CCS in Europe – Current Status and Future Prospects

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Overview

• What has been the motivation for developing CCS technologies and projects within Europe?

• What has been the outcome of European initiatives?

• Why hasn’t this led to large scale demonstration?

• …and what does the future hold for CCS in Europe
The E.ON Group: An overview

- We stand for **cleaner & better** energy and are a global, specialized provider of energy solutions.

- E.ON SE is one of Europe’s largest energy companies with over 62,000 employees and a presence throughout Europe, North America, Russia, Brazil and Turkey.

- Global Business Units Include:
  - Exploration & Production
  - Generation
  - E.ON Technologies
  - Global Commodities
  - Renewables

*As an owner and operator of coal and gas fired power plant – CCS is of direct relevance to E.ON*
European Motivation – Recognising a requirement to reduce greenhouse gas (GHG) emissions

First Kyoto Period (2008-2012): Under the Kyoto Protocol the EU-15 committed to GHG emissions reduction of 8% below 1990 levels – 16% was achieved

Second Kyoto Period (2013-2020): Further emission reductions are required over the second Kyoto period – 20% reduction – on track to achieve (22-27% expected)

EU2020 Growth Strategy: Emission reduction targets to achieve a 20% reduction of GHG emissions compared to 1990 levels – EU offers a conditional 30% reduction

2030 Climate and Energy Policy: 40% reduction in GHG emissions by 2030 (compared to 1990 levels)

2050 vision: Leaders have endorsed an emissions reduction target of 80-95% by 2050 This requires decarbonisation of Europe’s power sector (93-99% GHG reduction)
European Motivation – Implementing CCS

Tools & Policy:
- EU Emissions Trading Scheme
- CCS Directive
- CCS Readiness

EU Funded Research:
Around 40 projects since 1998 (FP3 to FP7)

Demonstration:
- New Entrants Reserve
- European Energy Programme for Recovery

Initiatives in progressing the development of CCS in Europe

National initiatives (UK):
- Carbon price floor
- Emissions performance standard (450 g CO₂/kWh)

National initiatives (UK): UK CCS Competition (phases 1 and 2) £1 bn for demos

More than 11 million tonnes of CO₂ stored at Sleipner

National initiatives (Norway):
- Norwegian CO₂ Tax
- Gassnova established
- Gas plants CCS ready

Initiatives can work!
European CCS Demonstrations on Power Plant

EEPR (2009):
- Janschwalde (DE)
- Porto-Tolle (IT)
- ROAD (NL)
- Belchatow (PL)
- Compostilla (ES)
- Don Valley (UK)

NER 300 (2012):
- Don Valley (UK)
- Belchatow (PL)
- Green Hydrogen (NL)
- Teeside CCS (UK)
- UK Oxy CCS (UK)
- C.Gen North Killingholme (UK)
- Porto-Tolle (IT)
- ULCOS-BF (FR)
- Getica (RO)
- Peterhead (UK)

NER 300 (2014):
- White Rose (UK)

1st UK Competition:
- Longannet
- Kingsnorth

2nd UK Competition:
- Peterhead
- White Rose
- Drax

- European Energy Programme for Recovery
- New Entrants Reserve 300 (first call)
- New Entrants Reserve 300 (second call)
- UK CCS Competition (1)
- UK CCS Competition (2)

Post
Pre
Oxy
Industrial
European CCS Demonstrations on Power Plant

ROAD (NL)
White Rose (UK)

**Situation in 2015:** Only 3 CCS demonstration projects in the advanced phases of project development

1st UK Competition 2nd UK Competition
Peterhead White Rose - Drax

- European Energy Programme for Recovery
- New Entrants Reserve 300 (first call)
- New Entrants Reserve 300 (second call)
- UK CCS Competition (1)
- UK CCS Competition (2)
Why are projects failing to progress?

**UK CCS Competition Phase 1**
- Changing the rules (Killingholme)
- Economic downturn (Kingsnorth)
- Failure to agree on overall project costs and contingencies (Longannet)

**EEPR Funded Projects**
- Environmental permitting and public acceptance *Porto Tolle* and *Janschwalde*
- Funding gaps and CO\(_2\) tax
  *Compostilla, Porto Tolle* and *Belchatow*

**Lessons Learnt:**
- Pilot capture plants have traditionally not focussed on addressing emissions (permitting challenges)
- Two-phase flow in in pipelines and within injection wells will occur
- Considerable amount of time required to appraise storage sites (5-10 yrs)
- Modifying existing storage infrastructure (e.g. platforms) can be a challenge
- Local, regional and national government support is essential to address legal challenges
Status of the Current Demos (UK Competition)

Project: Peterhead CCS Project
Location: Aberdeenshire, Scotland
Partners: Shell UK Ltd, SSE Ltd.
Process: Retrofit (gas) post combustion capture
Scale: 1 Mtpa
Storage: Offshore depleted gas field (62 miles)
Status: FEED underway, FID expected Q4 2015

Project: White Rose CCS Project
Location: North Yorkshire, England
Partners: Alstom, Drax, BOC
Process: New Build (coal) oxyfuel combustion
Scale: 2 Mtpa
Storage: Offshore saline formation (102 miles)
Status: FEED underway, FID expected Q4 2015

No progress expected before 2015 UK general elections
Status of the Current Demos (EEPR)

Project: Rotterdam Opslag en Afvang Demonstratieproject (ROAD) CCS Project
Location: Rotterdam, Netherlands
Partners: E.ON, GDF Suez
Process: Retrofit (coal) post combustion, Fluor EFG+
Scale: 1.1 Mtpa
Storage: Offshore depleted gas field (15.5 miles)
Status: FEED + flue gas tie-ins completed. Positive FID is dependent on closing funding gap

Project: Don Valley CCS
Location: South Yorkshire, England
Partners: 2Co Energy, Samsung, BOC
Process: Pre-combustion (coal), Rectisol
Scale: 5 Mtpa
Storage: Offshore saline formation (102 miles)
Status: Negotiations in 2014 to sell the project

EEPR + €150 million Dutch gov’t funding
Not likely to progress further
European Pilot Plants

Development across the innovation chain has led to the advancement of first generation systems to a point at which the technology is ready for demonstration.

