The Energy Institute (EI) welcomes the opportunity to make the following submission to the Business, Energy and Industrial Strategy Committee on carbon capture, usage and storage (CCUS).

1. About the Energy Institute

The Energy Institute (EI) is the chartered professional membership body bringing global energy expertise together.

We're a unique network with insight spanning the world of energy, from conventional oil and gas to the most innovative renewable and energy efficient technologies.

The global energy industry, the people working in it and wider society all benefit from the EI's work. We gather and share essential knowledge about energy, provide the skills that are helping us all use it more wisely, and develop the good practice needed to keep it safe and secure.

We articulate the voice of energy experts, taking the know-how of around 20,000 members and 250 companies from 120 countries to the heart of the public debate.

And we're an independent, not-for-profit, safe space for evidence-based collaboration, an honest broker between industry, academia and policy makers.

2. Energy Institute response

2.1. This response is based on views of EI members, collected via several member engagement activities about the role of CCUS technology in the UK's energy system, including:

- 'The Future of gas – The role of natural gas in the future energy system' report, based on a survey conducted by the EI. A total of 189 professionals from the oil and gas sector completed the survey online in January 2018.

- The Energy Barometer 2018, an annual survey of the EI College, a group of EI professional and pre-professional members. A total of 406 members (a sample size representative of EI professional and pre-professional members) completed the survey online in February 2018.

- Past editions of the Energy Barometer surveys conducted between 2015-2017.

- Discussion at the International Petroleum Week conference in London, February 2018.

- Ongoing consultation and engagement with industry specialists and subject matter experts.

- Other industry reports and analyses.

3. Executive Summary

3.1. Energy professionals associate the CCUS projects currently in operation abroad with policy incentives that are sufficient for companies to carry out capture and storage of carbon dioxide. Future large-scale deployment of CCUS in the UK will require similarly well-defined regulations and economic incentives.

3.2. In common with major industry forecasts, EI members believe that natural gas can retain a significant long-term role in the UK and global electricity and industrial supply mix, given its global abundance and flexibility which complements the intermittency of renewables. The long-term role of gas could be significantly greater given greater efforts to reduce fugitive methane emissions and the right policy environment to encourage cost reduction and implementation of CCUS technologies.

3.3. Development and deployment of CCUS technologies are of crucial importance in heavy industries such as iron and steel, chemicals, refining, cement and aluminium, due to the integral role of fossil fuel in those industrial processes. Decarbonising industries will require policies to look beyond renewables and energy efficiency and focus on CCUS technologies.

3.4. To meet the Paris climate change targets of holding the rise in global average temperature to well below 2°C, it seems likely that significant negative emissions will be needed globally, starting at scale from the 2030s. At present one of the most feasible options seems likely to be net removal of CO2 from the atmosphere through biomass conversion to electricity with CCS (BECCS).

3.5. While CCUS technologies are technically available, their development and cost reduction has been undermined by a combination of market and policy barriers. Energy professionals identify several cost-effective measures to overcome the barriers and to progress towards deploying CCUS at significant scale.

3.6. The discussion about the cost of CCUS projects is often conducted at the expense of consideration of the wider systemic value of the technology. Although CCUS is proving politically difficult to deliver in terms of near-term affordability, neither the Climate Change Act 2050 target in the UK nor the targets underpinning the Paris Agreement are affordable without CCUS.

3.7. In terms of other key measures to meet climate change targets, EI members single out energy efficiency as the key to a more productive economy and to cutting carbon at least cost. Energy professionals also identify supporting renewable energy and decarbonising transport as other measures to be prioritised by the Government to meet emissions reduction targets at least cost. However, these should not be perceived as alternatives to CCUS, rather as complementary measures.

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

4.1. EI members have repeatedly stressed the key role that CCUS technology needs to play in meeting the UK's emission reduction targets. In successive Energy Barometer surveys, CCUS has been identified as one of the technologies with the greatest potential for decarbonising and transforming the energy system. Such views closely align with other high-profile assessments, including:

- the Committee on Climate Change's (CCC) assessment of UK's Clean Growth Strategy[1]

- the CCC's advice on the 5th Carbon Budget[2]

- the CCC's report on the UK Climate action following the Paris Agreement[3]

- Lord Oxburgh's report to the Secretary of State for Business, Energy and Industrial Strategy from the Parliamentary Advisory Group on Carbon Capture and Storage (CCS) on the lowest cost decarbonisation for the UK[4]

- International Energy Agency report on 20 years of CCS technologies[5]

