POLICY BRIEF

11

Exploring Carbon Capture, Utilisation and Storage in the Indian Context:

ICRIER G20 Policy Series - Run Up to 2023

AMRITA GOLDAR
DIYA DASGUPTA

January 2022

Table of Contents

List of Figures

Abstract

A circular carbon economy (CCE) model aims to manage the carbon in the system as opposed to solely working towards its elimination. This policy brief focuses on the carbon capture, utilisation and storage (CCUS) component of such a model in the context of India. It highlights the relevance of this technology and discusses the global status of the same. This paper attempts to understand CCUS policies in some of the leading G20 countries that have been working in this field and draws possible lessons for India. It discusses India's involvement so far in pursuing this mitigation pathway and also details out the policy framework and programmes adopted in the United Kingdom and China to accelerate the deployment of these technologies. Some of the potential barriers to CCUS have been identified along with possible avenues for G20 engagement and next steps.

Keywords: *Carbon Capture, Utilisation and Storage (CCUS), Circular Carbon Economy (CCE), mitigation*

JEL classification: *Q54, Q55, Q56*

Authors' email: *agoldar@icrier.res.in; ddasgupta@icrier.res.in*

Acknowledgements

The authors would like to thank Dr. Rangan Banerjee and Dr. Sara Budinis who were appointed as reviewers and patiently guided the team. The authors would also like to express their sincere gratitude to the stakeholders ranging across various line ministries, private sector firms and eminent members of academia, who spared their valuable time to engage in consultations and provided their insight. Lastly, we would like to thank Dr. Deepak Mishra (Director & Chief Executive, ICRIER) for his constant support and encouragement.

Exploring Carbon Capture, Utilisation and Storage in the India Context

Amrita Goldar[1] and Diya Dasgupta[2]

Key Messages

- A circular carbon economy model aims to manage the carbon in the system as opposed to solely working towards its elimination. This policy brief focuses on the carbon capture, utilisation and storage component of such a model.
- The use of captured carbon dioxide does not translate into reduced emissions. Prior to ascertaining the climate benefits from CO_2 use, a number of considerations need to be taken into account, i.e., duration of carbon retention in the product, source of carbon, quantity and form of energy used to convert CO_2, scale of project for carbon use, etc.
- Countries such as the United Kingdom and China are spearheading the agenda of Carbon Capture, Utilization and Storage (CCUS). Their experience provides key insights into policies and programmes that can be adopted by India should it deem this emission mitigation pathway feasible. Some preliminary work is already under way with pilot projects being conducted by ONGC & IOL at the Koyali Refinery; Dalmia Cement setting up its carbon capture cement plant in Tamil Nadu; an industrial port in Tuticorin capturing CO_2 to produce baking soda and so on.
- There exist a number of technical and logistical barriers, to CCUS adoption, identified from literature, such as issues of land acquisition, in-depth assessment of storage sites to fulfil relevant criteria such as adequacy of capacity and injectivity rates, cap rock containment capacity to prevent CO_2 from escaping and so on. There is always a threat of CO_2 leakage and possible leakage points need to be scouted beforehand for necessary remediation plans to be prepared.
- There is a dearth of data pertaining to geological storage sites in India, which makes it difficult to undertake exhaustive feasibility assessments for CCUS projects.
- Co-operation between G20 countries on matters of CCUS related research and development is already underway by means of their engagement in international forums as well as bilateral partnerships. What is perhaps lacking at the moment is some kind of international benchmark for CCUS technologies.
- The Business 20 (B20) platform can help mobilise public acceptance of CCUS technologies and perhaps jointly address some of the apprehensions that fellow participants may have in terms of financing options, investments requirements, level of payoffs and so on.
- National policy options may be designed to provide incentives to the private sector in the form of tax concessions in exchange for investing in CCUS related projects or being engaged in production processes employing these technologies. Clarity in terms of national laws and regulations pertaining to CCUS is a prerequisite for building investor confidence.

---

[1] Senior Fellow, ICRIER
[2] Research Associate, ICRIER

1. Introduction

A circular economy refers to a closed loop system that aims to decouple economic growth and consumption of resources. The idea is to redefine value creation in a way that designs waste and pollutants out of the system, works towards regenerating natural capital and ensures that products and materials are kept in use. (Ellen MacArthur Foundation and Material Economics 2019). Building on this concept, a circular carbon economy (CCE) model focuses on adopting a technology-neutral, systems approach for the purpose of ensuring energy market stability and, at the same time, guaranteeing inclusive growth that caters to the sustainable development goals. The basic idea is to manage the carbon in the system as opposed to solely working towards carbon elimination. (IEF 2020)

The four R's of CCE namely reduce, reuse, recycle and remove are categories of mitigation options to be practiced in that order. 'Reduce' includes all such mitigation options that reduce the quantum of carbon entering the system such as energy efficiency and the use of non-biomass renewables and nuclear power. 'Reuse' entails capturing and using carbon as an input in processes that covert it into useful feedstock for industry. 'Recycle' refers to nature's carbon cycle wherein natural sinks such as plants, soil, etc., absorb carbon from the atmosphere and subsequently release it through decomposition and combustion. Thus, the bioenergy subsystem becomes carbon neutral provided an equivalent biomass grows and replaces what was used as bio feedstock for bio energy. Lastly, 'remove' involves eliminating carbon from the system by converting the captured carbon into feedstock for reuse or removing it by storing it via chemical or geological processes. (KAPSARC 2019)

This paper aims to explore the component of carbon capture utilisation and storage (CCUS) in the context of India to provide a holistic overview. The structure of the paper is as follows. Section II highlights the relevance of CCUS while a brief description of the global status is presented in Section III. India's involvement with CCUS is discussed in Section IV followed by the identification of some of the potential barriers in adopting CCUS technologies in Section V. Section VI highlights some of the possible action areas that India can push for in G20 discussions, if the country ultimately decides to actively pursue this mitigation option.

