CCUS Status and New Developments.

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CCUS a Key Climate Mitigation Option

Global CO₂ reductions by technology area

Reference Technology Scenario – RTS

Beyond 2 degrees Scenario – B2DS

Gt CO₂ cumulative reductions in 2060

Source: IEA ETP 2017
Current status of CCUS

- CCUS technology is proven and in use around the world.
- 21 large-scale CCUS projects in operation or under construction globally - CO$_2$ capture capacity of 40 Mtpa.
- 6 projects in construction as of March 2017
  - 3 projects to be operational in 2017 & 3 in 2018
  - CO$_2$ capture capacity of ~ 8 Mtpa.
- 11 more large-scale CCUS projects are in earlier stages of planning
  - CO$_2$ capture capacity of ~21 Mtpa.

Source: Global CCS Institute

Worldwide distribution

Significant milestones passed

- Sleipner project, 20 years of continuous operation in 2016
  - 16Mt CO2 stored and monitored
- Sleipner and Snohvit projects were re-permitted by Norwegian Government under EC CCS Directive in 2016
  - Conforms with requirements of London Convention for undersea storage.
  - Demonstrates that the CCUS-specific regulations are workable and achievable by projects and regulators
Significant milestones (2)

**Boundary Dam 3, Canada (2015)**
- Power sector, 120MWe retrofit
- Cansolv Amine technology
- 1.6 Mt CO$_2$ Captured
- 100,000 tonnes stored in DSF
- Rest sent for CO2-EOR

**Air Products, Texas USA (2014)**
- Hydrogen refining
- Vacuum Swing Absorption
- Over 4 Mt CO$_2$ Captured
- Existing pipeline for CO2-EOR

**Quest, Canada (2015)**
- Hydrogen refining
- Cansolv amine based technology
- Over 2.6 Mt CO$_2$ Captured
- 80km pipeline for storage in a DSF
New CCUS Projects

Emirates Steel Project, UAE
- Started November 2016
- DRI steel plant with Amine capture
- Compression and pipeline added
- 800,000 tonnes CO$_2$ for CO2-EOR

Petra Nova project, USA
- Started in January 2017
- Kansai-Mitsubishi amine capture
- Capture rate 1.4 Mtpa,
- CO2 sold for CO2-EOR

Illinois Industrial Carbon Capture project, USA (BioCCS)
- Started in April 2017
- 1Mt CO$_2$/y bioethanol plant
- Dehydrated, compressed, and stored in a deep saline formation.

Tomakomai, Japan
- Started April 2016
- Test CCUS in Japanese conditions
  100,000 t/y for 2 yrs into DSF
Learnings

- **Boundary Dam 3** and **Petra Nova** are PC boiler retrofits with Amine Scrubbing technology
  - Both capture units built on schedule and to cost
    - Cost over runs at BD3 due to existing boiler retrofit
  - Both projects could be built again at lower cost
    - 30%CAPEX, 20% OPEX
- **Kemper**
  - Capture plant built to schedule and cost
  - Cost overruns/delays in other plant areas
- **Air Products**
  - Vacuum Swing Absorption technology preferred to amines
    - Reduced energy consumption and improved project economics
    - 27,000:1 technology scale up successfully achieved
- **Quest** on shore injection better than expected
  - Ahead of schedule on tonnes CO₂ injected.
  - Modular construction design reduces cost for future projects
Learnings Captured & Shared

• Boundary Dam 3, first years learnings reported
• International CCS Knowledge Centre
  • Preparing 3 years learnings report from BD3
• IEAGHG now developing reports on learnings from:
  • Air Products CCUS project
  • Quest CCUS project
  • Available early 2017

http://ieaghg.org/docs/General_Docs/Reports/2015-06.pdf
Other Developments

Osaki Cool Gen Project, Japan - April 2017
- Operated by J-Power, J-Power is a 166MW IGCC demonstration project
- CO₂ capture slipstream test using physical absorption technology in late 2018/19.

