# Commercialisation of CCS

## "What needs to happen?"

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London December 5th 2016

# Background

- Global efforts to develop CCS have so far proved largely ineffective and CCS remains generally unattractive to investors
- Government programmes have largely failed to stimulate progress
- Despite the growing need for CCS the market remains largely inactive

However,

- The lessons learnt from past failures point the way to future success
- The UK CCS Commercialisation programme has delivered a wealth of knowledge
- This Paper builds on that knowledge

A different outcome requires a different approach

# The Value of CCS

- Addresses all carbon emitting sectors (Power, EII, Transport, Heat)
- Resulting value is delivered at the total energy system level in an economy
- IPCC non-CCS pathway 138% higher costs on a global basis
- ETI non-CCS pathway UK decarbonisation costs higher by 2% GDP p.a. by 2050
- UK CCS industry could yield £2bn-£4bn GVA p.a. by 2030 and 15k – 30k jobs
- Doubtful that GHG emissions targets global and local (UK) can be met without CCS
- No vibrant EII possible in UK without CCS (I&S, Cement, Fertilisers, Chemicals, etc.)
- BECCS can remove industrial quantities of $CO_2$ from the atmosphere

Imperative governments take firm decisions on whether or not CCS technology will form part of the energy mix and implement corresponding long term policies

# The Cost of CCS

- CCS continues to be compared with alternative technologies as if interchangeable
- Strike price will continue to be a comparator for power in the UK (the Press test)
- Competition Projects were expected to be £150-200/MWh ….“too expensive”
- CRTF[1] anticipated costs for first projects to be £161[2]/MWh
- Little credit can be anticipated for future cost reductions (waterfall) as capacity increases and costs come down
- What is an acceptable price for the first projects? New nuclear £92.5[2]/MWh, Off-shore wind £120[2]/MWh
- Important that strike price expectations are realistic and achievable

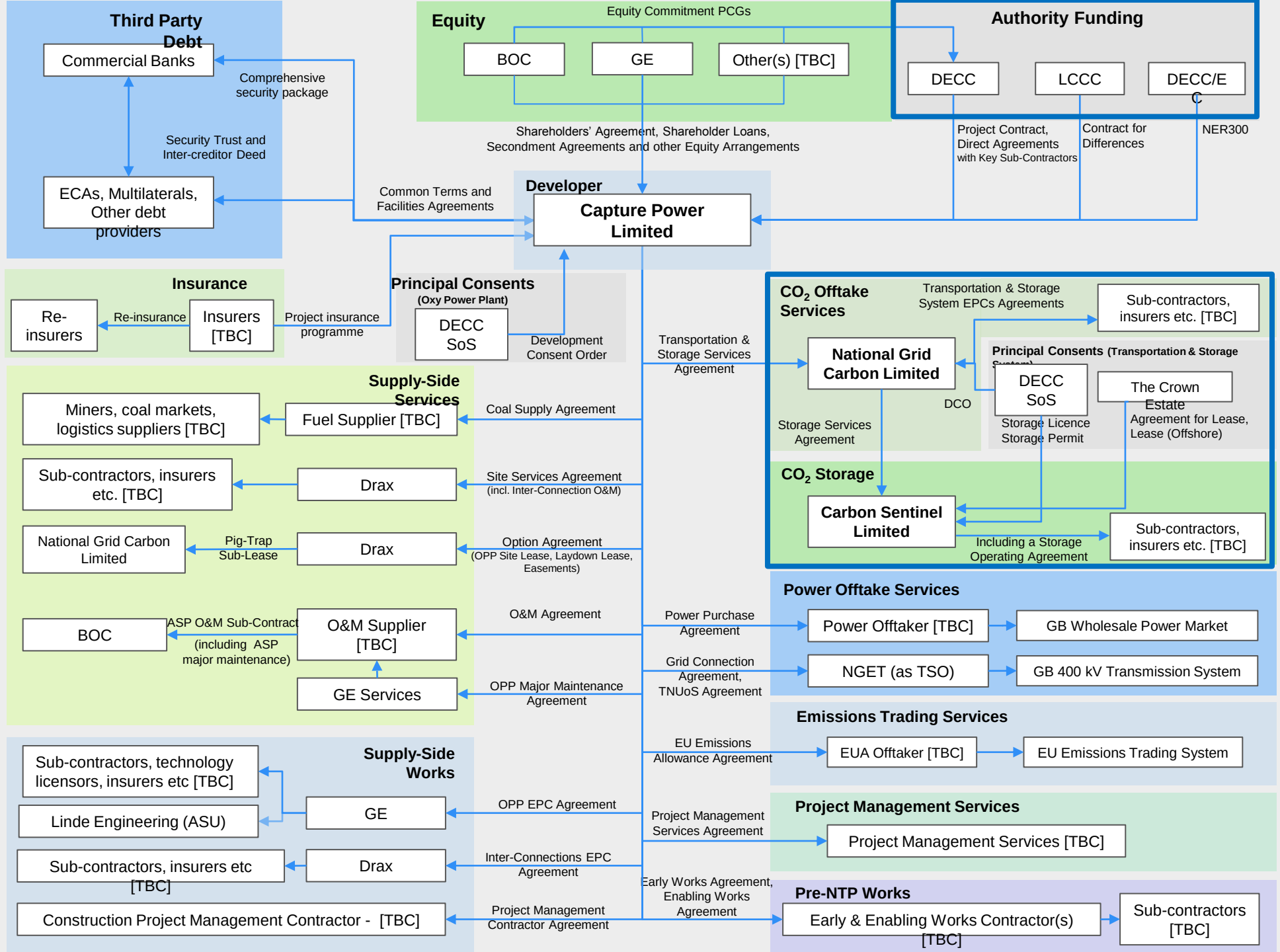
Based on lessons learnt from competition more competitive prices are achievable