2. Relevance of CCUS

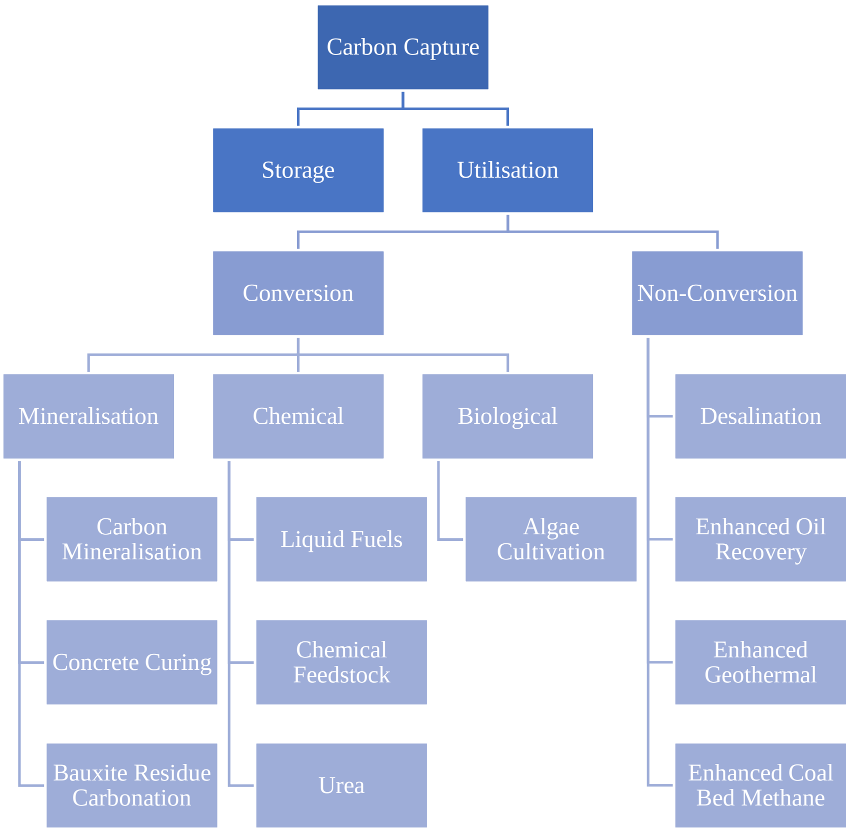
Direct air capture (DAC) refers to a technology that captures carbon from the atmosphere that can either be stored permanently in geological formations or used to produce fuels, chemicals, building materials, etc.[3] In case of permanent storage, CO_2 is removed from the atmosphere, generating negative emissions. However, the use of captured carbon can result in rerelease of CO_2 – for instance, when synthetic fuels produced from it are burnt. While this would not generate negative emissions, it will result in some climate benefits when fossil fuels are replaced by synthetic ones.

[3] Available at: https://www.iea.org/reports/direct-air-capture. Accessed October 16, 2020

Carbon capture utilisation (CCU) refers to the recycling of captured carbon to produce economically valuable products or services. Utilising carbon can take one of two forms, i.e., it can be used directly without conversion or indirectly with conversion. Captured carbon can be used to produce oil via enhanced oil recovery (EOR) processes. Alternatively, it can be used to produce fuels (e.g., methane, methanol, aviation fuels, gasoline, etc.), construction material, chemicals, plastics and algae-based products such as fertilisers and animal feed (Figure 1). The costs associated with carbon capture can be partially offset by the revenue generated from the utilisation measures. Each carbon utilisation pathway differs from the other in terms of characteristics with respect to technical maturity, market potential, economics and carbon reduction potential (C2ES and Cogentiv Solutions 2019).

Carbon capture storage (CCS), on the other hand, prevents the release of CO_2 in the atmosphere by capturing produced CO_2 from point sources, transporting it to preselected locations and storing it (Global CCS Institute 2019). Bioenergy in conjunction with CCS (BECCS) transforms into a negative emissions technology and can be used to address industrial sector emissions (IEA 2019)

Figure 1: Carbon Capture Utilisation and Storage



Source: Adapted from Pembina and ICO$_2$N (2015)

The renewed interest in carbon use has been driven by a number of factors, of which climate change mitigation takes precedence. CCU has an important role to play in reducing emissions and limiting the rise in global temperatures, particularly with respect to the 2015 Paris

Agreement. Moreover, there exist synergies between CCU and CCS. The other indirect driver involves the use of CO_2 as an alternative to fossil fuels as carbon sources. That is, carbon will continue to feature in a variety of applications such as organic chemicals that contain carbon, which provides them their structure and properties, aviation fuels, which will continue to be dominated by carbon-based fuels till such time that electricity or hydrogen emerge as viable alternatives, and so on. Additionally, developing new avenues for carbon use will contribute to providing opportunities for innovation and technology leadership (IEA 2019)

