FINANCING

Carbon Capture, Usage and Storage in the EMEA region

SEPTEMBER 2020

MUFG Bank Ltd
A member of MUFG, a global financial group

Contents

Introduction

Amidst a backdrop of a rapidly increasing focus on the impact of climate change from governments, regulators, investors and the general public, the move to a sustainable net-zero economy has moved to the top of the agenda for both politicians and industry. Good progress has been made in decarbonising power generation, however there has been limited success in reducing emissions from the heating, transport and industrial sectors. To drive change, industry and financiers must start embracing new and disruptive technologies to support the transition to a net zero economy.

Carbon capture, use, and storage (CCUS) is considered to be such a technology, and therefore has the potential to be a critical component of the portfolio of solutions needed to reduce the carbon-intensity of the GB electricity system, in tandem with improved energy efficiency and increased deployment of renewable generation.

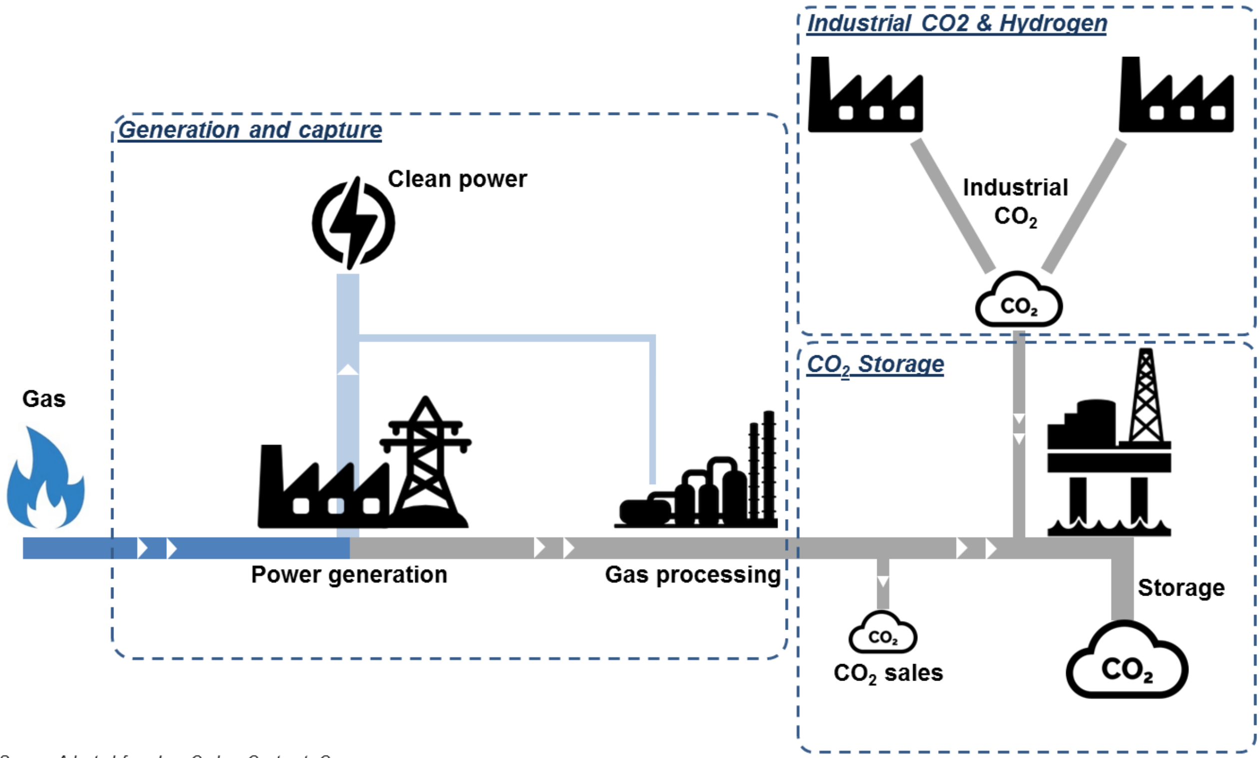
In this report we explore the CCUS chain and the role which Commercial Banks can play in enabling CCUS projects through financing.

The Role of CCUS

CCUS is expected to play a key role in achieving net zero targets due to the ability of the technology to reduce emissions across the energy system while providing the flexibility to manage fluctuations in generation from renewable sources. CCUS provides the ability to capture CO2 from fuel combustion or industrial processes including pre-combustion through the use of solvents and membranes, transport the CO2 via pipelines or ships for permanent storage in geological formations, or otherwise use it as a resource for products and services. As such, the technology serves as a key enabler to decarbonise currently carbon intensive industries such as steel and cement, or even allow for negative emissions where CO2 is captured from bio-based processes or from the air.

