

CARBON CAPTURE IN THE COAL SECTOR: RECENT PROGRESS AND BARRIERS

TOBY LOCKWOOD

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**IEA
CLEAN COAL CENTRE**



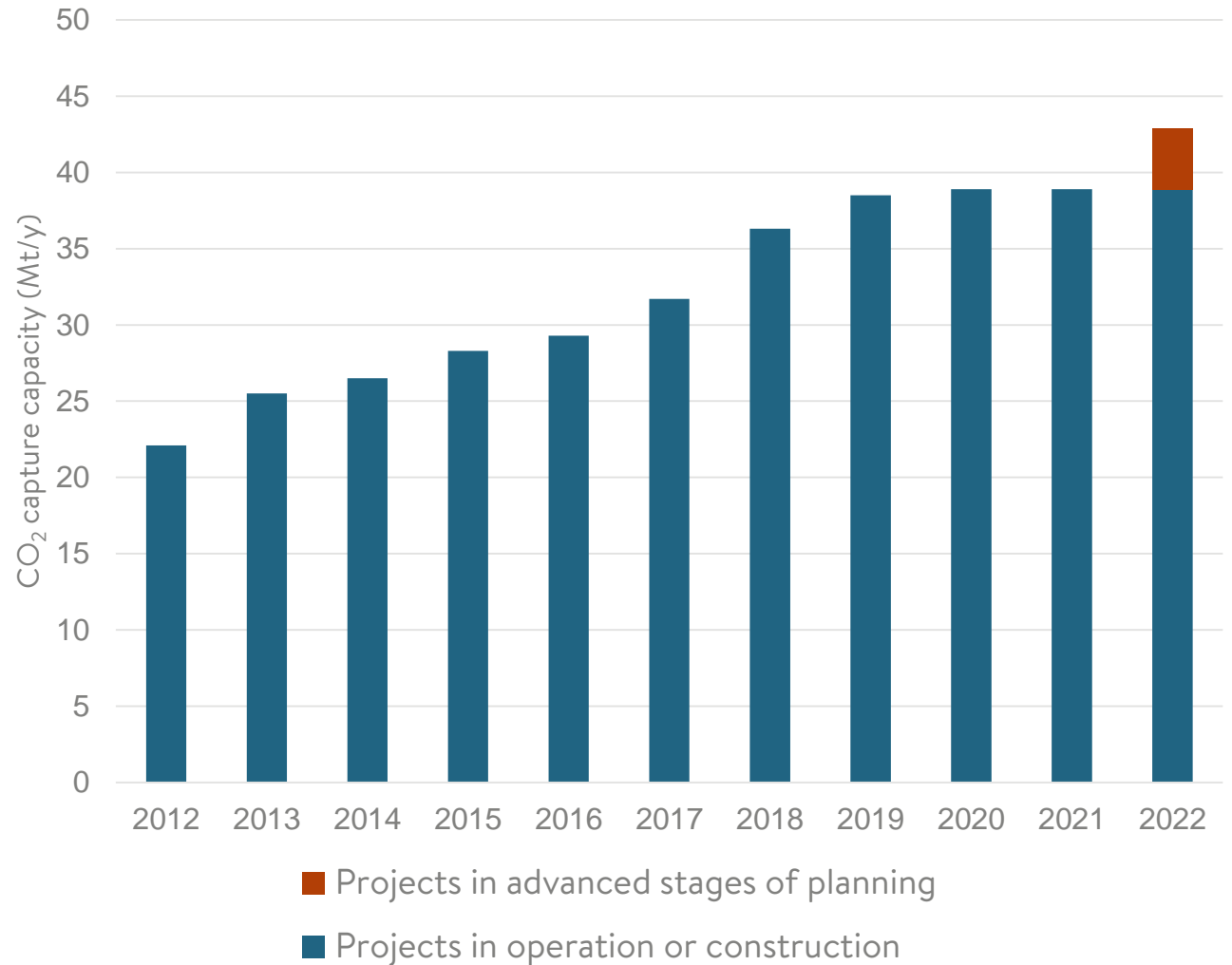
OUTLINE

- Status of CCS
- Overview of the three coal power projects
- Regional overviews
- Conclusions



