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Carbon Capture, Utilization, and Storage—What Is the Big Deal?

By Paul Greening, Euan Strachan, and Matthew Kapinos*

In this article, the authors explain that carbon capture, utilization, and storage can play a key role in suppressing emissions without negatively impacting economic growth.

Carbon capture, utilization, and storage ("CCUS") looks set to become one of the next major talking points in energy, as countries around the globe struggle to reduce carbon dioxide ("CO_2") emissions and fulfil commitments to reduce production of greenhouse gasses. The scale of the impact of national lockdowns and the global economic slowdown caused by COVID-19 has been clearly demonstrated by the significant drop in global carbon emissions over the course of 2020 (the International Energy Agency estimates that emissions declined by approximately six percent during 2020).[1] With carbon emissions now rebounding sharply off the back of economic recovery, governments around the globe face the difficult task of attempting to continue the suppression of emissions without negatively impacting economic growth. CCUS can play a key role in achieving this objective.

WHAT IS CCUS?

Essentially, CCUS is the process of capturing the CO_2 from an existing industrial process (either pre- or post-combustion) and subsequently storing the captured CO_2 in subterranean structures, namely either depleted oil and gas fields or deep saline aquifer formations. It is estimated that CCS technology can capture up to 90 percent of the CO_2 emissions produced from the use of fossil fuels in electricity generation and industrial processes, preventing the CO_2 from entering the atmosphere and contributing towards climate change.[2] However, it is important to bear in mind that emissions from the use of fossil fuels in

* Paul Greening, a partner in the Singapore office of Akin Gump Strauss Hauer & Feld LLP, advises a range of clients—including private equity and fund investors, project sponsors, and developers—on international energy, utilities, and infrastructure projects. Euan Strachan, an associate in the firm's Singapore office, advises clients on corporate transactions, focused on the energy sector. Matthew Kapinos, a partner in the firm's Houston office, guides energy and infrastructure clients through all phases of drafting and negotiating agreements for the purchase, sale, development, and financing of energy and infrastructure projects. The authors may be contacted at paul.greening@akingump.com, estrachan@akingump.com, and mkapinos@akingump.com, respectively.

[1] https://www.iea.org/news/after-steep-drop-in-early-2020-global-carbon-dioxide-emissions-have-rebounded-strongly.

[2] https://www.c2es.org/content/carbon-capture/.

electricity generation and industrial processes account for only 30–40 percent of total carbon emissions.

The CCUS chain is separated into four parts:

- Capture of CO_2—a variety of technologies may be utilized to enable the separation of CO_2 from gases produced during industrial processes. These technologies typically use different methods falling within the following categories:
  - Pre-combustion capture (i.e., extracting CO_2 from hydrocarbons before combustion takes place).
  - Post-combustion capture (i.e., capturing CO_2 following combustion of hydrocarbons).
  - Oxy-fuel combustion (i.e., combusting hydrocarbons in an almost pure oxygen environment, as opposed to air).
  - Direct air capture (i.e., capturing CO_2 directly from the atmosphere using a series of chemical reactions).
- Transport of CO_2—the captured CO_2 is then transported by pipeline, or ship (as a pressurized cryogenic liquid), to be safely stored, thereby avoiding release into the atmosphere.
- CO_2 storage—the CO_2 can then be stored in designated sequestration sites, typically located several kilometers below the surface of the earth, where it cannot have a detrimental environmental impact.
- CO_2 utilization—as an alternative to storage, CO_2 can also be used as a feedstock in a range of products and services, with the potential applications including direct use (i.e., where the CO_2 is not chemically altered) and the transformation of CO_2 into useful products through chemical and biological processes.

At every point in the CCUS chain, from production to storage and utilization, the industry has at its disposal a number of process technologies that are well understood and have excellent health and safety records. The commercial deployment of CCUS will involve the widespread adoption of these CCUS technologies, combined with robust monitoring techniques and government regulation.

WHY DOES CCUS NEED TO BE UTILIZED?

Put simply, CCUS will be essential until such time as all (or at least most) technology, industrial processes and power generation become carbon neutral. CO_2 is the primary greenhouse gas, accounting for approximately three-quarters of all emissions. In addition to causing climate change by trapping heat, thereby preventing it from being released into space, greenhouse gases also contribute towards respiratory disease caused by smog and air pollution. Other adverse effects include disruption in agriculture and wildfires.[3] We are currently unable to entirely avoid production of CO_2, but the continuing development of new technologies can help reduce carbon emissions, while significant CO_2 emitters (e.g., fossil fuels utilized in power generation, transport and cement production) can be replaced in certain sectors.

