Innovation and Progress in the Cement Industry

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6th Brazilian Cement Conference, CBC 2014

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Industry’s competitiveness and its challenges

Climate Change and CO_2 reduction

Saving of Natural Resources (minerals and energy)

Occupational Health and the Use of Cement

Sound Concrete Durability

Innovative Use of Cement and Concrete

Cost Efficiency

Agenda

1	Energy efficiency
2	Grinding
3	Emissions
4	New cements

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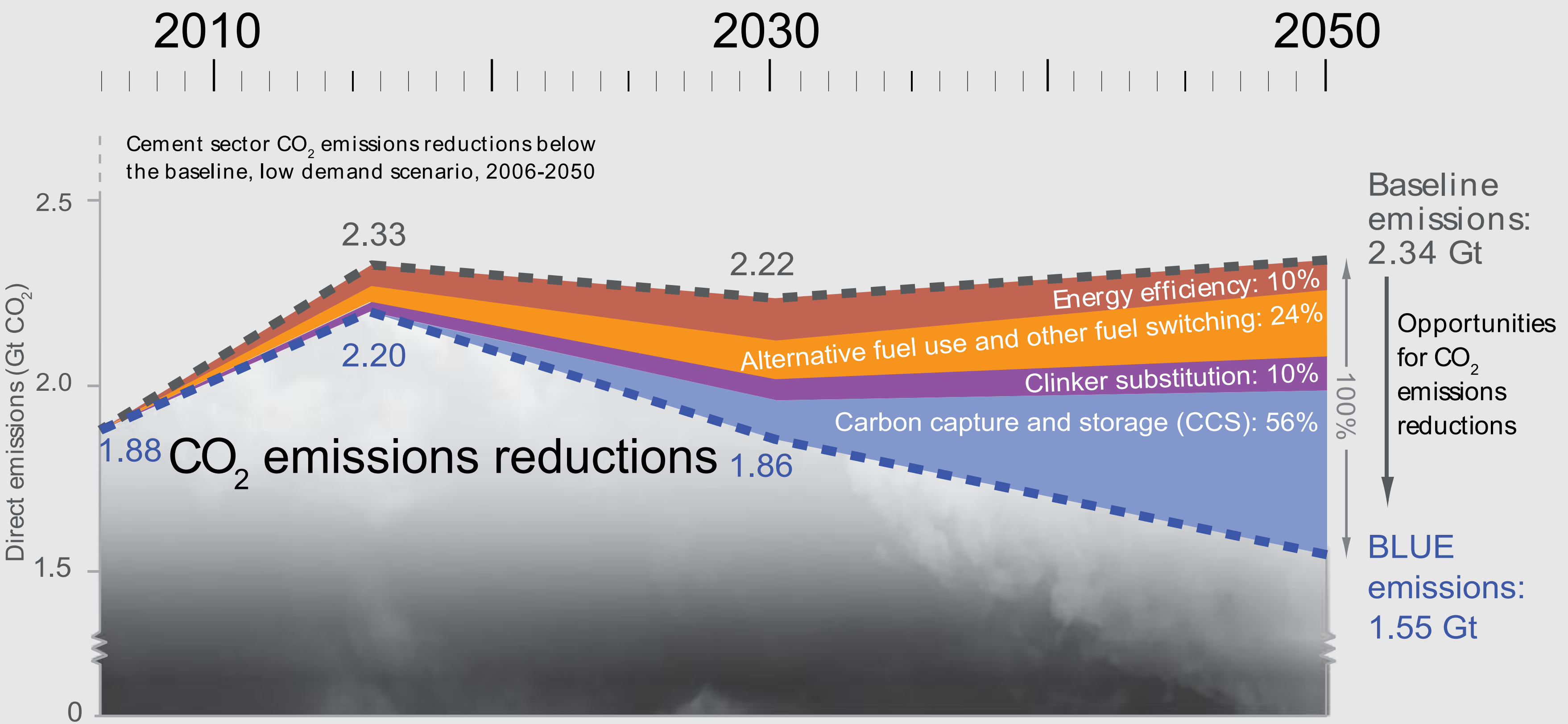
IEA roadmap targets for the cement industry



source: WBCSD/IEA

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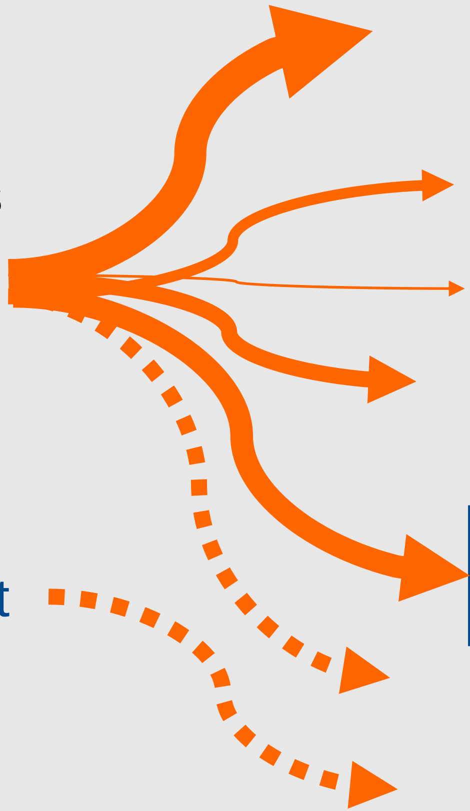
Waste heat recovery in clinker burning - in GJ/a

Kiln exit gas
and cooler
vent air,
27.1 million

Process heat



Raw material drying 11.7 million

Slag and/or lime stone drying, 2.9 million

Fuel drying and grinding 0.2 million

Excess heat (recoverable), 5.6 million

Non recoverable heat (<100 °C)
6.7 million

Generating electrical energy in future ?

Process integrated fuel drying, 3.2 million

German cement industry 2010

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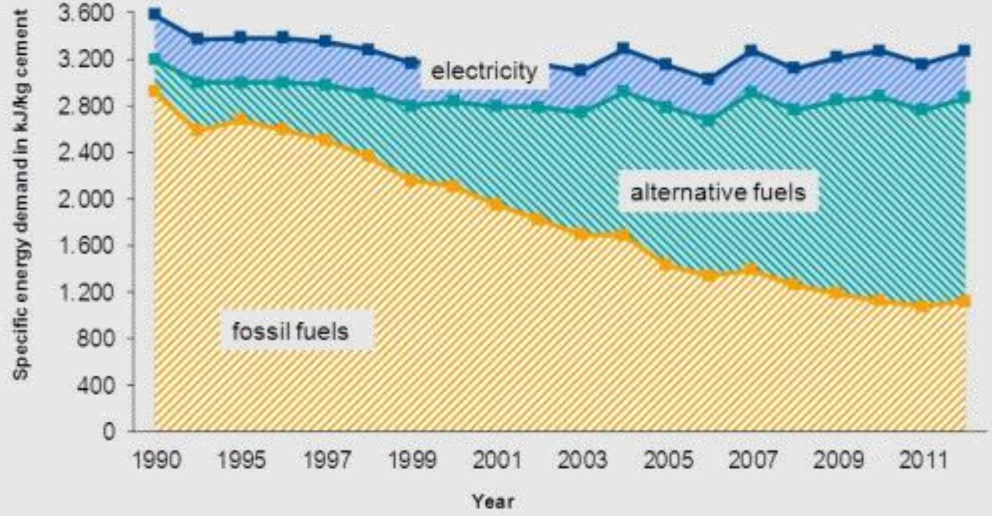
Energy efficiency – example Germany

