ETI Response to Energy & Climate Change Committee Call for Evidence on Carbon Capture and Storage (CCS)

Summary

The Energy Technologies Institute (ETI), a public-private partnership between global energy and engineering firms and the UK Government, believes that CCS will be a critical part of any affordable, secure and sustainable low carbon UK energy system in the future. However, it is important that the right steps are taken to ensure the cost of carbon reductions are affordable in the context of sustaining UK economic growth and industrial development.

CCS may be the single, most cost effective lever for reducing UK greenhouse gas emissions. Its potential, because of its flexibility of use, extends beyond the electricity sector and is central to a national strategy to meet carbon targets cost-effectively by:

- enabling flexible low carbon electricity generation from fossil fuels;
- cutting emissions from a range of industrial processes;
- producing flexible, low carbon fuels (hydrogen or synthetic natural gas for a range of end uses) from gasifying coal or biomass;
- delivering “negative emissions” (capturing and storing the carbon that plants takes from the atmosphere) when used with biomass technologies, delivering a net reduction in atmospheric CO_2 and offsetting emissions from activities which are particularly expensive to decarbonise.

ETI’s analysis of the UK energy system shows that deploying CCS to its full potential can reduce the cost of meeting carbon targets by up to 1% of GDP (compared to the costs if no CCS were deployed) – equivalent to a saving of around £1000 on average household bills for energy and transport costs in 2050. These savings arise because spending on more expensive alternatives for cutting emissions would be avoided.

The key technologies needed to deploy CCS (CO_2 capture, compression, pipelines and geological injection and storage) have been successfully applied in a range of contexts. The next step is to assemble and deploy these proven components at scale in a number of full chain projects. We believe the technical challenges are surmountable in engineering terms, but require the strategic will and investment to de-risk, drive down costs and build a network of CO_2 transport and storage infrastructure.

CCS will require upfront investment to create strategic infrastructure and prove storage sites, so the costs for early projects are likely to be high when measured on a simple £ per MWh basis. This does not mean CCS is uncompetitive. Our work suggests that net benefits (in terms of savings compared to implementing more expensive alternatives) start to flow by the late 2020s, if the UK deploys CCS effectively.

Our work shows that the total investment out to 2050 is estimated at around £60 to £80 billion on capture, transportation, storage plant and infrastructure. This scale of investment is significant, but deliverable within a supportive policy environment, and would quickly start to yield returns, in the form of avoided decarbonisation costs, job creation and safeguarding the position of key industries in the UK.

It is challenging to deploy CCS in a market economy. It requires large scale investment in complex new value chains, the returns on which are entirely dependent on long term policy certainty. Attracting the private investment needed to develop the sector will depend on creating confidence that it will command strategic support from policy-makers.

Specific Questions raised in the consultation

What types of CCS technology are currently being developed and how do they differ from one another?

There are three fundamental approaches to capturing CO_2 from fossil-fuelled power generation:

- **Post combustion capture** involves removing CO_2 from flue gases usually by scrubbing with an amine-based solvent. The technology is mature for industrial processes but has not yet been applied to a power station at full scale in the UK. It is capital intensive and results in a significant energy penalty on the plant. ETI is developing an alternative post combustion capture technology process using solid sorbents. This is targeted for retrofit to gas fired powerplants from the early 2020's
- **Oxyfuel capture** involves combusting fuel in a mixture of oxygen and carbon dioxide rather than air which makes separation of CO_2 much simpler, but requires an air separation unit to produce oxygen.
- **Pre combustion capture** involves the production of 'syngas', a mixture of H_2, CO_2 and CO through gasification of coal and/or biomass. CO_2 is separated and H_2 is burned in a turbine. The normal method of separation is with a solvent such as Selexol, but other technologies including membranes and physical separation are under development. ETI's pre-combustion capture technology project for coal powerplant uses a physical separation technology. As well as the capture part of such integrated gasification combined cycle (IGCC) plant, there is significant headroom for cost and performance improvement in the rest of the plant.

