Green Alliance policy insight
March 2015

Decarbonising British industry

why industrial CCS clusters are the answer

by Dustin Benton

Summary

Carbon capture and storage (CCS) holds the promise of being a low cost, low disruption means of addressing the worst consequence of fossil fuel use: CO_2 emissions. Its successful development would reduce the cost of decarbonisation by enabling existing fossil fuel power stations to continue to operate. It is also the only currently feasible technology able to cut the emissions of many energy intensive industries.

The UK's approach to developing the technology focuses only on the first of these benefits: reducing the costs of electricity production. Funds to develop CCS are being directed through the electricity market, within a framework that encourages competition between renewables, nuclear and CCS, to identify the least cost technology for electricity production.

Unfortunately, CCS is currently lagging behind in the race: power sector demonstrations are at least five years late, public and political support for CCS is limited and the cost of the demonstrations is equal to, or more expensive than, offshore wind which is currently the most expensive of the highly scalable low carbon power options. The result is that current policy will not deliver cost effective CCS quickly, nor will it develop the technology in a way that is relevant to industry, a major potential beneficiary.

We argue that a new strategy for CCS, using existing power sector demonstration plants as anchors for industrial CCS clusters, could cut the cost of CCS by nearly two thirds per tonne of CO_2, and increase the amount of carbon captured by nearly nine times.

But there is a catch. Cost reductions come from capturing CO_2 from less expensive industrial sources, and sharing transport and storage infrastructure. This requires much greater investment. We calculate the total cost of creating a CCS cluster in the Humber to be around £20 billion, compared to approximately £5 billion, which the White Rose CCS plant, proposed for the Humber region, would cost on its own.

For government, the choice is clear: expand plans for CCS or run the increasing risk that it will not offer a cost effective route to low carbon power. More critically it would leave energy intensive industries without an obvious route to decarbonisation. If the government wants to reduce these risks we recommend that it should:

- Identify and support CCS clusters: using infrastructure developed for power sector demonstration projects to connect industrial emitters. This will mean supporting a greater number of carbon capture plants within cluster areas.
- Adapt CCS policy for industry: Creating competition between the different low carbon technologies of renewables, nuclear and CCS is a good strategy for the power sector. But, for industry, where CCS is the main technology option, a better approach would be to foster competition between different means of capturing CO_2.
- Create a new funding mechanism to support CCS clusters: Neither the EU Emissions Trading Scheme nor Contracts for Difference will drive investment in CCS clusters. The alternative is to commit to rising carbon price compensation payments, which won't help industry to decarbonise.

The benefits of a new strategy for CCS are clear. It would provide a technical solution to the problem of carbon leakage; a more attractive and broader target for supply chain investment; and a means for industry to address its carbon risks directly by plugging into an existing CO_2 network.

The limitations of current UK CCS policy

British climate policy has focused on decarbonising electricity supply before other sectors, starting in the 2010s and finishing by 2030.

The underlying assumption has been that decarbonisation beyond the power sector can wait. Cutting emissions from industry, agriculture and transport has widely been seen by policy makers as a 2030s problem, to be addressed by as yet undeveloped technology. Unfortunately, this assumption has proved to be false for industry: the downsides of not helping British industry to decarbonise are already being felt in three ways.

First, even though European carbon prices are so low as to be ineffective in stimulating low carbon technology development, important industries still have to pay for carbon. This puts them in a difficult position, having to seek compensation from the government for every rise in the carbon price.

Second, deployment of low carbon electricity across the UK will only help some parts of industry to decarbonise. Companies that produce CO_2 as a by-product of their industrial processes will continue to pay for the carbon they release, even if they use low carbon electricity.

Third, the assumption that industry will decarbonise in later decades has created the impression that future low carbon technologies will make low carbon steel, cement, lime, fertiliser, chemicals and related production easy and cheap. Unfortunately, evidence from the Carbon Trust suggests that industrial technologies take 30 years to reach mass deployment of;[1] and technologies other than CCS that might help address industrial emissions are mostly speculative.