- Overall energy demand almost constant
- Electric energy: only 10 – 15%
- Increase of energy demand
  - grinding (higher fineness, alternative raw materials)
  - new gas cleaning strategies
- Alternative fuels replace and preserve fossil resources



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Waste heat recovery to increase energy efficiency

- Introduced more than two decades ago in Japan
- Many installations and good experience in Asia
- Economic feasibility depends on specific situation such as availability of excess heat, energy costs and overall efficiency
- More full-scale installations to be expected on global level

Source: SPZ Gebr. Wiesböck

Source: Holcim

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3	Emissions
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New grinding systems

General trends:

- Large installations
- Capacity: 850 t/h raw meal

  650 t/h cement

Innovations:

- New drive concepts
- Higher availability
- Better maintenance
- Geometry of rollers and tables

Sources: Gebr. Pfeiffer, FLS, Hefei, Thyssen-Krupp, Loesche

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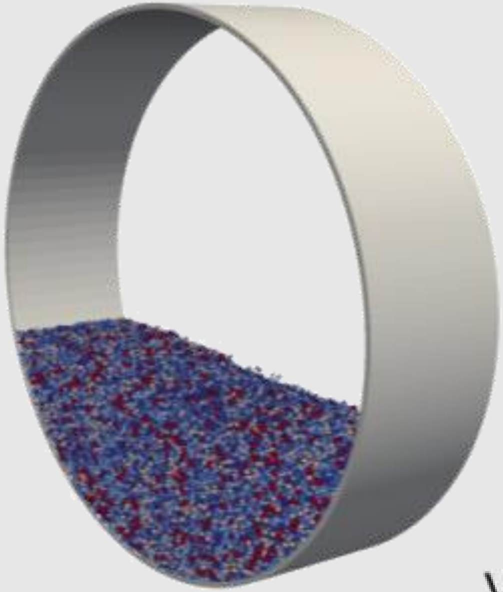
Optimisation of existing mills

Potentials:

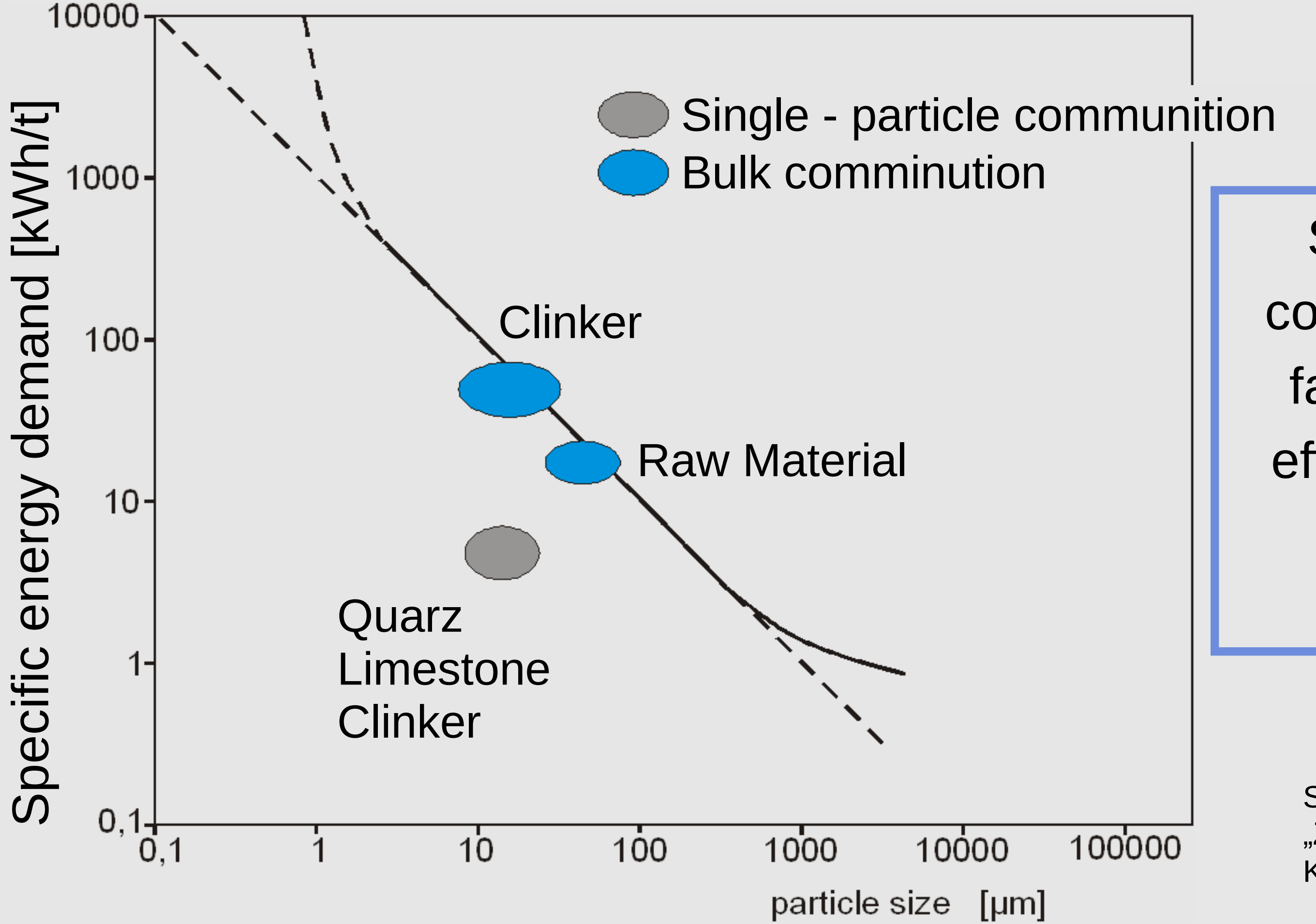
- Large number of existing mills
- Low energy efficiency
- Estimated savings of up to 10%

Challenges:

- Increasing demand
- Diversification of product portfolio
- Higher fineness
- Separated vs. inter-grinding
- Increased understanding of the process
- Development of new optimisation tools



Single particle vs. bulk comminution

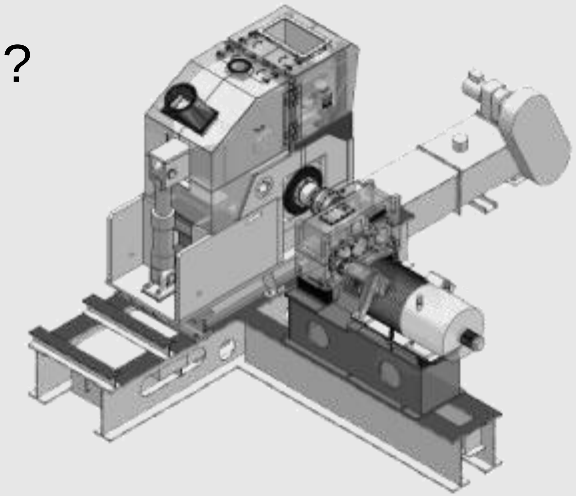


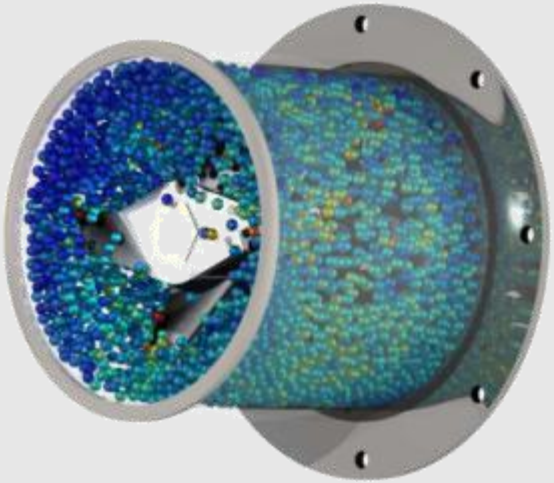
Single-particle comminution is by far more energy efficient than bulk material comminution.

