european cement research academy

ECRA's Oxyfuel project

International CCS Conference 20–21 May 2015

Langesund, Norway

Martin Schneider

ECRA: The European Cement Research Academy

ECRA was founded in 2003:

- as a platform to stimulate and undertake research activities in the context of the production of cement and its application in concrete
- to facilitate and accelerate innovation to guide the cement industry by creating and disseminating knowledge from research.

- ECRA initiates and provides seminars and workshops teaching state-of-the-art knowledge on cement and concrete technology and communicating the latest research findings
- ECRA undertakes dedicated research projects
- ECRA focuses on issues which individual companies may not be able to tackle alone and are of major importance to the cement industry as a whole

ECRA CCS Project: Objectives

- All CCS roadmaps require a significant contribution from the industrial sector, including the cement industry.
- Against this background, ECRA is investigating the technical and economical feasibility of CCS technologies
- Focus on oxyfuel and post-combustion technologies
- Sustainability aspect of CCS technologies is included
- CO_2 transport and storage are not included in the research project
- Joint (European) research activities to meet the huge challenge of significant CO_2 reduction
- Strong cooperation with CSI, CEMBUREAU, PCA, etc. to communicate the cement industry's activities on CCS and CO_2 reduction

ECRA's CCS Project

Phase I	Literature study (January - June 2007)	✓
Phase II	Study about technical and financial aspects of CCS projects, concentrating on oxyfuel and post-combustion technology (summer 2007 – summer 2009)	✓
Phase III	Laboratory-scale / small-scale research activities (autumn 2009 – autumn 2011)	✓
Phase IV	Prepare pilot plant (time-frame: 2 - 3 years)	
Phase V	Build and operate pilot plant (time-frame: 3-5 years)	
Phase VI	Demonstration plant (time-frame: 3-5 years)	

ECRA CCS Project Phase I to III

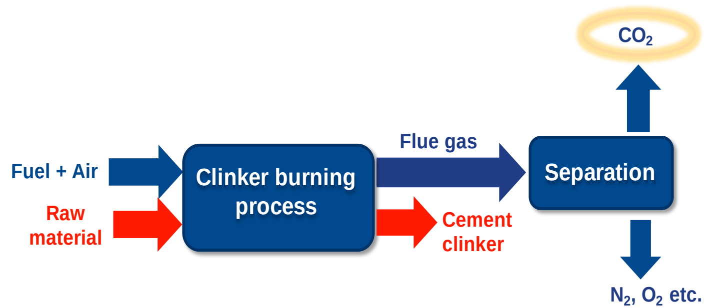
Literature study

Identification of suitable technologies

Technical feasibility

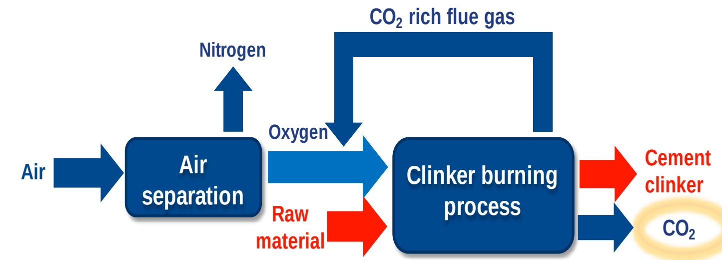
Lab-scale research

Post-Combustion



- End-of-the pipe technology, retrofitting possible
- Commercially available in other industry sectors
- Doubling of electrical and thermal energy