"UK CCS policy is not focused on developing the technology in a way that will be cost effective or relevant to industry."

Why CCS is good for power but better for industry

Carbon capture and storage (CCS) can address industrial process emissions and limit industry's exposure to carbon pricing. However, UK CCS policy is not focused on developing the technology in a way that will be cost effective or relevant to industry. Instead, it is being developed primarily as an option for electricity decarbonisation.

Drawbacks of the UK's approach to CCS demonstration

The UK's CCS programme incorporates two of the most significant demonstration schemes in the world. They are essential to moving the technology into widespread use, but they suffer from a number of drawbacks in their current form.

- **The UK's demonstration projects will not be cost competitive with other forms of low carbon power by 2020.** It is unrealistic to expect a relatively new technology like CCS to compete with more established low carbon power generation; but there is already pressure to require all low carbon technologies to compete in technology neutral auctions early in the 2020s.[2] Any future constraints in the funding of low carbon electricity through the levy control framework in the next parliament could also lead to competition between the three low carbon electricity technology families being pursued by the UK: renewables, nuclear, and CCS. In such a scenario, more established and cheaper technologies, like onshore wind, could mean no funding is directed towards developing power sector CCS.
- **The UK's deployment of power sector CCS is now significantly off track.** The Committee on Climate Change (CCC), in its most recent progress report to parliament, concluded that the CCS deployment programme has been beset by severe delays, leaving it five years behind schedule.[3] It described CCS demonstration policy as "at risk", assigning the CCS indicator a red traffic light. Front end engineering and design (FEED) studies due to finish by 2010, with the first CCS project coming online in 2014, are now due to complete in 2015. The programme is due to deliver two demonstration plants by 2020, rather than the four plants set out in the coalition agreement and in the Committee on Climate Change's indicators. If support for these

two projects is removed and new projects have to be started from scratch, subsequent plants would not be operational until the mid-2020s at the earliest.

- **Political and public support for the technology is limited.** In the UK, the government earmarked £1.1 billion of public funding to develop CCS during this parliament, but has spent only about a fifth of this.[4] Across Europe, despite initial interest in CCS from a number of countries, only the UK and the Netherlands are pursuing demonstration projects. Norway, previously the most advanced CCS player in Europe, has slowed development of the technology following cost overruns in its Mongstad pilot plant and a lower oil price; and Poland, significant both in political and emissions terms, has delayed its proposed Tauron CCS project.[5,6] At an international level, the recent Lima climate conference saw unexpected NGO protests against CCS as part of a wider campaign for fossil fuel divestment.[7] And DECC's public attitudes tracker shows that less than a quarter of people surveyed supported CCS, compared to four fifths of people supporting renewables, but this is largely because most people had not heard of CCS.[8]

"Continuing to pursue CCS only for the power sector is a weak strategy."

A new strategy for CCS is needed

For all these reasons, continuing to pursue CCS only for the power sector is a weak strategy. We argue that, instead, policy should shift towards developing CCS as the technology most likely to keep industry competitive in a low carbon Europe, while also being a useful option for electricity decarbonisation.

Recasting CCS policy in this way would improve public support for the technology and fit with the government's goal to rebalance economic activity towards low carbon manufacturing. It would also give industry a stronger incentive to support and develop CCS, as it will directly serve its needs. The low carbon cluster being developed in the Tees Valley shows that progressive industry is already thinking along these lines. This would broaden the supply chain opportunity for potential CCS investors, who are essential in bringing costs down. If industry engages properly in the development of CCS, it could accelerate the cost reductions needed to make the technology more viable for the power sector.

Finally, although the public investment necessary to develop CCS will be relatively high, the only other way to assist UK energy intensive industry in an economy where the carbon price is rising is to provide continuing, significant compensation to the most affected businesses.

A new approach: CCS clusters

"The UK can increase the value of its existing investment in CCS demonstration plants by using power stations to create CCS industrial clusters."

