Submission on Carbon Capture and Storage, UK Government decision on Scottish Cluster, Net Zero and Hydrogen

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1) Carbon Capture and Storage, definition, application

1) Carbon capture and storage (CCS) is used to describe an assemblage of technologies and activities which enable capture of carbon dioxide from a mixture of gases, purification, transport by shipping or pipe or tanker; followed by injection of liquefied pressurised CO2 into permanent storage within the pore space of geological formations deep underground.

2) Although the term CCS is frequently used to describe CO2 capture from fossil fuel power plant, the activity of CSCS can and does extend much more widely and includes separation of CO2 produced by processes in fundamental industries such as industrial chemicals, fertiliser manufacture, cement making, steelmaking, glassmaking. In addition, CCS can be applied to capture of biologically derived CO2 from fermentation making alcohol, from agricultural anaerobic digestion, from combustion of woody biomass (BECCS) or municipal organic wastes to provide heat. The industrial splitting of methane gas to make “blue” hydrogen also produces CO2. Separation of CO2 from ambient air, by Direct Air Capture (DAC) leading to storage is also often grouped with CCS – although is better described as Greenhouse Gas Removal (GGR).

3) The application of different types of CCS has been operated since the 1920s in chemical industry processes and separation of CO2 to transport, followed by injection into porous rocks deep below ground has been operated by the hydrocarbon industries since the early 1970s. These are industrial-scale projects at 1Mt/yr (million tonnes per year) or more, with the largest capturing and storing 7MtCO2/yr.

4) The industry research body Global CCS Institute compiles a global status annually of active projects. In 2021 this records 40 million tonnes CO2 per year captured in 2020, increasing to 49.8 MtCO2/yr captured in September 2021, and multiple additional projects planning a further 60.9 MtCO2/yr in preparation. Declaring Net Zero emission ambitions, particularly by industrial economies, to support the binding Paris 2015 UN climate protection 2°C limit has led to CCS being mentioned in 83% of national long-term strategies.

2) Operating and planned examples of CCS

5) Local to the UK, CCS has been operated on offshore hydrocarbon platforms by the Norwegian company Equinor, since 1996 at Sleipner in the central North Sea, and since 2008 at Snohvit in the Barents Sea. These each separate hydrocarbons from a mixture of about 10% natural CO2. The CO2 is securely injected into porous sandstones, where it is accurately monitored to understand its movement and natural containment. These projects, demonstrate the routine industrial scale of CO2 separation, transport, and secure storage. The impetus for these actions is a climate protection tax in Norway on offshore emissions of CO2, set at around £42/ton – the CCS activity of separation, purification, pipeline and injection through specialist boreholes is priced at less than this tax.

6) Based on the confidence and knowledge gained from 24 years of operation, Equinor is now designing and constructing a commercial CCS operation to fulfil the low carbon ambition of the Norwegian government. This Longship project will receive CO2 captured from Norwegian cement industry, and from energy to waste combustion in Oslo and will transport and store that offshore of Bergen. This project will operate 1.5MtCO2/yr injection from 2023. This will also offer commercial CO2 storage to other countries for the first time in the world. Specialist Norwegian shipping will collect CO2 from coastal sites of industry, and transport that for storage beneath Norwegian territorial waters. The business valuation of this project discovered enquiries from customers which totalled CO2 approximately 10 times the annual design capacity of Longship project. There is a huge unmet demand for CO2 storage around the North Sea, creating profitable green jobs for many decades.

7) Netherlands has also reached advance planning to develop CO2 storage offshore, using the PORTHOS project offshore of Rotterdam as part of the national NetZero pathway. This will store 2.5 MtCO2/yr in depleted gas fields, operating from 2024

3) UK development of CCS

8) The UK has undertaken industrial, academic and government research and development on CCS since the early 2000's. The UK has undertaken at least four cycles of CCS evaluation in Scotland – at Grangemouth refinery in the late 1990's, at Peterhead power plant in 2007, at Lonagnnet power plant in 2012, again at Peterhead in 2015, and currently with Acorn project including all industries from St. Fergus to Grangemouth. The current UK government seeks to reach Net Zero before 2050. Decarbonising industrial clusters as part of this ambition, and two projects have been awarded in 2021, to HyNet in the Mersey region, and to "East Coast Cluster" in Teesside and Humberside. These are intending to build CO2 capture and storage facilities for many million tonnes CO2 per year.

