CARBON CAPTURE AND STORAGE:

Mobilising Private Sector Finance

THE °CLIMATE GROUP

Ecofin Research Foundation
Workable solutions for a low-carbon future

GLOBAL CCS INSTITUTE

CCS is part of
THE CLEAN REVOLUTION

Cover Image: Detail of the world's first integrated carbon capture and storage project for power generation at AEP's Mountaineer plant, West Virginia, USA. Courtesy of Alstom.

EXECUTIVE SUMMARY

The Climate Group and the Ecofin Research Foundation are working on a joint initiative to assess, and possibly stimulate, private sector financing for first generation industrial scale carbon, capture and storage (CCS) projects. This brief report provides an overview of initial findings from a European perspective.

We canvassed over 30 private sector capital providers about the risks and returns of a post-combustion, new build, coal-fired power station. The following messages are emerging:

1. **Debt… not yet.** Ample debt may be available but only if three prerequisites can be addressed:
   - An indicator of performance across the whole capture and generation chain must be provided by a well-regarded equipment supplier or contractor.
   - Major sponsors who have successfully managed sizeable and complicated construction projects must be involved.
   - Economics of CCS must have a route to being competitive with other forms of generation, without public funding.
2. **Not for specialist equity.** Specialist equity, such as private equity or infrastructure funds, will not be mobilised to finance demonstration projects. Private equity sees demonstration of CCS, like technology funding – requiring high returns across a spread of projects. Infrastructure funds don't take the construction and integration risk inherent in demonstration CCS projects.
3. **On the balance sheet… but limited in scale.** Bond holders or equity holders from the big pension funds or insurance companies are comfortable with corporates using their balance sheets to finance CCS, but only as long as the scale is limited to just a couple of percent of group assets. Across the European utilities, though, this would enable a maximum of €5bn of funds to be available, and even then it is questionable if those utilities would be prepared to invest that much in CCS demonstrations whilst balance sheets are being delivered and capital budgets are being cut.
4. **Demonstrations helped by the private sector… but for two not eight projects.** Limited private sector funding means that a multitude of CCS demonstration projects cannot be pursued. It is generally agreed that government sources will provide part of the funding for CCS demonstration projects and that will be topped up by private sector sources. However, the initial findings of our initiative indicate that private sector funds will be adequate to support maybe just two CCS demonstrations – and that's across the whole of Europe. This is clearly a long way short of the UK's plans to have up to four demonstration projects, let alone Europe's ambition to see eight and hopefully twelve demonstration projects.
5. **Government funding needs to focus on fewer CCS demonstration projects.** Public sector financial support for CCS from European sources needs to be focussed on far fewer projects instead of being spread over numerous CCS technologies. This will ensure some of the challenges are faced – and hopefully overcome – rather than attempting to initiate CCS in a variety of settings which may simply result in none of the challenges being properly addressed. Once the concerns of private sector debt market participants are addressed, the need for government funds would be sharply reduced.

We intend to build on our initial findings through additional interviews with capital providers to widen the geographic reach as well as explore other examples of possible CCS projects such as enhanced oil recovery and/or retrofitting.

We will disseminate these findings to stakeholders such as capital providers, project developers and policymakers, in order to help break down the identified barriers.

ASSESSING PRIVATE SECTOR FINANCE FOR CCS

Carbon Capture and Storage (CCS), the process of capturing carbon dioxide and storing it instead of emitting it into the atmosphere, is viewed as one of the essential steps towards a low carbon economy. CCS technology is a technology that is still being developed (see Appendix 1 for further details about CCS).

To prove the technology at scale and kick start uptake, Governments have started awarding financial incentives to industrial scale CCS projects in the last few years. Most governments are stipulating the projects should be in operation by the end of 2015[1]. With typical three or four year construction periods, the need for private sector financing of CCS is becoming urgent.

The Climate Group and The Ecofin Research Foundation (Appendix 2) are working on a joint initiative to assess the amount of funding that might be available for, and to help increase private sector involvement in, financing first generation industrial scale CCS projects.

Between March and May 2010 the team canvassed over 30 private sector capital providers in Europe. We engaged with decision makers responsible for advocating lending recommendations to credit committees, and fund managers that manage equity portfolios or promote investments to investment committees, to see what risks need to be addressed and what return would be required for them to back CCS projects. Although based in Europe, many of the capital providers had a global remit.

Views were sought from a broad range of private sector capital providers, split broadly equally between debt and equity providers. Lenders to corporates formed the largest group of debt providers, but structured finance providers (including project financiers) were well represented too. In equity, the pension funds or insurance companies that provide corporate equity were the largest contributor, but private sector financers active in the specialist equity areas of private equity or infrastructure funds were also involved.

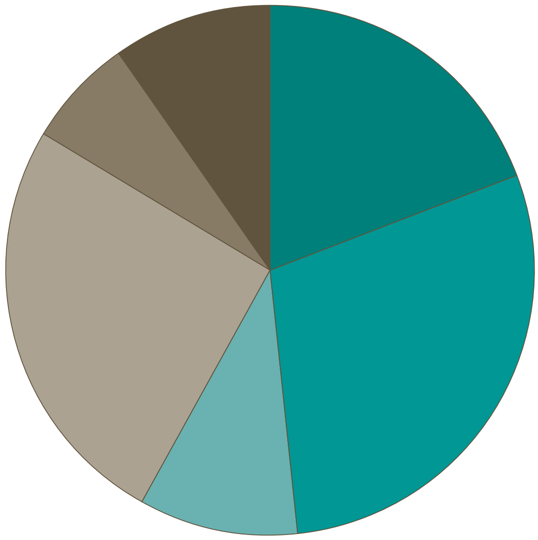


FIGURE I: PRIVATE CAPITAL PROVIDERS INTERVIEWED

(6)	STRUCTURED FINANCE
(9)	CORPORATE LENDING
(3)	CORPORATE DEBT
(8)	CORPORATE EQUITY
(2)	INFRASTRUCTURE FUND
(3)	PRIVATE EQUITY

Through discussions that lasted between one to two hours, we explored how capital providers view the operational and commercial risks of CCS. The knowledge on CCS varied greatly between participants, but regardless of familiarity with CCS, participants were very keen to be engaged on CCS.

