

A joint report by the Energy Technologies
Institute and the Ecofin Research Foundation

Carbon Capture and Storage

Mobilising private sector finance for CCS in the UK



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Energy Technologies Institute

The Energy Technologies Institute is a partnership between global energy and engineering companies and the UK Government bringing together projects and partnerships accelerating the development of affordable, clean and secure technologies to help the UK meet its legally binding 2050 climate change targets.

Ecofin Research Foundation

The Ecofin Research Foundation is a charity founded by Ecofin Limited, a London based investment management firm. The Foundation uses its knowledge of the global utility and finance sectors and its network of contacts to find practical solutions to help the move to a low carbon economy.

ETI and ERF worked together on this project to examine the conditions for mobilising private sector financing of carbon capture and storage.

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“Successfully deploying carbon capture and storage would be a huge economic prize for the UK”

Executive Summary

Successfully deploying carbon capture and storage would be a huge economic prize for the UK in its low carbon transition, cutting the annual cost of meeting our carbon targets by up to 1% of GDP by 2050.

Financial market conditions are very challenging and if private sector capital is to be mobilised, major challenges will have to be overcome.

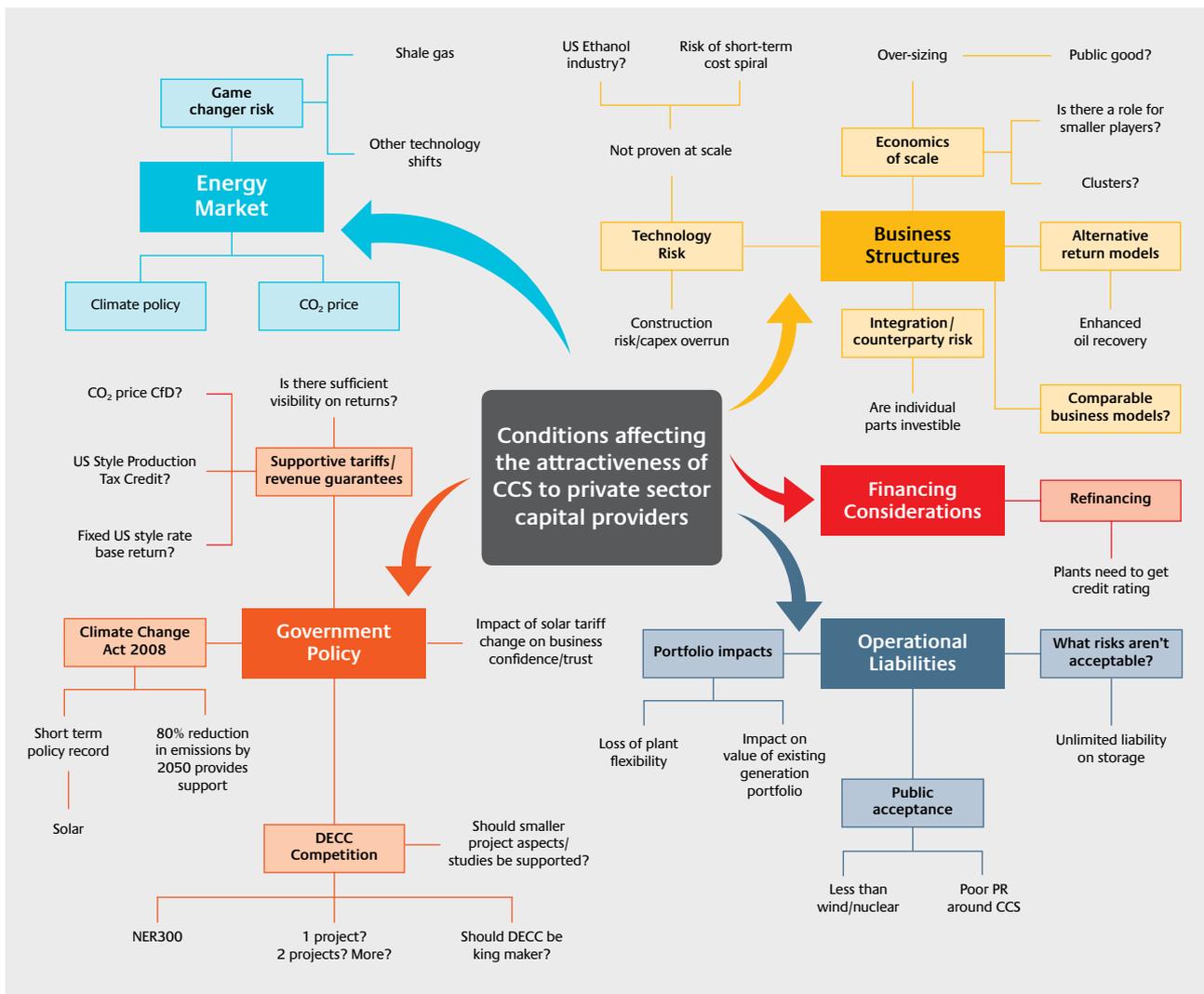
There is a risk that no projects will be investable to follow on the first project(s) which gain public sector capital support, preventing CCS from fulfilling its potential key role.

Further Work

Making early CCS projects investable is a key priority in enabling CCS to

develop and fulfil its potential in the UK’s transition to a low carbon economy. We plan further work which will involve detailed analysis of the challenges and how the solutions can be delivered. This will involve continued focused engagement with capital providers, project developers and other stakeholders.

Overview



Investability challenges

- The scale, policy risk and long term nature of financing needs for CCS projects are uniquely challenging.
- CCS will have to compete in challenging market conditions to gain access to finance
- Bank finance is tight due to markets and tougher regulatory requirements
- Major energy or utility companies have strategic interest in CCS, but have constrained balance sheet capacity and appetite for exposure to early CCS projects



Potential solutions

- Develop a compelling vision of how CCS can progressively solve for risks and access lower cost sources of finance
- Ways to reduce, manage and share risks are needed for the key early projects
- Consider a role for the Green Investment Bank in facilitating access to capital
- Create absolute visibility of returns based on clear revenue support over sufficient time periods

Confidence in long term policy

- CCS is policy dependent, so investors are highly sensitive to mixed signals around policy commitment, either to CCS itself or to broader carbon emission targets



Potential solutions

- Build on promising early steps (e.g. the commercialisation programme) to create a clear sense of direction for CCS
- Explore public-private partnerships and co-ordination mechanisms

Energy marketplace challenges

- Emerging reforms and market changes create significant uncertainty for investors, and EMR reward structures remain to be fully clarified



Potential solutions

- Attractive pricing for contracts for CCS projects with appropriate risk sharing
- Create rewards for broader CCS applications beyond the power sector

Business structures

- CCS projects involve a complex new value chain with novel business structures and counterparty arrangements



Potential solutions

- Actively explore the future regulatory and market framework, and industry collaboration on collective business structure challenges

Operational and technology risks

- There is appetite in the private sector to bear technology and integration risks
- Storage is a key area of risk, with major concerns about the uncapped nature of storage liabilities



Potential solutions

- Consider new ways to address concerns around storage liability risks, including a potential public sector role in derisking North Sea storage

1.0 Introduction

This report presents the findings of a joint project by the Energy Technologies Institute and the Ecofin Research Foundation to examine the conditions for mobilising private sector financing of carbon capture and storage in the UK. It is based on structured interviews with capital providers, project developers and other key stakeholders.