CCUS Technologies

The CO2 chain can be broken into capture, transport, and storage. Additionally, there is potential for the use of CO2, which to date remains the least developed part of the CCUS chain. An exception is the use of CO2 in an Enhanced Oil Recovery context, which has proven to be safe as well as technologically and commercially viable, providing valuable insights for the wider CCUS sector.



Source: Adapted from Low Carbon Contracts Company

CO2 Capture

Applications for CO2 capture are wide ranging, including options for deployment in industry, power, and hydrogen production:

- **Power** – The capture of CO2 from power plants such as those powered by natural gas would allow for a carbon neutral production of electricity. The key benefit of this solution is the role such plants could play in a carbon neutral economy with high renewable deployment. Provided some of the technological hurdles around ramp-ups and ramp-downs can be overcome, these plants could be deployed as peaking plants and as an alternative to large scale batteries which to date remain limited by their capacity.

  We see power with CO2 capture projects as an exciting opportunity for the project finance market, considering there is a long history of project financing power plants under the right support frameworks.

> *It is understood that the UK is currently exploring support for power with CO2 capture projects as part of its wider strategy on CCUS, potentially in the form of a dispatchable CfD. The standard UK CfD for renewable energy has proven to be financeable which provides a promising basis for the mechanism, but careful consideration needs to be given as to how a non-baseload CfD could work, as well as how the cross chain risks relating to the wider CO2 network can be mitigated.*

  Blue hydrogen – Hydrogen has gained significant interest in recent months, with governments and industry focussing on the role hydrogen could play in a future zero carbon economy. In the short to medium term it is unlikely that demand will be met by the production of green hydrogen from electrolysers as renewable output is used and required for the production of electricity. This creates a case for the production of blue hydrogen, but the development and deployment of projects is currently hampered by a lack of demand and cost competitiveness versus conventional hydrogen sources.

- **Industry** – The decarbonisation of carbon intensive industries such as steel, cement, and chemicals will be key in achieving a net zero economy. While innovation may bring zero-carbon production solutions in the future, the only feasible solution in the interim is to either capture the CO2 from emitters, or offset the emissions through CO2 removal (negative emissions). In time, we may see the emergence of new industrial processes, while in the interim existing plants could be retrofitted with capture devices.

CO2 Transport

The successful deployment of CCUS infrastructure will be dependent on safe and reliable transport infrastructure. While the gases behave differently, there are many similarities with and lessons to be learned from existing oil & gas ("O&G") infrastructure which could help with the development of this market.

- **Onshore pipelines** – The onshore transport of CO2 through pipelines is a proven concept, considering the US where there are 7200km of CO2 pipelines which have been operating for decades. The development of the pipelines however requires a market, and policymakers will need to decide how to incentivise these projects, and also who is best placed to develop this infrastructure considering there is an overlap of skills and experience with both gas utilities, and oil & gas majors.

  There are clear parallels with gas networks, which have demonstrated that pipelines supported by Regulated Asset Models can be structured as bankable projects.

- **Offshore pipelines** – Typically, CO2 is converted into a dense phase, highly pressured liquid format at a terminal before entering the offshore network. Thus, the offshore element to the transport infrastructure is subject to additional risks, and due to being installed in a submarine environment, more difficult to install and maintain.

  While there is plenty long-term precedents for onshore pipelines, there are few offshore precedents which provide the type of track record normally required by financiers. Early projects such as the Snohvit CO2 project in Norway which has a 153km offshore pipeline operating since 2008, will help the industry build the experience required.

Similar to the onshore element, a well-structured Regulated Asset Based (RAB) model could enable the development of these projects on a project finance basis, provided sufficient protections are put in place. Many of the potential developers for these projects are constrained by their balance sheets, and involvement of third party capital is likely to be an enabling factor. Additionally, there is an overarching question whether the offshore pipeline should be combined into a single project with the onshore pipeline, and/or the storage project.

It is noted, that compared to gas and oil pipelines, there are fewer environmental concerns and risks – in case of a leak the pipeline can be shut down and all that escapes into the sea is a limited amount of CO2.

