CCUS 2030: How the CCS Infrastructure Fund and an ambitious CCUS policy can contribute to a Resilient Green Recovery

Executive Summary

To reach net zero the UK must deploy CCUS at a very large scale by 2050 to support the decarbonisation of industry and power, produce clean hydrogen and generate Greenhouse Gas Removals. The ten-year period from now until 2030 is a crucial period for CCUS deployment in the UK and needs to lay the foundations which support subsequent rapid increases in CCUS deployment. The importance of CCUS for the UK was recognised in the Budget 2020 with the announcement of a CCS Infrastructure Fund (CIF) to support the development of the first UK CCS sites helping to reduce CO_2 emissions and establish new innovative industries.

The UK's success with offshore wind offers clear lessons for how CCUS can be progressed within the UK. In particular, the 'Commit and Review' approach to offshore wind provided the confidence that underpinned innovation and investment and drove down costs while contributing to decarbonisation.

The CCSA proposes that the government adopts a '10Mt Commit and Review' CCUS policy to deliver the UK's ambition to become a world leader in CCUS. The '10Mt Commit and Review' policy would;

- Ensure that the government's CCUS programme is aligned with the net zero recommendations made by the Committee on Climate Change.
- Give investors the confidence of a minimum market size over the next decade within which they can demonstrate clear cost reduction opportunities across the value chain.
- Provide the Government with the flexibility and information it needs to be able to make informed decisions on the appropriate level of CCUS deployment post-2030.
- Send a strong signal that the UK wishes to become a world leader in CCUS technologies, helping to attract the necessary investment.

The annual revenue support required to deploy the '10Mt Commit and Review' CCUS programme is around £0.9 bn resulting in a cost of CO_2 abatement of ~£90 tCO_2 in 2030. This compares favourably with the carbon abatement costs required for net zero enabling even the first phase of CCUS to be cost competitive. The ~£0.9 bn annual investment required to deliver a world leading UK CCUS sector also compares favourably with the level of investment that the UK made in developing a world class offshore wind sector. The CCSA calculates that the annual revenue support used to scale offshore wind to the equivalent stage of abating 10 $MtCO_2$ was between £2.3 – 2.8 bn. The experience with offshore development shows that costs could be reduced even further for subsequent phases of deployment.

The ongoing Covid-19 crisis and resulting economic slowdown has triggered a focus on how to structure a post Covid-19 recovery strategy which is also consistent with the UK's net zero target. The '10$MtCO_2$ Commit and Review' strategy proposed here would make a material contribution to a Resilient Green Recovery and aligns well with the key recommendations on how the UK should implement its recovery package from independent institutions such as the Committee on Climate Change, the Grantham Institute and the Oxford Smith School of Enterprise and the Environment. The CIF can make a critical contribution to delivery of the UK's CCUS programmes and this paper identifies seven areas where CIF investment could be targeted to deliver the first UK CCUS sites.

2030 Deployment Ambition

CCUS and net zero

There is consensus that if the UK is to reach net zero by 2050 it must deploy CCUS at a very large scale by 2050[i] [ii]. Analysis from the Committee on Climate Change suggests that between 75 million tonnes -175 million tonnes (Mt) of CO_2 needs to be stored per year in 2050[iii].

Irrespective of the exact CO_2 reductions required through CCUS in 2050 it is clear that it needs to be scaled from a sector that does not operate today in the UK to one that is abating many 10s of million tonnes of CO_2 per year in 30 years. By comparison, offshore wind took almost 20 years to scale to the stage where it was abating approximately 10 $MtCO_2$ per annum (p.a.)[iv]. UK ambition on CCUS needs a step change in ambition if it is to be consistent with net zero.

In addition to the level of annual abatement UK CCUS policy has to also deliver the following outcomes;

- *Cumulative storage capacity*: For the period to 2050 roughly 900 to 2,000 $MtCO_2$ of storage will be required and for ten-year periods after 2050 approximately 750 to 1,750 $MtCO_2$ will be required (assuming a flat storage profile from 2050). Capacity is not a limiting factor as the UK is blessed with ample geological storage capacity, with over 500 identified storage sites[v], totalling 78,100 $MtCO_2$ storage capacity. Five of the most suitable sites alone have approximately 895Mt of potential combined capacity[vi], which is a material contribution towards 2050 storage capacity requirements.
- *Geographical distribution:* The largest UK industrial clusters, CO_2 emitters and associated population centres are located in coastal regions around the country. To enable CCUS to contribute to decarbonisation of these regions will require CO_2 infrastructure on both the East and West coasts. Establishing CO_2 infrastructure sites in the three offshore areas that contain the majority of the UK's storage capacity – the Central North Sea, East Irish Sea and Southern North Sea – will provide the opportunity for CCUS to be deployed around the UK and within all of the key industrial regions.
- *Sector deployment:* The analysis is clear that CO_2 transport and storage infrastructure will be utilised by multiple sectors directly (industry, power, greenhouse gas removals) and indirectly via hydrogen and advanced fuels (heating and transport). While there is uncertainty over exact decarbonisation pathways for these sectors, there is very high confidence that all sectors will need CCUS to some extent.

2030 deployment ambition

The ten-year period from now until 2030 is a crucial period for CCUS deployment in the UK. It is one third of the way to 2050 when CCUS will be needed at a very large scale. This ten-year period therefore needs to lay the foundations which supports subsequent rapid increases in CCUS deployment.

The CCC recommendation that the UK should be storing at least 10 $MtCO_2$ p.a. by 2030 was based on analysis that was undertaken before the adoption of the UK's net zero target. The CCSA believes that this should be adopted as a 'deployment floor', which establishes the absolute minimum level of deployment needed by 2030 but with the flexibility to deliver higher volumes of CO_2 reductions if required.