Source: Höffl, „Zerkleinerungs- und Klassiermaschinen“

Future grinding technologies

- Is the optimum of comminution already reached?
- What can we learn from other industries?
- Analysis of grinding systems
- Division into sub-processes:
  - comminution
  - material handling
  - dispersion
  - classification …





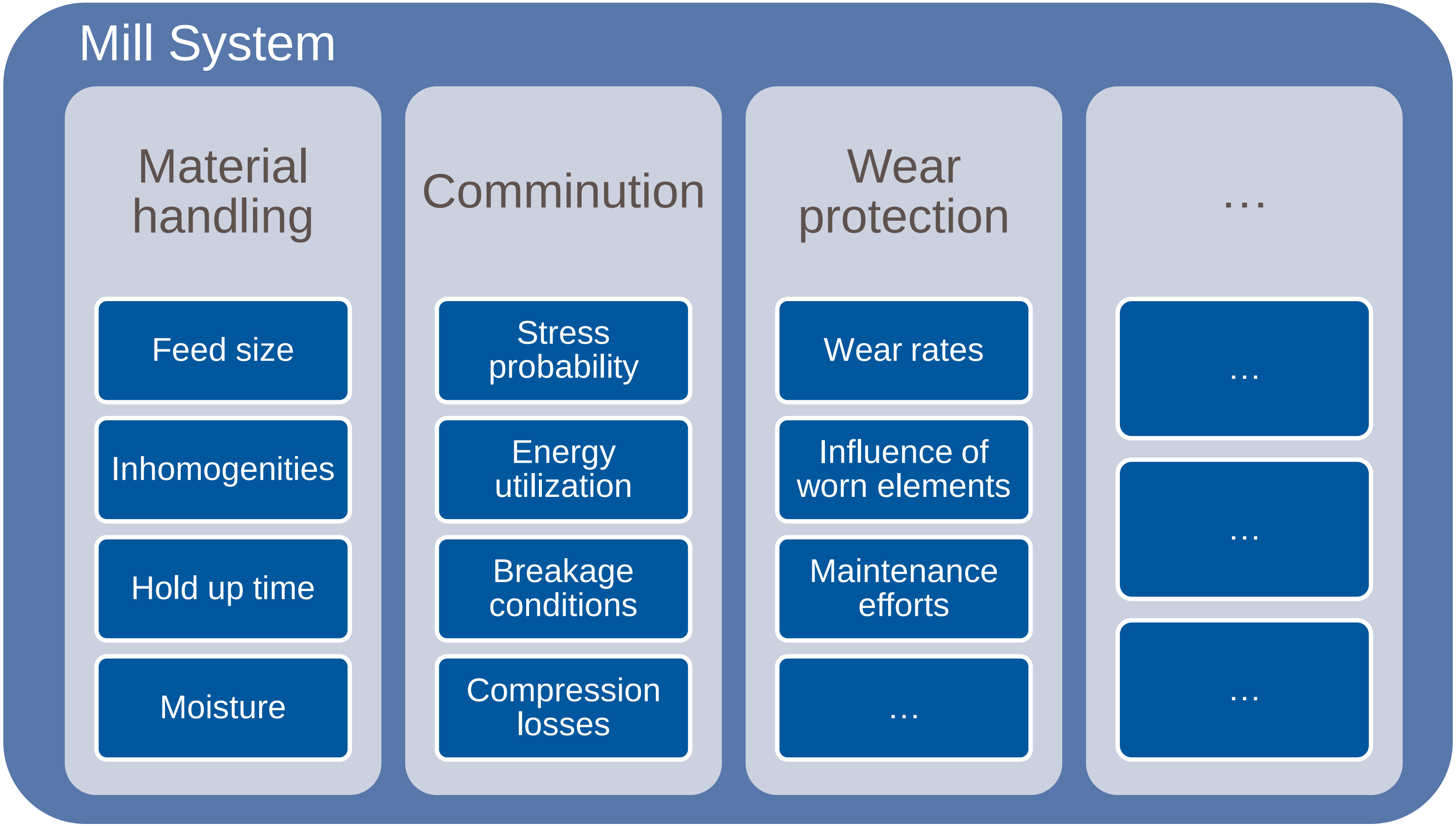
Sources: Cemag, Reichardt, R.

Round table „Future grinding technologies“

Development of new and innovative grinding technologies!

- Partners required for full access to researchers, suppliers and operators in the field of comminution
- Organisational structures required to ensure continuous work progress

Exemplary division into sub-processes



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1 Energy efficiency

2 Grinding

3 **Emissions**

4 New cements

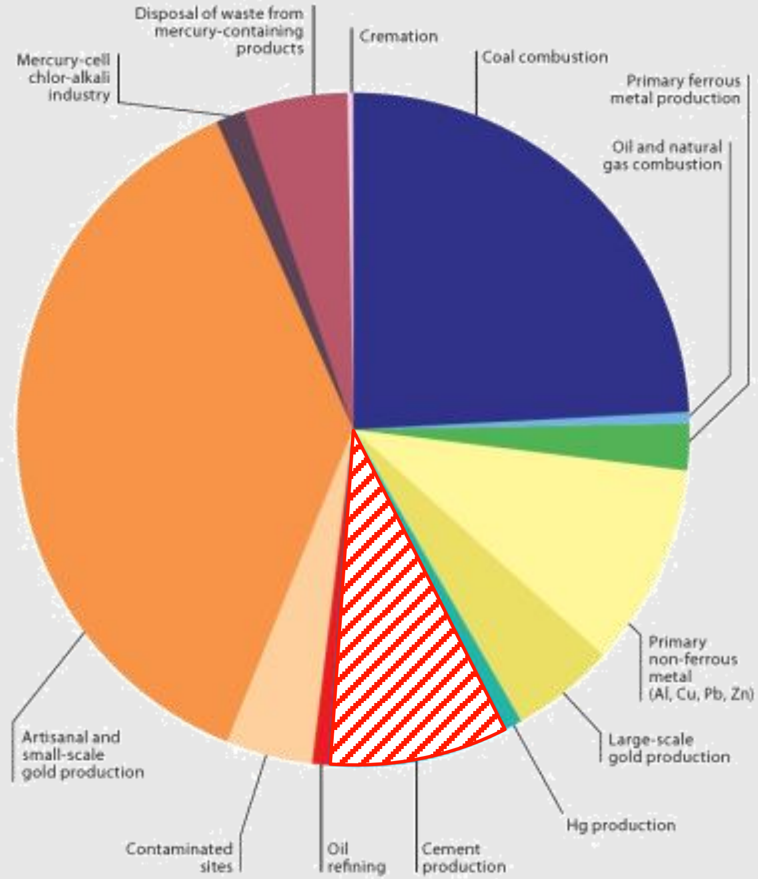
Mercury emissions – Global context

Minamata Convention on Mercury

- Globally binding instrument
- Targets at worldwide reduction of mercury emissions
- Open for signature in Oct 2013

UNEP Global Mercury Assessment

- Cement industry's Hg emissions: 9%
- Emissions of cement plants overestimated?