[1] (i) Department of Energy and Climate Change (2010) Clean coal: an industrial strategy for the development of carbon capture and storage across the UK.; (ii) G8 (2010) Muskoka Declaration.; (iii) European Commission (2009) Directive 2009/31/EC on the geological storage of carbon dioxide.

DISCUSSIONS ON COSTS AND REQUIRED POWER PRICES

Interviews with private sector capital providers were centred on a hypothetical 2GW new build coal plant with post combustion CCS. Based on costings put together by the Global CCS Institute (GCCSI) and supplemented by discussions with CCS project developers, we presented a CCS plant as a potential investment opportunity to private sector capital providers. The project was presented with a total costs that might approach €6bn but with the possibility that part of the costs might be borne by government sources – typically around one-half of the specific capital costs of the CCS equipment – leaving around €4.7bn for the private sector to fund.

Costs though might come down as the capital contingencies (Table I) or as the parasitic load drops or as utilisation rates improve (Table II).

TABLE I

CAPITAL COSTS	**Total €m**	**Net € / kW**	**Gross € / kW**	**Outturn €m**	**Net € / kW**	**Gross € / kW**
Conventional Island Costs	3,110			3,486	1,743	1,514
Conventional Island Contingencies	377					
Conventional Island Budgets	3,486	1,743	1,514			
CCS Island Costs	1,886			2,441	1,221	1,061
CCS Island Contingencies	556					
CCS Island Budgets	2,441	1,221	1,061			
Project Budget	**5,928**	**2,964**	**2,575**			
Oversize	0					
Amended Project Budget	**5,928**	**2,964**	**2,575**	**5,928**	**2,964**	**2,575**

	Total €m	**Net € / kW**	**Gross € / kW**
Contingencies Unused	0		
Cost Overrun	0		
Project Cost	**5,928**	**2,964**	**2,575**
Public Support	1,221	610	530
Funding requirement	4,707	2,353	2,045
Project Cost	**5,928**	**2,964**	**2,575**

TABLE II

TARGETS		**Unabated**	**Abated Today**	**Abated Tomorrow**
Capacity	MW	2,000		
Total Capex	€m	3,468	6,253	5,928
Incl Extra for CCS	€m		2,785	2,441
Parasitic Load				
Power	MW		319	198
Steam	GJ/MWh		4.0	2.0
Utilisation	Hours	7500	6000	6750

TABLE III

FUEL PRICES		
Coal	$/t	90
Gas	$/mmbtu	14
Oil Equivalent	$/bbl	84
CO_2	€/t	20

Our assessment of the Global CCS Institute costings, together with our assumptions on fuel costs (Table III), indicates that excluding any government contribution, power prices would have to be around €160/MWh to make it worthwhile building a coal fired power station with post-combustion CCS today. Allowing for the estimated improvement in efficiencies above, the required power price might drop to €140/MWh – still well above the €80/MWh that might be required to justify the same coal fired power station without CCS but which has to pay €20/t for CO_2 emitted to the atmosphere.

Should this be an accurate assessment of CCS economics, it would have to be questioned if this is an appropriate policy ambition. Charts I and II set out the CO_2 price that would be required to justify CCS. CO_2 would need to exceed €100/t to stimulate CCS.