However, the transition periods required to effect these changes are often lengthy as sectors struggle to move to carbon neutral, or zero emission, status. Transition periods are also likely to be extended in developing countries where economic growth is more rapid and there are fewer readily available and cost-efficient means of reducing emissions. In addition, certain sectors exist where it may simply be impossible to eradicate CO_2 production, such as in the petrochemical and refining industries, which will remain necessary for so long as there continues to be industrial demand for plastics and rubber.

With this in mind, it is clear that action needs to be taken in order to reduce the impact of CO_2 currently being produced and CCUS has the potential to play a key role in achieving that goal. Many of the locations most suitable for CCUS are in key oil and gas producing countries such as the United States, United Kingdom, Norway, Australia, Canada, those in the Middle East, and so on. However, not all sequestration sites currently being utilized/proposed are situated in former, or current, oil and gas producing provinces, but includes areas where the geology enables safe, long-term storage and in this regard much of Europe and parts of Asia, Africa and South America are also potential locations for CCUS to be implemented.

Asia, Japan, the United States, Australia, and 10 members of the Association of Southeast Asian Nations ("ASEAN") are forming a partnership to commercialize CCUS technology and are currently looking at potential CCUS sites in Southeast Asia to purchase up to 10 billion tonnes of CO_2 (equivalent to at least 10 years of emissions from thermal power generation in Japan).[4] The partnership is expected to launch in the summer of 2021. Singaporean sovereign wealth fund Temasek Holdings is also moving into the CCUS sector with a recent US$75 million Series D investment in Svante Inc., a Canadian company focused on developing several commercial scale carbon capture facilities to address emissions from CO_2-heavy industrial operations such as

[3] https://www.nationalgeographic.com/environment/global-warming/greenhouse-gases/.

[4] https://asia.nikkei.com/Spotlight/Environment/Japan-looks-to-ASEAN-nations-for-carbon-capture-and-storage.

cement manufacturing.[5] Temasek Holdings has also committed to halving the carbon emissions of its investment portfolio by 2030.

WHERE ARE THE KEY PROJECTS?

This section of the article highlights some of the key projects currently being undertaken in the CCUS space. It should be noted that the below represents only a sample of some of the ongoing projects where information is publicly available and is not intended to be an exhaustive list.

Exxon Mobil Gulf of Mexico CCS

U.S. major Exxon Mobil recently announced a proposal to establish a US$100 billion public-private CCS project that, if successful, could store up to 50 million metric tonnes of CO_2 by 2030, with capacity potentially doubling by 2040. The project, which follows Exxon's announcement that it had established a new "Low Carbon Solutions" business, is proposed to be situated in the Houston Ship Channel and captured CO_2 would be piped to offshore reservoirs in the Gulf of Mexico. Exxon has projected that the CCS market could be worth US$2 trillion by 2040.[6]

Schlumberger New Energy, Chevron, Microsoft and Clean Energy Systems—Carbon Negative Bioenergy

In March 2021, Schlumberger New Energy (a business unit formed to advance technologies that could help lower emissions and develop clean fuel sources), Chevron Corporation, Microsoft and Clean Energy Systems announced plans to develop a ground-breaking bioenergy with carbon capture and sequestration ("BECCS") project designed to produce carbon negative power in Mendota, California. The BECCS plant will convert agricultural waste biomass into a renewable synthesis gas that will then be mixed with oxygen in a combustor to generate electricity. It is projected that more than 99 percent of the carbon from the BECCS process can be captured for permanent storage by injecting CO_2 underground into geologic formations located nearby.

Once completed, the BECCS plant is expected to have the capacity to remove approximately 300,000 tonnes of CO_2 annually, equivalent to the emissions from electricity used by more than 65,000 homes. The venture follows an earlier announcement by California's Air Resources Control Board to begin phasing out almost all agricultural burning in the San Joaquin Valley

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[5] https://svanteinc.com/svante-raises-75-million-to-decarbonize-cement-and-hydrogen-production/.