The UK can increase the value of its existing investment in CCS demonstration plants by using power stations to create CCS industrial clusters. This makes economic sense because the projects will have to build pipelines and storage anyway and the cost of oversizing pipeline infrastructure is small compared to an incremental approach: a single oversized CO_2 transport pipe costs around £340 million, compared to the £1,000 million it would cost to develop incrementally the six single pipes required for a Humber cluster.[9] Transport and storage costs are over a quarter of the total cost of the CCS demonstrations. A range of research has shown that achievable, early cost reductions for CCS arise from increasing the scale and use of transport and storage, and that this is how costs can be brought down while improved capture technology is developed.[10]

To illustrate what this new approach to CCS in the UK could look like, we have outlined two options for the development of CCS in the Humber: one in which CCS is deployed as an electricity only technology as currently planned, and another which captures all the available CO_2 from local industries which have limited ability to decarbonise without CCS. All power sector costs are based on the CCS Cost Reduction Task Force's analysis of 'first of a kind' CCS projects.

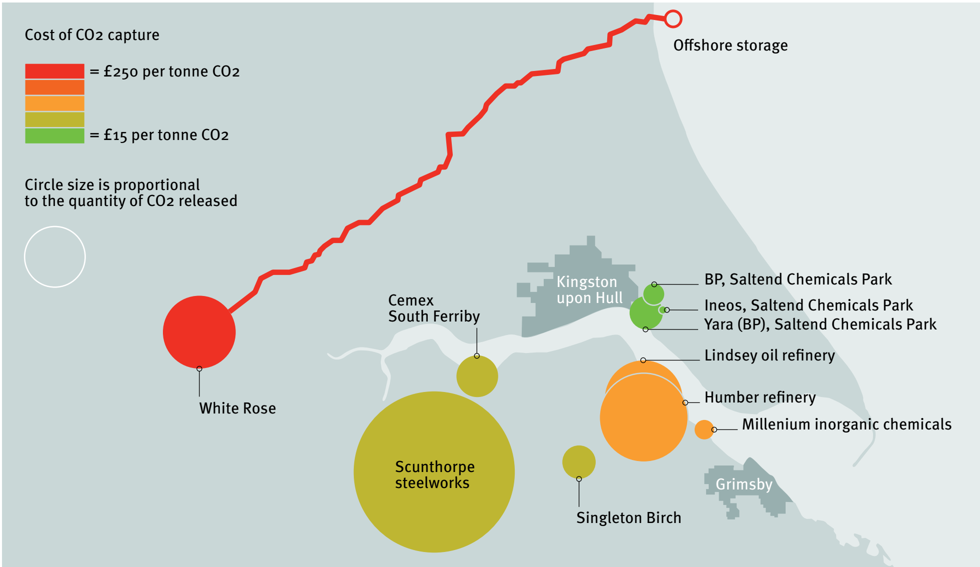
Electricity only CCS

£250/tCO2, capturing 1.5MtCO2/year
Total cost: £5 billion

The pipeline for the existing White Rose CCS demonstration project is already being designed to transport more CO2 than the power station will create.

An industrial CCS cluster
£91/tCO2, capturing up to 13MtCO2/year
Total cost: £20 billion

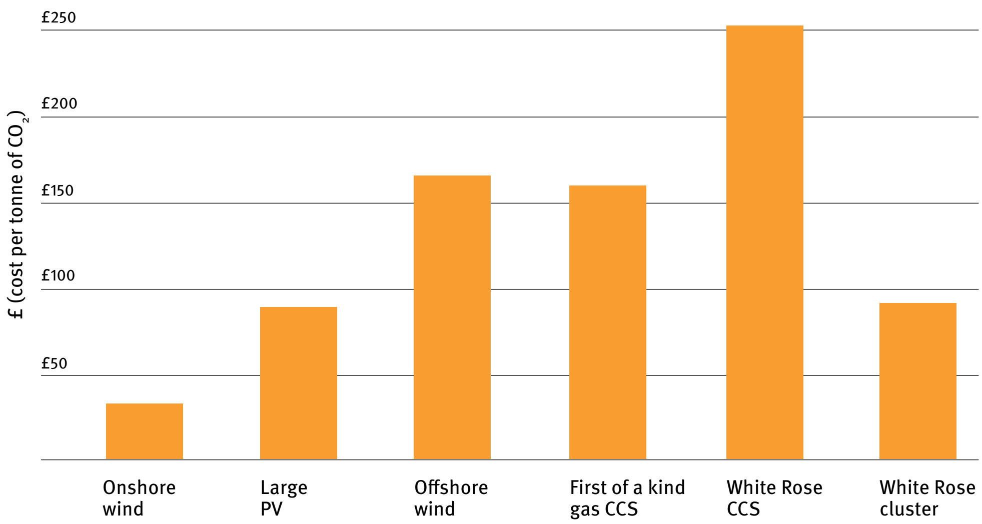
Industries in the vicinity of White Rose will almost certainly need CCS to decarbonise successfully, and sharing pipeline and storage infrastructure would make it cheaper.



