CCS progress from an industrial perspective – in EU and beyond

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A global supplier of cost-effective \( \text{CO}_2 \) capture plants and technology

- 20 years experience and competence within CCS in Aker
- A focused technology company
  - Core competence within flue gas treatment and \( \text{CO}_2 \) capture
  - Invested about €50M in technology
  - Leading one of the largest R&D programmes in Europe (SOLVit)
  - Operating an advanced mobile test unit (MTU)
  - Engaged in several CCS projects
  - About 300 employees in Aker have been engaged in CCS
  - Licensee provider of capture plants
  - Aker Clean Carbon’s step by step business approach:

  Develop – Test – Improve – Deploy

- Tiller test pilot
- Sleipner field
- Kårstø \( \text{CO}_2 \) pilot
- Kårstø demo study
- Mobile Test Unit
- A large-scale pilot constructed

The preferred partner
CCS progress from an industrial perspective – in EU and beyond

1) We still see high activity level in EU and USA/Canada
   • Large EPC contracts have been signed
   • Increased focus on Gas CCS projects both in UK, EU and especially in US
   • New markets/emitters starting to explore the CCS technology
   • As projects has matured - several projects have been stopped
   • Slower market development than foreseen
   • Large investments have been made by “small” technology suppliers like ACC
   • Listed CCS technology companies showing negative financial results

2) We experience very challenging Terms & Conditions from Utility sector
   • Risk averse (technology has not be deployed full scale yet)

3) Limited financial compensation from Utility sector in early phase
   • CCS not required to generate power
   • Possible green washing from some companies?

4) Several technology companies have developed the technology over decades
   • Dilemma: In order to get projects/funding extensive knowledge sharing is required
     ▪ Competitors will get “deep” knowledge of technology
     ▪ Technology company less commercial attractive for next project (“Techn is known”)   
     ▪ New players/suppliers get a “financially easy way” to offer capture technology
   • Intellectual Property Rights (IPR)
CCS progress from an industrial perspective – in EU and beyond

5) CCS projects are in principal mega projects involving:
   • Government and politicians
   • Local community and public
   • Finance
   • Local, National and International laws and regulations
   • Cross boarder cooperation

→ All time consuming and challenging for technology companies who shall also deliver on ongoing projects and develop the technology further

6) Collaboration with EPC providers and local construction companies
   • Challenging and time consuming

7) Delivery models vary from project to projects
   • FEED (paid/no payment, financial contribution…)
   • EPC model (EPCm, EP, C../ paid/no payment, financial contribution..)
   • Licensing

8) Competing technologies should focus on own technology
9. In the Norwegian context and Internationally KLIF’ statement is very positive:

“Based on all the new knowledge published within the last year, together with the calculations from NILU on specific expected emissions from TCM, KLIF consider that there is highly probable that specific emission targets for a full scale CO2 capture unit based on amines can be given”
Market trends in our area of work

**Utility market**
- Utility market want to be “Informed buyers” and “capture ready”
- Largest players invest in pilot plants and FEED studies
- High focus on reducing own risk
- Increasing concern about HSE issues
- Compensation format:
  - Lump sum contracts expected as Utility market are used to this format
- Active in pursuing funding opportunities
- Regulated market most interested (US specific)

**Refineries/ O&G**
- Limited interest as Governmental funding supports Utility market
- O&G clients interest due to asset owner of storage sites
- EOR potential is being explored
- Low gas prices supports example:
  - Energy demanding oil sand production with CCS
- O&G CAPEX focused, as gas is considered low cost

**Industry**
- Limited interest as locally produced product are sold on world market
  - CCS could potentially be a show stopper for local industry
- Not expected to increase investment in CCS hugely before global agreements
- Other emission sources than CO2 have more attention, SO2, fluor, particles, mercury.
- Cement industry has limited excess heat
Carbon Capture Geopolitics

- Carbon capture must be globally deployed to successful
- International cooperation will realise carbon capture:

“There is an ambitious growth path for CCS from 2010 to 2050 where CCS development will start in the industrialized countries but is expected to rapidly shift to developing regions after 2020.”

- IEA

The challenge to policy makers:

- UN Conference on Climate Change in Durban must send a clear message to the world:

“ Emitting CO₂ will no longer be free”
Carbon Capture and Storage (CCS) – Tested, safe and deployable

**CO₂ Capture**
- Mature technologies
- Upscale and cost reduction

**CO₂ Transport**
- Deployed in North America for Enhanced Oil Recovery (EOR)

**CO₂ Storage**
- 15 years safe storage in the Sleipner offshore field, Norway.
Pilot operations - background

- Key performance data are established specifically for actual power plant conditions
  - Flue gas
  - Steam
  - Physical environment
  - Design basis

- The performance data are substantiated by long term testing in pilot rigs
  - MTU: 13,000 hours (Longannet 10,000)
  - Tiller: 4,100 hours
  - Esbjerg: 7,000 hours