- **Shipping** – Shipping of CO2 is similar to transporting LNG, and is a proven technology with some vessels already in operation. While unlikely to be feasible or efficient on a very large scale, there is a clear role for this type of transport, and we see banks participating in the financing of vessels subject to the existence of an underlying market for CO2 providing the business case for the operation of these vessels.

CO2 Geologic Storage

Together with transport, storage infrastructure needs to be available in order to manage the supply of CO2 from various sectors. As of today, geological sites have been identified as highly prospective storage opportunities and reuse of O&G infrastructure. However, not every country has access to the right type of geological store, while some are at a clear advantage due to their geographic location. More widely, local and community concerns around injection of CO2 need to be addressed through stakeholder engagement and education.

- Compressed CO2 is pumped in a dense liquid-like phase through a pipeline to an offshore platform where it is then injected using a facility similar to those used for natural gas production. CO2 is trapped under impervious cap rock. Europe is mainly considering offshore storage. Countries such as the US have opportunities for both onshore and offshore storage.

- The current ambition is to support the geological storage part of the projects with adequate support mechanisms and business models. The UK, for example, is considering a RAB model. Developers are seeking models which enable project finance due to constrained balance sheets. Considering these projects are largely unproven in a large scale, offshore context, policymakers really need to consider support mechanisms that enable these structures.

- From a technological perspective, more evidence is needed that any potential risks (e.g. reservoir suitability and leaks) can be adequately managed. To some extent, there are learnings from offshore drilling, and financiers will have to be educated on how risks identified in this sector can be mitigated. Nevertheless, with the novelty of the technology and application, many unknown risks and uncertainties remain.

- Environmental concerns also need to be addressed, and financiers will need to see a clear assessment of potential risks in this regard. In case of saline aquifer, this should consider the environmental impact of releasing saline solution into the sea, while in case of depleted gas fields the risk of accidental release of gas reserves needs to be considered. For any type of reservoir, leakage risks, as well as seismic risks need to be assessed, and in absence of a long track record, will need to be protected against. Without an insurance market in this area, these risks will need to sit with governments.

CO2 Enhanced Oil Recovery (EOR)

As mentioned above, geological storage of CO_2 is possible in saline formations or depleted gas/oil reservoirs. The latter can be a component or an add-on to EOR processes.

EOR is a commercial market driven by oil production, and thus different to pure CO_2 storage. The injection of CO_2 (which is ideally already or newly captured) into oil reservoirs boosts oil recovery and enhances yield for the producers. The CO_2 is then trapped in the oil-depleted reservoir which can continue to serve as a CCS facility. Lessons learned from EOR experience can provide insights into technologies focused on pure CO_2 storage. For example, operational experience has shown that around 99% of CO_2 injected during EOR remains trapped.

EOR is commercially viable but inherently driven by oil prices. The use of CO_2 capture and storage for EOR ultimately depends on the economics of the oil prices, which therefore may be challenging for lenders to support unless viewed as equity “upside” in any wider CCUS project.

With EOR operations already established for 40+ years, EOR based CO2 projects benefit from a long track record and proven technology, making them easier to finance. International examples of CO2 EOR projects include:

The Sleipner field in **Norway** is a success story of the first large-scale, offshore conventional oil and gas field which has been turned into a commercial CO_2 storage, beginning in 1996. The field has since achieved CCUS hub status as it also stores CO_2 captured from neighbouring gas fields and over 17 Mt of CO_2 have been injected since the start of the project. With a track record of 24 years, it provides valuable insights into well design and engineering.

In the **United States and Canada**, the deployment of CCUS, especially in relation to CO_2 ROE, has been driven by industrial actors who are incentivised by policies such as the 45Q tax credit, as well as, federal and state funding.

Successful projects include the Illinois Industrial Carbon Capture and Storage project (IL-ICCS) in the US (operating since 2017) and the Quest Project in Canada (operating since 2015). Further offshore storage options in the Gulf of Mexico combine the use of saline formations and depleted reservoirs. The results from various projects in this geography can be extrapolated to provide insights into the characteristics of the subsurface in various formations.

We also note that a similar type of CO_2 injection-use can be found in related industries such as hydrogen storage, municipal wastewater disposal, waste management, geothermal energy production, and aquifer recharge.

CO2 Use

There is currently only limited use for CO_2, and as described in the previous section, CO_2’s main use at present is in the CO_2 EOR process. Further usage of CO_2 can be found in some industrial segments such as building materials and carbon nanotubes, as well as the food and beverage industry. Looking ahead, we expect new technologies to emerge, which offer exciting opportunities for CO_2 usage. For example, applications may exist in the production of fuels, chemicals and building materials. The logical location of such projects will be within CCUS clusters for ease of offtake from the network/capture sources.