Our calculations suggest that including industrial emitters in a cluster cuts the cost of CCS per tonne of CO_2 captured by nearly two thirds, from around £250 per tonne to around £90 per tonne. This could increase the amount of carbon sequestered by up to nine times the volume of the White Rose demonstration plant.[11]

A cluster could be much more cost effective than existing CCS demonstrations in terms of cost per tonne of CO_2. As the graph below shows, it would be competitive with the existing cost of other emerging decarbonisation technologies, including offshore wind and large scale PV.[12] Likewise, a cluster piggybacking on Peterhead's pipeline could see similar cost reductions.

Cost of CO2 abatement by different low carbon technologies[13]

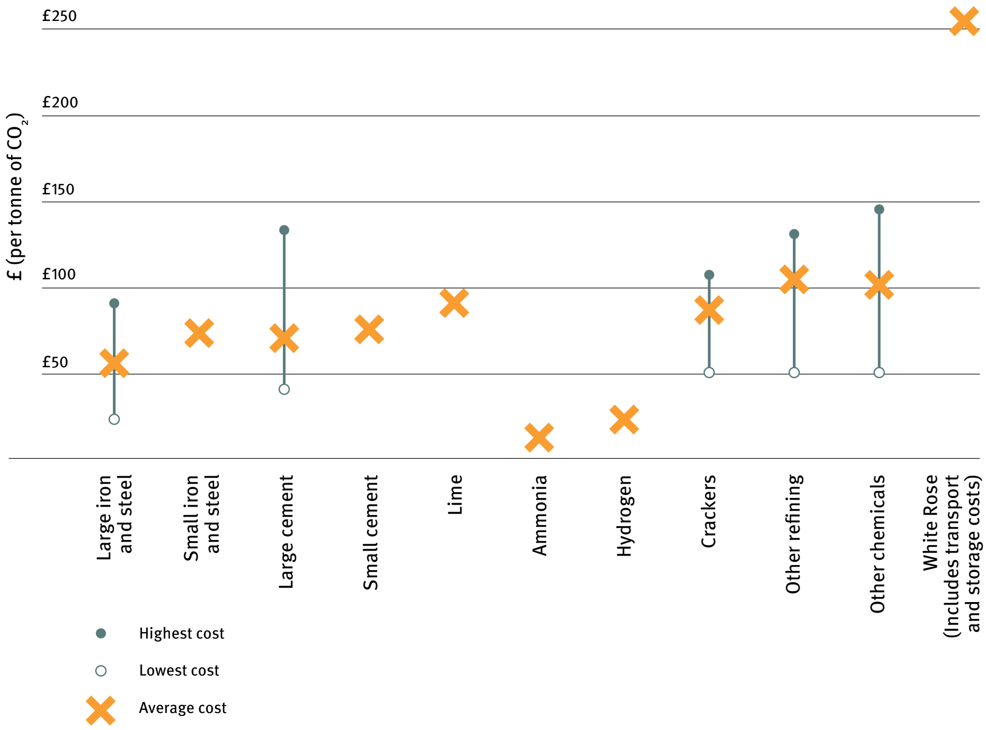


CCS clusters need greater investment

"Although it would need four times more investment than a single plant, a cluster would still be much more cost effective."