Source: UNEP 2013, reference year: 2010

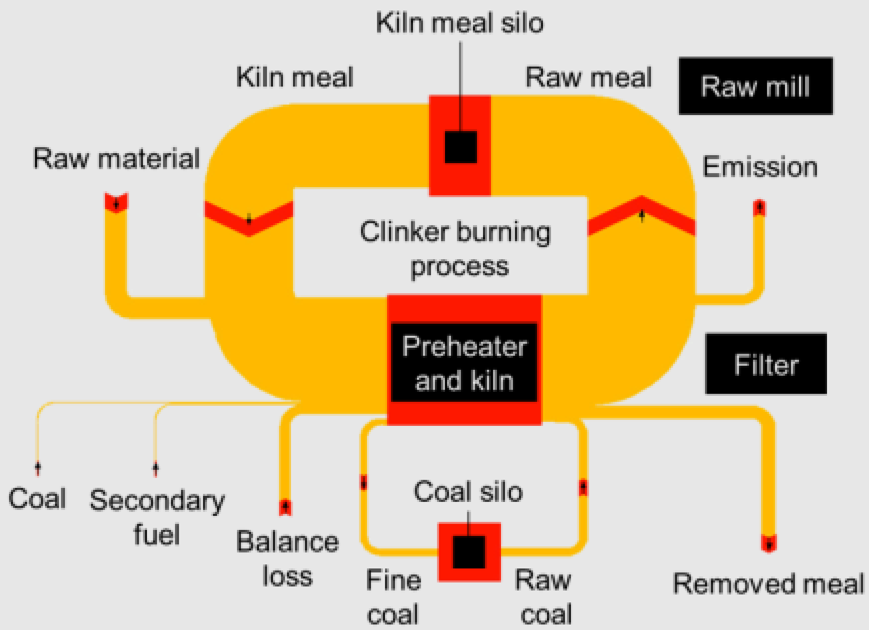
Mercury emissions – BAT and abatement strategies

Behaviour of mercury in clinker burning is well understood

- Knowledge gaps regarding binding forms

Abatement strategies:

- Input control for certain alternative materials and fuels
- Dust bleeding to release mercury cycles in combination with temperature control
- End-of-pipe solution ?



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NO_x reduction in the cement industry / BAT

In Europe:

BAT for NO_x Reduction in the cement industry:

- Primary measures/techniques
- Staged combustion
- SNCR
- SCR (subject to catalyst/process development)

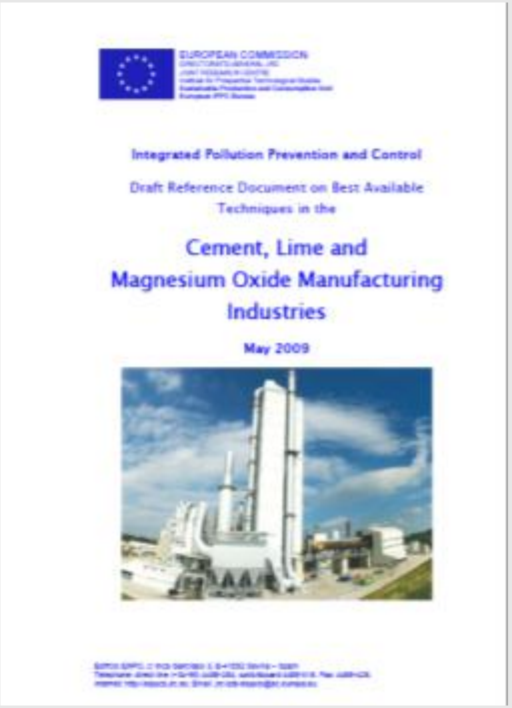
Achievable Emission Level (AEL):

< 200 - 450 mg/m^3 for preheater kilns

400 - 800 mg/m^3 for LEPOL and long rotary kilns

NH_3 slip from SNCR process:

30 - 50 mg/m^3



High efficiency SNCR process

Characteristics:

- Injection of reducing agent is process controlled
- Several injection layers according to the temperature profile in the riser duct

Objectives:

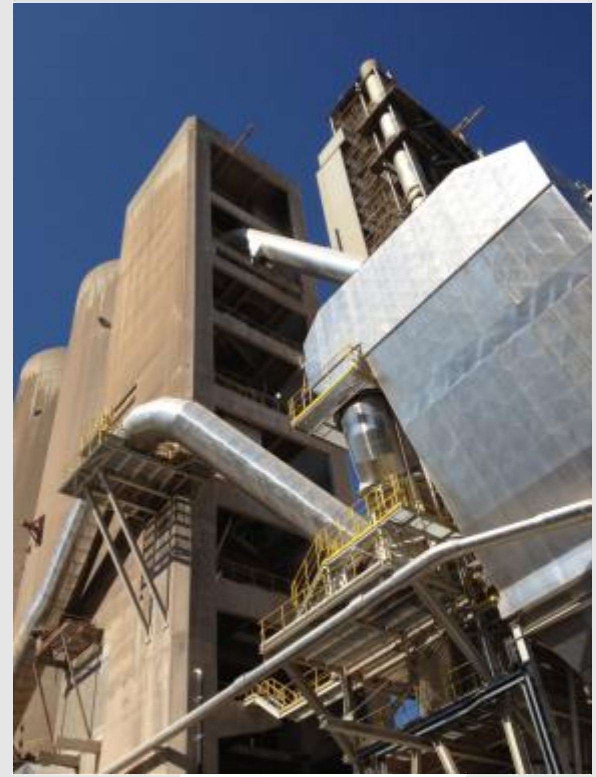
- Optimal distribution of reducing agent in the riser duct
- Low NH_3 slip (emission of unreacted ammonia)
- Reduced consumption of reducing agent