Establishing a CCUS programme that delivers at least 10 $MtCO_2$ p.a. by 2030 will lead to a number of benefits to the UK;

1. It will provide invaluable early experiences of operating CCUS 'at scale'. This is critical given that there are significant economies of scale associated with CCUS, such as the benefits of learning by doing, etc.
2. This level of deployment enables early lessons and experiences to be gained from CO_2 capture in the multiple sectors – industry, power, hydrogen and greenhouse gas removals (GGR)– that will need access to CCUS if they are to make a full contribution to net zero.
3. Establishing a deployment floor can enable ambition to be scaled up if required, e.g. if CCUS is seen as more effective approach to decarbonisation than alternatives.
4. 10 $MtCO_2$ provides a realistic basis upon which the higher levels of CCUS deployment needed by 2050 can be achieved. This assumes that the UK doubles the installed capacity of CCUS in every five-year period between 2030 and 2050.

By 2030, all of the UK's three main CO_2 storage regions – Central North Sea, Southern North Sea and the East Irish Sea – should have developed CO_2 transport and storage infrastructure. The UK ambition should not seek to create a competition that determines which region have access to CO_2 infrastructure and can decarbonise more effectively and which will not. The strategy should be focussed on how to phase the necessary CO_2 infrastructure into all of the UK's industrial regions so they all contribute to net zero and have the opportunity to benefit economically from CCUS technologies. Developing infrastructure in the three main storage regions will deliver the following;

- It provides all of the UK's major industrial sites with realistic opportunities to access CO_2 infrastructure enabling their contribution to emission reductions in the 2030s and 2040s. Failure to do this will either mean industry are unable to continue to operate in those locations, or that industry will be allowed to continue to emit and greater emissions reductions will be required in other sectors (which may well be more technically challenging and expensive).
- These three storage regions contain the vast majority of the UK's storage capacity enabling the first CCS projects to be progressively expanded to reach the UK's 2050 requirements.
- The development of the three storage regions will enable multiple industrial regions to access the infrastructure. This in turn will create the basis for a CCUS market within which investment, innovation and learning are stimulated helping to drive further CCUS cost reductions.

Significant scale up of CCUS will be required in the 2030s and 2040s to realise the levels of CCUS deployment required for net zero, i.e. 75 – 175$MtCO_2$ storage per year by 2050. Assuming a minimum of 10$MtCO_2$ storage is developed in the ten years to 2030 then the subsequent 20-year period to 2050 could require 65 – 165$MtCO_2$ of additional capacity being brought online. This has two important implications for the first phase of CCUS deployment;

1. The initial infrastructure established by 2030 must be designed to both enable the early CCUS projects and be appropriately sized to handle the initial phase of the 'at scale' rapid increase in CCUS needed from 2030.
2. To enable the rate of CCUS growth in the early 2030s, the UK must initiate progress on a second phase of projects in the early to mid-2020s so that these projects are ready to begin operation from 2030s.

Delivering 2030 ambition

Industry is actively developing multiple CCUS projects that seek to be operational in the 2020s. The ambition of these projects clearly shows that capturing and storing at least 10MtCO_2 p.a. is achievable and that substantially higher amounts of CCUS could be deployed if required. Indeed, all clusters have developed build options which could deliver a higher level of CCUS deployment ambition and enable multiple 10s MtCO_2 p.a. to be stored by 2030.

The investment required to develop early CO_2 transport and storage infrastructure in the three main storage regions – the Central North Sea, East Irish Sea and Southern North Sea – is estimated at ~£1.8 bn (see table[vii] below). The infrastructure from these three storage regions would link to the four industrial clusters – Teesside, Humberside, Merseyside & St Fergus – referenced by the Chancellor at Budget 2020. Developing the three storage regions will also enable other industrial sources of CO_2, e.g. South Wales, to access the infrastructure and support their clean growth.

This analysis indicates there is approximately a £1 bn difference between the funding announced at Budget 2020 for CCS infrastructure compared to the level of investment the CCSA believes is required to deliver CCUS at the scale required to reach net zero.

Delivering net zero requires the large-scale deployment of CCUS for industry, power, GGR and hydrogen production. A strong 2020s CCUS programme would seek to support CO_2 capture in all of these sectors in order to secure early experience, lessons and cost reductions that can inform subsequent large-scale deployment in the 2030s and 2040s. The investment in CO_2 capture could follow different permutations with the industrial clusters containing a variety of capture technologies across different sectors. The table below shows the investment requirements for a portfolio of capture technologies across all of the key applications that enable the capture of 10MtCO_2 by 2030. The capital investment required to deliver this scale of CO_2 capture is approximately £4.2 billion over the period to 2030.

The annual revenue support to deploy the CCUS programme described here is around £0.9 bn resulting in a cost of CO_2 abatement of ~£90 tCO_2 in 2030. This forecast cost of abatement compares favourably to the BEIS 2018 short-term traded values for UK policy appraisal.[viii] These show a 2030 carbon value of £80.83 tCO_2e for the central scenario rising to £121.24 tCO_2e for the high scenario. These carbon values have not been updated to take account of net zero and the BEIS high scenario now better reflects the carbon prices required to deliver net zero demonstrating that even this first phase of CCUS deployment will be cost competitive[ix].

In addition, the ~£0.9 bn of annual revenue support required to deliver a UK CCUS sector that abates 10MtCO_2 in 2030 also compares favourably with level of investment that the UK has made in developing a world class offshore wind sector. The CCSA calculates that the annual revenue support used to scale offshore wind to the equivalent stage of abating 10 MtCO_2 was between £2.3 – 2.8 bn. This demonstrates that for a materially smaller investment the government can support the realisation a world leading CCUS industry here in the UK.

Furthermore, while this first phase of CCUS deployment is already expected to deliver cost-effective abatement and a relatively low overall cost, the experience with offshore development in the UK shows that costs could be reduced even further for subsequent phases of deployment resulting in the delivery of very cost competitive carbon abatement for the UK economy.