9) The current UK government is operating an industry decarbonisation strategy, which is intended to remove CO2 emissions from all sectors of the industrial economy before 2050. Taken together with additional actions to decarbonise surface transport, and to continue decarbonisation of electricity, and to replace methane use by using manufactured hydrogen, the pathway is intended to

reach net zero emissions for the UK by 2050. Explicit in these plans is the construction and operation of very large CCS operations. In 2021 bidding consortia to become the first two regional clusters of industrial activity were awarded government support to move to design and intended construction of facilities to capture and store multiple millions of tonnes CO2 starting from the mid-2020s.

4) Why is CCS needed in Scotland?

10) Pathways to NetZero for Scotland have been modelled by the UK Climate Change Committee. In all these models, the introduction of CCS enables a NetZero balance of emissions and storage to be obtained. GGR is also needed, enacted by BECCS or DACCS. Even very optimistic projections of tree planting or peatland restoration, can not balance the CO2 storage required for NetZero, CCS is essential. On the anticipation of accessible and early date storage, the CCC recommended a 2045 Net Zero date for Scotland, and that was placed into law by the Climate change (Scotland)Act 2009. Ironically it is now an action by UK Government disabling CCS, which makes Scotland unable to attain a target recommended by the UK advisory body

5) Why Acorn was not selected

11) Acorn has long been recognised as being the best-investigated and most mature of all the UK decarbonisation clusters. It is also low risk, because the pipelines exist, the storage site is very well investigated, and minimal new infrastructure is needed. Acorn also opens up access to 80% of the geological storage around the UK, of many diverse geological types, providing the highest chance of developing secure storage geology. And Acorn can rapidly develop supplies of CO2 by shipping from sources around the UK – Wales, Southampton and London, as well as from around the North Sea and Baltic coasts. And Acorn provides resilience to other east coast UK and Norwegian or Netherlands sites – in case of temporary or longer shutdown, shipping can be quickly diverted to Acorn. However none of these attributes were designed into the BEIS project scoring matrix as important.

12) To evaluate rival bids for part of the £1Bn CCS Infrastructure Fund, BEIS devised a scoring template for different attributes of a proposed decarbonisation cluster; each attribute with a high or low potential mark. Expressions of Interest were made by Cluster bidders in April, but the marking criteria were not announced until later – in submission guidance dated May with Track 1 bids submitted by 9 July. Bids are to gain CapEx support for build costs and Business model support for OpEx costs of transport and Storage, industry capture, hydrogen and shortage of CO2 through the cross-chain liability.

13) When cluster bids were called for and evaluated the May 2021 BEIS document stated an ambition of 10MtCO2/yr by 2030. However by October 2020, the NetZero Strategy planned for 30 MtCO2/yr from CCS plus an extra 5 MtCO2/yr from GGR (eg BECCS and DACCS). It is obscure how this increase

was calculated, and especially how the large quantity of CO2 will be provided, transported and stored within the revenue support limits set by Treasury. However the BP East Coast Cluster release on 29 October 2021 states their ambition to store 27MtCO2/yr by 2030, 10 Mt from Teesside and 17My from Humberside. The HyNet project website states that they will also decrease CO2 emissions by 10 MtCO2/yr by 2030, although the same website states "25Mt carbon saved each year" which equates to 90 MtCO2/yr. This will be entirely achieved by making very large tonnages of hydrogen from natural gas, which requires equally large CO2 storage. However the conceptual storage plan from ENI storage operator indicates that the rate of CO2 injection will be 2Mt/yr or less, due to pipeline capacity – as this needs to be moved as gas CO2, not liquid, because of the very low pressures of the receiving reservoir. This also looks like a slow and expensive project with heaters of tens GWatt installed offshore to prevent CO2 from freezing.