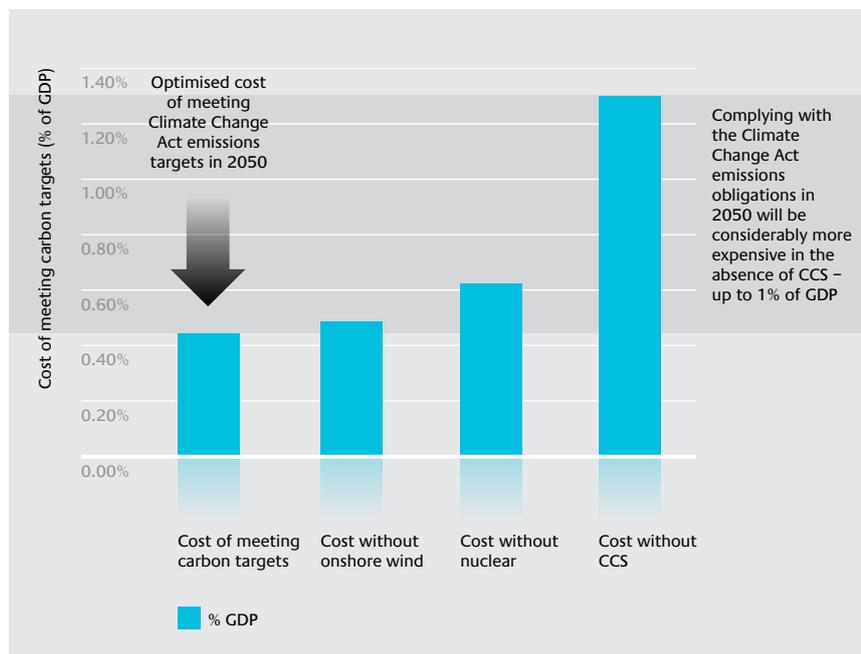
The UK has adopted ambitious targets to reduce greenhouse gas emissions by 80% by 2050. Achieving these targets will be hugely challenging in engineering and economic terms. Many future energy system scenarios envisage a key role for Carbon Capture and Storage (CCS) in enabling the UK to deliver its emissions targets at an affordable cost. CCS is the process of capturing and securely storing carbon dioxide instead of emitting it into the atmosphere.

CCS The key to affordable low carbon energy

Over the past 4 years ETI has developed a world class modelling tool for the UK energy system, the 'Energy System Modelling Environment' ('ESME'). ESME enables us to understand the best combinations of technologies to deliver affordable, secure and low carbon energy in the power, heat and transport sectors of the future. ESME has been used extensively by both DECC and the Committee on Climate Change, to support the UK Carbon Plan and government strategies on heat and bioenergy.

ETI's analysis shows that CCS has a crucial role to play in enabling the UK to meet its carbon targets affordably. If we make the right choices the extra cost of meeting carbon targets could be as little as 0.6% of GDP (about the same as we currently spend on child benefit). However if we fail to develop CCS that cost could more than double - adding extra costs for industries and consumers in the future (Figure 1).

**Figure 1. UK energy system:
Annual cost of meeting carbon targets in 2050**
An expensive life in the absence of CCS



CCS is valuable because it is flexible within the energy system:

- it can decarbonise both fossil fuel based power generation and other high emission industrial processes,
- it can be combined with gasification processes to produce flexible low carbon fuels (hydrogen, syngas)
- When applied to power generation, it does not have the inherent variability problems associated with other low carbon generation (eg solar, wind etc)
- it can actually remove carbon from the atmosphere, when it is applied with bioenergy sources.

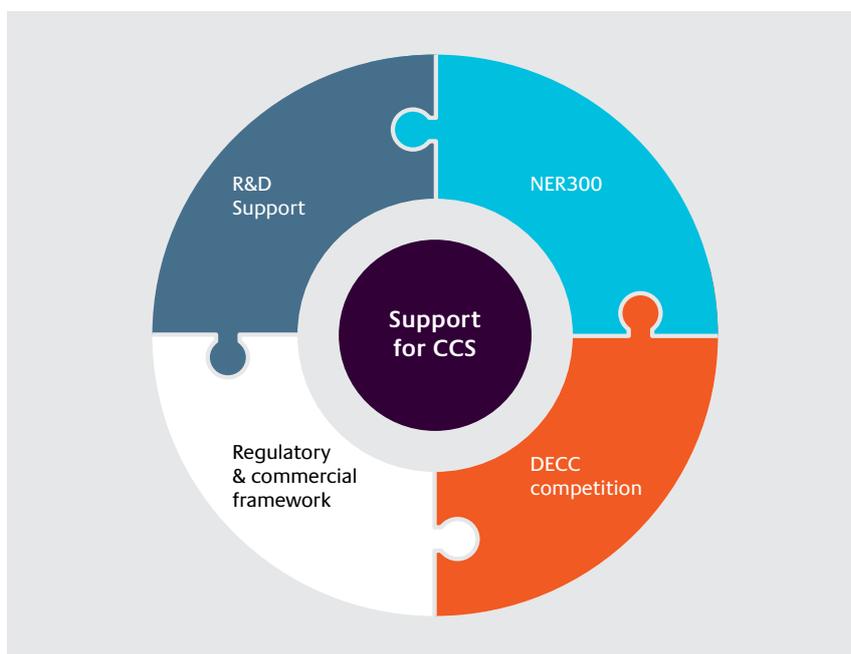
Successful deployment of CCS is a huge economic prize for a future low carbon UK economy.

Kick starting CCS in the UK

In April 2012 the government launched a CCS commercialisation programme offering £1bn of capital funding and premium price contracts for low carbon electricity generation to support the development of early CCS projects. Financial support is also available at an EU level to potential CCS developers through the New Entrant Reserve (NER300) programme. This EU funding may be used in conjunction with the UK CCS commercialisation programme funding.

Figure 2. Government support

Four elements supporting the CCS work programme



1.0 Introduction

While the UK CCS competition and the NER300 funding will provide necessary capital to support the development of initial CCS projects, private sector capital will be vital for the development of a CCS industry in the longer term.

CCS projects require large-scale investment and while many of the component technologies are relatively well-developed, the combination of them for the express purpose of low carbon power generation is unproven at scale. The returns needed to attract capital providers to make the billions of pounds of investment required in CCS will depend to a large degree on public policy decisions over extended timeframes.

Path to an established CCS industry

Moving CCS from a nascent technology to one that is commercially viable for private sector development and widely adopted will require reducing the overall costs, including the cost of capital sufficiently to make CCS commercially competitive with traditional generating technologies.

Now is the time to begin to address the challenges of mobilising private sector finance for CCS. The outcome

from DECC's commercialisation programme is expected autumn 2012 and this will create momentum behind one or a small number of projects. The challenge will then quickly turn to how to maintain momentum among the other projects which did not secure DECC funding, but which remain the potential follow on projects.