STATUS OF CARBON CAPTURE AND STORAGE

- 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**





RECIPES FOR SUCCESS

- 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)

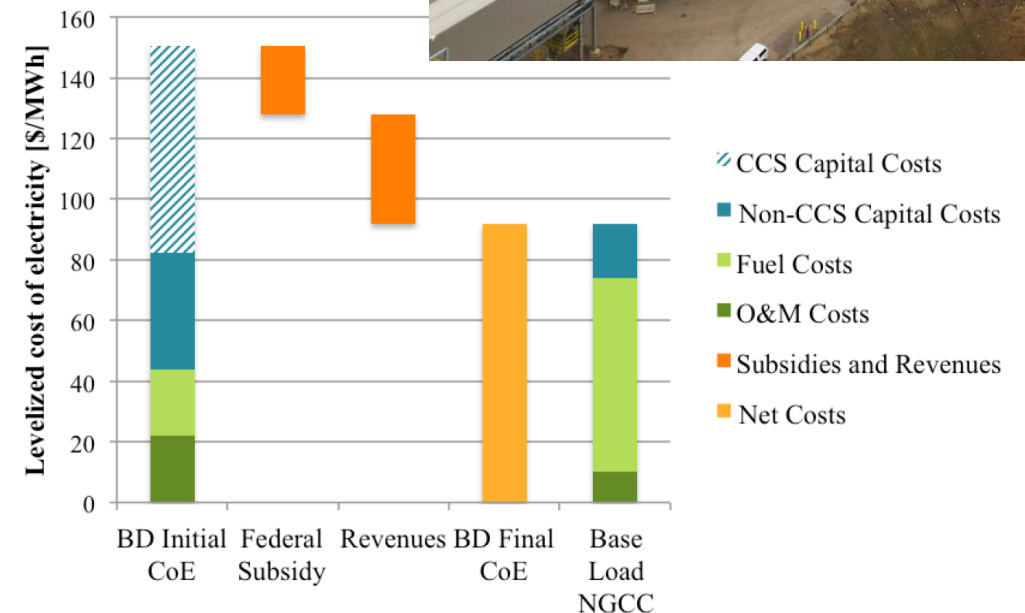


- Challenging for power sector to invest in current climate – low operating hours due to intermittent renewables
- EOR projects have been hit by low oil prices



BOUNDARY DAM 3

- 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 CO₂ 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





