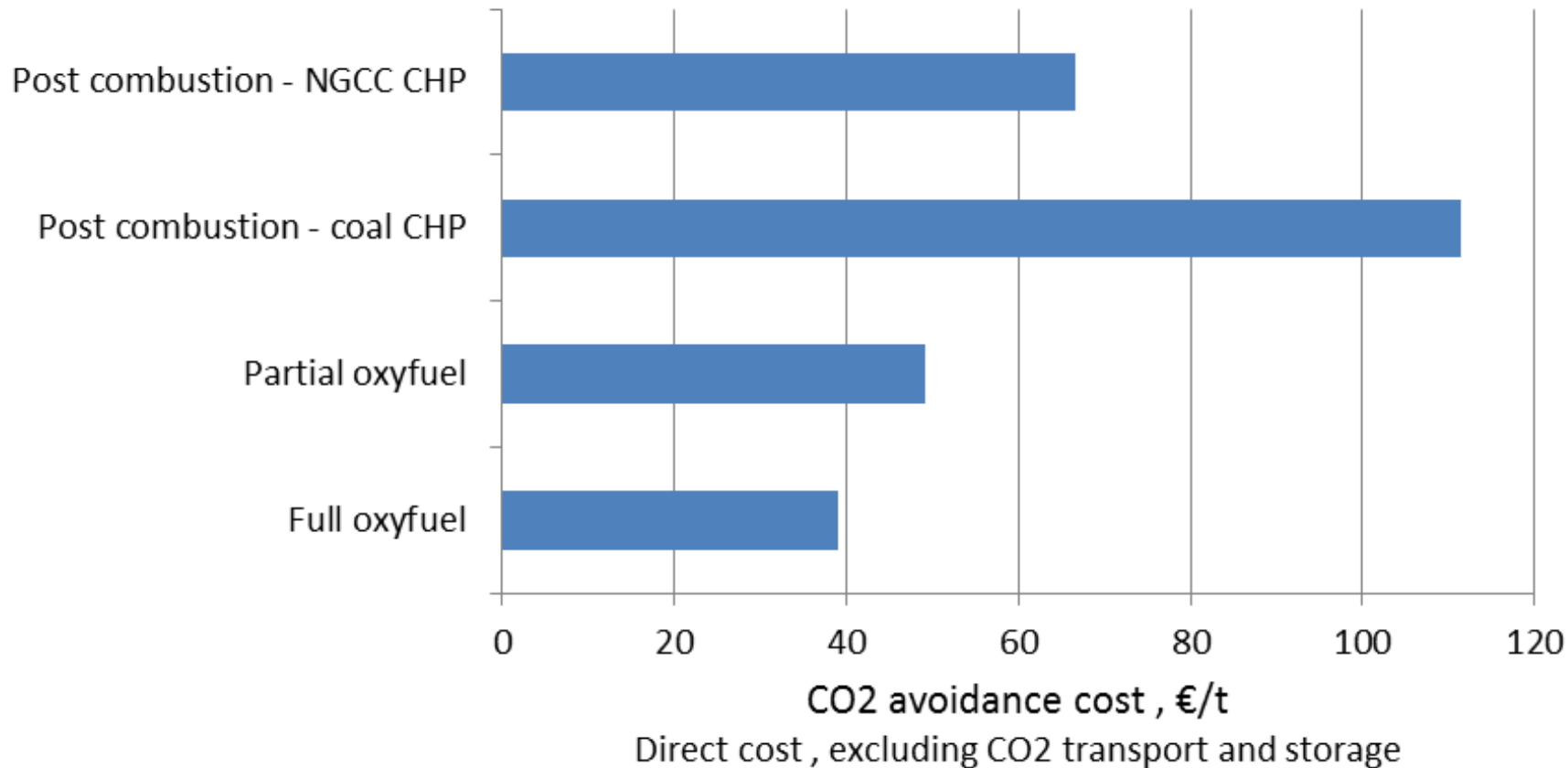
(€20/t CO₂ stored increases cement cost by about €10/t for full oxyfuel case)

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

CO₂ Avoidance Cost



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

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 CO₂ calcium looping unit, commissioned 2013
- Skyonic Corp, Texas
 - 83 kt/y CO₂ plant at a cement plant, under construction
 - “Sky Mine” post combustion process
 - NaOH + flue gas CO₂ → 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 CO₂ 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?