The White Rose project, as currently proposed, is likely to cost in the region of £250/tCO_2. This includes the full cost of capture, an oversized pipe designed to transport CO_2 from a number of sources, and a storage facility and associated infrastructure. By comparison, industrial capture, below shown excluding the costs of transport and storage, is more cost effective. The ability to add in industrial players to an existing transport and storage network as part of a cluster brings down the price per tonne of CO_2. However, as mentioned earlier, the investment needed for CCS cluster deployment is higher.

Cost of carbon capture for different industries, compared to the proposed cost of the White Rose plant (which includes transport and storage costs)



Our analysis suggests that the total investment cost of White Rose, if developed in its current configuration, would be around £5 billion over the 15 year lifetime of the contract for difference (CfD) that supports it.[14] This cost would be recovered partly via the electricity price, and partly by support delivered from the CfD. Using the same lifetime assumptions, turning it into a cluster would have a total cost closer to £20 billion (or £1.3 billion per year, assuming the projects are supported for 15 years).

Although it would need four times more investment than a single plant, a cluster would still be much more cost effective. It could store nearly nine times more CO_2 and cost close to two thirds less per tonne of CO_2, compared to a single plant.

The investment needed is high, but it would not be a uniquely large project for the energy sector: 2.2GW of offshore wind would cost £1.2 billion per year, and Hinkley C is predicted to cost around £2.3 billion per year. Both have strong support from government.[15]

Three steps to help UK industry decarbonise

The UK government can start to develop a new approach to CCS by using the two proposed power sector CCS demonstration projects as anchors for wider industrial clusters. This means building on the enabling approach it has already taken: indicating it will support oversized transport infrastructure, removing regulatory barriers to sharing infrastructure and providing support for companies to verify the amount of undersea CO_2 storage available.

But this enabling policy will not be enough on its own. The beginnings of a new approach can be seen in DECC's decision to fund the Teesside Collective, which is pursuing an overt clustering approach, linking potential CO_2 sources in a defined area.

A successful new policy should be built on three main pillars:

1.
Identify industrial CCS clusters

An explicitly geographical strategy should be replicated to form the first pillar of a new round of CCS policy, designed to decarbonise industry and power together. At present, clusters look impossible to create without having a CfD funded power station at the core of their development, because there is no other mechanism to fund CCS infrastructure. Future industrial clusters could be encouraged first in Teesside and then the Humber, using White Rose as an anchor. A cluster in the Forth estuary could use Peterhead as an anchor. Based on the pattern of UK CO_2 emitting industries, other clusters might be explored in the Liverpool Bay area and the Thames estuary.

In the short run, such a strategy would require government to set aside funding for industry led clusters, like it has done for the Teesside Collective. In the medium term, it could consider withdrawing carbon leakage list exemptions, which currently shield industry from carbon pricing, in areas where CCS infrastructure had been developed, and where there is no technical reason why the industry could not connect to the network. Such an approach would offer support to industry in the first instance, but would make it clear that it could not avoid addressing its carbon emissions indefinitely.

2.
Align energy, climate and industrial policy

"For industry, CCS is clearly the lead technology for carbon mitigation, and by a very substantial margin."

The second pillar of a new approach should be to broaden current CCS policy collaboration between the Department for Business, Innovation and Skills (BIS) and the Department of Energy and Climate Change (DECC). Existing CCS policy has been developed primarily by DECC. Policy tools it has designed for the power sector may not be appropriate for industry as they risk ignoring some of the crucial differences between power and industrial CCS projects.

On the negative side, industry 's investment horizons and appetite for risk may be more limited than the power sector. The international nature of both ownership and end markets for industrial players also makes it difficult for industry to raise finance and pass on the costs of CCS.

