International Perspectives on CCS

John Gale
General Manager
IEA Greenhouse Gas R&D Programme
2014 National CCS Conference
Sydney, Australia
2nd September 2014
What do we do?

Our Core Activities Are:

- Assessing Mitigation Options – Focus our R&D CCS
- Tracking Capture Technology Developments/Costs
- Monitoring Geological Storage Performance
- Providing Members and Policy Audience with Independent Technical Input
Commercial Application of CCS (to date)

- **Sleipner**: 1 Mt/y CO₂
- **Weyburn**: 2.5 Mt/y CO₂
- **In-Salah**: 1.2 Mt/y CO₂
- **Snohvit**: 0.7 Mt/y CO₂
- **Gorgon**: 4 Mt/y CO₂

- Major Scale up in Storage experience
- 600 MWe power plant
- Pressure Management involved

- 1996
- 2000
- 2004
- 2008
- 2012
- 2016
- 2018

- 350 km overland pipeline
- 160 km subsea pipeline
- 150 MWe
Components in use but not applied at large scale!
No commercial scale CCS power plant!
CCS power plants need to be incentivised or become competitive or there are sufficiently high carbon prices!
Large scale deployment needs defined long term regulations on liability and financial support
Boundary Dam, 110MWe
CO2-EOR Driving Expansion Of Industry CCS.

PROJECTED CO₂, EOR OPERATIONS, AND CO₂ SOURCES: 2020

<table>
<thead>
<tr>
<th>Oil production, 2020</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂–EOR projects</td>
<td>147</td>
</tr>
<tr>
<td>Oil production, 1,000 b/d</td>
<td>638</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CO₂ supplies, 2020</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sources</td>
<td>30</td>
</tr>
<tr>
<td>• Natural</td>
<td>6</td>
</tr>
<tr>
<td>• Industrial</td>
<td>24</td>
</tr>
<tr>
<td>CO₂ supply, MMcfd</td>
<td></td>
</tr>
<tr>
<td>• Natural</td>
<td>3.4</td>
</tr>
<tr>
<td>• Industrial</td>
<td>3.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>147 Number of CO₂-EOR projects</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural CO₂ source</td>
<td></td>
</tr>
<tr>
<td>Industrial CO₂ source</td>
<td></td>
</tr>
<tr>
<td>CO₂ pipeline</td>
<td></td>
</tr>
<tr>
<td>CO₂ proposed pipeline</td>
<td></td>
</tr>
</tbody>
</table>

Source: Advanced Resources International Inc. based on OGI EOR/Heavy Oil Survey 2014 and other sources.
PCC Scale up

- China building 1GW ultrasupercritical pf boilers in 2010
  - Yuhuan plant at 45% efficiency

- Belchatow, Poland largest lignite fired ultrasupercritical pf boilers at 858MW
  - 42% efficiency

- At appropriate scale for partial capture market in USA
- Need another scaled up operation in due course for EU/Asian markets
Reducing PCC energy penalty and costs

**USDOE Carbon Capture Programme**

- Develop 2nd-Generation technologies that:
  - Ready for demonstration in the 2020–2025 timeframe
  - Achieve capture costs of approximately $40/tonne of CO2 captured
- Develop Transformational technologies that:
  - Are ready for demonstration in the 2030–2035 timeframe
  - Achieve capture costs of less than $40/tonne of CO2 captured
The “IGCC Renaissance”

- IGCC was the sick man of the power generation world in the 1990’s
  - Gasification technology largely unchanged
  - Advances in GT’s improved its efficiency
- Projects
  - China, GreenGen (2013)
  - USA, Kemper County (2015)
  - Japan, Osaki COOLGEN (2016)
  - USA, Summit Clean Energy (2017)
  - USA, HECA (2019)
Pre-Combustion Capture

- All eyes on process operation
- Offers high efficiency
- Possibly high flexibility if coupled with H2 production
  - Store of burn hydrogen in GT
  - Use H2 for road transport
- Currently limited to 250MWe scale
  - Oxygen plant
  - Gas Turbine
1980's

