



Results and Outcome from Norcem CO₂ Capture Project CSLF – 23. Apr 2018

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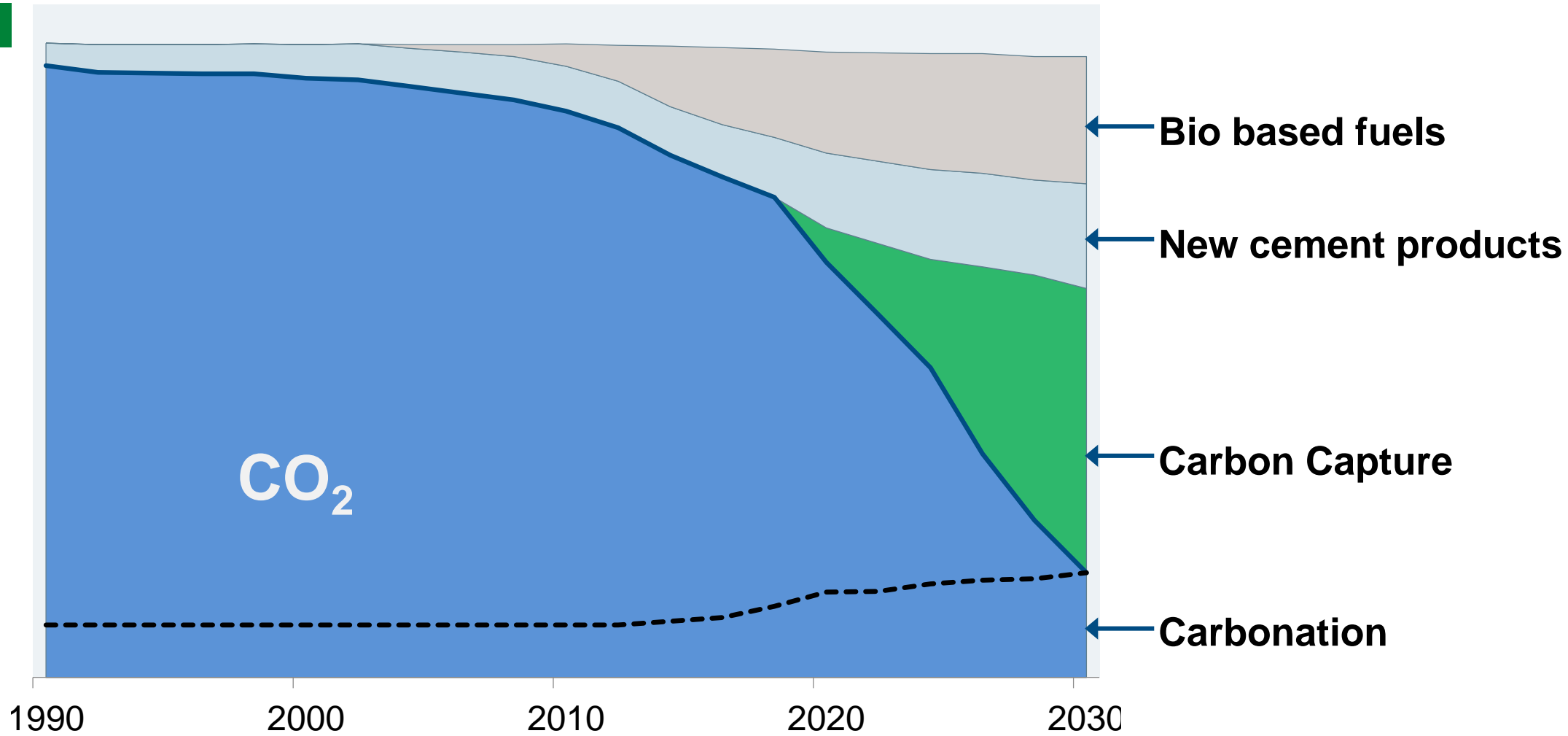


- Second largest company in the world within cement, concrete and aggregates
- 60,000 employees
- Located in more than 60 countries
- Aggregate reserves: 20 billion tonnes
- Cement capacity: 194 million tonnes
- CO2 emissions: ~ 70 million tonnes/ year
- Part of region Northern Europe – 5,000 employees
- In Norway: Norcem Brevik & Norcem Kjøpsvik
- Brevik Plant:
 - 1,3 million tonnes cement
 - 1 million tonnes CO2/ y

HeidelbergCement – a global actor within building materials

**HCNE Vision:
Carbon Neutral
Concrete Products
within 2030!**





We need carbon capture to fulfill our Zero Vision

Recap: Conclusions from 27. – 28. Oct 2014!