[6] https://www.reuters.com/business/sustainable-business/exxon-proposes-massive-carbon-capture-storage-project-houston-2021-04-19/.

region by 2025. Engineering and design work has already commenced on the project, with a final investment decision expected to be taken next year.[7]

Century Plant—Texas, United States

Despite being in operation since 2010, the Century Plant (developed by Occidental Petroleum and Sandbridge Energy) remains one of the largest CCS projects in the world with a processing capacity of up to 8.4 mtpa. The Century Plant is a key component of Occidental's enhanced oil recovery ("EOR") program in the Permian Basin.[8] The gas processing facility captures CO_2 from locally produced gas which is then transported via a 160 km pipeline to a CO_2 hub in Denver City before being injected into the Kinder Morgan Permian delivery system. The CO_2 is injected into oil reservoirs, causing trapped oil to flow more efficiently, and is permanently trapped within the subterranean reservoir. Occidental has continued to expand its presence in the CCUS space with the formation of Oxy Low Carbon Ventures which focuses on "developing carbon capture, utilization and storage technologies to remove human-made carbon dioxide from the atmosphere for use in lower carbon oil production operations and to help create other less carbon-intensive products, like fuels, chemicals and concrete."[9]

Longship—Norway

The proposed Longship full-scale CCUS project is the cornerstone of the Norwegian government's ambitious goal of developing a full-scale CCUS value chain in Norway by 2024. With total investment estimated at approximately US$1.85 billion (and overall cost of US$2.7 billion), Longship comprises three key elements, namely:[10]

- Norcem—The first aspect of the Longship project involves CO_2 capture at the Norcem cement factory in Brevik, Norway. The cement industry accounts for approximately five to seven percent of global CO_2 emissions and with the Norcem (part of the Heidelberg Cement Group) factory alone producing 1.2 million tonnes of cement annually, it is estimated that 400,000 tonnes of CO_2 can be captured from the plant on an annual basis (accounting for approximately 50 percent of the factory's CO_2 emissions). The proposal to become the world's first cement factory equipped with a CO_2 capture plant is aligned with

[7] https://www.slb.com/newsroom/press-release/2021/pr-2021-0304-slb-newenergy-chevron-mendota.

[8] https://www.oxy.com/OurBusinesses/OilandGas/PermianBasin/Pages/PermianEOR.aspx.

[9] https://www.oxylowcarbon.com/carbon-neutral/about-us.

[10] https://ccsnorway.com/the-project/.

Norcem's ambition of achieving zero emissions from concrete (over the course of its lifecycle) by 2030.

- Fortum Oslo Varme—Clean-energy developer, Fortum Oslo Varme AS, aims to capture 400,000 tonnes of CO_2 from its waste-to-energy plant located in Oslo. Currently, the heat recovered from waste incineration at the plant is used as feedstock in Oslo's district heating system and it is hoped that approximately 400,000 tonnes of CO_2 can be captured.
- Northern Lights—The third aspect of the Longship project comprises the transportation and storage of CO_2 captured by Norcem and Fortum Oslo Varme. Northern Lights, a joint venture project between Equinor, Shell and Total, proposes to transport liquid CO_2 from the industrial capture facilities highlighted above to a terminal at Øygarden in Vestland County, Norway. From there, liquefied CO_2 will be transported through pipelines to a North Sea reservoir for permanent storage. The Northern Lights project is planned to be developed in two phases:
  - Phase 1: Prove the concept to capture, transport, inject and store up to 1.5 million tonnes of CO_2 annually.
  - Phase 2: In the event that there is sufficient market demand for storage to support it, the Northern Lights joint venture partners will take a positive final investment decision to approve the development of Phase 2 which includes developing capacity to receive, inject and store an additional 3.5 million tonnes of CO_2 per annum or five million tonnes in aggregate.[11]

CarbonNet—Australia

The CarbonNet project, funded by the Australian Commonwealth and Victoria State governments, is currently investigating the potential for establishing a commercial-scale CCS network in the Bass Strait, offshore Victoria. It is proposed that multiple CO_2 capture projects in Victoria's Latrobe Valley would feed into the network via a shared pipeline, with the CO_2 being injected underground in offshore storage sites.[12] The CarbonNet project is critical to the success of other projects in Victoria such as the Hydrogen Energy Supply Chain ("HESC") demonstration project. It is hoped that CarbonNet's preferred storage site, the depleted Pelican gas field, could store CO_2 in a similar fashion to the Northern Lights project.