CHART I

REQUIRED POWER PRICE

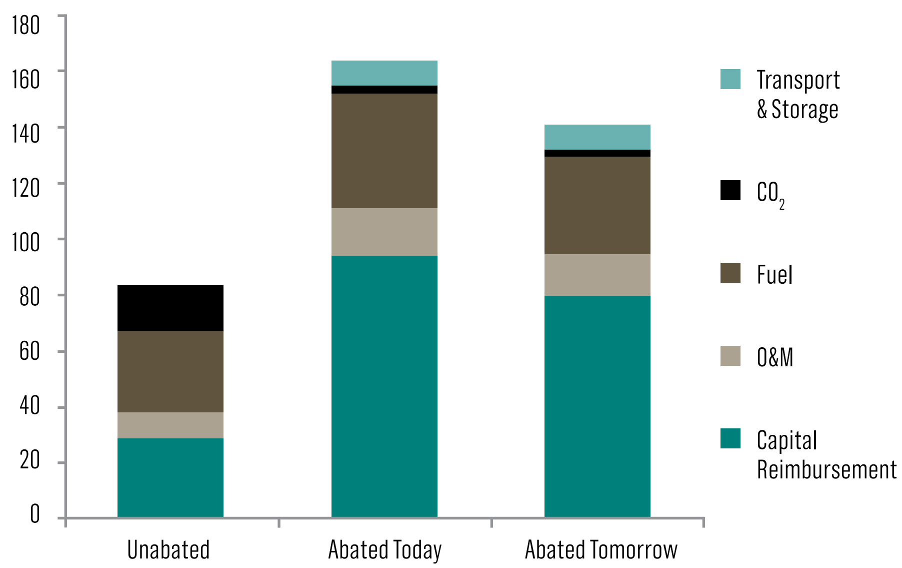
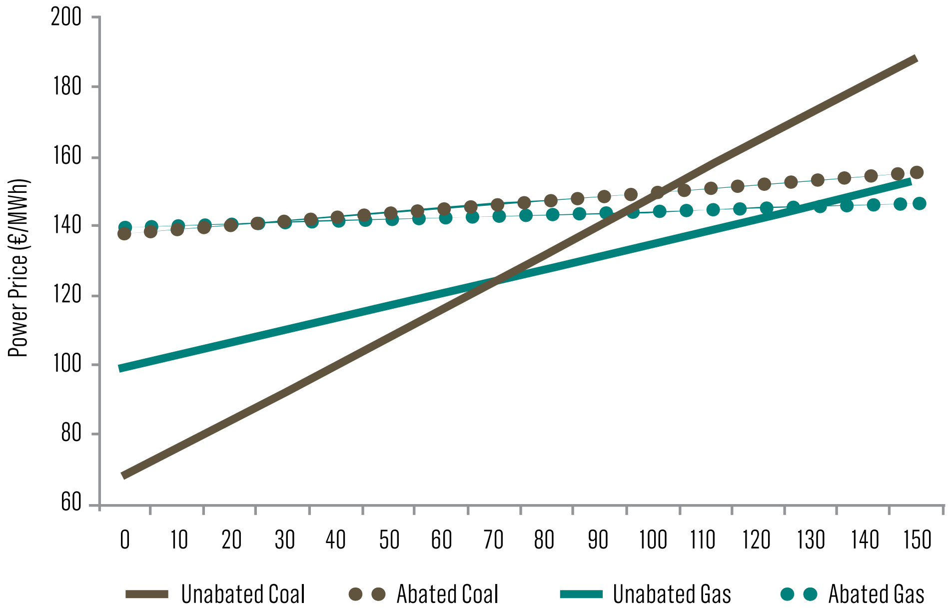


CHART II

REQUIRED LEVELISED POWER PRICE



DISCUSSIONS ON OPERATIONAL AND COMMERCIAL RISK ASSESSMENT

Our conversations with private sector capital providers were broken down further into two aspects.

1) First, we probed to assess private sector capital providers' views on the operational and technical challenges. Here we asked participants to assume the power station had a strong power purchase offtake contract in place that ensured any commercial risk was not borne by the project. This offtake contract would be with a strong counterparty such as the Government, and would cover changes in fuel costs. The economic value-added, if all goes to plan, can then be quantified as the benefit from moving from the higher cost of capital built into the power offtake contract - we used 13% pre-tax real - to the cost of capital that would be required on a conventional power station - we used 10% pre-tax real.

   Should the plant not achieve the reductions in parasitic load or availability, and incur 25% cost overruns, the €1.6bn of economic value-added could turn into a €2.5bn loss. Conversely, should the project hit its operational targets and the cost contingencies are not needed, the economic value-added could rise to over €3bn (Chart III).

2) Second, we asked the private sector capital providers to consider the risks of operating merchant capacity with CCS. Clearly the major concern might be that the plant with CCS might end up competing against an unabated power station and CO_2 prices stay below €100/t. In this circumstance, the risk to margins could be as much as €40/MWh – and each €10/MWh might equate to €1bn loss in value (Chart IV).

   An associated risk of developing coal fired power stations is a drop in gas prices – for example, if the shale gas revolution that has hit the US comes to Europe. Coal-fired CCS projects would find their economics totally undermined, even if gas-fired plant had to fit CCS (Chart V).

