# Learning from Doing: CCUS Reference Cases


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### IEA Greenhouse Gas R&D Programme


**2017 NETL CO2 Capture Technology Project Review Meeting**

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# Membership


**Cost-shared Technology Collaboration Programme**

# 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
  - $CO_2$ capture capacity of 40 Mt/yr
- 6 projects in construction as of March 2017
  - 3 projects planned to be operational in 2017 & 3 in 2018
- 5 more large-scale CCS projects at an advanced stage of development planning
  - $CO_2$ capture capacity of ~ 8 Mt/yr
- 11 more large-scale CCS projects are in earlier stages of planning
  - $CO_2$ capture capacity of ~21 Mt/yr

**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
  - 110 MWe, coal-fired
    - Solvent-based technology
    - >1.3Mt $CO_2$ captured
    - $CO_2$ used for CO2-EOR
- NRG Parish
  - 250 MW slip stream
    - Amine-based PCC technology
    - 90% capture
    - $CO_2$ sold for EOR
- Kemper County
  - IGCC technology/lignite
- Osaki CoolGen
  - IGCC Technology/Lignite
    - $CO_2$ 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
  - $CO_2$, sulphur and ash
  - Plus electricity – long term supply contracts

## Osaki CoolGen

- Stable low coal price *cf.* LNG
- Government subsidy for CAPEX
- Electricity sales offset OPEX

# Industry CCS

## Natural Gas Processing

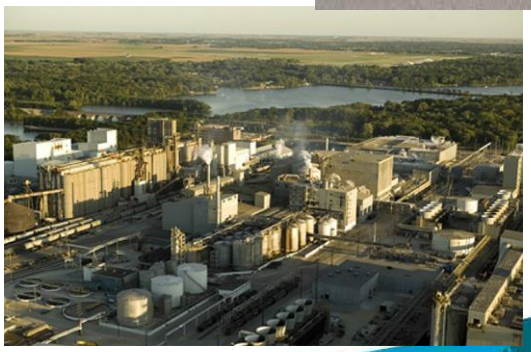
- Sleipner, North Sea
  - 20 years operation
  - 16Mt $CO_2$ stored
- Snøhvit, Barents Sea
  - Operating since April 2008
  - 0.7Mt/yr $CO_2$
- Lula, Brazil
  - Floating platform offshore
  - Membrane capture
- Gorgon, Australia
  - 3.5Mt/yr $CO_2$
  - Starts operation late 2017

# Business models

- **Sleipner/Snøhvit**
  - Capture plant cost included
    - Needed to make NG saleable
  - Offshore emissions tax of \$35/t $CO_2$
    - Pays for OPEX and capital investment of compression and pipeline costs
- **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/yr injected into deep saline aquifer
    - Air Products, PSA technology
      - Over 3 Mt/yr – used for CO2-EOR
  - Steel sector
    - Emirates Steel – amine-based capture
      - Now operational
      - 0.8 Mt/yr $CO_2$ for CO2-EOR
  - Bioethanol production
    - IICCS Project, Illinois USA
    - Start up Q2 2017
    - 1Mt/yr - deep saline aquifer



# Business models?

## Quest and Air Products

- Government support for CAPEX
- Air Products – OPEX offset by $CO_2$ sales
- Quest – OPEX offset by $CO_2$ 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

# Business models?

- **IICCS**
  - Government loans for 1st phase project development – Decatur (300,000 t/yr $CO_2$)
    - Compression, dehydration and storage components
  - Capital investment for phase 2 components
    - Up to 1Mt/yr $CO_2$
  - $20/t credits (45Q) for storage in deep saline aquifer
    - Offsets operating costs

# Jubail City CCU Project

- SABIC CCUS 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 500,000 Mt/yr $CO_2$, it was the biggest commercial capture unit (pre-NRG)
  - Business model: CAPEX/OPEX recovered through sale of products

# Learnings from UK CCS Competition


- Key messages
  - No technical barriers
  - Barriers were financial, commercial and policy related
  - Peterhead could have been delivered
  - 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

# Conclusions from UK Competition

- 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 from EU infrastructure fund with multi-party access rights
- UK example
  - Industrial hubs under development funded by $CO_2$ storage credits?
- USA example
  - Finance increase of existing $CO_2$ pipeline network
    - Section 45Q tax credit for $CO_2$ sequestration
    - U.S. DOE's Loan Programs Office

# Summary

- Significant progress has been made on CCUS demonstration project deployment
- 22 CCUS projects now operating worldwide storing 40 $MtCO_2$/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 still be needed to help drive down costs and/or make a business model attractive to industry
- Ultimately we need to create business models that allow projects to be self financing
  - No “one size 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

PCCC4

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Evaluating technology options to mitigate greenhouse gas emissions

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NATIONAL CARBON CAPTURE CENTER

**Call for abstracts opens 1st September 2017**

**Deadline 31st December 2017**

**Registration opens early March 2018**

**Technical programme announced 1st May 2018**

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# Thank you!


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