Injector configuration in the riser duct of a rotary cement kiln

SCR Demonstration projects in Germany and Austria

SCHWENK
Baustoffe fürs Leben

ROHRDORFER
ZEMENT



LAFARGE
CEMENT

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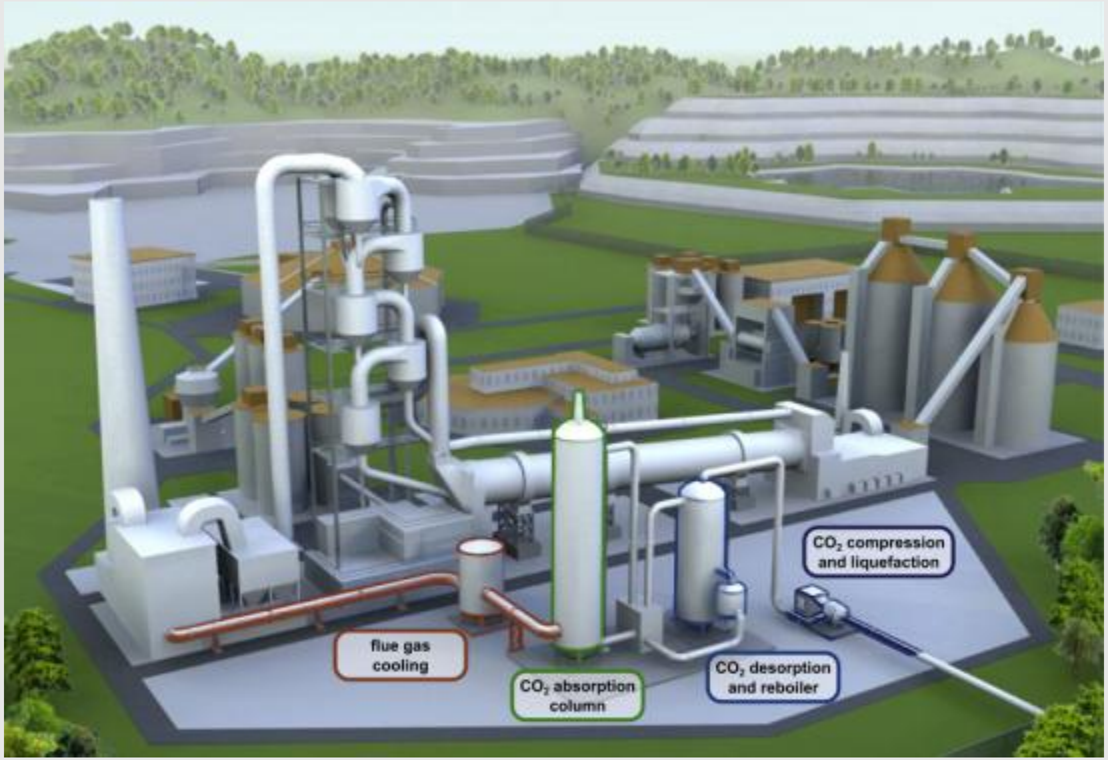
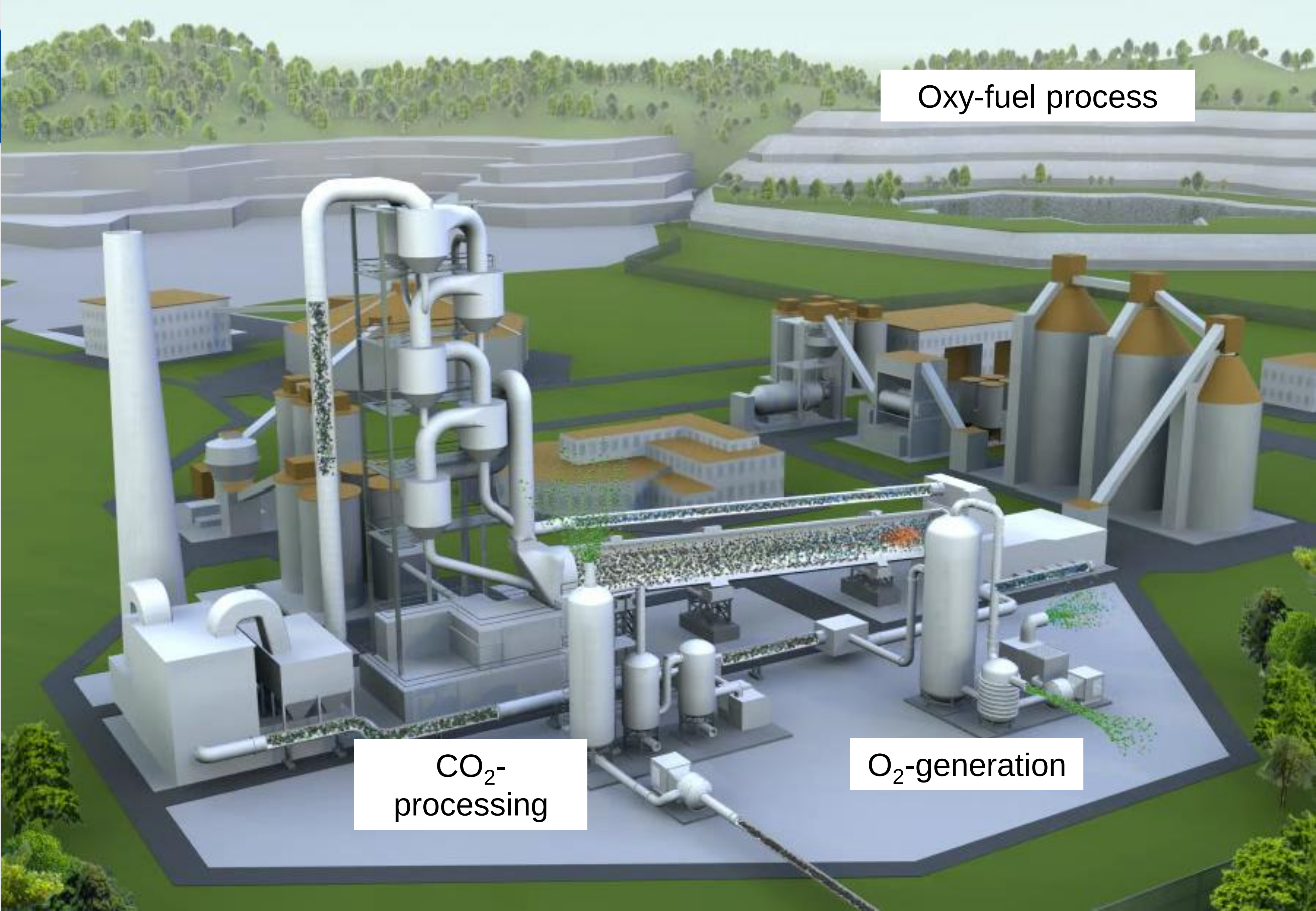
Post-combustion carbon capture

- Tail-end measure
- No impact on clinker burning process
- Different concepts
  - chemical absorption
  - carbonate looping
  - membranes
- Chemical absorption process requires low pressure steam - doubling of energy consumption