Yangchang Petroleum, China
- Physical adsorption from Coal to gas plant
- 800,000 t CO₂/y, to be used for CO₂–EOR
- Operation planned late 2018/2019

Gorgon, Western Australia
- Offshore- gas processing, using amine technology to capture 3.5Mt/y CO₂
- Injection into deep saline formations
- Starts operation late 2017

Kemper Project, USA
- Cancelled in June 2017 – costs overruns/delays

ROAD project, Netherlands
- Project developers pulled out in July 2017 – uncertainty over Government policy
CCUS in Europe

- First commercial CCUS project
  - Sleipner in 1996
- First CCUS regulations drafted
  - EC CCS Directive issued in 2009
- 6 CCUS projects supported under EC EPPR programme,
  - All closed
- 1 CCS project supported under NER 300
  - UK CCS competition closed – White Rose Project ended
- EU Zero Emissions Platform (ZEP) still pressing for EC for CCS
  - CCUS important for industry/regional development
  - Use of EU infrastructure funds to build CO2 pipeline network
- European Trading Scheme – €7.45 (18/10/17)
New CCUS Initiatives in Europe

• Norway

• FEED studies underway for CCUS projects:

• Timeline:
  - FEED contracts end Autumn 2018
  - Investment Decision – Spring 2019
  - Full scale project in 2020.
Netherlands

- ROAD project closed by power companies in June 2017
- July 2017, Statoil, Vattenfall & Gasunie sign an MoU to evaluate converting a gas power plant in the Netherlands into a H₂ powered plant.
  - The CO₂ emission reduction is 4 MT CO₂/y
- In October 2017, the Dutch Government announced a new Climate and Energy Plan
  - 49 per cent reduction in CO₂ emissions by 2030.
    - A reduction of more than 56 million tonnes of CO₂ per annum by 2030.
    - CCS will deliver at least 20 million tonnes in CO₂ emissions reductions every year by 2030.
    - CCS in industry, electricity sectors (bioCCS) and waste incineration
- New fund - 4 billion euros annually.
United Kingdom

• CCS completion closed in late 2015 without agreement for a demonstration project.
• ACORN project funded under EU ERA NET Programme for feasibility study
  • CO₂ capture from St Fergus gas terminal (gateway to North Sea)
  • CO₂ stored offshore using existing pipeline infrastructure
• October 2017, UK Government announces Clean Energy Growth Programme
  • CCS seen as a vital part of the solution
  • A new Ministerial CCUS Council, will be formed
  • As will a new CCS Cost Challenge Task Force.
Jubial City CCU Project

• SABIC CCU project uses the captured CO$_2$ to produce methanol and urea.
  • First commercial application of Linde post combustion capture technology
  • First capture unit on an ethylene glycol plant.
  • At 500,000Mt CO$_2$ pa it was the biggest commercial capture unit.
  • Business model CAPEX/OPEX recovered through sale of Products
Other CCU demonstrations

- SAGA City, Japan – waste incineration facility
- Toshiba amine technology, 10tpd CO2
- Carbon Clean Solutions
- 10MWe power plant in India
- Novel amine technology
The CCU Paradigm

- Carbon Capture and Utilisation (CCU) options are not mitigation options
  - No permeant storage – not a mitigation option
    - Classic non-mitigation examples – Methanol and Urea production
- But CCU can help CCUS deployment by
  - Demonstrating different capture technology at scale $\times$
  - Introducing new capture vendors $\checkmark$
  - Infrastructure development, i.e. pipelines $\times$
Summary

- CCUS a more significant climate mitigation option in B2DS
- Significant progress has been made on CCUS demonstration project deployment
- 21 CCUS projects now operating worldwide storing 40MtCO₂/yr
  - Most required Government support
  - Some industry projects are commercial without
- Early projects have identified cost reductions for next build plants
  - Learning by doing helps drive down costs
- CCU can contribute to capture technology rollout
  - But it is NOT a mitigation option
- Developments in Europe could lead to CCUS deployment