- Imperial College London Sustainable Gas Institute's White Papers series on the role of natural gas in future sustainable energy systems[6]

- UCL's report commissioned by Global CCS Institute on the potential contribution of CCS to a low carbon world, and the policies that may support that contribution.[7]

4.2. Energy professionals' positive perception about the role of CCUS technologies is not based on wishful thinking but derives from their recognition that CCUS technologies are already technically feasible and in operation. All components of integrated CCUS systems exist already and are in use today in fossil fuel extraction and refining.[8] Moreover, the advancement in CCUS technologies has been demonstrated in around 20 CO_2 storage projects operating globally, mainly in the United States and Canada but also in Norway, Brazil, Saudi Arabia and United Arab Emirates.[9] A similar number of facilities are under development, including projects in China and Australia. The developments are in industries such as power, natural gas processing, iron and steel and production, refining and chemicals.

4.3. The range of CCUS projects already in operation demonstrates that CO2 may be injected and stored safely deep underground.

4.4. However, those operating projects are typically cases where the addition of CCUS is a relatively small incremental investment due to the nature of the existing process, or where captured CO_2 has a commercial value.[10] Nevertheless, the projects result from policy incentives that are sufficient for

[1] https://www.theccc.org.uk/wp-content/uploads/2018/01/CCC-Independent-Assessment-of-UKs-Clean-Growth-Strategy-2018.pdf
[2] https://www.theccc.org.uk/publication/the-fifth-carbon-budget-the-next-step-towards-a-low-carbon-economy/
[3] https://www.theccc.org.uk/publication/uk-action-following-paris/
[4] http://www.ccsassociation.org/news-and-events/reports-and-publications/parliamentary-advisory-group-on-ccs-report/
[5] http://www.iea.org/publications/freepublications/publication/20YearsofCarbonCaptureandStorage_WEB.pdf
[6] https://www.sustainablegasinstitute.org/white_paper_series/
[7] http://hub.globalccsinstitute.com/sites/default/files/publications/201833/report-role-ccs-meeting-climate.pdf
[8] IPCC Fifth Assessment Report – Mitigation of Climate Change http://ipcc.ch/report/ar5/wg3/
[9] Global CCS Institute, https://www.globalccsinstitute.com/projects/large-scale-ccs-projects
[10] The role of CCS in meeting climate policy targets, A report commissioned by the Global CCS Institute and produced by University College London, October 2018

companies to carry out storage of CO_2. Hence our view that the large-scale future deployment of CCUS in the UK requires both well-defined regulations and economic incentives.

4.5. Energy professionals are realistic that, although the energy system is undergoing a long-term transition to low carbon, the era of fossil fuel is not yet over. For example, the IEA's World Energy Outlook 2017 predicts that global demand for natural gas will grow by an average 1.6% a year to 2023[11]; likewise, an annual average growth in oil consumption of about 1.4% is predicted. The BP Energy Outlook 2018 expects that natural gas will grow strongly by 2040, supported by broad-based demand and the continuing expansion of liquefied natural gas (LNG).[12] Another industry outlook foresees that oil and gas will be still crucial components of the world's energy future, accounting for 44% of world energy supply in 2050, compared to 53% today.[13]

4.6. Given this, EI members believe that CCUS deployed at the point of combustion has the greatest potential of any of the major technologies to reduce emissions in the natural gas lifecycle. The more cleanly gas is produced and used, the bigger the benefit in tackling climate change. In common with major industry forecasts, EI members believe that natural gas can retain a significant long-term role in the UK and global electricity and industrial supply mix, given its global abundance and flexibility which complements the intermittency of renewables. The long-term role of gas could be significantly greater given greater efforts to reduce fugitive methane emissions and the right policy environment to encourage cost reduction and implementation of CCUS technologies.

4.7. Furthermore, the development and deployment of CCUS technologies are of crucial importance outside of power generation. In fact, the case for CCUS is arguably stronger for heavy industries such as iron and steel, chemicals, refining, cement or aluminium, which account for around 17% of the UK's greenhouse gas emissions.[14] In contrast to power generation, there are limited alternatives, due to the integral role of fossil fuel in these industrial processes. Currently, most of the energy needed in such processes is in the form of heat – usually from combustion of natural gas and coal - which cannot be easily replaced by alternative low carbon fuel sources. Decarbonisation of industries therefore requires policies to look beyond renewables or energy efficiency and to focus on CCUS, as the best available option.