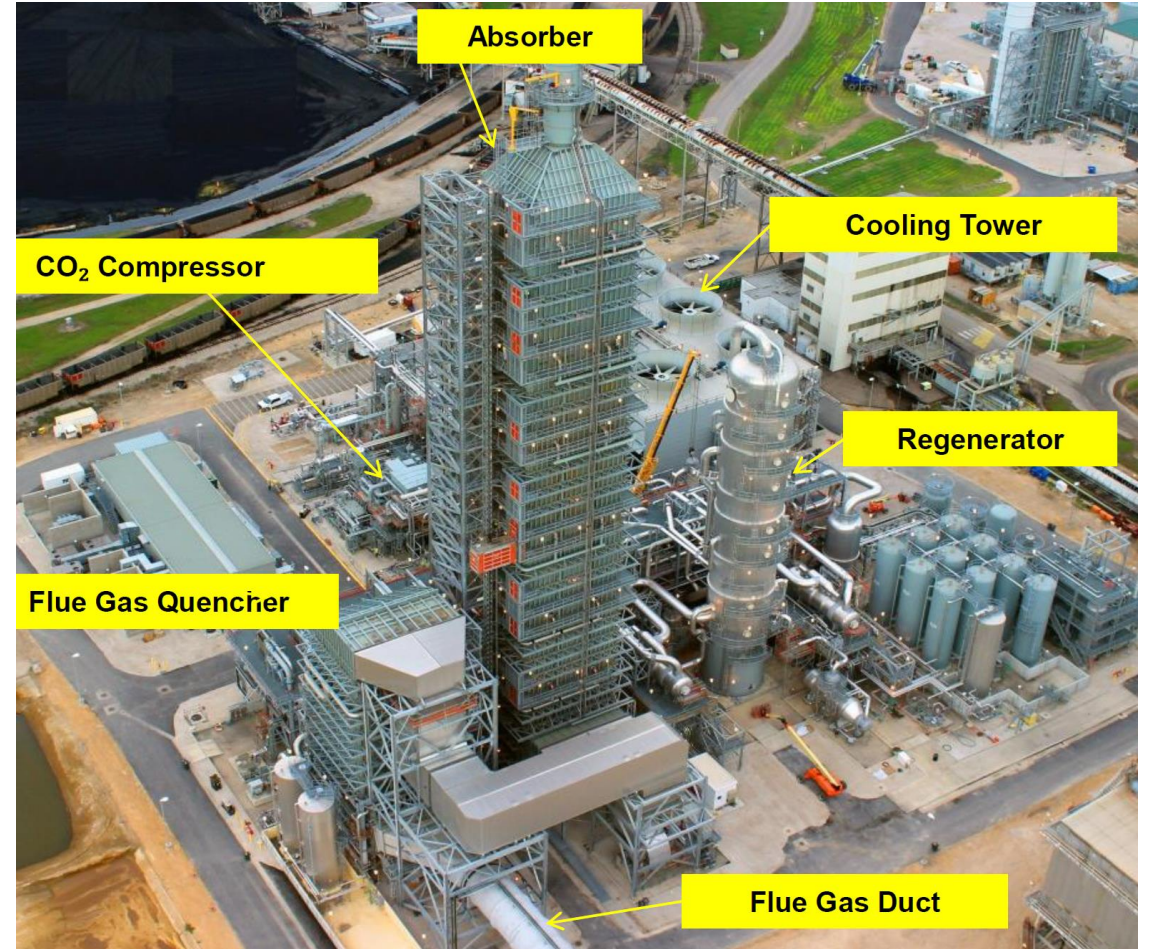
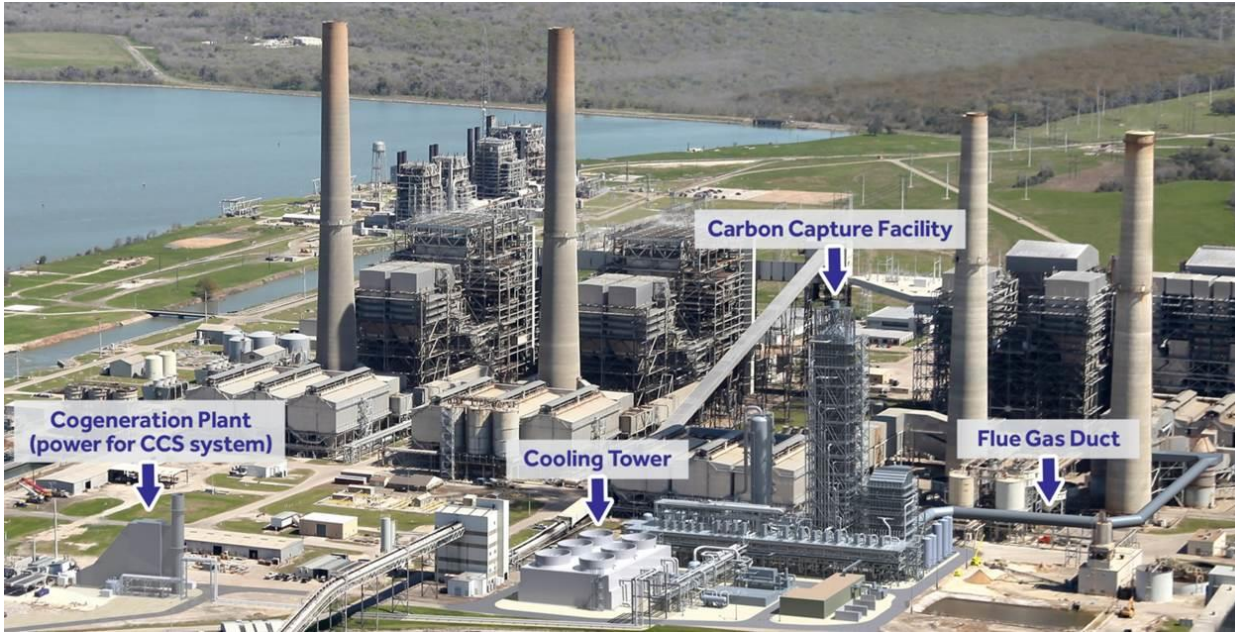
PETRA NOVA