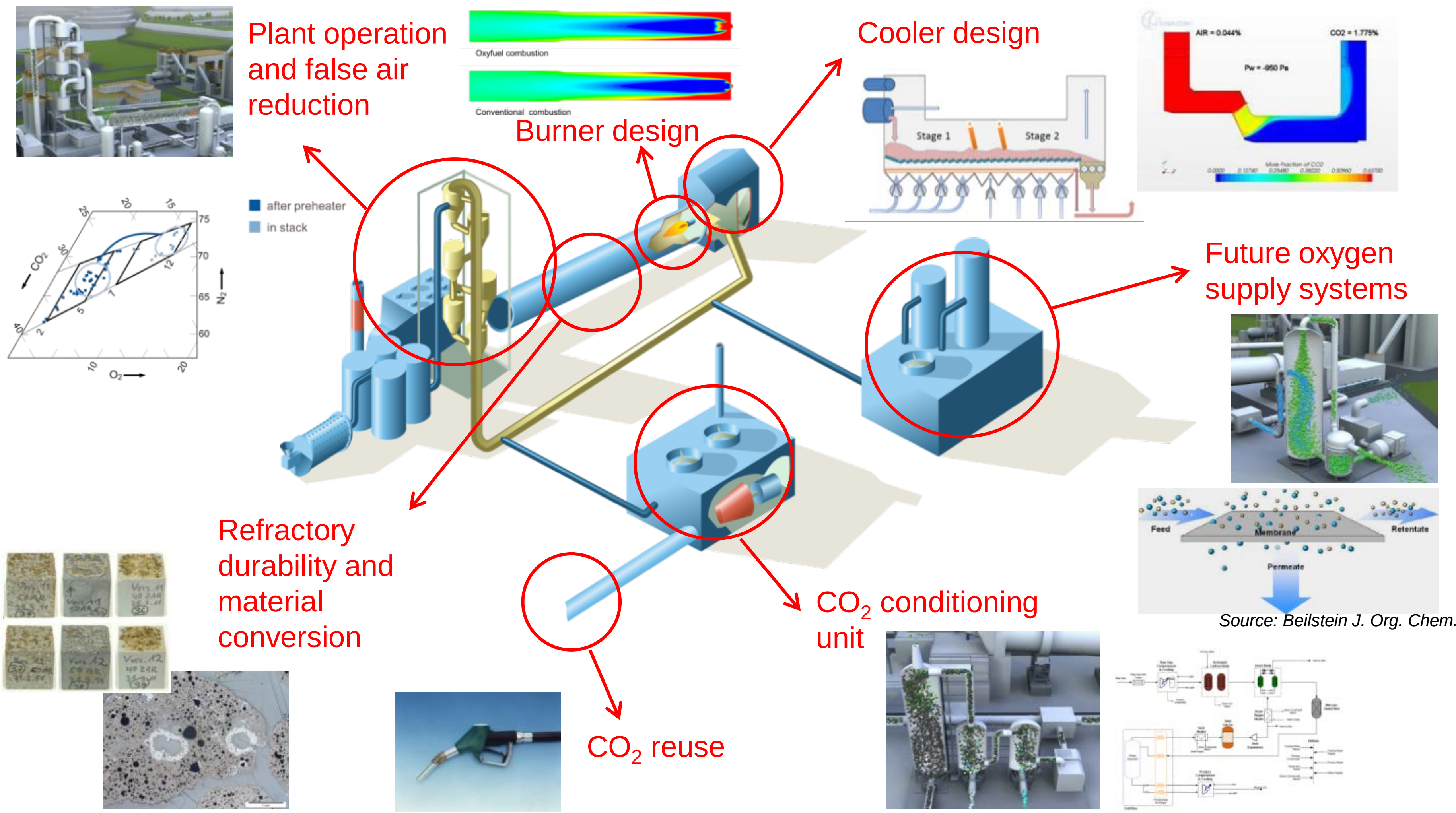
Oxyfuel



- Integrated concept
- Burning process is affected
- Kiln plant needs redesign, retrofitting possible
- Doubling of electrical energy

Research focus in phase IV was placed on Oxyfuel

Is the application of Oxyfuel technology feasible?



Academic Chair at the University of Mons

- ECRA chair "CO_2 to Energy: Carbon Capture in Cement Production and its Re-use" established in 2013
- PhD students, graduate students, visiting professors
- Main research focus:
  - Oxygen production; subsequent comparison of different production techniques
  - Flue gas treatment for CO_2 capture (oxyfuel combustion, post-combustion technologies)
  - Re-use of CO_2

Status of Phase IV.A - Work packages

No.	Sub-package (short title)	Who?	Status
A 1	Simulation study	Research Institute	Finalised
A 3	Advanced cooler design	IKN	Finalised
A 4	Future oxygen supply	Danish Technical University	Almost finalised
A 5	Experimental verification of sealing potential	Irish Cement + Research Institute	Finalised
B	Concept for a pilot plant:		
B 1	Plant capacity	Aixergee	Finalised
B 2	Design principle	Aixergee	Finalised
B 3	Dimensioning	CINAR + Fives FCB (supported by Research Institute)	Finalised
B 4	Control and safety devices	n.n.	Retendering
B 5	Cost estimation	Subgroup	Finalised
B 6	Concept for reuse	Subgroup	Finalised
D1	CO_2 overall balance	Student work/ UMons	on going

Concept for an industrial-scale Oxyfuel testing facility

Design of an industrial scale Oxyfuel kiln

Brownfield: New construction of a pilot plant using the infrastructure of an existing plant

Blackfield: Retrofitting an old existing plant

Plant size

500 to 1000 tpd production capacity due to

- Smaller scale-up gap to industrial size
- Possibly available old kiln existing
- Existing boundary conditions for installation etc. or high investment costs
- Utilization for commercial production after initial testing

What would the industrial testing cost?