Financing Considerations

The commercial roll out of CCUS will require sound commercial models which will make investment in the technology deliverable and affordable. To date, such models do not yet exist (outside of EOR and a few pilot projects), and the private sector is reliant on government intervention to support the roll out of CCUS.

Large capital requirements for the technology, together with increasing capital constraints and shrinking balance sheets mean that many developers will have to rely on third party capital to fund projects, and projects need to be both deliverable and bankable in order to progress.

Cross chain risks and interdependencies

One of the key issues surrounding the roll out of CCUS is that, while not entirely first of a kind, there is limited precedent for large scale CO2 storage and long term management in an offshore, submarine environment. In absence of a wider CO2 network, initial capture and transport projects will be entirely reliant on the success of the storage project, while having little or no influence over the success thereof.

Conversely, the storage facility itself will also be dependent on customers providing a supply of CO2. These "chain" risks mean that each individual project is unlikely to be willing to take revenue risk where dependent on the availability and capacity of a 3rd party.

Economic and liability issues

The Transport & Storage element has to store CO2 indefinitely and is responsible for any potential CO2 leakages. The sheer size of projects and potential liabilities (with lack of available insurance) means companies are not able to take unmitigated risks and bring forward the first few projects without further support. Such risks could be mitigated through adequate protections within a government supported business model.

Additionally, any project will require identification of a long-term, credit-worthy customer base and revenue stream, as well as appointment of appropriate economic regulator. Currently, the only mechanism for support is the EU ETS scheme, of which generation would take the most share.

Wider challenges

In addition to the typical considerations for any large infrastructure project, particular consideration should be given to the following challenges:

- *Lengthy appraisal and licensing process;*
- *Uncertainty of CO2 supply;*
- *Long term storage monitoring and CO2 leakage liability;*
- *For storage – exact economics considering size and injection rates unknown until operation;*
- *Cross chain performance and risks;*
- *Change of law risks;*
- *Policy uncertainty;*
- *Local and community concerns;*
- *Availability of highly experienced and creditworthy contractors which will enable projects to adequately pass completion risk down to subcontracts;*
- *Lack of track record; and*
- *Alignment of separate final investment decisions taken by separate projects (CO2 capture projects and T&S projects).*

Previous attempts to support a roll out of CCUS technology, such as the 2012-15 UK CCUS Commercialisation Programme, have confirmed that the private sector has limited risk appetite for some of the risks inherent in the early roll out of CCUS, with banks taking a particular cautious approach. Additionally, the combination of risks in a single entity was considered too complex and raised particular bankability issues, suggesting that another solution will have to be found to mitigate the crosschain risks inherent in the technology. Based on these lessons learned, we expect that future CCUS projects, at least while in the infancy of the sector, will be structured as a system of interacting business models that are aligned while protecting the individual elements of the chain from risks.

Any such support will need to consider in detail the various elements of the CCUS chain, including all interdependencies, and provide adequate protections and incentives. Parts of this business model may be structured under regulated models, with the regulator having discretion to adapt and evolve the business model as the technology matures and stakeholders build experience in the sector. While it may be desirable for government to provide significant discretion to the regulator, this in itself can create significant regulatory risk for market participants. As such there is a tension between actually "getting the first projects done" and the need to establish an "optimal" path to an enduring regime.

At MUFG we are following the CCUS market closely as we recognise the potential of this technology in the decarbonisation agenda.

Highlights

- CCUS is a disruptive technology that could support the transition to a net zero economy.
- CO2 chain can be broken into capture, transport, and storage. Additionally, there is potential for the use of CO2. Any support will need to consider in detail the various elements of the CCUS chain, including all interdependencies, and provide adequate protections and incentives.
- CCUS technology is relatively new, and likely expensive for the first few projects, requiring government intervention to enable a roll-out.
- There is limited precedent for large scale CO2 storage and long term management in an offshore, submarine environment but carbon capture used as part of enhanced oil recovery projects can provide insights and lessons learned for the development of CCUS.
- Large capital requirements for the technology, together with increasing capital constraints and shrinking balance sheets mean that many developers will have to rely on third party capital to fund projects, and projects need to be both deliverable and bankable in order to progress.
- A full commercial roll out of CCUS will thus require sound commercial models which will make investment in the technology deliverable and affordable.