- 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

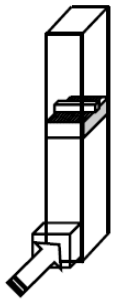
Sources	\$MM	Uses	\$MM
NRG Equity ²	\$300	Parish Site Capital ³	\$637
JX Nippon Equity	300	Oilfield and Pipeline Capital	300
Project Financing	250	Initial O&M, G&A, Fees, Other	80
DoE Grant	167		
Total	\$1,017	Total	\$1,017



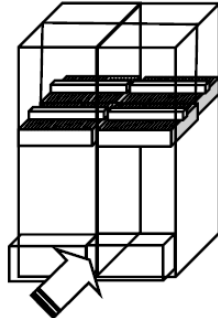
PETRA NOVA



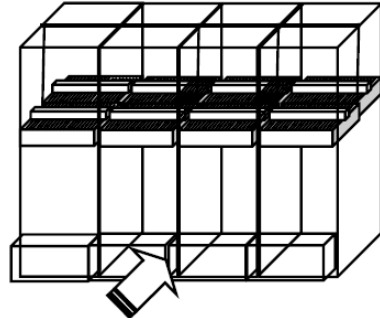
Plant Barry



Parish



Further Large Scale





KEMPER COUNTY IGCC

- 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



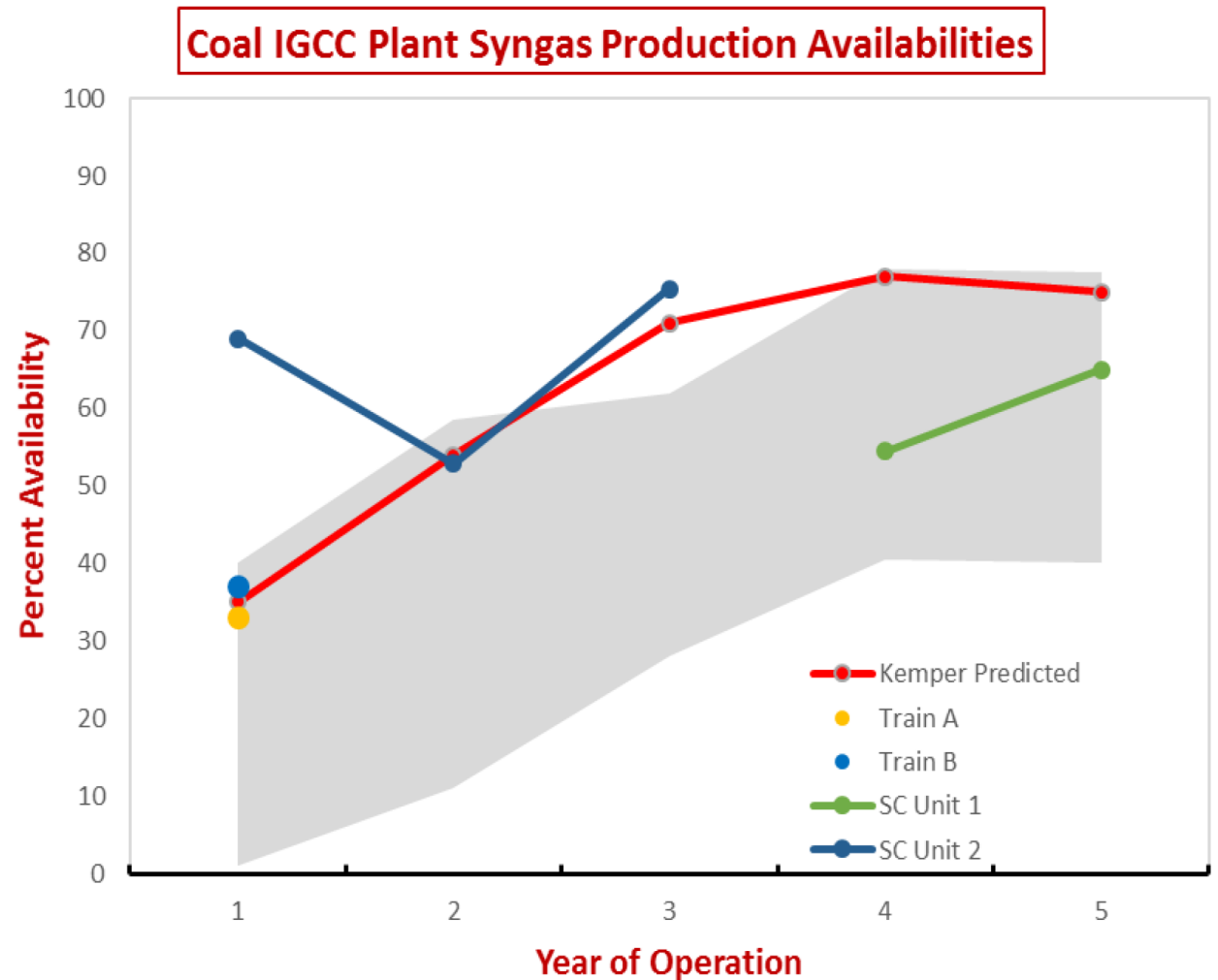


TECHNICAL ISSUES AT KEMPER

- 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



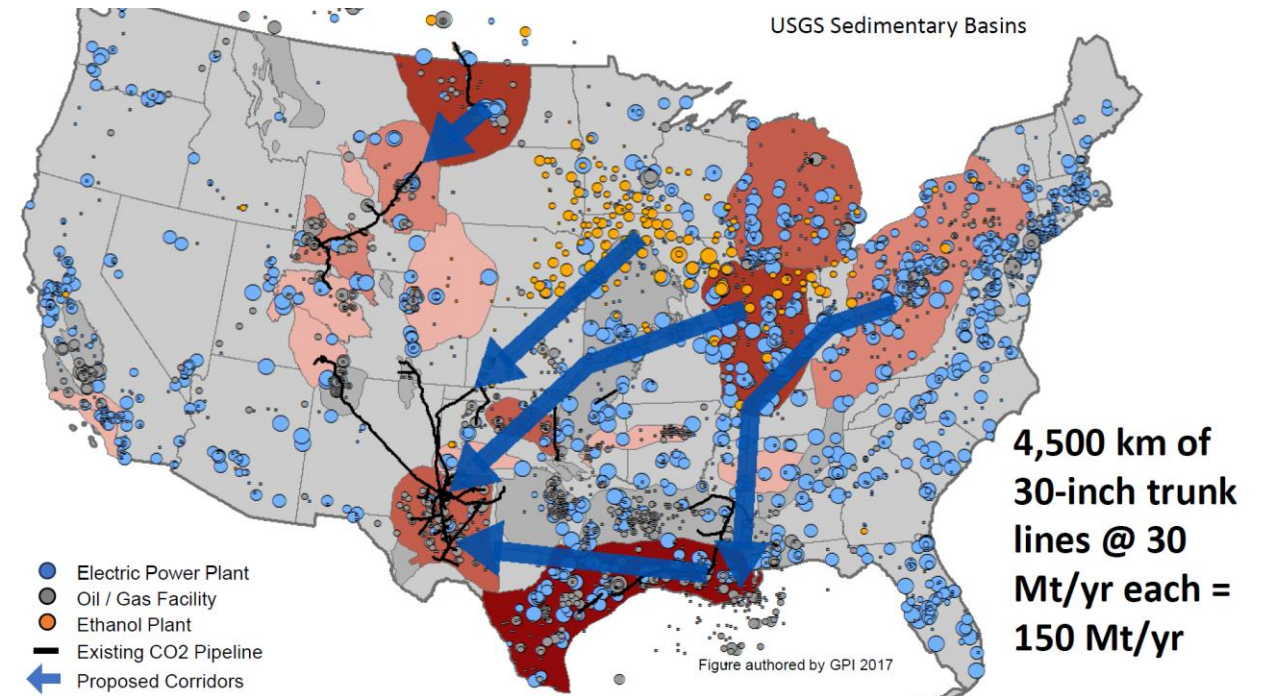


US OVERVIEW

- Well-established EOR industry – capture from NG, coal-to-chemicals, bioethanol