The follow on projects are those we need to progress in order to build a CCS sector capable of ramping up and making a large scale contribution through the 2020s. This will not be an easy challenge, and there is a real risk of a hiatus extending into the 2020s. The first follow on CCS projects will need to progress, potentially to final investment decision before many learnings have emerged from the projects supported by DECC's commercialisation programme. There is a real risk that nothing happens and there are no follow on projects until the agreements on the first projects are executed. It will be particularly important that details of the revenue structures eg. contracts for difference (CfD) are agreed. In addition follow on projects will have to compete with biomass conversions of existing coal which could be significantly cheaper on a cost per MW basis over the medium term. Follow on projects

need to be investable without the benefit of public funding and this will require significant progress on a range of strategic issues.

The cost of financing CCS is likely to be very high during the competition phase and is only likely to fall over time as technology, systems and industry integration are demonstrated. As perceived risk associated with CCS declines, the providers of finance, cost of capital and financing terms are also likely to evolve. Competition stage projects may require significant government support, concessional financing and committed equity. Later stage and early projects with an operating track record may begin progressively to attract lower cost project finance. Once the industry is mature, all else being equal, CCS should be able to attract long term debt on comparable terms to other power and infrastructure projects.

Figure 3 provides a stylised illustration of how the cost of capital and sources of finance might evolve as risks are addressed.

This project – understanding the requirement for mobilising private sector finance

The Energy Technologies Institute and the Ecofin Research Foundation have undertaken this project jointly to assess the conditions for private sector financing of CCS in the UK. We canvassed the views of key stakeholders through in depth interviews between March and August 2012. During this engagement we spoke to a range of potential private sector capital providers, project developers and other stakeholders including the European Investment Bank and the Department

of Energy & Climate Change (DECC). (see Acknowledgements for a list of interviewees).

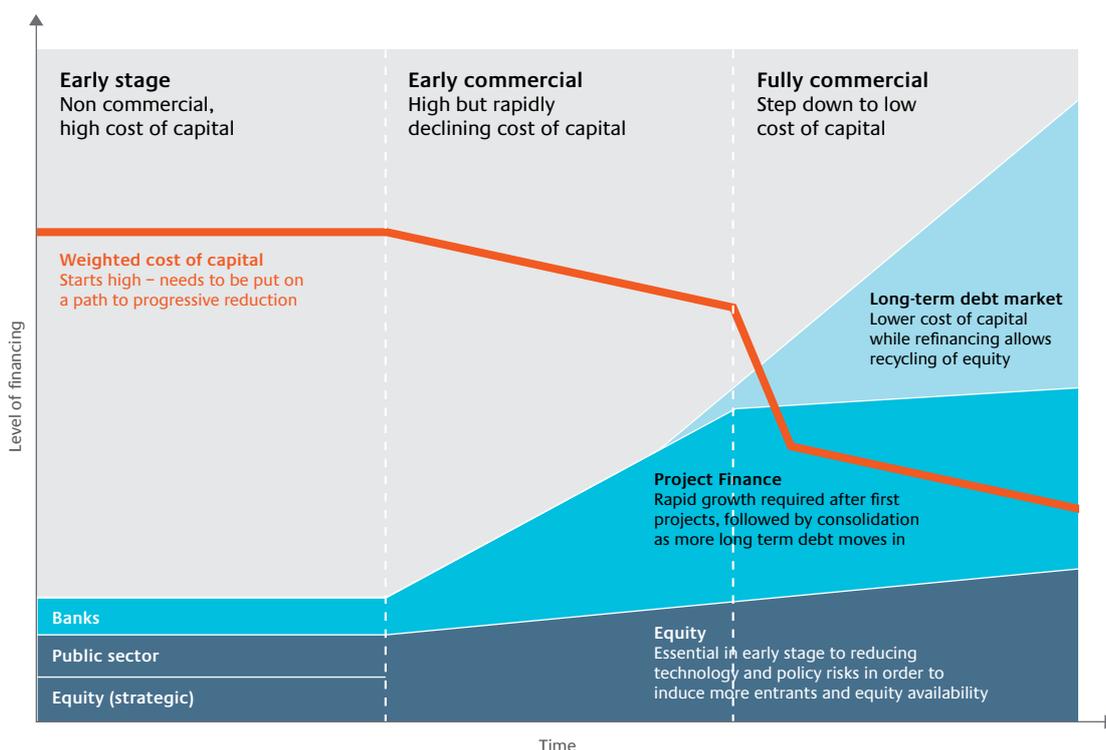
Our engagement centred on five key themes:

- Investment challenges – the critical financing considerations for project developers and capital providers
- Confidence in long term policy – the policy environment required for CCS
- Energy marketplace challenges – the impact the UK's energy market has on potential CCS projects

- Business structures – the challenges of potential business structures for CCS projects
- Operational and technology risks – the CCS-specific risks and challenges.

In this note we set out the challenges identified by the interviewees and propose some potential solutions.

Figure 3. Financing CCS
The path to a low cost industry



2.0 Challenges and potential solutions

2.1 Investment challenges

In this section we set out findings from our project engagement and we provide suggestions as to the direction in which potential solutions to these challenges may be found.

We recognise that there are a range of constraints on policy makers and further work on the details of suggested solutions will inevitably be needed.

The key message from our engagement is that there are major challenges to overcome in making CCS an investible proposition for a broad base of capital providers. Solutions for these challenges need to be sensitive to the needs of different types of investors.

Sources of finance

There is a range of potential sources of finance for large CCS projects. Our discussions focused on the sources of finance that interviewees identified as ‘most likely’ to be relevant in moving CCS to commercial deployment. These were:

- Public expenditure – to support pre-commercial projects at scale to de-risk subsequent debt and equity investments.
- Equity – provided by the companies involved in the project, institutional investors such as pension funds, or third parties such as venture capitalists. At pre- or early-commercial stage, the motivation for equity investors are likely to be strategic, rather than project returns.
- Project finance/bank debt – project specific loans from banks, often for a duration of between 5 and 12 years, are typically used to finance many energy generation projects. This may increase to 20 years when (if) the market improves but this would depend on and be limited by the length of the CfD. Project finance supports a specifically created project entity, without recourse to the sponsors’ corporate balance sheets.

The financing of projects can evolve as the risks associated with a project change. At the outset projects may be financed by equity and relatively high cost forms of debt. After the development phase equity holders may look to recycle their capital, while the projects may become attractive to debt investors. By refinancing in this way equity investors are able to crystallise the value of the risk premium embedded in their development equity.

Our discussions on financial challenges naturally reflected the particular institutional perspectives of interviewees. Capital providers raised the challenges arising from broader financial market developments, while potential project developers and sponsors were more mindful of issues around internal allocation of corporate capital budgets.

Challenges for Equity

At this early stage of the development of the CCS industry equity must play a significant role in taking development risk. The range of projects developed for DECC’s commercialisation programme demonstrates a variety of business models, each with different operating structures and with varying combinations of corporates with strategic interests in CCS and also a number of new entrants.

A number of key points emerged from our discussions. At this stage the motivation for investing in CCS appears to be largely strategic, rather than being based on expected returns from the project. The scale of investment required, and therefore the risks, in CCS projects are large and very difficult for the private sector to absorb. This, together with

lack of clarity about the long term future of CCS, limits appetite for equity or on balance sheet financing of the large projects required.

