Business, Energy and Industrial Strategy Select Committee: Carbon capture, usage and storage (CCUS) inquiry

Decarbonised Gas Alliance response

August 2018

About the Decarbonised Gas Alliance

1. The Decarbonised Gas Alliance (DGA) is an alliance of gas producers, transporters, suppliers and users, hydrogen and carbon capture experts, alongside R&D, supply chain and local government specialists whose knowledge and expertise will be vital in decarbonising the UK's gas system and improving poor air quality.

2. Our aim is to work with all levels of government and with other expert organisations to use the gas system as a whole to help deliver our emission reduction and air quality goals. We believe that decarbonising gas would make best use of our existing infrastructure and lower the overall costs of decarbonisation.

3. The DGA is a broad-based alliance, established in late 2016, and has now expanded to over 40 signatory organisations, which are listed in full in the appendix, including their UK headquarter locations. The DGA secretariat is managed by DNV GL, a global specialist firm which provides certification and other technical assurance covering a range of energy sources.

4. The DGA is happy to nominate a spokesperson from one of our signatory organisations to provide oral evidence to the inquiry, if this would be useful for the Select Committee.

Summary

5. This response focuses on the answer to the first two questions of the inquiry. The key points in our response include:

    - The Committee on Climate Change (CCC) has stated that the cost of meeting the 2050 decarbonisation target could be twice as high without CCS.
    - Many industrial processes cannot be electrified, and direct CO_2 capture and the use of hydrogen in place of natural gas will be needed to decarbonise industrial clusters.
    - The gas network heats 84% of homes and meets winter heating peaks that are five times larger than winter electricity peaks, with the cost of gas only one third the cost of electricity for households and businesses. It will therefore be very difficult and costly to fully electrify heating, and the use of hydrogen in place of natural gas is a real alternative. To produce cost-effective low-carbon hydrogen at scale, the reformation of methane with CCUS will be needed.
    - Hydrogen is also important to decarbonise some areas of transport and improve air quality. Similar to heat, the reformation of methane with CCUS will be needed alongside electrolysis to produce sufficient, low-carbon and cost-effective hydrogen.
    - CCUS will also be necessary in the power sector to ensure that reliable, dispatchable power is available when needed.
    - Other organisations, such as the CCC and Imperial College London, have concluded that CCUS will be vital for hydrogen to play a full role in decarbonisation.

- To achieve net zero emissions, it is also likely that bioenergy with CCUS and greenhouse gas removal and storage technologies will be used to some extent.
- CCUS projects are taking place around the world, with advances in Texas, Canada and Japan in particular.
- The UK has a number of strengths upon which to build a CCUS industry. These include industrial clusters, ample CO_2 storage capacity in the North Sea and East Irish Sea, and a world-class oil and gas industry to help deliver the CO_2 storage in practice.
- In order for CCUS to be deployed at scale in the 2030s, at least two carbon stores need to be opened by 2025, taking CO_2 from the production of hydrogen, from industry directly, from gas-fired power generation, and from bioenergy with CCS.
- A number of studies – including by Poyry and for the National Infrastructure Commission – have shown that a decarbonised energy pathway with CCUS is far more cost-effective than one without. Already, there are planned CCUS schemes that have CO_2 abatement costs lower than nuclear and offshore wind.
- But ultimately, as for offshore wind and solar, there is no substitute for deployment to reduce the costs of CCUS.
- We therefore strongly support the CCUS Cost Challenge Task Force report, which recommended a commitment to have at least two CCUS clusters operational from the mid-2020s.

Q1: How essential is CCUS for the UK to meet its carbon emission reduction targets to 2050?

6. We believe that CCUS is essential for the UK to meet its 2050 carbon emission reduction targets in a practical and cost-effective way.

