



CCS Now and the Challenge Ahead Post COP21

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CCS – a key climate policy option



- The IPCC AR5 indicated - CCS is a crucial technology to meet the 2⁰C target
 - Climate scenarios could not meet 2⁰C without CCS
 - The costs of meeting the 2⁰C will be 138% higher if CCS is not included as a mitigation option
- Post Paris CCS “lowered” the target to limit temperature rise to below 2⁰C target.
- CCS is expected to be an even more crucial technology if we are to achieve below 2⁰C target.

CCS – a key climate policy option (2)



- To go below 2°C significant reductions in greenhouse gas emissions will be required in all sectors not just the power sector.
- CCS is a key technology, probably the only one, that can achieve deep emissions cuts in the industry sector.
- “Negative emission” technologies like BioCCS will likely need to be deployed from 2030 onwards.



Capture Technology Developments



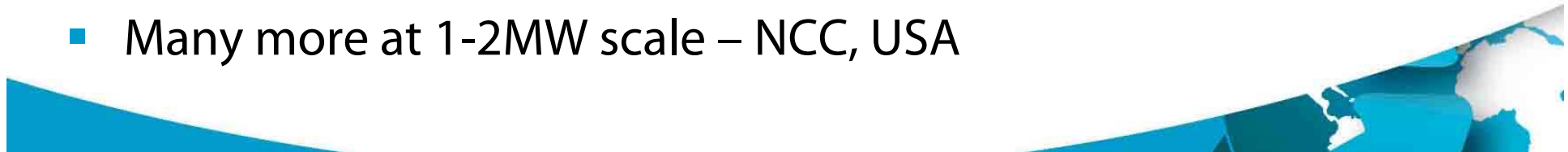
- Post Combustion Capture -
- Oxy combustion
- Supercritical CO₂ cycles
- Pre –combustion capture (IGGC)





Post Combustion Capture

- Significant progress in reducing energy of regeneration for amine based process
 - Now 2.0-2.3 MJ/Kg CO₂, Cansolv 201 solvent, +others
 - Down from 4-4.5MJ/Kg in 1990
 - MEA no longer definitive baseline for c technology comparison
- Significant number of vendors testing or tested at 10MW - 100,000t scale
 - Norway, TCM – Cansolv, Aker, Carbon Clean Solutions,
 - Canada, Shand – Hitachi
 - China, Shanghai – Huaneng Group
 - Japan, Tomakomai – MHI, Saga City, Toshiba
- Many more at 1-2MW scale – NCC, USA



PCC Developments in Power Sector



Boundary Dam 3, Canada



- Refit of existing coal fired unit
- Operational for 1 year
- CanSolv amine based PCC technology
- **110MWe**
- 95% capture
- CO₂ sold for EOR

NRG Parish, USA



- Refit of existing coal fired unit
- Now Operational
- MHI amine based PCC technology
- **250 MW slip stream**
- 90% capture
- CO₂ sold for EOR

Post Combustion Capture



- **Boundary Dam 3 Operational Achievements**

- March 2016 - a 90% reliability factor had been achieved for the first quarter of 2016
- July 2016 – 1 millionth tonne of CO₂ had been captured

- **Cost reduction from learning by doing**

- 30% CAPEX, 25% OPEX

- **A word from the wise!**

"A capture technology must be piloted at a scale that allows for reasonable engineering scale up to a commercial size"





Oxy Combustion

- Alstom/GE
 - 35MWth test facility at Schwarze Pumpe, Germany
 - Engineering design for White Rose 426MWe (gross) – now cancelled
- B&W
 - 30MWth Burner tests, Ohio, USA
 - Engineering design for FutureGen 2.0 159MWe project – now cancelled
- HUST, China
 - 35MWth test facility in Wuhan, China
 - Lead to a 200MWe FEED design



Callide Oxy Fuel Project



Key technical achievements

- 10,200 hours oxy-firing operation and 5,600 hours of CO₂ capture plant operation
- A boiler turn-down to 50% Load Factor was demonstrated
- > 95% capture of SO_x, NO_x, particulates and trace metals
- A high purity of CO₂ product (> 99.9%) was produced



“The project was successful and that the technology is ready to move to the full commercial scale.”



Supercritical CO₂ Cycles

- IEAGHG techno economic study has evaluated technology options
 - SCOC-CC, S-Graz, NET Power and CES.
- Cycle efficiencies , 49% to 55%
 - NGCC/CCS base case 52% efficiency
- LCOE of base-load plants were 84-95 €/MWh,
- The cost of CO₂ emission avoidance was 68-106 €/t CO₂ avoided.
- The base case was 90% capture
 - Could go to 98% without increasing the cost/t of CO₂ avoided,
 - Or essentially 100% if lower purity CO₂ was acceptable.