Capture	**Capital Costs (£bn)**	**CO_2 Captured (Mt p.a.)**
1 x 0.7GW gas power plant (1 capture train)	1.2	1.6
1 x post combustion capture plant for BECCS	0.5	1.5
1 x new H_2 fired power plant (CHP or CCGT)	0.9	1.5
3 x 340MW H_2 Auto Thermal Reformer trains	0.8	2.2
2 x CO_2 capture units on existing ammonia plants	0.1	0.7
1+ Industry post-combustion capture units	0.7	2.5
Total Capture Investment **CO_2 Captured**	**£4.2bn**	 **~10Mt p.a.**
Transport & Storage	**Capital Costs (£bn)**	
2 x "Near-Shore" depleted gas fields plus pipelines	0.4	
1 x Large capacity aquifer plus pipelines	0.8	
1 x Onshore plus offshore link to the aquifer above	0.6	
Transport & Storage Investment	1.8	
Total Investment	~6.0	
Revenue Cost of abatement		~£0.9 bn p.a. ~£90/t CO_2

CCUS funding

The government has made a number of very welcome announcements on industrial decarbonisation funding support. The level of committed funding – in aggregate – could make a material contribution to supporting the deployment of CCUS in the 2020s.

However, the funding packages are focussed on multiple industrial sectors or different segments of the decarbonisation value chain while their timing or focus means they are only able to support specific elements of the project development process, e.g. feasibility studies or capital investment.

This fragmented approach creates challenges as the first CO_2 capture plants and CO_2 infrastructure developed in a region must be progressed in parallel. If there is not the confidence that these projects will move forward together then the risk is that projects cannot be progressed by industry as there would be a material risk that the investment would be wasted if the other element of the CCUS chain failed to materialise.

Based on existing publicly available information, the different funding packages have been assessed against their ability to support the different stages of a project development timelines (see 'traffic light' table below) and also mapped across the different elements of the CCUS value chain (see project development timeline figure below).

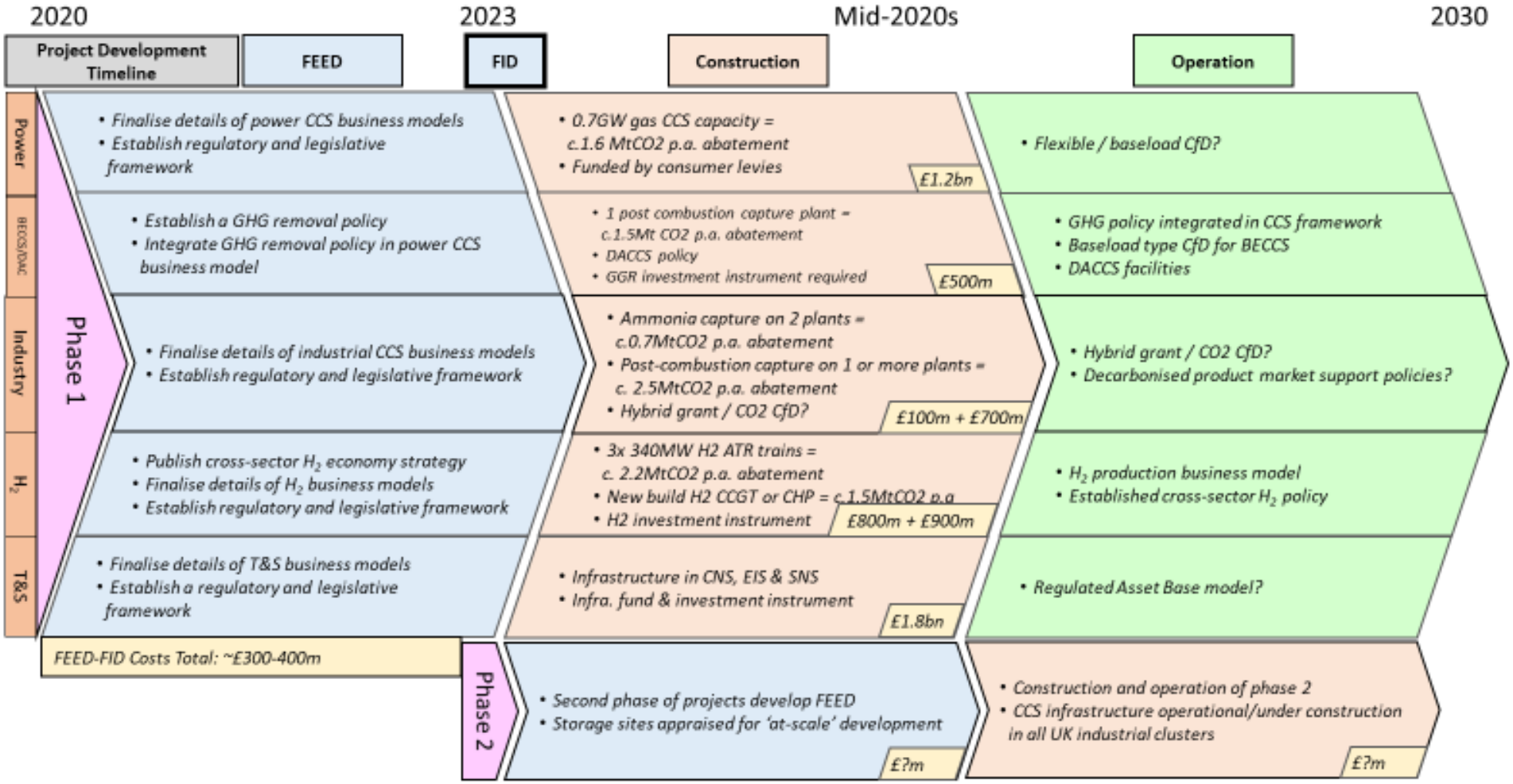
Based on this analysis and the review of investment requirements above the CCSA draws the following conclusions:

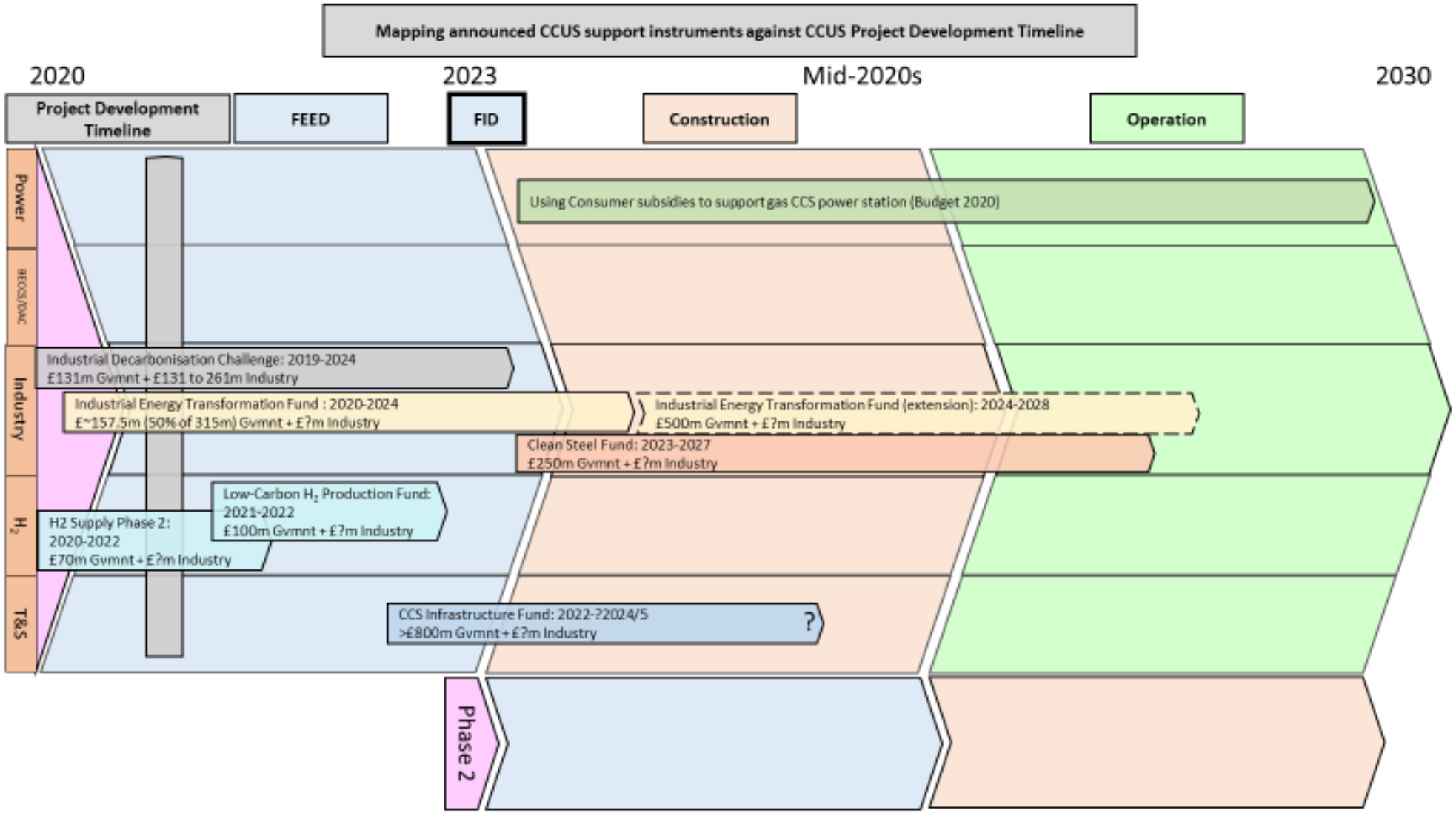
1. The majority of CCUS projects would appear to require funding from multiple, separate sources of funding if they are to progress through development, construction and operation. This creates a large funding coordination risk that the private sector will find hard to manage and will require active mitigation by Government.
2. A route to market is unclear for each segment of the CCUS value chain. The one possible exception is for gas power CCUS which may be able to access a CfD although this is also still subject to uncertainty.
3. It is not certain that adequate development support, e.g. for FEED studies, is available to progress sufficient projects that the goal of storing 10MtCO_2 by 2030 is available. In addition, as FEED studies are expected to attract a substantial proportion of industry funding it is critical to publish the 'Heads of Terms' that establish the key principles underpinning the CCUS business models. This will be required by the end of 2020 to provide the early projects with the detail and confidence on the route to market that they can direct the required investment into the FEED stage.
4. The level of investment required to develop CO_2 transport and storage infrastructure in 2030 that is consistent with net zero is greater than the announcement made at Budget 2020. Bridging this gap will require an increase in public funds or the ability to leverage public funds with private sector investment.
5. Industrial capital support appears dependent on an IETF extension. This might include some support for hydrogen production and / or use if this occurs within the plant boundary.
6. At present there is no indication of the instrument(s) that will progress investment in CCUS-enabled GGR technologies with the exception of the possible use of CfDs for early BECCS power plants.
7. There is no low-carbon hydrogen construction or operation support available.
8. There is no clarity on support for phase 2 projects, both for the design and construction phases. This risks stalling project development activity and unless addressed will mean that the required rapid increase in the scale of CCUS deployment in the early 2030s will not happen.