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[11] https://northernlightsccs.com/en/about.

[12] https://earthresources.vic.gov.au/projects/carbonnet-project.

deepC Store Project—Australia

The deepC Store Project is being led by an Australian company, Transborder Energy, with the stated aim of capturing CO_2 emissions from liquefied natural gas ("LNG") (expected to be those in which Japanese utility companies are invested) and other industrial plants located in Australia and throughout Asia Pacific and then injecting the captured CO_2 into a subsurface well close to a CO_2 Floating Storage and Injection hub facility located offshore Australia. The objectives of the deepC Store Project are aligned with the Australian government's Low Emissions Technology Statement, with CCUS having been identified as one of the five priority technologies to reduce emissions from energy, transport, agriculture, and heavy industry.

Transborder Energy has entered into memorandums of understanding with a number of entities such as the Commonwealth Scientific and Industrial Research Organization, Mitsui O.S.K. Lines, Ltd., Kyushu Electric Power Co., Inc., Osaka Gas Co., Ltd., TechnipFMC plc, and Tokyo Gas Australia Pty Ltd, with the view towards evaluating the technical, commercial and economic aspects relating to the proposed project.[13]

Other Australian Projects

Australia has been a leader in the development of CCUS technology and a number of other projects have been developed. The Gorgon Project, one of the world's largest natural gas project, also incorporates a CO_2 Injection Project which injects and stores CO_2 in a deep offshore reservoir, known as the Dupuy Formation, beneath Barrow Island where Gorgon is located. The Chevron lead project aims to reduce greenhouse gas emission from Gorgon by approximately 40 percent or over 100 million tonnes over the course of the project's life. However, since coming into operation in August 2019, the CO_2 Injection Project has been the subject of recent controversy due to allegations that the carbon capture technology is not operating as efficiently as originally anticipated.[14]

In addition to Gorgon, AU$245 million the Callide Oxyfuel Project, completed in 2015, successfully demonstrated that carbon capture technology could lower emissions produced by a coal-fired power station. More recently, extensive research into carbon capture, utilization and storage has been undertaken by CO2CRC at its Otway International Test Centre in Nirranda South, South-West Victoria, Australia.

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[13] https://transbordersenergy.com/deepc-store-news-background/2020/12/5/australian-offshore-co2-capture-and-storage-hub-project.

[14] https://www.smh.com.au/national/millions-of-tonnes-of-carbon-added-to-pollution-as-gorgon-project-fails-capture-deal-20210215-p572na.html.

The Acorn Project—United Kingdom

The Acorn Project, centered on the St Fergus Gas Terminal in North East Scotland, aims to deliver a low-cost CCUS system by 2023. Designed to be constructed rapidly by utilizing existing oil and gas infrastructure, Acorn was the first CO_2 appraisal and storage license to be awarded by the United Kingdom's Oil and Gas Authority. The Acorn Project comprises two elements:

- CCUS—Existing gas pipelines will be repurposed to take CO_2 (captured directly from the gas processing units at the St Fergus Gas Terminal) directly to Acorn's offshore CO_2 storage site (the depleted Goldeneye reservoir).
- Hydrogen—The second phase of the Acorn Project is focused on hydrogen production. Acorn Hydrogen will utilize North Sea natural gas as feedstock and reform it into hydrogen, with the CO_2 emissions being removed and stored using the CCUS infrastructure.[15] The first Acorn Hydrogen plant is scheduled to come online in 2025.

The Acorn Project (backed by Pale Blue Dot Energy (a subsidiary of CCUS specialist Storegga Geotechnologies), industry partners (Shell and Harbour Energy), the UK and Scottish government, as well as the European Union) has been designated as a European Project of Common Interest.[16] If successful, the creation of an international CO_2 storage hub in the North Sea could unlock opportunities for other CCUS clusters across the UK and, potentially, mainland Europe itself. Indeed, Equinor recently announced that it will partner with UK energy company SSE (formerly Scottish and Southern Energy) to establish a CCS project attached to a gas-fired power station located at Peterhead, Scotland, a short distance from the Acorn Project.