Appendix: CCUS Markets and Trends

UK	
Background and Experience	• Efforts to develop and commercialise the first CCS project in the UK date back to 2007, when the UK's government announced its first CCS funding competition for a full-scale CCS demonstration plant. Efforts to bring forward projects as part of this competition failed when candidates for participation in this competition decided to end their bids. • In 2009, the UK's Department for Energy and Climate Change announced support for a full-scale demonstration project, and in 2010 awarded money for two front end engineering and design (FEED) CCS demonstration projects at Kingsnorth and Longannet. As with the previous competition, both projects dropped their bids shortly after launch. • In April 2012, a new CCS roadmap was issued focussing on developing CCS as a commercially viable technology, both in terms of making it cost competitive as against other low-carbon technology and by tackling non-cost barriers to deployment (such as by creating an enabling regulatory framework and developing a storage strategy to ensure sufficient capacity is available as necessary). As part of these efforts, a CCS Commercialisation Programme awarded the Peterhead and White Rose projects funding for FEED studies which covered aspects of delivering large scale commercial CCUS projects, including commercial and financing arrangements, programme and risk management, consents and permitting, technical design, engineering and integration, health and safety, and lessons learnt. The UK CCS Commercialisation Programme was cancelled in November 2015.
Policy	• Previous attempts to bring forward the commercial CCUS projects provide valuable insights and lessons learned, including the importance of developing a framework which separates the business models for CO2 transport and storage infrastructure from the business models of capture projects. • The UK government continues with efforts to commercialise CCUS, and intends to make the UK a global technology leader by building on its current engineering, geological, and commercial advantages. The focus appears to be on the development of clusters (i.e. regional groupings where CCUS facilities share infrastructure and knowledge). The aim is to build a strategic supply chain, and grasp the opportunity to develop a large export market share of a potential globally significant sector. Further, the potential of linking CCUS infrastructure with hydrogen production is already recognised, as is the potential for the oil and gas sector to contribute to clean growth through a strategic re-use of O&G assets. • The UK government's Clean Growth Strategy (published in 2017) set the ambition to have the option to deploy CCUS at scale during the 2030s. In 2018 the government in its CCUS Action Plan announced a target to enable the UK's first CCUS facility to be commissioned from mid-2020.
Norway	
Background and Experience	• Norway has long experience of using CCUS techniques. Since 1996, CO2 from natural gas production on the Norwegian shelf has been captured and reinjected into sub-seabed formations. The CCUS projects on the Sleipner, Utgard and Snøhvit petroleum fields are the only CCUS projects currently in operation in Europe and the only projects in the offshore industry. • Norwegian CCS activities span a wide range of activities, from research and development to large scale demonstration projects and international work promoting CCUS. • Norway's experience reflects the geographical advantage of having depleted O&G fields and infrastructure that can be used to further develop CCUS projects, and industrial clusters close to the coast and in relative proximity to the infrastructure (e.g. pipelines and ships). • Currently under development is the Northern Lights CO2 transport storage project. The project is part of a Norwegian full-scale CCS which will capture of CO2 from industrial clusters in the Oslo-fjord region (cement and waste-to-energy), and ship liquid CO2 from these industrial capture sites to an onshore terminal on the Norwegian west coast. From there, the liquefied CO2 will be transported by pipeline to an offshore geological storage location subsea in the North Sea, for permanent storage.
Policy	• The Norwegian government has an ambition to develop a full-scale CCS value chain in Norway by 2024. As part of this ambition the government issued feasibility studies on capture, transport and storage solutions in 2016. • Similar to projects currently under consideration in the UK, Norway has recognised the benefits of "clustering" multiple CO2 capture projects to take advantage of economies of scale.

Wider Europe	
Background and Experience	• Europe benefits from favourable conditions with the North Sea basin as a prime region for storage as well as several industrial clusters around port cities (inter alia in the Netherlands, Denmark and France). It is clear, that cross-border CO2 transportation infrastructure has a major role to play in delivering a cost-efficient transition to a low-carbon economy.
Policy	• CCUS is an area of focus for the wider EU which has recognised the role of CCUS in reaching its long-term emissions reduction goal, as reflected in the 2030 climate and energy policy framework. • Amid different programs at EU and member-state levels, the Innovation Fund specifically pledges to invest up to EUR10bn by 2030 into R&D for a climate neutral future. • The Netherlands, in 2017, engaged with stakeholders to agree on a 'Climate Accord' which sets out a path and milestone goals for emission reduction and the phasing out of natural gas. This is a remarkable shift for a country that, similar to Norway, had important natural resources but had to rethink its energy sourcing as its own gas supply is exhausted and faced increasing public opposition. While this long-term shift faces technical, economic and political challenges, the switch to a zero-emission state continues. The Netherlands has begun to impose a CO2-tax on industry, but it is clear that other types of measures are also needed in order to achieve the 2030 emission target. The CO2-tax revenues are intended to help develop such measures, including CCUS (e.g. in empty gas fields). • Denmark is also focusing on emission reductions and sees CCUS as an enabling element. Following the signature of the Energy Agreement 2018, an even more ambitious climate agreement has been signed in June 2020. The new agreement seeks to reduce greenhouse gas emissions by 70% by 2030 on a 1990 baseline with climate neutrality by 2050 being the ultimate goal. CCUS is due to receive increased funding on a technology-neutral basis.