Funding Mechanism	Phase 1 Design	Phase 1 Construction	Phase 2 Design	Phase 2 Construction
IDC	🟢	🔴	○	○
IETF	🟢	🟡	○	○
IETF (extension)	○	🟢	🟢	🟡
Clean Steel Fund	○	🟢	🟢	🟡
Low-C H2 Prod. Fund	🟡	🔴	○	○
H2 Supply Comp. Fund	🟢	○	○	○
CCS Infra. Fund	○	🟢	○	○

🟢 Clearly targeted and well timed for this particular phase of project development
🟡 Ambiguously targeted and/or adequately timed for this particular phase of project development
🔴 Poorly targeted and/or poorly timed for this particular phase of project development
○ Not targeted by this fund

Mapping industry ambition for CCUS against a CCUS Project Development Timeline, highlighting expected investment and policy requirements




Mapping announced CCUS support instruments against CCUS Project Development Timeline
2020
2023
Mid-2020s
2030
Project Development Timeline
FEED
FID
Construction
Operation
Power
BECCS/DAC
Industry
H2
T&S
Using Consumer subsidies to support gas CCS power station (Budget 2020)
Industrial Decarbonisation Challenge: 2019-2024
£131m Gvmnt + £131 to 261m Industry
Industrial Energy Transformation Fund : 2020-2024
£~157.5m (50% of 315m) Gvmnt + £?m Industry
Industrial Energy Transformation Fund (extension): 2024-2028
£500m Gvmnt + £?m Industry
Clean Steel Fund: 2023-2027
£250m Gvmnt + £?m Industry
Low-Carbon H2 Production Fund:
2021-2022
£100m Gvmnt + £?m Industry
H2 Supply Phase 2:
2020-2022
£70m Gvmnt + £?m Industry
CCS Infrastructure Fund: 2022-?2024/5
>£800m Gvmnt + £?m Industry
?
Phase 2

CCUS deployment strategy

The Budget 2020 announced that the Government would "establish CCS in at least two UK sites, one by the mid-2020s, a second by 2030." This announcement marks a welcome increase in UK CCUS ambition, albeit it appears to fall short of the deployment levels required to realise net zero.

The Budget announcement suggests that the government proposes a 'staggered deployment' strategy to the roll out of CCUS, whereby the first site is developed and then a second site is developed a number of years later. The CCSA sees no benefits to this 'staggered deployment' approach and believes it risks having a negative impact on CCUS development. Specifically;

- This policy will unnecessarily delay the realisation of CCUS cost reductions in the UK, this risks imposing extra costs on the UK if deployment at scale is needed before the cost reductions have been achieved. Conversely, a greater level of deployment will accelerate cost reductions as economies of scale are realised and CCUS projects de-risked.
- The 'staggered deployment' of only two sites would send a signal to the market that government is cautious in its support for CCUS. This lack of confidence in the CCUS market opportunity risks limiting investment from both industry and the supply chain and will hinder the UK ambition to be a world leader in CCUS technologies.
- The lack of confidence in commitment to CCUS will limit the pool of financial institutions that engage on CCUS, risking a delay to cost savings that can be realised by improved financing of projects.
- The development of an internationally competitive UK CCUS industry risks being lost as more rapid progress in other markets, e.g. US, China, Norway, and the Netherlands, provides competitors with a head start in the development of a CCUS supply chain. None of the world's 23 operating or under construction CCUS projects are located in the UK and we have only six early stage projects out of at least 28 globally that are at an early or advanced stage of development.
- The UK has an oil and gas supply chain that is well placed to deliver CCUS at this scale, in the required timeframe and would like to see this as an integral part of their sector deal. An ambitious CCUS programme provides a critical opportunity to help the UK oil and gas industry supply chain diversify into the low carbon industries of the future.
- There are no learning-by-doing benefits from 'staggered deployment'. CCUS projects have long development timelines – three years of pre-FEED and FEED studies and up to four years of construction. The timeline in Budget 2020 would result in the overlapping deployment of the first two projects. Traditional learning by doing where you build and operate the first project before moving on is not credible for CCUS as it would leave large scale deployment too late.
- Delaying access to CCUS infrastructure risks locking in CO_2 emissions if necessary investments, e.g. in power or industry, over the next decade or so are unable to apply CCUS. This will require deeper emissions reduction to occur elsewhere in the economy which could be harder and more expensive to deliver.

Delivering cost reductions for CCUS in the UK will be determined largely by domestic policy. The two largest cost reductions levers for CCUS are[x];

- *Economies of scale*: The ability to develop shared infrastructure within a region that can be shared by multiple CO_2 emitters is a large cost reduction lever for delivering cost competitive CCUS. Further opportunities to share capture or compression facilities would also deliver further economies of scale.
- *Improvements in financing*: The development of operating CO_2 transport and storage infrastructure will substantially de-risk future projects. Linking clusters with CO_2 pipelines and/or ship transportation will provide storage options and flexibility, reduce risk, and therefore reduce the cost of funding. Coupled with an investment framework that is understood by the finance sector and has successfully delivered multiple early projects the cost of capital is expected to fall significantly.

Adopting the goal of developing at least 10MtCO_2 p.a. and establishing infrastructure in the three key storage regions in the 2020s will make a very substantial contribution to realising both of these CCUS cost reductions. This will enable the CCUS sector by 2030 to be well placed to deliver cost competitive CO_2 abatement across the UK economy and creating a world leading position in CCUS that can be exported.

Conversely, only developing two sites with the second operating by 2030 will push the realisation of these early drivers for cost reduction into the 2030s. The risk of delivering only two sites is that the economies of scale take longer to be realised and some regions will not have access to proven de-risked storage capacity in the 2030s.

The 2030s is when large scale CCUS deployment really needs to commence and between 2030 and 2040 another 30 MtCO_2 of additional CCUS capacity may need to be deployed if the UK is to be on target for reaching net zero. Having to deploy at this scale before the full cost reductions have been realised risks imposing higher decarbonisation costs on the UK economy than necessary.