On the positive side, many industrial processes have changed more significantly over the past 20 years than those of the power sector. Some industry already uses chemicals similar to those required for CCS. And industries may also have access to broader international supply chain networks, providing opportunities to transfer innovation. Connecting DECC and its Office of Carbon Capture and Storage's work to BIS's policy responsibilities, including the industrial strategy, would enable policy to be adapted to industry's specific requirements.

This broadening of emphasis would require changes to the way CCS is framed in policy terms. For the power sector, CCS is one option among many. It is a good option which

"A new funding mechanism is needed to support the development of industrial clusters and increase the overall cost effectiveness of CCS."

has the prospect of cutting the costs of decarbonisation and stranding fewer existing assets. But energy policy over the past five years has been explicit in seeing CCS as a technology that could fail, especially if either renewables or nuclear power is a cheaper option. This assumption is much less relevant for industry, where, from a technical perspective, CCS is clearly the lead technology for carbon mitigation, and by a very substantial margin.

If CCS is the main technological option available to decarbonise certain industries, it makes little sense to avoid promoting CCS specifically. Instead, policy makers may take some comfort from the fact that CCS is a technology family, with at least five different mechanisms of capturing CO_2, and there are several options within each mechanism. Competition between technologies could, therefore, be fostered between different means of capturing CO_2.[16]

3. Create a new funding mechanism to support clusters

The third and most challenging pillar is funding. As the analysis outlined here demonstrates, reducing the price per tonne of CO_2 stored comes at the cost of increasing the total investment in a cluster.

There are two existing sources of potential funding for a CCS cluster: contracts for difference (CfDs), funded via a levy on electricity bills, and carbon pricing. Neither is likely to be up to the task of funding industrial scale CCS.

The ability to fund a whole cluster via CfDs seems very unlikely, both because the mechanism is only designed for electricity generators and because the total size of the levy control framework (LCF) is quite limited. Already, each existing CCS demonstration project will require around £130 million per year of LCF spending. To put this in context, East Anglia One, a 714 MW tranche of offshore wind, will require around £167 million per year in support. Adding industrial CCS into the LCF before 2020 would exacerbate existing funding constraints, which are already a source of concern in the electricity industry. This would potentially undermine successful renewables or displace funding for new nuclear.

This matters because existing policy in effect requires CCS power projects to pay for CO_2 transport and storage infrastructure which could be relatively cheaply oversized to support an industrial cluster. Unfortunately, the limits on LCF funding mean that project promoters may choose to undersize their infrastructure to lower the cost of their project, even if this raises the total cost of a cluster.

Furthermore, an equity issue is raised by funding industrial CCS via a consumer levy. Even setting aside the regressive character of the existing levy, it isn't clear that electricity consumers should be levied to pay for a low carbon technology that is not being used for electricity generation.

The other existing option, using the EU's Emissions Trading Scheme (ETS) to drive uptake of industrial CCS, looks weaker still. At between £6 and £7 per tonne, carbon prices are currently far too low to encourage industry to fit CCS. Given the historic volatility of ETS prices, it is not clear that price rises from proposed reform of the ETS would encourage investment.

Nor is the UK's carbon floor price likely to provide much incentive as its rise has already been delayed due to concern about industrial competitiveness. Both mechanisms are hobbled by the fact that government is effectively subsidising the cost of carbon for industry via its compensation scheme for energy intensive industries.[17] This may be sound short term industrial policy, but it is reducing incentives for industry to explore the use of CCS as a solution.

Therefore, we conclude that a new funding mechanism is needed to support the development of industrial clusters and increase the overall cost effectiveness of CCS.

Conclusion

"The main benefit of industrial CCS is that it would help UK industry to prepare for a much lower carbon economy."

Helping British industry to decarbonise is crucial to the shape and balance of the UK economy. For many industrial sectors, CCS is the leading and, possibly, the only technology able to do this. CCS is also a strategically important technology to limit climate change more broadly. The Intergovernmental Panel on Climate Change's AR5 synthesis report finds that "many [climate] models cannot reach about 450 ppm CO_2eq concentration by 2100 in the absence of CCS."[18] Similar analysis from University College London on the cost of decarbonisation finds that carbon prices would need to double in a world in which CCS was unavailable.[19]

The UK has an opportunity to create CCS clusters using existing power sector demonstration schemes, with significant economic and environmental benefits. However, the high upfront investment cost will require a bolder approach from government and a new funding mechanism.