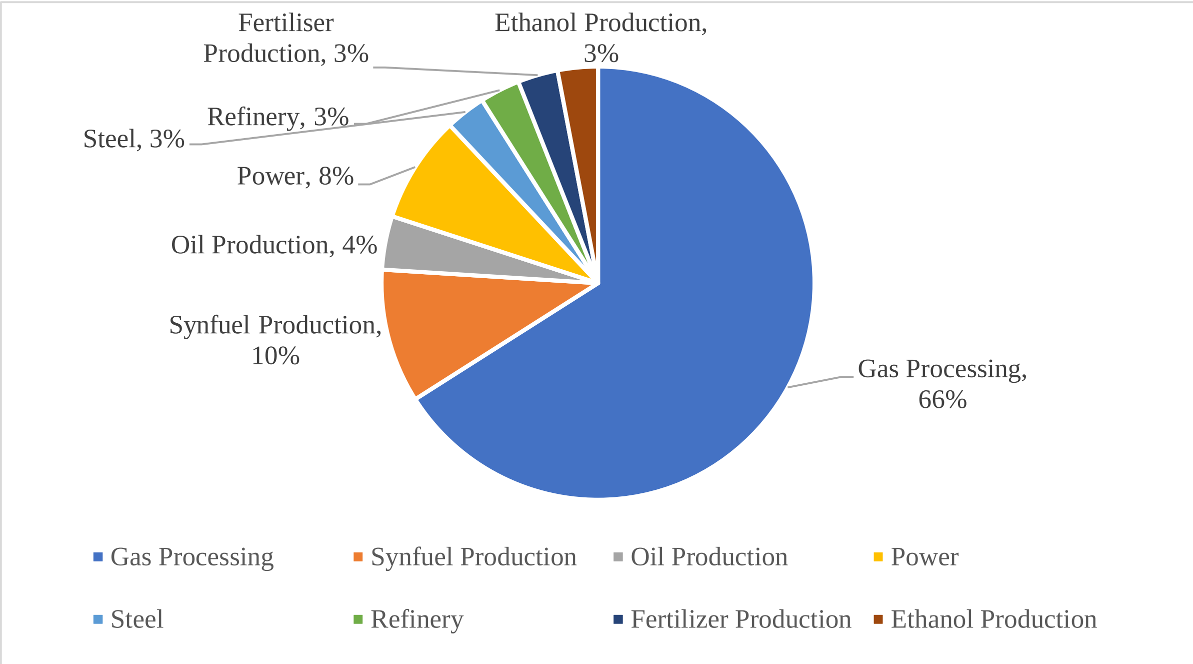
The role of CCUS is more pronounced when it comes to hard to abate sectors like the industrial sector. For instance, one fourth of the emissions from the sector are a result of chemical reactions taking place during industrial processes such as limestone calcination in producing cement, carbon oxidation of feedstock while producing chemicals, etc. Similarly, fuel burning to generate high temperature heat in cement, iron and steel, and chemical industries contributes to a substantial share of industrial emissions. Given the fact that industrial machinery are long lived assets, there is always the possibility of a lock-in of emissions for long periods of time. The effect of a lock-in with respect to the industrial sector typically persists for longer time periods as compared to other sectors like power, transport or buildings. Moreover, firms that try to incorporate low carbon technologies in production will be at a disadvantage in terms of rising costs and thus, there is very little room for firms to invest in low carbon processes, particularly in the short term. This is particularly true in cases where emissions are not regulated or there is no price on carbon (IEA 2019). The power sector is responsible for 40 per cent of the global emissions emanating from the energy sector and represents another promising avenue for adopting CCUS technologies. In light of electricity generation being dominated by fossil fuels globally and the rise in the stringency of emission regulations, CCUS retrofits allow power plant owners to continue operations as is, while also addressing carbon reduction targets (IEA 2020)

Carbon use does not exhibit the same functions as carbon storage or contribute to emission reductions of similar magnitude. However, it does support product and service development that contribute to curbing emissions and can be complemented with CCS technologies. Demand for carbon use can generate revenue streams for CCS projects – for example: demand for CO_2 EOR has generated investment in fourteen of the currently operating CCUS facilities globally. CCU demonstration projects also play a role in technology refinement in terms of carbon capture techniques. Moreover, short-term opportunities for carbon use, which involve the use of smaller quantities of carbon as compared to CCS, can take advantage of economies of scale by being located close to large-scale CCS projects. In cases where storage of small streams of carbon is not feasible, CCU can complement CCS (IEA 2019). However, it is equally important to note that use of carbon does not translate into reduced emissions. Prior to ascertaining the climate benefits from CO_2 use, a number of considerations need to be kept in mind, i.e., duration of carbon retention in the product, source of carbon, quantity and form of energy used to convert CO_2, scale of project for carbon use, etc. (IEA 2020)

3. Global Status

As per the data collected by the International Energy Agency (2019), there are at present eighteen large scale CCUS facilities in the world that capture 33 million tonnes of CO_2 every year. The sectoral representation of CCUS projects globally has been depicted in Figure 2 below.