- **CO2 emission is an unavoidable by product from the calcination reaction**
- **Carbon capture seems to be the only technology for CO2 mitigation in the cement industry**
- **We need to obtain knowledge and experience from real testing**
- **4 post-combustion technologies are selected**
- **Major part of planned testing will be executed in 2014**
- **Benchmark Study – Important outcome of the project – Comparison of technologies in a commercial scale perspective.**
- **Commercial scale not necessarily 100 % capture**
- **Before summer 2015 Norcem will have much more knowledge regarding the realism of industrial carbon capture; especially in the cement industry**
- **Need a market for CO2 (transport & storage/ reuse) for realization on technology concept**

Norcem CO₂ Capture Project

- **Project launched in May 2013 - plan to conclude in Mar 2017**
- **Project on behalf of the European Cement Industry!**
- **Partners:**
 - **Norcem**
 - **HeidelbergCement**
 - **ECRA (European Cement Research Academy)**
 - Role: Technical support & dissemination of project results
- **Total budget: 93 M NOK (11.7 M €)**
- **Gassnova / Climit-Program: 75 % funding**

Selected technologies in Phase I and II

Phase I:

Amine Technology (S26)
Aker Solutions

TRL 8-9



Membrane technology
(FSC – Flat sheet)
MC: NTNU, DNV GL,
Yodfat Engineers
TRL 4-5



Solid Sorbent
absorption technology
RTI (Phase I)
TRL 5



Regenerative calcium
cycle, Alstom Power
TRL 3



Phase II:

Solid sorbent absorption
technology
RTI (Phase II)

TRL 5!



Membrane technology
MemCCC – **New project
with own financial
support**

NTNU & Air Products

TRL 5!



Main results from testing

- Project itself has been a great success even not all results are as expected or wanted.
- Both Norcem and technology providers have learned a lot from pilot design and construction, preparations of infrastructure & utilities and testing on real conditions.
- MC/ MemCCC → exposure testing → focus on sorbent/ membrane performance/ lifetime and make the technology work as expected and performed under ideal conditions in lab. Pilot quality & operational problems.
- RTI experienced difficulties in design when upscaling from bench scale to 3-floor scale pilot.
- MC/ MemCCC, RTI and Alstom: A lot of assumptions had to be assumed and included by us to be able to evaluate the full scale economic performance(Benchmark Study).
- Aker Solutions → only vendor that managed to deliver full scale design incl. economic calculations.
- RTI and MC/ MemCCC did not manage to mature the technology from Phase I to Phase II.
- Total Annual Cost, TAC: In the range from 40 to 59 EUR per ton of CO2 avoided at plant level.
- All costs have increased from Phase I to II!
- Aker Solutions amine technology is by far the most mature technology – TRL 8-9 and ready for full scale demonstration.

Lessons Learned

- For Norcem and the technology providers it has been of vital importance to test under real conditions
- Norcem has learned a lot being host for the test programs → much more resource-demanding than first anticipated
- Very different demand for support!
- The exhaust gas experiences much more «aggressive» than first expected
- Transport of representative flue gas was not straight forward (avoid heat loss and condensations is a must!)
- Important to construct quality pilots – even though the test campaign is short!
- Presence is a «must» when you are developing new technology!
- Commercial partners is a «must» in order to ensure necessary drive towards commercialization!
- We have developed a quite good Benchmark analysis tool which gave us the opportunity to compare apples with apples!
- Time consuming to develop capture technologies and upscaling is more time consuming than anticipated!
- Close dialog with Gassnova – priceless!