10Mt Commit and Review

The CCSA believes that the UK's successful experience with offshore wind offers clear lessons for how CCUS can be progressed within the UK. In particular the 'Commit and Review' approach to offshore wind has been very successful at commercialising UK offshore wind[xi]. This approach provided confidence on the minimum market opportunity for offshore wind while providing the Government with the flexibility to adjust the ambition level in the event that expected cost reduction were not realised. The Offshore Wind Sector Deal notes that "Offshore wind is a success story for the UK. Long-term government support has underpinned innovation and investment in the sector, helping to drive down costs while contributing to decarbonisation of the economy".

Adopting a '10Mt Commit and Review' CCUS policy will deliver the same positive impacts, providing clarity and confidence on the UK CCUS market opportunity and enabling industry to respond and organise themselves in order to support delivery of the Government's ambitions for the sector. Committing to at least 10MtCO_2 by 2030 would deliver the following benefits;

- Provide CCUS with sufficient volume targets that it can demonstrate clear cost reduction opportunities across the value chain.
- Give investors the confidence of a minimum market size over the next decade.

- Give the Government, in the mid- to late-2020s, the opportunity to review progress on CCUS and – based on the evidence generated by early deployment – decide on the appropriate level of deployment for the period post-2030.
- Establish a clear, concrete deployment ambition that provides a strong signal that the UK wishes to become a world leader in CCUS technologies, helping to attract the necessary investment.

Giving confidence on the market opportunity in the ten-year period to 2030 provides sufficient time to enable industry and supply chain to develop and deploy projects. This forward visibility will need to be updated on a periodic basis so that there is sufficient forward confidence in the market to underpin private sector investment.

The '10Mt Commit and Review' will also provide the Government with sufficient flexibility to ensure that the CCUS sector can respond to wider changes in the transition to net zero and can be both scaled up rapidly and targeted to support the UK's delivery of net zero.

There is often a concern that establishing specific targets may lead to unintended outcomes. The '10Mt Commit and Review' policy is very unlikely to deliver any material negative outcomes and on balance these risks are significantly outweighed by the very significant benefits that the policy is expected to deliver. The benefits of setting an early deployment target is that any downsides are expected to be minimal as realising 10MtCO_2 of emission reductions from CCUS is material enough to kick start a CCUS sector but not of sufficient volumes that it will materially distort any given sector. The infrastructure developed through this policy also represents a 'no-regrets' investment. Even the lowest end of CCUS deployment foreseen in the CCC analysis would require all of this infrastructure to be utilised ensuring that this initial tranche of infrastructure will not become stranded assets.

Alongside providing confidence on the size of the CCUS market, an effective UK CCUS policy should also provide visibility on a number of other issues that are important to facilitate CCUS deployment;

- Clear statement on the investment instruments that will be available to support CCUS investment, including the revenue support available for CCUS to deliver the 10 MtCO_2 deployment goal.
- Clarity on the respective roles of government and the private sector in supporting delivery of projects.
- The establishment of public sector delivery capability, either within or outside of government, to manage a UK CCUS programme. The development of CCUS at scale across multiple sectors of the economy is complex and it is important the public sector has the skills, resources and accountability to enable deployment of this sector.
- Understanding which sectors the CCUS is required to contribute to CO_2 emission reductions and the regional distribution of CCUS clusters
- Other key objectives that CCUS projects are expected to deliver or adhere to.

CCUS and a Green Resilient Recovery

The ongoing Covid-19 crisis and resulting economic slowdown has triggered a focus on how to structure a post Covid-19 recovery strategy which is also consistent with the UK's net zero target. The emerging conversation has resulted in commentary from independent institutions such as the Committee on Climate Change[xii], the Grantham Institute[xiii] and the Oxford Smith School of Enterprise and the Environment[xiv] who have highlighted key investment focus areas which can ensure a UK recovery accelerates both economic and climate objectives together.

The '10MtCO_2 Commit and Review' strategy proposed here would make a material contribution to a Green Resilient Recovery and aligns well with the key recommendations on how the UK should implement its recovery package.

On the 6th May 2020, the Committee on Climate Change wrote to Prime Minister Boris Johnson on "Building a resilient recovery from the Covid-19 crisis". This letter outlined six principles to ensure a resilient recovery from the Covid-19 crisis, with climate change and net zero at the core. Appended to the letter was a series of climate policy guidelines which could support climate goals, economic recovery and be delivered in the near term. These included:

- *Reskilling and retraining programmes:* This highlighted the need for new and updated skills required to facilitate the energy transition to net-zero. Specific reference was made to how the suppressed economy in the North Sea oil and gas sector must be addressed with the future in mind, including CCS.
- *Targeted science and innovation funding:* Research and innovation funding was highlighted as key, alongside a medium-term focus on 'learning by doing' by deploying technologies at scale with supporting infrastructure.
- *Strengthening the energy system network:* The post Covid-19, recovery was highlighted as an opportune moment to accelerate the energy system transition, including CCS and hydrogen infrastructure.

In parallel, the Oxford Smith School paper identified three guidelines for policy makers to inform the design of a post Covid-19 package(s). CCUS aligns well with the three policy guidelines and should be considered as a priority in a Covid-19 recovery package.

1) Recovery policies can deliver both economic and climate goals

Hepburn et al. from the Oxford Smith School, highlighted that investment in 'Clean Energy Infrastructure' and 'Clean R&D Spending' would deliver the highest climate impact whilst also providing long-run employment multipliers and economic benefits. Investment in CCUS and low-carbon hydrogen are considered as 'clean', and for regions with lower to middle income, where clean R&D spending may not be possible, clean infrastructure investment could be a suitable alternative.

It has been estimated in various studies that developing UK CCUS projects and associated infrastructure can create and retain many tens of thousands of jobs in both the direct industries, the associated supply chain and wider linked economies [xv] [xvi] [xvii] [xviii].