- Recent projects were driven by EOR and strong DOE investment in storage appraisal and plant capital (part of economic stimulus)
- Some proposed power projects tried to recover costs from power markets

A game-changer for CCS?

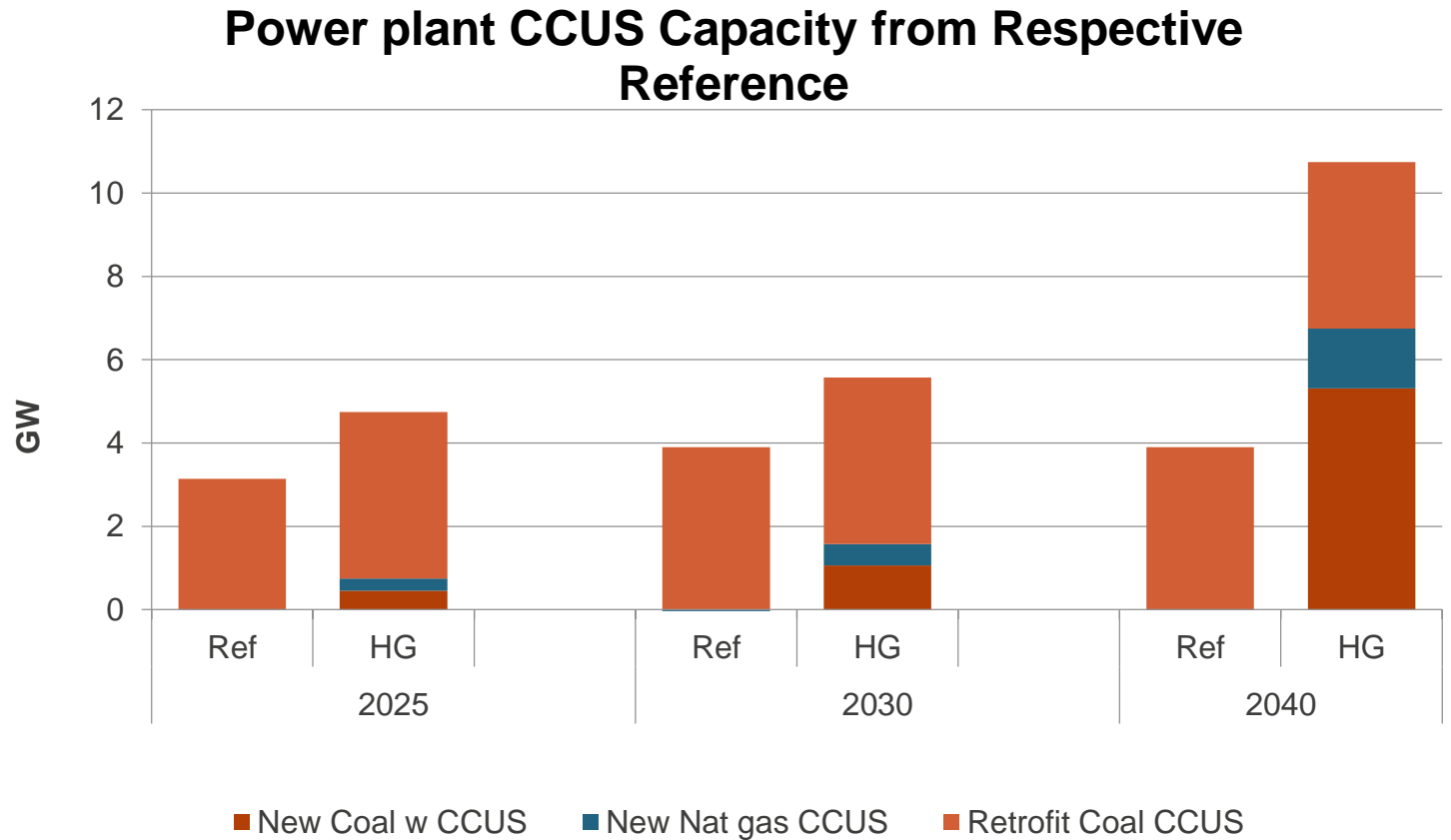
- In 2018, 45Q tax credit improved to give up to **\$35/t for EOR** and **\$50/t for saline storage** (increases linearly to 2026, can claim over 12 years)
- Projects need to operate by 2024