COMMITTEE ON CLIMATE CHANGE VIEW

7. Firstly, we note that the Committee on Climate Change (CCC) has repeatedly concluded that CCUS is vital, and that the costs of meeting the 2050 targets could be twice as high without it. In its response to the Clean Growth Strategy, the CCC stated: *"The Government should not plan to meet the 2050 target without CCS. A 'no CCS' pathway to even the existing 2050 target is highly challenging and likely to be much more costly to achieve. Furthermore, deeper reductions requiring the deployment of CCS will be needed to meet the aims of the Paris Agreement, whether by 2050 or subsequently."*[1]

8. The CCC went on to state: *"Carbon capture and storage (CCS) is part of the cost-effective pathway for an emissions reduction of 80% by 2050, and its absence could double the cost of achieving that reduction. CCS becomes even more important for deeper reductions by 2050 and is essential to reach net-zero emissions, committed to under the Paris Agreement."*[2]

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[1] Committee on Climate Change, An independent assessment of the UK's Clean Growth Strategy: From ambition to action, January 2018, p.10 https://www.theccc.org.uk/wp-content/uploads/2018/01/CCC-Independent-Assessment-of-UKs-Clean-Growth-Strategy-2018.pdf

[2] Committee on Climate Change, An independent assessment of the UK's Clean Growth Strategy: From ambition to action, January 2018, p.47 https://www.theccc.org.uk/wp-content/uploads/2018/01/CCC-Independent-Assessment-of-UKs-Clean-Growth-Strategy-2018.pdf

PRACTICAL RATIONALE

9. It is worth emphasising that the range of CCUS solutions being developed is now far wider than in 2015, when the previous Government cancelled CCS funding. There are a number of practical reasons why CCUS will be needed to facilitate deep decarbonisation in various sectors – in power generation, but also in heat, transport and directly in industry.

Industry

10. Many industrial processes cannot be electrified, due to the continuous, high grades of heat needed, and hydrogen may in some cases be an alternative to natural gas as a heat source. In addition, in the absence of low carbon feedstocks, significant quantities of CO_2 will result from these processes. CCUS will therefore be needed to decarbonise industry directly.

11. As the CCC has concluded: *"Industrial CCS can be done cost-effectively in areas in which there are sufficient volumes of CO_2, enabling development of CCS clusters that exploit economies of scale in infrastructure. This could be 'end-of-pipe' CCS, capturing CO_2 from the flues of industrial sites, but there could also be an important role for low-carbon hydrogen in achieving some of these reductions – low-carbon hydrogen production is also likely to require CCS."*

Heat

12. The gas network carries twice as much energy as the electricity network, and five times as much on cold winter evenings, when everyone turns the heating on. It provides heat to 84% of homes, and delivers energy to families, businesses and factories at only a third of the price of electricity.[3]

13. Peak electricity demand is up to 60 GW, but peak winter heat demand (currently 80% gas-based) is 350 GW.[4] Electrifying heating would therefore require enormous increases in generating capacity – equivalent to more than 30 Hinkley Point Cs[5] – and overhead transmission lines, and much of this new electricity infrastructure would lie idle in the summer when heating is not needed.

14. These practical factors show that fully electrifying heating would be very challenging and expensive. KPMG has calculated that an electric-only solution could cost an additional £274-318 billion by 2050, compared with a predominantly gas-to-hydrogen route costing £104-122 billion – both scenarios would meet the 80% carbon reduction target in 2050.[6] Installing electric heat pumps would cost £10,000 per home to change the central heating system,[7] and there are

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[3] Imperial College London, Centre for Energy Policy and Technology, Managing Heat System Decarbonisation: Comparing the impacts and costs of transitions in heat infrastructure, April 2016, Table 1 http://www.imperial.ac.uk/media/imperial-college/research-centres-and-groups/icept/Heat-infrastructure-paper.pdf; Department of Energy and Climate Change, United Kingdom housing energy fact file 2013, Tables 6a, 6b and 6d – data for 2011 (most recent year available) https://www.gov.uk/government/publications/united-kingdom-housing-energy-fact-file-2013; Department for Business, Energy and Industrial Strategy, Quarterly Energy Prices, December 2016, Tables 2.2.3, 2.3.3 and 3.4.1 https://www.gov.uk/government/statistics/quarterly-energy-prices-december-2016