Figure 2: Global Sectoral Shares of CCUS Projects



Source: IEA (2019)

At present, roughly 230 million tonnes of CO_2 are used across the globe per year, with the fertiliser industry being the largest consumer, followed by the oil and gas industry (IEA 2020). According to the Global Status of CCS Report (2020), there are 65 CCS facilities in the world, of which 26 are operational, 2 have suspended operations, 3 are under construction, 13 are in the advanced development stages and the remaining are in the early development stages. At present, the facilities that are in operation or under construction can capture and store 40 million tonnes of CO_2 per annum. In the period between 2010 and 2017, there was a decrease in the number of CCS facilities in the pipeline; in 2018, the CCS industry gained momentum. The uptick of CCS since 2017 has been driven by the Paris Agreement, which has attracted support from countries across the globe. While the construction of CCS facilities is capital intensive, it has been observed that "learning by doing" has contributed to driving down costs as and when new facilities come up. For instance, within a three-year period, the cost of capturing carbon fell from USD100 per tonne of CO_2 at the Boundary Dam facility (Canada) to less than USD65 per tonne CO_2 at the Petra Nova facility (US) (Global CCS Institute 2019). The United Kingdom is one of the first G20 countries to have announced its target of becoming carbon neutral by 2050 and is also the first country to have legally committed to becoming a net zero emitter of GHGs. In a similar vein, while China has had a long-standing history of being the world's largest coal consumer, it is also striving to become carbon neutral by 2060. In the section that follows, the policy framework and programmes adopted in the United Kingdom and in China to accelerate the deployment of CCUS technologies have been discussed. These provide key insights into possible strategies that India may consider adopting, should it decide to proceed along the path of CCUS.

3.1 United Kingdom (UK)

The UK endeavours to become a global leader in CCUS and wishes to have the option to deploy such technologies at scale in the 2030s, provided costs come down significantly. It is clear that CCUS deployment is conditional on the fact that it will be cost effective, which will be ascertained via operations of the first CCUS facility (Department for Business, Energy and Industrial Strategy (BEIS) 2018). Apart from legislations regulating CCS activity in the country, the UK has also adopted a number of policy decisions to incentivise CCUS deployment. In the periods between 2007 and 2011, and 2012 and 2015, two sets of CCS competitions were launched for developing CCS in the power sector. However, both competitions were cancelled before the funding was awarded. The Clean Growth Strategy (2017) introduced a new take on CCUS, wherein unlike previous approaches that solely focused on the power sector, the potential of CCS application in facilitating decarbonisation across several sectors like power, industry, heat, etc., was acknowledged.[4] The CCUS Action Plan was launched in 2018 to develop the first CCUS facility in the country through a government-industry collaboration, to be operational by the mid-2020s. The idea was to support the government's ambition of having the option to deploy CCUS measures later on. The Action Plan will also play a pivotal role in supporting the Industrial Clusters Mission that was announced by UK at COP24. (IEA 2019)

The UK is progressing towards its goal by adopting a three-pronged approach. The first involved the establishment of a CCUS Council, co-chaired by Energy and Clean Growth minister and the former chair of Shell UK and the Carbon Trust. The Council has been entrusted with the responsibility of providing advice regarding the progress and priorities under the Clean Growth Strategy. Additionally, it is also required to monitor the costs and deployment potential. Similarly, a CCUS Cost Challenge Taskforce was established in 2018 to provide insights on the possible strategies to adopt to reduce the cost of deployment of technologies and secure leadership in this area (BEIS 2018). The second is to encourage international collaboration to reduce costs. The government has chalked out plans to enhance R & D and international collaboration. In May 2018, the UK, in collaboration with Mexico and Saudi Arabia, took on the leadership of the Carbon Capture Challenge under Mission innovation. In 2015, the country announced the closure of all coal power plants that did not engage in carbon capture and storage (unabated) by 2025. Additionally, the government has committed to investing GBP100 million by 2021 to facilitate cost reductions in CCUS innovation and deployment and has been working towards this since 2011. The country has been actively participating in research on CCUS pilot projects both within and outside the UK through its

4 Available at: http://www.ccsassociation.org/new-about-ccs/reducing-costs/policy-and-regulation/. Accessed September 2, 2020.

participation in the International CCUS Programme under the International Climate Fund (IEA 2019). The third approach involves investing in technology innovation to drive down CCUS costs. Three CCUS innovation plans have been announced. These include a GBP20-million CCU Demonstration Programme to finance, design and construct demonstration projects, a GBP15-million fund for innovation projects that work towards driving down costs and a second contribution of £6.5 million for the Accelerating Carbon Technologies (ACT) programme that supports CCUS research projects being undertaken across eleven countries (BEIS 2018).

The industrial strategy adopted by the government is a joint partnership with businesses, local governments, universities, etc., to work towards achieving their goals. A number of grand challenges were introduced, which involved technological developments that would help in transforming industries. As part of these challenges, businesses and academia are invited to work together to develop innovative technologies. CCUS is expected to play a key role under the industrial strategy (BEIS 2018).