Doing so would have three significant benefits. First, CCS clusters provide a technical solution to the problem of carbon leakage from industry. This should be more attractive to both policy makers and industry than the status quo, in which a rising carbon price requires expensive compensation payments, which have no prospect of decreasing over time and do not help industry to adapt to a low carbon economy. Payments are already going to be £400 million over the three years from 2013 to 2016, which is £150 million more than was originally promised for this period.[20] Similar payments are much higher in Germany: €9 billion (£7 billion) per year and UK industry has suggested that it should have equivalent levels of compensation.[21] This scale of cost is much greater than the annual cost estimation of even the biggest CCS cluster identified in this analysis.

Second, increasing the number of actors with a prospect of using CCS broadens the case for CCS supply chain investment in the UK, which would raise the amount of UK content in British CCS projects. In a similar sector, offshore wind, analysis by Cambridge Econometrics suggests that, of all factors affecting the GDP benefits of investment, the proportion of UK content is the most significant.[22] The same is likely to be true for CCS.

But the main benefit of industrial CCS is that it would help UK industry to prepare for a much lower carbon economy. CCS clusters which provide a plug-in solution to reducing carbon emissions would be an attractive prospect for international investors in a world which needs heavy industry but which will have to decarbonise rapidly to meet internationally agreed climate goals.

Endnotes

[1] James Smith, 28 March 2013, 'We can meet our low carbon energy goals', www.carbontrust.com/news/2013/03/we-can-meet-our-low-carbon-energy-goals

[2] See, for example, Policy Exchange and EEF's calls for early technology neutral auctions: www.policyexchange.org.uk/media-centre/blogs/category/item/4-ways-government-can-reduce-the-cost-of-renewables-support and http://www.environmentalistonline.com/article/2014-05-20/blog-cfd-auctions-are-good-news-for-business.

[3] Committee on Climate Change, 2014, 'Meeting carbon budgets – 2014 progress report to parliament', www.theccc.org.uk/publication/meeting-carbon-budgets-2014-progress-report-to-parliament/

[4] The government set aside £1 billion in capital grant support and £125 million in R&D support for CCS in this parliament. It has spent around £225 million.

[5] S Ala-Kurikka, 2 March 2015, 'Oil price plunge raises question over CCS in Norway', *ENDS Europe*, www.endseurope.com/39697/oil-price-plunge-raises-question-over-ccs-in-norway

[6] A Botzki, 13 November 2014, 'Commission unlikely to review CCS directive in 2015', *Interfax*, interfaxenergy.com/gasdaily/article/14174/commission-unlikely-to-review-ccs-directive-in-2015

[7] See: 350.org, 8 December 2014, 'Activists protest outside fossil fuel industry side-event at COP20', 350.org/press-release/activists-protest-outside-fossil-fuel-industry-side-event-at-cop20/; and C Linnitt, 10 December 2014, 'Fossil Fuel Industry Arguments for Carbon Sequestration Cause Uproar at COP20 UNFCCC Climate Talks', *DesSmogCanada*, www.desmog.ca/2014/12/10/fossil-fuel-industry-arguments-carbon-sequestration-cause-uproar-cop20-unfccc-climate-talks

[8] DECC, 29 April 2014, *Public attitudes tracker survey –Wave 9*, www.gov.uk/government/uploads/system/uploads/attachment_data/file/306898/summary_of_key_findings_wave_9.pdf

[9] Based on a single 16MtCO2/year pipe vs six 2.7MtCO2/year pipes. See: www.eti.co.uk/wp-content/uploads/2014/05/CCS-Infrastructure-Development-All-Energy-2014ff-Den-Gammer.pdf

[10] See, for example: Mott Macdonald, May 2012, *Potential cost reductions in CCS in the power sector*, ukccsrc.ac.uk/system/files/publications/ccs-reports/DECC_CCS_360.pdf

[11] In reality, not all the available emissions in the area could be captured immediately, the underlying cost analyses contain significant uncertainties, and the calculations don't include the small extra costs of feeder pipelines from industry to the main pipeline, but they do give a sense of how clustering would affect the price of CCS.