A number of energy companies with large balance sheets (utilities or oil and gas companies) have broad strategic interest in the success of CCS. However our discussions revealed doubts that CCS projects would be sufficiently attractive in the foreseeable future to justify commitment of corporate capital at scale. Significant public support is seen as vital to the success of CCS in the absence of a clear advantage for early movement into CCS deployment. There is some room to support CCS through balance sheets, but this is limited by other demands on corporate balance sheets, the large scale of investment required and the desire to constrain CCS exposure to a small proportion of the corporate asset base.

Financial markets

Potential capital providers emphasised that CCS will have to work hard to attract debt finance, and that the role of debt would remain limited until significant further work had been done to derisk the value chain and the wider environment.

The general financing outlook for large scale capital projects has tightened considerably in the past few years, due to tough European and global economic conditions and regulatory changes. Basel III banking regulations have made it difficult for lenders to commit to long term finance beyond ten years. Anecdotal evidence suggested that the number of banks providing capital for large scale infrastructure projects has fallen from around 50 to as few as

10. This poses a problem as large scale investment required for CCS projects would probably require involvement from a number of parties through bank syndication.

Given tight market conditions, and the unproven nature of CCS, only a handful of the major banks are currently showing meaningful interest in financing CCS in the UK.

Decision making within financial institutions

Finance providers emphasised that CCS projects will need to compete for scarce capital. This competition is mediated through approvals initially by a bank's internal management committee before the transactions are considered by the internal credit committee which will consider funding on a project by project basis, focusing on the essential risk and return characteristics of investments. They will seek broad comfort around the quality of projects, developers and technologies, to inform a rounded view on risks. Financial institutions will be more inclined to invest staff time and effort in preparing and negotiating CCS projects if they can see a potential 'pipeline' of future projects. If doubts around the role of CCS remain unresolved less effort is likely to be given to preparing bankable projects and doing the detailed work necessary to address risks. In turn credit committees will remain less exposed to CCS and continue being cautious about approving projects in unproven areas. There is an on-going debate in banks regarding the opportunity cost of investing in particular projects. The debate centres on whether capital is better deployed on other sectors rather than a sector going through

a steep learning curve. This means that CCS faces a two level debate – even if the risk of CCS in general are acceptable, banks may still decide not to bank CCS initially in favour of more proven technologies.

CCS in its current form and with current issues still to be addressed presents a number of key challenges for credit committees:

- CCS requires very large scale investment. For banks looking to fund energy projects, renewable investments such as wind present a far more 'digestible' project given the track record of structuring and finance.
- In a competitive energy market CCS profitability will rely on public policy support – without this CCS cannot compete with conventional generating capacity.
- Capital providers are generally not familiar with CCS technology which still remains unproven at scale
- The underlying economics of the power generation asset to which CCS is fitted presents capital providers with a challenge. For example, load factors for gas plants move very rapidly from 60-80% to 20-30% in some cases without the corresponding increase in peak premiums when they are operating. Recovery of capex in a CfD world will require the plant to run so the question is – will the CfD also cover the market "subsidy" required to be a "must run" or be very high to compensate over a lower load factor?

These issues point to areas of focus for actions in the near term to create the conditions for private sector investment in CCS deployment.

2.1 Investment challenges



Potential solutions

Investment challenges

The scale and long term nature of the investment needed to develop CCS, along with the unproven nature of the industry, poses particular challenges. Addressing these challenges inevitably demands a long-term strategic vision for the sector’s financing.

Developing a financial vision for CCS

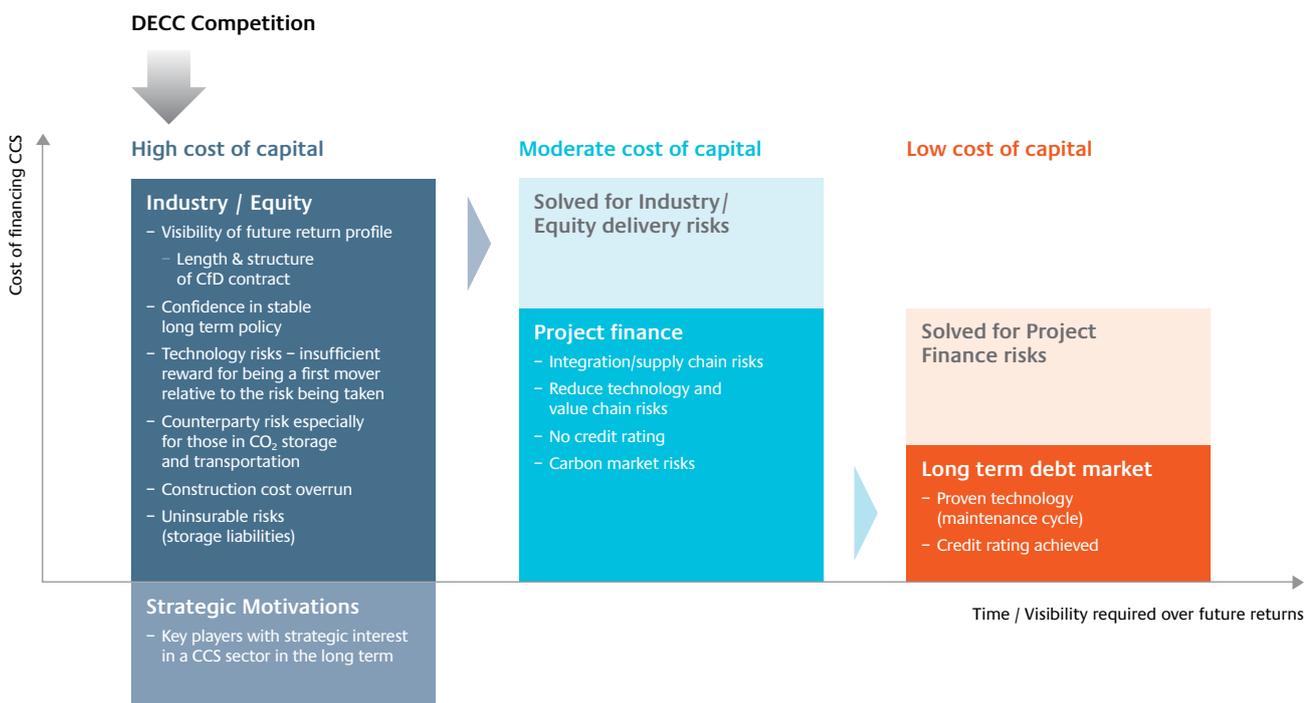
Figure 4 illustrates the potential approach to thinking about the evolution of financing for CCS over time and shows a “waterfall” where funding for the sector (or for an individual project) cascades from one investor group to another over time, as the industry or projects are derisked.

This evolution to a low cost of capital industry through refinancing and opening up new sources of financing will only happen as the sector or individual projects are genuinely derisked. For each refinancing step in the process projects will need to

meet the criteria for investment. Early stage equity funding is unlikely to want to take on upfront risk unless it is confident that it will be able to exit the investment through a refinancing event in a reasonable timeframe (i.e. will it be able to sell the project on to another financier once risks have been reduced). This suggests that long term CCS policy will need to be in place in order to attract even short term risk capital.