The UK Government announced its ambition of building the first ever 'net zero carbon' cluster by 2040 at the United Nations Climate Change Conference (COP24) in 2018. With a backing of about £170 million, the announcement has started to stimulate cluster formations. For instance, the Net Zero Teesside is in the process of developing an industrial cluster in northern England that will capture 6 million tonnes of CO_2 from gas power plants and industries. It is expected to be operational by 2030. Similarly, the Zero Carbon Humber, a partnership project, plans to build a net zero carbon industrial cluster in the Humber region. A pilot project for BECCS is already in the works at the country's largest power station and there are plans to develop a CCS and hydrogen network in neighbouring areas as well. In addition to these projects, companies are also engaged in developing innovative CCUS technologies such as a non-amine based capture technology that has been developed by C-Capture and is in the process of being tested, and the largest cement based carbon capture project that is being carried out by Carbon Clean Solutions in India (Global CCS Institute 2019).

3.2 China

CCUS has been included in the country's carbon mitigation strategies ever since the adoption of the 12th five-year plan (FYP). The National Climate Change Plan, spanning the period of 2012-2020, hails CCUS as a path breaking technology. Additionally, the 'Roadmap for Development of CCUS Technology' details the goals that are to be achieved in a phased manner, spread across five-year increments until 2050 (IEA 2020).

The preparation of the CCUS regulatory framework in China can be categorised into three stages. The first stage was during the period between 2006 and 2010. The country embarked on its journey towards low carbon development with the release of the 'Outline of the National Programme for Medium and Long-term Scientific and Technological Development'. Instead of focussing on any particular technique, it upheld the need to adopt clean technologies. Shortly after, in 2007, the country launched the 'National Scheme to Mitigate Climate Change' and the 'China Special Scientific and Technical Action Plan on Climate Change'. Both the plans included CCUS as one of the measures to tackle emissions. The second stage began during the

12th FYP (2011-2015) and saw the development of national level sub-FYPs that emphasised CCUS technology standardisation and its role in reducing GHG emissions as well as the positive externalities associated with their adoption in the industrial sector. The country sought to raise funds for these technologies via green finance. CCUS was also included in the work agendas of local authorities although their role was limited to reducing emissions. By the end of the period, China was equipped with national and provincial plans involving CCUS; the focus was not restricted to technical aspects and had transcended to incorporate issues of standardisation, intellectual property protection and so on. In the final stage, i.e., the 13th FYP (2016-2020), a number of sub-FYPs that incorporated CCUS were developed. Seven government ministries also came together to design the 'Guidelines on Establishing a Green Financial System' that aimed to rope in the private sector to participate in a public-private partnership model to provide green technologies in the public and private sectors. Furthermore, during this period, local provinces clearly mapped out the project objectives in terms of scale, investment value and capacity for emission reduction. The primary aim was to encourage low cost and large-scale deployment (Jiang, et al. 2020).

The operationalisation of policies pertaining to CCUS followed a staggered approach, which began with in-depth research and development exercises, followed by pilot projects and trials, international engagements and a clear demarcation of short-term and medium-term project objectives (Jiang, et al. 2020). Since 2007, China has been building its domestic CCUS technology capacity and has undertaken industry level pilot projects for carbon capture technologies. Additionally, three integrated carbon capture and storage projects in the field of chemical production and natural gas processing have entered the construction or operational phase. In an attempt to promote the deployment of CCUS, the Chinese government issued a notice in 2013 to extend provincial level support to projects in the Shaanxi and Guangdong regions. Full chain CCUS projects in China that include capturing, transporting and storage have been driven by EOR in oil fields with declining oil production. Eight small-scale pilot projects have been undertaken by major state-owned oil companies; these will be expanded to allow for higher capture rates either from existing sources or through collection of CO_2 from regional sources (IEA Clean Coal Center 2018).

Some of the factors favourable for CCUS development that are prevalent in the Chinese context include its long standing reliance on fossil fuels as a dominant energy source; prevalence of large scale concentrated emission sources that are suitable for capturing carbon; a substantial geological storage capacity and a well-developed industrial chain that provides ample opportunity for using CCU technologies (Clean Energy Ministerial 2020). In addition to the developments at home, in the period between 2005 and 2016, China has been involved in bilateral projects pertaining to CCUS with countries such as Australia, the EU, Italy, Netherlands, the US and Germany (Liu, et al. 2017). It is also engaged in multilateral collaborations with the Asian Development Bank (ADB) and has jointly developed the 'Roadmap for Carbon Capture and Storage Demonstration and Deployment in China'. The country is a member of the Global CCS Institute and hosts the annual workshop on CCUS. China is an active participant in the Carbon Sequestration Leadership Forum and the Clean Energy Ministerial conferences as well.

3.3 Involvement of International Forums

The Carbon Sequestration Leadership Forum (CSLF) is an international climate change initiative involving 25 national governments and the European Commission. It was established in 2003 and deals with developing low cost CCUS technologies and promotes legal, financial and regulatory mechanisms that can support projects (SABIC 2017). A number of task forces have also been established that cater to offshore CO_2 EOR, non-EOR carbon utilisation applications, BECCS etc. The Technology Roadmap (2017) launched by CSLF highlights some of the priority areas for research and development. It provides a list of recommendations for different policy time periods (short, medium and long term) with regard to carbon capture technologies, infrastructure, storage and utilisation (Ahmad 2019).

