CARBON CAPTURE IN THE COAL SECTOR: RECENT PROGRESS AND BARRIERS

TOBY LOCKWOOD

ECCRIA, CARDIFF, 5-7 SEPTEMBER 2018
• Status of CCS
• Overview of the three coal power projects
• Regional overviews
• Conclusions
• 22 projects in operation or construction phase (~38 Mt/y)
• Includes 2 operating coal power plants
• 4 in ‘advanced development’ (but only Lake Charles Methanol seems a near-term prospect)
• 11 more in earlier stages of planning (7 coal power, 8 in China)
• Recent deployment surge, but not much in pipeline – fairly small EOR projects in China
• 11 of the operating projects are related to natural gas processing
• Nearly all projects are for enhanced oil recovery (EOR)
• Only 5 active projects use dedicated saline aquifer storage of CO₂
• 4 of these are led by oil and gas companies (Shell, Statoil, Chevron)

• Challenging for power sector to invest in current climate – low operating hours due to intermittent renewables
• EOR projects have been hit by low oil prices
• First coal power CCS demo – Oct 2014
• New boiler, turbine, and Shell Cansolv SO₂ and CO₂ capture technology
• 160 MW output – 120 MW with CCS
• ~US$1.1 bn (1/3 on unit upgrade) – includes federal grant
• CO₂ for EOR (some to saline aquifer pilot)
• Drivers: Federal cap of 420 gCO₂/kWh would mean lost coal assets – SaskPower wanted to keep generation diverse
• SaskPower claim 30% cost saving for future units
• No further retrofit at BD planned, but feasibility study underway for 300 MW Shand plant
TECHNICAL ISSUES AT BD3

- Operational issues in first year led to low capture rate, penalties for CO$_2$ shortfall, and political opposition in the province
- Poor steam temperature control degraded solvent
- Fly ash in capture system caused most problems – resolved with additional water sprays and improved ESP
- Solvent foaming led to high pressure drops – solved with solvent filters and online demister washing
- Reached nameplate capacity in Nov 2015
PETRA NOVA

- Commissioned Jan 2017, on schedule and within budget
- Partners: JX Nippon, NRG, Hillcorp (EOR operator)
- $250m risk-tolerant financing from Japanese export credit agency
- Uses MHI’s KS-1 amine and separate gas plant to run CCS system
- 50% equity in oil field maximises the value of EOR
- Avoided contentious increase in electricity rates
- NRG claim a second plant could be 20-30% cheaper – but no current plans

<table>
<thead>
<tr>
<th>Sources</th>
<th>$MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRG Equity²</td>
<td>300</td>
</tr>
<tr>
<td>JX Nippon Equity</td>
<td>300</td>
</tr>
<tr>
<td>Project Financing</td>
<td>250</td>
</tr>
<tr>
<td>DoE Grant</td>
<td>167</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1,017</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Uses</th>
<th>$MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parish Site Capital³</td>
<td>637</td>
</tr>
<tr>
<td>Oilfield and Pipeline Capital</td>
<td>300</td>
</tr>
<tr>
<td>Initial O&amp;M, G&amp;A, Fees, Other</td>
<td>80</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1,017</strong></td>
</tr>
</tbody>
</table>
Southern Company’s 526 MW IGCC plant with 65% Selexol capture, new lignite mine, and 3 Mt/y for EOR
• Infamous cost overruns (from $4.1 to $7.8 bn) and >3 year delay
• First power generation on syngas Oct, 2016
• Ongoing technical issues and dramatic decrease in gas price forecast led to project being forced to run on natural gas (no CCS)
• Faced controversy over passing some of the costs to power customers throughout
• Kemper used Southern’s new TRIG gasifier technology, never before tested at such a large scale (two trains)
• 100% coal feed and 73% GT capacity reached, all by-products produced to spec

Ongoing issues:
• Inconsistent coal quality led to insufficient drying
• Poorly installed refractory caused spalling and clogging – bottom section replaced
• Syngas cooler superheater leaks at weld points – simply bypassed
• Sour water system overwhelmed at high feed rates – planned to resolve
A game-changer for CCS?

- In 2018, 45Q tax credit improved to give up to $35/t for EOR and $50/t for saline storage (increases linearly to 2026, can claim over 12 years)
- Projects need to operate by 2024
• CURC projection shows 45Q uptake for power retrofit and even new CCS power plant
• But few utilities currently interested in investing – lower-cost capture processes likely to dominate

![Power plant CCUS Capacity from Respective Reference](chart.png)
Final remaining EU CCS project, ROAD – cancelled in June 2017 (250 MW slipstream from new Maasvlakte coal unit)

Developers Uniper and Engie withdrew in the face of strong political movement for coal phase out in the Netherlands

Phase out of coal by 2030 will mean closure of 4 brand new USC units
EU interest in CCS has shifted to natural gas, industry, and heating:

- Dutch commitment to storing 18 Mt/y from industry by 2030, Rotterdam hub proposed
- UK Clean Growth Plan – focus on funding CCS in industry and for hydrogen gas-grid
- Norway funding FEED studies for full-chain CCS at cement plant and waste-to-power

Limited EOR options and offshore storage means infrastructure development is a barrier
- Recovery of ETS carbon price will not drive CCS alone
Yanchang Integrated CCUS Project will capture 0.36 Mt/y of CO₂ from an existing coal-to-chemicals plant in Shaanxi (operational 2020)

Sinopec Qilu is a fertiliser plant (coal/coke gasification) – 0.4 Mt/y under construction and to start 2019

August 2018, capture from natural gas and EOR in the Jilin Oil Field expanded to 0.6 Mt/y capacity

Sinopec’s Shengli (40 kt/y for EOR) and China Energy’s planned Jinjie project (150 kt/y for saline aquifer) are full-chain power plant projects
• CCS seems the only option for China’s enormous (>900 GW), young (median age of 12 years) coal fleet – unlikely to see early closure

• Over 18% of CO₂ stored by 2050 in 2DS is from Chinese coal power

• IEA report identifies 100 GW which could be retrofitted for <$50/MWh

• Incentives for large-scale CCS are not present - Paris target does not require CCS

• National ETS (in power sector from 2020) is unlikely to provide sufficient incentive

• Emissions intensity limits or portfolio standards for power companies could play a role
KEY POINTS

• ‘First wave’ of global interest in CCS coming to fruition and few new projects in the pipeline

• Shift in focus: slow progress of CCS over the past decade has become associated with the strong focus on coal

• Oil and gas industry have greater expertise and resources to move ahead with CCS

• Failed projects have damaged image of CCS with coal power, but technical issues and costs often overstated

• 45Q should drive new projects in the USA

• CCS must take off in China in next five years, but needs international support/pressure
The 9th International Conference on Clean Coal Technologies will be in Houston, USA, 3-7 June 2019

A leading international event on the cleaner use of coal, covering CCS, high-efficiency plant, pollutant controls cofiring, gasification, and much more

Join around 250 delegates from industry, research institutes, and government

Site visits and venue to be announced shortly
THANK YOU FOR LISTENING

ANY QUESTIONS?

Toby Lockwood
Toby.Lockwood@iea-coal.org