DECC’s commercialisation programme provides the vehicle for public sector funding of early stage projects. However delivering the evolution to a low cost of capital industry will require continued focus on a range of challenges, including the following:

Figure 4. A financial vision for CCS



– **Early follow on projects**

DECC funding through the commercialisation programme will help to launch the first one or two projects. Maintaining momentum in developing and derisking CCS will require follow on projects financed entirely or mainly with private sector capital and supported by CfDs. The financing challenges for these early follow on projects will be particularly acute, as they will need to commit investment when risk reduction from the first one or two projects will probably be limited. There is a need for innovative thinking about how to reduce, manage and share risks for these key follow on projects.

– **Sharing risks**

Policy can play an important role in reducing and sharing risk, particularly in the early stages of CCS development. Public sector participation in bearing risks, for example, through appropriately structured guarantee arrangements (the UK guarantee scheme or GIB could be potential vehicles) is an option. A collaborative approach could allocate risk to private sector investors where they are best placed to bear it, and remove or share risks which the public sector clearly has a role in shaping and bearing.

– **Sourcing capital**

The scale of capital required is a key challenge. Banks often form syndicates or clubs to assemble large-scale financing while still limiting their exposure against individual investment projects.

Could the public sector be involved in facilitating this for CCS? A role for the Green Investment Bank as a lead bank or a facilitator of syndicated or club financing of CCS projects is worth considering. Also, depending on where the equipment for the project is coming from the Export Credit Agencies could play a significant role in mobilising finance.

– **Engaging with financiers**

We suggest that policy makers engage in more depth with financiers (as do regulators such as Ofgem or Ofwat) to understand the particularities of the funding environment, the risks financiers are willing and able to take, what policy makers can do to incentivise private sector investment, and the scope for creating new investment or ownership vehicles. This is very important and could also extend to public sector involvement in engaging with potential financiers in Export Credit Agencies, sovereign wealth funds and the European Investment Bank.

Improving the visibility of future returns for investors

Regardless of the source of finance, visibility over future revenues (and, in particular, future returns) is critical to a project being investible. Private sector investors do not expect or want to be insulated from all risk, but investors are particularly wary of risks that are, in themselves, artefacts of policy. Policy design is central to the reliability of the revenue streams that CCS investments will deliver (through the design of policy support measures, such as CfD's).

Both project developers and financiers indicated that it is less about the type of revenue support offered to CCS by the government and more about the long-term credibility, viability and visibility of the proposed revenue support that will determine the investibility of CCS. Attracting risk capital in the near term requires providing investors with confidence that they will be able to refinance once project development risks have been dealt with, and this requires clarity over the long term return profile of the industry. A wider issue is that capital providers need clarity over the reforms in the energy market before they invest in the power sector let alone CCS.

– **Clear revenue support**

In principle investors felt that a CfD approach could work for CCS. But much will depend on the details of the contract proposed. Until there is clarity on the detail of the CfD offered financiers will not be able to consider investing in projects.

– **Length of support**

Policy support measures for returns to CCS projects, such as CFDs; need to be designed with investors' needs in mind. Investors need confidence that policy support will be in place for the time periods required to ensure they can recoup capital and secure reasonable returns. Reliable, longer term revenue support measures will support the market for project refinancing, and help attract upfront risk bearing capital.

2.2 Confidence in long term policy

A strong theme emerging from many of the interviews was doubt around the long term policy framework required to attract private sector capital. Within this broad theme we identified a number of strands:

Need for confidence in policy to support a long term future

Capturing and storing carbon has no intrinsic value unless use of carbon through enhanced oil recovery (EOR) is added into the equation. This is currently driving the US projects and 2-3 revenue streams in the UK could give capital providers more confidence and mitigate policy risk. Without EOR the route to realising returns for CCS investments is currently entirely dependent on policy support. Large scale CCS projects will need long term confidence in the policy regime that underpins returns to investors. Capital providers and project developers need tangible commitment to CCS becoming a new industry. Most felt that, while the government has created a CCS Roadmap, more tangible commitment and a coherent set of measures is needed to unlock private sector finance.

Doubts around broader policy stability

Many felt that there was not enough evidence around the stability of policy, indeed in some cases the reverse. A number of examples of broader policy instability were cited, including sudden change to policy on solar Feed-in-tariffs, subtle changes in words used by ministers around the commitment to decarbonising the power sector ('in the 2030s' instead of 'by 2030'), concerns around the affordability of

climate change and energy policy and differing emphases in statements by different parts of government.

The right choice of policy instruments?

A number of the interviewees questioned whether the government's decision to allocate early support for CCS through a competitive process was the right approach. Some felt a more collaborative approach to sharing risks and costs, with government taking a strategic shaping role would deliver more progress. Electricity market reforms were felt to be complex and it is not clear how this is intended to support CCS. The need for clear carbon pricing and long term alignment with European level policies, in particular, the Emissions Trading Scheme were mentioned.

Clearer support for CCS competitors

Many investors and developers perceived support for CCS to be less clear and firm than for other sources of power, such as wind or gas. At the same time CCS is seen as vulnerable to competition from these technologies. Many perceived the government's announcement that it would grandfather the Energy Performance Standard (EPS) for gas power stations consented at the 450 g/kWh out to 2045, to be negative for CCS, undermining confidence in the industry, supply chain and amongst investors. Policy support for renewables through the renewables obligation was seen to have worked in practice and to be clearer in intent than support for CCS. **"Government not putting enough umph into supporting this (CCS)" – financier**

In conclusion, there is a lack of clarity in the legal and regulatory framework for both CCS and in the UK energy market in general, and this leads to unquantifiable risks. As there is no obligation to develop CCS and the risks of investing in CCS are perceived to be high and returns low, investors are inclined to wait until they are confident that CCS has a long term future. This is underpinned by the fact that investors have other investment opportunities in technologies in which they have more confidence. To create momentum it is vital that the government demonstrates a strong commitment to developing a CCS industry in the UK.



Potential solutions

Building confidence in long term policy

Mobilising private sector capital to develop CCS will require a stronger sense of confidence in long term policy. There are a range of dimensions within this general theme:

– The broader environment

Because CCS is so policy-dependent, investors are particularly sensitive to perceptions of the UK's and Europe's broader commitment to cutting emissions. Confidence among investors will grow if they perceive decisive action being taken by policy-makers to achieve the very demanding trajectory set within carbon budgets.

- **Creating a clear sense of direction for CCS**

The UK government is seeking to support CCS development in a number of ways, most notably through DECC's commercialisation programme and CCS roadmap. These are very positive steps, yet still investors remain hesitant. To some extent this seems to reflect the UK's preference for a market-led approach, and overall complexity of the low carbon policy environment. CCS is fundamentally policy-dependent so a balance must be struck between the power of market incentives and the need for a degree of certainty to attract private capital in the first place. Private sector capital is more likely to enter, bear risks and drive the development of CCS if the market perceives a clear sense of direction among policy-makers.

- There is scope to build on the very positive steps the government has taken to build a broader and stronger strategy for the development of CCS and improving the existing CCS roadmap. This could include engaging key stakeholders in both public and private sectors in building a strategy for CCS financing.
- There is an opportunity to explicitly shape the outcome of the CCS commercialisation to facilitate follow on projects and investments in developing a broader CCS sector. For example, the public sector support could be structured to support industry clusters and ease the way for subsequent investments. Some interviewees suggested that development of a transport and storage of CCS

as regulated businesses to serve hubs would be a clear statement of intent from the government and foster investor confidence.