CHART III

ECONOMIC VALUE ADDED

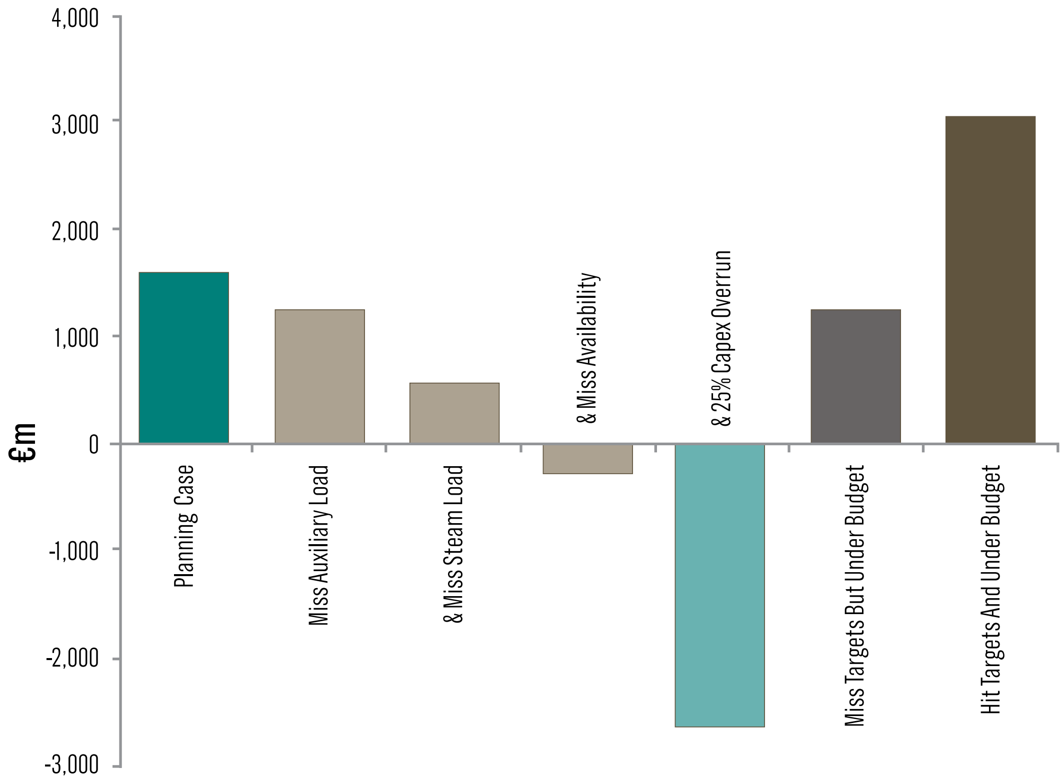


CHART IV

MARGIN RISK DEPENDING ON MARGINAL PLANT

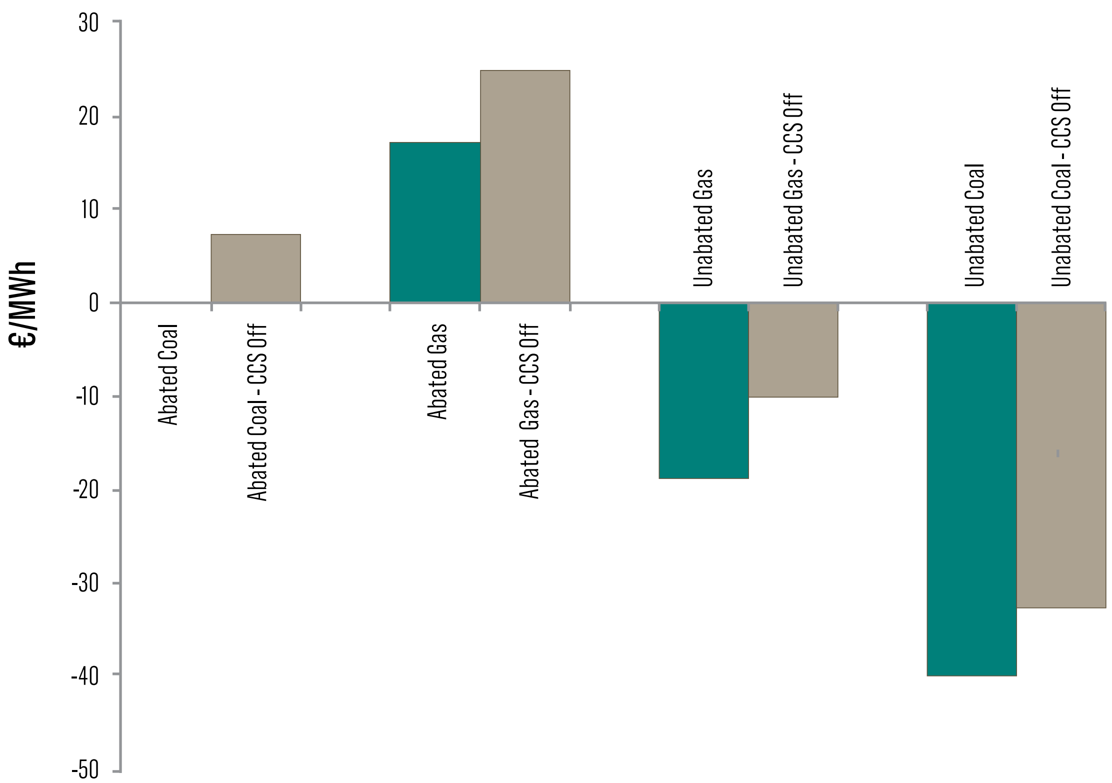
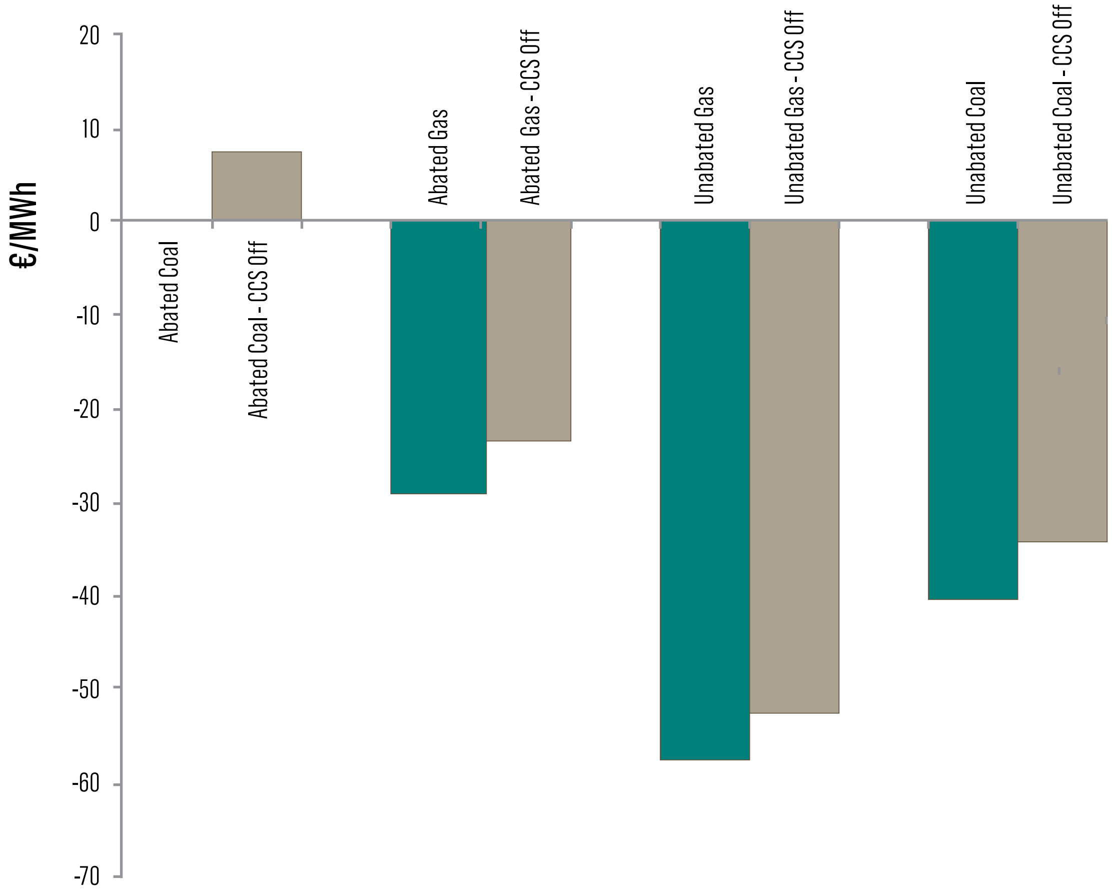