- Carried out 20 larger test campaigns
Mobile Test Unit operations
Testing in an industrial environment since 2008

Exhaust Gas from Coal Fired Power Plant
Exhaust Gas from Coal Fired Power Plant Super Critical Cycle
Exhaust Gas from Residual Catalytic Cracker & Combined Heat and Power Plant
Exhaust Gas from Cement Plant
Exhaust Gas from Gas Turbine
Exhaust Gas from Coal Fired Power Plant

2008 RISAVIKA GAS CENTRE
2009 SCOTTISHPOWER
2010 TECHNOLOGY CENTRE MONGSTAD
2011 NORCEM
2012 HEIDELBERGCEMENT Group
2013

The preferred partner
CO₂ Technology Centre Mongstad – TCM
Flexible amine plant in 2011

- **Technology:** Aker Clean Carbon
- **Capacity:** 78,000 tonnes CO₂/year
- **Two flue gas sources:**
  - Gas Power (CHP) flue gas: ~3.5 vol-% CO₂
  - Residual Catalytic Cracker (RCC) flue gas: 12.9 vol-% CO₂, resembling flue gas from coal
CO₂ Technology Centre Mongstad – TCM
Flexible amine plant in 2011

Construction of ACC Absorber Tower:
- Completed in 20 days
- 3.5 x 2 x 62 m
- Concrete w/liner
- Slip-form construction

Plant construction method:
- Modularization by Pre-Assembled Units (PAU) and prefabrication
- Construction of auxiliary and piperack
  Pre-Assembled Racks at Kvaerner Stord, transport to Mongstad and installed
UK - ScottishPower
Full-scale CO₂ capture plant by 2014

- Retrofit coal fired 300 MW
- Annual capture of 2 million tonnes CO₂
- CO₂ transport in pipeline, storage in depleted offshore gas field beneath the North Sea
- FEED contract award 2010 - submitted March 2011
- ACC sole technology provider in negotiations with ScottishPower-led consortium
- Funded by United Kingdom
- Eligible for European Union funding: NER300 (EU Flagship Programme)
Italy - Enel

Full-scale CO₂ capture plant by 2015

- Capture from 250MW equivalent, 660 MW coal fired plant
- Annual capture 1 million tonnes CO₂
- CO₂ transport in pipeline, storage in saline aquifer beneath the Adriatic Sea
- FEED contract award 2010 – submission May 2011
- ACC one of several FEED suppliers
- European Union funding:
  - Awarded to FEED (European Economic Plan for Recovery)
  - Eligible for full scale funding from NER300 (EU Flagship Programme)
Germany - EnBW

Full-scale capture plant feasibility study

- New coal fired 912 MW supercritical power plant
- Annual capture of 5 million tonnes
- CO₂ capture, transport & storage
- Contract award 2010 – phase 1 submitted March 2011
- Commercially driven project, no public funding
CCS is good for the environment and global warming

1950

No treatment

2010

Present treatment. Some Emissions:
- Dust: ~50 mg
- SO$_x$: 30 - 70 ppmv
- NO$_x$: 30 - 70 ppmv
- CO$_2$: ~13% vol.

2014?

Carbon Capture. Emissions:
- Dust: ±100%
- SO$_x$: ±99%
- NO$_x$: ±~25%
- CO$_2$: ±90%

“Without CCS, overall costs to halve CO2 emissions levels by 2050 will increase by 70%.” - IEA
Summary

- ACC is strongly committed to further develop CCS technology
  - Currently most funding from internally sources
- ACC can give commercial attractive guaranties
- Speed and momentum in deploying CCS is important:
  - Corporate perspective
  - Political perspective
  - Environmental
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The preferred partner
At the core of Aker Clean Carbon’s activities: Technology, Process Design and Equipment

Strategy:
Full scale plant and process design, and key equipment package

Characteristics:
- Comprehensive track record
- Uncompromising on environmental standards
- Cost and energy focus
- Modularization
- Process guarantees

Key Equipment
1. Absorber Tower
2. Desorber incl Reboiler
3. Direct Contact Cooler
4. Reclaimer
5. Energy Saver

Removal of NH₃, amines and nitrosamines

CO₂ to transport and storage

CO₂ Compressor

Water Wash & Water Balance

Removal of NH₃, amines and nitrosamines

Treated Flue Gas

ACC Direct Contact Cooler

ACC Absorber Tower

Flue Gas Fan

Filter package

ACC Reclaimer

ACC Energy Saver

ACC Reboiler

ACC Desorber

ACC Emission Control

The preferred partner
SOLVit: Key European CCS R&D programme

**SOLVit objective:**
Solvent development and selection – key to CCS cost reduction

**8 year programme from 2008**
**317 MNOK (~ €40M)**
- Research contributors: SINTEF, Norwegian University of Science and Technology (NTNU), ACC
- Supported by: Gassnova, Climit (Norway)
- Industrial partners phase 1: E.ON, ScottishPower, Statkraft