- **Creating co-ordination mechanisms**

Capital providers want strong private-sector involvement in developing the CCS industry, but this is more likely if the public sector leads, shapes and facilitates to some degree at the outset. For example electricity markets provide an interesting comparator, shaped as they are by policy makers and supported by a range of institutions and co-ordination mechanisms. Arguably CCS could benefit from similar activism in creating and shaping the new markets and infrastructures required to support a vibrant CCS sector in future.

- A process of dialogue could usefully be convened, drawing in the key public and private sector stakeholders to develop public-private partnerships and co-ordination mechanisms to develop CCS over the next decade.

- **Supporting the development of CCS**

A successful CCS sector requires development of new skills, capabilities, infrastructure and markets mostly led by the private sector though there is still an important role for public support in key areas including:

- Considering the case for further strategic public investment in key areas such as the proving of strategic geological stores in

the North Sea, or in key enabling infrastructure – potentially through the medium of the Green Investment Bank.

- Continued funding of research and development on key enabling technology capabilities.

- **Strengthening signals**

Investors' confidence in policy could be improved through stronger signals around policy commitment to CCS development. Areas to consider include:

- Adopting an explicit target for the carbon intensity of electricity generation (as suggested, for example, by the Committee on Climate Change), or setting a timetable for future review of the Emissions Performance Standard for new gas projects (without undermining the Government's commitment to grandfather out to 2045 a 450 g / KWh standard for projects consented at that level).
- Strengthening policy around 'capture-readiness' requirements, creating a clear expectation that this will be a real consideration in consenting new unabated fossil fuel projects.

2.3 Energy marketplace challenges

The UK energy market is currently undergoing major changes. Our project engagement reveals that investors are uncertain about how market conditions will affect early CCS projects and the future development of the industry.

Major changes in electricity markets create additional uncertainty

A quarter of the UK's older generation capacity will close over the next 10 years and more than £110bn of investment will be needed to replace it and upgrade the grid to meet the UK's electricity needs. At the same time DECC is introducing electricity market reforms (EMR) to stimulate investment in low carbon power generation. These are major changes, which create significant uncertainty about future markets and the competitive environment for potential CCS projects.

Other risks include market penalty risk

Some technology is not flexible (integrated gasification combined cycle for example) and must run even if the generator is making a loss on the power sold – how is this compensated in a market where flexibility is more essential/valued? Also, as mentioned previously, load factor may have a material impact on CfD recovery and is likely to change materially over the life of the investment. This is yet another market, separate from CCS which needs to be priced in.

Concerns over rewards structures

Energy markets will increasingly be shaped by policy action and are likely to undergo significant change over the lifetime of any CCS

investments. Interviewees raised concerns as to how new rewards structures might work with a potentially changing energy mix. At present it is uncertain if any CCS projects without public sector grant support will be investable and in a position to follow on from those first project(s) supported under the DECC commercialisation programme.

Finding ways to address key market uncertainties could significantly improve the environment for private sector investment in these crucial follow on CCS projects. While the EMR is currently the key process affecting the energy marketplace environment for potential early CCS projects, over time broader policy and market considerations will become important for the future development of CCS.



Potential solutions

Addressing key market uncertainties

The key directions for improving the energy market environment include:

– Attractive pricing

Strike prices for CCS projects will need to be sufficient to remunerate investors for the risks they are expected to bear. At the same time, appropriate structuring of contracts could reduce risks and, therefore, the required strike prices and the cost to consumers.

– Appropriate risk sharing in contracts for difference

The structure of risk sharing in contracts for difference need to be considered carefully. In particular, it makes sense to evaluate risks and identify those which are policy related, and therefore difficult for

the private sector to manage. For CCS this could include risks arising from policy support for competing forms of power generation such as wind. Experience in economic regulation and private finance initiative (PFI) arrangements has generated a range of tools for structuring and sharing risks which could be adapted for the specific challenges for early CCS projects.

– Creating confidence through delivery plans

There is scope to shape expectations about CCS by developing clear 'delivery plans' for EMR, including clarity on how support for low carbon generation will be allocated. This would help to give more confidence to potential follow on projects that there will be a market for CCS.

– Creating rewards for broader CCS applications in future

CCS offers potential to support decarbonisation through applications which extend beyond the power sector (e.g. in enhanced oil recovery, in cutting industrial emissions and to deliver 'negative emissions' through bioenergy applications). There is scope to support and shape markets for these applications by exploring how to create new reward mechanisms for the value that these approaches deliver to UK decarbonisation.

The broad shape of EMR and details of how CCS and other generation will be supported will inevitably impact the attractiveness of CCS as a potential investment. So improving clarity around this is a key priority in creating a coherent strategy for financing CCS.

2.4 Business structure challenges

In our interviews the issue of business structures attracted considerable attention. Many felt that this was an area of significant complexity, where new approaches would need to be developed. Most felt that the private sector will have to resolve most of the challenges, but that business structures will be shaped in part by the emerging market and regulatory framework for CCS.

Possible business structures for CCS

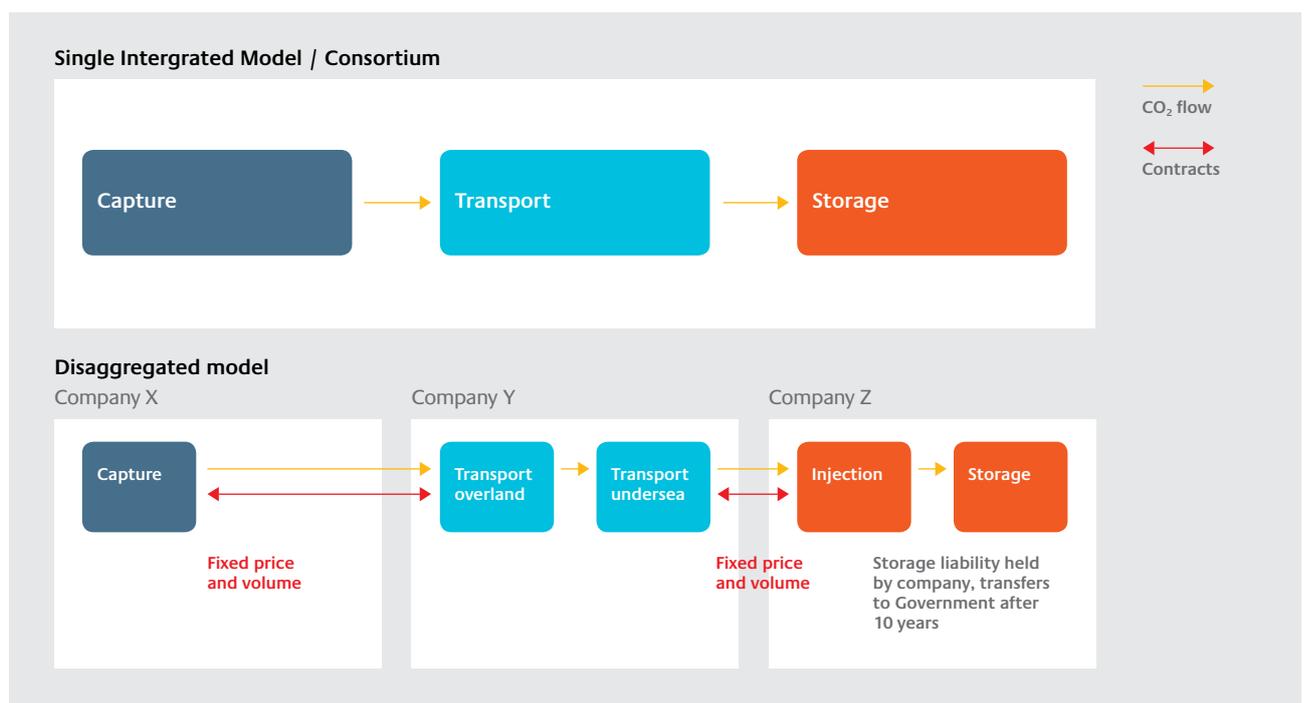
CCS projects can be structured in a number of ways, and this affects the perception of its risks amongst potential capital providers. Business structures range from fully