Supercritical CO₂ Cycles (2)



Other points

- The cycles could be net producers of water
- Cycles have small footprints
 - advantages at compact sites

Route to commercial deployment

- NET Power is constructing a 50MW power plant
- Toshiba has developed turbine component
 - **Critical component**
- Testing begins in 2017
- If successful will allow scale up to 295MWe



Pre-combustion capture



- Rectisol and Selexol capture technologies are commercially proven
 - Rectisol process in operation at Dakota Gasification facility since 2000
 - Selexol process to be demonstrated at Kemper County in late 2016
 - No cost overruns on capture component
- Osaki CoolGen Project - IGFC
 - Project is planned in three steps.
 - 166 MW oxygen-blown IGCC now operating
 - Add an amine based capture test facility , 2019 on
 - Add MCFC – 47-49% cycle efficiency

Industrial CCS



- Studies have shown us the adding CCS to industry processes is very site specific
- Standalone plants will have waste heat available for use
 - 50% capture may be limit in these cases
- Alternative to add new steam generator – costs start to increase



Industry CCS Developments

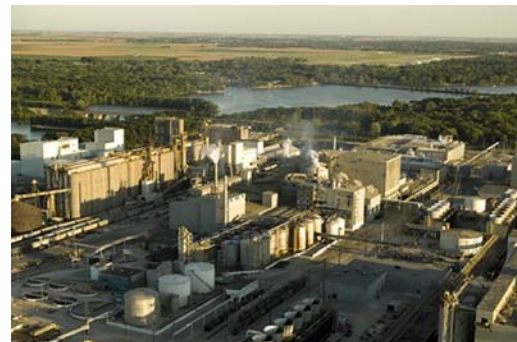


- Gas Processing sector - >20 years operational experience
 - PCC established technology (Sleipner, Snohvit)
 - Lula Project offshore Brazil demonstrating **membrane** technology at scale
 - Advantages for offshore applications using floating platforms
 - Gorgon, Australia – next project to come on stream – 3 X 1Mt/day PCC units



Industry CCS

- CCS now deployed in:
 - Hydrogen refining/upgrading
 - Quest – solvent based technology
 - » 1Mt injected into on shore 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



CO2 Utilisation



- Emotive topic at GHGT-13
- Not a mitigation option
- Except for CO2-EOR options do not permanently remove CO2 from the atmosphere
- Can it help to build CCS infrastructure?



CCU Value



- 3 new PCC vendors
 - Linde 500tpd plant at Jubail Industrial City, Saudi Arabia.
 - First demonstration of CO₂ capture on ethylene glycol production
 - Carbon Clean Solutions – 10tpd unit plant in India
 - First demonstration of CO₂ capture on coal power plant in India
 - Toshiba, 10tpd PCC on waste incinerator at Saga City, Japan
 - First CO₂ capture demonstration on waste incinerator
- Limited pipeline infrastructure development to date
 - Unlike CO₂-EOR in USA which added extensive pipeline network for reuse for CCS
- CCU unlikely to assist pipeline infrastructure development in Europe – need policy drivers



What Next?

- Next projects on horizon
 - Fluor to demonstrate at ROAD in 2018?
 - Capture at bio-CCS power plant in Japan in 2018?
 - Industry CCS project(s) in Norway 2010?
- Options and costs of 99-100% capture
 - Higher capture rates important to reduce residual emissions from CCS in future
 - Higher capture process rates or combination with biomass co-firing?
- Valuing CCS
 - Move beyond LCOE comparisons to system based assessments
 - Flexible CCS plants could complement flexible renewables

The Challenges for CCS (1)



- Raise its profile (positively) on international stage – COP/IEA Ministerials, CEM etc
- CCS included in 11 NDC's (+USA) at COP21
 - 62% of CO2 emissions in 2013
- In particular with Developing Countries that will continue to use fossil fuels