4.8. Initiatives such as the Teesside Collective in Tees Valley have worked hard to demonstrate the potential for a communal approach to equipping industrial zones with CCUS technologies in which infrastructure and knowledge is shared. We are looking forward to seeing more work done by potential CCUS clusters, as indicated in the recently published 'Delivering Clean Growth: CCUS Cost Challenge Taskforce Report'[15].

[11] https://www.iea.org/newsroom/news/2018/june/the-gas-industrys-future-looks-bright-over-next-five-years-according-to-iea-ana.html
[12] https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/energy-outlook/bp-energy-outlook-2018.pdf
[13] https://eto.dnvgl.com/2017/oilgas
[14] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/679334/2016_Final_Emissions_Statistics_one_page_summary.pdf
[15] https://www.gov.uk/government/publications/delivering-clean-growth-ccus-cost-challenge-taskforce-report

4.9. The Energy Institute also welcomes the CCUS Cost Challenge Taskforce's recommendation that the Government and industry should promote international cooperation and the development of pan-European CO_2 storage service. Achieving global emission targets is going to require global action in all low carbon technology areas, in particular CCUS where barriers have so far stood in the way of significant deployment. EI members position themselves in agreement with the Global CCS Institute's argument that Paris climate change targets cannot be met without CCS[16].

4.10. EI member opinion aligns with further studies that suggest net-zero or net-negative emissions will be needed to meet the Paris targets to hold the rise in global average temperatures to well below 2°C, let alone 1.5°C. It seems likely that it will be essential globally to achieve significant negative emissions, starting at scale from the 2030s. At present one of the most feasible options seems likely to be net removal of CO_2 from the atmosphere through biomass conversion to electricity with CCS (BECCS). The Energy Technology Institute points out that by 2050 BECCS could deliver around 55 million tonnes of net negative emission per annum in the UK, which accounts to roughly half the country emissions target in 2050[17]. Government support will be vital for initiatives such as Drax's pilot BECCS project at its power station in North Yorkshire. The positive response from Minister of State for Energy and Clean Growth, Claire Perry was encouraging.[18]

4.11. Those sceptical of the case for CCUS have cited the following objections:

4.11.1. that CCUS would "have already taken off if it was so good, just like solar and wind." This fails to recognise that CCUS involves much larger capital cost and requires longer term investment than solar and onshore wind projects, so needs absolute clarity about long-term policy support if it is to be developed.

4.11.2. that CCUS "is clearly too expensive." The surprisingly large cost reductions achieved in offshore wind are an excellent demonstration of the cost reductions achievable by sustained learning curves and deployment at scale, which should be similarly achievable with CCUS given a similarly sustained level of policy support and deployment. See point 5.7 below for further information on the cost of CCUS.

4.11.3. that deploying CCUS using the lowest cost CO_2 storage option of onshore saline aquifers "cannot guarantee containment forever and so will not be societally acceptable." From an efficacy point of view, the containment concern fails to recognise that 100% long-term containment is not essential, as long as the frequency/rate of any loss of containment is sufficiently small and monitored. Long-term CO_2 storage has been proven geologically feasible in various existing CCS projects. From a safety risk point of view, CO_2 is only a health hazard in quite exceptional circumstances that would be precluded in properly designed underground storage. The issue of societal acceptance needs more careful study and informed engagement before clear conclusions can be drawn.

[16] https://www.globalccsinstitute.com/sites/www.globalccsinstitute.com/files/content/mediarelease/123543/files/global-status-ccs-2017.pdf

[17] https://d2umxnkyjne36n.cloudfront.net/insightReports/The-Evidence-for-Deploying-Bioenergy-with-CCS-in-the-UK.pdf?mtime=20161107110603

[18] https://www.theguardian.com/environment/2018/may/21/drax-power-station-to-lead-fresh-carbon-capture-trial

5. How should the Government set targets for cost reduction in CCUS? How could CCUS costs be usefully benchmarked?

5.1. While CCUS technologies are technically available, the pace of development and deployment in the UK has been undermined by a combination of market and policy barriers.

5.2. EI members call for more action to tackle high investment risk caused by policy uncertainty in the CCUS area. Between 60-70% EI members think there is high or very high investment risk due to policy uncertainty in CCUS and other immature low-carbon technologies.

5.3. Energy professionals identify several cost-effective measures that should be pursued to support progress towards deploying CCUS at significant scale, including: provision of a stable policy framework, provision of government funding for demonstration projects, or setting sufficiently high carbon price and allowing the market to bring it forward.