The 900 MW gas-fired power station will include a CCS project designed to capture up to 1.5 million tonnes per annum of CO_2. SSE noted the plant would be ideally placed for access to CO_2 transport and storage infrastructure being developed by the Acorn Project. Both the Acorn and Peterhead projects have secured funding through the UK government's £171 million Industrial Decarbonisation Challenge Fund, as part of Scotland's Net Zero Infrastructure program.[17]

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[15] https://theacornproject.uk/about/.

[16] *Ibid*.

[17] https://www.upstreamonline.com/energy-transition/equinor-teams-up-with-sse-for-scottish-carbon-capture-and-storage-project/2-1-1009358.

Zero Carbon Humber—United Kingdom

The Zero Carbon Humber Partnership ("ZCH Partnership") is comprised of 12 large companies and organizations including Associated British Ports, British Steel, Centrica Storage Ltd, Drax Group, Equinor, Mitsubishi Power, National Grid Ventures, px Group, SSE Thermal, Saltend Cogeneration Company Limited, Uniper and the University of Sheffield's Advanced Manufacturing Research Centre.[18] The group has submitted a joint proposal worth approximately £75 million to accelerate decarbonization in the Humber, the UK's most carbon intensive industrial region,[19] with the stated goal being to create the world's "first net zero industrial cluster" by 2040.[20]

The ZCH Partnership's bid for obtaining funding addresses obtaining land rights and development consents, as well as front-end engineering design work, with the group anticipating taking a final investment decision during 2023. The anchor project for Zero Carbon Humber is the Hydrogen to Humber ("H2H") Saltend Project, which is being led by Equinor. H2H is intended to house the world's largest hydrogen production plant, along with a carbon capture facility. The plant, to be located at the Saltend Chemicals Park, will include a 600 MW auto thermal reformer ("ATR") used to convert natural gas to hydrogen. It is hoped that the plant will enable industrial customers in the area to switch to hydrogen as a fuel source while the plant moves to a 30 percent hydrogen to natural gas blend. If successful, H2H has the potential to reduce emissions from Saltend Chemicals Park by approximately 900,000 tonnes of CO_2 per year.[21]

In addition, National Grid Ventures intends to develop a pipeline network linking H2H to industrial sites throughout the Humber region to enable other businesses to switch to hydrogen and capture CO_2 emissions. CO_2 captured by H2H will be compressed at Centrica Storage's Easington site before being stored in the Southern North Sea using offshore infrastructure. It is hoped that these projects will play a significant role in the Zero Carbon Humber Project, helping to reduce the UK's annual CO_2 emissions by approximately 15 percent, saving around £27.5 billion in carbon taxes by 2040. Furthermore, it has the potential to safeguard employment in heavy industry throughout the region, with an estimated 55,000 jobs in carbon intensive industries being preserved.[22]

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[18] https://www.zerocarbonhumber.co.uk/who-we-are/.

[19] https://www.zerocarbonhumber.co.uk/the-vision/.

[20] *Ibid.*

[21] https://www.equinor.com/en/what-we-do/h2hsaltend.html.

[22] https://www.zerocarbonhumber.co.uk/the-vision/.

Abu Dhabi CCS—Abu Dhabi, United Arab Emirates

Earlier this year, the Abu Dhabi National Oil Company ("ADNOC") announced its intention to expand its existing CCS program, building on its position as one of the world's least carbon-intensive oil and gas producers with the goal of reducing its greenhouse emissions by 25 percent by 2030.[23] ADNOC currently operates the Al Reyadah facility in Abu Dhabi which can capture up to 800,000 tonnes of CO_2 per annum and plans to expand its CCS capacity by over 500 percent. In recent months, ADNOC has taken further steps to emphasize its commitment to the development of CCS by entering into separate agreements with Total and Italy's Eni to explore collaboration on CCS projects.

CHALLENGES AND OPPORTUNITIES

It is anticipated that the development of the CCUS sector will continue to gather pace as carbon emitters (both businesses and governments) struggle to meet emissions targets and satisfy environmental, social and governance ("ESG") objectives. The oil and gas industry faces significant hurdles in that regard and it is no coincidence that many of the key CCUS projects currently under development are being promoted by major hydrocarbon producers. In addition, however, there are a number of other factors which have the ability to hinder development in the CCUS sector.