We believe IGCC has significant potential for the future, because of its performance and the opportunity to produce hydrogen as an energy vector.

Compression and **transport** of CO_2 represents relatively mature technology, with significant experience in Enhanced Oil Recovery applications in North America.

Storage in a UK setting will be offshore in depleted oil and gas reservoirs and saline aquifers. Significant work is required to fully appraise storage sites before CO_2 storage takes place. ETI has completed an assessment of UK storage appraisal prospects and the results of this are now available under license from the Crown Estate and BGS – at www.CO2Stored.co.uk. ETI have also co-funded the UK's first saline aquifer appraisal drilling project with National Grid.

ETI have announced over £50m of CCS technology projects. In addition to the four mentioned above we are investing in development of measurement, monitoring and verification techniques for offshore storage sites and desk top tools and studies for assessing and designing CCS systems.

What contribution could CCS make towards the UK's decarbonisation targets? Are the UK Government's expectations reasonable in this regard?

ETI has created an internationally peer reviewed modelling capability for the UK energy system known as ESME – the Energy System Modelling Environment. This allows us to model the UK's pathway to decarbonisation by 2050 under a range of scenarios, taking into account the underlying costs, engineering properties and inter-dependencies of key energy technologies. This work robustly demonstrates that taking a system-wide approach substantially reduces the economic cost of decarbonisation.

Our modelling points to a critical role for CCS both within and outside the electricity sector. It suggests that if we do not successfully develop CCS in the UK, the annual cost of meeting carbon targets is likely to increase by over 1% of GDP by 2050. It also highlights the potential economic benefit of applying CCS in combination with biomass, as a means of generating negative carbon emissions. This would make it possible to meet carbon budgets and continue using fossil fuels in some applications where low carbon alternatives are particularly costly.

A coherent strategy for developing CCS means taking account of the costs and benefits across the entire energy sector. The electricity sector is the obvious starting point for developing CCS, as it is least exposed to international trade, can demonstrate and de-risk the full value chain at scale and through EMR has a reward mechanism available. However, our work also points clearly to the longer term importance of CCS in industrial and biomass applications – where it is possible to maximise the impact of resources by taking account of these broader decarbonisation benefits in decisions on contract pricing, allocation and contract design.

Are there any potential benefits (e.g. the ability to export CCS technology abroad) of successfully developing CCS to the UK economy and, if so, what are they?

A substantial reduction in the cost of the overall national energy system (1% of GDP by 2050) is likely to be the most important benefit to the UK economy. Spending on energy currently represents about 9% of GDP. Containing this cost burden, for both industry and consumers by deploying CCS to deliver low carbon energy cost-effectively, would have a major impact on national economic competitiveness and help to generate and safeguard jobs. We have commissioned work to assess the scale of the wider economic benefits associated with deployment of CCS.

A number of studies have also assessed the direct economic impact of CCS projects, on regional employment and value added, often in challenged regional economies. The creation of a significant new CCS sector would create new employment opportunities and enable the UK to build exportable skills (e.g. particularly in established strengths such as process and offshore engineering) and expertise relevant to an emerging global CCS industry. The CCS Technology Innovation Needs Assessment produced by the Low Carbon

Innovation Coordination Group estimates innovation in CCS can help create a UK industry with the potential to contribute further economic value of £3-16bn to 2050.

The development of CCS could also prolong the life of UK oil fields, through the application of captured CO_2 in enhanced oil recovery and there could be the potential to re-use some existing North Sea oil and gas infrastructure (e.g. platforms or pipelines) enabling a significant deferral of expensive decommissioning obligations.

Our initial estimates show there is enough storage capacity under UK waters to offer the potential to provide storage not just for the UK but for other European countries without a similar resource.

CCS also offers the only route to directly address emissions from some key high emitting industries which would help the UK remain an attractive location and maintain employment in industrial sectors such as refining, in future decades, as carbon prices become a growing part of their cost base.