[1] Cost Reduction Task Force
[2] 2012 prices Scottish power EA1

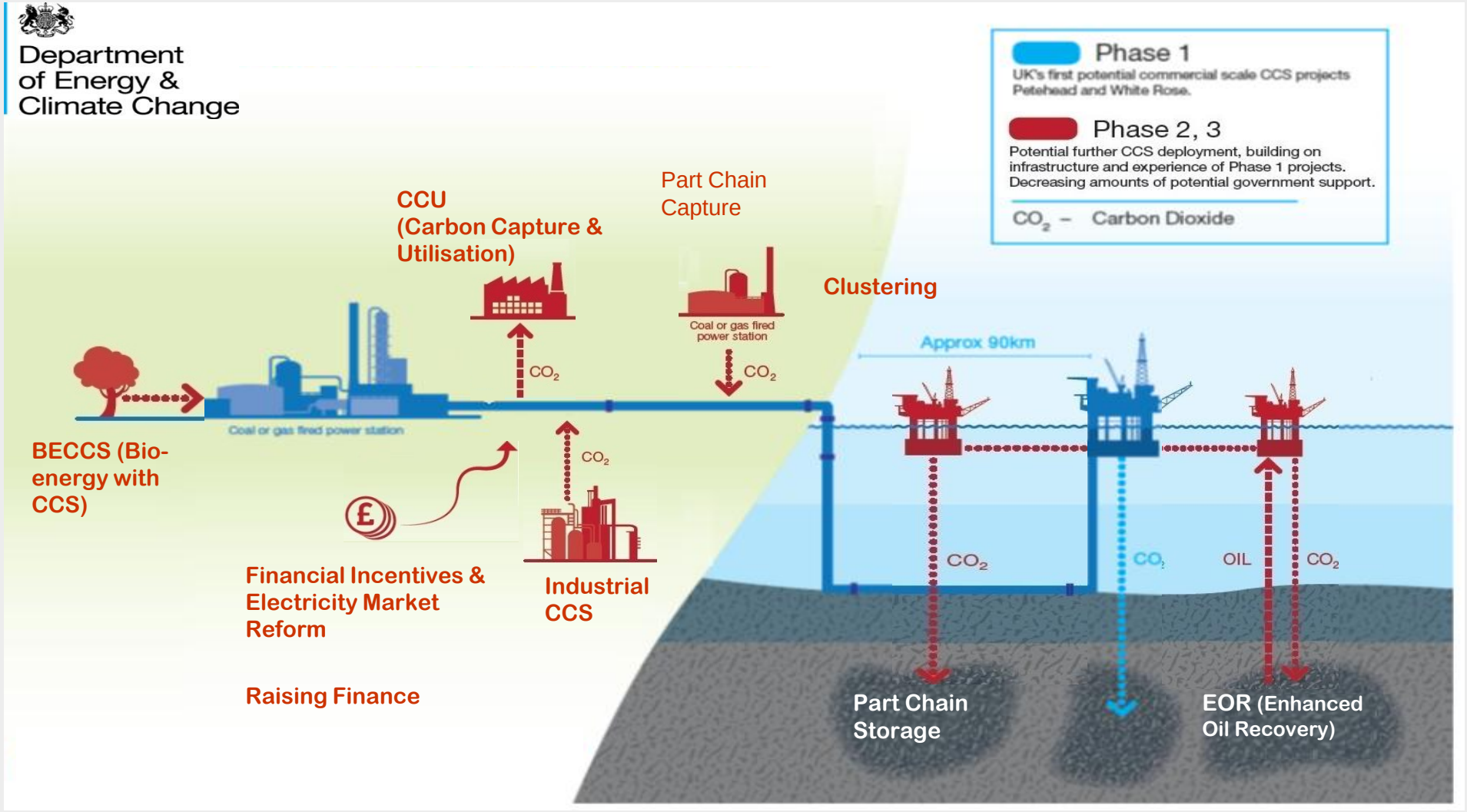
# The Cost of CCS Cont'd

- Cost reduction drivers: (CRTF)
  - Large scale CCS infrastructure - $CO_2$ storage hubs, large shared pipelines connecting $CO_2$ sites
  - Large scale power stations and technology improvements
  - Reduction in cost of capital through measures to reduce risk and improve investor confidence
  - Synergies with EOR in Central North Sea oil fields