CHART V

MARGIN RISK DEPENDING ON MARGINAL PLANT



THE CHALLENGES

GOOD NEWS

The study highlighted that some issues that are often considered barriers for CCS were not viewed as barriers by private sector capital providers.

- Mobilising multi-disciplinary teams should not pose difficulties. CCS requires chemical processes, power stations and oil or gas reservoirs experts; but bringing such teams together is routine in private sector finance.
- Storage has long-term liabilities that cannot be borne fully by the private sector, however these risks were not seen as deal-breakers. Whilst not undermining the challenges, capital providers thought such long-term liabilities can only be shouldered by governments and solutions would be forthcoming.

THE CHALLENGES

While some potential barriers were disregarded, other issues that have a significant impact on availability of private sector debt and equity for CCS were identified.

CHALLENGES FOR DEBT PROVIDERS

In several major institutions, the structured financed teams (that have a history in project finance) and the general corporate lending teams have been merged and now have similar requirements for lending following the downsizing of credit teams.

Across the group, debt providers generally need three issues to be addressed:

1) Fundamental to lending decisions is a **performance guarantee** for the entire plant which embraces not just the capture equipment but also the power station. The performance guarantee needs to cover the whole system (a wrap), not just individual components.

   A wrap is not just to insure against financial consequences of poor operations. It appears that the capital providers need to have an equipment provider or engineering contractor to be prepared to risk its reputation on the plant's performance. This ensures that the full weight of that company's resources and expertise is behind the project in the event that any operational difficulties are encountered.

   It is also worth reflecting that general performance guarantees do not provide the appropriate structure to cover the operational and technical risks of CCS. With CCS the risks are related to integrating the capture plant with the host power station. In its 25-30 year life, the plant has to operate throughout a range of operating conditions and flue gases vary by coal specification and ambient conditions. Capital providers need to be confident that the plant performance is robust in different operating environments.

2) **Sponsors of CCS must be major players** in their sector, be they utilities, fuel suppliers or equipment manufacturers. Following the financial crisis, even the most dedicated project finance teams are now facing capital constraints and capital allocation is likely to be driven at least partially by broader corporate relationships.

   However, it is not just important to involve major sponsors to foster corporate relationships. Major sponsors are more likely to have a track record of implementing projects of the scale and complexity involved with CCS. This experience will be crucial in ensuring CCS projects are kept within budget and that the target operating performance is met.

3) In the long term, generating from CCS plants must have **a route to achieving grid parity**. Either capital costs must be able to be reduced and/or fuel inefficiencies able to be improved so that CCS generated electricity could be competitive with nuclear or wind generation once adjusted for load factor and operating regime.

See Table IV for further details.

CHALLENGES FOR SPECIALIST EQUITY PROVIDERS

Specialist equity is not suited to CCS at the current stage (Table IV).

Large scale private equity funds would be wary of the operating challenges of the technologies. They would need comfort from a few CCS plants being up and running before they would be willing to finance any. Moreover, the business model of large scale private equity requires significant debt funding which is unlikely to be forthcoming in the current situation.

The operating challenges and absence of debt make CCS more suited for finance by venture capital. **Venture capitalists** do take technology risk, but by pooling investments across a variety of technological solutions to a problem; and on the premise that when a technology works project returns of 30% or higher will be made. Given the scale of CCS and the cost of each plant, it is hard to see a big enough portfolio of projects for venture capital type funding to be able to select their winners from. Further it is unlikely that CCS will be able to meet the high returns required by venture capitalists.

Infrastructure funds are another form of specialist equity that might look at CCS on the assumption that any merchant risk can be eliminated contractually. However, with their low cost of capital, infrastructure funds do not take construction risk. Moreover, like large scale private equity funds, their business models rely on putting debt into low risk projects.

CHALLENGES FOR CORPORATE DEBT OR EQUITY

It appears that holders of bonds or equity in the major corporates would not object to corporates devoting a proportion of their capital budgets to CCS demonstration projects, but only to a limited extent (Table IV).

Most big companies have R&D programmes and keep abreast with major technological developments to understand the new business opportunities and also the impact of these developments on their sectors and existing activities. Utilities have further reasons to support CCS as it is a technology that is being promoted by governments. Given the crucial importance of electricity and gas, even fully privately owned utilities have to work with governments. So it can be mutually beneficial for utilities to further government agendas, in this instance by exploring the scope to make CCS viable, however, this cannot be pushed too far, as one participant put it "CCS has less PR appeal than wind, or even nuclear".

Bond and equity holders stressed two further aspects. Firstly CCS related commitments must not be "material" until the economics are closer to being justified by reasonable expectations for wholesale power prices. In the words of one equity holder, "CCS must not become a new business line". This can be interpreted as meaning CCS related spending should be only 1-2% of a company's asset base.