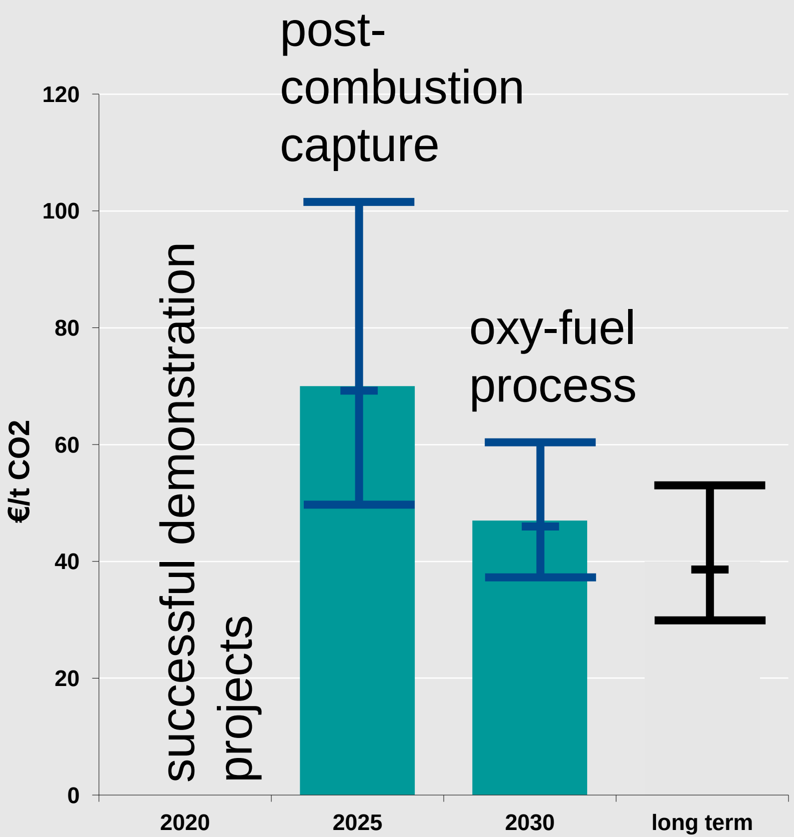



Oxy-fuel process
CO_2-processing
O_2-generation

Cost estimates

Commercially available:

- 2025 post-combustion capture
- 2030 oxy-fuel processing
- Cost per tonne CO_2 avoided (incl. investment, transport, storage)
- Post-combustion: 50−100 €/t
- Oxy-fuel: 40−60 €/t
- Significant increase in energy consumption
- Cement production cost will increase significantly



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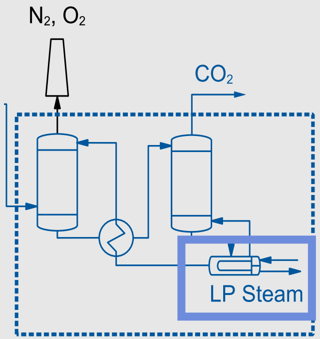
Utilization of captured CO_2 for methane production



CO_2 sources like power plants, cement plants, etc.

↓

CO_2 capture technologies

→ CO_2 → methane production

H_2 production with regenerative energies

→ H_2 → methane production

methane production

CCR – Current status and open questions

Opportunities:

- Could be a "big sink" for CO_2
- Can be driven by renewables
- Renewable energy can be produced at best location
- H_2 and methane can be stored
- Each step of the process is known

Open questions:

- Technical and economical feasibility

http://worldtravelmaps.info/wp-content/uploads/2012/08/europe-map-natural-gas-network.jpg

It would be good to understand the potentials and eventually liaise with partners

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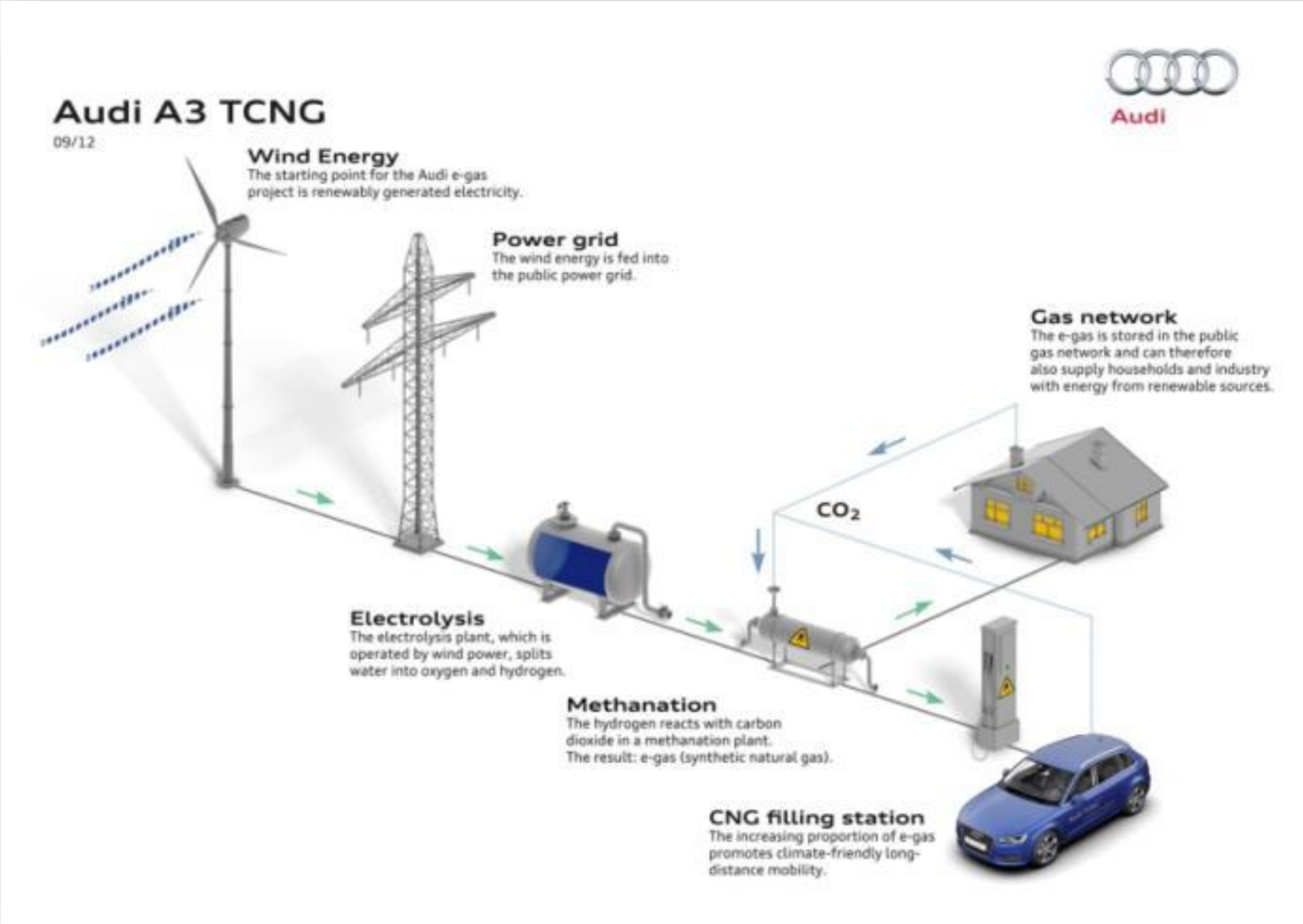
The use of CO_2: The Audi TCNG project as an example



https://www.audi-mediaservices.com/publish/ms/content/en/public/fotos/2013/01/25/A3120336.standard.gid-oeffentlichkeit.html