References

National Petroleum Council. (2019): Carbon Capture, Use, and Storage (CCUS) Report, Meeting the Dual Challenge, a Roadmap to At-Scale Deployment of Carbon Capture, Use, and Storage
https://dualchallenge.npc.org/downloads.php

Working Document of the NPC Study, Meeting the Dual Challenge, a Roadmap to At-Scale Deployment of Carbon Capture, Use, and Storage (2019), Topic Paper #1 Supply and Demand Analysis for Capture and Storage of Anthropogenic Carbon Dioxide in the Central U.S.
https://dualchallenge.npc.org/

Pale Blue Dot, Arup, Pinsent Masons (2019): CO2 Transportation and Storage Business Models Summary Report
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/677721/10251BEIS_CO2_TS_Business_Models_FINAL.pdf

HMG Consultation: Carbon capture, usage and storage (CCUS) (2018): business models
https://www.gov.uk/government/consultations/carbon-capture-usage-and-storage-ccus-business-models

CCUS Advisory Group (CAG) (2019): Investment frameworks for development of CCUS in the UK final report
http://www.ccsassociation.org/files/4615/6386/6542/CCUS_Advisory_Group_Final_Report_22_July_2019.pdf

European Commission: 2030 climate & energy framework
https://ec.europa.eu/clima/policies/strategies/2030_en

European Commission: Innovation Fund
https://ec.europa.eu/clima/policies/innovation-fund_en

Energypost: Carbon Capture (2019): Can CO2-EOR really provide carbon-negative oil?
https://energypost.eu/carbon-capture-can-co2-eor-really-provide-carbon-negative-oil/

IEA (2020): IEA and Denmark host ministerial roundtable discussion on making clean energy a key part of the global economic recovery
https://www.iea.org/news/iea-and-denmark-host-ministerial-roundtable-discussion-on-making-clean-energy-a-key-part-of-the-global-economic-recovery

CCUS Cost Challenge Taskforce Report (2018)
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727040/CCUS_Cost_Challenge_Taskforce_Report.pdf

Karen Turner, Oluwafisayo Alabi, Ragne Low and Julia Race, Centre for Energy Policy, University of Strathclyde, Scotland : Reframing the Value Case for CCUS: Evidence on the Economic Value Case for CCUS in Scotland and the UK (Technical Report)
https://strathprints.strath.ac.uk/67391/1/Turner_etal_CEP_2019_Reframing_the_value_case_for_CCUS_evidence_on_the_economic_value_case_for_CCUS.pdf

Department for Business, Energy & Industrial Strategy (2020): CCUS Innovation Programme: selected projects
https://www.gov.uk/government/publications/call-for-ccus-innovation/ccus-innovation-programme-selected-projects

Norwegian Petroleum, Carbon capture and storage
https://www.norskpetroleum.no/en/environment-and-technology/carbon-capture-and-storage/

Northern Lights – Part of The Full-Scale CCS Project in Norway
https://northernlightsccs.com/en/about

The Oxford Institute for Energy Studies, (2019): The great Dutch gas transition
https://www.oxfordenergy.org/wpcms/wp-content/uploads/2019/07/The-great-Dutch-gas-transition-54.pdf

S&P Global, (2020): Denmark agrees 70% cut to GHG emissions by 2030 in climate deal
https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/062220-denmark-agrees-70-cut-to-ghg-emissions-by-2030-in-climate-deal

ZEP, (2020): A Trans-European CO2 Transportation Infrastructure for CCUS: Opportunities & Challenges
https://zeroemissionsplatform.eu/a-trans-european-co2-transportation-infrastructure-for-ccus-opportunities-challenges/