14) There are many and detailed assessment criteria published by BEIS. However the out-turn of the marking process by BEIS shows that in practice a Cluster with a large tonnage of CO2 appears to win twice. This seems to be because the points awarded to the bidder with largest CO2 storage reduce the points awarded to runner-up bidders. As a simple example a winning bidder with 9 My/yr storage gain 9/9 points. The runner-up bidder with 3Mt/yr storage gains only 3/9 as a maximum. That opens up a large gap between bidders. That gap is increased by the measure of cost CO2 per tonne stored. That means that large supplies of CO2 captured from new-build equipment is less cost per tonne captured; and because larger pipes cost very little extra but transport a lot more CO2, the cost of transport is decreased. So the bidders with a lot of CO2 win again. That is in spite of the BEIS May document stating that an early Commercial Operation Date will count for 30% marks whereas emissions reduction potential (tonnage) counts for 25% of marks. There is much scope for marking schemes to be adjusted by "credibility factors"

6) Can Acorn win in another round like this?

15) The rules and criteria for Track 2 projects to compete in following on from the two selected in Track 1 are not yet known. The detail of these will be important for Acorn re-bidding. Rules for Track 2 need to be consulted without any further delay, or project staff teams may cool enthusiasm and dissipate. From the experience of 2021, the tonnage of CO2 is vital – as are the "credibility factors". If BEIS maintains the existing criteria, then total tonnage of CO2 can again be a deciding factor. The alliance between Teesside and Humberside to form a "super-cluster" emerged very late in the bidding process, and two formerly disparate clusters formed into one, by means of sharing a storage site, albeit with two entirely separate pipes capturing CO2 from two entirely separate onshore regions. This deal-making was able to exploit the Track 1 delivery rules set by BEIS.

16) So if two regions can form a single bid, could that happen again? In a second round of bidding, its possible to expect an Acorn bid, and also two, maybe three, new bidders from clusters in South Wales, Southampton, London, South Humber. Some of these are already larger than Acorn at startup. So a

lot rests on the “credibility” of projected CO2 increase from Acorn, for example as extra sites are progressively added in along to Grangemouth, or if shipping CO2 from elsewhere in the UK is not allowed, and especially if CO2 imported for profitable storage is not allowed, then it can be hard for Acorn to compete in tonnage.

17) Key mitigations could be i) to sign up partnerships from CO2 sources around the UK to be stored by Acorn and transported into Peterhead by shipping, ii) to increase credibility of future CO2 sources, such as very large scale making of blue hydrogen at St Fergus, where 30% of UK gas supply is landed at much less embedded carbon than HyNet; iii) to clarify that profitable import of CO2 is allowed from outside the UK, to decrease costs per tonne and scale-up into the future, iv) to include and value the positive attributes offered by Acorn into an adapted scoring matrix; v) to design criteria which value the decarbonisation and “levelling up” of outer regions of the UK; vi) especially on eastern Scotland, to value the Just Transition aspects which can value the skills retention and decent work for many tens thousands of individuals who can move from oil and gas extraction to CO2 injection.

7) Can Acorn commence without BEIS support?

18) It is known that Acorn passed the criteria for cluster transport and storage, or it would not be cited as a “reserve”. So technically the project is fine, so could this come into operation without BEIS? This is difficult, because its not just a simple payment to build the pipeline and boreholes – which may cost £200-300M, and could be provided by Scottish Government or the Scottish National Investment Bank. Indeed the Scottish Government offered several tens million CapEx support during the bidding process.

19) The really valuable support is in the licencing by OGA for engineering permission to store, and in the economic licence issued by BEIS to provide ultimate underwriting by the UK and takeover liability for CO2 when storage is completed. For Track 1 projects these licenses are rolled into the business models, which cover the OpEx and the costs of capture at industrial sites or hydrogen or electricity generating sites. The business contract also acts to insure the pipe and store operator against a shortage of captured CO2, and vice versa. And the provides payment for storage of the captured CO2. And provides permits to store CO2 and takeover of stored CO2 liability by the state when the store is closed. The value of this support is not publicly known. But by analogy with previous UK CCS competitions, that could be at least 3x the CapEx support, or around £2-3 Billion during a 15 year project lifetime. This is often considered to be an amount beyond the reach of Scottish Government, who do not receive many of the taxes from UK-ETS CO2 permits, offshore licensing, or tax on oil revenue. And there does not appear to be any precedent for Scottish Government to provide such long duration operating support. However a two crucial differences now are i) the high carbon price of £50-80/ ton in the UK-ETS and ii) the abundance of CO2 in Europe and globally seeking secure storage. This can create a commercially independent project model (see below), which is likely to be the best route forward for Acorn.