ANL/Battelle/EERC completed the first industrial scale pilot plant

1990 – 1995

EC Joule Thermie Project
- IFRF / Doosan Babcock / Int’l Combustion
NEDO / IHI / Jcoal Project

1998 – 2001

Vattenfall (ENCAP ++) CS Energy / IHI Callide Project

2003 - 2005

B&W CEDF (30MWt) large scale burner testing started

2007

2008

World’s FIRST 30 MWt full chain demonstration at Schwarze Pumpe

2008

30MWth Lignite

Alstom Schwarze Pumpe

2009 – Lacq – World’s first 30MWt retrofitted Oxy-NG boiler w/storage

2012 – Callide – World’s first 30MWt retrofitted Oxy-coal power plant

2012 – CIUDEN – World’s first 30MWt Oxy-CFB Pilot Plant

2009

Lacq

El Bierzo CFB Facility

El Bierzo PC Facility

2012

30MWth Coal

2003

FutureGen2 - Illinois (PC - 168MWe)

UK: White Rose Project (PC – 426MWe)

China: Shenhua Shenmu Project (PC – 200MWe)

By 2015-2019

Demonstration of 100–300MWe full scale power plant.

2015 – HUST Industrial Project for 35 MWt Oxy-coal power plant

2015

HUST Industrial Project for 35 MWt Oxyfuel Pilot Plant

2012

Oxy-CFB Pilot Plant

2015

Callide retrofitted Oxy-coal power plant

B&W

Alstom

Doosan Babcock

CEDF

Alstom CE

DBEL - MBTF

2008

30MWth Coal

2010

15MWth Coal

2012

40MWth Coal

2008

30MWth Lignite

Hitachi Babcock

Schwarze Pumpe

2010

30MWth Lignite

B&W CEDF (30MWt)

2007

large scale burner testing started

1998 – 2001

CANMET

US DOE Project / B&W / Air Liquide

2009

Lacq

First large scale 35MWt Oxy-Coal Burner Retrofit Test done by International Combustion

2012

FutureGen2 - Illinois (PC - 168MWe)

UK: White Rose Project (PC – 426MWe)

China: Shenhua Shenmu Project (PC – 200MWe)

Can we still achieve our goal to commercialise the technology by 2020???

Updated by S. Santos (02/06/14)
Demonstration planned

**FutureGen 2.0**

- Repower Meredosia Energy Center with oxy-combustion and CCS technology
  - Repowered gross: 168 MWe
  - Near-zero emissions
  - CO$_2$ capture rate: 98%
  - CO$_2$ capture volume: 1.1 MMT/yr
  - Pipeline transport: ~30 miles
  - Deep geologic storage

<table>
<thead>
<tr>
<th></th>
<th>Design</th>
<th>Construction</th>
<th>Power Production w/CCS</th>
<th>Post-close</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>2014</td>
<td>2017</td>
<td></td>
<td>2037</td>
</tr>
</tbody>
</table>

**What is making it work? – Delivery**

Partner Roles, bringing depth of know-how and resources

**OXY-POWER PLANT**

- Alstom: Delivery of Oxy-Power Plant
- Drax: Integration of Oxy-Power Plant
- BOC-Linde: O&M of ASU

**CO$_2$ TRANSPORT & STORAGE**

- Capture Power: Full-Chain Integration
- White Rose: Delivery of Transport & Storage network
- National Grid Carbon Ltd: O&M of Transport & Storage network

Investment decision end of 2014
Investment decision end of 2017
Industrial CCS projects
Can we go any faster?

- Scaling up capture technology at a rate consistent with good Chemical Engineering practise
- Pipelines scale up not an issue
- Availability of geological storage is the rate determining step
- Issues re storage could be a road block
  - Integrity/environmental impacts
  - Induced seismicity – the new public battleground?
Thank you, any Questions?

Contact me at: john.gale@ieaghg.org

Website: www.ieaghg.org

LinkedIn: www.linkedin.com/groups/IEAGHG-4841998

Twitter: https://twitter.com/IEAGHG