- These drivers are as relevant today as when the CRTF report was published
- No real technology barriers for large scale power stations/CCS infrastructure
- EOR can add additional value to CCS industry once reliable quantities of $CO_2$ are available off-shore
- Risk and investor confidence are major challenges that need to be addressed

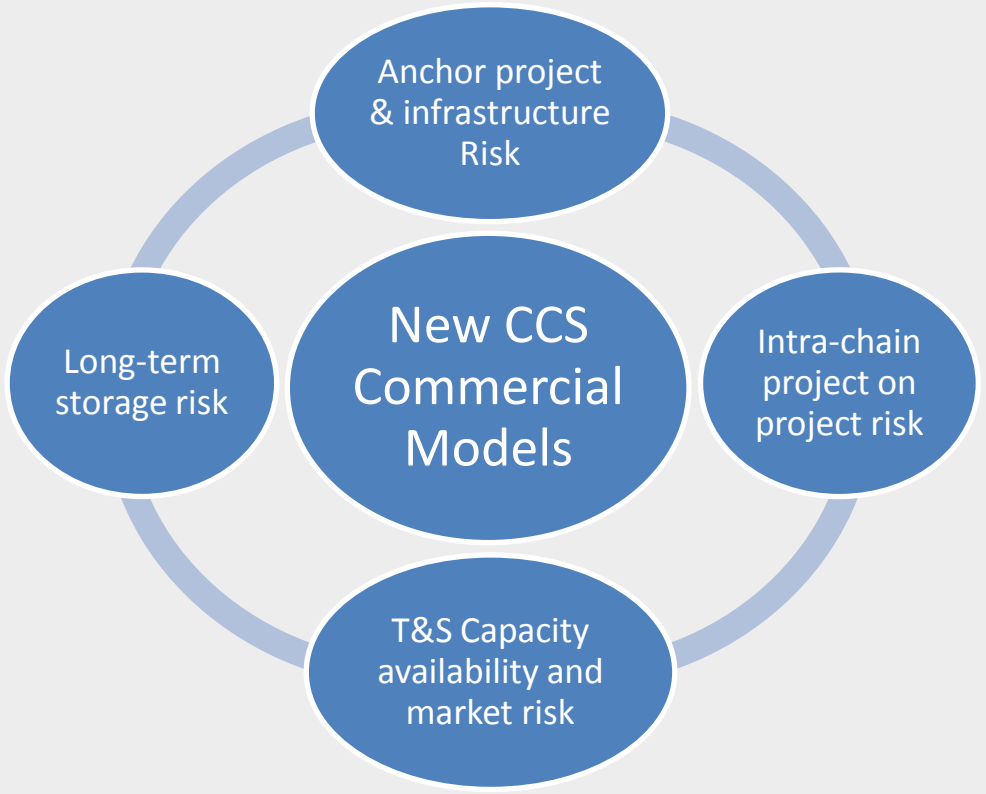
Competition "high prices" largely reflected competition design and risk allocation