Operational costs:

- Major cost driver of operational costs is oxygen costs

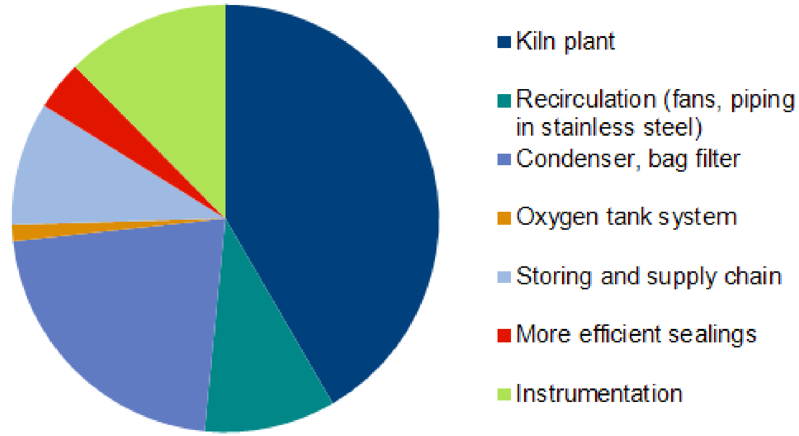
Investment costs:

- Strongly depend on plant environment and equipment to be installed or modified

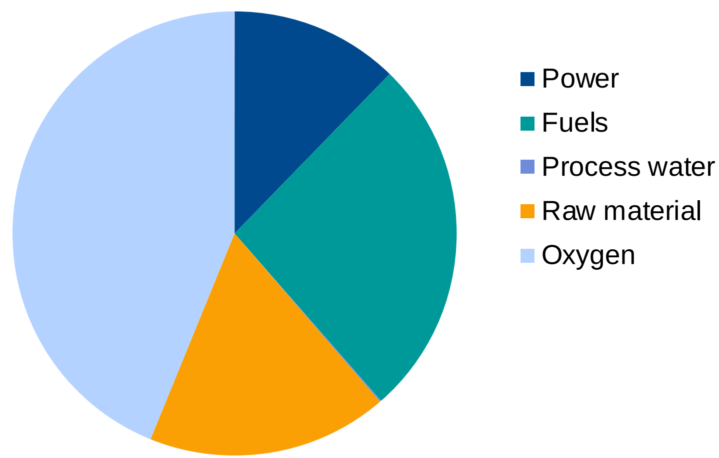
Estimated total budget required for 500 tpd testing facility:

40 - 60 M € (± 25 % uncertainty)

Equipment costs for brownfield



Variable operational costs for brownfield/blackfield



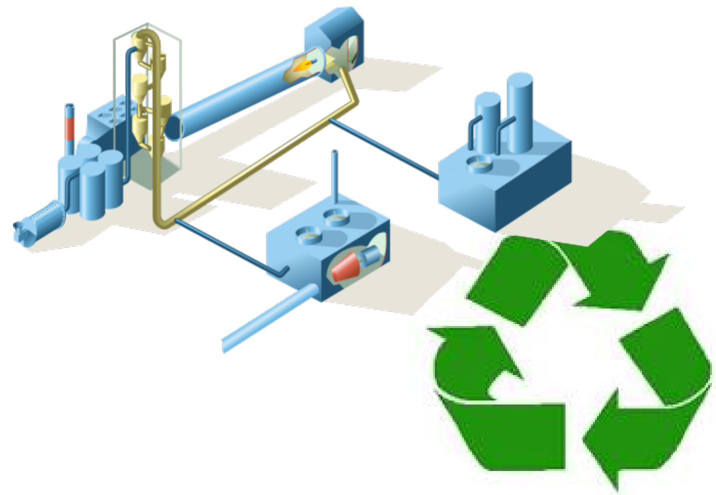
What to do with the facility after testing?

Potential options are:

- reuse for other research projects
- re-selling and reconstruction at another location
- operation for training aspects
- production of special cements or
- disposal of special wastes
- commercial operation

Options depend on:

- plant structure and construction
- infrastructure and proximity



Plant visits: From raw material supply to clinker handling

Plant inspection :

- Plant capacity
- Necessary plant modification
- Expected impact on investment
- Plant impression
- Space requirement
- Interview with plant management:
- Logistics and staff availability
- Permitting procedure
- National funding scheme
- Plant availability/ access/ further use
- Openness/willingness regarding this project

Next steps: Opportunity study

Objective:

- Technical feasibility study based on a specific plant location
- Evaluation of checklists from plant visits
- Economic feasibility study based on a specific plant location
- Reduction of cost uncertainty to ± 20 %

