



Learning from Doing: CCUS Reference Cases

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Resources for the Future Seminar

**Carbon Capture, Utilization, and Storage (CCUS): Status, Issues,
Needs**

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Current status of CCUS



- CCS technology is proven and in use around the world.
- 22 large-scale CCS projects in operation or under construction globally - CO₂ capture capacity of 40 Mtpa.
- 6 projects in construction as of March 2017
 - 3 projects to be operational in 2017 & 3 in 2018
- 5 more large-scale CCS projects at an advanced stage of development planning,
 - CO₂ capture capacity of ~ 8 Mtpa.
- 11 more large-scale CCS projects are in earlier stages of planning
 - CO₂ capture capacity of ~21 Mtpa.

Source: Global CCS institute

Worldwide distribution



Source: Global CCS Institute, 2016, "The Global Status of CCS 2016 – Summary Report"

Power Sector CCS



- Boundary Dam 3, Canada
 - 110MWe, coal fired
 - » Solvent based technology
 - » >1.3Mt CO₂ captured
 - » CO₂ used for CO₂-EOR
- NRG Parish
 - 250 MW slip stream
 - » amine based PCC technology
 - » 90% capture
 - » CO₂ sold for EOR
- Kemper County
 - IGCC technology/Lignite
 - Start up awaited
- Osaki CoolGen
 - IGCC Technology/Lignite
 - » Co₂ capture slip stream 2018/19



What have we learnt?



Power sector

- BD3 and NRG 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 had existing electricity supply contracts
 - BD3 more efficient turbine offset parasitic load
 - NRG added a new steam boiler for capture unit
- BD3 could be built again at lower cost
 - 30%CAPEX, 20% OPEX

Business Models

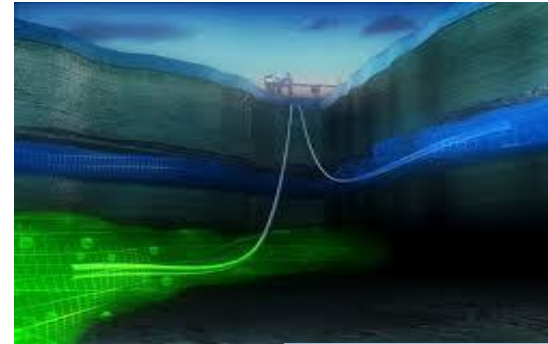


- **BD3, NRG & Kemper**
 - Long term stable fuel price for coal
 - Government subsidy for CAPEX
 - OPEX offset by sale of products
 - CO₂, Sulphur and ash
 - Plus electricity – long term supply contracts
- **Osaki CoolGen**
 - Government subsidy for CAPEX
 - Electricity sales offset OPEX

Industry CCS

- **Natural Gas Processing**

- Sleipner, North Sea
 - 20 years operation
 - 16Mt CO₂ stored
- Snohvit, Barents Sea
 - Operating since April 2008
 - 0.7Mt/y CO₂
- Lula, Brazil
 - Floating Platform offshore
- Gorgon, Australia
 - 3.5Mt/y CO₂
 - Starts operation late 2017



Business Models



- **Sleipner/Snohvit**

- Capture plant cost included
 - Needed to meet pipeline standards for NG
- Compression and pipeline capital costs
- Offshore emissions tax of €35/T
 - Pays for OPEX and capital investment

- **Lula**

- Cost recovery through increased oil production

- **Gorgon**

- Cost recovery through LNG sales

Industry CCS (2)

- CCS now deployed in:
 - Hydrogen refining/upgrading
 - Quest – solvent based technology
 - » 1Mt injected into deep saline aquifer
 - Air Products, PSA technology
 - » Over 3 Mt – used for CO₂-EOR
 - Steel sector
 - Emirates Steel – Amine based capture
 - » Now operational
 - » 800,000 tonnes CO₂ for CO₂-EOR
 - Bioethanol production
 - ICCS Project, Illinois USA
 - Start up Q2 2017
 - 1Mt/y - deep saline aquifer



Business Models?



- **IISD**

- Government loans for 1st phase project development – Decatur (300,000t/yr CO₂)
 - Compression, dehydration and storage components
- Capital investment for phase 2 components
 - Up to 1Mt/y CO₂
- \$20/t credits (Q45) for storage in deep saline aquifer
 - Offsets operating costs.

Business Models?



- **Quest and AirProducts**

- Government support for CAPEX
- AirProducts – OPEX offset by CO₂ sales
- Quest – OPEX offset by CO₂ storage credits

- **Emirates Steel**

- Pre-existing capture facility on DRI plant
- Capital investment only for compression and pipeline
- OPEX covered by additional oil and natural gas revenues

Jubial City CCU Project



- SABIC CCUS project uses the captured CO₂ 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 CO₂ pa it was the biggest commercial capture unit.
 - Business model CAPEX/OPEX recovered through sale of Products



Learnings from UK CCS Competition



LESSONS LEARNED

LESSONS AND EVIDENCE DERIVED FROM
UK CCS PROGRAMMES, 2008 - 2015



- Key messages
 - No technical barriers
 - Barriers were; financial, commercial and policy related
 - Peterhead could have been delivered
 - With White Rose issues included:
 - Risks re pipeline leakage
 - Financing of storage component

file:///fscluster2/data/IEAGHG/Homes/John.Gale/Documents/CCSA
_Lessons_Learned_report_digital_FINAL_June_2016.pdf

UK Competition Conclusions



- The full chain business model does not work
 - UK Government should fund the pipeline and storage component – new national storage company formed
- Building in larger pipeline networks increased the costs for first mover projects
- Depleted gas fields are a good starting point
- Rules on financing in the EU CCS Directive may be too onerous
- EU state Aid rules may prevent UK investment in such projects

Norwegian Model



- Industrial CCS Programme under development
 - 3 industry FEED studies underway
 - Decision by Spring 2018 to proceed with one (or more projects)
 - Commercial operation by 2021
- Capture facility separated from storage component
 - New storage and transport company to be set up
 - Ship transport and offshore storage
 - Funded by storage credits

Transport infrastructure



- EU example
 - Funded by EU infrastructure fund with multi party access rights
- UK example
 - Industrial hubs under development funded by CO₂ storage credits?
- USA example
 - Finance increase of existing CO₂ pipeline network
 - Section 45Q Tax Credit for Carbon Dioxide Sequestration
 - U.S. Department of Energy's (DOE) Loan Programs Office

Summary



- Significant progress has been made on CCUS demonstration project deployment
- 22 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
- Government support will be still needed to help drive down costs and/or make business model attractive to industry
- Ultimately we need to create business models that allow projects to be self financing
 - No “one fits all solution”
- Need to build out from existing transport and storage infrastructure
 - Options to finance additional infrastructure through government loans, taxes or storage credits are being considered.
 - Government investment needed to prove storage resource globally



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