Third Party Debt
Commercial Banks
Comprehensive security package
Security Trust and Inter-creditor Deed
ECAs, Multilaterals, Other debt providers
Equity
Equity Commitment PCGs
BOC
GE
Other(s) [TBC]
Authority Funding
DECC
LCCC
DECC/EC
Shareholders' Agreement, Shareholder Loans, Secondment Agreements and other Equity Arrangements
Project Contract, Direct Agreements with Key Sub-Contractors
Contract for Differences
NER300
Developer
Capture Power Limited
Common Terms and Facilities Agreements
Insurance
Re-insurers
Re-insurance
Insurers [TBC]
Project insurance programme
Principal Consents (Oxy Power Plant)
DECC SoS
Development Consent Order
Supply-Side Services
Miners, coal markets, logistics suppliers [TBC]
Fuel Supplier [TBC]
Coal Supply Agreement
Sub-contractors, insurers etc. [TBC]
Drax
Site Services Agreement (incl. Inter-Connection O&M)
National Grid Carbon Limited
Pig-Trap Sub-Lease
Drax
Option Agreement (OPP Site Lease, Laydown Lease, Easements)
BOC
ASP O&M Sub-Contract (including ASP major maintenance)
O&M Supplier [TBC]
O&M Agreement
GE Services
OPP Major Maintenance Agreement
Supply-Side Works
Sub-contractors, technology licensors, insurers etc [TBC]
Linde Engineering (ASU)
GE
OPP EPC Agreement
Sub-contractors, insurers etc [TBC]
Drax
Inter-Connections EPC Agreement
Construction Project Management Contractor - [TBC]
Project Management Contractor Agreement
Transportation & Storage Services Agreement
CO2 Offtake Services
Transportation & Storage System EPCs Agreements
Sub-contractors, insurers etc. [TBC]
National Grid Carbon Limited
Principal Consents (Transportation & Storage System)
DECC SoS
The Crown Estate
DCO
Storage Licence
Storage Permit
Agreement for Lease, Lease (Offshore)
Storage Services Agreement
CO2 Storage
Carbon Sentinel Limited
Including a Storage Operating Agreement
Sub-contractors, insurers etc. [TBC]
Power Offtake Services
Power Purchase Agreement
Power Offtaker [TBC]
GB Wholesale Power Market
Grid Connection Agreement, TNUoS Agreement
NGET (as TSO)
GB 400 kV Transmission System
Emissions Trading Services
EU Emissions Allowance Agreement
EUA Offtaker [TBC]
EU Emissions Trading System
Project Management Services
Project Management Services Agreement
Project Management Services [TBC]
Early Works Agreement, Enabling Works Agreement
Pre-NTP Works
Early & Enabling Works Contractor(s) [TBC]
Sub-contractors [TBC]