[4] Data for 2010 – half-hourly heat demand; actual electricity demand. Robert Sansom, Decarbonising Low Grade Heat for a Low Carbon Future, Doctoral thesis submitted to Imperial College London, October 2014, Figure 20 https://spiral.imperial.ac.uk:8443/handle/10044/1/25503

[5] Richard Howard and Zoe Bengherbi, Too hot to handle? How to decarbonise domestic heating, Policy Exchange, August 2016 http://www.policyexchange.org.uk/images/publications/too%20hot%20to%20handle%20-%20sept%2016.pdf

[6] KPMG, The UK Gas Networks role in a 2050 whole energy system, July 2016 http://www.energynetworks.org/assets/files/gas/futures/KPMG%20Future%20of%20Gas%20Main%20report%20plus%20appendices%20FINAL.pdf

[7] Richard Howard and Zoe Bengherbi, Too hot to handle? How to decarbonise domestic heating, Policy Exchange, August 2016 http://www.policyexchange.org.uk/images/publications/too%20hot%20to%20handle%20-%20sept%2016.pdf

issues with some homes not meeting the necessary insulation levels for heat pumps to work optimally. Adding these costs to consumer bills risks driving significant numbers of people into fuel poverty. The deployment of "greener" gases such as biogas, syngas and hydrogen also results in far less disruption to households, making use of existing infrastructure including domestic installations, avoiding the need to replace entire central heating systems. A recent Imperial College report for the Committee on Climate Change on the economics of heat decarbonisation found comparable costs between decarbonised gas and electrification scenarios, assuming a high uptake in domestic thermal storage.[8]

15. The gas networks are being made suitable to transport hydrogen through the Iron Mains Risk Reduction Programme, and projects such as H21 and the BEIS Hy4Heat programme are investigating the practical implications of using 100% hydrogen for home heating and cooking. At the same time, the HyDeploy study is investigating whether hydrogen can be blended in the gas grid, at concentrations of up to 20% or more, while a Swansea University study has just concluded that hydrogen could be blended by up to 30% in the gas grid with no need to change appliances.[9]

16. A key challenge will be producing cost-effective hydrogen at sufficient scale. We believe that the most viable route to do this at scale is through reformation of methane with CCUS. Although electrolysis using low carbon electricity will have a role to play, it is likely to be a more costly route, especially given that periods of free electricity may be minimised by the use of smart electric car charging infrastructure, other demand-side response measures, and electricity interconnectors, as a recent Poyry study concluded.[10] According to figures presented in the recent hydrogen and fuel cells roadmap, with carbon capture and storage (CCUS), methane reforming is currently less than half the cost of producing hydrogen through electrolysis.[11]

17. Others have drawn similar conclusions, including the following. Imperial College: *"The most important precondition for using hydrogen would be the development of large scale, low cost production facilities. This could be by electrolysis of water, although this is currently very expensive and not yet suited to large scale production, or through conversion of natural gas by steam methane reformation (SMR) … SMR produces carbon dioxide as a by-product and its use would therefore be very dependent on the availability of CCS."*[12]

18. Committee on Climate Change: *"Hydrogen pilots can also begin and must be of sufficient scale and diversity to allow us to understand whether this can be a genuine option at large scale. As large-scale hydrogen deployment would require use of carbon capture and storage (CCS), a strategy for CCS deployment remains an urgent priority."*[13]

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[8] See https://www.theccc.org.uk/wp-content/uploads/2018/06/Imperial-College-2018-Analysis-of-Alternative-UK-Heat-Decarbonisation-Pathways-Executive-Summary.pdf

[9] See http://www.swansea.ac.uk/press-office/latest-research/30oftheuksnaturalgascouldbereplacedbyhydrogencuttingcarbonemissions.php

[10] Poyry, Fully decarbonising Europe's energy system by 2050, May 2018 http://www.poyry.com/sites/default/files/media/related_material/poyrypointofview_fullydecarbonisingeuropesenergysystemby2050.pdf