The next chart shows the market value of the asset bases of the leading European utilities. When restricted to 1-2% of a company's asset base, to take on a 500MW coal-fired CCS project, companies would need an asset base above €75bn; even in consortia of three parties, an asset base above €25bn is needed. This limits involvement to around half-a-dozen utilities, and of these several have other priorities for their capital.

In aggregate it is difficult to see more than £5bn of funding being available for CCS demonstration projects.

CHART VI

FIGURE 2: ENTERPRISE VALUE AND LIMITS TO CCS INVOLVEMENT

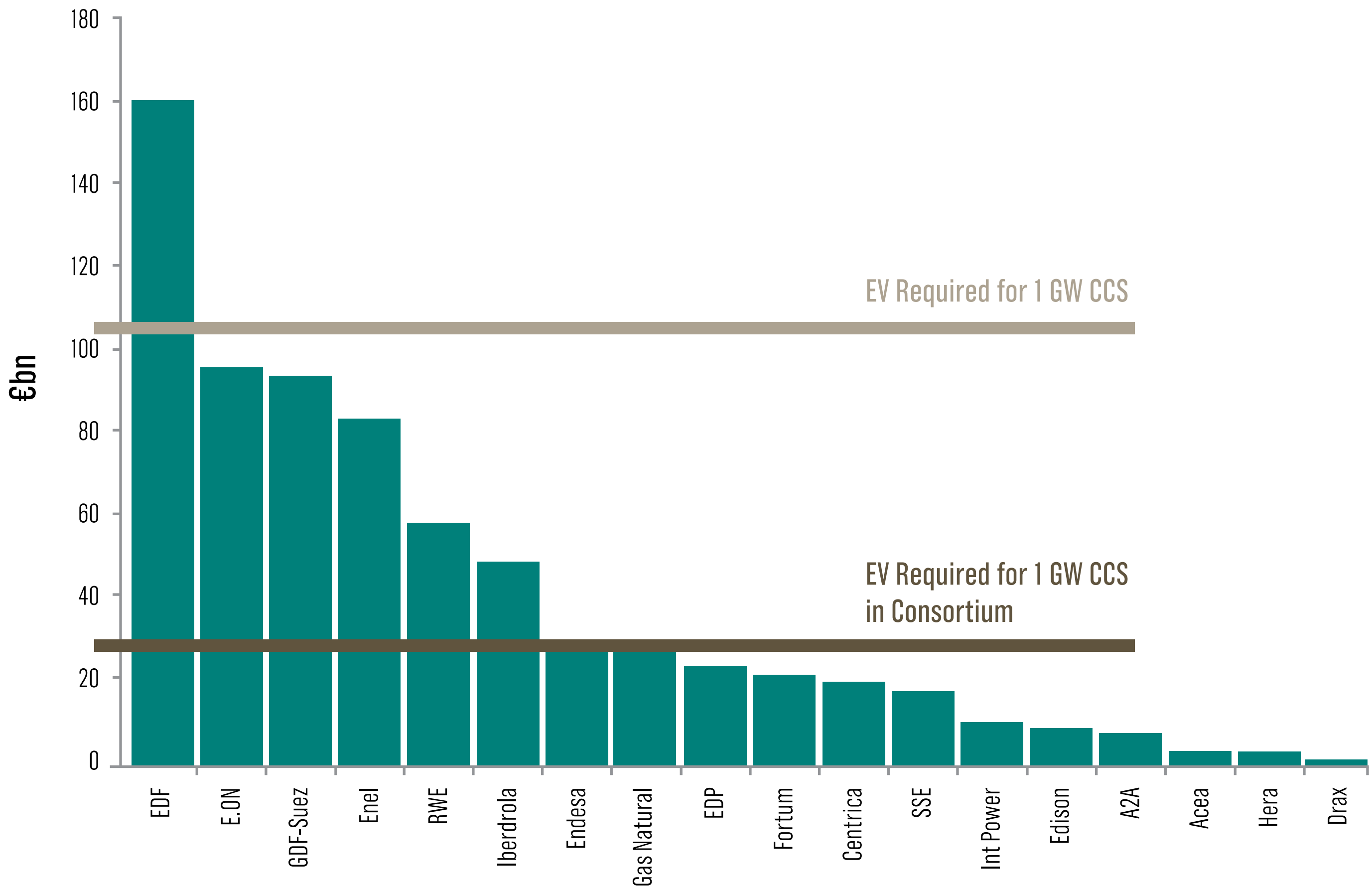


TABLE IV

OVERVIEW OF CHALLENGES ACROSS CAPITAL PROVIDERS

	SPECIALIST DEBT					SPECIALIST EQUITY
	Structured Finance	**Corporate Lending**	**Corporate Debt**	**Corporate Equity**	**Infrastructure Funds**	**Private Equity**
Interviews	6	9	3	8	2	3
Ready to fund?	Yes… but when we've seen it work	Yes… but only for strongest sponsors	Yes… if it wasn't experimental	Yes… but only so long as it's not significant	Yes… but only networks, once built, with take-or-pay tariff	Yes… but technology risks make this venture capital
Risks	1) Interface with different technologies 2) Operational interdependencies restricts availability 3) Poor economics without public support	1) Political sustainability of support 2) Balance sheets weak 3) Technology must work 4) Stranding existing assets	1) Opportunity cost of tieing up b/s in long lead time projects 2) Concentration high 3) Commercial (and political) risk from cheap gas	1) Game changer to make CCS redundant 2) Storage liability 3) Value of existing generation portfolio	1) Need a track record of a reference plant 2) Economics could jeopardise public support	Technological breakthrough needed to make it cost-competitive
Quotes	"Project on project risks" "Technology risk is the 'elephant in the room'"	"Too expensive to test" "Can't price with technical risk"	"Less PR appeal than wind, or even nuclear" "Utilities bad at big capital projects"	"Mustn't become a new business line" "Better to be a fast follower than a leader"	"Need to bullet-proof downside"	"A massive VC deal" "It's a concept"
Quantification of funds for CCS	Must be world scale sponsors, but even then in the $10m's; Can't price with technology risk	Only for players who have implemented major scale projects; Needs one wrap; 20% return needed	Credit ratios stretched already; Term needs to be 25 years	Limit to 1-2% of enterprise value; Max 10% capex if high teens WACC	Return needs to be in high teens, but very few funds even consider; More interest once in operation	Return needs to be in "30s" and need portfolio of small investments; More interest once construction/ operational issues proven
Potential solutions?	Performance quarantee with 5 year true-up; EOR applications	Layer protection with government fall-back	Build as capture ready, then switch after technology proven in government project	1) May support government compact, but public acceptance needs to be higher 2) CCS as insurance/ R&D	For refinance when running smoothly	Not appropriate

THE IMPLICATIONS

- The present thinking is, that governments will provide part of the funding for CCS demonstration projects and that the rest will be topped up by the private sector. However given the possible limits of 1-2% of enterprise value to be invested in CCS, it appears there may be less than £5bn of private sector funds from the major utilities to support CCS demonstration projects over the next ten years across Europe. If as much as half of available private sector finance is attracted to the UK, one demonstration project could get the go-ahead, not "up to four" as indicated in UK CCS Policy. This assumes that government sources cover half the extra costs of CCS power stations, which may indeed be optimistic. Similarly across Europe, there is likely to be private sector finance for only two demonstration projects, not the eight let alone twelve hoped for.