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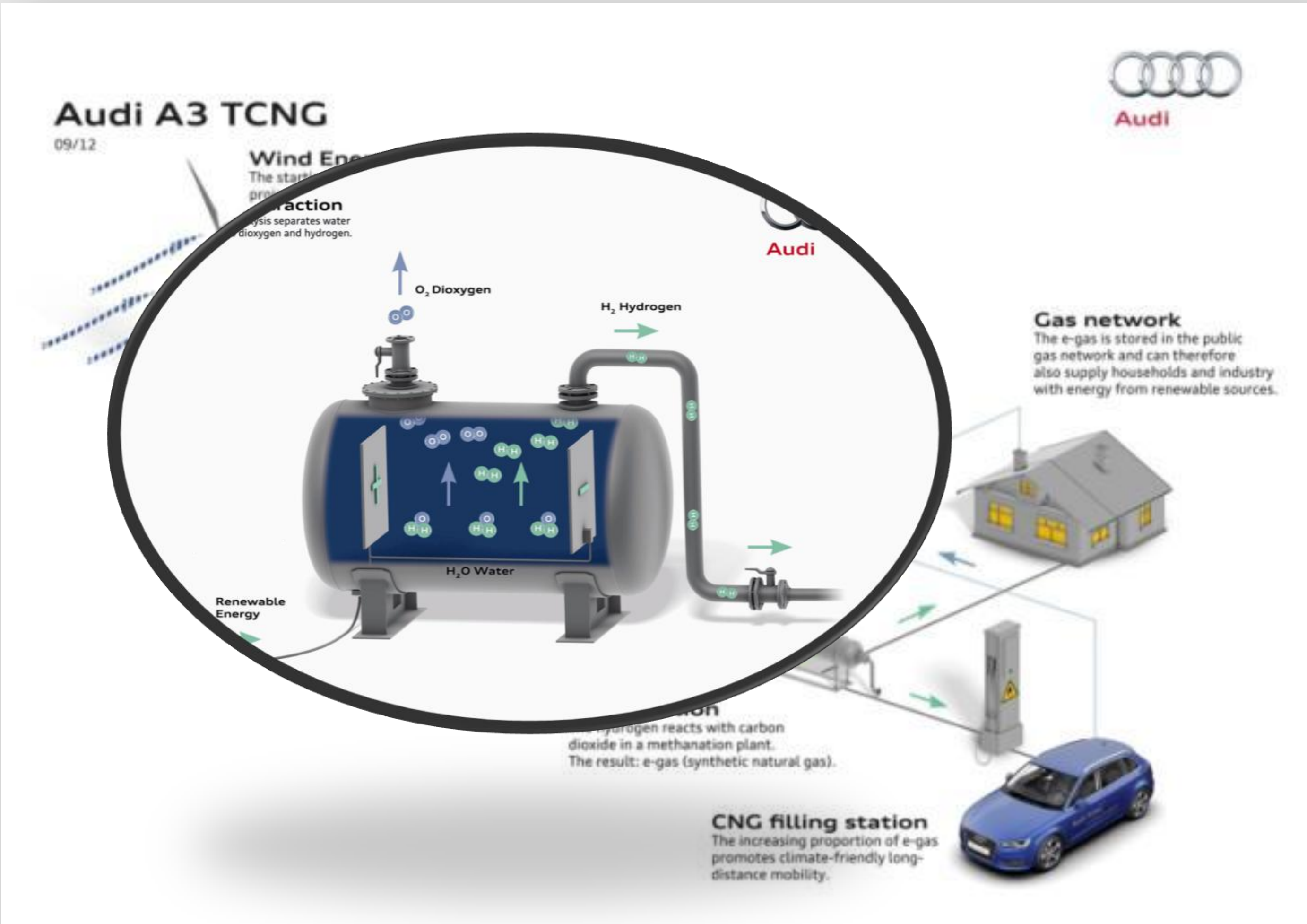

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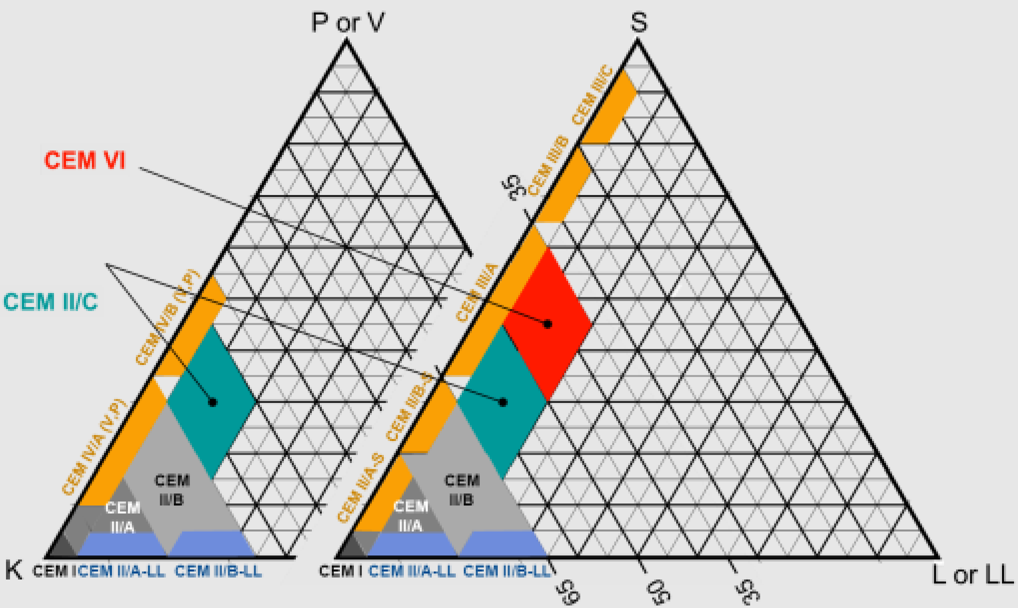
Future cements

Portland cement clinker based

- Well tried and proven constituents
- Good availability of materials
- Limited in CO_2 efficiency



New approaches

- Belite Calciumsulfoaluminate Ternesite
- Belite Rich Portland Cement
- Celitement

- First important steps reported
- Small volumes to start with
- Higher CO_2 efficiency

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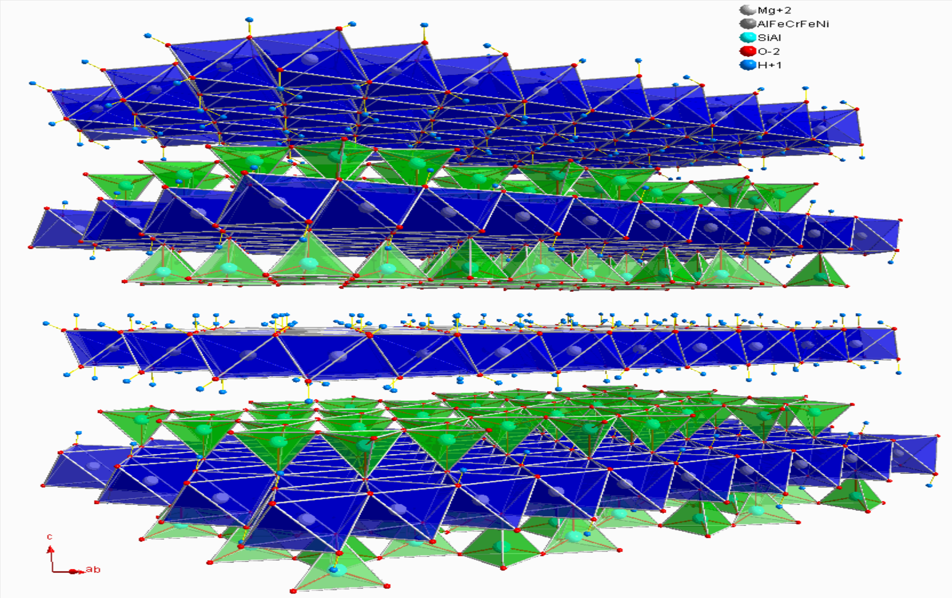
Calcined clays – a potential cement constituent