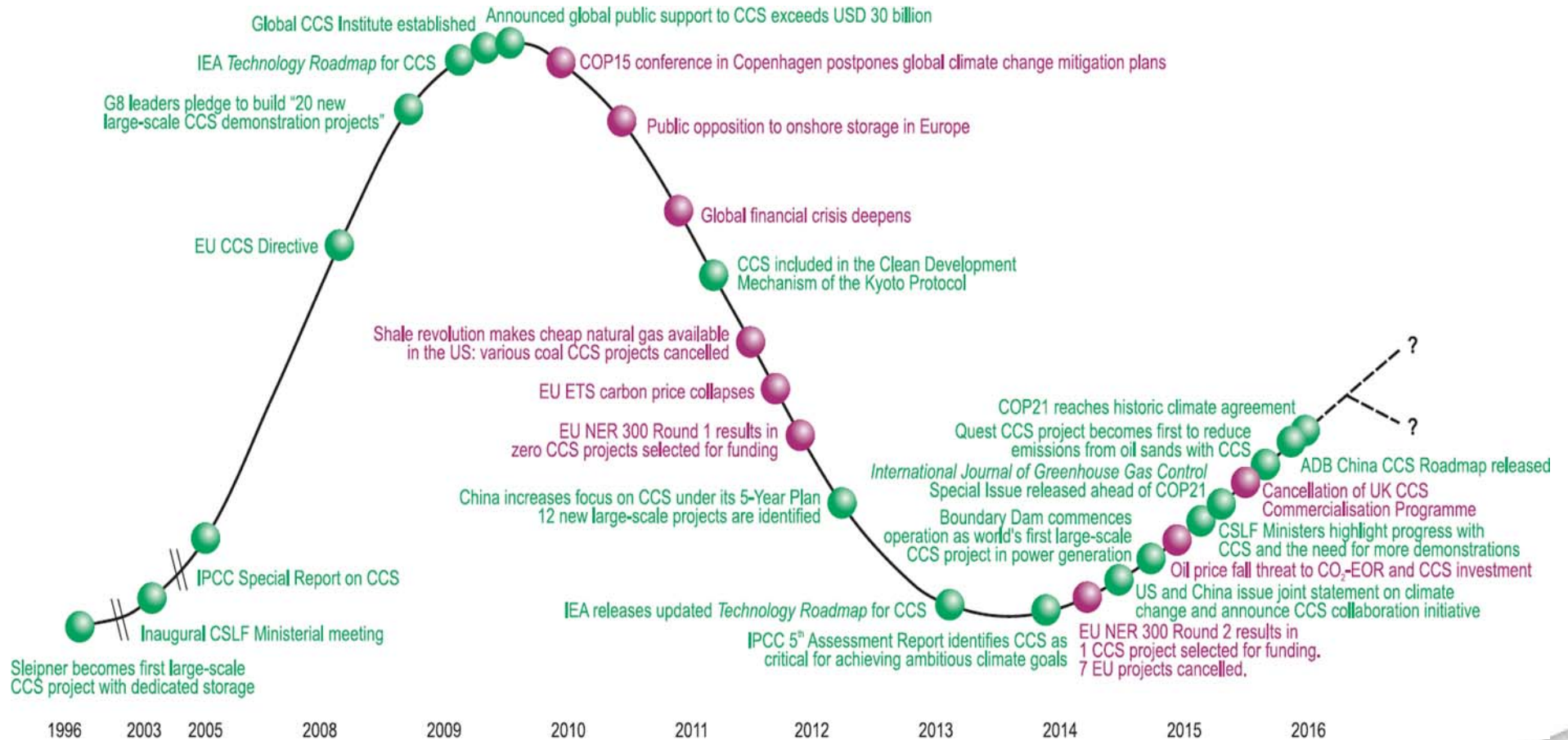
UNFCCC Side event: “CCS Opportunities for Africa”. 8th Nov 2016

Speakers from BHP/SaskPower, S.Africa, Nigeria, Ghana, UT BEG, CO2GeoNet, and IEAGHG (introducing and chairing).

Challenges for CCS (2)



- Consistent Policy support needed



Source:

IEA (2016), *20 years of CCS: Accelerating Future Deployment*.

Adapted from SBC Energy Institute (2016), *Low Carbon Energy Technologies Fact Book Update: Carbon Capture and Storage at a Crossroads*.

Challenges in Europe



- Focus on industry CCS
- Need to separate capture and transport/storage
 - Norwegian model/UK Competition learnings
- Build out from industrial hubs
 - UK – Teesside
- Build transport infrastructure into North Sea
 - Use EU Infrastructure Funds
- Is there the political will to start this process now?



Challenges for Developing Countries



- Prove their geological storage resource
- Knowledge transfer essential
- Financing for storage assessments required
 - Governments like Norway, USA etc co-ordinated by CSLF?
 - Clean Technology Centre and Network?
 - Global CCS Institute?
 - Oil and Gas Climate Initiative?



**NATIONAL CO₂
STORAGE
ASSESSMENT
GUIDANCE**

**Report: 2016/TR6
October 2016**

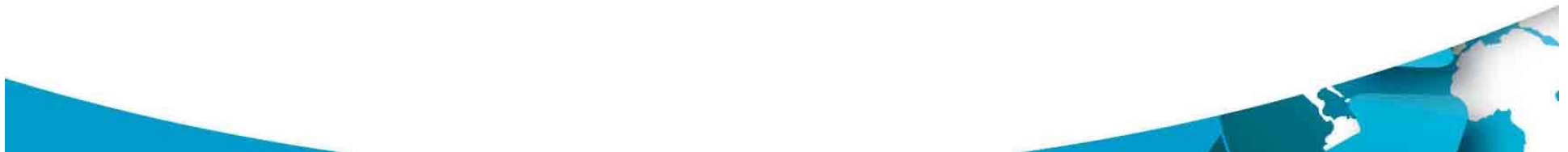




Summary

- Paris Agreement provides an opportunity window for CCS
- Significant progress made on CCS deployment around the globe
 - Positive Messaging needed
 - *You will never change entrenched mind-sets*
- Need to maintain momentum on CCS deployment but needs political support
- Europe we need to build out from industrial centres and get transport network in place
- Developing countries need help to start work on storage assessments now.

"it all starts and ends with the rocks"





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