This is a result of:
- R&D driven by EU or government funded initiatives
- Partnerships between utilities and technology suppliers

### Partnerships

**Post-CC:**
- Staudinger (E.ON/Siemens)
- Karlshamn (E.ON/Alstom CAP)
- Wilhelmshaven (E.ON/Fluor)
- Niederaussen (RWE/Linde, BASF)
- Ferrybridge (SSE/Doosan, HTC)
- Le Havre (EDF/Alstom AA)
- Aberthaw (RWE/Cansolv)
- TC Mongstad (Alstom CAP/Aker)

**Oxyfuel:**
- Compostilla (ENDESA)
- Lacq (Total)

**Pre-CC:**
- Puertollano (ELCOGAS)
- Buggenum (Nuon/Vattenfall)

### Large Generic:
- Heilbronn (post)
- Brindisi (post)
- Esbjerg (post)
- PACT (post)
- Renfrew (oxy)
- Schwarze Pumpe (oxy)
- Buggenum (pre)
- Puertollano (pre)

### Research Scale:
- CATO (NE)
- Tiller (NO)
- E.ON Oxyfuel CTF (UK)
- MTU
European Pilot Plants in Operation

- Consists of one amine (Aker) and one chilled ammonia plant (Alstom) – 100 ktCO₂/year
- CHP and refinery cracker gas source (3-13 % CO₂)
- 30 wt.% and 40 wt.% MEA campaigns completed
- Aker Advanced Amine and Alstom CAP campaigns completed in 2014.
- Emission reduction systems tested
- Cansolv currently testing on amine unit (CHP gas)

- 70 tpd post-combustion capture pilot
- Based on Fluor’s Econamine FG+ process
- 19400 m³/h of flue gas treated from 824 MWe coal-fired unit
- Process includes intercooling and lean vapour compression
- Gained more than 5000 hours of operation
- Investigated impact of dust and SO₃ on aerosol emissions
- Evaluation of energy saving systems is underway
European Pilot Plants – Post Combustion Experience

First Generation

- First pilots focused on reducing energy requirements of processes
- 3.5 → 3.0 GJ/tonne CO2 (MEA)
- Solvent screening
- Process optimisation
- Degradation
- Process analytics

Focus shifts towards emissions, corrosion, solvent management

- Electric dialysis reclaiming
- Degradation/Corrosion
- Measurement/mitigation of nitrosamines
- Measurement/mitigation of aerosol emissions
- Degradation

Second Generation

- First generation technology ready for large scale demonstration
- Cost Reduction
- Flexible Operation
- Footprint Reduction
- Alternative materials of construction
In summary

- Europe is aiming to decarbonise its power sector – CCS provides a means of achieving this whilst maintain economic growth and energy security.

- Public acceptance, lack of decisive government action, competing incentives and the collapse of the CO\textsubscript{2} price have impeded the demonstration of CCS in Europe.

- Market based mechanisms such as the Emissions Trading Scheme are best suited to achieving emission reductions at least cost – but only if they currently do not work.

- Biggest hope of demonstrating full chain CCS in Europe currently lies with the UK CCS Competition

- Large pilot plant activities in Europe are reducing – 1\textsuperscript{st} generation technologies are ready for deployment.
  – but what about the next generation of pilots?
Future Prospects

- Revision of the CCS Directive within the context of 2030 and 2050 targets
- Improving the Emissions Trading Scheme
- Reconsidering a European Emissions Performance Standard
- Creation of NER300 successor, NER400, has been agreed
- National subsidies, e.g. Contracts for Differences – Feed in Tariffs
  CCS is formally included in the UK Energy Act and is eligible for CfD payments anticipates 5 - 13 GW by 2030.

**Fruition of the current European demos may signify that CCS in Europe is emerging from the “Valley of Death”…**

…however, the correct regulatory environment and framework is required to ensure this ‘rise’ continues.
Thank You

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ROAD CCS: Host Power Plant (E.ON MPP3)

Output: 1070 Mwe
Efficiency: 46%
Operational: 2015
Capture Ready

Flue-gas interface construction work has already been completed
Connecting CCS and CCUS

Rotterdam industrial area has set a target to achieve a 50% reduction in CO2 emissions by 2025 (compared to 1990).

CCS expected to contribute 60-70% of this reduction

Proposed network will link various sources of CO2 such as the ROAD capture plant to CO2 sinks (e.g. greenhouses)
ROAD: CO2 Storage

- Depleted natural gas field (P18-4) will be used for CO2 storage (350 → 20 bar)
- Reservoir is 3.5 km below the sea bed
- Field is 20 km offshore
- 1.1 million tonnes per year will be stored
- Capacity is 8 million tonnes of CO2 (5 years)
- Applied for storage permit in 2010 – awarded in 2013
- Ready for CO2 injection