[11] E4tech and Element Energy, Hydrogen and Fuel Cells: Opportunities for Growth – A Roadmap for the UK, August 2016 http://www.e4tech.com/reports/hydrogen-and-fuel-cells-opportunities-for-growth-a-roadmap-for-the-uk/

[12] Imperial College London, Centre for Energy Policy and Technology, Managing Heat System Decarbonisation: Comparing the impacts and costs of transitions in heat infrastructure, April 2016 http://www.imperial.ac.uk/media/imperial-college/research-centres-and-groups/icept/Heat-infrastructure-paper.pdf

[13] Committee on Climate Change, Next steps for UK heat policy, October 2016 https://www.theccc.org.uk/publication/next-steps-for-uk-heat-policy/

Transport

19. The UK's air quality crisis has rightly been given considerable attention, and we applaud the progress in developing an electric vehicle infrastructure. But there are constraints that make full transport electrification difficult.

20. High take-up of electric cars (EVs) would put serious strain on local electricity networks, although charging at night could help to mitigate this. A standard 3.5 kW charger would more than double a household's normal peak usage of 2 kW. The My Electric Avenue project found that 32% of low voltage feeders (312,000 circuits) will require intervention when 40% – 70% of customers have EVs, based on 3.5 kW (16 amp) charging,[14] and the Green Alliance has estimated that just six "closely located" electric vehicles charging simultaneously at times of high demand would be sufficient to trigger local power shortages.[15]

21. In addition, battery-powered long-distance HGVs are some way from becoming viable, with the weight of the battery a major issue for payloads. And a number of rail electrification schemes have been cancelled recently, with electrification remaining an expensive solution for rail.

22. As a virtually zero-emissions fuel, hydrogen offers a number of transport benefits. It provides a similar driving range to petrol and diesel, with similar lengths of time to refuel. It is suitable for use by HGVs, without the weight issues of giant batteries. Hydrogen-powered trains are being trialled in Germany and will be introduced in the UK[16], and offer a far cheaper decarbonisation solution than further electrification for regional rail lines. And a mix of hydrogen vehicles and EVs would put less strain on local electricity networks.

23. Similar to the heat sector, a key challenge is producing sufficient quantities of low-carbon hydrogen. Hydrogen fuelling stations can be powered by on-site electrolysers, but to achieve sufficient scale for large vehicle fleets, we believe that methane reforming with CCUS will be essential.

Power

24. CCUS will also be needed in the power sector, as it would ensure the continued provision of reliable, dispatchable low-carbon power. Similar to nuclear, a gas-fired power station with CCS can operate continuously, but it has the advantage over nuclear of being able to ramp up and down far more quickly to meet demand, given increases in variable renewable generation. The extent of CCUS in the power sector will depend to some extent on the scale of the programme to replace existing nuclear reactors that are coming towards the end of their lives.

25. In addition, power projects can provide large volumes of CO_2 to provide an 'anchor' that enables transport and storage infrastructure to be developed, which can then be used by industry and smaller emissions sources.

Bioenergy with CCUS and greenhouse gas removal

26. Finally, we would note that, to achieve net zero emissions, it is likely that bioenergy with CCUS and greenhouse gas removal and storage technologies will be needed to some extent.

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[14] See http://myelectricavenue.info/sites/default/files/Summary%20report.pdf
[15] See https://www.ft.com/content/852dbb54-8411-11e7-a4ce-15b2513cb3ff
[16] Alsthom press release, 14 May 2018 http://www.alstom.com/press-centre/2018/05/alstom-confirms-plans-to-bring-hydrogen-trains-to-the-uk/

CCUS PROGRESS AROUND THE WORLD

27. CCS is taking place around the world. There are 21 projects operating at commercial scale today, including:

28. **Texas:** Two steam methane reforming plants in Port Arthur, Texas, have been retrofitted with carbon capture technology, and 1 million tonnes a year of CO_2 is now being captured and used.[17] In addition, the 50 MW NetPower gas-fired CCS power station demonstrator, using the Allam Cycle, is now in its testing phase.[18] US projects will be supported by staged increases to the 45Q tax credit that were agreed in the 2018 Budget: by 2026, the credit for CO_2 stored permanently underground will rise from $28 to $50 a tonne, while the rate for CO_2 used in enhanced oil recovery or other utilisation processes will rise from $17 to $35 a tonne over the same period.[19]