What are the main barriers (e.g. economic, political, regulatory, scientific and social) to developing large-scale integrated CCS projects in the UK and internationally? How can they be overcome?

CCS offers a unique potential to enable a genuinely economically viable transition to a low carbon economy. But its strategic characteristics (large-scale, complex new value chains, dependence on policy for returns, its cost structure with economies of scale and scope, and the long-term nature of risks and liabilities) mean there are a range of barriers and challenges that need to be overcome. These include:

- *Vision and policy commitment to CCS:* while DECC's CCS roadmap contains many of the right elements for developing a CCS sector, our work on private sector financing for CCS (carried out jointly with the Ecofin Foundation and published at http://eti.co.uk/downloads/literature/Ecofin_CCS_Report.pdf) shows that more work will be needed to unlock the necessary private sector investment. Confidence in long term policy commitment to CCS as a sector is vital for attracting investors to individual projects and in in building the supply chain and capability to deliver a multi-billion pound CCS sector capable of realising its full potential. A suitably constructed contract for difference can deliver an individual project, but consistent signals of government commitment (similar to the level of effort devoted to the strategic development of the offshore wind sector) will be needed to create the broader confidence to develop the CCS sector. This requires genuine commitment to a strategic industrial policy for building a strong sector over the long term.
- *Coherent long term sector strategy:* currently CCS is conceived mainly as a bolt-on technology for fossil fuel power, and policy discussions tend to focus on cost-competitiveness against alternative low carbon electricity generation. Our work shows that CCS has a broader strategic role in a cost-effective transformation of the UK's energy system. There is a need to increase this understanding and for this to be reflected in a stronger approach on the part of government to lead, shape and facilitate CCS deployment (similar to the level of strategic activism shown in developing the oil and gas or offshore wind sectors). A clearer vision of the roles of

the public and private sectors in building a substantial CCS sector needs to be developed, building on the useful groundwork in DECC's 2012 CCS roadmap.

- *Creating strong market drivers and rewards for deployment:* Our work shows that many of the most valuable applications of CCS lie outside the electricity generation sector. While CCS may deliver emissions reductions cost effectively there is no way for developers to capture the 'system value' (i.e. the cost savings from avoiding the need to invest in more expensive ways of cutting emissions). Electricity generation is the only application which has an economic driver and reward mechanism. Within the context of low and volatile EU carbon prices, new reward mechanisms and economic drivers need to be created to drive wider deployment of CCS in non-power applications (e.g. industrial applications, gasification, and for biomass applications rewards for the added value of negative emissions). Without market drivers, investment will not flow.
- *Creating a supportive framework for sector regulation and governance:* The development of CCS is currently being driven mainly by the government's commercialisation programme, focusing on competition between a number of standalone full chain CCS projects. There needs to be broader strategic co-ordination and planning of the sector's development on a range of issues including spatial strategy, shared infrastructure, cluster development, industry standards and governance. Public and private sectors need to come together to manage risks and develop a shared strategic direction to facilitate the multi-billion pound long term investments needed to develop a CCS sector.
- *Managing and sharing risks*: the CCS directive has created a regime around the geological storage of CO_2 which imposes uncapped liabilities on operators of stores over long time horizons, making CCS much more problematic to private investors and insurers. This approach risks impeding the development of the sector, in turn increasing the cost and difficulty of meeting carbon targets. All options within the framework of European law should be re-examined to create an appropriate balance of risk between operators and the state to secure investment in developing CO_2 storage with appropriate safeguards and operational standards.

Are there any safety issues associated with capturing, transporting and storing carbon dioxide? How could they be overcome? Who should have responsibility for ensuring these activities are safe?

There are safety issues associated with any form of pressurised gas system and CCS is no different.

These safety issues can in part be reduced through site selection. Offshore storage of CO_2 minimises the impact of any leakage from a store or the offshore pipeline and the selection of onshore pipeline routes needs to consider the potential impact of a containment failure.