EFFECT OF 45Q

- 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





CCS IN EUROPE: ROAD

- 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



Carbon capture and storage

Press release: The coal dinosaurs bow out of a low carbon Rotterdam

As the coal dinosaurs bow out of a low carbon Rotterdam, a focus on CO₂ transport and storage gives better opportunities for the port, new low carbon industrials and workers.



CCS IN EUROPE

- 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

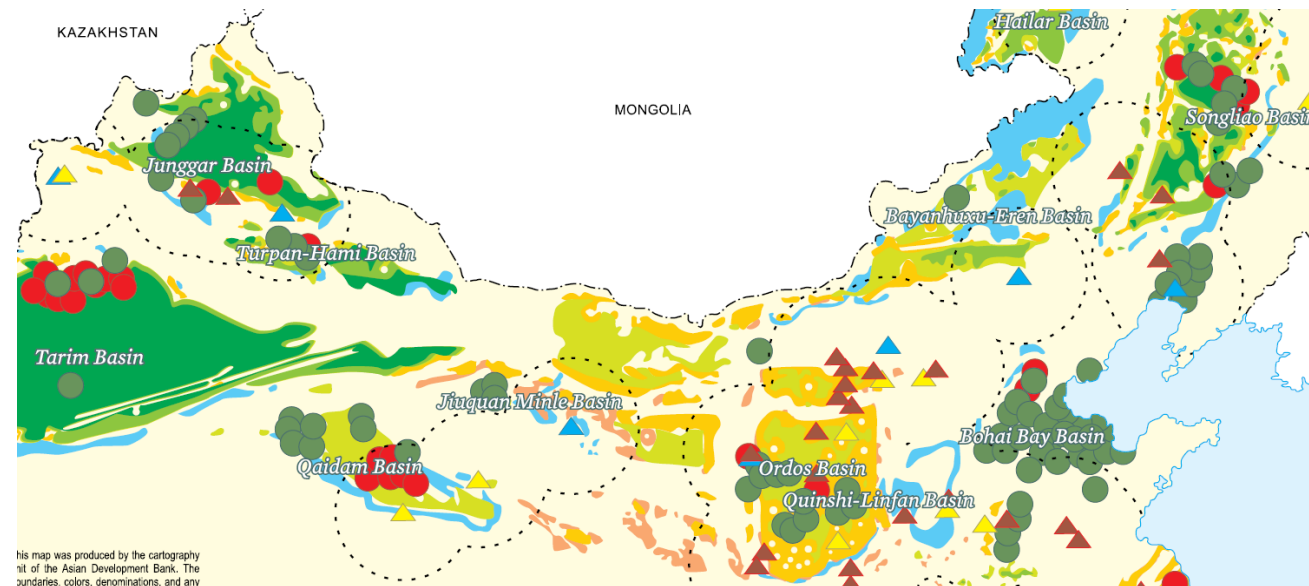


- Limited EOR options and offshore storage means infrastructure development is a barrier
- Recovery of ETS carbon price will not drive CCS alone