29. **Canada:** The Quest CCS project in Canada has been operating since November 2015,[20] and has stored over 1 million tonnes of CO_2 to date.[21] In addition, North West Refining's Sturgeon refinery will be the world's first to incorporate carbon capture from the outset and will use gasification technology to capture the CO_2 produced during the refining process.[22]

30. **Japan:** 2016 marked the start of CO_2 injection in April at the Tomakomai CCS Demonstration Project in Japan. The capture system uses emissions from a hydrogen production facility at Tomakomai port and is processing CO_2 at a rate of at least 100,000 tonnes per annum. The CO_2 is then injected into near-shore deep geologic formations.[23]

31. **Norway:** CO_2 has been stored offshore in Norway for more than 20 years. The Sleipner CO2 storage facility was the first in the world to inject CO_2 into a dedicated geological storage setting, and over 17 million tonnes has been injected since its inception in 1996. The Snøhvit facility has stored more than 4 million tonnes of CO_2 since 2008.

UK STRENGTHS TO BUILD UPON

32. The UK has excellent conditions to develop CCS at scale. Carbon capture infrastructure could be built around existing industrial clusters, including Teesside, Grangemouth, the North West and South Wales. UK offshore waters have ample CO_2 storage opportunities, estimated to be around 78 billion tonnes – simply utilising the top 15% of this storage capacity would be enough to meet entire UK needs for 100 years.[24] At the same time, the UK has a world class oil and gas industry with the expertise needed to deliver a CCS industry – and the Oil and Gas Technology Centre is available to channel and broker investments in technology development and testing offshore.

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[17] See http://www.globalccsinstitute.com/projects/air-products-steam-methane-reformer-eor-project
[18] See https://www.utilitydive.com/news/net-power-demo-plant-takes-key-step-toward-emissions-free-gas-generation/524674/
[19] See https://www.iea.org/newsroom/news/2018/march/commentary-us-budget-bill-may-help-carbon-capture-get-back-on-track.html
[20] See http://www.globalccsinstitute.com/projects/quest
[21] See https://www.gasworld.com/global-ccs-institute-applauds-shell-quest-ccs-milestone/2011423.article
[22] See https://nwrsturgeonrefinery.com/
[23] Global CCS Institute, The Global Status of CCS, 2016 http://hub.globalccsinstitute.com/sites/default/files/publications/201158/global-status-ccs-2016-summary-report.pdf
[24] Energy Technologies Institute, Pale Blue Dot, Costain and Axis, Progressing Development of the UK's Strategic Carbon Dioxide Storage Reserve: A Summary of Results from the Strategic UK CO_2 Storage Appraisal Project, April 2016 http://www.eti.co.uk/project/strategic-uk-ccs-storage-appraisal/

RECOMMENDATION

33. Our main recommendation is that in order to realise the Government's ambition to deploy CCUS widely in the 2030s, CCUS projects need to be up and running by the mid-2020s. We strongly support the CCUS Cost Challenge Task Force report, which recommended a commitment to have at least two CCUS clusters operational from the mid-2020s. These clusters should be taking CO_2 from the production of hydrogen, from industry directly, from gas-fired power generation, and from bioenergy with CCS. This would allow CCUS to play a full role in the deep decarbonisation of the four sectors highlighted above.

Q2: How should the government set targets for cost reduction in CCUS? How could CCUS costs be usefully benchmarked?