5.4. Considering our members priorities, the Energy Institute welcomes the measures contained in the Clean Growth Strategy, including plans to invest £100 million in CCUS innovation and the establishment of a new CCUS Council to facilitate partnership with the industry. We also welcome the formation of the BEIS CCUS Cost Challenge Taskforce and its policy recommendations for unlocking industry action and investment. We look forward to the Government CCUS Deployment Pathway planned by the end of 2018.

5.5. In advance of the Government's Review of Delivery and Investment Frameworks for CCUS, we would like to stress that, even with cost reductions, there will be cost and investment risk that cannot be entirely borne by the market. In light of the Cost Challenge Taskforce's recommendation that the Government and industry should agree on risk allocation for CCUS projects and consult with the finance community, we agree with the former President of the Energy Institute, Professor Jim Skea that without a sufficiently high carbon price, the investment risk should be underwritten by the Government.[19]

5.6. In the past, EI members expressed their disappointment with the cancellation by the Government of the £1bn CCUS competition. With new projects such as Teesside Collective, Caledonian Clean Energy and Drax BECCS coming forward, we observe that the Government's approach is becoming steady, predictable and inclusive. This is welcome, as we believe the UK CCUS industry is worthy of more consistent support than it has received previously. But energy professionals do have concerns about the level of funding committed in the Clean Growth Strategy, which they see as too modest to bring about long-term cost reduction and deployment of the technology.

5.7. The discussion about the cost of CCUS is often conducted at the expense of consideration of the wider systemic value of the technology. It is essential to remember that, although CCUS is proving politically difficult to deliver in terms of near-term affordability, neither the Climate Change Act 2050 target in the UK nor the targets underpinning the Paris Agreement are affordable without CCUS. As stressed by the Committee on Climate Change, "A 'no CCS' pathway to (…) the existing 2050 target is

[19] https://www.carbonbrief.org/carbon-brief-interview-prof-jim-skea

highly challenging and likely to be much more costly to achieve."[20] According to the IEA's estimation, the transformation of the power sector without CCS would be at least USD 3.5 trillion more expensive.[21] Ironically, cost reductions will likely be achieved only through actual deployment at scale. The sooner we move on this, the cheaper it is likely to be.

5.8. Consideration of CCUS should also be made in the context of its likely role as a crucial technology globally – and one in which UK companies are well placed to compete. Indeed, the potential for UK-developed CCUS in international markets is likely better than for UK-developed solar or even wind. CCUS projects will require the right blend of gas processing technology, large-scale infrastructure and engineering design, financing, and project management that have been the hallmarks of the success of UK oil and gas companies in supporting global supply chains.

6. If CCUS costs do not come down "sufficiently", what alternatives should the Government consider to meet the UK's climate change targets? How might the cost of these compare with CCUS?

6.1. The Energy Institute believes that the Government shouldn't consider other key decarbonising measures as alternatives to CCUS. Given the huge challenge of achieving UK and global targets, all measures seem likely to be needed.

6.2. In terms of other key measures to meet climate change targets, EI members single out energy efficiency as the key to a more productive economy and to cutting carbon at least cost. Energy professionals also identify supporting renewable energy, decarbonising transport and supporting nuclear energy as other measures to be prioritised by the Government to meet emissions reduction targets at least cost.

7. Conclusion

7.1. Most climate models, including those of the CCC in the UK and IPCC internationally, rely heavily on the use of CCUS to meet emissions targets and indicate that meeting the targets without CCUS comes at a significantly higher total cost. The Global CCS Institute's 2017 report on the *The role of CCS in meeting climate policy targets* stated that "Policy makers' decisions as to whether to pursue CCS should be based on a judgement as to whether the risks and uncertainties associated with attempting to deploy CCS outweigh the risks of not having it available as part of a future portfolio of mitigation options, in future years."[22]

7.2. The development of CCUS requires close cooperation between industry, government and academia in the UK and internationally. The EI urges discussion about the relative roles of each in CCUS development and deployment and would be very happy to coordinate any such discussions.

[20] https://www.theccc.org.uk/wp-content/uploads/2018/01/CCC-Independent-Assessment-of-UKs-Clean-Growth-Strategy-2018.pdf
[21] http://www.iea.org/publications/freepublications/publication/20YearsofCarbonCaptureandStorage_WEB.pdf
[22] http://hub.globalccsinstitute.com/sites/default/files/publications/201833/report-role-ccs-meeting-climate.pdf