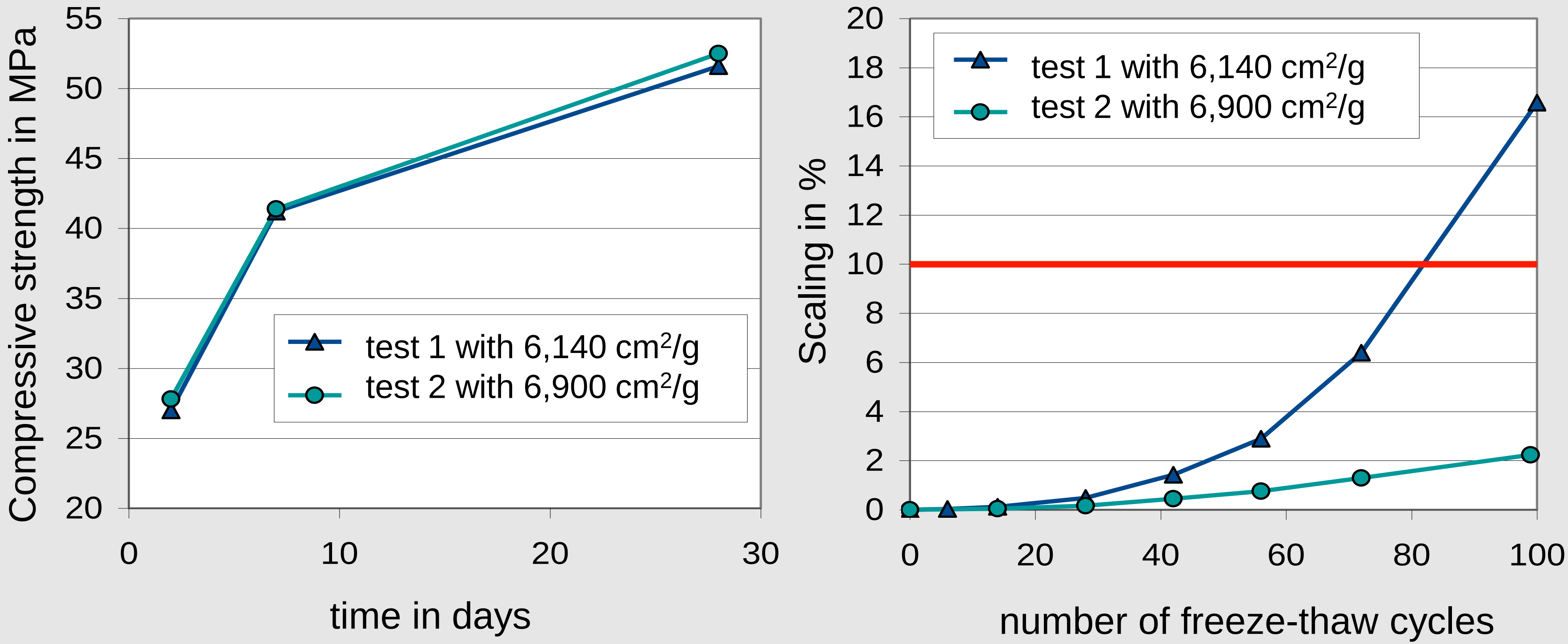
- High availability worldwide
  - 26% of the sedimentary rocks are clays or shales
- In Europe EN 197-1:
  - potential use in CEM II, CEM IV and CEM V
- Reactive silicon dioxide content shall be not less than 25 mass %



Source: http://www-esd.lbl.gov/ESD _staff/kleber/BioGeoChem/E5Tomi.htm

Cement optimization in the context of durability

Portland-limestone cement CEM II/B-LL with 30 M.-% limestone



Compressive strength (left) and scaling of concrete (cube test, right)

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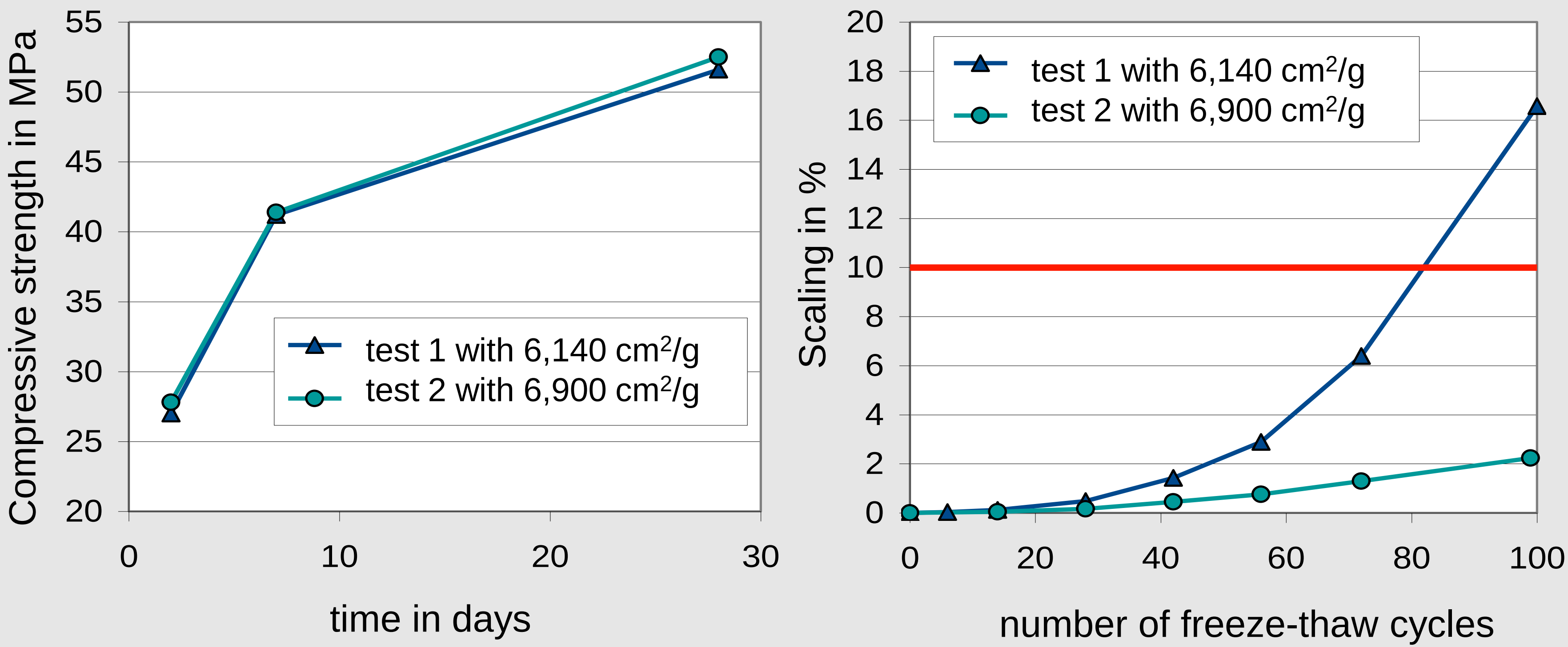

Compressive strength (left) and scaling of concrete (cube test, right)

compressive strength ≠ durability

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Thank you!