34. Our answer focuses on the second part of this question – benchmarking. Firstly, a number of studies have concluded that a decarbonised energy system that includes CCUS is far less costly than a decarbonised energy system without it. These include the CCC, as referred to in our answer to the first question, together with:

35. **National Infrastructure Commission:** Recent modelling for the National Infrastructure Commission on four decarbonised heat options (electrification through heat pumps, electrification through direct electric, hybrid gas-electric, hydrogen grid) concluded that a hydrogen grid would be the most cost-effective, costing £50 billion less than the next cheapest option (hybrid gas-electric), and costing less than half that of the two electrification options. The report identifies CCS as critical to the hydrogen grid option.[25]

36. **Poyry:** For Europe as a whole, a pathway to 2050 that includes decarbonised gas, with CCS in operation and widespread hydrogen production from methane, would be €1.15 trillion cheaper than a pathway relying on electricity only, and without CCS.[26]

37. **IPCC:** The IPCC has concluded that without CCUS, the cost of achieving the Paris Agreement objective of a rise in temperatures "well below 2 degrees" would be 138% higher on average – in moist models, the target actually could not be achieved without CCUS.[27]

38. Secondly, it is important to include the value of CCUS to the economy in any benchmarking exercise. A recent Summit Power report found that developing a network of CCS projects along the East Coast of the UK, capturing 75 million tonnes of CO_2 per year, would provide £163 billion of economic benefits through to 2060, outweighing the £34 billion of cost by a ratio of 5:1.[28]

39. Thirdly, it is worth noting that a number of projects that plan to use CCS at scale are already projected to be cost-competitive with decarbonisation through other routes. These include:

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[25] Element Energy and E4Tech, Cost analysis of future heat infrastructure options, Report for National Infrastructure Commission, March 2018 https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf

[26] Poyry, Fully decarbonising Europe's energy system by 2050, May 2018 http://www.poyry.com/sites/default/files/media/related_material/poyrypointofview_fullydecarbonisingeuropesenergysystemby2050.pdf

[27] Intergovernmental Panel on Climate Change, Climate Change 2014 Synthesis Report, referenced in the CCUS Cost Challenge Task Force report

[28] Summit Power, Clean Air – Clean Industry – Clean Growth: How Carbon Capture Will Boost the UK Economy: East Coast UK Carbon Capture and Storage Investment Study, October 2017 http://www.ccsassociation.org/news-and-events/reports-and-publications/clean-air-clean-industry-clean-growth/

40. **HyNet:** The HyNet project in the North West of England, which would convert industry to hydrogen and blend the remaining hydrogen in the domestic gas grid, would include the use of CCS to capture and store around 1.5 million tonnes of CO_2 a year in the Hamilton gasfield in the East Irish Sea. The project is aimed primarily at decarbonising industrial heat and is projected to have a total cost of abatement of £114 per tonne of CO_2. This includes the cost of a major new hydrogen production plant and a hydrogen distribution network, as well as the cost of dedicated infrastructure for CO_2 capture, transport and storage.[29] This compares favourably with abatement costs for nuclear (£125/tonne) and offshore wind (£131/tonne),[30] even though both technologies have benefitted from years of deployment.

41. **Teesside Collective:** The Teesside Collective project would take CO_2 which is already being separated from two existing industrial processes, and assumes the prior existence of large scale CO_2 transport and storage infrastructure. A study carried out by Poyry, which draws upon previous modelling undertaken by Amec Foster-Wheeler for the Teesside Collective CCS scheme, found that the total abatement costs for capture, transport and storage for the project would be £58 per tonne of CO_2.

42. Finally, as explained above, CCUS technologies exist today, and they will reduce in cost through scale-up and deployment. This is no different to the cost reductions we have seen in, for example, offshore wind and solar. Although activities such as R&D covering the various elements of the CCUS chain, and greater cross-sector collaboration, are important, ultimately there is no substitute for deployment to reduce costs.

[29] Cadent, HyNet North West: From vision to reality, 2018 www.hynet.co.uk
[30] Cadent, The Liverpool-Manchester Hydrogen Cluster: A Low Cost, Deliverable Project, Technical Report by Progressive Energy Ltd, August 2017 https://cadentgas.com/getattachment/About-us/Innovation/Projects/Liverpool-Manchester-Hydrogen-Cluster/Promo-LMHC-downloads/Technical-Report.pdf

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