# Next steps in CCS: Policy Scoping Document



# New Approaches - Risk




- UK Competition shows that private sector will not deliver commercially integrated CCS thorough anchor investments
- Multi-user CCS infrastructure creates multiple commercial interdependencies
- Off-shore storage of $CO_2$ is a high risk low-reward business
- CCS infrastructure development is vulnerable to failures in development of a user market
- $CO_2$ capture projects are vulnerable to non-availability of the CCS infrastructure

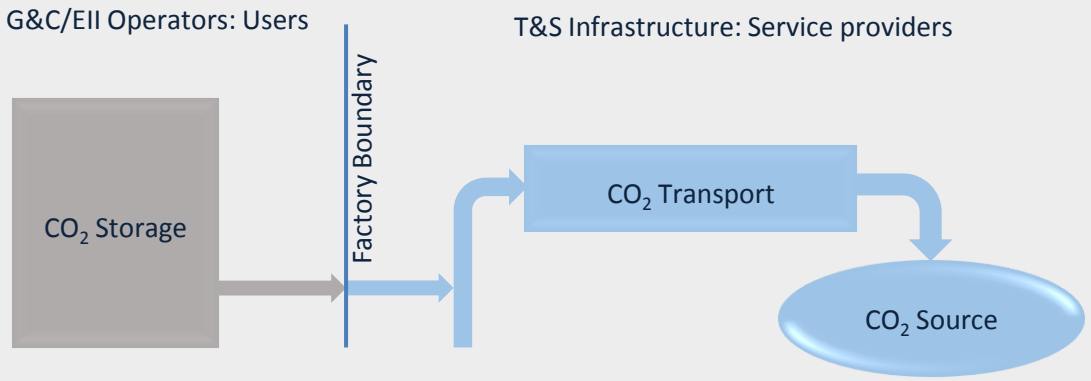
New Commercial models are required with an attractive risk reward profile

# CCS Specific Key Risks

- The CCS specific Key Risks contribute significantly to the cost of CCS:
  i. Cross chain default (project on project risk)
  ii. Post decommissioning $CO_2$ storage risk
  iii. Sub-surface $CO_2$ storage performance risk
  iv. Decommissioning cost sufficiency and financial securities relating to $CO_2$ storage permits
  v. Insurance market limitations for $CO_2$ transport and storage operations
- Cross chain default risk will not be taken by the private sector
- There is no appetite for long-term term storage risk
- Risk iii to v could be transferred back to the private sector with time and as confidence increases

For success, new commercials need to be based on a transfer of CCS Specific Key Risks to the Public Sector. This will also drive down the cost of CCS

# New Approaches – Commercial Models




- Industry likely to develop with discrete users and $CO_2$ T&S providers
- Commercial models need to reflect this part chain model
- Need to provide a template for future additions to the network

- Government backed T&S infrastructure required (too big to fail)
  - Public ownership of the full chain (NT&SCo Lord Oxburgh report)
  - Public ownership of part chain: Transport Co and Storage Co (or just Storage Co?)
  - Regulated Asset Based approach for Transport and Storage (or just Transport?)
  - Private sector investment with de-risking government support package to address key CCS specific risks

All providing project on project risk protection for the G&C/EII operator e.g. through:

- Continued payment of CfD
- Capacity market
- Other compensation

# New Approaches – Economies of scale

- Economies of scale can be achieved now.
- Ideal anchor project in the UK:
  - GT-CC c.a. 1GW net clean output with post combustion capture technology (Amines based)
  - 10-15 million MTA $CO_2$ Transport and Storage capacity
  - Coastal location industrial cluster Scotland and/or England (Firth of Forth, Teesside, Humberside)
  - Storage Endurance or Captain/Goldeneye
- Advantages:
  - Minimise scale-up of capture technology in terms of $tCO_2$/MWh
  - Reduce unit cost of CCS per MWh
  - Reduced $CO_2$ intensity (vs. coal) reduces T&S capacity usage per MWh
  - Establishes basis for future project including EII.
  - Shorter pipelines easier consenting (especially landowner issues, easements)