Cost

When considered as a whole, the process of carbon capture is expensive due to significant deployment and energy costs. An industrial plant with a CCUS element will utilize more fuel (typically hydrocarbons) than one without in order to extract, pump and compress CO_2, while the costs associated with deploying a CCUS unit are capital intensive. However, the cost of CCUS does vary significantly and there are examples (such as fertilizer manufacturing) where CO_2 is produced separately in concentrated streams and, consequently, it is much cheaper to implement CCUS. By contrast, however, processes such as cement production and power generation do not possess this ability and the cost of CCUS is markedly higher (particularly where fossil fuels are used as feedstock in the relevant industrial process). The success of CCUS projects with an EOR element is also closely tied to fossil fuels with the Petra Nova NRG project serving as an example of a project becoming economically challenging when oil prices are low.

The Petra Nova project was designed to reduce carbon emissions from one of the boilers of a coal burning power plant located near Houston, Texas. Petra

[23] https://www.hydrocarbonprocessing.com/news/2020/02/adnoc-announces-expansion-of-carbon-capture-program.

Nova was, upon achieving commercial operation in January 2017, one of only two power plants with CCS capability in the world. The project, undertaken by NRG Energy ("NRG") and Japan's JX Nippon Oil (a subsidiary of ENEOS Corporation, the global Japanese oil and energy company), involved the retrofit of a boiler with a post-combustion carbon capture treatment system to treat exhaust emissions from the boiler itself. Captured CO_2 is compressed into liquid using the KM-CDR Process (developed by Mitsubishi Heavy Industries and Kansai Electric Power Company), which utilizes a proprietary amine solvent.[24] Following compression, the CO_2 is transported to the West Ranch oil field for use in EOR before ultimately being deposited in the sandstone Frio Formation of the West Ranch field, approximately 5,000 feet below the surface. The Petro Nova project cost approximately US$1 billion to install and received funding from both the United States and Japanese governments. However, the project was established on the assumption that oil prices would remain high (NRG began developing Petra Nova in 2009) but this has proven not to be the case and a net loss has been suffered in respect of oil production at West Ranch. On May 1, 2020, NRG placed the Petra Nova facility into reserve shutdown status, citing the effects of the global economic downturn resulting from COVID-19, primarily low oil prices. The Petra Nova project had not been restarted at the time of writing but NRG has indicated that it will "continue to evaluate options" as the oil price environment evolves.[25]

Ultimately, research and development efforts in the CCUS space will need to continue in order to hone existing carbon capture technology and improve efficiency and drive down the cost of implementing such projects.

Regulatory

A key challenge for CCUS (as with the vast majority of new energy technology) is ensuring the development of an adequate regulatory framework. Existing petroleum and environmental legislation can be utilized to an extent but certain issues (for example, allocation of long-term liability for sequestrated CO_2) often require that bespoke regulations be put in place. The UK has been a leader in developing a regulatory framework to address CCUS technology with the adoption of the Energy Act 2008 (as amended) (the "Energy Act"). A key aspect of the Energy Act is the requirement to obtain a license for storing CO_2 offshore. Prior to the adoption of the Energy Act, offshore CO_2 storage was prohibited unless forming part of an EOR process as licensed under the Petroleum Act 1998.

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[24] https://sequestration.mit.edu/tools/projects/wa_parish.html.

[25] https://www.nrg.com/about/newsroom/2020/petra-nova-status-update.html.

Subsequently, the Storage of Carbon Dioxide (Amendment of the Energy Act 2008 etc.) Regulations 2011 (SI 2011/2453) came into force in 2011, extending the geographical scope of the prohibition on undertaking CO_2 storages activities without a license to include onshore projects. Additional legislation in the form of the Storage of Carbon Dioxide (Licensing etc.) Regulations 2010 (SI 2010/2221) (which implements the EU CCS Directive 2009)[26] addressing licensing and operator obligations in relation to storage of CO_2.

In 2016, CO_2 storage licensing powers were transferred from the UK Secretary of State for Business, Energy and Industrial Strategy to the Oil and Gas Authority ("OGA"). The OGA now acts as the licensing authority for offshore CO_2 storage, except in Scottish territorial waters, which are administered by Scottish ministers. Given the well-developed regulatory framework it is, perhaps, no coincidence that a number of key CCUS projects are currently under development both in the UK and offshore in its territorial waters.