A study investigating the deployment of a 75MtCO_2 p.a. storage industry by 2060[xix], comparable to the lowest CCUS deployment pathway in the 2019 CCC Net Zero report, concluded that CCUS can provide:

- 47,000 CCS jobs in the direct and indirect supply chain by 2060

- 178,600 linked-economy jobs directly relating to preserved industry and the associated supply chain by 2060
- 7,600 CCS jobs and 4,860 linked-economy jobs will be created and retained by 2032
- Societal and economic benefits returning 5-fold the investment cost (CAPEX and OPEX)
- Several £bn CO_2 storage service income, accepting CO_2 for storage from sources across international boundaries.
- Multipliers on investment in terms of jobs of 2.5 – 9 depending on the industry and project deployment phase.

The UK is well positioned to lead CCUS, low-carbon hydrogen markets and industrial decarbonisation globally. As highlighted in the recently published Energy Innovation Needs Assessment (EINA) series commissioned by BEIS[xx] the international export opportunities developing CCUS are material:

- 72,700 CCUS specific jobs in 2040 (up to £5.9bn GVA annually), both domestically and internationally
- 62,700 jobs servicing a CCUS export market
- Retention and expansion of current and future supply chain activity where the UK has a traditional expertise, such as EPCm (Engineering, Procurement, and Construction Management).

As noted in the CCC's Letter to the Prime Minister, the UK oil and gas sector is currently experiencing a significant downturn as a result of low oil prices. An ambitious CCUS programme represents an invaluable early opportunity to help diversify the sector into the low carbon industries of the future. Investing now in CCUS and the associated supply chain will ensure the UK is in the best position to maximise export opportunities, showcase UK decarbonisation expertise and show international leadership as other national economic stimulus packages are developed. Even prior to the Covid-19 crisis capital investment in the UK oil and gas sector was expected to decline. The level of capital investment proposed by the '10Mt Commit and Review' policy would make a material contribution to the activity of the oil and gas industry supply chain. Importantly, it would not overwhelm the supply chain given historical levels of investments have been much higher within the UK.[xxi]

2) Co-benefits can be captured

Decarbonisation policy has the ability to capture wider co-benefits which are non-climate and non-economic, ultimately, these will increase the desirability for climate policy implementation. CCUS has many benefits and co-benefits which can improve the standard of living of communities in direct or indirect association with project deployment.

a) *Air quality improvements:* The decarbonisation of combustion-based industry with CCUS has additional co-benefits for local communities through air quality improvements. It has been estimated that by decarbonising the industrial clusters with CCUS providing up to 75MtCO_2 storage per year, the wider societal health and wellbeing benefits could total £5bn to 2060[xxii].

b) *Regional 'levelling-up':* All of the proposed CCUS projects are located outside of London and the South East, often in regions of lower to middle income. These shovel ready projects have the ability to improve prosperity, be implemented quickly and build regional momentum as part of the Governments wider levelling up agenda.

3) Policy design is important

The timely and effective introduction of policy measures to stimulate economic recovery is critical and if designed well will result in productive assets for the future.

Government is actively progressing policy on business models for CO_2 infrastructure, clean hydrogen, industry and power as well announcing CCUS funding which has enabled a number of projects to progress towards becoming 'shovel-ready'. With the implementation of the right policies these projects can move quickly and contribute to economic and climate objectives. Accelerating the implementation of CCUS policy now will make an important contribution to the UK's medium- and longer-term goals, enabling it to become a world leader in CCUS and well placed to support deployment globally.

CCS Infrastructure Fund

The CCSA very much welcomes the Budget 2020 announcement to establish a CCS Infrastructure Fund (CIF) to support the development of UK CCS sites. It is also appropriate that the fund targets the development of CCS infrastructure. The development of strategic transport and storage infrastructure can play an important role in unlocking the cross-economy benefits of CCUS.

The CIF will be used to develop "CCS sites". While the Budget did not define "sites" the CCSA believes that this should be consistent with the Cost Challenge Taskforce's "Catalyst project" that was defined as "first capture projects in a regional cluster that will anchor the T&S enabler to that regional cluster". Critically each CCS site should be leveraged to open up one of the UK's three key storage regions.

The CIF was established to support the UK's reduction of carbon emissions and to help establish new innovative industries. However, as noted above, the CIF can also make an important contribution to the UK's Resilient Green Recovery. The UK has multiple well-advanced CCUS projects that can be progressed rapidly in the early 2020s. In addition to delivering on carbon reductions and creating new low carbon industries these projects are located, and will create jobs, in our industrial regions helping with both the Government's levelling up agenda and supporting sectors like oil and gas, and industry that have seen huge disruption from the economic consequences of Covid-19.

As noted in the section above on *CCUS funding* there have been a number of very welcome funding announcements that can help support CCUS. There is a huge opportunity to leverage these funds to support the deployment of CCUS. BEIS has been reviewing the applicability of these funds and the CCSA believes that with appropriate consolidation, co-ordination and targeting these can more effectively support the deployment of CCUS and better deliver on the objectives of the different funds.

The CCSA makes a number of recommendations below on the objectives and eligibility criteria for the fund. We provide these as initial inputs and would appreciate the opportunity for further engagement on the fund design.

Objectives

The CCSA recommends that the fund is integrated into the CCUS Business Models with the objective of supporting the '10Mt Commit and Review' policy that will establish the strategic national infrastructure to deliver CCUS at scale by 2030. This will act as the foundation for delivering net zero, levelling up the UK's industrial regions and becoming a world leader in CCUS technologies.

It is important to note that the CIF cannot be an alternative to the business models and that ultimately it is the business models which will underpin private sector investment in CCUS. The business models are key as they provide the revenue certainty needed by projects to invest in the CCUS facilities which will help to strengthen UK industrial competitiveness and economic resilience.

The CIF should therefore be targeted at addressing specific areas that would benefit from targeted investment and further consideration of these issues can be found below. This also highlights the importance of maintaining pace on the development of the business models so that projects have a route to market.