# Funding of CCS

- Revenue certainty provided by CfD fundamental to the viability of CCS on power
  - Critically importance that allocation of funding for CCS through the LCF is secure
- Development of CCS can take several years and is expensive
  - Early commitments required that a fully funded CfD at the right price will be available when developers take their FID.
  - It is likely significant public funding/compensation will be required to stimulate CCS project development
- CfD adaptation
  - Longer contract period (20 years for power) important to reduce costs of CCS
  - Mechanisms to reward flexible operation of power generation with CCS
  - Combination with BECCS
  - Equivalent mechanism for EII

CfD availability for CCS backed by LCF funding commitments are essential

# Funding of CCS Cont'd

- The strike price is affected by the way the CCS T&S infrastructure is funded
  - Anchor projects carry cost of CCS infrastructure inflating the strike price and reduces chance of realisation
  - Follow-on projects on a specific T&S network benefit, however future price reductions have so far proven unpersuasive
- Alternative approaches could help e.g.
  - Spread cost of CCS infrastructure over fossil fuel generators that continue to emit and not the generator installing CCS and producing clean power
  - CCS infrastructure could be funded by:
    - CCS Obligation Certificate scheme analogous the Renewables Obligation Certificate (ROC) scheme
    - Carbon Tax
    - Others

Applying polluter pays principle to CCS infrastructure would reduce strike prices

# Other Financial Support

- Grant funding
  - Positive in that it shows government commitment
  - To be effective it should be focussed on those risks that the private sector is not willing to take, e.g. project development, storage
- Loan Guarantees
  - Availability of loan guarantees e.g. through UK Guarantee Scheme reduce cost of finance
  - Increasing project ratings combined with longer term CfD could open the market to institutional investors and/or debt capital markets further reducing costs of capital.
  - Protections against CCS Specific Risks still required

Grant funding and Loan Guarantees can further reduce costs of CCS

# Conclusions

- To date, efforts around the world to develop a commercially viable CCS industry have largely failed. Different outcomes will require different approaches
- The private sector is very unlikely to deliver fully integrated CCS infrastructure and projects. CCS is considered a high risk, low reward business.
- CCS can support carbon reduction efforts across all major carbon emitting sectors and represents the low-cost route to decarbonisation
- A vibrant CCS industry will bring significant GVA and jobs to the economy
- Each year of delay increases the future costs of decarbonisation of the UK economy and carbon budgets cannot be met without it
- Private sector confidence in delivery is low. Clear and stable energy policy with a comprehensive and credible CCS delivery roadmap will be required

# Conclusions

- By optimising structure, scale, location, technology choices and introducing new commercial models the cost of CCS can be reduced significantly.
- The public sector will need to accept more development and operational risks especially around commercial full chain integration and storage
- Strike prices that are competitive with alternative forms of low-carbon generation should be achievable including for the first mover anchor projects
- In the UK, the creation of a government backed national $CO_2$ T&S company is necessary for the successful development of the CCS industry.
- The CfD is a key mechanism for financial viability of CCS for power generation and should be kept. Certainty around LCF availability for CCS is critical.
- A comparable mechanism to the CfD will need to be devised for EII.

# Conclusions

- CCS technology is ready for large scale deployment.
- Large scale power generation anchor projects (c.a. 1GW) connected to multi-user T&S CCS infrastructure should be envisaged from the outset.
- Alternative funding mechanisms aligned with the “polluter pays” principle could spread costs of CCS infrastructure across major emitters and reduce strike prices.
- UKGS financial guarantees should also be considered to increasing project credit ratings and reduce costs.

If the lessons of previous CCS development programmes are learnt and the remaining challenges to full commercialisation resolved though new commercial approaches, CCS will be able to play a key role in supporting the cost effective decarbonisation of energy use across the economy starting in the early 2020s.