The plant and pipeline operators should be responsible for the safety of their operation which should be subject to regulation and planning approvals.

How have other countries incentivised CCS development? How successful have they been? How do they compare to the UK's efforts?

In Norway and Algeria, CCS has been applied to high CO_2 gas field developments for many years and similar projects are under development elsewhere, including the Gorgon gas field in Australia. These developments are typically mandated by the field development plan approval process, either by the operating companies own standards or national or state legislation.

CCS has also played an integral role in onshore Enhanced Oil Recovery (EOR) in the USA.

Other countries are developing technologies and pursuing commercial scale demonstration of CCS in the power and industrial sectors. None are yet operational, although the Boundary Dam project in Canada is nearing completion. China has committed to cutting the carbon intensity of its economy and has launched an experimental, cap-and-trade pilot programme. Recent press coverage suggests that China may commit to cap its emissions by 2016, which would represent a major escalation of commitment, and the government has ordered firms in heavy-polluting industries to cut emissions by 30% by 2017. In April 2013, the National Development and Reform Commission detailed the way in which China would promote CCS pilot and demonstration programmes as an important task in China's 12th Five–Year greenhouse gas control plan.

Is the UK Government's approach, set out in its CCS Roadmap, likely to incentivise development of CCS in the UK?

The CCS Roadmap set out at a high level the steps needed to enable CCS deployment in the UK. However, there have been delays in delivering the roadmap, notably in the CCS Commercialisation programme. ETI's work on private sector financing suggest there is considerable scepticism about the UK's long term commitment to carbon targets. Industry and investors are looking towards Government to demonstrate a long term commitment to CCS and to provide further details of how it will do so.

Could the successful development of CCS improve international efforts to mitigate climate change? What role could UK CCS play in this?

Emerging economies are likely to remain dependent on fossil fuels use for decades to come, and CCS is vital to enable these economies to continue to grow while containing emissions. The International Energy Agency highlighted the importance of CCS in its Energy Technology Perspectives 2012 when it stated that "CCS is the only technology on the horizon today that would allow industrial sectors (such as iron and steel, cement and natural gas processing) to meet deep emissions reduction goals."

The UK is particularly well-placed to play a leading role in developing CCS due to:

- Its natural resources with access to a well characterised geological storage resource and the geography of its emissions clusters
- Its proven skills and capacity in offshore engineering and geology and proven capability for delivering large scale engineering projects
- Significant potential synergies with its domestic oil and gas sector
- Its world-leading climate change legislative framework and (generally) stable economic environment for investment.

What are the consequences of failing to develop CCS and what alternatives are available for decarbonisation if CCS fails?

ETI modelling suggests that if CCS is not successfully developed in the UK, the annual cost of meeting carbon targets is likely to increase by 1% of GDP by 2050.

This impact is felt across all sectors.

Our modelling suggests that:

In the transport sector this will require the abolition of liquid fuels and replacing the entire car fleet with zero carbon vehicles (electric and hydrogen), which would be extremely costly and difficult. With CCS introduced, approximately half the fleet could remain liquid fuelled with the remainder plug-in hybrid, with increasing efficiencies and use of biofuel blends. Infrastructure investments would be more limited and also incremental, as the transition progresses.

In the buildings sector no gas would be permissible for home heating and all buildings would need to be retrofitted with zero carbon technologies such as heat pumps, district heating (but not gas fired) or biomass boilers. With CCS, gas boilers could be retained in difficult to retrofit houses, or for use in retrofitted houses during peak demand periods during cold weather snaps and if the electricity supply is reduced due to intermittency of renewables.

The impact in both the buildings and transport sector would increase the peak demand for **electricity** sharply and this increase would have to be met from a combination of nuclear and renewables. Because of the intermittency of renewables, and the possibility that peak demand from both the buildings and transport sectors coincides with low supply from renewables, considerable back up supply would be needed. Overall, the impact on the electricity sector is that without CCS the required total installed UK generation capacity is increased by more than 50% higher.