Managing the Energy Transition towards 2050: Carbon Capture and Storage… Challenges and Opportunities

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CCS Green Paper
Launched 11\textsuperscript{th} April 2018

27 Task Force Members from:
Australia
India
South Africa
UK
USA

The Task Force was strongly supported by Jacob Ohrvik-Stott, Policy Officer, and Alana Collis, Manager, IChemE Energy Centre.
Meeting the 2°C IPCC & 1.5°C COP21 targets

- Mitigation costs 138% more without CCS
- Without CCS, <50% of IAM models solve the problem
- Most feasible solutions use BioEnergy + CCS (BECCS) - a key negative emissions technology
- CCUS needs to remove ~20% of target CO₂ – 800Gt total or 10Gt pa by 2050

CCS = Carbon capture & storage
IAM = integrated assessment models

Large-scale CCS Projects

Diagram courtesy of Global CCS Institute
To meet COP21 targets, we need to capture a total of ~10 Gt CO₂ pa by 2050. This is equivalent to ~2000 projects with a capture capacity of 5 Mtpa.

Large-scale CCS growth needs to dramatically accelerate...

- **Terrell Natural Gas Plant (formerly Val Verde, US)**: 0.4 Mtpa
- **Sleipner CO₂ Storage Project**: 1 Mtpa
- **~20 Commercial scale CCS projects in operation**
  - Ave. capacity 1.8 Mtpa
  - Total CO₂ capture capacity = 36 Mtpa

1972: 0.4 Mtpa  
1996: 1 Mtpa  
2019: 1.8 Mtpa  
2050: 5 Mtpa

Making CCS a commercial reality

- The barriers are not technical.

- We need a combination of the following:
  1) Provide a monetisation route (e.g. EOR, CO₂ pricing);
  2) Target other sectors as well as Power
     - Industrial Processes, Hydrogen Production
  3) Multi-plant large-scale deployment
     - taking advantage of economies of scale
     - cost reduction and efficiency improvements through learnings – and 1ˢᵗ to nᵗʰ plant improvements.
  4) A systems engineering approach to CCS
  5) Supportive policy framework
  6) New business models for sharing risk
CCS technologies are mature and deployable
New technology is coming through…

The Allam Cycle

NetPower

Molten Carbonate Fuel Cells
ExxonMobil - Cosia

70% CO₂

4% CO₂

Slide 8
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Routes to monetise stored CO₂

- CCS adds cost (so called ‘energy penalty’)
  - ~$50 per te CO₂ depending on source and technology used
- Costs can be recouped by monetising CO₂ by
  - Revenue generation through EOR or EGR (PetraNova)
  - A carbon price or other financial incentive
    - Carbon tax (Sleipner, Norway)
    - Carbon trading
    - Carbon tax credits, such as 45Q in US
- However, these are not currently available options in many countries/regions
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Mitigating direct industrial emissions

- Industrial emissions represent over 20% of the total anthropogenic CO$_2$ release globally.
- CCS is the most cost effective option for industrial decarbonisation and the only option where CO$_2$ is a by-product e.g. cement manufacture.
- CCS combined with process efficiency optimisation – for both existing and new build plants – should be a priority for industry...and for Chemical Engineers!

Recommendation: decarbonise this sector in UK by 2030.
Decarbonising heating networks with CCS

- Hydrogen is now seen as a leading contender for the decarbonisation of heating.
- CCS is required for the removal of CO$_2$ during the production of hydrogen from fossil fuel, e.g. steam methane reforming (SMR) of natural gas, or syngas from oil and heavy hydrocarbons.
- This process could deliver low-carbon hydrogen at the volumes and cost required globally...also for decarbonised transport.
- UK examples: H21 Leeds City Gate Hydrogen Project; Cadent Liverpool-Manchester Hydrogen Cluster
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A systems approach to CCS

- Optimise costs and benefits across the full value chain
- Developing transport infrastructure models for a range of regional contexts
- Defining the role of CCS in future low-carbon energy system
- Regionally dependent and multidisciplinary

![Diagram of CCS systems](image)
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A supportive policy environment

- Stable, enabling policy frameworks
  - Establish effective carbon pricing
    - Regional and international; minimise ‘carbon leakage’
    - Sector specific, as in Norway
  - Incentives and regulations that encourage investment in CCS
    - Contracts for Difference for Power; for (gas) Heating?
    - Industrial capture contracts
    - Tax credits for sequestration
    - International tradable permits
Fostering supportive market conditions – New Business Models