Deliverables:

- Identification of units to be replaced, overhauled or newly installed and maintenance standard
- Identification of limiting factors (risk analysis)
- Rough estimation of costs and time schedule

Partner: ThyssenKrupp Industrial Solutions AG

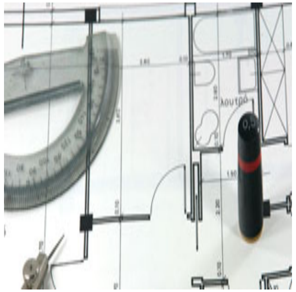
Next steps: Pre-engineering study

Objective:

- Basic engineering

Deliverables:

- Concept for layout and civil works (incl. drawings)
- General assembly drawings (3D), flow sheets, floor plans and global instrumentation plan
- Safety concept



- Calculations of material and gas streams
- Rough dimensioning of the plant and estimation of duct work
- Detailed cost assembly (uncertainty to ± 15 %)
- Proposal for time schedule

Next steps towards industrial testing

2014
- Evaluation of potential plant sites

2015
- Opportunity study
- Decision on plant site
- Pre-engineering

2016
- Funding aquisition

2017
- Design
- Engineering

2018
- Construction

2019
- Commissioning
- Starting testing phase

Communication and Dissemination

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CCS - Carbon Capture and Storage

Due to the long term growth of the global economy and the development in many markets of the world, the demand for cement and concrete construction materials will continue to increase significantly. Within this context, the technical potential to reduce overall CO_2 emissions from cement manufacturing with today's technology is limited and definitely less than what abatement strategies currently being discussed demand and what stakeholders expect. The capture of carbon dioxide and its geological storage, often referred to as "carbon capture and storage" (CCS) is seen today as an emerging technology capable of reducing CO_2 emissions significantly.

According to different abatement scenarios and the International Energy Agency's recently published Roadmap, the cement industry is expected to contribute to CO_2 mitigation globally by a set of different measures among which CCS plays a key role. Against this background ECRA has decided to look at the capture of carbon dioxide as a prerequisite for a safe geological storage of CO_2.

ECRA's goal is to examine the technical and economical feasibility of this technology as a potential application in the cement industry. ECRA lays strong emphasis on the global perspective of its research and also its sustainability aspect. This implies that not only CO_2 emissions as such, but also the huge energy demand for operating CCS plants will be taken into account. ECRA's CCS project is a long-term research project which started in 2007 and comprises five phases. Phases I, II and III have been completed and phase IV is currently underway.

ECRA CCS Project - Communication Bulletin

Carbon Capture Technology: ECRA's approach towards CCS
Communication Bulletin
29 August 2012

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Technical reports

ECRA CCS Project Phase III
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ECRA CCS Project Phase II
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ECRA CCS Project Phase I
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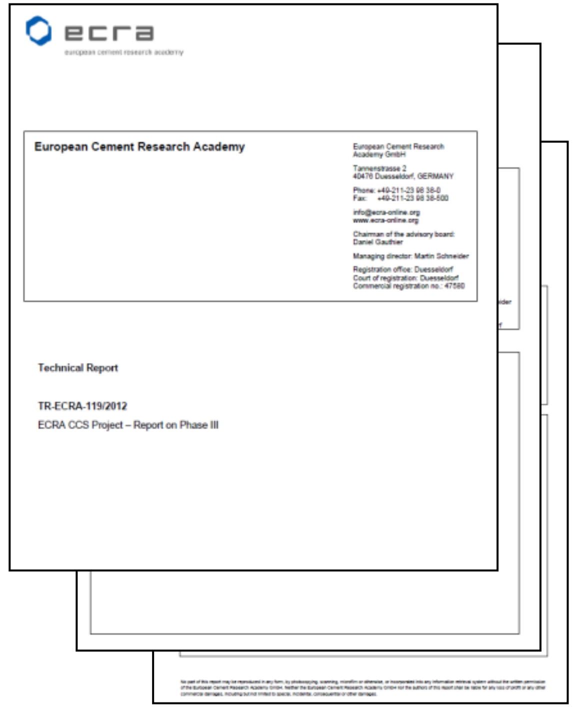
Animation: A Cement Plant with CCS

Technical reports
of phases I - III available



Challenges of CCS/R

Economic challenges

- Production costs will be increased by 36 to 110%
- Investment extremely high
- Currently, the legal and economic conditions regarding these technologies would impair the competiveness of cement production.

Technical challenges

- CO_2 storage or reuse strategy and infrastructure
- Oxyfuel still requires R&D
- Post-combustion requires further development

Thank you for your attention!

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