- In the current stage, where CCS plants are yet to be demonstrated at scale, projects will most likely have to be funded almost exclusively by public sources. Public funding will likely need to cover both the upfront capital costs and also the long-term fuel inefficiencies created by CCS. As the amount of private sector capital that is available to follow that public funding is limited, public funding should be focused on a few projects instead of the current trend of being spread across a suite of technologies and locations. Once the first plants are up and running, there should be little difficulty in attracting large scale private sector funding for other CCS plants.

- In order to be more appealing to private sector funding, CCS project developers should ensure that major corporates from the utility, fuel suppliers and equipment manufacturing sectors are involved in projects from the initial stages.

FURTHER WORK

It is important to note that the findings presented above are emerging results from a small sample group of capital providers in Europe. We plan to test our initial findings by conducting further interviews with capital providers and expanding the study to include North America, Asia and Australia. This will enable us to ensure that our findings are robust and are representative of the majority of capital providers.

We would also like to discuss with capital providers the impacts of enhanced oil recovery and retrofitting on the attractiveness of financing CCS. These considerations may be crucial in the demonstration phase of CCS as they may change the economics sufficiently to make CCS more attractive to capital providers.

We would like to increase the involvement of CCS project developers in the study to get a firm understanding of the funding needs and the financing mechanisms that are currently being considered by project developers. This will enable us to relate these proposed financing plans with the views of capital providers. We intend to work closely with the Global CCS Institute to achieve this.

Once we have identified the main risks, both actual and perceived, that concern private sector capital providers, we will disseminate this to a wide audience through a series of publications, presentations and other events.

APPENDIX 1

OVERVIEW OF CARBON CAPTURE AND STORAGE (CCS)

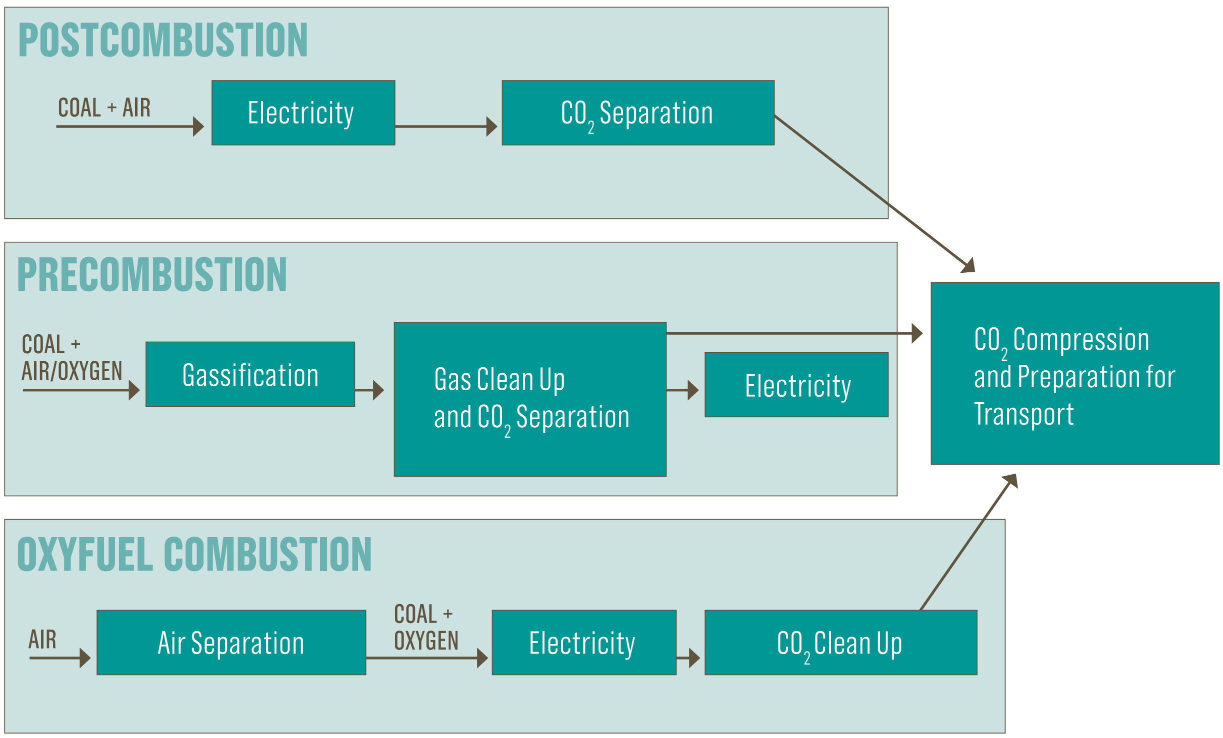
CCS consists of three separate components. First, carbon dioxide is captured using a chemical process. There are various processes that are currently being used to capture carbon dioxide for example using amines or chilled ammonia, and more are being developed. Once captured, carbon is transported via pipelines or tankers to a storage site where it is stored permanently. Possible storage sites consist of geological formations such as depleted oil and gas fields, deep saline aquifers (layers of porous rock that contain salty water) and unmineable coal seams. In a process called Enhance Oil Recovery (EOR) captured carbon dioxide can also be pumped into partially depleted oil fields to increase oil production of the field. The practice of injecting carbon dioxide into reservoirs has been in use for over 30 years.