■ Back up slides

The Norwegian full scale CCS Demonstration Project

CO₂-STORAGE

- Planning by Statoil and partners
- Intermediate storage on shore
- Offshore storage in the North Sea
- Huge capacity

CO₂-TRANSPORT

- By ship
- Responsibility Statoil



Norcem HeidelbergCement
Cement production



Yara Porsgrunn
Ammonia production



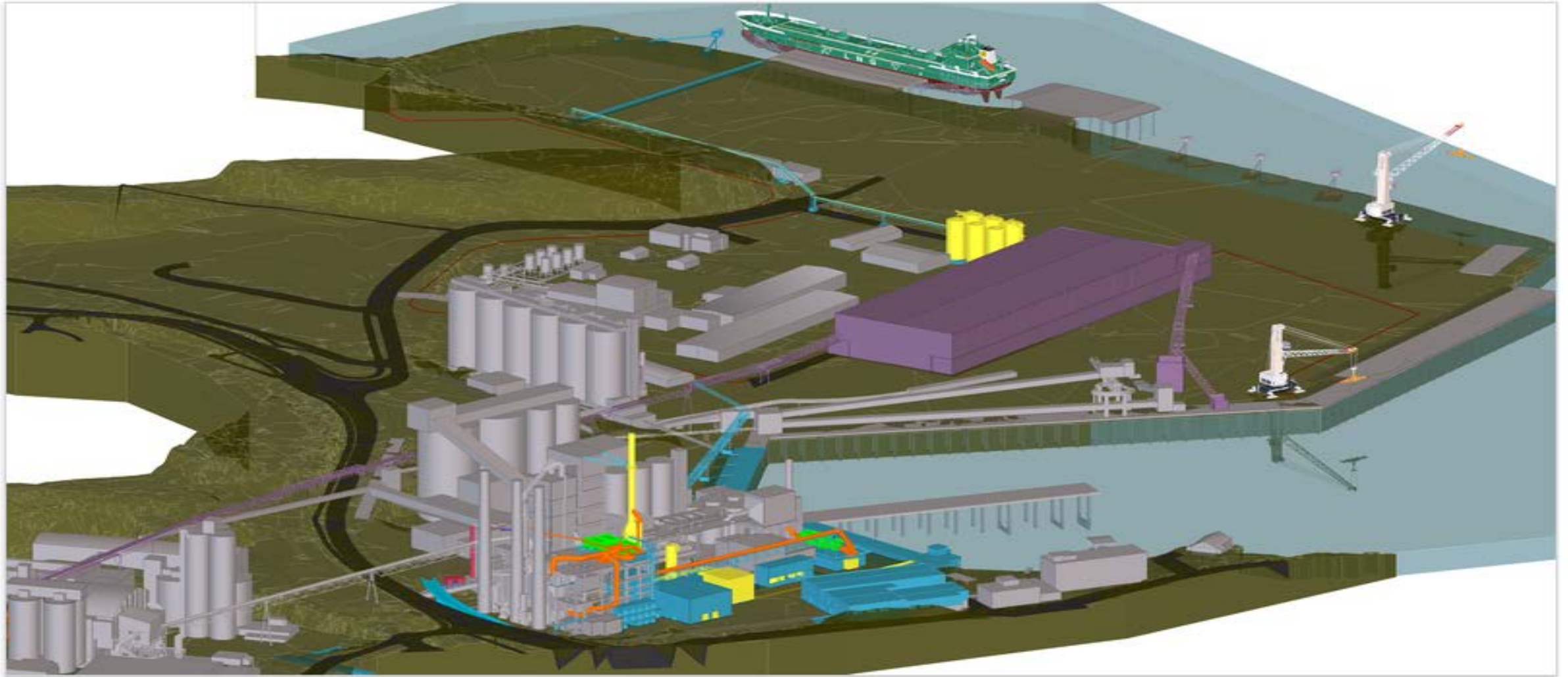
Fortum Oslo Varme AS
Waste-to-energy plant

Full Scale Carbon Capture at Norcem Brevik

Concept Study Results 2017	
Technology	Aminsolvent
Technology provider	Aker Solutions
Capture capacity	400 000 t/ år
Excess heat	46 MW
Intermediate storage CO2	5 300 t
Cost estimates (CAPEX/ OPEX)	± 30 %



Concept study – Layout/ Integration with existing cement plant



The road to a possible project realization:

- May - June 2018: Political process in Parliament
- If positive Parliament decision:
 - FEED project
 - Appr. 12 months execution - finalized Q2/2019
 - New QA-process and Parliament decision (and in parallel internally in HC) regarding realization at the earliest Q4/2019
- Construction period at Norcem Brevik: Approx. 3 – 3,5 years
- Ready for startup: 2023?



We cross our fingers for a positive decision in the Parliament!