To deliver this investment in CO_2 infrastructure programme should realise the following outcomes;

1. *CO_2 reductions*: In line with the CCC recommendations the UK should adopt a target of storing at least 10 $MtCO_2$ annually by 2030.
2. *Anticipatory capacity*: The infrastructure developed in the 2020s will need the capacity to support rapid deployment of CCUS in the 2030s. The CCC recommends that annual storage volumes may need to double to 20$MtCO_2$ by the mid-2030s.
3. *Geographical spread*: During the 2020s infrastructure development will be needed in all of the key storage regions (Central North Sea, East Irish Sea and Southern North Sea) and neighbouring industrial clusters to support the development of the innovative industries that can underpin clean growth in 2030s and 2040s.
4. *Sectoral application*: Infrastructure should be developed within those regions that can enable early deployment of capture across the key sectors that will require CCUS. These will help test the commercial model, deliver early lessons and inform subsequent CCUS deployment efforts.

CCUS Business Models are key to developing a UK CCUS sector. The design of the CIF should be integrated into the business models' design. Specifically, the fund element of the business models should be targeted on;

- Supporting delivery of the first CCS sites, e.g. by targeting investment at key risks or other enabling activities that occur during the first phase of CCS deployment face and/or
- Enabling the subsequent expansion of the early clusters, e.g. by supporting increased infrastructure capacity or the addition of new capture projects.

Eligibility criteria

The CIF should be targeted at supporting CO_2 transport and storage infrastructure in order to unlock the cross economy benefits of CCUS. This enables the full range of low-carbon technologies to be deployed (Clean hydrogen, GGRs, industrial & power).

The fund should be open to supporting a range of transportation solutions. While pipelines are expected to play a key role in transporting CO_2, eligibility should include shipping and rail transport where these can support the objectives of the fund, e.g. in supporting CCUS deployment in industrial regions or sites that are located further away from the main storage regions.

In addition, the CIF may also need to be targeted at addressing particular challenges that impact on the development of the first projects within each region. These could be issues that impact specifically on the early projects and cannot be addressed in the business models or be issues that need to be addressed in a timely manner but will ultimately be addressed by the business models as further experience is gained.

The CCSA has identified seven areas that the CIF could target, these have been broken down into three categories; 1) opportunities where the CIF provides the sole source of capital for infrastructure; 2) opportunities to leverage the CIF with industry investment and; 3) other areas that could benefit from CIF targeted investment. The CCSA would welcome the opportunity to discuss these further as the discussions on the design of the CIF progresses.

Opportunities to use the fund as sole, government-led support for T&S;

1. *Addressing cross chain risk*: As identified in the CCUS Advisory Group "[cross chain risk] can largely be removed if the initial capital expenditure for T&S in a cluster is funded by an HMG grant". This will address a material barrier that impacts on the first project(s). Enabling this investment could lower the risk for investment in subsequent projects. However, £800m is insufficient for the scale of CCUS infrastructure investment required in the 2020s if CCUS deployment is to be on track for net zero and would need to be expanded to c. £1.8 bn.
2. *Lower cost for users / consumers*: Providing the capital expenditure for infrastructure would help bring CCUS down the cost curve and lead to a lower cost for infrastructure users (and some consumers) helping to address disadvantage of first movers who may face higher costs. However, as with the *cross-chain risk* issue above, £800m is insufficient for the scale of CCUS infrastructure investment required in the 2020s and would need to be expanded to c.£1.8 bn.

Opportunities for government / industry co-investment;

1. *Fair allocation of CO_2 infrastructure costs to the first projects*: Payment of full T&S costs by the first project(s) in a given cluster pushes up costs for that first project to the point where the project may be perceived as uneconomic. Projects will want to bear their 'fair-share' of the network costs whilst they do not utilise the networks full capacity. The fund could be used to support the anticipatory investment in CO_2 infrastructure, reducing first project risk and allowing for future tie-ins.
2. *Establish public / private co-investment to leverage funds:* Combine the CIF with private sector investment with the goal of leveraging the £800mn and securing the funding needed to develop infrastructure in all of the storage regions.

Other targeted investment;

A number of other components of the CCUS value chain may also require access to capital grants in order to progress in the 2020s. It is not currently clear whether the previously announced sources of funding will be targeted to address these elements. In the event that the other funding sources are not applicable then considerations should be given to expanding the CCS infrastructure fund to encompass;

1. *FEED funding:* The next phase of CCUS development in the UK – the progression of projects through their FEED studies – is critical to the success of the UK CCUS programme. At present the sole source of FEED funding accessible by projects is through the Industrial Decarbonisation Challenge (IDC). It is not yet clear whether the IDC will be able to fund sufficient projects given the limited level of available funding and the fund being open to a wider range of industrial decarbonisation projects than just CCUS. In the event that the IDC

does not progress sufficient projects that can enables the '10Mt Commit and Review' goal of establishing infrastructure in the three storage regions to be achieved then the CIF should be used to help address this critical first phase of CCUS development.

2. *HMG co-financing of industrial capture plant:* Energy intensive industries are likely to have limited capital for expenditure on CO_2 capture plant. It is considered likely that a significant proportion of the capital will need to be funded by HMG. Industrial decarbonisation is a key component of the strategic case for investment in CCUS and a high political priority. Enabling early use of CO_2 infrastructure by industry would be an early demonstration of the cross economy benefits of developing a CCUS sector.
3. *Development of onshore infrastructure*: Hydrogen will be used for decarbonisation of the gas network, transport applications and power as well as industry. The presently announced funding sources do not appear to provide a good fit for capital support to either hydrogen infrastructure or production. Consideration should be given to whether an expanded fund should support these elements of the hydrogen value chain. Similarly, there may be value in targeting investment into onshore CO_2 transportation solutions that can facilitate a wider range of emitters to benefit from the application of CCUS.

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