Each separate part of the CCS value-chain - capture, transport and storage - has been demonstrated separately; however there is limited demonstration of the full CCS chain at an industrial scale[2].

There are three alternative CCS technologies being developed in the power sector – post-combustion, pre-combustion, and oxyfuel-combustion (Figure II).

FIGURE II

TECHNOLOGY ALTERNATIVES FOR CARBON DIOXIDE CAPTURE IN THE POWER SECTOR



[2] International Energy Agency (2009) Technology Roadmap - Carbon Capture and Storage.

In a post-combustion plant, carbon dioxide is captured from the flue gas after the fossil fuel is burned, in pre-combustion, the fuel is gassified and the carbon dioxide is removed before the fuel is burned, and in oxyfuel-combustion, the fuel is burned in oxygen which results in an almost pure stream of carbon dioxide.

Of these three technologies, post-combustion and pre-combustion technologies appear to us from a commercial perspective to be at about the same maturity while oxyfuel-combustion technology is less advanced. Post-combustion is often the most favoured technology as power stations tend to lose less operational flexibility and also as it is thought that it could be used to retrofit existing plants with CCS.

Power stations with CCS require major capital. A typical 1GW coal plant might cost £1.5bn to build, but adding the equipment to capture, transport and store carbon dioxide might add a further £1bn. Moreover additional fuel is required to run the capture and transport equipment resulting in the fuel requirements for every kWh generated to rise by about two-fifths compared to a conventional coal fired power station. The UK CCS levy proposes to raise between £7.2bn and £9.5bn for four demonstration plants.

BARRIERS TO CCS

Despite the promotion of CCS in the last few years its progress into a fully developed technology has been slow. Some of the likely barriers for the development of CCS are:

Integration

The CCS process requires the integration of four very different industries – chemical processing, power generation, transport networks and storage. Each of these has its own cultures and levels of risk and returns, and each relies on different capital providers.

Scale

Unlike other low carbon technologies, CCS is disadvantaged by its scale. With a high cost of demonstrating the technology at scale, it is not possible to 'learn-by-doing' as is usually the case in technological developments.

High capital and operational costs

As well as a high capital cost, CCS also leads to a higher operational cost. The energy intensive nature of CCS increases the fuel consumption of a plant with CCS compared to a plant with a similar output but without CCS.

First mover disadvantage

Finally there is likely to be a significant first mover disadvantage. Companies might be best placed to learn from the first movers' experience, rather than deploy their capital on developing the technology.

APPENDIX II

KEY PARTNERS

THE °CLIMATE GROUP

The Climate Group (www.theclimategroup.org) is an independent, not-for-profit organisation working internationally with government and business leaders to advance smart policies and technologies to cut global emissions and accelerate a clean industrial revolution. Its global coalition of companies, states, regions and cities around the world recognise the economic and environmental imperatives of taking decisive action now. The Climate Group was founded in 2004 and has operations in Australia, China, Europe, India and North America.

The Climate Group's CCS Programme is made possible by funding from the Global CCS Institute.

Ecofin Research Foundation

Workable solutions for a low-carbon future

The Ecofin Research Foundation (www.ecofinfoundation.org) is a UK registered charity established by, but independent from, Ecofin Limited a London based investment management firm that specialises in the global utility, infrastructure, alternative energy and environmental sectors. The Foundation uses its knowledge of the global utility and finance sectors and its network of contacts to promote the development of sustainable, low carbon solutions. Its understanding of the finance sector and experience with companies, capital providers and regulators enable it to engage and collaborate with stakeholders to deliver workable low carbon solutions.

GLOBAL CCS INSTITUTE

Launched in April 2009, the Global CCS Institute (www.globalccsinstitute.com) is aimed at accelerating worldwide commercial deployment of at-scale CCS. The Global CCS Institute receives AUD$100 million annual funding from the Australian Government and will be an independent authority on CCS by drawing together information, knowledge and expertise into a central base. The Global CCS Institute will advise on technologies and provide expert insight on costs and benefits and the operational and legislative requirements needed. It will work collaboratively with governments, NGOs and the private sector to drive international momentum for the development and deployment of safe, economic and environmentally sustainable commercial-scale CCS projects.

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