integrated projects with one party internalising the entire value chain, to a fully disaggregated industry where each part of the value chain is operated by a different party. It is also conceivable that there a single national supplier for infrastructure such as a pipeline or storage operator may be the most efficient approach to managing risk and developing the industry in a cost effective way in the medium term. Additionally the underlying economies of scale for some functions suggest that clusters are likely to become important.

Capital providers indicated that they would need to be confident about the contracts between the counterparties before investing in part of the value chain. A project where the entire

value chain was carried out by the same organisation was seen as a more 'bankable' model by potential financiers subject to the organization having the financial capacity to manage the risks over the long term. Of course this severely limits the universe of organisations that can develop CCS to the point where it would probably not happen in the UK without government taking more of the risk. Also, it may not be the most economically efficient model.

Figure 5. Potential Business Structures



“Clusters are not a ‘nice to have’ they are essential for a large scale industry.”

2.4 Continued – Business structure challenges

Multiple players and commercial complexity

Any business structure other than a fully integrated project will require multiple parties to work together. These parties often have very different risk/return expectations based on the industry to which they belong. For example an oil and gas company may not get the returns they need from transport and storage compared to other investment opportunities. Also, the risk of each component can be very different depending on which risks are passed on, for example take or pay versus ship or pay arrangements on the pipeline. This leads to complexity, not just in relation to risk allocation, that needs to be handled through commercial agreements. There are few clear models that can be adapted for CCS. For example a utility company with

a low risk appetite which operates the capture process may have very different return expectations from an oil and gas company which is operating the injection and storage processes. This raises questions about commercial contracting and business models for the different players within the CCS value chain.

Some interviewees suggested that the government could play a facilitator role in bringing the chain together, pointing to the example of the role played by key public sector players in the development of CCS in Rotterdam.

Counterparty risk

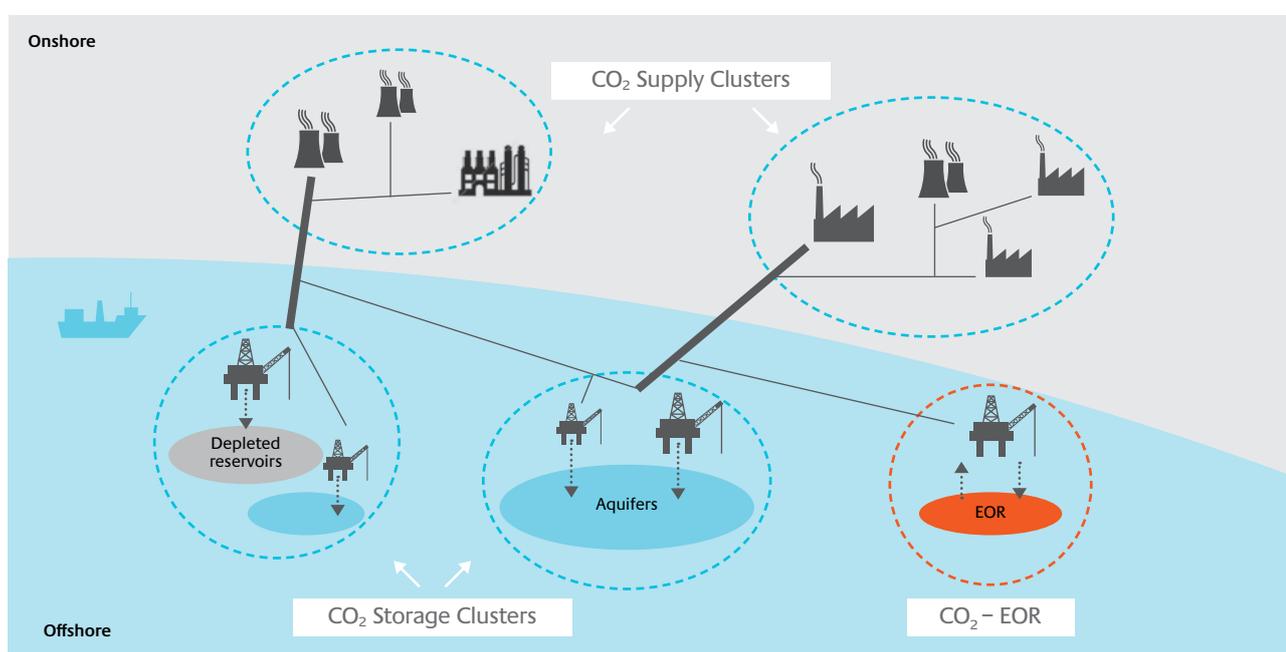
Even if a satisfactory working relationship, risk allocation and reward structure are agreed, the reliance on different parties gives rise to ‘counterparty risks’.

Potential capture plants, transport operators and storage operators are all mutually inter-dependent.

CCS clusters could help alleviate counterparty risk to some extent as it provides multiple sources of CO₂ and storage options to cope with possible disruption to CO₂ volumes. Many of those we interviewed felt that clusters make economic sense as the best approach to develop a CCS industry, including enabling access for neglected industrial CO₂ producers.

A related theme was the oversizing of transport infrastructure to accommodate future volumes of CO₂. The incremental upfront cost of ‘right sizing’ infrastructure for other potential CO₂ sources were not thought to be significant, and that it would be more cost effective in the long run if the infrastructure was right sized.

Figure 6. A potential vision for CCS clusters



Market framework for transport and storage

Some of our interviewees suggested that a more co-ordinated or regulated approach would make sense for the storage and transport elements as they are of national interest, and strategic clusters could be important. Interviewees recognised that it may be too late to establish a regulated model for initial projects, but suggested that it would be worth exploring this concept. A range of market or more co-ordinated models for offshore CCS infrastructure are possible. The regime for offshore wind transmission operators (OFTOs) is a possible comparator, enabling the development of dedicated infrastructure.



Potential solutions

Clarifying commercial models

In considering business structures for CCS, project developers and investors are currently confronted with a complex and uncertain environment, and a significant part of this relates to public policy uncertainty, in particular the framework for future infrastructure sharing and access. There is scope to improve the tractability of these challenges for the private sector.