The Carbon Capture Innovation Challenge (CCIC) under Mission Innovation (MI) is headed by Mexico, Saudi Arabia and the United Kingdom and was launched in 2018. It endeavours to provide an international platform for co-ordinating and collaborating on CCUS research and development that contribute to reducing emissions from carbon intensive sectors such as electricity and industry. The CCIC has a two-fold objective – identifying and prioritising best in line technologies and to encourage research, development and demonstration (RD&D) through collaborative efforts. The technical MI CCUS workshop held in the United States in 2017 brought together 260 global experts belonging to academia and industry for deliberating on possible opportunities and identifying RD&D synergies with respect to CCUS. They identified critical challenges as well as chalked out priority areas for further research. The 2019 MI CCUS workshop held in Norway focused on commercialising CCUS technologies and strengthening the association between industry, researchers, and public and private sectors through the process of identifying possible gaps in regard to technologies of common interest. The idea was to translate research into development activities for speeding up commercialisation (Mission Innovation 2019).

Recognising the need to accelerate momentum in CCUS deployment, the CCUS Initiative was launched in 2018 under the aegis of the Clean Energy Ministerial (CEM). It is headed by the UK, the US, Saudi Arabia and Norway and works towards fostering strategic partnerships to generate short and long-term investments directed towards CCUS. Knowledge dissemination pertaining to technology, regulation and policies is also encouraged. While the initiative complements the work undertaken under various programmes such as CSLF, MI, IEA GHG R&D, etc., it also adds value by leveraging CEM ministerial meetings, platforms and outreach mechanisms to push the CCUS agenda in the context of clean energy.[5]

4. India and CCUS

India had identified CCUS as a priority area in its Second Biennial Update Report that was submitted to the United Nations Framework Convention on Climate Change (UNFCCC). The country is an active participant in the Carbon Capture Innovation Challenge under Mission

---

5 Available at: http://www.cleanenergyministerial.org/initiative-clean-energy-ministerial/carbon-captureutilization-and-storage-ccus-initiative. Accessed August 8, 2020.

Innovation (MI). India launched a funding opportunity in 2018-19 under MI for carbon capture (IC3), sustainable biofuels (IC4) and converting sunlight (IC5). The idea was to aid collaboration between Indian researchers and other MI member countries and a budget of USD17 million has been sanctioned for 47 projects (IC3 – 20, IC4 – 14, IC5 -13) across the three themes.[6] Additionally, as of July 2020, under the Indo-US Strategic Energy Partnership (SEP), CCUS technologies are among the common areas that have been jointly identified for collaboration.[7]

The uptake of CCUS has been relatively slow in the country, primarily because of concerns regarding geological CO_2 storage, high costs and uncertainties regarding such technologies. Despite the scepticism associated with CCUS, some independent companies have ventured into this field. For instance, in July 2019, the Oil and Natural Gas Corporation (ONGC) and Indian Oil Corporation limited (IOL), signed an MoU to jointly work towards reducing carbon emissions through the implementation of CCUS at the Koyali Refinery in Gujarat.[8] Similarly, Dalmia Cement announced its plans to build a 5,00,000-tonne carbon capture cement plant in Tamil Nadu. As of September 2019, it has signed a Memorandum of Understanding (MoU) with UK based Carbon Clean Solutions (CCSL) for technology and operational services for running the plant. While some small-scale CCS cement plants exist in the EU and China, a plant of this capacity is the first of its kind. Dalmia Cement happens to be the first cement company in the world to have committed to becoming carbon negative by 2040.[9] Additionally, a plant situated in the industrial port of Tuticorin captures CO_2 generated from its boiler and uses it to produce baking soda, which has a wide market base in industries such as glass making, detergents and paper products.[10] Small-scale capture and utilisation plants for fertilisers are also in the works.

With regard to the increasing focus on 'hard to abate' sectors, CCUS is envisioned to play a key role particularly in the iron and steel industry. India is the second largest producer of steel and the country's steel industry is more energy and emissions intensive as compared to its global counterparts. Based on estimates by the IEA (2020), new capacity additions in India over the next decade are projected to account for 40% of the steel-making capacity of the country, which would be in operation in 2050 (excluding a few early retirements). It therefore warrants the need for investment in near zero emission technologies which need not be limited to the steel sector alone.

4.1 Lessons from UK and China

In terms of learnings from the experiences of the UK and China, it is evident that the respective governments adopted a staggered, multi-pronged approach to CCUS deployment. These

6 Available at: http://mission-innovation.net/wp-content/uploads/2019/05/MI-Country-Highlights-2019.pdf. Accessed September 9, 2020.

7 Available at: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1639577. Accessed August 21, 2020.

8 Available at: http://print.acjnewsline.org/?p=8534. Accessed August 21, 2020.

9 Available at: https://carboncleansolutions.com/media-center/news/article/2019/09/dalmia-cement-and-ccsl-sign-mou. Accessed August 2, 2020

10 Available at: https://www.theguardian.com/environment/2017/jan/03/indian-firm-carbon-capture-breakthrough-carbonclean. Accessed August 2, 2020.