Environmental

Paradoxically, despite the potential environmental benefits of the development of CCUS, the sector is not without risk. Perhaps the greatest concern regarding CCUS is the environmental risk associated with long-term storage of captured CO_2. Any gradual, or catastrophic, leakage would likely negate the initial environmental benefits of capturing and storing CO_2 emissions. CCUS is a favorite emissions reduction option for many politicians and coal companies because it does not involve transitioning to a different fuel source (such as wind, solar, or nuclear power).

Similarly, oil and gas producers view CCUS as having significant potential to help fulfil ambitious carbon emissions targets being driven by an increased focus on ESG and shareholder scrutiny. BP, for example, is aiming to become a "net zero" carbon emitter by 2050, with CCUS expected to play a key role in achieving this goal. In February 2020, BP announced that it had formed a consortium with Eni, Equinor, Shell and Total to develop the Net Zero Teesside project,[27] based in Teesside in North East England. Net Zero Teesside has been established with the aim of decarbonizing local industries by capturing up to 10 million tonnes of CO_2, equivalent to the annual energy usage of over three

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[26] Directive 2009/31/EC of the European Parliament and of the Council of April 23, 2009, on the geological storage of CO2 and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006).

[27] https://www.bp.com/en/global/corporate/news-and-insights/reimagining-energy/net-zero-teesside-project.html.

million homes.[28] French major, Total, has also committed to achieving "net zero" emissions by 2050 and currently allocates almost 10 percent of its R&D budget to carbon utilization and storage technologies.

However, the proposed use of CCUS as a means of achieving "net zero" ambitions has been met with criticism from some quarters with critics arguing that it will slow the energy transition and that the long-term environmental impact of large-scale, subterranean CO_2 storage are, as of yet, unknown.

Carbon Capture and Utilization ("CCU")

CCU is the process of capturing CO_2 to be utilized for a specific purpose, as opposed to storing it. A large number of industrial processes (for example, production of building materials such as concrete and steel) require vast amounts of energy and CCU can assist in reducing the associated greenhouse emissions. In January, U.S. oil major Chevron announced that it had made an investment in San Jose-based Blue Planet Systems Corporation, a startup that manufactures and develops carbonate aggregates and carbon capture technology intended to reduce the carbon intensity of industrial operations. Blue Planet manufactures carbonate-based building aggregate made from flue gas-captured CO_2.[29]

Potential to Offset Decommissioning Liabilities

CCUS potentially provides a solution to one of greatest challenges faced by oil and gas producers, decommissioning. With the prospect of mature fields reaching end of life, operators across the globe are keen to offset (or at least delay) the hefty costs associated with decommissioning oil and gas infrastructure, which highlights some of the key challenges associated with decommissioning). Existing structures and depleted wells can be repurposed for CCUS, with the UK's Acorn Project serving as an example. In addition, CCUS has the potential to create new revenue streams for oil and gas players by charging emitters for sequestration.

WHAT IS NEXT FOR CCUS?

Currently, CCUS is perhaps the only technology that can significantly reduce emissions from large-scale industrial operations. The Global CCS Institute claims, in its 2020 report entitled "Net-Zero and Geospheric Return: Actions Today for 2030 and Beyond," that global emissions must drop 50 percent by 2030 and reduce a further 50 percent from that level by 2040 in order to

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[28] https://www.netzeroteesside.co.uk/.

[29] https://www.businesswire.com/news/home/20210114005281/en/Chevron-Invests-in-Carbon-Capture-and-Utilization-Startup.

achieve net-zero by 2050, meaning that a drastic reduction of emissions is required over the course of the next decade and beyond.[30] The report recommends that rapid expansion of CCUS-related infrastructure and projects must be undertaken in order to achieve this, highlighting that, as of September 2020 there were only 19 large-scale industrial and two large-scale CCUS power facilities in operation, with a combined capacity of approximately 40 million tonnes of CO_2 and a further 20 additional projects under development.[31] CCUS projects and related infrastructure require approximately six to 10 years from conception to commissioning,[32] giving some indication of the scale of the task at hand. However, we anticipate a significant increase in focus on CCUS over the course of the decade, particularly from the oil and gas sector, as hydrocarbon producers come under pressure from governments and investors to fulfil their commitments to become "net zero" emitters.

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30 https://www.globalccsinstitute.com/resources/publications-reports-research/net-zero-and-geospheric-return-actions-today-for-2030-and-beyond/.

31 *Ibid*.

32 *Ibid*.