As part of developing the strategy for CCS the following areas could be explored:

- Considering the regulatory and market framework for transport and storage functions – strategic issues around access, market power, networks and public goods look likely to arise more in the transport and storage parts of the value chain, than in capture where global competition may increasingly drive the development of technologies. There is a case for policy makers to actively explore the future regulatory and market framework for investments in CO₂ transport and storage.
- Industry stakeholders could build on collaborative work undertaken (for example, through the UK's CCS cost reduction taskforce, or by the CCS Association) to address collective business structure and contractual challenges, such as contract terms or insurance products.

2.5 Operational and technology risks

Private sector capital providers and project developers are clear that the private sector should bear the operational risks of CCS technology. However, some of these risks themselves such as the approach being taken to storage liabilities are dependent on policy.

CCS adds operational liabilities directly to the running of the host plant through the use of new technology and increasing the complexity of plants. It also adds operational liability indirectly through the lengthening of the value chain to include transport and storage.

Technology and integration risks

The addition of new capture technology to conventional plants adds 'technology risk' to fossil fuel generation plants. Technology risk refers to the risk of the technology failing or underperforming, for example carbon capture rates being lower than predicted. A greater, related concern is 'integration risk' – the risk that when the different elements of CCS are put together, the various technologies do not produce expected results.

Integration of CO₂ capture will lead to parasitic losses in powering the capture process, but the technology risk relates to uncertainty about the magnitude of this parasitic loss in real operational conditions. This is further complicated because equipment providers are generally not willing to provide a 'full wrap' (a guarantee on the entire project) although they are able to provide guarantees on individual pieces of equipment. The lack of a full wrap leaves an technology integration risk as a major issue for CCS financing.

Apart from a loss of efficiency, the increased complexity of the plant is likely to increase maintenance required. This in turn will lead to a reduction in the availability of the plant. Clarity on a plant's availability is crucial in obtaining finance as it is a key consideration of financiers when considering investment in a power plant. Traditionally investment decisions in fossil plants are based on 80-90% utilisation/availability. Major changes in availability could lead to major impacts on the returns that the plant can deliver. It is possible that the investment community will be wary of CCS until it passes its first maintenance cycle which may be in 5 years of operation, but more likely 10 years.

Storage risk

Liabilities relating to CO₂ storage are a key concern as the details on potential size of liabilities and who bears the risks are still uncertain. There are various storage related risks including risk of small seepage, of large scale catastrophic escape events and of risks in characterisation of storage sites. Backed by studies and enhance oil recovery projects, there is generally comfort with seepage risks, but there are major concerns regarding the liabilities surrounding catastrophic escape.

Under the EU CCS directive long-term storage liability will be passed on to the government when 'all available evidence' indicates that the CO₂ will be permanently contained. Uncertainty remains about how these requirements will be interpreted in practice. In the period before this transfer of liability, operators will be liable to purchase carbon credits (EUAs) for any leakages, at the prevailing market price, and for the costs of corrective measures to arrest and prevent further leakage. Understandably project developers and financiers are nervous about taking on such an open ended risk.



Potential solutions

Supporting derisking

The private sector accepts that it should take the lead in managing risks relating to technology, operation and integration. Clarifying policy thinking around transport and storage, as suggested in the previous section, can help the private sector to develop solutions. The most challenging area for investors appears to be storage risks, which are driven largely by policy.

- There is widespread recognition that only the public sector can manage liability for CO₂ storage over very long time horizons. But private sector operators will still need to bear uncapped risks over long timescales, and face uncertainty about the precise nature of future regulatory hurdles to be cleared before liabilities can be passed to the government. There is a need for further open-minded engagement in this area, to improve the risk profile on this issue for investors. The uncertain and long term nature of the liability framework could undermine the willingness of private investors to support CCS projects.
- Insurance approaches may help, but the industry finds it hard to insure storage due to the uncapped future EUA prices. To date there are no insurance products available to cover storage risks and appropriate products may never be available. The industry is currently working to examine the scope for insurance solutions for many operational and technology risks. This work will need to be taken forward with the involvement of policy makers, with, as far as possible, a view to enabling market solutions.
- Public support for derisking key elements of the value chain could be valuable, both in itself, and in terms of signalling policy commitment. In particular, it is worth exploring how the public sector could support a co-ordinated approach to proving and derisking strategic CO₂ stores in the North Sea.

“CCS financing need public and private sector players to engage and explore options open-mindedly”

3.0 Conclusions and summary

A viable CCS industry would be a major economic prize for the UK, enabling the country to deliver its commitments to a low carbon economy affordably and efficiently. By 2050 a thriving CCS industry could save the UK economy up to 1% of GDP. But it won't happen without large scale private sector investment over the next decade.

Our engagement with investors clearly indicates that there are major challenges to overcome. There is a need to recognise the scale of this challenge and begin to create a strategic vision for financing the development of CCS. It is also crucial to draw on a range of methods and lessons learnt in other sectors where private sector investors have successfully engaged in delivering long-term, policy dependent investments, whether in utilities, infrastructure of public services.

Table 1 summarises an initial view of potential solutions to the challenges.

Challenge theme	Issue	Potential solutions
Investment challenges	Developing a financial vision for CCS	Focus on reducing, managing and sharing risks for early follow on projects Explore risk sharing structures and mechanisms Consider GIB role in facilitating sourcing of capital Increase depth of policy makers' engagement with potential financiers (as per Ofgem/Ofwat)
	Improving the visibility of returns	Clarify revenue support and ensure timescale is sufficiently long
Confidence in long term policy	Clear sense of direction	Improve the CCS roadmap through engagement with key stakeholders, including investors
	Co-ordination mechanisms	Explore the role and scope for public private sector co-ordination mechanisms
	Targeted public support for CCS	Consider public funding for strategic R&D, e.g proving of North Sea storage or enabling infrastructure
	Strengthening policy signals	Consider stronger policy signals on electricity decarbonisation or capture readiness
Energy marketplace	Attractive pricing	Right pricing of CCS contracts for difference
	Develop risk sharing approaches	Evaluate risks and develop strategy for risk sharing in projects supported by contracts for difference
	Create certainty	Examine scope to build certainty of a market for CCS through EMR delivery plans
	Create rewards for non-power CCS	Explore how to create reward mechanisms for non-power sector applications of CCS
Business structures	Regulatory and market frameworks	Consider case for regulatory or market frameworks to underpin business structures
Operational and technology risk	Storage risks	Consider strategies for addressing private sector concerns around storage liabilities
	Public support for derisking	Consider targeted public support for derisking (e.g. storage)

We recognise the constraints and pressures that both policy-makers, project developer and potential capital providers have to work within. These make CCS a particularly challenging, but highly valuable potential, investment. This summary of our suggested solutions is presented to stimulate debate and engagement. Most importantly, we believe that creating a vision for CCS financing needs a willingness on the part of the key public and private sector players to engage and to explore the issues and options open-mindedly.

Further Work

Making early CCS projects investable is a key priority in enabling CCS to develop and fulfil its potential in the UK's transition to a low carbon economy. We plan further work which will involve detailed analysis of the challenges and how the solutions can be delivered. This will involve continued focused engagement with capital providers, project developers and other stakeholders.

Feedback

We would welcome views on the issues raised in this document.

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if you have feedback on the ideas in this paper or how to take them forward.

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