involve adequate R & D, conducting pilot projects, mobilising funds and preparing regulatory policies, all of which are guided by predefined, time-bound objectives. In particular, the UK's approach to deploying CCUS technologies at scale that provides for a significant reduction in associated costs is something that is suitable in the Indian context as well. This becomes particularly important when balancing the goals of sustained economic development and poverty alleviation with mitigating climate change. In light of India's newly announced targets of carbon neutrality by 2070, against the backdrop of managing numerous developmental goals in an already resource strapped economy, perhaps a more staggered approach of focusing on select sectors in the economy would be more feasible. In this regard, some of the leading industries in the country such as Thermax, Dalmia Cement, Hindalco Industries, Siemens, etc., have come together to voluntarily pledge near zero emissions by 2050 and jointly launched the 'Industry Charter for Near Zero Emissions Ambition by 2050'. They pledged to pursue decarbonization measures, collectively and at the individual level so as to encourage their counterparts to contribute towards meeting the objectives of the Paris agreement. These industries committed to augment energy efficiency, renewable energy and adopt circular economy principles across their value chains. They also expressed intent to undertake carbon sequestration if the need arose. In addition, the signatories affirmed their resolve to develop roadmaps and encourage collaborations with technology providers for demonstrating implementation and domestic development of low carbon industrial technologies. They also committed towards tapping synergies across industrial sectors to build markets.[11] Many Indian steel and cement firms are considering including CCS as part of their arsenal for reducing emissions. Similarly, the Chinese approach of developing a roadmap with goals chalked out for every five years can be tailored to the Indian context, based on the applications of CCUS that are viable in the country. This, however, would follow after necessary steps have been taken to address barriers to CCUS in India, some of which have been discussed in the next section.

5. Possible Drawbacks and Barriers

Undoubtedly, CCUS adoption will play a crucial role in curbing emissions and is an indispensable component of emission mitigation for countries that strive to become net zero emitters in the near future. However, it is equally important to be cognisant of some of the barriers to CCUS adoption, particularly in the case of developing countries like India. This technology option calls for substantial investments and countries that are already strapped for financial capital will need to prioritise among a portfolio of mitigation options while balancing development needs.

In addition to this, there are a number of technical and logistical barriers, identified from literature, that also need to be addressed. In a country like India in particular, where land scarcity is a major impediment, issues of land acquisition for such projects will forever prove to be a contentious matter. Moreover, prior to the implementation of any CCUS project, assessing the storage potential of sites is a prerequisite. Potential reservoirs of carbon storage

[11] Available at: https://www.teriin.org/sites/default/files/files/near-zero-document_2020.pdf. Accessed on September 9, 2021.

need to fulfil certain criteria to ensure secure storage and efficient activity. These include adequacy of capacity and injectivity rates, cap rock containment capacity to prevent CO_2 from escaping, stability of the geological environment, etc. Additionally, the reservoir would also need to possess sufficient depth, favourable geothermal characteristics, exhibit low seismic activity and be located at a safe distance from freshwater aquifers (CEPAC, EDIPUCRS and Global CCS Institute 2015).

While CO_2 is non-combustible, exposure to high concentrations of CO_2 can prove detrimental for human health as well as the environment. It, therefore, is essential that possible leakage points are scouted for before-hand and necessary remediation plans kept handy. Monitoring operations need to be conducted before, during and after carbon is injected into the basin (CEPAC, EDIPUCRS and Global CCS Institute 2015). Given the dearth of data pertaining to geological storage sites in India, an exhaustive feasibility assessment for CCUS projects is unlikely at this point (Kumar, et al. 2019).

EOR is one of the most widely used carbon capture applications globally. However, there exist only a handful of oil fields in India that have been depleted to levels that justify EOR to be undertaken at a large scale (Kumar, et al. 2019). With respect to CCUS technologies and power plants, fresh carbon capture projects built on existing technology will involve high capital and operating costs. While plants with high capacity factors will be able to generate higher revenues from power sales, they will also face higher operating costs as compared to plants with lower utilisation rates. The increased cost will ultimately have to be passed on to the consumer (IEA 2020). This can prove to be problematic, especially in countries like India where the price of electricity is highly regulated.

Until such time that businesses and investors see government backing in the form of policy support or incentive packages, it is unlikely that CCUS as a mitigation option will be adopted on a commercial scale in India. Moreover, the commercial viability of CO_2-based products depends on the development of markets for such products, which in turn is contingent on the existence of transport infrastructure such as pipelines and terminals for carbon storage. Additionally, these pipelines will have to be strategically located to minimise transportation costs as well as to cater to the CO_2 supply needs of industries manufacturing CO_2 based products.

6. G20 Engagement and Possible Next Steps

Keeping in mind the multitude of benefits associated with CCUS, including reduction of GHG emissions, creation of supply chains, ensuring energy security etc., expediting the deployment of CCUS technologies can help G20 countries fulfil a number of their priorities together. While the importance of CCUS was acknowledged in passing during the G20 rounds of 2017 and 2018, it was only during the Japan Summit that concerted efforts were made towards recognising opportunities offered by CCUS technologies. The Saudi presidency released a ‘CCE Guide’ that provides an overview of the concept of a circular carbon economy and details the different options available under the 4 R’s. In line with this, the ‘CCE Accelerator’ was also released to facilitate CCE implementation, advance research and develop technologies and aid national and international co-operation. Building on this agenda, the Italian Presidency has pledged to prioritise carbon neutrality and climate change during the forthcoming G20 Summit.