8) Making different markets

20) Whilst the BEIS competition has focused on large industrial sources of CO2, there are additional markets which can pay for CO2 storage. These are becoming active now, and are likely to grow into the near future. Imagining low carbon industries locating into a zero carbon Scotland with ability to store CO2 could produce different outcomes

21) Because there is no international market price to store CO2 for environmental reasons, then much of the CO2 captured globally is sold to hydrocarbon companies using CO2 as solvent to extract oil more efficiently. However where national policy has created CO2 pricing for storage then captured CO2 is now being stored profitably. Examples include tax-break subsidy from 45Q legislation in the USA ($35 for EOR and $50 for aquifer storage), the California Fuel Standard for low carbon petrol and diesel ($65 to $200/tCO2 between 2016 and 2019), or the Canadian federal carbon tax $40/tCO2. In the UK including Scotland large emitters of CO2 must purchase emissions allowances. The revenue from these allowances goes to Westminster. Although these have historically traded at just £5-10/tCO2, since redesign into the UK-ETS market from 1st Jan2021 the number of certificates has decreased, this price is now £50- 80 tCO2. That makes some sources of CO2 in Scotland economic to capture and store.

22) CoP26 in Glasgow approved the Article 6 rule book which for the first time creates an agreed framework for international carbon trading. There is now an international market in voluntary carbon storage – where organisations seeking to decrease their Net output of carbon are seeking to purchase carbon storage which is reliable and has long duration for many centuries. Planting trees is often cited as one example, but that is very short duration and is subject to fire or storm damage. By contrast, purchase and geological storage of CO2 is reliable. An operating CCS system in Scotland could sell and guarantee high quality storage to global customers.

23) Direct Air Capture is a newly emerging technology, which could be installed anywhere in the world to remove CO2 from the global atmosphere. This has two constraints: first a source of abundant low cost energy to re-generate the capture solvents which could be provided by the projected 9GW of DeepWind offshore of the east coast; second a route to reliable low cost CO2 storage, supplied by Acorn. It is for these reasons that Acorn cluster includes a potential DACCS developer seeking to capture 0.5 – 1.0 MtCO2/yr. This too could be sold at a premium price for voluntary storage. However the proposal was not accepted by BEIS.

24) Transitioning the offshore oil industry could also be achieved by mandating compulsory CO2 storage, to exactly balance the fossil carbon extracted in oil or gas and the carbon incurred during processing and transport. This is the Carbon TakeBack Obligation www.carbontakeback.org. That maintains the financial, employment and skills value of limited offshore hydrocarbon production, and removes the environmental contamination. For example an environmental test,

by the Oil and Gas Authority would need verifiable permanent CO2 storage for the Cambo oilfield of about 2MtCO2/yr for 30 yr. That would cost about £40 per barrel of oil – but emissions free oil can be sold for a greater price in California, or would add £0.25 per litre

9) Independent commercial model

25) Sections above have described how navigating the BEIS Track 2 competition will be uncertain, powerless, and slow. Alternatively there are now a combination of circumstances which encourage a commercial offer. Acorn is ready to build. The CapEx can be underwritten by UK or Scottish Government. CO2 can be acquired from the Scottish cluster by known, predictable and reliable sources. The UK storage portfolio badly needs diversification and resilience, because the two chosen storage projects have known flaws which will need to be overcome. Abundant CO2 can be available around coastal UK, and can be shipped to Acorn, producing a flow of 2-8Ton/yr. The capture costs of this CO2 will be offset by the very high UK_ETS carbon price, meaning no CfD subsidy is needed. In addition there is a wide open market in Europe to ship CO2 to reliable storage. Capture of EU CO2 will be underpinned by the EU Innovation Fund. What is needed from the UK in 1) shipping to be counted in from UK and overseas 2) and OGA engineering storage licence 3) A economic storage licence from BEIS to underwrite long duration liability. In return the UK gets a managed transition from oil and gas, transfer of skilled people, and the start of a profitable CCS industry with minimum or no subsidy.