- Supportive policy frameworks that incentivise long-term investment
- Commercial models that spread risks equitably between stakeholders

Governments taking on long-term storage risks and liabilities

Sharing risks and costs between public and private sector

- Publicly funded CO₂ transport networks
- Shared transport and storage infrastructure for multiple CO₂ generation users

Governments & State

Business investors & Developers

G&C/Eli Operators: Users

T&S Infrastructure: Service providers

CO₂ Source

Factory Boundary

CO₂ Transport

CO₂ Storage

Anchor project & infrastructure Risk

Long-term storage risk

New CCS Commercial Models

Intra-chain project-on-project risk

T&S Capacity availability and market risk

ICheM E Energy Centre
Furthermore, deeper reductions requiring the deployment of CCS will be needed to meet the aims of the Paris Agreement, whether by 2050 or subsequently.

Although the Strategy states an ambition to deploy carbon capture use and storage (CCUS) in the 2030s, the level of detail and funding (which was directed at innovation only) are not commensurate with what will be needed.

The Government should set out plans in 2018 that kick-start a UK CCS industry in the 2020s.
CCUS Cost Challenge Taskforce report
July 2018

Four key messages for UK Government:
1. Need to recognise the CCUS opportunity and the urgency of acting now in order to deliver CCUS at scale, at lowest cost.
   - Project lead times are long, and time is limited if we are to deliver CCUS on the required scale by 2050, (>100 million te CO₂ pa)
   - Can be achieved with joint industry and Government vision and partnerships
     - First projects becoming operational from the mid-2020s and an industry pipeline of financeable projects.
2. CCUS can unlock value across the economy to enable low carbon industrial products, decarbonised electricity and gas, a hydrogen economy, greenhouse gas removal, and new industries based around utilising CO₂.
3. Need viable business models to move the technology to a sustainable commercial footing.
4. CCUS can already be deployed at a competitive cost.
   - Project concepts being proposed are comparable in cost with other first of a kind low carbon technologies.
   - Focus on deploying CCUS in clusters, with the cluster stakeholders identifying how the value of CCUS can best be secured to benefit their local economies and needs.

https://www.gov.uk/government/groups/ccus-cost-challenge-taskforce
Regions and Clusters

OCGI Clean Gas Project

Mt CO₂ pa


https://www.gov.uk/government/groups/ccus-cost-challenge-taskforce
UK Government funding to deliver on CCUS announced at COP 24 Katowice, December 2018

- Claire Perry, Minister of State for Energy and Clean Growth, announced £170M funding for an **Industrial Clusters mission under the Industrial Strategy** with the objective ‘…establish the world’s first net-zero carbon industrial cluster by 2040 and at least one low-carbon cluster by 2030’.

- Critically for CCUS, ‘in at least one cluster, by 2030, the low-carbon infrastructure needed to support industrial decarbonisation will be in place and operational.’

Committee on Climate Change Net Zero report, May 2019

- **CCS is a necessity not an option**
- CCS in industry, with bioenergy (for ‘negative emissions’), and very likely for hydrogen and electricity production.
- The scenarios involve aggregate annual capture and storage of 75-175 MtCO₂ in 2050, requiring
  - a major CO₂ transport and storage infrastructure
  - servicing at least five clusters
  - some CO₂ transported by ships or road vehicles.
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12th June 2019 UK Government commits to net zero emissions by 2050

2008 Climate Change Act amended - UK the first G7 country to legislate for net zero emissions.
Further UK Government Actions…

- **UK CCUS Deployment Action Pathway: Action Plan**
- **Review of delivery and investment models for CCUS**
  - Business models to overcome barriers to
    - deploying carbon dioxide capture in the industrial sector
    - deploying carbon dioxide capture in the power sector
    - establishing the infrastructure required to transport and store CO₂
- **Test the development of CCUS industrial decarbonisation clusters**
  - Work with the Teesside, Merseyside and Grangemouth to test the potential for development of CCUS industrial decarbonisation clusters.
- **Established CCUS Council**
- **International collaboration on CCUS**
  - MoU with Norway, Mission Innovation…
Summary…

- CC(U)S essential to meet IPPC zero-carbon target
- Widescale global deployment requires a collective technological-government-business approach:
- There are some encouraging large-scale projects but as yet no integrated CCS Systems producing a range of ‘green products’ from fossil fuels …power/heat/chemicals/materials
- The UK is having a third attempt at CCS with a more integrated approach and is committed to achieving its share of a zero-carbon target by 2050
- Green shoots, but a long way to go and a lot to do…