CCS PROJECTS IN CHINA

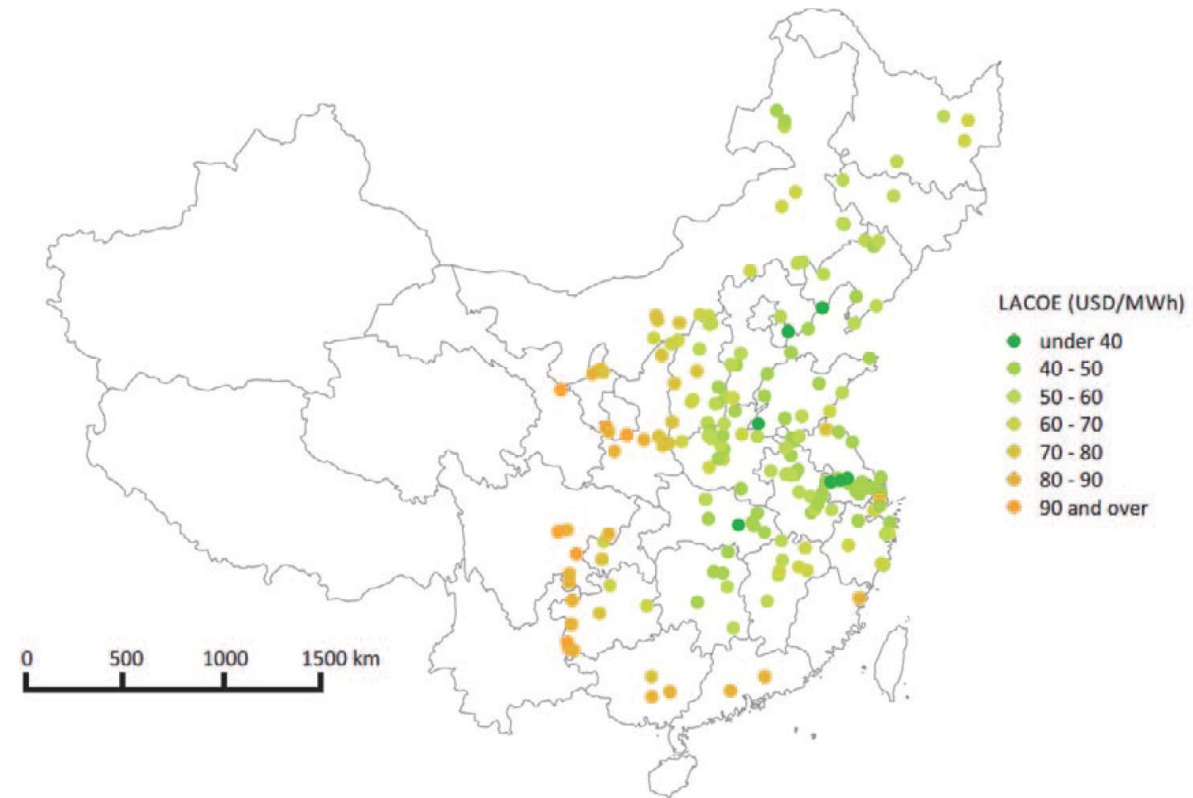
- **Yanchang Integrated CCUS Project** will capture 0.36 Mt/y of CO₂ from an existing coal-to-chemicals plant in Shaanxi (operational 2020)
- **Sinopec Qilu** is a fertiliser plant (coal/coke gasification) – 0.4 Mt/y under construction and to start 2019
- August 2018, capture from natural gas and EOR 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





CHINA: POTENTIAL FOR COAL POWER

- 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



CCT2019 IN HOUSTON!

- 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





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THANK YOU FOR LISTENING

ANY QUESTIONS?

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