As is evident from the discussion in the previous sections, there are a number of issues that need proper deliberation before India takes a stand on whether to venture on this particular path. Should India decide to pursue CCUS, some of the possible agenda items that the country can push for are briefly discussed in this section. Co-operation between G20 countries in matters of CCUS related research and development is already underway by means of their engagement in international forums as well as bilateral partnerships. What is perhaps lacking at the moment is some kind of international benchmark for CCUS technologies. More active participation by private sector firms can be envisaged under the B20 Engagement Group. The B20 platform can help mobilise public acceptance of CCUS technologies and perhaps jointly address some of the apprehensions that fellow participants may have in terms of financing options, investments requirements, level of payoffs and so on. This may be complemented by national policy options that provide incentives to the private sector in the form of tax concessions in exchange for investing in CCUS related projects or being engaged in production processes employing these technologies. Firms may, of their own accord, be keen on building a 'green brand' image for themselves and the financial incentives may act as an added bonus. Similarly, clarity in terms of national laws and regulations pertaining to CCUS is another prerequisite for building investor confidence.

7. Conclusion

It is important to take cognisance of the fact that the choice of policies for development and deployment of CCUS need to be tailored in accordance with the country's market conditions, stage of infrastructure development, cost of alternative pathways of reducing emissions and so on. At present, the appetite for CCUS technologies is limited in India. For the country to take a coherent stand on the matter, it would be worthwhile to wait for the technology to mature further and the associated costs to decline. While the importance of CCUS as a relevant carbon mitigation pathway is not contested, their applicability in the India context requires fulfilment of a checklist of action points, some of which have been discussed in previous sections. Provided that the prerequisites are appropriately fulfilled, the next steps for the country would involve building the necessary infrastructure and introducing policy guarantees that would aid in lowering the cost of technology once it is deployed at scale.

References

Ahmad, Fatima Maria. 2019. *Strengthening International Collaboration of Carbon Capture Use and Storage.* Centre for Climate and Energy Solutions.

C2ES and Cogentiv Solutions. 2019. *Carbon Utilization- A vital and Effective Pathway for Decarbonization.* Center for Climate and Energy Solutions.

CEPAC, EDIPUCRS and Global CCS Institute. 2015. *Brazilian Atlas of CO2 Capture and Geological Storage.* CEPAC, EDIPUCRS and Global CCS Institute.

Clean Energy Ministerial. 2020. "Clean Energy Ministerial CCUS Initiative Webinar: Progress and Layout of Carbon Capture Utilization and Storage in China." Accessed November 23, 2020. http://www.cleanenergyministerial.org/sites/default/files/2020-03/CCUSinChina_webinar5March2020_CleanEnergyMinisterial.pdf.

Department for Business, Energy and Industrial Strategy (BEIS). 2018. *Clean Growth: The UK Carbon Capture Usage and Storage Deployment Pathway.* Crown Copyright.

Ellen MacArthur Foundation and Material Economics. 2019. *Completing the Picture: How the Circular Economy Tackles Climate Change* . Ellen MacArthur Foundation.

Global CCS Institute. 2020. *Global Status of CCS.* Global Carbon Capture and Storage Institute Ltd.

Global CCS Institute. 2019. *Global Status of CCS.* Global Carbon Capture and Storage Institute Ltd.

IEA . 2020. *Energy Technology Perspectives 2020: Special Report on Carbon Capture Utilization and Storage.* IEA Publications.

IEA . 2020. *Iron and Steel Technology Roadmap: Towards more sustainable steel making.* International Energy Agency.

IEA. 2020. *The role of CCUS in low carbon power systems.* IEA Publications.

IEA Clean Coal Center . 2018. *Reducing China's Coal Power Emission with CCUS Retrofits.* IEA Clean Coal Center .

IEA. 2019. *Energy Policies of IEA Countries: United Kingdom 2019 Review.* IEA Publications.

IEA. 2019. *Putting CO2 to Use: Creating Value from Emissions.* IEA Publications.

IEA. 2019. *Transforming Industry Through CCUS.* IEA Publications.

IEF. 2020. "IEF Insight brief : The Circular Carbon Economy."

Jiang, Kai , Peta Ashworth , Shiyi Zhang, Xi Liang, Yan Sun , and Daniel Angus . 2020. "China's carbon capture, utilization and storage (CCUS) policy: A critical review." *Renewable and Sustainable Energy Review* 119: 109601.

KAPSARC. 2019. *Achieving Climate Goals by Closing the Loop in a Circular Carbon Economy*. King Abdullah Petroleum Studies and Research Center.

Kumar, Ravinder, Ravindra Jilte, Keval Chandrakant Nikam, and Mohammad Hossein Ahmad. 2019. "Status of carbon capture and storage in India's coal fired power plants: A critical review." *Environmental Technology & Innovation* 13: 94-103.

Liu, H. J., P. Were, Q. LI, Y. Gou, and Z. Hou. 2017. "Worldwide status of CCUS technologies and their development and challenges in China." *Geofluids.*

Mission Innovation. 2019. "Report of the Mission Innovation Carbon Capture, Utilization and Storage Experts' Workshop."

Pembina and ICO2N. 2015. "Carbon Capture and Utilization Factsheet." Accessed July 2020. https://www.pembina.org/reports/ccu-fact-sheet-2015.pdf.

SABIC. 2017. *Building a Better Future: Sustainability Report.* SABIC.

Indian Council for Research on International Economic Relations (ICRIER)

Our Offices:
4th Floor, Core 6A, India Habitat Centre, Lodhi Road, New Delhi-110003

Plot No. 16-17, Pushp Vihar, Institutional Area, Sector 6, New Delhi-110017

O: +91 11 43112400 / 24645218

F: +91 11 24620180 | **W:** www.icrier.org | **E:** info@icrier.res.in