[12] Calculations of cost per tonne of CO_2 are based on DECC's maximum strike price for low carbon technologies, compared to DECC's expected cost of new CCGTs. They don't incorporate the results of the latest contracts for difference (CfD) auctions for two reasons: first, some project promoters have indicated that they will not deliver their projects at the strike price they achieved. See www.linkedin.com/pulse/we-got-our-cfd-oh-dear-james-rowe for details. Second, because the comparison is primarily about how much the government has decided it would be willing to pay for low carbon technologies and both CCS and other low carbon technology costs may fall.

[13] These costs are based on CfD strike prices for onshore wind, large PV and offshore wind. Power sector CCS costs are based on CCS Cost Reduction Task Force analysis for 'first of a kind' CCS power projects. Industrial CCS costs are based on metanalysis of CCS costs by Element Energy and Imperial College London. The costs are presented in £/tCO_2, abated solely to enable comparison between industrial and power sector technologies.

[14] CfDs provide support to low carbon technology for 15 years, for all technologies other than nuclear. In this analysis, we have used a 15 year period to enable a CCS cluster to be compared with the current proposals for CCS demonstration projects.

[15] These figures account for the full cost of the project, not simply the proportion that would be funded from CfD payments. The figures for GW capacity reflect different technologies which would mitigate different quantities of emissions. The point of the comparison is to show that similarly expensive projects have been supported by government.

[16] The technology families include absorption technologies, eg both chemical and physical solvents; adsorption technologies, including those using adsorber beds and pressure swing adsorption; solid looping, such as calcium looping; cryogenics and membrane based separation.

[17] DECC, 31 July 2014, 'Energy-intensive industries: compensation for indirect costs of energy and climate change policies', www.gov.uk/energy-intensive-industries-compensation-for-carbon-leakage

[18] IPCC, *Climate change 2014 synthesis report: summary for policymakers*, www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_SPMcorr2.pdf

[19] Private correspondence with Dr Christophe McGlade, co-author of: 8 January 2015, 'The geographical distribution of fossil fuels unused when limiting global warming to 2 °C', *Nature*, 517, 187–190, www.nature.com/nature/journal/v517/n7533/full/nature14016.html

[20] A £250 million fund for energy intensive industry was announced in 2011: see www.gov.uk/energy-intensive-industries-compensation-for-carbon-leakage. It has since been increased to £400 million: see www.ft.com/cms/s/0/2f9d78e6-c894-11e3-8976-00144feabdc0.html#axzz3TsN7IVk9

[21] See House of Commons Environmental Audit Committee, 4 January 2013, *Energy intensive industries compensation scheme*, www.publications.parliament.uk/pa/cm201213/cmselect/cmenvaud/669/669.pdf. In fact, German payments cover more than compensation for CO_2 costs, though this has not always been clear in the discussion of industry compensation.

[22] For details, see: Cambridge Econometrics, November 2012, *A study into the economics of gas and offshore wind*, figure ES.3, www.camecon.com/libraries/downloadable_files/a_study_into_the_economics_of_gas_and_offshore_wind.sflb.ashx

Green Alliance
36 Buckingham Palace Road
London SW1W 0RE

T 020 7233 7433
ga@green-alliance.org.uk

www.green-alliance.org.uk
blog: www.greenallianceblog.org.uk
twitter: @GreenAllianceUK

The Green Alliance Trust
Registered charity no 1045395
Company limited by guarantee
(England and Wales) no 3037633

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ISBN 978-1-909980-44-0

Acknowledgements
With thanks to Mia Rafalowicz-Campbell and Amy Mount for their research assistance.

Author: Dustin Benton

We are grateful to Green Alliance's energy consortium for supporting this work:

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